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A Review: Green Chemistry

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Abstract

The capacity to foster or support a process for an extended length of time without jeopardising the needs of future generations is known as sustainability. The term "sustainable chemistry" describes the development of chemical products and procedures that reduce or eliminate the usage and manufacturing of dangerous compounds. Although environmentally friendly and sustainable technologies have advanced in other branches of science, their use in the pharmaceutical sector is still in its infancy. To assure its expansion in the pharmaceutical business, we therefore need to engage in the field of green chemistry. The goal of the current review was to highlight the importance of green chemistry, also known as sustainable chemistry, as well as its concepts and applications in the pharmaceutical sector in order to promote the creation of pharmaceuticals that are friendly to the environment and to minimise or cease the production of Hazardous synthesis-related products and intermediates.

Keywords: Green Chemistry, Green synthesis, Sustainable Chemistry, Pharmaceuticals, Anastas 12 principles.

Introduction

Other names for green chemistry include clean chemistry, benign chemistry, and sustainable chemistry. The fast expansion and progress of the medical and healthcare sectors is being aided by the pharmaceutical industry's and other industries' rapid development.

As a result, fewer people are dying and experiencing pain. But if development is also contributing to the degradation of our environment, what good is it? The various synthesis-related steps involved in the production of chemicals produce a large amount of contaminants, intermediates, and other waste. Without the correct filtration, these undesired waste products are discharged into the environment. As a result, the amount of toxins in our environment increased, which worsened the situation. As a result, more and more individuals are becoming conscious of the environment and attempting to adopt "green chemistry" to safeguard it.

The term "green chemistry" or "sustainable chemistry" refers to the development of chemical products and procedures that reduce or eliminate the usage and manufacture of hazardous materials. It covers decreasing or eliminating the use of dangerous compounds in chemical processes as well as reducing harmful and toxic intermediates and products as a new field of chemistry with ecological approaches.

Brief History

The book 'Silent Spring's' release in the 1960s awakened many people's minds. The scientific book increased understanding of ecological perception and highlighted the dangers of excessive use of natural resources. The book discussed the effects of particular substances on our ecosystem. Launched in 1970, the EPA stands for Environmental Protection Agency. The Stockholm conference, held in Sweden in 1972, was attended by representatives from a large number of nations in addition to UN members. The participants in this conference talked about the environmental harms that lead to the ecosystem's depletion and warned everyone about them. The EPA and the chemical industry focused mostly on pollution and dangerous poisons up until the 1980s. However, as scientists began promoting environmental awareness and looking for ways to prevent pollution, there was a substantial shift among chemists. Meetings were held by the Organisation for Economic Co-operation and Development (OECD), a global organisation comprising around 30 industrialised nations, and recommendations were made based on a cooperative modification of current chemical synthesis procedures and the prevention of pollution. In a paper he wrote in 1999, Paul Anastas outlined 12 green chemistry principles and discussed the significance of the field.

Study Methodology

A. Aim of the review

The purpose of the current review was to highlight the 12 tenets of green chemistry and how they are applied in the pharmaceutical industry.

B. Objective of the review

To comprehend and elaborate on the significance of green synthesis in the pharmaceutical industry.

What is Green Chemistry?

Green chemistry can also be described as

- Sustainable chemistry.
- Chemistry that is benign by design.
- Pollution prevention at the molecular level.
- Pay close attention to procedures and items that lessen or do away with the use of polluting materials.
- All of the above.

• Any synthesis, whether carried out in a classroom, a lab, or an industry, should produce no or as few byproducts as possible that contaminate the atmosphere.

The Benefits of Green Chemistry

- Economical
- Energy efficient
- Lowers cost of production and regulation
- Less wastes
- Fewer accidents

- Safer products
- Healthier workplaces and communities
- Protects human health and the environment

Why Do We Need Green Chemistry?

- Without a doubt, chemistry plays a significant role in our daily lives.
- Chemical advancements provide detrimental unanticipated side effects and new environmental challenges, necessitating the use of "greener" chemical goods. Eg. DDT.
- Green chemistry examines molecular approaches to preventing pollution. Due to the significance of chemistry in the modern world and the effects it may have on the environment, it is a very important field of chemistry.
- The Green Chemistry programme encourages the development of safer and more ecologically friendly chemical processes that limit or even completely stop the production of dangerous compounds.

Principles of Green Chemistry

1. Prevention. Avoiding garbage altogether is preferable to treating or cleaning up waste after it has already created.

2. Atom Economy. Maximising the inclusion of all components utilised during the process into the finished product should be a goal of synthetic approaches.

3. Less Hazardous Chemical Synthesis. When possible, synthetic approaches should be created to use and produce chemicals that are safe for both the environment and humans.

4. Designing Safer Chemicals. Chemical products should be made with toxicity reduction in mind while maintaining function efficacy.

5. Safer Solvents and Auxiliaries. When possible, auxiliary substances (solvents, separation agents, etc.) should be avoided, and when they are utilised, they should be harmless.

6. Design for Energy Efficiency. Energy needs should be minimised because of their negative effects on the environment and the economy. Conducting synthetic procedures at room temperature and pressure is recommended.

7. Use of Renewable Feedstocks. A raw resource or feedstock should, if technically and economically feasible, be renewable rather than diminishing.

8. Reduce Derivatives. Whenever possible, avoid unnecessary derivatization (blocking group, protection/deprotection, temporary change of physical/chemical processes).

9. Catalysis. Stoichiometric reagents are inferior to catalytic reagents, which should be as selective as feasible.

10. Design for Degradation. Chemical goods should be made to degrade into harmless degradation products rather than persist in the environment after serving their purpose.

11. Real-time Analysis for Pollution Prevention. To enable real-time in-process monitoring and control prior to the creation of hazardous compounds, analytical methods need to be further improved.

12. Inherently Safer Chemistry for Accident Prevention. It is important to choose the composition and form of a substance used in a chemical process in order to reduce the possibility of chemical accidents, such as releases, explosions, and fires.

A. Prevention of Waste/By-Products

• Preventing waste and byproducts is preferable to treating or cleaning up waste after it has already created.

• Execute a synthesis in such a way that the production of waste (by-products) is minimal or nonexistent.

• The cost of waste treatment and disposal is added to the overall cost of production.

• The unreacted raw materials are also included in the garbage.

• If discharged, this produces pollution and necessitates spending money on cleanup.

B. Maximum Incorporation of the Reactants into the Final Product/ Atom economy

- Synthetic procedures ought to be planned to maximise the inclusion of all starting ingredients and reagents into the finished product.

- Globally, most scientists believe that a reaction is successful if its yield is more than 90%.

$$\text{percentage yield} = \frac{\text{actual mass of product}}{\text{theoretical mass of product}} \times 100\%$$

Green Chemistry- Ramesh - GEC Kozhikode

$$C_6H_6 + H_2SO_4 + 2NaOH \longrightarrow C_6H_5OH + Na_2SO_3 + 2H_2O$$

(12x6)
+(1x6)
=78

(12x6)
+(1x6)
+16
=88

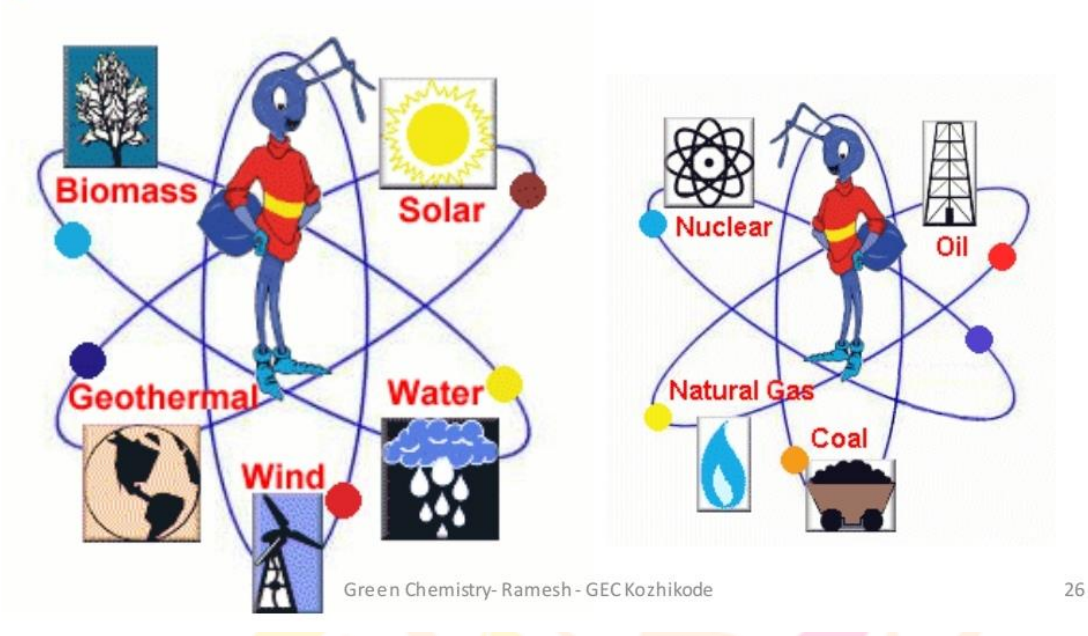
C. Less Hazardous Chemical Synthesis

- Whenever possible, synthetic procedures should be created to use and produce materials that are safe for the environment and human health.
- The synthetic chemicals (dyes, paints) ought to be safe to use.
- Thalidomide was used to decrease the affects of morning sickness and vomiting while pregnant.
- Children born to mothers who used the medication had birth abnormalities, such as missing or malformed limbs.
- Consequently, the use of thalidomide was outlawed.

With the development of technology, it is now possible to create and produce safer compounds.

- **D. Design for Energy Efficiency**
- Energy requirements should be minimised in order to reduce their negative effects on the environment and the economy. Conducting synthetic procedures at room temperature and pressure is recommended.
- The amount of energy needed during chemical synthesis should be kept to a minimum.

The amount of time needed to heat the starting material and the reagents in the reaction mixture to reflux must be kept to a minimum in order to use the least amount of energy.



- The use of a catalyst has the significant benefit of reducing the energy needed for a reaction.
- If the process is exothermic, it may be necessary to cool it down extensively, which raises the overall cost.
- If the end product is impure, it must be cleaned using ultrafiltration, recrystallization, or distillation. All of these processes need energy.
- If the final product is impure, it has to be purified by distillation, recrystallisation or ultrafiltration -All these steps involves energy.
- Energy can be added to a reaction through photochemical, microwave, or sonication Green

✓ Green methods

- The chosen solvent poses no risk to human health or the environment.
- The reaction must be conducted in the aqueous phase.
- The reaction (solventless reactions) must be conducted without the use of a solvent.
- It should be investigated whether liquid or supercritical liquid CO2 can be used. An improved approach is to conduct reactions in the solid phase.
- Immobilised solvents are an option.
- The immobilised solvent keeps the substance solvent, but because it is non-volatile, it shields people and the environment from the dangers of that substance.

Green chemistry in industry

1. Nanoparticles

Nanoparticles are defined as particles with a size between 1 nm and 100 nm. Because they have a vast surface area, nanoparticles have improved characteristics. The real process for creating nanoparticles is dangerous to the environment and poisonous. The disadvantage of the conventional synthesis procedure is that by-products cause the colloidal solution to become polluted. Therefore, green nanoparticle production was created to address this problem.

These nanoparticles may be used for large-scale production and are not only cost-effective but also environmentally benign.

This adheres to some green chemistry concepts, including prevention, less risky chemical synthesis, creating safer compounds, and real-time pollution prevention. Nanotechnology is still in the early stages of development in the pharmacy industry.6 In the past, nanoparticles were created via physical and chemical processes. Large-scale production of nanoparticles is a result of rising demand for them.

In order to create metal nanoparticles, a commercial approach was created. The need for employing clean, nontoxic, and environmentally acceptable methods to synthesise nanoparticles is becoming more and more apparent, nevertheless, as a result of the usage of hazardous solvents or high energy in these techniques.

Nanoparticles produced using green synthesis are more biocompatible than those produced chemically. Utilising environmentally friendly synthetic nanoparticles has three main advantages.

a) Environment friendly8 b) Non-toxic8 c) Cheap

For the creation of nanoparticles, a variety of microorganisms including yeast, fungi, bacteria, plants, etc. can be employed.

Table 1: Examples of microorganisms which are used for green synthesis of nanoparticles

Source	Examples
Yeast	Rhdosporidium diobovatum, saccharomyces boullardii
Fungi	Aspergillus fumigatus, Aspergillus clavatus, etc.
Bacteria	Serratia sp
Plant	Media azedarach, Tridax procumbens, etc.

2. Green solvents

Instead of using standard solvents, green solvents are employed. The use of "safer solvents and auxiliaries" is one of Anastas and Warner's 12 Principles of Green Chemistry. Flammable organic solvents are employed in many synthesis procedures, yet these traditional solvents are poisonous to our environment and harmful to human health. As a result, green solvents are currently replacing traditional solvents in a variety of industries. Excellent solvents are available. A critical factor in ensuring success during a reaction method may be the selection of the proper solvent for the particular reaction. These qualities should be taken into account when choosing a solvent for a reaction.

- Chemical compatibility with reagents and products.
- Solving of reagents.
- Temperature of the method.

3. Water as solvent:

A growing interest in using water as a solvent is a result of the constant development in the demand for a more sustainable approach to synthesis methods. One of the finest solutions in green chemistry to reduce the release of hazardous chemicals into the environment is the use of water as a solvent in chemical synthesis. Reactions are frequently carried out at mild experiment settings using water as the solvent, which allows the catalysts to be reused frequently and lowers the overall cost of the product.

4. Ionic liquids:

In the context of green solvents, we might want to talk about ionic liquids (ILs), which, at least temporarily, are regarded as both designer solvents and green solvents, primarily because they require a negligible vapour pressure and fundamentally don't add to the problem of volatile organic compounds.

5. Glycerol:

Biodiesel and bioethanol synthesis is an example of green technology. Glycerol, a byproduct produced and squandered during the manufacturing of biodiesel, is produced in vast quantities. This glycerol has a tonne of potential uses in the explosive, food, and medicinal industries.

6. Antimicrobial bandages

The covering of wounds or wounded bodily parts is done with bandages. The tissues around the wound and it are supported by it. This adheres to green chemistry's first and twelfth principles. 5 Bandages that promote wound healing are created using a green synthesis of nanoparticles. The bandages are then infused with the nanoparticles. For instance, Tridax procumbens, a weed plant impregnated on bandages that has demonstrated antibacterial action against both gram-positive and gram-negative bacteria, was used to create silver nanoparticles.5 Prosophis fracta and occasional were used to create silver (Ag) and philosopher's wool (ZnO) nanoparticles quickly, cheaply, and environmentally benign. On Acinetobacter baumannii and bacteria of the genus aeruginosa cultures, the minimum inhibitory concentrations (MIC) of these silver and ZnO nanoparticles and mixture thereof, Ag/ZnO, were determined. In the vicinity of the estimated MIC, cotton wound bandages were infused with silver, zinc oxide, and combined silver/zno nanoparticles, and their antibacterial activity was examined in vitro. Each type of nanoparticle demonstrated a high medication activity of the bandages.

Green synthesis of drugs

Drugs are synthesised using green procedures to limit the discharge of poisonous and hazardous byproducts into the environment. For the same, almost all of green chemistry's principles have been used. Preventive measures, atom economy, less risky chemical synthesis, safer solvent, catalysis, etc.

Impacts of green chemistry

1. Pharmaceutical analysis

Currently, laboratories and chemical-pharmaceutical industries must think about green chemistry through analysis and other means as well.

2. Environment

The residues generated in the chemical-pharmaceutical analyzes must be pre-treated before being returned to the environment. However, this process requires a cost that is more expensive depending on the toxicity and hazardousness of the solvent. Acetonitrile, for example, is incinerated and this process generates waste that contributes to acid rain. Even using a process to neutralize the toxicity of the solvent, it negatively affects us otherwise (World Health Organization, 1993). Acid rain damages cars, buildings, monuments, vegetation, rivers, lakes and so on.

3. Population

The population is affected by the current chemistry in many ways and in various ways. The choice of analytical techniques and reagents employed by analysts or chemical-pharmaceutical operators has an impact on patients who commonly obtain their medications from pharmacies or health centres.

4. Analyst

The physical-chemical analyst interacts with pharmaceutical analyses on a daily basis. He is the first person the entire analytic chain has an impact on. The body absorbs toxic solvents like acetonitrile fast, and as a result, breathing becomes impaired when cyanide is produced during metabolism (World Health Organisation, 1997). Methanol is a different illustration that is also beautiful according to pharmacological analyses.

5. Company

Chemical-pharmaceutical companies must increasingly think about green chemistry and/or green analytical chemistry principles, from turning off the light to selecting the reagent to be used in evaluating a pharmaceutical, from interacting with the collaborator to offering team training. Green chemistry must be viewed as a viable concept that spans from a better world to better people, businesses, and social interactions. A business that cherishes this cutting-edge, modern

approach will undoubtedly be successful. There won't be any employees there; only partners. There won't be a chief in it; only leaders.

6. Future

Through the 1972 Stockholm Conference on the Human Environment, the Conference of Nairobi in 1982, the 1992 Rio de Janeiro Conference on Environment and Development, the 2002 World Summit on Sustainable Development in Johannesburg, the 2012 Rio de Janeiro Conference on Sustainable Development, and the 2015 Paris Agreement, world leaders have already started this theoretical process (United Nations, 2017). The "Green & Sustainable Chemistry Conference," which brings together academic and corporate representatives to exhibit work and share ideas and knowledge, is one example of an academic-professional event.

Applications Of Clean Chemistry And Technology In Life

1. Eco-Friendly Dry clean-up of Clothes

Dry cleaning with perchloroethylene (PERC), a carcinogen, pollutes water resources. In order to address this issue, Joseph De Simons, Timothy Romark, and James created Micell, a cleaning agent for clothing consisting of liquid CO2. This method has now being used to create cleaning machines. Additionally, Micell Technology13 has created a metal cleaning system that uses CO2 and a surfactant, doing away with the requirement for halogenated solvents.

2. Solution to Turn Turbid Water Clear

Tamarind seed kernel powder, discarded as agricultural waste, is a good agent to make municipal and industrial waste water clear. The current follow is to use alum to treat such water, but it's been found that alum will increase poisonous ions in treated water and will cause diseases like Alzheimer's. On the other hand, kernel powder is not- poisonous, is perishable, and is cost-effective.

3 .Solar Array

The solar cell is among the most well-known examples of green technology. Through the process of photovoltaics, a solar cell directly transforms the energy in light into electrical energy. By using solar energy to generate electricity, less fossil fuel is consumed, which lowers pollution and greenhouse gas emissions.

4. Reusable Water Bottle

The reusable water bottle is another straightforward product that can be categorised as green. Getting plenty of water is good for you. The environment benefits greatly from reducing plastic waste. Therefore, fashionable reusable water bottles that you can fill yourself are green, eco-friendly, and good for your health.

5. Solar Water Heater

A fantastic approach to reduce energy bills at a much lower initial cost is to install a solar water heater. Compared to the expenditures connected with photovoltaic technology for power generation, the costs of installing a solar water heater are actually recovered far more quickly. This is because solar water heating systems are more cost-effective and efficient than the substantial solar array needed to power a whole home.

6. Wind Generator

A home wind generator can range in price significantly. Using components from their neighbourhood hardware stores, some people have constructed their own wind turbines. Others have added power acquired from their local electrical grid by purchasing kits or paying for professional installation. A home wind generator's ability to produce power varies nearly as much as its original cost. Only 10-15% of your home's energy costs can be offset by several kit-based generators.

7 .Rainwater Harvesting System

Rain collector systems are incredibly straightforward mechanical devices that attach to gutter systems or other rooftop water collecting networks and collect rainwater to be used for irrigation, flushing toilets and other non-potable purposes. These systems are incredibly affordable.

8. Insulation of House

According to EPA estimates, energy loss from inadequate insulation accounts for 10% of annual household energy use. If we seal off our house to stop energy leaking out, we will obtain a great return on our investment.

Summary And Conclusions

Green chemistry is not a newly discovered field of study. It's a novel strategy that will support real estate development by applying and extending the ideas of amateur chemistry. they are used in more than just the exploitation, processing, and synthesis of chemical substances. A number of novel analytical techniques are described that are fully compliant with elementary chemical principles. They are useful for carrying out chemical reactions and for analysing how they affect the environment. We can reduce material waste, maintain the atom economy, and prevent the use of hazardous chemicals by utilising novice chemistry techniques. Pharmaceutical companies and researchers were motivated to take into account green chemistry concepts when developing new procedures and choosing reagents.The idea and application of novice chemistry must be introduced to students at the least intermediate levels.The first word in the Keywords section is "Keywords" in 13-point Times New Roman, bold, italic, and "Small Caps" typeface, with a 6-point space between each word. There can be up to five keywords (or short sentences) in italics of 10 point Times New Roman, separated by commas and six spaces. Line spacing is 18 points.

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