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## GREEN CHEMISTRY AND GREEN ENGINEERING IN THE US

by

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The U. S. Environmental Protection Agency's Office of Pollution Prevention and Toxics has implemented a program to promote the design of chemical products and processes which reduce or eliminate the use and/or generation of hazardous substances. The Green Chemistry program is designed to work on a voluntary collaborative basis with industry and academia in the areas of research, education, tools development and public outreach and recognition.

The program is based around the idea that the moment a chemist puts pencil to paper to design how a chemical product will be made, he is intrinsically making decisions about:

- What hazardous wastes will be generated.
- What toxic substances will need to be handled by the workers making the product.
- What toxic contaminants might be in the product.
- What regulatory compliance issues are there in making this product.
- What liability concerns are there from the manufacture of this product.
- What waste treatment costs will be incurred.

By putting forethought into the selection of the method of making a chemical product such that all scientific, environmental, and economic

impacts of a particular process are considered, the synthetic chemist can have perhaps the most influence in achieving pollution prevention.

While the concerns listed above have become drastically more important, as well as costly, in the current environmental atmosphere, selection of what methods to choose in making a chemical product still center around the concept of yield. Yield can be roughly stated as what percentage of the starting material ultimately becomes the chemical product. The yield of a synthetic pathway has historically been a reasonable evaluation tool for a method of making a product because it correlated well with the economics of manufacture as well as the kinetics and thermodynamics of the manufacture. In a time where costs of regulatory compliance, waste handling, treatment and disposal, and liability insurance may well be as, or more, significant than the price of starting materials, it may be that sacrificing a little on yield in order to address the other concerns may be more beneficial. In other words, less is more.

In its efforts to promote pollution prevention, the EPA is recognizing the fundamental role of the chemist in designing ways of making chemicals that don't involve the use or generation of toxic substances. The Design for the Environment (DfE) Program in the EPA's Office of Pollution Prevention and Toxics (OPPT) has started several recent initiatives which are designed to support the role of chemists in pollution prevention in industry, academia and government.

**In academia, EPA is:**

- Funding grants for basic chemical research in synthetic methodologies that reduce or eliminate the use and generation of toxic substances in making a chemical.
- Collaborating with the National Science Foundation through a Memorandum of Understanding which provides for support of Environmentally Benign Chemistry through research grants, education and outreach.

**In industry, EPA is:**

- Providing suggestions to industry for alternative methodologies of making chemical products for the companies to consider in a voluntary pollution prevention program.
- Developing technical guidance to the chemical industry on how to review processes for assessing the potential of alternate synthetic pathways to achieve pollution prevention.

**Within government, EPA is:**

- reviewing the potential hazards of new chemicals reviewed by the agency in terms of the human health and environmental impact of the total manufacturing process and investigating alternative chemistry to mitigate the hazards.
- developing and using software which will allow EPA chemists to review the theoretical ways of making a chemical product and evaluate which approach is most environmentally benign.

Recently EPA has initiated an accompanying initiative known as Green Engineering which is working to promote engineering principles in the educational approaches at schools of chemical engineering. Through this mechanism, chemical engineers will be trained to incorporate pollution prevention into their design of new unit processes and systems.