GREEN CHEMISTRY

What Is Green Chemistry?

- "**Green chemistry** is 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." - Paul T. Anastas and John C. Warner, *Green Chemistry: Theory and Practice* (Oxford University Press: New York, 1998)

- "**Green chemistry** consists of chemicals and chemical processes designed to reduce or eliminate negative environmental impacts. The use and production of these chemicals may involve reduced waste products, non-toxic components, and improved efficiency." - Environmental Protection Agency: Introduction to the Concept Of Green Chemistry

- "By providing the scientific basis for a new wave of inherently safe materials, **green chemistry** can stimulate scientific and economic innovation, avoid the unintended health consequences of inadvertently hazardous materials, and contribute to sustainable economic growth and job creation. ... While the principles guiding green chemistry appear to be common sense, they bear little resemblance to the way we do chemistry today. Currently feedstocks are generally non-renewable; products we make and their building blocks often have significant toxicity; many of our substances persist, biaccumulate and biomagnify. We have historically tried to control exposure to hazardous substances in ways that are costly and often fail." - "Green Economic Innovation for the 21st Century: The Molecular Revolution," consensus statement signed by 24 participants at Beckman Center for the National Academy of Sciences, November 2008

Twelve Principles of Green Chemistry

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1. Prevention

It is better to prevent waste than to treat or clean up waste after it has been created.

2. Atom Economy

Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. Less Hazardous Chemical Syntheses

Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Designing Safer Chemicals

Chemical products should be designed to effect their desired function while minimizing their toxicity.

5. Safer Solvents and Auxiliaries

The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

6. Design for Energy Efficiency

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. Use of Renewable Feedstocks

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

8. Reduce Derivatives

Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. Catalysis

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Design for Degradation

Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. Real-time analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Source : http://www.toxipedia.org/display/toxipedia/Green+Chemistry