Epitome Journals
International Journal of Multidisciplinary Research

The Use of Green Chemistry Approach in Organic Synthesis : Focus and Review

Rameshwar R. Magar[3], Sunil S. Choudhare[2], Santosh V. Padghan[*1]
Dept of Chemistry
Sant Dnyaneshwar Mahavidyalaya, Soegaon,
Dist- Aurangabad-431120, MS, India
Email : svpadghan@gmail.com

Abstract :

Green chemistry is one of the most important research topics and has attracted most of the researchers. The use of green chemistry in chemical synthesis can reduce the damage to the environment occurred by the use of hazardous chemicals. With the increasing demands in relation to environmental protection, the use of green chemistry approach in organic synthesis is desirable. Green chemistry utilizes its own principles that reduce the use and generation of hazardous substances produced during the synthesis and also correlates with the environment. The use of green Chemistry approach based on three principles namely use of greener solvents, elimination of harmful byproducts and maintenance of atom economy.

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

Research Paper :

Introduction :

In past few decades, the community is polluted with hazardous and dangerous chemicals. In chemical industries the organic reactions are initiated by using different chemical reagents. The drainage from these industries directly mixes with usable water and thus pollutes the environment. The pollution has received the attention of so many researchers and thus introduces a new concept i.e. Green chemistry. The green chemistry was first used in 1991 by P. T. Anastas, for implementation of development in chemistry and chemical technology by industry. [1]

The main aim of green chemistry is replacement of toxic solvents by greener one and use of synthetic techniques, separation and purification which does not require any type of solvents. In organic synthesis solvents play an important role, it acts as a liquid medium for the reaction and also essential for the extraction, purification and drying of chemical products. Most of the organic solvents are hazardous and toxic causing environmental problems. The prolonged use and high exposure of toxic solvents leads to different occupational diseases like carcinogenicity. [2]

PRINCIPLES OF GREEN CHEMSITRY:

The green chemistry aims to eliminate the hazardous and toxic waste formed in the beginning of chemical process and also to protect our health and environment by inventing a new chemical method [3]. The following twelve principles of green chemistry provide a way for researchers to implement green chemistry.

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.

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

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 byproducts.

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, supercritical 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 in organic 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 stiochiometric 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 break down 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 byproducts. 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, where as the use of dioxane, acetonitriles, acids, formaldehyde and tetrahydrofuran are not recommendable from an environmental perspective [6]

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, sulphated metal oxides and mesoporous materials.

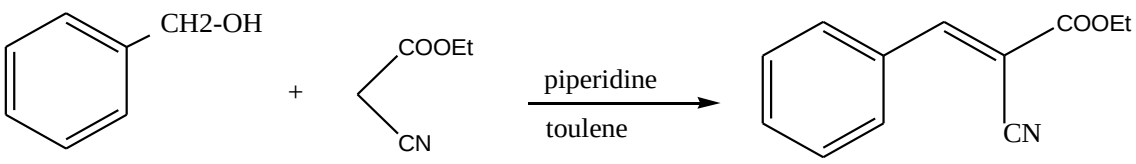
Applications of Green Chemistry :

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

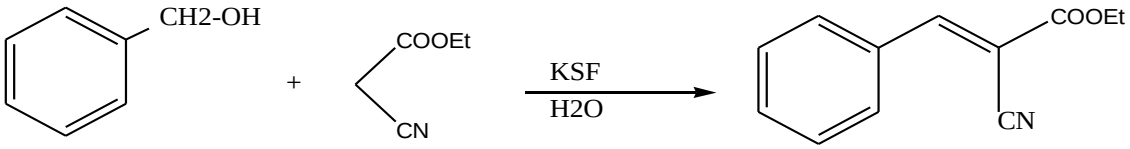
01) Preparation of 2-cyano, 3-phenyl, acrylic acid ethyl ester

Conventional method :

Non green solvent toluene is used; piperidine is toxic and is not ecofriendly.KSF is solid acid catalyst which is renewable.



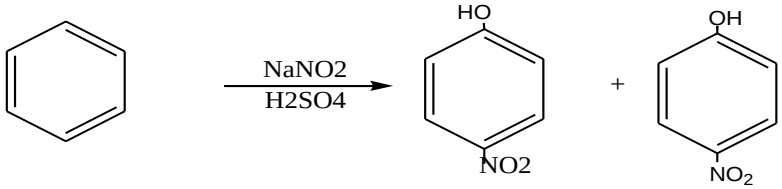
Greener approach :



02) Nitration of phenol

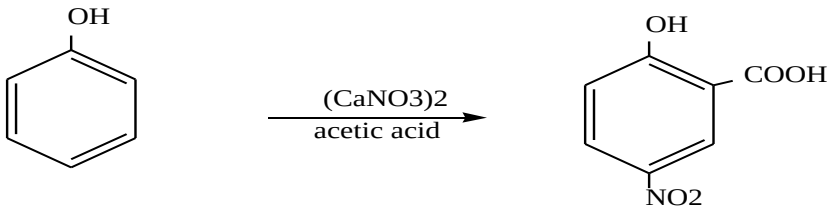
Conventional method :

Non green component sulphuric acid is used.



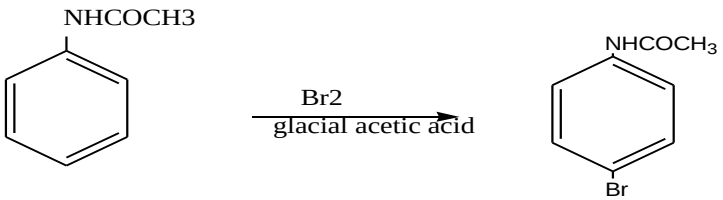
Greener approach :

Calcium nitrate is dissolved in warm acetic acid and salicylic acid is added to it, then the mixture is heated and poured ice cold water.



03) Bromination of acetanilide

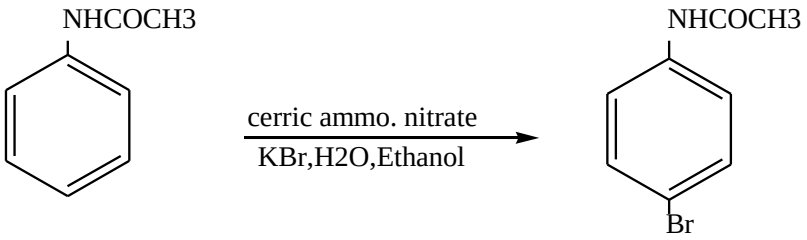
Conventional method :



Greener approach :

Acetanilide is dissolved in ethanol and then potassium bromide and cerric ammonium nitrate solution is added drop wise and stirred for 10 minutes at

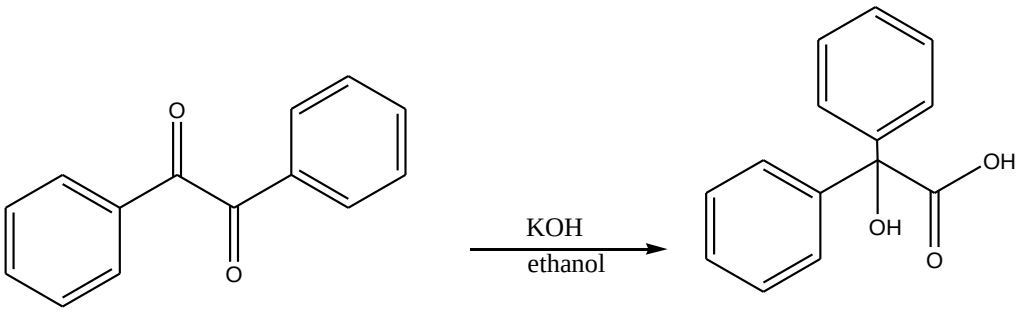
the room temperature. Solution is then poured into water and crystals are filtered.



04) Preparation of benzilic acid

Conventional method :

Benzyl reaction with KOH and ethanol gives benzilic acid.



Greener approach :

Benzil and solid KOH are powdered in mortar which is taken in dry conical flask and heated on a water bath for 20 minutes. Then it was cooled to room temp, dissolved in minimum amount of water and acidified.

Conclusion :

Green chemistry has grown from a small idea into a new approach to the scientifically based environmental protection. By using green chemistry principles we can change or modify the conventional methods which are not eco-friendly. Researchers and pharmaceutical companies need to be encouraged to consider the principles of green chemistry while designing and choosing reagents.

Acknowledgements :

We, the authors are thankful and acknowledge the support given by Dr. G. M. Agnihotri, the Principal of Sant Dnyaneshwar Mahavidyalaya, Soegaon, Dr. R. K. Barote, the Vice-principal of the college and all teaching and non-teaching staff for their support during this work.

References :

1. Bretherick L, ed. Hazards in the Chemical Laboratory, 6th edition. Royal Society of Chemistry, Cambridge, UK, 1994.

2. Martyn Poliakoff, J. Michael Fitzpatrick, Trevor. Farren Paul I, Anastas, Science, 2002, 2, 297.

3. Anastas PT, Williamson TC (Eds). Green Chemistry: Designing Chemistry for the Environment. ACS Symposium Series 626. American Chemical Society Washington DC, 1996.

4. Anastas PT. Green Chemistry: Theory and Practice. Oxford University Press, New York, 1998.

5. Bretherick L, ed. Hazards in the Chemical Laboratory, 6th edition. Royal Society of Chemistry, Cambridge, UK, 1994. 2

6. 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

7. Ruchi Verma *, Lalit Kumar and Vijay Bhaskar Kurba

8. Wardencki*, J. Cury³o, J. Namieoenik

Poland Polish Journal of Environmental Studies Vol. 14, No 4 (2005), 389-395

9. Sarbjeet Singh Gujrala, M.A. Sheelaa, Smriti Khatri*a, Rajeev K Singlab

Indo Global Journal of Pharmaceutical Sciences, 2012; 2(4): 397-408

10. Green Chemistry and Engineering: A Pathway to Sustainability - Anne E. Marteel-Parish and Martin A. Abraham

11. Green Chemistry & Engineering: A Practical Design Approach, Concepción Jiménez-González and sDavid J.C. Constable

12. Green Chemistry Fundamentals and Applications, Suresh Ameta and Rakshit Ameta

13. Sheldon RA. Catalysis: The Key to Waste Minimization. J Chem Tech Biotechnol 1997;68(4):381–388 2.

14. Noyori R. Pursuing practical elegance in chemical synthesis. Chemical Communications 2005;14:1807–1811 3.

15. Chemistry for the Environment. Interuniversity Consortium. http://www.incaweb.

