Plastics Scorecard
v.1.0 beta

Grading Criteria for Plastics Manufacturing

The Scorecard grades the major steps in plastics manufacturing on the basis of the inherent hazards of the chemicals used in each manufacturing stage. The manufacturing of a plastic product involves multiple steps.

- The first step is the manufacture of the **primary petrochemicals**[1] -- ethylene, propylene, benzene, xylenes methanol, toluene, and butadiene[2] -- which along with chlorine are at the foundation of the fossil fuel plastics.
- The second step is the conversion of the primary petrochemicals into **intermediate chemicals**. For example, "ethylbenzene" is an intermediate chemical formed from the primary petrochemicals ethylene and benzene.
- The third step is the manufacture of the **monomer** from the intermediate chemical. For example, styrene is the monomer formed from ethylbenzene. Monomers are the building blocks of polymers.
- The fourth step is the manufacture of the **polymer** from the monomer. Individual monomers are connected into a long chain to create a polymer. For example, polystyrene is the polymer formed from styrene monomer. In the polymerization of a monomer, there is always some amount of unreacted (or residual) monomer that becomes lodged in the polymer chain. Over time and with the appropriate conditions -- heat, shaking, contact with certain liquids, etc. -- the unreacted monomer will leak out of the product. **Catalysts** are used in polymerization to speed the rate at which monomers are linked together. While manufacturers reclaim and reuse catalysts in the manufacturing process, inevitably residual levels end up in the polymer.
- Finally the polymer is formed into a product. All plastics need and contain **additives**. From polymer manufacturing to the production of the plastic product, additives are used to both facilitate manufacturing (e.g., ease the flow of the resin through molding equipment) and to impart and enhance necessary properties in the final product – ranging from color to flexibility to resistance to degradation by light, air, water or heat**.** The major types of plastic additives include: antioxidants, antistatic agents, blowing agents, catalysts, colorants, flame retardants, impact modifiers, lubricants, plasticizers and heat and UV stabilizers. Increasingly manufacturers are turning to **nanomaterials** as a new type of additive to serve the above functions.

Recognizing that some chemicals used in plastics manufacturing pose significant threats to the environment and humans, governments are restricting certain chemicals of concerns that are commonly used as plastics additives, including:

- The brominated flame retardant additive - decabromodiphenyl ether (decaBDE) - which is restricted from use in plastic electronic casings by the European Union and the states of Maine and Washington.
- Bisphenol A, the monomer for manufacturing polycarbonate plastic, is restricted from use in children's drinking products by Canada, Minnesota, Chicago and Suffolk County, New York.
- Lead and phthalates are restricted in toys by the U.S. Consumer Product Safety Improvement Act.

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In addition, recent toxicological reviews show nanomaterials represent potentially serious new risks to human and environmental health.[3] The United Kingdom's Royal Society for example, characterized the nanotechnology risks as serious and recommended that nanomaterials be treated as new chemicals and be subject to new safety assessments prior to their inclusion in consumer products[4]. The Royal Society further recommended that factories and research laboratories treat nanomaterials as though they were hazardous, and that until the environmental impacts of nanomaterials are better understood, the release of nanomaterials into the environment should be avoided as far as possible. Nevertheless, no government or international body has yet to introduce a regulatory system to protect the health of workers, the public and the environment from the risks associated with nanotoxicity.

The Plastics Scorecard grades plastics on five manufacturing attributes:

1. Primary and Intermediate Chemicals
2. Monomers
3. Catalysts
4. Additives
5. Nanomaterials

The chemicals used in each of step of plastics manufacturing (with the exception of nanomaterials) are categorized into different levels of environmental and human health performance based on assessments using the Green Screen for Safer Chemicals (see Box 1). The grading criteria are designed to move to inherently safer chemicals in each stage of plastics manufacturing.

The grading criteria for each of the Feedstock Production attributes are described below.

Box 1. Green Screen Benchmark Levels for Chemicals*

Green Screen - "Red" Chemicals
Includes substances that are either: 1) persistent, bioaccumulative and toxic (PBT); 2) very high P + very high B (vPvB); 3) vPT; 4) vBT; or 5) a high human health priority endpoint in the Green Screen - a) carcinogenic; b) mutagenic; c) reproductive or developmental toxicant; d) endocrine disruptor; or e) neurotoxicant. Note that "toxic" (T) includes both human toxicity and ecotoxicity.

Green Screen - "Orange" Chemicals
Includes substances that are either: 1) moderate PBTs; 2) high P + high B; 3) high P + moderate T; 4) high B + moderate T; or 5)

Green Screen - "Orange" Chemicals
Includes substances that are moderate: P, B or T.

Green Screen - "Green" Chemicals
Are substances that are readily biodegradable (low P) and have low bioaccumulative capacity (B), low human toxicity and low ecotoxicity.

* Mark Rossi and Lauren Heine, 2007, *The Green Screen for Safer Chemicals: Evaluating Flame Retardants for TV Enclosures* (Spring Brook, NY: Clean Production Action).

2.A. Primary and Intermediate Chemicals

The grade for primary and intermediate chemicals begins at Grade C- (rather than Grade F) because these chemicals are used in closed manufacturing processes where exposures can be minimized. That said, however, the grading criteria still benefit plastics made from inherently safer primary and intermediate chemicals (which greatly benefit workers and surrounding communities).

2.A.1. **Grade C-** = Any primary or intermediate chemical used in the manufacture of the plastic is a Green Screen red chemical.

2.A.2. **Grade B-** = Any primary or intermediate chemical used in the manufacture of the plastic is a Green Screen orange chemical.

2.A.3. **Grade A+** = All primary and intermediate chemicals are Green Screen yellow or green chemicals.

2.B. **Monomers**

The grade for monomers begins at Grade F because these residual monomers do remain in the final plastic products and can lead to exposures during use and disposal as well as during manufacture. For example, the monomer bisphenol A (used to manufacture polycarbonate) has been restricted by certain governments in baby bottles.

2.B.1. **Grade F** = Any monomer used in the manufacture of the plastic is a Green Screen red chemical and the plastic is used in food contact items or children's products. This grade is only relevant to final products.

2.B.2. **Grade D** = Any monomer used in the manufacture of the plastic is a Green Screen red chemical. The grade is related to the inherent characteristics of the monomer.

2.B.3. **Grade C- =** Any monomer used in the manufacture of the plastic is a Green Screen orange chemical and the plastic is used in food contact items or children's products. This grade is only relevant to final products.

2.B.4. **Grade C+** = Any monomer used in the manufacture of the plastic is a Green Screen orange chemical.

2.B.5. **Grade A+ =** All monomers used in the manufacture of the plastic are Green Screen yellow or green chemicals.

2.C. **Catalysts**

The grade for catalysts begins at Grade C- (rather than Grade F) because these chemicals are generally captured and reused in the manufacturing processes. That said, however, the grading criteria still benefit plastics made from inherently safer catalysts. As residual levels of catalysts do end up in products and become an issue during recycling processes.

2.C.1. **Grade C-** = Any catalyst used in the manufacture of the plastic is a Green Screen red chemical.

2.C.2. **Grade B-** = Any catalyst used in the manufacture of the plastic is a Green Screen orange chemical.

2.C.3. **Grade A+** = All catalysts are Green Screen yellow or green chemicals.

2.D. **Additives**

The grade for additives begins at Grade F because additives can leak out of plastic products and lead to exposures during use and end of life management as well as during manufacture. For example, the phthalate plasticizers (including DEHP) have been restricted in children's products in the U.S. and Europe; and the polybrominated dipehnyl ether (PBDE) flame retardants have been restricted from use in certain products by the European Union and state governments in the U.S. Nanomaterial additives that have been tested for toxicity are captured within this attribute.

2.D.1. **Grade F** = Any additive used in the manufacture of the plastic is a Green Screen red chemical and the plastic is used in food contact items or children's products.

2.D.2. **Grade D** = Any additive used in the manufacture of the plastic is a Green Screen red chemical.

2.D.3. **Grade C- =** Any additive used in the manufacture of the plastic is a Green Screen orange chemical and the plastic is used in food contact items or children's products.

2.D.4. **Grade C+** = Any additive used in the manufacture of the plastic is a Green Screen red chemical.

2.D.5. **Grade A+ =** All additives used in the manufacture of the plastic are Green Screen yellow or green chemicals.

2.E. **Nanomaterials**

The grade for any nanomaterial begins at Grade C+ because of the lack of toxicity testing data for the vast majority of nanomaterials. Nanomaterial additives that have toxicity test data are captured under attribute 2.D - Additives.

2.E.1. **Grade C-** = Product contains nanomaterials that have not been tested for toxicity concerns.

2.E.2. **Grade A+** = Product does not contain nanomaterials.

ENDNOTES

[1] "Petrochemicals" will become an outdated term as more and more former petrochemicals are produced from biobased feedstocks.

[2] Sean Davis and Jamie Lacson, 2005, "Petrochemical Industry Overview," *The Chemical Economics Handbook* (Palo Alto, CA: SRI Consulting).

[3] See reviews: G Oberdörster and J Oberdörster, 2005, "Nanotoxicology: an emerging discipline from studies of ultrafine particles," *Environmental Health Perspectives* 113(7):823-839; P Hoet, I Bruske-Holfeld and O Salata, 2004, "Nanoparticles – known and unknown health risks," *Journal of Nanobiotechnology* 2:12

[4] The Royal Society and The Royal Academy of Engineering, UK, 2004, P85 Recommendation 10 - Nanoscience and nanotechnologies (http://www.royalsoc.ac.uk/).