International Journal of Innovative Environmental Studies Research 5(4):1-4, Oct.-Dec., 2017

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Sustainable Chemistry for Environmental Protection and Economic Development in Nigeria

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ABSTRACT

This paper tried to discuss the definition of sustainable chemistry, the 12 principles of sustainable chemistry and their applications in everyday life. It also discussed the utilization of these set of principles geared at reducing the use and generation of hazardous substances during the manufacture and at the application of chemical products. The paper also discussed sustainable chemistry as aiming at protecting the environment not by cleaning up, but by inventing new chemical processes that do not pollute and avoid producing hazardous and harmful products. The paper also talked about the importance of Sustainable Chemistry to the Economic Development of Nigeria. It is a newly but rapidly developing important area in the chemical sciences which all chemists must embrace in order to reduce the global warming by protecting the ozone layer. Conclusion was drawn and some suggestions made.

Keywords: Green Chemistry, atom economy, sustainable chemistry

INTRODUCTION

The main aim of any country is economic development. Nigeria is not left out in the race for reaching the highest possible level it could in economic development. However, it is not only reaching such economic level that matters much, but how sustainable is it. The pillars of economic development may include, meeting the economic, environmental, political, social, cultural and health needs. A nation may be considered developed if it has acquired a sustainability status in most of these areas. Before we go further let us look at the definition of sustainability.

Sustainable development is a mainstream recognition of a link between development and environment. It advocates meeting the economic, environmental, political, social, cultural and health needs of the present without compromising the ability of the future generations to meet their own needs. It seeks to minimize waste by maximizing recycling and discouraging the use of non-renewable resources, encourage sustainable use of finite renewable resources, discourage overtaxing the capacity of ecosystems to absorb or break down wastes, protect natural processes and climatic systems, including not overtaxing the capacity of global ecosystems to absorb or dilute wastes without adverse effects, and mobilize political and institutional structures within nations and internationally to support the achievement of these goals (Eneh, 2008).

Sustainable Chemistry

Sustainable Chemistry (also called Green Chemistry) is a chemical philosophy encouraging the design of products and processes that reduce or eliminate the use and generation of hazardous substances. Sustainable chemistry is the utilization of a set of principles that will help reduce the use and generation

of hazardous substances during the manufacture and application of chemical products. Sustainable chemistry aims to protect the environment not by cleaning up, but by avoiding the production of hazardous substances and inventing new chemical processes that do not produce those substances and not even as by-products. It is a rapidly developing and an important area in the chemical sciences. The fundamental idea of sustainable chemistry is that, the designer of a chemical is responsible for considering what will happen to the environment and human health after the chemical agent is produced. The principles of sustainable chemistry and some examples of their applications to basic and applied research are illustrated below:

Principles of Green Chemistry

***Pollution Prevention*:** It is better to prevent waste than to treat or cleanup waste after it is formed.

***Atom Economy*:** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. Choosing transformations that incorporate most of the starting materials into the product are more efficient and minimize waste, e.g., Diels–Alder reaction is 100% Atom Economy reaction as all the atoms of the reactants are incorporated in the cyclo-adduct.

***Less Hazardous Chemical Synthesis*:** Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. This principle focuses on choosing reagents that pose the least risk and generate only benign by-products. For example, in the manufacture of polystyrene foam sheet packing material, chlorofluorocarbons which contribute to O_3 depletion, global warming and ground level smog have now been replaced by CO_2 as the blooming agent.

***Designing Safer Chemicals*:** Chemical products should be designed to preserve efficacy of the function while reducing toxicity. New products can be designed that are inherently safer for the target application. Pharmaceutical products often consist of chiral molecules, and the difference between the two forms can be a matter of life and death – for example, racemic thalidomide when administered during pregnancy, leads to horrible birth defects in many new born. Evidence indicates that only one of the enantiomers has the curing effect while the other isomer is the cause of severe defects. That is why it is vital to be able to produce the two chiral forms separately. Catalysts that can catalyze important reactions that produce only one of the two mirror image forms are developed.

***Safer Solvents and Auxiliaries*:** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous. Widely used solvents in syntheses are toxic and volatile – alcohol, benzene (known carcinogenic), CCl_4, $CHCl_3$, perchloroethylene, CH_2Cl_2. Purification steps also utilize and generate large amounts of solvent and other wastes (e.g., chromatography supports). These have now been replaced by safer *green solvents* like ionic liquids, supercritical CO_2 fluid, water or supercritical water and also solvent-free systems that utilize the surfaces or interiors of clays, zeolites, silica, and alumina.

***Design for Energy Efficiency*:** 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. *Microwave irradiation*: For example, Beckmann rearrangement of oximes in the solid state with microwave irradiation gave quantitative yields of the products without the use of acid catalysts.

***Use of Renewable Feed stocks*:** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical. e.g., benzene used in the commercial synthesis of adipic acid which is required in the manufacture of nylon, plasticizers and lubricants, has been replaced to some extent by the renewable and nontoxic glucose and the reaction is carried out in water.

***Reduce Derivatives*:** Unnecessary derivatization (blocking group, protection/ deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible. This is because such steps can generate more waste. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Catalysts are used in small amounts and can carry out a single reaction many times and so are preferable to stoichiometric reagents, which are used in excess and work only once. They can enhance the selectivity of a reaction, reduce the temperature of a transformation, reduce reagent-based waste and

potentially avoid unwanted side reactions leading to a clean technology**.** Catalysis is crucial to the chemical and related industries. Apart from heavy metal catalysts softer catalysts like zeolites, phase transfer catalysts, e.g., crown ethers, are finding increasing industrial applications.

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

It is important to teach the values of green chemistry to tomorrow's chemists. They should learn to assess hazard with this knowledge and to adopt more sustainable chemical practices throughout their academic and industrial career. The practice of green chemistry means doing clean chemistry, and it cannot be less chemistry.

Our modern developed world is one which is heavily dependent on the use of chemicals. We must then worry about recycling, reusing and avoiding hazardous and useless by-products, but where these principles are not adopted in the industry, a lot of damage to the environment is caused right at the manufacturing stage. The philosophy of green chemistry is to strike at the root - at the production stage itself.

Specifically, green chemistry seeks to develop processes that are among other things, safe, energy efficient, have none or minimum side products and use easily available raw materials. It is essentially a chemical engineering practice to move towards a more sustainable and environmental friendly chemical industry.

Green Chemistry emerged in the scientific, political and industrial scene as the savior to lead us on the path of sustainability. Green or Sustainable Chemistry has appeal in the chemical industry because often greener methods are economically more viable.

They may sometimes require some investment but getting rid of hazardous wastes also means getting rid of their disposal and cost due to regulations. In totality, they still prove economically beneficial.

The environmental benefit cannot be undervalued. An industry that uses sustainable methods has better chances of surviving in the years to come, as raw material availability becomes scarce and environmental issues gain absolute importance.

As an example of the applications of sustainable chemistry, consider the traditional process for the synthesis of the Drug ***ibuprofen*** which consists of a six-step synthesis with an atom efficiency of 40%, the remaining 60% are undesired by-products and waste. The new process has only three catalytic steps and an approximately 80% atom utilization. In addition, the new process saves 20-40% of the total energy required in the traditional process.

Nigerian Economy and Sustainable Chemistry

In Nigeria, the introduction of sustainable chemistry is still insignificant despite the important role it can play in its sustainable economic development. Many of the practices in Nigeria are still far from the concepts of safety, pollution prevention, and design of energy efficiency. Environmental pollution and waste management are some of the disturbing problems Nigeria is facing. Many of the reasons behind these problems lie in policies, strategies and implementation adopted. Most frequently, income generation activities are dependent on an efficient use of energy and other resources, such as water, which may pose some serious problems to future generations if sustainability strategies are not adopted.

Other area where sustainable chemistry is of great importance is provision of entrepreneurial skills to citizens. Mobolaji, 2017 asserted that, when innovations from research in chemistry are converted into marketable products for commercial gain, chemistry entrepreneurship is on course. Many of the household materials being used on daily basis are the products of the chemistry researches. These products include soaps, hair cream, shoe polish, mosquito repellants, herbicides, gum, sanitizers, after shave lotion to mention but some. Chemistry entrepreneurship is an indispensable solution to the various problems of our society. We need it to solve the problem of unemployment that is bedeviling our nation.

The students' enrolment in tertiary institutions is increasing on yearly basis and it is an open secret that the government and private sectors have limited spaces to employ the graduates of these institutions, making the rate of unemployment to be correspondingly high. (Ogunsola 2009, Aja-Okorie and Adali, 2013) in their study also asserted that the situation of unemployment in Nigeria is indeed alarming. Chemistry entrepreneurship is not only suitable to tackle the problem of unemployment it is also appropriate for growing natural economy.

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 states. The report strongly recommends the imperative need to ration the use of energy resources in these countries and to implement energy conservation policies.

Sustainable chemistry could play a vital role in salvaging many of the devastating conditions which Nigeria is facing. The use of solar energy, introduction of sustainable farming, recycling, and the implementation of lifecycle thinking and lifecycle analysis as a management tool for some of the chronic issues, such as municipal waste management, are a few examples of how green chemistry can benefit Nigeria.

CONCLUSION AND RECOMMENDATIONS

So far, we can understand the contributions of green chemistry to the quality of life, human welfare, and sustainable economic development of our country. However, before green chemistry can contribute fully to these areas, Nigeria must integrate it into her policies. Those policies must be followed with strategies and implementation. Nigeria should acquire the potential for long-term maintenance of wellbeing of her citizens, which in turn depends on the wellbeing of the natural world and the responsible use of natural resources. This is because with the ever-growing human population in Nigeria, environmental pollution, depletion in supply of non-renewable energy sources and non-sustainable agriculture, may not augur well for her. Nigeria needs alternative energy sources, more environmental friendly products and agriculture, and processes that are more reliable, safer, secure, and affordable. Research and development in green chemistry is the only key to an industrialized, technologically advanced, economically vibrant, less polluted, and safer Nigeria.

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