APPLICATION OF GREEN CHEMISTRY FOR SUSTAINABLE DEVELOPMENT IN NIGERIA

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Abstract

With the ever growing human population in Nigeria, environmental pollution, depletion in supply of non-renewable energy sources, high cost of living and incessant power failures, the country needs an a alternative energy source, more environmental friendly products and processes that are more reliable, safer, secure and affordable. The focus of this paper is therefore on the application of green chemistry for sustainable development. The concepts of green chemistry and sustain ability were highlighted. Since green chemistry contributes to the quality of life, human welfare and sustainable development it should be integrated into the discipline of pure chemistry.

The term Green chemistry, coined by staff at the United state Environmental Protection Agency (U.S.E.PA) in the 1990s helped to bring focus to an increasing interest in developing more environmentally friendly chemical, processes and products. There were good examples of Green chemistry research in Europe in the 1980s, notably is the design of new catalytic systems to replace hazardous and wasteful processes of long standing for generally synthetic transformations, including Friedel - crafts reactions, oxidation and various base – catalyzed carbon – carbon bond-forming reaction. Some of this research had led to new commercial processes as early as the beginning of the 1990s (Clark, 1995).

In recent years Green chemistry has become widely accepted as a concept meant to influence education, research and industrial practice. It is important to note that it is not a subject area as organic chemistry. Rather, Green chemistry is meant to influence the way that chemistry is being practiced – be it in the teaching children, research a route to an interesting molecule, carrying out an analytical procedure, manufacturing a chemical or chemical formulation, or designing a product (Lancaster, 2002). Green chemistry has been promoted worldwide by an increasing but still small number of dedicated individuals and through the activities of some key organizations. These include the Green Chemistry Net work (GCN; established in UK (United Kingdom) in 1998). Other Green chemistry Networks exist in other countries like that of Italy, Japan, Greece and Portugal and new ones appear every year. The GCN was established to help promote and encourage the application of Green chemistry in all areas where chemistry plays a significant role (Clark, 2005). At about the same time as the establishment's of GCN, the Royal society of chemistry (RSC) launched the Journal of "Green Chemistry". The intention for this Journal was always to keep its readers of major events, initiative and educational and industrial activities as well as leading research around the world. Green chemistry can be considered as a series of reductions. These reductions lead to the goal of triple – line benefits of economic, environmental and social Improvements (Elkington, 1999). According to Clark, 2005), costs are saved by reducing waste (which is becoming increasingly expensive to dispose of

especially when Hazardous) and energy use (likely to represent a larger proportion of process cost in the future) as well as making process more efficient by reducing materials consumptions. These reductions also lead to environmental benefits in terms of both feed stocks consumption and end of life disposal. Furthermore, an increasing use of renewable resources will render the manufacturing industry more sustainable (Stevens and Vertie 2004). The reduction in hazardous incidents and the handling of dangerous substance provides additional social benefits not only to plant operators but also to local communities and through to the users of chemical – related products.

Some Recent Developments and Examples of Green Chemistry

Chemists from all over the world are using their creative and innovative skills to develop new processes, synthetic methods, analytical tools, reaction conditions, catalysts etc. under the new green chemistry cover (Okonkwo, Okunola and Ezeanyanaso, 2010). Some of these developments are:

- A continuous Process apparatus converts waste biomass into industrial chemicals, fuels and animal feeds. Another process convert waste biomass such as municipal solid waste, sewages sludge plastic and agricultural residues to useful products including hydrogen, ethanol and acetic acid.
- A method for mass production of taxol by semi continuous culture or the Taxus genus plant.
- A fermentation methods for the production of carboxylic acid
- A method of partially oxidizing alcohol, such as methanol to ethers, aldehydes, esters or acids, by using a super critical fluid mobile.
- A process for producing a fluoropolymer by supercritical carbon (IV) oxide.
- A cost – effective method of producing ethyl lactate, a non- toxic solvent derived from corn.
- A range of organic solvents; for example bio ethanol that are worker friendly and environmentally sound.
- A new environmentally friendly technology in mixed metals recovery from spent acid wastes has been used to recover zinc and ferrous chloride from pickle liquor.
- The demand for non –ionic surfactants is growing. A new example of this is alkyl glycoside which is made from saccharide. This product can be used as a replacement for alkyl sulphanate anionic surfactants in shampoos. Sodium silicate can be used as a more environmentally benign replacement for phosphorus containing additives in washing powder. Three coconut oil soap bases for liquid cleaning application have been developed. One of these products has a very light colour and low odour making it suitable for introducing dyes and fragrance.
- Feed stocks recycling of plastic wastes into valuable chemicals useful as fuels or raw materials.
- The first bio-pesticides for sugar cane, called Biocane has recently been launched in Australia. The product is based on a naturally - occurring fungus that has been cultured on broken rice grains to provide a medium for distribution. Biocane granules are claimed to be particularly effective against greyback cane grub.

Principles of Green Chemistry

In adopting green chemistry, according (Okonkwo, Okunola and Ezeanyanaso, 2010 pg138) the following principles must be ensured;

- It is better to prevent waste than to treat waste after it is formed
- Synthetic methods should be designed to maximize the incorporation of all material used in the processes into the final products.
- Practicable synthetic methodologies should be designed to use and generate substances that produce little or no toxicity to human health and the environment.
- Chemical products should be designed to preserve efficiency of function while reducing toxicity.
- The use of auxiliary substances (for example solvents or separation agents) should be made unnecessary wherever possible and innocuous when used.
- Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at an ambient temperature and pressure.
- Unnecessary derivation (blocking group, protection/deprotection and temporary modification of physical/chemical processes) should be avoided whenever possible.
- Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
- 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 products.
- Analytical methodologies need to be further developed to allow for real time in process monitoring and control, prior to the formation of hazardous substances.
- Substances used in a chemical process should be chosen to minimize the potential for chemical accidents including releases, explosion and fires.

Aims of Green Chemistry Principles

Green chemistry is aimed at helping practitioners involved in the inventions, design and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances (Pietro, Anastas and Tumas, 2000). The principles promote environmental chemistry at all levels; research, reduction to practice education, national and international policy and public perception. They help chemists and chemical engineers design more environmentally benign products and processes through the selection of feedstock, reagents, alternative synthetic transformations, solvents, reaction conditions and end products as well as the design of safer chemicals. For instance when considering what feed stock to use in generating a particular compound, the green chemist must explore whenever practicable. There is not guarantee that such renewable feed stocks is possible for a given reactions nor if they are that they will provide a net environmental benefits.

Nonetheless, the principles of green chemistry provides a set of design criteria and goals that can help improve the environmental performance of new products and processes. As they begin to apply the principles of green chemistry, chemists are discovering many pathways towards

environmentally greener designs. For instance, synthetic catalysts and bio catalysts, such as enzymes, offer a variety of alternative synthetic pathways that are consistent with the principles of green chemistry. These catalysts also enable the use of alternative reagents and feed stock previously impracticable with conventional chemistries. The two cross – cutting enabling technologies hold much promise in fulfilling the expectations for green chemistry.

Developing Countries and Green Chemistry

In developing countries, the introduction of green chemistry is still in its infancy stage, despite the significant role green chemistry can play. Any of the practices in developing countries are still far from the concepts of safety, pollution prevention and design of energy efficiency. Environmental pollution and waste generation (Okonkwo, Okunola and Ezeanyanaso 2010) are some of the aching problems many developing countries are suffering from. Many of the reasons behind these problems lie in policies and strategies adopted that are based on end of pipe treatment. Most frequently, income generation activities are dependent on an efficient use of energy and other resource such as water which may pose some serious problems to future generation.

According to (Okonkwo, Okunola and Ezeanyanaso, 2010), the united Nations reporting on the millennium development goals at a country level, indicated a high level of energy consumption and limited energy resources in most of the developing countries. This report strongly recommended the imperative need to ration the use of energy resources in these countries and to implement energy conservation policies. The same trend of difficulties developing countries face has been illustrated in the series of country reports produced by the rural development of the water and environment department of World Bank (Okonkwo, Okunola and Ezeanyanaso, 2010).

Green chemistry could play a pivotal role in salvaging many of the ailing conditions that many of the developing countries like Nigeria are subjected to. The use of solar energy, introduction of sustainable farming, recycling and the implementation of life cycle thinking and life cycle analysis as a management tool for some of the chronic issues such as municipal waste management, are of few examples of how green chemistry can benefit developing countries. Green chemistry can also have a very strong impact on water sufficiency issues in that part of developing countries where water resources are polluted. It is through the implementation of a cleaner production and the use of safe and biodegradable chemical that a huge volume of waste water could be reused to provide the emerging critical need of water in many of these countries.

Sustainable Development

The Brundland commission (World Commission on Environment and Development, 1987) defined sustainable development as the process in which the exploitation of natural resources, the allocations of investments and the process of technological development and organizational change are in harmony with each other for both current and future generation (Okonkwo, Okunola and Ezeanyanaso, 2010).

Based on this content "sustainability" is a path forward that allows humanity to meet current environmental and human health, economic and societal needs without compromising the progress and success of future generations (Craedal & Allenby, 1995). Sustainable practices refer to products, processes and systems that support this path. The processes that involves developing new energy resources which meet societal needs and to be sustainable must also be economically competitive and should not cause any harm to the environment or human health. Sustainability necessarily cuts across all disciplinary boundaries and requires a broad system view to integrate the different and competing factors involved. This includes "strategic connections between scientific research, technological development and societies efforts to achieve environmentally sustainable improvement in human well-being" (National Research Council 1999) and involves the creative "design of products, processes, systems and organizations and the implementation of smart management strategies that effectively harness technology and ideas to avoid environmental problems before they arise" (National of Engineering, 1997).

Sustainable Development and Chemistry

In a world with a continuously increasing populations and limited resources, the ideal of a sustainable development should be of a major concern for the future (Okonkwo, Okunola and Ezeanyanaso, 2010). It is only research and innovation that will allow the development of economic and social networks and process that fulfill the requirement of sustainability. The future has to be planned with visions, creativity and fantasy including brand new approaches and the explorations of the unknown. Sustainability in science and technology begins when we start thinking of how to solve a problem or how to turn science into technology. Chemistry as the science of matter and its transformation plays a central role in this process. It is the bridge between physics, material science and life sciences. Only chemical processes which have reached a maximum level in efficiency will lead to more sustainable products and production. Since scientist and engineers play a key role in those processes, their awareness, creativity and looking ahead is needed to bring reactions and chemical processes to maximum efficiency the term "Green Chemistry" has been coined for efforts towards this goal.

Future Challenges and Opportunities for the Chemical Profession and the Science of Chemistry

The principles of green chemistry have been considered as beginning points for the chemical profession in trying to deal with the novel ethical context in which humanity has been placed by the unprecedented power afforded to it in the 20^{th} century by science and technology (Jonas, 1984).

Generally, Green chemistry has major contributions to make to the quality of life, human welfare and sustainable development. However, before Green Chemistry can contribute fully to this area, it must be integrated into the discipline of chemistry itself. This requirement presents a number of major challenges to the chemical profession. Chemists will need to integrate into pure chemistry the question of why not a particular technology should be abandoned, improved or adopted on environmental protection basis. These questions must become as important in research and education and made as concrete as the ubiquitous question associated with what comprises chemical technology and how it actually works. Certainly the largest sustainability issues where chemists have so much to

offer will require new approaches that can only be built with long term commitment. For example finding an efficient way of converting solar to chemical energy is a large sustainability issue. The culture of present day chemistry places too many short term obstacles in the path of research problems of this type. Thus, the culture must adapt to recognize that certain sustainability problems will require novel approaches with inherently longer incubation periods. Chemists must learn how to better evaluate and sustain research programs. Rather than that of rapid publications of incomplete research work, which offer reasonable promise of bringing within the fullness of time, those critical advances that will genuinely promote the cause of sustainability. The science of chemistry cannot escape this growth and remain meaningful and important to humanity. Chemistry exert an enormous influence on human action and is thus inextricably intertwined with the forces that guide human actions especially ethnics and certain forms of passion.

As such, the power of scientific objectivity will be more openly directed by the action and passion such as our love of life and our desire to protect it. These forces are fully capable of directing chemists towards research that really matters to each and every human living and the future generations. (Okonkwo, Okunola and Ezeanyanaso 2010).

Finally, chemistry will have much to offer by becoming more meaningful to humanity, increasing in attractiveness as a career choice, growing to be more worthy of support, spawning new large economic developments and progressing to be interesting and compelling if chemists work to define and follow their natural and unique role in achieving a virtuous civilization that sees broad validity within the community of living things to the claim of existence in an environment of natural creations.

Conclusion

With the ever growing human population in Nigeria, environmental pollution, depletion in supply of non-renewable energy sources, high cost of living and incessant power failure, the country needs an alternative energy source, more environmental friendly products and processes that are more reliable, safe, secure and affordable. Research and development in green chemistry is the only key to an industrialized, technologically advance, economically vibrant, less polluted and a safer environment in Nigeria.

Recommendations

Since Green chemistry has major contributions to the quality of life, human welfare and sustainable development, it should be integrated into the discipline of pure chemistry. Sustainability issues where chemists have so much to offer require new approaches that can be built with long term commitment. This is because the present chemistry culture places too many obstacles in the path of research that enhances sustainability. Finally chemistry will have much more to offer by becoming more meaning to humanity in terms of economic development increased attractiveness in terms of career choice if the concept of green chemistry is integrated into pure chemistry practices.

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