



## Application of Green Chemistry for Environmental Protection and Economic Development in Nigeria: Issues and Challenges: A Review

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### ABSTRACT

*The paper explores the challenges and prospects of green chemistry as a tool for sustainable development in Nigeria. Green chemistry is a practice of using sustainable and environmentally friendly methods to create products, with the goal of reducing potential harm of using hazardous chemicals and substances for production in Nigeria, green chemistry has been proposed as a way to ensure sustainable development, given the numerous issues facing economic, environmental and social growth. This paper examines the implication of green chemistry for Nigeria development, including potential challenges and opportunities. It then concludes with discussion of the potential values of green chemistry and its importance for sustainable development in Nigeria.*

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### INTRODUCTION

Our world today is faced with environmental degradation resulting from menacing human and industrial activities in the quest for survival, civilization and technological advancement. Anthropogenic changes, unlawful refuse disposal, technological innovations, oil spillage, release of greenhouse gases, pollution and inappropriate disposal of toxic substances by industries resulting to inimical climatic changes have affected the course of our natural existence and biodiversity. The warming of the earth due to the depletion of the ozone layer, flood and ocean rise, outbreak of endemic diseases, and frequent inhaling of polluted air have all resulted in a high mortality rate of human lives and made our environment unsustainable. Our world is becoming more uncomfortable to live in even as the population increases exponentially on a daily basis (Manley, *et al.*, 2008).

Environmental damage or pollution caused by the lack of application of green chemistry will have an impact on the costs by the government or firms in overcoming environmental problems. The declining quality of the environment will also have an impact on economic growth and

lead to various social conflicts that are sustainable and involve various elements of society, entrepreneurs and government. Green chemistry is known as a study that aims to reduce or eliminate the danger of adverse effects of chemicals on the environment, including humans. Green chemistry is a very effective approach to prevent pollution because it can be used directly by scientists in the current situation (Sharma *et al.*, 2008).

Green chemistry is described as the movement towards more environmentally acceptable chemical product and processes (WCED, 1987). It comprises of research, education and commercial application of chemicals (DOE, 2004). Green chemistry can be applied through environment friendly old or new technologies (Bjorn Lamborg, 2001). Although nowadays green chemistry is accepted as a vital development in a way we practice chemistry and sustainable development but it is only applied in a small fraction of actual chemistry.

Green chemistry, similar to sustainable or circular chemistry, is an area of chemistry and chemical engineering focused on the design of products and process that minimize or eliminate

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the use and generation of hazardous substances. While environmental chemistry focuses on the effects of polluting chemicals on nature, green chemistry focuses on the environmental impacts of chemistry, including lowering consumption of nonrenewable resources and technological approaches for preventing pollution (Maltin et al., 2015).

In a short term, green chemistry has been focused heavily on developing new and environment friendly chemical processes using many technologies. Globalization era will demand increasing emphasis on product but it is important that the manufacturing should be through green chemistry methods. Green chemists and engineers employ biological systems and life cycle to create chemicals that lead to foundation of our economy. There are numerous applications of Green Chemistry in industry such as plastics, renewable energy technologies, pesticides, textile manufacturing, water purification, pharmaceuticals and basic chemical feedstock. It is believed that, overtime Green Chemistry will change chemistry as a whole towards an economy based on sustainable renewable energy, green jobs, and bio-based productions.

Green chemistry has now been around for three decades, and it has been creation an actual modification in our world. It has been extensively predictable that an evolution to a sustainable society dictates vital changes in resource and energy utilization. To efficiently use limited resources, both trans materialization and dematerialization must occur. Trans materialization is the process of shifting away from hazardous and non-renewable resources toward safer and/or renewable or recyclable materials [1-3]. Forthcoming chemicals and progressions should have chemical, physical, and toxicological properties that permit safe handling and disposal. Green chemistry aims to achieve this through the rational design of chemicals and processes according to a set of principles and metrics recognized during the past few decades. A synchronized revolution of many social, political, economic, and technological factors must focus, to achieve the full potential of green chemistry.

This perspective encourages interdisciplinary design and advance of new technologies that represent principles of sustainability.

### **Aim of the Review**

The current review aimed to highlight applications of green Chemistry for environmental protection and economic development in developing country (Nigeria). This paper is a review article describing green chemistry, sustainable development and its impact on the economy. To understand and provide an elaborate discussion on the importance of green synthesis, highlight the 12 green principles and application of green chemistry for sustainable development.

### **METHODOLOGY**

#### **Search Strategy**

To carry out this review we searched out the articles from various databases. Literature review is a method of collecting data in a way looking for information through books, newspapers, magazines, and other literature. The review articles in the research sourced from several journal studies related to green chemistry and its economic impact. Furthermore, the keywords included: green Chemistry, environment, sustainability, green principal and economic impacts

### **DISCUSSION OF REVIEW**

#### **Green Chemistry Concept**

The Green Chemistry concept emerged in 1990 aimed at reducing pollution using environmentally friendly solvents or green solvents. In the late 1990s, the idea of Green Chemistry began to grow slowly in Europe and the United States. Green Chemistry is an innovative approach that supports sustainable development and applies the concept of using environmentally friendly chemicals (Winterton, 2016). It prioritizes design process innovations that optimize performance and improve production by utilizing materials and energy that are safe for human health and the environment (Veleva and Cue, 2019).

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The term green chemistry is defined as, "The design, development, and implementation of chemical processes and manufactured products to reduce or eliminate substances hazardous to human health and the environment". (Anastas & Warner, 1998) "Green Chemistry" is the universally accepted term to describe the movement towards more environmentally acceptable chemical processes and products (Marteel-Parris and Abraham, 2014). It encompasses education, research, and commercial application across the entire supply chain for chemicals. Green Chemistry can be achieved by applying environmentally friendly technologies some old and some new. While Green Chemistry is widely accepted as an essential development in the way that we practice chemistry, and is vital to sustainable development, its application is fragmented and represents only a small fraction of actual chemistry (Anastas and Eghbali, 2010).

### The need for Green Chemistry

Chemistry has played a vital role in improving our life but all these developments are responsible for various environmental problems. Some examples can be mentioned here for chemical, which were synthesized for the benefit of human beings, has other detrimental effects like pesticides, chlorofluorocarbons (CFC as refrigerants), Dioxins, Thalidomide drug. Some diseases, which became famous by the discharge of poisonous pollutants from the industries, were Minamata disease (mercury poisoning), Itai-Itai Disease (cadmium poisoning), Methaemoglobinaemia (excessive amount of nitrogen fertilizers) etc. On the basis of what has been stated, it is clear that most of the environmental and health problems would not have been there, had the various industries followed the basic norms. It is in this context that green chemistry plays a vital role in keeping the environment clean. The concept of green chemist addresses environmental issues in an economic profitable manner. Green chemistry must permeate not only to the chemical industries, but it is necessary to bring about changes at the grass root level (Anastas and Warner, 1998).

### Principles of Green Chemistry

The twelve principles of green chemistry were introduced by Paul Anastas and John Warner in 1998. They are a guiding framework for the design of new chemical products and processes, applying to all aspects of the process life-cycle from the raw materials used to the efficiency and safety of the transformation, the toxicity and biodegradability of products and reagents used. They were briefed recently into the more suitable and memorable acronym, productively (Anastas and Warner, 1998).

The principles of green chemistry including.

1. **Waste prevention:** It is better to prevent waste, than to treat or clean up waste after it is formed.
2. **Atom economy:** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product
3. **Less hazardous chemical synthesis:** Practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Design for energy efficiency** Chemical products should be designed to preserve efficiency of function while reducing toxicity.
5. **Safer solvent and auxiliaries:** The use of auxiliary substances (for example solvents, or separation agents) should be made unnecessary wherever possible and innocuous when used.
6. **Use of renewable feedstock:** 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.
7. **Reduce derivatives:** Unnecessary derivitization (blocking group, protection/deprotection, and temporary modification of physical/chemical

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- processes) should be avoided whenever possible.
8. **Catalysis:** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
  9. **Design for degradation:** 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.
  10. **Real time 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.
  11. **Safer chemistry for accident prevention:** Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

#### **Reasons for Green Chemistry Principles**

Green chemistry is aimed to help practitioners involved in the invention, design, and application of chemical products and processes to reduce or eliminate the use and generation of hazardous substances (Pietro, Anastas, Black, Breen, *et al.* 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 feedstock to use in generating a particular compound, the green chemist will explore renewable feedstock whenever practical.

There is no guarantee that such renewable feedstock is possible for a given reaction nor, if they are, that they will provide a net

environmental benefit. Nonetheless, the principles of green chemistry provide 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 toward environmentally greener designs. For instance, synthetic catalysts and biocatalysts, 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 feedstock previously impractical with conventional chemistries. The two crosscutting enabling technologies hold much promise in fulfilling the expectations for green chemistry (Roberto Ballini, 2009).

#### **Economic Impacts of Green Chemistry**

Green chemistry has a role not only to protect the environment issue by preventing pollution before its creation; green chemistry is also a way of the firm to increase efficiency and reduce the costs of production, an opportunity for businesses to lighten their environmental burdens and make money (Marteel-Parris and Abraham, 2014). The same opinion also states that the application of green chemistry can improve economic performance (Saini and Singh, 2002). The economic benefits of green chemistry such as less need for investment in waste storage and treatment by the firms, as well as compensation payments for environmental damage. Recycling is one of the concepts in green chemistry and very fundamental in promoting a circular economy, which is a new paradigm of sustainability that is able to reduce environmental implications, and in creating new business opportunities (Peng and Weijun, 2011).

Green chemistry is central drivers in its advancement not only important to humans and the environment but are also crucial for business and economy. It helps in finding methods and techniques to speed up the chemical reactions using small amounts of reactants to deliver the same results and the same price of the product. It also helps in reducing the number of synthetic steps that enable increased production, increase

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in the plant capacity while saving energy and water consumption, using fewer chemicals for manufacturing the products results in reduced waste which results in reduced cost for disposing of chemical waste and toxic waste treatments (Cucciniello and Cespi, 2018). The industry is adopting green chemistry methodologies because they improve the corporate bottom line. A wide array of operating costs is decreased through the use of green chemistry

### **Green Chemistry and Sustainability**

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 (Graedel & Allenby, 1995). Sustainable practices refer to products, processes, and systems that support this path. For example, such processes might involve developing new energy resources to meet societal needs; but to be sustainable, they must also be economically competitive and not cause harm to the environment or human health (National Research Council, 1999).

In a world with a continuously increasing population and limited resources, the idea of a sustainable development is of major importance is it for the future. Only research and innovation will allow the development of economic and social networks and processes that fulfill the requirements of sustainability. The future has to be planned with visions, creativity, and fantasy, including brand new approaches and the exploration of the unknown (Cliff, *et al.*, 2004).

Sustainable development is an inherently political issue. There are limits to what can be achieved at a global level, unless the Governments give a firm lead by tackling difficult issues and, if necessary, providing the incentives to change people's behavior (Hazell *et al.*, 2000). For example, if approached in the right way, more efficient processes using less material and producing less waste can often go hand in hand with economic growth and improve the social well-being (Anastas and Zimmerman, 2018). However, this is not always the case and it may be unrealistic to expect commercial organizations to

adopt the more sustainable practices unless the financial and other frameworks within which they operate make this advantageous to their 'bottom line'. Individual chemists can still achieve a great deal within existing frameworks by the application of sound chemical science, common sense, and good management (Eneh and Owo, 2008).

### **Application of Green Chemistry**

Green chemistry widely used in the chemical, pharmaceutical, paper, polymer, clothes and colour industry. It plays a key role in different energy science, and the manufacture of innovative technique to make solar cells, fuel cells, and batteries for storing energy. In Nanoscience and technology, green chemistry also highly used. Since main goal of green chemistry is to minimize or eliminate waste in the chemical industry, it has inspired the creation of many green "next generation" catalysts (Anastas and Horvath, 1997).

### **Environmental Protection**

The role green chemistry in environmental protection is truly phenomenal. By encouraging the use of biodegradable and non-toxic chemicals along with promoting energy efficient production approaches, green chemistry significantly reduces the potential harm to ecosystems. Basically by adopting green chemistry principles, we reduce environmental pollution at its source. This involves the modification of equipment, technology, processes, products and raw materials in a way that the amount of pollutants or contaminants released in the environment is reduced (Tyson, 2007).

### **Reduced Toxicity**

Green chemistry plays a pivotal role in reducing the toxicity of various products and hazardous waste. One of the primary approaches of green chemistry is to design safer chemicals and manufacturing processes that also lead to the formation of less toxic byproducts. By developing policies that either decrease or eliminate the use of toxic chemicals in production processes, green chemistry also contributes to the reduction of

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harmful environmental impacts (Tundo *et al.*, 2000).

#### **Green Chemistry for Safety Improvement**

As green chemistry promotes the development of safer chemicals and processes, it minimizes exposure to hazardous substances that can pose risk to human health. In addition, green chemistry advocates for environmentally friendly manufacturing processes that decrease emissions of pollutants to improve air quality both indoors and outdoors (Garyali *et al.*, 2013).

#### **Green Chemistry in Pharmaceutical Industry**

In pharmaceutical industry green chemistry plays an important role and makes a revolution in it. A chemical company now makes ibuprofen (painkiller) in a three-step rather than a six-step process (Abuhijleh, 1994). Zocor (simvastatin), leading drug for treating high cholesterol, conventionally synthesized using a multistep method concerning huge quantities of hazardous reagents that formed a big amount of toxic waste. A bio-catalysis company, Codexis developed a new technique for synthesizing the drug using an engineered enzyme and a low-cost feedstock. The chemotherapy drug paclitaxel (marketed as Taxol) was made by take out from yew tree bark, a process that used a large amount of solvent for killing the tree. The drug is now made by growing tree cells in a fermentation vat (Garyali *et al.*, 2013).

#### **Energy Conservation**

Green chemistry is of fundamental importance for energy conservation as it focuses on developing and implementing energy efficient processes. The goal is to design sustainable technologies that require less energy to function properly. One-way green chemistry achieves energy conservation is by replacing stoichiometric chemical processes with more energy efficient catalytic alternatives. Moreover, green chemistry prioritizes the development of renewable feed stocks as an energy source, to protect nonrenewable resources and decrease greenhouse gas emissions (Foster ET AL., 2009).

#### **Resources Efficiency**

Green chemistry emphasizes overall resource efficiency by encouraging the use of raw materials and utilizing limited resources in a sustainable manner. Resource efficiency also involves designing processes that generate less waste. By doing so, we maximize the amount of desired products synthesized and minimize the formation of unwanted by products. Additionally, green chemistry principles ensure that the loss of valuable materials is kept at a minimum by incorporating multi step separation and purification techniques.

#### **Sustainable Manufacturing**

Green manufacturing is a holistic approach to producing less hazardous goods that minimize negative environmental impact. It can be achieved by using environmentally friendly materials, activities, and technologies that reduce the ecological footprint. Adopting sustainable manufacturing processes is key to receiving all other benefits of green chemistry (Nydia and Cecile, 2018).

#### **Cost Effectiveness**

While green chemistry is crucial for reducing or preventing environmental damage, its principles have an impact on the financial resources the government and firms require to overcome ecological problems. By reducing the production of waste, green chemistry ensures that the costs associated with waste disposal are minimized as well. Green chemistry is also reducing energy cost and operational expenses by implementing sustainable and recycling technologies (Amasuomo and Baird, 2016).

#### **Market Competitiveness**

There is growing demand for sustainable and environmentally friendly products, meaning that companies can gain competitive edge on the market by adopting green chemistry principles, in addition, green chemistry gives companies an opportunity to develop innovative processes and materials, enabling them to stay ahead and maintain a competitive position. In a nutshell, green chemistry can build your company

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reputation and promote a positive brand image, which in turn will attract consumers and investors.

### **Alignment with Evolving Regulations**

With increasing natural disasters, polluted environment, and global warming, government agencies prioritize setting environmental regulations that minimize or prevent further damage. The being said, accepting green chemistry principles allow companies to meet future regulatory requirements linked with chemical safety and environmental protection.

### **Unique Opportunities for Education**

Green chemistry offers a myriad of educational opportunities, letting students build a solid foundation to actively participate in creating a sustainable future. Additionally, green chemistry provides unique research projects that enable students to gain hands on experience in eco-friendly practices through chemistry.

### **SOME INNOVATIONS CONTROL KEYS IN 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 Ezeanyanoso, 2010). Some of these developments are: There several controls that can be manipulated at the different stages of chemical manufacturing process

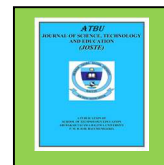
1. **Using alternative feedstock starting materials:** Selection of the starting materials has a major effect through the whole synthetic pathway. It determines what hazards will be faced by the workers extracting shippers transporting the substance, chemist handling the substance. It also predetermines possible future risk from the end products and waste. Using more environmentally benign alternative feedstock may improve the environmental profile of the whole process.
2. **Using alternative reagents:** Reagents are needed to transform the starting molecules into a target substance. Reagents are not necessarily consumed and are often recycled, but can still bear harm to people and environment exposed to the process. At this point, a chemist must balance the criteria of chemical efficiency and availability with potential hazard.
3. **Using alternative solvents:** Solvents are very common focusing point because a wide range of syntheses are performed in a liquid media. Many of the currently used solvents are volatile organic compounds. Many of those are responsible for air quality problems (smog, etc.) when released to air. While traditional organic solvents are easily available, well characterized, and regulated, there is a push for alternative systems that are more environmentally benign in the long run aqueous solvents, ionic liquids, immobilized solvents, supercritical fluids, etc.
4. **Changing target product:** chemistry is function oriented the target chemical is needed to perform a certain function or possess certain properties. This avenue is related to the search of the alternative final product, which may require radical change in the way synthesis is done.
5. **Process monitoring:** real time measurements (sensing) of process parameters and concentrations sometimes provide valuable information and hints how the process should be turned to avoid adverse effect or risk. Also, process monitoring may open avenues for making the process more cost effective.
6. **Alternative catalysis:** catalysis bears enormous benefits, not only from the standpoint of technical efficiency. Environmental benefits results from the use of much smaller amount of reagents in catalyzed reactions, which otherwise would contribute to the waste stream.

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Using fewer chemicals is also economically profitable. It should be noted, though, that many classes of catalysis (e.g. heavy metals) are very toxic. Hence the challenge of alternative catalysis is to develop environmentally benign options.

## DEVELOPING GREEN CHEMISTRY IN NIGERIA

Nigeria is confronted with several peculiar challenges which make a green agenda appear unattainable. The top of these include the solutions that have been adopted because of the inefficiencies in the energy and transportation systems, as well as waste management. The building industry also has its peculiar handicaps. But with the application of chemical science and growing understanding and ability to manipulate chemical molecules chemists have contributed significantly to the advancement of technology through ways such as synthesizing crop enhancing agricultural chemicals to ensure constant and viable food supply. Pharmaceuticals and chemical pesticides are also developed. In developing countries, the introduction of green chemistry is still in a stage of infancy, despite the significant need and the significant role green chemistry can play. Many 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 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 resources, such as water, which may pose some serious problems to future generations.

Sustainable chemistry could play a pivotal role in salvaging many of the ailing conditions that many of the developing countries are subjected to. 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 developing communities.

## Implementation of Green Chemistry in Education

Green chemistry must be understood by every individual well to be able in life [9]. Education can contribute to the realization of Green Chemistry by providing students with knowledge of chemical products and sites with new, more environmentally friendly methods. Also, education plays a role in educating students in designing technology based on Green Chemistry as well as providing insight into how to operate it.

The implementation of green chemistry in education should be explored to be sustainable. Implementation of Green Chemistry in education could be realized optimally with supported by two parties; they are Government and Educational institutions. The government is the policy holder that regulates the education component nationally, while the educational institutions are practitioners who implement policies that have been made by the government. Thus, both parties must synergize and harmonize because of mutual interconnection.

## Barriers to the implementation of Green Chemistry

1. **Economic and financial:** occasionally green chemistry is more expensive than conventional routes and future benefits are uncertain.
2. **Regulatory:** emphasis is on exposure reduction and not on hazard reduction, lack of global harmonization on regulation and environmental policy, insufficient funding for research and regulatory incentives.
3. **Technical:** non availability of suitable substitute reactions and solvent system, non-availability of trained chemist and engineers, poor knowledge about existing green products and processes and non-sharing of relevant information among industries

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4. **Organizational:** problems arise from intra organizational conflicts, lack of support at executive or technical level and lack of understanding in sales and marketing.
5. **Cultural:** poor awareness and wrong conception about efficiency and cost of green reactions among consumers and general public.
6. **Definition and metrics:** poor guidance on best practice and sufficient teaching on sustainable chemistry, difficulty in measuring greenness of a reaction and conducting multi-dimensional optimization.

### **Challenges and Opportunities for in Green 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 20th 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 (Clark, 1998).

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 exerts an enormous influence on human action and is thus inextricably intertwined with the forces that guide human actions especially ethics 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 and Ezeanyanoso 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 AND RECOMMENDATIONS**

With the ever-growing human population, environmental pollution, depletion in supply of non-renewable energy sources, high cost of living, and incessant power failures, Nigeria needs an alternative energy source, more environmentally friendly products, 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, and safer Nigeria.

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Green chemistry is the need of today and light of future which gives precious idea for the scientifically based environmental protection. Chemists, researchers and pharmaceutical companies must be used to consider the principles of green chemistry while designing the reaction mechanism and selecting catalyst. By applying green chemistry procedures, we can minimize the waste materials, reduce the use of toxic chemicals, maintain the atom economy and save the environment which is heritage of our next generation. To combine the technological progress with the safe the environment is one of the challenges of new millennium. Chemist will play a key role in the realization of the conditions for sustainable development and green chemistry may be their winning strategy.

Green chemistry can re-imagine itself as a champion and driver of sustainable development, transforming its image from often being seen as the source of environmental pollution and degradation to being recognized as the core sustainability science — a key driver of practical, sustainable and ethical solutions to many of the world's greatest challenges. To do so, it will need to undergo radical reforms that amount to a redesign of the field encompassing chemistry's image, approaches and practices — that will affect education, research and its funding patterns, and engagement with other disciplines, industry and society. We believe that these changes are desirable because the world needs chemistry's best endeavours to avert or mitigate the many global crises that are currently unfolding. We also believe that the proposed changes will reinvigorate the entire field of chemistry and transform its appeal as an ethical science worthy of investment and esteem by society.

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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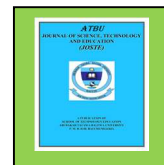
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