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Green Pathway for Life

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Abstract: *This review article presents a comparison between the old conventional methods of organic synthesis and greener methods taking into consideration principles of green chemistry as outlined by Paul Anastas et al. Green Chemistry research enables a more sustainable, pollution free future society.*

Key Words: *Green Chemistry, solvent free reactions, atom economy, sustainable chemistry, Catalysis, E factor, Energy Efficiency, Transesterification Reaction, Biodiesel, Use of Renewable feed stocks and microwave chemistry.*

I. Introduction

We have been depending on Chemistry in every walk of life. Most of the chemicals are subject to accidental spills or releases. Ignorance of safety standards and negligence has caused lot of environmental disasters. One of the worst Chemical disasters is Bhopal gas tragedy [1] due to leakage of methyl isocyanate where thousands of people died while sleeping and future generations had defects. It was found that love canal was contaminated by toxic waste dioxin [2] by Hooker chemical which caused birth defects [3] and many anomalies like enlarged feet, hands and legs, miscarriages, epilepsy, asthma [4] and leukemia [5]. Sandoz chemical spill [6] into Rhine river caused tons of herbicides, fungicides, pesticides and dyes into river causing a large stretch of it red. It was considered as Western Europe's worst environmental disaster in decade which caused thousands of dead fish & eels from the river after the incident and also officials in Germany and Netherlands shut water purification plants along the river leaving thousands of people without drinking water for days. Release of lead dust into Esperance harbour poisoned children and killed thousands of birds.

Today problem is not of manufacturing a product but of managing the waste associated with it. Since toxic chemicals once created cannot be prevented from entering the environment during disposal or unforeseen conditions like accidents or natural disasters. These wastes do not decay fast and result in polluting air, land and water. Chemists are now using innovative techniques to develop new synthetic methods [7-13], reaction conditions [14], catalysts at molecular level to avoid generating toxins.

Green Chemistry includes any chemicals process that improves the environment and the quality of life [12]. A pictorial representation of benefits of Green Chemistry is shown in Fig. 1.

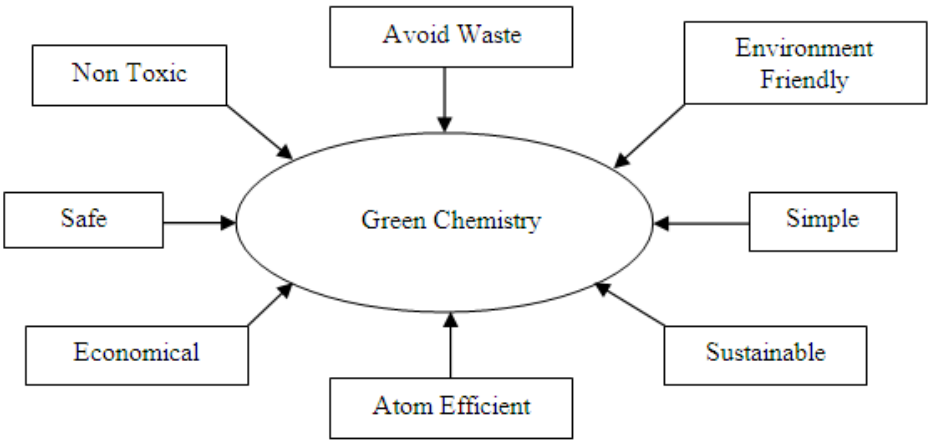

Fig. 1: Benefits of Green Chemistry.

By using the principles of Green Chemistry [15], efficiency in organic synthesis can be attained. Here I have compared old conventional method with new methods using principles of green and sustainable chemistry [16-18] like atom economy, E factor. These principles are illustrated in different synthesis given below.

II. Reactions

2.1 Multi Component Reaction – 3 Component coupling - Synthesis of Dihydropyrimidone based on following principles –

- Safer solvents and Auxiliaries
- Design for Energy Efficiency
- Catalysis

The combination of an aldehyde, a β-ketoester and urea under acid catalyst to give a dihydropyrimidone was 1st reported by Pietro Biginelli in 1893 and is referred to as Biginelli reaction [19]. This one pot condensation reaction generates dihydropyrimidones with pharmacological activity like antiviral, antibacterial [20] etc. Earlier low percentage yield of the product was obtained and even the substrates were limited. A lot of study has been done now and the reaction has been extended for a wide variety of substrates, solvents and acid catalysts. Recently, asymmetric methods [21-22] have been developed to give enantioenriched dihydropyrimidones.

The scope of this reaction is there because of the biological importance of this class of compounds and multi component reactions are atom efficient.

Difference between conventional method and green method [23-24] is that the conventional method requires conc. Sulphuric acid and is time consuming as it requires 18 hours to complete the entire process. For work up, solvent is required. Green method doesn't require sulphuric acid and it does not require hazardous organic solvents nor does it require catalyst, it is completed in one hour. Hence, both time and energy are saved and yield obtained is high. The chemical equations for conventional and green method of Biginelli reaction are shown in Fig. 2.

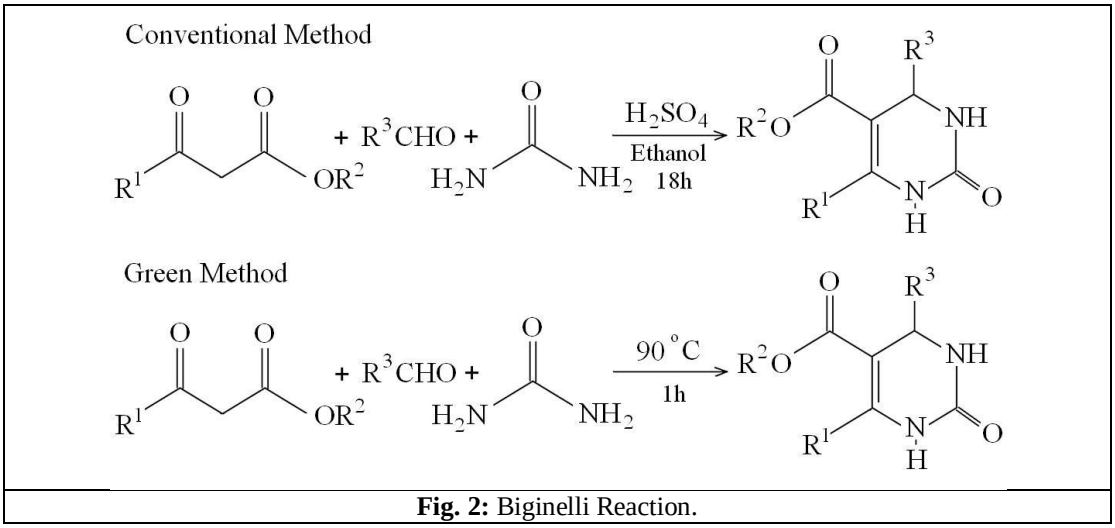

Fig. 2: Biginelli Reaction.

2.2 Radical coupling method for synthesis of 1, 1- Bis – 2 – Naphthol (BINOL) – It is an organic compound which is used as ligand for asymmetric synthesis [25], epoxidation and reduction [26].
It is precursor of another chiral ligand called BINAP. Conventional method has been replaced by greener method based on following principles of Green Chemistry –

- Atom Economy
- Safer Solvents and Auxiliaries
- Design for Energy Efficiency
- Catalysis

Reaction is carried out between naphthol and ferric chloride which acts as oxidizing agent to give 1,1- bis – 2 – naphthol. Conventional method requires refluxing where as reaction by green method can be carried out at room temperature. Thus by carrying out this reaction, energy is saved. Reaction is performed with simple grinding at room temperature without any solvent, and for work up water is used as solvent which is readily available. Hence it is an efficient method [27]. The chemical equations for conventional and green method for synthesis of BINOL are shown in Fig. 3.

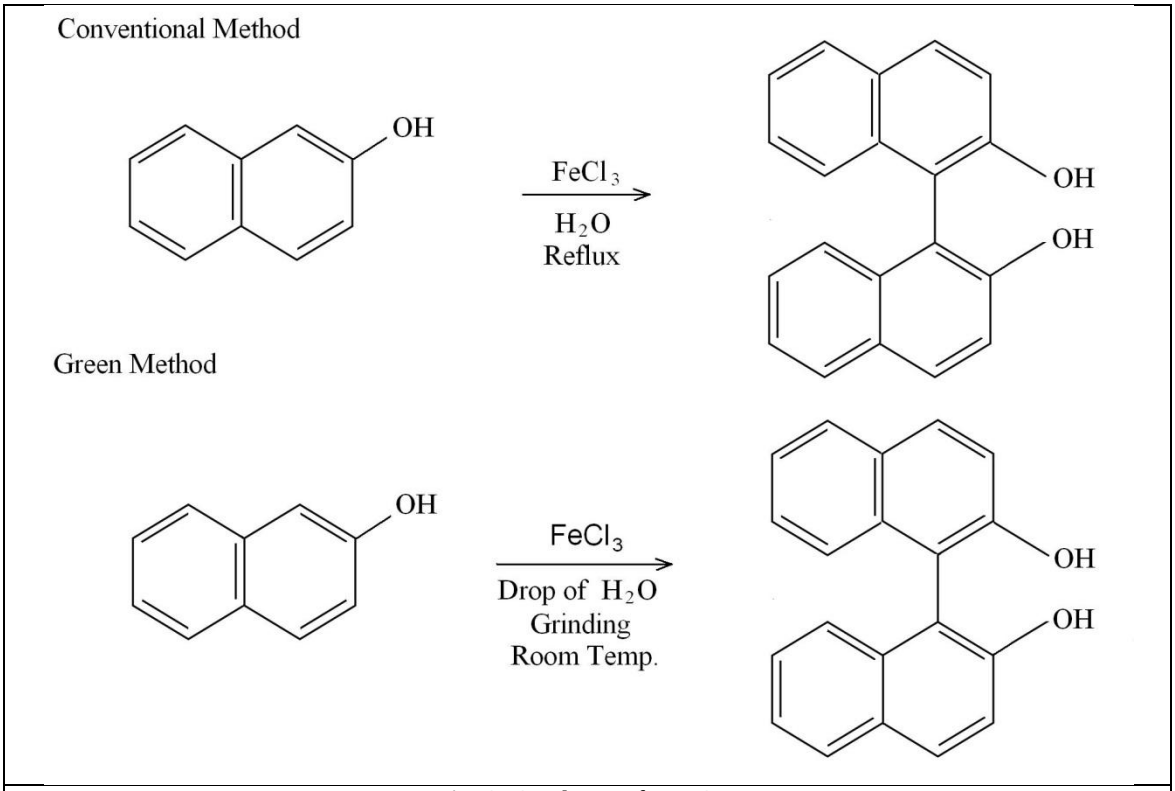

Fig. 3: Synthesis of BINOL.

2.3 Transesterification Reaction: Synthesis of Biodiesel - In this experiment, diesel (fuel) is synthesized from vegetable oil [28]. It involves transformation of one ester into another type of ester which is known as transesterification reaction. It is catalysed chemical reaction and involves vegetable oil and alcohol to yield fatty acid alkyl ester i.e. biodiesel and glycerol. A chemical reaction related to synthesis of biodiesel is shown in Fig. 4. Methanol is commonly used due to its low cost [29]. It is based on following principles.

- Less Hazardous chemical synthesis
- Design for Energy Efficiency
- Use of Renewable feed stocks

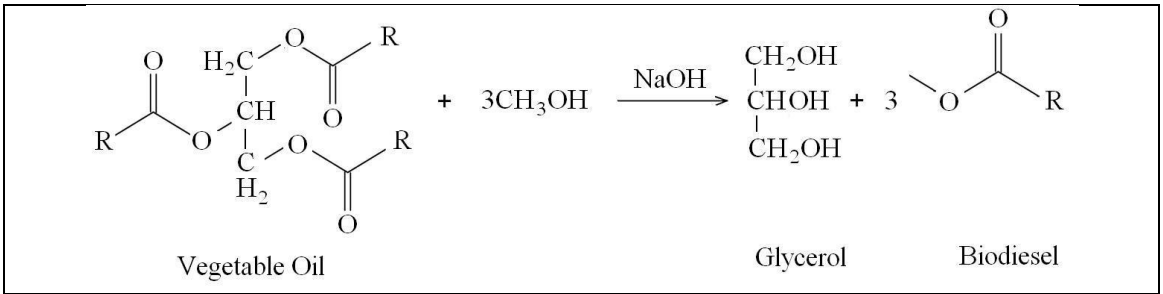

Fig. 4: Synthesis of Biodiesel.

Biodiesel is an alternative fuel to standard fossil fuel. The main advantage is renewability of feed stock [30-31]. Biodiesel burns cleaner than regular diesel. It reduces emissions of carbon monoxide and other hydrocarbons by 20 to 40%.

But some disadvantages of this process are deforestation and food prices will increase.

III. Conclusion

Greener technologies are being developed by taking into consideration important factors of Green Chemistry like microwave irradiation [32-36], grinding of chemical substances and mixing of reactants by shaker. By following green chemical research, problem of impact of chemicals on environment, health and society will be reduced making our earth a better place for living.

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