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Green Chemistry Plays Key Role in Eco-Friendly, Sustainable Development

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Abstract: *The importance of Green chemistry increased in the global era and in the pace of sustainable economic development. The fundamental principle of "Green chemistry" involves inventing new synthetic methods to produce a product that do not pollute the environment and less toxic to human and other living organisms (1). It is rapidly developing and plays a key role in achieving sustainable development in chemical production, for industrial and pharmaceutical applications. Global thirst for sustainable development through viable economy can be achieved by developing green technologies routed on green chemistry. So that it is important to understand the philosophy of green chemistry while developing new chemical and synthetic process. One must consider the green principles and make sure that their innovation should be according to guideline principles of Green chemistry and thus innovation leads to sustainable and eco-friendly development.*

Key words: Green chemistry, eco-friendly development, significance, sustainable development goals.

1. Introduction:

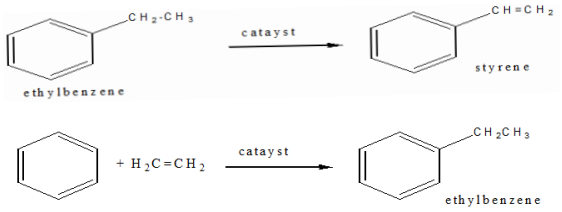
Sustainable Development goals of united nation address the global challenges emerging in the 21st century, the 17 Goals of UN sustainable development are inter connected (2). Especially Goal 3 of SDGs, good health and well-being, Goal 6 of SDGs, clean water and sanitation, Goal 7 affordable and clean energy, Goal 12 responsible consumption and production and 13 climate action, demands new and innovative practices in the industrial development. The study of green synthetic processes, green solvents, green extraction techniques, catalytic process invented by green chemist is very essence of purpose to fulfill the sustainability goals for world of industrial economy

1.1SIGNIFICANCE OF GREEN CHEMISTRY IN SUSTAINABL DEVELOPMENT:

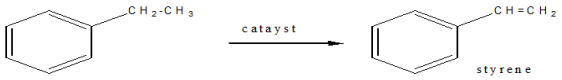
Green chemistry is multidisciplinary research area which involves knowledge from various disciplines like chemistry, chemical technology, biotechnology, molecular biology, ecology, toxicology. Ecological effects of technology use and synthetic processes, toxicity of the chemical production in manufacturing and pharma industry can be reduced by green synthetic process and using green solvents in the chemical production. The inputs from the various disciplines can help while developing new and innovative technologies and green synthetic routes for chemical production. Green (catalyst base) synthesis, solvent free extraction of organic compounds, minimizing the energy consumption in the synthetic process, used for industrial bulk production of chemicals, recyclable and reusable production are some of the best out puts of green chemistry and its applications

The greenness of a chemical synthesis can be evaluated quantitatively and qualitatively. **For example**:1. styrene is conventionally prepared from benzene as starting reactant but benzene is carcinogenic and more volatile aromatic compound (3). To synthesize styrene, we can use xylene as reactant which is cheaper and environmentally safer than benzene

From benzene:



From xylene: Xylene is 1,2 Dimethyl Benzene is known as O-xylene; styrene is obtained by catalytic process. Substitution of ethylene takes place in presence of catalyst (3).

C6H4(CH3)2 ———catalyst————————≥ 

The greenness of the above reaction is qualitative because styrene from xylene is environmentally sustainable with less human health risk. particular reaction. Use of heterogeneous catalyst or use of solid catalyst in liquid phase reaction enables not only easy removal of catalyst but re use of catalyst in the process

Conventionally methylisocyanate (MIC) can be prepared from phosgene (COCl2) and HCl obtained as by product which is corrosive and hazardous, while phosgene is highly toxic. New catalytic synthesis of the same eliminates the hazardous use of toxic chemical phosgene (4).

Conventional method:

CH3 NH2 + COCl2 ————————≥CH3NCO+HCl

(MIC)

Catalytic method:

CH3NH2+CO—***catalyst***——≥CH3NHCHO —*o2*——≥ CH3NCO

E-factor:

E factor is defined as the ratio of mass of waste to mass of product. The greenness of a chemical process quantitatively expressed in terms E factor which was introduced by Roger Sheldon. Ideal E factor of a chemical reaction is 0, achieved in petroleum refining products. Typical E-factor for the production of pharmaceutical lie between 25 and 100(4). The lesser E factor for a synthesis can be achieved by green chemical process in other words the lesser E factor of a process indicates greenness of the chemical process.

Green metrics: Green metrics is the various quantitative techniques to determine the greenness of a chemical process. E-factor, process mass intensity (PMI) (5) are the examples of this green metrics. PMI reflects the total mass of material in a process per mass of product. The ideal PMI is 1, indicating that all reagents are converted into product.

The concept of Green chemistry can be found in wide range of its applications in the Green Materials, Green Bioprocesses, Green Energy, Green Industrial Processes and Molecular Innovations, and Green Policy, Sustainability, and safety. Various industrial applications of chemistry and chemical materials has improved quality of human life, but this achievement has come at a price.

Many inorganic and organic materials cause harm full effects to human, ecosystem and environment. But Green chemistry plays a key role in green and sustainable development through green synthesis and energy efficient process of production, recyclable and reusable material production. Various international organizations working on principles of green chemistry i.e. prevention of wastage, incorporation all material used in the process, designing less hazardous synthetic methods, safer chemicals, biodegradable materials, using of renewable feed stock, more energy efficient process, catalytic process, use of green solvents etc.

2. The twelve principles of green chemistry: A brief review

2.1 Prevention of waste:

The first principle of green chemistry is to reduce the waste in the chemical process is more applicable to pharma industry because the E factor of pharma production lies in the range of E>25kg to 100 drug production releases more wastage in to the environment. Reducing wastage itself more ecofriendly production. "prevention is better than cure" is more appropriate quote in medical field and industrial production.

The more recent advancements in the field of biotechnology, molecular biology and nanotechnology enables us redesigning of drug synthesis, and more effective designing of drug molecule to show its desired action effectively.

2.2 Atom economy:

The atom economy, second principle of green chemistry insist a green chemist to incorporate maximum chemical reactants used in the process to convert into the product. Conversion efficiency of a chemical process in terms of all atoms involved in process. Atom economy can be calculated for a reaction is different from reaction yield. The atom economy of a chemical reaction A+B----->C+D where c is desired product can be shown by

Atom economy=Mass of C/mass of C+D

2.3 Less hazardous synthesis, Design of safe chemicals:

Third and fourth principles of green chemistry indicates to design a less hazardous chemicals or using less hazardous chemicals in the process. In the chemical reaction in a conventional process use harm metal catalyst like Hg(mercury), Pd(palladium) as catalyst. using less hazardous chemicals as a catalyst is more preferable. A part of drug molecule causes toxic effects can be removed by molecular designing without losing its medicinal effect. Computer aided drug designing is recent advancement in the field of drug designing.

2.4 Green solvents:

The fifth principle of green chemistry states use of green solvents in chemical reaction that is using of less hazardous solvents instead of more hazardous one, less flammable instead of more flammable and less toxic to environment and living organism, easy removal of solvent after reaction and recyclable solvents are more preferable. Green solvent extraction techniques are used in the extraction of bioactive molecule from the natural products, where green solvents play a key role.

2.4.1 Super critical carbon dioxide(S-CO_2): 'like dissolves in like' but though it is an inorganic compound, super critical carbon dioxide with unique physical properties like low viscosity and no surface tension can efficiently dissolve a wide range of organic compounds. Supercritical co_2 became an important commercial and industrial solvent

2.4.2 Super critical water: water is best known as universal solvent but many times organic substances or compounds are insoluble in water but soluble when it becomes supercritical water at 647K and 218atm.hence it is known as clean, cheap, green solvent.

2.5 Energy efficiency of reaction, Renewable feed stock:

The sixth and seventh principles of green chemistry states that energy efficiency in chemical process and use of renewable feed stock for a chemical process. In other words, greenness of the process can be determined by the reduction of energy consumed in the process using other alternate process to complete desire reaction. Renewable feed stock use for a chemical process provides no depletion of natural resources.

2.6 Reducing derivatives, use of green catalyst:

Reducing derivatives and by products, eighth principle of green chemistry is reducing waste by reducing byproducts in the process. Heterogeneous catalyst development enables chemist to use a solid catalyst in liquid phase reaction. The advantage of using a heterogeneous catalyst is easy removal of catalyst and re use of catalyst in the process that can reduce the wastage in the process.

2.7 Recent advancement in developing green catalyst:

Chemical reactions through Enzyme based catalysis and use of biocatalyst not only enhances the reaction but provides a green synthesis. “Directed evolution of enzymes" pave the way to design a biocatalyst required for the chemical reaction. Directed evolution of enzyme a new approach in the molecular biology to design desired enzyme through reverse engineering protein synthesis process. It is a revolution in the field of molecular biology and medicine.

2.8 Design for degradation, Real time analysis for pollution prevention:

The designing of chemical products after its use they must degrade into the soil, bio polymers are best example for this principle. Plastic is non degradable but biopolymers can be degradable by bacteria into the soil. The real time analysis of a chemical process, the production of a chemical can be analyzed through real time check, that is use of advanced analytical methods suggested in-process monitoring and control for the prior prevention of pollution through hazardous substances generated in the process

Biodegradability, prevention of pollution in real-time check enhances the green credentials of chemical product.

2.9 Inherently safer chemistry for accident prevention: use of chemical that minimize the potential risk of accidents, explosions are suggested for the chemical process under the research

3. GREEN CHEMISTRY IN SHAPING GREEN INDUSTRY AND REDUCTION OF GREEN HOUSE GASES(GHG`S):

Green industry which means production of industrial materials through green technology, green synthetic process, less energy consumption process, elimination of hazardous products in the production and reducing waste in the production. Hence implementation of Green chemistry and its applications have large scope in industries like manufacturing and pharmaceutical.

The production process of various materials like cement, steel, rubber, textile, paints, dyes, fabrication products, and cosmetic products, which includes use of different chemicals and chemical processes. If we implement the green chemical process in these areas there is a large decrease in waste, and thus lead to pollution free industrialization.

The use of green solvents in manufacturing of laundry detergents, spray cleaners, and other cleaning products for home and industry have been increased, adding these greener solvents improved their performance, for both environmental and human health reasons.

The use of renewable energy, the use renewable feedstock for energy production the production of reusable, recyclable helps in the reduction of environment pollution and protection of natural resources. Pharma industry is the one of the most waste generated area and causes drastic environment pollution. Using Green synthetic process and green solvents in extracting desired molecule from raw compounds, designing a drug molecule with no toxic effect are challenging issues in the drug discovery, however a challenge always take us to explore new ideas. Reducing use of energy in the chemical process and use of renewable energy reduces not only cost of the process and enormously reduces the Green House Gases in to the environment.

Conclusion: Sustainability and viable economy should go parallel then only the thirst of Sustainability and ambition for eco-friendly development, go green objectives can be achieved. To reach sustainable development ambition by year 2030, Implementing green synthetic practices in manufacturing and pharma industry is very essential and need of the hour. Consumers today are increasingly becoming sensitive towards the environment, embracing eco-friendly products with lower carbon footprints. A global report backs this. 66% of consumers are willing to pay more for sustainable products.

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