

# Importance of Green chemistry in oxidation and reduction

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**Abstract**— ‘Green chemistry’ the self-explanatory term is a branch of chemistry that involves the application of chemical product and processes in such a way that reduces the generation of hazardous chemical waste and its release into the environment. It is an intelligent way of doing chemistry in which the waste production is minimized, energy is saved and the depletion of natural resources is cut down to some extent.

Significant efforts have been made towards the development of new Green Technologies. It's benefits should reach to the common man. We can synthesize many organic molecules with the help of green chemistry methods. In this article we are trying to study about and utilization of green chemistry in different processes mainly oxidation and reduction processes.

**Index Terms**— Green Synthesis, Green Chemistry, Oxidation, Reduction

## I. INTRODUCTION

‘Green Chemistry’ is the unique branch of chemistry which involves in evolution of new tools, techniques and technologies (1). It is helpful to chemistry and chemical engineers in the field of research, main focus on the development and production of more eco-friendly and efficient products which may also have great financial benefits. It is an important tool in the field of chemistry (2). Or Green chemistry is defined as the building of chemical products which bring down the usage and production of hazardous materials.

Chemical wastes have a Sever effects on human health and environment. So this has to be taken off carefully and require effective measures. For the prevention of future damage to the environment and for the encouragement of new young people in the industry, the acceptance level of the people should be raised and the adoption of green and clean processes and the designing of green products (3).

This has made some progress but it is often commented that the new graduates making their way into the industry are not well equipped with the tools, technique and the culture so as to make a positive impact on the industry and to increase the demand for the green chemistry products and sustainable technology.

Globally it has been seen that there has been growth in the demand for cleaner technology and processes and their non-hazardous products (4). In order to make sure the success in future of the chemistry based industries, it is very important

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to equip the students with the required set of tools, their knowledge and the experience to work with it.

This helps us in maintaining and enhancing the high quality of provisions of the green and sustainable chemistry to enable change to low carbon and bio based economy which is developed on the high quality of pure and transitional research, its education and the training. Its networking and partnerships which is in the framework of the development (5).

## Green Chemistry: A Contribution for Sustainable Development of Society

Green chemistry has contributed a lot in the cleansing the environment and making our planet a beautiful place to live in .green chemistry has optimized global mass in order to minimize waste. It has designed processes at ambient temperature and pressure leading to minimization of energy consumption. Green chemistry has promoted the use and utilization of raw materials from renewable sources. It has replaced old compounds with the new ones which has lead to the maintenance of functional efficiency and has minimized their toxic impact on the environment and human health. The orientation of environmental molecular design has lead to the innovations such as replacement of the organic solvents with the supercritical liquids. It has lead to the replacement regarding brominated flame retardants. It has lead to the replacement of the non selective persistent pesticides.

## II. PRINCIPLES OF GREEN CHEMISTRY

1. Prevention of waste --- precautions need to be taken to create no waste materials, than to clear the wastage after it is created.
2. Development of atom economy – new ways and methods should be created to incorporate each and every material to be used in different processes for preparing the final product.
3. Usage of less hazardous chemical synthesis --- wherever it is possible synthetic methods must be practiced to create substances which are harmless and are non-toxic for the human health and environment.
4. Design and development of safe chemicals --- non toxic chemical products should be designed and developed to enhance their function and to create very low level of toxicity.
5. Usage of safe solvents and auxiliary substances --- the usage of auxiliary substances should be discarded

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- and they must only be used when it becomes necessary .
6. Designing of energy efficiency --- energy required by chemical processes must be recognized and their impact on the environment must be assessed and finances must be minimized. Usage of synthetic methods should only be allowed under favorable temperature and pressure.
  7. Usage of renewable materials --- renewable raw materials should be used and their usage must be promoted whenever possible and viable under technical and economical circumstances.
  8. Reduction of derivatives --- derivatization should be minimized and only be used under necessary circumstances because it requires additional reagents which create a lot of toxic waste which is very bad for the environment
  9. Use of catalytic reagents --- catalytic reagents are a better product than the stoichiometric reagents and their usage must be promoted.
  10. Designed to degrade --- chemical products at the end of their life cycle must break into innocuous products that won't exist on their own in the environment and pollute it(6).
  11. Analysis of prevention of pollution --- analytical methods should be designed and developed so as to analyze the importance of pollution .assessment of monitoring of pollution and the various steps to control the formation of hazardous materials.
  12. Safe chemistry for preventing accidental damage --- those chemical materials should be used which minimizes accidental damage including release of gases, explosion and breaking out of fire(7).
4. Healthy consumer products---healthy consumer products will be available for the people which will be safer than the phasing out products.
  5. Such products will be made from less waste materials and will be free of pesticides and cleaning products
  6. Less degrading and spoiling of food products--- food products will be safer from insects and worms and will be more healthy and nutritious and will take more time to rot and become spoiled and useless
  7. Decrease in the rate of global warming- due to usage of non polluting and non hazardous, non toxic materials the global warming will become slow .environment will be free of toxic gases and there will be less production of waste materials that cannot be disposed of and degraded or recycled.
  8. Recovery of ozone layer--- ozone layer stops the harmful UV Rays of the sun and protects us from various life taking diseases like skin cancer etc,
  9. Reduction in the production of greenhouse gases that create global warming will start the recovery of depleting ozone layer.
  10. Higher production--- green chemistry is very helpful for the growth of agricultural sector .it helps in creation and development of materials that are more environmental friendly, non hazardous and helps in increasing the production of crops by reducing the damage done to the crops .By insects and worms etc and increasing the immunity. Higher yields will help farmers to fetch better prices for their crops.
  11. Reduction in the use of petroleum products--- petroleum products create a lot of air pollution. They are also responsible for the increased levels of greenhouse gases that cause global warming. Increased usage of green chemistry products will help in the reduction of greenhouse gases and make our environment safe for living(8).

### Advantages of Green Chemistry

1. Clean air to breathe- non hazardous materials are released into the environment which leads to cleaner air and causes less damage to the lungs .also the usage of such environment friendly materials are a boon against air pollution.
2. Clean water to drink- sources of drinking water like rivers lakes and ponds etc,are saved from being polluted by non hazardous and nill pollution creating chemical materials. Minimized release of hazardous materials leads to control of water pollution .
3. Increase in safety of workers in the chemical industry--- due to use of non accidental and non hazardous chemical materials industry workers are saved from accidental explosion and health damages due to long exposure to hazardous materials which can be life saving boon for the industry and also for the workers.

### Disadvantages of Green Chemistry

1. Pests and weeds may develop hazards--- cross pollination between genetically modified organisms may result in new species that can be hazardous
2. Mono culture is employed --- big tracts of land must be available for mono culturing which is often not possible and brings many hardships to farmers(9).

### Applications of Green Chemistry

1. It can be used as starting materials
2. It can be used as green reagents
3. It can be used as green chemical products in the making of alternative hydrides
4. Green chemistry can be used in the manufacture of better drugs that is used to cure deadly diseases.

- Green chemistry has a very wide application in agriculture sector. They can be used as biological control agents.
  - It can be used in atomic economy and homogeneous catalysis.
  - Green chemistry can be used in halide free synthesis of aromatic halides
  - Chemists have developed new methods of producing polymers from renewable source such as biomass. Nature works polyactic acid (PLA) is a polymer of naturally occurring lactic acid (LA) which can be produced from fermentation of corn. This polymer can be manufactured from waste biomass. PLA is biodegradable and can be easily recycled and converted back into LA. It can be used to replace many petroleum based polymers .
  - The manufacturing of computer chips requires large amount of chemicals, water and energy. The mass of the chemicals and fossil fuels which is used for making a computer chip is 630 times the weight of the chip. Scientists have developed a process which uses supercritical carbon dioxide in one of the manufacturing steps in the preparation of the chip. This significantly reduces the amount of chemicals, energy and water which is required for the production of more chips
  - Condensed phase carbon dioxide is utilized as a solvent in the dry cleaning of the clothes. Carbon dioxide when used alone is not a good solvent for oils, waxes and greases but when it is used in combination with a surfactant it allows for the replacement of perchloroethylene which is used as a solvent to dry clean clothes, even though it is hazardous to the environment(10).
- Bionic leaf**- this green chemistry technology utilizes directed sunlight to split water to form hydrogen liquid fuels which will be a source of energy for production as a fuel in future.
  - Polymers from carbon dioxide**- polymers will be produced from carbon dioxide which will reduce carbon dioxide levels from the atmosphere.
  - Use of organic photovoltaic solar cells**- this green chemistry technology will help in making electricity cheaper .low generation prices from 1<sup>st</sup> and 2<sup>nd</sup> generation solar technologies will help in generation of better economy and improve the living standard of the society(11).

#### Role of Green Chemistry in Oxidation Reactions Oxidation Reactions

Oxidation is a process in which a carbon atom gains bonds to more electronegative elements specially oxygen.

Oxidizing Reagents: Reagents are substances or compounds which are added to the system to make a chemical reaction or to see if a chemical reaction is possible or not. Some of the reagents are responsible for oxidations are-

- Oxygen ( $O_2$ )
- Ozone ( $O_3$ )
- Hydrogen peroxide ( $H_2O_2$ ) and other inorganic peroxides, Fenton's reagent.
- Fluorine ( $F_2$ ), chlorine ( $Cl_2$ ), and other halogens.
- Nitric acid ( $HNO_3$ ) and nitrate compounds.
- Sulfuric acid ( $H_2SO_4$ )
- Peroxydisulfuric acid ( $H_2S_2O_8$ )
- Peroxymonosulfuric acid ( $H_2SO_5$ )

#### Uses of Green Chemistry in Oxidation Reactions

The improvements which is made in the impact on the environment due to the pharmaceutical and agricultural chemical industry have lagged behind and stalled the progress which is seen in the manufacturing of bulk commodity chemicals. Fine chemicals are prepared by reactions involving many steps which utilize stoichiometric reagents and chiral auxiliaries. The atom economy of manufacturing these is poor. Many of the biologically active compounds which are from the pharmaceutical and agricultural industries are highly oxygenated and are manufactured from the some type of the oxidation reaction. So there is more demand for the more selective oxidation catalysts (12).

#### Reduction Reactions

Reduction is a process in which a carbon atom gains bonds to less electronegative elements, especially hydrogen.

Reducing Reagents: Most common reducing reagents are

- Lithium aluminum hydride ( $LiAlH_4$ ), a very strong reducing agent.
- Nascent (atomic) hydrogen.
- Hydrogen without or with a suitable catalyst e.g. a Lindlar catalyst.
- Sodium amalgam ( $Na(Hg)$ )
- Sodium-lead alloy ( $Na + Pb$ )

#### Future of Green Chemistry

- Catalysis and oxidation reagents**-Most of the oxidation reagents and catalysts are made of toxic substances. These toxic substances such as heavy metals are required in large quantities to convert petrochemicals. These toxic substances can be very hazardous towards human health and environment and can cause a lot of damage. This will be changed by the use of benign substances.
- Using of non-covalent derivitization**- By utilizing dynamic complexation properties of the molecule can be altered to carry out a particular function without generating any waste materials which will be created if full derivitization is utilized.
- Biocatalysis in green chemistry**-directed evolution-this will help in the creation and development of new and better proteins (enzymes for biocatalysts) in the laboratory. This will replace old synthetic and harmful technologies and cleaner technology will be available for future use which will help in protection of environment.

6- Amalgam (chemistry)#Zinc amalgam (Zn(Hg)) (reagent for Clemmensen reduction)

7- Diborane(13).

### Role of Green Chemistry in Reduction Reactions

Reduction processes reduce the impact of chemicals on human health and on the environment by utilizing environment friendly processes and the reactions processes. The selection of the solvents and chemicals which are utilized for dissolve many of substances within the solution are of very much importance in green chemistry(14).They form a major source of waste in the industrial chemical manufacturing but careful selection can be used to increase reaction rates and lowering of reaction temperatures.

### III. CONCLUSION

As we are aware of the importance of recent advances in the area of green chemistry research and the efforts made in development of 'Green Technologies', significant efforts have been made towards the development of new Green Technologies. Its benefits should reach to the common man. Moreover, research driven labs either at Universities or Institutes develop Green methods at small scale which require further standardization to pilot scale, to be applicable at Industry level.

### ACKNOWLEDGEMENTS

JP and AK are thankful to DST for financial support (Grant registration#CS-236/2013). JP, RK and NS are also thankful to UPCST (Grant registration # CST/ D 6547/2017).

### REFERENCES

- [1] Ahluwalia V. K., Kidwai M., New Trends In Green Chemistry, Anamaya publisher New Delhi, 2nd edition, 2007, 5-18, 250.
- [2] Ahluwalia V.K., Green Chemistry Environmentally Benign Reactions, published by India books, 2<sup>nd</sup> edition, 2006, 1-10.
- [3] Choo J. L. and Trost B.M., Green Chemistry for chemical synthesis **PNAS** 2008, 105 (36), 13197- 13202.
- [4] Furniss B.S, Hannaford A.J, Smith P.W.G., Tatchell A.R ,Vogel's Textbook of Practical Organic Chemistry, Pearson education, 5th edition, 2005, 916-918.
- [6] Vogel I. A., Elementary Practical Organic Chemistry Part I, Small Scale Preparation, CBS publishers and distributors, Delhi, 2nd edition, 2003,263-264.
- [7] Meshram H., ICT, Hyderabad, Private Communication, 111-112.
- [8] Pavia D.L., Lampman G.M., Kriz G.S., Introduction to Spectroscopy, by Thompson books, 3rd edition, 2007, 26.
- [9] Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press.
- [10] Recent Research in Science and Technology 2014, 6(1): 97-100 ISSN: 2076-5061 Available Online: <http://recent-science.com/>
- [11] Chemistry of Waste Minimization, ed. J. H. Clark, Chapman and Hall, London, 1995; Corporate Image of the Chemical Industry, CIA (UK), 1993; Pan European Image Survey, CEFIC, 1994.
- [12] T. Bastock and J. H. Clark, in Specialty Chemicals, ed. B. Pearson, Elsevier, London, 1992
- [13] Kirchhoff, Mary, and Ryan, Mary Ann, eds. (2002) Greener approaches to Undergraduate Chemistry Experiments. Washington, DC: American Chemical Society.
- [14] Ryan, Mary Ann, and Tinneland, Michael, eds. (2002). Introduction to Green Chemistry. Washington, DC: American Chemical Society