

WHAT IS GREEN CHEMISTRY? AN OVERVIEW

Debarati Das Gupta*

Abstract 'ITC Limited' is a multi-business conglomerate that has, among its business portfolio Agri-Business, that has grown since its inception in 1990 to be one of India's largest exporters of agricultural products, with core competencies in select commodities like feed ingredients, foodgrains, marine products, processed fruits; contributing 56% of nearly US\$ 5.4 billion of ITC's foreign exchange earnings over the last ten years (2013). However, the very nature of the business makes it highly dependent on water, a scarce natural resource. Infact, in a research done by the United Nations Population Fund (November 6, 2003), as much as two-thirds of the world's population is predicted to be under high water stress in 2025. To meet these qualms, ITC has formulated an innovativemodel - the Soil and Moisture Conservation Programme.

This Situational Case Study, targeted towards management students, studying Corporate Governance, Strategic Management, Business Environment, Business Policy, aims to identify the embedded sustainability model of ITC's Agri-business division; analyse it in terms of its challenges and impact; and initiate discussion about Corporate Sustainability vis-a-vis Corporate Social Responsibility (CSR). This original work may also be undertaken for developmental related workshops/training programmes for students and working professionals of innovation, CSR, sustainability and shared, among others, in various Chambers of Commerce and Academic forums on the same. It is, however, not intended to serve as an endorsement, source of data, or illustration of effective or ineffective management. Certain names and information could have been disguised for confidentiality.

Keywords Corporate Social Responsibility, Corporate Sustainability, Embedded Sustainability, Strategic CSR, Triple Bottom Line (TBL)

Green chemistry focuses on the reduction, recycling, and/or elimination of the use of toxic and hazardous chemicals in production processes by finding creative, alternative routes for making the desired products that minimise the impact on the environment. Green chemistry is a more eco-friendly green alternative to conventional chemistry practices. The green chemistry movement is part of a larger movement ultimately leading to a green economy- namely sustainable development, sustainable business and sustainable living practices. Green chemistry can contribute to achieving sustainability in three key areas. First, renewable energy technologies will be the central pillar of a sustainable high-technology civilisation. Second, the reagents used by the chemical industry. Third, polluting technologies must be replaced by benign alternatives. The aim of the present article is to acquaint the academicians, researchers, scientists, and engineers with values and positive impact of green chemistry in innovation, application and technology.

The term "green chemistry," also known as clean chemistry or benign and sustainable chemistry, refers to the design of chemicals and formulation of processes that reduce the risk to humans and minimize environment pollution. The goal of green chemistry solutions is to lessen 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.

Green chemistry traces back several decades and can be linked to impact environmental activists, such as Rachel Carson. Her 1962 publication, "Silent Spring," helped direct the public's awareness to pesticides and their ties to environmental pollution. Less than a decade later, in USA the Environmental Protection Agency (EPA) was formed in 1970. The EPA references its existence as the extended shadow of Rachel Carlson who is considered a leading innovator of environmental protection, a cause that has paved the way to current green chemistry practices.

As reflected in the previous decade spanning to today, there has been a shift in the emergence of green chemistry trends. As eco-awareness spreads to the consumer market and as the hazards of certain materials and chemicals become better known, companies and manufacturers are working to revamp the way they use chemicals in their products. These practices include:

- Reducing formaldehyde (a gas linked to various health issues including cancer) use in the production of products.
- Eliminating/reducing dyes in manufacture.

* Final Year M. Sc. Student, UGC-Centre for Advanced Research in Chemistry, North Eastern Hill University (NEHU-Central University), Shillong, Meghalaya, India. Email:debaratidg@gmail.com

- Eliminating ozone-depleting CFC's in widely used products.
- Development of technology through chemicals that lessens green impact (i.e. converting sustainable plant-based materials to low-carbon chemicals).
- Creating a patented system to formalize and phase out raw materials for fabrication processes.
- Developing sustainable technology used in agrichemical treatment for farming.

The society is dependent in many ways on the chemical industry to maintain the current standards of living and improve the quality of our lives – ‘better living through chemistry’. The past few decades have been an era of successful chemistry. Developments in water treatment, waste disposal methods, agricultural pesticides and fungicides, polymers, materials sciences, detergents, petroleum additives and so forth, have all contributed to the improvement in our quality of life. But unfortunately all these advances come with a price tag of ‘pollution’. Today, with growing awareness, in industry, academia and the general public, of the need for sustainable development, the international chemistry community is under increasing pressure to change current working practices and to find greener alternatives. Scientists and engineers from both the chemical industry and the academic world have made efforts to correct pollution problems by the more extensive use of ‘green chemistry’ concepts, i.e. development of methodologies and products that are environmentally friendly. As the name implies, the green chemistry movement aims to make humanity’s approach to chemicals, especially synthetic organic chemicals, environmentally ‘benign’ or ‘sustainable’. ‘Organic chemistry textbooks, a generation from now will be unrecognisable compared with today’s standard texts’, predicts one of the progenitors of what is coming to be called green chemistry. For better living, what is needed is:

- (a) An increasing awareness in industry of the importance of concepts such as waste minimization and atom utilisation.
- (b) Greater involvement by governments in controlling the use of resources and the productive disposal of waste.
- (c) Emergence of other underpinning concepts as general principles which can be used the conception and execution of synthetic chemistry and in the usage of chemicals produced. (Ref: <http://www.segmentjournals.com/?id=1518>)

Green chemistry is the new and rapid emerging field of chemistry. Its growing importance is in utilisation of maximum possible resources in such a way that, there is negligible or minimum production of chemical waste. It is one of the best alternatives for traditional chemical synthesis process. Few derivatives of acetanilide (compounds I- IV)

were synthesized by conventional method as well as by green chemistry method. By applying the green synthesis method, we have not only avoided the use of acetic anhydride which is hazardous one but also the formations of by products are avoided. The atom economy was calculated on the basis of molecular weight of desired product and it was found to be in the range of 72% to 82% which signifies the utility of green synthesis method (Redasani, Kumawat, Kabra, Kansagara, & Surana, 2010).

With increasing number and quantities of chemicals in commerce and use, scientific attention continues to focus on the environmental and public health consequences of chemical production processes and exposures. Concerns about environmental stewardship have been gaining broader traction through emphases on sustainability and “green chemistry” principles. Occupational safety and health has not been fully promoted as a component of environmental sustainability. However, there is a natural convergence of green chemistry/sustainability and occupational safety and health efforts. Addressing both together can have a synergistic effect. Failure to promote this convergence could lead to increasing worker hazards and lack of support for sustainability efforts. The National Institute for Occupational Safety and Health has made a concerted effort involving multiple stakeholders to anticipate and identify potential hazards associated with sustainable practices and green jobs for workers. Examples of potential hazards are presented in case studies with suggested solutions such as implementing the hierarchy of controls and prevention through design principles in green chemistry and green building practices. Practical considerations and strategies for green chemistry, and environmental stewardship could benefit from the incorporation of occupational safety and health concepts which in turn protect affected workers (Schulte, McKernan, Heide11, Okun, Dotson, Lentz, Geraci, Heckel, & Branche1, 2013)

Although sustainability is an abstract concept with many interpretations and ramifications and the metrics thereof are yet to be rationalised, it is becoming increasingly evident that the rapidly advancing degradation of the natural environment, coupled with excessive consumption of natural resources, is threatening the sustainability of humanity. This paper explores how chemistry and the chemical enterprise are progressing towards a sustainable chemistry philosophy and practice and it also explores the role which sustainable chemistry and, in particular, sustainable chemistry education have in engaging with the wider philosophy of environmental sustainability. It is relevant to note that although chemistry has recently been cited as being of importance in enabling transitions to environmental sustainability, as to how these can be achieved by strategically-structured and targeted chemical education programs has not been debated in the literature to date; hence this paper offers some pioneering suggestions in this context. As for ‘sustainable development’,

there have been many definitions of 'green chemistry' which relate to the synthesis of environmentally benign molecules and materials, new chemical (energy efficient) processes and new quality control technologies which reduce effluent and waste. These definitions imply that 'green chemistry' and 'sustainable chemistry' are closely inter-related since the vision of green chemistry is holistically aligned with environmental sustainability. With its direct linkages to other major science disciplines, such as the life sciences, materials science, chemical engineering and environmental science, and its indirect linkages to economics and ethics, together with its principal aim to provide benefits to society, green chemistry is rapidly changing the negative public image of chemistry which has prevailed for decades (Hill, Kumar & Verma, n.d.)

The employment of green chemistry principles into the biorefineries can make a significant contribution to sustainable development by adding value to the sustainable use of biomass. A wide spectrum of bio-based products and bioenergy can be obtained feeding the full bio-based economy constructed on multi-disciplinary partnerships to foster necessary R & D & D direction having as key point principles of green chemistry. Green Chemistry and Biorefinery concepts are two approaches helping to develop new and more sustainable processes. The implementation of both methodologies impels to fossil-independent future with bioeconomy based on natural feedstock like biowaste and industrial by-products. The development of technologies for valorisation of these resources is a key role of society in the creation of sustainable and more environmentally friendly future (Morais & Bogel-Lukasik, 2013).

The successful implementation of green chemistry innovations involves cooperation between many sectors: academic, industrial, government and society. Green chemistry is dependent on both strong science and engineering, as well as on a variety of trends in economics, markets, and policy. While there have been great advances

in the underlying science needed to make green chemistry possible to implement, the actual rate of change has been slow. Still, there has been demonstrable progress. Interviews and workshops with key members of the green chemistry community in the United States, India, and China have revealed the most important barriers to its successful implementation. From these barriers, the cases, interview, and workshop data, there are a number of multi-stakeholder policy approaches and partnership models that would have a positive impact on the development and implementation of green chemistry technologies throughout the chemical industry. (Matus, 2011)

REFERENCE

- Redasani, V. K., Kumawat, V. S., Kabra, R. P., Kansagara, P., & Surana, S. J. (2010). Applications of Green Chemistry in Organic Synthesis. *International Journal of Chem Tech Research*, 2(3), 18-56.
- Schulte, P. A., McKernan, L. T., Heidel, D. S., Okun, A. H., Dotson, G. S., Lentz, T. J., Geraci, C. L., Heckel, P. E., & Branche, C. M. (2013). Occupational safety and health, green chemistry, and sustainability: A review of areas of convergence. *Environmental Health*, 12(31). doi:10.1186/1476-069X-12-31.
- Hill, J., Kumar, D. D., & Verma, R. K. (n.d.) Challenges for Chemical Education: Engaging with Green Chemistry and Environmental Sustainability; *The Chemist*, 86(1).
- Morais, A. R. C., & Bogel-Lukasik, R. (2013). Green chemistry and the biorefinery concept. *Sustainable Chemical Processes*, 1(18). doi: 10.1186/2043-7129-1-18).
- Matus, K. (2011). Understanding Innovation for Sustainable Development: A Comparison study of Green Chemistry in the United States, India and China. *Industrial Green Chemistry World Symposium cum exhibition 4th, 5th, and 6th December, 2011*.