Environment Conservation Journal 9 (1&2) 105-108, 2008
(ISSN 0972-3099)

Wastes encountered by green chemistry

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Abstract

Green chemistry involves an economically sustainable view of chemical research, development and manufacture and is dedicated to chemistry to benefit society. Now a days green chemistry is universally accepted term to reveal the movement towards more environmentally accepted chemical processes and products.

Keywords: *Green chemistry, HAZMAT, Twelve principles of Green Chemistry*

Introduction

Man has always inhabited two worlds. One is the natural world of plants, animals, air, water and soil, of which man himself is a part; while the other is the built world of social institutions and artifacts, which he created for himself by using science and technology. Since man inhabits both the worlds, so they constitute an important part of the environment (Deswal and Deswal, 2005). Throughout the history, mankind has adapted to the natural variations of the earth's system and its climate. Until very recently in the history of the earth, humans and their activities have not featured as a significant force in the dynamics of the earth system. But today, mankind has begun to match and even surpass the forces of nature in changing key earth's system process (Joseph, 2006).

Primitive humans used natural resources to satisfy their basic needs of air, water, food and shelter. These natural and unprocessed resources were readily available in the biosphere and the residues produced by the use of these resources were generally compatible with or easily assimilated by the environment. With the dawn of the industrial revolution, humans were better able to satisfy their needs. So, humans turned their attention to other needs beyond those associated with survival. These acquired needs are usually met by items that must be processed or manufactured or refined; and the production, distribution and use of such items usually results in more complex residuals or wastes, many of which are not readily assimilated by the environment.

Wastes are broadly classified as domestic, trade and industrial. Domestic wastes are originated from homes. Trade wastes originate from retail, commercial and business premises. Industrial wastes originate from all mineral manufacturing and processing establishments. Different types of industries produce large quantities of solid wastes. During last 50 years, about six million chemicals have been synthesized at the rate of 10,000 new ones every month. Some 60,000 to 70,000 chemicals are used extensively in millions of different commercial products. A chemical that causes certain hazard or risk is known as hazardous material (HAZMAT). HAZMAT is waste that poses substantial or potential threats to public health or the environment and generally exhibits any one or more of these characteristics:

(1) **Ignitability-** Ignitable wastes spontaneously combustible or have flash point less than 60 °C. e.g. waste oils and used solvents.

(2) **Corrosivity-** Corrosive wastes are acid and bass that are capable of corroding metal (12.5dHpH dH 2). e.g. battery acid.

(3) **Reactivity-** Reactive wastes are unstable under normal conditions. They can cause explosion, toxic fumes, gases or vapors when heated, compressed or mixed with water. e.g. Li-S batteries and explosives.

(4) **Toxicity-** Toxic wastes are harmful or fatal when ingested or absorbed. These wastes when land disposed, contaminated liquid may leach from the waste and pollute ground water. e.g. wastes containing mercury or lead.

These wastes not only degrade the quality of environment but also affect human life. So, there is an urgent need of some alternatives that provide better products that are not harmful to our environment. The term green chemistry (Morgenstern *et al.,* 1996) describes an area of research arising from scientific discoveries about pollution and from public perception, in much the same way as the identification and understanding of a deadly disease stimulating the call for a cure. Green chemistry, an approach to the synthesis, processing and use of chemicals that reduce risks to humans and the environment, covers the following areas (Sanghi, 2000) :

- Application of innovative technology to establishe industrial processes.
- Development of environmentally improved routes to important products.
- Design of new green chemicals and materials.
- Use of sustainable resources.
- Use of biotechnology alternatives.
- Methodologies and tools for evaluating environmental impact.

The term 'Green Chemistry' was coined at the Environmental Protection Agency (EPA) established in 1970. Green chemistry or environmental benign chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (*http://center.acs.org/applications/greenchem*). In late sixties and seventies great attention has been taken in the field of environment. Several laws were developed during this period in order to protect our environment; twelve major laws among them are:

(A) 1970 clean Air Act. Regulates air emissions.

(B) 1972 National Environmental Policy Act. Requires in part that EPA review environmental impact statements of proposed major federal projects.

(C) 1972 Clean water Act. Establishes the sewage treatment construction grant program and a regulatory and enforcement program for discharges of pollutants into US waters.

(D) 1972 Federal Insecticide, Fungicides and Rodenticides Act. Governs distribution, sale and use of pesticides products. All pesticides must be registered by EPA.

(E) 1972 Ocean Dumping Act. Regulates the international disposal of materials into ocean waters.

(F) 1974 Safe Drinking Water Act. Establishes primary drinking water standards.

(G) 1976 Toxic Substances Control Act. Requires the testing, regulating and screening of all chemical produced or imported in the U.S.

(H) 1976 Resource Conservation & Recovery Act. Regulates solid and hazardous waste form "cradle to grave".

(I) 1976 Environmental research & development demonstration Act. authorizes all EPA research programs.

(J) 1980 Comprehensive environmental response, Compensation and Liability Act, better known as Superfund. Provides for a federal "superfund" to clean up abandoned hazardous waste sites, accidental spills and other emergency releases of pollutants in the environment.

(K) Emergency planning and Community right-to-know act. Requires that industries report toxic releases and encourages planning by local communities to respond to chemical emergencies.

(L) 1990 Pollution Prevention Act. Seeks to prevent pollution by encouraging companies to reduce the generation of pollutants through cost-effective changes in production, operation and raw material use.

Green chemistry is the utilization of a set of principles that reduces or eliminates the use of generation of hazardous substances in the design, manufacture and application of chemical products associated with a particular synthesis or process. Thus chemists can greatly reduce risk to human health and the environment. Consequently, there have been efforts to achieve environmentally benign synthesis (Tundo, 1998) and various acts have been passed to control and treat pollution, in an endeavour to encourage industries and academics to devise novel technologies, processes and educational materials, discouraging the formation or use of hazardous substances. This revolution is rather recent and started in the real sense in the 1990s, especially in the developed nations like the US, Germany and UK, for instance. Eventually, it is appreciated that while it is necessary to proclaim enactments and legislations, what is perhaps more important is the realization of detriments not only by the chemists/technologists, the academia and policy makers but also by the common mass in good proportion, to enable create a sense of resistance (Bora *et. al.*, 2002).

Twelve principles of green chemistry (Anastus, 1998)

(1) It is better to prevent waste than to treat or clean it up after it is formed.

(2) Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

(3) 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) Use of auxiliary substances (solvents, separation agents, etc.) should be avoided whenever possible and, innocuous when used.

(5) Chemical products should be designed to preserve efficacy of function while reducing toxicity.

(6) 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) A raw material feedstock should be renewable rather than depleting, whenever technically and economically practical.

(8) Unnecessary derivatization (blocking group, protection/deprotection, and temporary modification of physical/chemical processes) should be avoided whenever possible.

(9) Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

(10) Chemical products should be designed so that at the end of their function, they do not persist in the environment and break down into innocuous degradation product.

(11) 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) Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions and fires.

Green chemistry aims towards the design of environmental friendly products and processes using environmental friendly materials and solvents, with no or minimal amount of waste generation. Complete conversion of the reactant molecules to useful products, called atom economy, is the first step in Green chemistry. The Green chemistry approach 'benign by design', when applied at the design stage, help assure the sustainability of new products across their full life cycle and minimize the number of mistakes. Thus we can say Green chemistry deals ideal synthesis, which covers safety, renewable materials, 100% yield in one step, no waste, simple separation and atom efficiency.

Conclusion

Though it is true that many industries and research organizations are yet to implement the principles of green chemistry, nevertheless some of them have begun to realize that the 'think green' culture is more than just a fashion. In fact, the winds of changes have already started blowing and the more successful chemistry researchers and chemical technologists will like to appreciate and apply the values of green chemistry in innovation, application and teaching.

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