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Review On General Purpose Of Catalysis In Green Chemistry

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Abstract

Green chemistry, also known as sustainable chemistry, refers to the development of chemical products and processes that minimize or eliminate the usage and production of harmful compounds. They only utilize environmentally friendly chemicals and chemical procedures. It is built on twelve principles that can be used to develop or reproduce molecules, materials, reactions, and processes that are safer for human health and the environment from the ground up. Green Chemistry decreases the environmental impact of chemical processes and technologies, as demonstrated in this article.

The goal of this research is to learn more about the role of catalysts in green chemical synthesis for a more sustainable future. In the ecologically friendly synthesis of novel and existing compounds, catalysis plays a critical role. Catalyzed processes require less energy to produce and produce fewer by-products, co-products, and other waste items, indicating increased efficiency. Catalysts can be created in such a way that they are not harmful to the environment. Catalysts come in a variety of shapes and sizes, and some of them have positive effects in the chemical industry.

Key words- Biocatalysis, Biomass, Ionic Liquids, Critical Fluids, Microwave Irradiation, Photocatalysis, Green Chemistry

Definition of green chemistry-

Green chemistry, also known as sustainable chemistry, is the development of chemical products and processes that reduce or eliminate the usage and manufacture of harmful compounds.[1] Chemical goods should be designed so that they do not persist in the environment after they have served their purpose and are broken down into environmentally friendly components.[2]

INTRODUCTION TO GREEN CHEMISTRY-

In the early 1990s, the concept of green chemistry was originally proposed. The first volume of the well-established green chemistry journal of the Royal Society of Chemistry was published in 1999, and the green chemistry institute was founded in 1997.[3] Green chemistry processes encompass practically all aspects of chemistry, including inorganic, organic, biochemistry, polymer, environmental, and toxicity. The goals of environmental protection and economic benefit can be achieved through several prevailing trends of the green programme, such as catalysis, bio-catalysis, and the use of safety alternatives: renewable feedstock (biomass), reaction solution (such as water, ionic Liquids, and supercritical liquids), reaction conditions (microwave irradiation), and new synthetic pathways (photo catalytic reaction).[4]

Concept of Pharmaceutical Green Chemistry

Pharmaceuticals are the most dynamic segment of the chemical business. It is at the vanguard of major shifts toward "greener" feedstock, cleaner solvents, alternative methods, and new concepts. All of these measures will improve the pharmaceutical industry's environmental credentials while also lowering costs and materials for manufacturing processes, paving the way for long-term sustainability.Green chemistry is a Hippocratic oath for chemists, and a new generation of scientists and technologists is being formed to analyse the processes and materials used in production and development efficiently in order to protect natural resources and the environment. If no hazardous substances are used or produced, the risk is zero, and there is no need to be concerned about removing hazardous substances from the environment or limiting exposure to them. "Green chemistry is about reducing waste, raw materials, risks, energy, environmental impact, and cost," as the phrase goes.[5]

Scientific Areas for Practical Applications of Green chemistry

The areas proposed for special focus under the green chemistry Principles were the following.

1.Use of alternative feedstock

2.Use of less hazardous reagent

3.Use natural processes like biocatalytic techniques

4.Use of alternative solvents

5.Designe of safer chemicals and products.

Green Chemistry's Latest Trends-

The green program's core goals are achieved through many prominent trends in the design, development, and use of chemical products and processes that decrease or eliminate the use or production of substances that are dangerous to human health and the environment."

a. Catalytic and biocatalytic reaction research in order to obtain highly selective, pure compounds without the formation of toxic byproducts;

b. Searching for new raw materials that are both harmless and renewable, such as biomass;

c. Developing environmentally friendly chemicals that are less toxic;

d. Developing and evaluating new non-toxic, renewable reaction media, such as water, ionic liquids, and supercritical fluids.

e. Developing and evaluating new reaction conditions, such as microwave, ultrasound, and light reactions.[6]

PRINCIPAL IN GREEN CHEMISTRY

There are twelve green chemistry principles that have been created By EPA's Paul Anastas and John Warner, who described their significance in practise in their Green Chemistry Theory and Practice book, published in 1998. Green chemistry principles call for the elimination or reduction of dangerous or harmful compounds from the synthesis, manufacture, and application of chemical products, reducing or eliminating the use of substances harmful to human health and the environment.

"Reducing Risk" and "Minimizing the Environmental Footprint" are two of the principles. In the past, various chemical industries have been associated with risk. Hazardous chemicals to humans and the potential of environmental pollution were linked to new chemical products, giving synthetic chemical materials a "bad name." Energy use, climate change, crisis, and depletion of natural resources are all factors in the environmental footprint.[7]

1.Prevention

2.Atom Economy

3.Less Hazardous Chemical Syntheses

4.Designing Safer Chemicals

5.Safer Solvents and Auxiliaries

6.Design for Energy Efficient

7.Use of Renewable Feedstock

8.Reduce Derivatives

9.Catalysis

10.Design for Degradation

11.Real-time analysis for Pollution Prevention

12 Inherently Safer Chemistry for Accident Prevention

What is Catalysis-

Catalysis is a term used in chemistry to describe the process of modifying the rate of a reaction by using a substance that isn't consumed by the reaction.

How it related to green chemistry

Chemical operations produce large amounts of trash every day. Stoichiometric equivalents, in particular, produce undesirable byproducts such as inorganic salts. More efficient catalytic alternatives are progressively replacing stoichiometric chemical methods, allowing scientists to save energy and resources. Moving away from stoichiometric processes and toward homogeneous and heterogeneous catalytic reactions using organic, organometallic, inorganic, and biological catalysts is referred to as greener catalysis.[8]

Role of Catalyst in green chemistry

Green chemistry is an area of chemistry that focuses on the discovery and use of environmentally friendly chemicals and processes . Catalysis is a key component of green chemistry. Green chemistry, often known as environmentally benign chemistry or sustainable chemistry, minimises toxicity. Its objective is to design and execute pollution avoidance solutions other than waste management that reduce waste, save energy, and reduce natural resource depletion. Green chemistry is considered environmentally friendly because it is thought to reduce carbon emissions and pollution. Catalysis has aided in the reduction of pollution in our environment. Catalysts have been used to improve air quality by removing and controlling NOx emissions, reducing the use of Volatile Organic Compounds (VOCsi), developing alternative catalytic technology to replace the use of chlorine or chlorine-based intermediate in chemical synthesis and waste minimization, and developing alternative catalytic technology to replace the use of chlorine or chlorine-based intermediate in chemical synthesis and waste minimization. Catalysis allows for more efficient and selective reactions, resulting in the elimination of vast volumes of by-products: and other waste chemicals.[9]

Types of Catalysis –

Depending on the number of phases in which the catalytic reaction is carried out, homogeneous or heterogeneous catalysis can be used for synthetic processes.Homogeneous catalysis is a single-phase reaction that is usually liquid/liquid, whereas heterogeneous catalysis is a multi-phase reaction. The use of homogeneous catalysts provides a number of advantages, including decreasing reaction temperatures and thereby saving energy.[10]

The following are some of the catalysts:

1.METAL CATALYST – Using well selected metal catalysis can make a reaction more ecologically friendly. Transition metals are frequently utilized as catalysts in reducing reactions like hydrogenation.Metal catalysts can be pure metals or bimetallic or multimetallic mixtures of metals, or they can be spread on solid supports like silica, alumina, or carbon.[11]

2)METAL OXIDE CATALYST- For catalytic oxidation, transition metal oxides have been utilized. In the production of bulk chemicals, molecular oxygen is preferred, whereas in the production of fine chemicals, hydrogen peroxide is preferred. Although more expensive than molecular oxygen, hydrogen peroxide is environmentally friendly because it is converted to water during the oxidation reaction.Because it is transformed to molecular oxygen, ozone is also environmentally friendly, but its generation necessitates particular handling and equipment.[12]

3)METAL COMPLEXES- In homogeneous catalysis, metal complexes are commonly utilised. A transition metal complex was used to synthesise naproxen with a 97% yield under high pressure. Chiral metal complexes catalyse inhomogeneous phase reactions while also controlling the reaction's stereo specificity.[13]

4)BIOCATALYSTS- Enzyme and antibody catalysts are used in both homogeneous and heterogeneous systems.

•ANTIBODY CATALYSTS- Another form of biocatalyst that is frequently employed is antibody catalysts. Antibody specificity and selectivity are related to the antigen structure required to elicit an immune response.

•ENZYME CATALYSTS- Selectivity is one of the most notable characteristics of enzyme catalysts. They are regioselective, which means they can distinguish between several identical groups within the same molecule. Enzyme catalysis can take place in both aqueous and non-aqueous solvents, including supercritical fluids.[14]

Solid acid and bases As catalyst-

Acid and base catalysed reactions are important in the oil refining and petrochemical sectors, as well as in the production of a wide range of speciality chemicals like medicines, agrochemicals, and flavors and perfumes. In liquid-phase homogeneous systems or on inorganic supports in vapour phase systems, many of these processes require the use of conventional Brnsted acids (H2SO4, HF, HCl, p-toluene-Sulfonic acid) or Lewis acids (AlCl3, ZnCl2, BF3). Similarly,NaOH, KOH, NaOMe, and KOBut are examples of common bases. As a result of their subsequent neutralisation,The formation of inorganic salts that eventually find their way into aqueous streams.[15]

Additional advantages of using solid acids and bases as catalysts include:

-Separation and recycling are made easier, resulting in a faster process and lower production costs.

-Solid acids, such as H2SO4, HF, are safer and easier to handle than their liquid equivalents. Very corrosive and necessitates the use of costly construction materials

-Trace levels of (neutralized) catalyst contamination in the product are often avoided.

When the latter is a dependable.

-Granular chemicals are safer and easier to operate than their liquid counterparts.

Solid Acid Catalysis –

One of the most important applications of heterogeneous catalysis is in acid-catalyzed processes. Solid catalysts are utilised in a wide range of applications. Acidic Clays, zeolites, supported heteropoly acids, and mixed oxides like silica–alumina and sulfated zirconia are among them.Hybrid organic–inorganic materials, such as mesoporous oxides, and organic ion exchange resins Organic sulfonic acid moieties are suspended in the air.[16]

WITH A SOLID BASE

There are much fewer examples of reusable solid base catalysts in use than there are for solid acids.This is most likely due to the fact that acid-catalyzed reactions are far more common in the manufacture of Substances that are widely available. The different types of solid bases that have been reported are similar.Anionic clays, basic zeolites, and anionic clays are all alternatives to the solid acids detailed in the preceding sections.Mesoporous silica grafted with organic bases pendent.[17]

Catalytic C–C Bond Formation

Another important transformation in organic synthesis is the production of C–C bonds, and carbonylation is an important catalytic technique for producing C–C bonds. It's utilised in the bulk chemicals industry to make acetic acid by catalysing the carbonylation of methanol with rhodium and since they are 100 percent atom efficient, they are increasingly being used in fine chemistry.Manufacture of chemicals The Hoechst-Celanese method, for example, is a beautiful illustration of this.Manufacturing of the analgesic ibuprofen, with a production capacity of several thousands of tonnes per year.[18]

TECHNOLOGY OF ENZYMES IN BIOCATALYTIC REDUCTION

Reductions are important in organic synthesis because they lead to chiral compounds with new functionalities.Such processes can be catalysed by enzymes with exceptional stereo-, regio-, and chemoselectivity, resulting in The path to not just high-added-value but also shorter classical synthetic pathways Compounds, as well as bulk chemicals, are available.Enzymes, nature's catalysts, offer nearly limitless access to a wide range of chemical reactions.Reactions. Reductions in particular can result in the formation of not just multiple chiral centres, but also multiple chiral centres.But also new functional groups in products that are in high demand in the pharmaceutical and fine chemical industries.[19]

Are Biocatalytic Reactions Green?

Today, the statement "biocatalysis is intrinsically green" has become a mantra for many Researchers.First of all, researchers should be aware that no chemical transformation (including Biocatalytic reactions) is green, as in all cases resources are consumed and waste is generated, Thereby putting a burden on the environment. We believe that a given reaction of methodology can Be greener than another reaction. Such a comparison, however, should be based on quantitative Data rather than on general statements. Comparative full life cycle assessments (LCA) represent The "gold standard" for such comparisons, but are usually time-intensive due to the large data basis Required for a meaningful comparison. Sheldon's E-factor6 and possibly its derivative, the E+-Factor, taking energy-related CO_2 emissions into account,7 represent an acceptable alternative for The preparative chemist.[20]

Conclusion

There is a need to update or adapt traditional procedures that are not environmentally friendly, use dangerous solvents, and are not atom specific in the sense that they do not follow green chemistry principles. This could be beneficial to students' safety while also being environmentally sustainable. For the first time, a new approach has been established. IN organic synthesis, non-conventional approaches are used. Catalysis is crucial in the environmentally friendly synthesis of compounds. By substituting an environmentally friendly synthetic approach for a standard synthetic pathway, several by-products, co-products, possible wastes, and pollutants can be avoided. The reduction of a number of steps that normally occur during synthesis shows the possibility for catalyst to be employed for environmentally friendly synthesis. The use of catalysts in chemical synthesis can be quite beneficial. Inventing environmentally friendly technology and producing ecologically friendly chemicals.

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