CHAPTER 1
Introduction

Plastics are ubiquitous in our modern lives and provide benefits to people across the globe. Lightweight, durable, flexible, and easy to form, their use continues to grow rapidly. Cell phones, baby car seats, blood bags, backpacks, chairs, cars, and clothing are among the many products made with plastics and reflect their beneficial properties. Yet plastic litter, gyres of plastics in the oceans, and toxic additives in plastic products are raising public awareness, consumer demand, retail pressure, and regulations for a more sustainable material.

Businesses, hospitals and individuals are increasingly seeking plastics that are more sustainable across their life cycle—from raw material extraction to manufacturing to use to end of life. They want to know the sources of a plastic's raw materials, whether it contains chemicals of high concern to human health or the environment, the plastic's carbon footprint, its recycled content and whether it is recyclable, compostable, or biodegradable in the environment at the end of its useful life. Existing tools cover aspects of these life cycle areas of interest, however, they do not focus on the inherent hazards of the chemicals used to manufacture and contained within plastics.

The Plastics Scorecard is a method for evaluating the chemical footprint of plastics and a guide for selecting safer alternatives. Version 1.0 (v1.0) addresses the progress to safer chemicals in plastics manufacturing and in the chemical footprint of plastic products. Chemical footprinting is the process of assessing progress toward the use of safer chemicals and away from chemicals of high concern (CoHCs).[3] Clean Production Action defines chemical footprint as the number and volume of CoHCs used in manufacturing and supply chains, and contained in the final product (CPA, 2014).

The goals of the Plastics Scorecard are to inform the selection of safer plastics by businesses and catalyze manufacturers to reduce the number and volume of CoHCs in manufacturing processes and products. If successful the Plastics Scorecard will advance the development and use of plastics that use inherently safer chemicals in all steps of polymer production as well as in the selection of additives. The Plastics Scorecard is for anyone interested in identifying and selecting plastics based on inherently less hazardous chemicals. Product designers, material specifiers and purchasers will all find value in the both the criteria for evaluating plastics as well as the assessments of individual plastics. The Plastics Scorecard reveals the human and environmental health problems associated with plastics and sets criteria for identifying more environmentally preferable plastics.

Plastics Scorecard v.1.0 *beta*

In 2009, Clean Production Action released the *Plastics Scorecard v1.0 beta*. The intent of *Plastics Scorecard v.1.0 beta* was to create a transparent, robust, replicable method for benchmarking plastics against each other based in life cycle thinking, accounting for feedstock production, chemical and plastics manufacturing, use, and end of life factors. Guided by principles of sustainable resources, green chemistry, and closed loop systems, the *beta* version created a scoring system for three core stages of a plastic product's life cycle: feedstock production/raw material extraction, manufacturing, and end of life management. At the core of the *beta* version of the Plastics Scorecard were the goals of reducing the chemical footprint of plastics across their life cycle and creating a method that would drive meaningful change in material selection.

For the feedstock stage the *beta* version of the Plastics Scorecard focused on reducing the impacts of biobased feedstocks or increasing the use of post-consumer recycled (PCR) content. Including PCR content in the feedstock was seen as the means for lowering the environmental impacts of fossil fuel extraction. The manufacturing stage covered the inputs into plastics after feedstock production—primary and intermediate chemicals, monomers, additives, catalysts, with a special focus on nanomaterials. The end of life stage considered pollution from recycling and incineration, and compostability or biodegradability in the marine environment.

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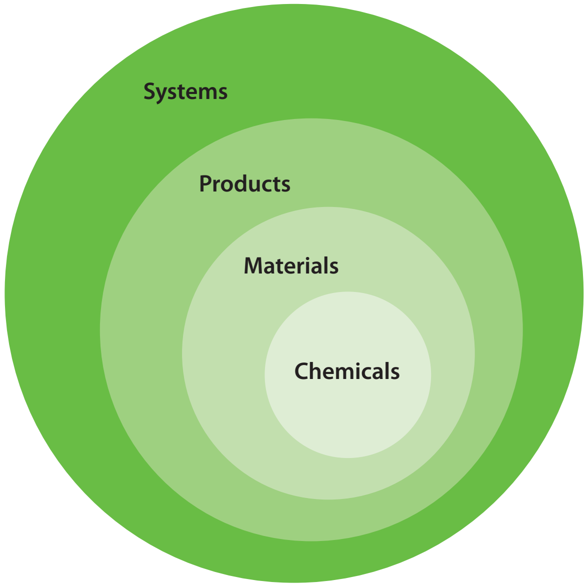
Pilots of the *beta* version revealed an inconsistent treatment of plastics made from biobased as opposed to fossil fuel feedstocks. This orientation of the Plastics Scorecard was intentional because the opportunity to green biobased plastics, especially in the feedstock stage, are huge, whereas the only alternative for greening up feedstocks for fossil fuels is to use recycled content. For plastics made from biobased materials the source of the feedstock is usually known, e.g., corn from the Midwestern U.S. For fossil fuel-based plastics, the geographical source and the type of fossil fuels used—coal, natural gas, or crude oil—is known only generically—as an average of all production. Thus the *beta* version struggled with specifying metrics that are both actionable for designers, material specifiers, and purchasers while remaining useful for assessing different plastics and their feedstocks.

3 BizNGO (2008) defines "chemical of high concern" as having the following properties: 1) persistent, bioaccumulative and toxic (PBT); 2) very persistent and very bioaccumulative (vPvB); 3) very persistent and toxic (vPT); 4) very bioaccumulative and toxic (vBT); 5) carcinogenic; 6) mutagenic; 7) reproductive or developmental toxicant; 8) endocrine disruptor; or 9) neurotoxicant. Toxic, or T, includes both human toxicity and ecotoxicity.

FIGURE 1

Chemicals at the Core of Systems Change



Plastics Scorecard v.1.0

Reflecting upon the failings of the *beta* version of the Plastics Scorecard, it became clear that downstream users of plastics needed a method for evaluating and comparing plastics based on the inherent hazards of the chemicals in plastics. As Figure 1 illustrates, chemicals are core to materials, which in turn are core to products, which in turn are core to systems. Thus changing materials like plastics to make them inherently safer across their life cycle requires addressing the inherent hazards of chemicals.

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Today's fossil fuel-based plastics are not manufactured according to the Principles of Green Chemistry. They rely primarily upon inherently hazardous chemicals—chemicals that are likely to be carcinogens, reproductive/developmental toxicants, or endocrine disruptors. In short, chemicals that are unhealthy for humans and the environment. Examples abound of the inherent hazards of the fossil fuel-based plastics. Polyvinyl chloride (PVC) plastic is made from the carcinogens vinyl chloride monomer (VCM) and ethylene dichloride. Polystyrene plastic is made from the carcinogens benzene and styrene. Polycarbonate is made from the endocrine disruptor, bisphenol A (BPA).

The most effective means for reducing the risks from CoHCs in plastics is to avoid their use in the first place. In so doing, workers and local communities and environments are not exposed from manufacturing practices, consumers are not exposed during use, and again workers and local communities and environments are not exposed during recycling, incinerating, or landfilling at end of life. Using inherently safer chemicals has positive repercussions throughout the life cycle of a plastic product.

Green chemistry, as defined by Anastas and Warner (1998) is the "the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products." Their 12 Principles of Green Chemistry define an alternative path to manufacturing plastics based on the pursuit of processes that reduce and eliminate the use or generation of hazardous substances in the design, manufacture, and application of chemical products. The Plastics Scorecard addresses four of the 12 Principles of Green Chemistry:

#3. Design less hazardous chemical syntheses: Design syntheses to use and generate substances with little or no toxicity to humans and the environment.

#4. Design safer chemicals and products: Design chemical products to be fully effective, yet have little or no toxicity.

#8. Use safer solvents and reaction conditions: Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.

#12. Minimize the potential for accidents: Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

The Plastics Scorecard brings a unique lens to evaluating plastics with its focus on the inputs into production versus the outputs of production. How do we move to inherently safer chemicals in manufacturing and in products? How do we optimize safer chemicals in plastics? The Plastics Scorecard helps to identify and score chemicals that are used to produce plastics based on inherent hazard. The scores allow the user to evaluate the progress to safer chemicals in manufacturing as well as the overall chemical footprint of plastic products.

The following chapters of the Plastics Scorecard v1.0 report are:

- ***Chapter 2. Why Plastics?*** An overview of the deep and impactful connections between plastics, chemicals, and human health and the environment.
- ***Chapter 3. Measuring the Chemical Footprint of Plastics***
  - A method for evaluating the chemical footprint of polymer manufacturing and plastic products.
  - Applying the method to two plastic products: intravenous (IV) bags and electronic enclosures.
- ***Chapter 4. Strategies for Reducing the Chemical Footprint of Plastics***

The strength of the Plastics Scorecard v1.0 is in its clear focus on advancing inherently safer chemicals across the life cycle of plastics. To advance a green chemistry economy, the current practices of plastics manufacturing and their associated high consumption of inherently high hazard chemicals needs to shift to inherently safer chemicals.

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