DEPARTMENT OF ECOLOGY
State of Washington

Biobased, Biodegradable, Compostable

Focus on Bioplastics Degradability

Overview

With the expansion of biobased, biodegradable, and compostable plastics in the market - as well as the different definitions for such products - consumers may be confused about the labels on these materials. In some cases, the confusion leads consumers to wrongly sort these products at their end-of-life. This incorrect sorting can cause problems with traditional plastic recycling, contaminate compost, and result in more products ending up in landfills and incinerators.

Bioplastics, according to the Society of the Plastics Industry (SPI) Bioplastics Council, are defined as plastics that are biodegradable, have biobased content, or both. Bioplastics are divided into three main types[1]:

- Bio-based biodegradable
- Bio-based non-biodegradable
- Fossil fuel-based biodegradable

Biodegradable bioplastic products are typically intended for short life applications such as single-use packaging, food waste collection bags, or food service ware (e.g., utensils, cups, plates), and are often promoted as compostable at the end-of-life[2].

The primary driving factors for creating bioplastic products include:[1,2,3]

- Reducing the use of fossil fuel-based plastics
- Making the separate collection of organic materials, such as yard waste and food waste, more practical and hygienic, thereby raising acceptance levels of the collection
- Helping divert organic waste such as food waste and yard debris from landfills and into composting

To make the right choice to recycle, compost, or dispose of these products at a product's end-of-life, consumers need to know the differences among them and be able to identify these products from fossil fuel-based plastics.

Disclaimer: This focus sheet is not intended as an endorsement of "biobased," "biodegradable," or "compostable" plastic products by the Washington State Department of Ecology. Here, we provide general definitions, clarify misconceptions, and discuss end-of-life management.

What is plastic?

"Plastic," in general, means something that is moldable, pliable, or easily shaped. Often, we associate the material called "plastic" as being made only from fossil-based components. However, plastic products such as solids, films, or filaments can be made from biological or synthetic materials. The broad meaning of "plastic" requires that we be more intentional and specific in how the term is used.

What is a "biobased" plastic[3]?

A biobased plastic is fully or partly made from biological raw materials as distinguished to one hundred percent fossil fuel raw material (oil) used in manufacturing conventional plastics. Common biological raw materials include corn, seaweed, potatoes, cassava, and sugarcane.

Figure 1. USDA Certified Biobased Product logo

The United States Department of Agriculture's (USDA) Bio-Preferred Program[4] created a certification program for promoting products with biobased content in 2002. This program helps consumers identify products such as inks, lubricants, detergents, and bioplastics, that meet biobased content standards.

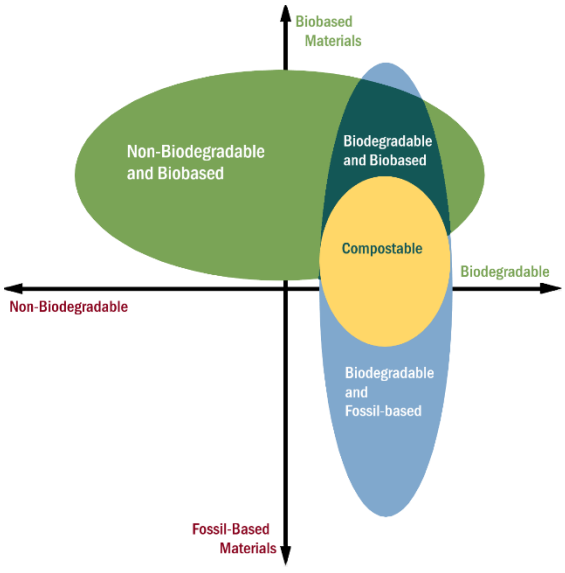
A voluntary program, BioPreferred, allows products meeting or exceeding the minimum biobased content to use the USDA Certified Biobased Product Logo (Figure 1).

Please note that just because a plastic product is **biobased** does **not** necessarily mean the product is biodegradable or compostable.

What is a "biodegradable" plastic[5]?

"Biodegradable" does not necessarily mean a material is compostable or recyclable. A biodegradable plastic can degrade by naturally occurring microorganisms such as bacteria, fungi, and algae. Natural degradation can yield water (H_2O), carbon dioxide (CO_2), biomass, and inorganic compounds, if degrading in aerobic environments. Degrading in anaerobic environments can produce methane (CH_4).

However, biodegradable claims can be misleading or confusing when users cannot identify the environment and timeframe required for a biodegradable plastic to fully degrade. For example, biodegradable plastics exposed to sun, oxygen, and water may degrade much faster than the same biodegradable plastic disposed of in a landfill.



The Federal Trade Commission's "Green Guides" state: "It is deceptive to make an unqualified biodegradable claim for plastics entering the solid waste stream if the plastics do not completely degrade within one year after disposal. Unqualified biodegradable claims for plastics that are disposed of in landfills, incinerators, and recycling facilities are deceptive because these facilities do not present conditions in which complete degradation will occur within one year."

In 2022, Washington State's Organics Management law attempted to eliminate consumer confusion by amending sections of the Plastic Product Degradability law (Chapter 70A.455 RCW). The law includes requirements to add specific colors, marks, and design patterns to products to help consumers identify compostable bioplastics. Washington allows products to be labeled "compostable" if they meet labeling requirements and specific American Society for Testing and Materials (ASTM) standards (RCW 70A.455.040).

What is a "compostable" plastic[6]?

A compostable plastic is biodegradable in an aerobic municipal or industrial composting environment[7], yielding water (H_2O), carbon dioxide (CO_2), biomass, and inorganic compounds. According to compostable product standards, the biodegradation during composting should be at a rate similar to other feedstocks being composted within 180 days. Also, the decomposition process should not leave visual or toxic residue that would adversely impact the ability of the finished compost to support plant growth.

Many of Washington's compost facilities use a shorter time frame for their composting processes - some as short as 60 days - which can be problematic for fully composting biobased plastic "compostable" products.

For a plastic product and a product that incorporates plastics and polymers (multiple layer product) as coatings or additives with paper and other substrates to be labeled as commercially "compostable", each product must meet scientific standards, such as the ASTM D6400-12[6] and ASTM D6868-21[8,] respectively.

Below are the key specifications for both standards:

- ***Disintegration:*** After 12 weeks (84 days) in a controlled composting test, no more than ten percent of the original dry weight of test products remains after sieving on a 2.0-mm sieve.
- ***Biodegradation:*** Within 26 weeks (180 days), 90% of the organic carbon in test plastics, or in each layer of the multiple layer products (with the plastic coatings, polymeric additives, paper, or other substrates), individually, must convert to carbon dioxide.
- ***Nontoxic to plants****:* Each product must have less than 50% of the maximum allowable concentrations of certain heavy metals found in Table 3 of 40 CFR Part 503.13. Additionally, the germination rate and the plant biomass for two different plant species grown in the sample composts shall be no less than 90% when contrasted with blank composts.
- ***Thickness dependent:*** Compostability of a product within a specific timeframe dependent on its thickness. Thus, a product must also state the maximum thickness at which the compostability requirements are passed. For example, a 1 mm thick product may completely compost under industrial composting conditions, while a 2 mm thick product may be too thick and may not compost at a rate sufficient to meet the compostability standard under the same industrial composting conditions.

The BioProducts Institute (BPI) established criteria to certify products meeting compostable specifications. If a product meets the specifications, it can display the BPI Compostable Logo (Figure 2).

Please note that there are currently no ASTM standard test methods available for evaluating the ability of a plastic to compost in a backyard home composting environment.

Figure 2. BPI Compostable Logo

What are common misconceptions about bioplastics?

Misconception: Biobased plastics are always biodegradable, and fossil fuel-based plastics are never biodegradable or compostable.

Fact: Biobased plastics, made fully or partly from biological raw materials, might not be compostable or biodegradable. Some fossil fuel-based plastics are biodegradable or compostable. Whether a material is biodegradable or compostable does not depend on its origin, but on how the product is made and the conditions it is exposed to during composting or disposal. Conditions that affect biodegradation and compostability include temperature, duration of treatment, the presence of microorganisms, oxygen, and moisture levels.

Misconception: Biodegradable plastics are always compostable.

Fact: The terms "biodegradable" and "compostable" are often used interchangeably, but they are not the same. Composting is a controlled or managed process where biodegradation may occur in an environment over a specific period of time. Compostable plastics are those that biodegrade in select aerobic municipal and industrial composting operations at the rate comparable to other feedstocks being composted. The term "biodegradable" must be qualified by the environment and timeframe.

Misconception: Compostable plastics are suitable for all industrial composting operations.

Fact: The standards for compostability (ASTM 6400-21 and ASTM D6868-21) are based on complete biodegradation within 180 days under aerobic municipal and industrial composting conditions. Even if these compostable standards are met, differences between operating conditions (composting feedstocks, pile size, temperature, composting methods, and so forth) and composting management means that the product may not be compostable in all facilities. This can be problematic because incompletely degraded plastic fragments are considered contamination and must be screened out of the finished compost. This leads some facilities not to accept compostable plastics with incoming feedstocks.

Misconception: All compostable plastics are suitable for home composting.

Fact: Compostable plastics generally cannot be composted in a backyard setting. Certification schemes in the US only test according to professionally managed aerobic municipal and industrial composting conditions. These compost systems typically operate at higher temperatures than those found in backyard composting conditions. There are currently several national standards for bioplastic home compostability in Europe. For example, the certifier TÜV AUSTRIA BELGIU offers such a home compostability certification scheme, and DIN CERTCO offers a certification for home compostability according to the Australian standard AS 5810. Bioplastics are tested under the conditions found in home composting -- particularly lower temperature -- have longer composting times compared to conditions under industrial composting. Bioplastics that meet these standards are certified for home composting by TÜV's OK composting HOME protocol and certification.

Misconception: Bioplastics are always more environmentally friendly than traditional fossil fuel-based plastics.

Fact: Bioplastics have certain benefits, depending on the desired attributes of the materials. For instance, biobased plastics primarily use biological raw materials, replacing some or all the fossil fuel materials use for the product. However, it takes fossil fuels to grow the crops that are used to manufacture bioplastics, so bioplastics do not always lead to less fossil fuel use or reduce environmental impact when compared to fossil fuel-based plastics overall. Bioplastics and compostable plastics can help divert waste from landfills and incinerators if they are accepted by a composting system. Some bioplastics are recyclable, having the same chemical properties as a fossil fuel-based plastic. However, it is not easy for the general public to distinguish which bioplastics should be recycled, which can be composted, and which must be disposed of in a landfill. Confusion often leads to contamination and expense for the composter and recycler. For these reasons, bioplastics are not always a solution, and must be linked to specific environmental goals.

Misconception: Biodegradable plastics will break down in the landfill.

Fact: Modern landfills are designed to reduce oxygen and moisture, limiting biodegradation. The Federal Trade Commission's "Green Guides" cautions that items destined for landfills, incinerators, or recycling facilities will not degrade within a year, so marketers should not make unqualified degradable claims for these items.

Misconception: Biobased plastics are not recyclable.

Fact: A few manufactures are making biobased plastics that are chemically and structurally identical to fossil fuel-based materials. For example, polyethylene terephthalate (PET, #1) can be made with biological raw materials and recycled where PET is collected for recycling. However, it may be a challenge for customers to distinguish between these recyclable biobased plastics and non-recyclable biobased plastics. This can create contamination problems with traditional fossil fuel-based plastic recycling.

What are possible management practices for these products at their end-of- life?

- **Recycling**. Some biobased bioplastics, like Coke's PlantBottle™, can be recycled with traditional recyclables. That's because the PlantBottle™ made with biobased polyethylene terephthalate (bio-PET) is chemically and structurally identical to PET made from fossil fuel-based materials despite being made from biological raw materials. However, many bioplastics are not currently accepted in curbside recycling programs and could possibly contaminate traditional fossil fuel-based plastic recycling.
- **Composting**. Bioplastics that are compostable (such as a bioplastic bag or take-out container that meets specific standards) can be used to collect and divert organic wastes like food scraps to composting. However, check with your local municipality or composting facility first, as not all facilities accept compostable plastics. Non-compostable biobased plastics (like biobased PET) are not suitable for composting.
- **Disposal**. Bioplastics that are not currently recyclable or compostable, and compostable plastics that are not accepted at a compost facility, should be disposed of with other solid wastes. Your local recycling, compost, or solid waste operators can help you make the right choice to recycle, compost, or dispose of the products at their end-of-life. Whenever possible, use reusable or durable items.

Learn more about bioplastics

- SPI Bioplastics Council
  https://www.plasticsindustry.org/supply-chain/recycling-sustainability/bioplastics
- US Composting Council's Compostable Plastic Toolkit
  www.cptoolkit.org
- Biodegradable Products Institute:
  www.bpiworld.org
- ASTM International standard test methods:
  http://www.astm.org
- Bioplastics Simplified: Attributes of Biobased and Biodegradable Plastics
  http://plasticsindustry.org/files/Bioplastics%20Simplified.pdf

References

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2. Thompson, R.C., Moore, C.J., vom Saal, F.S, and Swan, S.H. 2009. Plastics, the environment and human health: current consensus and future trends. Philosophical Transactions of the Royal Society B. 364:2153-2166.
3. Shen, L., Haufe, J., and Patel, M.K. 2009. Product overview and market projection of emerging bio-based plastics. PRO-BIP. Utechet University, Netherland.
4. USDA BioPreferred Program: http://www.biopreferred.gov/WhatLabelMeans.aspx.
5. van den Oever, M., et al., 2017, Bio-based and biodegradable plastics: facts and figures — focus on food packaging in the Netherlands, Report No 1722, Wageningen University, Wageningen, accessed 6 November 2019
6. ASTM Standard D6:400-21, 2021. Standard Specification for Labeling of Plastics Designed to be Aerobically Composted n Municipal or Industrial Facilities.
7. ASTM Standard D6868-21, 2021. Standard Specification for Labeling of End Items that incorporate Plastics and Polymers as Coatings or Additives with Paper and Other Substrates Designed to be Aerobically Composted in Municipal or Industrial Facilities.

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