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Review

Future trends in green chemistry

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	Abstract
Published on: 29 Dec 2024	<p>Green chemistry, also known as sustainable chemistry, focuses on designing products and processes that minimize or eliminate hazardous substances, promoting ecological and economic benefits. This article explores the principles, advancements, and future trends of green chemistry, emphasizing its applications in diverse fields such as pharmaceuticals, agriculture, and energy. Green chemistry aims to address critical global challenges like pollution, resource depletion, and sustainability. Through innovations like atom economy, renewable feedstocks, and safer chemical synthesis, green chemistry offers a pathway to a sustainable future.</p>
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INTRODUCTION

Green chemistry, defined as the development of chemical products and processes that reduce or eliminate the use and production of hazardous substances, represents a transformative approach to sustainability. Emerging in the early 1990s with the Pollution Prevention Act and the 12 principles established by Paul Anastas and John Warner, green chemistry integrates ecological considerations into the core of chemical research and industry.

In order to lower the hazards to the environment and public health, green chemistry uses renewable feedstocks, energy efficiency, waste control, and atom economy. The impact of this sector has spread to a number of industries, including consumer goods, energy, agriculture, and pharmaceuticals. By reducing manufacturing costs and increasing process efficiency, green chemistry not only reduces the environmental impact of chemical processes but also opens up new business prospects.

Green chemistry combines tools and procedures that enable chemical engineers' study into the synthesis of chemical compounds and methods to limit or eliminate the usage of harmful chemicals in order to create more

environmentally friendly, efficient products with less waste. It will now have a significant impact on the fertilizer and chemical industries (1).

Aim of "Green Chemistry" to make prolonged molecular existence. Given this goal, it is hardly surprising that it has been used in a variety of business sectors. Green chemistry is the part of environmental chemistry synthesis that have ecological approaches and it involves decreasing or eliminating the use of hazardous and toxic substances to make hazardous chemical compounds(2). Establishment of molecular sustainability is the main ambition of green chemistry method. It is hardly unexpected that it has been used in various industrial areas given this objective from agriculture to the fields of aircraft, automobiles, cosmetics, electronics, energy, home goods, and pharmaceuticals (3).

As a result, green chemistry provides risk-free production of a variety of compounds. It is very difficult for industries and research to develop non-hazardous products under green chemistry(4). A novel approach to produce, process, and using chemicals called "green chemistry" goal to decrease the chances to danger for both human health and the ecosystem, such as (4,5):

- ♣ The Environmentally Benign Chemistry
- ♣ The clean Chemistry
- ♣ The Atom Economy

What is Green chemistry?

Green or Sustainable Chemistry is a term that refers to the creation of chemical products and processes that reduce or eliminate the use and production of harmful substances. The practice of chemistry in a manner that maximizes its benefits while eliminating or at least greatly reducing its adverse impacts has come to be known as green chemistry. As a new branch of chemistry with ecological approaches it involves reducing or eliminating the use of harmful substances in chemical processes as well as reducing harmful and toxic intermediates and products. To be called "green," each reaction should have three green components: solvent, reagent /catalyst and energy consumption. Another aspect of the definition of Green Chemistry is found in the phrase "use and generation".(6-8)

Basic Principles of Green Chemistry

The processes of green chemistry developed to date primarily cover all areas of chemistry, including organic, inorganic, biochemical, polymeric, toxicological, environmental, physical, and technological, among others. Green chemistry is founded on twelve principles that can be used to create or recreate molecules, materials, reactions, and processes that are safer for human health and the environment. Green chemistry is a Hippocratic oath for chemists, and a new generation of scientists and technologists is emerging that economically examines the materials and processes utilized in development and production in order to protect the environment and natural resources. There is no risk if no hazardous materials are utilized or produced, hence there is no need to be concerned about eliminating hazardous materials from the environment or restricting exposure. Green chemistry is a Hippocratic oath for chemists, and a new generation of scientists and technologists is emerging that economically examines the materials and processes utilized in development and production to protect the environment and natural resources. "Green chemistry is about reducing waste, raw materials, risks, energy, environmental impact, and cost." If no hazardous compounds are utilized or created, there is no risk and no need to concern about removing them from the environment or restricting exposure to them.(9)

Principles of green chemistry are

Waste Prevention (G-1): Try to develop such conditions in the process that produces very less waste (side product) generates.

Atom Economy (G-2): A synthetic approach used to be designed to increase the formation of all input substance into finished output. Therefore, such synthetic techniques should be used to transform as many reactant atoms as possible into manufactured goods.

Safe Chemical Synthesis (G-3): This synthetic approach should be planned to utilize and industrialized substances that have low toxicity impact to human being and animal as well as environment.

Designing Safer Chemicals (G-4): It is necessary to develop chemical compounds that affect their essential functions while reducing and eliminating their toxicity.

Safer Solvents and Auxiliaries (G-5): In processes, auxiliary substances like solvents and partition agents should be avoided; however, if they are used, they should be nontoxic materials. In processes, auxiliary substances like solvents and separation agents should be escape; however, if it is used, it should be nontoxic materials.

Design for Energy Efficiency (G-6): In light of the detrimental effects that chemical processes have on the economy and the environment, their energy requirements should be reduced. The best place to carry out synthetic operations is at atmospheric temperature and pressure.

Use of Renewable Feed stocks (G-7): When scientifically and financially achievable, a raw material or feedstock should be renewable rather than finite.

Reduce Derivatives (G-8): Use of blocking groups, protection and temporary modification of physical or chemical processes are undesirable derivatives that should be minimized or avoided whenever possible because they call for additional reagents.

Catalysis (G-9): Catalytic chemicals should be of better-quality to stoichiometric reagents. (which are as selective as feasible).

Design for Degradation (G-10): The chemical compounds should be produced in such a way that they decompose into harmless elements at the end of their use and do not remain in the environment for long.

Pollution Prevention Real-Time Analysis (G-11): Analytical methodologies must be further improved to allow real time while during production monitoring and control before to the production of potentially dangerous chemicals.

Inherently Safer Chemistry for Accident Prevention (G-12): To lessen the possibility of chemical-related events such as explosions, releases, and combustion, the substances and the form of a substance used in a chemical procedure must be identified.

In Pharmacy

Naproxen

A catalyst made of chiral metal the BINAP (2, 2'-bis (biphenyl phosphino)- 1,1'-binaphthyl) a ligand is used to manufacture naproxen with a decent yield and a manageable reaction process (10)

Ibuprofen

The BASF-introduced, more environment friendly technique of synthesizing ibuprofen uses half as many steps as the conventional method. The latest method atom effectiveness is almost two times than previous synthesis. In an attempt to develop sustainable methods, BASF developed the BASILTM (Bi-phasic Acid Hunting Using Ionic Liquids) technology, which generates the common photo catalyst compound alkoxy phenylphosphine (11).

Production of compounds for atorvastatin

Initially ethyl-4-chloro-3-oxobutanoate undergoes applying biocatalytic reduction glucose and keto-reductase to produce useful material that is necessary for the activity of the enzyme, yielding a high-yield product called [S] ethyl-4-chloro-3-hydroxybutyrate. And second stage, halogens are added to the halo hydride to promote the the cyano group has been replaced for the chloro group (12).

Future Trends In Green Chemistry

As it stands, green chemistry has not yet gone mainstream. Green chemistry has the potential to reduce the carbon footprint on the environment by enhancements in solvent technologies, catalysis, and synthetic efficiency. However, the evolution of green chemistry is changing rapidly. The growth of valuechain collaboration is increasing and there are multiple new chemistries being developed. In terms of awareness and education, that too is growing. However, the real challenge for green chemistry is to take the game to the mass market from its current niche form.

The usage of renewable energy sources, waste reduction techniques, some endangered resources, wastes that contaminate the environment, and life cycle analysis have all gained importance in light of the current circumstances. The cost of the product and the production of hazardous materials are decreased via green chemistry. By virtue of its ideas, it advances the pharmaceutical sector and drug corporations towards economic and environmental benefits. It had to do with biology, drugs, etc. By investigating novel processes that produce the Number of products and the fewest hazardous products, it overcomes such difficulties. It makes chemical reactions simpler. In the globalized world, a sustainable future can be built with the help of green science. It offers solutions to issues that people are currently confronting, including global warming, sustainable farming, energy requirements, harmful, and the consumption of organic materials. As an illustration, consider developing new chemicals and procedures for the production and usage of hazardous materials. It offers a unique arena for original study on the potential for other environmentally friendly and sustainable technologies. A field known as "green chemistry" seeks to advance the creation of chemicals and compounds that will protect the environment. The new reality's reaction offers economic advantages to be attained by lowering production costs and conserving energy. The globe should actively participate in the avoidance of pollution in our country and employ using green chemistry as a novel method, we can protect both human health and the environment.

CONCLUSION

Green chemistry offers a promising path toward sustainability by integrating environmental considerations into chemical processes and product development. Its principles promote waste reduction, renewable resource utilization, and safer chemical synthesis, contributing to both ecological preservation and

economic efficiency. As industries and researchers continue to adopt green chemistry practices, its potential to address global challenges such as pollution, climate change, and resource scarcity becomes increasingly evident. The future of green chemistry lies in its ability to innovate and create sustainable solutions for a healthier planet and society.

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