SIX CLASSES: A NEW APPROACH TO REDUCING THE USE OF HARMFUL CHEMICALS AND PREVENTING REGRETTABLE SUBSTITUTIONS

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Introduction

Most of the more than 80,000 chemicals currently on the market have not been adequately evaluated to ensure that they can be used safely in consumer products. In the U.S., progressive reform of the Toxic Substances Control Act (TSCA) is stalled, in Canada the Chemical Management Plan is moving through its categorization process, and in the EU, REACH dossiers are being reviewed. In the mean time, chronic health problems are on the rise, including neurological disorders, reduced fertility, autoimmune disorders, and some kinds of cancer. Some environmental chemicals are known to cause such disorders and many more are suspected of it, but few have been adequately tested.

Given the pace of "new" chemical entering the marketplace, the expense of testing, the challenge of ensuring alternatives are indeed safer, and efforts by some sectors to prevent regulatory response, it is very difficult for regulators to replace harmful chemicals in commerce with safer alternatives. Often when a chemical is proven to be toxic, it is replaced by a closely related one, in a cycle of "regrettable substitutions."

Although research has shown that chemicals in certain chemical classes or families are likely to be harmful, chemicals in these categories continue to be used in consumer products without adequate toxicological information. The "Six Classes" project aims to prevent the current cycle of substitutions of a harmful chemical with a similar chemical by proposing a conceptual shift from addressing chemicals one by one to addressing chemicals with similar properties as a class. By educating decision makers in manufacturing, retail and government as well as consumers and non-profit organizations about "Six Classes" that contain many of the harmful chemicals in consumer products, it may be possible to reduce the use of these chemicals.
Once classes of chemicals with a potential for health and ecological harm are identified and their use is reduced, alternatives need to be found and proven to indeed be safer. Alternatives assessment needs to be broadly defined by first asking if a chemical is necessary. If a harmful chemicals is not needed, the alternative can be not adding any chemical. In cases where a replacement is needed, the tools and techniques to assess human health and environmental impacts of chemicals have made substantial progress and are becoming better suited to guide the selection of safer alternatives. The 12 Principles of Green Chemistry can provide guidance on the design and manufacture of improved alternatives.

Materials and methods

In summer 2013, twenty-two participants from academia, business, government and the non-profit community came together at the Blue Mountain Center in New York Sate to develop innovative solutions to reduce the use of harmful chemicals in consumer products. During four days of lectures and discussions, participants developed strategies for reducing toxics in consumer products. The result was the Blue Mountain Blueprint to Reduce the Use of Chemical Classes of Concern. The aim of the Blueprint is to educate manufacturers, retailers, government decision makers and consumers about the scientific background and rationale for reducing the use of six classes of harmful chemicals used in consumer products. This intends to begin the process of reducing the use of harmful chemicals in products and also avoiding regrettable substitutions.

Results and discussion

The many thousands of chemicals on the market can be grouped or classified in different ways. One way is according to their chemical composition and structure. Another is according to their functionality, i.e. where and how they are used. A third is according to whether they have intrinsic properties that render them harmful, such as being cancer-causing or bioaccumulative.

"Six Classes" or families were identified that contain a large proportion of the harmful chemicals that are commonly used in many consumer products but are not yet adequately regulated. Many are volatile or semi-volatile and can migrate from the products to which they were added into indoor air and dust, resulting in human exposure. Persistent compounds can also migrate to the outdoor environment thereby causing ecosystem exposure. A variety of chemical classes were considered, but only those with significant numbers of peer-reviewed scientific papers demonstrating their harm were selected. Chemicals used in foods, drugs and pesticides are not included because a number of laws do regulate these.

The six classes as listed below are defined according to their chemistry and uses in products:

1. **Per- and polyfluoroalkyl substances** are used as stain-, oil- and water-repellants and surfactants in consumer products such as cookware, clothing, outdoor apparel, ski waxes, carpeting, cosmetics, and food packaging[1]. Due to the strength of the carbon-fluorine bond, they are highly persistent in the environment, and have been found in humans and biota worldwide[2]. The most well-studied members of the class contain eight carbon backbones and have been associated with kidney and testicular cancer, early menopause, thyroid disruption, delayed puberty, elevated total cholesterol, and obesity[3,4,5,6]. These chemicals have unique properties, and suitable substitutes for all their uses are yet to be found. However, in light of their persistence and potential for harm, their use in some applications such as food packaging, cookware and cosmetics can be questioned. Safer substitutes are available for some uses.
2. **Chlorinated antimicrobials** such as triclosan and triclocarban are used to prevent microbial growth in a variety of personal care products such as soap, deodorant, toothpaste and mouthwash, and embedded in the plastic used to make furniture, fitness mats, toys, lunchboxes, cutting boards and countertops[7]. They can be ingested or absorbed through the skin, and have been detected in the urine of 75% of Americans tested[8,9]. Triclosan, the most studied member of this class, is an endocrine disruptor for estrogenic, androgenic and thyroidal systems, and can lead to hypersensitivity to airborne allergens[10,11,12]. According to the U.S. Food and Drug Administration (FDA), in most cases antimicrobials provide no additional benefit to consumers beyond soap and water.
3. **Organohalogen and organophosphate flame retardants** are used in furniture and baby product foam, building insulation, electronics, and other products to meet flammability requirements[13]. Flame retardants, notably polybrominated diphenyl ethers (PBDEs), have been detected in most Americans, with highest levels in children[14,15]. The well-studied members of the class have been linked to endocrine disruption, cancer, and reproductive, neurologic and immune impairments[16,17,18,19,20]. As currently used in home furniture, children's products, building insulation and electronics casings, flame retardants do not significantly increase fire safety[21]. Furthermore, when materials containing halogenated flame retardants burn, they can produce more smoke, soot and toxic gases, which are the leading causes of fire deaths.
4. **Bisphenol and phthalate plasticizers** are used during the creation of various plastic consumer products such as toys, food and water containers, and personal care products such as cosmetics, shampoos, and lotions. They have been detected in most humans. The well-studied members of this class are known endocrine disruptors, which, at very low concentrations, can disrupt the normal function of the reproductive, metabolic, neurologic and immune systems. They are most harmful during critical windows of development of the fetus. While nearly all the listed chemicals in the six classes are suspected of having endocrine disrupting qualities, the phthalate plasticizers and bisphenol A are especially problematic due to their high volume of use and adverse impact on biological systems at very low levels.
5. The fifth class consists of **some solvents**, used, for example, in paint, inks, nail polishes, coatings, degreasers and dry cleaning. As volatile compounds, many of the non-water based solvents release vapors that humans inhale and absorb. Harmful solvents include aliphatic and aromatic hydrocarbons and organohalogen solvents. Less toxic ones include solvents based on citrus or plant oils, oxygenated hydrocarbon solvents, and n-methyl pyrrolidone. Some solvents are associated with neurotoxicity, reproductive toxicity, carcinogenicity and liver and kidney damage[22]. The functions performed by

solvents in some consumer products are needed, but for many products and applications, less harmful solvents or non-solvent based processes are available.

6. **Some metals** are toxic, the most problematic being arsenic, cadmium, chromium, lead and mercury. Metal toxicity can result in reduced mental and central nervous function, lower energy levels, damage to blood, lungs, kidneys, liver and other organs[23,24,25,26,27]. Although metals have important applications, in some cases, there are safer alternatives to the use of toxic metals.

Four of these "Six Classes" described above contain organohalogens (compounds in which carbon is bonded to bromine, chlorine, or fluorine). These chemicals are often toxic, lipophilic, and/or resistant to degradation, leading to their persistence and bioaccumulation in humans and ecosystems. They are not found naturally in mammalian biochemical processes. All 22 chemicals globally banned as Persistent Organic Pollutants under the Stockholm Convention are organohalogens, and three of them are brominated flame retardants. Replacement organohalogens in these four classes are still used at high levels in consumer products, in spite of their similarity to chemicals that have been banned or phased out.

Through a series of eight webinars, we presented the "Six Classes" concept to manufacturers, retailers, and other decision makers. Over 1,400 participants registered for the "Six Classes" Webinar Series, featuring eight short lectures by distinguished scientists. Participants included government decision-makers, regulators, scientists, NGOs, industry and retail representatives. As a result of attending the webinar series, several major retailers and manufacturers decided to reduce the use of chemicals in one or more of the "Six Classes" in their products.

The first six webinars in this series described the chemical properties, uses in consumer products and toxicology of the "Six Classes" introduced above. The seventh webinar explored the question: **"Do we need this chemical?"** This is the first question to ask when deciding whether or not to use a chemical of concern in a process or product. Discontinuing the use of chemicals with unnecessary functions in products is an effective way to reduce the use of chemicals in the "Six Classes", without the need to find safer alternatives. If the function is necessary, then truly safer alternatives are needed.

The process of exploring **green chemistry alternatives** was the subject of the eight and final webinar in the "Six Classes" series. When creating a new chemical, mixture, product or formulation, green chemistry can be used to replace chemical products and processes that pose threats to human health and the environment with chemicals and processes that have been designed with the health of humans and ecosystems in mind. At the point of initial design of a new chemical, process for its commercial-scale use, or substitution of an existing chemical, there are increasingly many green chemistry tools and protocols (such as the GreenScreen^{TM}) that allow for assessment of human health and environmental impacts.

Conclusion

The concept of the "Six Classes" can facilitate decisions about reducing the use of potentially harmful chemicals. This collaborative approach has educated product manufacturers so they chose to reduce their use of one or more of the "Six Classes" of chemicals. Before using a chemical from one of the "Six Classes" in consumer products, manufacturers can ask if the chemical's use is essential. If it is indeed necessary, might there be safer alternatives that are not in one of the "Six Classes"? While waiting for improved chemical regulations (e.g. TSCA reform and REACH), the concept of chemical classes, through its simplicity, can be a useful starting point to reduce our use of and exposure to chemicals in classes known to be harmful to human and environmental health.

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