



**Evaluating  
the Chemical  
Footprint  
of Plastics**



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

**July 1, 2014**



## Executive Summary



## Chapter 1: Introduction



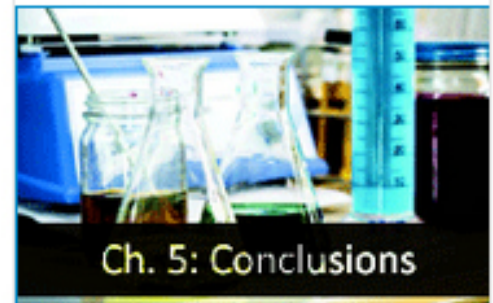
## Ch. 2: Why Plastics



## 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 #	Adverse Health Effects / Key CoHC	Key Use
Acrylonitrile / 26252-2-5	Respiratory irritation/asthma; Neurotoxic; Reproductive toxicity	Common Occupational Health Concerns: MSDs
Acrylonitrile/Butadiene / 26252-2-5	Respiratory irritation/asthma; Neurotoxic; Reproductive toxicity	Chemical Hazards in the State of California or Significant Use: Toys, Kids Drinking Water and Baby Bottles; Medical / Life-Critical; High Use
1,4-Dioxane / 101-07-0	MSD: Group 2 Carcinogen; Reproductive Toxicity; Acute organ toxicity, MSDs; Occupational health hazard	California Prop 65: International Agency for Research on Cancer (IARC) Group 2B (Possible Carcinogen); Reproductive toxicity for Occupational Safety and Health

## 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 determine the hazard levels of chemicals in the Plastics Footprint. The GreenScreen® is a chemical based assessment tool developed by Clean Production Action. The GreenScreen® also uses the hazard levels to the public to allow decisions, with each hazard level setting a progressively safer chemical.

**GreenScreen®** for Safer Chemicals

**GreenScreen®** and Assessment of Eight Chemicals Used to Manufacture Polymers

The GreenScreen® for Safer Chemicals was used to assess and determine the hazard levels of chemicals in the Plastics Footprint. The GreenScreen® is a chemical based assessment tool developed by Clean Production Action. The GreenScreen® also uses the hazard levels to the public to allow decisions, with each hazard level setting a progressively safer chemical.

**GreenScreen®** for Safer Chemicals

## App. 2: GreenScreens

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

Polymer	Primary Chemicals (CAS #)	Intermediates (CAS #)	Monomers (CAS #)
Acrylonitrile Butadiene Styrene (ABS)	Acrylonitrile (26252-2-5)	Styrene (100-42-5)	Acrylonitrile (26252-2-5)
High Density Polyethylene (HDPE)	Ethylene (74-84-4)	None	None
Low Density Polyethylene (LDPE)	Ethylene (74-84-4)	None	None
Polycarbonate (PC)	None	None	None
Polystyrene (PS)	Styrene (100-42-5)	None	Styrene (100-42-5)
Polypropylene (PP)	Propylene (114-50-4)	None	Propylene (114-50-4)

## App. 3: Chemical Hazards

**FIGURE 1**  
**Chemicals at the Core of Systems Change**

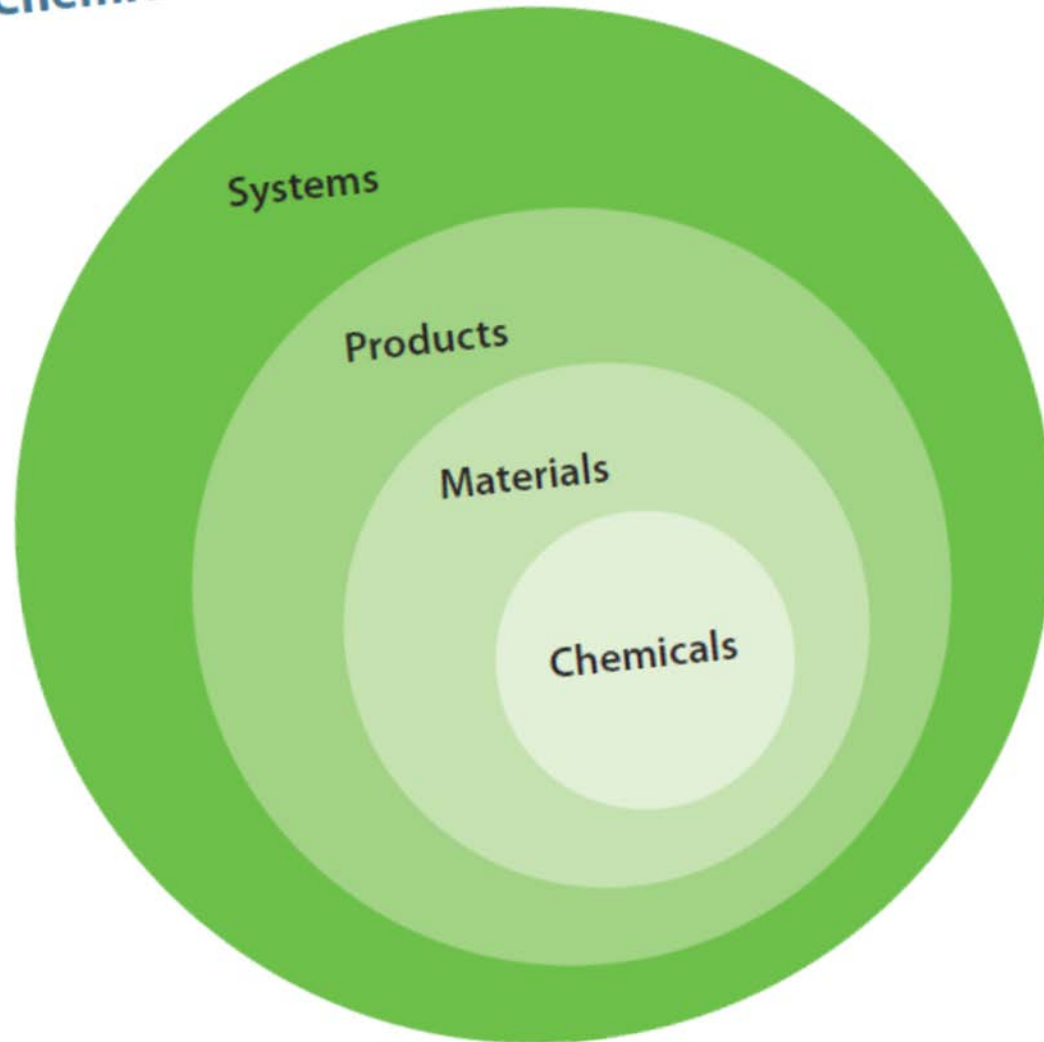
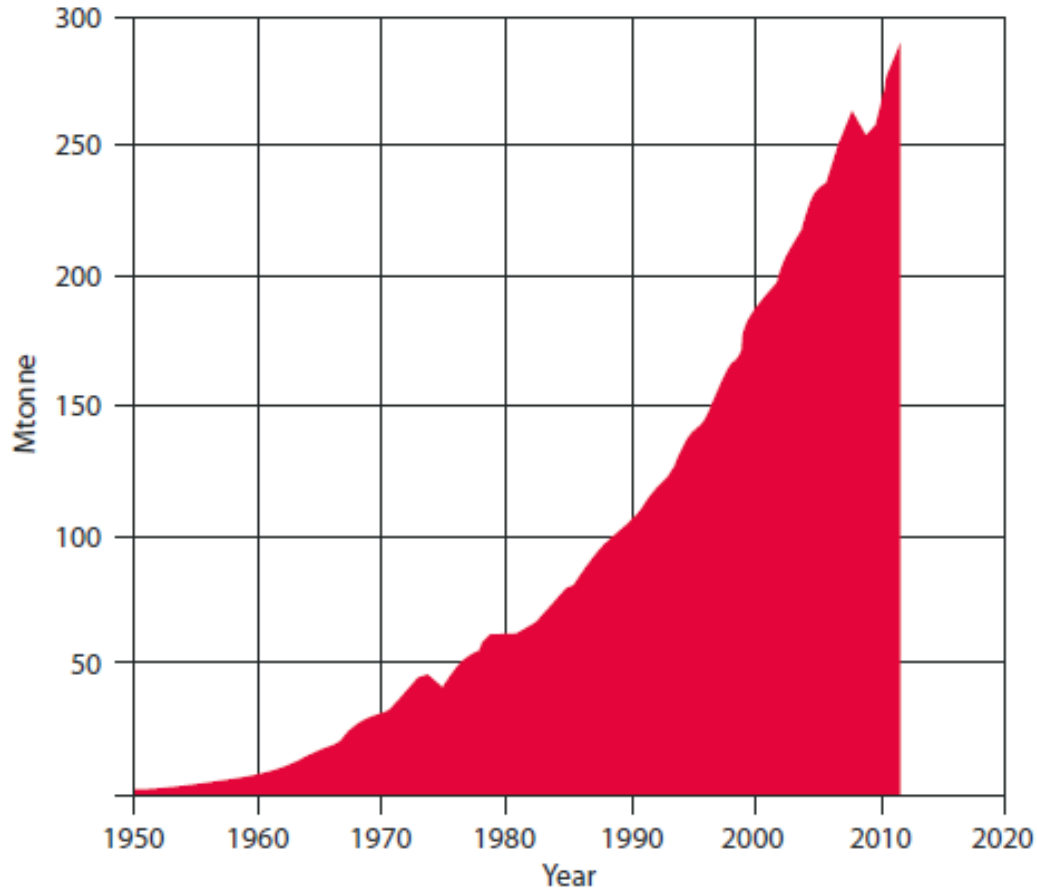


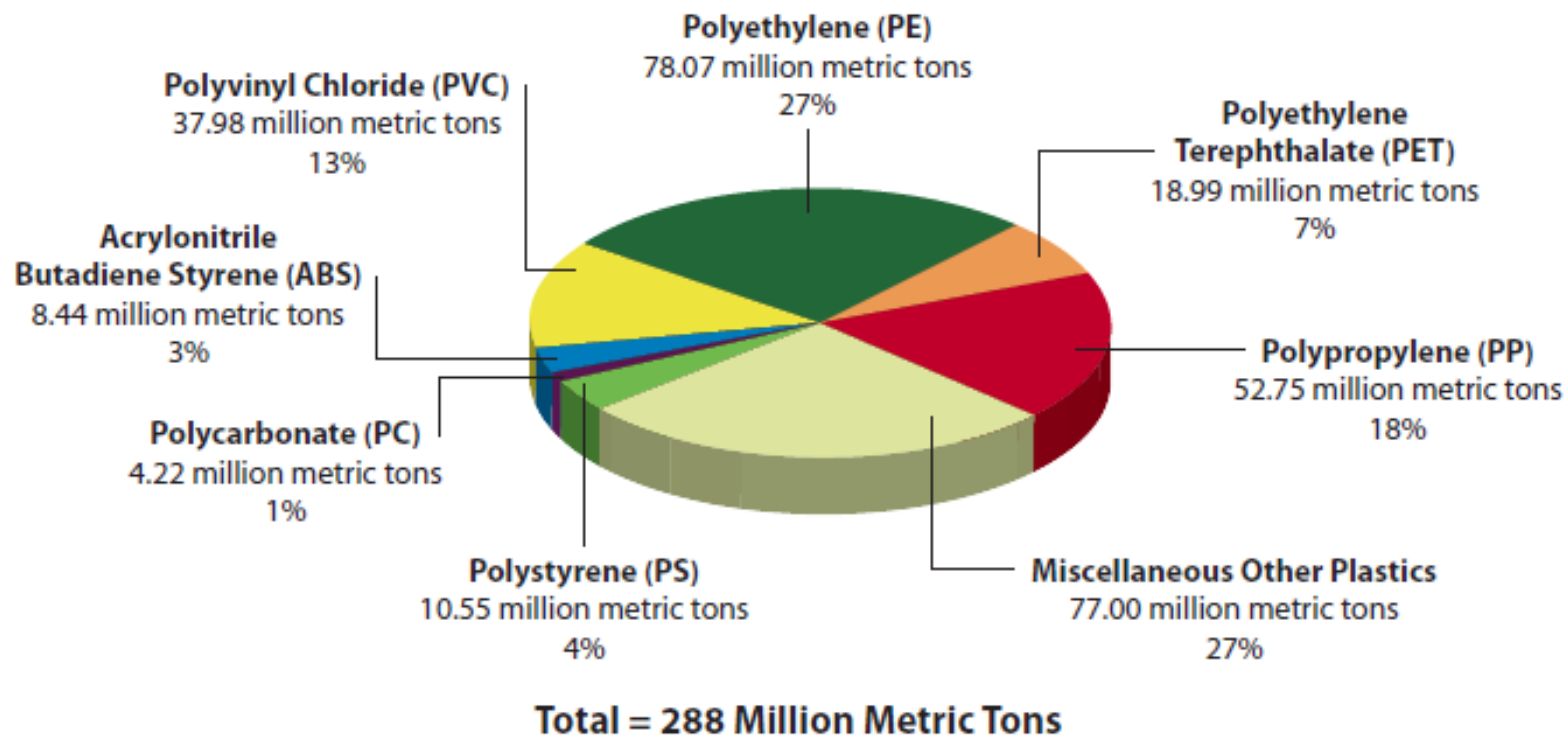
FIGURE 2 World Plastics Production 1950–2012



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

<sup>a</sup>Chemicals 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.

<sup>c</sup>Source: 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).***



PRACTICE  
Greenhealth™

*Standardized Environmental  
Questions for Medical Products*

Chemicals of Concern

PVC

Phthalates

Halogenated Organic Flame Retardants

Carcinogens/Reproductive Toxicants

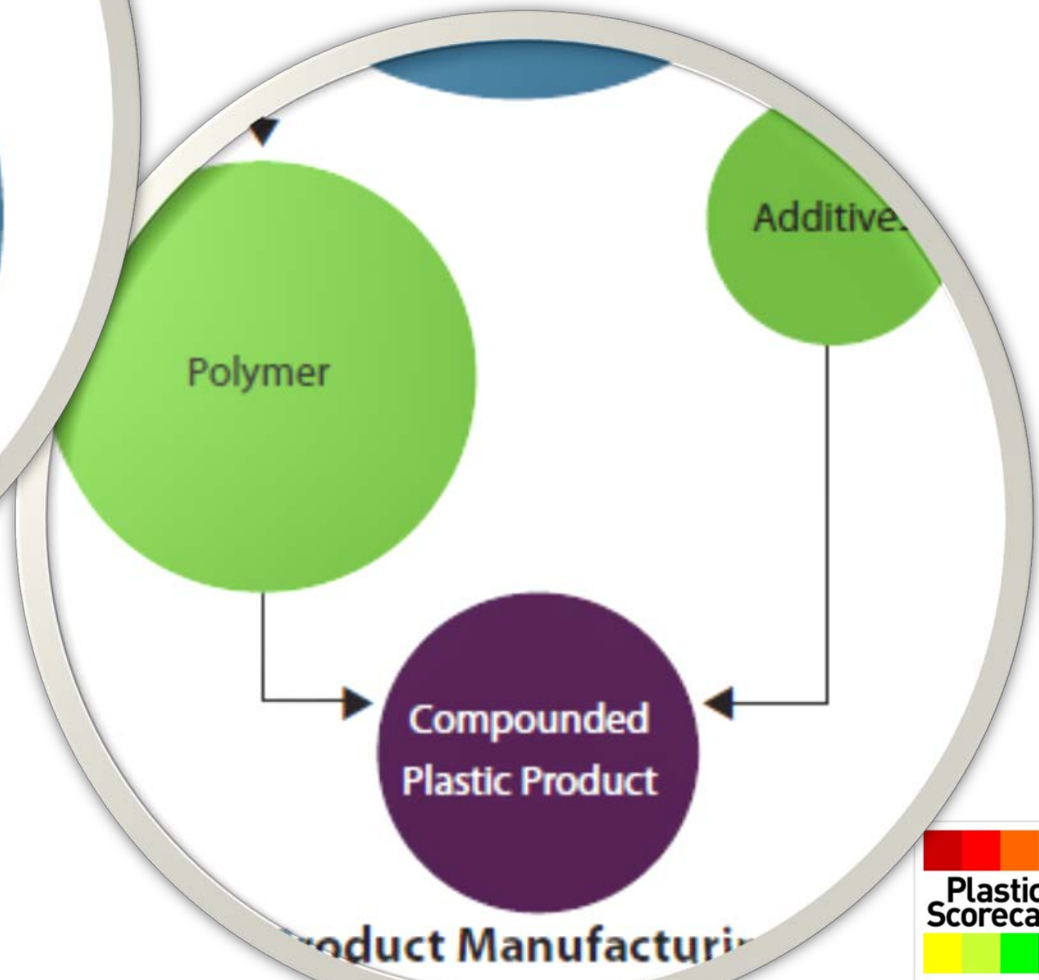
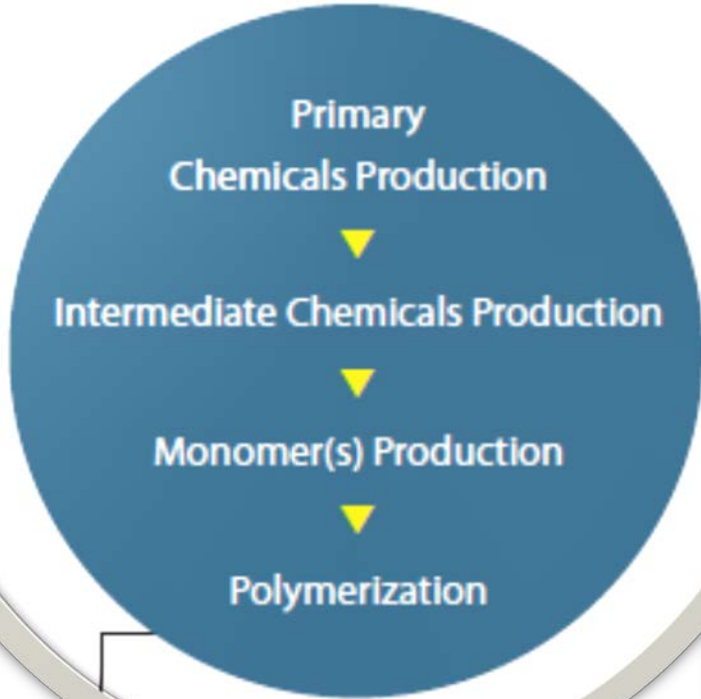
**DEHP/PVC Reduction:**  
Eliminate DEHP/  
PVC from at least one  
product line\*.

B

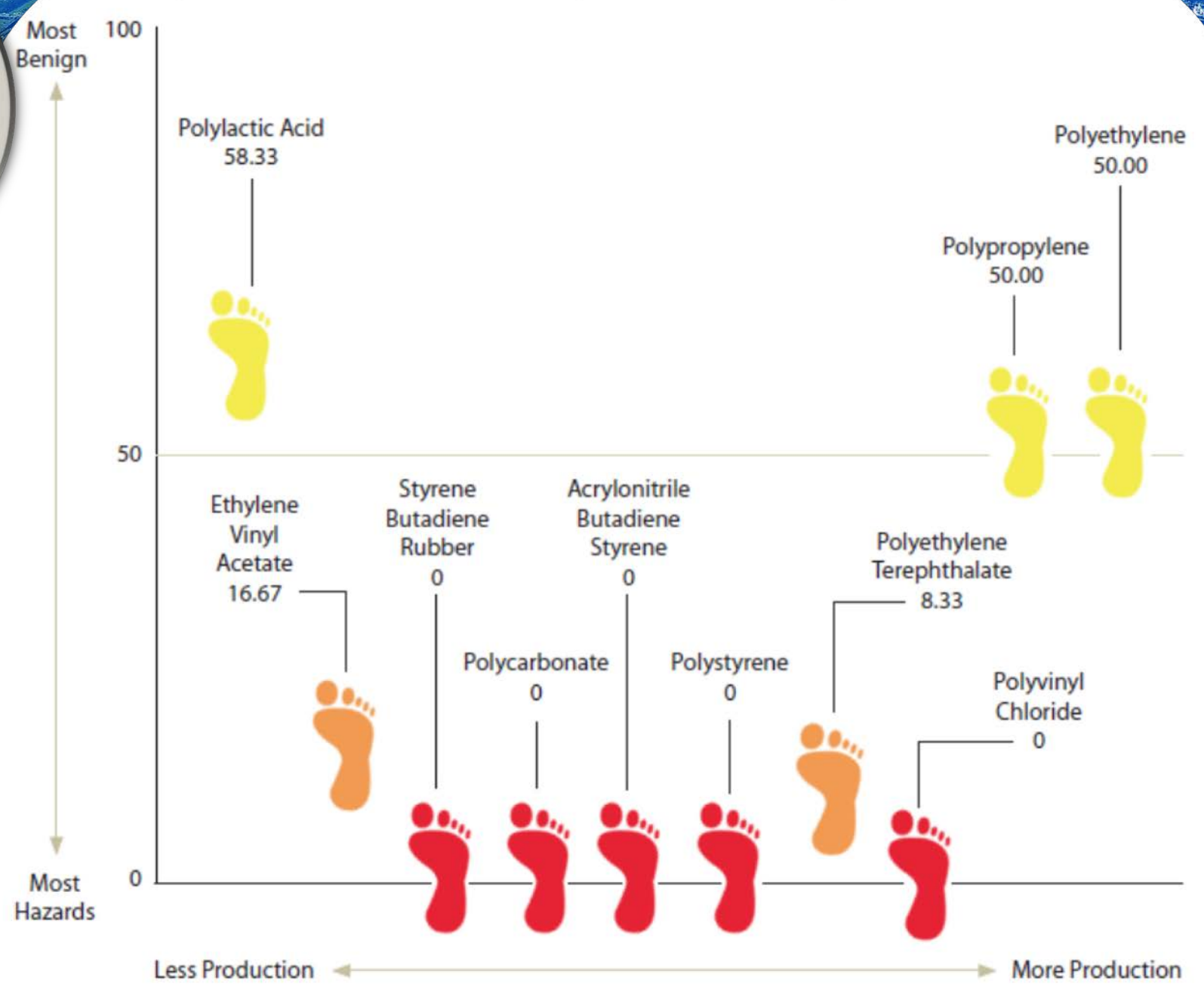
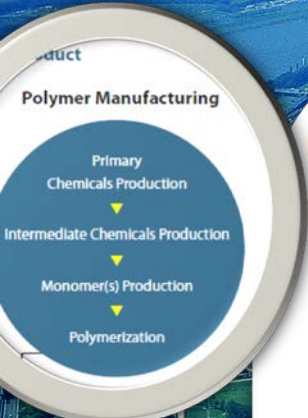


in Manufacture  
Product

## Polymer Manufacturing



# FIGURE 6 Progress to Safer Chemicals in Polymer Manufacturing



■ For each manufacturing step, no core chemical inputs are chemicals of high concern.
 ■ Every manufacturing step involves the use of chemicals of high concern.

	Benzene (71-43-2)	Cumene (98-06-2)	
		Sulfuric Acid (7664-93-9)	
	Propylene (115-07-1)	Phosgene (75-44-5)	
	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 (7

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



PVC

3

31%



Polyolefins

0

0%

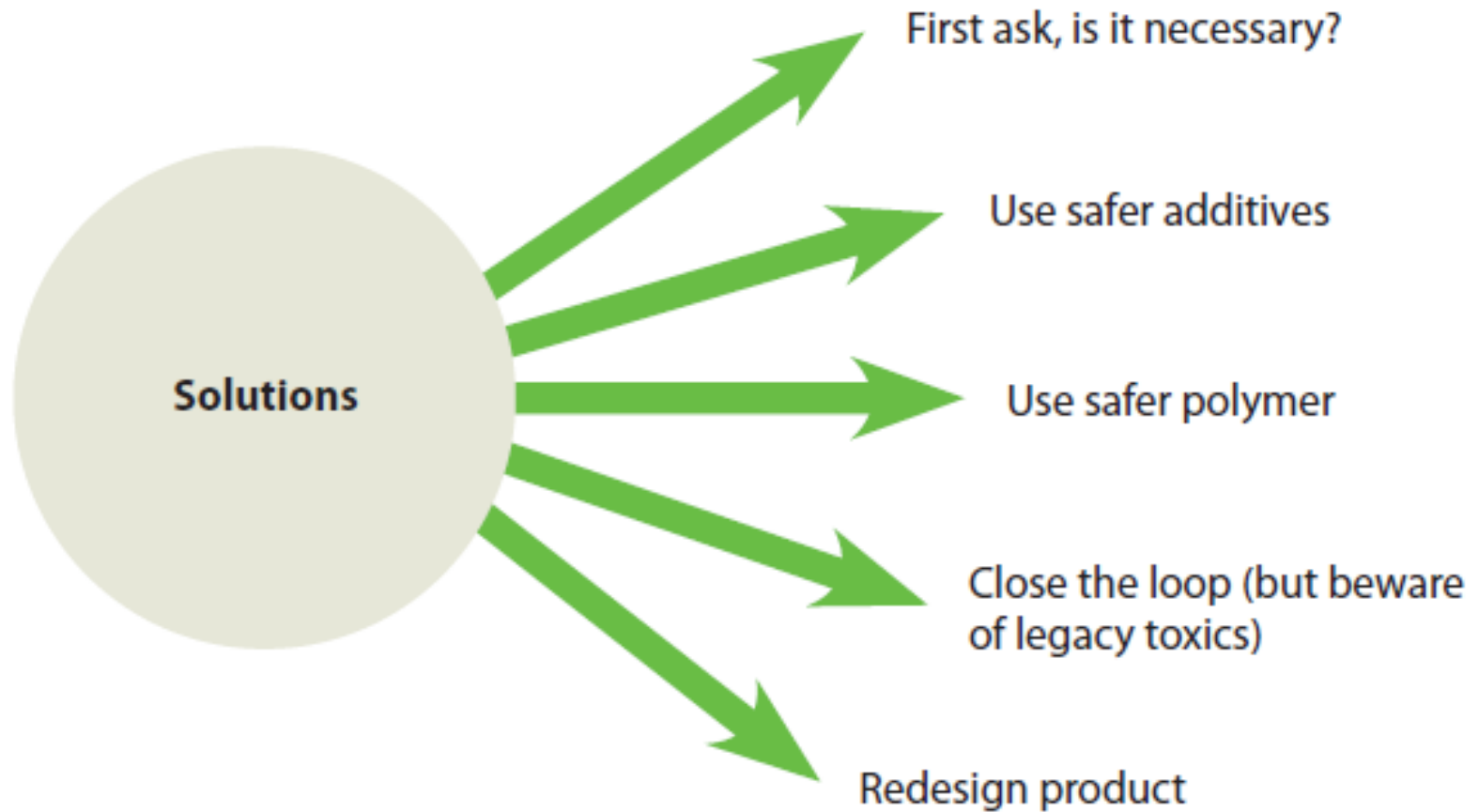


Number of  
Chemicals of High  
Concern

Chemicals of  
High Concern  
by Weight

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 23231

ADVERTISEMENT CORRECTION NOTICE

On page 11 of our January 27th multi-page advertisement we are advertising the LG H0200 Player. HD DVD combo player. Due to manufacturer inventory, more items 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



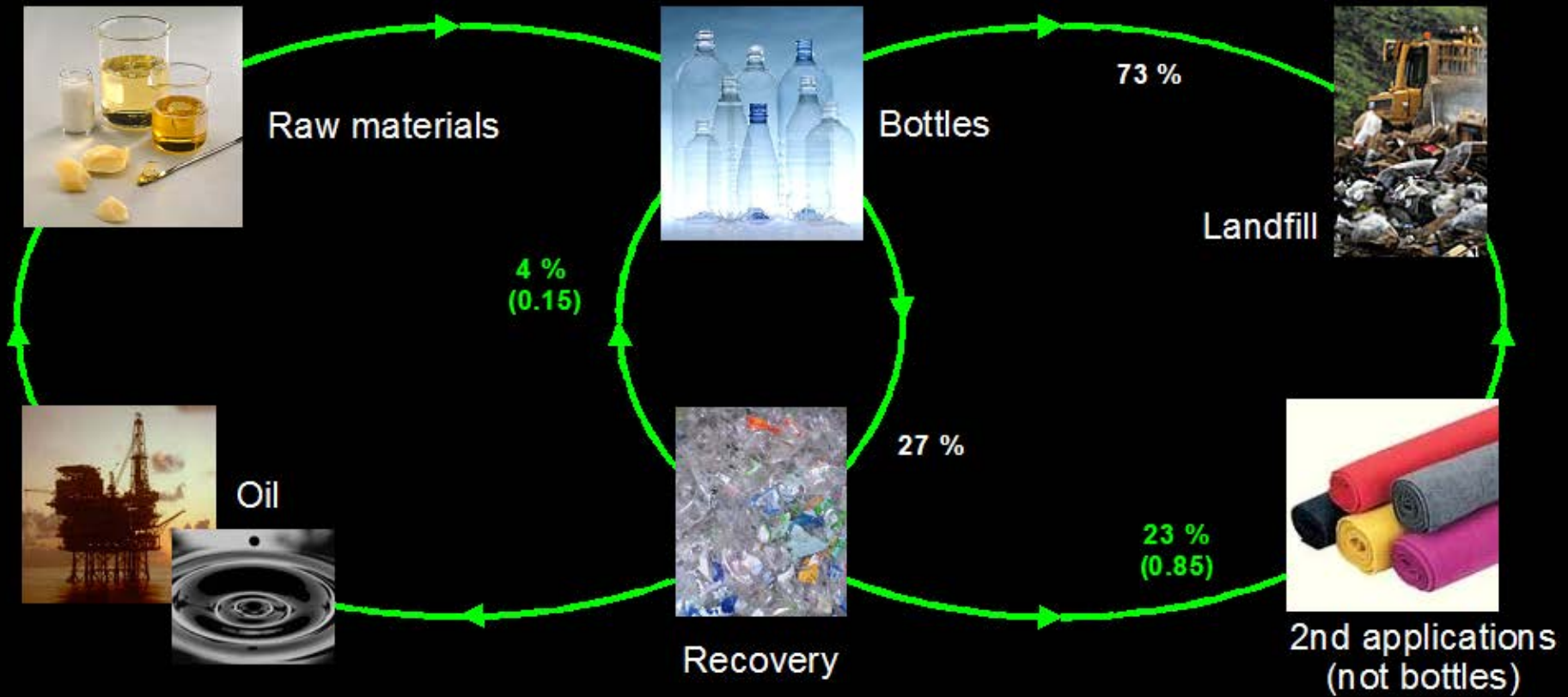
100

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](http://www.bizngo.org/sustainable-materials/plastics-scorecard)