



**Evaluating
the Chemical
Footprint
of Plastics**



**Mark Rossi, Ph.D.
&
Ann Blake, Ph.D.**

September 15, 2014



Executive Summary



Chapter 1: Introduction



Ch. 2: Why Plastics



Ch. 3: Chemical Footprint



Ch.4: Strategies



Ch. 5: Conclusions

APPENDIX 1
Health Hazards of Chemicals of High Concern (CoHCs) in Plastics Production

Chemical CAS #	Alternative Health Effects (toxic) (AHE)	Health Risk
Acrylonitrile (AN) 255-261-5	Respiratory irritation; eye irritation; skin irritation; reproductive toxicity; developmental toxicity; carcinogenicity	Chronic respiratory health (asthma); reproductive health (infertility); carcinogenicity
Acrylonitrile-butadiene copolymer (ABS) 250137-09-0	Respiratory irritation; eye irritation; skin irritation; reproductive toxicity; developmental toxicity; carcinogenicity	Chronic respiratory health (asthma); reproductive health (infertility); carcinogenicity
1,4-Dioxane 107-11-3	ANIL (Group 1) carcinogen; reproductive toxicity; developmental toxicity; carcinogenicity	Carcinogenicity; reproductive health (infertility); developmental toxicity

App. 1: Health Hazards

APPENDIX 2
GreenScreen® and Assessment of Eight Chemicals Used to Manufacture Polymers

The GreenScreen® for Safer Chemicals was used to assess and compare the hazard levels of chemicals in the plastics footprint. This GreenScreen® is a chemical hazard assessment tool developed by GreenScreen Action. The GreenScreen® assesses the hazards in the plastics supply chain, with each assessment including a GreenScreen® score.

GreenScreen® products are ranked from best to worst. There are 3 hazard categories defined in the GreenScreen® based on toxicity (GHS), which is further subdivided into categories based on the type of polymer manufacturing for these plastics that is the focus of this assessment. These categories are: GreenScreen® (GHS) 1.0, GreenScreen® (GHS) 2.0, and GreenScreen® (GHS) 3.0. GreenScreen® assessments are eight chemicals related to the plastics manufacturing of primary plastics.

App. 2: GreenScreens

APPENDIX 3
Polymers and Hazard Rankings of their Primary Chemicals, Intermediate Chemicals, and Monomers

Polymer	Primary Chemicals (CAS #)	Intermediate Chemicals (CAS #)	Monomers (CAS #)
Acrylonitrile-butadiene copolymer (ABS)	Acrylonitrile (AN) 255-261-5	Acrylonitrile-butadiene copolymer (ABS) 250137-09-0	Acrylonitrile (AN) 255-261-5 Butadiene (BD) 106-99-0
High-density polyethylene (HDPE)	Ethylene 74-84-0	Ethylene 74-84-0	Ethylene 74-84-0
Low-density polyethylene (LDPE)	Ethylene 74-84-0	Ethylene 74-84-0	Ethylene 74-84-0
Polycarbonate (PC)	Phenol 108-95-2 Carbon dioxide (CO2) 74-79-6	Phenol 108-95-2 Carbon dioxide (CO2) 74-79-6	Phenol 108-95-2 Carbon dioxide (CO2) 74-79-6

App. 3: Chemical Hazards

FIGURE 1
Chemicals at the Core of Systems Change

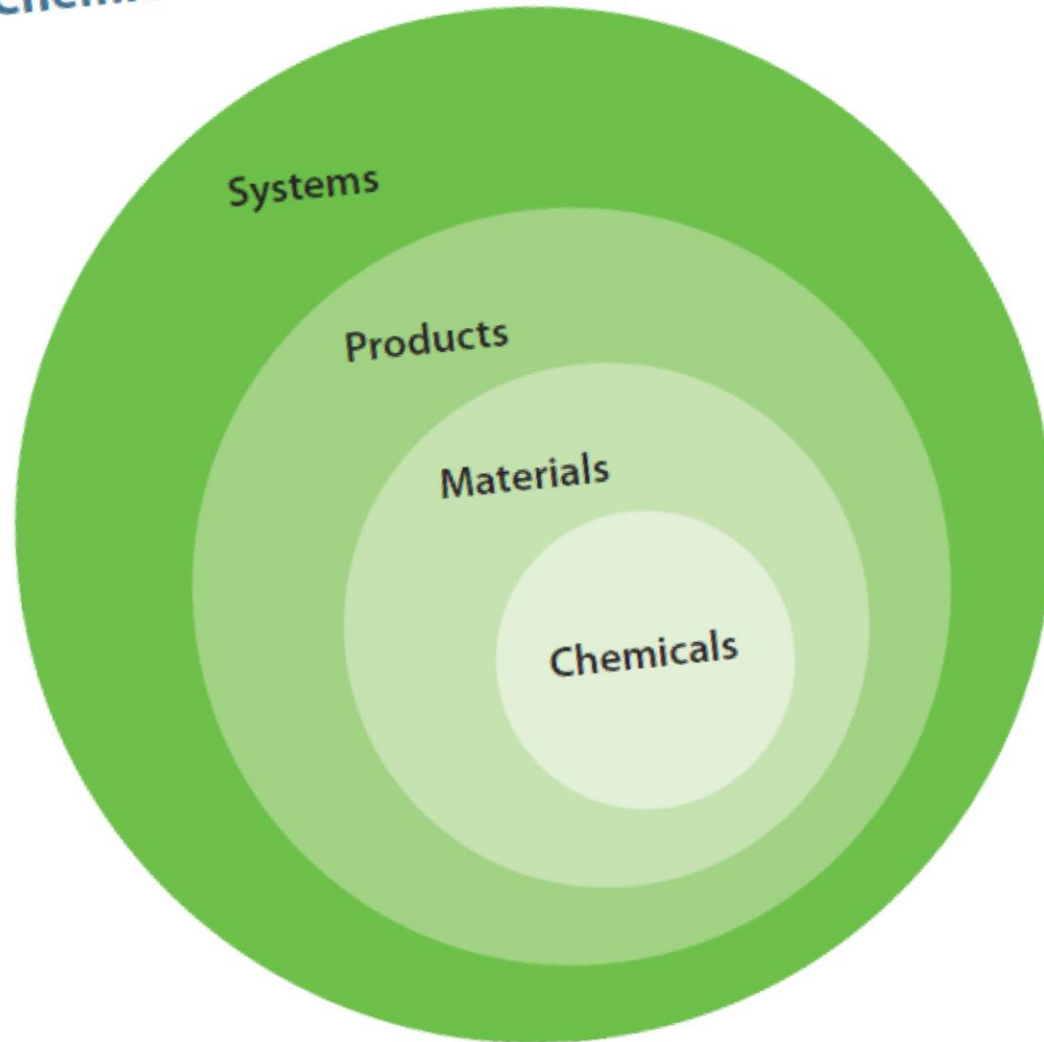
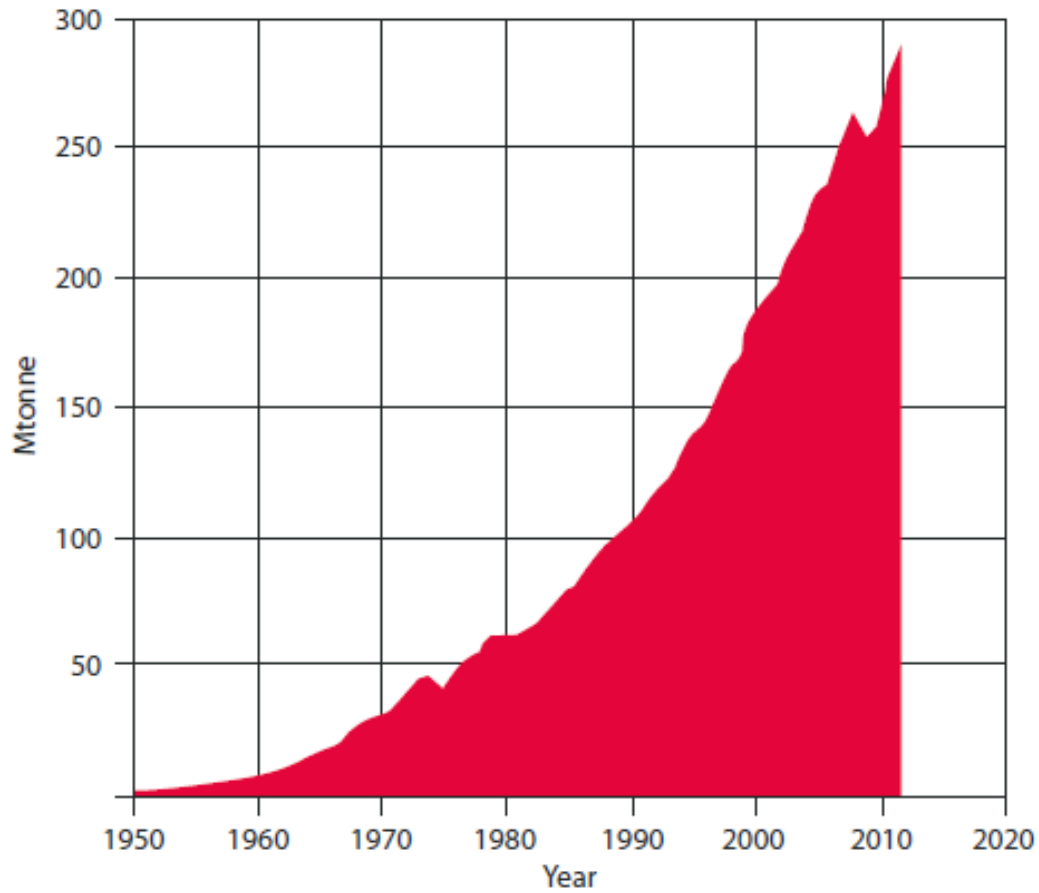


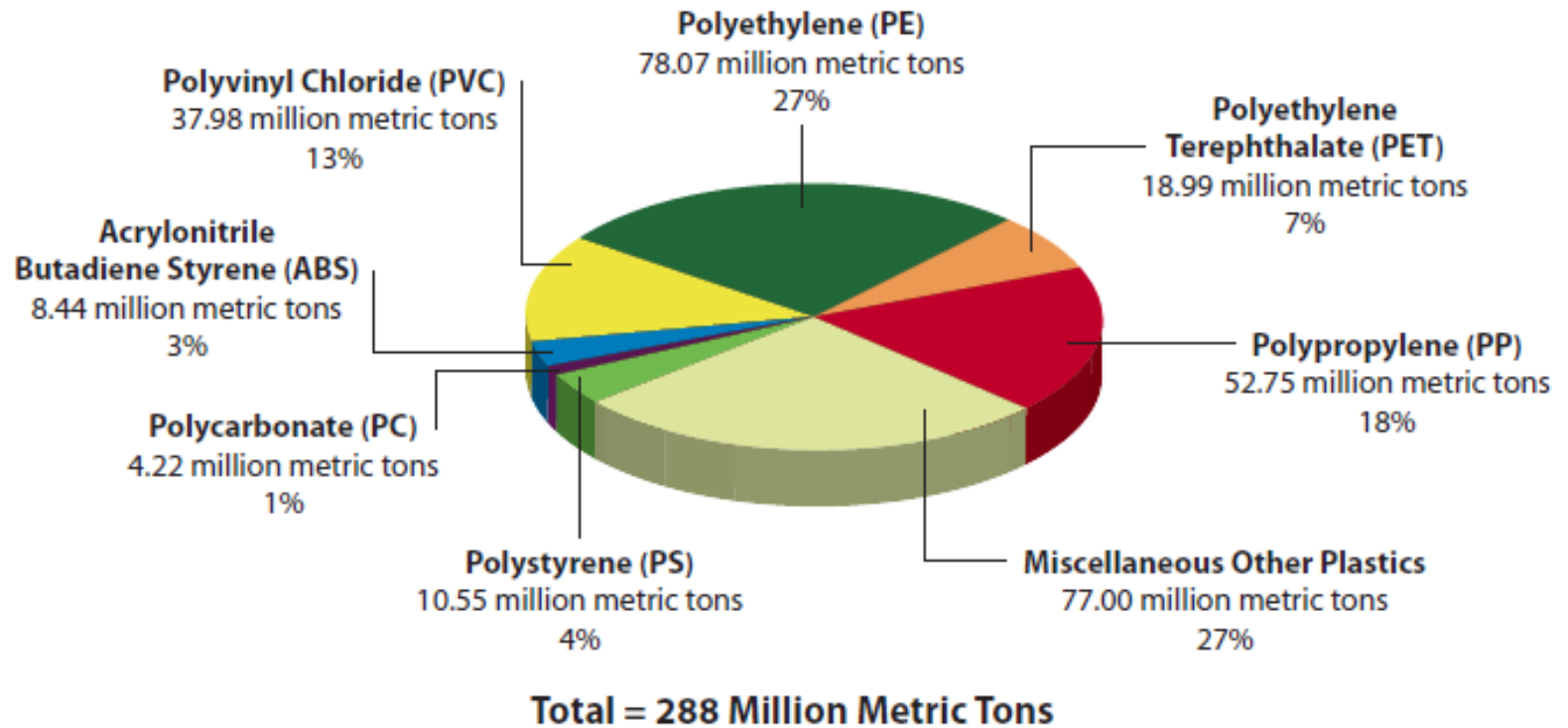
FIGURE 2 **World Plastics Production 1950–2012**



Includes thermoplastics, polyurethanes, thermosets, elastomers, adhesives, coatings and sealants and PP-fibers. Not included PET-, PA- and polyacryl-fibers.

Source: Plastics Europe, 2013.

FIGURE 3 Global Production of Plastics (2012)



Sources: Plastics Europe, 2013; Sagel, 2012.

TABLE 3 Plastics and the Chemicals of High Concern they Consume

Chemicals of High Concern (plastics)	Total Global Consumption (million metric tons)	Consumed by Plastics (%)	Consumed by Plastics (million metric tons)
Ethylene dichloride (PVC) ^b	43.45	97%	42.14
para-Xylene (PET) ^b	42.89	88%	37.62
Benzene (PS) ^b	39.67	85%	33.52
Vinyl chloride monomer (PVC) ^b	32.79	97%	31.80
Ethylbenzene (ABS, PS) ^b	27.57	99%	27.29
Styrene (ABS, PS, SAN, SBR) ^b	23.63	91%	21.38
Ethylene glycol (PET, Nylon) ^a	21.00	80%	16.80
Cumene (PC) ^b	12.23	84%	10.27
Butadiene (ABS, SBR) ^b	9.28	94%	8.75
Acrylonitrile (ABS) ^a	5.35	96%	5.16
Phenol (PC) ^c	8.90	55%	4.88
Bisphenol A (PC, epoxy resins) ^c	4.04	96%	3.86
Acetone (PC) ^d	5.67	45%	2.53
Total	270.79	90%	243.48

^aChemicals of High Concern* to human health or the environment = carcinogen, mutagen, reproductive / developmental toxicant, persistent, bioaccumulative, toxicant (PBT); endocrine disruptor; or chemical of equivalent concern.

^cSource: Chemical Economics Handbook articles (c), (d), (e), (f), (g), (h), (i), (j), (k), (l), (m), (n), (o), (p), (q), (r), (s), (t).

Acrylonitrile Butadiene Styrene
 Phthalate
 Terephthalate

PLA = Polylactic Acid
 PP = Polypropylene
 PS = Polystyrene
 PVC = Polyvinyl Chloride

SAN = Styrene Acrylonitrile
 SBR = Styrene Butadiene Rubber



“workers carry a body burden of plastics-related contaminants that far exceeds those documented in the general public . . . existing epidemiologic and biological evidence indicates that women in the plastics industry are developing breast cancer and experiencing reproductive problems at elevated rates as a result of these workplace exposures” (DeMatteo, et al., 2011).



*Standardized Environmental
Questions for Medical Products*

Chemicals of Concern

PVC

Phthalates

Halogenated Organic Flame Retardants

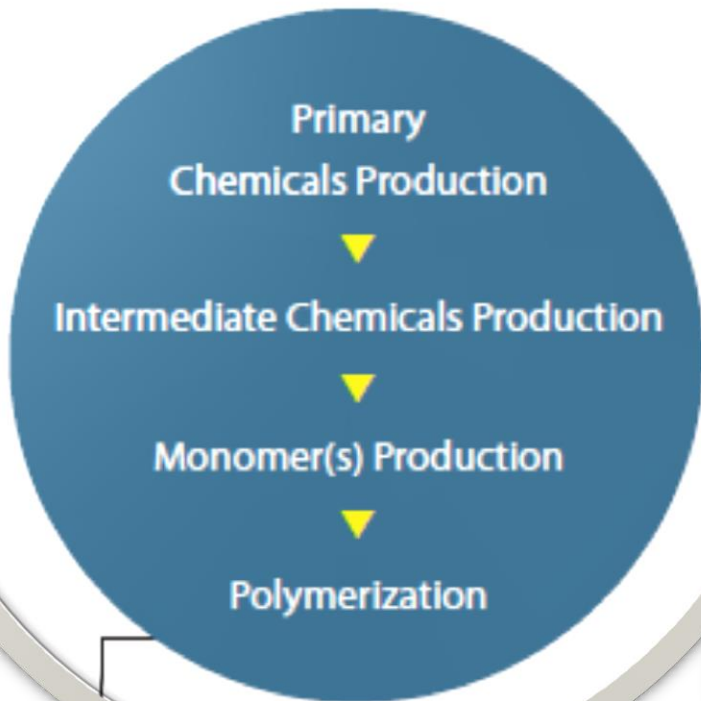
Carcinogens/Reproductive Toxicants

DEHP/PVC Reduction:
Eliminate DEHP/
PVC from at least one
product line*.

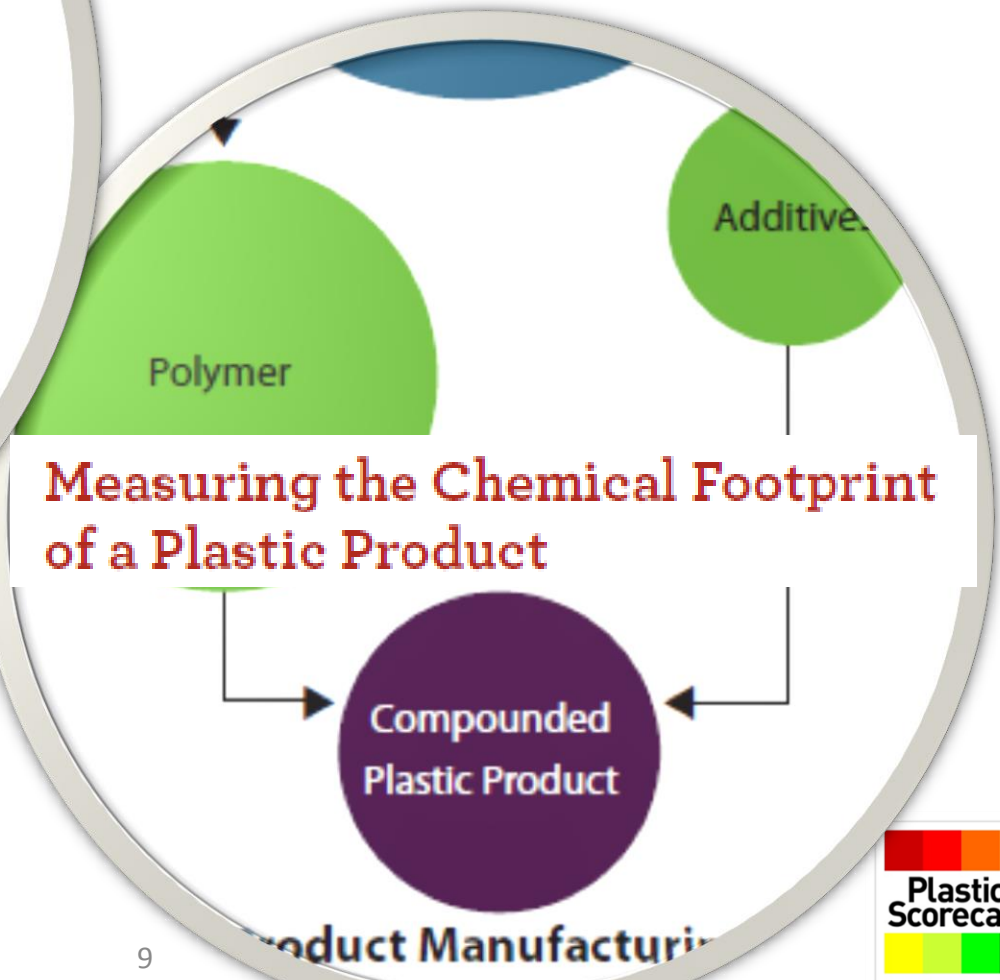


Progress to Safer Chemicals in Polymer Manufacturing

Polymer Manufacturing



Measuring the Chemical Footprint of a Plastic Product



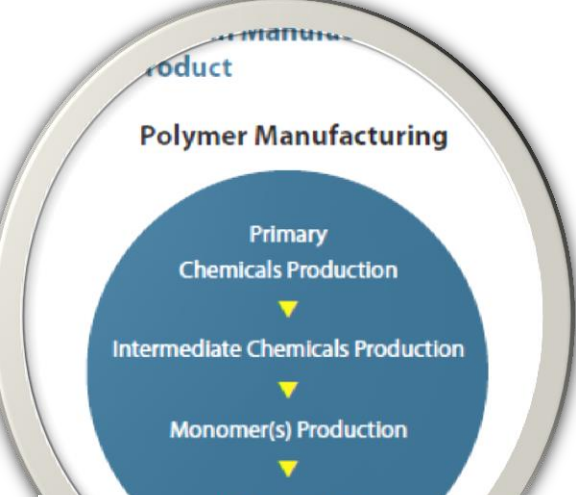


TABLE 5 Plastics Scorecard Progress to Safer Chemicals in Polymer Manufacturing

Polymer	Polymer Manufacturing: Progress to Safer Chemicals Score			
	Primary Chemicals	Intermediate Chemicals	Monomer(s)	Total Manufacturing
Best Case Polymer	33.33	33.33	33.33	100.00

TABLE 5 **Plastics Scorecard: Progress to Safer Chemicals in Polymer Manufacturing**

Polymer	Polymer Manufacturing: Progress to Safer Chemicals Score			
	Primary Chemicals	Intermediate Chemicals	Monomer(s)	Total Manufacturing
Best Case Polymer	33.33	33.33	33.33	100.00
Polystyrene (PS)	0.00	0.00	0.00	0.00
Polyvinyl Chloride (PVC)	0.00	0.00	0.00	0.00

Polymers and Hazard Rankings of their Primary Chemicals, Intermediate Chemicals, and Monomers

	Chlorine (7782-50-5)	Acetone (67-64-1)	p-tert-butyl...
		Phenol (108-95-2)	(98-54-4)
ethylene (PE)	Ethylene(74-85-1)	Ethylene(74-85-1)	Ethylene(74-85-1)
ethylene Terephthalate (PET)—Terephthalic Acid (TPA) Route	para-Xylene (106-42-3)	Ethylene Glycol* (107-21-1)	Bis-(2-hydroxyethyl)-terephthalate* (BHET) (959-26-2)
	Methanol (67-56-1)	Acetic Acid* (64-19-7)	
		Terephthalic Acid* (TPA) (100-21-0)	
Polylactic Acid (PLA)	Glucose* (50-99-7)	Lactic Acid* (50-21-5)	Lactide* (L-lactide - 4511-42-6; DL-lactide - 615-95-2)
Polypropylene (PP)	Propylene* (115-07-1)	Propylene* (115-07-1)	Propylene* (115-07-1)
Polystyrene (PS)	Ethylene (74-85-1)	Ethylbenzene (100-41-4)	Styrene (100-42-5)
	Benzene(71-43-2)		
Vinyl Chloride (PVC)	Ethylene (74-85-1)	Ethylene Dichloride (EDC) (107-06-2)	Vinyl Chloride Mono... (75-01-4)
	Chlorine (7782-50-5)		
butadiene Rubber (SBR)	Ethylene (74-85-1)	Ethylbenzene (100-41-4)	1,3-Butadiene (7...
	Benzene (71-43-2)		Styrene (100-42-5)

mark List Translator 1 or GreenScreen®

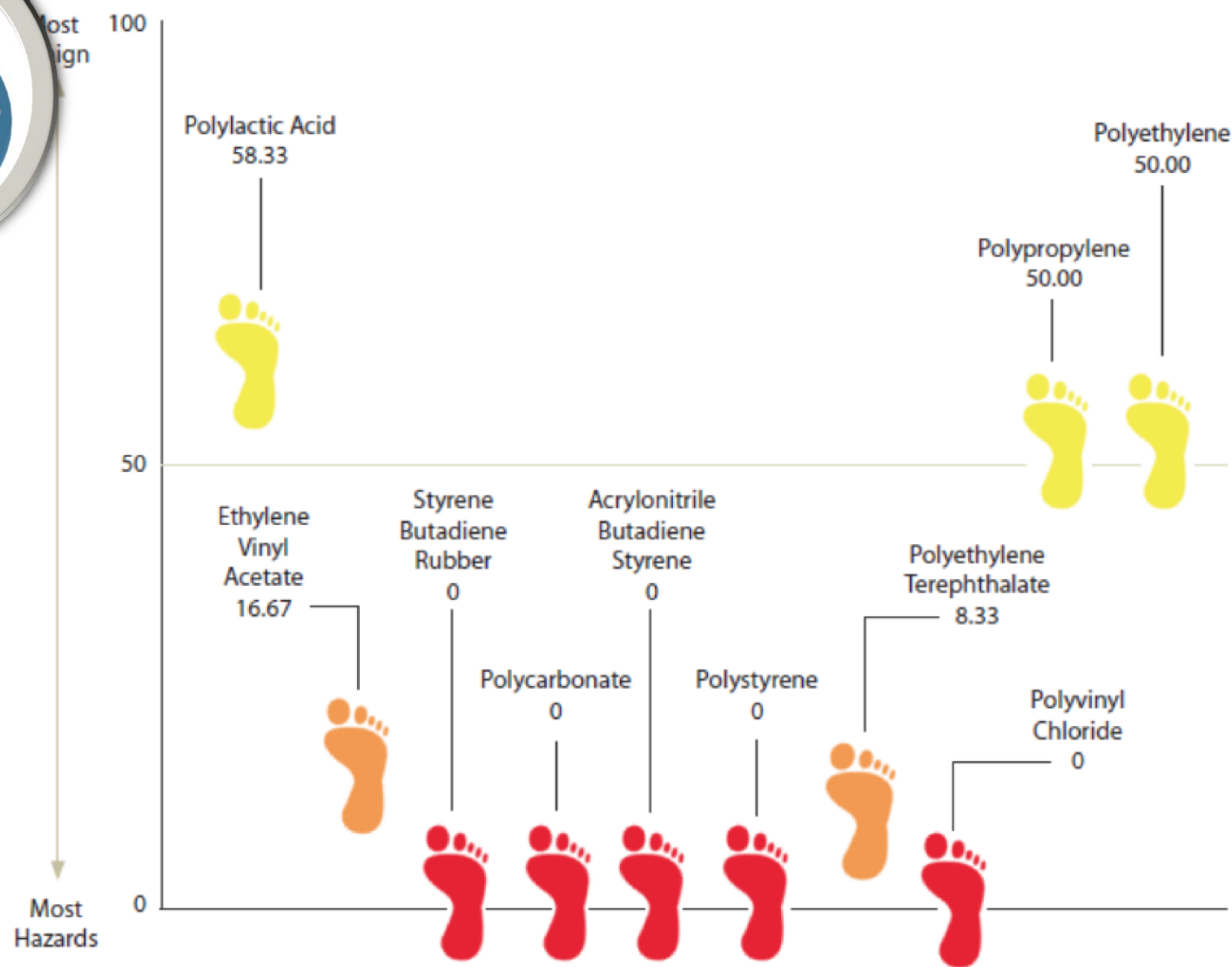
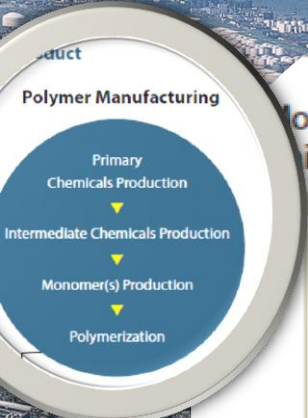
Verified GreenScreen® Benchmark 3

Actual GreenScreen® assessment with determination of GreenScreen® Benchmark Score of U - unspecified.

* = verified GreenScreen® assessment

data that defines the chemical
mark List Translator 1 or GreenScreen®

FIGURE 6 Progress to Safer Chemicals in Polymer Manufacturing



Most Hazards

Less Production

More Production

Measuring the Chemical Footprint of a Plastic Product





Measuring the Chemical Footprint of a Plastic Product

TABLE 6 Plastic Intravenous (IV) Bag

Estimated Chemical Footprint of Polyvinyl Chloride (PVC)
Phthalate (DEHP)

Functional Use: Chemical Ingredients	Weight (%)
Polymer: PVC ¹	68.80%
Plasticizer: DEHP ²	30.00%
Antioxidants: including Bisphenol A (BPA) ³	0.50%
Heat stabilizers ⁴	0.50%
Lubricants ⁵	0.10%
Slip Agents ⁶	0.10%
Monomers and oligomers—residual: vinyl chloride monomer (VCM) ⁷	0.0001%
Solvent—residual ⁸	unknown
Catalyst—residual	unknown
Total	100.00%

FIGURE ES-2 Estimated Chemical Footprint of IV Bags Made from PVC/DEHP and Polyolefins



3



PVC



0



Polyolefins

Number of
Chemicals of High
Concern

Chemicals of
High Concern
by Weight

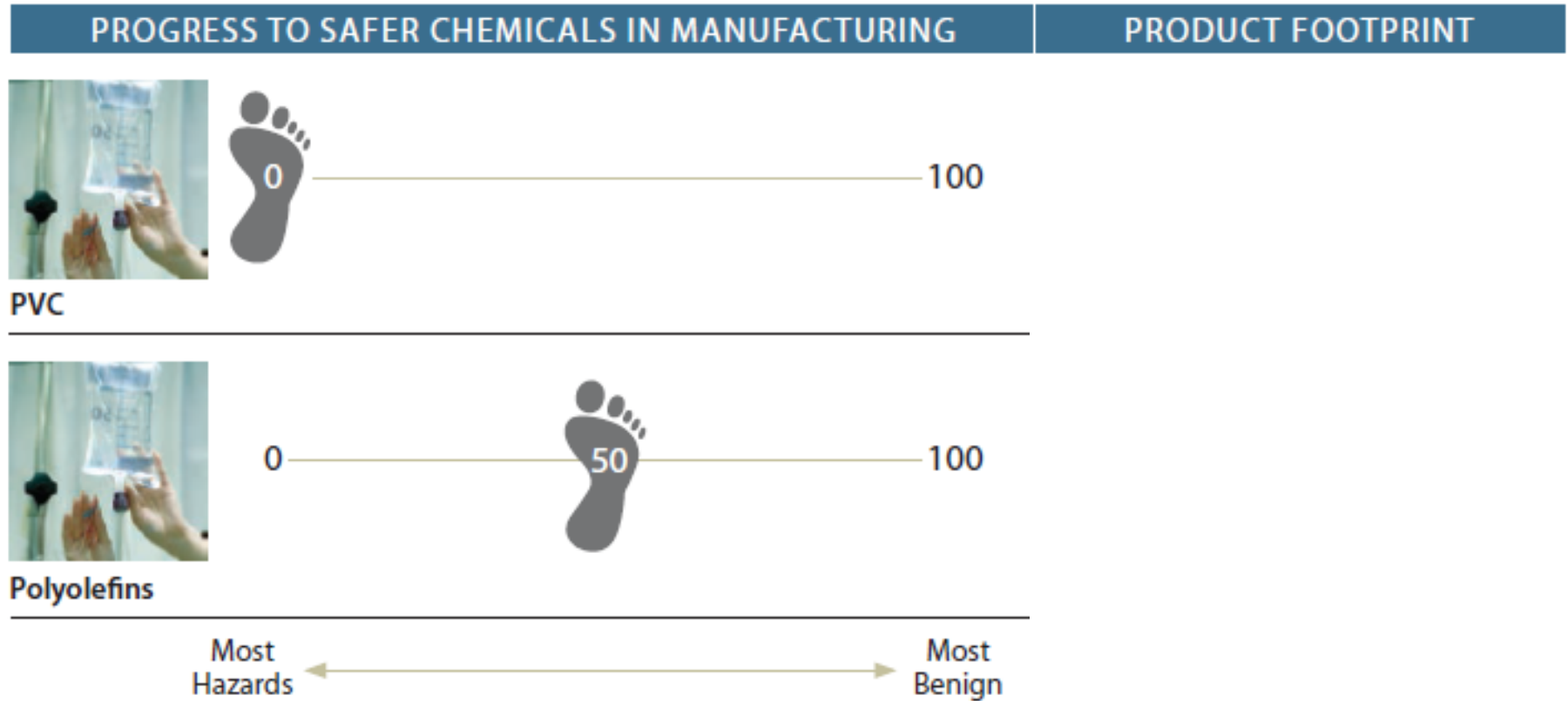
PVC = Polyvinyl chloride; DEHP = di(2-ethylhexyl) phthalate

FIGURE 7 Chemical Footprint of IV Bags Made from PVC/DEHP & Polyolefins

PROGRESS TO SAFER CHEMICALS IN MANUFACTURING

PRODUCT FOOTPRINT

FIGURE 7 Chemical Footprint of IV Bags Made from PVC/DEHP & Polyolefins



PVC = Polyvinyl chloride; DEHP = di(2-ethylhexyl) phthalate

FIGURE 7 Chemical Footprint of IV Bags Made from PVC/DEHP & Polyolefins

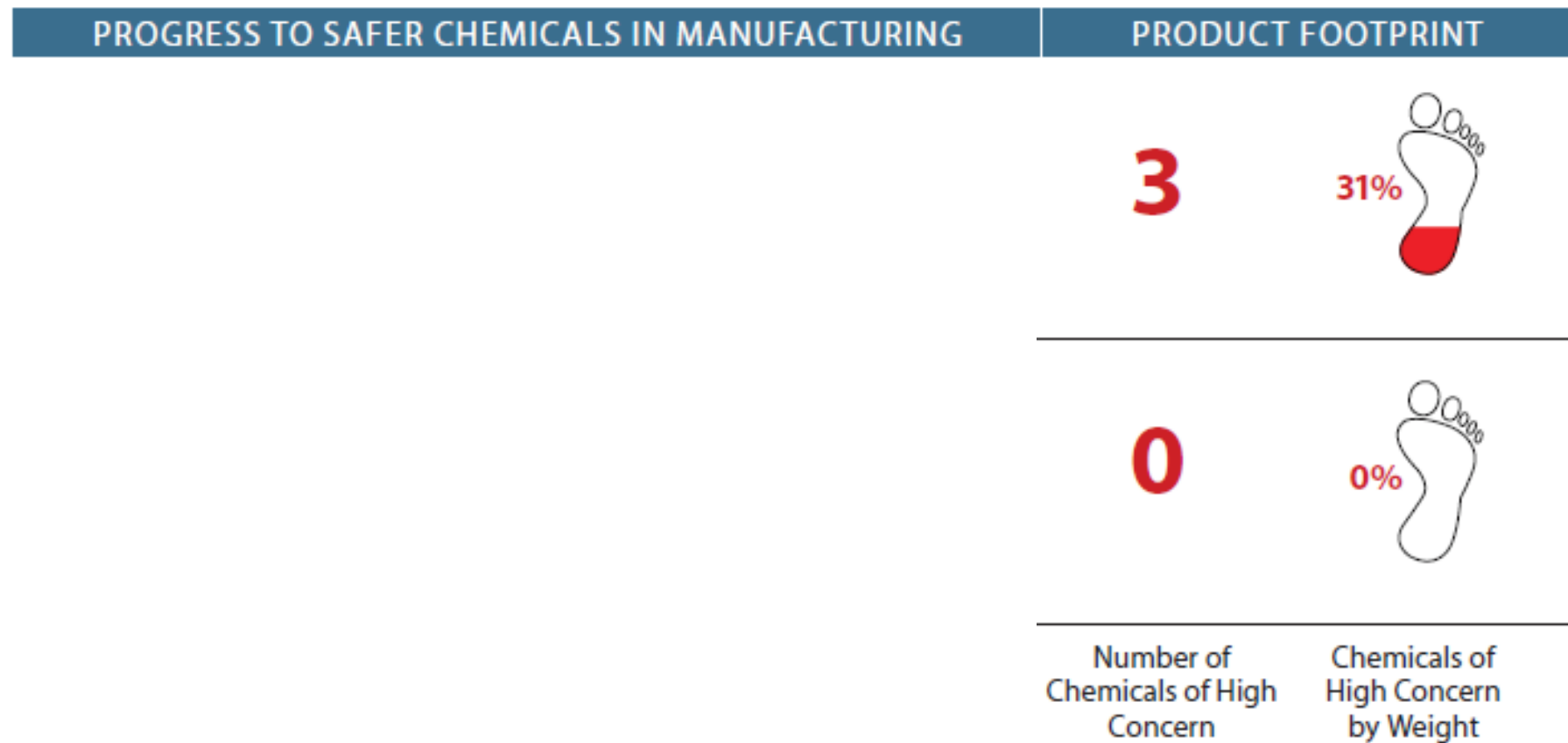
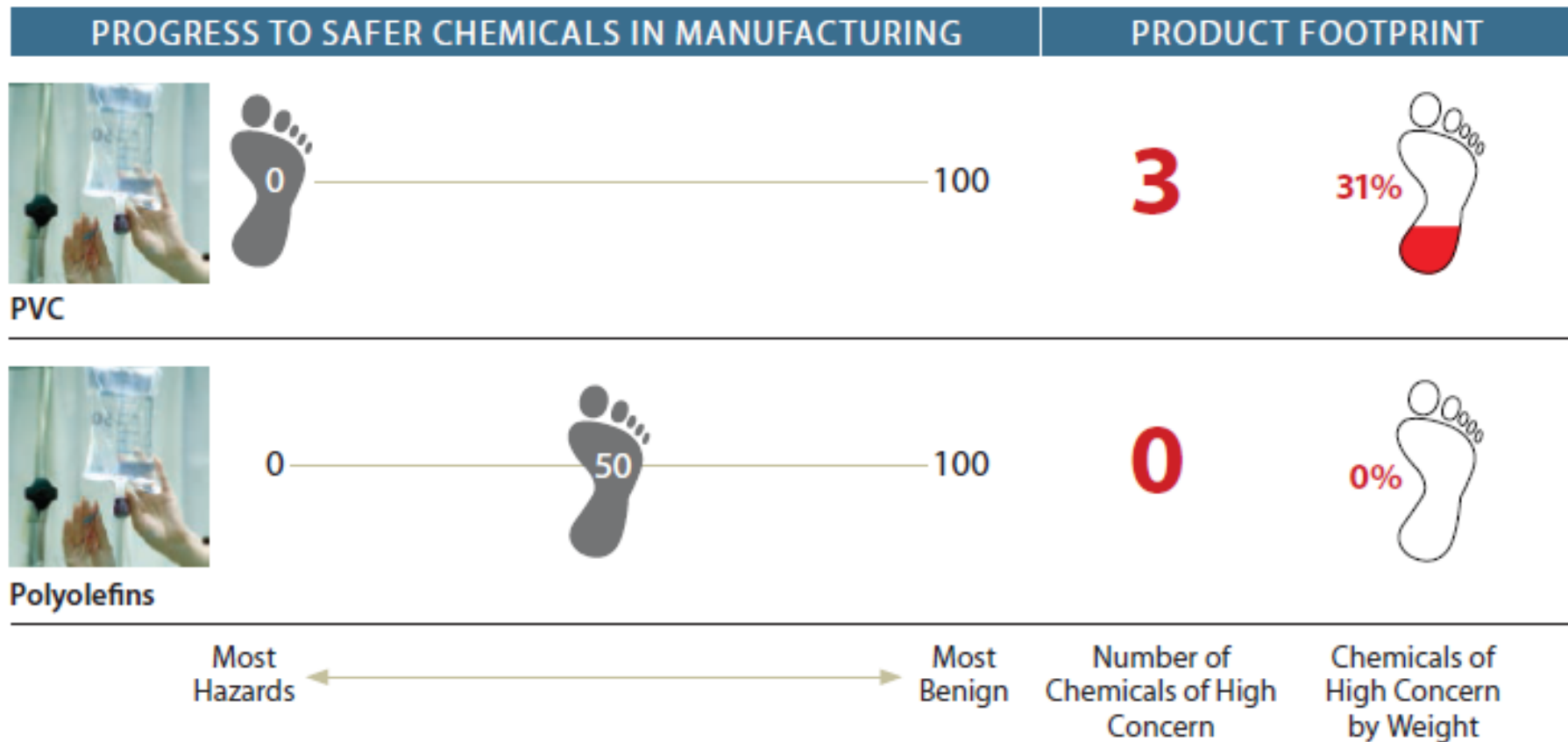
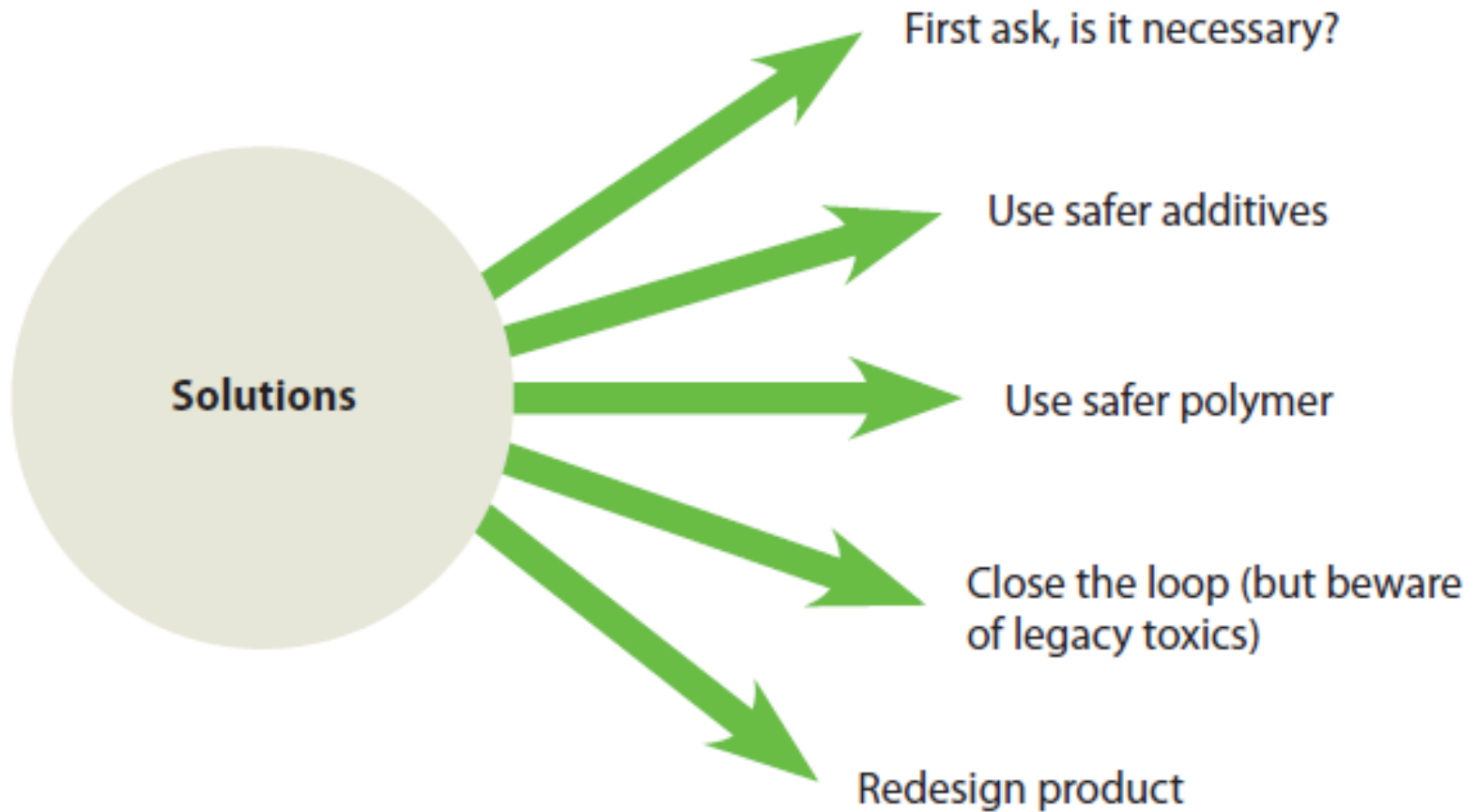


FIGURE 7 Chemical Footprint of IV Bags Made from PVC/DEHP & Polyolefins



PVC = Polyvinyl chloride; DEHP = di(2-ethylhexyl) phthalate

FIGURE 9 Solutions to Reducing Chemical Footprint of Plastics



Is it Necessary?



Lynne Peeples [Become a fan](#)
lynne.peeples@huffingtonpost.com

[Follow](#) [Like](#) 1.6k

Kaiser Permanente Pledges To Stop Buying Flame-Retardant Furniture

Posted: 06/03/2014 7:50 pm EDT | Updated: 06/03/2014 7:59 pm EDT



Use Safer Additives

FIGURE ES-3 Estimated Chemical Footprint of Electronic Enclosures Made from HIPS with DecaBDE & PC/ABS with RDP



5



HIPS with Deca BDE



5

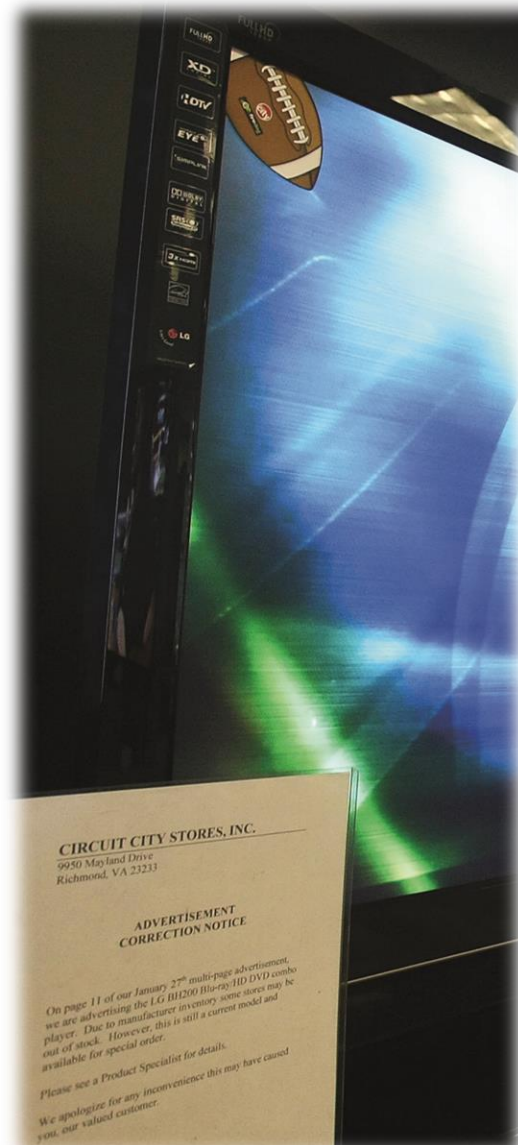


PC/ABS with RDP

Number of
Chemicals of High
Concern

Chemicals of
High Concern
by Weight

ABS = Acrylonitrile Butadiene Styrene; DecaBDE = Decabromodiphenyl Ether; PC = Polycarbonate; RDP = Resorcinol Diphenylphosphate



CIRCUIT CITY STORES, INC.
9950 Mayland Drive
Richmond, VA 23233

ADVERTISEMENT
CORRECTION NOTICE

On page 11 of our January 27th multi-page advertisement, we are advertising the LG BH200 Blu-ray/DVD combo player. Due to manufacturer inventory store stores may be out of stock. However, this is still a current model and available for special order.

Please see a Product Specialist for details. We apologize for any inconvenience this may have caused you, our valued customer.

Use Safer Polymer

PROGRESS TO SAFER CHEMICALS IN MANUFACTURING



PVC



100



Polyolefins



0

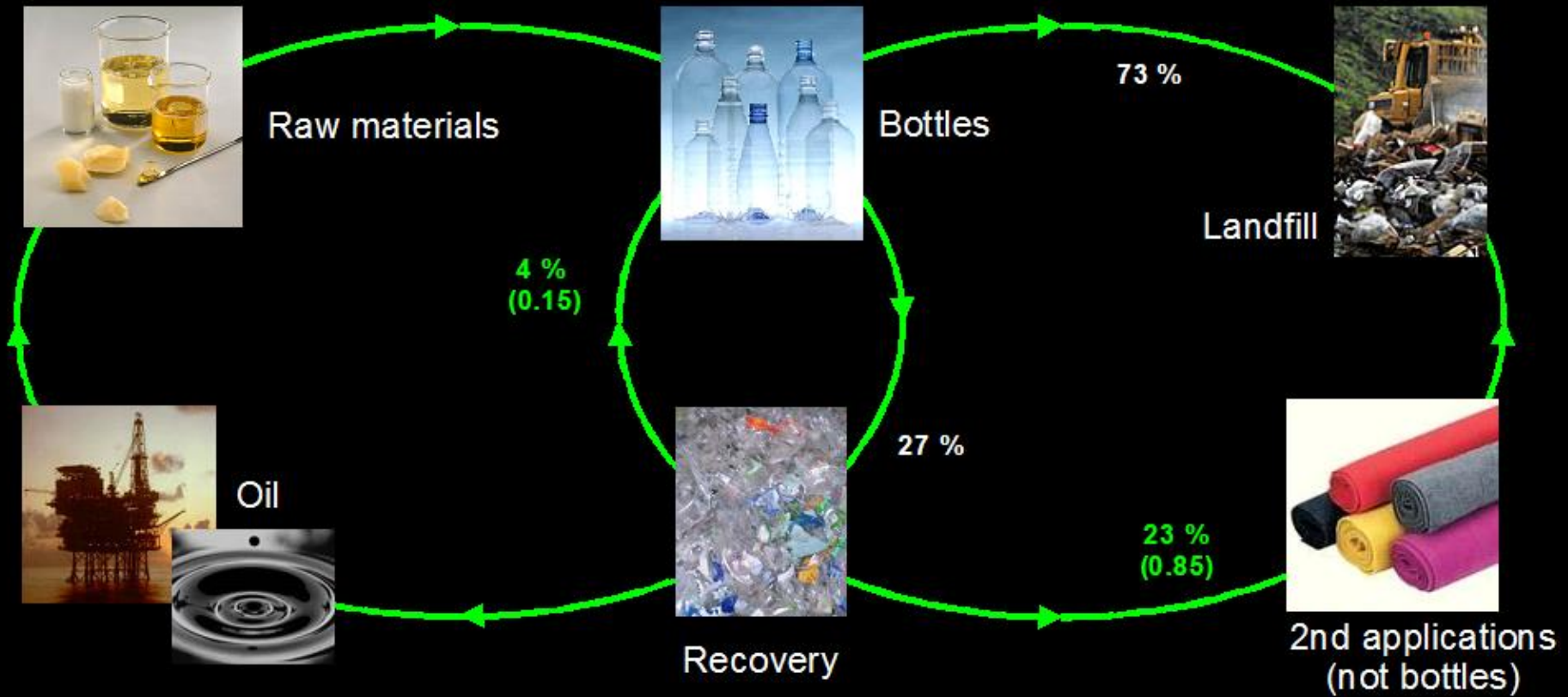
100

Most Hazards

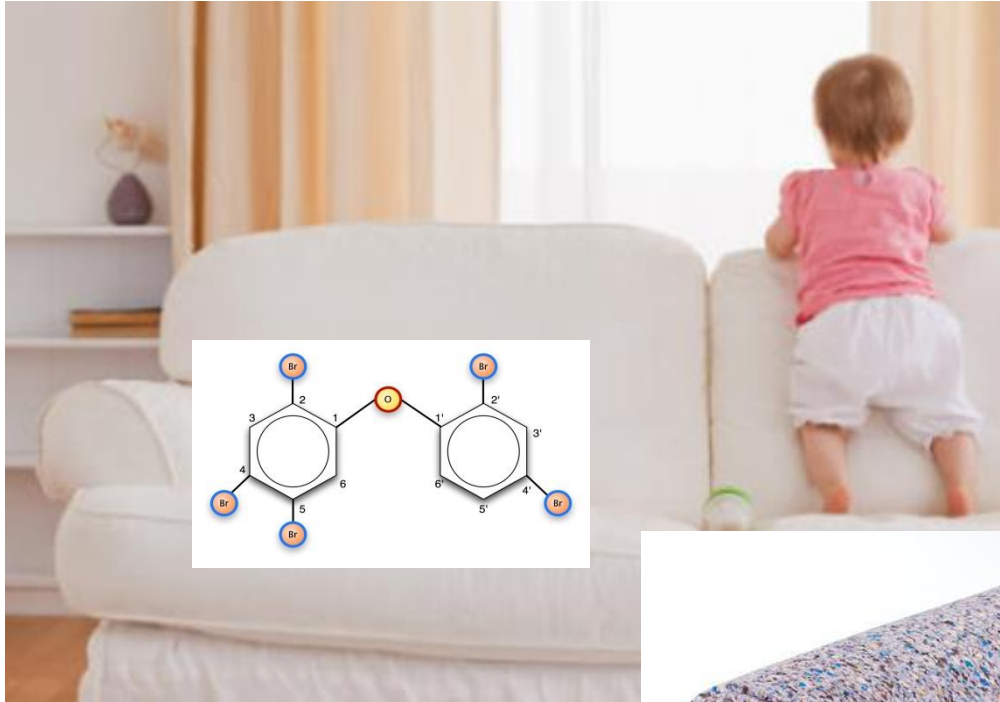
Most Benign

PVC = Polyvinyl chloride; DEHP = di(2-ethylhexyl) phthalate

Close the Loop



Close the Loop (beware of toxics legacy)



Re-design Product



Reducing Chemical Footprint of Plastics

- Know the chemical constituents in a compounded plastic product
- Know whether chemicals of high concern (CoHCs) are used in manufacturing or contained in final product
- Prioritize CoHCs for avoidance or substitution
- Select safer alternatives
- Continuous improvement—reducing the number and volume of CoHCs over time



Evaluating
the Chemical
Footprint
of Plastics



www.bizngo.org/sustainable-materials/plastics-scorecard