GREEN CHEMISTRY: REDUCTION OF HARMFUL SUBSTANCES IN THE CREATION OF CHEMICAL PRODUCTS

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ABSTRACT:

This Review literature provides an overview of twelve principles and applications of Green Chemistry. It is used in the creation of chemical products and also to reduce the production of harmful thus it is also known as sustainable chemistry. It mainly deals with the reduction of negative consequences and harmful substances from the most frequently used chemicals and chemical reactions. All areas of chemistry, including organic, inorganic, biochemistry, polymer, toxicology, environmental, physical, technological, etc have been developed by the twelve principles of green chemistry .This paper also explain about the applications, advantages and disadvantages of green chemistry in various fields.

Keywords: Green Chemistry, toxicology, biochemistry, sustainable chemistry.

INTRODUCTION:

The development of resource-efficient and sustainable chemical methodologies and processes has become one of the most important goals of synthetic organic chemistry in the 21st century. Various attempts were undertaken to minimize the adverse environmental impact and maximize the efficiency of chemical reactions. As one of numerous advances, multicatalysts, i.e., the modular combination of distinct catalysts for consecutive transformations in a single flask emerged as a highly valuable tool for the construction of complex molecular frameworks from simple and readily available starting materials.

The concept of green chemistry incorporates a new approach 3-8 to the synthesis, processing and application of chemical substances in such manner as to reduce threats to health and environment. This new approach is also known as:

- Environmental chemistry
- Clean chemistry
- Atom economy
- Benign-by-design chemistry

Green Chemistry is commonly presented as a set of twelve principles proposed by Anastas and Warner. The principles comprise instructions for professional chemists to implement new chemical compound, and new synthesis and technological processes.

BASIC PRINCIPLES OF GREEN CHEMISTRY:

The **twelve principles** of green chemistry are:

1. **Prevention**: Preventing waste is better than treating or cleaning up waste after it is created.
2. **Atom economy.** All materials used in the process by synthetic method should try to maximize the incorporation into the final product.
3. **Less hazardous chemical syntheses**. Generating substances which are toxic to human as well as to the environment should be avoided by synthetic methods.
4. **Designing safer chemicals. Chemical substances should be non toxic** and should be designed in a way to achieve their desired function.
5. **Safer solvents and auxiliaries**. Auxiliary substances should be non hazardous when they are used and it should be avoided wherever possible.
6. **Design for energy efficiency**. The process should be conducted at ambient temperature and pressure as well as the energy requirements should be minimised.
7. **Use of renewable feedstock's**. Renewable feedstock or raw materials are preferable to non-renewable ones whenever it is to do practically.
8. **Reduce derivatives**. Unnecessary generation of derivatives should be minimised or avoided if possible, such as the use of protecting groups ; such type of steps require additional reagents and may produce additional waste.
9. **Catalysis**. Catalytic reagents are superior to stoichiometric reagents that are used in small quantities to repeat a reaction.
10. **Design for degradation**. Chemical substances should be designed in such a way that they should not pollute the environment and when their function is complete they should breakdown into non-harmful products.
11. **Real-time analysis for pollution prevention**. To permit real-time, in-process monitoring and control before hazardous substances form, the analytical methodologies should be further developed.
12. **Inherently safer chemistry for accident prevention**

To evaluate the environmental impact of nanotechnology, researches use green chemistry increasingly as a powerful tool. As nanomaterials are developed the process to make them must be considered to ensure their long-term economic viability.

Figure-1:12 principles of green chemistry

The 12 principles of green chemistry in brief are as follows

1. Prevention:

It is the first principle of Green chemistry which tells about the age old proverb prevention is better than cure deals with the prevention of waste production that is unfavourable for the humans and the environment .The harmful organic wastes are produced by some Complex reactions during Harsh reaction conditions toxic reactions and use of improper solvents. The 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.

Exactly 30 years ago, in a factory in Bhopal, water entered the tank E-610, which held 42 tons of Methyl Isocyanate (MIC). MIC is a highly toxic compound with a very low boiling point and can only be stored in stainless steel or glass containers. On reaction with water, MIC violently releases toxic gases, which is what happened in the Union Carbide plant in Bhopal. It instantly started producing the toxic gases, which Killed, more than 2500 people, leading to the worst chemical disaster.

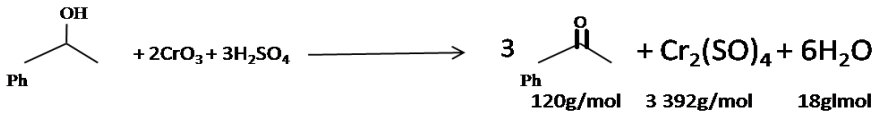
figure:2-Bhopal incident causing 2500 deaths

Organic waste are produced at certain stages of synthesis thus they are called "Dirty reactions" this is due to use of toxic reactants and solvents. The common basic reactions of organic reactions are halogenations, oxidation, alkylation, nitration and sulfonation that are used in different branches in industries. [1]

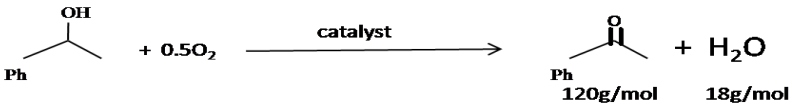
2. Atom Economy:

Atom economy is the second principle of green chemistry. This principle stress on need of synthetic method to maximize incorporation of all materials into the final product used in the process.

$$\text{Atom efficiency} = \frac{\text{Molecular weight of desired product}}{\text{Molecular weight of all substances formed}}$$



$$\text{Atom efficiency} = \frac{3 \cdot 120}{3 \cdot 120 + 6 \cdot 18} = 42\%$$



$$\text{Atom efficiency} = \frac{120}{120 + 18} = 87\%$$

Synthesis of ibuprofen can be done by using this principle of green chemistry[2].

A new "green" method of ibuprofen synthesis was developed in 1990,which involves only three

steps, and results in formation of regenerated products from the transitional materials And this process is one of the processes of "green synthesis" [3, 4].

3. Less hazardous chemical synthesis:

The chemical synthesis must be done in such a way that there should be use of less substance and useful substances that are harmless to the environment and human health. In the multiple-step Chemical synthesis of compounds there is a use of toxic reagents. Thus, these products must be redesigned to prevent contamination [5]

This principle of Green chemistry deals with the use of less hazardous Chemical synthesis and the replacement of these chemical substances with the biological enzymes to make the synthesis non toxic clean and clear an example of this process was applied in the synthesis of polycarbonate which resulted in the replacement of toxic carbonyl chloride solvent carbon dioxide it also removed dichloromethane a harmful solvent in this process. [6]

4. Safer chemicals:

The main aim of this principle of Green chemistry is the reduction of toxicity in the chemical products. The decrease in toxicity by maintaining the function and efficiency is one of the challenging aspects in Chemistry. The balance between optimal performance of the product and chemical product function can be obtained by producing nontoxic or safe substances. This principle of Green Chemistry encourages the chemists to invite new and harmless substance that are decomposable and are environmental friendly. There are many examples of safer chemicals produced from Green chemicals. The production of polymers of poly phenylene sulphone (PPSO) used in the preparation of indoor airplanes. Organic compound known as sea Nina is completely degradable substances which is one of the best examples for this principle of Green chemistry. [7]

5. Safer solvents and auxiliaries:

The unconscious use of solvents and separating agent must be avoided because that causes wastage of large amount of solvents. This type of wastage of solvents is seen in chromatographic process and organic solvents used in this process are usually flammable, corrosive, and toxic and the recycling process of these organic solvents required high energy efficient distillation with considered energy.

The solvents used must be of low volatility, harmless, physically stable and chemically stable easy to use and recycle.

According to the suitability of use, conventional solvents are suitable, usable, and undesirable

Table 1-Solvent selection based on usability [8].

Suitable	Usable	Undesirable
Methanol	cyclohexane	Pentane
Ethanol	methylcyclohexane	hexane
propan-1-ol	heptane	diisopropyl ether
propan-2-ol	isooctane	dichloromethane

6. Design of Energy Efficiency:

Energy requirement in a chemical process which is necessary in majority of the industries .For the minimization of this energy requirement, which is necessary for both environmental and economical basis and it, is done by using ambient temperature and pressure.

Steps used in improving energy efficiency in the chemical industry are

(1)Maintenance and recover

Heat and energy losses can be reduced by good insulation and well-maintained equipment. Fuel for office heating and hot water production can be obtained by converting the waste produced from chemical process that usually contains energy value.

(2) Chemical reactions –choice and conditions

In order to minimize energy requirements it is necessary to choose the reactions and catalysts of low temperatures. Catalysts are developed so that the process can be run at lower temperatures and pressures (high temperatures and pressures require enough energy).

(3) Combined Heat and Power (CHP)

Simultaneous generation of electrical and useful heat energy in a single process from production plants which produces own cogeneration (Combined Heat and Power or CHP). And the excess heat released during the cogeneration process can be used on site for various purposes. [9]

7. Use of renewable feed stock:

According to this principle of green chemistry the purpose for the use of renewable feedstock for technical and economical purpose must be rationalized, especially for the raw materials used in food industry. The biodegradable Packaging of food substances have become new trend in the recent times. The use of solar energy, green energy, hydropower, biomass energy and bio fuels for this packaging and energy purpose is recommended by this principal of Green chemistry. [10]

In the recent times an American country Natural works has manufactured lactic acid bottles as a part of Green chemistry. [11]

8. Reduce derivatives:

Reduction of derivatives is the eighth principle of Green chemistry which deals with the prevention of waste formation. The use of blocking agents make cause unnecessary waste products. This principle of Green chemistry advises the use of biological products for the synthesis of drug molecules it also tells us to avoid the use of unnecessary agents to speed up the reaction and also prevents waste production the use of solvents like acetic acid, water, ethanol, 1-butanol, 2-butanol, acetate etc can be used to reduce the waste. These are known as green solvents. [12]

9. Catalysis:

The use of bio catalyst for industrial application has been increasing rapidly in the past few decades. This cytochrome P450 is available in the form of a pure catalyst and provides energy for microorganisms. The catalysis is a process of decrease in activation energy and speed up the reaction. The stoichiometric reagents are less selective than that of catalytic agents of catalytic agents. Other biodegradable catalyst use less energy and catalyst specific and economical the only disadvantage is the lack of teeth sensitivity and poor stability.

10. Design of degradation:

Degradation the chemical substance is necessary for the prevention of harmful toxicants. This principle of Green chemistry deals with the termination of activities of which converts products into harmful substances in the environment this can be obtained by recycling [13]

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.

APPLICATIONS OF GREEN CHEMISTRY:

1. Chemicals From Glucose:

These are the chemical compounds as the set of chemicals. Glucose is the alternative product of chemicals. To control the fragment compound production the biotechnological strategies are used. The essential or vital compounds include catechol, hydroquinone. The initial material used is benzene. By using benzene amid glucose, the usage of diverse reagent can be lowered, which shows certain toxicity.[14]

2. Polysaccharide polymers:

These are essential group of compounds that includes wide spread of packages. They also have dangerous consequences. The more range of compounds can exploited. As polysaccharide is the far extra environmentally feed stock. Feed stock should be used as the beginning material. Polysaccharide feed stock can be used in place of petroleum feed stock as the polysaccharide. Feed stock is organic and they have the benefit of renewable. As well as these do not cause any chronic toxicity to environment or to human health.

A. Green Chemical Reactions:

(i). Production of aromatic amines which are halide free

By treating benzene with chlorine with the help of nitrogen and then the chlorine is displaced with the new group by nucleophillic substitution aromatic amines can be manufactured. Nitrobenzene is treated with aniline in the presence of tetra methyl ammonium hydroxides to give tetra methyl –ammonium salts.

(ii).Homogenous catalysis and atom economic system: Trost has advanced this system .The main objective of this process is that the useless by products of atom formed during this process can be reduced.

B. As green reagents:

(i). Liquid oxidation reactor:

By this process the oxidation of the organic chemicals with pure oxygen can be carried out safely. This process takes place at low temp. The amount of the vent gas can be decreased due to this low temp.

(ii). Complexes formed by green oxidative transmissions

Other oxidation methods have bad ecological impacts**.** By using the molecular oxygen as the number one oxygen the contamination can be decreased. Many of the ligands have been developed or come ahead in progress that shows strong oxidative decomposition in the oxidizing environment.

(iii). Non-phosgene Isocyanate synthesis: The maximum crucial or the most important polymers are polyurethanes. By using phosgene, polyurethanes can be prepared typically. Phosgene is tremendously (extremely) poisonous gasoline, which is a disadvantages. As it is very harmful or dangerous it may leads to lethal (dead). By using this technique, the poisonous gas phosgene can be kept away. The precursors of polyurethanes & their Isocyanate should be synthesized.[15]

C. Reaction condition for green solvents:

The solvents which are high in quantity and are applicable in a large manner which shows poor impact on human health, such solvents are comfortable and hard to handle. [16]

D. **Manufacturing of Drugs:**

(i).Drugs which are oligonucleotides:

Artificial oligonucleotides drugs have wide range of healing property. Presently by using HL-30 TM at a dose of 90 mmol/a production is carried out. It has numerous characteristics like:

- Non-renewable.
- Non-biodegradable.
- It is single supply raw material. It contributes 40% of raw material fees

E. **Products of green chemicals:**

(i).Other method for designing nitrites:

Different structures of compounds which have toxicity are studied in their process and the changes are done to reduce the toxicity. The mechanism that causes the chronic toxicity is due to the removal of the hydrogen cyanide from cyanohydrins. The functions can be decreased as improved, depending on the nature of the substitution present at the alpha carbon.

(ii). Polyaspartic acids (donlar's):

The soya bean cyst nematode can be managed by using the bio rational techniques. Soya bean cyst nematode fungus is an agricultural hassle. Various glycinoeclepin A Analogous have been developed and tested to find a solution for the bio rational problem. For hatching the soya bean cyst nematode eggs, various analogues have been found which have inhibitory action .These eggs in the woman can last for 11 to 12 days in soil.[17]

PHARMACEUTICAL APPLICATIONS OF GREEN CHEMISTRY:

The environmental performance can be improved by using the knowledge related to Green chemistry[18]my pharmaceutical companies. Green chemistry is engaged in elaborating new and innovative Drug Delivery methods. These methods of green chemistry those are less toxic and more beneficial to patients.
For example:
1. The manufacturing of intermediate separation process of atorvastatin takes place in two steps-
a. In the first step ethyl-4 chloro-3-oxobutanone is reduced with combination of keto-reductase and glucose for the regeneration of the useful substance, which is useful for the enzymatic activity for the formation of the product (S) ethyl-4-chloro-3-hydroxybutyrate with high yield, takes place by biocatalytic method.
b. In seconds step, the substitution of the floor with the cyano group is accelerated by the Halo hydride hydrogenase in the presence of natural catalyst the reaction takes place at neutral P^H and atmospheric temperature.[19]
2. Few workers have invented that with huge or large proportion of drug molecules, the preparation of amines can be done quickly and in an inexpensive manner.[20]
3. In the Industries the manufacturing of wines take space in two steps, the process is very costly and a large amount of by products are coming out as a waste material.
4. On the other hand by washing little amount of catalyst, the reaction can be carried out quickly in one step and also the waste products won't be produced by using the concept of Green chemistry.
5. By using catalyst such as H_2SO_4 , $MgBr_3.OEt_2$, $AlCl_3$,$CaCo_3$, NaOAc,Et_3N the Aspirin synthesis can be done with the microwave irradiation insolvency approach have been designed.[21]
6. The formation of naproxen with chiral metal catalyst containing 2,2 bis(diphenylphosphino)-1, 1^1-binapthyl ligand with fine quality of product and this was described by Anastas et al.[22]

TRENDS IN GREEN CHEMISTRY:
This provides an ample opportunity to demonstrate their inventiveness in the practice of sustainability in the fields of physical chemistry, organic chemistry, biochemistry, geochemistry, physics, engineering and other allied areas to promote awareness and facilitate practice of green chemistry which includes

- Source Reduction
- Incorporate Sustainability early in the design process
- To Create Industrial Processes that Avert Hazard Problems
- Development of Eco-friendly chemicals and materials
- Analysis on the ecotoxicological and environmental effects of biomass processing
- Use of Environmentally Benign Solvent systems
- Generating Wealth from Waste[23]

Industrial Applications of Green Chemistry

- Designing Safer Chemicals Production
- Food & Flavor Industry
- Green Technologies in the Pharmaceutical Industry
- Paper & Pulp Industry
- Polymer Industry
- Sugar & Distillery Industries
- Textile and Tannery Industry
- Green Chemistry in Agrochemicals
- Waste minimization in drug discovery

GREEN CHEMISTRY IN ROUTINE LIFE:

- Bleaching agents. [24],[25]
- Green dry cleaning of clothes.[26],[27]
- To change turbid water into clear green solution.[28],[29]

ADVANTAGES OF GREEN CHEMISTRY:

- Minimise energy usage
- Customization
- Worldwide regulatory data analysis
- Lower levels of chemicals are released to environment
- Cleaner production technologies
- Safer recycling and disposal
- Minimise hazardous waste and by products
- Scarcity of certain raw materials is reduced
- Choice of compatibility ,renewable safe and non toxic reagents

DISADVANTAGES OF GREEN CHEMISTRY

- High implementing cost
- Lack of human resources and skills
- Prolonged time
- Consistency and reproducibility may vary in continuous production
- It is an expensive process.

CONCLUSION:

Green Chemistry is new philosophical approach that through application and extension of the principles of green chemistry can contribute to sustainable development .Presently it is easy to find in the literature many interesting examples of the use of green chemistry rules. Great efforts are still undertaken to design an ideal process that start from non-polluting materials. It is clear that the challenge for the future chemical industry is based on safer products and processes designed by utilizing new ideas in fundamental research. Furthermore, the success of green chemistry depends on the training and education of a new generation of chemists., the more successful chemistry researchers and educationalists will be those that can appreciate the value of green chemistry in innovation, application and teaching (as well as recognizing the important role that green chemistry can play in enhancing the attractiveness of chemistry as a discipline). While many exciting new greener chemical processes are being developed it is clear that a far greater number of challenges lie ahead.

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