Plastics Scorecard
v.1.0 beta

Grading Criteria -- Use and End of Life

The Plastics Scorecard grades plastics on one use attribute (which also applies to end of life) and on another end of life attribute:

- Chemical releases and breakdown byproducts during use and end of life management.
- Compostability (and biodegradability in the marine environment) of single use biobased plastic products.

From the perspective of green chemistry, the primary concern with plastic materials in products is what happens to the chemicals contained in the plastic itself during use and disposal. Will they leak out of the product during use or end of life management - when exposed to sunlight, air, heat or certain types of liquids; or when abraded? And what happens when these chemicals are released into the environment, people and animals - do they breakdown into more toxic byproducts?

When addressing the use and disposal stages of a plastics life cycle, the Scorecard focuses on those attributes that are unique to the plastic material itself rather than on attributes that are related to product design or are generic to plastics as a class of materials. The Plastics Scorecard is designed to compare plastics to each other, not to other materials. Thus the Scorecard is not appropriate for comparing the life cycle concerns between, for example, wood windows and plastic windows. In addition, the property of being light weight -- for example, increasing mileage rates of automobiles through the increased use of plastics -- is not a useful point of comparison in the Scorecard because all plastics share that quality. While there are relative differences in the weight of various plastic materials to each other, it is not considered a significant issue in the Scorecard - especially in relation to the toxicity concerns related to the release of monomers and additives and their breakdown products into the environment and humans.

It is widely known in regulatory circles that plastic products unreacted (or residual) monomers and additives leak out of products into the environment, people and animals. Bisphenol A leaking out of baby bottles is probably the most widely known example of unreacted monomer leaking out of a product. Health Canada concluded that "the main source of exposure for newborns and infants is through the use of polycarbonate baby bottles when they are exposed to high temperatures and the migration of bisphenol A from cans into infant formula."[1]

Yet, since all plastics contain unreacted monomer they all have the same issue, that small amounts of unreacted monomer are present in the product and leak out over time. For example, taking the case of polystyrene, its monomer styrene is commonly found in food packaging and indoor environments. Unreacted styrene monomer is found in polystyrene food packaging ranging from 60 to 2250 ppm (parts per million).[2] The European Union concluded that polystyrene plastic typically contains 300-600 ppm unreacted styrene monomer with typical levels of 400 ppm.[3] The US Food and Drug Administration (FDA) limits the level of some monomers in food contact applications, including acrylonitrile from acrylonitrile butadiene styrene (ABS) and styrene from polystyrene. The FDA level for styrene from polystyrene polymers in contact with fatty foods is 0.5% or 5000 parts per million (ppm) and 0.5% in rubber-modified polystyrene.[4] The Agency for Toxic Substances and Disease Registry identified contaminated indoor air as the primary source of styrene exposure in the general population and polystyrene-containing products as a source of that styrene, including: polystyrene in carpets, floor tiles, insulation and consumer products.[5]

More widely known to the general public is that the additives in plastic products can leak out of the products as well. The phthalates in PVC plastics are one example, as are the brominated flame retardants in many different plastics. Both of which have been restricted in certain uses (as noted in the Grading Criteria for Manufacturing section).

Finally, during end of life management, toxic chemicals in plastics can be released through incineration, landfill leachate (the wastewater from landfills) or recycling. Perhaps the most widely know concern with end of life management of plastics is that dioxins and furans form when PVC plastic is burned, especially at low temperatures.[6]

Turning to the end of life management of plastics as a material, the guiding principle for the Plastics Scorecard is closed loop systems - with reuse of the product at the top of the waste management hierarchy followed by recycling or composting, with closed loop recycling (recycling the same product back into itself) the most preferred recycling option. The Plastics Scorecard addresses the issue of closed loop material systems in part in Feedstock Production through the use of post consumer recycled (PCR) content as a feedstock for new products. The Scorecard (v.1.0 beta) does not address the issue of recycling rates of individual plastic products because it varies depending on the individual product and the country. For example, polypropylene, which is not widely recycled in household recycling programs is widely recycled in the auto sector.

The Plastics Scorecard includes the issue of the compostability and marine biodegradability of biobased plastics because companies increasingly are claiming or at least implying that just because it is biobased means it will readily breakdown in the environment. This is not necessarily so, and a handful of organizations across the globe certify whether biobased products are indeed compostable.[7] The Scorecard includes marine biodegradability of single use plastic products because the fossil fuel based plastics are polluting land and sea across the globe. The garbage gyre in the north pacific, which consists primarily of plastics, is estimated to be twice the size of Texas.[8] Thus a part of the environmental improvement that biobased plastics can provide relative to the fossil fuel-based plastics is that they degrade in aquatic environments.

The grading criteria for the use and end of life attributes are described below.

3.A. **Chemical Releases and Breakdown Byproducts (relates to both use and end of life)**

“Breakdown byproducts” include chemical byproducts that result from: combustion, incineration, metabolism, aerobic or anaerobic degradation, photodegradation, oxidation or hydrolysis.

3.A.1. **Grade F** = A Green Screen red chemical is released from the plastic during its use or disposal; or a Green Screen red chemical is a breakdown byproduct from chemicals contained in the plastic.

3.A.2. **Grade C- =** A Green Screen orange chemical is released from the plastic during its use or disposal; or a Green Screen orange chemical is a breakdown byproduct from chemicals contained in the plastic.

3.A.3. **Grade A+** = No Green Screen red or orange chemicals are released from the plastic during use or disposal; and no Green Screen orange or red chemicals are breakdown byproduct from chemicals contained in the plastic.

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3.B. Compostability and Biodegradability in the Marine Environment of Single Use Biobased Plastic Products

This is a product-specific criterion that applies to single use plastic products made from biobased feedstocks.

3.B.1. **Grade C+** = Product is not certified compostable.

3.B.2. **Grade A -** = At the end of the product's life the product must be certified commercially compostable, meeting either: ASTM D6400, ISO 17088 or DIN EN 1342 and verified by a third party such as: Biodegradable Products Institute, Din Certco or Japan Bioplastics Association.

3.B.3. **Grade A+** = Meets criterion 3.B.2. and is biodegradable in the marine environment.

ENDNOTES

[1] Health Canada, 2008, "Government of Canada Takes Action on Another Chemical of Concern: Bisphenol A" (http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/_2008/2008_59-eng.php - accessed 7/15/08).
[2] Gordon L. Robertson, 2005, *Food Packaging: Principles and Practice* (CRC Press).
[3] European Union, European Chemicals Bureau, 2002, *Risk Assessment Report – Styrene* (http://ecb.jrc.it/DOCUMENTS/Existing-Chemicals/RISK_ASSESSMENT/REPORT/styrenereport034.pdf -- accessed 7/22/08).
[4] U.S. Food and Drug Administration, 2008, Code of Federal Regulations, Title 21, Part 177 – Indirect Food Additives: Polymers -- http://www.access.gpo.gov/nara/cfr/waisidx_08/21cfr177_08.html (accessed 7/21/08).
[5] U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, 2006, *Draft Toxicological Profile for Styrene* (http://www.atsdr.cdc.gov/toxprofiles/tp53.html -- accessed 7/22/08).
[6] For example, see: T Shibamoto, et al., 2007, "Dioxin Formation from Waste Incineration", *Reviews of Environmental Contamination* & *Toxicology vol.* 190: 1-41.
[7] For example, see the Biodegradable Products Institute -
8 See: Algalita Marine Research Foundation, 2007, "Pelagic Plastic" (http://www.algalita.org/pdf/AMRFWhitePaper.pdf - accessed 9/24/09) and Wikipedia, Great Pacific Garbage Patch (http://en.wikipedia.org/wiki/Great_Pacific_Garbage_Patch - accessed 9/24/09).