Role of Individual, In Solving Global Sustainability Challenges by Integration of Green Chemistry and Green Engineering

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Research Article

Abstract: Green chemistry as a scientific movement of the 1990s for better design and innovations in the chemical industry was extended to – Green Engineering which covers technological applications, engineering processes and products. The twelve principles of Green Chemistry cover the fundamental aspects of Chemistry, chemical engineering and technology. The American society for Engineering Education, for example, has establish a Green Engineering program to teach and promote issues of green design in industrial processes and systems. The goal of Green Engineering program is to incorporate risk related concepts into chemical processes and products designed by Educators, Software, Industry and sources. Most developing countries also embraced and are in the process of formalizing role of engineering chemistry through legislation and education. The paper highlights the origin, aim and principle to current status, the legal framework, concepts, processes and role of integration of Green Chemistry and Green Engineering and associated studies.

1. Introduction

1.1Origin of Green Chemistry

The term Green Chemistry, coined by staff at the US EPA in the 1990s, helped to bring focus to an increasing interest in developing more environmentally friendly chemical processes and products. It is universally accepted term to describe the movement towards more environmentally acceptable chemical processes and products. In recent years Green Chemistry has become widely accepted as a concept meant to influence education, research and industrial practice. Attempts at controlling pollution and improving environmentally quality since 1970s led to the emergence of sustainable chemistry or Green Chemistry. Green Chemistry is sustainable safe and non-polluting chemical science which enables man to manufacture products with minimum consumption of materials and energy and also production of minimum waste. Green Chemistry is instrumental for avoiding materials that cause problems in the environment by introduction of products which are toxic, persistent and tend to undergo biomagnifications e.g. pesticides such as DDT, Parathion etc.

1.2Origin of Green Engineering

Green Chemistry as a scientific movement of the 1990s for better design and innovations in the chemical industry was extended to Green Engineering which covers technological applications, engineering processes and products. Green Engineering is a substantial addition to Green Chemistry with very similar aims and principles which lead to sustainable developments through engineering and new design of processes and products. According to Environmental Protection Agency (EPA) : "Green Engineering embraces the concept that decisions to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of an industrial process or product. The goal of the Green Engineering is to incorporate risk related concepts into chemical processes and products designed by academia and industry.

2 Integration of Green Chemistry and Green Engineering

2.1 Objective of Green Chemistry

i) Objective of Green Chemistry is embraces the cost of waste. Hundred of tones of hazardous waste are released to the air, water and land by industry every hour of every day. The chemical and Engineering industry are the biggest sources of such waste. The costs of waste to a chemical manufacturing company are high and diverse. It is related to legislation, Health and safety, waste Disposal, Hazard evaluation, inefficient use of raw materials etc.

ii) To help, promote and encourage the application of Green Chemistry in all areas where chemistry plays significant role.

iii) Green Chemistry can be considered as a series of reductions. These reductions lead to the goal at triple bottom-lime benefits of economic, environmental and social improvement. It consist of following aspects

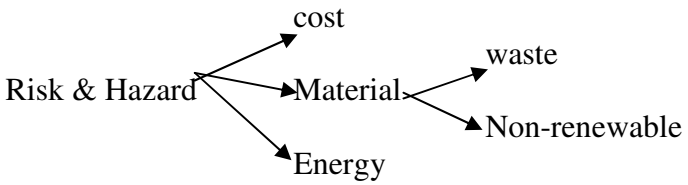

Fig. 1.2.1 Reducing concept

iv) The Green Chemistry approach of "benign by design" should, when applied at the design stage, help assure the sustainability of new products across their full lifecycle and minimize the number of mistakes we make.

Premanufacturing	1. Waste minimization 2 safe and responsible extraction
Manufacturing	1. Greater use of catalyst 2. safe and intensive processing
Product Delivery	1. Close to market manufacturing 2. minimum packaging
Product Use	1. Use of chemicals in formulation 2. safer products
End of line	1. Reusable 2. biodegradable and disposal

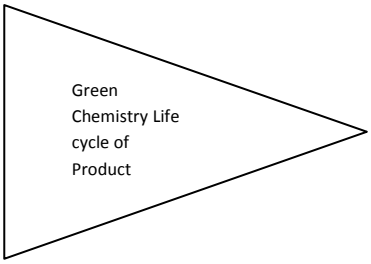

Fig. 2.2.2 Green Chemistry Life cycle of Product

v) Green chemistry as dictionary for features of ideal synthesis. Green chemistry metrics are now available and commonly based on "Atom efficiency", whereby we seek to maximize no of atoms introduced into a processes into the final product.

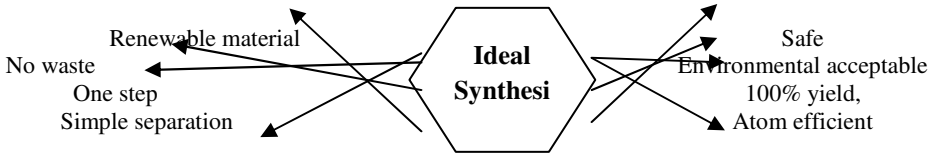

Fig. 2.2.3 Ideal Synthesis

vi) To achieve greener chemical process we will need to make increasing use of environmentally friendly technologies.
vii) Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substance in the design , manufacture and application of chemical product.

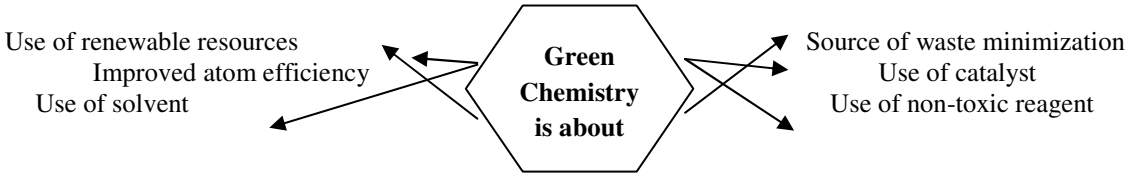

Fig. 2.2.4 Green Chemistry

2.2 Objectives of Green Engineering

1) Green engineering is the design, commercialization and use of processes and products, which are feasible and economical while minimizing i) generation of pollution at the source and ii) risk to human health and environment.
2) Objective of green engineering is to embraces the concept that decisions to protect human health and the environment.
3) It is aiming to four major section of the scientific and technological community.

i) academia ii) University teachers iii) software scientists iv) Industrial chemical engineers.

4) It lead to sustainable development through engineering and new design of process and products.

2.3 Principles of Green Chemistry

1. Pollution Prevention
2. Atom Economy
3. Less Hazardous Chemical Synthesis
4. Designing Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Design for Energy Efficiency
7. Use of Renewable Feed stocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-time analysis for Pollution Prevention
12. Inherently Safer Chemistry for Accident Prevention

2.4 Principle of Green Engineering

1. Materials and energy must be Inherently non-hazardous, Rather Than Circumstantial Designers

need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible.

2. Prevention of Waste Instead of Treatment It is better to prevent waste than to treat or clean up waste after it is formed.
3. Design for Separation and Purification Processes Separation and purification operations should be designed to minimize energy consumption and materials use.
4. Maximize Efficiency in products and processes Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.
5. Output-Pulled Versus Input-Pushed Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials
6. Conserve Complexity Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.
7. Durability Rather than Immortality Targeted durability, not immortality, should be a design goal for products. After useful use of a product to disintegrate under natural conditions
8. Meet Need, Minimize Excess (Products) Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flow.
9. Minimize Material Diversity Material diversity in multicomponent products should be minimized to promote disassembly and value retention.
10. Integrate Material and Energy Flows Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows
11. Design for Commercial "Afterlife" Products, processes, and systems should be designed for performance in a commercial "afterlife."
12. Renewable Rather Than Depleting Material and energy inputs should be renewable rather than depleting

3. Green Chemistry & Institutional Framework

i) American society for Engineering Education: 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.

ii) Defining the principles conference, held in Sadestin, Florida in may of 2003. The preliminary principles forged at this multidisciplinary conference are intended for engineers to use a guidance in the design or redesign of product and processes.

iii) The goal of Green Engineering program is to incorporate risk related concepts into chemical process and products design by academia and industry. This inclusive Educators, Software, Industry and Outreach.

iv) EPA's Green Engineering team is comprised of chemical engineers and industrial hygienists with diverse industrial and academic experiences. The team has more than 80 years of combined experience in industry. Including the chemical process is agriculture, pulp and paper industries.

v) Through the support of US Environmental Protection Agency (EPA), a Green Engineering project has fostered efforts to incorporate green engineering into chemical engineering Curriculum. It supported several initiatives including development of a Text book, Green Engineering, Environmentally conscious design of chemical process and dissemination through regional and national workshops.

vi) The Americans launched the high profile presidential green chemistry awards in mid-1990s and effectively disclosed some excellent case studies covering products and process.

vii) Green Chemistry Network (GCN) established in UK in 1998 and now with about 1000 members worldwide and green chemistry institute established in the USA in mid-1900s now part of American Chemical Society and with "Chapter" in several country around the world.

viii) The Royal Society of Chemistry (RSC) launched the journal " Green Chemistry" the intention for this journal was always to keep its reader aware of major events, initiatives and educational and industrial activities, as well as leading research from around the world.

ix) In 1992, The Earth Summit, also known as UN Conference on Environment and Development (UNCED) was held in Rio de Janeiro to reconcile worldwide economic development with protecting the environment. The summit brought together 117 heads of states and representatives 178 nations, who agreed to work towards the sustainable development of the planet.

x) Environmental Impact Assessment (EIA) can broadly be defined as a study of the effects of a proposed project, plan or program on the environment. The legal methodological and procedural foundation of EIA were established in 1970 by the enactment of the National Environmental Policy Act (NEPA) in the USA.

4. Role of Individual in Solving Global Sustainability Challenges by Integration of Green Chemistry & Green Engineering

4.1 Sustainable development

Sustainable development means many things to many people and the range of actions and their implications is

as varied. It is development that meets the needs of the present without compromising the ability of feature generation to meet their own needs it consists of environment, economy and community. The achievement of sustainably development will require action by the International Community, National Government, Commercial and non-commercial organization & Individual action by citizens. The individual action by citizen play very vital role in solving global sustainability challenges such as Global warming, Acid rain, Ozone depletion by integration of Green Chemistry and Green Engineering. It has been recognized that pursuing high growth objectives without considering of environmental degradation and natural resources depletion threatens sustainability. Major environmental problem like ozone hole in the stratosphere, the global warming and green house effect the spread of environmental pollution by polychlorinated compounds in the remote places of the planet, plastic pollution of the ocean are some of the problems causing International concern. Green Engineering is a substantial addition to green chemistry with very similar aim and principles which leads to sustainably developments through engineering and design of process and products.

4.2 Roll of Individual incorporating Green engineering and green chemistry :

i) Use of Environmental impact Assessment (EIA) : The first phase of an environmental assessment is called an Initial Environmental Examination (IEE) and second is Environmental Impact Studies. (EIS).

ii) Environmental Management Plan (EMP) : An environmental management plan is a detailed plan and schedule of measures necessary to minimize mitigate etc. any potential environmental impacts identified by the EIA (World Bank 1999). It includes the actions needed to implement these measures, including the following features.

- EMP should describe with technical details each mitigation measures.
- The EMP should include monitoring objectives that specifies the type of monitoring activity that will be linked to the mitigation measures.
- EMP should includes an estimate of the cost of the measures and activities recommended.
- EMP must be operative throughout the hole project cycle.

iii) Implication of Environmental impact statement

iv) Implication of Public participation techniques

v) EIA related studies

vi) Individual and Environmentally friendly technologies : There is a pool of technologies that are becoming the most widely studied or used in seeking to achieve the goals of green chemistry.

Eg. 1) Catalysis is truly well established technology Acid catalysts for example Have been used in Alkylation isomerisation and other reactions for many years have progressively improvement from traditional soluble or liquid systems, through solid acids such as clay. Use of zeolite to catalysis the Fridel-Craft reaction of anisole with acetic anhydride . In comparison to the use of traditional route using AlCl3, the the zeolite based method is more selective.

e.g. 2) Use of heterogeneous catalysis is the use of TS1, a titanium silicate catalyst for selective oxidation reaction (21) such as the 4-hydroxylation of phenol to the commercially important hydroquinone.

e.g. 3) The direct reaction of oxygen with benzene to give phenol would be 100 % atom efficient and based on the most sustainable oxidant truly an ideal synthesis if an individual we can only device a good in a catalysts to make it viable.

e.g. 4) Polylactic acid has become the basic of one of the best recent commercial example of the potential value. Cargill – Dow now manufacture Polylatic acid polymer materials using a starch feedstock. The material are finding it widespread use an versatile sustainable and biodegradable alternatives to Petro plastics.\

vii) Preventation of Acid rain : Acid rain is a rain or any other form of precipitation that is acidic, meaning that is causes elevated level of hydrogen ions (low pH) , it can harmful effects on plants, aquatic animals and infrastructure as we individual and integration of green chemistry and green engineering play vital role to minimize the problem.

- The burning fossil fuel is still one of the cheapest ways to produce electricity so people are now researching new ways to burn fuel which do not produce so much pollution.
- Government need to spend more money on pollution.
- Use of Green Chemistry technology to washed Sulphur out of smoke by spraying a mixture of water and powder lime stone into smoke stock.
- Car are now fitted with catalytic converters which remove three dangerous chemicals from exhaust gases.\
- Government and individual investing researching different ways to produce energy.
- Fluidized bed combustion also reduces amount of Sulphur Emitted by power production.
- A number of International treaties on the long range transport of Atmosphereic pollutants have been agreed for example Sulphur Emittion Reduction Protocol, Air Quality Agreement, in 1980 the US Congress passed Acid Deposition act.

- Institutional strengthening for environmental monitory and enforcement including human resources development.
- Formulate measures for improving the policy frame work for reduction of Sulphurdioxide and other acid rain causing gas emission.
- Use of catalytic converts in the cast to cut down air pollution.
- Individual can contribute directly by the conserving energy sense energy production causes the largest portion of the acid deposition problem. .for example individual can

i) Buy vehicles with low Nox emissions and properly maintain the vehicle.

ii) Be well informed.

iii) Insulate your home and best you can carpool – use public transportation,walk or bicycle whenever possible.

iv) Only use electric appliances when you need then.

5. Future Trends and Challenges

It summarized some key areas in the future relationship between Environmental Science, Green Chemistry, and Green Engineering and their implication for producers, researches, and society as a whole.

i) There will be a continuing balance between the needs of the environment and the social and economic needs of society.

ii) Government intervention is likely to make use increasingly of a variety of economic instruments as well as "command and control" regulations.\

iii) There are price implications for both producers and consumers as environmental costs continue to be included in the price of goods and services.

iv) The general public and NGOs tend to distrust the chemical industry and the use of chemicals and this is likely to increase unless there is action by industries that use chemical themselves.

v) There is a continuing need for the development of green metrics that demonstrate to all where progress is being made and where further action is required.

vi) European Union industrialists will come under increasing pressure to consider the environmental lifecycle of their products "from cradle to grave".

i) Role of Green Engineering to measure the headline indicators for sustainable development.

6. Conclusion

Attempts at controlling pollution and improving environmental quality since 1970s lead to the emergence of sustainable chemistry or green chemistry. In recent times synthetic chemistry is mostly based on green chemistry this is applicable to production of new and existing chemical products. In ideal case green chemistry helps in avoiding feedstock and catalysts eliminating generation of hazardous intermediates and by products. Green chemistry and environmental chemistry are intimately linked with each other. Knowledge of environmental chemistry helps the development of green chemical process. The framework of green engineering through its twelve principles covers some of the most important industrial process and technological issues developed in the last decade. Education of engineers and changes in attitude and methods of the old professionals are the key components for green design and innovative alternatives. Academic also play a vital role in the development of green engineering curriculum, primarily by authoring the Green Engineering Text Book reviving materials and providing input on program applicability to student. The individual action by citizen play vital role in solving global sustainability challenges such as Global warming, Acid rain, Ozone depletion etc. by integration of green chemistry and green engineering.

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