



AN OVERVIEW ON GREEN CHEMISTRY

MAHENDRA GHOSH

Assistant Professor, Department of Chemistry, Bankura Christian College, Bankura-722101, West Bengal, India.

ABSTRACT: Green chemistry is an approach to the design, manufacture and use of chemical products to intentionally reduce or eliminate chemical hazards. It focuses on the reduction, recycling/ elimination of the use of toxic and hazardous chemicals in production processes by finding creative, alternative routes for making the desired products that minimize the impact on the environment. The present review work focuses on the importance and economic development of green chemistry. It is new branch in chemistry dealing with reduction of harmful and toxic chemicals in the synthesis and replacing it with ecofriendly methods. The principle of green chemistry with various benefits have been discussed to understand the basic requirement for replacement of conventional synthetic method with green chemistry synthesis. To describe it the synthetic approach for the synthesis of acetanilide has been discussed and compared.

Index terms: Green Chemistry, Principle, Eco-friendly, Benefits, Conventional, Acetanilide.

1. INTRODUCTION:

New chemistry is required to improve the economics of chemical manufacturing and to enhance the environmental protection. The green chemistry concept presents an attractive technology to chemists, researchers, and industrialists for innovative chemistry research and applications. Primarily, green chemistry is characterized as reduction of the environmental damage accompanied by the production of materials and respective minimization and proper disposal of wastes generated during different chemical processes. According to another definition, green chemistry is a new technique devoted to the synthesis, processing, and application of chemical materials in such manner as to minimize hazards to humankind and the environment.

Numerous new terms have been introduced associated with the concept of “green chemistry,” such as “eco-efficiency,” “sustainable chemistry,” “atom efficiency” or “atom economy,” “process intensification and integration,” “inherent safety,” “product life cycle analysis,” “ionic liquids,” “alternate feed-stocks,” and “renewable energy sources.”

Hence, there is an essential need to improve the synthetic and engineering chemistry either by environmental friendly starting materials or by properly designing novel synthesis routes that reduce the use and generation of toxic substances by using modern energy sources.

The accelerated progress in science and technology now a days has led to economic development in world, but such economic development also cause environmental degradation which is manifested by climate change, the issue of ozone holes and accumulation of non destructive organic pollutant in all parts of biospheres.

So the present situation required the solution to balance the use of natural resources and environmental conservation. From last two decades awareness for environmental protection has increased by using the concept of “Green Chemistry”. The new laws and regulations have a Aim to protect the ecosystem from harmful chemicals and develop new compounds by the approach of Green chemistry which are less dangerous to human health and the environment.[1]

Green chemistry is new branch of chemistry involves pulling together tools and techniques that helps to chemical engineers in research related to the creation of chemical product and processes that reduce or eliminate the use of harmful chemicals as well as reducing harmful and toxic products for the development of more eco-friendly and efficient product with less wastage. Green chemistry is now going to become an essential tool in the field of synthetic chemistry.[2,3]

1.1. Definition of Green Chemistry: Green chemistry, also known as sustainable chemistry,[4] is the design of chemical products and processes that minimize or eliminate the use or generation of substances hazardous[5] to humans, animals, plants, and the environment.

According to environmental protection agency, green chemistry is defined as a chemistry that designs chemical products and processes that are harmless to the environment. Chemical products should be made in such a manner that they do not remain in the environment at the end of their application and broken down into components that are harmless to environment.[6]

1.2.History: The term green chemistry was first given by Poul .T. Anastas in 1991 in special program launched by the US environmental Protection Agency (EPA) to implement sustainable development in chemistry ,chemical technology by industry ,academia and government. In 1995 the annual US presidential green chemistry challenge was announced. In 1996 the working party on green chemistry was created, acting within the framework of International Union of Pure and Applied Chemistry. The first book and journals on the subject of green chemistry were introduced in 1990 by the royal society of chemistry. Green chemistry includes a new approach to the synthesis, processing and application of chemical substances in such a manner to reduce scourge to health and environment like:

- Clean Chemistry
- Atom Economy
- Environmentally benign chemistry. [7-13]

Twelve principles of Green chemistry have been developed by Poul Anastas, speaks about the reduction of dangerous or harmful substances from the synthesis, production and application of chemical products. When designing a green chemistry process it is impossible to meet the requirements of all twelve principles of the process at the same time, but it attempts to apply as many principles during certain stages of synthesis. [14,15]

1.3. Principles of Green Chemistry

1.3.1. Pollution Prevention: It is to prevent waste and to treat and clean up waste after it has been created.

1.3.2. Atom Economy:Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

1.3.3. Less Hazardous Chemical Synthesis: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

1.3.4. Designing Safer Chemicals: Chemical product should be designed to affect their desired function while minimizing toxicity.

1.3.5. Safer Solvents and Auxiliaries:The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.

1.3.6. Design for Energy Efficiency: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

1.3.7. Use of Renewable Feedstock's: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.

1.3.8. Reduce Derivatives: The unnecessary derivatization like use of blocking groups, protection, deprotection should be avoided whenever impossible.

1.3.9. Catalysis: The catalytic reagents are superior stoichiometric reagents.

1.3.10. Design for Degradation: The chemical products should be designed so that at the end of their function they breakdown into harmless degradation products and do not persist in the environment.

1.3.11. Real-time analysis for Pollution Prevention: Analytical methodologies need to be further developed to allow for real-time, in process monitoring and control prior to the formation of hazardous substances.

1.3.12. Inherently Safer Chemistry for Accident Prevent: The substances used in the chemical process should be chosen to minimize the potential for chemical accidents, explosion and fires. This principle can motivate chemistry at all levels like research, education and public perception. [16]

1.4. Benefits of Green Chemistry

• Benefits for health

- Cleaner air: Less release of hazardous chemicals to air leading to less damage to lungs.
- Cleaner water: less release of hazardous chemical wastes to water leading to cleaner drinking and recreational water.
- Increased safety for workers in the chemical industry; less use of toxic materials; less personal protective equipment required; less potential for accidents. (e.g., fires or explosions)
- Safer food: elimination of persistent toxic chemicals that can enter the food chain; safer pesticides that are toxic only to specific pests and degrade rapidly after use.
- Less exposure to such toxic chemicals as endocrine disruptors.

• Benefits for environment

- Plants and animals suffer less harm from toxic chemicals in the environment.
- Lower potential for global warming, ozone depletion, and smog formation.
- Less chemical disruption of ecosystems.
- Less use of landfills, especially hazardous waste landfills.

• Economy and business

- Higher yields for chemical reactions, consuming smaller amounts of feedstock to obtain the same amount of product.
- Fewer synthetic steps, often allowing faster manufacturing of products, increasing plant capacity, and saving energy and water.
- Reduced waste, eliminating costly remediation, hazardous waste disposal, and end-of-the-pipe treatments.
- Allow replacement of a purchased feedstock by a waste product.
- Better performance so that less product is needed to achieve the same function.
- Reduced use of petroleum products, slowing their depletion and avoiding their hazards and price fluctuations.

2. REVIEW LITERATURE

2.1. Green chemistry aims to reduce or even eliminates the production of any harmful bi products and maximizing the desired product without compromising with the environment. The three key developments in green chemistry include use of super critical carbon di oxide as green solvent, aqueous hydrogen peroxide as an oxidizing agent and use of hydrogen in asymmetric synthesis. It also focuses on replacing traditional methods of heating with that of modern methods of heating like microwave radiations so that carbon footprint should be reduces as low as possible. [17]

2.2. The work focuses to reduce the chemical wastage by applying the concept of green chemistry. Few derivative of acetanilide were synthesized by conventional method as

well as by green chemistry method. In conventional method there was wastage of chemicals by the formation of acetic acid molecule but by green synthesis method the formation of byproducts was avoided and the atom economy was calculated on the basis of molecular weight of desired product and it was found to be in the range of 72 to 82% which signify the utility of green synthesis method. [18]

2.3. Due to technology development the quality of life on earth became much better but harmful effect of chemistry also became pronounced main among them being the pollution of land, water and atmosphere. This is caused mainly due to the use of harmful reactants and effect of by-product of chemical industries, which are being discharge into air, rivers and the land, but by applying the concept of green chemistry these all problems can be reduced. [19]

2.4. Green chemistry is a term that refers to the production of chemical products and processes that reduce the use of and production of harmful substances. [20]

2.5. The green chemistry revolution provides the various numbers of challenges to those who practice chemistry in industry, education and research. It is the modern science of chemistry deals with the application of environment friendly chemical compound in the various area of our life such as industries. The chemical industries supply us a huge variety of essential product, from plastic to pharmaceuticals, these industries has a potential to damage our environment, so green chemistry serves to promote the design and efficient use of chemicals and chemical processes. [21]

3. Experimentation

The synthesis of acetanilide by green chemistry has various disadvantages as there is a lot of wastage of acetic acid molecule, which can be minimized by green chemistry.

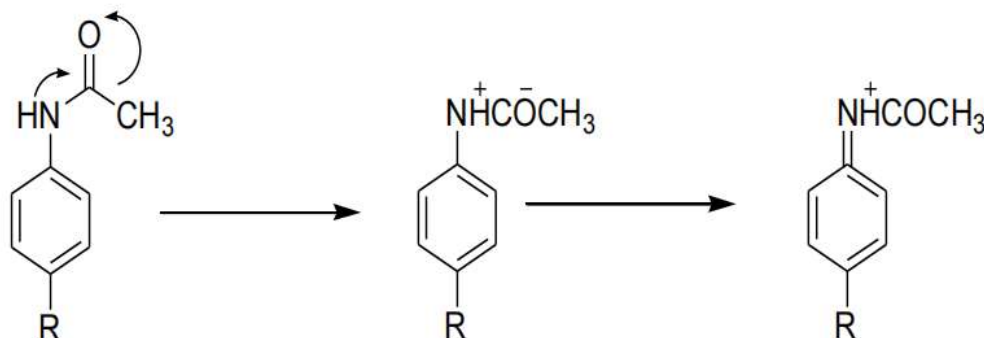
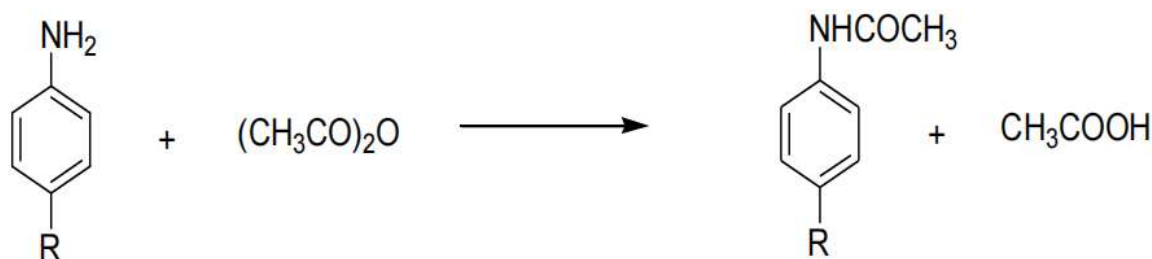
3.1. Synthesis of compounds by conventional method

- In a 250 ml beaker containing 125 ml of water, 4.6 ml of conc. Hydrochloric acid and 5.1 g of aniline / substituted anilines were introduced.
- Stirred until all the anilines passes completely into solution.
- To the resulting solution, 6.9 g (6.4ml) of redistilled acetic anhydride was added and stirred until it was dissolved.
- Poured immediately in a solution of 3.8 g of crystalline sodium acetate in 25 ml of water.
- Stirred vigorously and cooled in ice. Filtered the acetanilide and substituted acetanilide with suction, washed with 10 ml water, drained well and dried upon filter paper. The crude products were recrystallized from boiling water and methylated spirit.

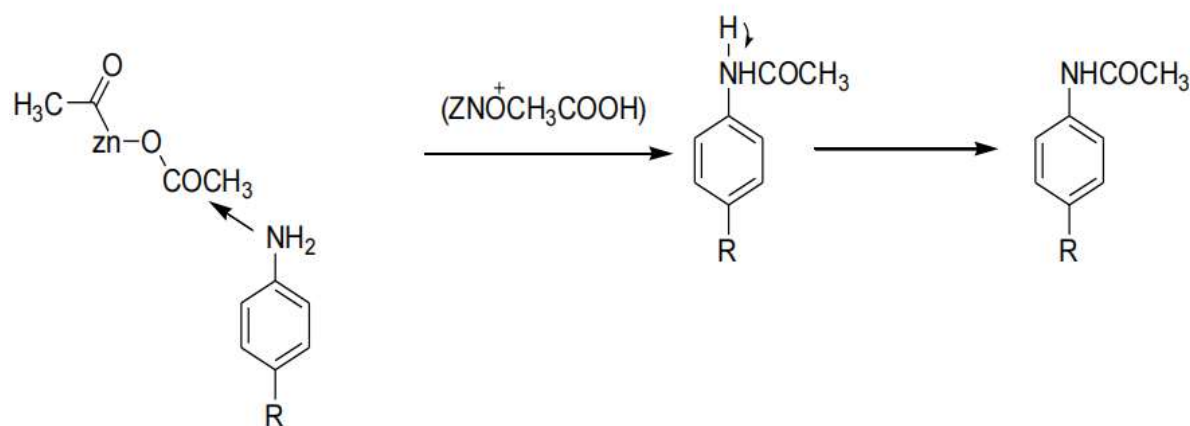
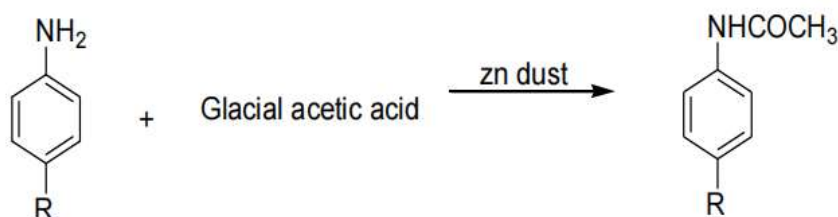
• **Non green component:** Acetic anhydride leaves one molecule of acetic acid unused.

3.2. Synthesis of compounds by green chemistry method

- A mixture of aniline / substituted anilines (3.3g) and zinc dust (0.16g) in acetic acid (10ml) in 100 ml round bottom flask was heated over a gentle flame using water condenser.
- Heating was continued for about 45 min., the reaction mixture was then carefully poured in cold water (33ml) in 250ml beaker with vigorous stirring.
- The shining crystals of product were separated slowly. After 15 min, crystals were collected by filtration. The solid crystals were washed over the Buchner funnel with water and product was dried and crystallized in boiling water.
- **Green context:** Minimize waste by-products, avoids use of acetic anhydride.



Synthesis and mechanism by conventional method



Synthesis and mechanism by green chemistry method

4. CONCLUSION

The ultimate aim of green chemistry is to entirely cut down the stream of chemicals pouring into the environment. This aim seems unattainable at present, but progress in the green chemical research areas and their application through successive approaches will certainly provide safer specialty chemicals and much more satisfactory processes for the chemical industry.

This review article will definitely help to understand the importance of green chemistry, which is basic requirement in today's pharmaceutical industries. The approach will help to avoid the utilization of the toxic chemicals leading to various hazards in the industry. These conventional methods can be replaced easily by the methods which utilize non toxic and environment friendly techniques for the synthesis of same. One of such approach has been discussed for the synthesis of acetanilide. The approach will definitely help in the synthesis by keeping the environment safe.

5. REFERENCE

1. Singhal M., Singh A. Khan S.P, Green Chemistry Potential for Past, Present and Future Perspectives, 2012; 3(4).
2. Ahluwalia V.K, Kidwai M., New Trends In Green Chemistry, Anamaya publisher New Delhi, 2nd edition, 2007; 5-18.
3. Ahluwalia V.K, Green chemistry Environmentally Benign Reactions, published by India books, 2nd EDITION, 2006; 1-10.
4. Mutlu, Hatice; Barner, Leonie (2022-06-03). "Getting the Terms Right: Green, Sustainable, or Circular Chemistry?". *Macromolecular Chemistry and Physics*. 223 (13): 2200111. doi:10.1002/macp.202200111. ISSN 1022-1352. S2CID 249357642.
5. ^ "Green Chemistry". United States Environmental Protection Agency. 2006-06-28. Retrieved 2011-03-23.
6. Vojvodic V. Environmental Protection :Green Manufacturing in the pharmaceutical industry and cost reduction, KenInd, 2009; 58(1): 32-33.
7. Anastas. P.T, Warner J.C, Green chemistry Theory and Practice, Oxford University, Press, New York, 1998.
8. Anastas P.T, Hovarth I.T, Innovations and Green Chemistry, Chemistry review, 2007; 107.
9. Ravichandaran S., International Journal, 2010; 2(4): 2191.
10. Trost B.M, Atom economy- A challenge for organic synthesis: Homogeneous catalysis leads the way, 1995; 34: 259.
11. Sheldon R.A, Green solvents for sustainable organic synthesis: State of art, 2005; 7: 267.
12. Bharati V.B, Resonance, 2008; 1041.
13. Ahluwalia V.K and Kidwai M., New Trends in Green Chemistry, Anamaya Publisher, New Delhi, 2004.
14. Anastas P., Warner, Green Chemistry: Theory and Practice, Oxford University Press, Oxford, 1998.
15. Anastas P.T, Heine L.G, Williamson T.V, Green Chemical Synthesis and Processes, American Chemical Society, Washington DC, 2000.
16. Singhal M, Singh A, Khan S.P, Sultan E, Sachan N.K, Green chemistry potential for past present and future perspectives.
17. Gujral. S.S, Sheela. M.A, Khattri S., Singhla R.K. A Focus and Review on the Advancement of Green Chemistry, Indo Global Journal of Pharmaceutical Science, 2012; 2(4): 397-408.
18. Redasani V.K, Kumawat V.S, Kabra R.P, Surana S.J, Application Of Green Chemistry in Organic Synthesis, International Journal of Chem Tech Research, 2010.
19. Singhal. M, Singh A., Khan S.P, Green Chemistry Potential for Past, Present and Future Perspectives, International Research Journal of Pharmacy, 2012; 3(4).
20. Ivankovic. A., Dronjic A., Review of 12 Principles of Green Chemistry in Practice, International Journal of Sustainable and Green Energy, 2017; 6(3): 39-48.
21. Chanshetti U., Green Chemistry: Challenges And Opportunities In Sustainable Development, International Journal of Current Research, 2014; 6.