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Evaluation of Bisphenol A (BPA) in Products Regulated by the State of Washington

by

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Abstract

In 2012, the Washington State Department of Ecology (Ecology) conducted a study to assess bisphenol A (BPA) levels in products regulated by Washington State law. The law prohibits the sale or distribution of the following products containing BPA: (1) bottles, cups, or other containers designed to be filled with liquid, food, or beverage and intended for children three years of age or younger and (2) sports bottles less than 64 ounces (RCW 70.280).

Ecology collected 74 products from nine retailers in Washington State during July 2012. Product types included baby bottles, sippy cups, toddler containers (bowls and plates), and plastic and metal sports bottles. A total of 85 samples (including 11 product subcomponents, such as baby bottle parts) were sent to a laboratory for analysis of total BPA.

The majority of samples tested (96%) did not contain BPA above a reporting limit of 1 ppm. Almost all of these products were labeled "BPA-free" and most consisted of polypropylene, Tritan™ copolyester plastic, or low-density polyethylene.

Three out of 85 samples contained BPA levels above the reporting limit. Two baby bottle samples labeled "BPA-free" contained BPA concentrations of 1.0 ppm and 1.3 ppm.

One of the samples tested had a considerably higher BPA level (100 ppm). This sample was a discount sports bottle labeled polycarbonate and did not advertise "BPA-free" on its packaging. It appeared to be an older product and the only one of its kind in the store.

Results of this study support the conclusion that manufacturers have largely moved away from using polycarbonate plastic in baby bottles, sippy cups, and sports bottles available to Washington State consumers.

Acknowledgements

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Introduction

Bisphenol A

Bisphenol A (BPA) is a monomer used in the production of polycarbonate and epoxy resins. Polycarbonate is a hard, clear plastic used to make products such as reusable bottles, tableware, compact disks, and eyeglass lenses. Epoxy resins are used as protective linings on metallic food and beverage cans to prevent spoilage. BPA is also sometimes found in other types of resins, and in flame retardants, polyvinyl chloride plastic, dental fillings, and thermal paper receipts.

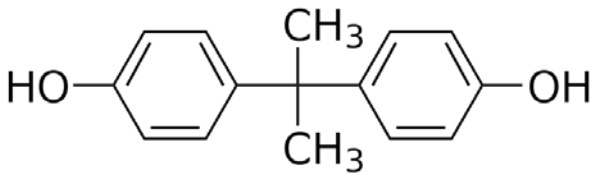

Figure 1. Chemical Structure of Bisphenol A.

BPA is readily excreted from the body and does not appear to bioaccumulate, yet humans are chronically exposed to the chemical due to its ubiquity in consumer products. A representative study found detectable levels of BPA in the blood of 93% of Americans over 6 years old (Calafat et al., 2008). Food packaging made with BPA is thought to be the primary route of exposure for humans (EPA, 2010). BPA can migrate into food and beverages from residual BPA in can linings and polycarbonate drinkware or through hydrolysis of polycarbonate in drinkware (Aschberger et al., 2010). BPA migration from polycarbonate varies based on several factors, including contact time, temperature, and pH of the liquid (Aschberger et al., 2010).

Animal studies have shown BPA to be a reproductive, developmental, and systemic toxicant, as well as weakly estrogenic (EPA, 2010). The National Toxicology Program (U.S. Department of Health and Human Services) and the U.S. Food and Drug Administration have stated "some concern" for effects on the brain, behavior, and prostate gland in human fetuses, infants, and children at current human exposure levels (NIH, 2008). Newborns and small children are thought to be at particular risk for exposure, with studies estimating newborn BPA levels to be 11 times greater than adults (Edginton and Ritter, 2009).

Actions in Washington State

In 2010, Washington State passed a law regulating the sale of certain cups and containers containing BPA (RCW 70.280). Effective July 1, 2011, manufacturers and retailers were banned from selling bottles, cups, and containers designed to be filled with liquid, food, or beverages and intended for children under age three. A second ban, which began July 1, 2012, prohibited the sale of any sports bottle up to 64 ounces that contains BPA. Metal cans less than 0.0149"

thick are not subject to the ban. For more information on the BPA law, visit www.ecy.wa.gov/programs/swfa/bpa.html.

BPA is also included in the Child Safe Products Act (CSPA) Reporting List (WAC 173-334). Beginning in August 2012, manufacturers of children's products must report to Ecology if their products contain BPA. For more information on CSPA, visit www.ecy.wa.gov/programs/swfa/cspa/.

Study Design

The goal of this study was to evaluate BPA levels in bottles, cups, and containers affected by the Washington State ban. The objective was to collect products sold by Washington State retailers and analyze the products for total BPA. The design and methods for this study are described in detail in a Quality Assurance Project Plan (Mathieu, 2012).

Products were purchased in July 2012 from eight retail stores in the south Puget Sound area and one on-line retailer. Samples were collected from large retailers and from stores that sell discount items. Six retailers stated that they primarily carry the same merchandise, supplied by the same distribution center, in all of their stores throughout Washington State, indicating that products bought in the south Puget Sound area would be representative of merchandise available throughout the state. One retailer stated that their stores may carry different products, depending on regional interests, which may be a limitation of sampling in one area. One retail store was a stand-alone store, not part of a chain, and thus representative of products available at that store. The on-line retailer was considered representative of products available to anyone in the state.

A total of 74 individual products were collected for this study. Products made of hard plastic or polycarbonate-like material were targeted for collections. All selected products were subject to the Washington State ban and included baby bottles, cups, and containers intended for children under age three, as well as sports bottles. Figure 2 shows the number of samples in each category that were collected and analyzed for this study.

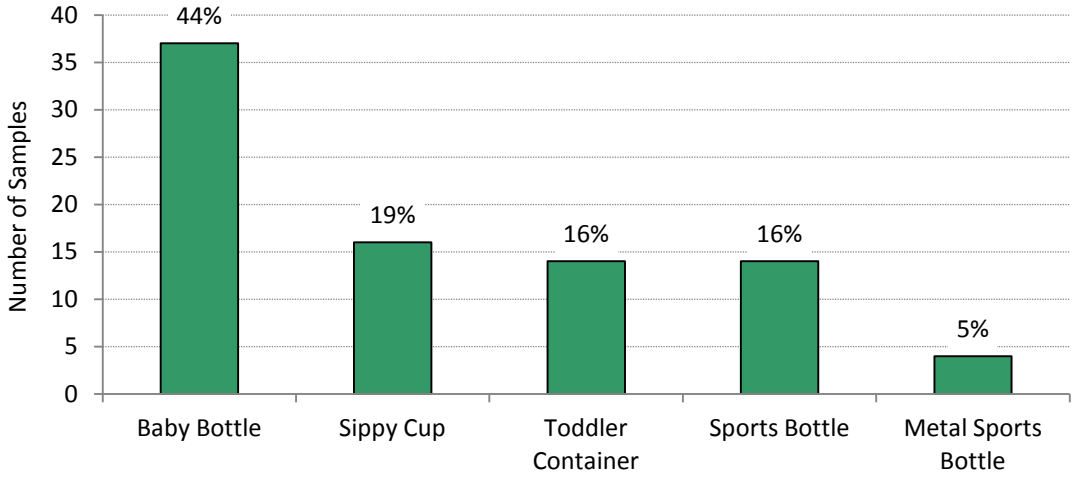

Figure 2. Number and Types of Products Collected for the 2012 Study.

Product parts consisting of different material or function were separated for individual analysis. All base or bottle parts consisting of hard plastic or metal material were sampled from each product. Eleven samples of subcomponent product parts were analyzed from selected products. These parts included cup lids and straws, as well as baby bottle parts (nipples, cap rings, a vent tube, and a plastic insert liner).

A total of 85 samples (including subcomponents) were sent to a laboratory for BPA analysis. For this study, BPA levels are reported if exceeding 1 ppm (part per million). The project reporting limit was set to 1 ppm to identify products made with BPA-containing polycarbonate or other plastic materials. The law does not specify a regulatory concentration level of BPA not to be exceeded. Instead, the law states that products subject to the ban cannot be sold if they *contain* BPA. Ecology's enforcement of this provision will be consistent with its guidance on practical quantification limits (PQL) (Ecology, 2012) under the Children's Safe Product Act, which currently specifies a PQL of 20 ppm.

Methods

Sample Processing

Products purchased from stores were brought back to Ecology headquarters for processing, assigned a unique identification number, removed from packaging, and photographed. Product information such as country of manufacture, manufacturer, and stock-keeping unit codes were recorded.

Products were deconstructed into individual parts consisting of one type of material and color. Plastic samples were reduced in size with stainless steel tools to approximately 2x2 cm square pieces, wrapped in aluminum foil, and placed in labeled 8-oz. glass jars. Metal samples were wrapped whole in aluminum foil and placed inside labeled plastic Ziploc bags. Samples were shipped to the laboratory at ambient air temperature to reduce the potential for contamination through wet or blue ice. Chain-of-custody procedures were followed throughout the process.

All sample processing was conducted on a clean bench lined with aluminum foil. Stainless steel tools used for size reduction were decontaminated between samples with the following procedure: hot water scrub with Liquinox soap, deionized water rinse, acetone rinse, and hexane rinse. All staff wore powder-free nitrile gloves while handling samples.

Laboratory Procedures

TestAmerica West Sacramento Laboratory analyzed total BPA in all samples by liquid chromatography-tandem mass spectrometry (LC/MS/MS), following Environmental Protection Agency (EPA) Method 1694 with quantification by isotope dilution.

Before analysis, plastic samples were cryogenically frozen and milled in a BPA-free cryogenic chamber. After cryomilling, 1 gram of sample was spiked with BPA-d6 surrogate/internal standard and extracted via sonication and microwave-assisted solvent extraction. After extraction, samples were concentrated, reconstituted in water, and cleaned up using solid phase extraction cartridges. This analysis is aimed at achieving a “total” concentration of BPA in the product, as opposed to a leaching or migration test.

Four samples consisted of solid metal material and could not be cryomilled. These samples were extracted whole via immersion in solvent and sonication. Extracts were then concentrated, reconstituted in water, and cleaned up using solid phase extraction cartridges.

The reporting limit of 1 ppm, as outlined in the Quality Assurance Project Plan, was selected to evaluate BPA levels indicative of products made with BPA-containing polycarbonate or other material. Values below 1 ppm were observed in several samples that are documented in case narratives available upon request.

Data Quality

Ecology's Manchester Environmental Laboratory (MEL) conducted a review of the TestAmerica data packages for data quality. Case narratives describing the quality of laboratory data, including holding times, instrument calibration, and quality control tests, are available upon request.

Quality control tests for each batch analyzed consisted of a method blank, laboratory control sample (LCS), matrix spike/matrix spike duplicate, and laboratory duplicate. All method blanks were below reporting limits. LCS and matrix spike recoveries were within measurement quality objectives (MQOs), averaging 87% and 100%, respectively. All laboratory duplicates and the associated source samples were below reporting limits and therefore not calculated.

A surrogate/internal standard was analyzed with every sample. Surrogate recoveries for all but three samples were within MQOs. Three samples had surrogate recoveries ranging from 1.3 to 4.8%; the associated samples were below reporting limits and were qualified "UJ" as estimates. These samples were metal matrices with colored exteriors that may have interfered with surrogate recovery.

Sample #1207064-20 was analyzed slightly more than 12 hours past the calibration verification standard. The result was below detection limits and likely unaffected. However, the result was qualified "UJ" as an estimate to be conservative.

The concentration measured in sample #1207064-54, a sports bottle, exceeded the calibration range. The sample was diluted and reanalyzed but still above the calibration range. Both analyses were within 10% (relative percent difference) of each other. The original analysis is used in this report and the result is qualified "E" as an estimate.

Results and Discussion

Baby Bottles

A total of 37 baby bottle samples were analyzed for BPA, representing 27 distinct products. Six samples consisted of product parts other than bottles (e.g., liner, nipples, cap rings.). In four cases, the same product was purchased from two different retailers and analyzed individually. Table 1 displays BPA concentrations measured in baby bottles and baby bottle components.

Table 1. BPA Levels Measured in Baby Bottles.

MEL Sample ID	Result (ppm)	Sample Type
1207064-05	1.0 U	Baby Bottle
1207064-06	1.0 U	Baby Bottle
1207064-07	1.0 U	Baby Bottle
1207064-14	1.0 U	Baby Bottle
1207064-15	1.0 U	Baby Bottle
1207064-16	1.0 U	Baby Bottle
1207064-17	1.0 U	Baby Bottle
1207064-18	1.0 U	Baby Bottle
1207064-26	1.0 U	Baby Bottle
1207064-27	1.0 U	Baby Bottle
1207064-28	1.0 U	Baby Bottle
1207064-29	1.0 U	Baby Bottle
1207064-30	1.0 U	Baby Bottle
1207064-47	1.0 U	Baby Bottle
1207064-49	1.0 U	Baby Bottle
1207064-50	1.0 U	Baby Bottle
1207064-51	1.0 U	Baby Bottle
1207064-52	1.0 U	Baby Bottle
1207064-53	1.0 U	Baby Bottle
1207064-55	**1.0**	Baby Bottle
1207064-56	1.0 U	Baby Bottle
1207064-57	**1.3**	Baby Bottle
1207064-58	1.0 U	Baby Bottle
1207064-59	1.0 U	Baby Bottle
1207064-60	1.0 U	Baby Bottle
1207064-61	1.0 U	Baby Bottle
1207064-62	1.0 U	Baby Bottle
1207064-63	1.0 U	Baby Bottle
1207064-75	1.0 U	Baby Bottle
1207064-83	1.0 U	Baby Bottle
1207064-85	1.0 U	Baby Bottle
1207064-37	1.0 U	Liner
1207064-76	1.0 U	Nipple
1207064-38	1.0 U	Cap Ring
1207064-77	1.0 U	Vent Tube
1207064-79	1.0 U	Nipple
1207064-82	1.0 U	Cap Ring

U: Not detected at or above level indicated

Two out of 37 baby bottle samples (5%) contained BPA levels above reporting limits. These samples were at, or very close to, the reporting limit of 1 ppm. Both products were purchased from the same retail store, and both products advertised “BPA-free” on the packaging.

We sampled the same product as one of the detected samples (#1207064-55) from a different store. The same product bought from a different store did not contain BPA levels above the reporting limit. The two bottles came from different packages (i.e., one was sampled from a “3-pack” and one was bought individually-packaged), but they were the same product.

Although much data has been collected on leaching and migration of BPA from plastic baby bottles, little information is available on "total" concentrations of BPA in baby bottles made of polycarbonate or other plastic materials. One study found total BPA levels ranging from 7 to 58 ppm in polycarbonate baby bottles (Biles et al., 1997). All baby bottle concentrations measured in the current 2012 study were below the low end of this range.

Sippy Cups and Containers

BPA was analyzed in 16 sippy cup samples and 14 containers (bowls and plates) intended for children under three years old. Two lids were analyzed in addition to the cup part of the product for sippy cups. No additional parts were analyzed for containers. Table 2 displays BPA levels measured in sippy cups and containers.

No samples in this category contained BPA levels greater than the 1 ppm reporting limit.

Table 2. BPA Levels Measured in Sippy Cups and Containers Intended for Children.

MEL Sample ID	Result (ppm)	Sample Type
1207064-09	1.0 U	Cup
1207064-11	1.0 U	Cup
1207064-12	1.0 U	Cup
1207064-19	1.0 U	Cup
1207064-22	1.0 U	Cup
1207064-33	1.0 U	Cup
1207064-34	1.0 U	Cup
1207064-35	1.0 U	Cup
1207064-36	1.0 U	Cup
1207064-41	1.0 U	Cup
1207064-44	1.0 U	Cup
1207064-68	1.0 U	Cup
1207064-69	1.0 U	Cup
1207064-70	1.0 U	Cup
1207064-80	1.0 U	Lid
1207064-81	1.0 U	Lid

MEL Sample ID	Result (ppm)	Sample Type
1207064-08	1.0 U	Bowl
1207064-10	1.0 U	Plate
1207064-20	1.0 UJ	Bowl
1207064-21	1.0 U	Bowl
1207064-32	1.0 U	Bowl
1207064-40	1.0 U	Bowl
1207064-42	1.0 U	Bowl
1207064-45	1.0 U	Bowl
1207064-64	1.0 U	Bowl
1207064-65	1.0 U	Plate
1207064-66	1.0 U	Bowl
1207064-78	1.0 U	Bowl
1207064-84	1.0 U	Bowl
1207064-31	1.0 U	Bowl

U: Not detected at or above level indicated.
UJ: Not detected at or above the estimated detection limit shown.

Sports Bottles

A total of 14 plastic sports bottles and 4 metal sports bottles were analyzed for BPA. One additional product part – a straw from a plastic sports bottle – was analyzed as part of the 14 plastic samples. Results of the analysis are presented in Table 3.

Table 3. BPA Levels Measured in Plastic and Metal Sports Bottles.

MEL Sample ID	Result (ppm)	Sample Type
1207064-02	1.0 U	Sports Bottle
1207064-03	1.0 U	Sports Bottle
1207064-04	1.0 U	Sports Bottle
1207064-13	1.0 U	Sports Bottle
1207064-24	1.0 U	Sports Bottle
1207064-25	1.0 U	Sports Bottle
1207064-43	1.0 U	Sports Bottle
1207064-46	1.0 U	Sports Bottle
1207064-54	**100 E**	Sports Bottle
1207064-71	1.0 U	Sports Bottle
1207064-72	1.0 U	Sports Bottle
1207064-73	1.0 U	Sports Bottle
1207064-74	1.0 U	Sports Bottle
1207064-39	1.0 U	Straw

MEL Sample ID	Result (ppm)	Sample Type
1207064-01	1.0 UJ	Metal Sports Bottle
1207064-23	1.0 U	Metal Sports Bottle
1207064-48	1.0 UJ	Metal Sports Bottle
1207064-67	1.0 UJ	Metal Sports Bottle

U: Not detected at or above level indicated.
UJ: Not detected at or above the estimated detection limit shown.
E: Estimated concentration.

One out of 14 sports bottle samples (7%) was detected above reporting limits, and the measured concentration (100 ppm) was considerably higher than any other sample in this study. This sample was the only product in our study labeled polycarbonate and one of the few products that did not advertise “BPA free” in its packaging. The sample also appeared to be an older product and was the only one of its kind in the store.

Summary of Results

Results of this study show that the vast majority of products tested did not contain BPA above 1 ppm. Manufacturers of baby bottles and sippy cups have largely moved away from using polycarbonate plastic in their products. An industry poll showed that the majority (97%) of producers are no longer selling polycarbonate to be used in the manufacture of baby bottles or sippy cups intended for the U.S. market (FDA, 2012). Sports bottle makers have also phased out polycarbonate use and primarily market products advertised as "BPA-free." The majority of labeled baby bottles and sippy cups tested in this study were made of polypropylene plastic. Several sports bottles consisted of Tritan™ copolyester polymers and low-density polyethylene. Almost all products tested contained packaging that advertised the product was "BPA-free".

Results of this 2012 study are summarized as follows:

- A total of 85 samples representing 74 individual products collected from Washington State retailers were analyzed for BPA.
- The majority of sampled products did not contain BPA above the reporting limit of 1 ppm (96% of samples). Almost all of these products were labeled "BPA-free" and most consisted of polypropylene, Tritan™ copolyester, or low-density polyethylene plastic.
- Three out of 85 tested samples (4%) contained BPA levels above the reporting limit of 1 ppm.
- Two baby bottle samples contained BPA concentrations of 1.0 ppm and 1.3 ppm. These samples were labeled "BPA-free."
- One sample had a considerably higher BPA level (100 ppm). This sample was a discount sports bottle labeled polycarbonate and did not advertise "BPA-free" on its packaging. It appeared to be an older product and the only one of its kind in the store.

Recommendations

Based on findings of this study, the following recommendations are made:

- Results of this study should be reviewed for the purpose of possible enforcement of the Washington State BPA law.

- Ecology should further clarify enforcement procedures for ensuring compliance with the BPA law. Considering the voluntary industry withdrawal of the use of polycarbonate in regulated product types, this may take low priority.

- Follow-up sampling and analysis should be considered to confirm sample concentrations near the reporting limit.

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Appendix. Acronyms and Abbreviations

Acronyms

BPA	Bisphenol A
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
MEL	Manchester Environmental Laboratory
RCW	Revised Code of Washington
WAC	Washington Administrative Code

Units of Measurement

ppm	part per million