iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** XII **Month of publication:** December 2022

DOI: https://doi.org/10.22214/ijraset.2022.48373

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XII Dec 2022- Available at www.ijraset.com

Role of Green Chemistry in Organic Synthesis and Protection of Environment

Ananya Das[1], Abir Sadhukhan[2], Soumallya Chakraborty[3], Somenath Bhattacharya[4],
Dr. Amitava Roy[5], Dr. Arin Bhattacharjee[6]
[1, 2]Student, [3,4]Assistant Professor, [5]Professor, [6]Principal
Department of Pharmaceutical Technology, Global College of Pharmaceutical Technology, Nadia, West Bengal, India

Abstract: Nowadays green chemistry plays a vital role in organic chemistry. It minimizes the effect and use of hazardous substances on the environment and human health. The main goal of green chemistry is to use of green solvents (PEG, water, acetone, alcohol) eliminate the toxicity, uses of small quantity of catalyst and minimize the potential for chemical accident during work. Green chemistry is one type of chemistry where main focus is to eliminate or minimize the hazards by applying suitable process and raw materials. So it is more effective to pharmacists or chemists for avoiding this bad impact on human health, environment. Green chemistry also known as sustainable chemistry. Green chemistry is always interesting matter to pharmacists as well as chemists for synthesis pharmaceutical products. Green chemistry brings a new path for synthesizing safer chemical products. For manufacturing pharmaceutical products by using green chemistry, there have many criteria or methods that should be followed for synthesis chemical products during manufacturing condition. Some of these are prevention waste, Atom economy, less hazardous chemical syntheses, designing safer chemicals, safer solvents, design for more energy efficient chemical, use of renewable feed stocks, reduce derivatives in any compounds, catalysis, design for degradation, real time analysis for pollution prevention, inherently safer for accident prevention, etc. These methods should be considerable before synthesized chemical products by applying green chemistry for eliminating or minimizing hazardous in chemical products during synthesis.
Keywords: Green chemistry, Green solvents, Toxicity, Chemical accident, Biocatalysts, Enzymes, Degradation, Environment.

I. INTRODUCTION

Chemistry is the interesting part in science from the beginning of the 17th century. Here have different types of molecules, compounds, complexes that show variety of properties in physical and chemical that should be known before handling of such chemicals. Sometimes hazardous occur during manufacturing times. In such case we need to apply green chemistry for avoiding of such difficulties or maximizing yield of products. So, green chemistry has a great significance in chemistry [1-2].

The definition and concept of green chemistry was projected by Anastas and Warner. Green chemistry is a set of principles that reduces or eliminate the use and production of hazardous materials in the manufacture cum application of chemical products. Paul T. Anastas is an American scientist, the Administrator for EPA's office of research and development (ORD) widely known as "Father of green chemistry" for his contribution in the field of chemistry [1-3].

II. HISTORY OF GREEN CHEMISTRY

The green chemistry concept was formally developed at Environment protection agency in response to pollution prevention Act (1990). The concept was originated by Trevor kletzin in his paper (1978) where he proposed that chemists should seek processes for environment. In 1991, Paul T. Anastas coined the term Green Chemistry for first time. Paul T. Anastas is called as father of green chemistry [1, 3-4].

III. CONCEPT OF GREEN CHEMISTRY

The concept of 'green chemistry' first introduced by Anastas in 1991 in a program organized by US Environmental protection agency (EPA). Green chemistry show a new way to the synthesis and application of chemical substances without producing any waste as a pollutant. Green chemistry is a set of 12 principles which mainly focused of protection of environment from pollution, use of non- toxic solvents, raw materials from renewable resource, biocatalysts. Now pollution and global warming is a serious problem in our daily life. As the number of industries increase the level of pollution increase simontensouly.

And because of increasing the environment concerns, green chemistry became much more important. Chemical industries are now interested in this processes which are eco-friendly, much more economical, easier to undertake. Use of some solvents which are recoverable such as water, acetone, methanol, etc., have remarkable importance in green chemistry and known as green solvents [1,5-8].

IV. TWELVE PRINCIPLES OF GREEN CHEMISTRY [1,2,5-9]

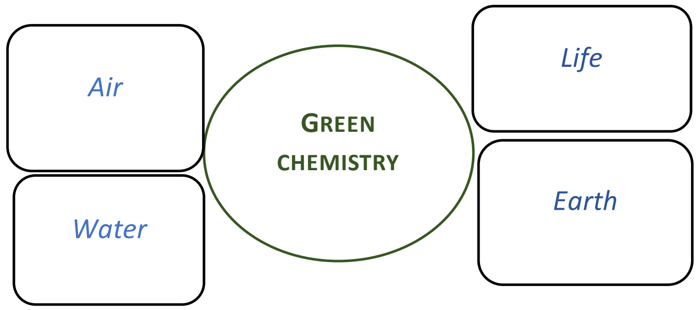

Figure: Aspects of Green Chemistry [1,5,10]

A. Prevent Waste

Prevention of waste is better than to clean up waste after it has been generated. It also reduces the risks associated with waste and reduces the harmful effect of it on animal life and environment [5,6,11].

B. Atom Economy

In one word atom economy is the final product contains maximum proportion of the starting materials. Atom economy improves the reaction processes by reducing the waste of atoms from reactants to products. It is the ratio of "the mass of desired product" by "the total mass of products" and can be expressed by percentage. The concept of atom economy was developed by American chemist Barry Trost and is represented as follows:

Percentage of atom economy = (Mass of desired product)/(Total mass of all reactants) × 100

For example, Propane is obtained from the catalytic hydrogenation of propene at high temperature, where the atom economy is 100 % [4,12].

C. Design Less Hazardous Chemical Syntheses

There are many chemical products which are not only harmful but also produce toxicity when disposed of. But it is possible to reduce the injurious effects by using alternative eco-friendly feed stocks. This method of synthesis and generated substances possess no harmful effect on environment and human health. Chlorine is essential in many plastics and chemical industries nowadays for making plastics. The mercury cell process was used to make chlorine in the past. But the waste product of mercury has a worst effect on human health and environment. The mercury cell-based chloro alkali process is the cause of minamata disease that struck Ontario in 1970 and severely affect native communities. Now the use of cellulose-based technology has used and the used of mercury cell decreased. It minimized the emissions of mercury in environment. An American agricultural biotechnology and agrochemical corporation, The Monsanto company developed a method for producing polyurethanes which eliminate the use of Monasto Company has developed a method of phosgene [12-13].

D. Designing Safer Chemicals

Solvents have an important role in most of industry like pharmaceutical industry, chemical industry. It is not possible to avoid the use of solvents in all cases. For this reason, we can try to replace the toxic solvents with some others which are safe and non-toxic. As a case study in 2019 a cost-intensive ionic liquids are used as a solvent in alkylation of isobutene by China petroleum and Chemical crop. They made high-quality alkylate in the industrial scale [14].

E. Safer Solvents And Auxiliaries

Solvents have an important role in most of industry like pharmaceutical industries. It is not possible to avoid the use of solvents in all cases. In many synthetic process solvents is required in a large volume.

For this reason, we can try to replace the toxic solvents like benzene, carbon tetrachloride, formaldehyde, etc., with some others which are safe and non-toxic. Carbon tetrachloride evaporated easily and creates air pollution. Benzene and formaldehyde are also harmful for human population. Now carbon tetrachloride had been substituted by chloroform while benzene had been substituted by toluene.

Table: List of some replacing solvents [15-18]

Solvents	Adverse effects	Replacing solvents
N,N-dimethyl formamide	Toxicity	Acetonitrile
Benzene	Carcinogenic	Toluene
Hexane	Toxicity	Heptane
Pyridine	Carcinogenic	Triethylamine
n-pentane	Low flashpoint	n-heptane

As a case study in 2019 a cost-intensive ionic liquids are used as a solvent in alkylation of isobutene by China petroleum and Chemical crop. They develop a large-quality of alkylate product that triggered in the industrial scale [3-4, 15].

F. Design For Energy Efficiency

Green Chemistry deals with that chemical synthesis routes where need less amount of energy in reaction steps and also avoiding heating, cooling, vacuum condition in chemical synthesis routes. Requirements of energy should be recognized for their environmental effects. Synthetic methodologies should be applied at room temperature and pressure. There are so many reactions which need high temperature and pressure. But green chemistry shown us several ways to avoid these conditions like microwave chemistry, sonochemistry and so on. Uses of catalysts are also able to reduce the energy requirement of some chemical reactions. Now the use of microwave-heating process is applied for some organic reactions like intramolecular hetero-Diels-Alder cyclo addition of alkenyl-tethered 2(1H)-pyrazolines, cyclotrimerization reaction of diyne, etc. Some azoheterocycles i.e. pyrrole, indole, carbazole, react quickly with alkyl halides to give N-alkyl derivatives under microwave conditions [6-7, 16-17].

G. Use Of Renewable Feed Stocks

It is better to use the chemical products which are made from renewable resources (example, agricultural products) rather than other equivalent chemicals. Green chemistry led to switch to use of biomass as a feedstock and a source of energy. Plant based products are in large quantity in nature and is a suitable resource for producing bioproducts and biofuels. For example, Dicarboxylic acid produced from petroselinic acid which is a fatty acid occur naturally in several vegetables and animals fats and oils. Now the use of biodiesel as an alternative source of fuel has increased tremendously as a result hazardous emission of motor vehicles decreased. Biodiesels are not toxic and biodegradable in water. With a flash point of 160° C, biodiesel is classified as a non-flammable liquid and this property safe the motor vehicle from such accidents when compared to gasoline and petro-diesel [8-10, 18].

H. Reduce Derivatives

The use of temporary derivatives such as protecting or deprotecting groups, modification of physical or chemical processes should be avoided if possible. There are such steps in many chemical reactions which require additional number of reagents and can produce waste [9,14,19].

I. Catalysis

Catalyst plays an important role in green chemistry. Stoichiometric reagents are the primary source of waste. But the use of suitable catalyst can minimize the waste, increase the selectivity of reaction and reduce the time of reaction. Biocatalysts (enzymes) are the natural substances derived from biological sources are biodegradable. There are so many advantages of biochemical reactions like they are stereo selective, chemo selective. For example, Fumarase enzyme is used for obtaining malic acid by hydration of fumaric acid. Penicillin is converted into 6-APA by the enzymepenacylase [10,13,18-20].

J. Design Chemicals And Products That Degrade After Use

Chemical products should be designed so that during the time of work chemical should be stable and after the work they can degrade easily and degradation products are non-toxic and not harmful for human life.

As an example, linear sodium dodecylbenzene sulfonate (SDBS) is used as a detergent which is less toxic and readily break down into small molecules and the process in eco-friendly also [8-9, 20-21].

K. Analyze In Real Time To Prevent Pollution

Live monitoring of chemical reaction helps us to understand the real situation of the reaction. Real time analysis is an important part in chemical and allied industries to prevent the formation of any polluting substances and reduce the chances of potential threat to various probable hazards. It ensures the ultimate safety of environment and animal life [6-9, 21-22].

L. Minimize The Potential For Accidents

The ultimate aim of green chemistry is minimizing the risk of accidents. Chemicals which are used should be safe and inherently minimized the risk of accidents. It can protect industries and laboratories from accident and reduces the hazards [7-10, 22-25].

V. CONCLUSION

Pollution is now a big problem in front of us which affect environment and human health also. The concept of green chemistry is based on 12 principles helps to reducing harmful substances produced from many synthetic processes in chemistry. It is not possible to apply all 12 principles at the same time but it attempts to apply some principles at certain stages of reactions. The ultimate goal of green chemistry is to maintain economical balance and to protect the environment from chemical hazards. Some examples are as use of biocatalyst (enzymes), green solvents (water), alternative reaction conditions (i.e. microwave activation), etc.

Conflict of Interest: Nil

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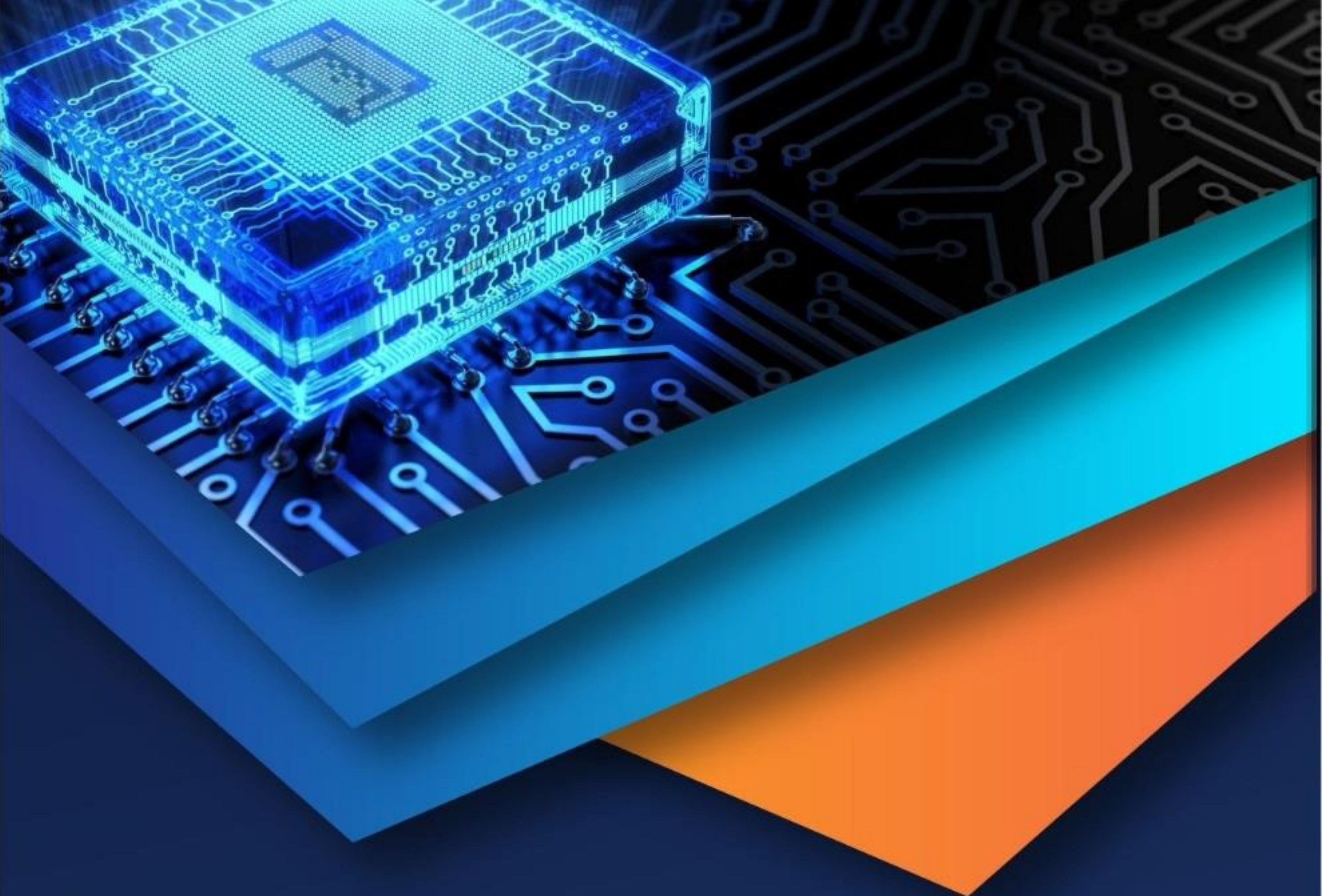

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