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FENCELINE WATCH
THE DESCENDANTS PROJECT
LOUISIANA BUCKET BRIGADE
PORT ARTHUR COMMUNITY ACTION NETWORK
BEND THE CURVE

to the
U.S. Environmental Protection Agency (EPA)

on the Pre-Prioritization of Existing Chemical Substances under the Toxic Substances Control Act (TSCA)

31 October 2024

SUMMARY. We recommend that EPA select **benzene**, **ethylbenzene** and **styrene** for consideration as a category of chemical substances under TSCA section 26(c) for designation as high priority chemicals. Cumulative (and aggregate) exposure to these chemicals poses serious environmental justice and human health concerns, and all are used to make polystyrene and other problematic and unnecessary petrochemical plastics.

We further recommend that EPA select **antimony and compounds** for consideration as TSCA high priority chemicals for similar reasons and actions, including cumulative risk evaluation.

We further recommend that EPA select all **bisphenols**, including **bisphenol A** and **bisphenol S**, as a category of chemical substances under TSCA section 26(c) for designation as high priority chemicals for similar reasons and actions, including cumulative risk evaluation.

SUBMITTERS. These nonprofit commenters are fighting every day for environmental justice, against petrochemical plastic pollution, and for a positive vision of clean air and water and healthy communities for all, based on lived experience in Texas and Louisiana.

Vessel Project of Louisiana – The Vessel Project of Louisiana is a grassroots mutual aid, disaster relief, and environmental justice organization founded in Southwest Louisiana in response to several federally declared disasters, including hurricanes Laura and Delta, winter storm Uri, and the May flood of 2021. The Vessel Project realizes the intersectionality of the challenges that plague BIPOC communities and works holistically to achieve environmental and climate justice, voting rights, and access to housing, energy, clean water, safe fresh produce, and healthcare. https://www.vesselprojectoflouisiana.org/

Texas Environmental Justice Advocacy Services (t.e.j.a.s.) – T.e.j.a.s is dedicated to providing community members with the tools necessary to create sustainable, environmentally healthy communities by educating individuals on health concerns and implications arising from environmental pollution, empowering individuals with an understanding of applicable environmental laws and regulations and promoting their enforcement, and offering community building skills and resources for effective community action and greater public participation. Our goal is to promote environmental protection through education, policy development, community awareness, and legal action. Our guiding principle is that everyone, regardless of race or income, is entitled to live in a clean environment. https://www.tejasbarrios.org/

Fenceline Watch – As people living in the Houston, Texas surrounded by fossil fuel infrastructure, we rise in response to the rapid oil and gas expansion in the midst of a global climate crisis. Fenceline Watch is dedicated to the eradication of toxic multigenerational harm on communities living along the fenceline of industry. We believe a functional revolution is necessary to achieve equitable living conditions for low-resourced fenceline communities of color. We advocate to eliminate disparities of environmentally vulnerable communities and seek to increase effective access to justice- including redress, remedy, and inclusion in the decision-making process. https://www.fencelinewatch.org/

The Descendants Project – The Descendants Project is committed to the intergenerational healing and flourishing of the Black descendant community in the Louisiana river parishes. The lands of the river parishes hold the intersecting histories of enslavement, settler colonialism, and environmental degradation. Through programming, education, advocacy, and outreach, The Descendants Project is committed to reversing the vagrancies of slavery through healing and restorative work. We aim to eliminate the narrative violence of plantation tourism and champion the voice of the Black descendant community while demanding action that supports the total well-being of Black descendants. https://www.thedescendantsproject.org/

Port Arthur Community Action Network – PACAN is an environmental justice advocacy and community development organization serving the City of Port Arthur and the Southeast Texas region that keeps the community informed of the issues while seeking justice involving the protection of environmental and community rights. PACAN's success is the combined effort of intersectionality with a diverse group, unified by a common cause; to avoid climate catastrophe, save the future of humanity, and save our world. We will continue to keep the public informed and advocate for initiatives that will improve the life chances of all citizens, for a better community. Remember, "Nothing about us, without us". https://www.pa-can.com/

Louisiana Bucket Brigade – When Louisiana's fenceline communities need a strong, action-driven ally, Louisiana Bucket Brigade is there. Since 2000, we've worked with towns and neighborhoods next to the state's oil refineries, chemical plants and other petrochemical infrastructure — the places most impacted by pollution. We partner with the communities to help residents amplify their voices and challenge the petrochemical industry's relentless expansion. Louisiana Bucket Brigade uses grassroots action to hold the petrochemical industry and government accountable for the true costs of pollution. We work to create an informed, healthy society that hastens the transition from fossil fuels. https://labucketbrigade.org/

Bend the Curve – The mission of Bend the Curve is to transform the petrochemical industry so that it no longer harms people and the planet. We envision a just transition to sustainable production that protects human health, racial justice, and climate progress. To bend the curve and reverse harmful trend lines requires radical optimism fueled by persistent will. Our goals are to slash the use and production of petrochemicals and petrochemical plastics, ensure a just transition for workers and communities whose prosperity is at stake, and advance market adoption of safer, more sustainable materials, products and solutions. https://bendthecurve.org/

INTRODUCTION. EPA has welcomed public comments on the selection of five chemical substances from a candidate list of 27 chemicals. In this pre-prioritization phase, EPA selection of these substances will inform further data gathering to determine whether to formally designate any or all as high priority chemical substances under TSCA, as revised.

We strongly urge EPA apply two criteria to guide selection of pre-priority chemicals:

A. Does the chemical substance pose ENVIRONMENTAL JUSTICE concerns?

Under the Biden Administration, environmental justice remains a high national priority. Executive Order 12898 requires EPA to:

> *To the greatest extent practicable and permitted by law … each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States.*[1]

While EPA has done a good job in analyzing the environmental justice impacts of hazardous air pollutants under the Clean Air Act, your successful advancement of environmental justice under TSCA has been less explicit.

Now is the time for EPA to correct that short-coming by assessing whether the production, use and disposal of each of the 27 candidate chemicals potentially results in disproportionate impacts on communities of color, low-income people, and other vulnerable groups who are potentially exposed or susceptible populations.

B. Is the chemical used in the production of PETROCHEMICAL PLASTICS?

Public concern about plastics is at an all time high. The production, use and disposal of plastics poses growing hazards to racial justice, human health, climate progress, and the environment. About 70 to 80% of all petrochemicals are used to make plastics.[2,3]

By selecting plastics-related chemicals for designation as high priority substances under TSCA, EPA will achieve synergy with its other programs, such as the National Strategy to Prevent Plastic Pollution.[4] Further such EPA action will timely anticipate the outcome of the pending Global Plastics Treaty, under which negotiators are considering a declining cap on production of virgin fossil plastics, a list of chemicals of concern in plastics to phase out, and a prohibition on the most problematic uses of plastics.[5]

RECOMMENDATIONS. Based on our analysis of these factors, we recommend that EPA select the following group of substances for designation as TSCA high priority chemicals.

For each recommendation below, we urge EPA to consider each group of chemicals as a "category of chemical substances" as defined in Section 26(c) and designate them as high priority chemicals. This should lead to the preparation of a cumulative risk evaluation based on cumulative (and aggregate) exposure to all chemicals in the category and elimination of any unreasonable risk to potentially exposed or susceptible subpopulations.

1. **EPA should select three chemicals – BENZENE, ETHYLBENZENE, and STYRENE – as a category of chemical substances for pre-prioritization**

Plastics Use. All three of these petrochemicals are integrally connected to plastics production. More than half of all benzene is used to make ethylbenzene, almost all of which is used to produce styrene.[6] Almost all styrene is used to make various plastics, including various several types of resins, rubber and elastomers.[7]

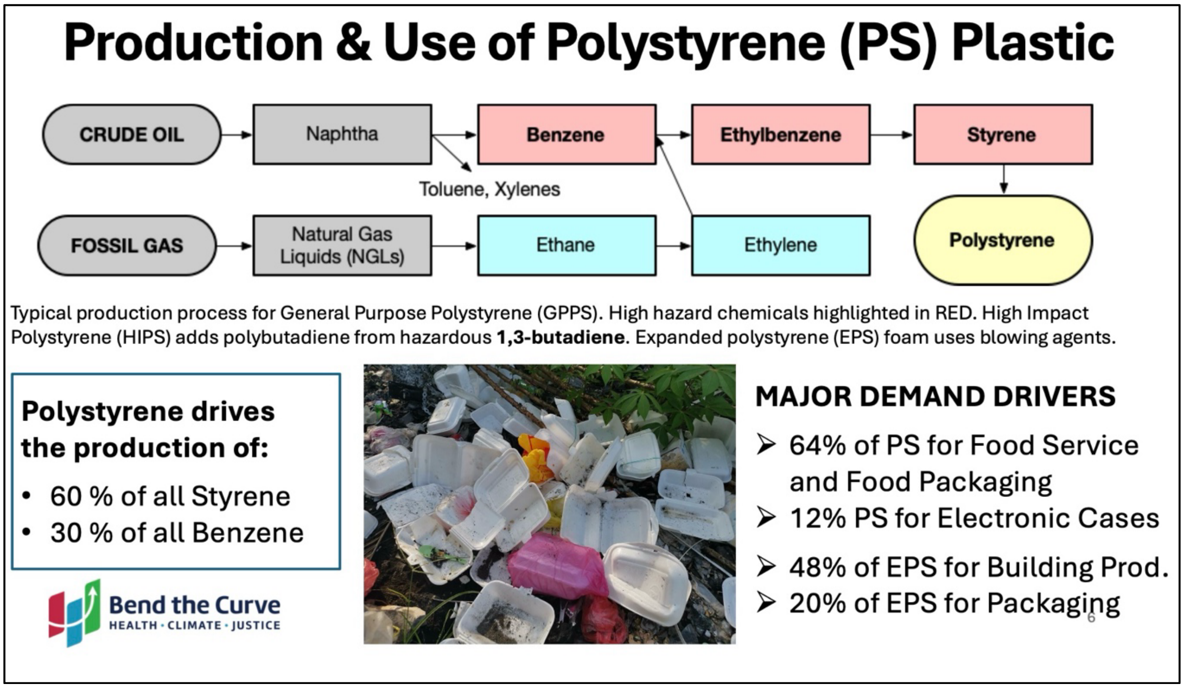
The production of just one major type of plastic, polystyrene, consumes about 60% of all styrene and 30% of all benzene, the largest single end-use market for each chemical.[8]

More than 80% of all benzene is used to make many different types of plastics, including polystyrene but also polycarbonate, polyethylene terephthalate, polyurethanes and phenolic resins.[9]

Figure 1 illustrates the production process for polystyrene plastic and the market drivers of plastics use, many of which are problematic and unnecessary.

In fact, the industry stakeholder group, U.S. Plastics Pact, has called for the elimination of polystyrene in all packaging applications by 2025 and in plastic cutlery by 2030.[10]

Figure 1



Typical production process for General Purpose Polystyrene (GPPS). High hazard chemicals highlighted in RED. High Impact Polystyrene (HIPS) adds polybutadiene from hazardous **1,3-butadiene**. Expanded polystyrene (EPS) foam uses blowing agents.

Health Hazards. All three chemicals are carcinogens and hematotoxicants (adversely affecting blood health) that also pose fetal toxicity hazards and threaten children's health.[11, 12, 13]

The six major U.S. styrene manufacturers reported high air emissions of all three chemicals in 2023, including 146,156 pounds of benzene; 142,903 pounds of ethylbenzene; and 248,893 pounds of styrene.[14] Actual emissions were probably higher than that due to the reliance on industry self-reporting, and the chronic underestimation of so-called fugitive emissions (leaks from thousands of connectors at each chemical plant) often by a factor of five- to fifteen-fold.[15]

Fenceline communities also face significant exposures to benzene air emissions from oil refineries and petrochemical plants, many of which produce benzene to supply the production of plastics. Fenceline monitoring data from 136 industrial facilities are summarized in Table 1.[16] According to EPA reporting protocol, the Δc benzene level equals the difference between the highest concentration of benzene measured at a fenceline monitor in a two-week period and the lowest concentration measured. This method is meant to attribute the net emissions from a single source to fenceline exposure.

Benzene in the air near industrial facilities continues to pose serious health risks. Comparison of the measured values with various health advisory levels adopted by authoritative agencies and peer-reviewed research reveal unchecked health hazards.

Table 1. Net Δc Benzene Concentration in Air (μg/m^3) Attributable to Industrial Facility Emissions

	Annual summary data of TWO- WEEK sampling				Annual summary data of ANNUAL sampling			
Year	**Min.**	**Med.**	**Max.**	**Avg.**	**Min.**	**Med.**	**Max.**	**Avg.**
2018	0.09	2.25	998	6.9	0	0	55.3	1.35
2019	0.06	2.18	565	4.78	0	2.88	290	5.35
2020	0	1.83	208	4.15	0	3	52	4.56
2021	0	1.86	298	3.94	0	2	30.2	3.83
2022	0	1.8	260	3.73	0	3	20.9	3.79
2023	0	1.7	161	3.2	0	2	21.9	3.54
2024	0.03	1.64	70	3.29	0	2	18.7	3.27

For example, Health Canada recommends keeping chronic benzene exposures below 0.6 μg/m^3 to protect against leukemia (at the 10 in one million risk level) and below 0.9 μg/m^3 to protect again hematotoxicity (adverse effects on blood health).[17]

California Office of Environmental Health Hazard Assessment adopted inhalation Reference Exposure Levels of 3 μg/m^3 for both 8-hour and chronic exposure to benzene based on hematological effects, and 27 μg/m^3 for acute benzene exposure based on developmental, immune system, and hematologic system toxicity.[18]

Independent scientists derived toxicity values to protect against acute blood toxicity from short-term benzene exposure of 85 μg/m^3 for 1-hour and 10 μg/m^3 for 24-hour exposures.[19]

For the reported values above, benzene exposure frequently exceeds these health advisory levels at the median, average, and maximum concentrations for both two-week periods and the annual sampling period. The acute toxicity health advisory levels are also exceeded for some time periods, based on the maximum values reported.

Environmental Justice. The cumulative exposure to plant workers, nearby workers (occupational non-users), and frontline community residents to all three of these chemicals also poses serious environmental justice concerns around styrene manufacturing plants, oil refineries, and certain petrochemical plants.

Table 1 shows that the footprint of four of the six major U.S. styrene manufacturers disproportionately impacts environmental justice communities. These four plants account for 90% of reported air emissions of benzene, ethylbenzene and styrene in 2023 and 78% of all styrene production capacity.

Table 1. Toxic Air Emissions and Environmental Justice Impacts of Major U.S. Styrene Manufacturers

Cumulative Impacts of Styrene Production	Styrene Plant:	American Styrenics	Cos-Mar	Westlake Styrene	Lyondell Chemical	INEOS Styrolution	INEOS Styrolution
	Plant Location:	St. James, LA	Carville, St. Gabriel, LA	Sulfur, LA	Channelview, TX	Pasadena, Bayport, TX	Texas City, TX
Styrene, tons / year	Plant Capacity	907,000	1,280,000	285,000	1,400,000	850,000	454,000
	Production, 2019	CBI	1,234,456	281,770	CBI	841,624	399,261
TOXIC AIR Emissions (pounds, 2023)	**Benzene**	19,987	22,500	13,095	81,617	6,158	2,799
	Ethylbenzene	10,168	37,000	6,426	76,030	3,536	9,743
	Styrene	63,658	101,000	22,322	39,023	2,754	20,136
	Subtotal - AIR	**93,813**	**160,500**	**41,843**	**196,670**	**12,448**	**32,678**
Socio-economic status within a 3-mile radius of a plant [Shaded values exceed the national average]	Total Population:	1,592	1,185	8,485	2,494	24,062	31,197
	People of Color	67 %	72 %	12 %	83 %	32 %	63 %
	Low Income	31 %	38 %	24 %	47 %	19 %	47 %
	Less than High School Education	15 %	16 %	13 %	31 %	8 %	17 %
	Limited English Speaking Households	0 %	3 %	2 %	45 %	1 %	6 %
	Under Age 5	3 %	3 %	7 %	5 %	7 %	7 %
	Over Age 64	18 %	12 %	14 %	7 %	15 %	16 %

The proportion of people of color who live within three miles of each of these four plants is 63%, 67%, 72% and 83%, compared to the national average of 40%. Low-income residents therein make up 31%, 38%, 47% and 47%, compared to the national average of 30%.

The populations living within three miles of the other two plants are slightly higher in children under age 5 (near both plants, 7% versus national average of 5%) and for having less education that high school (near one plant, 13% versus national average of 11%).

2. **EPA should select ANTIMONY AND COMPOUNDS as a category of chemical substances for pre-prioritization**

Plastics Use. Sixty percent of antimony is used in plastics, with more than half of all antimony used as a flame-retardant synergist in PVC plastics and with brominated flame retardants in other plastics.

About 6% of antimony is used as a polymerization catalyst for PET polyester plastic, from which it's been shown to migrate. (See Table 2.)

Appendix A, attached to these comments, is an excerpted chapter from a technical report on the uses, hazards, exposures and risks associated with PET plastic. A substantial portion of this chapter cites authoritative science and government reports on antimony.[20]

Table 2. About 60% of Antimony is Used a Plastic Additive

USE CATEGORY	MAJOR PRODUCTS	SHARE (2010)	MAJOR MARKETS	MARKET SHARE
Plastic Additive	Flame Retardants	52%	PVC (vinyl) plastic Other plastics * Rubber Textile back-coating	42% 40% 10% 8%
	PET Catalyst	6%	Polyester clothes, textiles PET plastic bottles Other PET packaging Other PET use	66% 24% 5% 5%
	Heat Stabilizer	1%	PVC (vinyl) plastic	
	Colorant	1%	Yellow-orange pigments	
Other Additive	Glass	1%	Solar cell glass Cathode ray tubes	
	Ceramics	1%	Construction	
Metallurgical	Batteries	27%	Lead-acid batteries	
	Lead Alloys	11%	Construction Ammunition	

* Includes acrylonitrile butadiene (ABS), polypropylene (PP), polybutylene terephthalate (PBT), polyamides (nylon), high-impact polystyrene (HIPS), unsaturated polyester resins (UPR), high-density and low-density polyethylene (HDPE/LDPE), epoxies, adhesives, paints and coatings.

Sources: Henckens et al. (2016) [40], EU (2008) [24], See also Chapter 2 Endnotes for Global Market Insights (2020) [19], Grand View Research (2019) [21].

Health Hazards. These uses expose consumers to antimony compounds in household dust and from skin contact, and in food and beverages from migration of antimony from PET plastic bottles and other packaging.

In fact, a screening level risk assessment concluded that aggregate and cumulative exposure to antimony and antimony compounds posed an unreasonable risk to children's health.

(See Appendix A for results of this risk assessment and citation to authoritative sources).

Environmental Justice. Population wide, antimony and compounds raise serious environmental justice concerns.

According to the national biomonitoring data, Latinx people and African-American residents are exposed to higher levels of antimony at the 75th, 90th and 95th percentile of population-wide exposure. (See Figure 2.)

Children are also exposed to antimony at much higher levels than adults across the population. (Figure 3.)

Fig. 2. Racial disparities, antimony exposure

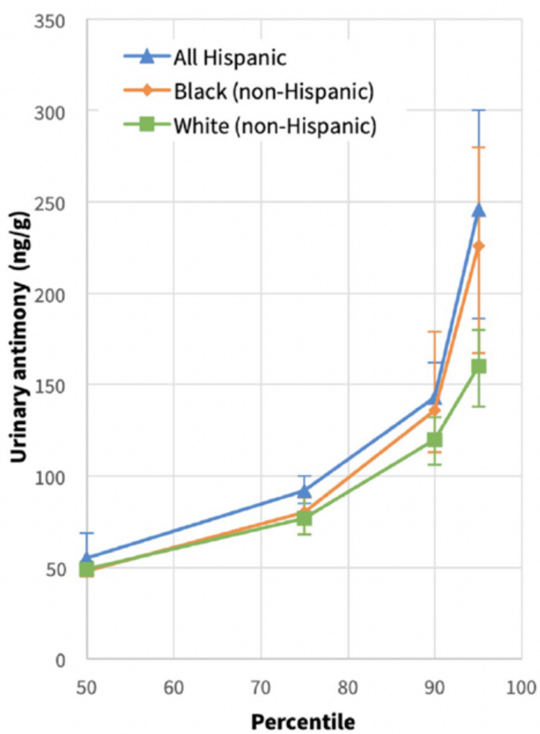
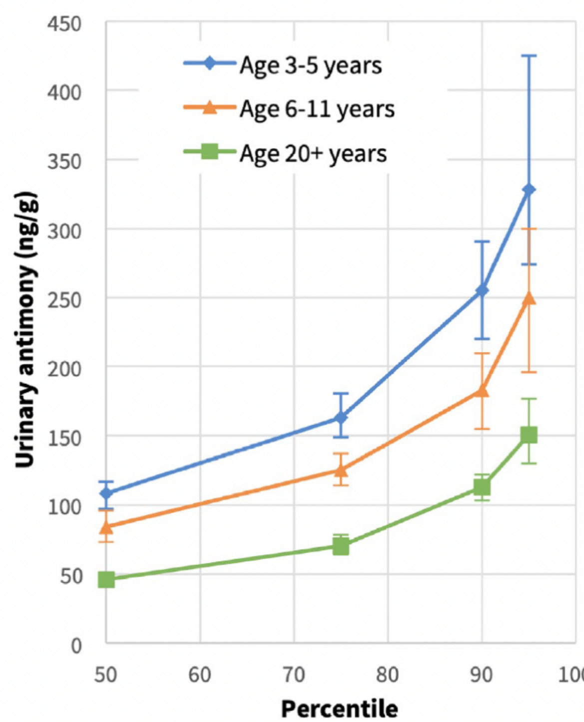


Fig. 3. Age disparities, antimony exposure



3. **EPA should select all BISPHENOLS, including Bisphenol A and Bisphenol S, as a category of chemical substances for pre-prioritization**

Plastics Use. About 98% of all bisphenol A (BPA) is used in plastics with about 65% as a monomer to produce polycarbonate plastics, about 30% an intermediate chemical in the production of epoxy resins, and small amount as an antioxidant additive in PVC and a precursor for the manufacture of the flame retardant TBBPA.[21] (See Table 3.)

Table 3. Plastic Related Use of Bisphenol A (Source: Trasande et al., 2024)

Use	% Total use	PRF main estimate	PRF low estimate	PRF high estimate	Comments
Polycarbonate plastic	65%	100%	100%	100%	All plastic related
Epoxy resins	30%	100%	100%	100%	All plastic related
Other	5%	50%	25%	75%	Partially plastic related, including BPA as stabilizer and an antioxidant in the production of PVC and as a precursor in the manufacturing of a brominated flame retardant, TBBPA. TBBPA is primarily used as a flame retardant in additive to plastics, but also paper and textiles
All uses	100%	98%	96%	99%	

Abbreviations: BPA, bisphenol A; PRF, plastic-related fraction; PVC, polyvinyl chloride; TBBPA, tetrabromobisphenol A.

Health Hazards. BPA is a well-recognized endocrine disrupting chemical with widespread population exposure associated with a variety of adverse reproductive and metabolic affects. The European Food Safety Authority (EFSA) recently lowered its presumed safety threshold by a factor of 20,000.[22]

Replacement bisphenols, used as substitutes for BPA, display similar health hazards, including bisphenol S and others.[23] To properly assess cumulative impacts and avoid regrettable substitution in risk management, EPA should treat the entire class of bisphenols as a category of chemical substances.

Environmental Justice. Research has shown higher levels of exposure among American women than men. Some studies have shown the African-American women face higher exposures than white women or revealed other racial/ethnic disparities in BPA exposure.[24]

Research has also revealed that workers are exposed to BPA at significantly higher levels than the environmentally-exposed general population.[25] Chemicals workers involved in the manufacture of BPA and epoxy resins are at especially high risk.

CONCLUSION. To address unsolved environmental justice concerns and the rapidly growing petrochemical plastics crisis, EPA should select these three categories of chemical substances to designate as high priority chemicals under TSCA:

1. Benzene, ethylbenzene and styrene
2. Antimony and compounds
3. Bisphenols, including bisphenol A, bisphenol S and all other bisphenols

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DEFEND OUR HEALTH

Solutions for a Toxic-Free Tomorrow

PROBLEM PLASTIC:

How Polyester and PET Plastic Can be Unsafe, Unjust, and Unsustainable Materials

July 2022

PROBLEM PLASTIC:
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This report is published by Defend Our Health, a U.S.-based nonprofit organization working to create a world where all people have equal access to safe food and drinking water, healthy homes, and products that are toxic-free and climate-friendly.

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DEFEND OUR HEALTH

Solutions for a Toxic-Free Tomorrow

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TABLE OF CONTENTS

Acknowledgments .... 3 »

Executive Summary .... 4 »

Chapter 1: Tackling Petrochemical Pollution, One Plastic at a Time .... 8 »

Plastic waste dominates the public and political perception of plastic pollution .... 9 »

Plastic pollution reframed: Environmental health and climate justice threat .... 10 »

Why take a deep dive into one plastic, PET resin and polyester fiber .... 10 »

Chapter 2: The PET Plastic Market - from Petrochemicals to Fast Fashion & Plastic Bottles .... 16 »

What is PET plastic and how is it made? .... 17 »

Who makes PET plastic and where do they do it? .... 18 »

What is PET plastic used for and who consumes it? .... 24 »

Chapter 3: Chemicals that Migrate from PET Plastic and Polyester May Threaten Your Health .... 27 »

Many additives may escape from PET resin and fiber during use .... 28 »

Antimony that escapes from plastic packaging threatens consumers' health .... 31 »

Antimony exposure from all sources threatens children's health .... 36 »

Unjust exposure to antimony from plastics contributes to environmental racism .... 40 »

Potentially safer alternatives to antimony catalysts are widely available, effective, and affordable .... 41 »

Chapter 4: Conclusions and Recommendations .... 45 »

Appendices

Appendix 1: Antimony Toxicology .... 50 »

Appendix 2. Migration of Antimony from PET Plastic Bottles and Other Products .... 54 »

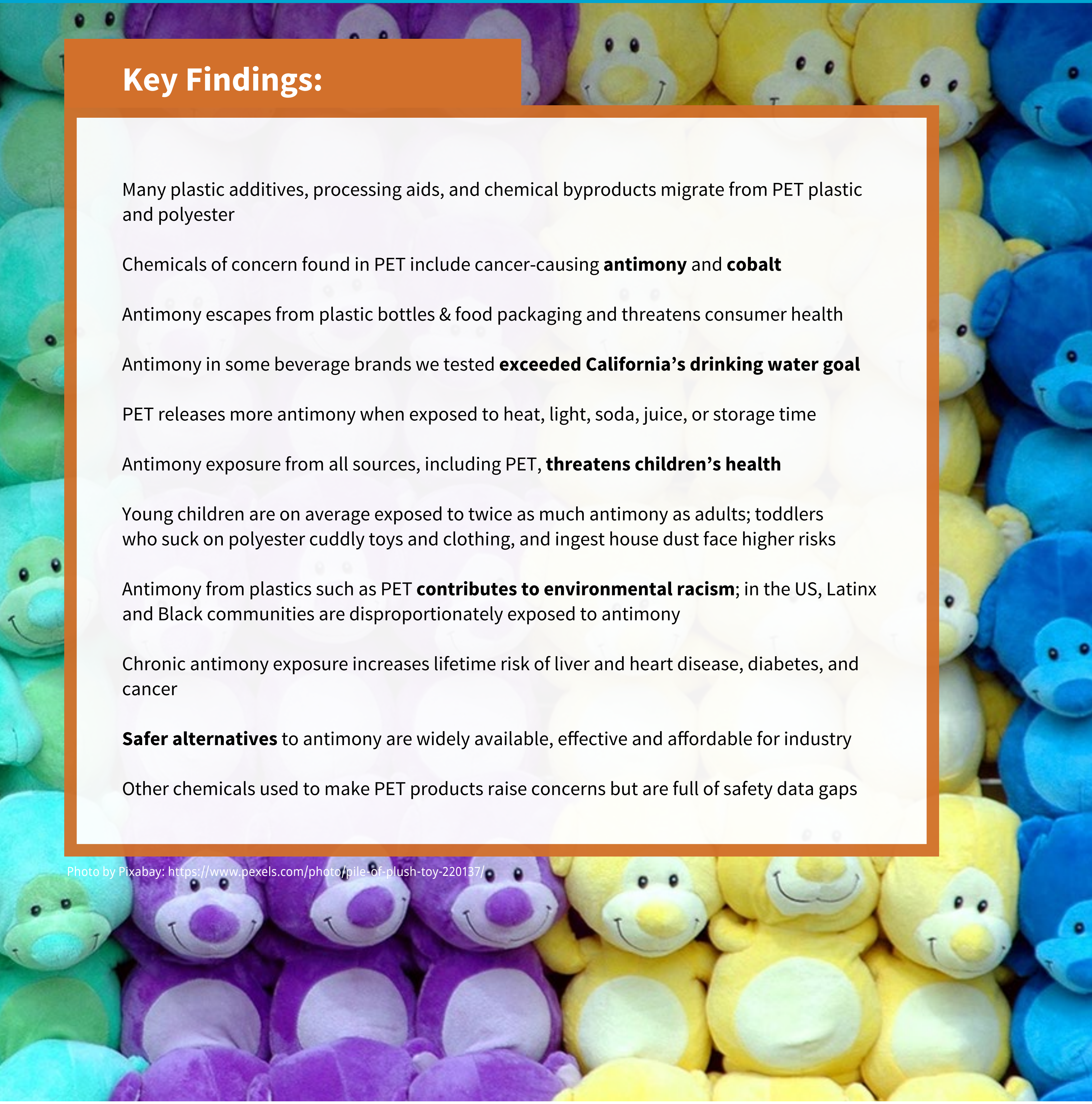
Appendix 3. Drinking Water Standards for Antimony .... 59 »

Appendix 4. Antimony Hazards to Workers .... 62 »

Appendix 5. Alternatives to Antimony as a PET Polymerization Catalyst .... 64 »

CHAPTER 3

Chemicals that Migrate from PET Plastic and Polyester May Threaten Your Health



Key Findings:

Many plastic additives, processing aids, and chemical byproducts migrate from PET plastic and polyester

Chemicals of concern found in PET include cancer-causing **antimony** and **cobalt**

Antimony escapes from plastic bottles & food packaging and threatens consumer health

Antimony in some beverage brands we tested **exceeded California's drinking water goal**

PET releases more antimony when exposed to heat, light, soda, juice, or storage time

Antimony exposure from all sources, including PET, **threatens children's health**

Young children are on average exposed to twice as much antimony as adults; toddlers who suck on polyester cuddly toys and clothing, and ingest house dust face higher risks

Antimony from plastics such as PET **contributes to environmental racism**; in the US, Latinx and Black communities are disproportionately exposed to antimony

Chronic antimony exposure increases lifetime risk of liver and heart disease, diabetes, and cancer

Safer alternatives to antimony are widely available, effective and affordable for industry

Other chemicals used to make PET products raise concerns but are full of safety data gaps

Photo by Pixabay: https://www.pexels.com/photo/pile-of-plush-toy-220137/

Table 3-3. Total Daily Exposure of Children to Antimony Exceeds Safety Limits

Exposures reported below for plastic bottles, drinking water, food, and upholstered furniture are estimates for adult exposures from authoritative sources. Note that on a per unit body weight basis, children drink more fluids, eat more food, breathe more air, and have a greater skin surface area than adults [31]. Therefore, the values reported below are likely to be underestimates for children's exposure.

EXPOSURE PATHWAY	EXPOSURE SOURCE	DAILY EXPOSURE (IN NG/KG/D)		NOTES
		TYPICAL	HIGH	
INGESTION	PET Plastic Bottles	12	29	Based on migration into bottled water before and after six months of storage [16]. Greater migration likely from plastic-bottled soda and juices due to lower pH (higher acidity).
	Drinking Water	?	24	May be higher from antimony leaching from plumbing materials and fittings, including tin solder [18].
	Food	62	80	Based on a well-balanced diet. May be higher from migration from heated PET plastic food trays [23].
	Polyester Cuddly Toys	?	208	Children who suck or chew on cuddly toys, blankets, and other polyester or PET plastic items, extract antimony in their saliva, and/or ingest polyester particles or fibers.
	House Dust	133	500	About 100 milligrams per day of dust are ingested by children's frequent hand-to-mouth activity [33]. Sources include antimony used with flame retardants in plastics.
Estimated child exposure from ingestion only		**> 207**	**841**	
DERMAL	Polyester Fabric	?	?	Antimony can escape from polyester clothing during skin contact with perspiration [34]. Sleeping with cuddly toys may also cause antimony exposure from skin contact.
	Upholstered Furniture	?	1,500	Skin contact with textiles with antimony trioxide added to enhance effect of flame retardant chemicals.
INHALATION	House Dust	5	21	Assumes that a child aged 1 to <2 years old inhales eight meters cubed of air per day of air [33].
	Outdoor Air	?	21	
Estimated child exposure from all sources		**> 212**	**2,383**	
Daily Exposure Limit	California EPA, OEHHA:	140		Acceptable Daily Dose (ADD) of antimony for its Public Health Goal for Antimony in Drinking Water (2016) [35]
	Unites States EPA, IRIS:	430		Reference dose (RfD) for antimony adopted by U.S. Environmental Protection Agency, IRIS (1987) [36]

Source: Unless otherwise noted, all values are based on the European Union Risk Assessment Report: Diantimony Trioxide (2008) [24], an aggregate risk assessment developed for Europe by the Swedish Chemical Inspectorate. See pp. 362-384. Daily exposure values are expressed as nanograms of antimony per kilogram of bodyweight per day. About half the population is exposed at the "Typical" exposure level. "High" exposure represents a reasonable worst-case scenario for each source. Additional exposure not included above occurs during breastfeeding.

3. Potentially Safer Alternatives to Antimony Catalysts are Widely Available, Effective, and Affordable

Eliminating unnecessary uses of plastics and substituting with safer materials is the best way to prevent environmental release and exposure to all plastic-related chemicals. For continuing uses of PET plastic resin and polyester fiber, an alternatives assessment can reveal whether existing processing aids such as antimony can be replaced with safer substitutes.

Antimony trioxide remains the dominant polymerization catalyst used to manufacture polyethylene terephthalate (PET) plastic for beverage bottles, other packaging, and polyester fiber for clothing and other textile applications [39]. However, given the growing concerns about the hazards and scarcity of antimony [40], the market has begun to shift to alternative catalysts.

We conducted an alternatives assessment for PET catalysts based on readily available information (see Appendix 5). The results are summarized in Table 3-4, which shows that potentially safer alternatives to antimony are functionally equivalent, commercially available, and comparably affordable.

Table 3-4. Comparison of Alternative PET Catalysts to Antimony Compounds

CATALYST COMPOUNDS	SAFER	EFFECTIVE	AVAILABLE	COST
Organo-aluminum salt	MAYBE	YES	YES	LOWER
Germanium oxide	YES	YES	YES	HIGHER
Titanium alkoxide complex	YES	YES	YES	~ SAME
Dibutyltin oxide	NO	?	YES	HIGHER
Enzyme (biobased)	YES	YES?	?	HIGHER?

Question marks indicate insufficient data to make a definitive conclusion.
For a detailed comparison of known PET catalysts, see Appendix 5.

This conclusion is supported by other evidence. Sustainability researchers have determined that the use of antimony as a PET polymerization catalyst is 100% substitutable [40]. Germanium oxide is already widely as used a catalyst to produce PET for plastic bottles in Japan [7]. Suntory sells plastic-bottled beverages made from PET plastic catalyzed with an aluminum-based catalyst developed by Toyobo [41]. Antimony is not used as a PET catalyst in Europe and a substantial portion of polyester production in Asia has switched to antimony alternatives [42]. Prominent textile manufacturers, including Herman Miller now advertise that their products are made of antimony-free polyester [43].

Our testing results provide preliminary evidence to suggest that some PET plastic manufacturers may have already begun transitioning to non-antimony catalysts for use in plastic bottles sold in the US. In our laboratory analysis, antimony was not detected in three out of sixteen plastic bottle samples tested using XRF (with a detection limit of 3 to 5 parts per million). XRF did not detect titanium or aluminum in these samples, but results of the more sensitive ICP-MS suggest that three of those antimony-free plastic bottles may have the three highest titanium concentrations in the plastic (Mountain Dew, Simply Lemonade, and 7-up), and two of them may have the highest results for aluminum (Simply Lemonade and 7-up) [12]. Both titanium- and aluminum-based PET polymerization catalyst systems are now commercially available and may have been used in the production of PET used in these bottles.

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