Green Chemistry and Education

Obot, Ime Bassey
Department of Chemistry
University of UYO, PMB 1017, UYO
Akwa Ibom State, Nigeria

GREEN CHEMISTRY has evolved from its roots in academic research to become a mainstream practice supported by academia, industry, and government. While green chemistry encompasses human health and the environment, it is guided by very specific principles of chemical practice. The interest in using green chemistry and its practices has extended internationally to become an alternative to traditional pollute-and-then clean-up industrial practice in developing countries. This evolution is marked by significant contributions from institutions with different goals that are being satisfied through a common mechanism.

What is Green Chemistry?

Green Chemistry is the use of chemistry for pollution prevention. More specifically, it is the design of chemical products and processes that are environmentally benign. Green Chemistry encompasses all aspects and types of chemical processes that reduce negative impacts to human health and the environment.

Green Chemistry provides an approach focused on the principle of moving pollution prevention upstream to change fundamental processes and emphasises the use of chemical principles and methodologies for source reduction.

Why Green Chemistry?

There is no doubt that our lives have been enhanced by chemistry. However, environmental problems such as DDT, (Dichlorodiphenyltrichloroethanal), ozone depletion are all too familiar examples of chemistry gone wrong. In responding to the growing concern, government introduced regulations to limit pollution and exposure to hazardous chemical and materials. Green Chemistry represents a fundamental shift from this model towards a pollution prevention paradigm. Its premise is that a benign process and products presents no risk.

The importance of Green Chemistry as an alternative in the developing world cannot be overstressed. Sustainable development depends on providing goods and services for a growing population without sacrificing environmental quality. Estimates from the United Nations put the world population as high as 10.7 billion people by 2050 and this nearly doubled population creates a huge demand for chemical goods and services in the near future. Much of the growth of the chemical industry is likely to take place in the developing world, coincident with the rising population. However, many of the global environmental impacts attributable to this population growth have ties to chemical processes or products: [1]

- loss of biological species in forest and in water
- ozone depletion
- downstream pollution from unsustainable agricultural practices
- the pollution of fresh and marine waters, further depleting food sources
- the introduction of persistent organic pollutants into the ecosystem
- changing climates, causing as yet unpredictable changes in the hydrologic cycle with manifestations in flood, drought, sea level change, and the spread of infectious diseases.

The Twelve Principles of Green Chemistry [4]

1. **Prevention:** It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy:** Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemistry 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.
4. **Designing Safer Chemicals:** Chemical products should be designed to effect their desired function while minimising their toxicity.
5. **Safer Solvents and Auxiliaries:** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency:** Energy requirements of chemical processes should be recognised for their environment and economic impacts and should be minimised. If possible, 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 whenever technically and economically practicable.
8. **Reduce Derivatives:** Unnecessary derivatisation (use of blocking groups, protection/deprotection, temporary modification of physical/ chemical processes) should be minimised or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis:** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation:** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

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. **Inherent Safer Chemistry for Accident Prevention:** Substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosion, and fires.

The Future of Green Chemistry

There is no doubt that the emerging area of Green Chemistry has identified scientific principles, approaches, and methodologies that have demonstrated the most positive aspects of chemistry. While the successes of Green Chemistry thus far seem quite large in terms of quantitative benefit to human, health and the environment, they are merely the tip of the iceberg when compared to the potential. To reach this full potential, greater awareness, adoption, and development of Green Chemistry practices are necessary. [2]

Sustainable economic development depends on the chemical industry to produce a vast array of chemical products. Thus, in the future, the main sustainability target with regard to chemicals will be to apply inherently safe chemicals, which are unlikely to pose a risk to human health and environment even without specific exposure control measures due to the lack of hazardous properties. This should be particularly valid for open applications. In contrast, very hazardous chemicals should be authorised and used only in closed systems or in installation where releases are negligible, thus posing no risk for human and environment.[3]

Green Chemistry is a dynamic match of scientific, economic and social interests that leads to a future where chemistry is viewed as fundamental to protecting the environment. However, the success of Green Chemistry, will depend directly on the training and dedication of a new generation of Chemists—the students of today.

World Wide Web Resources [5]

Some websites that may be useful for those trying to incorporate Green Chemistry into their teaching are given below:

1. http://www.acs.org/education/greechem/
2. http://www.lanl.gov/greenchemistry/
3. http://www.epa.gov/greenchemistry/
4. http://www.rsc.orq/is/iournals/current/green/greenpub.htm.
5. http://www.rsc.org/is/journals/current/green/GCOO2001.htm
6. http://www.chemsoc.org/networks/gcn/.

REFERENCES

Benedick, R.E. 2000. “Human Population and Environmental Stresses in the Twenty-first Century” in Globaler Wandel Global Change; Kreibich, R. and Simonis, U.E. Eds; Berlin.

CHEMRAWNXlV Website: http://cires.colorado.edu/env_prog/chemrawm/.

GCl Website: http://www.lanl.gov/greenchemistry/.Listserver: gci@lanl.gov

Anastas, P.T. and Warner, J.C. 1998. *Green Chemistry: Theory and Practice*; Oxford University Press: New York. p.30

Dennis L.H., David L.S., and Janet, M.B. 2000. *Journal of Chemical Education* Vol 77 No. 12.