International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol. 3, No.4, pp 1882-1885, Oct-Dec 2011

Perspective and Fate of Green Chemistry

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Abstract : The term 'Green Chemistry' has emerged with an aim to protect human health and the environment in an economically viable and sustainable manner. The designing of environmentally benign products is being guided by certain principles, laid down by the father of green chemistry- Paul T Anastas from the US. The environment is a common resource shared by the entire globe. Green chemistry is a welcome step towards protecting the environment. Green chemistry represents the pillars that hold up our sustainable future. It is imperative to teach the value of green chemistry to tomorrow's chemists. It is clear that many industries and research of many academics recognize the significance of green chemistry. In the practice of green chemistry a set of principles that reduces or eliminates the use of hazardous substance in the design, manufacture and applications of chemical products are utilized. This article presents a brief description on perspectives and fate of green chemistry.
Keywords:Green chemistry, twelve principles, designing safer solvents, designing safer chemicals, sustainable development.

Introduction

It has come to be recognized in recent years, that the science of chemistry is central to addressing the problems faced by the environment. The utilization of various sub disciplines of chemistry and the molecular sciences has increased an appreciation in the emerging area of the **green chemistry** [1,2] which is needed to design and attain sustainable development. A central driving force for this increasing awareness is that green chemistry accomplishes both economic and environmental goals simultaneously through the use of sound, fundamental scientific principles. The drive towards clean technology in the chemical industry, with an increasing emphasis on the reduction of waste at source, will require a level of innovation and new technology. It is a challenge before the chemists to develop synthetic methods that are less polluting, i.e. to design clean or '**green**' chemical transformations. Industries and scientific organizations have put clean technology as an important R&D concern. The area of chemistry which is particularly directed to achieve such goals is termed as '**green chemistry**'. Green chemistry is a central issue, in both academia and industry, with regard to chemical synthesis in the 21st century[3]. Green chemistry concerns the development of chemical technology and processes that are designed to be incapable of causing pollution. Green chemistry encompasses all type of chemical processes including synthesis, catalysis, analysis, monitoring, separation and reaction conditions that reduces the risk to human health and environment relative to current state of the art. The impact of cumulative changes brought about by human activities is increasingly becoming evident both in terms of development and more so in the form of deterioration of the environment. Green chemistry is a welcome step towards protecting the mother earth.

The green chemistry revolution provides an enormous number of opportunities to discover and apply new synthetic approaches using alternatives feedstocks, ecofriendly reaction conditions, energy minimizations and the design of less toxic and inherently safer chemicals. The origin and basis of green chemistry for achieving environmental and economic prosperity is inherent in sustainable world. Green chemistry is not different from traditional chemistry in as much as it embraces the same creativity and innovation that has always been central

to classical chemistry. However, there lies a difference in that historically synthetic chemists have not been seen to rank the environment consciousness throughout the world there is a change for chemists to develop new products, processes and services that achieve necessary social, economical and environmental objectives. According to the work carried out by Paul T Anastas, the following principles of green chemistry have been formulated.

Principles of green chemistry

Green chemistry is defined as environment benign chemical synthesis. Any synthesis, whether performed in teaching laboratories or industries should create none or minimum by-products which pollute the atmosphere. Green chemistry is one of the most fundamental and powerful tools to use on the path to sustainability. In fact, without green chemistry and green engineering, there is no path to sustainability. Green chemistry protects the environment, not by cleaning up, but by inventing new chemical processes that do not pollute the environment. The principles of green chemistry can guide chemists towards fulfilling their unique and vital role in achieving sustainable development. The implementation of 12 principles[2-11] of Green chemistry is briefly described in Table 1.

Green Chemistry in day to day Life

Since its inception in 1991, green chemistry has taken rapid strides embracing catalysis, benign solvents, renewable feedstock, green nanomaterials, biodegradable polymers and others. With the advancement of science, green chemistry has changed our life style. Some of it important applications are described.

Dry cleaning of clothes

Percholoroehylene (PERC) $Cl_2C=CCl_2$, commonly being used as a solvent for dry cleaning. It is known that PERC contaminates groundwater and is a suspected human carcinogen. A green technology developed by Joseph which make use of liquid CO_2 as a surfactant for dry cleaning cloths, thereby replacing PERC. Dry cleaning machines have been developed using this technique. Micelle technology has also evolved a metal-cleaning system that uses CO_2 as a surfactant, thereby eliminating the need of halogenated solvents[12].

Table 1. Examples of implementation of green chemistry principles into practise.

Nr	Principle	Examples:
1	Prevention	Use of solvent-less sample preparation techniques [2]
2	Atom Economy	Hydrogenation of carboxylic acid to aldehydes using solid catalysts
3	Less Hazardous Chemical Syntheses	Adipic acid synthesis by oxidation of cyclohexene using hydrogen peroxide [3]
4	Designing Safer Chemicals	New, less hazardous pesticide (e.g. Spinosad) [4]
5	Safer Solvents and Auxiliaries	Supercritical fluid extraction, synthesis in ionic liquids [5]
6	Design for Energy Efficiency	Polyolefins – polimer alternative to PWC (polimerization may be carried with lower energy consumption) [6]
7	Use of Renewable Feedstocks	Production of surfactants [7]
8	Reduce Derivatives	On-fiber derivatization vs derivatization in solution in sample preparation [8]
9	Catalysis	Efficient Au(III)-catalyzed synthesis of b-enaminones from 1,3-dicarbonyl compds. and amines [9]
10	Design for Degradation	Synthesis of biodegradable polymers [10]
11	Real-time analysis for Pollution Prevention	Use of in-line analyzers for wastewater monitoring
12	Inherently Safer Chemistry for Accident Prevention	Di-Me carbonate (DMC) is an environmentally friendly substitute for di-Me sulfate and Me halides in methylation reactions [11].

Versatile bleaching agent

It is common knowledge that paper is manufactured from wood (which contains about 70% polyssacharides and about 30% lignin). For a good quality paper, the lignin must be completely removed. Initially, lignin is removed by placing pieces of wood into a bath of NaOH and Na_2S. By this process about 80-90% of lignin is decomposed. The remaining lignin was so far removed through reaction with Cl_2 gas. The use of chlorine removes all the lignin to give good quality white paper but causes environmental problems. Chlorine also reacts with aromatic rings of the lignin to produce dioxins which are potential carcinogen and cause health problems. A versatile bleaching agent has been developed by Terrence Collins of Carnegie Mellon University. It involves the use of H_2O_2 as a bleaching agents which promote the conversion of H_2O into hydroxyl radicals that are involved in oxidation/bleaching[13].

Green solution to turn turbid water clear

Tamarind seed kernel powder, discarded as agricultural waste, is an effective agent to make municipal and industrial wastewater clear. The present practice is to use Al-salt to treat such water. It has been found that alum increases toxic ions in treated water and could cause diseases like Alzheimer's. On the other hand kernel powder is not-toxic and is biodegradable and cost effective.

Seaweed to remove Crhromium from Leather effluent

Conventionally, chemical precipitation methods are employed to remove Cr, but they lead to the formation of chrome-bearing solid wastes, whose disposal again is a problem. The metal exists in its highly carcinogenic hexavalent form Cr (VI) in the effluent. Currently, uses a cheap, abundantly available seaweed, *Sargassum wegtii* to remove Cr. The seaweed added toa chrome tanning solution fully removed the heavy metal in 6 hours. A maximum uptake of 35 mg of Cr/gm of seaweed was reported. Later, the chrome-loaded seaweed were used to make $Cr_2(SO_4)_6$ (chromium sulphate), which is a major tanning agent. This method is of special significance due to the cost effectiveness and environmental sustainability.

Copper removal with Peanuts

Waste water from electroplating, pulp and paper industries contain Cu and affect marine and human life. For cleaning wastewater, peanut shell are an effective tool which removes poisonous Cu ions from industrial wastewater. Though the industry uses many chemical methods to remove heavy metals from wastewater, most of them are highly expensive. Peanut shell cleans 95 per cent of Cu ions. This method seems to be cheaper and eco-friendly.

Conclusions

Green chemistry is not a new branch of science. It is a new philosophical approach that through application and extension of the principles of green chemistry can contribute to sustainable development. Great efforts are still undertaken to design an ideal process that starts from non-polluting materials. It is clear that the challenge for the future chemical industry is based on production of safer products and processes designed by utilizing new ideas in fundamental research. Furthermore, the success of green chemistry depends on the training and education of a new generation of chemists. Student at all levels have to be introduced to the practice of green chemistry. Green Chemistry has the potential of wiping out the possible occurrence of tragedies like Bhopal Gas by paving way for safe eco-friendly environment. There is utmost need to emphasize on creating awareness about green chemistry not only amongst the chemists and scientific community but also industries and commercial institutions.

Acknowledgements

Dr. SR thanks the beloved Chancellor, Director, Principal and Dean of Vel Tech Dr.RR & Dr.SR Technical University, Avadi ,Chennai for their constant support and encouragement.

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