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GREEN CHEMISTRY

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ABSTRACT

The expanding progression of industrial development has been a pioneer for world economic growth. Green chemistry has been defined as 'the employment of techniques and methodologies that reduce or eliminate the use or production of feedstocks, products, by-products, solvents, and reagents that are harmful to human health or the environment'. The quality-by-design approach is well-known in the pharmaceutical industry, and it has a great influence on analytical methods and procedures. In the green method of chemistry, the core consideration is directed towards the design of a material or the chemical procedure; four of twelve principles are associated with design, e.g. designing fewer hazardous chemical syntheses, designing harmless chemicals and products, designing for energy effectiveness, and designing for degradation. One of the most active fields of research and development in green chemistry is the establishment of analytical methodologies, leading to the beginning of so-called green analytical chemistry. The Chemistry and the Environmental Division of EuChem has assumed Green Chemistry as one of its areas of interests, but one question to solve is where Green Chemistry should be placed within the context of Chemistry and Environment. The concept of Green Chemistry, as primarily conceived by Paul Anastas and John Warner, is commonly presented through the twelve principles of Green Chemistry.

KEYWORDS: green chemistry, sustainable, environmental, pharmaceutical analysis.

INTRODUCTION

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal.

The aim of green chemistry is to reduce chemical-related impact on human health and virtually eliminate contamination of the environment through dedicated, sustainable prevention programs. Green chemistry searches for alternative, environmentally friendly reaction media and at the same time strives to increase reaction rates and lower reaction temperatures.

The green chemistry concept applies innovative scientific solutions to solve environmental issues posed in the laboratory. Paul T. Anastas, an organic chemist working in the Office of Pollution Prevention and Toxins at the EPA, and John C. Warner developed the Twelve Principles of Green Chemistry in 1991. These principles can be grouped into "Reducing Risk" and "Minimizing the Environmental Footprint."

Definition

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 little or no waste material.

Green chemistry, also called sustainable chemistry, is an area of chemistry and chemical engineering focused on the design of products and processes that minimize or eliminate the use and generation of hazardous substances.

History

Green chemistry was "born" at the beginning of the 1990s when the Pollution and Prevention Act was passed in the United States. The stated that prevention was better than a cure and also recognised that a variety of disciplines needed to be involved to achieve the desired goals. The early developments occurred mainly in the United States, as documented below, but many other countries also developed similar initiatives.

Paul Anastas and John Warner coined the two-letter word "green chemistry" and developed the twelve principles of green chemistry.

In 2005 Ryoji Noyori identified three key developments in green chemistry: use of supercritical carbon dioxide as green solvent, aqueous hydrogen peroxide for clean oxidations and the use of hydrogen in asymmetric synthesis.

Principles

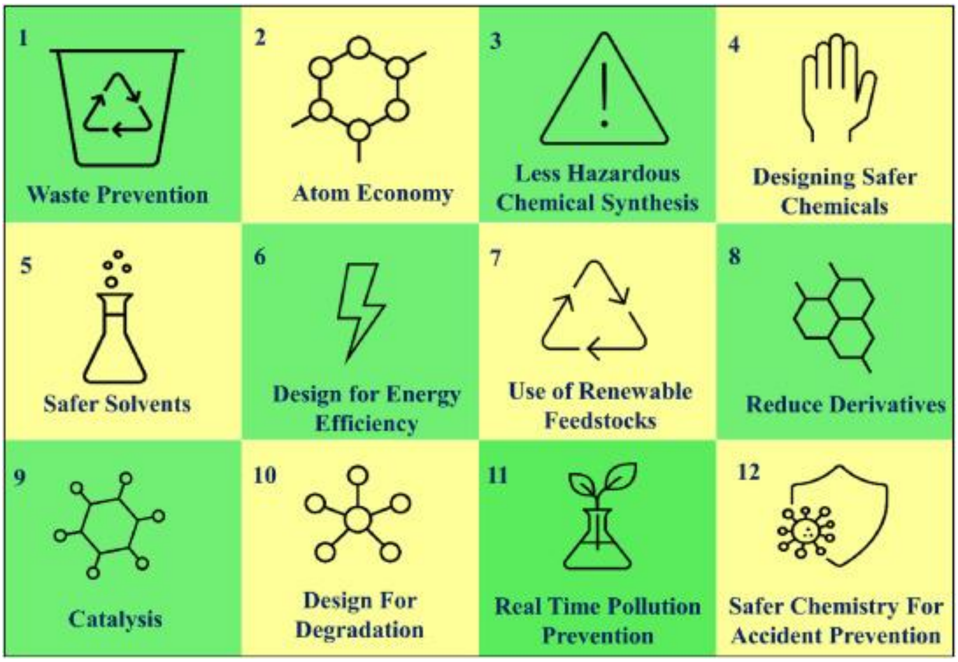

Fig. 1. Twelve Principles of Green Chemistry.

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.

Green Chemistry in pharmaceutical industry

According to the ACS Green Chemistry Institute, "After all of the research advancements in green chemistry and engineering, mainstream chemical businesses have not yet fully embraced the technology. Today, more than 98% of all organic chemicals are still derived from petroleum." As the green chemistry movement continues to influence policy, business practices and consumer perception, companies must find new ways to "go green" while maintaining their bottom line. This is particularly true in the pharmaceutical industry.

Green chemistry nowadays is surpassing the idea of being a sheer lab inquisitiveness into the large-scale pharmaceutical application in industries. However, industries being one of the most dynamic areas, always remain in the forefronts of any substantial changes. These changes in the terms of innovative ideas, conventional feed stocks, safer raw materials, and alternative mechanisms in laboratories at pilot scale seems fascinating to apply in industries.

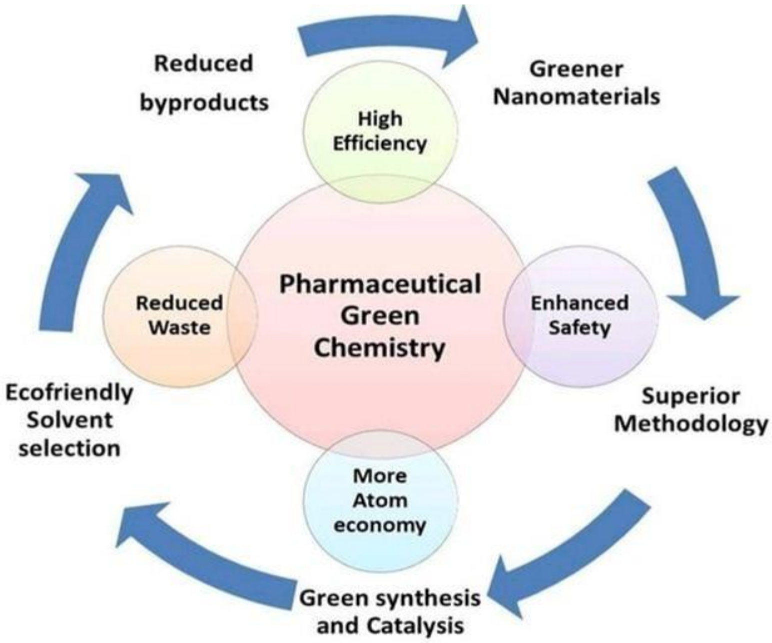

Fig. 2. Representation of the Procedures of Pharmaceutical industries towards Green Chemistry principles.

Advantages

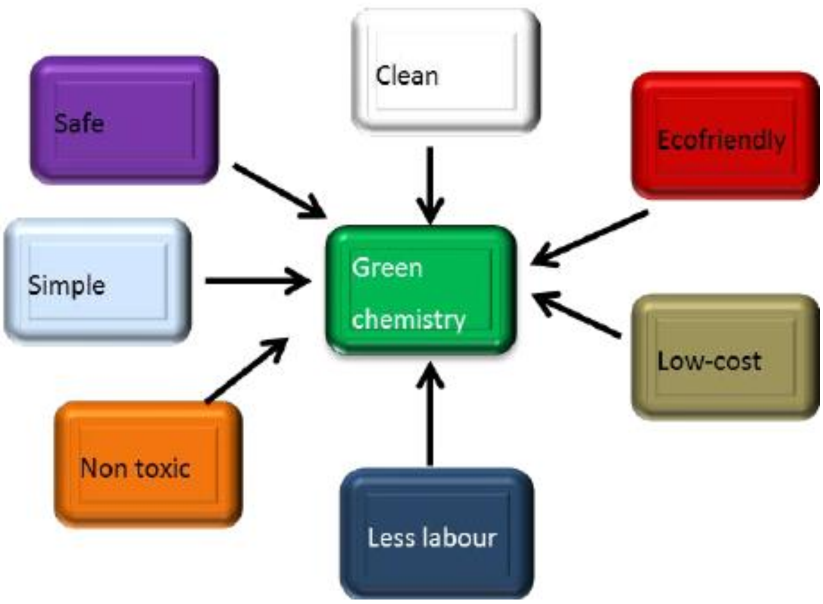

Fig. 3. Advantages Green Chemistry.

- Green Chemistry provides less waste formation.
- In fact Green Chemistry is a new approach to ensure preservation of human health and the environment. Energy conservation and consumption has long been known to produce a major environmental effect.
- Microwave irradiation in the solid state is a technique that is being utilized to affect chemical transformations rapidly, in contrast to those that have classically been conducted in liquid solutions.
- Solvent-free microwave assisted reactions provide an opportunity to work with open vessels and thus, avoiding the risk of high pressure and increasing the potential for scale up of such reactions.
- The practical feasibility of microwave assisted solvent free synthesis has been demonstrated in various useful transformations and in the synthesis of heterocyclic systems.
- If you use the principles of green chemistry in your business and apply clean technology, you could improve efficiency, reduce waste and produce safer chemicals for users.
- It could also help you comply with existing and future legal requirements and a growing list of restricted substances and materials.
- Marketing your improved environmental performance can help you to raise your business' profile and increase sales.

Disadvantages

Fig. 4. Disadvantages Green Chemistry.

- The basic task of green chemistry is designing chemical products and processes that reduce or eliminate harmful substances.
- This goal is also the biggest of green chemistry that is reflected in time, costs and lack of information in specifical, converting from an old, traditional product to a new "green" product, design of a new product and process is often not easy and quite expensive, no known alternative chemical or raw material inputs, also there is a lack of unity on what is considered safe.
- With the high cost of implementation and the lack of information, that will lead to a lack of green chemistry where is no identified alternative in order to used chemical raw materials or alternative technologies for green processes. Moreover, there is also a lack of human skills.
- Ionic liquids are the future of green chemistry. Although there is no doubt that those are valuable in chemical synthesis.
- When applying 12 principles that define green chemicals, ionic liquids do not look principally green. While, as is well known, ionic liquids are slightly volatile due to the low vapor pressure, yet it is only one of the several things that make a substance green.

- For instance, ion-based, fluoro-anion-based and imidazole-based liquids are expected to be poisonous but cannot reach the environment through evaporation. The problem is that most ionic liquids are water-soluble and can simply reach the biosphere via that pathway.

CONCLUSION

The challenges in resource and environmental sustainability require more efficient and benign scientific technologies for chemical processes and manufacture of products.

Green chemistry addresses such challenges by opening a wide and multifaceted research scope thus allowing the invention of novel reactions that can maximize the desired products and minimize the waste and byproducts, as well as the design of new synthetic schemes that are inherently, environmentally, and ecologically benign.

Therefore, combining the principles of the sustainability concept as broadly promoted by the green chemistry principles with established cost and performance standards will be the continual endeavour for economies for the chemical industry.

It is, therefore, essential to direct research and development efforts towards a goal that will constitute a powerful tool for fostering sustainable innovation.

Green chemistry alone cannot solve the pressing environmental concerns and impacts to our modern era, but applying the twelve principles of green chemistry into practice will eventually help to pave the way to a world where the grass is greener.

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