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July 1, 2014
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)

Polyethylene (PE)  
78.07 million metric tons  
27%

Polyvinyl Chloride (PVC)  
37.98 million metric tons  
13%

Acrylonitrile Butadiene Styrene (ABS)  
8.44 million metric tons  
3%

Polycarbonate (PC)  
4.22 million metric tons  
1%

Polystyrene (PS)  
10.55 million metric tons  
4%

Polyethylene Terephthalate (PET)  
18.99 million metric tons  
7%

Polypropylene (PP)  
52.75 million metric tons  
18%

Miscellaneous Other Plastics  
77.00 million metric tons  
27%

Total = 288 Million Metric Tons

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

*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.

\(^a\): Chemical Economics Handbook articles (c), (d), (e), (f), (g), (i), (m), (n), (o), (p), (q), (s), (t).

\(^b\): Chemicals in parenthetical form with a letter (e.g., ABS, PS) indicate that they are part of a specific chemical family or type.

\(^c\): Chemicals in parenthetical form with a letter (e.g., PC, epoxy resins) indicate that they are part of a specific chemical family or type.

\(^d\): Chemicals in parenthetical form with a letter (e.g., PC) indicate that they are part of a specific chemical family or type.

PLA = Polylactic Acid
SAN = Styrene Acrylonitrile
SBR = Styrene Butadiene Rubber
PP = Polypropylene
PS = Polystyrene
PVC = Polyvinyl Chloride
“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
Polymer Manufacturing

- Primary
  - Chemicals Production
  - Intermediate Chemicals Production
  - Monomer(s) Production
  - Polymerization

- Additives
  - Polymer
  - Compounded Plastic Product

Product Manufacturing
Progress to Safer Chemicals in Polymer Manufacturing

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

1. Primary Chemicals Production
2. Intermediate Chemicals Production
3. Monomer(s) Production
4. Polymerization

- Polylactic Acid 58.33
- Ethylene Vinyl Acetate 16.67
- Styrene Butadiene Rubber 0
- Acrylonitrile Butadiene Styrene 0
- Polycarbonate 0
- Polystyrene 0
- Polyethylene Terephthalate 8.33
- Polyethylene Chloride 0
- Polyethylene 50.00
- Polypropylene 50.00
- Polyvinyl Chloride 0

Most Benign
Most Hazard
Less Production
More Production
<table>
<thead>
<tr>
<th>Chemical</th>
<th>CAS Number</th>
<th>Chemical</th>
<th>CAS Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene (71-43-2)</td>
<td></td>
<td>Cumene (96-45-8)</td>
<td></td>
</tr>
<tr>
<td>Propylene (115-07-1)</td>
<td></td>
<td>Sulfuric Acid (7664-93-9)</td>
<td></td>
</tr>
<tr>
<td>Chlorine (7782-50-5)</td>
<td></td>
<td>Phosgene (75-44-5)</td>
<td></td>
</tr>
<tr>
<td>Acetone (67-64-1)</td>
<td></td>
<td>Phenol (108-95-2)</td>
<td></td>
</tr>
<tr>
<td>Ethylene (74-85-1)</td>
<td></td>
<td>p-tert-butylbenzene (98-54-4)</td>
<td></td>
</tr>
<tr>
<td>Ethylene Glycol* (107-21-1)</td>
<td></td>
<td>Bis-(2-hydroxyethyl)terephthalate* (BHET) (959-26-2)</td>
<td></td>
</tr>
<tr>
<td>Methanol (67-56-1)</td>
<td></td>
<td>Acetic Acid* (64-19-7)</td>
<td></td>
</tr>
<tr>
<td>Terephthalic Acid* (TPA) (100-21-0)</td>
<td></td>
<td>Lactic Acid* (50-21-5)</td>
<td></td>
</tr>
<tr>
<td>Glucose* (50-99-7)</td>
<td></td>
<td>Lactide* (L-lactide - 4511-42-6; D-lactide - 615-95-2)</td>
<td></td>
</tr>
<tr>
<td>Polylactic Acid (PLA)</td>
<td></td>
<td>Propylene* (115-07-1)</td>
<td></td>
</tr>
<tr>
<td>Polystyrene (PS)</td>
<td>Ethylene (74-85-1)</td>
<td>Ethylbenzene (100-41-4)</td>
<td>Styrene (100-42-5)</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>Benzene (71-43-2)</td>
<td>Ethylene Dichloride (EDC) (107-06-2)</td>
<td>Vinyl Chloride Monomer (75-01-4)</td>
</tr>
<tr>
<td>Chlorine (7782-50-5)</td>
<td>Ethylene (74-85-1)</td>
<td>Ethylbenzene (100-41-4)</td>
<td>1,3-Butadiene (106-99-0)</td>
</tr>
</tbody>
</table>

* = verified GreenScreen* assessment

**Legend:**
- ❘ Verified GreenScreen* Benchmark 3
- □ Actual GreenScreen* assessment with determination of GreenScreen* Benchmark Score of U - unspecified.
- * = verified GreenScreen* assessment
FIGURE ES-2 Estimated Chemical Footprint of IV Bags Made from PVC/DEHP and Polyolefins

<table>
<thead>
<tr>
<th></th>
<th>Number of Chemicals of High Concern</th>
<th>Chemicals of High Concern by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC</td>
<td>3</td>
<td>31%</td>
</tr>
<tr>
<td>Polyolefins</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

PVC = Polyvinyl chloride; DEHP = di(2-ethylhexyl) phthalate
**Figure 9** Solutions to Reducing Chemical Footprint of Plastics

- First ask, is it necessary?
- Use safer additives
- Use safer polymer
- Close the loop (but beware of legacy toxics)
- Redesign product
Is it Necessary?

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

Lynne Peeples  Become a fan
lynne.peeples@huffingtonpost.com
Use Safer Additives

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Chemicals of High Concern</th>
<th>Chemicals of High Concern by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIPS with Deca BDE</td>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>PC/ABS with RDP</td>
<td>5</td>
<td>1%</td>
</tr>
</tbody>
</table>

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

PROGRESS TO SAFER CHEMICALS IN MANUFACTURING

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