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Green Chemistry – A Review

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Abstract: ***Green chemistry is chemistry for the safest environment. It is a way of thinking that can help chemistry in research and production to develop more eco-friendly solutions. Green chemistry is considered an important role of a comprehensive program to protect human health and the environment. Green chemistry is a science-based non-regulatory and economically driven approach to achieving the goals of environmental protection and sustainable development.***

Keyword: Environment, Chemistry, Waste

1. Introduction

Green chemistry can be defined as the practice of chemical science and manufacturing in a manner that is sustainable, safe, and non-polluting and that consumes minimum amounts of materials and energy while producing no waste material. The practice of green chemistry begins with recognition that the production, processing, use, and disposal of chemical products may cause harm when performed improperly. Green chemistry may modify chemical products and processes with the objective of reducing wastes and the use or generation of particularly dangerous materials. Far from being economically regressive and a drag on profits, green chemistry is about increasing profits and promoting innovation while protecting human health and the environment.

2. Need of Green Chemistry

It is an innovative way to deal with chemicals before they become hazards, with the goal of making chemicals and products "benign by design." Green chemistry is reduces the use of toxic substances before they contaminate with the environment and human beings. It is a marked departure from the past where society managed industrial and municipal wastes by disposal or incineration. Green chemistry seeks to reduce the toxicity of chemicals in the first place, rather than merely manage their toxic waste after use and disposal. Green chemistry focuses on improving the building blocks of manufacturing the feed stocks and the catalysts used to make things so products can be engineered to be safer, easily reused and not persist in the environment. The use of fewer hazardous substances means healthier air quality, cleaner drinking water and a safer workplace. Green chemistry changes the design of products and industrial processes so they do not threaten human health or the environment.

3. What is Green Chemistry?

Green chemistry is essential to sustainable development because of the inherent focus on how we make things and what products we create as scientists. As a science, green chemistry has been clearly defined since the publication of the book Green Chemistry: Theory and Practice in 1998 by Paul Anastas and John Warner. The subject addresses the heart of the pollution problem and asks molecular designers to consider creating materials and products that are sustainable from the very beginning (i.e., at the design stage). Through this approach, we can ensure that the building blocks that make up our economy are truly sustainable. If these building blocks are sustainable, then the end product will be much more likely to be sustainable as well.

4. Green Chemistry Definition

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.

5. The Twelve Principles of Green Chemistry

Prevent Waste

The ability of chemists to redesign chemical transformations to minimize the generation of hazardous waste is an important first step in pollution prevention. By preventing waste generation, we minimize hazards associated with waste storage, transportation and treatment.

Maximize Atom Economy

Atom Economy is a concept, developed by Barry Trost of Stanford University that evaluates the efficiency of a chemical transformation. Similar to a yield calculation, atom economy is a ratio of the total mass of atoms in the desired product to the total mass of atoms in the reactants. One way to minimize waste is to design chemical transformations that maximize the incorporation of all materials used in the process into the final product, resulting in few if any wasted atoms. Choosing transformations that incorporate most of the starting materials into the product is more efficient and minimizes waste.

Design less Hazardous Chemical Synthesis

Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. The goal is to use less hazardous reagents whenever possible and design processes that do not produce hazardous by-products. Often a range of reagent choices exist for a particular transformation. This principle focuses on choosing reagents that pose the least risk and generate only benign by-products.

Design Safer Chemicals and Products

Chemical products should be designed to affect their desired function while minimizing their toxicity. Toxicity and ecotoxicity are properties of the product. New products can be designed that are inherently safer, while highly effective for the target application. In academic labs this principle should influence the design of synthetic targets and new products.

Use Safer Solvents/Reaction Conditions

The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used. Solvent use leads to considerable waste. Reduction of solvent volume or complete elimination of the solvent is often possible. In cases where the solvent is needed, less hazardous replacements should be employed. Purification steps also generate large sums of solvent and other waste (chromatography supports, e.g.). Avoid purifications when possible and minimize the use of auxiliary substances when they are needed.

Increase Energy Efficiency

Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic and purification methods should be designed for ambient temperature and pressure, so that energy costs associated with extremes in temperature and pressure are minimized.

Use Renewable Feedstocks

Whenever possible, chemical transformations should be designed to utilize raw materials and feedstocks that are renewable. Examples of renewable feedstocks include agricultural products or the wastes of other processes. Examples of depleting feedstocks include raw materials that are mined or generated from fossil fuels (petroleum, natural gas or coal).

Avoid Chemical 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. Synthetic transformations that are more selective will eliminate or reduce the need for protecting groups. In addition, alternative synthetic sequences may eliminate the need to transform functional groups in the presence of other sensitive functionality.

Use Catalysts

Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Catalysts can serve several roles during a transformation. They can enhance the selectivity of a reaction, reduce the temperature of a transformation, enhance the extent of conversion to products and reduce reagent-based waste (since they are not consumed during the reaction). By reducing the temperature, one can save energy and potentially avoid unwanted side reactions.

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. Efforts related to this principle focus on using molecular-level design to develop products that will degrade into hazardless substances when they are released into the environment.

Analyze in Real-Time to Prevent Pollution

It is always important to monitor the progress of a reaction to know when the reaction is complete or to detect the emergence of any unwanted by-products. Whenever possible, analytical methodologies should be developed and used to allow for real-time, in-process monitoring and control to minimize the formation of hazardous substances.

Minimize the Potential for Accidents

One way to minimize the potential for chemical accidents is to choose reagents and solvents that minimize the potential for explosions, fires and accidental release. Risks associated with these types of accidents can sometimes be reduced by altering the form (solid, liquid or gas) or composition of the reagents.

6. Green Chemistry Goals

- Ensure principles of green chemistry are widely used
- Decrease adverse impacts to human health and the

environment via improved design of products and processes
- Promote innovation and economic development
- Improve competitiveness of goods on global market

7. The Benefits of Green Chemistry

Green chemistry and green engineering offer many benefits to scientists, educators, businesses, policymakers, and the public. For scientists, it provides a platform for not only avoiding or eliminating hazards and waste, but also for creating new, innovative, and efficient methodologies. For educators, it can be a tool for inspiring students to pursue scientific careers, providing context to a subject that is often abstract. For businesses, it can help realize cost savings through reduced waste disposal costs and reduced worker liability costs, while offering competitive advantage in existing markets, offering a greater value added to customers, and over all higher innovation potential that leads to the creation of new markets. For policymakers, it is projected to advance opportunities for environmental outcomes that go beyond what is now possible with existing regulatory policies and reduce social conflict around the trade-off between the environment and economic growth. And for the public, it means a cleaner, safer environment, as well as greater economic opportunities.

8. Conclusion

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. Researchers are identifying the barriers within the chemical industry that pre vent or slow the adoption of green chemistry.

Green chemistry awards help publicizes 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. 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. Green economic innovation for the 21st Century will require green chemistry**.**

Great efforts are still undertaken to design an ideal process that starts from non-polluting initial materials, leads to no secondary products and requires no solvents to carry out the chemical conversion or to isolate and purify the product. However, more environmentally friendly technologies at the research stage do not guarantee that they will be implemented on an industrial scale. Adoption of environmentally benign methods may be facilitated by higher flexibility in regulations, new programs to facilitate technology transfer among academic institutions, government and industry and tax incentives for implementing cleaner technologies.

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