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Review Article

Green chemistry experiments in postgraduate laboratories

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Abstract: The present review focus on various green chemistry approaches which could be used in the practical classes for postgraduate level when compared with conventional synthetic methods. These methods avoid the usage of hazardous substances and are environmental friendly.
Keywords: Conventional, atom economy, green chemistry.

INTRODUCTION

Green chemistry is "the utilization of a set of principle that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products." Now a lot of approaches are being made in the laboratories particularly at the postgraduate and undergraduate level to make students understand the meaning of green and safe chemistry. Also various harmful by products could be reduced by utilizing alternative approaches to synthesize common synthetic products [1,2].

GREEN CHEMISTRY SET OF PRINCIPLES

Green chemistry is based on12 principles[3].

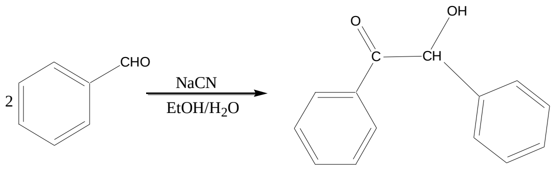
1. Checking the waste generation: This principle aims at reducing unwanted material by developing approaches which reduces the number of reaction steps and materials like (solvents, handling aids).
2. Atom and molecular approach: Products made through bottom-up nanotechnology are more efficient which is built up by using atom –by-atom and molecule-by-molecule approach. It also reduces waste. Synthesis involving less material should be designed.
3. Safer chemical productions: This aims at enhancing process safety by reducing use of dangerous solvents and finding their alternatives.
4. Scheming safer resources: This deals with minimizing adverse effects.
5. Solvents and other materials: The use of other ingredients (e.g. solvents, separation agents, etc.) should be reduced and be safe.
6. Designing products for energy efficiency: The energy required for synthesizing should be assessed for environmental and economical effects and their use should be reduced. Ambient temperature and pressure should be used for synthetic methods.
7. Use of renewable raw material: Raw material which could be utilized further should be used instead of diminishing ones which are technically and economically feasible.
8. Minimising the use of derivatives: The derivatives of compounds should be reduced or avoided which include group blockage, protection/deprotection, brief modification.
9. Catalysis: Catalyst could fasten the reaction where higher temperature is the necessity. In the processes energy factor should be considered very important from the environmental and economic point of view.
10. Design according to degradation: Nanoparticles are metabolized within the body so the need of the hour is to produce harmless products. Also when nanomaterials are exposed to the environment must decompose into non-reactive products.
11. Real-time monitoring and process control: Analytical methods should be established further which would ensure that dangerous substances are not formed. This also takes into consideration that extra energy is reduced and that by products are avoided.
12. Inherently safer chemistry: Substances involved in chemical procedures should be selected which could reduce accidents which involves release, blast and fires.

APPLICATION OF GREEN CHEMISTRY IN ORGANIC SYNTHESIS:

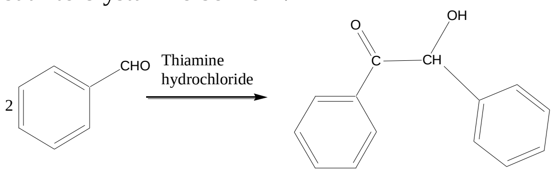
A few examples of common preparations are given below and how these could be made safer and environment friendly is also described.

a. Thiamine hydrochloride catalyzed synthesis of benzoin[4,5].

Conventional method: Poisonous sodium cyanide is used in the synthesis.



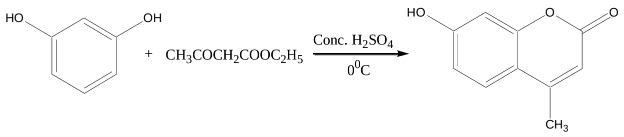
Greener approach: The thiamine hydrochloride is first dissolved in water and then ethanol is added and the solution is cooled by swirling the flask in an ice water bath. Then sodium hydroxide solution is added drop wise to the thiamine solution. Then benzaldehyde is added to the reaction mixture and it is heated on a water bath for about 90 min. The mixture is cooled in ice bath to crystallize benzoin.



- Hazardous and poisonous cyanide ion is replaced by thiamine hydrochloride.
- Works at less temperature.

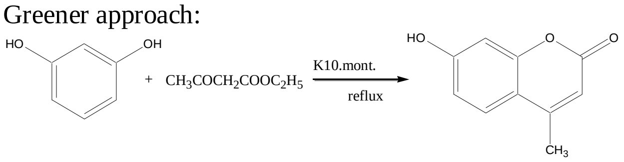
b. Clay catalysed solid state synthesis of 7-hydroxy-4-methylcoumarin [4,6].

Conventional method:



Here acid used is highly corrosive

Greener approach:

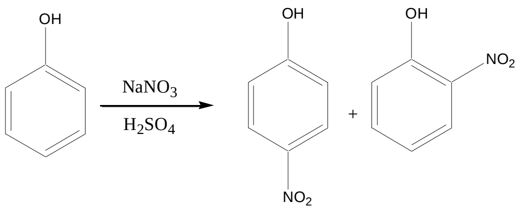


Resorcinol is dissolved in ethyl acetoacetate and then K10montmorrilonite clay is added to this . Then it is heated gently in water bath. After completion of the reaction, mixture was cooled to room temperature and compound is extracted with ether.

- Strong and corrosive H_2SO_4 is avoided.
- Catalyst is used here which can be reused.
- Reaction time is less.

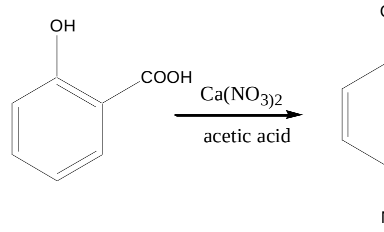
c. Nitration of phenol[4,7]

Conventional method:



Non green component used here is sulphuric acid.

Green approach:

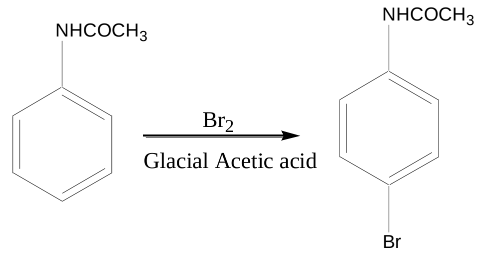


Calcium nitrate is dissolved in warm acetic acid and salicylic acid is added to it. Then the mixture is heated and poured in ice cold water. Crystals are formed.

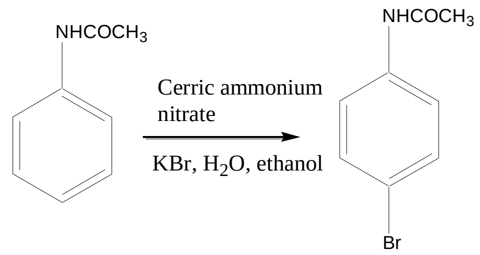
- The process is quick and eco-friendly.
- Selective nitration is achieved.

d. Bromination of acetanilide[4,8].

Conventional method:

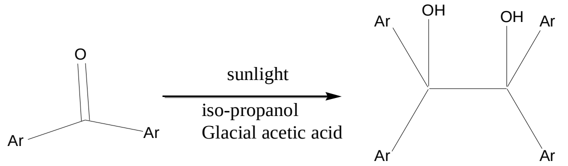


Greener approach: Acetanilide is dissolved in ethanol and then potassium bromide and ceric ammonium nitrate solution solution is added drop wise to the acetanilide solution and stirred for 10 minutes in room temperature. The solution is poured in ice-cold water and crystals are filtered.



- Corrosive molecular bromine is replaced with a novel brominating agent.
- Chlorinated solvents are avoided.
- Use of acetic acid as solvent is avoided.
- It is fast reaction.

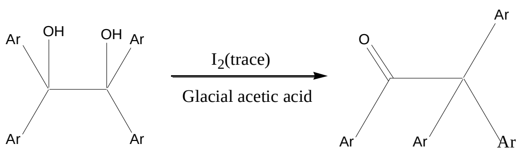
e. Photoreduction of benzophenone to benzopinacol[4,9].



Benzophenone is taken in test-tube dissolved in isopropanol. A drop of glacial acetic acid is added. The reaction mixture is exposed to bright sun light. Crystals of compound starts appearing after sometimes. It is kept in sunlight for few days for the reaction to complete.

Green Context:
Safe chemicals and safer reaction conditions are used and renewable source of energy is used.

f. Preparation of benzopinacolone [4,10]



Benzopinacol is placed in flask and iodine in glacial acetic acid is added. The reaction mixture is refluxed. The reaction mixture is allowed to cool down to room temperature and then kept in the refrigerator overnight. The crystals appeared are collected.

CONCLUSION

There is a need to change or modify the conventional methods which are not eco-friendly, utilize hazardous solvents, not atom specific in the sense that does not matches green chemistry principles. This could be useful for the safe being of students and is also environment friendly.

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