Why We Need Green Chemistry

Chemistry has improved our quality of life, and made thousands of products possible. Unfortunately, this achievement has come at a price: our collective human health and the global environment are threatened. Our bodies are contaminated with a large number of synthetic industrial chemicals, many of which are known to be toxic and carcinogenic while others remain untested for their health effects. They come to us from unlabeled products, chemically contaminated food, air, water and dust while the developing fetus is exposed directly to chemicals in the womb. Many chemicals work their way up the food chain and circulate round the globe: pesticides used in the tropics are commonly found in the Arctic; flame retardants used in furniture and electronics are now commonly found in marine mammals.

Yet as cancer rates rise and evidence increases about the link between certain chemicals and birth defects and learning disabilities[1] our regulatory system has been unable to make chemical producers provide full testing information or promote inherently safer chemicals. While some efforts are underway to overhaul chemicals policy, most notably by the recent passing of the European Union's new chemicals policy, REACH, the focus must also be on overhauling the way chemicals are designed from the outset. This is what Green Chemistry sets out to do.

WHAT IS GREEN CHEMISTRY?

Green chemistry is an approach to the design, manufacture and use of chemical products to intentionally reduce or eliminate chemical hazards.[2] The goal of green chemistry is to create better, safer chemicals while choosing the safest, most efficient ways to synthesize them and to reduce wastes.

HOW IS GREEN CHEMISTRY DIFFERENT?

Chemicals are typically created with the expectation that any chemical hazards can somehow be controlled or managed by establishing "safe" concentrations and exposure limits. Green chemistry aims to eliminate hazards right at the design stage. The practice of eliminating hazards from the beginning of the chemical design process has benefits for our health and the environment, throughout the design, production, use/reuse and disposal processes.[3] In 1998, two US chemists, Dr Paul Anastas and Dr John Warner outlined Twelve Principles of Green Chemistry to demonstrate how chemical production could respect human health and the environment while also being efficient and profitable.[4]

One example of the difference between traditional chemistry and green chemistry is the use of petroleum. Today's chemical industry relies almost entirely on non-renewable petroleum as the primary building block to create chemicals. This type of chemical production typically is very energy intensive, inefficient, and toxic—resulting in significant energy use, and generation of hazardous waste. One of the principles of green chemistry is to prioritize the use of alternative and renewable materials including the use of agricultural waste or biomass and non-food-related bioproducts. In general, chemical reactions with these materials are significantly less hazardous than when conducted with petroleum products. Other principles focus on prevention of waste, less hazardous chemical syntheses, and designing safer chemicals including safer solvents. Others focus on the design of chemicals products to safely degrade in the environment and efficiency and simplicity in chemical processes.

The Benefits of Green Chemistry

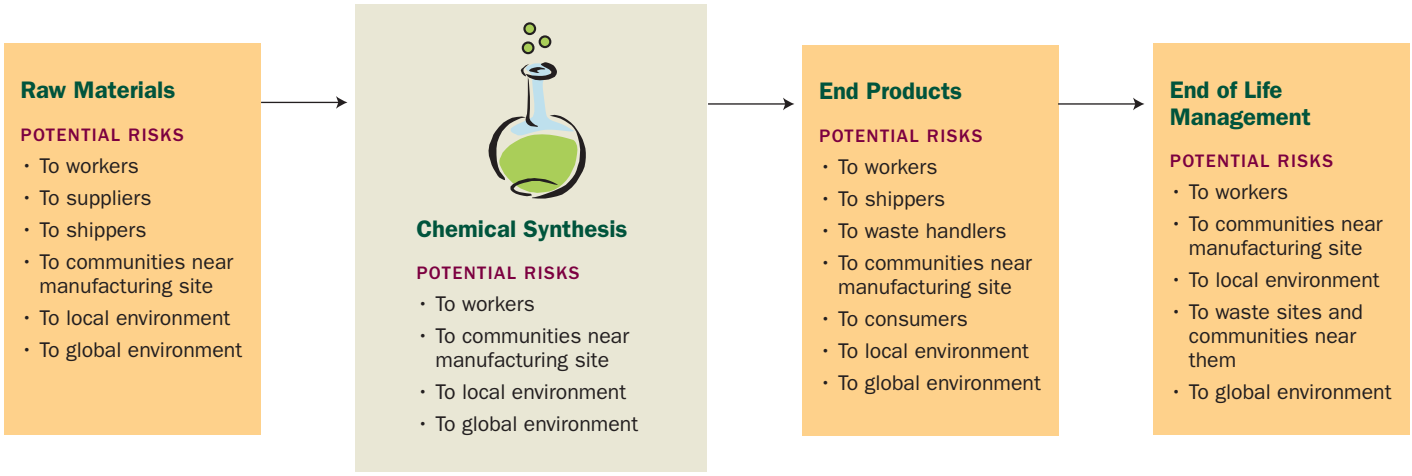
- Economical
- Energy efficient
- Lowers cost of production and regulation
- Less wastes
- Fewer accidents
- Safer products
- Healthier workplaces and communities
- Protects human health and the environment
- Competitive Advantage

A transformation to green chemistry techniques would result in safer workplaces for industry workers, greatly reduced risks to fenceline communities and safer products for consumers. And because green chemistry processes are more efficient companies would consume less raw materials and energy as well as save money on waste disposal.

HOW TO DESIGN SAFER CHEMICALS

The more we know about how a chemical's structure causes a toxic effect, the more options are available to design a safer chemical.[5] Chemists now have access to many sources of information to determine the potential toxicity of the molecules they design and the ingredients they choose. Green chemists are trained to integrate this information into the design of molecules to avoid or reduce toxic properties. For example, they might design a molecule large enough that it is unable to penetrate deep into the lungs, where toxic effects can occur. Or, they might change the properties of a molecule to prevent its absorption by the skin or ensure it safely breaks down in the environment.

The benefits of green chemistry reduce risks all along the life cycle of chemical production and use



Green chemists also take a life cycle approach to reduce the potential risks throughout the production process. They work to ensure that a product will pose minimal threats to human health or the environment during production, use, and at the end of its useful life when it will be recycled, or disposed of. A green chemistry approach is one of "continual improvement, discovery, and innovation"[6] that will bring us ever closer to processes and products that are safe within natural ecosystems. Ultimately a product should safely degrade as a biological nutrient or it should be safely recycled.

GREEN CHEMISTRY IN OUR STORES

The application of Green chemistry concepts is becoming more widespread. The Green Chemistry and Consumer network in the UK, for instance, alerts retailers and consumers around the world to new developments in safer product design. The case studies also give a small life cycle assessment of the discovery.[8]

Green Paints in All Colors

Many now recognize that volatile organic compounds (VOCs), the source of "new paint smell," are harmful to health and the environment. Old-fashioned, water-soluble "milk paints" in powder form have been around for decades, but are still not widely available. Great strides have been made to bring home paints to the market that contain low or no VOCs, and are just as attractive. One company, Archer RC paint, won a 2005 Presidential Green Chemistry Award with a bio-based paint which in addition to lower odor, has better scrub resistance and better opacity.

Green Plastics in All Shapes and Sizes

Some plastic products can now be made from plant sugars from renewable crops, like corn, potatoes and sugar beets instead of non-renewable petroleum. For example, the U.S.-based company NatureWorks LLC markets a bio-based polymerPLA, from corn that is used in food and beverage packaging, as well as a 100% corn fiber, Ingeo, that is used in blankets and other textiles. Interface Fabrics uses PLA in their fabrics but also carefully integrates green chemistry principles when choosing dyes for their PLA based product lines.[9] A collaboration of groups have produced Sustainable Biomaterials Guidelines[10] that outline a comprehensive sustainable life cycle approach from agricultural practices through to end of life recycling and composting.

Firms on the Path to Green Chemistry

A number of companies in the past few years have adopted chemical policies that put them on the path to green chemistry. Some have adopted the Precautionary Principle and the Green Chemistry Principles, others have taken a hard look at their supply chain, eliminated toxic chemicals, elected to label their products, and supported public policies that aim towards sustainable and safe chemical use.

These companies represent a wide range of products and include: Avalon, Dell, H&M Herman Miller, Ikea, Interface, Kaiser Permanente, Rohm and Haas Company, and Seventh Generation.

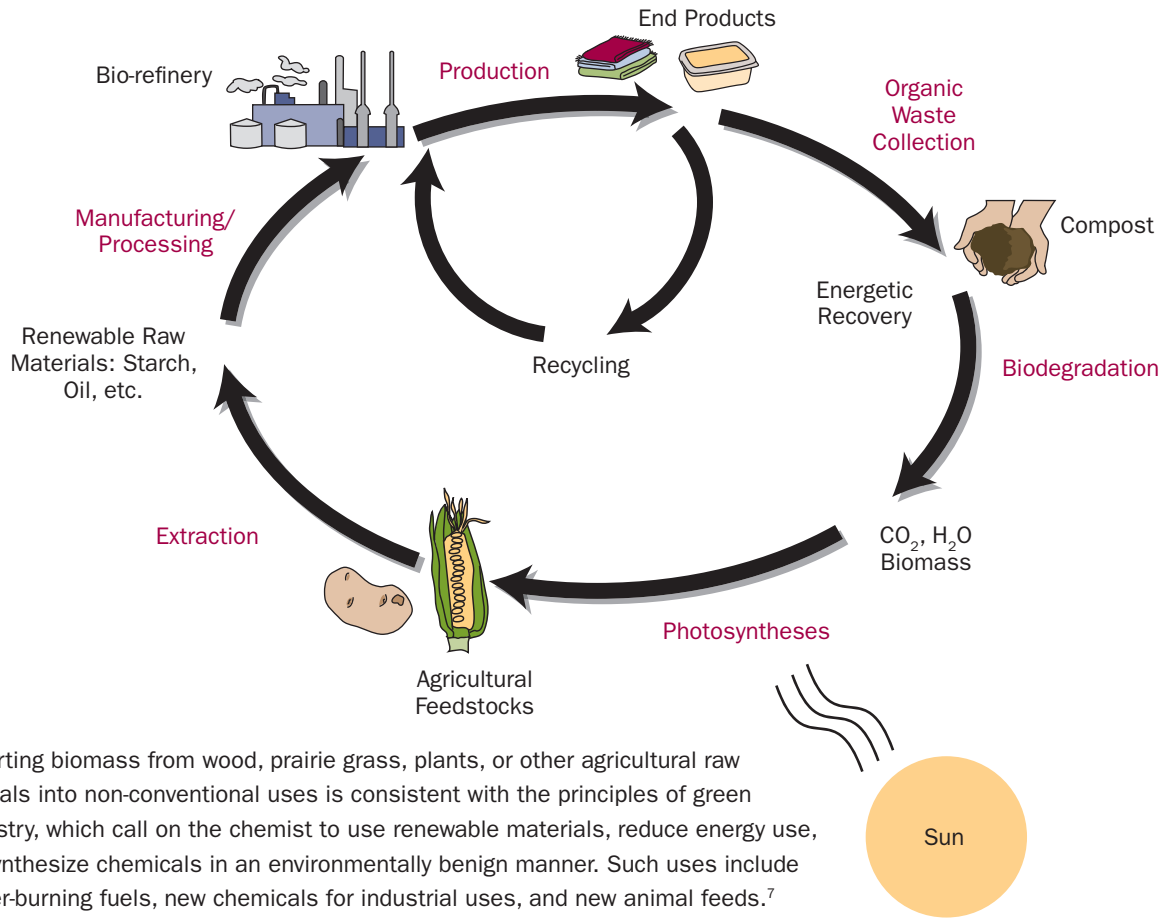
Green Carpets in All Sorts of Places

In 2003, Shaw Carpet won a Presidential Green Chemistry Challenge Award with its carpet tile backing, EcoWorx. EcoWorx replaces conventional carpet tile backings that contain bitumen, polyvinyl chloride (PVC),[11] or polyurethane with polyolefin resins which have low toxicity. This product also provides better adhesion, does not shrink, and can be recycled. Carpets with EcoWorx backing are now available for our homes, schools, hospitals and offices.

Closing the Loop with Green Chemistry

Green Chemistry Principle 7: Use of Renewable Feedstocks

"A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable."



Converting biomass from wood, prairie grass, plants, or other agricultural raw materials into non-conventional uses is consistent with the principles of green chemistry, which call on the chemist to use renewable materials, reduce energy use, and synthesize chemicals in an environmentally benign manner. Such uses include cleaner-burning fuels, new chemicals for industrial uses, and new animal feeds.[7]

These are just a few examples which demonstrate how some companies are integrating green chemistry principles into their product design.[12]

ADOPTING GREEN CHEMISTRY

Consumers and business purchasing departments can promote green chemistry by demanding safer, non-toxic products from manufacturers. This will help give a competitive advantage to those companies who screen the chemicals used in their products and demand safer substitutes from their suppliers. Such demand will also help increase the number of green chemistry courses in universities, training the next generation of chemists to consider life cycle impacts of the chemicals they design. To what degree the chemical industry is actually adopting green chemistry principles is unknown because some of the most innovative examples are proprietary. Rohm and Haas is an exception by detailing how green chemistry principles relate to how some of their products are brought on to the market.[13] Green chemistry awards help publicize the feasibility of green chemistry but much more needs to be done. Governments have a major role in adopting policies that promote green chemistry innovation and implementation in the commercial sector (see *Why Promote Green Chemistry* factsheet). At the same time the chemical industry has a duty to integrate the principles of green chemistry into their manufacturing processes while product manufacturers and retailers have a responsibility to demand chemicals from their suppliers that have been tested and shown to be inherently safe.

"It is within these [green chemistry] principles that true competitive advantage resides."

J. M. Fitzpatrick, Ph.D.
Rohm and Haas International Conference on Green and Sustainable Chemistry
Tokyo Japan, 2003

RESOURCES

- Anastas, P. T., and J. C. Warner (1998) *Green Chemistry: Theory and Practice* Eds. Oxford University Press: Oxford, UK.
- Canadian Green Chemistry Network, *http://www.greenchemistry.ca/index.htm*
- Carnegie Mellon Institute for Green Oxidation Chemistry, *http://www.chem.cmu.edu/groups/Collins/*
- Green Chemistry and the Consumer Network, *http://www.chemsoc.org/networks/gcn/industry.htm#consumer*
- Green Chemistry Institute
- *http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=greenchemistryinstitute%5Cindex.html*
- University of Massachusetts Lowell Center for Green Chemistry *http://www.greenchemistry.uml.edu/*
- University of Scranton Greening Across the Chemistry Curriculum, *http://academic.scranton.edu/faculty/CANNM1/dreyfusmodules.html*
- US EPA, Green Chemistry, *http://www.epa.gov/greenchemistry/index.html*
- Worldwide Universities Network's Green Chemistry Partnership, *http://www.wun.ac.uk/greenchem/index.htm*

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ENDNOTES

1 Environmental and Occupational Causes of Cancer. Collaborative on Health and the Environment. Available at *http://www.healthandenvironment.org/wg_cancer_news/216*; State of the Evidence 2006: What is the Connection between the Environment and Breast Cancer? Breast Cancer Fund. Available at *http://www.healthandenvironment.org/wg_cancer_news/216*

2 Anastas and Warner, *Green Chemistry: Theory and Practice*, 1998

3 Ibid.

4 See Resources section plus visit *http://www.epa.gov/greenchemistry/index.html*

5 Anastas and Warner, *Green Chemistry: Theory and Practice*, Oxford University Press. 1998

6 Ibid.

7 Ibid.

8 The newsletters can be downloaded for free at *http://www.chemsoc.org/networks/gcn/industry.htm*

9 See *Healthy Business Strategies*

10 Sustainable Biomaterials Guidelines available at *www.healthybuilding.net/biopolymers*

11 PVC is problematic for many reasons: it is a petroleum-based material, it is made with vinyl chloride monomer, a known carcinogen, and it produces dioxin (a highly toxic chemical) during its manufacture and when burned.

12 Interface, Shaw and other companies' case examples of green chemistry applications are featured in *Healthy Business Strategies for Transforming the Toxic Chemical Economy* available at *www.cleanproduction.org*.

13 EHA and Sustainability. Rohm and Haas. 2005. *http://www.rohmhaas.com/EHS/pdfs/EHSreport05.pdf*