The Use of Green Chemistry Approach in Organic Synthesis and Recent Developments

Dr.A.Dharma Reddy

Associate Professor,

Department of Chemistry, C.K.M. Arts and Science College, Warangal

Abstract:

In many areas, including the use of green solvents, solvent-free synthesis, sustainable catalytic materials, reduced energy consumption, and improved atom economy, the idea of green chemistry introduced the environmentally friendly synthetic protocols for the synthesis of heterocycles.

The majority of researchers are interested in green chemistry, one of the most significant study areas. Green chemistry can lessen the environmental harm caused by the use of dangerous chemicals in chemical synthesis. The use of green chemistry in organic synthesis is preferred due to the rising environmental protection concerns. Green chemistry employs its own concepts that are related to the environment and decrease the usage and production of potentially dangerous compounds during synthesis. The use of greener solvents, getting rid of toxic byproducts, and maintaining atom economy are the three pillars of the green chemistry method.

Keywords: Green Chemistry, Greener solvents, Atom economy etc.

Introduction:

By developing novel reactions that can maximise desired products and minimise byproducts, creating new synthetic schemes and apparatus that can streamline operations in chemical productions, and other methods, green chemistry for chemical synthesis addresses our future challenges in working with chemical processes and products.

Different chemical reagents are used in the chemical industry to start organic processes. These industries' runoff immediately contaminates the environment by mixing with potable water. As a result of the attention that pollution has garnered from so many researchers, a new idea known as "green chemistry" is presented.

The neighbourhood has been exposed to toxic and dangerous chemicals throughout the last few decades. Different chemical reagents are used in the chemical industry to start organic processes. These industries' runoff immediately contaminates the environment by mixing with potable water. As a result of the attention that pollution has garnered from so many researchers, a new idea known as "green chemistry" is presented.

The major goal of green chemistry is to replace harmful solvents with more environmentally friendly ones and to use synthetic approaches for separation, purification, and purging that don't use any kind of solvents. Solvents play a significant role in the synthesis of organic compounds; they serve as a liquid medium for the reaction and are also necessary for the extraction, purification, and drying of chemical products. The majority of organic solvents are toxic and dangerous, which causes issues for the environment. The high exposure and sustained usage of hazardous solvents causes a variety of occupational illnesses, including carcinogenicity.

Guidelines for green chemistry:

Green chemistry seeks to develop a new chemical process while also eradicating the toxic and hazardous waste produced at the beginning of the chemical process [3]. Researchers can use the following twelve green chemistry concepts to put green chemistry into practise.

Figure: Principles of Green Chemistry

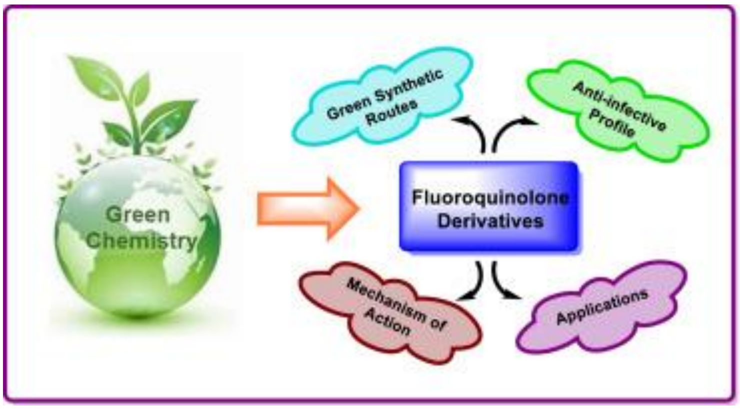
Prevention: It is most important for a chemist to carry out organic synthesis by following pathway so that generation of hazardous or toxic waste is prevented. By preventing generation of toxic substances we minimize the hazards of waste storage, transportation and its treatment.

Atom economy: In order to find out the efficiency of organic reaction or chemical transportation, the concept of green chemistry is introduced by Bary Trost of Stanford University. Green chemistry is the ratio of total mass of atoms in desired product to the total mass of atoms in the reactant.

$$\textbf{Percent atom economy} = \frac{\text{Mole. Weight of desired product X 100\%}}{\text{Mole. Weight of all reactant}}$$

To minimize the hazardous or toxic waste, the chemical transformation is designed in such a way that it utilizes all the materials used in the reaction to convert into the final product resulting in few wasted atoms.

Design less hazardous chemical synthesis: In organic transformation, synthetic methodologies should be designed in order to use and generate substances that possess little or no toxicity to human health and environment. For a particular transformation number of reagent choices exists. This principle mainly focuses on the selection of reagents that cause least risk and generate only useful by products.



Design safer chemicals and products: Due to chemical toxicity the designing of safer chemicals is mostly essential. There is the existence of correlation between chemical structures i.e. presence of functional groups and the existence of toxic effects. The new products can be designed that are inherently safer while highly effective for target application.

Use of safer solvents /auxiliaries: To avoid the generation of hazardous/ toxic waste use of innocuous solvents should be considered, for example water, super critical carbon dioxide. Reduction or elimination of solvents is often possible while in some cases where solvent is needed, less hazardous solvents should be employed.

Design for energy efficiency: Some chemical transformations require energy for its completion which affects over environment. Hence energy requirements of chemical reactions should be minimized for environmental or economic impacts. If possible, the synthetic methods should be conducted at the ambient temperature and pressure.

Use of renewable feedstock: Whenever possible, the chemical transformation should be designed to utilize raw materials and feed stocks that are renewable.

Reduce derivatives: A commonly used technique inorganic synthesis is the use of protection or de-protection, temporary modification of physical or chemical process which requires additional reagents and thus generates hazardous waste. Hence such unnecessary derivatisation should be minimized or avoided.

Catalysis: Catalytic reagents are superior to stoichiometric reagent. They enhance the selectivity of reaction and extent of conversion to products by reducing temperature.

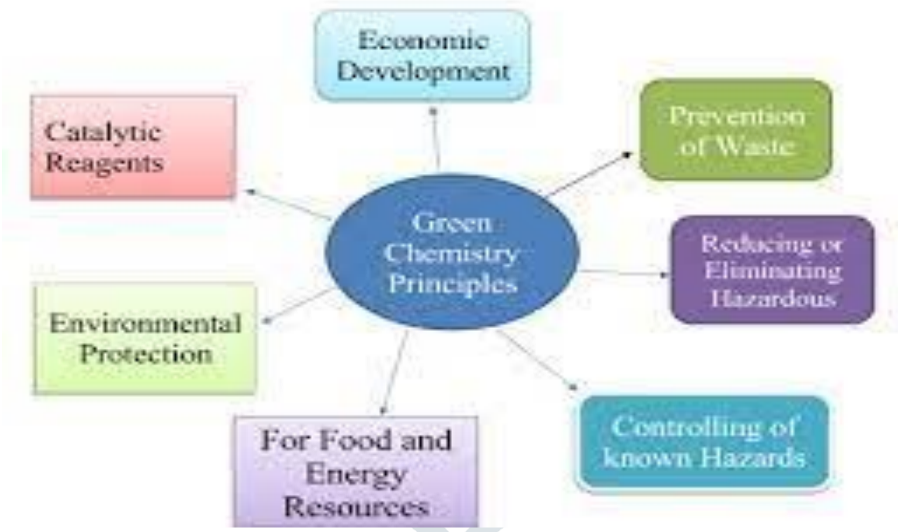
Design for degradation: Chemical products should be designed so that, at the end of their function they breakdown into degradation products and do not persist in the environment.

Real time analysis for pollution prevention: It is always important to monitor the progress of the reaction to know when the reaction is complete or to detect the generation of unwanted by products. Methods and technologies should be developed so that the prevention or minimization of generation of hazardous waste is achieved.

Minimize the potential for accidents: The reagents and solvents should be selectively chosen to minimize the potential for chemical accidents like explosions, fires etc. These accidental risks may be reduced by altering the form (solid, liquid, or gas) or composition of the regents.

Solvents:

In chemical laboratories and industry, the use of organic solvents generates hazardous and toxic waste which affects over the health safety of workers and environmental pollution [5]. To avoid the toxic effects of organic solvents the new concept of green solvent is introduced, which is non toxic and benign to environment[3,4]. Result of comprehensive framework demonstrated by Capello et al on 26 organic solvents have shown that simple alcohols (methanol, ethanol) are environmentally preferable solvents, whereas the use of dioxane, acetonitriles, acids, formal dehydeand tetrahydrofuran are not recommendable from an environmental perspective.



Catalysis :

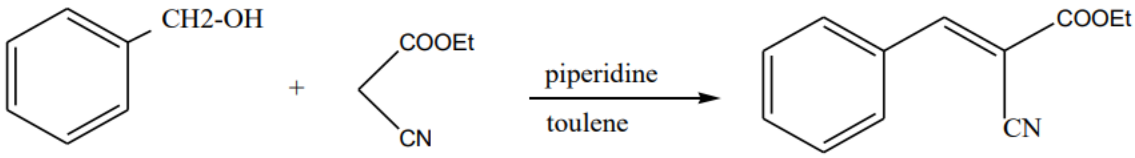
Catalyst is the substance which affects over the rate of the reaction without taking part in it. Green catalyst plays a very important role in chemical transformation, by replacing hazardous regents it reduces the environmental impact as well as cost of the chemical process. The design and application of a new catalyst and catalytic system are simultaneously achieving the dual goals of environmental protection and economic benefit. The choice of catalyst is of prime importance in any chemical transformations. The main goal of green chemistry is the replacement of highly corrosive hazardous and polluting acid catalyst with eco-friendly and renewable catalyst. A wide range of green catalyst i.e. solid acid catalysts are available for the replacement of hazardous organic reagents ex. Zeolites, clays, Sulphate metaloxides and mesoporous materials.

Applications of Green Chemistry:

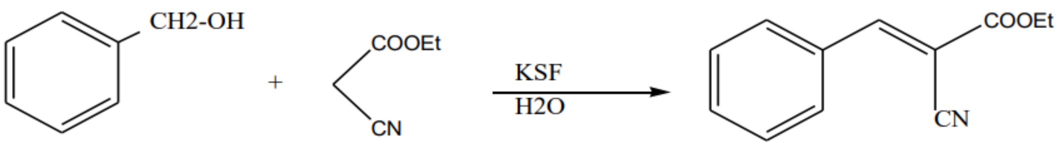
A few examples of common preparations are given below and how these could be safer and environmentally friendly is described.

Preparation of 2-cyano, 3-phenyl, acrylic acid ethylester Conventional method:

Non green solvent toluene is used; piper dine is toxic and is note co friendly. KSF is solid acid catalyst which is renewable.



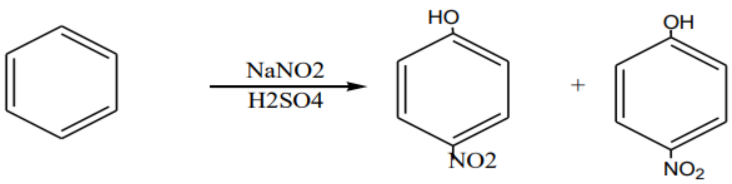
Green Approach



02) Nitration of phenol

Conventional method :

Non green component sulphuric acid is used.



Conclusion:

Green chemistry has grown from a small idea into a new approach to the scientifically based environmental protection. By using green chemistry principles, can change or modify the conventional methods which are note co-friendly. Researchers and pharmaceutical companies need to be encouraged to consider the principles of green chemistry while designing and choosing reagents.

References:

1. Anastas PT, Williamson TC(Eds).Green Chemistry: Designing Chemistry for the Environment. ACS Symposium Series 626. American Chemical Society Washington DC, 1996.
2. Anastas PT.G reen Chemistry: Theory and Practice. Oxford University Press, New York, 1998.
3. Bretherick L, ed. Hazards in the Chemical Laboratory, 6th edition. Royal Society of Chemistry,

Cambridge, UK, 1994.2

4. Christian CF and Konrad H.What is a green solvent? A comprehensive framework for the environmental assessment of solvents. Green Chem 2007;9:927–934