National Conference on "Recent Trends in Mathematical Modeling, Simulation Methods, Computations, and Physical Sciences"
(MMSCP-2019), Organised by Hislop College, Nagpur, Maharashtra, India
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 4 | ISSN : 2456-3307

Green Chemistry : A Tool to Reducing Waste and Improving Sustainability In Chemical Industry

Jessie M. Moses[#]
[#]Assistant Professor, Hislop College, Temple Rd, Civil Lines, Nagpur, Maharashtra, India

ABSTRACT

Green Chemistry reflects the efforts of academia and industry to address the challenges related to sustainable development of the chemical industry and continuous progress is being made, both in academia and industry. Briefly, green chemistry is the utilization of a set of principles that reduce or eliminate the use and generation of hazardous substances.in the design, manufacture and application of chemical products. Many industries all over the world produce chemicals for their products that are harmful to the environment, human health and to all living species. Green Chemistry is the use of chemistry for the prevention of chemical pollution to the environment by using chemicals that are benign, or not harmful. Green Chemistry is often said to be a 'Cradle to grave approach'. This approach describes the need to consider all factors in the production of a chemical from the source of raw materials, to the disposal/recycle of the product once its useful lifetime has ended. The basic principle of green chemistry is that it is better to prevent waste than to treat or clean up waste after it is formed.

Keywords : Green Chemistry, Hazardous Substances, Disposal, Recycle

I. INTRODUCTION

The Green Chemistry revolution is providing an enormous number of challenges to those who practice chemistry in industry, education and research. With these challenges however, there are an equal number of opportunities to discover and apply new chemistry, to improve the economics of chemical manufacturing and to enhance the much tarnished image of chemistry. A reasonable working definition of green chemistry can be formulated as follows: Green chemistry efficiently utilizes (preferably renewable) raw materials, eliminates waste and avoids the use of toxic and/or hazardous reagents and solvents in the manufacture and application of chemical products (Sheldon,2000).

The goal of green chemistry solutions is to reduce or eliminate hazardous impacts of chemicals over a chemical product's life-cycle. Key guidelines associated with green chemistry are outlined in the Environmental Protection Agency's "Twelve Principles of Green Chemistry," which serves as the basis of creating and implementing chemicals and processes (Sheldon, 2007). Green Chemistry started after the Pollution Prevention Act of 1990 was passed. The Office of Pollution Prevention and Toxics (OPPT) began to develop ways to make chemical products and processes less hazardous to humans and the environment. There are many companies, foundations, clinics and individual chemists that are involved in Green Chemistry. The EPA and the Syracuse Research Corporation developed the Chemistry Expert System (GCES) which is used to develop and analyze the various principles of Green Chemistry. They find out sources of waste and evaluate the amount and risk produced and explore

opportunities to solve these problems. To achieve this, the Alternative Solvents Database (SolvDB) was constructed to help chemists and researchers so that they can efficiently find out alternatives to the harmful chemicals being used at the time.

Most manufactured products involve one or more chemical processes. We cannot imagine what our life will be like without the products by the chemical industry. Through the practice of green chemistry, we can create alternatives to hazardous substances we use as our raw materials. We can design chemical processes that reduce waste and reduce demand on diminishing natural resources. We can employ processes that use minimal amount of energy. Thus by using green chemistry, we can achieve all these and still maintain economic growth and opportunities while providing affordable products and services to a growing world population. This is a field open for innovation, new ideas and revolutionary progress. Over the years different principles have been proposed that can be used when thinking about the design, development and implementation of chemical products and processes. Paul Anastas of America coined the twelve principles of Green Chemistry in 1994 towards ideal synthetic methods to save natural resources [Anastas, 1998]. These principles enable scientists and engineers to protect and benefit the economy, people and the planet by finding creative and innovative ways to reduce waste, conserve energy, and discover replacements for hazardous substances. It is important to note that the scope of green chemistry and engineering principles go beyond concerns over hazards from chemical toxicity and include energy conservation, waste reduction, and life cycle considerations such as the use of more sustainable or renewable feedstock and designing for end of life or the final disposition of the product.

Principles of Green Chemistry:

There are twelve principles of Green Chemistry. These principles help to forge a path ahead in designing products and processes that would be less environmentally damaging while maintaining or enhancing product performance and economic cost. Designing processes to minimize environmental impact has become, in recent years, essential to industrial and engineering chemistry, and is likely to shape the field for the next 100 years (Jessop. et.al, 2009)

There are twelve principles of Green Chemistry are summarized as under.

1. **Prevention**: It is better to prevent waste than to treat or clean up waste after it is formed.
2. **Atom Economy**: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical syntheses**: Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing safer Chemicals**: Chemical products should be designed to preserve efficacy of function while reducing toxicity.
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.
6. **Design for Energy Efficiency**: Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable feedstocks**: A raw material or feedstock should be renewable rather than depleting wherever technically and economically practicable.

8. **Reduce Derivatives**: - Unnecessary derivatization (blocking group, protection/ deprotection, temporary modification) should be avoided whenever possible.
9. **Catalysis**: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Designed for Degradation**: Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into safe degradation products.
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.
12. **Inherently Safer Chemistry for Accident Prevention**: Substances and the form of a substance used in a chemical process should be chosen to minimize potential for chemical accidents, including releases, explosions, and fires.

By using the above principles of green chemistry in the design and manufacture of chemical products and processes, many industries in the world have been successful in lowering the overall costs associated with environmental safety and health.

Examples:

1. **Computer Chips**

Many chemicals, large amount of water, and energy are required to manufacture computer chips. In the study conducted in 2003, the industrial estimate of chemicals and fossil fuels required to make a computer chip was a 630:1. This means that it takes 630 times the weight of the chip in source materials just to make one chip. But it is a 2:1 ratio for the manufacture of an automobile.

1. Scientists at the Los Alamos National Laboratory (Voss, 2002) have developed a process that uses supercritical carbon dioxide in one of the steps of chip preparation, and it significantly reduces the quantities of chemicals, energy and water needed to produce chips.
2. Richard Wool, former director of the Affordable Composites from Renewable Sources (ACRES) program at the University of Delaware, found a way to use chicken feathers to make computer chips. The protein, keratin in the feathers was used to make a fiber form that is both light and tough enough to withstand mechanical and thermal stresses. The result is feather-based printed circuit board that actually works at twice the speed of traditional circuit boards. Although this technology is still under research for commercial purposes, this has led to other uses of feathers as source material, including biofuel .

2. **Paint**

Oil-based "alkyd" paints give off large amounts of volatile organic compounds (VOCs). These volatile compounds evaporate from the paint as it dries and cures and many have one or more environmental impacts. Carbon dioxide has also been successfully introduced into some dry-cleaning processes. So, various consumer formulations no longer contain a VOC solvent [Clarke, 2005].

- ✓ Procter & Gamble and; Cook Composites and Polymers created a mixture of soya oil and sugar that replaces fossil-fuel-derived paint resins and solvents, cutting hazardous volatiles by 50 percent. Chempol (R) MPS is an innovative, Sefose (R)-based alkyd resin technology that enables formulation of paints and coatings with less than half the Volatile Organic Compounds, or VOC's, of traditional, solvent-borne alkyd coatings. Sefose (R) technology from P&G is prepared from natural, renewable feedstock in a patented, solvent less process. Chempol (R) MPS

alkyd resins are specially-formulated to perform like traditional, petroleum-based solvents and create paint that is safer to use and produces less toxic waste

- ✓ Sherwin-Williams developed water-based acrylic alkyd paints with low VOCs that can be made from recycled soda bottle plastic (PET), acrylics and soybean oil. These paints combine the performance benefits of alkyds and low VOC content of acrylics. In 2010, Sherwin-Williams manufactured sufficient new paints to eliminate over 800,000 pounds, or 362,874 kilograms of VOCs.

3. Gold Nanoparticles

A simple, economic, and environmentally benign experimental route to synthesize gold nanoparticles using tea leaves in an aqueous media at room temperature was reported [Sharma, 2012]. The single-step method circumvents the use of surfactant, capping agent, or template and follows several principles of green chemistry.

4. Biodegradable Plastics

Several companies have been working to develop plastics that are made from renewable, biodegradable sources.

- ✓ Nature Works of Minnetonks, Minnesota, makes food containers from a polymer called polylactic acid branded as Ingeo. The scientists at Nature Works discovered a method where microorganisms convert cornstarch into a resin that is just as strong as the rigid petroleum-based plastic currently used for containers such as water bottles and yogurt pots. The company is working toward sourcing the raw material from agricultural waste.
- ✓ BASF developed a compostable polyester film that called “Ecoflex (R)”. They are manufacturing and marketing fully biodegradable bags, "Ecovio (R),"made of this film along with cassava starch and calcium carbonate. Certified by the Biodegradable Products Institute, the bags completely disintegrate into water, CO2 and biomass in industrial composting systems. The bags are tear-resistant, puncture-resistant, waterproof, printable and elastic. Instead of using conventional bags if these bags are used then kitchen and yard waste will be efficiently degrade in municipal composting systems.

II. CONCLUSION

Green Chemistry will be one of the most important fields in the future. Although this field has developed rapidly in the last 20 years, it is still at an early stage. Promoting ‘Green Chemistry’ is a long term task and many challenging scientific and technological issues need to be resolved; these are related to chemistry, material science, engineering, environmental science, physics and biology. Scientists, engineers and environmentalists should work together to promote the development of this field. There is no doubt that the development and implementation of green chemistry will contribute greatly to the sustainable development of our society.

In short, the benefits of Green Chemistry (USEPA,Washington 2017) can be summarized as follows :-

i) Cleaner air resulting from less release of hazardous chemicals to air leading to less damage to lungs.
ii) Cleaner water due to less release of hazardous chemical wastes to water leading to cleaner drinking and recreational water.
iii) Safer food because of elimination of persistent toxic chemicals that can enter the food chain.
iv) Safer consumer products of alltypes.
v) Lower potential for global warming, ozone depletion and smog formation.
vi) Less chemical disruption of ecosystems.

vii) Higher yields for chemical reactions consuming smaller amounts of feedstock.

viii) Reduced waste, eliminating costly remediation and hazardous waste disposal.

ix) Increased consumer sales by earning and displaying a safer product label (eg. Safer Choice Labeling)

x) Improved competitiveness of chemical manufactures and their customers.

III. REFERENCES

[1]. Sheldon, R.A.(2003) C.R. Acad. Sci. Paris, IIc, Chimie/Chemistry, 3, 541–551.

[2]. Sheldon R. A., Isabel W. C. E. Arends. and Hanefeld .Ulf., (2007) Introduction : Green Chemistry and Catalysis, Isabel Arends, Ulf Hanefeld, Wiley, 1.

[3]. Anastas, P. T. and Warner, J. C.,(1998) Green Chemistry: 12 Principles of Green Chemistry,Theory and Practice, Oxford University Press: New York,30.

[4]. Jessop, P. G., Trakhtenberg, S. and Warner, J.(2009) ACS Symposium Series, The Twelve Principles of Green Chemistry, 12, 401-436.

[5]. Voss, D. (2002) MIT Technology Review, Supercritical Carbon Dioxide: Carbon dioxide could make microchips smaller faster and cleaner to build.

[6]. Clarke, J. H. (2005) Part 1: Green Chemistry for Sustainable Development : Green Chemistry and Environmentally Friendly Technologies, Wiley ISBN 3-527-30985-3 : 12

[7]. Sharma, R. K., Gulati, S. and Mehta S., (2012) Preparation of Gold Nanoparticles Using Tea: A Green Chemistry Experiment, J. Chem. Educ. 89 (10), 1316–1318.

[8]. https : // www.epa.gov / benefits-green-chemistry