

Draft Technical Supporting Documentation for Regulatory Determinations:

Safer Products for Washington Cycle 2, Implementation Phase 3

Hazardous Waste and Toxics Reduction
Washington State Department of Ecology
Olympia, Washington

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Technical Supporting Documentation for Regulatory Determinations

Safer Products for Washington
Cycle 2 Implementation Phase 3

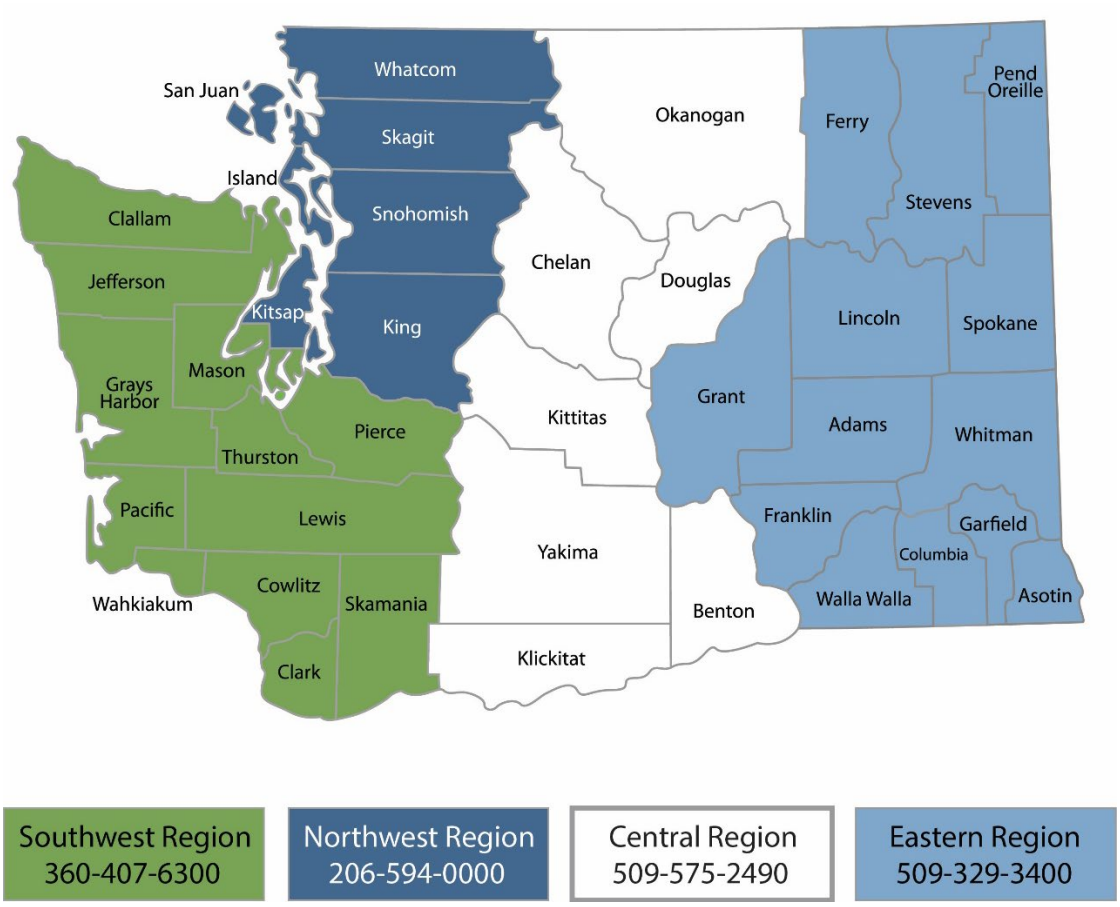
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Executive Summary

This publication is the technical companion to the Draft Regulatory Determinations Report to the Legislature: Safer Products for Washington Cycle 2, Phase 3,[3] which fulfills the requirement for the regulatory determinations phase (Phase 3) of the second review cycle (Cycle 2) of Safer Products for Washington.

In this report we describe the supporting technical information for draft regulatory determinations for the 15 priority consumer products reviewed in Cycle 2 as directed by Chapter 70A.350 RCW.[4]

RCW 70A.350.040(1)[5] specifies that Ecology may make one of the following regulatory determinations for each chemical-product combination in this report:

- Determine that no regulatory action is currently required.
- Require a manufacturer to provide notice of the use of a priority chemical or class of priority chemicals consistent with RCW 70A.430.060.[6]
- Restrict or prohibit the manufacture, wholesale, distribution, sale, retail sale, use, or any combination thereof, of a priority chemical or class of priority chemicals in a consumer product.

To restrict priority chemicals in priority products, Ecology must confirm the following (RCW 70A.350.040(3)):

- Safer alternatives are feasible and available.
- The restriction will either reduce a significant source or use of a priority chemical or is necessary to protect the health of sensitive populations or sensitive species.

A sensitive population means a category of people identified by the department that may be or is disproportionately or more severely affected by priority chemicals.

A **sensitive species** means a species or grouping of animals identified by the department that may be or is disproportionately or more severely affected by priority chemicals.

The regulatory determinations described in this supporting technical report are general. They align with the three options outlined in RCW 70A.350.040(1).

[3] https://apps.ecology.wa.gov/ecy/publications/SummaryPages/2604042.html
[4] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350
[5] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.040
[6] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.430.060

The priority products evaluated were determined to be significant sources or uses of priority chemicals as summarized in our previous report, Identification of Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2.[7]

We have recommended restrictions on priority chemicals in products only if we determined that safer alternatives are feasible and available.

In addition, our Draft Market Analysis[8] contains information on potential market implications that may result from these draft regulatory determinations.

The technical report also contains appendices:

- Providing a citation list that identifies the peer-reviewed science, studies, reports, and other sources of information used to support our draft regulatory determinations.
- Detailing laws and legislation in other jurisdictions on consumer products containing priority chemicals.
- Summarizing Washington's various regulations addressing toxics in consumer products.
- Highlighting examples of alternatives for some priority products available on the market.

We must report final recommended regulatory determinations to the Legislature by June 2027. This allows the Legislature an opportunity to amend the recommended regulatory actions before we adopt them in rule (Chapter 173-337 WAC)[9] in June 2028.

Ecology will also start a rulemaking in December 2026. We intend to invite public comment on the preliminary draft rule in the summer of 2027. In early 2028, we expect to release the formal draft rule for public comment and host hearings for interested parties to provide formal testimony. The law requires we adopt regulatory actions in rule by June 2028.

[7] https://apps.ecology.wa.gov/publications/SummaryPages/2504030.html
[8] https://apps.ecology.wa.gov/publications/SummaryPages/2604045.html
[9] https://app.leg.wa.gov/WAC/default.aspx?cite=173-337

Regulatory Determinations

Legislative requirement

The Washington State Legislature directed Washington Department of Ecology (Ecology), in consultation with Washington Department of Health (Health), to implement a regulatory program to reduce toxic chemicals in consumer products (Chapter 70A.350 RCW)[10] in 2019. The implementation program is called Safer Products for Washington.

The law requires Ecology to determine regulatory actions to:

- Increase transparency.
- Reduce the use of priority chemicals in priority consumer products.

Ecology and Health (jointly, "we") identify regulatory determinations for each chemical-product combination based on our evaluations to identify safer, feasible, and available alternative chemicals, materials, or processes to the priority chemicals. This report details our approach and technical analyses but does not establish regulations or restrictions on these chemical-product combinations.

Identifying safer, feasible, and available alternatives

Prior to restricting the use of a priority chemical, we are required to confirm that alternatives are safer, feasible, and available for the applicable priority product. The statute does not define feasible or available. To determine whether an alternative is safer, feasible, and available, we evaluate:

- Whether the chemical is functionally necessary.
- The hazards of the priority chemical class.
- The hazards of the alternative(s).
- Whether manufacturers use the alternative for the relevant application.

Safer alternatives

RCW 70A.350.010[11] defines safer as "less hazardous to humans or the environment than the existing chemical or process." To implement this law, we focus on pollution prevention. Pollution prevention involves reducing, eliminating, and preventing pollution at the source. Safer Products for Washington contributes to pollution prevention by reducing significant sources or uses of priority chemicals when safer alternatives are feasible and available. Reducing use of hazardous chemicals in products reduces risks for people and the environment.

Safer alternatives to priority chemicals can be either alternative chemicals or alternative materials or processes that eliminate the need for priority chemicals.

[10] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350
[11] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

To determine whether alternative chemicals are safer than priority chemicals, we developed hazard-based criteria, which are described in our Safer Products for Washington Cycle 1 Implementation Phase 3 report.[12] The criteria for safer focus on how we identify safer alternative chemicals that function like priority chemicals. In that report, we identify minimum and additional hazard tiers for what is considered safer.

The criteria also include within-class criteria that must be met for a chemical within a priority chemical class to be considered safer than other chemicals in the class. In most cases, alternatives that meet the minimum criteria are less hazardous than priority chemicals. However, we can use the additional criteria to identify safer alternatives when the chemicals used in the product meet the minimum criteria. This ensures that the alternatives are safer than the existing chemical or process.

To assess priority chemical classes, we focus on the data-rich chemicals—those that authoritative bodies reviewed or those with publicly available hazard assessments. Using authoritative lists and existing hazard assessments is efficient because it helps us avoid duplication of work. In this report, we rely on authoritative lists from government agencies and intergovernmental organizations—including the United States (U.S.), the European Union (EU), and the United Nations (UN). We used many of these lists in previous regulations, including the Children's Safe Product Act List of Chemicals of High Concern to Children.

We also relied on existing hazard assessments that:

- Have transparent criteria for hazard evaluation.
- Have transparent data requirements.
- Are either third-party reviewed or publicly available.

Hazard assessments collect existing data into a single report and score or rank the chemical. They provide a systematic way to integrate data from multiple sources. Other government agencies and industry often use these hazard assessment methods. That means we can integrate our methods with tools that manufacturers already use, making collaboration and information sharing easier. Our Safer Products for Washington Cycle 1 Implementation Phase 3 report identifies existing hazard assessment methods and certifications that meet our transparency and independence requirements and criteria for safer. For some alternatives where hazard assessments are unavailable but there is evidence of long-standing use with no indication of significant hazards, we further support our decision making with additional information and references.

[12] https://apps.ecology.wa.gov/publications/SummaryPages/2204018.html

Feasible and available alternatives

We based our process for identifying feasible and available alternatives on the Interstate Chemicals Clearinghouse (IC2) Guide.[13] It provides a framework that aligns with other authoritative bodies, while still offering enough flexibility to meet the requirements in Washington's law. Based on the IC2 Guide, we set criteria to identify feasible and available alternatives. These criteria, described in our Safer Products for Washington Cycle 1 Implementation Phase 3 report,[14] focus on identifying alternatives that manufacturers already use in the relevant application.

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Referenced hazard assessments

- GreenScreen assessments were accessed from https://database.toxservices.com/, or https://chad.theic2.org/ unless otherwise indicated. A description of the GreenScreen methodology is available at https://www.greenscreenchemicals.org/learn/guidance-and-method-documents-downloads.
- Scivera GHS+ assessments were accessed from https://rapidscreen.scivera.com/, and description of the GHS+ methodology is available at https://www.enhesa.com/chemical-intelligence-solutions/ghsplus.
- ChemFORWARD assessments were accessed from https://alternatives.chemforward.org/, and a description of the ChemFORWARD methodology is available at https://www.chemforward.org/our-approach.
- U.S. EPA Safer Chemicals Ingredients List (SCIL) was accessed from https://www.epa.gov/saferchoice/safer-ingredients. A description of the Safer Choice Criteria is available at https://www.epa.gov/saferchoice/standard.
- Cradle to Cradle Certified® products and Material Health Certificates were accessed from https://c2ccertified.org/certified-products. A description of the Cradle to Cradle Certified® Material Health Standard is available at https://c2ccertified.org/the-standard/material-health-certificate. Cradle to Cradle Certified® is a registered trademark of the Cradle-to-Cradle Products Innovation Institute. The Cradle-to-Cradle Certified® Material Health Certificate™ is a trademark of the Cradle-to-Cradle Products Innovation Institute.

[13] https://www.theic2.org/wp-content/uploads/2022/09/IC2_AA_Guide_Version_1.1.pdf
[14] https://apps.ecology.wa.gov/publications/SummaryPages/2204018.html

Technical analyses overview

The chapters in this report are organized by the chemical-product combinations. These chapters outline the results of technical analysis (required in RCW 70A.350.040[15]) aiming to identify safer, feasible, and available alternative chemicals, materials, or processes for each chemical-product combination. Each chapter includes:

- The scope of each priority product.
- The scope of each priority chemical class.
- Information that supports Ecology's findings about whether alternatives are safer.
- Information that supports Ecology's findings about whether alternatives are feasible and available.
- Ecology's regulatory determination: restriction, reporting requirement, or no action.

[15] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.040

Chapter 1: Per- and Polyfluoroalkyl Substances and Alkylphenol Ethoxylates in Architectural Paints

Priority product scope

As defined in the Safer Product for Washington Cycle 2 Implementation Phase 2 report (Ecology, 2025b), the scope of this priority product includes paints intended to be applied on interior and exterior surface of buildings and other structures by professionals or non-professionals. Paints, primers, and clearcoats, such as varnishes or lacquers, for wood applications (i.e., wood paints) are included in this scope.

Special purpose architectural paints used in specific infrastructure applications are included in this scope. These are described later in the chapter and considered separately in our "**Regulatory determinations**" section.

Automotive paints, other special purpose paints, and industrial original equipment manufacturer coatings that are applied in factory settings aren't included in this scope.

Priority chemicals scope

Both per- and polyfluoroalkyl substances (PFAS) and alkylphenol ethoxylates (APEs) were previously listed as priority chemical classes (Ecology, 2022b). Per Revised Code of Washington (RCW) 70A.350.010(10)[16] (Washington State Legislature, 2019), PFAS were defined as "a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom." APEs were listed under the category of "phenolic compounds" and further defined in our report, Regulatory Determinations Report to the Legislature: Safer Products for Washington Cycle 1 Implementation Phase 3.[17]

Functions of PFAS in the priority product

The functions of PFAS in architectural paints were taken from a report by Organisation for Economic Co-operation and Development (OECD) on per- and polyfluoroalkyl substances (PFAS) and alternatives in coatings, paints, and varnishes (OECD, 2022), further supported by a report issued by the Danish Environmental Protection Agency on PFAS and alternatives in construction products (Miljøstyrelsen, 2024). The functions are listed below in Table 1.

[16] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010
[17] https://apps.ecology.wa.gov/publications/SummaryPages/2204018.html

Table 1: Functions provided by PFAS in architectural paints.

Function of PFAS	Which type of PFAS typically provides this function
Durability	Fluoropolymers
Weather resistance	Fluoropolymers
Corrosion resistance	Fluoropolymers
Abrasion/scratch resistance	Fluoropolymers
UV resistance	Fluoropolymers
Fire resistance	Fluoropolymer
Lubricity	Fluoropolymer, fluorosurfactants
Anti-blocking	Fluorosurfactants
Oil repellence	Fluorosurfactants
Anti-soiling	Short-chain PFAS
Levelling	Short-chain PFAS
Wetting	Short-chain PFAS
U.S. EPA volatile organic compound (VOC)-exempt solvent (EPA, 2019; Hydrite, 2025; State of California, 2025; University of Waterloo, 2017)	Parachlorobenzotrifluoride (PCBTF)

We further defined and matched the different functions served by PFAS in architectural paints based on the U.S. EPA CompTox functional use categories (A. Williams, 2025). Some of the functions defined by CompTox could be defined and matched to more than one function as their definitions matched with the description of the PFAS functions listed in the OECD document. For functional use categories not defined by the U.S. EPA, we used definitions provided by SpecialChem (SpecialChem, 2025e).

We describe the functions listed for PFAS in architectural paints, and our matching of analogous functions below.

Surface modifier

A surface modifier is defined as a chemical substance added as an ingredient to adjust the optical properties of the mixture and affect the appearance of the surface where the mixture was applied by increasing gloss (EPA, n.d.-o).

A surface modifier is matched to the functions of durability.

Waterproofing agent

A waterproofing agent is defined as a chemical that forms water beads, protecting surfaces from water (EPA, n.d.-o).

A waterproofing agent is matched to the functions of durability and weather resistance.

Film former

A film former is defined as a chemical substance that can form a thin continuous sheet to act as a barrier on the surface where the chemical substance is applied (EPA, n.d.-o).

A film-former is matched to the functions of durability and weather resistance.

Corrosion inhibitor

Corrosion inhibitor is defined as a chemical that prevents corrosion on metallic materials (EPA, n.d.-o).

Corrosion inhibitor is matched to the functions of corrosion resistance.

Scratch resistance agents

Scratch resistance agents are defined as chemicals protecting surfaces from damage caused by abrasion, which can include cleaning or everyday wear (SpecialChem, 2025h). Scratch resistance agents help increase the hardness of the surface, reduce frictions, and improve slip.

Scratch resistance agents are matched to abrasion and scratch resistance.

Light stabilizers or UV absorbers

Light stabilizers or UV absorbers are defined as chemicals that protect products from deterioration caused by UV light by absorbing UV light (EPA, n.d.-o).

These functions are matched to UV resistance.

Flame retardant

A flame retardant is defined as a chemical substance capable of altering the degradation or combustion process of the material where the chemical substance is added to (EPA, n.d.-o). A flame retardant can act by suppressing smoke.

A flame retardant is matched to fire resistance.

Lubricating agent

Lubricating agent is defined as chemical substances that reduces friction between surfaces (EPA, n.d.-o).

A lubricating agent is matched to lubricity.

Anti-blocking agent

An anti-blocking agent is defined as a chemical substance that prevents or reduces the adhesion of a material, whether it is to the material itself or to another material (EPA, n.d.-o).

Anti-blocking agent is matched to anti-blocking.

Anti-stain agent

An anti-stain agent is defined as a chemical substance providing stain blocking and soil resistance capabilities (EPA, n.d.-o).

We initially matched this function to oil repellence because a fluorosurfactant (MAFLON S.p.A, n.d.) is cited as an example of the oil repellence function provided by PFAS in architectural paint (OECD, 2022). A search on the company website indicates that only one out of fifteen fluorosurfactants provided oil repellency function (MAFLON S.p.A, n.d.). This means that oil repellency function is an additional benefit not typically provided by fluorosurfactants, which are levelling and wetting (Miljøstyrelsen, 2024; OECD, 2022).

We note that, in at least one instance (Aculon, n.d.), oil repelling coatings are intended for the oil and gas industry. We also note examples of PFAS providing stain or oil resistance function during our alternative analyses (Green CE, n.d.; Kumar, 2025; Rajendran, 2024; White, 2025). We matched anti-stain agent to stain or oil resistance, rather than oil repellence.

Anti-soiling

Anti-soiling is defined as the ability of paints to prevent the build-up of dust and dirt (OECD, 2022). SpecialChem defines dirt pick-up resistance as the breakdown and washing away of dirt and dust that result from UV-light activated-photochemical reactions that occur on the coating surface (SpecialChem, 2025f). Increasing the slip level is suggested as another process that will increase dirt pick-up resistance (SpecialChem, 2025f).

Functions are matched to anti-soiling are:

Matting agent

A matting agent is defined as a chemical that controls the light reflection of materials by modifying the surface texture (SpecialChem, 2025g).

Slip agent

A slip agent is defined as a chemical that enhances the ability of the coating product to spread (EPA, n.d.-o).

Leveling agent

A levelling agent is defined as a chemical that reduces surface tension and promotes even flowing of coating materials (SpecialChem, 2025i).

This function is matched to levelling.

Wetting agent

A wetting agent is defined as a chemical that promotes the coating of organic liquid on solid material (EPA, n.d.-o).

This function is matched to wetting.

Solvent

A solvent is defined as a chemical substance that dissolves another substance, particles, or colloids, thin, and extract (EPA, n.d.-o).

The functions of PFAS in architectural paints are matched and listed in **Table 1**. The result of this matching is displayed in **Table 2**.

Table 2: Functional use categories matched to functions of PFAS.

Functional Use Categories	Function of PFAS
Surface modifier, waterproofing agent, or film former	Durability
Waterproofing agent or film former	Weather resistance
Corrosion inhibitor	Corrosion resistance
Scratch resistance agent	Abrasion and scratch resistance
Light stabilizer or UV absorber	UV resistance
Flame retardant	Fire resistance
Lubricating agent	Lubricity
Anti-blocking agent	Anti-blocking
Anti-stain agent	Stain or oil resistance*
Matting agent or slip agent	Anti-soiling
Levelling agent	Levelling
Wetting agent	Wetting
Solvent	U.S. EPA volatile organic compound (VOC)-exempt solvent (Hydrite, 2025; State of California, 2025; University of Waterloo, 2017)

*Stain and oil resistance, instead of oil repellence. See discussions under the "**Anti-stain agent**" function and "**Safer chemical alternatives**" sections in this chapter.

Note: Relevant functions are matched to functions of PFAS according to the U.S. EPA's CompTox functional use categories (A. Williams, 2025).

Functions of APEs in the priority product

The Safer Product for Washington Cycle 2 Implementation Phase 2 report (Ecology, 2025b) provides the basis of the functions of APEs in architectural paints, which include surfactant and emulsifier. Below are the definitions of functions listed for APEs in architectural paints:

Surfactant

A surfactant is defined as a chemical substance with surface active properties, capable of reducing surface tension of water when added to water (EPA, n.d.-o). A surfactant promotes the penetration of, or spread over, the surface of another material and reduces interfacial tension between two liquids (e.g., water and another material).

Emulsifier

Emulsifier is defined as a chemical substance that ensures that oil and water mixture will maintain an even distribution of ingredients that won't separate (EPA, n.d.-o).

Hazards of the priority chemical class

We describe the hazards associated with PFAS in our Cycle 1, Phase 3 Priority Products Report to the Legislature (Ecology, 2022b). The hazards of concern for data-rich PFAS included carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are known to be persistent in the environment, and some bioaccumulate.

We describe the hazards associated with APEs in our Cycle 1, Phase 3 Priority Products Report to the Legislature (Ecology, 2022b). The hazards of concern for APEs include endocrine activity, aquatic toxicity, and persistence.

The hazards of PFAS and APEs indicated that these chemical classes didn't meet our minimum criteria for safer (Ecology, 2022b, 2022c).

Safer, feasible, and available alternatives

Search for alternatives

Although the Safer Products for Washington framework lists safer first, followed by feasibility and availability, we evaluated criteria for feasibility and availability before safer for this chemical-product combination.

First, we made a list of potential alternatives with chemical functions that would fit our matching for PFAS, and a list of potential alternatives to APEs, as shown in **Table 2**. We followed these steps:

- We consulted the OECD document on PFAS in architectural paints (OECD, 2022), which has already identified alternatives to PFAS in architectural paints.
- We consulted the Danish EPA report on PFAS and alternatives in construction products (Miljøstyrelsen, 2024).

- We consulted the U.S. EPA Safer Chemical Ingredients List (SCIL) (OCSPP, 2013a), the Pharos database (Pharos, n.d.-b), the ZeroPM database (Figuière et al., 2025; Romain et al., 2025; ZeroPM, 2025), and the Interstate Chemicals Clearinghouse Chemical Hazard Assessment Database (IC2, n.d.).
- We examined the different products and use categories compiled in the EPA CompTox Chemicals Dashboard (EPA, n.d.-k; A. J. Williams et al., 2017), which is based on prior U.S. EPA efforts to catalogue and define the functions of chemicals used in consumer products (Dionisio et al., 2018; Isaacs et al., 2016; Phillips et al., 2017), including chemicals used in paints.
- We considered a prior alternative assessment on APEs performed by Washington State Department of Ecology (Ecology, 2021).

Paints could be composed of the following components: "pigments," "resins or binders," "additives," and "solvent" (Ecology, 2025b). Fluoropolymers are often used as resins or binders, while fluorosurfactants and short-chain PFAS were often used as additives.

During our evaluation of alternatives for PFAS, we identified additives that can impart the same function as that of resins or binders, as advertised by the chemical suppliers and paint companies. Where applicable, additives are included as alternatives to binders in paints for PFAS.

APEs are additives. We only considered additive alternatives for APEs.

Second, once the initial list of alternatives that would fit our matching as shown in **Table 2** was collated, we determined their feasibility (Ecology, 2022d) using the following steps:

- We used business-to-business chemical marketplace websites, such as SpecialChem (SpecialChem, 2025e), Knowde (Knowde, 2025), and UL Prospector (UL Prospector, n.d.) to determine the presence and trade names of alternatives.

We noted that Green Seal® prohibits PFAS in paints and coatings in its standard (Green Seal, n.d., 2025). However, the transition process was still occurring during our evaluation for safer chemical alternatives. Therefore, resources from Green Seal® were excluded from any considerations for this priority product category and we did not assume Green Seal® products were PFAS-free.

We also note that several companies in the coating industry, such as Allnex (allnex, 2025), BYK (BYK, 2024), Clariant (Clariant, 2025d), Micro Powders (Coatings World, 2024; Micro Powders, n.d.-f), and GARDCO (Ampp Staff, 2025), previously proclaimed their transition to PFAS-free formulations. Other companies, such as Evonik (EVONIK, 2025b), Münzing (Carluccio & Vitale, 2025), Momentive (SpecialChem, 2025j), and Syensqo (SpecialChem, 2025k), offer PFAS-free alternatives in their portfolios. These resources were used in our search for alternatives to PFAS in architectural paints.

Third, once the initial list of feasible alternatives that would fit our matching was collated as shown in **Table 2**, we then determined their availability (Ecology, 2022d):

- We looked at the current architectural paint market and sought examples of paints containing safer alternatives. Our search included looking for examples of products that were advertised as PFAS or APEs replacements. Specifically, we searched for paints containing alternatives by browsing through the safety data sheets for products from the top 25 paint companies in the U.S. (APV, n.d.; Axalta, 2025; BEHR, 2025g; Benjamin Moore, n.d.; Cloverdale Paint, n.d.; Diamond Vogel, n.d.; Everest Systems, n.d.; Gemini Industries, n.d.; Hentzen, 2025; HIS Paint Manufacturing Company, n.d.; ICP Group, 2025; IFS Coatings, 2025; Induron, 2024; Lanco Paints, n.d.; Mercury Paint, n.d.; NIC Industries, 2025; PCI Magazine, 2025; PPG, 2025b; RPM International Inc., n.d.; Sheboygan Paint Company, n.d.; Sherwin-Williams, 2025b; Star Step PCG, 2025; Tnemec Company, Inc., n.d.-e; True Value Hardware, n.d.).

Some alternatives to fluoropolymers might not be sold to the public and be available for purchase at paint stores. In such cases, if a chemical trade name was available, we would consider the alternatives to be feasible and available.

Fourth, with the initial list of feasible and available alternatives matched as shown in **Table 2**, we then screened the chemical-product combinations using chemical hazard assessments, such as EPA SCIL, Scivera GHS+, ChemFORWARD, and GreenScreen®, to determine if they met our criteria for safer (Ecology, 2022c, 2022b). We note that we focused our search on safer alternatives, rather than better-than- or equally-performing-as-PFAS alternatives.

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). We determined that PFAS and APEs didn't meet our minimum criteria for safer (Ecology, 2022c). Alternatives that did meet our minimum criteria are considered safer alternatives.

Table 3 below highlights safer alternatives to PFAS and APES in architectural paints. The table also shows the hazard assessment scores and tier each chemical met in our criteria for safer.

Selected chemical alternatives that meet at least our minimum criteria for safer are listed in Table 3. For simplicity, only alternatives that are safer, but also feasible and available as described in subsequent sections, are added to **Table 3**.

Explanations on how the inclusion of these chemicals on EPA SCIL, or how the verified Scivera GHS+, ChemFORWARD, or GreenScreen® hazard assessment scores corresponded to our minimum or additional criteria for safer can be found in our previous reports (Ecology, 2022c, 2022b). Further discussions on the chemical hazard assessment of selected safer chemical alternatives are provided below.

Table 3: Alternatives to PFAS and APEs in architectural paints.

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Polymethyl methacrylate CASRN: 9011-14-7	Scivera GHS+ [Green/Yellow]	Minimum
Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol 113669-95-7	GreenScreen® BM-3 (non-respirable), GreenScreen® BM-U (respirable), Scivera GHS+ [Yellow]	Minimum
Nepheline syenite 37244-96-5	EPA SCIL Full Green Circle (processing aids and additives), Scivera GHS+ [Yellow]	Minimum
2-Propenoic acid, butyl ester, polymer with ethenyl acetate 25067-01-0	EPA SCIL Full Green Circle (polymer function), Scivera GHS+ [Yellow]	Minimum
Carnauba wax 8015-86-9	EPA SCIL Full Green Circle (uncategorized), Scivera GHS+ [Green/Yellow]	Additional
Zinc phosphate 7779-90-0	Scivera GHS+ [Yellow]	Minimum
Sodium benzoate 532-32-1	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Siloxanes and Silicones, di-Me, reaction products with silica 67762-90-7	Scivera GHS+ [Yellow]	Minimum
3-Aminopropyltriethoxysilane 919-30-2	GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum
Kaolin, calcined 92704-41-1	EPA SCIL Half-Green Circle (processing aids and additives), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Polyethylene 9002-88-4	Scivera GHS+ (Yellow), ChemFORWARD Hazard Band B	Minimum
Ethene, homopolymer, oxidized 68441-17-8	EPA SCIL Full Green Circle (polymer), Scivera GHS+ [Yellow]	Minimum
Hydrated silica 112926-00-8	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Polyacrylic acid 9003-01-4	EPA SCIL Full Green Circle (polymer), Scivera GHS+ [Yellow]	Minimum
N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl)oxamide 23949-66-8	GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum
Ammonium polyphosphates 68333-79-9	Scivera GHS+ [Green/Yellow]	Minimum
Aluminum hydroxide 21645-51-2	GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum
Carboxymethylcellulose sodium 9004-32-4	EPA SCIL Full Green Circle (processing aids and additives), Scivera GHS+ [Green/Yellow]	Additional
Polypropylene or polypropylene wax 9003-07-0	EPA SCIL Full Green Circle (polymer), Scivera GHS+ [Yellow]	Minimum
Isobutyltrimethyoxysilane 18395-30-7	Scivera GHS+ [Yellow]	Minimum
Triethoxyoctylsilane 2943-75-1	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Cellulose 9004-34-6	EPA SCIL Full Green Circle (processing aids and additives), Scivera GHS+ [Yellow]	Minimum
Hydrogenated castor oil 8001-78-3	EPA SCIL Half-Green Circle (processing aids and additives), GreenScreen® BM-2	Minimum
Docusate sodium 577-11-7	GreenScreen® BM-2, Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
1-methoxy-2-propanol acetate 108-65-6	EPA SCIL Half-Green Circle (solvent), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Alcohols, C9-11-iso-, C10-rich, ethoxylated 78330-20-8	EPA SCIL Full Green Circle (surfactant), Scivera GHS+ [Yellow]	Minimum
Sodium C14-16 olefin sulfonate 68439-57-6	EPA SCIL Full Green Circle (surfactant), Scivera GHS+ [Yellow]	Minimum
Sodium C10-16 alkylbenzenesulfonate 68081-81-2	EPA SCIL Full Green Circle (surfactant), Scivera GHS+ [Yellow]	Minimum
Dimethyl carbonate 616-38-6	GreenScreen® BM-2, Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Propylene carbonate 108-32-7	EPA SCIL Full Green Circle (solvent), GreenScreen® BM-3, Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum

Polymethyl methacrylate (CASRN: 9011-14-7)

This chemical met our minimum criteria for safer.

Polymethyl methacrylate scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2025a).

This chemical is a polymer and scored as a very high hazard for persistence. All other endpoints scored as low hazard, though with limited evidence.

There is a potential concern for unreacted monomer (methyl methacrylate, CASRN: 80-62-6) for this chemical, with respect to dermal and respiratory sensitization and irritation. However, it is listed as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2020h) and meets our minimum criteria for safer as a potential residual.

Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (CASRN: 113669-95-7)

This chemical meets our minimum criteria for safer.

Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (non-respirable) scored BM-3 in a GreenScreen® assessment (ToxServices LLC, 2026b). Assessors gave a high hazard score for persistence, and a low or very low score for all other endpoints. Surrogates and expert judgement were often used to assign scores, since there was limited data for the chemical itself.

Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (respirable) is scored as a BM-U in a GreenScreen® assessment (ToxServices LLC, 2026b), due to a data gap for carcinogenicity via the inhalation route.

The authors highlight that as a polymer with high molecular weight and low water solubility, this chemical is unlikely to be significantly bioavailable, but that an inhalation concern could be relevant if particles of this polymer were inhaled in sufficient quantities to cause lung overload. However, there is no current evidence of carcinogenicity for this chemical and no structural alerts were reported for carcinogenicity. Therefore, we consider this as equivalent to a likely low score in our criteria for carcinogenicity.

Systemic toxicity (repeat-dose only) scored as a data gap, but systemic toxicity (single-dose) was scored as low hazard. As a polymer, this chemical is scored as high hazard for persistence but low hazard for bioaccumulation. All other hazard endpoints were scored as low hazard based on the limited data available for the chemical and suitable surrogates.

Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2019j). It was given a high hazard score for persistence with limited evidence. Assessors gave a data gap for endocrine activity, and a moderate score for reproductive and developmental toxicity.

Nepheline syenite (CASRN: 37244-96-5)

This chemical met our minimum criteria for safer.

Nepheline syenite is listed on EPA SCIL as a Full Green Circle for the processing aid and additive function. The functional use criteria for processing aids and additives functions used by EPA SCIL meets at least our minimum criteria for safer (Ecology, 2022c).

Nepheline syenite scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021o). The assessment noted data gaps for endocrine activity and respiratory sensitization. We don't require data for endocrine activity in our criteria, and both reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Carcinogenicity and mutagenicity scored as moderate hazard. Persistence was scored as very high hazard for this inorganic mineral—it is naturally occurring, but it isn't biodegradable.

2-Propenoic acid, butyl ester, polymer with ethenyl acetate (CASRN: 25067-01-0)

This chemical met our minimum criteria for safer.

2-Propenoic acid, butyl ester, polymer with ethenyl acetate is listed on EPA SCIL as a Full Green Circle for the polymer function. The functional use criteria for polymers used by EPA SCIL meets our minimum criteria for safer (Ecology, 2022c).

2-Propenoic acid, butyl ester, polymer with ethenyl acetate scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018b). There was a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard. We don't require data on endocrine activity in our criteria. This polymeric chemical scored as high hazard for persistence.

All other endpoints were scored as low or moderate hazard, primarily based on this polymer being described as of low concern by the Australian National Industrial Chemicals Notification and Assessment Scheme program.

Carnauba wax (CASRN: 8015-86-9)

This chemical met our additional criteria for safer.

Carnauba wax is listed on EPA SCIL as a Full Green Circle for an uncategorized function. Chemicals with uncategorized function on EPA SCIL meet at least our minimum criteria for safer (Ecology, 2022c).

Carnauba wax scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2020e).

Data gaps were noted for endocrine activity, neurotoxicity and respiratory sensitization. We don't require data for endocrine activity in our criteria, and this chemical was scored as moderate hazard for reproductive toxicity and developmental toxicity.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. Persistence was scored as moderate hazard. All other endpoints were scored as low hazard.

Zinc phosphate (CASRN: 7779-90-0)

This chemical met our minimum criteria for safer.

This chemical scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2017g).

Zinc phosphate scored as a moderate hazard for carcinogenicity, mutagenicity, reproductive, developmental, and endocrine activity.

Data gaps were noted for acute toxicity (dermal) and neurotoxicity. The data gap or acute toxicity (dermal) is allowable as acute toxicity was scored as low hazard for the oral and inhalation routes. The data gap for neurotoxicity is allowable as there was sufficient data to score acute and systemic toxicity.

Systemic toxicity was scored as a high hazard based on several studies. Zinc phosphate was reported to cause changes in hematological parameters in rats with a LOAEL of 53.8 mg/kg/day reported in a 90-day repeat-dose oral study. A 16-week subchronic inhalation (10, 30 or 100 ug/m3 for 5 hours/day, 3 days/week) of zinc sulphate, a surrogate for zinc phosphate, showed minimal lung injury and inflammation. Further, zinc supplementation at 150 mg a day in human volunteers was associated with headache, nausea, and gastric discomfort—possibly attributable to a disruption in copper homeostasis. For comparison, the background intake of zinc via food is reported at approximately 10 mg per day.

Zinc phosphate scores as very high for acute and chronic aquatic toxicity as zinc is toxic to several aquatic species at low levels. This chemical scores as a high hazard for persistence, but the assessors note this isn't as relevant for this inorganic chemical. Although there are some concerns for this chemical as described, it meets our minimum criteria for safer.

Sodium benzoate (CASRN: 532-32-1)

This chemical met our minimum criteria for safer.

Sodium benzoate was scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2022g).

Assessors noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity were scored as low hazard. We don't require data on endocrine activity in our criteria.

Data gaps were also noted for respiratory sensitization and sensory irritation. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. We don't require data on sensory irritation in our criteria.

Sodium benzoate was assigned as Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2020e). The assessment noted data gaps for endocrine activity and neurotoxicity. Reproductive toxicity and developmental toxicity were scored as low hazard based on the oral route of exposure. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The assessor noted that there was an abundance of data due to sodium benzoate longstanding use as a food preservative, with eye irritation as the only identified hazard.

Siloxanes and Silicones, di-Me, reaction products with silica (CASRN: 67762-90-7)

This chemical met our minimum criteria for safer.

This chemical scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2019g).

The assessment noted data gaps for endocrine activity, respiratory sensitization, and sensory irritation. We don't require data on endocrine activity in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. We don't require data on sensory irritation in our criteria. Persistence was scored as very high hazard for this polymeric ingredient, but this is allowable in our criteria due to low or moderate hazard scores assigned for other endpoints, including a low hazard score for bioaccumulation.

3-Aminopropyltriethoxysilane (CASRN: 919-30-2)

This chemical met our minimum criteria for safer.

3-Aminopropyltriethoxysilane scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2026a). The assessment noted data gaps for endocrine activity, neurotoxicity (repeat-dose only) and respiratory sensitization. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low and moderate hazard, respectively.

The data gap for neurotoxicity (repeat-dose) is allowable as neurotoxicity (single-dose) was scored as moderate hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as moderate hazard. Eye irritation and skin irritation were both scored as very high hazard, but this is allowable in our minimum criteria as long as neither persistence and bioaccumulation score as very high—persistence was scored as low hazard, and bioaccumulation was scored as very low hazard in this assessment.

This chemical was scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2019a).

While a data gap was noted for endocrine disruption, carcinogenicity and mutagenicity were scored as low hazards, and reproductive toxicity and developmental toxicity were scored as moderate hazards. Dermal irritation, eye irritation, and environmental mobility were scored as very high hazards. No other endpoints in this assessment were scored above a moderate hazard.

Kaolin, calcined (CASRN: 92704-41-1)

This chemical met our minimum criteria for safer.

Kaolin, calcined is listed on EPA SCIL as a Half Green Circle for the processing aids and additive function. The functional use criteria for processing aids and additives functions used by EPA SCIL meets at least our minimum criteria for safer (Ecology, 2022c).

Kaolin, calcined scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021n).

Data gaps were noted for endocrine activity, neurotoxicity, and respiratory sensitization. We don't require data on endocrine activity in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low (oral, dermal) or moderate (inhalation, systemic toxicity). The data gap for respiratory sensitization is allowable as dermal sensitization scored as low hazard. This chemical scored very high hazard for persistence, but this is less concerning for human health and the environment due to this chemical being based on naturally occurring inorganic minerals with low hazard scores for acute and chronic aquatic toxicity, and bioaccumulation.

This chemical was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2024a). The assessors noted data gaps for endocrine activity, reproductive toxicity (all routes), developmental toxicity (dermal and inhalation), systemic toxicity (single-dose inhalation, repeat-dose dermal) and neurotoxicity (repeat-dose, all routes).

Developmental toxicity was scored as low hazard for the oral route based on lack of results in reproductive and developmental toxicity assays for relevant analogue compounds. Systemic toxicity (single-dose) was scored as low hazard for the oral and dermal routes, and for repeat dose for the oral route. Systemic toxicity (repeat-dose) inhalation was scored as a high hazard based on respiratory tract effects in exposure studies with relevant analogue compounds below 0.02 mg/L. All other endpoints were scored as low or moderate hazard. Scores for persistence and bioaccumulation were not assigned by the assessor due to the chemical being inorganic. As an inorganic chemical, it is expected to be persistent in the environment but not bioaccumulative.

Polyethylene or polyethylene wax (CASRN: 9002-88-4)

These chemicals met our minimum criteria for safer.

Polyethylene or polyethylene wax was scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021k).

Data gaps were noted for endocrine activity, neurotoxicity, and respiratory sensitization. We don't require data for endocrine activity in our criteria. Reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. This polymer is scored as very high hazard for persistence, but this is allowable in our minimum criteria due to low or moderate scores for all other endpoints.

Ethene, homopolymer, oxidized (CASRN: 68441-17-8)

This chemical met our minimum criteria for safer.

This chemical is on EPA SCIL as a Full Green Circle for the polymer function. The functional use criteria for polymers used by EPA SCIL meets our minimum criteria for safer (Ecology, 2022c).

Ethene, homopolymer, oxidized scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018e).

Assessors note data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data for endocrine activity in our criteria and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. Data on sensory irritation isn't required in our criteria. This polymer was scored as high hazard for persistence, but this is allowable in our minimum criteria due to low or moderate hazard scores for all other endpoints.

Hydrated silica (CASRN: 112926-00-8)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2022f).

A data gap was noted for endocrine disruption, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity is not required in our criteria.

A data gap was also noted for neurotoxicity, but acute toxicity (dermal and oral) were scored as low hazard, acute toxicity (inhalation) was scored as high hazard, and systemic toxicity was scored as high hazard – this fulfills our data requirements and still meets our minimum criteria. Carcinogenicity was scored as moderate hazard**.** All other endpoints were scored as low hazard.

This chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2025c). The assessment noted data gaps for carcinogenicity (dermal), reproductive toxicity (dermal, inhalation), developmental toxicity (dermal, inhalation), systemic toxicity (dermal repeat-dose), neurotoxicity (all routes) and respiratory sensitization. The assessment classified this chemical as GHS Category 3 for systemic toxicity (single-dose inhalation), which corresponded to a moderate hazard.

Apart from neurotoxicity, all other hazard endpoints were scored as low hazard based on other routes of exposure and this fulfills our data requirements**.** The data gap for neurotoxicity is allowable as systemic toxicity was scored as moderate (inhalation) or low hazard (oral and dermal), and acute toxicity was scored as low hazard for all routes of exposure.

Polyacrylic acid (CASRN: 9003-01-4)

This chemical met our minimum criteria for safer.

Polyacrylic acid is on EPA SCIL as a Full Green Circle for the polymer function. The functional use criteria for polymers used by EPA SCIL meets our minimum criteria for safer (Ecology, 2022c).

This chemical scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2025b).

Polyacrylic acid noted data gaps for endocrine activity, neurotoxicity, and sensory irritation. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable

as acute toxicity scored as low hazard and systemic toxicity scored as moderate hazard. Data for sensory irritation isn't required in our criteria. This polymer was scored as high hazard for persistence, but this is allowable in our minimum criteria as all other endpoints scored as low or moderate hazard.

N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl)oxamide (CASRN: 23949-66-8)

This chemical met our minimum criteria for safer.

This chemical scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2025h). Data gaps were noted for reproductive toxicity, endocrine activity, and neurotoxicity (repeat-dose). Data isn't required for endocrine activity in our criteria, and developmental toxicity was scored as low hazard.

This chemical is predicted to be inactive for estrogen agonism, antagonism, and binding by US EPA. The low score for developmental toxicity is based on modeling that doesn't predict effects, including the Teratogenic Potential in Humans model battery, CASE Ultra, Leadscope, and SciQSAR. Assessors gave a moderate hazard score for carcinogenicity.

This chemical received very high hazard scores for chronic aquatic toxicity and persistence. This is allowable in our minimum criteria as all other hazard endpoints scored as low, and this meets our data requirements.

N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl)oxamide scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2023d).

Assessors noted data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data on sensory irritation isn't required in our criteria.

Data on endocrine activity isn't required in our criteria, but both reproductive toxicity and developmental toxicity were scored as low hazard. This was based on a 2-generation reproduction study in rats report which reported a NOAEL of 110mg/kg/day (the highest dose tested) for a surrogate chemical (desmedipham, CASRN: 13684-56-5) and lack of alerts in QSAR modeling (OECD and Leadscope).

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Eye irritation was scored as moderate hazard, and persistence was scored as high hazard. All other hazard endpoints were scored as low hazard.

Ammonium polyphosphates (CASRN: 68333-79-9)

This chemical met our minimum criteria for safer.

Ammonium polyphosphate was scored as a BM-3 polymer in a GreenScreen hazard assessment and meets our minimum criteria for safer (ToxServices LLC, 2020a).

The assessment is specific to what is described as Type II ammonium polyphosphate, characterized by a high molecular weight, decomposition temperature of 300°C, lower water solubility, and a composition of 50 to 1,000 phosphate units. This is sold by Clariant under the trade name Exolit® AP 422. It contrasts with Type I ammonium polyphosphate which is

characterized by a lower molecular weight, decomposition temperature of 150°C, higher water solubility, and a composition of less than 100 phosphate units.

The assessment noted a data gap for endocrine activity but scored both reproductive and developmental toxicity as low hazard. A very high hazard score was assigned for persistence based on an expected half-life of greater than 180 days in the soil and sediment and a hydrolysis half-life of greater than 1 year for chemical surrogates (several phosphates, pyrophosphates, and a sulfate with related chemical structures).

A ChemFORWARD hazard assessment scored ammonium polyphosphate (MW ≥ 1000) as a Hazard Band SC chemical (ChemFORWARD, 2020a). Hazard Band SC or "special conditions" chemicals are characterized by a CHA where additional information is required to determine the hazard score for use in any application.

The assessment noted data gaps for carcinogenicity and endocrine activity but determined there was a low potential for these hazards based on the large molecular weight and minimal residual monomer content. Data gaps were assigned for developmental and reproductive toxicity via the oral and inhalation routes, repeated systemic toxicity and neurotoxicity for all exposure routes, and respiratory irritation and sensitization.

Reproductive and developmental toxicity were scored as low hazard for the dermal route, and single-dose neurotoxicity (oral and inhalation routes) and systemic toxicity (oral route only) were assigned low hazard. This assessment doesn't meet our minimum criteria for safer on its own, but it does provide additional information that supports the overall conclusion that ammonium polyphosphate meets our minimum criteria.

A verified Scivera GHS+ assessment scored ammonium polyphosphate as a Green/Yellow chemical (Scivera, 2022d).

The assessment noted data gaps for endocrine activity and respiratory sensitization. Endocrine activity isn't required to meet our minimum criteria, and both reproductive and developmental toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. All other hazard endpoints were scored as low or moderate hazard.

Aluminum hydroxide (CASRN: 21645-51-2)

This chemical met our minimum criteria for safer.

Aluminum hydroxide scored BM-2 in a GreenScreen® assessment as listed on the Swedish Confederation of Professional Employees (TCO) Certified Accepted Substance List (TCO, n.d.). Although this assessment was not publicly available, chemicals listed on TCO Certified Accepted Substance List with GreenScreen® BM-2 meet our minimum criteria for safer (Ecology, 2022c).

Aluminum hydroxide was scored as BM-2 on an expired public GreenScreen® (Pharos, 2026). In that assessment, this chemical scored as moderate hazard for developmental and endocrine activity. Aluminum hydroxide had a data gap for neurotoxicity (single) and scored as a high hazard for acute aquatic toxicity and chronic aquatic toxicity, with a very high score for persistence.

Aluminum hydroxide scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2025c).

Assessors noted data gaps for endocrine activity, neurotoxicity, and respiratory sensitization. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Persistence was scored as very high hazard for this inorganic substance. All other endpoints were scored as low hazard in the assessment.

Carboxymethylcellulose sodium (CASRN: 9004-32-4)

This chemical met our additional criteria for safer.

Carboxymethylcellulose sodium is on EPA SCIL as a Full Green Circle for the processing aid and additive function. The functional use criteria for processing aids and additives functions used by EPA SCIL can meets our minimum or additional criteria for safer (Ecology, 2022c).

This chemical scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2022b). Assessors noted data gaps for endocrine activity, neurotoxicity, respiratory sensitization and sensory irritation. Data for endocrine activity isn't required in our criteria. Reproductive toxicity and developmental toxicity scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization scored as low hazard. Data on sensory irritation isn't required in our criteria. All other endpoints scored as low or moderate hazard.

Polypropylene or polypropylene wax (CASRN: 9003-07-0)

These chemicals met our minimum criteria for safer.

Polypropylene or polypropylene wax is on EPA SCIL as a Full Green Circle for the polymer function. The functional use criteria for polymers used by EPA SCIL meets our minimum criteria for safer(Ecology, 2022c).

Polypropylene or polypropylene wax scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018a).

Assessors noted data gaps for endocrine activity and neurotoxicity. Data for endocrine activity isn't required in our criteria. Reproductive toxicity and developmental toxicity scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored low hazard. Persistence was scored as high for this polymer, but this is allowable in our minimum criteria as all other hazard endpoints scored as moderate or low hazard.

Isobutyltrimethoxysilane (CASRN: 18395-30-7)

This chemical met our minimum criteria for safer.

Isobutyltrimethoxysilane scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2024a).

This chemical had data gaps in endocrine activity and neurotoxicity endpoints. Data for endocrine activity isn't required in our criteria and reproductive toxicity and developmental toxicity scored low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored low hazard. Assessors gave a high hazard score for dermal irritation. All other endpoints were scored as low or moderate hazard.

Triethoxyoctylsilane (CASRN: 2943-75-1)

This chemical met our minimum criteria for safer.

Triethoxyoctylsilane scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021y).

Assessors noted data gaps for endocrine active and respiratory sensitization. Data for endocrine activity isn't required in our criteria. Reproductive toxicity and developmental toxicity scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. This chemical was scored as low hazard for neurotoxicity based on a NOAEL of 250mg/kg/day reported in a 90-day OECD Guideline 408 study in rats. At 400mg/kg/day, minimal adverse effects were reported in peripheral nerves of the female rats in the study.

Although neurotoxicity was scored as low hazard, we considered the underlying data for this endpoint more closely due to the GHS Category 3 classification reported for neurotoxicity in the ChemFORWARD assessment described below. This chemical scored as high hazard for chronic aquatic toxicity and dermal irritation. Persistence and bioaccumulation both scored as moderate hazard.

This chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2023f). Assessors noted data gaps for reproductive and developmental toxicity (dermal, inhalation), endocrine activity, and repeated dose systemic exposure (dermal, inhalation), as well as single- (inhalation) and repeat-dose neurotoxicity (dermal, inhalation). Respiratory sensitization was noted as a data gap. Data for endocrine activity isn't required in our criteria. Reproductive toxicity and developmental toxicity were scored low hazard based on the oral route.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. For single-dose neurotoxicity (oral, dermal), this chemical was scored as moderate hazard (Category 3) based on two OECD 401 studies in rats that showed clinical signs of neurotoxicity. These studies were not designed to study neurotoxicity. However, slowed movement and coordination disturbances were observed consistent with a GHS Category 3 classification (transient effects). All other endpoints were scored as low or moderate hazard based on other routes of exposure, and this meets our data requirements.

Cellulose (CASRN: 9004-34-6)

This chemical met our minimum criteria for safer.

Cellulose is on EPA SCIL as a Full Green Circle for the processing aid and additive function. The functional use criteria for processing aids and additives functions used by EPA SCIL can meet our minimum or additional criteria for safer (Ecology, 2022c).

Cellulose scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2022c).

Assessors noted data gaps for endocrine activity, neurotoxicity, and sensory irritation. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Cellulose scored high hazard for persistence. All other endpoints were scored as moderate or low hazard.

Hydrogenated castor oil (CASRN: 8001-78-3)

This chemical met our minimum criteria for safer.

Hydrogenated castor oil is on EPAs SCIL as a Half Green Circle for the processing aid and additive function. The functional use criteria for processing aids and additives functions used by EPA SCIL can meet our minimum or additional criteria for safer(Ecology, 2022c).

This chemical scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2025b).

Assessors gave moderate scores for reproductive toxicity, developmental toxicity, and endocrine activity but carcinogenicity and mutagenicity scored as low hazard. Hydrogenated castor oil had data gaps for neurotoxicity, both single and repeat exposure.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity both scored as low hazard. All other hazard endpoints scored low or very low hazard.

Docusate sodium (CASRN: 577-11-7)

This chemical met our minimum criteria for safer.

Docusate sodium scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2025g). Assessors noted a data gap for endocrine activity. This chemical received a moderate hazard for developmental toxicity and low hazard for reproductive toxicity.

Assessors assigned a very high hazard for eye irritation, and high hazards for skin irritation and acute aquatic toxicity. Acute toxicity and chronic aquatic toxicity were scored as moderate hazard. All other endpoints were scored as low or very low hazard.

This chemical was scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2017c).

Docusate sodium had data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data on endocrine activity isn't required in our criteria. Docusate sodium received moderate hazard for reproductive toxicity and developmental toxicity.

The data gap for neurotoxicity is allowable as acute toxicity scored as low hazard (dermal and inhalation) and moderate hazard (oral), and systemic toxicity was scored as low hazard. High hazards were assigned for dermal irritation and chronic aquatic toxicity with very high hazard for eye irritation. All other endpoints were scored as moderate or low hazard.

Docusate sodium was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2024b). Assessors agreed with the other reports and gave a high hazard for eye irritation, with moderate hazard for developmental toxicity and skin irritation. Assessors noted data gaps for carcinogenicity, reproductive toxicity, developmental toxicity, systemic toxicity (repeat-dose) and neurotoxicity (repeat-dose) for the dermal and inhalation routes.

Developmental toxicity was scored as moderate hazard based on the oral route, and other endpoints noted above were scored as low hazard based on the oral route—this meets our data requirements. Endocrine activity was also noted as a data gap, but we don't require data on endocrine activity in our criteria. Dermal irritation was scored as moderate hazard, and eye irritation was scored as high hazard. All other endpoints were scored as low or moderate hazard.

1-methoxy-2-propanol acetate (CASRN: 108-65-6)

This chemical met our minimum criteria for safer.

This chemical is on EPA SCIL as a Half Green Circle for the solvent function. This rating isn't sufficient on its own to meet our minimum criteria for safer (Ecology, 2022c).

1-methoxy-2-propanol acetate scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021c). This chemical had data gaps for endocrine activity and respiratory sensitization. Data on endocrine activity isn't required in our criteria. Reproductive toxicity was scored as low hazard, and developmental toxicity was scored as moderate hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Assessors assigned a high hazard for eye irritation. All other endpoints considered in our criteria were scored as low or moderate hazard.

1-methoxy-2-propanol acetate was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2023e). Assessors noted data gaps for endocrine activity, reproductive toxicity (dermal) and neurotoxicity (repeat-dose, all routes). Data on endocrine activity isn't required in our criteria. Reproductive and developmental toxicity were scored as low hazard based on other routes of exposure.

Assessors assigned neurotoxicity (single-dose) GHS Category 3, corresponding to moderate hazard score. Respiratory irritation was scored as moderate hazard. All other endpoints were scored as low hazard.

Alcohols, C9-11-iso-, C10-rich, ethoxylated (CASRN: 78330-20-8)

This chemical met our minimum criteria for safer.

Alcohols, C9-11-iso-, C10-rich, ethoxylated is listed on EPA SCIL as a Full Green Circle for the surfactant function. This rating isn't sufficient on its own to meet our minimum criteria for safer (Ecology, 2022c).

This chemical scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2019b).

Assessors noted data gaps for endocrine activity and respiratory sensitization. Alcohols, C9-11-iso-, C10-rich, ethoxylated scored very high for eye irritation, and high hazards for dermal irritation, acute aquatic toxicity, and chronic toxicity, all with limited evidence.

Sodium C14-16 olefin sulfonate (CASRN: 68439-57-6)

This chemical met our minimum criteria for safer.

This chemical is listed on SCIL as a Full Green Circle for the surfactant function. This rating isn't sufficient on its own to meet our minimum criteria for safer (Ecology, 2022c).

This chemical is listed as a safer alternative to PFAS in cleaning products during Safer Products for Washington Cycle 1.5 (Ecology, 2024d). Sodium C14-16 olefin sulfonate was listed to score low for carcinogenicity, mutagenicity, and reproductive and developmental toxicity according to a verified Scivera GHS+ assessment (Scivera, 2019n). Acute aquatic toxicity was high, but both persistence and bioaccumulation were low.

Sodium C10-16 alkylbenzenesulfonate (CASRN: 68081-81-2)

This chemical met our minimum criteria for safer.

This chemical is listed on SCIL as a Full Green Circle for the surfactant function. This rating isn't sufficient on its own to meet our minimum criteria for safer (Ecology, 2022c).

This chemical was listed as a safer alternative to PFAS in cleaning products during Safer Products for Washington Cycle 1.5 (Ecology, 2024d). Sodium C10-16 alkylbenzenesulfonate was listed to score low for carcinogenicity, mutagenicity, and reproductive and developmental toxicity according to a verified Scivera GHS+ assessment (Scivera, 2021d). Acute aquatic toxicity was high, but both persistence and bioaccumulation were low.

Dimethyl carbonate (CASRN: 616-38-6)

This chemical met our minimum criteria for safer.

Dimethyl carbonate scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2025f). Assessors gave moderate scores for carcinogenicity and mutagenicity. They noted data gaps for endocrine activity and neurotoxicity (repeat-dose). Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard and moderate hazard, respectively. The data gap for neurotoxicity (repeat-dose) is allowable as neurotoxicity (single-dose) was scored as moderate hazard.

Dimethyl carbonate scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018c).

Assessors noted data gaps for endocrine activity and neurotoxicity. Data for endocrine activity isn't required in our criteria, and assessors scored reproductive toxicity and developmental toxicity as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard.

Dimethyl carbonate was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2023a). Assessors noted data gaps for endocrine activity, reproductive toxicity (dermal and inhalation), developmental toxicity (dermal), systemic toxicity (repeat-dose, dermal), and neurotoxicity (repeat-dose, all routes). Data on endocrine activity isn't required in our criteria.

Reproductive toxicity was scored as low hazard based on the oral route, and developmental toxicity was scored as low hazard (oral) and moderate hazard (inhalation). The data gap for neurotoxicity (repeat-dose) is allowable as neurotoxicity (single-dose) was scored as moderate hazard (oral and inhalation) or low hazard (dermal).

Propylene carbonate (CASRN: 108-32-7)

This chemical met our minimum criteria for safer.

Propylene carbonate is on EPA SCIL as a Full Green Circle for the solvent function. This rating isn't sufficient on its own to meet our minimum criteria for safer (Ecology, 2022c).

Propylene carbonate scored BM-3 in an expired GreenScreen® assessment (ToxServices LLC, 2021e). Assessors noted a data gap for endocrine activity and a high hazard score for eye irritation. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard.

Propylene carbonate scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2025f).

Assessors gave high hazard for eye irritation and assigned data gaps for both endocrine activity, respiratory sensitization, and sensory irritation. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Data on sensory irritation isn't required in our criteria. All other hazard endpoints were scored as low hazard.

Propylene carbonate was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2020d). Assessors noted data gaps for endocrine activity, reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), systemic toxicity (single-dose, inhalation), systemic toxicity (repeat-dose, dermal), neurotoxicity (single-dose, inhalation), and neurotoxicity (repeat-dose, oral and dermal).

Data on endocrine activity isn't required in our criteria. Reproductive toxicity, developmental toxicity, systemic toxicity (single-dose), systemic toxicity (repeat-dose) and neurotoxicity (repeat-dose) were scored as low hazard based on other routes of exposure and this meets our data requirements. Neurotoxicity (single-dose) was scored moderate hazard for the oral route and low hazard for the dermal route. All other endpoints were scored as moderate or low hazard.

Safer process alternatives

Clean oiled surfaces

In Safer Products for Washington Cycles 1 and 1.5 Implementation Phase 3 (Ecology, 2022b, 2024b),[18,19] we identified cleaning using safer products as a safer process alternative, to address the oil repellence or stain and oil resistance function provided by PFAS. Rather than applying a chemical to provide stain or oil repellence or resistance, the stain or oil on the painted surface could be cleaned using EPA Safer Choice-certified products (Ecology, 2024d), such as:

- Krud Kutter House Wash by Rust-Oleum (Rust-Oleum Corporation, 2025)
- Professional Cleaner Degreaser Concentrated by Rust-Oleum (Rust-Oleum Corporation, n.d.)
- Husky 908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-a)
- Reliance Degreaser by SYSCO Corporation (Keystone, n.d.)

Clean soiled surfaces

Using safer products as a method we identified cleaning to address the anti-soiling function provided by PFAS, as a safer process. Specifically, soiling that occurred on paint surface could be cleaning using EPA Safer Choice-certified products (OCSPP, 2013b), such as:

- Professional Cleaner Degreaser Concentrated by Rust-Oleum (Rust-Oleum Corporation, n.d.)
- JAWS Professional 7908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-b)
- JAWS Professional 9908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-c)

Safer product alternatives

Interior and exterior mineral paints by KEIM

KEIM mineral paint products are available in the US and have a Gold Material Health Certificate (v5.0) from the Cradle to Cradle® Certification Program (Cradle to Cradle Products Innovation Institute, 2026). Products with Gold Material Health Certificates (v5.0) can meet our minimum criteria for safer if we can verify that the final rating was not adjusted based on exposure. We confirmed with the Cradle to Cradle assessor for these products that the final rating was not adjusted based on exposure (B. Sterzik, personal communication, September 28, 2026), thus these products meet our minimum criteria for safer.

[18] https://apps.ecology.wa.gov/publications/SummaryPages/2204018.html
[19] https://apps.ecology.wa.gov/publications/SummaryPages/2404023.html

KEIM mineral paints are advertised as suitable for mineral substrates (such as plaster, concrete, and natural stone), organic wood surfaces, steel, and acrylic surfaces. Relevant products from KEIM are matched to functions including durability, corrosion resistance, weather resistance, UV resistance, anti-blocking, anti-soiling, abrasion or scratch resistance, fire resistance, and use of a US EPA VOC-exempt solvent.

Interior paints by Alkemis Paint

If we can confirm some additional details, products with Material Health Certificate™ of Gold or Platinum in version 3.1 and newer according to the Cradle to Cradle® Certification Program (Cradle to Cradle Products Innovation Institute, 2025) could be considered as meeting our minimum criteria for safer (Ecology, 2022c, 2025b). Interior Paint (Color Codes 1-120) by Alkemis Paint has Material Health Certificate™ rating of Gold according to the Cradle to Cradle® Certification Program version 3.1 (Alkemis Paint, 2026). This product is advertised to provide similar functions as paints that use PFAS, namely abrasion and scratch, UV, and fire resistance, as well as water repellence. We are in the process of confirming that these Alkemis Paint products meet the additional requirements for our minimum criteria and intend to update this description if we can review the necessary information before publication of our final report.

Feasible alternatives

APEs

With respect to APEs, we checked both the documents issued by the Washington State Department of Enterprise Services (DES, 2025), and Department of Transportation (WSDOT, 2025), to see if APEs were required to be used for architectural coating in the state of Washington. There were no requirements to use APEs according to these documents.

Further, in our consultation with the Washington State Construction Center of Excellence, APE-free paints were mentioned to "have become the industry norm in the EU and Canada, where regulatory action preceded the US market" (Rupp, 2026), indicating the feasibility of APE-free alternatives.

PCBTF

The American Coatings Association has had concerns on the inclusion of PCBTF for this priority product category (Ecology, n.d.-e), including on the feasibility of the alternatives. However, the safer alternatives we identified were feasible (BEHR, 2018, 2025h; Gemini Industries, 2025; MG Chemicals, 2025; Urban Restoration Group US Inc., 2019).

Fluorosurfactants, short-chain PFAS

Based on Tables 1 and 2, fluorosurfactants and short-chain PFAS were associated with the functions of lubricity, anti-blocking, stain and oil resistance, anti-soiling, levelling and wetting. Additional performance and cost considerations were not apparent for these types of PFAS, as concerns from the industry on performance and cost were focused on fluoropolymers (ACC's Performance Fluoropolymer Partnership, 2023; Ecology, n.d.-e; Miljøstyrelsen, 2024; Monopol Colors, 2026; OECD, 2022). Further, an article written by individuals associated with Arkema,

Inc. has shown that PFAS-free waterborne all-acrylic latex, the type of paints where fluorosurfactants were traditionally used, was feasible (Chervenak et al., 2024, 2024). Therefore, we consider the safer alternatives identified for fluorosurfactants and short-chain PFAS to be feasible.

Fluoropolymers

Special purpose architectural coatings

Based on our research and input received during our alternative analyses, fluoropolymers are applied for special purpose coatings. Special purpose architectural coatings require high-performing paints capable of passing tests such as, Xenon Arc testing (Element, 2026), QUV (Q-Lab, n.d.), EMMAQUA® (Atlas, n.d.), and American Architectural Manufacturing Association (AAMA) 2605 standard (High Performance Coatings, 2026a; Tnemec Company, Inc., n.d.-a). Further discussions for these tests were provided below:

- Xenon Arc testing (Element, 2026), which indicated that fluoropolymers performed better than acrylic-urethane alternative for durability and weather resistance functions (ACC's Performance Fluoropolymer Partnership, 2023; OECD, 2022). We didn't identify safer and feasible acrylic-urethane alternatives for these functions.
- QUV-B test (Q-Lab, n.d.), which indicated that fluoropolymers performed better than polyester- and acrylic-based alternatives for durability, and weather and UV resistance functions (ACC's Performance Fluoropolymer Partnership, 2023). We identified polyester (CASRN: 113669-95-7) and acrylic (CASRNs: 9011-14-7, 25067-01-0, and 9003-01-4) as safer and feasible alternatives for these functions.
- EMMAQUA® test (Atlas, n.d.), which indicated that fluoropolymers performed better than polyurethane alternative for weather and UV resistance functions (OECD, 2022). We didn't identify safer and feasible polyurethane alternatives for these functions.
- AMMA 2605 (High Performance Coatings, 2026a; Tnemec Company, Inc., n.d.-a), where fluoropolymers were mentioned to surpass this standard (ACC's Performance Fluoropolymer Partnership, 2023).

These tests were most associated with the functions of durability, weather resistance, and UV resistance for specific applications. It is worth pointing out, too, that the applications of fluoropolymers for special purpose architectural coatings appears to be heavily focused on metal structures (ACC's Performance Fluoropolymer Partnership, 2023). Special purpose architectural coatings are currently defined as paints limited to those used for the functions of durability, weather resistance, and UV resistance and are used:

- On the internal or exterior surface of chemical storage tanks.
- For metal parts used in the oil and gas industry construction.
- For metal parts in sports stadiums and monuments.

- For metal parts in water tanks and towers, aquariums, dams, airports and ports, train and bus stations, bridges, schools, and hospitals.

Performance of Architectural Special Purpose Coatings

We note that architectural paints used for special purpose architectural coatings are unlikely to be available to consumers at paint stores, and that obtaining these types of paints is typically done through procurement requests or proposals made by contractors or architects (*Meeting with AGC Chemicals*, personal communication, April 29, 2026).

In our consultation with the Washington State Construction Center of Excellence, contractors listed procurement standards (Rupp, 2026) and chose which paint products to use based on the advertised tests that the paint products could meet or surpass. This indicated that meeting or surpassing certain tests special purpose architectural coatings were based on voluntary choice, indicative of performances of the paint materials (ACC's Performance Fluoropolymer Partnership, 2023; OECD, 2022), rather than based on binding requirements.

Meanwhile, the 2025 Design Guidelines & Construction Standards issued by the Washington State Department of Enterprise Services (DES, 2025), as well as the 2026 Standard Specifications for road, bridge, and municipal construction issued by the Washington State Department of Transportation (WSDOT, 2025), didn't mention PFAS in their documents. Therefore, for the state of Washington, there were no established procurement standards that required PFAS to be used for structures that would fall under the definition of special purpose architectural coatings either.

In the case of special purpose architectural coatings, there didn't appear to be any specific required procurement standards that must be met before paint products could be chosen for a project or made available to contractors or architects. We didn't include test performance as criteria when considering the feasibility of alternatives to fluoropolymers for special purpose architectural paints.

Cost

While the initial cost of using fluoropolymers for special purpose architectural coatings was more expensive than using the alternatives (Miljøstyrelsen, 2024), the long-term cost might be lower when compared to using the alternatives, as there could be less need for recoating (ACC's Performance Fluoropolymer Partnership, 2023; Miljøstyrelsen, 2024; Monopol Colors, 2026; OECD, 2022). There were no binding procurement standards for special purpose architectural coatings, but using alternatives to fluoropolymers may result in increased costs in the long term as the need for recoating could be increased (ACC's Performance Fluoropolymer Partnership, 2023; Miljøstyrelsen, 2024; OECD, 2022).

Fluoropolymers for special purpose architectural coatings are unlikely to be the type of paints that consumers would encounter in a paint shop (*Meeting with AGC Chemicals*, personal communication, April 29, 2026). The issue of cost, from the standpoint of paint shop consumers, in terms of fluoropolymers for special purpose coatings, wasn't relevant. In the two works related to PFAS in architectural paints (Cahuas et al., 2022; Healthy Building Network,

2023), cited in our previous report (Ecology, 2025b), where paint samples were collected from paint shops, fluoropolymers were not discussed at all.

The issue of cost could be relevant to municipalities, owners of water towers, or building or monumental structures, which were the more likely consumers of fluoropolymers for special purpose architectural paints.

Some of the known structures in Washington containing fluoropolymers for special purpose architectural paints included:

- Mount Si High School (Lumiflon USA, 2022)
- Facebook Spring District (Lumiflon USA, 2021)
- Amazon Spheres (Lumiflon USA, 2024)
- Bainbridge Island Water Tower (Tnemec Company, Inc., n.d.-b)
- Chehalis Village Water Tanks (Tnemec Company, Inc., n.d.-c)
- Sammamish Water Tower (Tnemec Company, Inc., n.d.-g)
- Mukileto Water District Tank (Tnemec Company, Inc., n.d.-f)
- Washington State University Potable Water Tank (High Performance Coatings, 2026b)

The potential increased long-term costs from the need to recoat would be relevant to the owners of these structures, particularly for municipalities with limited funding for maintenance.

It is worth noting, that we were unable to find concrete examples that compared the long-term cost from using fluoropolymers vs. the alternatives for special purpose coatings for structures other than bridge paint (ACC's Performance Fluoropolymer Partnership, 2023; OECD, 2022). There was a comparison, provided by a supplier of fluoropolymer paint for special purpose coatings in Europe, that indicated that a hospital façade, if painted with non-fluoropolymer-based paint, could cost up to 13 times higher, across 40 years span, than if the façade was to be painted with fluoropolymer-based paint (Monopol Colors, 2026).

Due in part to this uncertainty, we have separated fluoropolymers used in special purpose architectural paints from our broader regulatory determination for other architectural paints in this draft report.

The reporting requirement recommended below will help us learn more about these products sold in Washington to determine if future regulatory action is needed for these special purpose architectural paints. We invite feedback or information relevant to the potential trade-offs we highlighted for alternatives to fluoropolymers in special purpose architectural paints.

Available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

The results of our availability evaluations for PFAS in architectural paints are presented in Table 4. While the feasible and available analyses occurred before the safer analysis, as described

earlier under the "**Search for alternatives**" section of this chapter, only safer, feasible, and available alternatives are listed in Table 4 below.

There are examples of alternatives available to consumers, available for purchase at paint stores, that aren't for special purpose architectural coatings. For example, the term "durability" was often advertised for many paint products available to paint stores consumers—though the durability of these products were likely different to the durability of fluoropolymers intended for special purpose architectural coatings described earlier. Still, we included safer, feasible, and available alternatives available in paint stores in Table 4 for transparency.

We note that for the specific function of corrosion resistance for special purpose architectural coatings, typically provided by fluoropolymers (OECD, 2022), we found that an alternative additive, namely zinc phosphate (CASRN: 7779-90-0), to be feasible and available (Tnemec Company, Inc., n.d.-d, 2025). Further, in our research, lubricity hasn't been associated with special purpose coatings even if fluoropolymers could provide this function (**Table 1** and **Table 2**). Therefore, alternatives for this function were considered as feasible and available.

Prior publications didn't discuss the feasibility and availability to fluoropolymers for special purpose architectural coatings for the function of abrasion and scratch resistance (ACC's Performance Fluoropolymer Partnership, 2023; OECD, 2022). Alternatives for this function were considered as feasible and available.

We were unable to find example architectural paint products using fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (CASRN: 113669-95-7). However, this chemical was an alternative to fluoropolymers. As mentioned earlier, alternatives to fluoropolymers for special purpose architectural coatings could have no matching paint products sold in the marketplace, as these types of paints were not typically purchasable by consumers at paint stores (*Meeting with AGC Chemicals*, personal communication, April 29, 2026). Based on this, we considered fatty acids, castor-oil, caustic-oxidized, distillation residues, and esters with 1,3-butanediol (non-respirable) to be feasible and available.

We were unable to find an example of architectural paint product using hydrogenated castor oil. We consider this alternative to be feasible, but not available.

We noted that dimethyl carbonate (EPDM Roofing Association, 2021; Hydrite, 2025) and propylene carbonate (Hydrite, 2025), were previously listed as alternatives to PCBTF, which indicated the feasibility and availability of these alternatives. Further, all the APEs alternatives (i.e., surfactant and emulsifier functions) were PFAS alternatives for levelling and wetting functions (Table 4).

Regarding applicable types of architectural paints, we considered whether paints were applicable to interior or exterior use, and type of surface they are suitable for based on available information.

Table 4: Feasible and available alternatives to PFAS and APEs in Architectural Paints.

Chemical (CASRN)	Relevant function(s)	Mapped PFAS or APEs function(s)	Applicable type of architectural paint
Polymethyl methacrylate (9011-14-7)	Surface modifier, film former, anti-blocking agent (Environmental Protection Agency, n.d.-m), durability (OECD, 2022; *SYNAQUA® 9511*, n.d.)	Durability, Anti-blocking	Exterior-acrylic; Interior; Wood; Metal
Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (113669-95-7)	Durability (SK Chemicals, 2020), weather resistance, corrosion resistance (Polynt, 2020), anti-stain agent (Environmental Protection Agency, n.d.-k), stain resistance (Reichhold, 2020a, 2020b)	Durability, Weather resistance, Corrosion resistance, Stain/oil resistance*	Exterior-masonry, concrete; Interior; Wood; Metal
Nepheline syenite (37244-96-5)	Durability (Pharos, n.d.-a; Sibelco, n.d.)	Durability	Exterior- vinyl, cement, stucco, plaster, masonry, brick; Wood; Primer
2-Propenoic acid, butyl ester, polymer with ethenyl acetate (25067-01-0)	Film former (BASF, 2026)	Weather resistance	Exterior-masonry; Wood
Carnauba wax (8015-86-9)	Waterproofing agent, scratch resistance agent, lubricating agent (Environmental Protection Agency, n.d.-e)	Weather resistance, Abrasion/scratch resistance, Lubricity	Wood

Chemical (CASRN)	Relevant function(s)	Mapped PFAS or APEs function(s)	Applicable type of architectural paint
Zinc phosphate (7779-90-0)	Corrosion inhibitor (Environmental Protection Agency, n.d.-t; Jones et al., 2017)	Corrosion resistance	Metal; Primer
Sodium benzoate (532-32-1)	Corrosion inhibitor (Environmental Protection Agency, n.d.-r)	Corrosion resistance	Metal
Siloxanes and Silicones, di-Me, reaction products with silica (67762-90-7)	Corrosion inhibitor (Environmental Protection Agency, n.d.-q)	Corrosion resistance	Metal
3-Aminopropyl triethoxysilane (919-30-2)	Corrosion inhibitor (Wacker, 2024b)	Corrosion resistance	Metal; Primer
Kaolin, calcined (92704-41-1)	Corrosion inhibitor, anti-stain agent (Imerys, 2025)	Corrosion resistance, Stain/oil resistance*	Interior; Wood; Metal
Polyethylene wax (9002-88-4)	Scratch resistance agent, anti-blocking agent (Environmental Protection Agency, n.d.-n)	Abrasion/scratch resistance, Anti-blocking	Exterior-plaster, masonry; Interior; Wood
Ethene, homopolymer, oxidized (68441-17-8)	Scratch resistance agent, anti-blocking agent (Environmental Protection Agency, n.d.-j)	Abrasion/scratch resistance, Anti-blocking	Exterior-plaster, masonry, concrete; Interior Wood

Chemical (CASRN)	Relevant function(s)	Mapped PFAS or APEs function(s)	Applicable type of architectural paint
Hydrated silica (112926-00-8)	Scratch resistance agent, anti-blocking agent (EVONIK, n.d.-b), matting agent (Environmental Protection Agency, n.d.-l)	Abrasion/scratch resistance, Anti-blocking, Anti-soiling	Exterior-masonry, concrete; Interior; Wood; Primer
Polyacrylic acid (9003-01-4)	UV resistance (Synthomer, 2024)	UV resistance	Exterior-acrylic, Interior; Metal
N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl) oxamide (23949-66-8)	UV absorber (Songwon, 2025)	UV resistance	Wood; Metal
Ammonium polyphosphates (68333-79-9)	Flame retardant, smoke suppressant (Environmental Protection Agency, n.d.-c)	Fire resistance	Exterior; Interior; Wood; Metal
Aluminum hydroxide (21645-51-2)	Flame retardant, smoke suppressant (Environmental Protection Agency, n.d.-b)	Fire resistance	Exterior-concrete; Interior; Wood; Metal
Carboxymethyl cellulose sodium (9004-32-4)	Lubricating agent(Environmental Protection Agency, n.d.-i)	Lubricity	Interior; Wood
Polypropylene or Polypropylene wax (9003-07-0)	Lubricating agent, anti-blocking agent, slip agent (Environmental Protection Agency, n.d.-o)	Lubricity, Anti-blocking, Anti-soiling	Exterior-masonry; Interior; Wood; Metal; Primer
Isobutyl trimethoxysilane (18395-30-7)	Stain resistance (EVONIK, 2019; Kaufman Products, Inc., 2019)	Stain/oil resistance*	Exterior-masonry, concrete

Chemical (CASRN)	Relevant function(s)	Mapped PFAS or APEs function(s)	Applicable type of architectural paint
Triethoxyoctylsilane (2943-75-1)	Anti-stain (ChemPoint, 2026; Momentive, n.d.; SQ Quimica, n.d.; The Dow Chemical Company, 2020; Univar Solutions, 2026)	Stain/oil resistance*	Exterior- masonry, concrete
Cellulose (9004-34-6)	Anti-stain agent, matting agent (Environmental Protection Agency, n.d.-f)	Stain/oil resistance*, Anti-soiling	Interior; Wood
Hydrogenated castor oil (8001-78-3)	Grease resistance (Acme-Hardesty, n.d.)	Stain/oil resistance*	Wood
Docusate sodium (577-11-7)	Levelling agent, wetting agent, surfactant, emulsifier (Environmental Protection Agency, n.d.-h)	Levelling, Wetting, Surfactant, Emulsifier	Exterior-masonry; Metal
1-methoxy-2-propanol acetate (108-65-6)	Levelling agent, wetting agent (Environmental Protection Agency, n.d.-a)	Levelling, Wetting	Interior; Wood; Metal; Primer
Alcohols, C9-11-iso-, C10-rich, ethoxylated (78330-20-8)	Levelling agent, wetting agent, surfactant, emulsifier (MÜNZING, n.d.)	Levelling, Wetting, Surfactant, Emulsifier	Exterior; Interior; Wood; Primer
Sodium C14-16 olefin sulfonate (68439-57-6)	Wetting agent, surfactant, emulsifier (Environmental Protection Agency, n.d.-s)	Wetting, Surfactant, Emulsifier	Interior; Wood; Primer
Sodium C10-16 alkylbenzene sulfonate (68081-81-2)	Wetting agent, surfactant, emulsifier (Environmental Protection Agency, n.d.-d)	Wetting, Surfactant, Emulsifier	Wood

Chemical (CASRN)	Relevant function(s)	Mapped PFAS or APEs function(s)	Applicable type of architectural paint
Dimethyl carbonate (616-38-6)	Solvent (Environmental Protection Agency, n.d.-g) (U.S. EPA VOC-exempt) (EPA, 2019; Hydrite, 2025)	U.S. EPA VOC-exempt solvent	Exterior-concrete; Interior; Wood; Primer
Propylene carbonate (108-32-7)	Solvent(Environmental Protection Agency, n.d.-p) (U.S. EPA VOC-exempt) (EPA, 2019; Hydrite, 2025)	U.S. EPA VOC-exempt solvent	Exterior-acrylic; Wood

*Stain and oil resistance, instead of oil repellence. See discussions under the "**Anti-stain agent**" function and "**Safer chemical alternatives**" sections.

Note: We display information here differently than other tables in this report for clarity and accessibility. Detailed information about the mapping can be found in the "**Functions of PFAS in the priority product**" and "**Functions of APEs in the priority product**" sections of this chapter. Information including examples of trade names available in the marketplace and architectural paints with alternatives as ingredients can be found in **Appendix E**.

Conclusions on alternatives

Reducing a significant source or use

Manufacturers have reported use of PFAS in architectural paints, and past studies have detected PFAS or organic fluorine in paint in around half of tested paint products on the market, although studies are limited. APEs are reported as ingredients in manufacturer safety data sheets of some paint products at concentrations ranging from 0.1%—5%.

We described architectural paints and a significant use of PFAS and APEs in our report, "Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2" (Ecology, 2025b). We note that according to the Washington PaintCare program, over 13 million gallons of paint were sold in Washington in 2023.

Safer alternatives are feasible and available

Setting aside the considerations on performance and cost for fluoropolymers for special purpose coatings, as discussed earlier in the "**Feasible alternatives**" section, safer alternatives are identified for all functions served by PFAS and APEs in architectural paints that met either our minimum or additional criteria for safer (Ecology, 2022c). The alternatives are currently used in architectural paints—the applications of interest—and are described as feasible and available based on our evaluations.

Regulatory determinations

PFAS and APES in architectural paints (most uses)

Our regulatory determination is a restriction on PFAS and APEs for architectural paints should be adopted, except for special purpose architectural paints as described below. Restricting the use of PFAS and APEs in architectural paints would reduce a significant source of potential exposure of PFAS and APEs to the people and the environment.

Reporting requirement for fluoropolymers for special purpose architectural paints

Our regulatory determination is a reporting requirement for fluoropolymers in special purpose architectural paints should be adopted.

As mentioned earlier in the "**Feasible alternatives**" section, special purpose architectural paints are currently defined as paints limited to those used for the functions of durability, weather resistance, and UV resistance and are used:

- On the internal or exterior surface of chemical storage tanks.
- For metal parts used in the oil and gas industry construction.
- For metal parts in sports stadiums and monuments.
- For metal parts in water tanks and towers, aquariums, dams, airports and ports, train and bus stations, bridges, schools, and hospitals.

We invite feedback or information relevant for our consideration of alternatives to fluoropolymers in special purpose architectural paints. Providing information to Ecology will help inform future potential regulatory action for these special purpose architectural paints.

Chapter 2: PFAS and 6PPD in Artificial Turf

Priority product scope

As defined in our Safer Products for Washington Cycle 2 Implementation Phase 2 report (Ecology, 2025b), the scope of this priority product includes artificial or synthetic turf intended for use on indoor or outdoor surfaces. The scope includes all components of the artificial turf, including artificial grass blades, infill, and backing materials.

Priority chemical scope

We listed this product category for both the PFAS chemical class and for 6PPD.

In RCW 70A.350.010(10)[20] (Washington State Legislature, 2019), PFAS was defined as a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom 6PPD was defined as the chemical compound N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine.

In RCW 70A.350.010(14), PFAS is listed as a priority chemical. It is described further in our Regulatory Determinations Report to the Legislature: Safer Products for Washington Cycle 1, Implementation Phase 3 (Ecology, 2022b).

6PPD was listed as a priority chemical in RCW 70A.350.010(14). It is described further in our previous legislative reports: Identification of Priority Chemicals Report to the Legislature: Safer Products for Washington Cycle 2 Implementation Phase 1 (Ecology, 2024a) and Technical Supporting Documentation for Priority Chemicals: Safer Products for Washington Cycle 2 Implementation Phase 1 in Chapter 8: Technical Support for 6PPD (Ecology, 2024c).

Function of the priority chemical in the priority product

We determined the functional uses for both PFAS and 6PPD in artificial turf materials through a review of available literature and patents, including a technical document on PFAS in artificial turf issued by California Department of Toxic Substances Control (DTSC) (DTSC, 2026). We also consulted with the Synthetic Turf Council (STC), which is self-described as representing most artificial turf manufacturers in the United States.

PFAS are sometimes used during the manufacturing process for making artificial turf. The type of PFAS used are fluoropolymers, which can be used as a polymer processing aid (PPA) during extrusion of other polymers used for artificial grass blades. The types of polymers used as blades can be nylon or polyolefins (DTSC, 2026), which include polyethylene (PE) and polypropylene (Innovene Manufacturing Belgium NV, 2006; 陈玉坤 & 贾德民, 2011).

6PPD is used in tires which can be broken down and used as crumb rubber infill for artificial turf. In tires, 6PPD is used as an antiozonant to protect tires from breaking down due to reaction with atmospheric ozone. To our knowledge, the 6PPD in crumb rubber infill is from the use in tires and 6PPD doesn't perform a necessary function in the infill material itself. Infill

[20] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

materials can be used in a variety of artificial turf applications, including sports or athletic, indoor and outdoor, landscaping, dog parks, and pet relief areas.

Hazards of the priority chemical class

We described the hazards associated with PFAS in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature published in 2022 (Ecology, 2022b). Hazards of concern for members of the class include carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are also very persistent, and many are bioaccumulative. These hazards indicated that PFAS do not meet our minimum criteria for safer (Ecology, 2022b, 2022c).

We described the hazards associated with 6PPD in our Identification of Priority Chemicals Report to the Legislature: Safer Products for Washington Cycle 2 Implementation Phase 1 (Ecology, 2024a) and Technical Supporting Documentation for Priority Chemicals: Safer Products for Washington Cycle 2 Implementation Phase 1 in Chapter 8: Technical Support for 6PPD (Ecology, 2024c). Hazards of concern for 6PPD and its breakdown products, including 6PPD-quinone (6PPDQ), include reproductive toxicity, skin sensitization, aquatic toxicity, persistence, and bioaccumulation. 6PPD and its breakdown products demonstrate high hazard overall, especially to sensitive aquatic organisms, and therefore do not meet our minimum criteria for safer (Ecology, 2022b, 2022c).

Safer, feasible, and available alternatives

Safer alternatives

We consulted the STC (M. Taylor, personal communication, March 13, 2026) and the DTSC report on PFAS in alternative turfs (DTSC, 2026) to identify potential safer alternatives to PFAS and 6PPD in artificial turf. We performed web searches using an internet search engine (Google, n.d.) to further identify potentially safer chemical alternatives to PFAS in polymer processing aids. We also looked at patents associated with artificial turf products and infill materials.

“Safer” varies across hazards and applications (Ecology, 2022b). We determined that PFAS and 6PPD did not meet our minimum criteria for safer (Ecology, 2022c). Therefore, alternatives that met our minimum criteria were considered safer alternatives.

Safer chemical alternatives for PFAS

Our findings for safer chemical alternatives to PFAS polymer processing aids are shown in Table 5 below. Further discussions on the chemical hazard assessment of safer chemical alternatives are provided after the table.

Table 5: Chemical alternatives to PFAS in artificial turf with hazard assessment scores.

Chemical	CASRN	Hazard Assessment Scores	Tiers met in criteria for safer (minimum or additional)
Oxidized PE wax	68441-17-8	EPA SCIL Full Green Circle (polymer function), Scivera GHS+ [Yellow]	Minimum
Calcium stearate	1592-23-0	EPA SCIL Full Green Circle (processing aid and additive function), Scivera GHS+ [Green/Yellow], GreenScreen® BM-3	Additional
Erucamide	112-84-5	GreenScreen® BM-2_{DG}	Minimum

Oxidized PE wax (CASRN: 68441-17-8)

Oxidized PE wax met our minimum criteria for safer (Ecology, 2022c).

Oxidized PE wax is on EPA SCIL as a Full Green Circle for use as a polymer. EPA SCIL's criteria for polymers can meet our minimum criteria for safer (Ecology, 2022c).

Oxidized PE wax scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018e). Assessors noted data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data is not required for endocrine activity in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable, as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Data on sensory irritation is not required in our criteria. Persistence was scored as high for this polymeric ingredient. All other hazards were scored as moderate or low hazard.

Calcium stearate (CASRN: 1592-23-0)

Calcium stearate met our additional criteria for safer (Ecology, 2022c).

Calcium stearate is listed on EPA SCIL as a Full Green Circle for the processing aids and additives functional use and this can meet our additional criteria for safer (Ecology, 2022c).

Calcium stearate scored BM-3 in a GreenScreen® assessment as listed on the Swedish Confederation of Professional Employees (TCO) Certified Accepted Substance List (TCO, n.d.). Chemicals listed on TCO Certified Accepted Substance List with GreenScreen® BM-3 can meet our additional criteria for safer (Ecology, 2022c).

Calcium stearate was scored Green/Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021h). Assessors noted data gaps for endocrine activity, neurotoxicity, and respiratory sensitization. Data on endocrine activity is not required in our criteria, and

reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Data on sensory irritation is not required in our criteria, but it was scored as moderate hazard. All other endpoints were scored as low hazard.

Calcium stearate was assigned Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2022a), indicating that calcium stearate met our additional criteria for safer (Ecology, 2022c). The assessment noted data gaps for carcinogenicity (dermal and inhalation), reproductive and developmental toxicity (inhalation), endocrine activity, systemic toxicity (repeat-dose, inhalation), neurotoxicity, respiratory sensitization and respiratory irritation. Carcinogenicity was scored as low hazard for the oral route, and reproductive and developmental toxicity were scored as low hazards for the oral and dermal routes. Systemic toxicity (single- and repeat-dose) and neurotoxicity (single- and repeat-dose) were scored as low hazards for the oral and dermal routes. Our criteria for safer does not require data for all routes of exposure, and the low hazard scores reported for other routes of exposure are sufficient to meet our data requirements. We do not require data for respiratory sensitization because skin sensitization was scored as low hazard. Data on endocrine activity and respiratory irritation were not required to meet our additional criteria for safer (Ecology, 2022c).

Erucamide (CASRN: 112-84-5)

Erucamide met our minimum criteria for safer (Ecology, 2022c).

This chemical scored BM-2_{DG} in a GreenScreen® assessment (ToxServices LLC, 2021b). The assessment noted data gaps for reproductive toxicity and endocrine activity. Data for endocrine activity is not required in our criteria, but we do require data for either reproductive toxicity or developmental toxicity. Developmental toxicity was scored as low hazard with high confidence in the assessment, and this meets our data requirements. All other hazard endpoints were scored as low hazard.

Safer process alternatives to PFAS

Eliminate the use of PPAs

Based on conversations with STC and other communications with industry (T. Virgo, personal communication, May 7, 2026), our understanding is that fluoropolymers as PPAs are not necessary in manufacturing artificial turf products. Industry has communicated to us that other measures, including routine maintenance of extrusion equipment and manufacturing process changes, can avoid the need to use fluoropolymers as PPAs. This aligns with voluntary commitments by artificial turf manufacturers represented by STC to "...proactively engage with their component and raw material suppliers to ensure that the products contain no PFAS-based ingredients, including polymeric PFAS processing aids" (STC, n.d.). Because STC has stated they represent over 90% of artificial and synthetic turf manufacturers in the United States, the commitments to stop using PFAS in these products account for a large majority of the market.

In at least two patents, PPA-less manufacturing of artificial turf could be possible due to using siloxane grafted on to the polymers used for artificial turf. This aids the manufacturing process of artificial turf fibers (Sick, BERG, Hamann, et al., 2025; Sick, BERG, REHOSEK, et al., 2025). The specific siloxane quoted in the patents is siloxanes and silicones, di-me, 3-hydroxypropyl me, ethoxylated (CASRN: 68937-54-2). This chemical is scored Yellow in a verified Scivera GHS+ assessment, which meets our minimum criteria for safer (Ecology, 2022c).

This grafted siloxane chemical is dimethicone-based, and much of the hazard evaluation was based on studies on dimethicone. The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity were scored as moderate and low hazards, respectively. Neurotoxicity was reported as a data gap, but systemic toxicity was scored as low hazard. Persistence was scored as very high for this polymer based on studies of dimethicone. Acute and chronic aquatic toxicity were scored as moderate and high hazards, respectively. The Safer Products for Washington Cycle 1.5 Implementation Phase 3 (Ecology, 2024b, 2024d), report states that dimethicone was considered safer only if the oligomer cVMS concentrations contained less than 1000 parts-per-million (ppm) level in the final product. Therefore, siloxanes and silicones, di-me, 3-hydroxypropyl me, ethoxylated would also meet our minimum criteria for safer (Ecology, 2022c) if the oligomer cVMS concentrations are less than 1000 ppm in the final product.

In our view, use of a grafted siloxane chemical is less preferrable than changes to the manufacturing process described below. Although it does meet our criteria as a safer alternative process relative to use of PFAS, it is less optimal than process changes that avoid use of polymer processing aids or grafted siloxanes altogether.

Reduce polymer shear stress without altering the formulation of the resin

Although specific manufacturing process changes to remove the need for fluoropolymer PPAs were not shared with us, there were several known, identified potential changes that could be done during the manufacturing of artificial turf (DTSC, 2026). These changes involve methods in reducing the polymer shear stress in the extrusion die:

1. Reduce extrusion rate.
2. Increase the die-land temperature with a heater to drop the shear stress below the critical shear stress for the resin's melt fracture.
3. Streamline the die's design by analyzing stresses through the die.
4. Increasing the die gap where the extrusion occurs.

Safer chemical alternatives to 6PPD

Because 6PPD doesn't serve a chemical function in this product, we didn't evaluate chemical alternatives and only assessed material alternatives.

Safer material alternatives for 6PPD

There were no known safer, feasible, and available alternatives to 6PPD in motor vehicle tires, which is the upstream source of 6PPD in crumb rubber infill used in artificial turf. Due to this,

we looked at alternative infills to crumb rubber instead, as removing crumb rubber from turf fields would also remove 6PPD.

Additional considerations for alternative materials and products

There have been additional human health and environmental concerns for some infill products that generate microplastics, inhalation hazards, use antimicrobials and/or antifungals, or could cause allergic reactions (Massey et al., 2020).

Some synthetic infill materials, including crumb rubber itself, have been shown to release microplastics (National Collaborating Centre for Environmental Health, 2025). This led to a European Union ban by 2031 for "granular infill for use on synthetic sport surfaces" (European Union, 20250617). For this reason, we have not included other synthetic plastics that may generate microplastics in our evaluation. Synthetic coatings on infill products, including antimicrobial and antifungal coatings, may also have additional hazard concerns, and therefore require additional consideration. Infill can also have inhalation hazard concerns. For example, silica, the principal constituent of sand, is a carcinogen if inhaled in the form of crystalline silica dust (Massey et al., 2020; National Cancer Institute, 2015).

We determined plant-based infills are safer if we have matching information from a product or patent discussing how antimicrobial or antifungal concerns are addressed and ensures that if a chemical treatment is used for this purpose it also meets our minimum criteria for safer.

Some people may be allergic to plant-based alternatives including tree nuts and coconut (Massey et al., 2020). Allergies are not included in our criteria for safer but may be relevant to some users of turf products. We found information that suggests allergies to just the shell material are less common than allergies to the nut itself. Infill materials may be processed to reduce contamination with the part that causes allergic reactions in some people. However, the U.S. Foods and Drug Administration (FDA) does not have any food allergen thresholds to reference these claims against (FDA, 2026). Although this is outside the scope of our evaluation, this may still be a relevant consideration for purchasers and users of these types of infill.

Our findings on specific safer material alternatives are discussed below.

Coconut coir fiber

Safer plant-based infill material can include coconut coir fiber. According to a patent (Carapella & MENON, 2025) filed by a supplier of this material (fibreinfill.com, n.d.; GreenPlay®, n.d.), coconut coir fiber is advertised to be "mold and fungus resistant," and no further anti-microbial or anti-fungal treatments are applied to the coconut coir fiber infills. The resistance to mold and fungus is associated with coconut coir fiber's resistance to water according to the patent for this infill material (Carapella & MENON, 2025). However, it is important to note that resistance means mold and fungal risk is minimized, but not completely eliminated.

Coconut coir fiber meets our additional criteria for safer as a natural biological material with longstanding use in products for which we have not identified significant hazards. The material can be used by itself without additional chemical treatment.

Olive pit particles

Safer plant-based infill material can include olive pit particles. According to two patents (Smollett, Gill, & KRAMER, 2021; Smollett, Gill, & Kramer, 2021) filed by a supplier of this material (FieldTurf, n.d.), no further anti-microbial or anti-fungal treatments are applied to olive pit particles. Other patents also mentioned thermal treatment of olive pit particles as a method for "antimicrobial…and biodegradation resistance" (Sick et al., 2024; Sick, Grochla, & Hamann, 2025). Some infill has the optional use of antimicrobial products by the user (FieldTurf, 2019). We didn't assess hazards of the antimicrobial treatment because this isn't required.

We haven't identified chemical hazards in olive pits, so they meet our additional criteria for safer as a natural biological material with longstanding use in products. The material can be used by itself without additional chemical treatment.

Walnut shell

Safer plant-based infill material can include walnut shell. According to a patent (Heinlein, 2019) filed by a company acquired (Cincinnati Business courier, 2010) by a supplier of this material (Motz, n.d.), thermal treatment is applied to walnut shells to reduce the potential for mold formation. Furthermore, sodium bicarbonate (CASRN: 144-55-8) is used for antimicrobial treatment of the walnut shells (Heinlein, 2019).

We haven't identified chemical hazards in walnut shells, so they meet our additional criteria for safer as a natural biological material with longstanding use in products. Together with the use of sodium bicarbonate, the infill meets our minimum criteria.

Sodium bicarbonate was scored Yellow in a verified Scivera GHS+ assessment, indicating that this chemical meets our minimum criteria for safer (Ecology, 2022c). Carcinogenicity, mutagenicity, reproductive toxicity and developmental toxicity were all scored as low hazard. Endocrine activity was scored as moderate hazard based on inclusion in a screening list, but no other data was presented that indicated a hazard. Persistence scored as high, but this is less relevant for inorganic chemicals such as sodium bicarbonate, because it breaks down to form sodium hydroxide and carbonic acid in water.

Sodium bicarbonate is also scored as a Full Green Circle on EPA SCIL under the processing aid and additives functional use category, indicating that this chemical also meets our additional criteria for safer (Ecology, 2022c).

Cork

Safer plant-based infill material can include cork. Several interested parties have communicated that cork-based infill should be considered as a potential alternative.

We reached out to a cork-based infill manufacturer, Amorim Cork Solutions, and learned that their Nature range of cork-based infill do not use any coatings or additives (Amorim, n.d.; P. Pinto, personal communication, October 2, 2026). The cork has only been transformed by mechanical processes and can be used by itself as infill material without chemical treatment.

We are not aware of any known chemical hazards with cork-based infills that are 100% cork. Due to this, cork meets our additional criteria for safer as a natural biological material with longstanding use in products.

Safer product alternative to 6PPD

BrockFILL™ by Brock USA, LLC

Products with Material Health Certificate™ of Gold or Platinum in version 3.1 and newer according to the Cradle to Cradle® Certification Program (Cradle to Cradle Products Innovation Institute, 2025) meet our minimum criteria for safer (Ecology, 2022b).

BrockFILL™ by Brock USA, LLC (wood (loblolly pine) particle infill) has Material Health Certificate™ of Gold according to the Cradle to Cradle® Certification Program version 4.1 (Brock USA, n.d.-b). Products with this certification can meet our minimum criteria for safer if we can confirm that endpoints were not adjusted based on exposure potential during end use of the product or if this adjustment is well-supported by available information.

There could be an inhalation concern for this product as wood dust is classified as a known human carcinogen by the California OEHHA (OEHHA, 2019), the US National Toxicology Program (National Toxicology Program, n.d.-b) and the International Agency for Research on Cancer (IARC, n.d.), because studies suggest that routine exposure to significant amounts of wood dust on a reoccurring basis, such as from chipping or sanding in woodworking, is associated with nasal cancers.

We reached out to Brock USA and the Cradle to Cradle assessor for this product to learn more and evaluate this potential concern. The Cradle to Cradle assessor for this product communicated that a red risk flag was adjusted to yellow because wood dust is classified as a carcinogen. However, the assessor determined no respirable wood dust was anticipated during typical use of this product. The assessor confirmed that they verified that use of engineering controls during production and communication of best practices to prevent wood dust exposure during installation.

Brock USA also provided information on the expected particle size of their infill product, as well as described how wood dust is removed during manufacturing, including fine mesh screening and use of an aspirator unit in manufacturing to remove fine materials (T. Murphy, personal communication, October 21, 2026). They report in their technical data sheet only between 0 - 2% of the infill is expected to be smaller than 0.5 mm (or 500 microns), with the majority measured over 0.5 mm by a modified ASTM C136 method (Brock USA, 2022). BrockFILL™ products are declared by Brock USA as not containing ingredients that require reporting under California Proposition 65, such as wood dust (Brock USA, 2018). This information is consistent with the conclusions from the Cradle to Cradle assessor.

Additionally, according to the BrockFILL™ supplier (Brock USA, n.d.-b), the drying process (700 F) applied to the harvested wood chips used to make the infill “destroys all bacteria, mold, and fungus spores.” They also confirmed there are no added antimicrobials or antifungals used in the product (Brock USA, n.d.-b).

After reviewing this information, we determined that this product is a safer alternative to use of infill that contains 6PPD, such as crumb rubber from tires.

Safer process alternatives to 6PPD

Eliminate the use of infills

There are four patents that indicate that artificial turf fibers can be tufted; therefore, they could be applied to artificial turf systems with no infill (PALMER & Fowler, 2026; Penninck, 2024; Vachon, 2021; Verleyen & BEAUPREZ, 2016). As no infills were needed, infill free artificial turf could be considered as a safer process alternative.

Organically managed grass

We have identified organically managed grass (Pollard & Buscemi, 2021) as a safer process alternative to artificial turf as a whole. This product alternative avoids synthetic pesticides and fertilizers, which reduces exposure to potentially hazardous chemicals. Organically managed grass as an alternative also removes the need for fluoropolymer PPA and crumb rubber infill and therefore avoids use of PFAS and 6PPD altogether.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Feasible and available alternatives to PFAS in artificial turf

Feasible and available alternatives to PFAS as PPA in artificial turf are listed below in Table 6.

Table 6: Feasible and available safer alternatives to PFAS as PPA in artificial turf.

Chemical or Material and CASRN	Example alternatives available in marketplace
Oxidized PE wax 68441-17-8	OXIDIZED POLYETHYLENE WAX by escom Chemie GmbH (escom Chemie GmbH, n.d.), OXIDIZED PE WAX by Ataman Chemicals (Ataman Chemicals, n.d.-d), DONGRAY® OPE WAX 620A by FengShun DongRay Fine Chemical (FengShun DongRay Fine Chemical, n.d.)
Calcium stearate 1592-23-0	Calcium Stearate L-155 by Blachford (Dar-Tech, n.d.-b), Coad® 13P Calcium Stearate by Norac Additives LLC (Norac, 2013), Coad® Calcium Stearate by Norac Additives LLC (Norac Additives LLC, 2025)
Erucamide 112-84-5	INNOSLIP – E SERIES by Pathwell (Pathwell Co., Ltd., 2024)
Siloxanes and Silicones, di-Me, 3-hydroxypropyl Me, ethoxylated* 68937-54-2	Poly(dimethylsiloxane-b-ethylene oxide), methyl terminated by Polysciences (Polysciences, n.d.), LA-ST493 by Nanjing Silfluo New Material Co., Ltd. (Nanjing Silfluo New Material Co., Ltd., n.d.), Poly(dimethylsiloxane-co-ethylene oxide), AB block copolymer by Scientific Polymer Products, Inc. (Scientific Polymer Products, Inc., 2020)

*Not as PPA added to the formulation, but as a grafted polymer that aids the manufacturing process of artificial turf fibers (Sick, BERG, Hamann, et al., 2025; Sick, BERG, REHOSEK, et al., 2025)

Oxidized PE wax is listed among PPA alternatives to PFAS for artificial turf according to our consultation with STC (A. Daniell, personal communication, April 24, 2026). According to a patent, Oxidized PE is a PPA option for use in artificial turf (Martin & Sandkuehler, 2015).

Calcium stearate was also was listed among a list of PPA alternatives to PFAS for artificial turf according to STC (A. Daniell, personal communication, April 24, 2026). Calcium stearate is a PPA option for use in artificial turf according to a patent (Martin & Sandkuehler, 2015) it is also listed as a PPA used for artificial turf in two other patents (Sick, BERG, Hamann, et al., 2025; Sick, Hamann, & BERG, 2025).

Erucamide is mentioned as a PPA option used in artificial turf according to a patent (Martin & Sandkuehler, 2015). Erucamide was further listed as a PPA used for artificial turf in two patents (Sick, BERG, Hamann, et al., 2025; Sick, Hamann, & BERG, 2025) and was mentioned as a PPA for polyolefins according to suppliers of this chemical (Biesterfeld SE, 2025; Pathwel Co., Ltd., n.d.; 페스웰, 2022).

There were trade names listed by chemical suppliers for calcium oxidized PE wax (Ataman Chemicals, n.d.-d; escom Chemie GmbH, n.d.; FengShun DongRay Fine Chemical, n.d.), calcium stearate (Dar-Tech, n.d.-b; Norac, 2013; Norac Additives LLC, 2025), and erucamide (Pathwell

Co., Ltd., 2024) (Table 6 above). Therefore, these safer chemical alternatives were feasible and available.

For grafted polymers, **siloxanes and silicones**, di-me, 3-hydroxypropyl me, ethoxylated (CASRN: 68937-54-2) were determined to be feasible and available. There are two patents that specifically mentioned the use of this chemical in artificial turf manufacturing (Sick, BERG, Hamann, et al., 2025; Sick, BERG, REHOSEK, et al., 2025). There were also available trade names for this chemical (Nanjing Silfluo New Material Co., Ltd., n.d.; Polysciences, n.d.; Scientific Polymer Products, Inc., 2020) (Table 6 above).

Application of artificial turfs made with siloxane grafted on to the polymers include field hockey and other sports, as well as landscaping (ACT Sport, n.d.; AGL Grass, n.d.; DIYrubberfloors, n.d.; Kiefer USA, n.d.; Limonta Sport, n.d.; TenCate, n.d.; U.S. Sports Turf, n.d.). This indicates that eliminating the use of PPAs is feasible and available.

Further, reducing polymer shear stress without altering the formulation of the resin is also a feasible and available option.

Feasible and available alternatives to 6PPD in artificial turf

Feasible and available alternatives to artificial turf infill are listed below in Table 7, followed by details of our analysis.

Table 7: Feasible and available safer alternative artificial turf infill materials.

Alternative	Example alternatives available in marketplace
Coconut coir fiber	NaturalCool by GreenPlay (GreenPlay®, n.d.), GreenPlay Fibre™ by GreenPlay (fibreinfill.com, n.d.)
Olive pit particles	PureSelect by FieldTurf (FieldTurf, n.d.)
Walnut shell	Safeshell by MOTZ (Motz, n.d.)
Organically managed grass	Sports fields in Ohio (Kaplan et al., 2021), Pennsylvania (Pollard et al., 2021), and Massachusetts (Buscemi et al., 2020; Massey & Pollard, 2020)
Cork	Amorim Nature by Amorin Cork Solutions (Amorim, n.d.)
Wood (loblolly pine) particle	BrockFILL™ by Brock USA (Brock USA, n.d.-b)

Coconut coir fiber infill from GreenPlay (GreenPlay®, n.d.), olive pit particles infill from FieldTurf (FieldTurf, n.d.), and walnut shell infill from MOTZ (Motz, n.d.; Turf Network, Inc., 2024) are all advertised for sports or athletic applications. Walnut shell infill from MOTZ was also advertised for pet turf (Turf Network, Inc., 2024). These examples indicate that these safer infill materials are feasible and available.

Although we have identified organically managed grass as safer and available, we have not determined if it is feasible in all applications of turf. For example, it may not be feasible in some dog parks, pet relief areas, and indoor field uses. However, there are case studies for organically managed grass used for outdoor sports fields in Ohio (Kaplan et al., 2021), Pennsylvania (Pollard et al., 2021), and Massachusetts (Buscemi et al., 2020; Massey & Pollard, 2020), which demonstrate the that organically managed grass would be considered as safer, feasible, and available for some applications.

With respect to safer product alternative to 6PPD, BrockFILL™ is advertised primarily for outdoor sports or athletic applications (Brock USA, n.d.-a), Therefore, BrockFILL™ is feasible and available for these applications. On its website, BrockFILL™ is advertised to withstand pet urine (Brock USA, n.d.-a), indicating a potential application of BrockFILL™ for pet turf .

Products advertised by artificial turf companies indicate that infill-free artificial turf systems can be used indoor and outdoor, for sports, and landscaping applications (ACT Sport, n.d.; AGL Grass, n.d.; DIYrubberfloors, n.d.; Kiefer USA, n.d.; Limonta Sport, n.d.; TenCate, n.d.; U.S. Sports Turf, n.d.). This indicates that no-infill artificial turfs, as safer process alternative to 6PPD, are feasible and available.

Conclusions on alternatives

Reducing a significant source or use

We described artificial turf as a significant source and use of PFAS and 6PPD in our Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 report (Ecology, 2025b). In that report, we summarized studies that reported PFAS and 6PPD compounds detected in different components of artificial turf products and their potential to release PFAS, 6PPD, and 6PPDQ to the environment (DTSC, 2024; Lauria et al., 2022; Zuccaro et al., 2023).

Granular infill including rubber and plastic granules in artificial turf were estimated to account for approximately 38% of microplastic releases to the environment in Europe and highlighted as the largest single source of microplastic pollution (ECHA, n.d.-b). While there are likely differences between use of turf in Europe and in Washington State, it is reasonable to infer that artificial turf infill is a significant source of microplastics in our environment as well. This estimate includes other synthetic infill materials and is not specific to crumb rubber, but because crumb rubber is a common type of infill material known to contain 6PPD, it highlights a significant source of microplastics containing 6PPD to the environment in Washington.

We also summarized available information used to estimate the volume of artificial turf sold or present in Washington State. Together, this information suggests that several million square feet of artificial turf are used in Washington, and that artificial turf has the potential to release PFAS, 6PPD, and 6PPDQ during use and disposal—showing artificial turf as a significant source and use of PFAS and 6PPD (Claudio, 2008; Ecology, 2025b; Kole et al., 2023).

Necessary to protect sensitive species

We also highlighted the potential for artificial turf to release PFAS, 6PPD, and its transformation product 6PPDQ, into the environment and as a potential source of exposure in sensitive populations and species, including coho salmon (de Haan et al., 2023; Ecology, 2025b; Kole et al., 2023). 6PPD and 6PPDQ are highly toxic to several fish species, with a reported LC_{50} in coho salmon of 95 ng/L (Tian et al., 2021, 2022). PFAS and 6PPD have also both been identified as reproductive toxicants in animal studies, and this is relevant to potential exposure from artificial turf in sensitive populations such as people of childbearing age and workers who install and maintain fields as part of their occupation (DTSC, 2024; Ecology, 2022b, 2025b; EPA, 2024b; ITRC, n.d.).

Safer alternatives are feasible and available

Safer alternatives to PFAS and 6PPD in artificial turf that meet either our minimum or additional criteria for safer (Ecology, 2022c) are identified. The alternatives are currently used in artificial turf and are described as feasible and available based on our evaluations.

Regulatory determination

Our regulatory determination is that a restriction on PFAS and 6PPD in artificial turf should be adopted.

We've determined that safer alternatives to PFAS and 6PPD are feasible and available. A restriction on the use of PFAS and 6PPD in artificial turf will reduce a significant use and source of potential exposure of PFAS and 6PPD to the people and the environment—and a restriction on 6PPD is necessary to protect sensitive species, including coho salmon.

Chapter 3: PFAS in Cookware and Kitchen Supplies

Priority product scope

As defined in the Safer Products for Washington Cycle 1.5 Implementation Phase 3[21] and Safer Products for Washington Cycle 2 Implementation Phase 2[22] reports, the scope of this priority product includes durable houseware items used in homes and restaurants to prepare, dispense, or store food, foodstuff, or beverages. Cookware types can be categorized into:

- **Stove top cookware**: Items such as pots and pans, cooktop griddles and skillets that are placed over direct heat (flames, induction, electric coil, and glass top stoves, etc.) for cooking.
- **Bakeware**: Includes items that are used for cooking over indirect heat, such as baking pans, baking trays, air fryer baskets, and muffin trays.
- **Small domestic appliances and gadgets**: Appliances that require direct electric source for cooking or prepping food, such as deep fryers, air fryers, rice cookers, hot pots, sandwich makers, waffle makers, coffee pots, blenders, and electric can openers.
- **Cooking utensils**: Includes handheld tools in the kitchen used to prepare, cook, and serve food, such as spatulas, ladles, graters, tongs, and cutting boards They come in various materials like wood, stainless steel, plastic, or silicone and may be suited for different purposes.

Coatings applied to any part or component of the cookware that aren't in direct contact with foods, such as coatings on outer surfaces used to make the cookware look attractive and shiny, aren't considered part of the food contact surface of cookware. These coatings are not in the scope of our review.

Other FDA authorized uses of PFAS in food contact applications that don't fall under the scope of this priority product are as follows (FDA, 2025):

- Disposable containers for storage or packaging of food, such as pizza boxes, food wrappers, and to-go boxes.
- Disposable items used in cooking such as foil or parchment paper.
- PFAS used in sealing gaskets for industrial food processing equipment.
- Major appliances such as refrigerators, dishwashers, kitchen stoves, and microwaves.

[21] https://apps.ecology.wa.gov/publications/summarypages/2404024.html
[22] https://apps.ecology.wa.gov/publications/SummaryPages/2504031.html

Priority chemical scope

As defined in RCW 70A.350.010(10):[23]

Perfluoroalkyl and polyfluoroalkyl substances or "PFAS chemicals" means a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

We referred to disclosures required in California pursuant to the Safer Food Packaging and Cookware Act (AB 1200) and manufacturer provided information to identify the types of fluoropolymers used in cookware (Calphalon, n.d.-b; T-fal, n.d.-a). The common PFAS chemicals associated with non-stick cookware coating are polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP), and perfluoroalkoxy alkanes (PFA). PTFE and fluoroalkoxysilanes can also be used as additives in different types of coatings. PFAS chemicals such as GenX and PFBS are used as processing aids for making fluoropolymers used in cookware coatings (EPA, 2018).

Function of the priority chemical in the priority product

Nonstick Function

We identified the nonstick function of PFAS in cookware in our Technical Supporting Documentation for Regulatory Determinations Report to the Legislature: Safer Products for Washington Cycle 1.5 Implementation Phase 3 report (Ecology, 2024d). PFAS is used in cookware and kitchen supplies as fluoropolymer coatings to provide the nonstick function. The nonstick function provided by PFAS prevents food from sticking to the cooking surface and facilitates the dislodging of cooked food from the surface of a cookware or kitchen supply product, making it easier for the user to clean after use.

Fluoropolymers can be used in cookware as additives in other types of coatings such as ceramic coatings and polyether ether ketone (PEEK) coatings to enhance nonstick capabilities.(Jeon & Kim, n.d.) Some PFAS chemicals are also used as processing aids in making fluoropolymers such as PTFE used in cookware coatings (FDA, 2025; ITRC, 2026).

No Function

PFAS has no necessary function in regular kitchen utensils. As such, an alternative analysis to PFAS in kitchen utensils isn't required. While fluoropolymers are commonly added to stovetop, bakeware, and small domestic appliance categories of cookware to create a nonstick surface, they have seen minimal use in regular kitchen utensils category. Items, such as spatulas, knives, tongs, graters, cutting boards, storage containers, and server ware, are normally made of alternative materials like wood, metals, plastics, silicones, glass. To our knowledge, PFAS coated kitchen utensils are rare. Instead, PFAS are more often used in specialized tools such as lab grade spatulas (Thomas Scientific, n.d.).

Stove top cookware, bakeware, and small domestic appliances with no coatings are readily available on the market. Cookware without nonstick coatings, such as stainless-steel, cast iron

[23] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

pans, and carbon steel pans, can be used successfully to cook without food sticking to the surface. However, this requires proper preheating, using ample amounts of oil, and allowing food to cook properly before moving it.

While the function of PFAS in cookware is to make the cookware nonstick, the main function of a cookware is to cook food. The nonstick capability makes it easier for the user to cook and clean but isn't a required function in cookware.

Hazards of the priority chemical class

We described the hazards associated with PFAS in our Regulatory Determinations Report to the Legislature: Safer Products for Washington Cycle 1 Implementation Phase 3 (Ecology, 2022b). Hazards of concern for members of the class include carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are very persistent, and many are bioaccumulative. These hazards indicate that PFAS are a hazardous class of chemicals and don't meet our minimum criteria for safer (Ecology, 2022b).

Safer, feasible, and available alternatives

Safer alternatives

To find safer alternatives we began by reviewing products advertised and sold as "PFAS-free." Alternatives to cookware with PFAS-based chemicals that are available in the market are advertised as "PFAS-free," "PTFE and PFOA-free," or "non-toxic." Cookware with these labels include options such as stainless steel, cast iron, carbon steel, ceramic coated cookware, true ceramic cookware, and more.

"Safer" varies across hazards and applications (Ecology, 2022b). For alternative types of cookware advertised as non-stick, we only evaluated the chemicals used to provide the non-stick function in the non-stick coating against our criteria for safer. For alternative types of cookware without a non-stick coating, we evaluated the base material of the cookware that is expected to contact food during cooking.

Safer chemical alternatives

Ceramic coatings are advertised as alternatives to fluoropolymer coatings in cookware. While ceramic refers to a class of inorganic materials, ceramic coatings used in cookware are usually hybrids made using the sol gel process. The sol gel process is a chemical process that transforms liquid precursor chemicals into a solid material (Jeon & Kim, 2011; Pfluon, 2024). A sol solution containing a cluster of precursor molecules transforms into a gel which is then heat cured to form a hard, wear resistant, high temperature resistant coating on the surface of cookware.

In general, to make a nonstick ceramic cookware coating manufacturers combine inorganic colloidal silica, organic silanes (methyltrimethoxysilane), release agents, coloring agents and solvents. At this stage, the precursor molecules form a colloidal dispersion of smaller clusters by reacting and combining with each other forming a stable sol solution. This liquid sol is sprayed

onto the cookware surface where sol particles crosslink to form a gel under specific conditions. Heat curing removes the remaining solvents and transforms the gel into a hard solid ceramic coating on the cookware surface. The spray coating is usually done in multiple layers with different compositions of release agent additives to create a top layer with nonstick properties.

Organic silicone polymers are added to ceramic coating formulations to enhance nonstick properties (Jeon & Kim, n.d.).We reviewed manufacturer websites for cookware and coatings to identify silicone resin coatings as chemical alternatives to fluoropolymer coatings in bakeware products (Wacker, 2024a). Specific silicone polymers and the CASRNs used in PFAS-free coatings that provide nonstick functions in cookware items were obtained through manufacturer orders.

In early 2025, we contacted nine different manufacturers who sold their products in Washington and requested information about their products; manufacturers had six months to respond. We asked them about the specific chemicals used in their cookware to impart nonstick function, and the types of cookware they sold. They provided this information to us.

We then used this information to determine if the chemicals used specifically for the nonstick function met our criteria for safer. Chemicals that met our minimum criteria as safer alternatives are identified in Table 8 below.

Table 8: Alternatives to PFAS in cookware and kitchen supplies with hazard assessment scores and tier they meet in our Criteria for Safer.

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Dimethyl (siloxane & polysiloxane) and silica reaction products 67762-90-7	EPA SCIL Half-Green Circle (defoamer), Scivera [Yellow]	Minimum
Silsesquioxanes, Me Ph 67763-03-5	Scivera GHS+ [Yellow]	Minimum
Colloidal silica, silicon dioxide, amorphous silica (non-respirable size) 7631-86-9 (SVID-556167) 112926-00-8	Scivera [Yellow], ChemFORWARD Hazard Band B, EPA SCIL Full Green Circle	Minimum
Methyltrimethoxysilane* 1185-55-3	Scivera [Yellow]	Minimum
Polydimethylsiloxane/dimethicone 63148-62-9, 9006-65-9, 9016-00-6	GreenScreen BM-2, Scivera [Yellow], EPA SCIL Yellow Triangle (defoamer)	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Silicone resin/Phenyl Methicone 63148-58-3	Under evaluation	Under evaluation
Siloxanes and Silicones, di-Me, hydroxy-terminated 70131-67-8	Scivera [Yellow], EPA SCIL Half-Green Circle (defoamer)	Minimum
Caraway CBI chemical Confidential	Scivera [Yellow]	Minimum
GreenPan CBI chemical Confidential	Scivera [Yellow]	Minimum

*Methyltrimethoxysilane is a precursor reagent used in the sol gel process and is used is most ceramic coatings (Wacker, n.d.-a).

Dimethyl (siloxane & polysiloxane) and silica reaction products (CASRN: 67762-90-7)

This chemical meets our minimum criteria for safer.

This chemical scores as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2019g). The Scivera assessment gave a moderate score for systemic toxicity due to inhalation hazard, and a high score for persistence. A data gap was assigned for endocrine activity, but reproductive toxicity and developmental toxicity were scored as low hazard. Data on endocrine activity isn't required in our criteria.

The assessment noted a data gap for respiratory sensitization, but this is allowable as dermal sensitization was scored as low hazard. Persistence was scored as very high hazard for this polymeric ingredient. This is still allowable in our minimum criteria as no other endpoints were scored above moderate hazard including bioaccumulation which was scored as low hazard. This polymer meets our minimum criteria for safer if residuals are not present above 1000 ppm.

This chemical is listed on EPA's SCIL as a Half-Green Circle in the defoamer function category. Depending on their chemistry, Safer Choice evaluates defoamers against either the surfactant, polymer, or master criteria (EPA, 2016). For silicone-based defoamers, the polymer criteria is generally applied. This provides additional evidence that this chemical meets our minimum criteria for safer.

Silsesquioxanes, Me Ph (CASRN: 67763-03-5)

This chemical meets our minimum criteria for safer.

Silsesquioxanes, Me Ph scored as Yellow chemical in a verified Scivera assessment (Scivera, 2026e). It was assigned very high hazard for persistence but scored low hazard with limited evidence for all other endpoints including bioaccumulation. Assessors note the potential for trace impurities or residuals from manufacturing in the form of low molecular weight

silsesquioxanes oligomers. Assessors also note that cyclic siloxanes such as D4, D5, and D6 are not expected to be constituents of this polymer. This polymer meets our minimum criteria for safer if residuals are not present above 1000 ppm.

Colloidal silica, silicon dioxide, amorphous silica (non-respirable size) (CASRN: 7631-86-9, 112926-00-8)

This chemical meets our minimum criteria for safer.

Colloidal silica, silicon dioxide (non-respirable size) (CASRN: 7631-86-9, SVID-556167) was scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2020k). The assessment noted a data gap for endocrine activity but scored reproductive toxicity as low hazard and developmental toxicity as moderate hazard. The moderate score for developmental toxicity was based on injection of colloidal silica into the amniotic cavity of five-day old chick embryos and doesn't raise concern for use of this chemical in cookware.

Data on endocrine activity isn't required in our criteria and there is no indication of endocrine related effects reported. Data gaps were reported for neurotoxicity and respiratory sensitization. The data gap for neurotoxicity is allowable, as acute toxicity for dermal and oral routes scored as low hazard, acute toxicity for the inhalation route scored as moderate hazard, and systemic toxicity scored as moderate hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization was scored as low hazard. Persistence was scored as high hazard for this inorganic substance, but bioaccumulation was scored as low hazard. These scores meet our data requirements.

Amorphous silica was scored as Hazard Band B in a ChemFORWARD assessment (CASRN: 112926-00-8) (ChemFORWARD, 2025c). The assessment noted data gaps for carcinogenicity (dermal), reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), systemic toxicity (dermal), neurotoxicity (single- and repeat-dose, all routes), and respiratory sensitization.

The data gaps for carcinogenicity, reproductive toxicity, developmental toxicity, and systemic toxicity are allowable as these endpoints were scored as low hazard based on other routes of exposure. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low or moderate hazard for at least one route of exposure. The data gap for respiratory sensitization is allowable as dermal sensitization scored as low hazard.

It is important to note that crystalline silicon dioxide can be a respiratory hazard if inhaled, so our assessment of this chemical is limited to the amorphous form.

Methyltrimethoxysilane (CASRN: 1185-55-3)

This chemical meets our minimum criteria for safer.

Methyltrimethoxysilane was scored as a Yellow chemical in a verified Scivera GHS+ assessment (Scivera, 2020l). Endocrine activity was scored as moderate hazard based on thyroid effects reported in an OECD 422 guideline study in rats with a reported NOAEL of 50 mg/kg/bw/day; the LOAEL was 250 mg/kg/bw/day based on histopathological changes in the thyroid gland (males and female rats) and liver (female rats).

In contrast, both developmental toxicity and reproductive toxicity were scored as low hazard based on lack of relevant effects observed up to a NOAEL of 1000 mg/kg/bw/day. Carcinogenicity and mutagenicity were scored as moderate hazard based on mixed results reported in in vitro studies.

A data gap was reported for respiratory sensitization, but this is allowable as dermal sensitization was scored as moderate hazard. Persistence was scored as high hazard, while bioaccumulation was scored as low hazard. This chemical meets our minimum criteria for safer, but confidence in its future status as a safer alternative could be increased with additional data on endocrine activity.

Polydimethylsiloxane/Dimethicone (CASRN: 63148-62-9, 9006-65-9, 9016-00-6)

This chemical meets our minimum criteria for safer.

As acknowledged in the reports for the Safer Products for Washington Cycle 1.5 Implementation Phase 3 (Ecology, 2024b, 2024d), dimethicone meets our minimum criteria safer if the oligomer cVMS concentrations in the final product are less than 1000 ppm.

Dimethicone was scored as BM-2 in a GreenScreen® hazard assessment (ToxServices LLC, 2025e, 2025c, 2025d). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity wasn't required in our criteria (Ecology, 2022c). A data gap was identified for repeated dose neurotoxicity, but data were included on acute and systemic toxicity. Persistence was scored as very high hazard for this polymeric ingredient.

Dimethicone (CASRN: 63148-62-9/9006-65-9/9016-00-6) scored Yellow in three different verified Scivera GHS+ assessments. Dimethicone already meets our minimum criteria based on the GreenScreen described above; however, we reviewed these assessments as well to confirm they don't conflict with this finding (Scivera, 2018g, 2019f, 2021u).

- **Dimethicone (CASRN: 63148-62-9)** had a data gap for endocrine activity; however, both reproductive and developmental toxicity scored as low hazard (Scivera, 2021u). Additionally, data gaps were noted for both respiratory sensitization and sensory irritation. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as a low hazard. Data for sensory irritation isn't required in our criteria. Persistence was scored as very high hazard for this polymeric ingredient.
- **Dimethicone (CASRN: 9006-65-9)** had data gaps noted for endocrine activity, respiratory sensitization, and skin irritation, as well as a data gap for neurotoxicity (Scivera, 2019f). Data for endocrine activity isn't required in our criteria, and the assessment scored reproductive toxicity and developmental toxicity as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. The data gap for neurotoxicity is allowable as systemic toxicity and acute toxicity were scored as low hazard. Data on skin irritation isn't required in our criteria. Persistence was scored as high hazard for this polymeric ingredient.

- **Dimethicone (CASRN: 9016-00-6)** had data gaps noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation (Scivera, 2018g). Data for endocrine activity isn't required in our criteria, and the assessment scored reproductive toxicity and developmental toxicity as moderate hazard. Reproductive and developmental toxicity were scored as moderate hazard as some limited data reported a chance of fetal abnormalities and placental site formation abnormalities observed with silicone device implants (not specific to dimethicone). The data gaps for neurotoxicity and respiratory sensitization are allowable as acute toxicity, systemic toxicity, and dermal sensitization scored low hazards. Data on sensory irritation isn't required in our criteria. Mutagenicity and genotoxicity were scored as moderate hazard due to a study of organosilicon compounds suggesting clastogenic activity potential in vitro, but other multiple mutagenicity studies were negative. Acute aquatic toxicity was scored as high hazard. Persistence was scored as very high hazard for this polymeric ingredient.

Silicone resin/Phenyl Methicone (CASRN: 63148-58-3)

This chemical is currently being evaluated in a GreenScreen hazard assessment. We will update the description of this chemical in our final report and describe if it meets our criteria for safer.

Siloxanes and Silicones, di-Me, hydroxy-terminated (CASRN: 70131-67-8)

This chemical meets our minimum criteria for safer.

Siloxanes and Silicones, di-Me, hydroxy-terminated scored as Yellow in a verified Scivera assessment (Scivera, 2018h). There was a data gap for endocrine activity, but reproductive toxicity, developmental toxicity, mutagenicity, and carcinogenicity all scored as low hazard with limited evidence. This polymeric ingredient was scored very high for persistence. This polymer meets our minimum criteria for safer if residuals are not present above 1000 ppm.

Siloxanes and Silicones, di-Me, hydroxy-terminated is also present on EPA's SCIL as a Half Green Circle in the defoamer category (OCSPP, 2013a). Depending on their chemistry, Safer Choice evaluates defoamers against either the surfactant, polymer, or master criteria (EPA, 2016). For silicone-based defoamers, the polymer criteria is generally applied. This provides additional evidence that this chemical meets our minimum criteria for safer.

Confidential chemical used in Caraway products

This chemical meets our minimum criteria for safer.

As part of their manufacturer order, Caraway disclosed that they use a chemical in their products to provide the non-stick function. We can't disclose the identity of this chemical because Ecology has agreed to grant this information confidential status due to it being considered as trade-secret. This chemical was assessed in a verified Scivera GHS+ assessment as a Yellow chemical. It scored as very high for persistence with limited evidence but scored as a low hazard for all other endpoints.

Confidential chemical used in GreenPan products

This chemical meets our minimum criteria for safer.

As part of a manufacturer order, GreenPan disclosed that they use a chemical in their products to provide the non-stick function. We can't disclose the identity of this chemical because Ecology has agreed to grant this information confidential status due to it being considered as trade-secret. This chemical was assessed in a verified Scivera GHS+ assessment as a Yellow chemical. It scored as very high for persistence but scored as a low hazard for all other endpoints based on limited available data.

Safer material alternatives

Cookware with no additional coatings for nonstick were considered as material alternatives to PFAS in cookware. We identified the primary materials or chemicals in each of these alternative types of cookware to assess for safer. Our assessments of the material alternatives are described below.

Stainless steel (CASRN: NA)

Stainless steel meets our minimum criteria for safer based on a review of relevant literature.

We determined that stainless steel meets our minimum criteria for safer by referencing a report published by the Finnish Institute of Occupational Health titled, "Review on Toxicity of Stainless Steel" and a related peer-review publication by the same authors (Santonen et al., 2010; Taxell & Huuskonen, 2022). These analyses conclude that evidence supports very low toxicity and non-carcinogenicity of stainless steels, including grades commonly used in cookware.

Stainless steels are iron-based alloys with a chromium content of at least 10.5%. Several different grades of stainless steel are available, and these are defined by the amount of different metals and other elements they contain, including iron, chromium, nickel, molybdenum, and carbon. There are five types of stainless steels that vary in their composition of iron, chromium, nickel, and carbon: 200 series, 300 series, 400 series, precipitation hardening (PH) grades, and duplex grades.

The 200 series are lower-performing alloys typically found in budget cookware. The 200-series grades have manganese that partially substitute for nickel. This is more cost-efficient but results in weaker corrosion resistance. The 200-series is common in household appliances, automotive, and food and beverage industrial applications.

The 300 series (austenitic) are the most widely used alloys. Grades 304 (also known as 18/8, with 18% chromium and 8% nickel) and 316 are the most prevalent in the food industry, chemical and medical equipment, and cookware (Kamerud et al., 2013). Grade 316 has the addition of molybdenum relative to the chromium and nickel found in 304, which provides additional resistance to chloride ions. Grade 303 is more commonly used in machining and releases significantly more nickel than other grades due to its sulfur content (Haudrechy et al., 1997).

The 400 series has ferritic grades (e.g., 430, used in appliances) and martensitic grades, which contain little to no nickel. It is used mainly for knives, cutlery, and budget cookware, but isn't recommended for prolonged contact with acidic or wet foods.

The lack of hazards from stainless steel are largely due to the chromium (III)-rich oxide passive surface layer that limits exposure to constituent metals (e.g., nickel). The toxic soluble form of chromium, chromium (VI), hasn't been detected in release tests. To our knowledge, the only well-established hazard of concern from stainless steels in cookware is skin sensitization from nickel released from prolonged skin contact. Research from Santonen et al. shows the levels released from most stainless steels are estimated to fall well below the EU nickel release limit of 0.5 ug/cm2/week in artificial sweat for induction of nickel allergy (Santonen et al., 2010). Some exceptions are high-sulphur grade stainless steels, such as American Iron and Steel Institute (AISI) 303, which should be avoided for applications involving prolonged skin contact (Santonen et al., 2010; Taxell & Huuskonen, 2022).

One study examined metal leaching from stainless steel cookware in acidic environments (e.g., tomato sauces). It found that nickel and chromium concentrations were elevated in acidic sauces, depending on cooking time, grade of stainless steel, and previous usage of the cookware. The authors acknowledged that the use of stainless-steel cookware can contribute to overall metal intake. The levels reported in the study for nickel in a serving of tomato sauce was below the tolerable upper intake level, and the chromium levels were below the lowest dose known to cause allergic contact dermatitis. Although the significance of its contribution to allergic contact dermatitis is unknown, limiting use may be helpful for those with sensitivities, as oral doses may cause dermatitis in some individuals (Kamerud et al., 2013).

Further, Santonen et al. note that reported releases of metals from stainless steel have been low compared to intake of chromium and nickel from the food itself. Additionally, the Council of Europe Guidelines on metals and alloys used as food contact materials concluded that uptake of nickel and chromium by foods cooked in stainless steel doesn't increase concern for health (Santonen et al., 2010).

Cast iron (CASRN: 11097-15-7)

Cast iron meets our minimum criteria for safer.

Cast iron used in cookware is an alloy of iron, carbon (2-5%) and silicon (1-3%) with other trace elements, such as: phosphorous, manganese and manganese compounds, sulfur, chromium, nickel, and copper (Balow & Whyte, 2008; СОНКИН, 2017). To determine if cast iron meets our minimum criteria, we reviewed hazard assessments of the major components of cast iron, which are iron, carbon, and the magnetite (Fe_3O_4) layer (Abyazi & Fakheri, 2025; Arab et al., 2009) that contacts food. Each of these are described in the following sections.

Iron (CASRN: 7439-89-6)

Iron meets our minimum criteria for safer.

Iron is an essential mineral for health, but high exposures cause toxicity in people. Iron dusts have the potential to cause adverse health effects if inhaled. Neither of these are expected to

occur from use of cast iron cookware. Taking this into account, we reviewed an existing hazard assessment on iron to confirm that other hazard data still met our minimum criteria for safer.

Iron was scored as Red in a verified Scivera GHS+ hazard assessment (Scivera, 2021m). However, the combined hazard profiles within the assessment meet our minimum criteria for safer. Carcinogenicity, mutagenicity, and developmental toxicity all scored as moderate hazards with limited evidence.

Carcinogenicity was scored as moderate hazard based on equivocal data. Iron isn't classified as a carcinogen, but some studies have reported hyperplasia or carcinogenic effects following inhalation exposure to iron dusts. Mutagenicity is scored as moderate hazard based on mixed results observed in in vitro studies. Developmental toxicity is scored as moderate hazard due to effects observed with toxic doses of iron during pregnancy. Systemic toxicity was scored as high hazard based on effects observed either through inhalation of iron dusts or at oral doses of 1500 mg/kg. Persistence was scored as a very high hazard in the assessment. However, because iron is an abundant element, we don't consider this relevant to the overall hazard classification.

The assessment noted a data gap for respiratory sensitization, but this is allowable because dermal sensitization was scored as moderate hazard. All other human and environmental health hazard endpoints were scored as moderate or low.

Iron was assigned Hazard Band C in a ChemFORWARD hazard assessment and this meets our minimum criteria for safer (ChemFORWARD, 2026b). The assessment noted data gaps for several endpoints for the dermal and inhalation routes of exposure including carcinogenicity, reproductive toxicity, developmental toxicity, acute toxicity, and neurotoxicity (single- and repeat-dose). Hazards scores were assigned for these endpoints based on the oral route of exposure, and all were scored as low hazard. Systemic toxicity (single-dose) was identified as a data gap for all exposure routes.

Systemic toxicity (repeat-dose) was assigned GHS Category 1 was based on a subchronic inhalation study of rats exposed to iron oxide aerosols six hours per day, five days per week for 13 weeks with a reported LOAEC of 0.02mg/L; this corresponds to a very high hazard score. Studies have also reported gastrointestinal symptoms in humans with LOAELs as low as 1mg/kg/day, however the assessment notes these aren't comparable to GHS guidance values. This reflects that while iron is essential for life, too much iron can be harmful. Iron is inherently persistent, but this isn't considered a significant hazard concern for human or environmental health as it is an abundant natural element.

Carbon (non-nano) (CASRN: 7440-44-0)

Carbon meets our minimum criteria for safer.

Carbon (non-nano) was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2025e). The assessment noted data gaps for the dermal and inhalation routes for reproductive toxicity, developmental toxicity, acute toxicity, systemic toxicity (single-dose dermal only and repeat-dose), and neurotoxicity (single- and repeat-dose). These endpoints were scored as low or moderate hazard based on other routes of exposure. Carbon is inherently persistent.

Magnetite (CASRN: 1309-38-2)

Magnetite meets our minimum criteria for safer.

Magnetite was assigned Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2026c). This assessment indicated data gaps for: reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), acute toxicity (dermal), systemic toxicity (single dose dermal and inhalation, repeated dose dermal), neurotoxicity (single dose dermal and inhalation, repeated dose oral, dermal, and inhalation), and respiratory sensitization (all exposure routes). Repeated dose inhalation exposure was scored as a GHS Category 2, or moderate hazard. Prolonged human exposure can cause benign pneumoconiosis, and prolonged animal exposure may lead to negative lung effects.

All other endpoints were scored as low hazard based on other routes of exposure and this meets our data requirements. Respiratory sensitization didn't have any classifiable data; however, this wasn't required to meet our minimum criteria for safer, as there was sufficient data for skin sensitization to be scored as low hazard.

Carbon Steel (CASRN: 11121-90-7)

Carbon steel meets our minimum criteria for safer.

Carbon steel is composed of iron with 0.05% to 2% carbon by weight, and with small amounts of manganese, aluminum, and phosphorus (Vatis & Kearns, 2025). Please refer to the descriptions above for assessments above for iron and carbon as these are the primary components of carbon steel cookware.

Titanium (non-nano) (CASRN: 7440-32-6)

Titanium (non-nano) meets our minimum criteria for safer.

Titanium cookware may consist of a cookware surface that is made by bonding multiple layers of metals chosen from stainless steel, aluminum, and copper with a layer of titanium on the food contact surface (曹倩, 2020). Additionally, cookware advertised as no-coating nonstick can have a micro dot pattern pressed on to the surface of the cookware to create a hydrophobic surface (Our Place, n.d.).

Titanium was assigned Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2026e) and meets our minimum criteria for safer. The assessment noted data gaps for: carcinogenicity (dermal), reproductive toxicity (inhalation), developmental toxicity (inhalation), systemic toxicity (repeat-dose inhalation), neurotoxicity (repeat-dose inhalation), and endocrine activity. Carcinogenicity was assigned to Category 2 for the inhalation route based on inhalation of titanium powders, and this corresponded to a moderate hazard score in our criteria. Data on endocrine activity isn't required in our criteria.

Titanium was expected to persist in the environment as an inorganic compound, but no score was assigned as it is a stable inorganic compound. All other human health and environmental endpoints were scored as low hazard based on other routes of exposure.

Safer process alternatives

Cooking Oils for Non-Stick Surfaces

We considered the use of cooking oils as a process alternative to mimic the nonstick function of PFAS in cookware. It's normally used during the cooking process to act as a temporary barrier between food and the cooking surface to prevent sticking. The use of cooking oils to season material alternatives, such as cast iron and carbon steel, is an effective method for creating a nonstick surface. Seasoning is a process of oil polymerization and can be accomplished by heating the oil below its smoke point. It's important to note that the smoke point of cooking oils should not be exceeded, as it can generate other harmful byproducts such as polycyclic aromatic hydrocarbons and acrolein. This is the case for use of cooking oils in both PFAS and non-PFAS cookware.

Cooking oils listed on the EPA Safer Chemicals Ingredients list as a Full Green Circle for the processing aids and additives function meet our additional criteria for safer. These include: corn oil (CASRN: 8001-30-7), coconut oil (CASRN: 8001-31-8), palm oil (CASRN: 8002-75-3), soybean oil (CASRN: 8001-22-7), olive oil (CASRN:8001-25-0) and more (OCSPP, 2013a). We don't consider the relative nutritional value of chemicals, such as cooking oils, as part of our chemical hazard evaluation.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Chemical alternatives

Safer chemical alternatives we identified above are feasible and available as demonstrated by their use in existing cookware and kitchen supply products. We identified examples of safer chemical alternatives used across the product category, including in stove top cookware, bakeware, small domestic appliances, and gadgets (see Table 9) through the information included in manufacturer orders.

For some identified safer chemical alternatives, we can't share the identity of the chemistry used in the product because Ecology has agreed to grant this information confidential status due to it being considered as trade-secret. However, we have reviewed these products and determined that the ingredient(s) used to provide the non-stick function met our minimum criteria for safer.

Table 9: Feasibility and availability of safer chemical alternatives in cookware and kitchen supplies.

Chemical and CASRN	Example alternatives available in marketplace and sold to the public	Cookware category
Silica, Polydimethylsiloxane 7631-86-9 63148-62-9	Ceramic coated frying pans, grills and griddles, saucepans, all-purpose pans from Calphalon (Calphalon, n.d.-a)	Stovetop cookware
Silica, Dimethyl (Siloxane & Polysiloxane) and Silica Reaction Products 7631-86-9 67762-90-7	Nonstick aluminum cookware sets, Nonstick stainless steel cookware sets from Brentwood (Brentwood, n.d.-c)	Stovetop cookware
Organic silicone resin 67763-03-5	Carbon steel griddles and comals, saucepans from Brentwood (Brentwood, n.d.-a, n.d.-b)	Stovetop cookware
Silicone resin, Polydimethylsiloxane 63148-58-3*, 63148-62-9	Specialty makers, sandwich and panini makers and other domestic appliances from Brentwood	Small domestic appliances
Siloxanes and silicones, di-me, hydroxy-terminated 70131-67-8	Cookware with ceramic coatings from MasterPan (Walmart, n.d.-b)	Stovetop hybrid bakeware
Confidential CASRN: Confidential	Pots, pans, skillet, bakeware, SDAs from GreenPan (GreenPan, n.d.)	Stovetop cookware, bakeware, small domestic appliances
Confidential CASRN:Confidential	Ceramic coated frying pans, saucepans, griddle and grill pans, stock pots, Dutch ovens, stock pots from Caraway (Caraway, n.d.)	Stovetop cookware

*Hazard assessment pending.

We identified ceramic-based coatings as a feasible chemical alternative based on their nonstick features and availability in the current market. However, cookware manufacturers have raised some concerns over the durability and lifespan of ceramic-coated pans in comparison to the traditional PTFE pans. Some manufacturers have shared information describing longer lifetime costs of ceramic cookware compared to PTFE cookware from an anticipated more frequent replacement rate.

Direct comparison studies by Guerrero-Vacas et al. show that PTFE coatings perform better in terms of nonstick retention and harsher abrasive testing related to impact phenomenon. However, some ceramic coatings performed comparatively in nonstick retention and fared better when subjected to mild abrasive conditions similar to daily use of scrubbing with scouring pads (Guerrero-Vacas et al., 2024, 2025).

The studies show that there are differences in durability and nonstick performance within the numerous ceramic coatings tested. It should be noted that there were differences in the thickness of the numerous coatings that were compared. Testing wasn't done on commercially available cookware, so the results may vary with commercially available cookware.

Generally, all nonstick pans are meant to be heated between low to medium heat, are prone to scratches and wear, and should be replaced when the nonstick coating is scratched or cracked. While the nonstick ability of PTFE coated cookware may be more durable, it is also more prone to scratches. On the other hand, ceramic coated pans are harder to scratch and tolerate higher temperatures. However, they are more brittle and prone to cracking.

In instances where durability and heat tolerance are primary concerns, cookware made from material alternatives such as cast iron, stainless steel, and carbon steel perform better.

Material/ Process alternatives

Safer material alternatives that are feasible and available were identified based on the products currently available on the market. We found information about the primary materials in each material alternative through California disclosures and general descriptions on their websites. Information on some products was also obtained through published peer reviewed journal articles. A non-exhaustive list of alternative cookware and process alternatives, such as cooking oils, found through these sources are listed in Table 10 below.

Table 10: Feasible and available alternatives on the market for cookware and kitchen supplies.

Material/ Process	CASRN(s)	Example alternatives available in marketplace and/or sold to the public
Cast iron (Iron, Carbon, and Magnetite)	7439-89-6, 7440-44-0, 1309-38-2	Pans, griddles, skillets, pizza pans, load pan, muffin pans (Lodge, n.d.)
Carbon steel (Iron and Carbon)	7439-89-6, 7440-44-0	Woks, frying pans (Misen, n.d.)
Titanium	7440-32-6	Frying pans (Our Place, n.d.)
Stainless steel	12597-68-1	Frying pans (Target, n.d.-c; T-fal, n.d.-b), saucepans (IKEA, n.d.), baking trays (Walmart, n.d.-c), multipurpose cooker pots (Instant Pot, n.d.), electric kettles (Target, n.d.-a)
Cooking oils	Various	Commercially available corn oil, canola oil, coconut oil, palm oil, soybean oil, olive oil and more.

Conclusions

Reducing a significant source or use

We described cookware and kitchen supplies as a significant source and use of PFAS in our previous report, titled "Technical Supporting Documentation for Regulatory Determinations Report to the Legislature: Safer Products for Washington cycle 1.5 Implementation Phase 3" (Ecology, 2024d). Briefly, PFAS is widely used in cookware in non-stick coatings. People can be exposed to PFAS when cookware products are manufactured, used, and disposed. PFAS-based coatings such as PTFE can degrade into other PFAS substances if heated to high temperatures (above 500 °F) and can be a source of exposure to PFAS (Alaraby et al., 2026; Brunning et al., 2025; Schlummer et al., 2015). PTFE coatings can get scratched and chip over time, exposing people to small particles of PTFE that is also a PFAS (Alaboodi et al., 2024; Cole et al., 2024; Luo et al., 2022). As such, sensitive populations, including children, can be exposed to PFAS from food prepared in cookware containing PFAS. Finally, at end of life, cookware containing PFAS that are disposed in landfills can contribute to increased levels of PFAS in landfill leachate and additional environmental releases (Bolan et al., 2021; Lang et al., 2017).

Safer alternatives are feasible and available

Safer chemical and material alternatives have been identified that meet our minimum criteria and are feasible and available. The safer alternatives identified include chemicals that can replace the non-stick function associated with PFAS and PTFE-coatings in stovetop cookware, bakeware, and small domestic appliances. Further, safer material and process alternatives provide additional options for cookware and kitchen supplies that can replace the primary function of non-stick cookware that contains PFAS, which is to cook and prepare food.

Additionally, kitchen utensils don't require PFAS chemicals for nonstick properties. Alternative materials used to make kitchen utensils are readily available. We determined that an alternative analysis isn't required for kitchen utensils.

We have received input that restrictions of PFAS in consumer products could limit the availability of PFAS for other essential uses, such as some medical devices like pacemakers. We are not evaluating these uses or suggesting regulatory action on those uses. Thus, we didn't consider medical or other non-cookware uses of PFAS as relevant to our analysis of alternatives to PFAS in cookware and kitchen supplies.

Regulatory determination

Our regulatory determination is a restriction for PFAS in cookware and kitchen supplies should be adopted.

The information from this report and our past reports shows that safer chemical and material alternatives for PFAS in cookware and kitchen supplies are feasible and available, and that a restriction on PFAS would reduce significant use of PFAS and source of potential exposure to people and the environment.

Chapter 4: Cyclic Volatile Methylsiloxanes (cVMS) in Cosmetics

Priority product scope

As defined in the Safer Product for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b), the scope of this priority product included cosmetic products intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body for cleansing, beautifying, promoting attractiveness, or altering the appearance as defined in Revised Code of Washington (RCW) 70A.560.010(1)[24] (Washington State Legislature, 2023) and RCW 69.04.012[25] (Washington State Legislature, 1945).

Cosmetic products containing active ingredients, as defined by the U.S. Food and Drug Administration (FDA) (Center for Drug Evaluation and Research, 2023), were included in this definition. However, active ingredients regulated by FDA themselves wouldn't be subjected to potential regulation (Ecology, 2025b).

Priority chemical scope

Cyclic volatile methylsiloxanes (cVMS) are defined based on their chemical structure as containing alternating silicon and oxygen atoms in a cyclic arrangement, with each silicon atom also bonded to two methyl groups (Ecology, 2024c). The most common cVMS are octamethylcyclotetrasiloxane (D4), decamethylcyclopentasiloxane (D5), and dodecamethylcyclohexasiloxane (D6) (Ecology, 2024c), with the "D" representing the two methyl groups per silicon (i.e., dimethyl), and the number representing the number of silicon atoms in the cyclic arrangement. During our research, we found that hexamethylcyclotrisiloxane (D3) and tetradecamethylcycloheptasiloxane (D7) weren't used as ingredients in cosmetic products. We didn't consider cyclomethicone alone, as this chemical was a mixture containing D4-D7 (INKEEDecoder, n.d.-a). Therefore, our evaluations were focused on D4, D5, and D6, though the priority chemical scope of cVMS also meant that any regulatory actions taken for cVMS would include D3, D7, as well as cyclomethicone.

Functions of the priority chemical in the priority product

The list of cVMS functions in cosmetic products was taken from several sources, including the European Chemicals Agency (ECHA) (ECHA, 2019), European Commission's CosIng (EC, n.d.-d, n.d.-c, n.d.-b), Cosmetic Ingredient Review (Johnson Jr et al., 2011), and the Green Chemistry & Commerce Council (GC3) (Green Chemistry & Commerce Council, 2021). GC3 divided the functions according to the specific cVMS chemical and example cosmetic products combination, and this list was supplemented by the list of uses of D4, D5, and D6 according to Environmental Working Group (EWG) Skin Deep® Cosmetics Database (Table 11) (EWG, n.d.-e, n.d.-d, n.d.-c).

[24] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.560.010
[25] https://app.leg.wa.gov/RCW/default.aspx?cite=69.04.012

Table 11 only includes cosmetic products with at least three specific products that contained cVMS in their formulation from 2020 onward, based on information from EWG's Skin Deep® Cosmetics Database. For example, there were only two specific products of baby lotion containing D5 (EWG, n.d.-d). Therefore, baby lotion wasn't listed in Table 11.

Table 11: Functions provided by cVMS in example cosmetic products and the cVMS that provide the listed function per row.

Function of cVMS	Example cosmetic product	Which cVMS provide this function
Carrier	Foundation	D4 and D5
Carrier	Moisturizer (facial, foot), after shave, anti-aging skin product, around-eye cream, blemish balm or beauty balm (bb) cream, beard care, blush, body firming lotion, body oil, bronzer/highlighter, brow liner, color or complexion corrector (cc) cream, concealer, exfoliant/scrub, eye liner, eye makeup remover, eye shadow, facial cleanser, hair spray, hair styling aid, serum (hair), hand cream, lip balm, lip gloss, lipstick, makeup primer, makeup remover, mascara, mask, nail treatment, other eye makeup, serum (skin), setting powder/spray, sunless tanning, toner/astringents	D4, D5, and D6
Emollient	Moisturizer, after shave, anti-aging skin product, around-eye cream, bb cream, baby oil, beard oil, body firming lotion, body oil, cc cream, concealer, exfoliant/scrub, eye liner, facial powder, hand cream, lip balm, lip gloss, mask, sunless tanning, toner/astringents	D5 and D6
Anti-perspirant salt delivery	Anti-perspirant and deodorant	D5
Anti-staining	Anti-perspirant and deodorant	D5
Emollient	Anti-perspirant and deodorant	D5
Anti-billowing	Anti-perspirant and deodorant	D5
Conditioning agent	Hair conditioner, beard care, beard oil	D5
Color protection and or Damage repair, prevention, protection	Hair conditioner and serum (hair), hair color and bleaching, hair-loss treatment	D5
Anti-frizzing agent	Serum (hair), detangler, hair spray, hair relaxer, hair styling aid	D5
Slip and smoothing agent	Serum (hair), styling gel/lotion, styling mousse/foam	D5
Heat protectant	Serum (hair)	D5 and D6

Function of cVMS	Example cosmetic product	Which cVMS provide this function
Decrease greasiness	Serum (hair), shampoo	D6
Lubricity	Sunscreen (baby, beach & sport)	D5 and D6

The functions of cVMS listed by GC3 (Green Chemistry & Commerce Council, 2021) were defined based on the U.S. Environmental Protection Agency (EPA) CompTox functional use categories (A. Williams, 2025). For functional use categories listed by GC3 (Green Chemistry & Commerce Council, 2021) not defined by the U.S. EPA, we used definitions provided by SpecialChem (SpecialChem, 2025e).

We defined and matched other functions relevant to the functions defined by GC3 (Green Chemistry & Commerce Council, 2021) in order to search for alternatives. For example, the function of ”color protection and or damage repair, prevention, or protection” defined by GC3 (Green Chemistry & Commerce Council, 2021) didn’t correspond to any specific chemical functions.

Therefore, relevant chemical functions that could provide “color protection and or damage repair, prevention, or protection” are defined and matched to this function. The definitions of functions listed for cVMS in cosmetic products, and of other functions we matched to the functions provided by cVMS, as defined by GC3 (Green Chemistry & Commerce Council, 2021) are provided below.

Solvent

A solvent is defined as a chemical substance used to dissolve, thin, or extract other substances, including particles and colloids (EPA, n.d.-o). A solvent can also be referred to as a “vehicle,” which can act like a carrier. Because of this, we matched solvent to the function of carrier. We matched the function of solvent to the function of anti-perspirant salts delivery.

Emollient

An emollient isn’t defined in the list of U.S. EPA functional use categories, but SpecialChem defines an emollient as, “a chemical substance capable of softening, smoothing, and conditioning skin and hair” (SpecialChem, 2025b). Therefore, an emollient is meant to improve texture and flexibility of cosmetic products.

Conditioning agent

A conditioning agent is defined as a chemical substance that enhances the softness of and provides hydration to hair and skin (SpecialChem, 2025a). Conditioning agent is matched to the functions of emollient and conditioning agent (hair), as well as the function of color protection and or damage repair, prevention, or protection.

Smoothing agent

According to SpecialChem, a smoothing agent reduces roughness and enhances softness (SpecialChem, 2025d). Smoothing agent is matched to emollient function, and to slip and smoothing agent functions.

Humectant

A humectant prevents the loss of moisture in cosmetic products (EPA, n.d.-o). We matched this function to the function of emollient.

Absorbent

An absorbent is a chemical substance that takes in and holds other substances (EPA, n.d.-o). This function is matched to the function of anti-perspirant salts delivery because an absorbent can absorb perspirations in deodorants without anti-perspirants. An absorbent can therefore provide similar end goal (e.g., reduced perspirations) to the function provided by cVMS in cosmetics as anti-perspirant salt delivery and as anti-staining.

Anti-stain agent

An anti-stain agent is included in the list of U.S. EPA functional use categories. However, this use isn't defined in the context of cosmetics industry, as it's defined as a chemical substance that provides, "stain blocking and soil resistance in soft surface cleaners and protectors" (EPA, n.d.-o). We didn't use this function when searching for safer chemical alternatives, but it was listed here because it was also listed the by GC3 as a function of cVMS (Green Chemistry & Commerce Council, 2021).

Film former

A film former is defined as a chemical substance that forms a thin continuous sheet to act as a barrier on the surface where the chemical substance is applied (EPA, n.d.-o). This function is matched to the following functions:

- Anti-staining
- Color protection and or damage repair, prevention, or protection
- Heat protectant

Anti-billowing

Anti-billowing refers to the ability of cVMS to control foams in anti-perspirants, particularly in aerosol spray or roll-on applications (CASEMINE, n.d.; Pader & Netzbandt, 1978).

Anti-caking agent

Anti-caking agent is defined as a chemical substance that prevents granulates or particulates from sticking (EPA, n.d.-o). We match this function to the function of anti-billowing.

Anti-static agent

An anti-static agent is a chemical substance that prevents or reduces the accumulation of static charge in a material (EPA, n.d.-o), which includes the anti-frizz function.

Softener and conditioner

Softener and conditioner is defined as a substance that softens materials, which improves feel, facilitates finishing process, or provides improved workability (EPA, n.d.-o). This function is matched to the functions of anti-frizz and slip and smoothing agent.

Slip promoter/agent

A slip promoter/agent enhances the ability of the cosmetic product to spread (EPA, n.d.-o; SpecialChem, 2025c).

Surfactant

When added to water, a surfactant reduces the surface tension of the water, which then promotes the spread or penetration of cosmetic ingredients (EPA, n.d.-o). We matched surfactant to the function of "to decrease greasiness."

Lubricating agent

Lubricating agent is defined as chemical substances that reduce friction between surfaces (EPA, n.d.-o).

The functions listed above were matched to the functions of cVMS in cosmetic products shown in Table 11. The results are shown in Table 12 below.

Some of the functions defined by CompTox could be connected to more than one function, as their definitions matched and defined with the description of the cVMS functions listed by GC3 (Green Chemistry & Commerce Council, 2021). For example, the emollient definition included mentions of conditioning and smoothing. Therefore, we considered conditioning agent and smoothing agent to be matchable to the function of emollient. Increasing possible relevant functions provided us with more opportunities to find safer alternatives to cVMS.

Table 12: Possible relevant functions of chemicals according to U.S. EPA's CompTox functional use categories (A. Williams, 2025) matched to the functions of cVMS.

Relevant functions of chemicals (A. Williams, 2025) matched to functions of cVMS	Function of cVMS
Solvent	Carrier
Emollient, conditioning agent, smoothing agent, or humectant	Emollient
Solvent, absorbent*	Anti-perspirant salt delivery
Absorbent*, film former	Anti-staining
Anti-caking agent	Anti-billowing
Conditioning agent	Conditioning agent (hair)
Conditioning agent or film former	Color protection and or Damage repair/prevention/protection
Anti-static agent or softener and conditioner	Anti-frizzing agent
Smoothing agent, slip promoter/agent, or softener and conditioner	Slip and smoothing agent
Film former or softener and conditioner	Heat protectant
Surfactant	Decrease greasiness
Lubricating agent	Lubricity

*Absorbent was listed in this table for the purpose of material alternative, rather than chemical alternative, to the functions provided by cVMS in anti-perspirants and deodorants.

Hazards of the priority chemical class

We described the hazards associated with cVMS in our Cycle 2, Phase 1 Priority Chemicals Report to the Legislature (Ecology, 2024c). Hazards of concern include endocrine activity, as well as reproductive and aquatic toxicity. In addition, cVMS can bioaccumulate in organisms and are also persistent in the environment. These hazards indicate that cVMS are a hazardous class of chemicals and don't meet our minimum criteria for safer (Ecology, 2022b, 2022c).

Safer, feasible, and available alternatives

Search for alternatives

The Safer Products for Washington framework lists criteria for safer first, then feasible, and finally available. For this chemical-product combination, however, criteria for feasible and available alternatives were considered before criteria for safer. Our steps for this process are outlined below:

First, using steps described below, we made a list of potential alternatives with chemical functions that would fit our matching as shown in Table 12:

- We consulted the U.S. EPA Safer Chemical Ingredients List (SCIL) (OCSPP, 2013a), the Pharos database (Pharos, n.d.-b), and the Interstate Chemicals Clearinghouse Chemical Hazard Assessment Database (IC2, n.d.).
- We reviewed different products and use categories already collated in the U.S. EPA CompTox Chemicals Dashboard (EPA, n.d.-k; A. J. Williams et al., 2017), which was based on prior U.S. EPA efforts to catalog and define the functions of chemicals used in consumer products (Dionisio et al., 2018; Isaacs et al., 2016; Phillips et al., 2017).
- We consulted the work by Goussard et al. on cVMS alternatives (Goussard et al., 2022).
- We examined the reported cosmetic products ingredients listed in the California Safe Cosmetics Program Product Database (CDPH, n.d.).
- We relied on resources provided in the GC3 (Green Chemistry & Commerce Council, 2021) and information provided by chemical suppliers to find safer chemical alternatives to cVMS in cosmetic products.

In our research, we looked for alternatives marketed as replacements to cVMS. This approach included companies that could be interested in reformulating their cosmetic products. However, we looked at other chemicals that could provide the same functions as cVMS. We considered product types containing these chemicals for functions provided by cVMS even if they did not contain cVMS.

This approach considered consumers interested in switching to, or who were already using, cosmetic products that don't contain cVMS. The prevalence of cosmetic products in the marketplace that don't contain cVMS further supported this direction. For instance, we previously estimated that the overall presence of cosmetic products that contain cVMS to be around 12% (Ecology, 2025b). This suggests that at least ~85% of cosmetic products in the market don't contain cVMS as ingredients.

Second, after developing the list of alternatives where we matched different functions to alternatives, as shown in Table 12, we then determined their feasibility using the following steps:

- We used business-to-business chemical marketplace websites, such as SpecialChem (SpecialChem, 2025e), Knowde (Knowde, 2025), UL Prospector (UL Prospector, n.d.), and Covalo (Covalo, n.d.) to determine if they were described as feasible.
- We used INCI Beauty (INCI Beauty, 2026) and CosIng (EC, n.d.-a) to determine the International Nomenclature Cosmetic Ingredient (INCI) names and Chemical Abstract Service Registry Number (CASRN) of alternative chemicals if they weren't readily available.

We note that the use of business-to-business chemical marketplace websites was adapted from prior works by Bălan, et al. (Bălan et al., 2024) and van Dijk, et al. (Dijk et al., 2023).

Third, with the list of feasible alternatives matched to different functions, as shown in Table 12, we then determined their availability (Ecology, 2022d) by searching for examples of cosmetic products where alternatives without cVMS were used. We relied on the EWG Skin Deep® Cosmetics Database (EWG, n.d.-f), INCI Beauty (INCI Beauty, 2026), and INCIDecoder (now called INKEEDecoder) (INCIDecoder, n.d.-b) for this evaluation. We matched the availability of alternatives to their functions and example cosmetic products applications.

For a feasible alternative to be considered available, we looked for two things: a trade name chemical(s) intended for the same cosmetic product use as cVMS (Table 11), and a product on the market that listed the safer chemical alternative as an ingredient.

Finally, we compiled a list of feasible and available alternatives that matched the functions shown in Table 12. We then reviewed chemical hazard assessments, such as EPA SCIL, Scivera GHS+, ChemFORWARD, and GreenScreen®, to determine whether each alternative met our criteria for safer (Ecology, 2022c, 2022b).

Safer alternatives

Safer chemical alternatives

Safer varies across hazards and applications (Ecology, 2022b). We determined that cVMS didn't meet our minimum criteria for safer (Ecology, 2022c). Selected safer chemical alternatives that meet at least our minimum criteria are listed below in Table 13. For simplicity, only alternatives that are safer, but also feasible and available as described in subsequent sections, were added to Table 13.

We aimed to list at least two alternatives for every function and for example cosmetic product application. Our previous reports explain how EPA SCIL listing, verified Scivera GHS+ or ChemFORWARD hazard band assessment scores, and GreenScreen® assessment scores corresponded to our minimum and or additional criteria for safer (Ecology, 2022c, 2022b). Further discussions on the chemical hazard assessment of selected safer chemical alternatives are provided below.

Table 13: Alternatives to cVMS in cosmetic products with hazard assessment scores and tier they meet in our criteria for safer.

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Propanediol 504-63-2	EPA SCIL Full Green Circle (solvent function)	Minimum
Isododecane 31807-55-3	GreenScreen® BM-2	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Tripropylene glycol 24800-44-0	Scivera GHS+ [Yellow]	Minimum
Glycerin 56-81-5	EPA SCIL Full Green Circle (solvent function), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Caprylic/Capric triglyceride 73398-61-5	EPA SCIL Full Green Circle (solvent function), Scivera GHS+ [Green/Yellow]	Additional
Dipropylene glycol 110-98-5	EPA SCIL Full Green Circle (solvent function), Scivera GHS+ [Green/Yellow]	Additional
Neopentyl glycol diheptanoate 68855-18-5	GreenScreen® BM-3DG	Additional
Carnauba wax 8015-86-9	EPA SCIL Full Green Circle (uncategorized function), Scivera GHS+ [Green/Yellow]	Additional
Coconut oil 8001-31-8	EPA SCIL Full Green Circle (processing aid and additive function), Scivera GHS+ [Green/Yellow]	Additional
Hydrogenated olive oil 226993-75-5	GreenScreen® BM-3DG	Additional
Vitis vinifera (Grape) seed oil 85594-37-2	EPA SCIL Full Green Circle (skin conditioning agent function)	Additional
Sweet almond oil 8007-69-0	EPA SCIL Full Green Circle (skin conditioning agent function)	Additional
Behenyl behenate 17671-27-1	Scivera GHS+ [Yellow]	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Zea mays (Corn) starch* 9005-25-8	EPA SCIL Full Green Circle (processing aid and additive function), Scivera GHS+ [Green/Yellow]	Additional
Magnesium hydroxide* 1309-42-8	EPA SCIL Full Green Circle (processing aid and additive function), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Dimethicone** 63148-62-9, 9006-65-9, 9016-00-6	GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum**
White mineral oil, petroleum 8042-47-5	EPA SCIL Full Green Circle (solvent function), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Cetearyl alcohol 67762-27-0	EPA SCIL Full Green Circle (emollient and processing aid and additive functions), Scivera GHS+ [Green/Yellow]	Additional
Hydrated silica 112926-00-8	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Calcium stearate 1592-23-0	EPA SCIL Full Green Circle (processing aid and additive function), GreenScreen® BM-3, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band B	Additional
Hydroxypropyl guar 39421-75-5	EPA SCIL Full Green Circle (polymer function)	Minimum
Polyvinylpyrrolidone 9003-39-8	EPA SCIL Full Green Circle (polymer function), Scivera GHS+ [Yellow]	Minimum
3-Aminopropyltriethoxysilane 919-30-2	GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Behentrimonium chloride 17301-53-0	GreenScreen® BM-2, Scivera [Yellow]	Minimum
Castor oil 8001-79-4	EPA SCIL Half-Green Circle (solvent function), Scivera GHS+ [Green/Yellow]	Minimum
Coco-glucoside 110615-47-9	EPA SCIL Full Green Circle (surfactant function), Scivera GHS+ [Yellow]	Minimum
Sodium C14-16 olefin sulfonate 68439-57-6	EPA SCIL Full Green Circle (surfactant function), Scivera GHS+ [Yellow]	Minimum
Sodium xylenesulfonate 1300-72-7	EPA SCIL Full Green Circle (surfactant function), Scivera GHS+ [Yellow]	Minimum

*These chemicals are considered safer material alternatives rather than safer chemical alternatives.

**Dimethicone is considered safer if the oligomer cVMS concentrations are less than 1000 ppm in the final product (Ecology, 2024d).

Propanediol (CASRN: 504-63-2)

This chemical meets our minimum criteria for safer.

EPA SCIL lists Propanediol with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's criteria for solvents can meet our minimum criteria for safer after further evaluation of mutagenicity and sensitization.

Propanediol is scored as a Grey chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2026d). The chemical is Grey due to insufficient data on carcinogenicity. Propanediol isn't classified as a carcinogen by any authoritative organization. In addition, OECD QSAR Toolbox modeling reported in the assessment didn't note any structural alerts for carcinogenicity. Based on this information, propanediol received a score of likely low in our criteria for safer rather than a data gap (Ecology, 2022c).

The assessment also scores mutagenicity as low hazard based on multiple negative mutagenicity studies and no structural alerts in OECD QSAR modeling for mutagenicity. Dermal sensitization is also scored as low hazard in the assessment based on lack of sensitizing effects observed in animal studies and no structural alerts. This additional information is sufficient to meet our data requirements for these endpoints.

Isododecane (CASRN: 31807-55-3)

This chemical meets our minimum criteria for safer.

This chemical is scored as BM-2 GreenScreen® hazard assessment (ToxServices LLC, 2025j). There was a data gap in the assessment for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazard. Data for endocrine activity wasn't required in our minimum criteria. Isododecane received high scores for single-dose systemic toxicity, skin irritation, and bioaccumulation. Chronic aquatic toxicity scored very high. All other hazard endpoints scored as moderate or low hazard.

Tripropylene glycol (CASRN: 24800-44-0)

This chemical meets our minimum criteria for safer.

EPA SCIL lists tripropylene glycol with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's criteria can meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization. The Scivera GHS+ assessment referenced below scores mutagenicity and dermal sensitization as low hazards. Therefore, this provides additional support that tripropylene glycol meets our minimum criteria for safer.

This chemical scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018i). Assessors noted data gaps for endocrine disruption, neurotoxicity, respiratory sensitization, and sensory irritation. We don't require a score for endocrine disruption in our criteria, and both developmental and reproductive toxicity were scored as low hazard. The data gap for neurotoxicity is allowable because both systemic toxicity and acute toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable because dermal sensitization was scored as low hazard. Data for sensory irritation isn't required in our criteria. Assessors gave a moderate score for persistence.

Glycerin (CASRN: 56-81-5)

This chemical meets our minimum criteria for safer.

EPA SCIL lists glycerin with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's solvent criteria can meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization. The Scivera GHS+ assessment referenced below scores mutagenicity and dermal sensitization as low hazards. Therefore, this provides additional support that glycerin meets our minimum criteria for safer.

This chemical scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2019k). Assessors noted data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. We don't require a score for endocrine disruption in our criteria, and both developmental and reproductive toxicity scored as low hazard. Neurotoxicity, respiratory sensitization, and sensory irritation data weren't needed as the assessment had data on acute and systemic toxicity, and skin sensitization.

Glycerin was assigned Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2021c). The assessment noted data gaps for reproductive toxicity (dermal, inhalation), developmental toxicity (dermal, inhalation), endocrine activity, systemic toxicity (single-exposure, all routes) and neurotoxicity (repeat-exposure, all routes). Reproductive toxicity and developmental toxicity scored as low hazard for the oral exposure route. Systemic toxicity (repeat-exposure) scored as low hazard for all routes, and neurotoxicity single-dose scored as low hazard for the oral and inhalation routes. Data for endocrine activity wasn't required to meet our minimum criteria, and the assessors reported that a two-generation reproductive toxicity experiment didn't observe effects on fertility or estrous cycle.

Caprylic or Capric triglyceride (CASRN: 73398-61-5)

This chemical meets our additional criteria for safer.

EPA SCIL lists Caprylic or capric triglyceride with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's solvent criteria can meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization. The Scivera GHS+ assessment mentioned below scores both mutagenicity and dermal sensitization as low hazards, which meets our requirement for additional data. Therefore, this provides additional support that caprylic/capric triglyceride meets our additional criteria for safer.

Caprylic or capric triglyceride scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2020g), indicating caprylic or capric triglyceride met our additional criteria for safer. All hazard endpoints with sufficient data were scored as low hazard. There were data gaps noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Although there was a data gap for endocrine activity, both reproductive toxicity and developmental toxicity scored as low hazards. Data for endocrine activity isn't required in our criteria for safer. The data gap for neurotoxicity is allowable, as both acute and systemic toxicity scored low hazard. The data gap for respiratory sensitization is allowable as skin sensitization was scored as low hazard. Data on sensory irritation isn't required in our criteria.

Dipropylene glycol (CASRN: 110-98-5)

This chemical meets our additional criteria for safer.

EPA SCIL lists Dipropylene glycol with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's solvent criteria can meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization. The Scivera GHS+ assessment mentioned below scores both mutagenicity and dermal sensitization as low hazards, which meets our requirement for additional data. Therefore, this provides additional support that dipropylene glycol meets our additional criteria for safer (Ecology, 2022c).

Dipropylene glycol scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2021a). Although there was a data gap noted for endocrine activity, both reproductive and developmental toxicity scored as low hazard. Data for endocrine activity isn't required in criteria. There were data gaps noted for neurotoxicity, respiratory sensitization, and sensory irritation. The data gap for neurotoxicity is allowable, as both acute toxicity and systemic

toxicity scored low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization scored low hazard. Data on sensory irritation isn't required in our criteria.

Neopentyl glycol diheptanoate (CASRN: 68855-18-5)

This chemical meets our additional criteria for safer.

Neopentyl glycol diheptanoate was scored as BM-3DG GreenScreen® hazard assessment (ToxServices LLC, 2025k). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazard. Data for endocrine activity isn't required in our criteria. All other endpoints scored low or very low hazard.

Carnauba wax (CASRN: 8015-86-9)

This chemical meets our additional criteria for safer.

Carnauba wax is listed with no function on the EPA SCIL with a Full Green Circle (OCSPP, 2013a). Chemicals with uncategorized function on EPA SCIL can meet at least our minimum criteria for safer.

Carnauba wax scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2020e). A data gap was noted for endocrine activity, but reproductive toxicity and developmental toxicity scored as moderate hazard. Data gaps were noted for neurotoxicity, respiratory sensitization, and sensory irritation. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization scored as low hazard. Data for sensory irritation isn't required in our criteria. Persistence and bioaccumulation scored as moderate hazard and low hazard, respectively.

Coconut oil (CASRN: 8001-31-8)

This chemical meets our additional criteria for safer.

EPA SCIL lists this chemical with a Full Green Circle for use as processing aids and additives (OCSPP, 2013a). The functional use criteria for processing aids and additives meets our additional criteria, with no additional information needed.

A Scivera GHS+ verified assessment scored this chemical as Green/Yellow (Scivera, 2025d). The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity scored as low hazard. Data gaps were noted for acute toxicity (inhalation) and neurotoxicity. These data gaps are allowable as acute toxicity (dermal and oral) and systemic toxicity scored as low hazard. All other hazard endpoints scored as low hazard.

Hydrogenated olive oil (CASRN: 226993-75-5)

This chemical meets our additional criteria for safer.

Hydrogenated olive oil was scored as BM-3DG GreenScreen® hazard assessment (ToxServices LLC, 2025i), indicating it meets our additional criteria for safer. The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity wasn't required in our criteria for safer.

Vitis vinifera (Grape) seed oil (CASRN: 85594-37-2)

This chemical meets our additional criteria for safer.

EPA SCIL lists this chemical with a Full Green Circle for use as a skin conditioning agent, which is evaluated against the master criteria (EPA, n.d.-aa; OCSPP, 2013a). Chemicals evaluated against the EPA SCIL master criteria met our additional criteria for safer.

Sweet almond oil (CASRN: 8007-69-0)

This chemical meets our additional criteria for safer.

EPA SCIL lists this chemical with a Full Green Circle for use as a skin conditioning agent, which is evaluated against the master criteria (EPA, n.d.-aa; OCSPP, 2013a). Chemicals evaluated against the EPA SCIL master criteria met our additional criteria for safer.

Behenyl behenate (CASRN: 17671-27-1)

This chemical meets our minimum criteria for safer.

Behenyl behenate scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2019h). Although there was a data gap for endocrine activity, both reproductive and developmental toxicity scored low hazard. Data for endocrine activity isn't required in our criteria for safer. Data gaps for neurotoxicity and sensory irritation were noted in this assessment. However, these are allowable, as both acute and systemic toxicity were scored as low hazard, and this meets our data requirements. Persistence scored as high hazard, but all other endpoints scored as low hazard.

Zea mays (Corn) starch (CASRN: 9005-25-8)

This chemical meets our additional criteria for safer.

EPA SCIL lists zea mays (corn) starch with a Full Green Circle for use as a processing aid and additive (OCSPP, 2013a). The functional use criteria for processing aids and additives meets our additional criteria, with no additional information needed.

Additionally, zea mays (corn) starch scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2025h). There was a data gap for endocrine activity, as both reproductive and developmental toxicity scored low hazard. Data for endocrine activity isn't required in our criteria for safer. This assessment further supports that this chemical meets our additional criteria for safer.

Magnesium hydroxide (CASRN: 1309-42-8)

This chemical meets our minimum criteria for safer.

EPA SCIL lists magnesium hydroxide with a Full Green Circle for use as a processing aid and additive (OCSPP, 2013a). The functional use criteria for processing aids and additives meets our minimum or additional criteria with no additional information needed.

Magnesium hydroxide scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2025e). Although there was a data gap for endocrine activity, both reproductive and developmental toxicity scored low hazard. Data for endocrine activity isn't required in our criteria for safer. Data gaps were noted for neurotoxicity and acute inhalation toxicity. The data gap for neurotoxicity and acute inhalation are allowable, as systemic toxicity, acute dermal toxicity, and acute oral toxicity were all scored as low hazard. Magnesium hydroxide is an inorganic compound and scores as very high hazard for persistence; however, this is less relevant for this compound, as it naturally forms in the environment.

Magnesium hydroxide was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2023b). No human health hazards were identified in the assessment, and aquatic toxicity was scored as low hazard. As an inorganic chemical, persistence was expected to be high for this chemical, but no score was assigned. Several data gaps for this chemical were identified that couldn't be filled using suitable surrogates: reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), endocrine activity, acute toxicity (dermal), neurotoxicity (single-dose, dermal and inhalation).

Acute toxicity, neurotoxicity, reproductive toxicity, and developmental toxicity all scored as low hazards for the oral route. This meets our data requirements. Data for endocrine activity isn't required in our criteria (Ecology, 2022c).

Dimethicone (CASRN: 63148-62-9, 9006-65-9, 9016-00-6)

The Safer Products for Washington Cycle 1.5 Implementation Phase 3 reports (Ecology, 2024b, 2024d) show that dimethicone meets our minimum criteria safer if the oligomer cVMS concentrations in the final product are less than 1000 ppm.

Dimethicone was scored as BM-2 in a GreenScreen® hazard assessment (ToxServices LLC, 2025e, 2025c, 2025d). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazard. Data for endocrine activity wasn't required in our criteria (Ecology, 2022c). A data gap was identified for repeated dose neurotoxicity, but data were included on acute and systemic toxicity. Persistence scored as very high hazard for this polymeric ingredient.

Dimethicone (CASRN: 63148-62-9, 9006-65-9, 9016-00-6) scored Yellow in three different verified Scivera GHS+ assessments. Dimethicone already meets our minimum criteria based on the GreenScreen described above. We reviewed these assessments to confirm they don't conflict with this finding, which we explain below (Scivera, 2018g, 2019f, 2021u):

- **Dimethicone (CASRN: 63148-62-9)** had a data gap for endocrine activity; however both reproductive and developmental toxicity scored as low hazard (Scivera, 2021u). In addition, data gaps were noted for both respiratory sensitization and sensory irritation. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as a low hazard. Data for sensory irritation isn't required in our criteria. Persistence also scored as very high hazard for this polymeric ingredient.

- **Dimethicone (CASRN: 9006-65-9)** had data gaps noted for endocrine activity, respiratory sensitization, and skin irritation, as well as a data gap for neurotoxicity (Scivera, 2019f). Data for endocrine activity isn't required in our criteria, and the assessment scored reproductive toxicity and developmental toxicity as low hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization was scored as low hazard. The data gap for neurotoxicity is allowable, as systemic toxicity and acute toxicity scored as low hazard. Data on skin irritation isn't required in our criteria. Persistence scored as high hazard for this polymeric ingredient, but without additional supporting information.
- **Dimethicone (CASRN: 9016-00-6)** had data gaps noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation (Scivera, 2018g). Data for endocrine activity isn't required in our criteria, and the assessment scored reproductive toxicity and developmental toxicity as moderate hazard. Reproductive and developmental toxicity were scored as moderate hazard, as some limited data reported a chance of fetal abnormalities and placental site formation abnormalities observed with silicone device implants. These aren't specific to dimethicone. The data gaps for neurotoxicity and respiratory sensitization are allowable, as acute toxicity, systemic toxicity, and dermal sensitization scored low hazards. Data on sensory irritation isn't required in our criteria. Mutagenicity and genotoxicity scored as moderate hazard due to a study of organosilicon compounds suggesting clastogenic activity potential in vitro. However, other multiple mutagenicity studies were negative. Acute aquatic toxicity scored as high hazard. Persistence scored as a very high hazard for this polymeric ingredient.

White mineral oil, petroleum (CASRN: 8042-47-5)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists white mineral oil, petroleum with a Full Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's solvent criteria can meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization. The Scivera GHS+ assessment described below scores both mutagenicity and dermal sensitization as low hazard, which meets our requirement for additional data. Therefore, white mineral oil, petroleum meets our minimum criteria for safer.

White mineral oil, petroleum scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021aa). There was a data gap noted for endocrine activity, both reproductive and developmental toxicity scored low hazard. Data for endocrine activity isn't required in our criteria. There were data gaps for neurotoxicity, respiratory sensitization, and sensory irritation. The data gap for neurotoxicity is allowable, as acute toxicity scored as a low hazard and systemic toxicity scored as a moderate hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization was scored as low hazard. Data for sensory irritation isn't

required in our criteria. Persistence was scored as a high hazard, but bioaccumulation was scored as a low hazard.

White mineral oil, petroleum was scored as Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2023g). The assessment noted data gaps for reproductive toxicity (inhalation), endocrine activity, and neurotoxicity (repeat-dose, all routes). Data on endocrine activity isn't required in our criteria for safer, and no endocrine-related adverse effects were noted in supporting studies.

Reproductive toxicity was scored as low hazard for the oral and dermal routes, and this meets our data requirements. The data gap for neurotoxicity (repeat-dose) was allowable, as hazard scores were assigned for acute toxicity, systemic toxicity, and neurotoxicity (single-dose), and all were scored as low or moderate hazard. The assessment scored persistence as moderate based on measured data, concluding that white mineral oil and petroleum was inherently—but not readily—biodegradable.

Cetearyl alcohol (CASRN: 67762-27-0

This chemical meets our additional criteria for safer.

Cetearyl alcohol scores Full Green Circle on EPA SCIL for use as emollient, processing aids, and additives (OCSPP, 2013a). EPA SCIL processing aids and additives can meet our additional criteria for safer with no additional information needed.

A verified Scivera GHS+ hazard assessment scored cetearyl alcohol as Green/Yellow chemical (Scivera, 2019e). The assessment noted data gaps for endocrine activity, respiratory sensitization, aspiration potential, and sensory irritation. Data for endocrine activity isn't required in our criteria, and both reproductive toxicity and developmental toxicity scored as low hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as a low hazard. Data for sensory irritation isn't required in our criteria.

Hydrated silica (CASRN: 112926-00-8)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2022f). A data gap was noted for endocrine disruption, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity isn't required in our criteria. A data gap was noted for neurotoxicity. However, acute toxicity (dermal and oral) scored as low hazard, acute toxicity (inhalation) scored as high hazard, and systemic toxicity scored as high hazard. Carcinogenicity was scored as moderate hazard. All other endpoints were scored as low hazard. This fulfills our data requirements and still meets our minimum criteria.

A ChemFORWARD hazard assessment assigned this chemical as Hazard Band B (ChemFORWARD, 2025c). The assessment noted data gaps for: carcinogenicity (dermal), reproductive toxicity (dermal, inhalation), developmental toxicity (dermal, inhalation), systemic toxicity (dermal repeat-dose), neurotoxicity (all routes), and respiratory sensitization. The assessment classified this chemical as GHS Category 3 for systemic toxicity (single-dose

inhalation), which corresponded to a moderate hazard. Apart from neurotoxicity, all other hazard endpoints scored as low hazard based on other routes of exposure and this fulfills our data requirements. The data gap for neurotoxicity is allowable, as systemic toxicity scored as moderate (inhalation) or low hazard (oral and dermal), and acute toxicity scored as low hazard for all routes of exposure.

Calcium stearate (CASRN: 1592-23-0)

This chemical meets our additional criteria for safer.

Calcium stearate is listed on EPA SCIL as a Full Green Circle for use as a processing aid and additive (OCSPP, 2013a). EPA SCIL's processing aids and additives criteria can meet our minimum or additional criteria for safer.

Calcium stearate received a BM-3 score in a GreenScreen® assessment, as reported on the Swedish Confederation of Professional Employees (TCO) Certified Accepted Substance List (TCO, n.d.). Chemicals listed on TCO Certified Accepted Substance List with GreenScreen® BM-3 can meet our additional criteria for safer.

Calcium stearate scored as a Green/Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021h). The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity scored as low hazard. Data for endocrine activity isn't required in our criteria. Data gaps were noted for neurotoxicity and respiratory sensitization. The data gap for neurotoxicity is allowable as both acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as low hazard.

A ChemFORWARD assessment assigned calcium stearate with Hazard Band B (ChemFORWARD, 2022a). The assessment noted data gaps for: carcinogenicity (dermal and inhalation), reproductive and developmental toxicity (inhalation), endocrine activity, systemic toxicity (repeat-dose, inhalation), neurotoxicity, and respiratory sensitization. Carcinogenicity scored as low hazard for the oral route. Reproductive and developmental toxicity scored as low hazards for the oral and dermal routes. Together, this meets our data requirements. Systemic toxicity (single- and repeat-dose) and neurotoxicity (single- and repeat-dose) scored as low hazards for the oral and dermal routes. Data on endocrine activity isn't required in our criteria. Both reproductive toxicity and developmental toxicity scored as low hazard for the oral and dermal routes. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as low hazard.

Hydroxypropyl guar (CASRN: 39421-75-5)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists hydroxypropyl guar as a Full Green Circle for use as a polymer (OCSPP, 2013a). EPA SCIL's criteria for polymers can meet our minimum criteria for safer (Ecology, 2022c).

Polyvinylpyrrolidone (CASRN: 9003-39-8)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists polyvinylpyrrolidone as a Full Green Circle for use as a polymer (OCSPP, 2013a). EPA SCIL's criteria for polymers can meet our minimum criteria for safer (Ecology, 2022c).

Polyvinylpyrrolidone scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2020b). A data gap was noted for endocrine activity, but both reproductive and developmental toxicity scored as low hazard. Data for endocrine activity isn't required in our criteria. Data gaps were noted for neurotoxicity and sensory irritation. The data gap for neurotoxicity is allowable, as acute toxicity (dermal) scored as moderate hazard, acute toxicity (oral and inhalation) scored as low hazard, and systemic toxicity scored as low hazard. Persistence scored as high hazard for this polymeric ingredient.

3-Aminopropyltriethoxysilane (CASRN: 919-30-2)

This chemical meets our minimum criteria for safer.

3-Aminopropyltriethoxysilane scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2026a). The assessment noted data gaps for endocrine activity, neurotoxicity (repeat-dose only), and respiratory sensitization. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity scored as low and moderate hazard, respectively. The data gap for neurotoxicity (repeat-dose) is allowable, as neurotoxicity (single-dose) scored as a moderate hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization was scored as moderate hazard. Eye irritation and skin irritation both scored as very high hazard, but this is allowable in our minimum criteria as long as neither persistence nor bioaccumulation score as very high. In this assessment, persistence scored as a low hazard and bioaccumulation scored as a very low hazard.

This chemical scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2019a). A data gap was noted for endocrine activity, but reproductive toxicity and developmental toxicity scored as a moderate hazard. Data on endocrine activity isn't required in our criteria. Dermal irritation and eye irritation scored as very high hazard, but this is allowable in our minimum criteria as long as neither persistence nor bioaccumulation score as very high. In this case, persistence was scored as moderate hazard and bioaccumulation as low hazard.

Behentrimonium chloride (CASRN: 17301-53-0)

This chemical meets our minimum criteria for safer.

Behentrimonium chloride scored as BM-2 in a GreenScreen® hazard assessment (ToxServices LLC, 2025a). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazards. Data for endocrine activity isn't required in our criteria(Ecology, 2022c). Data gaps were identified for neurotoxicity (single-dose) and systemic toxicity (single-dose). These data gaps are allowable, as neurotoxicity (repeat-dose) and systemic toxicity (repeat-dose) scored as low hazard and moderate hazard, respectively. Eye irritation scored as high hazard, and skin irritation scored as very high hazard.

Acute aquatic toxicity scored as a very high hazard, and chronic aquatic toxicity scored as a high hazard. These scores are allowable in our minimum criteria if neither persistence nor bioaccumulation score as a very high hazard. In this case, persistence scored as a low hazard, and bioaccumulation scored as a moderate hazard.

This chemical was scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2017b). The assessment noted data gaps for endocrine activity, acute toxicity (inhalation), neurotoxicity, and respiratory sensitization. Data for endocrine activity is not required in our criteria and reproductive toxicity and developmental toxicity were scored as low hazard. The data gaps for acute toxicity (inhalation) and neurotoxicity are allowable as acute toxicity (dermal) scored as moderate hazard, acute toxicity (oral) scored as high hazard, and systemic toxicity scored as moderate hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as moderate hazard.

We also note that this compound is an example of quaternary ammonium compounds (QACs). While there are hazards related to QACs (Arnold et al., 2023; DTSC, n.d.-d; Hora et al., 2020), behentrimonium chloride meets our minimum criteria and is used as an anti-frizzing agent. As we continue to learn more, this and other QACs may be revisited in a future cycle of Safer Products for Washington.

Castor oil (CASRN: 8001-79-4)

This chemical meets our minimum criteria for safer.

EPA SCIL lists castor oil as a Half-Green Circle for use as a solvent (OCSPP, 2013a). EPA SCIL's criteria for this use meet our minimum criteria for safer with further evaluation of mutagenicity and sensitization.

The Scivera GHS+ assessment mentioned below scores both mutagenicity and dermal sensitization as low hazards, which meets our requirement for additional data. Therefore, this provides additional support that castor oil meets our minimum criteria for safer (Ecology, 2022c).

Castor oil scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2021i). A data gap was noted for endocrine activity, but both reproductive and developmental toxicity scored low hazard. Data for endocrine activity isn't required in our criteria. There were data gaps noted for neurotoxicity, respiratory sensitization, and sensory irritation. The data gap for neurotoxicity is allowable, as acute toxicity and systemic toxicity scored as low hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as a low hazard. Data for sensory irritation isn't required in our criteria.

Coco-glucoside (CASRN: 110615-47-9)

This chemical meets our minimum criteria for safer.

EPA SCIL lists this chemical as a Full Green Circle for use as a surfactant (OCSPP, 2013a). However, this rating isn't sufficient alone to meet our minimum criteria for safer.

Coco-glucoside was scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2023b). The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity both scored as low hazard. Data on endocrine activity is not required in our criteria. The assessment noted data gaps for acute toxicity (inhalation), neurotoxicity, and sensory irritation. The data gap for acute toxicity (inhalation) and neurotoxicity are allowable, as acute toxicity (dermal and oral) and systemic toxicity scored as low hazard. Data for sensory irritation isn't required in our criteria. Dermal irritation and eye irritation scored as high and very high hazard, respectively. These irritation scores are allowable in our criteria if neither persistence nor bioaccumulation score as very high. In this case, both persistence and bioaccumulation scored as low hazard and this meets our minimum criteria.

Sodium C14-16 olefin sulfonate (CASRN: 68439-57-6)

This chemical meets our minimum criteria for safer.

EPA SCIL lists this chemical as a Full Green Circle for use as a surfactant (OCSPP, 2013a). However, this rating is not sufficient alone to meet our minimum criteria for safer.

Sodium C14-16 olefin sulfonate was scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2019n). A data gap was noted for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazard. Data gaps were noted for respiratory sensitization and sensory irritation. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as a low hazard. Data for sensory irritation isn't required in our criteria. Acute aquatic toxicity, dermal irritation, and eye irritation scored as high hazards, but this is allowable in our minimum criteria since both persistence and bioaccumulation scored as low hazard.

Sodium xylenesulfonate (CASRN: 1300-72-7)

This chemical meets our minimum criteria for safer.

EPA SCIL lists this chemical as a Full Green Circle for use as a surfactant (OCSPP, 2013a). However, this rating isn't sufficient alone to meet our minimum criteria for safer.

Sodium xylenesulfonate scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2025g). A data gap was noted for endocrine activity, but both reproductive toxicity and developmental toxicity scored as low hazard. Data for endocrine activity isn't required in our criteria. Respiratory sensitization was also noted as a data gap, but this is allowable as dermal sensitization scored as a low hazard. Eye irritation scored as a very high hazard, but this is allowable in our minimum criteria since all other endpoints were scored as low hazard.

Safer process alternative

Clean stained clothes

Similar to the safer process alternatives described in the Safer Products for Washington Cycles 1 and 1.5 Implementation Phase 3 reports (Ecology, 2022b, 2024b), we also propose a safer cleaning method as an alternative to the anti-staining function of cVMS in antiperspirants and deodorants. For example, an EPA Safer Choice-certified cleaning product (OCSPP, 2013b), such as Synthetic Labs' Green Oxygen Destainer by Synthetic Labs (TURI, n.d.), could be used to remove stains on clothes that are caused when antiperspirant and deodorant ingredients react with sweat or body oils (Arm & Hammer, n.d.; MAGS Skin, 2025). We consider this a safer process alternative.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

The results of our feasible and available evaluations are presented in Table 14 below. As described in the "**Search for alternatives**" section above, alternatives were first evaluated for feasibility and availability and then evaluated for safer. Table 14 includes only alternatives that meet all three criteria.

Additionally, zea mays (corn) starch and magnesium hydroxide are considered safer materials for use as anti-staining and antiperspirant salts delivery because zea mays (corn) starch and magnesium hydroxide absorb sweat in deodorants without antiperspirants.

Below, Table 14 displays a shortened version of findings for feasible and available products. We've modified this table to highlight the large array of products, which can be found in **Appendix F**.

CASRN of the alternatives were displayed in parentheses following the alternative names. Relevant function(s) of safer, feasible, and available alternatives were obtained from of U.S. EPA CompTox functional use categories (A. Williams, 2025) or based on advertisements by chemical suppliers. Defined and matched cVMS functions were based on functions of cVMS in Table 14. Further explanations of defining and matching are provided in the "**Functions of the priority chemical in the priority product**" section.

Table 14: Feasible and available alternatives for cVMS.

Chemical (CASRN)	Relevant function(s)	Matched cVMS function(s)	Cosmetic products applications
Propanediol (504-63-)	Solvent (EPA, n.d.-b), Emollient (Yearn Chemicals, 2024)	Carrier, emollient	Foundation, after shave, anti-aging skin product, bb cream, beard care, blush, body firming lotion, bronzer/highlighter, brow liner, cc cream, concealer, exfoliant/scrub, eye shadow, facial cleanser, hair spray, hair styling aid, lip balm, lip gloss, lipstick, makeup primer, mascara, mask, other eye makeup, serum (skin), setting powder/spray, toner/astringent
Isododecane (31807-55-3)	Solvent (EPA, n.d.-t; Goussard et al., 2022), Emollient (Innovation Company, n.d.-b)	Carrier, Emollient, Anti-perspirant salt delivery	Foundation, around-eye cream, bb cream, beard care, blush, body oil, bronzer/highlighter, brow liner, cc cream, concealer, eye makeup remover, eye shadow, facial cleanser, hair spray, hair styling aid, serum (hair), lip balm, makeup primer, makeup remover, mascara, other eye makeup, setting powder/spray, anti-perspirant and deodorant
Tripropylene glycol (24800-44-0)	Solvent (EPA, n.d.-ah)	Carrier	Moisturizer (facial, foot), exfoliant/scrub, eye makeup remover, makeup remover
Glycerin (56-81-5)	Solvent, emollient, conditioning agent, humectant, slip promoter/agent, softener and conditioner, lubricating agent (EPA, n.d.-q)	Carrier, Emollient, Conditioning agent, Color protection and/or Damage repair/prevention/protection, Slip and smoothing agent, Lubricity	Moisturizer (facial, foot), anti-aging skin product, around-eye cream, body oil, lip gloss, lipstick, nail treatment, toner/astringent, after shave, bb cream, body firming lotion, cc cream, facial powder, anti-perspirant and deodorant, hair conditioner, beard care, hair loss treatment, serum (hair), styling mousse/foam, sunscreen (beach & sport)

Chemical (CASRN)	Relevant function(s)	Matched cVMS function(s)	Cosmetic products applications
Caprylic/Capric triglyceride (73398-61-5)	Solvent (EPA, n.d.-p)	Carrier, Anti-perspirant salt delivery	After shave, body firming lotion, cc cream, serum (hair), serum (skin), sunless tanning, anti-perspirant and deodorant
Dipropylene glycol (110-98-5)	Solvent (EPA, n.d.-a)	Carrier, Anti-perspirant salt delivery	Mask, anti-perspirant and deodorant
Neopentyl glycol diheptanoate (68855-18-5)	Solvent, emollient, smoothing agent (Brenntag Beauty and Personal Care, 2025; Goussard et al., 2022), Reduce whitening, fast spreading (inolex, n.d.-a), Softener and conditioner (EPA, n.d.-r)	Carrier, Emollient, Anti-staining, Slip and smoothing agent, Lubricity	Nail treatment, sunless tanning, eye liner, sunless tanning, anti-perspirant and deodorant, serum (hair), styling gel/lotion, sunscreen (baby), sunscreen (beach & sport)
Carnauba wax (8015-86-9)	Emollient, skin conditioning agent, film former, softener and conditioner (Environmental Protection Agency, n.d.-e), Thermal stability (Koster Keunen, Inc., 2025)	Emollient, Heat protectant	Moisturizer, concealer, exfoliant/scrub, eye liner, facial powder, anti-perspirant and deodorant, serum (hair)
Coconut oil (8001-31-8)	Emollient, humectant, conditioning agent (EPA, n.d.-j)	Emollient, Conditioning agent	Moisturizer, anti-aging skin product, around eye cream, baby oil, beard oil, body firming lotion, body oil, cc cream, hand cream, lip balm, lip gloss, mask, sunless tanning, beard oil
Hydrogenated olive oil (226993-75-5)	Skin conditioning agent (EPA, n.d.-w)	Emollient	Moisturizer
Vitis vinifera (Grape) seed oil (85594-37-2)	Emollient (Bela Vizago Nature, 2024)	Emollient	Moisturizer, anti-aging skin product, baby oil, beard oil, body oil, concealer, hand cream

Chemical (CASRN)	Relevant function(s)	Matched cVMS function(s)	Cosmetic products applications
Sweet almond oil (8007-69-0)	Emollient, conditioning agent, humectant (EPA, n.d.-af)	Emollient, Conditioning agent, Color protection and/or Damage repair/prevention/protection	Moisturizer, around eye cream, bb cream, exfoliant/scrub, lip balm, lip gloss, mask, hair conditioner, beard care, hair loss treatment
Behenyl behenate (17671-27-1)	Emollient, skin conditioning agent, humectant, softener and conditioner (EPA, n.d.-g), Slip agent (Stearinerie Dubois, 2023)	Emollient, Slip and smoothing agent	Moisturizer, serum (hair), styling gel/lotion, styling mousse/foam
Zea Mays (Corn) starch (9005-25-8)	Absorbent (EPA, n.d.-ae) (material alternative)	Anti-perspirant salt delivery, and anti-staining	Anti-perspirant and deodorant (material alternative)
Magnesium hydroxide (1309-42-8)	Absorbent (EPA, n.d.-u) (material alternative)	Anti-perspirant salt delivery, and anti-staining	Anti-perspirant and deodorant (material alternative)
Dimethicone (63148-62-9/ 9006-65-9/ 9016-00-6)	Anti-staining, heat protectant (Green Chemistry & Commerce Council, 2021), Film former, (EPA, n.d.-m, n.d.-y) Softener and conditioner, (EPA, n.d.-m, n.d.-ab) Lubricating agent (EPA, n.d.-m, n.d.-ab, n.d.-y)	Anti-staining, Heat protectant, Lubricity	Anti-perspirant and deodorant, serum (hair), sunscreen (baby), sunscreen (beach & sport)
White mineral oil, petroleum (8042-47-5)	Emollient (Sonneborn, n.d.)	Emollient	Anti-perspirant and deodorant

Chemical (CASRN)	Relevant function(s)	Matched cVMS function(s)	Cosmetic products applications
Cetearyl alcohol (67762-27-0)	Emollient, surfactant (EPA, n.d.-f; Goussard et al., 2022)	Emollient, Decrease greasiness	Anti-perspirant and deodorant, serum (hair)
Hydrated silica (112926-00-8)	Anti-caking agent (Environmental Protection Agency, n.d.-l)	Anti-billowing	Anti-perspirant and deodorant
Calcium stearate (1592-23-0)	Anti-caking agent (EPA, n.d.-h)	Anti-billowing	Anti-perspirant and deodorant
Hydroxypropyl guar (39421-75-5)	Film former (EPA, n.d.-s), color protection (Syensqo, 2024)	Color protection and/or Damage repair/prevention/protection	Hair conditioner and serum (hair), hair color and bleaching
Polyvinylpyrrolidone (9003-39-8)	Film former (EPA, n.d.-z), color protection (Ashland, n.d., 2023)	Color protection and/or Damage repair/prevention/protection	Hair conditioner and serum (hair), hair color and bleaching
3-Aminopropyl triethyoxysilane (919-30-2)	Film former (Momentive Performance Materials, 2025)	Color protection and/or Damage repair/prevention/protection	Hair conditioner and serum (hair)
Behentrimonium chloride (QAC) (68607-24-9)	Anti-static agent, softener and conditioner (Mckinley Resources, 2022)	Anti-frizzing agent	Serum (hair), detangler, hair spray, hair relaxer, hair styling aid

Chemical (CASRN)	Relevant function(s)	Matched cVMS function(s)	Cosmetic products applications
Castor oil (8001-79-4)	Anti-static agent, softener and conditioner (EPA, n.d.-i)	Anti-frizzing agent	Serum (hair), detangler, hair spray, hair relaxer, hair styling aid
Coco-glucoside (110615-47-9)	Surfactant (Ecology, 2024d; EPA, n.d.-l)	Decrease greasiness	Serum (hair), shampoo
Sodium C14-16 olefin sulfonate (68439-57-6)	Surfactant (Ecology, 2024d; Environmental Protection Agency, n.d.-s)	Decrease greasiness	Serum (hair)
Sodium xylenesulfonate (1300-72-7)	Surfactant (Ecology, 2024d; EPA, n.d.-ac)	Decrease greasiness	Serum (hair), shampoo

Note: We display information here differently than other tables in this report for clarity and accessibility. Information including examples of trade names available in the marketplace and cosmetics with alternatives as ingredients can be found in **Appendix F**.

Conclusions on alternatives

Reducing a significant source or use

We describe cosmetics as a significant source and use of cVMS in our Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 report (Ecology, 2025b). We summarized information from the European Chemicals Agency (ECHA) and peer-reviewed literature that reported cVMS used in many cosmetic formulations at concentrations generally between 5 to 20% in products. We estimate market revenue for cosmetic products to be around 2 billion dollars per year in Washington based on population.

People, including children, can be exposed to cVMS in cosmetics when these products are used. Workers who regularly use cosmetic products as part of their jobs may have higher exposures. Further, ECHA reported that for consumer products, “cosmetic products represent by far the largest use and releases of D4, D5, and D6 to the environment”, and estimated that cosmetic products account for 91% of releases of cVMS to the environment (ECHA, 2019). As such, a restriction on cVMS in cosmetics would reduce a significant source and use of these chemicals.

Safer alternatives are feasible and available

We identified safer alternatives to cVMS for a range of functions and cosmetic products uses. These alternatives either meet our minimum or additional criteria for safer (Ecology, 2022c).

The alternatives are currently used in cosmetic products and are feasible and available based on our evaluations.

Regulatory determination

Our regulatory determination is a restriction on the use of cVMS in cosmetic products should be adopted.

Restricting the use of cVMS in cosmetics will reduce significant use of cVMS, as well as a source of potential exposure for people and the environment.

Chapter 5: PFAS in Firefighting Personal Protective Equipment (PPE)

Priority product scope

RCW 70A.400.005(4)[26] defines "firefighting personal protective equipment" (PPE) as:

> "Any clothing designed, intended or marketed to be worn by firefighting personnel in the performance of their duties, designed with the intent for use in fire and rescue activities, including jackets, pants, shoes, gloves, helmets, and respiratory equipment."

Protective equipment that has the primary purpose of covering the body for protection (e.g., jackets, gloves, boots, and suits) will be grouped as apparel firefighting PPE. All other protective equipment that isn't meant to cover the body (e.g., self-contained breathing apparatuses [SCBAs]) will be grouped as non-apparel firefighting PPE.

The Department of Labor and Industries under WAC 296-305-01005,[27] Safety Standards for Firefighters, divides protective clothing for firefighters into five types:

- Structural firefighting protective clothing.
- Liquid splash-protective clothing.
- Vapor-protective clothing.
- High temperature-protective proximity clothing.
- Wildland firefighting clothing.

In addition to the five types of firefighting gear defined as protective clothing, WAC 296-305-02501[28] and WAC 296-305-05109[29] outlines the requirements for firefighting gear specific to emergency medical operations and technical rescue operations.

In this Cycle 2 regulatory determinations report, we focused our analysis of alternatives on a subset of apparel firefighting PPE. The information we received from manufacturer orders on other apparel PPE such as chemical, biological, radiological, and nuclear (CBRN), liquid splash, vapor protective, and proximity PPE, as well as non-apparel PPE such as self-contained breathing apparatus (SCBAs), was limited. These other types of PPE will require additional research to evaluate. As such, we haven't evaluated these other types of apparel firefighting PPE and non-apparel firefighting PPE in Cycle 2. For more information on the potential uses of PFAS in these other types of firefighting PPE, refer to the Cycle 1.5 technical report (Ecology, 2024d).

[26] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.400.005
[27] https://app.leg.wa.gov/wac/default.aspx?cite=296-305-01005
[28] https://app.leg.wa.gov/WAC/default.aspx?cite=296-305-02501
[29] https://app.leg.wa.gov/WAC/default.aspx?cite=296-305-05109%20

Descriptions of each type of firefighting protective clothing, that we focused on for cycle 2, phase 3 alternatives analysis, are outlined in Table 15 below.

Table 15: Types of protective clothing and National Fire Protection Association (NFPA) requirements.

Protective Clothing Type	Description	Required NFPA Standard(s) Per Chapter 296-305 WAC
Structural firefighting	Includes a helmet, coat, pants, boots, gloves, and a hood. Structural firefighters' protective clothing provides limited protection from heat but might not provide adequate protection during hazardous materials incidents. This type of protective clothing is typically referred to as turnout gear and is used when firefighters enter direct flames.	Clothing: NFPA 1971, Protective Ensembles for Structural Firefighting, 1991 or 1997 edition Gloves: NFPA 1971, Protective Ensembles for Structural Firefighting, 2000 edition Footwear: NFPA 1971, Protective Ensembles for Structural Firefighting, 2007 (or later) editions NFPA 1970, 2025 edition is the new consolidated NFPA standard on Protective Ensembles for Structural and Proximity firefighting, work apparel, open circuit self-contained breathing apparatus (SCBA) and personal alert safety systems (PASS).
Emergency medical Protective Clothing	Single or multi-use clothing that provides limited physical protection and barrier protection against body fluid-born pathogen contact with the wearer's body during delivery of emergency patient care and other medical functions.	NFPA 1999, 1999 edition, standard protective clothing for emergency medical operations is now consolidated into the new NFPA 1950, Standard on Personal Protective Equipment for Technical Rescue Incidents, Emergency medical Operations, and Wildland and Urban Interface Firefighting, 2025 edition
Technical Rescue Protective Ensemble	Clothing worn by firefighters that includes but not limited to garments, helmets, goggles, gloves and footwear during complex rescue incidents requiring specially trained personnel and special equipment to complete the mission.	NFPA 1950, Standard on Personal Protective Equipment for Technical Rescue Incidents, Emergency medical Operations, and Wildland and Urban Interface Firefighting, 2025 edition

Protective Clothing Type	Description	Required NFPA Standard(s) Per Chapter 296-305 WAC
Wildland and Urban Interface	Clothing worn by firefighters during fire suppression and property conservation efforts in woodlands, forests, grasslands, brushes, and other such vegetation or any combination of vegetation, involving a fire situation but not within buildings or structures.	NFPA 1977, 2005 edition consolidated into the new NFPA 1950 Standard on Personal Protective Equipment for Technical Rescue Incidents, Emergency medical Operations, and Wildland and Urban Interface Firefighting, 2025 edition
Station Wear Uniform	Station uniforms worn by firefighters are not intended to be personal protective equipment but are required to meet the NFPA 1975 standards. Station wear performance requirements includes pants and overalls but excludes shirts, socks and underwear.	NFPA 1975, 1990 or 1994 edition consolidated into the new NFPA 1970,

Priority chemical scope

As defined in RCW 70A.350.010(10),[30] the scope of the PFAS priority chemical class is defined as:

> "Perfluoroalkyl and polyfluoroalkyl substances" or "PFAS chemicals" means a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

[30] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

Function of the priority chemical in the priority product

To identify alternatives, we first determined whether the priority chemical is necessary to meet the performance requirements of the priority product at the chemical, material, or product level. If the priority chemical isn't serving a function, the chemical can be removed without substitution.

Firefighting PPE mainly consists of three different layers that provide different types of protection. The number of layers used in firefighting PPE depends on the type of operation the gear is being used for and its performance requirements. We looked at these different layers of personal protective clothing and identified the functions of PFAS in these components to meet the performance requirement.

Thermal barrier layer

Thermal barriers are the innermost layer of structural turnout gear. It acts as an insulating layer protecting the firefighter from intense heat. This layer has no functions associated with PFAS.

Outer Shells

Outermost layers or outer shells are the first layer of defense for the firefighters that provides flame resistance, thermal protection, mechanical strength and water repellency (NFPA, 2025). While flame resistance, thermal protection and mechanical strength is provided by the fabric, PFAS based durable water repellents provide water repellency in outer shells to prevent the gear from absorbing moisture.

Outer shells of structural, technical rescue, and emergency management system (EMS) gear are subject to the water absorption resistance test to determine how much water the outer shell absorbs (NFPA, 2025). The requirement limits how much water can be absorbed to keep the weight of the gear down in order to reduce firefighter fatigue and mobility.

Moisture Barrier Layer

Moisture barriers are sandwiched between the thermal barrier and the outer shells. Moisture barriers are usually multi-component materials made of expanded polytetrafluoroethylene (ePTFE) membranes laminated onto a flame-resistant fabric coated with durable water repellant (DWR) or flame-resistant polyurethanes (Munevar-Ortiz et al., 2024). The functions of PFAS chemicals are related to the performance requirements of the gear that must pass certain tests according to the National Fire Protection Association (NFPA) requirements listed in Table 16 below.

Table 16: Relevant tests for gear materials, their application, and relevant sections used to identify functions of PFAS material based on performance requirements according to the NFPA (NFPA, 2025). See relevant sections on details for testing methods.

Test Methods	Test method Application	NFPA sections
Water penetration resistance test	To evaluate the ability of the material to keep water from getting through.	Section 9.4.2
Liquid penetration resistance test	To evaluate the ability of the material to keep certain liquids from getting through. A list of liquids to be tested is available in section 9.4.3.4.2	Section 9.4.3
Viral penetration resistance test	To evaluate the resistance of materials used to penetration by blood borne pathogens using Phi-X174 bacteriophage penetration as a test system.	Section 9.4.5
Liquid barrier performance test (alternate test for viral penetration resistance)	To evaluate the ability of the garment moisture barrier to keep blood borne pathogens from coming in contact with the firefighter using hydrostatic penetration water resistance and impact penetration water resistance tests.	Section 9.11
Flame resistance test	To establish the flame resistance properties of the materials used in garment construction.	Section 9.2.1
Heat and thermal shrinkage resistance test (melting, separation, ignition)	To determine if the components used to construct protective garments will melt, separate or easily ignite.	Section 9.2.4
Particulate blocking test	To replicate smoke exposure used to evaluate particulates penetrating the hood in addition to the flame resistance and the heat and thermal shrinkage resistance test.	Section 9.4.4
Light degradation resistance test	To test the moisture barrier for UV resistance. The test applies to moisture barrier but is tested as a composite to simulate real world conditions.	Section 9.4.10

The ePTFE membranes are a chemically resistant, hydrophobic material and have a variety of uses:

- ePTFE membranes are used in moisture barriers because they provide water, liquid, and viral penetration resistance including protection from blood borne pathogens.
- When used in structural hoods, ePTFE membranes act as a particulate blocker.
- ePTFE membranes are thermally stable and have a high melting temperature that can withstand the flame resistance test and the heat and thermal shrinkage test.

The performance requirement for moisture barriers requires all components to be thermally stable to maintain their structural integrity. The inherent properties of the ePTFE membrane and the flame-resistant fabric prevents it from melting during the heat and thermal shrinkage resistance test, but flame retardants are usually added to prevent other materials from melting, such as flame-resistant polyurethanes present in the moisture barrier (Herkert et al., 2025) and seam tapes.

To our knowledge, flame retardants can be present for this anti-melting function in moisture barriers regardless of whether they use ePTFE membranes or alternatives, and so we didn't include this function as part of our alternatives analysis or evaluate flame retardants in these products.

The heat and thermal shrinkage resistance test in the new updated edition of NFPA 1970 measures the moisture barrier material as part of a composite which includes all three layers. Therefore, alternative membrane materials used to replace ePTFE that can pass this test without melting or shrinking as a composite are considered safer alternatives if the materials used to make the membrane meet our minimum criteria for safer.

ePTFE passes the UV-degradation resistance test on its own due to its inherent properties but the new updated edition of the standard tests the moisture barrier as part of the composite with all three layers allowing alternative materials to meet the performance standards of the NFPA without the need for ePTFE.

Table 17 summarizes the functions of PFAS, the relevant components, and protective clothing type for apparel firefighting PPE evaluated in Cycle 2.

Table 17: Summary of the functions of PFAS, the relevant components, and protective clothing type for apparel firefighting PPE.

Component	Performance requirement by PFAS	Relevant Protective Clothing Type
Thermal barrier	No function	Structural Turnout
Outer Shells without DWR	No function	Wildland and Urban Interface Station Wear Uniform
Outer Shells with DWR	Water absorption resistance or water repellency	Structural Turnout Technical Rescue Protective Ensemble Emergency Medical Protective Clothing
Moisture Barriers	Water, Liquid and viral penetration resistance, anti-melting (thermal degradation resistance)[+] UV degradation resistance[*], Particulate blocking	Structural Turnout Technical Rescue Protective Ensemble (optional) Emergency medical Protective Clothing

[*] Relevant only in NFPA 1971, 2007 edition and later. The new NFPA 1970, 2025 edition allows for testing as a composite instead of a standalone material in moisture barriers.

[+] The anti-melting function isn't provided solely by ePTFE used in the moisture barrier. Its inherent resistance to thermal degradation prevents it from melting during the thermal shrinkage test. Other materials may have flame retardants added to achieve this property.

Hazards of the priority chemical class

We described the hazards associated with PFAS in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature (Ecology, 2022b). Hazards of concern for members of the class include carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are very persistent and some are bioaccumulative. These hazards indicate that PFAS don't meet our minimum criteria for safer.

Safer, feasible, and available alternatives

Safer alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). To identify potential safer alternatives, we used our authority under 70A.350.030(4) RCW[31] and 70A.350.040(2) RCW[32] to order data from manufacturers of firefighting PPE (Ecology, n.d.-b). In the request, we asked for information on their products that meet NFPA standards, specifically:

> "Any chemical ingredients, known impurities, or expected byproducts (including surface treatments) used in any component (including not only fabric, but also machined metal parts, seals, electrical components and lubricants, etc.) to provide water resistance, liquid, chemical and viral penetration resistance, wear resistance, high thermal performance and/or anti-melting."

In the orders, we asked that each of the above responses include:

- a description of the product
- the product component that uses the ingredient
- the name and CASRN and functional of the chemical ingredient.

For polymers, we asked that mole ratios of all monomers be provided, as well as residual monomers or oligomers, a representative structure of the polymer, the molecular weight (MW) average, and an oligomeric characterization (e.g., %MW < 500 Da, %MW < 1000 Da).

The quality of these responses was variable, and many have required significant follow-up to clarify the information to gather the necessary information. This protracted follow-up has resulted in a significant delay in our analysis of alternatives. We're actively working with one major manufacturer through our confidentiality process to gather the information required.

To further support the analysis, we reviewed patent literature on durable water repellents and moisture barrier materials used in firefighting PPE. We compared this information the manufacturer orders mentioned above, as well as information publicly available on manufacturer websites. Together, these efforts help us better understand the way that different chemicals and materials are used in combinations to meet NFPA standards and the chemistries companies have employed to move away from use of PFAS.

Safer chemical alternatives

We looked for alternative chemistries used to fulfill the same functions of PFAS in thermal barriers, outer shells and moisture barriers as described in our Cycle 1.5 Technical Supporting Documentation for Regulatory Determinations Report (Ecology, 2024d). Our analysis of safer focused on only chemistries used to replace the function of PFAS. Other ingredients or

[31] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.030
[32] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.040

materials in the firefighting PPE are expected to be similar or unchanged in these products, relative to products that use PFAS.

Thermal barriers

As determined in our Cycle 1.5 Technical Support for Regulatory Determinations Report,[33] PFAS has no function in the thermal barrier component of structural turnout gear. None of the manufacturers we contacted in the manufacturing order process identified thermal barrier as a component using PFAS.

Since PFAS has no function, we determined that an analysis for safer alternatives wasn't necessary in thermal barriers. We investigated feasible and available thermal barriers.

Outer shells

For outer shells, we evaluated alternative ingredients reported by manufacturers that are used in durable water-repellent coatings of firefighting PPE that meets various NFPA standards.

The chemicals identified in Table 18 below are ingredients used to replace the function of PFAS in durable water repellents applied to outer shells of all types of gear described.

[33] https://apps.ecology.wa.gov/publications/summarypages/2404024.html

Table 18: Chemicals used to replace the function of PFAS in durable water repellents applied to outer shells in firefighting PPE.

Chemical	CASRN	Hazard assessment score	Tier met in criteria for safer (minimum or additional)
Chemicals used in durable water repellents by Safety Components (Chemical A)	Confidential Chemical A	Scivera GHS+ [Green/Yellow] and Greenscreen BM-3	Additional
Chemicals used in durable water repellents by Safety Components (Chemical B)	Confidential Chemical B	Scivera GHS+ [Yellow]	Minimum
Disclosure pending **(Milliken)**	Non-PFAS DWR on Horizon Fabrics	Insufficient information - Disclosure Pending	Not available
Disclosure pending **(Milliken)**	Non-PFAS DWR on Synergy Fabrics	Insufficient information - Disclosure Pending	Not available
Paraffin waxes and hydrocarbon waxes	8002-74-2	GreenScreen BM-3, Scivera GHS+ [Green/Yellow]	Additional

Moisture barriers

For moisture barriers, ePTFE (PFAS) is used as a thin film that is laminated to flame resistant fabric to prevent seepage of liquids through the gear and protect the user from contact with liquids. We evaluated alternative moisture barrier membrane materials reported by manufacturers that are used in firefighting PPE that meet NFPA standards.

The alternative materials reported by manufacturers and found on manufacturer websites are listed in Table 19 below.

Table 19: Alternatives to PFAS in firefighting PPE with hazard assessment scores and tier they meet in our criteria for safer.

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Polyurethane 9009-54-5	Scivera GHS+ [Yellow]	Minimum
Expanded polyethylene (ePE) 9002-88-4	Scivera GHS+ [Yellow]	Minimum
Nonwoven polyimide membrane 60842-76-4	Scivera GHS+ [Yellow]	Minimum

Durable Water repellents in outer shells

Durable water repellent by Safety Components

Elevate textiles, the parent company for Safety Components, supplied information on two chemicals providing water repellent functions in their proprietary durable water-repellent formulation under a confidentiality agreement. The information was provided through LION, a PPE manufacturer that uses their product.

1. While LION didn't explicitly state the durable water repellent used in their PPE, the product information from their website confirms the use of Armor AP fabric from Safety Components in outer shells of their LionExpress turnout gear (LION, n.d.-a).
2. Safety Components also makes Sigma fabric using the same durable water repellent finish used in their multipurpose wildland and technical rescue gear (Carter, 2021).

While we're unable to disclose the specific chemicals, we determined that both chemicals reported in the formulation (Chemical A and B) meet our minimum criteria for safer.

Safety Components Chemical A

This chemical meets our additional criteria for safer.

Chemical A from Safety Components scored as a Green/Yellow in a verified Scivera GHS+ assessment and scored BM-3 in a GreenScreen assessment. There was a data gap for endocrine activity. Endocrine activity isn't required in our criteria, and all other endpoints scored as moderate or low hazard.

Safety Components Chemical B

This chemical meets our minimum criteria for safer.

Chemical B from Safety components scored as a Yellow in a verified Scivera GHS+ assessment. It scored as very high hazard for persistence, but as low hazard for all other endpoints.

Durable water repellent by Milliken

Similarly, a company that supplies durable water repellents to Milliken signed a confidentiality agreement to provide us with information on the chemicals in their product. These durable water repellents are used in fabrics manufactured by Milliken and used by multiple PPE manufacturers. It can be found on their outer shell products like Horizon and Synergy fabrics.

We're still waiting for a submission from them to conduct an assessment to see if the chemicals in their formulation meet our minimum criteria for safer.

Paraffin waxes and hydrocarbon waxes (CASRN: 8002-74-2)

This chemical meets our additional criteria for safer.

This chemical was scored as Benchmark-3 in a GreenScreen hazard assessment (WAP Sustainability Consulting LLC, 2023). The assessment noted a data gap for endocrine activity. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. Chronic aquatic toxicity was scored as moderate hazard. Persistence was scored as low hazard, and bioaccumulation as very low hazard. All other endpoints were scored as low hazard.

This chemical was scored as Green/Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021q). Data gaps were noted for endocrine activity, acute toxicity (inhalation), and respiratory sensitization. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity (oral and dermal) scored as low hazard, and systemic toxicity scored as moderate hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. All other endpoints were scored as low or moderate hazard.

In addition, this chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2023c). The assessment noted data gaps for neurotoxicity (single- and repeat-dose), respiratory sensitization, and respiratory irritation.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity (single-dose) was scored as low hazard based on the oral and dermal routes of exposure. The assessment classified paraffin wax as GHS Category 2 for systemic toxicity (oral, repeat-dose) based on LOAEL of 19.5mg/kg/day reported in a 90-day study on rats, which corresponds to a moderate hazard score. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard.

The assessment didn't classify paraffin wax under GHS for carcinogenicity, mutagenicity, reproductive toxicity, or developmental toxicity which correspond to hazard scores of low for these human health endpoints.

Moisture Barrier membrane materials

Polyurethane (CASRN: 9009-54-5)

This chemical meets our minimum criteria for safer.

Polyurethane based membranes were previously evaluated as part of Safer Products for Washington Cycle 1.5 (Ecology, 2024d).

Polyurethane-knits and polyurethane-laminates can be engineered to specifications as described above to provide water repellency to apparel without the need of a durable water repellant.

Polyurethane has been evaluated as Yellow in a verified Scivera GHS+ assessment (Scivera, 2019m), indicating it doesn't contain known carcinogens, mutagens, reproductive or developmental toxicants. The assessment noted a data gap for endocrine activity. It scored as moderate with limited evidence for both developmental and reproductive toxicity.

While different monomers are used throughout polyurethane manufacturing and can be chemicals of concern (e.g., diisocyanates), we determined polyurethane, as a durable water repellant material alternative, isn't a regrettable substitute for two reasons:

1. EPA and others predict low residual concentrations and exposure potential for diisocyanates in cured polyurethane products.
2. Untreated thermoplastic polyurethane is a safer alternative to PFAS-treated thermoplastic polyurethane (Ecology, 2022b).

Materials constructed with an altered weave contain smaller pores that inhibit the passage of water through the fabric, which gives surface water repellency. In some apparel, an altered weave as described is feasible and available to provide the function of surface water repellency. Similarly, laminated textiles prevent liquids or other soils from seeping through the textile providing a barrier function.

Expanded Polyethylene (ePE) (CASRN: 9002-88-4)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021k). Data gaps are noted for endocrine activity, neurotoxicity, and respiratory sensitization.

Data on endocrine activity isn't required in our criteria, and both reproductive toxicity and developmental toxicity were scored as low hazard.

The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Persistence was scored as very high hazard for this polymer. All other hazard endpoints were scored as moderate or low hazard.

Polyethylene was previously identified as a safer alternative process in Cycle 1 of Safer Products for Washington (Ecology, 2022b). Expanded Polyethylene is made of the same polymer that has been expanded into a foam mold. Chemical blowing agents can be used for this foaming process, but none should remain in the final product. Polyethylene doesn't contain any components of known high concern, and Ecology's PFAS in Food Packaging Alternatives Assessment[34] identified it as a safer alternative.

In addition, some polyethylene fabrics have received a certification showing they meet at least our minimum criteria. One example is, Carnegie Xorel® (Carnegie, n.d.-a) which makes wall coverings, upholstery, and panel fabrics from PE. These fabrics are Cradle to Cradle Certified® (C2CC®) with a Platinum Material Health Certificate™ (Carnegie, n.d.-b).

Polyimide (CASRNs: 60842-76-4)

Polyimide meets our minimum criteria for safer.

Polyimide was scored as a Yellow chemical in a verified Scivera GHS+ assessment (Scivera, 2026a). This polymer scores as very high for persistence but low hazard for all other endpoints in our criteria. Pyromellitic dianhydride (CAS: 89-32-7) and 4,4'-oxydianiline (CAS 101-80-4) are used to make polyimide and could be present as residual monomers, and these would not meet our criteria for safer. However, residual monomers are expected to be below 1000 ppm based on available information on the polymerization process. If residual monomers are below 1000 ppm, polyimide can meet our minimum criteria.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Structural Turnout (NFPA 1970, 2025 edition)

The structural turnout gear that meets the NFPA (2025) requires all three layers of protection. We looked for feasible and available alternatives for each of the three layers of turnout gear separately. There are multiple commercial options for each of the layers that are interchangeable as long as they meet the NFPA requirements as a composite.

[34] https://apps.ecology.wa.gov/publications/SummaryPages/2204007.html

Thermal barriers

We determined that use of PFAS isn't necessary to meet NFPA 1971 or NFPA 1970 standards for thermal barriers in structural or proximity gear. The products may contain PFAS-free durable water repellents, but those aren't required to meet the NFPA performance standards (Carter, 2021).

None of the manufacturers reported using thermal barriers with PFAS in their submissions. We found several thermal barriers on the market that meet the relevant NFPA standards. Based on this information, we didn't evaluate alternatives to PFAS in thermal barriers. Examples of thermal barriers currently available in the market are listed in Table 20 below.

Table 20: Some examples of thermal barriers available in the market (non-exhaustive list).

Manufacturer	Thermal Barrier Product Trade Name
Safety Components	Glide Ice 2-layer
Milliken & Company	Equinox 2-layer and 3-layer
Tencate	Defender M Elite SL2
Tencate	Titanium SL2

Outer shells

Based on the information available from manufacturer websites and the manufacturer orders we identified feasible and available alternatives that use non-fluorinated durable water repellents in the outer shells of structural turnout gear.

The fabric manufacturer websites advertise their products as PFAS free and identify the trade names for the durable water repellents used in their fabrics. The PPE apparel manufacturers advertise specific fabrics used in their final product. Some examples of feasible and available outer shell fabrics that use non-fluorinated DWRs and meet the performance standards of the NFPA 1970 or NFPA 1971 are listed in Table 21 below.

Table 21: Feasible and available outer shell options for structural turnout PPE (non-exhaustive list).

Chemical	DWR Trade names	Outer shells fabrics	Available PPE Products
Confidential	PF Zero by Safety Components (Carter, 2021)	Armor AP™	LionExpress™ (LION, n.d.-a)
Disclosure pending	Non-PFAS DWR by Milliken	TecGen71®	AeroFlex® VaporLite® panels (Fire-Dex, n.d.-a)
Disclosure pending	Non-PFAS DWR (Hydropel) by Milliken	Milliken Horizon™ (Fire-Dex, n.d.-e)	FXM Express
No information	FreeFAS	PBI® Stretch XT (MSA, n.d.)	Athletix™ turnout by Globe (MSA, 2026)

Moisture barriers

Alternatives to ePTFE moisture barriers that meets the NFPA 1970 or NFPA 1971 are currently feasible and available in the market. Manufacturers of PPE apparel advertise their completely PFAS free options with the moisture barriers mentioned in Table 22 below.

Table 22: Feasible and available moisture barriers.

Chemical	Product Trade Names	Applicable apparel Types
Polyurethane	Stedair Clear, Milliken Assure (Fire-Dex, n.d.-e), Porelle® membranes, Alpex Blocker® FR3	Garments (coats, pants, overalls), gloves, boots
Expanded Polyethylene (ePE)	Gore-Tex MS Sapphire XT (PPE101, 2024)	Structural boots
Nonwoven polyimide membrane	Nomex Nano Flex (Fuchshuber Techno-Tex, 2019)	Structural hoods
Unknown	Innovate	Garments (coats, pants, overalls)

Feasible and Available composites for structural gear

Table 23 below provides some examples of PFAS free structural turnout gear composites containing all three layers of protection that are feasible and available.

Table 23: Feasible and available PFAS free composites for all three layers of structural turnout gear (non-exhaustive list).

Manufacturer	Moisture barrier	Thermal liner	Outer shell
MSA Globe (MSA, 2026), FireDex	Innovate	Glide Ice™ 2-Layer	PBI® Max
FireDex	Assure	Glide Ice™ 2-Layer	Armor AP™
FireDex (Fire-Dex, n.d.-c)	Assure	Equinox™ 2-Layer and 3 layer	Horizon™
Ricochet Maverick package (Ricochet, 2025)	Assure	Equinox™ 3 layer	Horizon™

Feasible and available boots, gloves and hoods for structural turnout gear

Table 24 below provides some examples of PFAS free structural turnout boots, gloves, and hoods for structural turnout gear that are feasible and available. The information was provided by the manufacturer and is available from manufacturer websites.

Table 24: Feasible and available PFAS free boots, gloves and hoods for structural turnout gear.

Chemical/Material	Moisture Barrier	Gear type	Products
Polyurethane	Porelle® membranes	Structural gloves	FC-1000- The Flame® Structural Glove (FireCraft, n.d.), DexPro gloves
Expanded polyethylene	Gore-Tex Crosstech® MS Sapphire XT (LION, 2024)	Structural boots	Lion V-Force boots (LION, n.d.-f)
Non-woven polyimide membrane	Nomex® Nano Flex	Structural hoods	RedZone (LION, n.d.-c)

Feasible and available outer shells for non-structural gear

For non-structural gear outer shells may or may not use durable water repellents depending on the type and NFPA requirements as described previously in **Table 16**. Wildland firefighting gear and station uniforms don't have a moisture absorbance limit in NFPA 1977 and NFPA 1975 standards. Thus, manufacturers can make these without the use of durable water repellents.

Other types of gear such as technical rescue and emergency medical operations gear does require water repellency in their outer shells. Examples of feasible and available outer shells for all types of non-structural gear that either have no durable water repellent or an alternative PFAS free durable water repellents are listed on Table 25 below.

Table 25: Feasible and available outer shell options for non-structural firefighting PPE.

Chemical	DWR Trade names	Outer shell fabrics	Applicable PPE categories	Example PPE products
N/A	No DWR application	Tecasafe® Plus (TenCate, 2010)	Wildland, Station wear	CrewBoss Classic Dual Compliant Pants (CrewBoss, n.d.-a), Brush Shirt (CrewBoss, n.d.-b)
Confidential	PF Zero by Safety Components	Sigma	Wildland/ Technical Rescue, Technical Rescue/EMS	Versapro® (LION, n.d.-e), TR51™ (LION, n.d.-d) by LION
Disclosure pending	Non-PFAS DWR (Hydropel) by Milliken	Westex® DH	EMS	Medpro™ (LION, n.d.-b) by LION
Disclosure pending	Non-PFAS DWR by Milliken	Synergy® Nomex® 600 IIIA	Technical Rescue/EMS	Option in Custom Technical Rescue (Ricochet, n.d.) by Ricochet
Disclosure pending	Non-PFAS DWR by Milliken	TecGen51®	Technical Rescue, EMS, Wildland	TecGen51® (Fire-Dex, n.d.-d) multipurpose gear, EMS gear, Technical Rescue gear by FireDex

Feasible and available boots, shrouds, and gloves for wildland and urban interface firefighting gear

Based on the information available from some manufacturers and manufacturer websites Wildland and Urban interface gear that meets the NFPA 1977 standard without the use of PFAS are feasible and available. Table 26 below provides examples of boots, gloves and shrouds.

Table 26: Wildland and Urban interface boots, gloves, and shrouds (non-exhaustive list).

Products	Applicable PPE categories
IFR Shrouds by ERB	Wildland Shroud
1972 Arch-Ease Last Crew boots by Whites boots	Wildland boots (Whites Boots Shop, 2026)
Wildland gloves by Veridian	Wildland gloves (Veridian, n.d.)

Moisture barriers for non-structural gear

Moisture barriers aren't required in Wildland and Urban Interface firefighting gear and Station wear uniforms to meet the performance requirements of NFPA 1977 and NFPA 1975 standards.

In technical rescue operations gear, moisture barriers are optional and are only required when protection from bodily fluids and blood borne pathogens are required. Moisture barriers for technical rescue gear is usually a removable layer that can be zippered or snapped on when needed. For EMS gear it can be removable when dual certified (Ricochet, n.d.) to technical rescue standards or sewn (Fire-Dex, n.d.-b) in for EMS operations only.

Innotex Energy Prime is a versatile gear certified to meet the NFPA 1951, 1977, and 1999 standard (consolidated in NFPA 1950 standard) that uses polyurethane based Alpex Blocker FR3 moisture barrier that is safer, feasible and available.

Conclusions

Reducing a significant source or use

As outlined in our past report, Technical Supporting Documentation for Regulatory Determinations Report to the Legislature, firefighting PPE is a significant source and use of PFAS (Ecology, 2024d).

- Firefighters are exposed to PFAS from PPE, and firefighters are a sensitive population who have disproportionately higher exposures to PFAS relative to the general population (Peaslee et al., 2020; Rosenfeld et al., 2023).
- Families of firefighters have the potential to be exposed to PFAS from PPE via contaminated clothing.

- Disposal of firefighting PPE can contribute to environmental contamination and expose other terrestrial and aquatic biota over time (Ecology, 2024d).

Safer alternatives are feasible and available

Based on the current information we have determined that:

- PFAS doesn't have any function in thermal barriers.
- The durable water repellent by Safety Components that is used in outer shells meets our minimum criteria for safer and is feasible and available.
- We are in the process of evaluating if the chemicals in other non-PFAS durable water-repellent finishes used on outer shell fabrics meet our minimum criteria for safer. They are, however, feasible and available for all types of gear we evaluated for this cycle.
- Moisture barriers for structural turnout gear are safer, feasible and available.
- Moisture barriers for non-structural turnout gear such as technical rescue and EMS gear are also feasible and available.

A summary of the types of gear and the status on alternative analysis is listed in Table 27 below.

Table 27: Summary of alternatives analysis for safer, feasible and available based on the type of gear.

Gear type	Layer	Safer, Feasible, Available
Structural Turnout	Thermal barrier	Yes
	Outer shell	Yes (one alternative DWR, another pending)
	Moisture barrier	Yes
Station Wear	Single layer	Yes
Technical Rescue	Outer shell	Yes (one alternative DWR, another pending)
	Moisture barrier (optional)	Yes
Wildland	Outer shell (no DWR)	Yes
	Outer shell (with DWR)	Yes (one alternative DWR, another pending)
EMS Gear	Outer shell	Yes (one alternative DWR, another pending)
	Moisture barrier	Yes

To date, we have identified one feasible and available durable water repellent used in outer shells that meets our minimum criteria for safer. We're in the process of obtaining disclosure of chemicals used in another feasible and available durable water-repellent finish used in outer shells to determine if it can meet our minimum criteria for safer. We intend to include this information in our final analysis pending disclosure of the ingredients to further strengthen our finding that alternatives are safer, feasible and available for these products.

Regulatory determination

Our regulatory determination is that a restriction on use of PFAS in structural turnout gear, wildland firefighting gear, station wear, technical rescue and EMS gear should be adopted.

A restriction on PFAS in firefighting PPE would reduce a significant source and use of PFAS.

Chapter 6: Per- and Polyfluoroalkyl Substances in Floor Waxes and Polishes

Priority product scope

Floor wax and polish products can be used in a variety of resilient (elastic) floor surfaces (CreativeMaterials, n.d.; Zhejiang Halead flooring Co., Ltd, n.d.) including cork, linoleum, rubber, and vinyl (CreativeMaterials, n.d.; Ecolab Inc., 2017; Zhejiang Halead flooring Co., Ltd, n.d.). As defined in our Safer Products for Washington Cycle 1.5 Implementation Phase 3[35] (Ecology, 2024b, 2024d) and Safer Products for Washington Cycle 2 Implementation Phase 2[36] (Ecology, 2025b) reports, the scope of this priority product includes formulated products designed to polish, protect, or enhance a floor's surface. Examples of these products include multi-surface floor finishes, low gloss, semi-gloss, and high gloss polishes. Products intended for, and discussions on, non-resilient (hard) floor surfaces are covered in the **hard surface sealers chapter**.

Priority chemical scope

Per- and polyfluoroalkyl substances (PFAS) were previously defined as a priority chemical class (Ecology, 2024b). Per Revised Code of Washington (RCW) 70A.350.010(10)[37] (Washington State Legislature, 2019), PFAS were defined as, "a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom."

Function of the priority chemical in the priority product

The chemical functions initially identified for PFAS in floor waxes and polishes are to provide water and oil repellency, and to increase the spreading abilities of other components in a wax or polish formulation as described during Safer Products for Washington Cycle 1.5 Implementation Phase 3 (Ecology, 2024b, 2024d).

However, recent works by the California Department of Toxic Substances Control (DTSC) (CSCP, 2026a) and BASF (Moy, 2024), and further confirmed in a patent on PFAS-free floor finish, indicated that the type of PFAS used in floor wax and polish products solely functioned as a surfactant (i.e., fluorosurfactant) (Savaglio et al., 2025). This was supported by responses we received to our manufacturer orders.

In December 2025, Washington Department of Ecology sent manufacturer orders to five companies requesting information on products currently offered for sale in Washington where all PFAS and non-PFAS alternative chemicals are used for surfactant, wetting agent, and protectant functions. Requests for confidential business information (CBI) by manufacturers

[35] https://apps.ecology.wa.gov/publications/summarypages/2404024.html
[36] https://apps.ecology.wa.gov/publications/SummaryPages/2504031.html
[37] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010

were only made for chemicals providing surfactant or wetting agent function, and not for chemicals providing protectant function.

This implied that PFAS are only used for surfactant or wetting purpose in floor wax and polish, as the replacements for PFAS are considered a trade secret. Therefore, only surfactant and wetting agent functions of PFAS were examined for floor wax and polish products.

A surfactant is defined as a chemical that, when added to water, reduces the surface tension of the water, which then promotes the spread or penetration of floor wax or polish ingredients (EPA, n.d.-o). Wetting agent is defined as chemical that promotes the coating of organic liquid on solid material (EPA, n.d.-o).

Hazards of the priority chemical class

We described the hazards associated with PFAS in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature (Ecology, 2022b). Hazards of concern for PFAS include carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are known to be persistent in the environment and some bioaccumulate in organisms. PFAS are a hazardous class of chemicals that didn't meet our minimum criteria for safer (Ecology, 2022b).

Safer, feasible, and available alternatives

Safer alternatives

Search for alternatives

While the Safer Products for Washington framework lists safer first, then feasible, and finally, available (Ecology, 2022b). In reality, feasible and available are considered first, before safer was considered, for this chemical-priority product combination. The steps are outlined below:

First, we made a list of potential alternatives that could provide surfactant or wetting agent function using steps described below:

- We consulted the U.S. EPA Safer Chemical Ingredients List (SCIL) (OCSPP, 2013a), the Pharos database (Pharos, n.d.-b), and the Interstate Chemicals Clearinghouse Chemical Hazard Assessment Database (IC2, n.d.)
- We performed web searches using internet search engine (Google, n.d.)
- We examined the different products and use categories already compiled in the EPA CompTox Chemicals Dashboard (EPA, n.d.-k; A. J. Williams et al., 2017), which were based on prior U.S. EPA efforts to catalogue and define the functions of chemicals used in consumer products (Dionisio et al., 2018; Isaacs et al., 2016; Phillips et al., 2017), including chemicals used in waxes and polishes.

Second, once the initial list of alternatives that could provide surfactant or wetting agent has been collated, we determined their feasibility (Ecology, 2022d) using SpecialChem (SpecialChem, 2025e), Knowde (Knowde, 2025), and UL Prospector (UL Prospector, n.d.) to find

example chemical trade names indicating the use of the alternatives for the function of surfactant or wetting agent. We performed an internet search (Google, n.d.) and considered information from manufacturer orders.

Third, once the list of feasible alternatives that could provide surfactant or wetting agent function has been collated, we determined if they were available (Ecology, 2022d). We looked for, at least, an example product in the market with the chemical alternative listed as an ingredient providing surfactant or wetting agent function.

Fourth, once the list of feasible and available alternatives that could provide surfactant or wetting agent function has been collated, we screened them using chemical hazard assessments, such as EPA SCIL, Scivera GHS+, ChemFORWARD, and GreenScreen®, to determine if they met our criteria for safer (Ecology, 2022c, 2022b).

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). We determined that PFAS didn't meet our minimum criteria for safer (Ecology, 2022c). Therefore, alternatives that do meet our minimum criteria are considered safer alternatives.

Selected safer chemical alternatives are listed in Table 28. For simplicity, only those that were safer, but also feasible and available as described in subsequent sections, are included.

Explanations on how the inclusion of these chemicals on EPA SCIL, on how the verified Scivera GHS+ or ChemFORWARD hazard band assessment scores, or on how the GreenScreen® assessment scores corresponded to our minimum and/or additional criteria for safer could be found in our previous reports (Ecology, 2022b, 2022c). Further discussions on the chemical hazard assessment of selected safer chemical alternatives are provided below Table 28.

Table 28: Alternative to PFAS in floor waxes and polishes with hazard assessment scores and tier they meet in our criteria for safer.

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer
Dipropylene glycol monomethyl ether 34590-94-8	EPA SCIL Full Green Circle (solvent function), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Alcohols, C12-14, ethoxylated 68439-50-9	EPA SCIL Full Green Circle (surfactant function), GreenScreen® BM-2, Scivera GHS+ [Yellow]	Minimum
Alcohols, C12-16, ethoxylated 68551-12-2	EPA SCIL Full Green Circle (surfactant function), Scivera GHS+ [Yellow]	Minimum
Oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether 134180-76-0	Scivera GHS+ [Yellow]	Minimum

Dipropylene glycol monomethyl ether (CASRN: 34590-94-8)

This chemical met our minimum criteria for safer.

This chemical is on EPA SCIL as a Full Green Circle for the solvent function (OCSPP, 2013a). This rating isn't sufficient on its own to meet our criteria for safer on its own.

Dipropylene glycol monomethyl ether scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2020a). This chemical had data gaps for endocrine activity and respiratory sensitization. Assessors gave moderate hazards for neurotoxicity, eye irritation, and persistence. All other endpoints considered in our criteria for safer were scored as low hazard.

Dipropylene glycol monomethyl ether scored Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2021b). This chemical received moderate hazards for neurotoxicity (single-dose) and respiratory irritation. Assessors noted a data gap for endocrine activity.

Alcohols, C12-14, ethoxylated (CASRN: 68439-50-9)

This chemical met our minimum criteria for safer.

Alcohols, C12-14, ethoxylated is on EPA SCIL as a Full Green Circle for the surfactant function (OCSPP, 2013a). This rating isn't sufficient on its own to meet our minimum criteria for safer.

This chemical scored BM-2 in an expired GreenScreen® assessment (ToxServices LLC, 2021d). Assessors assigned moderate hazards for developmental toxicity, and high hazard for acute aquatic and chronic aquatic toxicity. There were data gaps for endocrine activity and neurotoxicity (repeat exposure). Reproductive toxicity was scored as low hazard. Our minimum criteria for safer allowed the data gap for repeat-dose neurotoxicity since there was sufficient data to score the systemic toxicity (single and repeat-dose) and neurotoxicity (single dose) endpoints.

Data for endocrine activity aren't required in our minimum criteria for safer, and the GreenScreen® assessment didn't identify any data for this endpoint. Persistence and bioaccumulation were scored as very low and low hazard, respectively.

Alcohols, C12-14, ethoxylated scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2019c). This chemical had data gaps for endocrine activity and respiratory sensitization. Assessors gave moderate hazard for developmental toxicity, as well as very high hazards for eye irritation and acute aquatic toxicity. Carcinogenicity, mutagenicity, and reproductive toxicity, persistence, and bioaccumulation all scored as low hazard.

Alcohols, C12-16, ethoxylated (CASRN: 68551-12-2)

This chemical met our minimum criteria for safer.

This chemical is on EPA SCIL as a Full Green Circle for the surfactant function (OCSPP, 2013a). This rating isn't sufficient on its own to meet our minimum criteria for safer.

Alcohols, C12-16, ethoxylated scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2019d). This chemical had data gaps for endocrine activity and respiratory sensitization. Carcinogenicity, mutagenicity, and reproductive toxicity all scored as low hazard. Assessors gave moderate hazard score for developmental toxicity. They assigned high hazard score for dermal irritation and chronic aquatic toxicity, with very high hazard scores for eye irritation and acute aquatic toxicity. Persistence was scored as moderate hazard and bioaccumulation as low hazard.

Oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether (CASRN: 134180-76-0)

This chemical met our minimum criteria for safer.

Oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2020i). This chemical had data gaps for endocrine activity, neurotoxicity, and respiratory sensitization. However, this chemical scored low hazard for carcinogenicity, mutagenicity, reproductive toxicity, and developmental toxicity. Oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether received a high hazard score for eye irritation, persistence, and acute aquatic toxicity. Bioaccumulation was scored as low hazard.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

The results of our feasible and available evaluations are presented in Table 29. While the feasible and available analyses occurred before the safer analysis, as described earlier under the "**Search for alternatives**" section, only safer, feasible, and available alternatives that could provide surfactant or wetting agent function are listed in Table 29.

We further note that, based on responses to our manufacturer orders, oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether (CASRN: 134180-76-0) has been used in floor wax and polish products by Buckeye, (e.g., Gym Bond, Arena® 50, 1st Down®, Verde™ Ultra, and Lucent®) and Ecolab (e.g., High Gloss NP Floor Finish). This further demonstrates the feasibility and availability of oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl)oxy]-1-disiloxanyl]propyl] ether.

Table 29: Feasibility and availability of safer chemical alternatives in floor waxes and polishes.

Chemical and CASRN	Relevant function(s) of chemical or advertised function by chemical suppliers	Example chemical trade names available in marketplace	Example floor waxes or polishes with chemicals as ingredients	Surfaces
Dipropylene glycol monomethyl ether 34590-94-8	Surfactant, wetting agent (EPA, n.d.-n)	Dipropylene glycol monomethyl ether by Alfa Chemistry (Alfa Chemistry, n.d.-b), DOWANOL DPM by Ataman Chemicals (Ataman Chemicals, n.d.-c)	2K Supra A.T. by LOBA-Wakol LLC (LOBA-Wakol LLC, 2012, 2026), Tough Guy Low Maintenance Floor Finish by Grainger (W.W. Grainger Inc., 2015), Super Gloss Floor Wax by Lundmark (Lundmark Wax Co, 2018)	Cork, linoleum, vinyl
Alcohols, C12-14, ethoxylated 68439-50-9	Surfactant, wetting agent (EPA, n.d.-d)	GENAPOL® LA 120 SG VITA by Clariant (Clariant, 2025c)	Super Gloss Floor Wax by Lundmark (Lundmark Wax Co, 2018), US Patent No. US20160194511A1 (Perdigon & Tysak, 2016)	Linoleum, vinyl
Alcohols, C12-16, ethoxylated 68551-12-2	Surfactant (EPA, n.d.-e)	ROKAnol L30A by PCC Chemax (PCC Chemax, n.d.), IndSurf LA-2375 by IndSpyre Solutions Inc. (IndSpyre Solutions, Inc., 2026)	QUIK FILL 33 FLOOR FINISH RESTORER by Ecolab Inc. (Ecolab Inc., 2025), QC 33 FLOOR FINISH RESTORER by Ecolab Inc. (Ecolab Inc., 2019)	Linoleum, vinyl, rubber

Chemical and CASRN	Relevant function(s) of chemical or advertised function by chemical suppliers	Example chemical trade names available in marketplace	Example floor waxes or polishes with chemicals as ingredients	Surfaces
Oxirane, 2-methyl-, polymer with oxirane, mono[3-[1,3,3,3-tetramethyl-1-[(trimethylsilyl) oxy]-1-disiloxanyl] propyl] ether 134180-76-0	Wetting agent (EPA, n.d.-x)	Silsurf A010-D-UP by Siltech Corp (Siltech Corp, 2022)	Maxim products by Midlab: Premium Wet Look Floor Finish (Midlab, n.d.-a), Fast Cure NP Floor Finish (Midlab, n.d.-b), Premium High Solids NP Floor Finish (Midlab, n.d.-d), LVT Restore;(Midlab, n.d.-c), Products by American Cleaning Solutions: Duro-Sheen Urethane Fortified Floor Finish (American Cleaning Solutions, n.d.-a), Solutions Plus Labor-Saver Scrubbable Floor Finish (CPID, n.d.-b), Standfast Floor Finish (American Cleaning Solutions, n.d.-b)	Linoleum, vinyl, rubber

Note: Chemicals are listed with corresponding CASRNs, functions in floor waxes and polishes, examples of trade names, products on the market that use the alternatives, and the type of surfaces where the wax or polish products can be applied. NA indicates not available.

Conclusions on alternatives

Reducing a significant source or use

We describe how the use and disposal of floor wax and polish products can be a potential source of exposure (Zhou et al., 2022) to PFAS in people, and can contribute to releases to the environment in our report, "Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 1.5 Implementation Phase 3" (Ecology, 2024d). In that report, we refer to information from our PFAS Chemical Action Plan (Ecology, 2022a) and from peer-reviewed literature (Guo et al., 2009; Liu et al., 2014) that report use of PFAS in floor wax and polish products.

Safer alternatives are feasible and available

Safer alternatives to PFAS in floor waxes and polishes that meet either our minimum or additional criteria for safer (Ecology, 2022c) are identified. The alternatives are currently used in floor waxes and polishes—the applications of interest—and are described as feasible and available based on our evaluations.

Regulatory determination

Our regulatory determination is that a restriction on the use of PFAS in floor waxes and polishes should be adopted. Restricting the use of PFAS in floor waxes and polishes would reduce a significant use of PFAS and source of potential exposure to people and the environment.

Chapter 7: PFAS in Hard Surface Sealers

Priority product scope

As defined in the Safer Products for Washington Cycle 1.5 Implementation Phase 3 (Ecology, 2024b, 2024d) and Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b) reports, the scope of this priority product includes formulated products used to seal hard porous surfaces (i.e., non-resilient) such as concrete, stone, unglazed tile, and wood.

Priority chemical scope

As defined in RCW 70A.350.010(10)[38] (Washington State Legislature, 2019),

“Perfluoroalkyl and polyfluoroalkyl substances" or "PFAS chemicals" means a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom.

Function of the priority chemical in the priority product

Hard surface sealers are intended to protect hard porous surfaces from liquids and soils in both indoor and outdoor environments. The chemical functions identified for PFAS in these products are to add water repellency, oil repellency and stain resistance, and dirt repellence or anti-soiling properties via surface energy modification (Ecology, 2024b, 2024d).

We determined the functional use of PFAS in hard surface sealers through a review of relevant publicly available data such as ingredient disclosures, ingredient marketplaces such as SpecialChem (SpecialChem, 2025e), and safety data sheets.

Functions listed for PFAS were defined based on the U.S. EPA CompTox functional use categories (EPA, n.d.-o). Other functions not listed for PFAS, but can serve the same purpose, were defined and matched to PFAS functions as functional categories (OECD, 2025).

Table 30: Functions provided by PFAS chemicals in hard surface sealers.

Priority Product	Functional Category	Function of PFAS
Hard Surface Sealer	Waterproofing, surface modifier, film former, surfactant	Water repellency
Hard Surface Sealer	Anti-stain agent, surface modifier, sealant, film former, polymer	Oil repellency, stain/oil resistance
Hard Surface Sealer	Matting agent, surface modifier, slip control agent, film former	Dirt repellence (anti-soiling or dirt pick-up resistance)

[38] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

Hazards of the priority chemical class

We described the hazards associated with PFAS in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature published in 2022 (Ecology, 2022b). Hazards of concern for members of the class include carcinogenicity, reproductive and developmental toxicity, and systemic toxicity. In addition, PFAS are also very persistent, and many are bioaccumulative. These hazards indicate that PFAS don't meet our minimum criteria for safer (Ecology, 2022b, 2022c).

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). To identify potential alternatives to PFAS in hard surface sealers, we evaluated other similarly functioning chemicals used in these products. To determine what alternative chemistries are used in these products and provide similar functions to PFAS we referred to information from several sources including:

- Online databases such as Pharos (Pharos, n.d.-b) and ZeroPM (ZeroPM, 2025)
- Ingredient/material marketplace websites such SpecialChem (SpecialChem, 2025e), Knowde (Knowde, 2025), UL Prospector (UL Prospector, n.d.)
- Ingredient Disclosures and Safety Data Sheets (SDS)
- Manufacture and retailer websites

The safer alternatives we've identified that can replace the functions of PFAS in hard surface sealers are summarized in Table 31, followed by descriptions of the information used to determine these alternatives met our criteria for safer.

Table 31: Alternatives to PFAS in hard surface sealers with hazard assessment scores and tier they meet in our Criteria for Safer.

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
2-Propenoic acid, 2-methyl-, polymer with butyl 2-propenoate and methyl 2-methyl-2-propenoate 25035-69-2	Scivera GHS+ [Yellow], EPA SCIL Full Green Circle (polymer)	Minimum
Polybutene 9003-29-6	EPA SCIL Full Green Circle (polymer)	Minimum
Triethoxy(2-methylpropyl)silane 17980-47-1	Scivera GHS+ [Yellow]	Minimum
Triethoxyoctylsilane 2943-75-1	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Siloxanes and Silicones, di-Me, hydroxy-terminated 70131-67-8	Scivera GHS+ [Yellow], EPA SCIL Half-Green Circle (defoamers)	Minimum
3-Aminopropyltriethoxysilane 919-30-2	Scivera GHS+ [Yellow]	Minimum
Isobutyltrimethoxysilane 18395-30-7	Scivera GHS+ [Yellow]	Minimum
Trimethoxymethylsilane 1185-55-3	Scivera GHS+ [Yellow]	Minimum
Paraffin wax 8002-74-2	GreenScreen BM-3, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band B	Additional
Carnauba wax 8015-86-9	Scivera GHS+ [Green/Yellow], EPA SCIL Full Green Circle	Additional
Beeswax 8012-89-3	EPA SCIL Full Green Circle	Minimum
Tung oil 8001-20-5	Scivera GHS+ [Green/Yellow]	Additional
Poly(vinyl alcohol) 25213-24-5	EPA SCIL Full Green Circle (polymer)	Minimum
Silica gel, pptd., cryst.-free 112926-00-8	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Minimum
Hydroxyethyl cellulose 9004-62-0	Scivera GHS+ [Yellow], EPA SCIL Full Green Circle (processing aids and additives)	Additional

2-Propenoic acid, 2-methyl-, polymer with butyl 2-propenoate and methyl 2-methyl-2-propenoate (CASRN: 25035-69-2)

This chemical meets our minimum criteria for safer.

This chemical is listed on the EPA SCIL as a Full Green Circle with a functional use as a polymer, indicating it has been verified to be of low concern based on experimental and modeled data (OCSPP, 2013a). This is sufficient to meet our minimum criteria for safer.

This chemical was scored as scored as [Yellow] in a verified Scivera GHS+ hazard assessment (Scivera, 2017a). Data gaps were noted for endocrine activity, neurotoxicity, and respiratory sensitization. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as moderate hazard. Persistence was scored as high hazard for this polymeric ingredient. The assessment relies heavily on conclusions from listing of this chemical as a polymer of low concern in a Tier I IMAP assessment rather than experimental or modeled data.

Polybutene (CASRN: 9003-29-6)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists polybutene as a Full Green Circle with functional use as a polymer, indicating it has been verified to be of low concern based on experimental and modeled data (OCSPP, 2013a). No other hazard assessments were found for this polymer. Potential hazards of concern include persistence as this polymer isn't expected to be biodegradable.

Triethoxy(2-methylpropyl)silane (CASRN: 17980-47-1)

This chemical meets our minimum criteria for safer.

This chemical was scored as [Yellow] in a verified Scivera GHS+ hazard assessment (Scivera, 2024b). Data gaps were noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. Data on sensory irritation isn't required in our criteria. Persistence and bioaccumulation were scored as low hazard.

Triethoxyoctylsilane (CASRN: 2943-75-1)

This chemical met our minimum criteria for safer.

Triethoxyoctylsilane scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2021y). Assessors noted data gaps for endocrine active and respiratory sensitization. Data for endocrine activity isn't required in our criteria and reproductive toxicity and developmental toxicity scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. This chemical was scored as low hazard for neurotoxicity based on a

NOAEL of 250mg/kg/day reported in a 90-day OECD Guideline 408 study in rats. At 400mg/kg/day, minimal adverse effects were reported in peripheral nerves of the female rats in the study. Although neurotoxicity was scored as low hazard, we considered the underlying data for this endpoint more closely due to the GHS Category 3 classification reported for neurotoxicity in the ChemFORWARD assessment described below. This chemical scored as high hazard for chronic aquatic toxicity and dermal irritation. Persistence and bioaccumulation both scored as moderate hazard.

This chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2023f). Assessors noted data gaps for reproductive and developmental toxicity (dermal, inhalation), endocrine activity, and repeated dose systemic exposure (dermal, inhalation), as well as single- (inhalation) and repeat-dose neurotoxicity (dermal, inhalation). Respiratory sensitization was noted as a data gap.

Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard based on the oral route. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. For single-dose neurotoxicity (oral, dermal), this chemical was scored as moderate hazard (Category 3) based on two OECD 401 studies in rats that showed clinical signs of neurotoxicity. These studies weren't designed to study neurotoxicity but slowed movement and coordination disturbances were observed consistent with a GHS Category 3 classification (transient effects). All other endpoints were scored as low or moderate hazard based on other routes of exposure, and this meets our data requirements.

Siloxanes and Silicones, di-Me, hydroxy-terminated (CASRN: 70131-67-8)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2018h). While a data gap was noted for endocrine disruption, other human health endpoints were scored as low hazard including carcinogenicity, mutagenicity, reproductive toxicity, and developmental toxicity.

Additionally, the EPA SCIL lists this chemical as a Half-Green Circle with a functional use as a defoamer (OCSPP, 2013a). This score means based on available experimental and modeled data, the chemical is anticipated to be a low hazard, but that additional data could strengthen confidence in its classification as safer by EPA.

3-Aminopropyltriethoxysilane (CASRN: 919-30-2)

This chemical met our minimum criteria for safer.

3-Aminopropyltriethoxysilane scored BM-2 in a GreenScreen® assessment (ToxServices LLC, 2026a). The assessment noted data gaps for endocrine activity, neurotoxicity (repeat-dose only) and respiratory sensitization. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low and moderate hazard, respectively. The data gap for neurotoxicity (repeat-dose) is allowable as neurotoxicity (single-dose) was scored as moderate hazard. The data gap for respiratory sensitization is allowable as

dermal sensitization was scored as moderate hazard. Eye irritation and skin irritation were both scored as very high hazard, but this is allowable in our minimum criteria as long as neither persistence and bioaccumulation score as very high – persistence was scored as low hazard and bioaccumulation was scored as very low hazard in this assessment.

This chemical was scored as Yellow in a verified Scivera GHS+ assessment (Scivera, 2019a). While a data gap was noted for endocrine disruption, carcinogenicity and mutagenicity were scored as low hazards, and reproductive toxicity and developmental toxicity were scored as moderate hazards. Dermal irritation, eye irritation, and environmental mobility were scored as very high hazards. No other endpoints in this assessment were scored above a moderate hazard.

Isobutyltrimethoxysilane (CASRN: 18395-30-7)

This chemical met our minimum criteria for safer.

Isobutyltrimethoxysilane scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2024a). This chemical had data gaps in endocrine activity and neurotoxicity endpoints. Data for endocrine activity isn't required in our criteria and reproductive toxicity and developmental toxicity scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. Assessors gave a high hazard score for dermal irritation. All other endpoints were scored as low or moderate hazard.

Trimethoxymethylsilane (CASRN: 1185-55-3)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2020l). Carcinogenicity, mutagenicity, and endocrine disruption were scored as moderate hazard, while reproductive toxicity and developmental toxicity were scored as low hazard. A data gap was noted for respiratory sensitization, but this is allowable as dermal sensitization was scored as moderate hazard. Persistence was scored as a high hazard but bioaccumulation was scored as low hazard. All other endpoints were scored as low or moderate hazard.

Paraffin wax (CASRN: 8002-74-2)

This chemical meets our additional criteria for safer.

This chemical was scored as Benchmark-3 in a GreenScreen hazard assessment (WAP Sustainability Consulting LLC, 2023). The assessment noted a data gap for endocrine activity. Data on endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. Chronic aquatic toxicity was scored as moderate hazard. Persistence was scored as low hazard, and bioaccumulation as very low hazard. All other endpoints were scored as low hazard.

This chemical was scored as Green/Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021q). Data gaps were noted for endocrine activity, acute toxicity (inhalation), and respiratory sensitization. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for

neurotoxicity is allowable as acute toxicity (oral and dermal) scored as low hazard, and systemic toxicity scored as moderate hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. All other endpoints were scored as low or moderate hazard.

In addition, this chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2023c). The assessment noted data gaps for neurotoxicity (single- and repeat-dose), respiratory sensitization, and respiratory irritation. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity (single-dose) was scored as low hazard based on the oral and dermal routes of exposure. The assessment classified paraffin wax as GHS Category 2 for systemic toxicity (oral, repeat-dose) based on LOAEL of 19.5mg/kg/day reported in a 90-day study on rats, which corresponds to a moderate hazard score. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard. The assessment didn't classify paraffin wax under GHS for carcinogenicity, mutagenicity, reproductive toxicity, or developmental toxicity which correspond to hazard scores of low for these human health endpoints.

Carnauba wax (CASRN: 8015-86-9)

This chemical met our additional criteria for safer.

Carnauba wax is listed on EPA SCIL as a Full Green Circle for an uncategorized function (OCSPP, 2013a). Chemicals with uncategorized function on EPA SCIL meet at least our minimum criteria for safer (Ecology, 2022c).

Carnauba wax scored Green/Yellow in a verified Scivera GHS+ assessment (Scivera, 2020e). Data gaps were noted for endocrine activity, neurotoxicity and respiratory sensitization. We don't require data for endocrine activity in our criteria, and this chemical was scored as moderate hazard for reproductive toxicity and developmental toxicity. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. Persistence was scored as moderate hazard. All other endpoints were scored as low hazard.

Beeswax (CASRN: 8012-89-3)

This chemical meets at least our minimum criteria for safer.

The EPA SCIL lists beeswax as a Full Green Circle, indicating it is low hazard as verified through experimental and modeled data (OCSPP, 2013a).

Tung oil (CASRN: 8001-20-5)

This chemical meets our additional criteria for safer.

This chemical was scored as Green/Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2018j) and meets our additional criteria for safer. Data gaps were noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. Data for endocrine activity isn't required in our criteria and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as

dermal sensitization scored as low hazard. Data on sensory irritation isn't required in our criteria. Eye irritation was scored as moderate hazard; all other endpoints were scored as low hazard.

Poly(vinyl alcohol) (CASRN: 25213-24-5)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists vinyl acetate vinyl alcohol polymer (i.e., poly (vinyl alcohol)) as a Full Green Circle with functional use as a polymer (OCSPP, 2013a). This indicates US EPA considers it as a low hazard polymer as verified through experimental and modeled data. This is sufficient to meet our minimum criteria for safer.

Silica gel, pptd., cryst.-free (CASRN: 112926-00-8)

This chemical meets our minimum criteria for safer.

This chemical was scored as Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2022f). A data gap was noted for endocrine disruption, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity isn't required in our criteria. A data gap was noted for neurotoxicity, but acute toxicity (dermal and oral) were scored as low hazard, acute toxicity (inhalation) was scored as high hazard, and systemic toxicity was scored as high hazard. This fulfills our data requirements and still meets our minimum criteria. Carcinogenicity was scored as moderate hazard. All other endpoints were scored as low hazard.

This chemical was assigned Hazard Band B in a ChemFORWARD hazard assessment (ChemFORWARD, 2025c). The assessment noted data gaps for carcinogenicity (dermal), reproductive toxicity (dermal, inhalation), developmental toxicity (dermal, inhalation), systemic toxicity (dermal repeat-dose), neurotoxicity (all routes) and respiratory sensitization. The assessment classified this chemical as GHS Category 3 for systemic toxicity (single-dose inhalation), which corresponded to a moderate hazard. Apart from neurotoxicity, all other hazard endpoints were scored as low hazard based on other routes of exposure and this fulfills our data requirements. The data gap for neurotoxicity is allowable as systemic toxicity was scored as moderate (inhalation) or low hazard (oral and dermal), and acute toxicity was scored as low hazard for all routes of exposure.

Polypropylene (CASRN: 9003-07-0)

This chemical meets our minimum criteria for safer.

Polypropylene or polypropylene wax is on EPA SCIL as a Full Green Circle for the polymer function (OCSPP, 2013a). The functional use criteria for polymers used by EPA SCIL meets our minimum criteria for safer (Ecology, 2022c).

Polypropylene or polypropylene wax scored Yellow in a verified Scivera GHS+ assessment (Scivera, 2018a). Assessors noted data gaps for endocrine activity and neurotoxicity. Data for endocrine activity isn't required in our criteria and reproductive toxicity and developmental toxicity scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and

systemic toxicity scored as low hazard. Persistence was scored as high for this polymer, but this is allowable in our minimum criteria as all other hazard endpoints scored as moderate or low hazard.

Hydroxyethyl cellulose (CASRN: 9004-62-0)

This chemical meets our additional criteria for safer.

The EPA SCIL lists hydroxyethyl cellulose as a Full Green Circle for the processing aids and additives function and this can meet our minimum and additional criteria for safer (OCSPP, 2013a).

This chemical is scored as Yellow in a verified Scivera GHS+ hazard assessment. Data gaps were noted for endocrine activity, neurotoxicity, and sensory irritation. Data for endocrine activity isn't required in our criteria, and reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. Data on sensory irritation isn't required in our criteria. Persistence was scored as high hazard for this polymer. All other hazard endpoints were scored as low hazard.

Safer process alternatives

Floor Cleaning with EPA Safer Choice Certified Products

Rather than using chemical alternatives in hard surface sealer products to provide functions such as oil resistance, oil repellency, or stain resistance, use a process alternative of promptly cleaning oiled or soiled surfaces using cleaning products containing safer chemistries. EPA Safer Choice Certified cleaning products are available and are marketed for use on a variety of hard surfaces (OCSPP, 2013b). EPA Safer Choice Certified cleaning products can meet our criteria for safer, and that meets our requirements for designation as a safer process alternative.

EPA Safer Choice Certified cleaning products that meet our criteria and can be used to clean oiled surfaces include:

- Krud Kutter House Wash by Rust-Oleum (Rust-Oleum Corporation, 2025).
- Professional Cleaner Degreaser Concentrated by Rust-Oleum (Rust-Oleum Corporation, n.d.).
- Husky 908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-a).
- Reliance Degreaser by SYSCO Corporation (Keystone, n.d.).

EPA Safer Choice Certified cleaning products that meet our criteria and can be used to clean soiled surfaces include:

- Professional Cleaner Degreaser Concentrated by Rust-Oleum (Rust-Oleum Corporation, n.d.).
- JAWS Professional 7908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-b).

- JAWS Professional 9908 PeroxAll Concentrated Peroxide Cleaner by Canberra Corporation (Canberra, n.d.-c).

This alternative process isn't without limitations. Applicability may vary depending on surface or surface area of intended use, but they are feasible and available for some applications.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

To demonstrate that the safer alternatives outlined above are feasible and available, we looked for products already on the market that use alternatives for the same functions as those identified for PFAS. Table 32 summarizes examples of hard surface sealers that use the safer alternatives identified, as well as examples of these chemicals sold for use as ingredients in products. This shows they are feasible and available for use in hard surface sealers.

Table 32: Feasibility and availability of safer alternatives for PFAS in hard surface sealers.

Chemical and CASRN	Functions	Example alternatives available in marketplace and/or sold to the public
2-Propenoic acid, 2-methyl-, polymer with butyl 2-propenoate and methyl 2-methyl-2-propenoate 25035-69-2	Water repellency	Matte 20 by Sinak* (SINAK, n.d.), DURAMUL™ 1533 by Synthomer (Synthomer, 2020)
Polybutene 9003-29-6	Water repellency	GENFLASH by 3GEN Masonry Products, Inc.* (3GEN Masonry Products, Inc., n.d.), Indopol® L-3 by Ineos Oligomers (INEOS Oligomers, 2024)
Triethoxy(2-methylpropyl)silane) 17980-47-1	Water repellency	1099 Silane by Perma Tint* (Permatint, n.d.), Isobutyltriethoxysilane by Silver Fern (Silver Fern Chemical Inc., n.d.)
Triethoxyoctylsilane 2943-75-1	Water repellency	L&M™ AQUAPEL PLUS™ by LATICRETE International* (LATICRETE International, 2026),GRAFFITI-SHIELD™ by W.R. Meadows of Canada* (Gemite, 2024), Andisil® 137 Silane by Dar-Tech (Dar-Tech, n.d.-a), Triethoxyoctylsilane by Bisley International LLC (Bisley International LLC, 2021)

Chemical and CASRN	Functions	Example alternatives available in marketplace and/or sold to the public
Triethoxyoctylsilane 2943-75-1	Oil repellency, stain/oil resistance, dirt repellence (anti-soiling or dirt pick-up resistance)	XIAMETER™ OFS-6341 Silane by Dow (The Dow Chemical Company, 2020), Silquest™ A-137 by Momentive (ChemPoint, 2026; Momentive, n.d.), DEA SILAN137 by SQ Quimica (SQ Quimica, n.d.), Husqvarna HTC Stain Protection (Husqvarna, 2023)
Siloxanes and Silicones, di-Me, hydroxy-terminated 70131-67-8	Water repellency, oil repellency, stain/oil resistance	Sure Klean® Custom Masonry Sealer* (PROSOCO, Inc., 2015) POLYMER FD 350 by WACKER® (Wacker, n.d.)
3-aminopropyltriethoxysilane 919-30-2	Water repellency	Resuprime® 3830/3835 Standard (Part B) Hardener by Sherwin Williams Co.* (Sherwin-Williams, 2026), GENIOSIL® GF 93 by Wacker (Wacker, 2024b)
Isobutyltrimethoxysilane 18395-30-7	Water repellency	PROSOCO® SL100 Water Repellent* (PROSOCO, Inc., 2021) SIL-ACT® ATS-190FD by ACT* (ACT, n.d.-b),SIL-ACT® ATS-22 by ACT* (ACT, n.d.-a), ATS-100 (ACT, 2021), Protectosil® 100 by Evonik (EVONIK, 2019)
Isobutyltrimethoxysilane 18395-30-7	Oil repellency, stain/oil resistance, Dirt repellence (anti-soiling or dirt pick-up resistance)	Protectosil® 100 by Evonik (EVONIK, 2019), SilaneSeal 100 (337) by Kaufman Products, Inc. (Kaufman Products, Inc., 2019)
Paraffin wax 8002-74-2	Water repellency	BEHR PREMIUM Water-Based Polyurethane Floor Finish – Satin* (BEHR, 2023), CERETAN® MT 8415 by MÜNZING (MÜNZING, 2025b), ULTRALUBE® CT 1348 by keim-additec surface LLC (keim-additec surface LLC, n.d.), OnWax® Micro 3920 by ITS USA Inc. (Integrated Chemical Specialties, n.d.)
Carnauba wax 8015-86-9	Water repellency	Liquid Carnuba Floor Wax by Correction Enterprises* (North Carolina Department of Adult Correction - Correction Enterprises, n.d.), CERETAN® MC 6015 by Munzing (MÜNZING, 2025a)

Chemical and CASRN	Functions	Example alternatives available in marketplace and/or sold to the public
Beeswax 8012-89-3	Water repellency	Looking Glass Beeswax Polish by Earthpaint Inc.* (Earthpaint Incorporated, 2014), 100% Beeswax by Fiebing Company (Fiebing Company, Inc., 2023)
Poly(vinyl alcohol) 25213-24-5	Oil repellency, stain/oil resistance	Stone Edge Surfaces Primer 100 by Stone Edge Surfaces*, Selvol™ Polyvinyl Alcohol 443 by Sekisui (Sekisui Specialty Chemicals, n.d.-b)
Silica gel, pptd., cryst.-free 112926-00-8	Oil repellency, stain/oil resistance	BENWOOD STAYS CLEAR ACRYLIC POLYURETHANE LOW LUSTER (W423) by Benjamin Moore & Co.*, SPHERILEX® DP-0115 by Evonik (EVONIK, n.d.-c)
Silica gel, pptd., cryst.-free 112926-00-8	Dirt repellence (anti-soiling or dirt pick-up resistance)	BEHR PRO® Concrete & Masonry Primer (PR060)* (BEHR, 2025b), Acematt TS 100 by Ataman chemicals (Ataman Chemicals, n.d.-a)
Polypropylene 9003-07-0	Dirt repellence (anti-soiling or dirt pick-up resistance)	H&C® SHARKGRIP® Slip-Resistant Additive by H&C Products Group*, Coathylene® PD 0580 by Axalta (Axalta, 2022)
Hydroxyethyl cellulose 9004-62-0	Dirt repellence (anti-soiling or dirt pick-up resistance)	BEHR PRO® Block Filler Primer (PR050)* (BEHR, 2025a), CELLOSIZE™ QP-30000H by Dow (Chempoint, n.d.)

* Example products that contain alternative.

Conclusions on alternatives

Reducing a significant source or use

We describe hard surface sealers as a significant source and use of PFAS in our report, Safer Products for Washington Cycle 1.5, Phase 3 Regulatory Determinations Technical Report (Ecology, 2024d). Hard surface sealers and the related category floor waxes and polishes can contain perfluoroalkyl carboxylic acids and fluorotelomer alcohols and fluoropolymers, which are types of PFAS. More recent work by Cousins et al. has also highlighted use of PFAS in commercial stone sealers, which are included in the hard surface sealers category (Savvidou et al., 2026). These products can contribute to release of persistent PFAS chemicals to the environment. Many PFAS are associated with hazards to human health and biota and some bioaccumulate.

Safer alternatives are feasible and available

We have identified safer alternative chemicals that can replace the functions of PFAS in hard surface sealers. These alternative chemistries are sold and used in various sealers products that are marketed for use on a wide range of hard surface types. This demonstrates hard surface sealers using safer alternative chemicals to PFAS being both feasible and available.

Regulatory determination

Our regulatory determination is that a restriction on use of PFAS in hard surface sealers should be adopted.

Ecology determined that safer alternatives to PFAS are both feasible and available. A restriction on the use of PFAS in hard surface sealers would reduce a significant use of PFAS and a source of exposure for people and the environment.

Chapter 8: OFRs in Insulation

Priority product scope

The scope of this priority product includes materials used in buildings to provide thermal insulation between indoor and outdoor spaces or between two indoor spaces, as defined in the Safer Products for Washington Cycle 2 Implementation Phase 2 reports (Ecology, 2025a, 2025b).

Materials used as thermal insulation may be installed in various places within buildings, such as floor ceiling assemblies, roof ceiling assemblies, wall assemblies, crawl spaces, and attics (DOE, 2024). Thermal insulation includes all types of insulation such as fiberglass, mineral wool, plastic foam insulation, among others.

Priority chemical scope

Organohalogen flame retardants (OFRs) were defined as a priority chemical class by the Washington State Legislature under RCW 70A.350.010[39] (Washington State Legislature, 2019). This includes all flame-retardant chemicals containing one or more halogen elements bonded to carbon.

OFRs are used mainly in plastic foam insulation, such as polystyrene foam (XPS, EPS), rigid polyurethane and polyisocyanurate (polyiso) foam boards, and polyurethane spray foam insulation.

Function of the priority chemical in the priority product

We found information on common OFRs and their functions in product safety data sheets (SDS), health product declarations (HPD) (HPD Collaborative, n.d.), EPA's Comptox database (EPA, n.d.-k), peer-reviewed journal articles, chemical commerce sites such as SpecialChem (SpecialChem, 2025e), and communication with manufacturers of insulation and flame retardants.

Flame retardant

OFRs are primarily used in plastic foam insulation as flame retardants to meet minimum mandatory fire safety requirements or flammability ratings specified in the Washington State Building Code, 2021 Chapter 51-50 WAC[40] (WBCC, n.d.-b) and Chapter 51-51 WAC[41] (WBCC, 2024a). The Washington State building code follows the International Building Code (IBC) (ICC, 2025a) and International Residential Code (IRC) (ICC, 2025b) with amendments specific to Washington State.

[39] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.350.010
[40] https://app.leg.wa.gov/wac/default.aspx?cite=51-50
[41] https://app.leg.wa.gov/WAC/default.aspx?cite=51-51

Flammability rating requirements for foam plastic insulation by construction type and applicable spaces such as interior or exterior walls, attics, crawls spaces, roofing, and floors are specified in the IBC and IRC. Plastic foam insulation materials are assigned a flammability rating in accordance with the ASTM E84 (ASTM, 2026a) or UL 723 (UL Standard, 2025) tests. These tests measure how quickly the flame travels through the surface of the material, also known as the flame-spread index (FSI), as well as how much smoke that material produces, which is known as the smoke development index (SDI). Class A is the highest rating achievable for insulation materials and may be required for use in some buildings and applications.

Viscosity diluent (processing aid)

Some OFRs such as TCPP used in polyurethane foam have a secondary function as a viscosity reducer during the processing phase, and act as a processing aid. The viscosity diluent function (processing aid) of TCPP is also identified by the flame retardant manufacturers in their product descriptions (ICL Industrial Products, n.d.-a). In a mixture of hydroxy functional groups (polyol) used in the reaction to produce polyurethane, TCPP reduces the intermolecular forces between the components, therefore reducing the viscosity of the polyol mixture and aiding the polymerization process (Gürkan & Yaman, 2023).

Some common OFRs used in different types of insulation and their functions are summarized in Table 33 below.

Table 33: Examples of OFRs in insulation foam and their functions.

Organohalogen Flame Retardant chemical	CASRN	Function(s)	Insulation material type
Brominated styrene-butadiene copolymer (Polymeric OFR)	1195978-93-8	Flame retardant	Polystyrene foam (XPS, EPS)
Hexabromocyclododecane* (HBCD)	25637-99-4	Flame retardant	Polystyrene foam (XPS, EPS)
Tetrabromophthalic acid mixed esters with diethylene glycol and propylene glycol (TBPA-diol mixed esters)	77098-07-8	Flame retardant	Rigid polyurethane (Albermarle, n.d.)
Tris(1-chloro-2-propyl) phosphate (TCPP)	13674-84-5	Flame retardant, viscosity diluent	Rigid polyurethane/ polyiso, polyurethane spray foam
Chlorinated paraffins	85535-85-9	Flame retardant	One part spray foam insulating foam sealant (CPID, n.d.-a)

*Historical use currently phased out voluntarily by the manufacturers (EPA, 2022; Minnesota Department of Health, 2024)

Other considerations for insulation as a product

To determine feasible alternatives to OFRs in insulation, we may consider other factors such as energy codes, moisture and air barrier properties, and compressive strength in addition to the flammability ratings, because all types of insulation products aren't compatible in all applications. These considerations are relevant when comparing different types of insulation materials as alternatives for specific applications.

Energy codes

Insulation materials need to meet minimum energy efficient standards for thermal insulation, according to the Washington State Energy Code (WSEC) Chapter 51-11C[42] (WBCC, 2024b) and Chapter 51-11R WAC[43] (WBCC, n.d.-c) in the Washington State Building Code (WBCC, n.d.-a). The standards closely follow the International Energy Conservation Code (IECC) (ICC, 2025c), which specifies the minimum thermal efficiency required according to the insulation application space.

Insulation materials are assigned R-values per inch of the material as a measure of thermal insulation efficiency. Foam plastic insulation materials that commonly use OFRs to meet fire safety standards often achieve higher R-values (Alaska Housing Finance Corporation, n.d.), which is an important consideration for construction of zero energy buildings (Peterson et al., 2025).

Air barrier

Spray foam products insulate and air seal without the need for secondary products. Spray foam can be used to fill gaps and stop air leaks in many areas of the home, such as attic hatches, windows, doors, wiring holes, and open soffits (Spray Foam Coalition, 2025). It can be applied continuously in attics, crawlspaces, basements, and on the exterior to provide air permeable insulation in high-performance energy star or net zero energy homes.

Continuous rigid polyiso insulation can serve an air barrier when integrated with other materials (facers) to form a continuous air barrier system within the building envelope, provided it is installed at a minimum half inch thickness and the joints are appropriately sealed (PIMA, n.d.-b). Applying continuous insulation via XPS rigid boards also provides the same benefits by preventing air leakage.

Water resistive barrier

With proper application and sealing, most of the plastic foam insulation we evaluated can have some water resistive barrier properties. In our communications with spray foam and XPS industry association groups, both have highlighted the moisture barrier properties of these types of insulation.

[42] https://app.leg.wa.gov/wac/default.aspx?cite=51-11C
[43] https://app.leg.wa.gov/wac/default.aspx?cite=51-11R

In addition to closed cell spray foam and XPS, polyiso continuous insulations are classified as water resistive barriers when the joints are properly sealed and taped along the top and bottom plates of the wall, around all openings, and integrated with window and door flashings (PIMA, n.d.-b).

Compressive strength

In certain insulation applications, such as under slabs in commercial applications of warehouses and in commercial roofing areas where there is expected foot traffic and equipment weight, the applicable insulation material is required to have some compressive strength to withstand the load on its surface. Plastic foam insulation such as XPS, EPS, and polyiso rigid boards (Extruded Polystyrene Foam Association, n.d.; Harborfoam, n.d.; PIMA, n.d.-a) are commonly used in these applications.

Hazards of the priority chemical class

We described the hazards associated with OFRs and determined they are a hazardous class of chemicals in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature (Ecology, 2022b). We approached OFRs as a chemical class and evaluated the hazards of OFRs based on those with sufficient hazard data.

Human health hazards of concern for data-rich OFRs include carcinogenicity and developmental toxicity. In addition, data-rich OFRs are associated with hazards including aquatic toxicity, persistence, and bioaccumulation. These associated hazards for data-rich OFRs indicated that OFRs didn't meet our minimum criteria for safer (Ecology, 2022b, 2022c). A polymeric OFR, butadiene styrene brominated copolymer, may be able to meet our minimum criteria based on a report on flame retardant alternatives to hexabromocyclododecane published by US EPA, but it doesn't meet our within-class criteria due to very high environmental persistence (EPA, 2014a).

Based on the determination in 2022 that OFRs are a hazardous class of chemicals, alternatives outside of the OFRs class need to meet our minimum criteria to be considered safer. OFRs would need to meet our minimum criteria and within-class criteria to be considered safer.

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). In order to find safer chemical flame retardant alternatives in plastic foam insulation, we searched for alternatives to OFRs compatible with plastic foam insulation in commercial flame retardant websites like SpecialChem (SpecialChem, 2025e). We also reviewed ingredients of commercial flame retardants marketed for these uses. Table 34 below provides a list of commercially available flame retardants that are advertised to be compatible with plastic foam insulation products in scope.

Table 34: Alternatives to OFRs with hazard assessment scores and Criteria for Safer tier.

Chemical and CASRN	Trade names	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Triethyl phosphate 78-40-0	Levagard TEP-Z	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band D	Minimum
Ammonium polyphosphate (Type II) 68333-79-9	MFLAM AP230, Exolit AP422A	ChemFORWARD Hazard Band SC (requires trade name), GreenScreen BM-3, Scivera GHS+ [Green/Yellow]	Minimum
Diethoxyphosphoryl methanol 3084-40-0	Veriquel R100	GreenScreen BM-2	Minimum

Triethyl phosphate (CASRN: 78-40-0)

This chemical meets our minimum criteria for safer.

Triethyl phosphate scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2025i), and this meets our minimum criteria for safer. Data gaps were noted for endocrine activity and respiratory sensitization. Data on endocrine activity isn't required in our criteria, and both reproductive toxicity and developmental toxicity scored as low hazard. The data gap for respiratory sensitization is allowable, as dermal sensitization scored as low hazard. Acute toxicity was scored as moderate hazard for the oral route, but low hazard for the inhalation and dermal routes. Eye irritation was scored as high hazard. All other endpoints were scored as low hazard, including persistence and bioaccumulation.

A ChemFORWARD hazard assessment scored triethyl phosphate as a Hazard Band D chemical (ChemFORWARD, 2022b). Hazard Band D chemicals can meet our minimum criteria for safer in some cases but require additional analysis. The assessment noted data gaps for reproductive and developmental toxicity for the dermal and inhalation routes but assigned a score of moderate for reproductive toxicity (GHS Category 2) and a score of low for developmental toxicity for the oral route of exposure.

Data gaps were assigned for systemic toxicity (single-dose) for the dermal and oral routes, but the inhalation route was scored as low hazard. Systemic toxicity (repeat-dose) was scored as low hazard for the oral route but assigned a data gap for the dermal and inhalation routes. Neurotoxicity (single-dose) was scored as moderate (GHS Category 3) for the oral and inhalation routes and assigned a data gap for the dermal route. Neurotoxicity (repeat-dose) was scored as low for the oral route and assigned a data gap for the dermal and inhalation routes. The assignment of Hazard Band D by ChemFORWARD was based on the worst individual hazard

endpoint ratings for carcinogenicity, reproductive toxicity, and other (human health) due to classification as a volatile organic compound (VOC).

A GHS Category 2 classification (H351, suspected carcinogen) for carcinogenicity was assigned based on a combination of surrogate and modeling data. In our criteria for safer, a GHS Category 2 classification for carcinogenicity correlates to a moderate hazard score. A GHS Category 2 classification (H361, suspected reproductive toxicant) was assigned for the reproductive toxicity endpoint based on a combination of surrogate data and a non-guideline mating study in rats.

In our criteria for safer, a GHS Category 2 classification for reproductive toxicity correlates to a moderate hazard score. Our minimum criteria for safer allows a score of moderate for carcinogenicity and for reproductive toxicity. Therefore, triethyl phosphate meets our minimum criteria for safer based on further analysis of the information provided in the ChemFORWARD assessment.

Ammonium polyphosphate (Type II, CASRN: 68333-79-9)

This chemical meets our minimum criteria for safer.

Ammonium polyphosphate was scored as a BM-3 polymer in a GreenScreen hazard assessment and meets at least our minimum criteria for safer (ToxServices LLC, 2020a). The assessment is specific to what is described as Type II ammonium polyphosphate, characterized by a high molecular weight, decomposition temperature of 300°C, lower water solubility, and a composition of 50 to 1,000 phosphate units—this is sold by Clariant under the trade name Exolit® AP 422. This contrasts with Type I ammonium polyphosphate, which is characterized by a lower molecular weight, decomposition temperature of 150°C, higher water solubility, and a composition of less than 100 phosphate units. The assessment noted a data gap for endocrine activity but scored both reproductive and developmental toxicity as low hazard. A very high hazard score was assigned for persistence based on an expected half-life of greater than 180 days in the soil and sediment and a hydrolysis half-life of greater than one year for chemical surrogates (several phosphates, pyrophosphates, and a sulfate with related chemical structures).

A ChemFORWARD hazard assessment scored ammonium polyphosphate (MW ≥ 1000) as a Hazard Band SC chemical (ChemFORWARD, 2020a). Hazard Band SC or ”special conditions” chemicals are characterized by a CHA where additional information is required to determine the hazard score for use in any application. The assessment noted data gaps for carcinogenicity and endocrine activity but determined there was a low potential for these hazards based on the large molecular weight and minimal residual monomer content.

Data gaps were assigned for developmental and reproductive toxicity via the oral and inhalation routes, repeated systemic toxicity and neurotoxicity for all exposure routes, and respiratory irritation and sensitization. Reproductive and developmental toxicity were scored as low hazard for the dermal route, and single-dose neurotoxicity (oral and inhalation routes) and systemic toxicity (oral route only) were assigned low hazard.

This assessment doesn't meet our minimum criteria for safer on its own, but it does provide additional information that supports the overall conclusion that ammonium polyphosphate meets our minimum criteria.

A verified Scivera GHS+ assessment scored ammonium polyphosphate as a Green/Yellow chemical, and this meets at least our minimum criteria for safer (Scivera, 2022d). The assessment noted data gaps for endocrine activity and respiratory sensitization. Endocrine activity is not required to meet our minimum criteria, and both reproductive toxicity and developmental toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization as scored as low hazard. All other hazard endpoints were scored as low or moderate hazard.

Diethoxyphosphorylmethanol (CASRN: 3084-40-0)

This chemical meets our minimum criteria for safer.

Diethoxyphosphorylmethanol scored as BM-2 chemical in a certified GreenScreen hazard assessment, and this meets our minimum criteria for safer. The assessment was contracted by ICL Group, who produces diethoxyphosphorylmethanol under the trade name VeriQuel™ R100 for use as a flame retardant, and provided to Ecology (Gradient, 2025). The assessment was prepared by toxicologists at Gradient and certified by a Licensed GreenScreen Profiler. The assessment notes a data gap for respiratory sensitization, but skin sensitization was scored as low hazard. Systemic toxicity scored as moderate hazard based on Taiwan's GHS classification for this chemical as Specific Target Organ Toxicity – Single Exposure – Category 3 for respiratory irritation; there was no additional data available for this endpoint. Persistence scored as very high based on experimental data in surface water from an OECD TG 309 study, which showed that VeriQuel™ R100 doesn't degrade in water. All other endpoints were scored as low or very low hazard.

Safer material alternatives

Material alternatives are insulation materials other than plastic foam used for providing thermal insulation in buildings. These materials don't require the OFRs to achieve the flammability ratings required in the building codes. Material alternatives may be inherently flame-resistant materials that require no flame retardants or that use safer alternatives. While various material alternatives can be used to replace plastic foam insulation, they may not be feasible in all applications.

Material alternatives were found on Habitable's "Guidance for specifying healthier insulation and air sealing materials" document (Healthy Building Network, 2019), and from alternative insulation material product websites. While the guidance document from Habitable considered all types of chemicals in insulation (Healthy Building Network, 2019), our analysis is based on chemicals providing the flame retardant function, or in the case of inherently flame resistant materials on hazards of the material itself. Some of the material alternatives are discussed below.

Glass fibers: fiberglass, mineral wool, stool wool (i.e., glass, oxide, chemicals) (CASRN: 65997-17-3)

These chemicals can meet our minimum criteria for safer.

Glass fibers are included on the US EPA Safer Chemicals Ingredients List as a Full Green Circle under the processing aids and additives functional use, and this can meet our minimum or additional criteria for safer (OCSPP, 2013a).

The CASRN 65997-17-3 encompasses several types of inorganic glass materials. These substances are commonly referred to as fiberglass, glass wool, mineral wool, and stone wool. These are inorganic mineral fiber insulation materials produced by melting natural raw materials such as glass, rock, or slag and spinning them into non-combustible fibers. These materials aren't flame retardants but are inherently flame-resistant materials commonly used as insulation. There are some additional considerations for hazard assessment of these materials as described below.

These materials are scored as a [Red] chemical in a Scivera GHS+ hazard assessment (Scivera, 2023c). The [Red] score generally wouldn't meet our minimum criteria for safer. However, the CASRN associated with this chemical can represent a range of materials, and available information suggests this variability relates to their toxicity. Data gaps were identified in the assessment for endocrine activity, neurotoxicity, and sensory irritation. Data on endocrine activity isn't required in our criteria, and both reproductive and developmental toxicity were scored as low hazard. The data gap for neurotoxicity is allowable as systemic toxicity was scored as moderate hazard. All other relevant endpoints were scored as a low hazard. These materials were scored as [Red] due to a high hazard score for carcinogenicity. However, the carcinogenicity of this material is related to whether glass fibers can be cleared by the lung following inhalation.

Glass fibers which aren't bio-persistent aren't anticipated to be carcinogenic, whereas bio-persistent fibers are associated with carcinogenicity (National Toxicology Program, 2021; OEHHA, 2015b). This was described in an updated review of these materials by the US National Toxicology Program in 2011, which focused the listing for carcinogenicity to "Glass wool fibers (inhalable and biopersistent)." This finding was subsequently adopted as a revision to the CA Proposition 65 listing for these materials, thereby no longer requiring a Prop 65 warning label for insulation products that use bio-soluble (non-biopersistent) glass fibers, although the warning may still be required for other chemicals used in these products.

Similar to this finding, European Union allows testing either in a cancer bioassay or short-term bio persistence test and a negative result can exempt glass fibers from a carcinogenicity classification (European Union, 1997). Insulation materials can be made with glass wool fibers that are bio-soluble and meet the European Union's exemption criteria for glass fibers (ECHA, n.d.-c; Knauf Insulation, n.d.-a; pink batts, n.d.). Fibers that meet the criteria from European Union aren't anticipated to be carcinogenic, and are listed under the identifying EC number 926-099-9 (ECHA, n.d.-c) along with trade names.

This information resolves the initial concern for potential carcinogenicity of these materials highlighted in the Scivera assessment. Therefore, bio-soluble glass fibers used in insulation products meet our minimum criteria for safer.

Other material alternatives still under assessment:

We are still evaluating if material alternatives such as wood fiber, sheep's wool, hemp fiber, cellulose, expanded cork boards, and magnesium oxide cement spray foam are suitable for certain insulation applications. Some of these material alternatives may also use added flame retardants to meet fire safety standards. We will need to assess these flame retardants to see if they can meet our minimum criteria for safer as part of our continued work. We are aware that some of these material alternatives may use boric acid or borate-based chemicals as flame retardants and pest deterrents. Boric acid likely doesn't meet our minimum criteria for safer, as it has a harmonized classification as a reproductive toxicant under ECHA CLP (Repr. 1B, H360FD), and this corresponds to a high hazard for reproductive toxicity in our criteria for safer.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Available chemical alternatives

We looked for halogen-free flame retardants that were advertised as compatible with plastic foam insulation products on flame retardant manufacturer websites and chemical websites such as SpecialChem (SpecialChem, 2025e). These halogen-free flame retardants that met our minimum criteria for safer are considered safer and available alternatives.

Available halogen-free flame retardants that met our minimum criteria for safer with their trade names and applicable types of foam are listed in Table 35 below.

Table 35: List of available chemical flame-retardant alternatives.

Chemical and CASRN	Trade names	Compatible foam types	Function
Triethyl phosphate 78-40-0	Levagard TEP-Z (LANXESS, n.d.)	Polyurethane, polyiso	Flame retardant, viscosity diluent
Diethoxyphosphorylmethanol 3084-40-0	Veriquel R100 (ICL Industrial Products, n.d.-b)	Polyiso rigid foam, polyurethane, spray foam	Flame retardant, viscosity diluent
Ammonium polyphosphate (Type II) 68333-79-9	MFLAM AP230 (MEI WANG, n.d.), Exolit AP422A (Clariant, n.d.-b)	Polyurethane, polyiso	Flame retardant

Feasible chemical alternatives

Available chemical alternative flame retardants listed in Table 35 are considered feasible if insulation products that use these chemicals as flame retardants are available for sale in the US market and can achieve a UL Class A rating (the highest fire rating). Consequently, an insulation product available for sale in the United States that uses an alternative flame retardant we determined meets our minimum criteria for safer demonstrates that the alternative is safer, feasible, and available.

To find insulation products with safer, feasible, and available flame retardants, we looked for full ingredient disclosure of insulation products in the product safety data sheets (SDSs), and health product declarations (HPDs). However, we found that most manufacturers of non-halogenated plastic foam insulation products didn't list their flame-retardant ingredients in the SDSs or HPDs. Next, we looked for feasible non-halogenated insulation products in the Declare database (Declare, n.d.). We looked for flame-retardant ingredients listed in the third-party verified Declare labels of these products to determine whether they used alternatives that met our minimum criteria for safer.

Available certified declare labels are categorized as (Declare, n.d.):

- Living Building Challenge (LBC) Red List Free: 100% of ingredients above 100 ppm in the final product disclosed and doesn't contain any LBC Red List chemicals.
- LBC Red list Approved: A minimum of 99% of ingredients present in the final product disclosed but may contain one or more red list chemical with an approved exception.
- Declared: 100% of ingredients in the final product disclosed but contains one or more red list chemicals without an approved exception.

LBC Red List Free and Declared products were considered evidence of safer, feasible, and available alternatives if they only used flame retardants that meet our minimum criteria for safer or didn't contain flame retardant chemicals.

We found several non-halogenated polyiso foam board insulation products in the Declare database. These products are advertised for use in roofing applications and can meet a UL Class A fire rating for building insulation (the highest level).

We identified several non-halogenated polyiso boards with an LBC Red List Free label that had contained no flame retardants. We considered these products to be safer, feasible, and available. We also identified one other product with Declare Red List Approved label that listed triethyl phosphate as the flame retardant, which meets our minimum criteria for safer.

Feasible alternative polyiso insulation products with halogen free flame retardants or no flame retardants are listed in Table 36 below.

Table 36: Feasible alternative polyiso insulation products.

Insulation type	Alternative FR	Application space	Insulation product	Achievable UL Rating
Rigid polyiso	Triethyl phosphate (Declare Label)	Roofing systems, Walls	Dupont Thermax NH (DuPont, 2022)	Class A (DuPont, n.d.)
Rigid polyiso	No FR reported (Declare Label)	Roofing systems	Versico NH (Versico, 2026), InsulBase NH (Carlisle SynTec Systems, 2017)	Class A (Carlisle, n.d.; Versico, n.d.)

Veriquel R100 is another reactive flame retardant that is designed to be a drop-in replacement for TCPP in polyurethane foam (ICL Industrial Products, n.d.-b). It has been reported to us by a chemical manufacturer that it has been shown as feasible for rigid polyiso and polyurethane boards in a controlled factory environment (ICL Industrial Products, n.d.-b). Additionally, the chemical manufacturer shared that it is already in use in the US market, however they couldn't disclose the specific insulation products that use this alternative. If an insulation product manufacturer that uses Veriquel R100 disclosed that information to us, it would meet our requirements as safer, feasible, and available. However, without additional evidence of use in a product on the market we can't demonstrate it as feasible at this time.

Manufacturers have also shared their view that some other FRs products available on the market for rigid polyiso/polyurethane foams are not feasible for their products. Exolit AP422A (ammonium polyphosphate) is advertised as a suitable replacement to n-pentane blown rigid PIR/PUR foams (Clariant, n.d.-b), but the European manufacturer of the flame retardant has told us that the market for this product is currently nonexistent in the US, and we were unable to find a product to demonstrate it is feasible (H. Champion & S. Waldemar, personal communication, September 23, 2025).

While safer chemical alternative FRs are advertised as available for all other types of plastic foam insulation, we could not demonstrate they were feasible in on-site spray foam

polyurethane, or XPS and EPS polystyrene rigid foams. We could not find any insulation products of these types on the US market that used the safer alternatives we identified.

Chemicals such as triethyl phosphate and Veriquel R100 are advertised as being compatible with spray foam, but manufacturers have told us that they cannot achieve the same flammability rating in spray foam formulations without the use of additional brominated diols, especially in open cell low pressure spray foam applications (M. Goode, personal communication, August 15, 2024). Therefore, we need more information on the different types of spray foam insulation and applications where Veriquel R100 can be used to better understand its feasibility.

Aluminum hypophosphite (CASRN: 7784-22-7), an inorganic phosphorous-based chemical, available under the trade name EVERFLAM HPAL, is advertised as being compatible with XPS and EPS foams (Everkem s.r.l, 2024). However, industry groups have told us that polystyrene foam products like XPS and EPS with non-halogenated FRs are not feasible due to processing difficulties, as well as not enough flame retardancy with incorporating inorganic phosphorous compounds in polystyrene foam (EPA, 2014b). We didn't find any non-halogenated XPS and EPS insulation products for sale in the Declare database and or in our general search.

Feasible and available material alternatives

We also looked for material alternatives in the Declare database to determine whether they were feasible and available. Declare Red List Free and Red List Approved glass fiber-based insulation products were considered safer, feasible, and available if they contained no flame retardants and were advertised to meet a UL Class A rating (the highest fire rating).

Safer, feasible, and available material alternatives found through the Declare are listed below in Table 37.

Table 37: Safer, feasible, and available material alternatives to plastic foam insulation products.

Insulation material	Insulation Product	Certification Criteria	Achievable UL Rating
Mineral wool	Knauf Ecobatt (Knauf Insulation, n.d.-b)	Declare: Red list free	Class A (Knauf Insulation, 2025)
Stone wool	Rockwool AFB evo (Rockwool, n.d.)	Declare: Red list free	Class A (Rockwool, 2026)
Fiber glass	AttiCat®, PROPINK® FIBERGLAS® Expanding Blown-in, and ProCat™, PROPINK® L77 Loosefill Insulation (Owens Corning, 2016a)	Declare: Red list approved	Class A (Owens Corning, 2026a)
Fiber glass	PINK NEXT GEN™ FIBERGLAS™ Unfaced Batts and Rolls (Owens Corning, 2016b)	Declare: Red list approved	Class A (Owens Corning, 2026b)

While material alternatives, such as mineral wool and fiberglass, can be used instead of plastic foam insulation in certain applications, these materials aren't expected to completely replace them. This is, in part, because the application of plastic foam insulation is currently considered a more efficient way to achieve maximum thermal efficiency (i.e., energy codes) with additional air and water resistive barrier properties. Also, in applications where compressive strength is required non-plastic foam insulation options are currently limited.

As indicated earlier, we are still evaluating if other material alternatives not limited to wood fiber, sheep's wool, hemp fiber, cellulose, expanded cork boards, and magnesium oxide cement spray foam can meet our criteria for safer (Ecology, 2022c). We will examine the applications or use case scenarios of these alternative materials to see if they can be a feasible and available alternative to insulation that use OFRs for some applications. This evaluation will continue in the next cycle of Safer Products for Washington.

Conclusions on alternatives

Reducing a significant source or use

We described insulation products as a significant source and use of OFRs in our previous reported entitled Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025a). Briefly, OFRs are commonly used in foam plastic insulation products at concentrations up to 45%. Foam plastic insulation is used

in many building projects, including around 22% of single-family housing (Home Innovation Research Labs, 2019).

The Washington State Department of Commerce estimates that over 1.1 million new homes will be needed to keep pace with housing needs in the state (COM, 2023). Together, this demonstrates insulation products, including rigid polyiso products, are a significant source and use of OFRs and a restriction on OFRs in rigid polyiso products would reduce a significant source and use of OFRs.

Safer alternatives are feasible and available for some applications

In our analysis, we have identified rigid polyiso boards used in roofing assemblies with no organohalogen FRs that are safer, feasible, and available. These products are likely feasible for wall assemblies as well, but we don't have adequate information to demonstrate their market availability in the US at present.

Chemical alternatives to flame retardant TCPP in spray foam insulation are safer and available, but we couldn't confirm they're feasible. Chemical alternatives to brominated flame retardant for XPS and EPS polystyrene foam are also available, but we couldn't confirm they are feasible.

Material alternatives, such as fiberglass and mineral wool, are safer and available for some applications, but may not be compatible with all applications. We plan to expand our understanding of their feasibility across applications as part of our continued work.

Regulatory determinations

Our regulatory determination is that a restriction for OFRs in rigid polyiso foam insulation used in roofing assemblies should be adopted.

We recognize that only a subset of the polyiso market has shifted to use safer alternatives. With this in mind, we will work during rulemaking to determine a reasonable implementation timeframe for restriction and invite input from polyiso manufacturers.

For other types of insulation products, our regulatory determination is that a reporting requirement should be adopted.

We plan to extend our analysis of insulation into Cycle 3 of Safer Products for Washington to further evaluate whether safer alternatives are feasible and available for other insulation applications. We encourage manufacturers to continue to innovate and work toward moving away from OFRs broadly in insulation products.

Chapter 9: Lead and Lead Compounds, and Cadmium and Cadmium Compounds in Jewelry and Accessories

Priority product scope

As defined in the Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b), the scope of this priority product included articles and accessories intended to be worn by a person, and kits to make jewelry and accessories sold to consumers. Examples of jewelry include, but are not limited to ,rings, necklaces, watches, hair accessories, body piercings, and decorative clothing attachments.

Priority chemicals scope

Lead and lead compounds, as well as cadmium and cadmium compounds were previously defined as priority chemical classes during Safer Products for Washington Cycle 2 Implementation Phase 1 (Ecology, 2024c).

Washington has already restricted lead and lead compounds, as well as cadmium and cadmium compounds in children's products, which included children's jewelry, through the Children's Safe Product Act (CSPA) (Ecology, n.d.-a, n.d.-c, 2023b).

Functions of the priority chemicals in the priority product

At the **chemical level**, lead and cadmium compounds could be used as heat stabilizers for plastics (DTSC, n.d.-e; Ecology, 2025b; Minnesota Pollution Control Agency, n.d.), specifically polyvinyl chloride (PVC), wire, and cables (Baerlocher, 2013; International Programme on Chemical Safety, n.d.; TURI, 2006). PVC wire or cables can be used for jewelry or accessories (Best Beads Chain & Leather, n.d.; MandalaCraftsInc, n.d.).

At the **material level**, lead and lead compounds, as well as cadmium and cadmium compounds, could be used to make the jewelry shiny or brighter in color, and to make jewelry or accessories heavier (i.e., as a base material for the jewelry or accessories) (DTSC, n.d.-e, n.d.-b; Minnesota Pollution Control Agency, n.d.).

Hazards of the priority chemical classes

We describe the hazards associated with lead and lead compounds, as well as cadmium and cadmium compounds, in our Cycle 2, Phase 2 Technical Supporting Documentation for Priority Consumer Products (Ecology, 2025b).

Hazards of concern for lead and lead compounds include carcinogenicity, reproductive and developmental toxicity, neurotoxicity, and ecological toxicity. Hazards of concern for cadmium and cadmium compounds include carcinogenicity, reproductive and developmental toxicity, systemic toxicity (e.g., organs, tissues), and ecological toxicity. These hazards indicate that lead and lead compounds, as well as cadmium and cadmium compounds, don't meet our minimum criteria for safer (Ecology, 2022b).

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). We consulted the U.S. EPA Safer Chemical Ingredients List (EPA SCIL) (OCSPP, 2013a), and the Pharos database (Pharos, n.d.-b), to initially identify potential alternatives to lead and cadmium compounds for the function of PVC wire and cables heat stabilizer. We performed web searches (Google, n.d.) to further identify potential alternatives to lead and cadmium compounds in jewelry and accessories for the heat stabilizer function. Based on these efforts, we came up with an initial list of alternatives.

To add to the initial list of alternatives, we examined the different products/use categories already compiled in the U.S. EPA CompTox Chemicals Dashboard (EPA, n.d.-k; A. J. Williams et al., 2017), which was based on prior U.S. EPA efforts to catalogue and define the functions of chemicals used in consumer products (Dionisio et al., 2018; Isaacs et al., 2016; Phillips et al., 2017). We consulted a prior alternative assessment performed by the Federal Institute for Occupational Safety and Health in Germany through the Substitution Support Portal (SUBSPORT) (BAuA, n.d.).

Once the list potential safer chemical alternatives was collated, we screened them using chemical hazard assessments, such as EPA SCIL, Scivera GHS+, ChemFORWARD, and GreenScreen®, to determine if they met at least our minimum criteria for safer (Ecology, 2022c).

Selected safer chemical alternatives were listed below (Table 38). For simplicity, only alternatives that met at least our minimum criteria for safer and that are feasible and available as described in subsequent sections were added to Table 38.

Table 38: Chemical alternatives to lead and cadmium compounds for PVC wire and cables heat stabilizers in jewelry and accessories.

Chemical and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Magnesium oxide 1309-48-4	EPA SCIL Full Green Circle (processing aids and additives)	Minimum
Calcium stearate 1592-23-0	EPA SCIL Full Green Circle (processing aids and additives), GreenScreen® BM-3, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band B	Additional
Epoxidized soybean oil 8013-07-8	EPA SCIL Full Green Circle, GreenScreen® BM-3, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band B	Additional
Acetyl tributyl citrate 77-90-7	GreenScreen® BM-3, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band C	Additional

Explanations on how the inclusion of these chemicals on EPA SCIL or on how the verified Scivera GHS+ or ChemFORWARD hazard assessment scores corresponded to our minimum or additional criteria for safer can be found in our previous reports.(Ecology, 2022c, 2022b) Further discussions on the chemical hazard assessment of selected safer chemical alternatives are provided below.

Magnesium oxide (CASRN: 1309-48-4)

This chemical met our minimum criteria for safer.

Magnesium oxide is listed on EPA SCIL as a Full Green Circle for the processing aids and additives functional use (OCSPP, 2013a). The functional use criteria for processing aids and additives used by EPA SCIL meets our minimum or additional criteria for safer (Ecology, 2022c). Magnesium oxide is an inorganic substance and is inherently very persistent.

Calcium stearate (CASRN: 1592-23-0)

Calcium stearate meets our additional criteria for safer.

Calcium stearate is listed on EPA SCIL as a Full Green Circle for the processing aids and additives functional use (OCSPP, 2013a). The functional use criteria for processing aids and additives used by EPA SCIL can meet our minimum or additional criteria for safer.

Calcium stearate scored BM-3 in a GreenScreen® assessment as listed on the Swedish Confederation of Professional Employees (TCO) Certified Accepted Substance List (TCO, n.d.). According to Regulatory Determinations Report to the Legislature for Safer Product for

Washington Cycle 1 Implementation Phase 3,[44] a chemical listed on TCO Certified Accepted Substance List with GreenScreen® BM-3 met our additional criteria for safer.

Calcium stearate was scored as a Green/Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021h), indicating calcium stearate met our additional criteria for safer. The assessment noted a data gap for endocrine activity. Reproductive toxicity and developmental toxicity were scored as low hazard with high confidence. Data for endocrine activity isn't required in our criteria. Further data gaps were noted for neurotoxicity and respiratory sensitization. This data wasn't needed to meet our additional criteria for safer as the assessment had data on acute and systemic toxicity, and skin sensitization.

Calcium stearate was assigned Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2022a), which indicated that calcium stearate met our additional criteria for safer. The assessment noted data gaps for carcinogenicity (dermal and inhalation), reproductive and developmental toxicity (inhalation), endocrine activity, systemic toxicity (repeat-dose, inhalation), neurotoxicity, respiratory sensitization and respiratory irritation. Carcinogenicity was scored as low hazard for the oral route, and reproductive and developmental toxicity were scored as low hazards for the oral and dermal routes. Systemic toxicity (single- and repeat-dose) and neurotoxicity (single- and repeat-dose) were scored as low hazards for the oral and dermal routes. Our criteria for safer doesn't require data for all routes of exposure, and the low hazard scores reported for other routes of exposure are sufficient to meet our data requirements. We don't require data for respiratory sensitization because skin sensitization was scored as low hazard. Data on endocrine activity and respiratory irritation were not required to meet our additional criteria for safer.

When considered together, these hazard assessments indicated that calcium stearate met our additional criteria for safer.

Epoxidized soybean oil (CASRN: 8013-07-8)

This chemical met our additional criteria for safer.

The EPA SCIL scored epoxidized soybean oil as a Full Green Circle using the master criteria (OCSPP, 2013a). Chemicals that meet the EPA SCIL master criteria meet our additional criteria for safer.

Epoxidized soybean oil scored BM-3 in a GreenScreen® assessment according to TCO Certified Accepted Substance List.(TCO, n.d.) Chemicals listed on TCO Certified Accepted Substance List with GreenScreen® BM-3 can meet our additional criteria for safer.

Epoxidized soybean oil scored as a Green/Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021v), indicating epoxidized soybean oil met our additional criteria for safer. The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity isn't required to meet the additional criteria for safer. Data gaps were noted for acute inhalation toxicity,

[44] https://apps.ecology.wa.gov/publications/SummaryPages/2204018.html

neurotoxicity, and sensory irritation. Acute toxicity was scored as low hazard for the oral and dermal routes of exposure, and this meets our data requirements. Data for neurotoxicity isn't required as systemic toxicity was scored as low hazard. Data on sensory irritation isn't required in our criteria (Ecology, 2022c).

Epoxidized soybean oil was assigned Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2019d), which indicated that epoxidized soybean oil met our additional criteria for safer. No human health or environmental hazards were identified for this chemical. Data gaps were noted for carcinogenicity (inhalation), reproductive and developmental toxicity (dermal and inhalation), endocrine activity, acute toxicity (inhalation route) systemic toxicity (single-dose inhalation, repeat-dose dermal and inhalation) and neurotoxicity (single-dose inhalation, repeat-dose dermal and inhalation). Endocrine activity isn't required to meet our additional criteria for safer. Carcinogenicity, reproductive toxicity, developmental toxicity, acute toxicity, and systemic toxicity, and neurotoxicity were all scored as low hazard based on other routes of exposure and this fulfills our data requirements.

Acetyl tributyl citrate (CASRN: 77-90-7)

This chemical met our additional criteria for safer.

Acetyl tributyl citrate scored BM-3 in a GreenScreen® assessment (ToxServices LLC, 2023a), indicating it meets our additional criteria for safer. Assessors noted a data gap for endocrine activity and neurotoxicity (single-dose). Endocrine activity isn't required to meet our additional criteria for safer. The data gap for neurotoxicity (single-dose) is allowable as neurotoxicity (repeat-dose) and systemic toxicity (single-dose and repeat-dose) were scored as low hazard and this fulfills our data requirements. This chemical received a high hazard score for acute aquatic toxicity and moderate hazard for chronic toxicity. In addition, assessors assigned moderate hazard score for persistence and very low hazard for bioaccumulation.

Acetyl tributyl citrate scored as a Green/Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2023e), indicating this chemical met our additional criteria for safer. The assessment noted data gaps for endocrine activity, acute toxicity (inhalation only), respiratory sensitization, neurotoxicity, and sensory irritation. Endocrine activity isn't required to meet our additional criteria for safer. Further, data for acute toxicity for all routes of exposure weren't required, and that the assessment scored acute toxicity for dermal and oral exposure as low, so this chemical met our data requirements. A data gap for respiratory sensitization was allowed as skin (dermal) sensitization was scored as low hazard. Data on sensory irritation isn't required in our criteria. Data for neurotoxicity isn't required because systemic toxicity scored as low hazard.

Furthermore, this chemical scored Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2019a) according to Safer Product for Washington Cycle 1 Implementation Phase 3 (Ecology, 2022b). Since publication of that report, the assessment score has been updated and assigned Hazard Band C (ChemFORWARD, 2019a). No other changes to the assessment were noted and it appeared that the shift in scoring was due to the high hazard score for aquatic toxicity. The assessment identified acute and chronic aquatic toxicity data consistent with a GHS Category 2 classification.

Our additional criteria for safer only allows for high hazard scores for acute and chronic aquatic toxicity if persistence and bioaccumulation don't score as high hazard. The data on persistence for this chemical is consistent with a moderate hazard score, and the modeling data on bioaccumulation indicates low hazard. There was a data gap for neurotoxicity (single-dose), but neurotoxicity (repeat-dose) scored as moderate hazard. There was a data gap for endocrine disruption, but this endpoint wasn't required to meet our criteria for safer, and both reproductive and developmental toxicity were scored as low hazard based on the oral route. As such, a review of this assessment further confirmed it met our additional criteria for safer.

Safer material alternatives

We consulted the list of jewelry materials published by the California Department of Toxic Substances Control (DTSC) (DTSC, n.d.-c), and a prior alternative assessment listed on SUBSPORT (BAuA, n.d.) to determine safer material alternatives to lead and lead compounds, as well as cadmium and cadmium compounds for the functions of to make the jewelry shiny or brighter in color and to make jewelry or accessories heavier (i.e., as a base material for the jewelry or accessories).

Selected safer material alternatives are listed below in Table 39. For simplicity, only alternatives that are safer, but also feasible and available as described in subsequent sections, were added to Table 39.

Table 39: Material alternatives to lead, lead compounds, cadmium and cadmium compounds.

Material and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Calcium carbonate 471-34-1	EPA SCIL Full Green Circle (processing aids and additives), Scivera GHS+ [Yellow]	Minimum
Zirconium dioxide 1314-23-4	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Titanium (non-nano) 7440-32-6	ChemFORWARD Hazard Band C	Minimum
Niobium (non-nano) 7440-03-1	ChemFORWARD Hazard Band B	Minimum
Magnesium carbonate 546-93-0	EPA SCIL Full Green Circle (processing aids and additives)	Minimum
Stainless steel (304 or 316L grade) CASRN: NA	NA (see discussion)	Minimum

Material and CASRN	Hazard Assessment Scores	Tier met in our criteria for safer (minimum or additional)
Biological materials CASRN: NA	NA (see discussion)	Minimum

Explanations on how the inclusion of these materials on EPA SCIL or on how the verified Scivera GHS+ or ChemFORWARD hazard assessment scores corresponded to our minimum or additional criteria for safer could be found in our previous reports (Ecology, 2022c, 2022b). Further discussions on the chemical hazard assessment of selected safer material alternatives were provided below.

Calcium carbonate (CASRN: 471-34-1)

This chemical meets our minimum criteria for safer.

Calcium carbonate is listed on the EPA SCIL as a Full Green Circle for the processing aids and additives functional use (OCSPP, 2013a). The functional use criteria for processing aids and additives used by EPA SCIL can meet our minimum or additional criteria for safer.

Calcium carbonate was scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2020d), indicating calcium carbonate could meet our additional criteria for safer. The assessment noted a data gap for endocrine activity, but reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity isn't required in our criteria for safer. Data gaps were noted for neurotoxicity, respiratory sensitization, and sensory irritation. The data gap for neurotoxicity is allowable as systemic toxicity and acute toxicity were scored as low hazard. Data for respiratory sensitization isn't required because dermal sensitization was scored as low hazard. Data on sensory irritation isn't required in our criteria. The assessment scored persistence as very high hazard for this chemical, and this can meet our minimum but not our additional criteria for safer.

Zirconium dioxide (CASRN: 1314-23-4)

This chemical meets our minimum criteria for safer.

Zirconium dioxide scored Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021ab), indicating zirconium oxide met our minimum criteria for safer. The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard. Data for endocrine activity isn't required in our criteria for safer. A data gap was noted for respiratory sensitization; however, this is allowable as skin sensitization was scored as a moderate hazard. Carcinogenicity was scored as a moderate hazard, and persistence was scored as a very high hazard.

Zirconium dioxide was assigned Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2025f), which indicated that zirconium dioxide met our minimum criteria for safer. The assessment noted data gaps for carcinogenicity (oral and dermal), reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), acute toxicity

(dermal), systemic toxicity (single-dose dermal and inhalation, repeat-dose dermal), neurotoxicity (single-dose dermal, repeat-dose dermal and inhalation) and endocrine activity. Carcinogenicity was scored as a moderate hazard with low confidence due to chemical characterization as a poorly soluble bio-persistent granular dust, but there were no data demonstrating carcinogenic effects. Other human health endpoints were scored as low hazard based on other routes and this fulfills out data requirements. Data on endocrine activity isn't required in our criteria for safer.

Titanium (non-nano) (CASRN: 7440-32-6)

This chemical meets our minimum criteria for safer.

Titanium (non-nano) was assigned Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2026e), which indicated that titanium (non-nano) met our minimum criteria for safer. The assessment noted data gaps for carcinogenicity (dermal), reproductive toxicity (inhalation), developmental toxicity (inhalation), systemic toxicity (repeat-dose inhalation), neurotoxicity (repeat-dose inhalation) and endocrine activity. Carcinogenicity was assigned to Category 2 for the inhalation route, and this corresponded to a moderate hazard score in our criteria for safer. Data on endocrine activity isn't required in our criteria for safer. Titanium was expected to be persistent in the environment as an inorganic compound, but no score was assigned as this was expected for all stable inorganic compounds. All other human health and environmental endpoints were scored as low hazard based on other routes of exposure and this fulfills our data requirements.

Niobium (non-nano) (CASRN: 7440-03-1)

This chemical meets our minimum criteria for safer.

Niobium (non-nano) was assigned Hazard Band B in a ChemFORWARD assessment (ChemFORWARD, 2026d), which indicates it may meet our additional criteria. However, individual endpoint scores indicated that niobium (non-nano) only met our minimum criteria for safer. The assessment noted data gaps for carcinogenicity (all routes), reproductive and developmental toxicity (dermal and inhalation), systemic toxicity (repeat-dose dermal and inhalation), neurotoxicity (repeat-dose dermal and inhalation), and respiratory sensitization.

We generally required data for carcinogenicity, but there were no empirical data indicating carcinogenic potential and niobium was outside of the applicability domain for available predictive models for this endpoint—we considered the carcinogenic hazard of niobium as likely low. Systemic toxicity (single-dose, inhalation) was scored as a moderate hazard based on assignment of Category 3 for respiratory irritation, which was based on an acute inhalation study in rats for niobium pentoxide, where exaggerated breathing was observed both during and four-days following post exposure.

Mutagenicity was scored as low hazard, and reproductive and developmental toxicity were both scored as low hazard for the oral route. Data on respiratory sensitization isn't required as skin sensitization was scored as a moderate hazard. Data for other routes of exposure was sufficient to score all other endpoints as low or moderate hazard, and this fulfills our data requirements. A score for persistence wasn't assigned, but as a metal this chemical is expected

to be very persistent in the environment. Our additional criteria for safer doesn't allow for very persistent chemicals, and so this chemical only met our minimum criteria for safer.

Magnesium carbonate (CASRN: 546-93-0)

This chemical meets our minimum criteria for safer.

Magnesium carbonate is listed on EPA SCIL as a Full Green Circle for the processing aids and additives functional use (OCSPP, 2013a). The functional use criteria for processing aids and additives used by EPA SCIL can meet our minimum or additional criteria for safer. Magnesium carbonate is a inorganic substance and is assumed to be very persistent.

Stainless steel (304 and 316L grades) (CASRN: NA)

Stainless steel meets our minimum criteria for safer.

A review of the relevant literature for stainless steel indicates it is a safer alternative to both lead and cadmium in jewelry. Stainless steels are iron-based alloys with a chromium content of at least 10.5%. Several different grades of stainless steel are available. Each type is defined by the amount of different metals and other elements it contains, including iron, chromium, nickel, molybdenum, and carbon. The American Iron and Steel Institute (AISI) 304 and 316L stainless steel grades are austenitic-type stainless steels known to be used for jewelry and/or accessories (PandaHall.com, n.d.; Someone & HerOwn, n.d.; Xu, 2025).

The potential hazard concern for these alloys relate primarily to the possibility of exposure to the constituent metals contained in the alloy, such as nickel. However, studies have shown that the potential exposure to constituent metals in stainless steel alloys is limited due to passive formation of a chromium(III)-rich oxide layer on the surface of these materials. Further, the toxic soluble type of chromium, chromium(IV), is not formed or released from these alloys. The only well-established hazard of concern for stainless steel alloys as used in jewelry is potential skin sensitization from low amounts of nickel released following prolonged skin contact.

Due to the potential for sensitization, the European Union under REACH has set nickel release limits of 0.5 $\mu g/cm^2$/week for applications with prolonged skin contact and 0.2 $\mu g/cm^2$/week specifically for piercing post applications (European Parliament, 2006). Research described in a report by the Finnish Institute of Occupational Health shows that the levels released from most grades of stainless steels, such as those used in jewelry, fall well below the 0.5 $\mu g/cm^2$/week limit (Santonen et al., 2010). Some high-sulfur containing grades of stainless steel, such as AISI 303, have been shown to release higher levels of nickel than other grades that in some situations may exceed the 0.5 $\mu g/cm^2$/week limit. These types of stainless steel should be avoided for applications such as jewelry with prolonged skin contact (Santonen et al., 2010; Taxell & Huuskonen, 2022). Based on this information, we consider AISI grade 304 and grade 316L to be safer material alternatives to lead and lead compounds, as well as cadmium and cadmium compounds for use in jewelry and accessories. Inclusion of metal alloys as safer material alternatives also has the prerequisite that the alloys comply with relevant U.S. laws (ASTM, 2020; ASTM, 2026b; Fish & Wildlife Service, n.d.; U.S. Consumer Product Safety Commission, n.d.).

Natural biological materials

Heavier natural decorative materials listed by DTSC meet at least our minimum criteria for safer. DTSC defines these as materials that are used "in its natural state and [have] not [been] treated in a way that adds lead" (DTSC, n.d.-c). These natural biological materials have a long history of use in products, and we haven't identified significant hazards associated with them. These materials can be used by themselves without additional chemical treatment. Inclusion of these materials as safer material alternatives also has the prerequisite that the materials comply with relevant U.S. laws (ASTM, 2020; ASTM, 2026b; Fish & Wildlife Service, n.d.; U.S. Consumer Product Safety Commission, n.d.).

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Feasible alternatives

We used SpecialChem (SpecialChem, 2025e), Knowde (Knowde, 2025), and an internet search engine (Google, n.d.), to determine the feasibility chemical and material alternatives. Our analyses indicated that the safer alternatives to lead and lead compounds, as well as cadmium and cadmium compounds, in jewelry and accessories are feasible. The results of our feasibility evaluations are presented below in Table 40.

Alternatives for the function of PVC wire and cables heat stabilizer were feasible, as indicated by the presence of advertised lead- and cadmium-free PVC cords (Best Beads Chain & Leather, n.d.; MandalaCraftsInc, n.d.). Further, magnesium oxide, calcium stearate, epoxidized soybean oil, and acetyl tributyl citrate could all function as PVC heat stabilizers (EPA, n.d.-v, n.d.-h, n.d.-ad, n.d.-c).

Alternatives for the functions of to make jewelry shiny or brighter in color and as base material are feasible based on the list of jewelry materials provided by DTSC (DTSC, n.d.-c, n.d.-b).

Table 40: Feasibility of all safer alternatives for lead, cadmium, and their compounds in jewelry and accessories.

Chemical or material and CASRN	Function	Example alternatives feasible in marketplace
Magnesium oxide 1309-48-4	PVC wire and cables heat stabilizer	MagPro® 150 by Europiren (Europiren, n.d.)
Calcium stearate 1592-23-0	PVC wire and cables heat stabilizer	SAK-CZD by Sun Ace (Sun Ace, 2017)

Chemical or material and CASRN	Function	Example alternatives feasible in marketplace
Epoxidized soybean oil 8013-07-8	PVC wire and cables heat stabilizer	Plastic additive 15 by Milipore Sigma (Sigma-Aldrich, n.d.)
Acetyl tributyl citrate 77-90-7	PVC wire and cables heat stabilizer	Uniplex 84 by LANXESS (LANXESS, 2026)
Calcium carbonate 471-34-1	To make jewelry shiny or brighter in color	Precipitated Calcium Carbonate for Silver Polish (Canadian Conservation Institute, 2017)
Zirconium dioxide 1314-23-4	To make jewelry shiny or brighter in color	Zirconium oxide polishing (Zhengzhou Xinli Wear-resistant Materials Co. Ltd., n.d.)
Titanium (non-nano) 7440-32-6	To make jewelry shiny or brighter in color	Anodic oxidation of titanium (Del Curto et al., 2014; Paiva et al., 2011)
Niobium (non-nano) 7440-03-1	To make jewelry shiny or brighter in color	Anodic oxidation of niobium (Seeley, 2003)
Zirconium dioxide 1314-23-4	Base material	Cubic zirconia by Atlantic Gems, Inc. (Atlantic Gems Supply Shop, n.d.), Cubic zirconia by WeJEWELER (WeJEWELER, n.d.)
Titanium (non-nano) 7440-32-6	Base material	Titanium Fiber Felt (Ti) by Nanochemazone (Nanochemazone, n.d.), Titanium wire by Stanford Advanced Material (Stanford Advanced Materials, n.d.-b)
Niobium (non-nano) 7440-03-1	Base material	NB0881 Niobium Ring, Nb Ring by Stanford Advanced Materials (Stanford Advanced Materials, n.d.-a)
Magnesium carbonate 546-93-0	Base material	Round - Shaped White Magnesite Beads Semi Precious Gemstones by Beadingsupplies (Amazon, n.d.-h)

Chemical or material and CASRN	Function	Example alternatives feasible in marketplace
Stainless steel (304 or 316L grade) CASRN: NA	Base material	Stainless Steel Circular Horseshoe Ring by Urban Body Jewelry (Urban Body Jewelry, n.d.)
Natural biological materials CASRN: NA	Base material	RED CORAL Charm by Areamil Botique (Areamil Boutique, n.d.), Classic Cork Bracelets by Elisabetta Studio (Elisabetta Studio, n.d.)

Available alternatives

We used an internet search engine (Google, n.d.) to determine the availability (Ecology, 2022d) of chemical and material alternatives. Our analyses indicated that safer and feasible alternatives to lead and lead compounds, as well as cadmium and cadmium compounds, in jewelry and accessories were available. The results of our availability evaluations are presented below in Table 41.

Table 41: Examples of alternatives for jewelry and accessories available in the marketplace.

Type of jewelry or accessories	Example alternatives available in marketplace
PVC wire- or cables-containing, or PVC accessories	Plastic Lacing Cord by MandalaCraftsInc (MandalaCraftsInc, n.d.), Round PVC cord BLACK by Best Beads (Best Beads Chain & Leather, n.d.), Anodized Aluminum & PVC Earring Back by Rings & Things (Rings & Things, n.d.)
To make jewelry shiny or brighter in color	Calcium Carbonate 98% 325 Whiting (New Mexico Clay, n.d.), Zirconium Oxide Powder by Bayville Chemical Supply Company Inc. (Bayville Chemical, n.d.), Pure Anodized Titanium Wire by Creating Unkamen (Creating Unkamen, n.d.-b),100 Anodized Niobium Jump Rings by Creating Unkamen (Creating Unkamen, n.d.-a)
Base material	Cubic Zirconia Lead Free Chains by glazdjewels (glazdjewels, n.d.), Titanium Earrings, Hypoallergenic Screw Back G23 Implant Grade for Sensitive Ear by S&TStores (eBay, n.d.), Titanium Hoop Earrings by Limerencia (Limerencia, n.d.), Gold filigree leaf dangle niobium earrings by for rebel skin (for rebel skin, n.d.), Grenache – Bracelet by Tangled Vine Jewelry (Tangled Vine Jewelry, n.d.), Gold Stainless Steel Heart Chain by Shiny Little Blessings (Shiny Little Blessings, n.d.), Stainless Steel Jewelry by Painful Pleasures (Painful Pleasures, n.d.), RED CORAL Charm by Areamil Botique (Areamil Boutique, n.d.), Classic Cork Bracelets by Elisabetta Studio (Elisabetta Studio, n.d.)

Conclusions on alternatives

Reducing a significant source or use

We describe jewelry and accessories as a significant source and use of lead and lead compounds, as well as cadmium and cadmium compounds, in our report, Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b).

In that report, we summarized several testing studies from the US, EU, and other countries that show the continued presence of these toxic heavy metals in products on the market. The concentrations detected in products are highly variable, with detections ranging from 1 ppm (0.0001%) to up to 98% of the product by weight. We estimated that the costume and novelty (fashion) jewelry market in Washington was around $370 million in 2017. This highlights jewelry and accessories as a significant use of cadmium and lead.

People have the potential to be exposed to lead and cadmium from jewelry and accessories during product use, primarily through incidental ingestion of these metals after handling contaminated products. This is of particular concern for sensitive populations such as newborns and infants because higher exposures to lead and cadmium are associated with lifelong human health impacts. Thus, a restriction on cadmium and lead in jewelry and accessories would reduce a significant use of these metals and a source of exposure in people, including sensitive populations.

Safer alternatives are feasible and available

Safer alternatives are identified for lead and lead compounds, as well as cadmium and cadmium compounds, in jewelry and accessories that meet either our minimum or additional criteria for safer for all functions that we identified.

Safer alternatives are feasible and available for the functions that we identified in jewelry and accessories.

Regulatory determination

Our regulatory determination is that a restriction on lead and lead compounds, as well as cadmium and cadmium compounds, in jewelry and accessories should be adopted.

Restricting the use of lead and lead compounds, as well as cadmium and cadmium compounds, would reduce a significant use of these chemicals and source of potential exposure to lead and lead compounds, as well as cadmium and cadmium compounds in people, including sensitive populations such as children.

Chapter 10: 6PPD in motor vehicle tires

Priority product scope

As defined in the Safer Products for Washington Cycle 2 Implementation Phase 2 reports (Ecology, 2025a, 2025b). The scope of this priority product includes new or replacement tires for a motorized vehicle intended for on-highway or off-highway use.

Priority chemical scope

As defined in the Safer Product for Washington Cycle 2 Implementation Phase 1 reports (Ecology, 2024a, 2024c),.the priority chemical for this category is N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD).

Function of the priority chemical in the priority product

6PPD is used as an antioxidant, antiozonant, and polymer stabilizer for rubber products, including tires. 6PPD transforms into 6PPDQ during product use.

Hazards of the priority chemical

We described the hazards associated with 6PPD and 6PPDQ in our Cycle 2, Phase 1 Priority Chemicals report (Ecology, 2024c). Hazards of concern for 6PPD and 6PPDQ include acute and chronic aquatic toxicity, especially in coho salmon. In addition, 6PPD is associated with reproductive toxicity, skin sensitization, and moderate persistence and bioaccumulation. These hazards show that 6PPD and 6PPDQ don't meet our minimum criteria for safer (Ecology, 2022b, 2022c).

Safer, feasible, and available alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). In addition to assigning 6PPD in tires as a priority product, the Washington Legislature has also assigned (Ecology, n.d.-d) Ecology to assess potential alternatives to 6PPD in a separate alternatives assessment (6PPD AA). This assignment allocated funding for Ecology to conduct research on the hazards and performance of potential alternatives. The completed 6PPD AA is planned for publication in December 2026 and this analysis for Safer Products for Washington is built on the work done to-date to support the legislature directed 6PPD AA.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

As far as we are aware, all tires on the road in the US use 6PPD as an antiozonant. That is what has been communicated to us by the tire industry, and it was confirmed by testing of over 350 tires from Emissions Analytics (Emissions Analytics, 2025). There have been detections of other

antiozonants in tires in addition to 6PPD, but none that replace 6PPD entirely. In addition, there are large variations in 6PPD concentration in tires, but we have been unable to discern what causes this variation, and if a lower concentration of 6PPD across a large variety of tires is feasible.

Many potential alternatives to 6PPD in tires have been proposed and are listed on California DTSC's 6PPD page (DTSC, n.d.-a) along with preliminary alternative assessments from manufacturers about whether these alternatives are feasible. However, no alternative has been definitively identified by manufacturers as having the performance capability to replace 6PPD yet, as all manufacturers state they need further testing. In addition to these assessments, Ecology has contracted several rubber antiozonant tests using ASTM D1149 dynamic ozone testing method (ASTM, 2025). The results of this testing are summarized in Table 42 below, and reports can be found on the 6PPD alternatives EZView page (Ecology, n.d.-d).

6PPD contributes a wide variety of beneficial properties to tire rubber, but we have heard from manufacturers that the function of dynamic ozone resistance is the hardest to replicate in alternatives. ASTM D1149 testing was our attempt to narrow the list of potential alternatives to those that may be able to provide sufficient antiozonant activity. In this test, rubber strips with variable formulations are repeatedly stretched while exposed to ozone until breaking (ASTM, 2025). However, we are unsure of the level of performance required to make a viable tire, and it may be that formulation changes would allow compounds that didn't behave well in our testing to work well in another rubber mixture. For example, carbon nanotubes were shown to perform similarly to 6PPD in another study (Krupp et al., 2024), but we were unable to replicate that performance in our testing. Conversely, just because a compound performed well in our testing doesn't mean that it has all the properties required to replace 6PPD in full for a tire. It may be that tire formulations need additional ingredients to fully replace 6PPD.

The results of ASTM D1149 can be difficult to interpret. Results are provided as pictures, time to crack, and time to breaking. Times are given in ranges, and depending on when they are checked, it may be that several days have passed between checks, making differentiation between samples difficult at times. Also, it is unclear whether time to cracking or time to breaking is more important. Time to breaking seems more tied to safety, but tires will most likely be replaced before that time, and formation of cracks in the tire would also be undesirable. Furthermore, Kraibut et al. (2026) stated that crack growth isn't actually a sign of ozone damage, and that rubbing/abrasion tests are more indicative of ozonation. However, we haven't heard this feedback from manufacturers regarding our contracted testing. Further, since we didn't have rubbing tests performed as part of our assays, we only have the time to cracking and time to breaking data points to compare alternatives one-to-one.

Table 42: Summary of potential alternatives to 6PPD with qualitative description of rubber performance.

Chemical	CASRN	Dynamic Ozone Resistance (ASTM D1149)
7PPD	3081-01-4	Similar to 6PPD
IPPD	101-72-4	Similar to 6PPD
CCPD	4175-38-6	Similar to 6PPD
77PD	3081-14-9	Similar to 6PPD
Durazone 37	121246-28-4	Similar to 6PPD
Irganox 1076	2082-79-3	Not sufficient
Irganox 1520 L	110553-27-0	Not sufficient
SA6000	Unknown	Similar to 6PPD
Kumanox 19	Unknown	Similar to 6PPD
Sinapic Acid	530-59-6	Not sufficient
Rambutan Peel Extract	296-955-8	Not sufficient
Alpha-Tocopherol	59-02-9	Not sufficient
Octyl Gallate	1034-01-1	Not sufficient
TMQ	26780-96-1	Not sufficient
Graphene	1034343-98-0	Not sufficient
Carbon Nanotubes	308068-56-6	Not sufficient in our testing
Flexsys Alternative	Unknown	Not tested by Ecology
Perpetuus Graphene Nanoplatelets	Unknown	Not tested by Ecology

Ultimately, although several potential alternatives have been proposed—and some performed similarly to 6PPD in our ASTM D1149 testing—we are not aware of any tires on the market that do not use 6PPD. At this time, we were unable to identify any feasible and available alternatives.

Safer alternatives

The 6PPD AA has published hazard criteria (Ecology, 2023a) that will be used. These criteria use the Safer Products for Washington hazard criteria (Ecology, 2022c), as well as add additional aquatic toxicity standards due to the known environmental exposure of urban streams from stormwater. The additional requirements include required testing on several aquatic organisms, limits on the aquatic toxicity (LC50>0.1 mg/L), and required testing of ozonation products of the potential alternative. We know that antiozonants are designed to form transformation products upon exposure to ozone, so we want to make sure that the toxicity of these transformation products is considered.

To assess potential safer alternatives, we relied on published toxicity information, as well as contracting out our own testing. This included testing on coho salmon, rainbow trout, small crustaceans (*H. azteca*), and water fleas (*C. dubia*). We also ozonated several potential alternatives and tested the toxicity of the ozonation mixtures.

Safer chemical alternatives

We don't have enough information to say that any potential alternative meets the published 6PPD AA hazard criteria (Ecology, 2023a). This is largely due to a lack of information on the toxicity of ozonation products of potential alternatives. Although we contracted some aquatic toxicity testing of both parent compounds and ozonated versions of alternatives, we have been unable to obtain enough ozonated mixtures to test all the species of interest. In addition, there is no standardized method for ozonation and testing ozonated mixtures, so it would be ideal to perform testing on a variety of mixtures to make sure that a wide variety of potential transformation products are analyzed.

However, we have been able to determine that two potential alternatives, 7PPD and IPPD, don't meet our minimum safer criteria. As shown in the 2021 6PPD alternatives hazard assessment technical memo (Manahan, 2021), both these chemicals score as high for reproductive toxicity. However, IPPD scored high because 6PPD was used as a surrogate, as IPPD lacked data for this endpoint. In addition, both 7PPD-quinone and IPPD-quinone show similar toxic profiles to 6PPD-quinone and coho salmon in our testing (Ecology, n.d.-d). This means neither would meet the additional aquatic toxicity criteria of the 6PPD AA.

There is published data for two other chemicals, 77PD and CCPD, that shows that they don't meet the additional aquatic toxicity criteria. CCPD shows toxicity to coho salmon with a 96 hour LC50 of 0.032mg/L, while 77PD shows toxicity to fathead minnow with a 96 hour LC50 of 0.06mg/L (Carson et al., 2025). However, we haven't fully evaluated these studies and the exposure potential of these chemicals. We don't have results for all endpoints of interest, so we

haven't ruled them out yet. These chemicals show much lower aquatic toxicity than 6PPD-quinone, which has an LC50 as low as 41ng/L (0.000041mg/L) toward coho (Lo et al., 2023). It is possible that 24 hour or other exposure durations are more relevant than 96 hour due to environmental exposure. Therefore, factors such as degradation potential, leaching potential, and behavior in the environment could be considered as part of our analysis in a future alternatives assessment.

Some of the chemicals investigated are listed below in Table 43. Results of the toxicity studies can be found on our 6PPD alternatives EZView page (Ecology, n.d.-d).

Table 43: Potential 6PPD alternatives and current evaluation showing if it meets our criteria for safer.

Chemical	CASRN	Safer Criteria Status
7PPD	3081-01-4	Does not meet criteria
IPPD	101-72-4	Does not meet criteria
CCPD	4175-38-6	More data needed
77PD	3081-14-9	More data needed
Durazone 37	121246-28-4	More data needed
Irganox 1076	2082-79-3	More data needed
Irganox 1520 L	110553-27-0	More data needed
SA6000	Unknown	More data needed
Kumanox 19	Unknown	More data needed
Sinapic Acid	530-59-6	More data needed
Rambutan Peel Extract	296-955-8	More data needed

Chemical	CASRN	Safer Criteria Status
Alpha-Tocopherol	59-02-9	More data needed
Octyl Gallate	1034-01-1	More data needed
TMQ	26780-96-1	More data needed
Graphene	1034343-98-0	More data needed
Carbon Nanotubes	308068-56-6	More data needed
Flexsys Alternative	Unknown	More data needed
Amine Functionalized Graphene	Unknown	More data needed

Conclusions on alternatives

Reducing a significant source or use

As far as we are aware, 6PPD is currently used in all motor vehicle tires in the US. Thus, an eventual restriction on 6PPD in tires would reduce a significant use of this chemical. Further, 6PPD use in tires is thought to be a primary source of releases of 6PPD and its transformation product 6PPDQ to the environment. As such, an eventual restriction on 6PPD would reduce a significant source of 6PPD and 6PPDQ to the environment in Washington.

Necessary to protect sensitive species

6PPD is used in motor vehicle tires as an antiozonant and, as part of its intended use, reacts with ozone to form transformation products including 6PPDQ. Motor vehicle tires are a primary source of 6PPD and 6PPDQ to the environment. 6PPDQ is highly toxic to coho salmon with a reported LC50 as low as 41 ng/L. It's associated with acute pre-spawn mortality events and urban runoff mortality syndrome. Therefore, an eventual restriction on 6PPD in motor vehicle tires is necessary to protect sensitive aquatic species, most notably coho salmon.

Regulatory determination

Our regulatory determination is that a reporting requirement for use of 6PPD in motor vehicle tires should be adopted.

We didn't identify any safer, feasible, and available alternatives to 6PPD in tires. Therefore, current information does not yet support a restriction.

A safer alternative to 6PPD will protect sensitive species in Washington, and we need more information to complete this work. Due to lack of information on concentrations of 6PPD used in various types of tires described above, we believe a reporting requirement would be valuable to help us understand feasibility of alternatives and the potential to reduce use of 6PPD in tires.

Chapter 11: BTEX Substances in Nail Products

Priority product scope

As defined in Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b), the scope of this priority product includes nail products broadly, examples include:

- Nail art products
- Nail coatings
- Nail glues
- Nail hardeners
- Nail polish removers
- Nail polish thinners

Priority chemical scope

As defined in the Safer Products for Washington Cycle 2 Implementation Phase 1 (Ecology, 2024c), the scope of the priority chemical class for this product category is BTEX substances which include benzene, ethylbenzene, toluene, and xylenes.

Function of the priority chemical in the priority product

BTEX substances in nail products function as solvents making up about 70% of the bulk of the product composition (De Paula et al., 2025). For products such as nail polishes, solvents often dissolve or maintain other ingredients in suspension during product application. Following application, solvents evaporate from the liquid into the air as part of the drying process. As solvents, BTEX substances help spread color evenly in nail coatings and make them dry faster (De Paula et al., 2025). Rather than relying on solvent evaporation, UV-curable nail product compositions contain polymerizable acrylate monomers and oligomers which undergo a curing process when exposed to UV light (Mieriņa et al., 2025).

Performance needs include that the solvent needs to be able to dissolve other ingredients, as well as uniform (rheological modification) and rapid evaporation (drying time control) after the product is applied. For thinners and removers, solvents must be able to dissolve the material you're trying to remove.

We determined the functional use of BTEX substances as solvents in nail products through review of nail products formulations available on the market by ingredient disclosures or safety data sheets. To identify these products, we referred to reports published by the California Department of Toxic Substances Control (DTSC) (DTSC, 2022, 2023b, 2025), and by searching for use of BTEX substances in nail products in databases such as EWG's Skin Deep® database (EWG, n.d.-f) and the California Safe Cosmetics Program (CSCP) product database (CSCP, 2026b).

Hazards of the priority chemical class

Nail salon technicians face are regularly exposed to volatile organic compounds, including BTEX substances (Lamplugh et al., 2019). We described the hazards associated with BTEX substances in our Cycle 2, Phase 1 Priority Chemicals Report to the Legislature (Ecology, 2024c). Hazards of concern include carcinogenicity and mutagenicity, reproductive and developmental toxicity, neurotoxicity, and systemic toxicity. In addition, BTEX substances are associated with aquatic toxicity. Taken together, these hazards indicated that BTEX substances don't meet our minimum Criteria for Safer (Ecology, 2022c, 2024c).

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). To identify potential alternatives to BTEX substances in nail products, we focused our evaluation on other common solvents or similarly functioning chemicals used in these products. To determine what other common solvents are used in these products, we referred to information from several sources including:

- California Department of Toxic Substances Control (DTSC) Reports on Nail Products: Potential Alternatives to Toluene in Nail Products (DTSC, 2023b).
- California Safe Cosmetics Program (CSCP) Product Database (CSCP, 2026b).
- International Nomenclature of Cosmetic Ingredients (INCI) (INCI Beauty, n.d.).
- Mintel Global New Products Database (Mintel GNPD, 2022).
- Ingredient Disclosures and Safety Data Sheets (SDS).

Of the BTEX substances, toluene is the primary chemical used as a solvent in nail products. Other BTEX substances may be present in products as a contaminant (Anderson et al., 2025; Cosmetic Ingredient Review, 1987; Huang et al., 2026).

We referred to the Mintel New Products Database as a supporting source of information. The Mintel New Products Database uses product labeling to characterize product contents in the database. To better understand the market shift over the last several years, we searched the database for BTEX substances in the nail color cosmetics sold in the U.S., focusing on products added to the database between 2019 and 2026.

From 2019 to 2026, none of the nail color cosmetics ingredient labels summarized in Mintel's database for the US market contained toluene and no nail color cosmetic products containing benzene, ethylbenzene, or xylenes were identified in the database during this timeframe (Mintel GNPD, 2022). This doesn't necessarily mean that none of these products contain benzene, toluene, ethylbenzene, or xylenes, only that they aren't listed on the product labels. For example, in CA DTSC's 2019 testing study, they found several products that contained

detectable levels of benzene, toluene, ethylbenzene, or xylenes that didn't include these as ingredients on their product labels (DTSC, 2023a).

In contrast, several alternative solvents were reported in a large percentage of nail color cosmetics across this timeframe including ethyl acetate, isopropyl alcohol, propylene carbonate, and butyl acetate. Based on this information, we explored these ingredients as potential alternatives to BTEX substances for use as solvents in nail products. We determined that each of these four ingredients met our minimum or additional criteria and were safer than BTEX substances for use as solvents in nail products as shown in Table 44 and summarized below.

Table 44: Alternatives to BTEX substances in nail products with hazard assessment scores and tier they meet in our Criteria for Safer.

Chemical	CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Ethyl acetate	141-78-6	GreenScreen BM-2, Scivera GHS+ [Yellow], EPA SCIL Half-Green Circle (solvent criteria), ChemFORWARD Hazard Band B	Minimum
Butyl acetate	123-86-4	GreenScreen BM-3, Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B	Additional
Isopropyl alcohol	67-63-0	GreenScreen BM-2 (expired), Scivera GHS+ [Yellow], EPA SCIL Full Green Circle (solvent criteria), ChemFORWARD Hazard Band B	Minimum
Propylene carbonate	108-32-7	GreenScreen BM-3, Scivera GHS+ [Yellow], EPA SCIL Full Green Circle (solvent criteria), ChemFORWARD Hazard Band C	Minimum

Ethyl acetate (CAS: 141-78-6)

This chemical meets at least our minimum criteria for safer.

Ethyl acetate was scored as BM-2 in a GreenScreen® hazard assessment, and this meets our minimum criteria for safer (ToxServices LLC, 2023c). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard with high confidence. Data for endocrine activity isn't required in our minimum criteria.

A verified Scivera GHS+ hazard assessment scored ethyl acetate as a Yellow chemical and this also meets our minimum criteria for safer (Scivera, 2021l). The assessment noted a data gap for endocrine activity. Reproductive toxicity and developmental toxicity were scored as moderate hazard with low confidence. Persistence and bioaccumulation were both scored as low hazard.

Ethyl acetate was scored as Hazard Band B in a ChemFORWARD hazard assessment, further indicating it meets our minimum criteria for safer (ChemFORWARD, 2021a).The assessment also noted a data gap for endocrine activity. Several data gaps were identified specifically for the dermal exposure route including reproductive and developmental toxicity, systemic toxicity (single- and repeat-exposure), and neurotoxicity.

Data gaps were also assigned for oral systemic toxicity (single- and repeat-exposure), and oral carcinogenicity hazard. However, overall, the assessor described that no hazards have been identified for the dermal route and that ethyl acetate has a relatively robust health effects dataset for the oral and inhalation routes.

Systemic toxicity (single-dose) was scored as moderate hazard based on respiratory tract irritation observed in two human inhalation studies consistent with a GHS Category 3 classification. Systemic toxicity (repeat-dose) was scored as moderate hazard based on inhalation studies in rats that identified LOAEC values of 0.9 mg/L based on reversible decreased body weight observed. Neurotoxicity (single-dose) was scored as moderate hazard for the inhalation route due to the EU harmonized H336 classification—this is based on acute exposure studies in mice where transient narcotic effects were observed consistent with a GHS Category 3 classification.

Ethyl acetate is listed on the EPA Safer Chemicals Ingredient List as a Half-Green circle for the solvents functional use (EPA, 2009; OCSPP, 2013a). The functional use criteria for solvents used by EPA Safer Choice can meet our minimum criteria for safer, but we also require additional data on mutagenicity and sensitization. Ethyl acetate was scored as low hazard for mutagenicity and low for respiratory or skin sensitization in the GreenScreen, Scivera GHS+, and ChemFORWARD hazard assessments referenced above, and this meets the additional data requirement. Therefore, the listing of ethyl acetate further confirms that ethyl acetate meets our minimum criteria for safer.

Butyl acetate (CAS: 123-86-4)

This chemical meets our additional criteria for safer.

Butyl acetate was scored as BM-3 GreenScreen® hazard assessment, and this meets our additional criteria for safer (ToxServices LLC, 2023b). The assessment noted a data gap for endocrine activity, but both reproductive toxicity and developmental toxicity were scored as low hazard with high confidence. Data for endocrine activity is not required in our minimum criteria.

A verified Scivera GHS+ hazard assessment scored butyl acetate as a yellow chemical, this meets our minimum criteria for safer (Scivera, 2021g). The assessment noted data gaps for endocrine activity and respiratory sensitization. Developmental toxicity was scored as moderate hazard with low confidence. A review of the developmental toxicity endpoint indicated that the moderate score was assigned based on a NOAEC of 750 ppm (3.6 mg/L/6h/day) for vapor inhalation in an OECD Guideline 416 two generation reproductive toxicity study (ECHA, 2010; Scivera, 2021g). Our Criteria for Safer allows chemicals to score low for developmental toxicity if the NOAEC is above 2.5 mg/L/6h/day vapor/gas inhalation

exposures. Therefore, butyl acetate scores low for developmental toxicity in our criteria for safer and meets our additional criteria.

A ChemFORWARD hazard assessment scored butyl acetate as Hazard Band B which also meets our additional criteria for safer (ChemFORWARD, 2021a). The assessment noted a data gap for endocrine activity. Several data gaps were identified specifically for the dermal exposure route, including for reproductive and developmental toxicity, systemic toxicity (single- and repeat-dose), and neurotoxicity (repeat-dose only). The assessment also reported a data gap for the oral route for neurotoxicity (repeat-dose only). However, the assessor described that overall butyl acetate has a relatively robust dataset for the oral and inhalation routes and no hazards were identified for the dermal route based on the available data.

Isopropyl alcohol (CAS: 67-63-0)

This chemical meets at least our minimum criteria for safer.

Isopropyl alcohol was scored as BM-2 in an expired GreenScreen® hazard assessment (ToxServices LLC, 2014a). BM-2 chemicals meet our minimum criteria for safer and although the assessment has expired it aligns with more recent hazard assessments by other organizations. The assessment notes a data gap for endocrine activity, and reproductive and developmental toxicity were scored as moderate with high confidence. Data for endocrine activity is not required in our minimum criteria. Systemic toxicity (single-dose) was scored as very high hazard with high confidence based on data in humans from large dose acute exposure reported in the Hazardous Substances Data Bank corresponding to a GHS Category 1 classification for this hazard endpoint (ToxServices LLC, 2014a).

According to the data referenced in the Hazardous Substance Data Bank, symptoms are observed when acute doses exceed 20 ml of isopropyl alcohol in water; this isn't expected to occur during normal use of nail products. In addition, a very high score for systemic toxicity (single-dose) is allowed in our minimum criteria, but only if persistence or bioaccumulation are scored as moderate hazard and neither is scored as very high hazard. Isopropyl alcohol was scored as very low hazard for both persistence and bioaccumulation. Systemic toxicity (repeat-dose) was scored as low hazard. Thus, considering the underlying data and requirements, this assessment demonstrates isopropyl alcohol meets our minimum criteria for safer.

A verified Scivera GHS+ hazard assessment scored isopropyl alcohol as a yellow chemical, which also meets our minimum criteria for safer (Scivera, 2022e). The assessment notes a data gap for endocrine activity. Reproductive toxicity is scored as moderate hazard and developmental toxicity as low hazard. Neurotoxicity is scored as high hazard for repeat-dose exposure with low confidence due to a GHS classification as category 1 from the Japan METI/MOE screening list. A high hazard score for neurotoxicity (repeat-dose) is allowed in our minimum criteria but only if persistence and bioaccumulation are not both scored as very high hazard. In the Scivera assessment for isopropyl alcohol, both bioaccumulation and persistence were scored as low hazard.

Thus, this assessment further supports that isopropyl alcohol meets our minimum criteria for safer.

A ChemFORWARD hazard assessment of isopropyl alcohol scored it as Hazard Band B, this meets at least our minimum criteria for safer (ChemFORWARD, 2024c). The assessment identified a data gap for endocrine activity. It also identified several data gaps specifically for the dermal route of exposure, including reproductive and developmental toxicity, systemic toxicity (single- and repeat-dose) and neurotoxicity (single- and repeat-dose), but reported data for other exposure routes for each of these endpoints.

Carcinogenicity also was reported as a data gap for the inhalation route, but was not identified as carcinogenic using modeling data for the oral or dermal routes. The assessor describes the data as robust for health effects with respect to the oral route of exposure and with no specific health hazards identified, but with moderate hazard for neurotoxicity for the inhalation route due to data corresponding to a GHS category 3 classification.

Isopropyl alcohol is listed on the EPA Safer Chemicals Ingredient list as a Full Green Circle for the solvents functional use (EPA, 2009; OCSPP, 2013a). The functional use criteria for solvents used by EPA Safer Choice can meet our minimum criteria for safer, but we also require additional data on mutagenicity and sensitization. Isopropyl alcohol was scored as low hazard for mutagenicity and low or moderate for respiratory or skin sensitization in the GreenScreen, Scivera GHS+, and ChemFORWARD hazard assessments referenced above, and this meets the additional data requirement. Therefore, the listing of isopropyl alcohol further confirms that it meets our minimum criteria for safer.

Propylene carbonate (CAS: 108-32-7)

This chemical meets our minimum criteria for safer.

Propylene carbonate was scored as BM-3 in a GreenScreen® hazard assessment. The assessment expires in June 2026, but generally aligns with more recent hazard assessments by other organizations (ToxServices LLC, 2021f). The assessment notes a data gap for endocrine activity, and reproductive and developmental toxicity are both scored as low hazard with high confidence. Data for endocrine activity is not required in our minimum criteria.

A Scivera GHS+ hazard assessment of propylene carbonate scored it as a Yellow chemical (Scivera, 2025f). The assessment notes a data gap for endocrine activity, but reproductive and developmental toxicity are both scored as low hazard with high confidence. Respiratory sensitization is also reported as a data gap. Data gaps for endocrine activity and respiratory sensitization are allowable in our criteria for safer.

A ChemFORWARD hazard assessment scored propylene carbonate as Hazard Band C and this meets at least our minimum criteria for safer (ChemFORWARD, 2020d). The assessment assigned a Hazard Band C score because there is mixed evidence that it might affect developmental toxicity at high oral doses but not enough to trigger a GHS warning. This corresponds to a low score in our criteria for safer.

The assessment noted data gaps for endocrine activity. Data gaps were also reported for reproductive and developmental toxicity by the dermal and inhalation routes, but the oral route was scored as moderate hazard for reproductive and developmental toxicity based on equivocal evidence for developmental toxicity at high doses. Data gaps were also reported for

systemic toxicity by the inhalation route (single-dose only) and dermal route (repeat-dose only), for neurotoxicity for the inhalation route (single-dose only), and for the oral and dermal routes (repeat-dose only). Data was available for other exposure routes for neurotoxicity (single- and repeat-dose) and systemic toxicity (single- and repeat-dose) and were scored as moderate or low hazard. Our additional criteria for safer don't require data for all routes of exposure if there is sufficient data on other routes to score the endpoint.

Propylene carbonate is listed on the EPA Safer Chemicals Ingredient list as a Full Green Circle for the solvents functional use (EPA, 2009; OCSPP, 2013a). The functional use criteria for solvents used by EPA Safer Choice can meet our minimum criteria for safer, but we also require additional data on mutagenicity and sensitization. Propylene carbonate was scored as low hazard for mutagenicity and low for either respiratory or dermal sensitization in the GreenScreen, Scivera GHS+, and ChemFORWARD hazard assessments referenced above, and this meets the additional data requirement.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Alternative products that utilize the safer chemistries mentioned above have been identified and are currently in use. Product databases such as INCI Beauty supply data showing the prevalence of products containing these alternative chemicals across nail product sub-categories: information shown in Table 45.

Table 45: Percentage distribution within each associated nail product sub-use category in the INCI Beauty associated cosmetic database (INCI Beauty, n.d.).

Chemical and CASRN	Nail Polishes	Nail Hardeners	Topcoats	Varnish Bases	Nail Care and Treatments
Ethyl acetate 141-78-6	84%	80%	72%	66%	53%
Butyl acetate 123-86-4	84%	77%	72%	66%	53%
Isopropyl alcohol 67-63-0	81%	69%	66%	56%	49%

Using the EPA's CompTox ChemExpo platform, 1258 products containing isopropyl alcohol, 39 products containing propylene carbonate, 1215 products containing ethyl acetate, and 1333 products containing butyl acetate were identified in the "Personal Care – Nails" formulation product use category (Dionisio et al., 2018).

Data obtained from Mintel New Global Product Database showed products containing safer alternative chemistries as evidence of feasibility and availability. The data also shows that these solvents are used in mixtures with one another in individual products. For the North American Market between January 2019 and May 2026, of 648 total products with ingredient information reported in the nail color cosmetics category, the percentages of products containing these individual chemistries are shown below:

- Isopropyl alcohol – 73.3%
- Butyl acetate – 63.0%
- Ethyl acetate – 63.4%
- Propylene carbonate – 1.2%

In addition, California listed nail products containing toluene as a priority product in 2023. At that time, California set an alternative analysis threshold of 100 ppm. They tested 522 nail products representing 142 unique brands purchased in 2024 that covered the primary types of products within this category. These products included nail lacquers, gel topcoats, nail strengtheners, base coats, gel polishes, and topcoats (DTSC, 2025). Their study demonstrated that around 95% of tested nail products did not contain detectable levels of toluene. Around 5.2% of products contained toluene above 100 ppm, and only around 1% were above 1000 ppm. This was a decrease from their testing study in 2019, which reported toluene above 100 ppm in 11.7% of products and above 1000 ppm in approximately 9% of products. This indicates a market shift across this timeframe and indicates that alternatives are technically feasible (DTSC, 2025).

We reviewed products currently on the market that contain the identified safer alternative solvents to confirm they were feasible and available. The review shows examples of products that contain alternatives either alone or in combination across the various product applications of the nail products category. Select examples are noted in Table 46 and described briefly below.

Table 46: Feasibility and availability of safer alternatives for nail product sub-categories.

Chemical and CASRN	Art Products	Coatings	Hardeners	Polish Thinners	Polish Removers
Isopropyl alcohol CASRN: 67-63-0	OPI "I Cannoli Wear OPI" Nail Lacquer (OPI, n.d.-a), Pueen Nail Art Stamp Party Kit (PUEEN, n.d.)	Essie 'All-in-One' Top & Base Coat (Essie, 2026), Londontown- 2-in-1 Hardener and Base Coat (LONDONTOWN, n.d.-b)	Sally Hansen Hard As Nails (Sally Hansen, n.d.-a), Essence the Extreme Nail Hardener (INCIDecoder, n.d.-a)	Deglaze Nail Polish Thinner (Palate Polish, n.d.), BeBeauty Nail Polish Thinner (BeBeauty, n.d.)	Pro Nail Isopropyl Alcohol (Lunali Nail Supply, n.d.), F.O.X Gel Remover (F.O.X. Nails USA, n.d.)
Butyl acetate CASRN: 123-86-4	Sugar Fix Miracle Gel Polish- Sally Hansen (Sally Hansen, n.d.-b), Essie- Ballet Slippers Original Nail Polish (Essie, n.d.)	Côte Beauty- Smoothing Base Coat (Cote, n.d.),OPI Top Coat (OPI, n.d.-b)	Sally Beauty Secrets Nail Hardener and Thickener (Sally Beauty Supply LLC, n.d.)	Londontown Lacquer Refresh Nail Polish Thinner (LONDONTOWN, n.d.-a), KBShimmer Restoration Drops Polish Thinner (KBShimmer, 2026)	Vitry Vdis150 Extra Mild Nail Polish Remover (Zeina Care, n.d.), DazzleDry Non-Acetone Remover (Dazzle Dry, n.d.-b)
Ethyl acetate CASRN: 141-78-6	Dazzle Dry- "Peacefully Me" Nail Lacquer (Dazzle Dry, n.d.-a), Pleasing- "Granny's Pink Pearls" Nail Polish (Pleasing, n.d.-b)	Pleasing Perfect Pearl (Pleasing, n.d.-a), Olive & June Nail Primer (Olive and June, n.d.)	Nail-Aid Biotin Ultimate Strength Armor-Hard Nails (Nail-Aid, n.d.), IDUN Minerals Nail Hardener (IDUN Minerals, n.d.)	Ella + Mila Polish Thinner (Ella+Mila, n.d.), Mavala Thinner (Mavala USA, n.d.), KBShimmer Restoration Drops Polish Thinner (KBShimmer, 2026)	Vitry Vdis150 Extra Mild Nail Polish Remover (Zeina Care, n.d.),DazzleDry Non-Acetone Remover (Dazzle Dry, n.d.-b)
Propylene carbonate CASRN: 108-32-7	Moon Cat White Rabbit Nail Polish (Mooncat, n.d.-a)	Moon Cat Matte Nail Polish (Mooncat, n.d.-b)	Creative Nail Design Nail Strengthener (Creative Nail Design, n.d.)	Non-applicable	Walgreens Nail Polish Remover Pads With Keratin (Walgreens, n.d.), 365 by Whole Foods Market Nail Polish Remover (Whole Foods Market, n.d.-b)

Conclusions on alternatives

Reducing a significant source or use

We described nail products as a significant use of toluene and other BTEX substances in our report, Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b). In that report, we summarized several testing studies including a recent report by California DTSC that described the presence of toluene as a BTEX substance in nail products. In the referenced 2019 testing study by DTSC, 156 nail products were tested and toluene was reported above 100 ppm in 11.7% of products (DTSC, 2023a). In that same study, other BTEX substances were also detected, including benzene in 5 products, ethylbenzene in 10 products, ortho-xylene in 8 products, and meta- or para- xylene in 11 products, but none of these substances were listed on the associated product labels.

As described above, more recent testing reported by DTSC in 2025 saw a decrease to only 5.2% of products reported with toluene above 100 ppm (DTSC, 2025). This suggests many nail product manufacturers are already reformulating their products, but that a significant number of products may still contain toluene or other BTEX substances. As such, a restriction on BTEX substances in nail products would reduce a significant use of these chemicals.

Necessary to protect sensitive populations

We also highlighted the potential for exposure to BTEX substances from nail products in sensitive populations including people of childbearing age, children, and especially nail salon workers. In our previous report, we estimated around 2.3 million women in Washington used nail polish or other nail products in 2020 (Ecology, 2025b), along with an unknown number of children, men, and nonbinary people.

We also referenced a report by the California Healthy Nail Salon Collaborative that noted Washington had 1,073 registered nail salons in 2016 (Sharma et al., 2018), highlighting a significant worker population in Washington who has the potential to be exposed to BTEX substances from nail products.

As summarized in the sections above and our previous priority chemicals report, hazards of BTEX substances include developmental and reproductive toxicity and neurotoxicity; and these can also have greater impacts on these sensitive populations (Ecology, 2025b). Therefore, due to the significant number of nail products that may still contain toluene or other BTEX substances, and the large number of people who use nail products, we conclude a restriction is also necessary to protect sensitive populations in Washington.

Safer alternatives are feasible and available

We have identified many nail products that utilize the safer alternative solvents that meet our minimum criteria for safer. These alternative chemistries are sold and used in various nail products which are indicative of market-based performance characteristics being met. The prevalence of existing products that contain alternatives as well as the products studies

referenced in this chapter highlight much of the industry moving away from BTEX substances and transitioning to the safer alternatives summarized in this chapter. Based on these findings, we determined that these safer alternative solvents are both feasible and available across the breadth of the nail products category.

Regulatory determination

Our regulatory determination is a restriction on BTEX in nail products should be adopted. This restriction would reduce a significant use of BTEX substances and a potential source of exposure for people and the environment.

Chapter 12: PVC and PVDC in Plastic Packaging

Priority product scope

As defined in the Safer Products for Washington Cycle 2 Implementation Phase 2, the scope of this priority product includes packages and packaging components as defined in RCW 70A.222.010.[45] Our definition of packaging for this category does not include items intended for long-term storage of products (greater than one year by the end-consumer).

Priority chemical scope

As defined in the technical report for Safer Product for Washington Cycle 2 Implementation Phase 1,[46] the scope of the priority chemical class for this product category is organobromine and organochlorine substances (Ecology, 2024c). The focus for this product category is polyvinylchloride (PVC) and polyvinylidene chloride (PVDC), as described in the technical report for Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b). PVC and PVDC are organochlorine substances used as synthetic polymers in various types of plastic packaging.

Function of the priority chemical in the priority product

Producers use PVC and PVDC in various types of plastic packaging (ECVM, 2024; Paisley, 2007; Plastic Ingenuity, n.d.; Vinyl Institute, 2018). Some plastic packaging use PVC as the primary polymer, while other packaging may use PVC or PVDC as coatings or layers to provide specific performance properties.

PVC is used as packaging in both rigid and flexible forms, and often is the bulk polymer present in packaging materials. PVC is used in packaging materials for a variety of products, ranging from electronics, toys and household items to food and beverages.

The functions of PVC in packaging can be described at the product, material, and chemical level:

As a product, PVC protects packaged contents during handling and makes an appealing display for consumers. For some products, packaging conveys information about the product or its contents.

As a material, PVC works as a rigid or flexible polymer that can be formed into a desired shape for packaging. Any PVC alternative must be able to accommodate a variety of sizes and shapes. Polymers like PVC that can be made transparent and colorless with high clarity may be preferred for displaying some packaged products.

As a chemical, PVC acts as a barrier to protect packaged products. The necessary barrier properties depend on the packaged product. They can include acting as a physical barrier or a limited barrier to moisture and oxygen.

[45] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222.010
[46] https://apps.ecology.wa.gov/publications/SummaryPages/2404026.html

PVDC is primarily used as a barrier layer in rigid or flexible packaging and not a bulk polymer present in packaging materials (Paisley, 2007). PVDC barriers are generally used for products that require additional protection from moisture and oxygen during transport and storage.

- **At the product level**, PVDC is layered with other bulk polymeric materials.
- **At the material level**, PVDC acts as a thin layer that enhances the performance of multi-layer packaging. Any PVDC alternative must be compatible with the surrounding layers of the packaging. Polymers which can be made transparent and colorless with high clarity may be preferred for displaying some packaged products.
- **As a chemical**, PVDC blocks moisture and oxygen. This is especially important for certain types of products during transport and storage, such as food (Pilcher Hamilton, 2024), supplements, pharmaceuticals (Solvay, 2018), and electronic parts (Cloudfilm, 2024; Patsnap, 2026).

We determined the functions of PVC and PVDC in packaging through a literature review, including materials provided by manufacturers and users of PVC and PVDC packaging. To analyze the applications of PVC and PVDC packaging, as well as potential alternatives, we grouped packaging uses into several broad categories based on our understanding of the necessary performance properties for specific applications. Table 47 summarizes these categories, polymers, and functions.

Table 47: Packaging categories, polymers, and associated functions of those polymers.

Packaging Categories	Polymer	Functions of Packaging
Rigid packaging (non-food)	PVC	Physical barrier, clarity
Flexible packaging (non-food)	PVC	Physical barrier, clarity, flexibility
Rigid packaging (food and barrier)	PVC	Physical barrier, clarity
	PVDC	Clarity, oxygen barrier, moisture barrier
Flexible packaging (food and barrier)	PVC	Physical barrier, clarity, flexibility
	PVDC	Clarity, oxygen barrier, moisture barrier
Can linings (food and beverages)	PVC	Physical barrier, corrosion resistance
Pharmaceutical and supplement packaging	PVDC	Oxygen barrier, moisture barrier
Labels and shrink sleeves	PVC	Flexibility, printability

Hazards of the priority chemical class

We described the hazards associated with organobromine and organochlorine substances in our Safer Products for Washington Cycle 2, Phase 1 technical report (Ecology, 2024c). There is variability in hazard amongst members of the class, with hazards of concern including carcinogenicity and mutagenicity, reproductive and developmental toxicity, systemic toxicity, and neurotoxicity. In addition, members of the chemical class are also associated with ecological toxicity, persistence, and bioaccumulation.

Taken together, these hazards indicate that organobromine and organochlorine substances do not meet our minimum criteria for safer (Ecology, 2022b). We further clarified the hazards associated with PVC and PVDC as organochlorine polymers in our Safer Products for Washington Cycle 2, Implementation Phase 2 Technical Supporting Documentation (Ecology,

2025b). Hazards of concern for PVC and PVDC include use of other hazardous organochlorine substances during manufacture, such as vinyl chloride, and the potential to form hazardous and persistent pollutants as degradation products at end of life including microplastics and dioxins (Ecology, 2025b).

Safer, feasible, and available alternatives

Safer alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). We have not completed a full hazard analysis of alternatives for PVC and PVDC in plastic packaging in Cycle 2 of Safer Products for Washington. An analysis of plastic packaging has different factors to consider relative to other products we have evaluated in the program.

Plastic packaging has a short use phase relative to the products it contains and is usually discarded the same year it is produced (EPA, 2017). This means that a hazard comparison of plastic packaging should account for the chemicals used in its manufacture and what happens to the packaging after disposal.

With this in mind, we have begun to collect and analyze hazard information on polymers that are potential alternatives to PVC or PVDC in plastic packaging—this includes information on monomers, polymer properties, and degradation products.

Note: These pieces of information are only our initial considerations for how polymer alternatives may be assessed. As part of our ongoing work, we will consider whether these or other factors are necessary for a sufficient analysis of safer alternatives for PVC and PVDC in plastic packaging.

Monomers

To better incorporate information on hazards of chemical inputs, we are reviewing existing hazard assessments of monomers used in different polymer types, and working to fill gaps where hazard information is not readily available. Monomers are the fundamental building blocks of the polymers used in the manufacture of plastic packaging and can help us better understand potential hazards of polymer production. In some cases, residual monomers from manufacturing can also be present in polymers used in the plastic packaging and end up in products or the environment (Gupta et al., 2024; Muzeza et al., 2023; Wang et al., 2023). As part of our ongoing work, we plan to use the hazard information to compare monomers using our criteria for safer framework.

Table 48 below summarizes the monomers used to produce polymers found in plastic packaging, including their hazard assessment scores and the corresponding hazard tier level in our criteria for safer.

Note: We have not yet reviewed these hazard assessments in detail. The assigned hazard tiers are preliminary and may change as we learn more.

Table 48: Polymers with corresponding monomers used in their production, preliminary hazard scores, and the associated hazard tier of the monomer.

Polymer	Monomer(s)	Monomer CASRN(s)	Hazard Assessment Score	Preliminary Monomer Hazard Tier*
PVC	Vinyl chloride	75-01-4	GreenScreen BM-1 (Rosenblum, 2015), Scivera GHS+ [Red] (Scivera, 2019o)	Hazardous
PVDC	Vinylidene chloride	75-35-4	GreenScreen LT-1 (Pharos, 2025), Scivera GHS+ [Red] (Scivera, 2018k)	Hazardous
Polyethylene (LLDPE, LDPE, HDPE)	Ethylene	74-85-1	GreenScreen BM-2 (ToxServices LLC, 2021c), Scivera GHS+ [Yellow] (ToxServices LLC, 2021c)	Minimum criteria
Polypropylene (PP, BOPP)	Propylene	115-07-1	GreenScreen BM-2 (ToxServices LLC, 2021g), Scivera GHS+ [Yellow] (Scivera, 2017e)	Minimum criteria
Polyethylene terephthalate (PET, BOPET)	Terephthalic acid	100-21-0	GreenScreen BM-2 (expired) (ToxServices LLC, 2013c), Scivera GHS+ [Yellow] (Scivera, 2021w)	Minimum criteria
Polyethylene terephthalate (PET, BOPET)	Ethylene glycol	107-21-1	GreenScreen LT-1 (Pharos, 2025), Scivera GHS+ [Red] (Scivera, 2020f)	Hazardous
Polyamide 6 (Nylon 6)	Caprolactam	105-60-2	Scivera GHS+ [Yellow] (Scivera, 2023a)	Minimum criteria
Polylactic acid (PLA)	Lactic acid	50-21-5	GreenScreen BM-2 (ToxServices LLC, 2013b), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Minimum criteria
Polylactic acid (PLA)	Lactide	95-96-5	GreenScreen BM-3 (ToxServices LLC, 2020b) (expired)	Additional criteria
Polyhydroxyalkanoates (PHA)	Multiple variations	Multiple	N/A	N/A

Polymer	Monomer(s)	Monomer CASRN(s)	Hazard Assessment Score	Preliminary Monomer Hazard Tier*
Polybutylene adipate terephthalate (PBAT)	1,4-butanediol	110-63-4	ChemFORWARD Hazard Band C (ChemFORWARD, 2025a)	Minimum criteria
Polybutylene adipate terephthalate (PBAT)	Adipic acid	124-04-9	Scivera GHS+ [Yellow] (Scivera, 2020c), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Minimum criteria
Polybutylene adipate terephthalate (PBAT)	Terephthalic acid	100-21-0	GreenScreen BM-2 (ToxServices LLC, 2013c), Scivera GHS+ [Yellow] (Scivera, 2021w)	Minimum criteria
Cellulose	Beta-D-glucose	492-61-5 (50-99-7)	GreenScreen BM-3 (ToxServices LLC, 2013a), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Additional criteria
Polycaprolactone (PCL)	Caprolactone	502-44-3	Scivera GHS+ [Yellow] (Scivera, 2017d)	Minimum criteria
Polybutylene succinate (PBS)	1,4-butanediol	110-63-4	ChemFORWARD Hazard Band C (ChemFORWARD, 2025a)	Minimum criteria
Polybutylene succinate (PBS)	Succinic acid	110-15-6	Scivera GHS+ [Yellow] (Scivera, 2017f), ChemFORWARD Hazard Band C (ChemFORWARD, 2025d)	Minimum criteria
Starch	Alpha-D-Glucose	492-62-6 (50-99-7)	GreenScreen BM-3 (ToxServices LLC, 2013a), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Additional criteria

Polymer	Monomer(s)	Monomer CASRN(s)	Hazard Assessment Score	Preliminary Monomer Hazard Tier*
Polyvinyl alcohol (PVA, PVOH)	Vinyl acetate	108-05-4	GreenScreen LT-1 (Pharos, 2025), Scivera GHS+ [Yellow] (Scivera, 2021z), ChemFORWARD Hazard Band C (ChemFORWARD, 2025b)	Hazardous
Ethylene vinyl alcohol (EVOH)	Ethylene	74-85-1	GreenScreen BM-2 (ToxServices LLC, 2021c), Scivera GHS+ [Yellow] (Scivera, 2018d)	Minimum criteria
Ethylene vinyl alcohol (EVOH)	Vinyl acetate	108-05-4	GreenScreen LT-1 (Pharos, 2025), Scivera GHS+ [Yellow] (Scivera, 2021z), ChemFORWARD Hazard Band C (ChemFORWARD, 2025b)	Hazardous

* Hazard tiers assigned are based on a preliminary review and may change as we learn more.

Polymer Properties

We are also collecting hazard information on the base polymers used in packaging products. Historically, regulatory agencies considered many polymers to be low hazard concern due to their large molecular weight and low expected absorption or uptake by biological organisms, including people (EPA, 2013b). More recent research has highlighted the potential for people and wildlife to take up polymeric particles, such as microplastics from the environment (ITRC, 2023; Landrigan et al., 2025), and the potential for impacts has not yet been fully characterized. This is complicated by the presence of chemical additives in many polymers that may be responsible for some of the effects observed in studies of polymer particles.

This means that the hazard assessments of many polymers are based on limited data. There is some uncertainty in their associated hazards, particularly particle size and degradation products, which are especially relevant for short-use phase or disposal products such as plastic packaging. These associated hazards are not always considered in existing hazard assessment methods or past studies on polymer toxicity, but these hazard assessments remain useful tools to understand some hazards of the bulk polymer materials used in products, including packaging.

Table 49 below summarizes polymers used in plastic packaging along with their hazard assessment scores and the corresponding hazard tier in our criteria for safer.

Table 49: Base polymers used in packaging are listed alongside their hazard scores, corresponding CASRNs, and preliminary hazard tier in our criteria for safer.

Polymer	CASRN	Hazard Assessment Scores	Preliminary Polymer Hazard Tier
PVC	9002-86-2	Scivera GHS+ [Yellow] (Scivera, 2021s)	Hazardous (fails within-class criteria)
PVDC	9002-85-1	N/A	N/A
Polyethylene (LDPE, LLDPE, HDPE)	9002-88-4	Scivera GHS+ [Yellow] (Scivera, 2021k), ChemFORWARD Hazard Band B (ChemFORWARD, 2023d)	Minimum criteria
Polypropylene (PP, BOPP)	9003-07-0	Scivera GHS+ [Yellow] (Scivera, 2018a), EPA SCIL Full Green Circle (polymers) (OCSPP, 2013a)	Minimum criteria
Polyethylene terephthalate (PET, BOPET)	25038-59-9	Scivera GHS+ [Yellow] (Scivera, 2021r)	Minimum criteria
Polyamide 6 (Nylon 6)	25038-54-4	Scivera GHS+ [Yellow] (Scivera, 2026c)	Minimum criteria
Polylactic acid (PLA)	26100-51-6	ChemFORWARD Hazard Band D (ChemFORWARD, 2021d)	Minimum criteria
Polyhydroxyalkanoates (PHAs)	Multiple	N/A	N/A
Polybutylene adipate terephthalates (PBAT)	60961-73-1	N/A	N/A
Cellulose	9004-34-6	Scivera GHS+ [Yellow] (Scivera, 2022c), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Additional criteria
Polycaprolactone (PCL)	24980-41-4	Scivera GHS+ [Yellow] (Scivera, 2018f)	Minimum criteria
Polybutylene succinate (PBS)	25777-14-4	Scivera GHS+ [Yellow] (Scivera, 2022a)	Minimum criteria
Starch	9005-25-8 (multiple)	Scivera GHS+ [Green/Yellow] (Scivera, 2025h), EPA SCIL Full Green Circle (processing aids and additives) (OCSPP, 2013a)	Additional criteria

Polymer	CASRN	Hazard Assessment Scores	Preliminary Polymer Hazard Tier
Polyvinyl alcohol (PVA, PVOH)	9002-89-5	Scivera GHS+ [Green/Yellow] (Scivera, 2019i), EPA SCIL Full Green Circle (polymers) (OCSPP, 2013a)	Additional criteria
Ethylene vinyl alcohol (EVOH)	25067-34-9	N/A	N/A

Note: We have not yet reviewed these hazard assessments in detail and hazard tiers assigned are preliminary and may change as we learn more. We plan to incorporate known hazard information on potential alternatives in their polymer form in our continued analysis.

Degradation Products

To account for hazards related to breakdown of plastic packaging after it is discarded, we're looking into polymer degradation products with a focus on microplastic formation when larger plastic materials fragment. The science on microplastics is evolving, but many studies suggest these particles are likely hazardous to human health and the environment. What we know is that, for many polymers, these microplastics are expected to persist in the environment for very long periods of time.

To account for the potential hazards of persistent microplastics expected to accumulate in the environment from packaging, we intend to focus on the "ultimate biodegradability" of the base polymer type. Ultimate biodegradability in this context refers to complete breakdown of the polymer by microorganisms into carbon dioxide, water, inorganic minerals, and biomass. While we recognize that hazards related to release or breakdown of additives used in polymers is relevant, we do not have sufficient information to include this factor as part of our analysis, and these can vary significantly depending on the packaging application. In contrast, there appears to be information on the ultimate biodegradability of many base polymer types, and this can be used as a measure of persistence and indicator of the potential for anticipated and unforeseen long-term impacts.

As part of our ongoing work, we will determine the appropriate measure of biodegradability that will allow us to make comparisons between PVC, PVDC, and alternatives. We have based our preliminary analysis of biodegradability of different polymer types on literature references (Dallaev et al., 2025; Ghimire et al., 2026) and polymers advertised to meet various biodegradability or composting standards, such as ASTM D6400 (ASTM, n.d.; Chen, 2026) or EN 13432 (TÜV SÜD, n.d.) and related certifications such as through BPI (BPI, 2026) or TÜV SÜD (TÜV SÜD, n.d.).

Table 50: A list of base polymers and whether they are likely to meet biodegradability or compostability standards.

Polymer	CASRN	Biodegradable or Compostable
PVC	9002-86-2	No (Kudzin et al., 2024)
PVDC	9002-85-1	No
Polyethylene (LDPE, LLDPE, HDPE)	9002-88-4, 25087-34-7, 9002-88-4	No
Polypropylene (PP, BOPP)	9003-07-0	No
Polyethylene terephthalate (PET)	25038-59-9	No
Polyamide 6 (Nylon 6)	25038-54-4	No
Polylactic acid (PLA)	26100-51-6	Yes (Dallaev et al., 2025)
Polyhydroxyalkanoates (PHAs)	Multiple	Yes (Dallaev et al., 2025)
Polybutylene adipate terephthalates (PBAT)	60961-73-1	Yes (Dallaev et al., 2025)
Cellulose	9004-34-6	Yes (Hubbe et al., 2025)
Polycaprolactone (PCL)	24980-41-4	Yes (Dallaev et al., 2025)
Polybutylene succinate (PBS)	26247-20-1	Yes (Dallaev et al., 2025)
Starch	Multiple	Yes (Dallaev et al., 2025)
Polyvinyl alcohol (PVA, PVOH)	9002-89-5	Yes (Dallaev et al., 2025)
Ethylene vinyl alcohol (EVOH)	25067-34-9	No

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

We haven't completed a full analysis of feasibility or availability of alternatives for this category in Cycle 2 of Safer Products for Washington. The preliminary information indicates that alternatives are likely feasible and available for many uses of PVC and PVDC, but we need additional time to complete our analysis. A reporting requirement on PVC and PVDC in plastic packaging will provide additional information to support our continued evaluation. Table 51 summarizes examples of alternative polymer resins sold for use in plastic packaging.

Table 51: Polymers with associated CASRNs, advertised applications, and examples of commercialized polymer resins sold on the market.

Chemical	CASRN	Advertised Applications	Commercialized Base Polymer Examples
Polyethylene (LDPE, LLDPE, HDPE)	9002-88-4, 25087-34-7, 9002-88-4	Rigid, film, food uses	LDPE (Dow, n.d.-d; Sabic, n.d.-a), LLDPE (Dow, n.d.-c), HDPE (Dow, n.d.-b)
Polypropylene (PP, BOPP)	9003-07-0	Rigid, film, food uses	PP (Sabic, n.d.-c)
Polyethylene terephthalate (PET)	25038-59-9	Rigid, film, food uses	PET (Sabic, n.d.-b)
Polyamide 6 (Nylon 6)	25038-54-4	Film, food uses	PA6 Resin (Now Plastics, n.d.-a), Domamid® (DOMO Chemicals, 2026), Ultramid (BASF, n.d.-c)
Polylactic acid (PLA)	26100-51-6	Rigid, film, food uses	Ingeo (NatureWorks, n.d.)
Polyhydroxyalkanoates (PHAs)	Multiple	Rigid, film, food uses	Danimer Scientific PHA ("PHA Certifications," n.d.), PHAXTEC (Phaxtec, n.d.)
Polybutylene adipate terephthalates (PBAT)	60961-73-1	Rigid, film, food uses	ecoflex® (BASF, n.d.-b)
Cellulose	9004-34-6	Film, food uses	Aventa (cellulose acetate) (Eastman, n.d.-a)
Polycaprolactone (PCL)	24980-41-4	Film, food uses	Polyeff PCL (Polyeff, n.d.), Capa™ (Ingevity, n.d.)

Chemical	CASRN	Advertised Applications	Commercialized Base Polymer Examples
Polybutylene succinate (PBS)	26247-20-1	Film	PBS-BG5000M (AFC Ecoplastics, n.d.), BioPBS (Mitsubishi Chemical America, 2018)
Starch	Multiple	Barrier	Starch Based Resin (Syntex America, n.d.)
Polyvinyl alcohol (PVA, PVOH)	9002-89-5	Barrier	Selvol PVA (Sekisui Specialty Chemicals, n.d.-a), SoarnoL™ (PVOH/EVOH copolymer) (Soarus LLC, n.d.)
Ethylene vinyl alcohol (EVOH)	25067-34-9	Barrier	SoarnoL™ (PVOH/EVOH copolymer) (Soarus LLC, n.d.)

This information was collected from publicly available resources including reports compiled by other organizations focused on plastics, submissions from interested parties, and advertisements from plastic resin and packaging product manufacturers. While there is evidence that these polymers can be used in plastic packaging, we need additional time to determine whether they are feasible for specific applications.

We've identified some commercialized examples of these polymers used in plastic packaging. Table 52 summarizes examples of commercialized plastic packaging with alternative polymers.

Table 52: Applications of plastic packaging, along with potential feasible alternative polymers and examples of those polymers available in packaging products sold on the market.

Application	Potential Feasible Polymer(s)	Commercialized Packaging Examples
Rigid packaging	LDPE, LLDPE, PP, PLA	LDPE rigid plastic tubes (Container & Packaging, n.d.), LLDPE rigid food container (DK Hardware, n.d.), PP clear folding carton (BEP Packaging, n.d.), PLA Cosmetic bottles (Jarsking Packaging, 2023)
Pallet stretch wrap	PBAT, PLA	PLA+PBAT pallet wrap stretch film (Ameson, n.d.)
Blister packs	PP, cellulose (paper)	PP blister inserts (PakFactory, n.d.), PP blister packs (Panaro, n.d.), Paper blister packaging (TOPPAN, n.d.)
Clamshells	PLA	PLA Clamshell (Good Start Packaging, n.d.)
Printed Labels	BOPP, PP, PE	BOPP or PP Printed labels (Wizard Labels, n.d.), PE Labels (Star Label Products, n.d.)
Shrink wrap	LDPE, PLA, PHA, Starch	LDPE shrink wrap (Bioaqualife, n.d.), PLA+PHA+Starch-based polymers shrink wrap (Natural Shrinkwrap, n.d.)
Food film wrap	BOPP, HDPE, PLA	BOPP film (Cosmo Films, n.d.), HDPE film (CS Hyde, n.d.), PLA film (Naturepoly, 2025)

Application	Potential Feasible Polymer(s)	Commercialized Packaging Examples
Food vacuum packaging	EVOH+PE+PP, Nylon 6	PA/EVOH/PE or PE/EVOH/PE multi-layer high-barrier vacuum bags (CloudFilm, n.d.), PA/EVOH/PE, PP/EVOH/PE, or PP/EVOH/PP multi-layer film (Now Plastics, n.d.-b), Nylon 6 protective liner and vacuum packaging (Nylene, 2022)
Beverage caps	PP, HDPE	PP caps (Porter Bottle, n.d.), HDPE bottle caps (U.S. Plastics Corp., n.d.)
Barrier properties	Requires more information	PA/EVOH/PE or PE/EVOH/PE multi-layer high-barrier vacuum bags (CloudFilm, n.d.)

As a next step, we intend to continue engagement with manufacturers of packaging products to understand the breadth of their packaging applications and limitations. We plan to use this information with our ongoing hazard evaluation of these materials to determine which specific packaging applications may have safer, feasible, and available alternatives. This review of alternatives to PVC and PVDC in plastic packaging will extend into Cycle 3 of the Safer Products for Washington program.

Conclusions on alternatives

We need additional time to complete our full analysis of alternatives to PVC and PVDC in plastic packaging. We are extending this analysis into Cycle 3 of Safer Products for Washington.

Our regulatory determination for PVC and PVDC in plastic packaging is a reporting requirement should be adopted.

This will provide additional information to support our continued analysis of alternatives for this category and any subsequent regulatory action.

Chapter 13: PCBs in Printing Inks

Priority product scope

As defined in the Safer Products for Washington Cycle 1 Implementation Phase 3 report (Ecology, 2022b), the scope of this priority product includes printing inks sold in any form or packaging for personal, commercial, or industrial use. The category doesn't include dyes, toner powder, liquid toner, or printed products.

Example products include (non-exhaustive list):

- Dye-Based Ink
- Pigment-Based Ink
- Cartridges
- Offset Lithography Inks
- Digital Printing Inks
- Flexography Inks
- Rotogravure Inks
- Screen Printing Inks

Priority chemical scope

Polychlorinated biphenyls (PCBs) are defined in RCW 70A.350.010(13):[47]

> "Polychlorinated biphenyls" or "PCBs" means chemical forms that consist of two benzene rings joined together and containing one to ten chlorine atoms attached to the benzene rings.

Function of the priority chemical in the priority product

As described in the Safer Products for Washington Cycle 1 Implementation Phase 3 report, PCBs don't perform a function in inks (Ecology, 2022b). PCBs are generated due to non-specific chlorination processes and can contaminate pigments used in inks. Pigments can contain PCBs from the manufacturing process, and common examples include some diarylide yellows, phthalocyanines, and titanium dioxide. Thus, pigments added to inks can contain PCBs.

Hazards of the priority chemical class

We describe the hazards associated with PCBs in our Cycle 1, Phase 3 Regulatory Determinations Report to the Legislature published in 2022 (Ecology, 2022b). PCBs are persistent, bioaccumulative, and toxic (PBT) compounds. Hazards of concern for human health include carcinogenicity and developmental toxicity. In addition, PCBs are also associated with

[47] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

acute aquatic toxicity, persistence, and bioaccumulation. Taken together, these hazards indicate that PCBs do not meet our minimum Criteria for Safer (Ecology, 2022b).

Safer, feasible, and available alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). During Cycle 1 of Safer Products for Washington, we determined that specifically for oil-based CMYK offset lithography inks, inks with lower PCB concentrations are safer, feasible, and available. However, we didn't have sufficient information to make a broad determination for all inks within the product scope.

In our 2022 Regulatory Determinations Report to the Legislature (Ecology, 2022b), we found that lower concentrations of PCBs were feasible and available, but we believed that federal law limited our ability to set a different limit than EPA and we declined to take regulatory action at that time. However, we don't believe we are pre-empted from prohibitions on the use of PCBs in products (Ecology, 2025b).

As a result, our focus for this category is identifying chlorine-free pigments to determine if they are feasible and available for use in printing inks.

We are interested in engaging in future projects such as one previously proposed by the organization ChemFORWARD (ChemFORWARD, 2024d) where they would work with manufacturers to determine whether chlorine-free pigments are feasible and available for use in various types of printing inks. We anticipate such projects will be considered as part of Ecology Water Quality program grants in the future, and if a project of this type is funded and completed the data could contribute to our analysis.

Conclusions

Our Cycle 2 regulatory determination for PCBs in printing inks is no action should be adopted.

We plan to continue work on this product category in future cycles of the program as new information becomes available.

Chapter 14: Sealants, Caulks, and Adhesives

Priority product scope

Sealants, caulks, and adhesives are used to seal or fill joints and seams or bond materials together. As defined in the Safer Products for Washington Cycle 2 Implementation Phase 2 technical report (Ecology, 2025b), the scope of this priority product includes sealants, caulks and adhesives that contain ortho-phthalates used in architectural or home maintenance applications. For the purposes of this priority product, caulks are considered to be a low-elasticity subcategory of sealants, and the term "sealant" is used to include caulks.

This category doesn't include hard surface sealers used to seal porous surfaces. The scope doesn't include adhesives which aren't intended for use in architectural or home maintenance applications, such as those used for product labeling.

Priority chemical scope

The scope of the priority chemical class for this product includes all ortho-phthalates, as defined in RCW 70A.350.010[48] (Washington State Legislature, 2019) and the Safer Product for Washington Cycle 1 Implementation Phase 3 report (Ecology, 2022b). The scope of this chemical class doesn't include tere-phthalates or iso-phthalates.

Function of the priority chemicals in the priority product

At the chemical level, the primary function of ortho-phthalates is as a plasticizer for the polymer base resin in caulks, sealants, and adhesives.

Plasticizers increase the flow and thermo-plasticity of a polymer, by decreasing the viscosity of the polymer melt, glass transition temperature, melting point, and elastic modulus of the finished product. This is accomplished by the plasticizer inserting itself between polymer chains, allowing for easier deformation of the material.

In a sealant or adhesive, an ortho-phthalate functions as a primary external plasticizer for polymer base resins and contributes to desirable properties in the product such as:

- Low-temperature properties
- Elongation
- Softness
- Flexibility
- Viscosity
- Toughness
- Set time
- Impact resistance
- Filler/Extender
- Peel

Sealants and adhesives used in building construction are formulated using a diverse range of polymer base types. Some polymer base types, such as acrylics, polyvinyl acetate, and some rubbers can readily utilize are highly compatible with polar plasticizers like ortho-phthalates.

[48] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.350.010

Other base types, such as polyurethanes and epoxies, can only utilize ortho-phthalates as plasticizers with limitations, ortho-phthalates yet still commonly use phthalates as plasticizers. Polymer base types such as silicones, hot-melt styrene butadiene or polyolefins, polysulfides, and polyamides typically can't effectively use phthalate plasticizers.

In our research for safer alternatives to ortho-phthalate plasticizers in construction sealants and adhesives we reviewed representative products from many different polymer base types, including:

- Epoxy
- Polyurethane
- Acrylic Latex
- Silane Modified Polymer
- Silicone
- Polyvinyl acetate, Ethylene-vinyl acetate
- Polyolefin, Polyamide
- Polysulfide
- Butyl
- Siliconized Acrylic
- Polyurea

Construction sealants and adhesives are put to a wide range of uses, through several different application types (tube, bead, trowel, spray, hot-melt). Construction uses considered included:

- General Assembly & Repair
- Window and Door Sealing
- Kitchen and Bath
- Trim and Molding
- Exterior Joints
- Concrete & Masonry
- Roofing & Gutter
- HVAC
- Flooring Control Joints
- Structural Glazing
- Panel & Board
- Subfloor
- Interior Carpet
- Wood Floor
- Vinyl Floor
- Tile and Stone
- Extreme Load Floors
- Outdoor Carpet
- Moisture pH Barrier

To investigate the functions of plasticizers in sealants and adhesives and the range of available plasticizer options, we reviewed industry publications (BASF, n.d.-a; Daniels, 2025; Eastman, n.d.-c, n.d.-b; Petrie, 2026). We referenced third-party chemical analyses (Ecology Center Healthy Stuff Lab, 2023) that reported detections of ortho-phthalate and other plasticizers in adhesives and sealants.

Cradle-to-Cradle Certified products (Cradle to Cradle Products Innovation Institute, 2025) were used to identify sealant and adhesive products that don't contain ortho-phthalates. We investigated sealant and adhesive products advertised or otherwise referenced as phthalate-free.

Publicly available safety data sheets, technical data sheets, and Health Product Declarations for sealant and adhesive products were reviewed to examine the plasticizers used. Additionally, we contacted major manufacturers of construction sealants and adhesives to solicit information on products without ortho-phthalates and alternative plasticizers used. From this research, we developed a list of safer alternative plasticizers in use in commercial construction sealant and adhesive products.

Hazards of the priority chemical class

We described the hazards associated with ortho-phthalates in our Cycle 1, Implementation Phase 3 Regulatory Determinations Report to the Legislature published in 2022 (Ecology, 2022b). Hazards of concern include carcinogenicity, reproductive and developmental toxicity, and endocrine disruption. Most ortho-phthalates don't meet our minimum criteria.

However, there is some variability in hazard assessment scores for chemicals in the ortho-phthalates class, notably for dimethyl phthalate (DMP), diethyl phthalate (DEP), and di(2-propylheptyl) phthalate (DPHP) which meet our minimum criteria but not our additional or within-class criteria (Ecology, 2022b).

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). Most ortho-phthalates don't meet our minimum criteria for safer. DMP and DEP do meet our minimum criteria, but to our knowledge they aren't used in sealants, caulks, and adhesives, likely due to their higher volatility relative to other ortho-phthalates.

DPHP meets our minimum criteria, and is much less volatile than DMP and DEP, but it doesn't meet our within-class criteria. Our within-class criteria for ortho-phthalates requires that alternatives within the priority chemical class score low for carcinogenicity, reproductive toxicity, developmental toxicity and endocrine disruption because these hazards are associated with the ortho-phthalate class.

DPHP was scored as moderate for developmental toxicity and endocrine disruption in a GreenScreen® hazard assessment (ToxServices LLC, 2022) and was assigned a data gap for carcinogenicity. Similarly, in a verified Scivera GHS+ assessment, carcinogenicity, developmental toxicity, and endocrine activity were scored as moderate hazard for DPHP (Scivera, 2021f). DPHP was assigned a data gap for carcinogenicity in a ChemFORWARD assessment (ChemFORWARD, 2020c). As such, DPHP doesn't meet our within-class criteria based on any of these assessments.

Taken together, ortho-phthalates don't meet either our minimum or within-class criteria for safer. Therefore, non-phthalate alternatives will need to meet our minimum criteria to be considered safer (Ecology, 2022b, 2022c). Any ortho-phthalates would need to meet both our minimum criteria and within-class criteria to be considered safer than other ortho-phthalates in the class.

We identified several chemical alternatives that can serve the plasticizer function in sealant, caulk, and adhesive products, summarized in Table 53. Hazard assessments used to determine whether these alternatives meet either our minimum or additional criteria for safer are described following Table 53.

Table 53: Safer alternatives that function as plasticizers in sealants, caulks, and adhesives, hazard assessment scores, and criteria for safer tier level (Ecology, 2022b, 2022c).

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Dioctyl terephthalate (DOTP) 6422-86-2	GreenScreen® BM-3DG, Scivera GHS+ [Green/Yellow], ChemFORWARD Hazard Band B	Additional
Triacetin 102-76-1	GreenScreen® BM-3DG (expired), Scivera GHS+ [Yellow], ChemFORWARD Hazard Band B, EPA SCIL Green Full Circle (solvent)	Additional
Siloxanes and Silicones, di-Me; Dimethicone; Poly[oxy(dimethylsilylene)] 63148-62-9, 9006-65-9, 9016-00-6	GreenScreen® BM-2, Scivera GHS+ [Yellow], ChemFORWARD Hazard Band SC, EPA SCIL Yellow Triangle (defoamer)	Minimum
Propane-1,2-diol, propoxylated 25322-69-4	Scivera GHS+ [Yellow], EPA SCIL Yellow Triangle (solvent)	Minimum
Propylene glycol 57-55-6	GreenScreen® BM-2 (expired), Scivera GHS+ [Yellow], EPA SCIL Half-Green Circle (solvent)	Minimum

Chemical and CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Oxydiethylene dibenzoate 120-55-8	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Dipropylene glycol dibenzoate 27138-31-4	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C, EPA SCIL Full Green Circle (skin conditioning agents, emollients)	Minimum
Diisononyl adipate 33703-08-1	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Diisononyl cyclohexanedicarboxylate (DINCH) 166412-78-8, 474919-59-0	Scivera GHS+ [Yellow], ChemFORWARD Hazard Band C	Minimum
Soybean oil, methyl esters 67784-80-9	EPA SCIL Green Half-Circle (solvent)	Minimum

Di(2-ethylhexyl) terephthalate, dioctyl terephthalate (DEHT, DOTP) (CASRN: 6422-86-2)

This chemical meets our additional criteria for safer.

DEHT scored as BM-3DG in an expired GreenScreen® assessment, (ToxServices LLC, 2021a) and this meets our additional criteria for safer (Ecology, 2022b, 2022c). The assessment noted data gaps for endocrine activity and neurotoxicity (repeat-dose). Data for endocrine activity isn't required in our criteria. Our criteria allow the data gap for neurotoxicity (repeat-dose) because there is sufficient data to score the neurotoxicity (single-dose) endpoint as low hazard.

A ChemFORWARD hazard assessment scored DEHT as Band B (ChemFORWARD, 2019b), indicating that it meets our minimum criteria for safer (Ecology, 2022b, 2022c). The ChemFORWARD analysis noted a data gap for endocrine activity but scored other endpoints as low hazard.

DEHT was scored as a Green/Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021e), further demonstrating it meets our additional criteria for safer (Ecology, 2022b, 2022c). The assessment noted data gaps for endocrine activity, acute toxicity (inhalation only), and sensory irritation. Our criteria don't require data for acute toxicity for all routes of

exposure, and the assessment scores acute toxicity for both dermal and oral exposure as green. Sensory irritation doesn't align to a specific endpoint in our criteria, and we don't require data for this endpoint.

DEHT is listed in the CleanGredients database (Palatinol® DOTP) as meeting the Safer Choice Master Criteria based on an assessment by a Safer Choice authorized third-party profiler (CleanGredients, 2025). This provides additional evidence that it meets our additional criteria for safer (Ecology, 2022b, 2022c).

Triacetin (CASRN: 102-76-1)

This chemical meets our additional criteria for safer.

Triacetin was scored as a Benchmark-3DG chemical in an expired GreenScreen® hazard assessment (ToxServices LLC, 2020c). The assessment noted data gaps for endocrine activity and neurotoxicity (single- and repeat-dose), but all other hazard endpoints were scored as low or very low hazard.

A publicly available, third-party reviewed ChemFORWARD hazard assessment of triacetin scored it as Hazard Band B (ChemFORWARD, 2020f). The ChemFORWARD analysis didn't identify any hazard flags. Triacetin has a data gap for endocrine disruption.

However, the weight of evidence suggests that triacetin isn't an endocrine disruptor. ToxCast data didn't identify any in vitro activity for androgen, estrogen, or thyroid pathways (EPA, n.d.-ag) and there was no evidence of endocrine disruption based on pathological data from reproductive or repeat dose toxicity studies. In our criteria, a chemical only scores high for endocrine disruption if there is evidence that endocrine disruption is the mechanism of action for another hazard endpoint which scores high. That means that if systemic toxicity scored high because of thyroid toxicity that was linked to endocrine disruption, then both systemic toxicity and endocrine disruption would score high. Because all other endpoints for triacetin are low, it is unlikely that endocrine disruption could score high.

Triacetin was scored as Green/Yellow in a verified Scivera GHS+ hazard assessment (Scivera, 2021x). A data gap was noted for endocrine disruption. Eye irritation was scored as moderate hazard. All other endpoints considered in our criteria were scored as low hazard.

Additionally, the EPA Safer Chemicals Ingredients List (SCIL) lists triacetin as a Full Green Circle with a functional use as a solvent (OCSPP, 2013a). This indicates that it has been verified by EPA to be a low hazard based on experimental and modeled data.

Siloxanes and Silicones, di-Me; Dimethicone;Poly[oxy(dimethylsilylene)] (CASRNs: 63148-62-9, 9006-65-9, and 9016-00-6)

These chemicals meet our minimum criteria for safer.

These three chemicals were scored together as BM-2 in an expired GreenScreen® assessment (ToxServices LLC, 2025e, 2025c, 2025d) and this meets our minimum criteria for safer (Ecology, 2022b, 2022c). The assessment noted data gaps for endocrine activity and neurotoxicity (repeat-dose). Eye irritation was scored as moderate hazard. All other endpoints were scored as low or very low hazard. The assessment is focused on high molecular weight dimethicone, and

dimethicone will only meet our minimum criteria if cyclic volatile methylsiloxane monomers are present below 1000 parts per million in the final product (Ecology, 2024b, 2024d).

These three CASRNs meet our minimum criteria for safer based on Scivera GHS+ hazard assessments:

- **Siloxanes and silicones, di-Me (CASRN: 63148-62-9)** scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021u). Carcinogenicity, mutagenicity, reproductive, and developmental endpoints scored as low hazard. A data gap was noted for endocrine disruption; this chemical wasn't found on any lists for endocrine disruption. Persistence was noted as a very high hazard, primarily based on listing on the 2007 Canada Domestic Substance List and experimental data. Additionally, the EPA SCIL lists this CASRN as a Yellow Triangle with a functional use as a defoamer, with some concern noted for aquatic toxicity. The Yellow Triangle indicates that the chemical has met Safer Choice Criteria as a defoamer, and that there is some room for improvement even though it is among the safest available.
- **Dimethicone (CASRN: 9006-65-9)** scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2019f). Carcinogenicity, mutagenicity, reproductive, and developmental endpoints scored as low hazards. Data gaps were noted for endocrine disruption; this chemical wasn't found on any lists for endocrine disruption. Persistence and acute aquatic toxicity endpoints were both noted as high (H) hazards with limited evidence based on authoritative listing on the 2007 Canada Domestic Substance List.
- **Poly[oxy(dimethylsilylene)] (CASRN: 9016-00-6)** scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2018g). Carcinogenicity scored low, and mutagenicity, reproductive, and developmental endpoints scored as moderate hazards all with limited evidence. A data gap was noted for endocrine disruption; this chemical wasn't found on any lists for endocrine disruption. Persistence scored as very high with limited evidence based on listing on the 2007 Canada Domestic Substance List and experimental data from a related substance (siloxanes and silicones, di-Me). Acute aquatic toxicity scored as a high hazard with limited evidence based on listing of a related substance on the 2007 Canada Domestic Substance List: siloxanes and silicones, di-Me.

Propane-1,2-diol, propoxylated (CASRN: 25322-69-4)

This chemical meets our minimum criteria for safer.

Propane-1,2-diol, propoxylated was scored as a Yellow chemical in a verified Scivera GHS+ hazard assessment (Scivera, 2021t). While a data gap was noted for endocrine disruption, carcinogenicity, mutagenicity, reproductive, and developmental endpoints all scored as low hazard.

Additionally, the EPA SCIL lists this chemical as a Yellow Triangle with a functional use as a solvent (OCSPP, 2013a), indicating it has met Safer Choice Criteria as a solvent and is among the safest solvents available, though with some room for improvement.

Propylene glycol (CASRN: 57-55-6)

This chemical meets our minimum criteria for safer.

A verified Scivera GHS+ hazard assessment scored propylene glycol as a Yellow chemical (Scivera, 2020j). Endocrine activity scored as a moderate hazard with limited confidence only due to listing as a chemical of interest on The Endocrine Disruption Exchange, Inc (TEDX) screening list (TEDX - The Endocrine Disruption Exchange, 2018). Other health endpoints listed as moderate include systemic toxicity, dermal sensitization, and sensory irritation. A data gaps was noted for respiratory sensitization. Other human health hazards in this assessment scored as low hazard.

Propylene glycol was scored as a Benchmark-2 chemical in an expired GreenScreen® hazard assessment (ToxServices LLC, 2014b). The assessment noted data gaps for endocrine activity, systemic toxicity (single-dose), neurotoxicity (repeat-dose), and respiratory sensitization. Reproductive toxicity, developmental toxicity, systemic toxicity (repeat-dose), and neurotoxicity (single-dose) were all scored as moderate hazard. All other endpoints were scored as low or very low hazard.

The EPA SCIL lists this chemical as a Green Half-Circle with functional use as an enzyme and enzyme stabilizer and as a solvent (OCSPP, 2013a). This means that based on available experimental and modeled data, EPA has concluded this chemical is anticipated to be a low hazard. Gathering additional data would increase confidence in its classification as a safer chemical.

Oxydiethylene dibenzoate (CASRN: 120-55-8)

This chemical meets our minimum criteria for safer.

A verified Scivera GHS+ hazard assessment scored oxydiethylene dibenzoate as a Yellow chemical (Scivera, 2019l). Carcinogenicity and developmental toxicity were scored as moderate hazard. Data gaps are noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. We don't require data on endocrine activity in our criteria, and reproductive toxicity was scored as low hazard. The moderate hazard score for developmental toxicity was due to incomplete ossification observed in rabbits at 200 mg/kg/day. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity were scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization was scored as low hazard.

Oxydiethylene dibenzoate (also known as diethylene glycol dibenzoate) was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2020b). The assessment noted data gaps for reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), endocrine activity, systemic toxicity (repeat-dose, dermal and inhalation), and neurotoxicity (repeat-dose, all routes). Reproductive toxicity was scored as low

hazard based on the oral route. Developmental toxicity was assigned GHS Category 2 based on effects on body weight and spleen weights in a two-generation study in rats, this corresponds to a moderate hazard score in our criteria. Neurotoxicity (single-dose) oral and inhalation were both assigned GHS Category 3, and this corresponds to a moderate hazard score in our criteria. Acute aquatic toxicity was assigned GHS Category 2, and this corresponds to a high hazard score in our criteria. All other endpoints were scored as low hazard in the assessment.

Dipropylene glycol dibenzoate (CASRN: 27138-31-4)

This chemical meets our minimum criteria for safer.

A verified Scivera GHS+ hazard assessment scored dipropylene glycol dibenzoate as a Yellow chemical (Scivera, 2021p). The assessment noted data gaps for endocrine activity, neurotoxicity, respiratory sensitization, and sensory irritation. We don't require a score for endocrine activity to meet our minimum criteria. The data gap for neurotoxicity is allowed as systemic toxicity and acute toxicity were both scored as low hazard. A data gap for respiratory sensitization is allowed as dermal sensitization was scored as low hazard. Our criteria for safer doesn't require data on sensory irritation. Carcinogenicity, mutagenicity, developmental toxicity, and eye irritation were scored as moderate hazard. Acute aquatic toxicity was scored as high hazard, and chronic aquatic toxicity was scored as moderate hazard. All other endpoints were scored as low hazard.

Dipropylene glycol dibenzoate was assigned Hazard Band C in a ChemFORWARD assessment (ChemFORWARD, 2019c). The assessment notes data gaps for carcinogenicity (dermal and inhalation), reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), systemic toxicity (repeat-dose dermal and inhalation) and neurotoxicity (single-dose dermal, repeat-dose all routes) and endocrine activity. Developmental toxicity is assigned GHS Category 2 which corresponds to a hazard score of moderate in our criteria. Systemic toxicity (single-dose) was assigned GHS Category 2 (oral) and Category 3 (inhalation) which correspond to scores of moderate hazard and high hazard in our criteria, respectively. Neurotoxicity (single-dose) oral and inhalation were both assigned GHS Category 3 which both correspond to a score of moderate hazard in our criteria. Acute and chronic aquatic toxicity were both scored as high hazard. Data on endocrine activity isn't required in our criteria. The data gap for neurotoxicity (repeat-dose all routes) is allowed as acute toxicity and systemic toxicity were scored as moderate hazard and high hazard, respectively. All other hazard endpoints were scored as low or moderate hazard based on other routes of exposure.

Dipropylene glycol dibenzoate is listed on the EPA SCIL as a Full Green Circle under the emollients function. Emollients are evaluated against the Safer Choice Master Criteria (EPA, n.d.-aa).

Diisononyl adipate (CASRN: 33703-08-1)

This chemical meets our minimum criteria for safer.

A verified Scivera GHS+ hazard assessment scored diisononyl adipate as a Yellow chemical (Scivera, 2021j). Reproductive and developmental toxicity were scored as moderate hazard. Data gaps are noted for endocrine activity, neurotoxicity, respiratory sensitization, and sensory

irritation. Data for endocrine activity isn't required in our criteria. The data gap for neurotoxicity is allowable as acute toxicity and systemic toxicity scored as low hazard. The data gap for respiratory sensitization is allowable as dermal sensitization scored as low hazard. Data on sensory irritation isn't required in our criteria. All other human and environmental health endpoints scored as low hazard.

Diisononyl cyclohexanedicarboxylate (DINCH) (CASRNs: 166412-78-8 and 474919-59-0)

This chemical meets our minimum criteria for safer.

DINCH was scored as a Yellow chemical in a verified Scivera assessment (Scivera, 2021b). The assessment noted data gaps for acute toxicity (inhalation only), respiratory sensitization, and sensory irritation. Our criteria don't require data for acute toxicity for all routes of exposure, and the assessment scores acute toxicity for dermal and oral exposure as green, so this meets our data requirements. A data gap for respiratory sensitization is allowed as skin (dermal) sensitization is scored as green. Sensory irritation doesn't align to a specific endpoint in our criteria, and we don't require data for this endpoint. Endocrine disruption, dermal irritation, and persistence were scored as moderate hazard, all other endpoints were scored as low hazard.

DINCH was assigned Hazard Band C in a ChemFORWARD hazard assessment (ChemFORWARD, 2026a). The assessment noted data gaps for reproductive toxicity (dermal and inhalation), developmental toxicity (dermal and inhalation), acute toxicity (inhalation only), systemic toxicity (single-dose inhalation only, repeat-dose dermal and inhalation), and neurotoxicity (single-dose inhalation only, repeat-dose dermal and inhalation). Endocrine activity was scored as moderate hazard based on anti-androgenic and possibly steroidogenesis effects observed in in vitro and in vivo studies but without plausibly linked adverse health effects. All other endpoints were scored as low or moderate hazard based on other routes of exposure.

Soybean oil, methyl esters (CAS: 67784-80-9)

This chemical meets our minimum criteria for safer.

The EPA SCIL lists soybean oil as a Green Half-Circle with functional use as a solvent (OCSPP, 2013a). Based on available experimental and modeled data, the chemical is anticipated to be a low hazard. Gathering additional data would increase confidence in its classification as a safer chemical. Chemicals listed on EPA SCIL evaluated under the solvent functional criteria can meet our minimum criteria for safer if we can confirm that the mutagenicity and sensitization endpoints meet our minimum criteria. Sensitization isn't expected for soybean oil, methyl esters, but in the worst-case scenario a score of very high would still meet our minimum criteria as this chemical wouldn't score as very high for persistence or bioaccumulation. Mutagenicity is also expected to score as low as studies available on this chemical from the National Toxicology Program were negative for genetic toxicity (National Toxicology Program, n.d.-a).

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

To demonstrate that the safer alternatives described in the above section are feasible and available for use in sealants, caulks, and adhesives, we constructed a list of products already on the market that use these ingredients (Table 54). The product examples cover a range of base-polymer types and applications.

A wide variety of silicone products that don't use plasticizers are advertised for most applications. For window and door sealing, kitchen and bath sealants and adhesives, concrete and masonry applications, as well as roofing and gutter sealants, product formulations using safer alternative plasticizers are also advertised for other base polymer types. These include polyurethane, acrylic latex, siliconized latex, and silane-modified polymer formulations.

Structural glazing is almost universally performed with silicone sealants which don't use plasticizers. Subfloor, panel and board installation, carpet, and floor installation adhesives, are advertised that use safer plasticizers in polyurethane and acrylic latex formulations.

During our search, we found that sealant and adhesives less commonly use polyamide as a base polymer type, and that these uses are primarily in factory settings outside of the scope of our priority product.

We didn't identify alternatives for the base polymer types of polysulfide or polyurea. However, our understanding is that sealants and adhesives products using other base polymers for which we did identify alternatives can be used in the applications where polysulfide or polyurea products are commonly used. Based on this, we conclude that safer alternatives to ortho-phthalates are feasible and available broadly across the product category as summarized in Table 54.

Table 54: A list of safer alternative chemicals, compatible polymers and applications in sealants, caulks, and adhesives, and example products.

Alternative Plasticizer	Applicable Polymer Types	Applicable Uses	Example products using alternative
No Plasticizer	Silane Modified Polymer, Siliconized Latex	Window & Door Sealing, General Assembly & Repair	SafeCoat Almighty Adhesive (AFM Safecoat, n.d.-b), SafeCoat Caulking Compound (AFM Safecoat, n.d.-a), Titebond ProGrade Plus Caulk (M. Sanger, personal communication, December 18, 2025)
Dioctyl terephthalate (DOTP) 6422-86-2	Polyurethane, Acrylic Latex, Silane Modified Polymer	All except Structural Glazing	Dynatrol I-XL Hybrid (Ecology Center Healthy Stuff Lab, 2023), Frontier Adhesives (C. Gentry, personal communication, February 9, 2026), Taylor Adhesives (C. Gentry, personal communication, February 9, 2026), WAKOL Adhesives (E. Underwood, personal communication, April 1, 2026)
Triacetin 102-76-1	polyvinyl acetate	Wall Repair	Henry Company BarriBond HP (Henry Company, 2025c), Henry Company Air-Bloc® LF Liquid-Applied Flashing (Henry Company, 2025a)
Siloxanes and Silicones, di-Me 63148-62-9	silicone	All except paintable applications	3M Fire Barrier Watertight Sealant (3M Canada Company, 2026), DOWSIL™ 786 Silicone Sealant (Dow, 2025)
Dimethicone 9006-65-9	silicone	All except paintable applications	Rapidstick™ RS-60 All-In-One Silicone Sealant (BowlWare US, n.d.; Chemtools Pty Ltd, 2025)
Poly[oxy(dimethylsilylene)] 9016-00-6	silicone	All except paintable applications	ProGrade 920 Silicone Roof Sealant (Henry Company, 2025b)

Alternative Plasticizer	Applicable Polymer Types	Applicable Uses	Example products using alternative
Propane-1,2-diol, propoxylated 25322-69-4	Latex, siliconized acrylic	Trim & Molding, Panel & Board, Wood Floor, Vinyl Floor	Taylor Adhesives (C. Gentry, personal communication, February 9, 2026), WAKOL Adhesives (E. Underwood, personal communication, April 1, 2026)
Propylene glycol 57-55-6	siliconized acrylic, silane modified polymer	Trim & Molding, Panel & Board, Wood Floor, Vinyl Floor	SafeCoat 3 in 1 Adhesive (allergEAZE, n.d.), Taylor Adhesives (C. Gentry, personal communication, February 9, 2026), WAKOL Adhesives (E. Underwood, personal communication, April 1, 2026)
oxydiethylene dibenzoate 120-55-8	silane modified polymer, polyvinyl butyl, polyurethane, siliconized acrylic, acrylic latex, epoxy	All except Structural Glazing	DAP Alex Painter's Acrylic (Ecology Center Healthy Stuff Lab, 2023), Flex Premium Molding & Trim Sealant (DAP Global Inc., 2025b), Dynaflex 230 Premium Elastomeric Interior/Exterior Sealant (DAP Global Inc., 2025a), Polycom EcoBlend (C. Gentry, personal communication, February 9, 2026), Helmicol 3029 A and B (Helmitin Inc., 2025a, 2025b), Helmicol 3031 A (Helmitin Inc., 2021b), Helmicol 3035 A (Helmitin Inc., 2025c), Helmicol 3040 A and B (Helmitin Inc., 2025d, 2025e), Helmicol 3416 A (Helmitin Inc., 2021a)

Alternative Plasticizer	Applicable Polymer Types	Applicable Uses	Example products using alternative
Dipropylene glycol dibenzoate 27138-31-4	silane modified polymer, polyvinyl butyl, polyurethane, siliconized acrylic, acrylic latex, epoxy	All except Structural Glazing	DAP Alex Painter's Acrylic (Ecology Center Healthy Stuff Lab, 2023), Flex Premium Molding & Trim Sealant (DAP Global Inc., 2025b), Dynaflex 230 Premium Elastomeric Interior/Exterior Sealant (DAP Global Inc., 2025a), Polycom EcoBlend (C. Gentry, personal communication, February 9, 2026), Helmicol 3425 (DAP Global Inc., 2025a), Polycom EcoBlend (C. Gentry, personal communication, February 9, 2026), Helmicol Adhesives 3425 A and B (Helmitin Inc., 2018, 2024)
diisononyl adipate 33703-08-1	Rubber, latex/acrylic, polyurethane, silane modified polymer	Window & Door Sealants, Trim & Molding, General Assembly & Repair	Prosoco R-Guard FastFlash Roller Grade (PROSOCO, Inc., 2016)
Soybean oil, methyl esters 67784-80-9	PVA, rubber, acrylic, polyurethane	Wood Floor, Vinyl Floor	Taylor Adhesives (C. Gentry, personal communication, February 9, 2026), Aquaflex Waterproof Acoustic Flooring Adhesive (Aquaflex, 2019)

Conclusions on alternatives

Reducing a significant source or use

We characterized sealants, caulks and adhesives as a significant use of ortho-phthalates and source of potential exposure in our previous report, Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b). Briefly, ortho-phthalates are used in a range of sealant, caulk, and adhesives products and can comprise from 0.1% to 40% of these products by weight. We estimated that the volume of adhesives and sealants used in Washington ranged between 45—133 million pounds for the building and construction, consumer do-it yourself (DIY), and retail sectors (Ecology, 2025b).

Safer alternatives are feasible and available

Safer alternatives to ortho-phthalates in sealants, caulks and adhesives were identified across a range of base-polymer types (**Table 53**). These alternatives are used in many types of sealant, caulks, and adhesives products which are suitable for a broad range of applications, and this shows they are feasible and available (**Table 54**).

Regulatory determination

Current information demonstrates that safer alternatives to ortho-phthalates in sealants, caulks, and adhesives are feasible and available and that a restriction would reduce a significant use of ortho-phthalates and source of potential exposure to people and the environment.

Our regulatory determination is a restriction on use of ortho-phthalates in sealants, caulks, and adhesives should be adopted.

Chapter 15: 1,4-dichlorobenzene in Solid Deodorizers

Priority product scope

As defined in the Safer Products for Washington Cycle 2 Implementation Phase 2 technical report (Ecology, 2025b), the scope of this priority product includes deodorizer products sold as solids that contain 1,4-dichlorobenzene (1,4-DCB). This includes toilet, garbage, and urinal deodorizer blocks and other solid continuous-action air fresheners.

The product category doesn't include deodorizing products sold in liquid form, or as packs or powders intended to dissolve in water.

Priority chemical scope

The priority chemical for this product category is 1,4-DCB. 1,4-DCB is a member of the organobromine and organochlorine priority chemicals class, which is defined in Safer Products for Washington Cycle 2 Implementation Phase 1 (Ecology, 2024a).

We are focused on 1,4-DCB specifically because we didn't find evidence of other organobromine or organochlorine substances used in the same way as 1,4-DCB. 1,4-DCB is sold as a solid chemical in deodorizers and intended to turn into a vapor and gradually spread into air.

Function of the priority chemical in the priority product

The chemical function of 1,4-DCB in solid deodorizers is as the primary deodorizer. Deodorizers are chemical substances that mitigate or remove undesirable odors over time (Chin et al., 2013; OECD, 2025).

1,4-DCB accomplishes its function as a deodorizer through sublimation, a physical process where the solid chemical transforms into a vapor. We determined this function of 1,4-DCB in solid deodorizers through review of literature on 1,4-DCB and review of manufacturer advertising and safety data sheets (Ecology, 2025a).

Hazards of the priority chemical class

We described the hazards associated with organobromine and organochlorine substances in our Cycle 2, Phase 1 Priority Chemicals technical report (Ecology, 2024c). Hazards of concern for 1,4-DCB specifically include carcinogenicity and eye irritation (ECHA, n.d.-a; OEHHA, 2015a). In addition, 1,4-DCB is associated with aquatic toxicity and persistence in the environment (ECHA, n.d.-a). These hazards indicate that 1,4-DCB does not meet our minimum criteria for safer (Ecology, 2022c).

Safer, feasible, and available alternatives

Safer alternatives

Safer chemical alternatives

"Safer" varies across hazards and applications (Ecology, 2022b). To identify potential alternatives to 1,4-DCB in solid deodorizers we focused our evaluation on deodorizer or similarly functioning chemicals that are used in these products. We referred to information from several sources to determine what other chemistries are used in these potential alternative products. The sources included:

- OECD Environment Health and Safety Publication (2025): Series on Testing & Assessment: Internationally Harmonised Functional, Product, and Article Use Categories (OECD, 2025)
- Mintel Global New Products Database (Mintel GNPD, 2022)
- California Air Resources Board (2004 Airborne Toxic Control Measure) Health Risk and Needs Assessment: Para-Dichlorobenzene Solid Air Fresheners (CARB, 2004)

Alternative chemicals that were identified by Ecology from these data sources are listed in Table 55 below.

Table 55: Alternatives to 1,4-dichlorobenzene in solid deodorizers with hazard assessment scores and tier they meet in our Criteria for Safer.

Chemical	CASRN	Hazard Assessment Scores	Tier met in Criteria for Safer (minimum or additional)
Camphor / bornan-2-one	76-22-2	Scivera GHS+ [Grey]	Minimum
Carbon	7440-44-0	ChemFORWARD Hazard Band C	Minimum
Clinoptilolite	12173-10-3	EPA SCIL Full Green Circle (processing aids and additives)	Additional
Sodium bicarbonate	144-55-8	Scivera [Yellow], EPA SCIL Full Green Circle (processing aids and additives)	Additional

Camphor / bornan-2-one (CASRN: 76-22-2)

This chemical meets our minimum criteria for safer.

Bornan-2-one was scored as a Grey chemical in a Scivera GHS+ chemical hazard assessment (Scivera, 2026b), indicating that there was insufficient data for some critical endpoints.

Data gaps were noted for carcinogenicity, reproductive toxicity, endocrine activity, respiratory sensitization and sensory irritation. Data for endocrine activity is not required to meet our minimum criteria. The data gap for respiratory sensitization is allowed as dermal sensitization was scored as low hazard. Sensory irritation does not correspond to an endpoint in our criteria for safer. Carcinogenicity was scored as a data gap due to a lack of an adequate long-term carcinogenicity study.

However, bornan-2-one has not been classified as carcinogenic by any authoritative organizations. QSAR analyses using the OECD QSAR Toolbox do not identify any structural alerts for oncogenic or carcinogenic potential for the chemical. Further, mutagenicity was scored as low hazard for this chemical based on results from in vitro and in vivo studies. Based on this information, we consider carcinogenicity as likely low hazard in our criteria.

The data gap for reproductive toxicity was due to lack of a guideline-compliant in vivo reproductive toxicity study; but there is sufficient data for developmental toxicity to meet our data requirements. This chemical has not been classified for reproductive toxicity by any authoritative organizations. Bornan-2-one does have structural alerts for potential reproductive and developmental toxicity in QSAR modeling using the OECD ToolBox DART scheme. Developmental toxicity for bornan-2-one was scored as low hazard with high confidence based on in vivo data from the enantiomer D-camphor (CASRN: 464-49-3). Studies in both rats and rabbits have not observed any adverse effects on fetal viability, growth, or morphological development with fetal NOAELs greater than 800mg/kg/day.

Carbon (CASRN: 7440-44-0)

Carbon was assigned Hazard Band C in a ChemFORWARD assessment and this meets our minimum criteria for safer (ChemFORWARD, 2025e). Carbon is the fundamental building block for organic chemicals and is generally considered safe. However, in its elemental form, carbon can present some acute toxicity in the form of respiratory effects including irritation. Transient narcotic effects have also been observed in rats given very high oral doses (2,000 mg/kg) of low density carbon, but it is unclear whether this was due to impurities. Impurities of carbon can include polyaromatic hydrocarbons (PAHs) and metals but our understanding is that it can be sourced as an ingredient at high purity (>99.99%). Carbon meets our minimum criteria for safer if these impurities are under 100 ppm (Ecology, 2022b).

Clinoptilolite (CASRN: 12173-10-3)

Clinoptilolite is listed on the EPA Safer Chemicals Ingredients List as a Full Green Circle under the processing aids and additives functional use category and this meets our additional criteria for safer (Ecology, 2022c; OCSPP, 2013a). Clinoptilolite is an aluminosilicate mineral form and a type of zeolite. These qualify for the processing aids and additives category and meet the baseline requirements of the EPA Safer Choice Master Criteria (EPA, 2013a, 2024a).

Sodium bicarbonate (CASRN: 144-55-8)

Sodium bicarbonate was scored as a [Yellow] chemical in a Scivera GHS+ hazard assessment and this meets at least our minimum criteria for safer (Scivera, 2022h). Carcinogenicity,

mutagenicity, reproductive toxicity and developmental toxicity were all scored as low hazard. Endocrine activity was scored as moderate hazard based on inclusion in a screening list, but no other data is presented that indicates a hazard. Persistence is scored as high, but we consider this as less relevant for inorganic chemicals such as sodium bicarbonate, which dissociates to form sodium hydroxide and carbonic acid in water. Therefore, discounting the high score for persistence, this means that sodium bicarbonate also meets our additional criteria for safer.

Sodium bicarbonate is also scored as a Full Green Circle on the Safer Chemicals Ingredients List under the processing aids and additives functional use category and this also meets at least our minimum criteria for safer (EPA, 2013a, 2024a; OCSPP, 2013a).

Safer process alternatives

Ice-filled urinal (CASRN: 7732-18-5)

Ice (water) meets our additional criteria for safer.

Water (CASRN: 7732-18-5) is listed on the EPA Safer Chemicals Ingredient list as a Full Green Circle for the solvent functional use (OCSPP, 2013a). Feasibility of ice for this purpose is described in the next section of this chapter.

Feasible and available alternatives

To show that the alternatives identified are used in products on the market, we often need to cite specific products or trade names—these are meant as examples only. Any reference in this publication to people, organizations, services, products, or activities don't constitute or imply endorsement, recommendation, or preference by the Washington Department of Ecology.

Camphor / bornan-2-one (CASRN: 76-22-2)

Camphor is a naturally derived essential oil from the camphor tree. Non-para camphor products lose their smell because camphor slowly turns from solid to vapor at room temperature. This dominates other odorous compounds from being smelled or perceived (Shabbir & Parvinzadeh Gashti, 2026). Additionally, the inherent antimicrobial properties kill odor-causing bacteria and fungi in the air as it turns to vapor (Ivanov et al., 2021; Silva-Beltrán et al., 2023).

Carbon (CASRN: 7440-44-0)

Deodorizing products containing carbon in the disordered form and are currently available and sold. The carbon within these products adsorbs odors as a function of carbon's porous structure and high surface area. Molecules that cause odors can be trapped in pores through weak intermolecular interactions, thus removing them from the air (Ambarsari et al., 2023). The carbon in these products is often derived from bamboo or other types of charcoal.

Clinoptilolite (CASRN: 12173-10-3)

Clinoptilolite is a zeolite that is found in products marketed for odor control. The large surface area and porous structure of the zeolite capture odor-causing molecules in its lattice (Fuss et al., 2021). In some product forms, the material is then aired out externally to "recharge", or otherwise to off-gas captured odors, after that it's suitable for reuse and reapplication in areas

ranging from small pet sized areas to approximately 600 sq. ft (Clean Control Corporation, 2022; Home Depot, n.d.).

Sodium bicarbonate (CASRN: 144-55-8)

Sodium bicarbonate, or baking soda, is a commonly used household deodorizer. Products containing sodium bicarbonate have been marketed and sold for this intended use for decades. Chemically, sodium bicarbonate can act as both an acid and a base to neutralize a wide range of odor compounds into an odorless salt form (Qamaruz-Zaman et al., 2015). The produced odorless salts have negligible vapor pressure and do not easily turn to vapor in ambient conditions.

Ice-filled urinal

Ice can serve as an alternative process instead of using 1,4-DCB in specific deodorizing applications, particularly in urinals or similar bathroom systems. Businesses and establishments such as stadiums or restaurants may also have access to viable quantities of excess ice that can be utilized for deodorizing urinals.

The urea present in urine is susceptible to hydrolysis. The hydrolysis of urea produces ammonia, which in turn produces strong odors (Ray et al., 2018). The melting of ice over time mitigates the need for a deodorizer product. As urine passes through the ice, the melting ice cubes provide a continuous, slow stream of water that dilutes residual urine and washes contents down the drain. The reduced temperature lowers the vapor pressure of ammonia and other odorous compounds in urine limiting their ability to be smelled in air (Stahn et al., 2022).

Table 56: A list of safer alternative chemicals, their function, and example products.

Chemical	CASRN	Functions	Example alternatives available in marketplace and/or sold to the public
Carbon	7440-44-0	Deodorizer	OdoBan Charcoal Odor Eliminator (#760A61) (Clean Control Corporation, 2022; Home Depot, n.d.), PureGuardian Bamboo Charcoal Air Purifying Bags (Guardian Technologies, n.d.)
Sodium bicarbonate	144-55-8	Deodorizer	Arm & Hammer Deodorizing Air Freshener with Baking Soda (Church & Dwight Co., Inc., 2024), Arm & Hammer Baking Soda Products (Church & Dwight Co., Inc., 2025), Lavex 4oz. Non-Para Deodorant Block (Lavex Janitorial, 2018)
Clinoptilolite	12173-10-3	Deodorizer	OdoBan OdoRocks Odor Eliminator (#79561) (Clean Control Corporation, 2021), Bear River Zeolite (Bear River Zeolite, 2025)
Camphor / bornan-2-one	76-22-2	Deodorizer	Fresh Products Non-Para Fragrance Super Block (Fresh Products, n.d.)

Conclusions on alternatives

Reducing a significant source or use

We determined that solid deodorizers are a significant use of 1,4-DCB, an organochlorine substance, in our Technical Supporting Documentation for Priority Products: Safer Products for Washington Cycle 2 Implementation Phase 2 (Ecology, 2025b). 1,4-DCB is commonly used in deodorizer products and can comprise 99% of these products by weight. We estimated that 287,500 to 718,750 pounds of 1,4-DCB is used for solid deodorizers in Washington based on scaling a use report in the United States to the population of Washington State. This represents a significant use of 1,4-DCB as an organochlorine substance.

Necessary to protect sensitive populations

In our Cycle 2, Phase 2 report (Ecology, 2025b), we also described the potential for exposure to 1,4-DCB from use in solid deodorizers in sensitive populations. Solid deodorizers are used in both private and public spaces. 1,4-DCB turns to vapor and contaminates room air as part of its intended use as a deodorizing chemical. This has the potential to expose this chemical to sensitive populations including people of childbearing age and children through inhalation. Additionally, workers who use solid deodorizer products as part of their job have the potential for higher exposures than the general population. Exposure to 1,4-DCB is also reported as

higher in some populations based on race and ethnicity. The information in this chapter highlights the need to restrict 1,4-DCB in solid deodorizers to protect sensitive populations.

Safer alternatives are feasible and available

We have identified several safer alternative chemicals and processes that can replace the deodorizing function of 1,4-DCB in solid deodorizers. These alternative chemistries are sold and used in solid deodorizers that are marketed for use in a variety of spaces and sizes.

Additional feasible and available alternatives are also on the market, but we did not have sufficient information on their ingredients to determine whether they can meet our criteria for safer. Other states have already restricted 1,4-DCB in solid deodorizer products, and this suggests that the impact of a restriction on the market for these products would be limited. Some states and districts with current restrictions on the use of 1,4-DCB include California (Thomson Reuters Westlaw, 2026), Connecticut (Connecticut State, n.d.), Delaware (Delaware State, n.d.), and the District of Colombia (District of Columbia, n.d.). California has restricted 1,4-DCB in these products for approximately twenty years. The safer alternatives described in this chapter, and existing restrictions in other jurisdictions demonstrate that alternatives to 1,4-DCB in solid deodorizers are feasible and readily available.

Regulatory determination

Our regulatory determination is a restriction on use of 1,4-DCB in solid deodorizers should be adopted.

We determined that safer alternatives to 1,4-DCB are both feasible and available and a restriction on the use of 1,4-DCB in solid deodorizers would reduce a significant use of 1,4-DCB, a potential source of exposure to people and the environment in Washington and it is necessary to protect sensitive populations.

Appendix A: Abbreviations and Acronyms

Table 57: Abbreviations and acronyms with definitions.

Term	Definition
6PPD AA	6PPD Alternatives Assessment.
6PPD	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine
6PPD-quinone	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine-quinone
ACA	American Coatings Association
ACC	American Chemistry Council
ACT	Advanced Chemical Technologies, Inc.
AISI	American Iron and Steel Institute
APEs	Alkylphenol Ethoxylates
BAuA	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin
BTEX	Benzene, Toluene, Ethybenzene, Xylenes
CalEPA	California Environmental Protection Agency
C2CC	Cradle to Cradle Certified
CARB	California Air Resources Board
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential Business Information
CBRN	Chemical, Biological, Radiological, and Nuclear
CDPH	California Department of Public Health
CHA	Chemical Hazard Assessment
COM	Washington State Department of Commerce
CMYK	Cyan, Magenta, Yellow, and Key (black)
CSCP	California Safer Cosmetics Program
CPID	Consumer Product Information Database

Term	Definition
DEP	Diethyl phthalate
DES	Washington State Department of Enterprise Services
DEHT	Bis(2-ethylhexyl) terephthalate
DINCH	Diisononyl cyclohexanedicarboxylate
DIY	Do-It-Yourself
DMP	dimethyl phthalate
DOE	U.S. Department of Energy
DOTP	Dioctyl terephthalate
DPHP	Di(2-propylheptyl) phthalate
DTSC	California Department of Toxic Substance Control
DWR	Durable Water Repellant
EC	European Commission
ECHA	European Chemicals Agency
ECVM	European Council of Vinyl Manufacturing
EMS	Emergency Management System
EPA	U.S. Environmental Protection Agency
EPA SCIL	U.S. Environmental Protection Agency Safer Chemical Ingredients List
ePTFE	Expanded Polytetrafluoroethylene
EPS	Expanded Polystyrene
EWG	Environmental Working Group
FDA	U.S. Food & Drug Administration
FEP	Fluorinated ethylene propylene
FSI	Flame spread index
HPD	Health Product Declarations

Term	Definition
HVAC	Heating, ventilation, and air conditioning
IARC	International Agency for Research on Cancer
IBC	International Building Code
IC2	Interstate Chemicals Clearinghouse
ICC	International Code Council, Inc.
IECC	Internation Energy Conservation Code
INCI	International Nomenclature Cosmetic Ingredient
IRC	Intrinsic Reaction Coordinate
ITRC	Interstate Technology Regulatory Council
LBC	Living Building Challenge
LOAEC	Lowest-Observed-Adverse-Effect Concentration
LOAELs	Lowest-Observed-Adverse-Effect-Level
MW	Molecular weight
NFPA	The National Fire Protection Association
OCSPP	U.S. EPA Office of Chemical Safety and Pollution Prevention
OECD	Organisation for Economic Co-operation and Development
OEHHA	California Office of Environmental Health Hazard Assessment
OFRs	Organohalogen flame retardants
PBT	Persistent, Bioaccumulative, and Toxic
PCBs	Polychlorinated biphenyls
PCBTF	Parachlorobenzotrifluoride
PEEK	Polyether ether ketone
PIMA	Polyisocyanurate Insulation Manufacturers Association
PFA	Perfluoroalkoxy alkanes

Term	Definition
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PPA	Polymer processing aid
PPM	Parts per million
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QSAR	Qualitative Structure-Activity Relationship
RCW	Revised Code of Washington
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals Regulation
SCBAs	Self-Contained Breathing Apparatus
SDS	Safety Data Sheets
SDI	Smoke Development Index
STC	Synthetic Turf Council
SUBSPORT	Germany's Substitution Support Portal
TCO	Swedish Confederation of Professional Employees
TCPP	Tris (1-Chloro-2-Propyl) Phosphate
TEDX	The Endocrine Disruption Exchange, Inc.
TURI	Toxics Use Reduction Institute
UV	Ultraviolet
WBCC	Washington State Building Council
WSDOT	Washington State Department of Transportation
WSEC	Washington State Energy Code
XPS	Extruded Polystyrene Foam

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Appendix C: Existing and Pending Regulations in Other Jurisdictions

This appendix provides a non-exhaustive list of existing and pending regulations for the priority product chemical combinations discussed in this report. We reviewed actions from other nations, as well as actions at the United States federal and state levels. This is not an exhaustive list of regulations on chemicals and chemical classes but instead focuses on regulations relevant to the products under consideration in this report.

6PPD

6PPD in motor vehicle tires is a priority product-chemical combination in California, and the United States EPA granted a petition to begin rulemaking on 6PPD in tires in 2023. There are currently no other jurisdictions that restrict 6PPD in motor vehicle tires, and no jurisdictions that regulate 6PPD in artificial turf.

Table 58: Existing and proposed regulations for 6PPD in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2023	22 CA ADC § 69511.7[49]	Specifies motor vehicle tires with 6PPD as a priority product/chemical combination.
United States	2023	TSCA Sect. 21 Petition[50]	Granting of the petition to USEPA from the Yurok Tribe, the Port Gamble S'Klallam Tribe, and the Puyallup Tribe of Indians to establish regulations prohibiting 6PPD in tires.
United States	2024	EPA Advanced Notice of Proposed Rulemaking (ANPRM) Docket EPA-HQ-OPPT-2024-0403[51]	ANPRM for 6PPD and 6PPD-quinone under TSCA Section 6(a). The ANPRM seeks information on the potential risks associated with 6PPD and 6PPD-quinone, and potential alternatives in order to inform the Agency's future actions.

[49] govt.westlaw.com/calregs/Document/I3EA124E01FD411EEB1A4DEEA2C4D3A06?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)

[50] epa.gov/system/files/documents/2023-11/pet-001845_tsca-21_petition_6ppd_decision_letter_esigned2023.11.2.pdf

[51] https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0403

Alkylphenol ethoxylates (APEs)

We didn't identify any existing regulations specific to APEs in paint. The European Union (Annex XVII) restricts nonylphenol (NP) and nonylphenol ethoxylates (NPEs) at concentrations equal to or greater than 0.1% by weight in various products.[52]

[52] https://reach-info.ineris.fr/sites/snar-reach/files/pdf/annexe_xvii_2023_en.pdf

BTEX

California and the European Union regulate toluene in nail products.

Table 59: Existing and proposed regulations for BTEX substances in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2005	CA Health & Safety Code § 111792[53]	California Safe Cosmetics Act of 2005. Requires manufacturers, packers, and distributors of cosmetic products to report to the California Department of Public Health all products sold in California, which contain ingredients known or suspected to cause cancer, birth defects, or other reproductive harm.
Calif.	2016	CA Health and Safety Code § 25257.2[54]	Establishes guidelines for healthy nail salon recognition programs specifying best practices including banning dibutyl phthalate, formaldehyde, or toluene.
Calif.	2023	22 CA ADC § 69511.6[55]	Lists nail polish with toluene as a priority product that must be reported by manufacturers.
European Union	2013	Regulation (EU) No 344/2013 amending Regulation (EC) No 1223/2009[56]	Restricts use of toluene in nail products to a 25% threshold.
United States	2018	21 U.S.C. § 364c(c)(4)[57]	Under the federal Food, Drug, and Cosmetics Act, cosmetics sold on a retail basis to consumers, in stores or online, must bear a list of ingredients, with the names of the ingredients listed in descending order of predominance.
Vt.	2014	18 V.S.A. Chapter 038A[58]	Requires reporting of children's products containing chemicals of high concern to children, including benzene, toluene, and ethylbenzene. Authorizes the Department of Health to adopt rules to expand the list of chemicals of high concern to children or to regulate the sale of a children's product containing a chemical of high concern to children.

[53] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=111792.
[54]https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=25257.2.
[55]govt.westlaw.com/calregs/Document/I567B56912D3E11EEA7E9A14F754E407C?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)
[56] data.europa.eu/eli/reg/2013/344/oj
[57] uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title21-section364c&num=0&edition=prelim
[58]Legislature.vermont.gov/statutes/chapter/18/038A

cVMS

cVMS are restricted in cosmetics in the European Union, and octamethylcyclotetrasiloxane (D4) is restricted in California.

Table 60: Existing and proposed regulations for cVMS in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2005	CA Health & Safety Code § 111792[59]	California Safe Cosmetics Act of 2005. Requires manufacturers, packers, and distributors of cosmetic products to report to the California Department of Public Health all products sold in California, which contain ingredients known or suspected to cause cancer, birth defects, or other reproductive harm.
Calif.	2023	CA Health & Safety Code § 108980[60]	Prohibits the manufacture, distribution, or sale of cosmetic products containing any of a specified list of intentionally added ingredients, including octamethylcyclotetrasiloxane (D4).
Calif.	2025	CA Health and Safety Code 108985 et seq[61]	Prohibits the manufacture, distribution, or sale of hair relaxer products containing any of a specified list of intentionally added ingredients, including octamethylcyclotetrasiloxane (D4). Requires the Department of Toxic Substances Control to adopt regulations for the purposes of implementation, interpretation, and enforcement.
European Union	2024	Regulation (EU) 2024/1328[62]	Restricts D4, D5, and D6 in consumer and professional products by June 2027.
Vt.	2014	18 V.S.A. Chapter 038A[63]	Requires reporting of children's products containing chemicals of high concern to children, including D4. Authorizes the Department of Health to adopt rules to expand the list of chemicals of high concern to children or to regulate the sale of a children's product containing a chemical of high concern to children.

[59] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=111792.
[60] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=108980
[61] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=108985
[62] data.europa.eu/eli/reg/2024/1328/oj
[63] legislature.vermont.gov/statutes/chapter/18/038A

Lead and cadmium

There are many existing regulations on lead and cadmium in jewelry. Most apply to children's products, but a few entities restrict lead and cadmium in jewelry regardless of whether it is marketed for children.

Table 61: Existing and proposed regulations for lead and cadmium in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2006	CA Health and Safety Code § 25214.2 [64]	Requires jewelry only be made of only approved metals, not lead.
Calif.	2008	CA Health & Safety Code § 108555[65]	Prohibits the sale or distribution of children's products coated with paints or lacquers containing lead or cadmium.
Calif.	2008	CA Health and Safety Code § 25214.2 [66]	Prohibits sale or distribution of jewelry that isn't children's jewelry unless made solely from specified materials. For children's jewelry, establishes lead and cadmium limits in jewelry coatings and components.
Calif.	2010	CA Health and Safety Code § 25214.2 [67]	Bans cadmium above 0.03% in children's jewelry.
Calif.	2020	CA Health and Safety Code § 25214.2 [68]	Reduces lead and cadmium limits for jewelry.
Conn.	2010	Conn. Gen. Stat. Ch. 416 § 21a-12d[69]	Bans cadmium in children's products.
Conn.	2008	Conn. Gen. Stat. Ch. 420d § 21a-335 et seq[70]	Established standards governing the maximum allowable amount of lead in children's products.

[64] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=25214.2.
[65] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=108555.
[66] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=25214.2.
[67] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=25214.2.
[68] leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=25214.2.
[69] cga.ct.gov/current/pub/chap_416.htm#sec_21a-12d
[70] cga.ct.gov/current/pub/chap_420d.htm

Entity	Year	Regulation or Policy	Requirements and standards
Del.	2008	6 Del. Ch. 25C[71]	Prohibits the sale and distribution of a toy containing a lead over the 0.06 limit set by 16 CFR 1303.
European Union	2009	Directive 2009/48/EC[72]	Restricts the presence of lead and cadmium in toys and components of toys.
European Union	2011	Regulation (EU) No 494/2011[73]	Restricts the use and sale of jewelry with cadmium concentration of equal to or greater than 0.01% by weight of the metal.
European Union	2015	Regulation (EU) No 2015/628[74]	Restricts use and sale of jewelry with a lead concentration of equal or greater than 0.05% by weight of the metal.
Ill.	2006	410 ILCS 45/3[75]	Restricts the sale and manufacture of lead-bearing children's products including jewelry.
Ill.	2008	410 ILCS 45/6[76]	Amends 410 ILCS 45 to require warning labels on other lead-containing products.
Ill.	2010	430 ILCS 140/[77]	Regulates the sale and distribution of children's products or product components manufactured after July 1, 2011 containing cadmium over 75 parts per million.
Maine	2008	22 MRSA § 1316-A[78]	Restricts the manufacture and knowing sale or distribution of lead-containing children's products except as authorized.
Md.	2008	MD Environment Code §§ 6-1301 – 6-1311[79]	Bans lead-containing children's products, including children's jewelry, and requires product testing.

[71] delcode.delaware.gov/title6/c025c/index.html
[72] data.europa.eu/eli/dir/2009/48/2022-12-05
[73] data.europa.eu/eli/reg/2011/494/2011-06-10
[74] data.europa.eu/eli/reg/2015/628/oj
[75] ilga.gov/legislation/ILCS/ilcs3.asp?ActID=1523&ChapterID=35
[76] https://www.ilga.gov/Legislation/ILCS/Articles?ActID=1523&ChapterID=35
[77] ilga.gov/legislation/ilcs/ilcs3.asp?ActID=3270&ChapterID=39
[78] legislature.maine.gov/statutes/22/title22sec1316-A.html
[79] https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=6-1301&enactments=True&archived=False

Entity	Year	Regulation or Policy	Requirements and standards
Md.	2009	MD Environment Code §§ 6-1304[80]	Clarifies requirements for manufacturers to test children's products for lead, including children's jewelry.
Md.	2011	MD Environment Code § 6-1402[81]	Prohibiting a person, on or after July 1, 2012, from manufacturing, selling, offering for sale, or distributing in the State any children's jewelry that contains cadmium at 0.0075% by weight.
Mich.	2007	MCL 368-1978-5-54B[82]	Prohibits the sale and distribution of children's jewelry containing lead.
Minn.	2007	Minnesota Statutes § 325E.389 (repealed)[83]	Banned lead in jewelry. Repealed in 2023. Lead prohibitions are now codified in Minnesota Statutes § 325E.3892
Minn.	2023	Minnesota Statutes § 325E.3892 Subd. 2[84]	Amendment prohibiting the import, manufacture, sale, distribution, or offer for use certain products, including jewelry, containing lead exceeding 90 parts per million or cadmium exceeding 75 parts per million.
N.Y.	2019	NY Env Conserv Law § 37-0115[85]	Restricts the sale and distribution of children's products containing lead beginning January 1, 2021.
N.Y.	2019	NY Env. Conserv. Law §§ 37-0901 – 37-0913[86]	Requires manufacturers of children's products containing dangerous chemicals to notify the state and retailers; bans the sale of children's products containing certain dangerous chemicals, including lead and cadmium.
United States	2008	15 U.S.C. § 1278a[87]	Consumer Product Safety Improvement Act (CPSIA). Amended the Consumer Product Safety

[80] https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=6-1304&enactments=True&archived=False
[81] mgaleg.maryland.gov/mgawebsite/laws/StatuteText?article=gen&section=6-1402&enactments=False&archived=False
[82] legislature.mi.gov/Laws/MCL?objectName=mcl-368-1978-5-54B.&highlight=children%27s,jewelry
[83] https://www.revisor.mn.gov/statutes/cite/325E.389
[84] https://www.revisor.mn.gov/statutes/cite/325E.3892
[85] https://newyork.public.law/laws/n.y._environmental_conservation_law_section_37-0115
[86] https://newyork.public.law/laws/n.y._environmental_conservation_law_article_37_title_9
[87] https://uscode.ecfr.io/title/15/section/1278a

Entity	Year	Regulation or Policy	Requirements and standards
		Public Law 110-314, Title I § 101[88]	Act. Established lead limits for children's products, including jewelry.
Vt.	2008	9 V.S.A. §§ 2470e – 2470g[89]	Bans the manufacture and sale of any children's product containing lead and specifically addresses children's jewelry.
Vt.	2014	18 V.S.A. Chapter 038A[90]	Requires reporting of children's products containing chemicals of high concern to children, including cadmium. Authorizes the Department of Health to adopt rules to expand the list of chemicals of high concern to children or to regulate the sale of a children's product containing a chemical of high concern to children.

[88] https://www.cpsc.gov/s3fs-public/pdfs/blk_pdf_cpsia.pdf
[89] https://legislature.vermont.gov/statutes/section/09/063/02470e
[90] legislature.vermont.gov/statutes/chapter/18/038A

Organobromine/Organochlorine substances

1,4-dichlorobenzene is restricted in toilet and urinal care products in several states and the European Union. Regulations on PVC in packaging have been proposed in California, Massachusetts, Minnesota (also PVDC), New Jersey, New York, North Carolina, and Vermont but haven't been adopted. New Zealand prohibited PVC food trays in 2022, and British Columbia restricted PVC and PVDC in some food packaging in 2024, with a restriction on PVC film wrap beginning in 2028.

Table 62: Existing and proposed regulations for organobromine and organochlorine substances in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
British Columbia, Canada	2023	B.C. Reg. 254/2023[91]	Restricts use of food and beverage packaging containing PVC and PVDC for takeout, delivery, or immediate consumption, except film wrap wholly comprised of PVC, in 2024. Restricts PVC film wrap beginning July 1, 2028.
Calif.	2004	17 CA ADC § 94509[92]	Prohibits manufacture, sale, or distribution of any solid air fresheners or toilet/urinal care products containing PDCB (1,4-dichlorobenzene).
Conn.	2009	R.C.S.A. Section 22a-174-40[93]	Prohibits the sale, supply, or manufacture of any solid air freshener or toilet/urinal care product that contains 1,4-dichlorobenzene.
D.C.	2011	D.C.M.R. Section 20-729[94]	Prohibits the sale, supply, or manufacture of any solid air freshener or toilet/urinal care product that contains 1,4-dichlorobenzene.
Del.	2009	D.A.C. Title 7 1141[95]	Prohibits sale or supply of any solid air fresheners or toilet/urinal care products manufactured on and after May 1, 2009, that contain para-dichlorobenzene.
European Union	2014	Annex XVII to REACH[96]	Restriction on the sale of 1,4-dichlorobenzene in concentration of 1% or greater by weight, when placed on the market for use as an air freshener or deodorizer in toilets, homes, offices, or other indoor public areas.

[91] bclaws.gov.bc.ca/civix/document/id/lc/bcgaz2/v66n20_254-2023
[92] govt.westlaw.com/calregs/Document/IFD6EE7C35A2011EC8227000D3A7C4BC3?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)
[93] https://eregulations.ct.gov/eRegsPortal/Browse/RCSA/Title_22aSubtitle_22a-174Section_22a-174-40/
[94] https://dcregs.dc.gov/Common/DCMR/SectionList.aspx?SectionNumber=20-729
[95] https://regulations.delaware.gov/AdminCode/title7/1141
[96] https://echa.europa.eu/substances-restricted-under-reach/-/dislist/details/0b0236e1807e30f9

Entity	Year	Regulation or Policy	Requirements and standards
Maine	2009	ME DEP Chapter 152[97]	Prohibits sale, supply, or manufacture for use in Maine any Solid Air Fresheners or Toilet/Urinal Care Products that contain para-dichlorobenzene, beginning January 1, 2009.
Mass.	2009	310 CMR 7.25[98]	Prohibits sale, supply, or manufacture for use in Massachusetts and solid air freshener or toilet/urinal care products that contain para-dichlorobenzene, beginning January 1, 2009.
Md.	2009	CMR § 26.11.32.10[99]	Prohibits sale, supply, or manufacture for use any solid air fresheners or toilet and urinal care products that contain para-dichlorobenzene, beginning January 1, 2009.
New Zealand	2022	Waste Minimisation Regulations 2022[100]	Prohibits manufacture or sale of specific plastic products to include PVC food trays or containers.
N.J.	2009	N.J.A.C. 7:27, Sub Ch. 24[101]	Prohibits sale or manufacture for use in New Jersey of solid air fresheners or toilet/urinal care products containing para-dichlorobenzene, beginning January 1, 2009.
N.Y.	2010	NY CRR Tit. 6 Ch. III Subch. A § 235[102]	Prohibits sale or manufacture for use in New York of solid air fresheners and toilet/urinal care products containing para-dichlorobenzene, beginning January 1, 2010.
R.I.	2019	Air Pollution Control Regulation No. 31[103]	Prohibits sale or manufacture for sale in Rhode Island any solid air freshener or toilet/urinal care product that contains para-dichlorobenzene.
Utah	2014	R307-357[104]	Limits VOCs in solid air fresheners and toilet and urinal care products to 3% by weight, beginning September 1, 2014.
Va.	2010	9VAC5 Ch. 45-430[105]	Limits VOCs in solid air fresheners and toilet and urinal care products to 3% by weight, beginning August 1, 2010.

[97] https://www.maine.gov/sos/rulemaking/agency-rules/department-environmental-protection-rules
[98] https://www.mass.gov/regulations/310-CMR-700-air-pollution-control
[99] https://regs.maryland.gov/us/md/exec/comar/26.11.32.10
[100] https://legislation.govt.nz/secondary-legislation/pco-drafted/2022/69/en/latest/#LMS654254
[101] https://dep.nj.gov/aqm/rules/rules27/
[102] https://www.law.cornell.edu/regulations/new-york/title-6/chapter-III/subchapter-A/part-235
[103] https://rules.sos.ri.gov/regulations/part/250-120-05-31
[104] https://adminrules.utah.gov/public/rule/R307-357/Current%20Rules?
[105] https://law.lis.virginia.gov/admincode/title9/agency5/chapter45/section430/

Organohalogen flame retardants (OFRs)

We didn't identify any existing regulations specific to organohalogen flame retardants in building insulation. The table below identifies regulations on specific organohalogen flame retardants, PBDEs, in consumer products broadly.

Table 63: Existing and proposed regulations for organohalogen flame retardants (OFRs) in consumer products broadly.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2003	CA Health and Safety Code § 108920 et seq[106]	Prohibits products, or flame-retarded parts of products, containing more than 1/10 of 1% pentaBDE or octaBDE beginning June 1, 2006.
Calif.	2018	CA Business and Professions Code §§ 19100-19104[107]	Prohibits halogenated, organophosphorus, organonitrogen, or nanoscale flame retardants above 1,000 parts per million in new juvenile products, mattresses, and upholstered furniture.
Hawaii	2004	HRS §332D[108]	Prohibits manufacture, processing, or distribution in commerce of a product, or a flame-retarded part of a product, containing more than 1/10 of 1%, by mass, of pentaBDE, octaBDE, or any other chemical formulation that is part of these classifications.
Ill.	2005	410 ILCS 48/[109]	Prohibits manufacture or distribution of commercial products, or flame-retardant parts of products, containing more than 1/10 of 1% pentaBDE or octaBDE.
Maine	2003	38 MRSA §1609[110]	Requires written notice from manufacturers or trade associations prior to the sale or distribution of products containing brominated flame retardants.
Maine	2004	38 MRSA §1609[111]	Bans products containing more than 1/10 of 1% of penta- or octa-BDE beginning in 2006, and deca-BDE beginning in 2008 if safer alternatives are available.

[106] leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=HSC&division=104.&title=&part=3.&chapter=10.&article=
[107] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=BPC&sectionNum=19100
[108] capitol.hawaii.gov/hrscurrent/Vol06_Ch0321-0344/HRS0332D/HRS_0332D-0002.html
[109] www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2707&ChapterID=35
[110] legislature.maine.gov/legis/statutes/38/title38sec1609.html
[111] legislature.maine.gov/legis/statutes/38/title38sec1609.html

Entity	Year	Regulation or Policy	Requirements and standards
Maine	2017	38 MRSA §§1691-1699B[112]	Designates decabromodiphenyl ether (deca BDE) and hexabromocyclododecane (HBCD) as priority chemicals. Requires manufacturers or distributors intentionally adding deca BDE and/or HBCD to certain children's products to file a report with the Department.
Maine	2017	38 MRSA §1609-A[113]	Prohibits the sale of residential upholstered furniture containing more than 1/10 of 1% of halogenated, phosphorus-based, nitrogen-based, and nanoscale flame retardants.
Maine	2021	38 MRSA §1609-A[114]	Prohibits the sale of residential upholstered furniture containing more than 1/10 of 1% of halogenated, phosphorus-based, nitrogen-based, and nanoscale flame retardants. Updates 2017 Maine law to reflect California standards.
Mass.	2021	Mass. Gen. Laws Ch. 21A, §28[115]	Bans 12 different types of flame retardants (including pentaBDE and octaBDE) in the manufacture, sale, and distribution of bedding, carpeting, children's products, residential upholstered furniture, or window treatments manufactured after December 31, 2021.
Md.	2005	MD Environment Code §§ 6-1201 – 6-1205[116]	Bans new products containing more than 1/10 of 1% of the flame retardants penta- and octa-BDE. Requires Maryland Department of Environment to report decaBDE in consumer products, and make recommendations regarding the use, sale, and disposal of consumer products containing it.
Md.	2010	MD Environment Code § 6-1202.1[117]	Bans mattresses, residential upholstered furniture, and electronic equipment containing decaBDE beginning December 31, 2010, and additional products containing deceBDE beginning December 31, 2012, and December 31, 2012.
Md.	2020	MD Health–General Code § 24-306.1[118]	Prohibits the sale of any juvenile product, mattress, upholstered furniture, or reupholstered furniture that contains more than 0.1% by mass of halogenated, phosphorus-based, nitrogen-based, and nanoscale flame retardants.

[112] https://legislature.maine.gov/statutes/38/title38ch16-Dsec0.html
[113] https://legislature.maine.gov/legis/statutes/38/title38sec1609-A.html
[114] https://legislature.maine.gov/legis/statutes/38/title38sec1609-A.html
[115] malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter21A/Section28
[116] https://law.justia.com/codes/maryland/environment/title-6/subtitle-12/section-6-1201/
[117] https://law.justia.com/codes/maryland/environment/title-6/subtitle-12/section-6-1202-1/
[118] https://law.justia.com/codes/maryland/health-general/title-24/subtitle-3/section-24-306-1/

Entity	Year	Regulation or Policy	Requirements and standards
Mich.	2004	MCL 451-1994-II-4-147-2[119]	Prohibits the manufacture, processing, or distribution of a product or material that contains more than 1/10 of 1% of penta-BDE or octa-BDE.
Minn.	2007	Minnesota Statutes §§ 325E.386 – 325E.387[120]	Bans products containing more than 1/10 of 1% of penta- or octa-BDE. Requires study into deca-BDE and safer alternatives.
Minn.	2015	Minnesota Statutes § 325F.071[121]	Bans specified toxic flame retardants, including deca-BDE, from children's products and residential upholstered furniture. Specifies that alternatives cannot be carcinogens, endocrine disruptors, or otherwise cause developmental toxicity.
Minn.	2019	Minnesota Statutes § 325F.071[122]	Expands flame retardant ban adopted in 2015 to include residential textiles and mattresses.
Nev.	2021	NRS § 597.7131 et seq[123]	Prohibits any organohalogenated flame retardant chemical in amounts greater than 1,000 parts per million in the manufacture, sale, and distribution of children's products, upholstered residential furniture, residential textiles, business textiles, or mattresses. Exempts polymeric flame retardants.
N.H.	2019	New Hampshire Revised Statutes Title XXXI Chapter 359-Q[124]	Prohibits the sale of halogenated, phosphorus-based, nitrogen-based, and nanoscale flame retardants in residential upholstered furniture.
N.Y.	2004	NY Env. Conserv. Law § 37-0111[125]	Restricts products containing more than 1/10 of 1% of flame retardants penta-BDE and octaBDE on January 1, 2006. Creates a task force on flame retardant safety to review and report on relevant studies, risk assessments, findings, or rulings on deca-BDE and its alternatives.

[119] https://www.legislature.mi.gov/Laws/MCL?objectName=mcl-451-1994-II-4-147-2
[120] https://www.revisor.mn.gov/statutes/cite/325E.386
[121] https://www.revisor.mn.gov/statutes/cite/325F.071
[122] https://www.revisor.mn.gov/statutes/cite/325F.071
[123] https://www.leg.state.nv.us/NRS/NRS-597.html#NRS597Sec7131
[124] https://gc.nh.gov/rsa/html/XXXI/359-Q/359-Q-mrg.htm
[125] https://newyork.public.law/laws/n.y._environmental_conservation_law_section_37-0111

Entity	Year	Regulation or Policy	Requirements and standards
N.Y.	2019	NY Env. Conserv. Law §§ 37-0901 – 37-0913[126]	Requires manufacturers of children's products containing dangerous chemicals to notify the state and retailers; bans the sale of children's products containing certain dangerous chemicals, including organohalogen flame retardants.
N.Y.	2021	NY Env. Conserv. Law §§ 37-1001 – 37-1013[127]	Beginning January 1, 2024, prohibits the sale of any new upholstered furniture or mattress that contains any intentionally added flame retardants. Beginning January 1, 2025, prohibits a custom upholsterer from repairing upholstered furniture using replacement components that contain flame retardants. Beginning January 1, 2024, prohibits the sale of any electronic display that contains intentionally added organohalogen flame retardants.
Ore.	2005	ORS 453.085[128]	Bans products containing more than 1/10 of 1% of pentaBDE or octaBDE.
Ore.	2009	ORS 453.085[129]	Bans products containing more than 1/10 of 1% of decaBDE. Phases out replacement parts containing pentaBDE, octaBDE, and decaBDE.
R.I.	2006	R.I. Gen. Laws § 23-13.4-3[130]	Prohibits the manufacture, processing, and distribution of a product or flame-retardant part of a product containing more than 1/10 of 1% of penta-BDE.
R.I.	2017	R.I. Gen. Laws § 23-26-3.1[131]	Beginning January 1, 2020, prohibits the manufacture and sale of residential upholstered bedding and furniture containing organohalogen flame retardants.

[126] https://newyork.public.law/laws/n.y._environmental_conservation_law_article_37_title_9
[127] https://newyork.public.law/laws/n.y._environmental_conservation_law_article_37_title_10
[128] https://oregon.public.law/statutes/ors_453.085
[129] https://oregon.public.law/statutes/ors_453.085
[130] webserver.rilegislature.gov//Statutes/TITLE23/23-13.4/23-13.4-3.htm
[131] https://webserver.rilegislature.gov//Statutes/TITLE23/23-26/23-26-3.1.htm

Entity	Year	Regulation or Policy	Requirements and standards
United Nations	2009	UN Stockholm Convention on Persistent Organic Pollutants[132]	Listed in the Stockholm Convention under Annex A, to be eliminated from production and as possible by manufacturers and producers.
Vt.	2009	9 V.S.A. § 2973[133]	Bans the flame retardants octaBDE and pentaBDE from all products, and decaBDE from certain home products (mattresses and pads, residential furniture, televisions and computers). Prohibits a manufacturer from replacing decaBDE with a known or suspected human carcinogen, or a chemical identified by the U.S. EPA as causing birth defects, hormone disruption, or harm to reproduction or development.
Vt.	2013	9 V.S.A. § 2974[134]	Bans Tris (TCEP & TDCPP) from children's products and furniture.

[132] pops.int/Implementation/IndustrialPOPs/BDEs/Overview/tabid/5371/Default.aspx
[133] https://legislature.vermont.gov/statutes/section/09/080/02973
[134] https://legislature.vermont.gov/statutes/section/09/080/02974

Ortho-phthalates

We didn't identify any existing regulations specific to ortho-phthalates in sealants, caulks, and adhesives. Some states have regulated ortho-phthalates in other consumer products. For example, California requires manufacturers to disclose to use of ortho-phthalates in cleaning products (CA Health and Safety Code §§ 108950 et seq, 2017)[135]. California and Maryland both restrict the intentional addition of two ortho-phthalates, DBP and DEHP, in cosmetic products (CA Health and Safety Code § 108980, 2020[136] and MD Health–General Code § 21-259.2, 2021[137]). Maine has adopted restrictions on ortho-phthalates in food packaging (32 MRSA § 1733).[138]

PCBs

We didn't identify any relevant regulations specific to PCBs in printing inks. The Toxic Substances Control Act (TSCA) is the primary federal law pertinent to PCBs in the United States. Intentional use of PCBs is broadly restricted under TSCA, and inadvertent PCBs in products are limited to an average annual concentration of less than 25 ppm (40 CFR Section 761.3).[139]

Table 64: Selected federal regulations for PCBs in consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
United States	1977	15 U.S.C. § 2605(e)[140]	Except as otherwise provided, prohibits the manufacture of any PCB by January 1, 1979, and the distribution in commerce of PCBs by July 1, 1979.
United States	2020	40 CFR 761[141]	40 CFR 761.20 requires components with PCB concentrations greater than or equal to 50 ppm to be totally enclosed. 40 CFR 761.3 defines excluded manufacturing process—a manufacturing process in which quantities of inadvertently generated PCBs have a concentration less than 25 ppm annual average and 50 ppm maximum. 40 CFR 761.3 defines excluded PCB products as PCB materials which appear at concentrations less than 50 ppm.

[135] https://california.public.law/codes/health_and_safety_code,_division_104,_part_3,_chapter_13
[136] https://california.public.law/codes/health_and_safety_code_section_108980
[137] https://mgaleg.maryland.gov/mgawebsite/laws/StatuteText?article=ghg&section=21-259.2&enactments=false
[138] https://www.mainelegislature.org/legis/statutes/32/title32sec1733.html
[139] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-R/part-761
[140] https://uscode.house.gov/view.xhtml?path=/prelim%40title15/chapter53&edition=prelim
[141] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-R/part-761

PFAS

PFAS are regulated in many products across the United States. We identified regulations specific to artificial turf, cookware, floor waxes, hard surface sealers, architectural paints, and firefighting personal protective equipment. Additionally, the European Union, Colorado, Connecticut, Maine, and Minnesota have broad restrictions on PFAS in consumer products. Regulations on PFAS in paints have been proposed in Maryland and New York but not adopted. We didn't identify any regulations specific to PFAS in floor waxes or hard surface sealers.

Table 65: Existing and proposed regulations for PFAS in relevant consumer products.

Entity	Year	Regulation or Policy	Requirements and standards
Calif.	2020	CA Health and Safety Code § 13029[142]	Requires manufacturers to disclose whether the personal protective equipment they produce contains PFAS beginning January 1, 2022.
Calif.	2021	CA Health and Safety Code §§ 109010 – 109014[143]	Beginning January 1, 2023, requires posting of information if certain chemicals, including PFAS, are present in cookware on a website. Beginning January 1, 2024, requires disclosure of certain chemicals in cookware, including PFAS. Ensures that a company isn't misleading consumers by claiming that cookware is free of a particular toxin when it contains a similar compound in the same chemical class.
Calif.	2025	CA Labor Code § 147.4[144]	Requires the state to consider modifying its safety order regarding firefighter personal protective equipment and a timeline phase out PFAS in firefighter personal protective equipment starting in 2028.
Colo.	2019	CO Rev. Stat. § 25-5-1305[145]	Requires manufacturers to disclose whether the personal protective equipment they produce contains PFAS beginning August 2, 2019.

[142] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=13029
[143] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=109010
[144] https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=LAB&sectionNum=147.4
[145] https://law.justia.com/codes/colorado/title-25/products-control-and-safety/article-5/part-13/section-25-5-1305/

Entity	Year	Regulation or Policy	Requirements and standards
Colo.	2022	CO Rev. Stat. §§ 25-15-601 – 25-15-604[146]	Enacts the Perfluoroalkyl and Polyfluoroalkyl Chemicals Consumer Protection Act. Includes labeling requirements for manufacturers of cookware containing PFAS, prohibition on PFAS-free claims unless no PFAS has been intentionally added.
Colo.	2024	CO Rev. Stat. §§ 25-15-601 – 25-15-605[147]	Amends Perfluoroalkyl and Polyfluoroalkyl Chemicals Consumer Protection Act to prohibit a person from installing artificial turf that contains intentionally added PFAS chemicals on property in the state. As part of a phase out timeline for products containing intentionally added PFAS, bans sale or distribution of several products, including cookware beginning January 1, 2026.
Conn.	2024	Conn. Gen. Stat. Ch. 446z § 22a.903c[148]	Beginning July 1, 2026, prohibits manufacture or sale of several products containing intentionally added PFAS, including cookware, without a label indicating the presence of PFAS and unless the manufacturer provides prior notice with specific information about the PFAS in the product for sale. Beginning January 1, 2026, manufacturers must provide notice to purchaser of turnout gear if the product contains intentionally added PFAS. Beginning January 1, 2028, prohibits manufacture or sale of several products containing intentionally added PFAS, including cookware and turnout gear.
European Union	2023	Annex XV[149]	Proposal to restrict PFAS in mixtures or articles placed on the market with derogations for some uses.

[146] https://colorado.public.law/statutes/crs_25-15-601
[147] https://law.justia.com/codes/colorado/title-25/environmental-control/article-15/part-6/section-25-15-601/
[148] https://www.cga.ct.gov/current/pub/chap_446z.htm#sec_22a-903c
[149] echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea

Entity	Year	Regulation or Policy	Requirements and standards
Ill.	2026	415 ILCS 170/20[150]	Requires disclosure of PFAS in firefighting personal protective clothing beginning January 1, 2026. Prohibits the manufacture, sale, or distribution of firefighting personal protective clothing with intentionally added PFAS beginning January 1, 2027. Prohibits the manufacture, sale, or distribution of auxiliary firefighting personal protective equipment with intentionally added PFAS beginning January 1, 2030.
Ind.	2023	IN Code § 36-8-27-2[151]	Beginning June 30, 2024, prohibits fire departments from purchasing firefighter gear unless it contains a label indicating whether or not the firefighter gear contains a PFAS chemical.
Mass.	2024	Massachusetts Gen. Laws Ch. 111, § 245[152]	Requires written notice to purchasers if personal protective equipment contains PFAS starting January 1, 2025. Prohibits the sale or distribution of firefighting personal protective equipment that contains intentionally added PFAS beginning January 1, 2027.
Maine	2021	38 MRSA § 1614[153]	Restricts the sale of products containing PFAS in the State of Maine starting January 1, 2030, with an exemption for currently unavoidable uses.
Maine	2023	38 MRSA § 1614[154]	Extends deadline for manufacturers to notify Maine DEP of their products for sale in the state that contain intentionally added PFAS from January 1, 2023, to January 1, 2025.

[150] https://www.ilga.gov/Legislation/ILCS/Articles?ActID=4187&ChapterID=36&Chapter=ENVIRONMENTAL%20SAFETY&MajorTopic=HEALTH%20AND%20SAFETY
[151] https://law.justia.com/codes/indiana/title-36/article-8/chapter-27/section-36-8-27-2/
[152] https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXVI/Chapter111/Section245
[153] legislature.maine.gov/statutes/38/title38sec1614.html
[154] legislature.maine.gov/statutes/38/title38sec1614.html

Entity	Year	Regulation or Policy	Requirements and standards
Maine	2024	38 MRSA § 1614[155]	Amends existing PFAS law. Beginning January 1, 2026, prohibits PFAS in cleaning products, cookware, cosmetics, dental floss, juvenile products, menstrual products, textile articles, ski wax, and upholstered furniture. Beginning January 1, 2029, prohibits PFAS in artificial turf, outdoor apparel for extreme weather conditions, and certain refrigerants.
Md.	2022	MD Environment Code § 6-1603[156]	Requires notification firefighting personal protective equipment that contains PFAS.
Md.	2024	MD Environment Code §§ 6-16A-01 – 6-16A-05[157]	Prohibiting a person from installing, supplying, selling, soliciting, or offering for sale playground surfacing materials that contain a certain concentration of lead or a component product, material, or substance to which PFAS chemicals were previously intentionally added for certain purposes, beginning October 1, 2024.
Minn.	2023	Minnesota Statutes § 116.943[158]	Requires reporting of PFAS use in products beginning January 1, 2026. Prohibits intentionally added PFAS beginning January 1, 2025, in 11 product categories, including cookware. Starting in 2032 all uses are banned with an exemption for currently unavoidable uses.
N.J.	2026	NJ Statutes § 56:8-229[159]	Beginning January 20, 2027, requires producers of certain firefighting personal protective equipment containing PFAS to provide written notice to purchaser. Beginning January 20, 2028, prohibits sale, manufacture, and distribution of firefighting personal protective equipment containing intentionally added PFAS.

[155] legislature.maine.gov/statutes/38/title38sec1614.html
[156] https://mgaleg.maryland.gov/mgawebsite/laws/StatuteText?article=gen&section=6-1603&enactments=False&archived=False
[157] https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=6-16A-01&enactments=False&archived=False
[158] https://www.revisor.mn.gov/statutes/cite/116.943#stat.116.943
[159] https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

Entity	Year	Regulation or Policy	Requirements and standards
N.J.	2026	NJ Statutes §§ 56:3-53 – 56:3-63[160]	Prohibits intentionally added PFAS in cosmetics, carpet and fabric treatments, and food packaging beginning in January 2028. Requires manufacturers to label cookware containing PFAS in order to offer the cookware for sale in the state beginning in January 2028.
N.M.	2025	NMSA 74-15-1 et seq[161]	Prohibits the sale of cookware containing intentionally added PFAS after January 1, 2027, with exceptions for some polymer forms of PFAS.
N.Y.	2020	NY General Business Law § 391-u[162]	Requires written notice to purchasers if personal protective equipment contains PFAS.
N.Y.	2025	NY General Business Law § 391-u[163]	Prohibits the sale or distribution of firefighting personal protective equipment that contains intentionally added PFAS beginning January 1, 2028.
R.I.	2025	R.I. Gen. Laws § 23-18.18[164]	Prohibits the sale of cookware and firefighting personal protective equipment containing intentionally added PFAS after January 1, 2027.
Sweden	2018	KIFS 2017:7 (in Swedish)[165] Explanation document (in English)[166]	Must report PFAS that are deliberately added to chemical products to the Swedish Chemicals Agency's Products Register. This requirement applies to those who manufacture or import notifiable products, irrespective of the percentage of the substance in that product. Examples of products include textiles and leather, firefighting foam, and household goods.

[160] https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

[161] https://nmonesource.com/nmos/nmsa/en/item/4415/index.do#!fragment/zoupio-_Toc233796342/BQCwhgziBcwMYgK4DsDWszIQewE4BUBTADwBdoAvbRABwEtsBaAfX2zgCYBmLgdgE4AbFwAsHAJQAaZNlKEIARUSFcAT2gByDZIiEwuBEpXqtOvQZABlPKQBC6gEoBRADJOAagEEAcgGEnkqRgAEbQpOzi4kA

[162] https://newyork.public.law/laws/n.y._general_business_law_section_391-u*2

[163] https://newyork.public.law/laws/n.y._general_business_law_section_391-u*2

[164] https://webserver.rilegislature.gov/Statutes/TITLE23/23-18.18/INDEX.htm

[165] https://www.kemi.se/download/18.409a5d0a193955be16be5e6/1786624477562/KIFS-2017-7-konsoliderad.pdf

[166] https://www.kemi.se/en/the-swedish-products-register/products-which-are-notifiable-to-report

Entity	Year	Regulation or Policy	Requirements and standards
Sweden	2026	KN 2026/01597 (In Swedish) (Proposed)[167]	Proposal to ban PFAS above certain thresholds in clothing, footwear, waterproofing agents for clothing and footwear, kitchen utensils and cookware, cosmetic products, and ski wax. If adopted the ban would take effect January 1, 2028.
Vt.	2024	9 V.S.A. § 2494f[168] 9 V.S.A § 2494s[169]	Prohibits the manufacturing or sale of artificial turf, cookware, and other products containing intentionally added PFAS, with varying effective dates. Requires written notice to purchasers if personal protective equipment contains PFAS.
Vt.	2025	9 V.S.A § 2494s[170]	Amends existing law to restrict the sale of personal protective equipment containing intentionally added PFAS after July 1, 2029.

[167] https://resource.chemlinked.com.cn/chemical/articles/file/nationellt-forbud-mot-pfas-i-vissa-konsumentprodukter.pdf
[168] legislature.vermont.gov/statutes/section/09/063/02494f
[169] https://legislature.vermont.gov/statutes/section/09/063/02494s
[170] https://legislature.vermont.gov/statutes/section/09/063/02494s

Appendix D: Washington's Toxics in Consumer Products Regulations

Table 66: Washington state laws and rules that address toxic chemicals in consumer products.

Year	RCW/ WAC	Description	Chemical(s) addressed	Products covered	Requirements or standards
1998	RCW 15.54.820[171]	Waste-derived fertilizer[172]	Arsenic, cadmium, cobalt, mercury, molybdenum, nickel, lead, selenium, and zinc	Fertilizers made from waste products	Requirements for testing and limits for these metals.
2003	Chapter 70A.230 RCW[173]	Mercury reduction	Mercury	Bulk mercury, fluorescent lamps, novelties, manometers, thermometers, thermostats, motor vehicle switches	Restricts sale of mercury containing products, requires removal from schools, and establishes labeling and recycling requirements.
2007	Chapter 70A.405 RCW[174]	Flame retardants	Brominated flame retardants (PBDEs)	Noncomestible products	Restricts noncomestible products containing PBDEs.
2009	Chapter 70A.435 RCW[175]	Lead wheel weights	Lead	Wheel weights	Requires replacement of lead wheel weights with environmentally preferred wheel weights.
2010	Chapter 70A.335 RCW[176]	Bisphenol A	Bisphenol A	Food and beverage containers	Restricts sale or distribution of food or beverage containers containing bisphenol A.
2010	Chapter 70A.340 RCW[177]	Brake friction material	Copper	Brake pads	Restricted asbestos and several heavy metals in brake pads. Phased out the use of copper in vehicle brake pads by 2025.

[171] app.leg.wa.gov/rcw/default.aspx?cite=15.54.820
[172] Primarily covers agricultural fertilizers but also applies to consumer products such as compost available at retail stores.
[173] app.leg.wa.gov/rcw/default.aspx?cite=70A.230
[174] app.leg.wa.gov/rcw/default.aspx?cite=70A.405
[175] app.leg.wa.gov/rcw/default.aspx?cite=70A.435
[176] app.leg.wa.gov/rcw/default.aspx?cite=70A.335
[177] app.leg.wa.gov/rcw/default.aspx?cite=70A.340

Year	RCW/ WAC	Description	Chemical(s) addressed	Products covered	Requirements or standards
2011	Chapter 70A.445 RCW[178]	Antifouling paints	Copper, cybuterine	Boat paint	Phases out the use of copper-based antifouling paint when safer chemicals are available.
2012	Chapter 173-901 WAC[179]	Better brakes	Asbestiform fibers, cadmium, chromium, lead, mercury, copper	Brake friction materials (for example, pads and drums)	Implements Chapter 70A.340 RCW
2014	RCW 36.26.280[180]	Preference – products and products in packaging that does not contain PCBs	PCBs	Products and packaging purchased by the state	Establishes a procurement policy avoiding PCBs.
2016	Chapter 70A.430 RCW[181]	Children's Safe Products restrictions	Lead, cadmium, ortho-phthalates, specified flame retardants, and chemicals listed as high concern for children	Children's products, including jewelry and cosmetics	Limits presence of lead, cadmium, phthalates, and flame retardants in children's products. Requires reporting of chemicals of high concern to children.
2017	Chapter 173-334 WAC[182]	Children's Safe Products Reporting Rule	As listed in WAC 173-334-130	Children's products	Establishes list of chemicals for which reporting is required and implements requirements for reporting created under CSPA.

[178] app.leg.wa.gov/rcw/default.aspx?cite=70A.445
[179] app.leg.wa.gov/wac/default.aspx?cite=173-901
[180] https://app.leg.wa.gov/RCW/default.aspx?cite=39.26.280
[181] app.leg.wa.gov/rcw/default.aspx?cite=70A.430
[182] app.leg.wa.gov/wac/default.aspx?cite=173-334

Year	RCW/ WAC	Description	Chemical(s) addressed	Products covered	Requirements or standards
2018	Chapter 70A.222 RCW[183]	Toxics in packaging	Lead, cadmium, mercury, and hexavalent chromium	Packages and packaging components	Restriction on these chemicals in packaging.
2018	Chapter 70A.222 RCW[184]	Toxics in packaging	PFAS	Plant fiber-based food packaging	Restriction on PFAS in this food packaging after safer alternatives have been identified by the department.
2018	Chapter 70A.400 RCW[185]	Firefighting agents	PFAS	Firefighting foam and personal protective equipment	Establishes restrictions on PFAS-containing firefighting foams and requires buyer notification of firefighting personal protective equipment containing PFAS.
2023	Chapter 70A.560 RCW[186]	Toxics in cosmetics	Ortho-phthalates, PFAS, formaldehyde and formaldehyde releasers, methylene glycol, mercury and mercury compounds, triclosan, m-phenylenediamine, o-phenylenediamine, and lead	Cosmetic and personal care products	Restricts the use of certain chemicals and chemical classes in cosmetic products. Requires Ecology to provide support to small businesses and manufacturers, and to adopt rules to restrict formaldehyde-releasing chemicals.

[183] app.leg.wa.gov/rcw/default.aspx?cite=70A.222
[184] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222
[185] app.leg.wa.gov/rcw/default.aspx?cite=70A.400
[186] app.leg.wa.gov/rcw/default.aspx?cite=70A.560

Year	RCW/ WAC	Description	Chemical(s) addressed	Products covered	Requirements or standards
2023	Chapter 173-337 WAC[187]	Safer Products Restrictions and Reporting	PFAS, ortho-phthalates, specified flame retardants, alkylphenol ethoxylates, bisphenols	Aftermarket stain-resistant and water-resistant treatments for application to textile and leather consumer products; carpets and rugs; leather and textile furniture and furnishings; fragrances in beauty and personal care products; vinyl flooring; electric and electronic products; recreational wall padding; polyurethane foam recreational products; laundry detergent; drink can linings; food can linings; thermal paper; apparel and accessories; apparel intended for extreme and extended use; automotive washes; automotive waxes; cleaning products; cookware and kitchen supplies; firefighting personal protective equipment; floor waxes and polishes; footwear; gear for recreation and travel; hard surface sealers; ski waxes	Adopts restrictions and reporting requirements for priority chemical-product combinations identified through each 5-year review cycle.
2025	Chapter 173-339 WAC[188]	Cosmetic Products Restrictions	Formaldehyde and formaldehyde releasers	Cosmetic products	Restricts manufacture, sale and distribution of cosmetic products containing intentionally added formaldehyde releasers.
2026	Chapter 70A.565 RCW[189]	Lead in cookware	Lead	Cookware and cookware components	Establishes concentration limits for lead in cookware.

[187] app.leg.wa.gov/wac/default.aspx?cite=173-337
[188] app.leg.wa.gov/wac/default.aspx?cite=173-339
[189] app.leg.wa.gov/rcw/default.aspx?cite=70A.565

Appendix E: Product details for Table 4 – PFAS and APEs in Architectural Paints

This appendix extends on the information in **Table 4** above, providing examples of safer alternatives to PFAS and APEs used in architectural paints. Example trade names and products with safer alternative ingredients for functions associated with PFAS and APEs are listed below, including citations for each product.

Polymethyl methacrylate (binder, acrylic) (CASRN: 9011-14-7)

Example trade names available in marketplace

SYNAQUA® 9511 by Arkema (Arkema, 2022; SYNAQUA® 9511, n.d.), TAFTIC™ AR650L by Toyobo (Toyobo, 2023)

Example architectural paints with alternative as ingredient

Products by Imperial Paints: ECOS Matte Paint (Imperial Paints, 2023b), ECOS Eggshell Paint (Imperial Paints, 2023a), ECOS Varnish (Imperial Paints, 2023c), ECOS Wood Stain (Imperial Paints, 2023d)

Fatty acids, castor-oil, caustic-oxidized, distillation residues, esters with 1,3-butanediol (binder, polyester) (CASRN: 113669-95-7)

Example trade names available in marketplace

SKYBON ES-710 by SK Chemicals by Reichnold-Polynt (SK Chemicals, 2020), Polymac® HS 57-5789 by Reichnold-Polynt (Polynt, 2020), EPOTUF® 607 (Reichhold, 2020a), EPOTUF® D808-XD-71 (Reichhold, 2020b)

Example architectural paints with alternative as ingredient

NA

Nepheline syenite (additive) (CASRN: 37244-96-5)

Example trade name available in marketplace

MINEX® 10 by Sibelco (Sibelco, 2025)

Example architectural paints with alternative as ingredient

Premium Plus® Exterior Satin Enamel (9050) by Behr (BEHR, 2025e), WB Primer Black Part B by Leggari (Leggari Products, LLC, 2022), Pure Performance Interior Latex Eggshell Midtone Base 9-320 by Pittsburgh Paint Co. (Pittsburgh Paints Co., 2025)

2-Propenoic acid, butyl ester, polymer with ethenyl acetate (binder, acrylic) (CASRN: 25067-01-0)

Example trade name available in marketplace

Joncryl® 1907 by BASF (BASF, 2026)

Example architectural paints with alternative as ingredient

High-Build Exterior Texture Flat - Medium White (437) by Benjamin Moore & Co. (Benjamin Moore, 2021)

Carnauba wax (additive) (CASRN: 8015-86-9)

Example trade name available in marketplace

AquaBead® 425E by Micro Powders (Micro Powders, n.d.-a), MICROKLEAR 418 by Micro Powders (Micro Powders, n.d.-c)

Example architectural paints with alternative as ingredient

Scuffmaster® ScrubTough Max by Wolf-Gordon (Wolf-Gordon, 2026a), Monocoat Oil Plus 2C by Rubio (Rubio Monocoat, 2023), Scuffmaster® Ambient Metallic (Neutral) by Wolf-Gordon (Wolf-Gordon, 2024)

Zinc phosphate (additive) (CASRN: 7779-90-0)

Example trade name available in marketplace

HALOX® 700 by ICL-HALOX (ICL-HALOX, n.d.)

Example architectural paints with alternative as ingredient

HP ACRYLIC METAL PRIMER - RED (HP1100-20) by Benjamin Moore & Co. (Benjamin Moore, 2024b), UNI-BOND MASTIC WHITE BASE by Tnemec (Tnemec Company, Inc., 2025)

Sodium benzoate (additive) (CASRN: 532-32-1)

Example trade name available in marketplace

Sodium benzoate by Netchem (Netchem, n.d.)

Example architectural paints with alternative as ingredient

Premium® Direct-To-Metal Eggshell Paint (7200) by Behr (BEHR, 2025d)

Siloxanes and Silicones, di-Me, reaction products with silica (additive) (CASRN: 67762-90-7)

Example trade name available in marketplace

METHYL SILICA AM-2-120 by Asilpax International B.V. (Asilpax International, n.d.)

Example architectural paints with alternative as ingredient

Premium® Direct-To-Metal Eggshell Paint (7200) by Behr (BEHR, 2025d)

3-Aminopropyltriethoxysilane (additive) (CASRN: 919-30-2)

Example trade name available in marketplace

GENIOSIL® GF 93 by Wacker (Wacker, 2024b)

Example architectural paints with alternative as ingredient

3369-3380 CombiColor Aqua Anti-Rust Primer by Rust-Oleum (Rust-Oleum Europe, 2024), FIRETEX FX7002 White by Sherwin Williams (Sherwin-Williams, 2025a)

Kaolin, calcined (additive) (CASRN: 92704-41-1)

Example trade name available in marketplace

Opacilite™ by Imerys (Imerys, 2025)

Example architectural paints with alternative as ingredient

DTM METAL PLUS H2O Series 100% Acrylic Interior/Exterior Paint (4700-4740) by Peintures MF/MF Paints (Peintures MF/MF Paints, n.d.), Premium Plus® Interior Semi-Gloss Enamel (3050) by Behr (BEHR, 2025f)

Polyethylene wax (additive) (CASRN: 9002-88-4)

Example trade name available in marketplace

AQUAMAT® 272 by BYK (BYK, 2021)

Example architectural paints with alternative as ingredient

Monocoat Oil Plus 2C by Rubio (Rubio Monocoat, 2023), Tnemec White (Tnemec Company, Inc., 2023)

Ethene, homopolymer, oxidized (additive) (CASRN: 68441-17-8)

Example trade name available in marketplace

DEUREX® MO 4220 by Deurex (Deurex, 2024), AQUAWAX 214VF by Micro Powders (Micro Powders, n.d.-b)

Example architectural paints with alternative as ingredient

Ultra Spec Scuff-X Interior Satin Finish (N486) by Benjamin Moore & Co. (Benjamin Moore, 2024a)

Hydrated silica (additive) (CASRN: 112926-00-8)

Example trade name available in marketplace

SPHERILEX® DP-0117 by Evonik (EVONIK, n.d.-b), AEROSIL® 200 HV by Evonik (EVONIK, n.d.-a)

Example architectural paints with alternative as ingredient

REGAL SELECT PREMIUM INTERIOR PAINT & PRIMER (N549) by Benjamin Moore & Co. (Benjamin Moore, 2025b), BEHR Drywall Plus Primer & Sealer (73) (BEHR, 2025c), THORULTRA PREMIUM ENAMEL WATERBORNE ACRYLIC SEMI-GLOSS by Richard's Paint (Richard’s Paint, 2020), High Build Primer by P.O.R. Products (P.O.R. Products, 2018)

Polyacrylic acid (binder, acrylic) (CASRN: 9003-01-4)

Example trade name available in marketplace

Pliotec™ PA95 by Synthomer (Synthomer, 2024)

Example architectural paints with alternative as ingredient

6648 DTM Interior/Exterior Semi-Gloss Enamel by Kelly-Moore Paints (Kelly-Moore, 2022)

N-(2-Ethoxyphenyl)-N'-(2-ethylphenyl) oxamide (additive) (CASRN: 23949-66-8)

Example trade name available in marketplace

SONGSORB® CS 312 by Songwon (Songwon, 2025)

Example architectural paints with alternative as ingredient

US Patent no. US20220259410A1 (Desrats et al., 2022)

Ammonium polyphosphates (additive) (CASRN: 68333-79-9)

Example trade name available in marketplace

FR CROS® 486 by Budenheim (Budenheim, 2020; Pharos, n.d.-b), TF-201 by Sichuan Taifeng New Flame Retardant (TF, n.d.)

Example architectural paints with alternative as ingredient

Fireshell IB4, IB, JM IC, BMS IC by ICP Building Solutions Group (ICP Building Solutions Group, 2019), PROTEGA Steel 1001 and 1002, Wood-S by Protega AB (Protega AB, 2023a, 2023b, 2024)

Aluminum hydroxide (additive) (CASRN: 21645-51-2)

Example trade name available in marketplace

Martinal® OL-104 by Huber Engineered Materials (Huber Engineered Materials, 2025), Inorganic Flame Retardant EcoFlame I-78 by Ascent Petrochem (Ascent Petrochem, n.d.-b)

Example architectural paints with alternative as ingredient

Fireshell IB4, IB, JM IC, BMS IC by ICP Building Solutions Group (ICP Building Solutions Group, 2019)

Carboxymethyl cellulose sodium (additive) (CASRN: 9004-32-4)

Example trade name available in marketplace

CMC FP7000 by Kima Chemical (Kima Chemical, 2019; Knowde, 2025)

Example architectural paints with alternative as ingredient

Arborcoat Waterborne Exterior Stain Semi Transparent (N638) by Benjamin Moore & Co. (Benjamin Moore, 2022a)

Polypropylene or Polypropylene wax (additive) (CASRN: 9003-07-0)

Example trade name available in marketplace

Ceridust™ 6050 M by Clariant (Clariant, 2025a), Propyltex® 325S by MicroPowders (Micro Powders, n.d.-e), PropylMatte 31 by Micro Powders (Micro Powders, n.d.-d)

Example architectural paints with alternative as ingredient

Prominence Interior Satin Ultra Deep Base, 84-3440 by PPG Architectural Finishes (PPG, 2025a)

Isobutyltrimethoxysilane (additive) (CASRN: 18395-30-7)

Example trade name available in marketplace

Protectosil® 100 by Evonik (EVONIK, 2019)

Example architectural paints with alternative as ingredient

CoatMasters® 2007R by IMRAE (IMRAE Corporation, 2020)

Triethoxyoctylsilane (additive) (CASRN: 2943-75-1)

Example trade name available in marketplace

XIAMETER™ OFS-6341 Silane by Dow (The Dow Chemical Company, 2020; Univar Solutions, n.d.-b), Silquest™ A-137 by Momentive (ChemPoint, 2026; Momentive, n.d.), DEA SILAN137 by SQ Química (SQ Quimica, n.d.)

Example architectural paints with alternative as ingredient

NA

Cellulose (additive) (CASRN: 9004-34-6)

Example trade name available in marketplace

S191C by Valida Powder (Sappi, n.d.), Ceridust™ 8091 VITA by Clariant (Clariant, 2025b), Valida S231C, 3% by Sappi (Sappi, 2025), CERAFLOUR® 1004 by BYK (BYK, 2026)

Example architectural paints with alternative as ingredient

EVER30 EVEREST Low Odor / Zero VOC Interior Eggshell Paint by Dunn-Edwards Corporation (Dunn-Edwards, 2025), Rubio Monocoat DuroGrit (Rubio Monocoat, 2024)

Hydrogenated castor oil (additive) (CASRN: 8001-78-3)

Example trade name available in marketplace

Hydrogenated Castor Oil (HCO) 90 Degree Melt Point (MP 90) by Acme-Hardesty (Acme-Hardesty, n.d.; UL Prospector, n.d.)

Example architectural paints with alternative as ingredient

NA

Docusate sodium (additive) (CASRN: 577-11-7)

Example trade name available in marketplace

METOLAT® 288 by MÜNZING (MÜNZING, 2024)

Example architectural paints with alternative as ingredient

Scuffmaster® Solid Metal by Wolf-Gordon (Wolf-Gordon, 2026b)

1-methoxy-2-propanol acetate (additive) (CASRN: 108-65-6)

Example trade name available in marketplace

Propylene Glycol Monomethyl Ether AcetatePMA by BC Chemical (BC Chemical, n.d.)

Example architectural paints with alternative as ingredient

Acrylic Urethane Gloss (V500 PART A) by Benjamin Moore & Co. (Benjamin Moore, 2022b), Hydrotech® HydroSeal Metal Primer by Sika (Sika Corporation, 2024)

Alcohols, C9-11-iso-, C10-rich, ethoxylated (additive) (CASRN: 78330-20-8)

Example trade name available in marketplace

METOLAT® 775 by MÜNZING (MÜNZING, n.d.)

Example architectural paints with alternative as ingredient

Prominence Interior Satin Ultra Deep Base, 84-3440 by PPG Architectural Finishes (PPG, 2025a), Pure Performance Interior Latex Eggshell Midtone Base 9-320 by Pittsburgh Paint Co. (Pittsburgh Paints Co., 2025)

Sodium C14-16 olefin sulfonate (additive) (CASRN: 68439-57-6)

Example trade name available in marketplace

Calimulse® AOS by Pilot Chemical (Pilot chemicals, 2018)

Example architectural paints with alternative as ingredient

Eco Spec® Interior eggshell (W374) by Benjamin Moore & Co. (Benjamin Moore, 2025c), REGAL SELECT PREMIUM INTERIOR PAINT & PRIMER, SEMI-GLOSS FINISH BLACK by Benjamin Moore & Co. (Benjamin Moore, 2025a)

Sodium C10-16 alkylbenzene sulfonate (additive) (CASRN: 68081-81-2)

Example trade name available in marketplace

Calimulse® L-50 by Pilot Chemical (Pilot chemicals, 2022)

Example architectural paints with alternative as ingredient

TimberSoy Wood Stain - Bio-Based Penetrating Wood Stain by Eco Safety Products (Eco Safety Products, 2022)

Dimethyl carbonate (solvent) (CASRN: 616-38-6)

Example trade name available in marketplace

Dimethyl carbonate (DMC) by Kowa Chemicals (Kowa American Corporation, n.d.)

Example architectural paints with alternative as ingredient

Nexus wht Precat, 20 by Gemini Industries, Inc. (Gemini Industries, 2025), HI-TEMP 1000V ALUMINUM by PPG Architectural Coatings Canada, Inc. (PPG Architectural Coatings Canada, Inc., 2025), WILCOX SPRAY PAINT (Wilcox, n.d.), Eastwood OPTIFLOW Epoxy Primer Catalyst (The Easthill Group, 2020)

Propylene carbonate (solvent) (CASRN: 108-32-7)

Example trade name available in marketplace

Jeffsol® PC (Azelis, n.d.)

Example architectural paints with alternative as ingredient

Behr Premium Transparent Quick Dry Oil Base Wood Finish – Cedar Naturaltone #4901 (BEHR, 2018), Muralshield by Urban Restoration Group US Inc. (Urban Restoration Group US Inc., 2019)

Appendix F: Product Details for Table 14 – cVMS in Cosmetics

This appendix extends on the information in **Table 14** above, providing examples of safer alternatives to cVMS used in cosmetics. Example trade names and products with safer alternative ingredients are listed below, including citations for each product.

Propanediol (CASRN: 504-63-2)

Example trade names available in marketplace

1,3-Propanediol by Yearn Chemicals (Yearn Chemicals, 2024), SpecBio® Propanediol natural by Spec-Chem Industry Inc. (Spec-Chem Industry Inc., n.d.), Elixi-CARE PDO by Connect Chemicals (Connect Chemicals, 2026), Novaguard™ 13PD NG by DKSH (DKSH, 2026), Farmoist™ ZMP by Farmorganic (Farmoganic, 2026a), PROPANEDIOL by Ataman Chemical (Ataman Chemicals, n.d.-e).

Example cosmetic products with alternative as ingredient

Milky Hydra Face Serum by Kiko (INCI Beauty, 2025b), Original Foundation SPF 20, Neutral Tan 21 by Bareminerals (EWG, n.d.-a), Ultimate Skin Solution Ingrown Eliminator + Skin Smoother by Billie (Billie, n.d.), Renaissance Serum by DUPUIS (DUPUIS, n.d.), Skin Perfector Hydrating Tint6, Dark Rich Tint by Sigma Beauty (Sigma Beauty, n.d.), Levi Fisher Smooth Operator, Detangling & Conditioning Beard Serum by Oyin handmade (Oyin Handmade, n.d.), Beauty Light Wand, Pinkgasm by Charlotte Tillbury (Charlotte Tilbury, n.d.), Strong Body Gel by ADIPEAU (Adipeau, n.d.), Glow Lust™ Radiant Luminizer – Morganite by Auric (Auric, n.d.), Zero-to-Brow Tinted Brow Gel by NYX Cosmetics (NYX Cosmetics, n.d.), Hand & Body Lotion by Gabriel Cosmetics (gabrielcosmetics, n.d.), Re-vive Weightless Longwear Concealer by Haley's,(Haley's, n.d.) Renew Face Polish by Oak Essentials (Oak Essentials, n.d.), Culture Duochrome Liquid Eyeshadow by Juvia's Place (Juvia's Place, n.d.), Purifying Whipped Cleanser by DEINDE (C.O. Bigelow, n.d.), Xtra Large Bombshell Volumizer by Color Wow (Color Wow, n.d.), Toddler & Baby Hair Gel for Soft Styling by T is for Tame (T is for Tame, n.d.), Revival+ Vitality Redensifying Eye & Lip Cream by Marcelle (Marcelle, n.d.), Stay the Night Shimmer Topper, Jackie Frost by Trixie Cosmetics (Trixie Cosmetics, 2026), Cooling Water Jelly Tint Blush + Lip Stain by Milk Makeup (Milk Makeup, n.d.), Snow Mushroom Water Primer by Volition (Volition Beauty, n.d.), Bellissima Volumizing Mascara by Honeybee Gardens (Honeybee Gardens, n.d.), Hydra-Peel Off Mask by Sacheu (SACHEU, n.d.), Summer Flame - Stay the Night Shimmer Topper by Trixie Cosmetics (Trixie Cosmetics, n.d.-b), Phyto Tonic - Brightening Vitamin C Probiotic Mist by Me Time Botanicals (Me Time Botanicals, n.d.), Purifying Facial Toner, Aloe + Lime by LARK SKIN CO. (Lark Skin Co., n.d.)

Isododecane (CASRN: 31807-55-3)

Example trade names available in marketplace

Isonaturane® 12 by Global Bioenergies (Global Bioenergies, 2023), Creasil® ID CG by The Innovation Company (Innovation Company, n.d.-a), Isododecane by MakingCosmetics (MakingCosmetics, 2025), Permethyl 99A by Presperse Inc (Presperse Inc, n.d.), Creasil® ID JSQI by The Innovation Company (Innovation Company, n.d.-b), PUROLAN™ IDD by Lanxess (LANXESS, 2023)

Example cosmetic products with alternative as ingredient

Instant Age Rewind Perfector 4-In-1 Glow Makeup by Maybelline (Maybelline, n.d.), Caffeine Eye Cream (Mario Badescu, n.d.), Skin Perfecting Tint, Radiant by Hi Beautiful You (Hi Beautiful You, n.d.), Clean & Fresh Beard Serum by Reuzel (INKEEDecoder, n.d.-b), Beauty Light Wand, Pinkgasm by Charlotte Tillbury (Charlotte Tilbury, n.d.), Moonlight Glow Balancing Body Oil by Tree Hut (Tree Hut Shea®, n.d.), Light Lock Highlight Fluid, Unrestrained by about face (Ulta Beauty, n.d.-a), Big Lash Stardaze Hair & Brow Glitter Mascara Topper Holographic Dream by Revolution (INKEEDecoder, n.d.-c), CC Screen 100% Mineral CC Cream, 426W, SPF 50 by Supergoop (EWG, 2026e), Re-vive Weightless Longwear Concealer by Haley's (Haley's, n.d.), Kill Lash Mascara Remover by Clio (CLUBCLIO Official, n.d.), Player One - Play Pigment by Trixie Cosmetics (Trixie Cosmetics, n.d.-a), Hydrating Cream Cleanser by Hard Night Good Morning (Hard Night Good Morning, n.d.), Wig & Weave Oil Free Shine (Ultimate Shine) by DeMert (evasbeautysupply, n.d.), Moisturizing Oil – Hydrating Oil by Kenra Professional (Kenra Professional, n.d.), Clear Smoothing Serum by Paul Mitchell (Paul Mitchell, n.d.), Hydro Salve Lip Balm by Baxter of California (Gentleman + Son, n.d.), Seamless Eye Primer by Viseart Paris (Viseart Paris, n.d.), Big Mood Waterproof Mascara by e.l.f. Cosmetics (e.l.f. Cosmetics, 2026), Mesmerize Positive Light Liquid Luminizer by Rare Beauty (Ulta Beauty, n.d.-c), Makeup Grip Set & Refresh Spray by MCoBeauty (MCoBeauty US, n.d.), Post-Shave Soother by Clinique For Men™ (Clinique, n.d.), Antiperspirant Deodorant Stick by Duradry (Duradry, n.d.), Deodorant Action Control Spray by Garnier (INCIDecoder, 2024a)

Example cosmetic products with alternative as ingredient

Facial Moisturizer by CLn (CLn Skin Care, n.d.), Diabetics' Dry Skin Therapy Foot Cream by EASE-Z (EASE-Z, n.d.)

Tripropylene glycol (CASRN: 24800-44-0)

Example trade name available in marketplace

Tripropylene Glycol by Univar (Univar Solutions, n.d.-a)

Example cosmetic products with alternative as ingredient

Hydrating Milky Moisturizer by BYOMA (INCIDecoder, 2025), Peel Shot Exfoliating White Rice Ampoule by Dr. Melaxin (Ulta Beauty, n.d.-d), Micellar Water Makeup Remover Cleansing Tissues by CALA (Amazon, n.d.-d)

Glycerin (CASRN: 56-81-5)

Example trade names available in marketplace

Glycerine Vegetable - USP 99.7% by New Directions Aromatics (New Directions Aromatics, n.d.), Glycerol by Siliconechem (Siliconechem, n.d.), Organic Glycerin by Ekologie Forte (Ekologie Forte, n.d.), GLE90 Natural Glycerin Emollient by Ascent Petrochem (Ascent Petrochem, n.d.-a), GLYCERIN 96% STAR KPO PALM distributed by Tilley Distribution (Tilley Distribution, n.d.), Glicerina 99,5 TRID. USP. V by ErcaWilmar (ErcaWilmar, 2025), Purified Glycerin by Kao Chemicals (Kao Chemicals, n.d.), Glycerine (Palm Free) 99.5%, Refined Organic by O&3r (O&3, 2024), Pricerine™ 9091 by Croda (Croda, 2025b)

Example cosmetic products with alternative as ingredient

Very Emollient Body Lotion by Alba Botanica (INCIDecoder, 2019), Idebenone Blackberry Intense Cream by Mary&May (Mary&May, 2026), Eye Cream Firm + Brighten by Follain (Follain, n.d.), Moisturizing Vegetable Glycerin by 365 by Whole Foods Market (Whole Foods Market, n.d.-a), Restore Healing Balm by Doctor Rogers (DOCTOR ROGERS, n.d.), Cooling Water Jelly Tint Blush + Lip Stain by Milk Makeup (Milk Makeup, n.d.), After Gel Nail Recovery Treatment by Must Have Beauty (Dollar Tree, n.d.), Aging Care Toning Water by Muji (MUJI USA, n.d.), Gillette Venus for Facial Hair & Skin Care Cleansing Primer (Amazon, n.d.-e), Brightening Vitamin C BB Beauty Balm, Sheer Tint, SPF 30 by Andalou Naturals (EWG, 2026g), Nursing Balm by ATTITUDE (ATTITUDE, n.d.-a), CC Cream Zinc SPF 30 by Juice Beauty (Juice Beauty, n.d.), Skin Finish by REFY beauty (REFY beauty, n.d.), Deodorant Spray Lime, 75ml by Alverde (German Drugstore, n.d.), Chemistry Deodorant, Serene Clean by Kosas (Kosas Cosmetics, n.d.), Real Repair Cocoa Butter Hawaiian Deep Conditioning Minute Mask by Alba Botanica (Walmart, n.d.-a), Greenhorn - Unscented Beard Wash by Whiskey 'N Hardtack (GOVX, n.d.), Moisturizer – Organic Avocado Oil + Hempseed Oil for Hydration, Growth, and Healthy Curls | Watermelon Fragrance by CurlMix (CurlMix, n.d.), Forever Blonde Dramatic Repair by Paul Mitchell (EWG, 2024c), Volumizing Glam Mousse by Blake Brown Beauty (Blake Brown, n.d.), Sheer Mineral Face Sunscreen Lotion, Fragrance Free, SPF 30 by Alba Botanica (EWG, 2026a)

Caprylic/Capric triglyceride (CASRN: 73398-61-5)

Example trade names available in marketplace

Lexol® GT-865 MB by Inolex (inolex, n.d.-b), NEOBEE M-5 COSMETIC – STEPAN by Tilley Distribution (Stepan, n.d.), Crodamol™ GTCC by Croda (Croda, 2025c)

Example cosmetic products with alternative as ingredient

Crop Soother™ Ball Aftershave Lotion by MANSCAPED (MANSCAPED, n.d.), Dry Skin Lotion by Natralia (AromaTherapeutix, n.d.), Hand Crème by OUAI (OUAI, n.d.), Dry Scalp Serum by Bouclème,(Bouclème US, n.d.), Medium Gradual Self Tanning Lotion | Just Shut Up and Sun Kiss Me Everyday by b.tan (Amazon, n.d.-c), Aluminum Free Spray Deodorant, Bourbon Leather by Mando (Mando, n.d.)

Dipropylene glycol (CASRN: 110-98-5)

Example trade names available in marketplace

Dipropylene Glycol by Hi-tech Spring (Hi-tech Spring, 2024), Dipropylene Gly LO+ by Dow (Dow, n.d.-a)

Example cosmetic products with alternative as ingredient

Recovery Anti-Aging Sheet Mask by PMD Beauty,(PMD Beauty, n.d.), Antiperspirant Deodorant for Men, Trailblazer by Old Spice (EWG, 2023), Old Spice Gentleman's Total Body Deodorant Spray - Vanilla & Shea (H-E-B | Here Everything's Better, n.d.)

Neopentyl glycol diheptanoate (CASRN: 68855-18-5)

Example trade names available in marketplace

Neopentyl Glycol Diheptanoate by Brenntag Beauty & Personal Care (Brenntag Beauty and Personal Care, 2025), LexFeel® 7 by Inolex (inolex, n.d.-a)

Example cosmetic products with alternative as ingredient

Nourishing Cream Hand & Nail by Onagrine,(Onagrine, n.d.), Tanning Sunscreen Spray, SPF 15 by Coppertone (EWG, n.d.-b), Fixline Eyeliner Gel – Black by Ofra Cosmetics (Ofra Cosmetics, n.d.), Whole Body Deodorant, Unscented by Mando (EWG, 2024d), Spray Antiperspirant for Sensitive Skin by fenjal (MAKEUP, n.d.), Hairitage by Mindy McKnight Split End Rescue (Hairitage by Mindy, n.d.), Keratin Golden Smoothing Balm by Ion (Sally Beauty, n.d.-b), Kids Tear Free Sunscreen Lotion, SPF 50 by Coppertone (EWG, 2026c), Sheer Mineral Sunscreens, SPF 30 by Cetaphil (EWG, 2026d)

Carnauba wax (CASRN: 8015-86-9)

Example trade names available in marketplace

2442L Carnauba by KahlWax (KahlWax, 2025), Carnauba Wax SP-63 by Strahl & Pitsch,(Strahl & Pitsch, 2025), STARPHERE CarnaWax Pellets by Korea Particle Technology (KPT) (Korea Particle Technology, 2017), Seatons Carnauba Wax™ by Croda (Croda, 2025a), Powdered Carnauba Wax #1 NF ARP by Koster Keunen (Koster Keunen, Inc., 2025), NAT ORGANIC CARNAUBA WAX by Naturochim (Naturochim - cosmetics, 2025)

Example cosmetic products with alternative as ingredient

Multi Balm Lavender Oil Body-Hands-Feet Soothing by Alteya Organics (Alteya Organics, n.d.-b), Natural Makeup Color Correcting Concealer Wheels by Omiana Beauty (Omiana Beauty, 2025), Natural Lip Balm and Sugar Lip Scrubs by Sunrise Artisan Bath and Body (Sunrise Artisan Bath And Body, n.d.), EyeLine Pencil by Elate Beauty (Elate Beauty, n.d.), Quiet on the Set Setting Powder, 03 Medium Neutral by theBalm (Amazon, n.d.-i), Citrus - Stick Deodorant by Real Purity (Real Purity, n.d.), Rebound Thermo232 ‑ Carnauba wax by Mistik (Mistik, 2022)

Coconut oil (CASRN: 8001-31-8)

Example trade names available in marketplace

PARYOL 507 CC/R by A&A Fratelli Parodi (A&A Fratelli Parodi, 2024), Coconut Oil by Cremer Oleo (Cremer Oleo, 2018), Coconut Oil Refined by Jan Dekker (Jan Dekker, 2026), Coconut 100KC by Samyang KCI (Samyang KCII, 2025), Coconut Oil, ORGANIC by SanaBio (SanaBio, 2021), COCOS NUCIFERA OIL by Ataman Chemical (Ataman Chemicals, n.d.-b)

Example cosmetic products with alternative as ingredient

After Sun Avocado And Herbs Moisturizer by A for Avocado (INCIDecoder, 2024b), Anti-Aging Hand Cream by OSEA (LOLITA BEAUTÉ, n.d.), Hydra Eye Balm by Jenni Kayne (Jenni Kayne, n.d.), Baby Oil by 365 by Whole Foods Market (Whole Foods Market, n.d.-c), Beard Oil No. 01 by Semblance For Men (Amazon, n.d.-b), Nursing Balm by ATTITUDE (ATTITUDE, n.d.-a), Blue Lagoon Body Oil by A'del Natural Cosmetics (A’del Natural Cosmetics, n.d.), CC Cream Zinc SPF 30 by Juice Beauty (Juice Beauty, n.d.), Coconut Reishi Nourishing Hand & Body Lotion, Purely Coconut by Alaffia (GoSupps.com, n.d.), Lip Balm by V76 (Sportique, n.d.), Radiance Bronze Gloss by Jenny McCarthy (Formless Beauty, n.d.), overnight lip mask by Pure Heaven (Pure Heaven, n.d.), Browning Lotion Organic by Poofy Organics (Poofy Organics, n.d.), The Best Beard Oil by Brickell (Brickell Men’s Products®, n.d.)

Hydrogenated olive oil (CASRN: 226993-75-5)

Example trade name available in marketplace

Olive Butter (SIO) by SIO (SIO, 2018)

Example cosmetic products with alternative as ingredient

Psoriasis Moisturizing Cream by CeraVe (CeraVe, n.d.)

Vitis vinifera (Grape) seed oil (CASRN: 85594-37-2)

Example trade names available in marketplace

GRAPESEED OIL by Bela Vizago Nature (Bela Vizago Nature, 2024), Grapeseed Oil by Mosselman (Mosselman, n.d.), Grapeseed Oil, Cold Pressed Organic by O&3 (O&3, n.d.)

Example cosmetic products with alternative as ingredient

Nourish Moisturizing Oil For Intimate Skin by Always (INCIDecoder, 2023), Peptide Face Cream by ATTITUDE (ATTITUDE, n.d.-b), Calendula Baby Oil by Earth Mama (Earth Mama Organics, 2026), Beard Oil No. 01 by Semblance For Men (Amazon, n.d.-b), Neem Oil For Skin by Athar'a Pure (Athar'a Pure, n.d.), Natural Makeup Color Correcting Concealer Wheels by Omiana Beauty (Omiana Beauty, 2025), Hand Salve by Mountaineer Brand Products (Mountaineer Brand Products, 2026)

Sweet almond oil (CASRN: 8007-69-0)

Example trade names available in marketplace

Refined Sweet Almond Oil by Huiles Bertin (Huiles Bertin, 2025), Organic Sweet Almond Oil by Farmoganic (Farmoganic, 2026b), Sweet Almond Oil by Vigon (Vigon, 2018), OLIK ALMOND VIRGIN ORGANIC by Pilmon (Pilmon, 2024), SWEET ALMOND OIL REFINED by Ataman Chemical (Ataman Chemicals, n.d.-f), Plantasens® Sweet Almond Oil Ref by Clariant (Clariant, 2022)

Example cosmetic products with alternative as ingredient

Sweet Almond Face Moisturizer by LATHER (LATHER, n.d.), Intense Repair Eye Balm by LAMAV (LAMAV, n.d.), Natural BB Cream – Fair by Lily Lolo (Lily Lolo, n.d.), Nourishing Body Scrub P91 - Sweet Almond Oil + Shea Butter by Typology (Typology, n.d.), Lavender Mint Lip Balm by Alteya Organics (Alteya Organics, n.d.-a), The Glow Mask - detoxifying turmeric mask for normal and dry skin by CLN&DRTY Natural Skincare (CLN&DRTY Natural Skincare, n.d.), Clarifying Conditioner by Q+A (INCI Beauty, 2025a), Explorer Beard Oil by Morton Essentials (Morton Essentials, n.d.), NOW Sweet Almond Oil by Lazy Acres (Lazy Acres, n.d.), Rice Water Conditioner Bar for Hair Growth by KITSCH (KITSCH, n.d.)

Behenyl behenate (CASRN: 17671-27-1)

Example trade name available in marketplace

DUB™ BB by Stearinerie Dubois (Stearinerie Dubois, 2023)

Example cosmetic products with alternative as ingredient

Rich Cream with Ceramides by Good Molecules (Ulta Beauty, n.d.-e), Rosemary Oil Strengthening Hair & Scalp Cleanser by Camille Rose Naturals (Camille Rose Naturals, n.d.), Heat Styling Lotion by Better Natured (Sally Beauty, n.d.-a), Spring It On Mousse, Ultra Definition, Strengthens & Protects by all about curls (Amazon, n.d.-a)

Zea Mays (Corn) starch (CASRN: 9005-25-8)

Example trade name available in marketplace

Natrasorb Bath by Nouryon (Nouryon, n.d.)

Example cosmetic products with alternative as ingredient

24HR Fresh-Feel Deodorant Balm by Nuxe Bio (INCIDecoder, 2021), Funk Butter Natural Deodorant, Unscented by Oyin Handmade (BLK + GRN, LLC, n.d.)

Magnesium hydroxide (CASRN: 1309-42-8)

Example trade name available in marketplace

Caremag D by Clariant (Clariant, n.d.-a)

Example cosmetic products with alternative as ingredient

Deodorant, Unscented by Trader Joe's (EWG, 2024e), Natural Spray Deodorant – Bergamot and Elemi by VOS (VOS, 2023)

Dimethicone (CASRN: 63148-62-9/9006-65-9/9016-00-6)

Example trade names available in marketplace

XIAMETER™ PMX-200 Silicone Fluid 200 cSt by Dow (Dow, n.d.-f), XIAMETER™ PMX-200 Silicone Fluid 100 cSt by Dow (Dow, n.d.-e)

Example cosmetic products with alternative as ingredient

No Marks 48hr Anti-perspirant Deodorant Roll-On by Vichy (INCIDecoder, 2022a), Protect & Care Anti-perspirant Deodorant Spray by Nivea (INCIDecoder, 2022b), Acidic Color Gloss Heat Protection Treatment by Redken (Ulta Beauty, n.d.-b), Daily Sunscreen Lotion, Light Citrus, SPF 30 by TruKid (EWG, 2026f), Sport Sunscreen Stick, SPF 50+ by Banana Boat (EWG, 2026b)

White mineral oil, petroleum (CASRN: 8042-47-5)

Example trade name available in marketplace

Lilac™ by Sonneborn (Sonneborn, n.d.)

Example cosmetic products with alternative as ingredient

Fresh Active 48 Hs Deodorant Roll-on by Nivea for Men (Amazon, n.d.-f)

Cetearyl alcohol (CASRN: 67762-27-0)

Example trade names available in marketplace

Lipocol™ CS-50 MB by Vantage (Vantage, 2025), LANETTE® O by BASF (BASF, 2025)

Example cosmetic products with alternative as ingredient

Spray Deodorant, Vanilla Bliss by Lume (Lume, n.d.), Antiperspirant Underarm Stick by Carpe (Carpe, n.d.), Hair Lotion by 2Girls With Curls (EWG, 2024a)

Hydrated silica (CASRN: 112926-00-8)

Example trade name available in marketplace

SIPERNAT® 22 LS by Evonik (EVONIK, 2025a)

Example cosmetic products with alternative as ingredient

FRAGRANCE-FREE Natural Deodorant by Ethique (ethique, n.d.)

Calcium stearate (CASRN: 1592-23-0)

Example trade name available in marketplace

Dapracare® CS MB by Italmatch Chemicals (Italmatch Chemicals, 2022)

Example cosmetic products with alternative as ingredient

Shiseido - Ag Deo 24 Deodorant Roll On DX (Shiseido, n.d.)

Hydroxypropyl guar (CASRN: 39421-75-5)

Example trade name available in marketplace

Jaguar HP-8 by Syensqo (Syensqo, 2024)

Example cosmetic products with alternative as ingredient

Brush Proof Cream by L’ Oreal (INCIDecoder, 2024c), Oil Color Ammonia-Free, Hair Colour 6 CC Permanent Hair, Light Brown Copper Copper by Matrix (Sally Beauty, n.d.-c)

Polyvinylpyrrolidone (CASRN: 9003-39-8)

Example trade name available in marketplace

Advantage™ Revive polymer by Ashland (Ashland, n.d., 2023)

Example cosmetic products with alternative as ingredient

Butter Blend & Flaxseed Double Duty Elongate & Define Jelly by Creme of Nature (Creme of Nature, n.d.), Colorways Vibrant Semi-Permanent Hair Color by Paul Mitchell (SleekShop, n.d.)

3-Aminopropyltriethyoxysilane (CASRN: 919-30-2)

Example trade name available in marketplace

Silsoft™ A-1100 fluid by Momentive (Momentive Performance Materials, 2025)

Example cosmetic products with alternative as ingredient

Absolut Repair Molecular Pre-treatment by L'Oreal Professional (INCIDecoder, 2024d)

Behentrimonium chloride (QAC) (CASRN: 68607-24-9)

Example trade name available in marketplace

Behentrimonium Chloride by McKinley Resources (Mckinley Resources, 2022)

Example cosmetic products with alternative as ingredient

Kids Detangling Spray with Fresh Fruity Scent by Johnson's (EWG, 2024b), Herbal Gro Hair Therapy Spray by Mane n’ Tail (Mane n’ Tail, n.d.), Blow-Out Creme, Fragrance Free by SEEN (SEEN, n.d.)

Castor oil (CASRN: 8001-79-4)

Example trade name available in marketplace

Ricinus Communis Seed Oil by Alfa Chemistry (Alfa Chemistry, n.d.-a)

Example cosmetic products with alternative as ingredient

Natural Hair Oil for Afro Hair - Seal by Afrocenchix ("Afrocenchix Seal - Natural Hair Oil For Afro Hair 200Ml," n.d.), Can't Believe It's Knot Butta by Soultanicals (Soultanicals, n.d.), Brilliant Moisture Hair & Scalp Oil by Zotos (Sally Beauty, n.d.-d), ORGANIC Castor Oil Pure Cold-Pressed for Hair & Skin by pura d'or (Amazon, n.d.-g), Freestyle Texturizer by rahua (rahua, n.d.)

Coco-glucoside (CASRN: 110615-47-9)

Example trade name available in marketplace

BergaSoft CG 50 by Berg + Schmidt (Berg Schmidt, 2019)

Example cosmetic products with alternative as ingredient

Hair Repair by Plaine Products (Plaine Products, n.d.), Volumizing & Shine Shampoo - Sensitive Skin by Attitude (ATTITUDE, n.d.-c)

Sodium C14-16 olefin sulfonate (CASRN: 68439-57-6)

Example trade name available in marketplace

Rhodacal® A 246L by Syensqo (Syensqo, 2025)

Example cosmetic products with alternative as ingredient

Detox Salty Scalp Scrub by Being Fenshe (Target, n.d.-b)

Sodium xylenesulfonate (CASRN: 1300-72-7)

Example trade name available in marketplace

STEPANATE® SXS by Stepan (Stepan Company, n.d.)

Example cosmetic products with alternative as ingredient

Keratin Silicone-free Shampoo by Pantene (INCIDecoder, 2026)