Prospect and Challenges of Research in the Chemical Sciences in Nigeria: A Review

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Abstract
Chemistry is a broad science, embracing the concepts of creation of molecules, manipulation of atoms and dealing with the microscopic and macroscopic scales. It covers the interaction with plants, animals and human through agriculture, biology, medicine and with the physical world through electronics, new building materials and new sources of energy. It affects the people of our planet, protecting and preserving our health, ecology, culture and heritage. For this definition to be true, then the place for research in chemistry / the chemical sciences should not be under estimated. Chemical research is carried out yearly in all the Nigerian universities at the Bachelor of Science, Masters and the Doctorate level; the polytechnics both at the Ordinary National Diploma and the Advance National Diploma. Surprisingly, due to the poorly equipped chemistry laboratory in the Country, research are contracted out to private institutions or Chemical laboratory with little or no supervision and with no standard analytical procedure provided. Results are generated without confirmation of standards operational procedures for the instrument and that of the analytical procedure used. Results are generated and are swept under the carpet and dumped on the library shelf. This paper attempt to highlight the prospect and challenges encountered with research in the chemical sciences in Nigeria and with a view of proffering solution to them.

Key Word: Analysis, Challenges, Chemistry, Chemical Science, Limitations, Nigeria, Prospect, Research

Introduction

From inception, research in Chemistry - a branch of the Chemical Sciences, is considered to be an important tool for attaining national goals. Which is why the assertion, “What is in the world that isn’t Chemistry” and “Chemistry rules the world” is valid till date. Chemistry is the mother of science and it is the foundation for all scientific research [1]. Research provides the researcher and other stakeholders with the desired result for sustainable development and innovations - it help to discovers, elucidates and evaluates new knowledge, ideas, and the technologies essential in driving the future of society and humanity.

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Innovation in the chemical science, may operate both in compounding, chemical modification and in social field [2]. This act does not only result to the birth of an idea or a discovery, but it also result in the application and practice – taking the outputs of research and invention and using them to put new goods, services or processes into use [3]. Research in the chemical sciences also initiate the spring up of industries. It could be seen as the life wire of any network of producers, distributors, and consumers of goods and services in a local, regional, or national community. It also enhance the quantity or/and quality of products of an economic system that consist of tangible consumable items and tasks performed by the manufacturing or technically productive enterprises in a particular field, country, region, or economy viewed collectively, or individually. It may also leads to industrialization, especially with an adequate practice of the chemical sciences in the Nigerian schools. Researchers are trained to

design, optimize, and evaluate chemical synthetic pathways based on the selectivity and/or yield of a reaction steps called chemical analysis. Chemical analysis could be seen to consist of those analytical techniques that use no mechanical or electronic instruments other than a balance. The method usually rely on chemical reactions between the substances being analyzed (the analyte) and a reagent that is added to the analyte. This method ensures the safety of chemicals, quality, productivity, control, consistency, among other factors that affects the everyday life. During chemical analysis, the separation of a substance into its constituent elements is observed usually by chemical means, for the study and identification of each components. Chemical analysis or analysis in Chemistry could be qualitative or quantitative. Qualitative analysis determines the nature of substance that are present in a compound while quantitative analysis determines how much of each substance are present in a compound. For the purpose of this work, the scheme below represent steps or mechanism employed in research in Chemistry or the chemical analysis. The first steps involves the formulation of research questions. This step see the researcher first sit down to brain storm on the nature of research he/she wish to undertake. He asked questions seeking to address the importance of his proposed research, not just to himself but to his immediate community. He looks at the cost implications; the availability of useful analytical facilities at his disposals; the hazards and human risk involved in the analytical procedure; the health effects of the waste generated and the effects of the waste generated on the environment. When this questions has been answered and a logical conclusion reached on the nature of research the researcher want to undertake, then he move on to "select an analytical procedure". At this point, the researcher gathers to/and review available literatures of existing procedures. While in this process, questions are asked and answers provided by expert on that field and considerations are made. At this time, the researcher should be able to considers the availability and cost of analytical grade consumables; availability of analytical machines or facilities such as mechanical or electrical instruments; distance between these materials and instruments from the point of research; cost implications resulting from cost analysis which covers travels and the risk involves in travels; health risk for handling chemicals or consumables used for the work among other. When this stage is settled, the researcher move to samples collection. Though, the scheme for the procedure for chemical analysis could be general notwithstanding, there could be more steps or less steps as the case may be for instance, sampling may not be introduced as a step of chemical analysis procedure if the samples are brought to the laboratory for analysis and the laboratory itself does not do sampling. Sample preparation follows immediately after samples collection. It is importance for the researcher to know the role of sample preparation as a step in analytical procedure. The majority of analytical procedures requires that the sample is broken down or digested into a solution which contains as large as possible share of the analyte from the sample (ideally all of it) and as little as possible of the other components of the sample matrix. In analytical chemistry sample matrix is the term for describing jointly all sample components except the analyte. The matrix components often act as interfering compounds, which can artificially increase or decrease the result. Therefore it is important to minimize their content in the solution obtained from the sample. If the interfering compounds cannot be fully eliminated and the interference cannot be corrected (which is quite usual in chemical analysis) then their effect has to be taken into account in measurement uncertainty estimation. The researcher should be aware that sample preparation is often the most work-intensive part of chemical analysis and in most cases, it is also the part, which has the largest uncertainty contribution. Sample preparation usually involves either of the two approaches: firstly, "essentially destroying the sample matrix so that a solution containing the analyte and few matrix components are obtained. This are often done by digesting analytical samples with acids or fusing with alkalis or salts. This approach is suitable for determining elements and separating the analyte from the sample matrix so that a solution containing the analyte is obtained where the amount of matrix components is as small as possible. This is usually done by a set of extractions and this approach is suitable for organic analyte. When these processes are fulfilled, the prepared samples are chemically analyzed. In other words, known concentrations of chemical samples are made to combine or react with unknown chemicals (or known amounts of chemicals with an unknown amount of chemicals)

and uses known reaction results to determine what or how much of a chemical is present. These reactions may also isolate the desired compound. It is important to note that analytical methods requires that systems are demonstrated with real samples and that methods and technology reported in journals should be sufficiently innovative, robust and compared to other available methods for the intended application. The final product is thus subjected to specific instruments to measure, isolate, and identify unknown compounds. From this stage, the researcher is expected to tabulate or report the results obtained before discussing or interpreting them. Analyzing date is a unique aspect of research in chemistry. The purpose of analyzing data is to obtain usable and useful information. The analysis, irrespective of whether the data is qualitative or quantitative, may describe and summarizes the data; identify relationships between variables; compare variables; identify the difference between variables and forecast outcomes. In other words, data analysis is the process of bringing order, structure and meaning to the mass of collected data. It is a "messy", ambiguous, time consuming, creative, and fascinating process. Then, this process leads to the drawing of conclusion based on research finding. This paper owes its significance to the fact that research is not only a major criteria for obtaining a degree in any of the tertiary institution in Nigeria, but it is also a standard for promotion or attaining new height in our tertiary institution especially in Chemistry and its related discipline. This processes thus, discussed above not notwithstanding, could be cumbersome, but note that it is key for the design and development of new product as a results of the breakthrough achieved thus impacting live. Though, the paper is limited to scientific academic research, this paper is poised to highlight the factors limiting a research in the chemical sciences especially in the academia.

Importance of Research in Chemical Science

Research discovers, explains and establishes new knowledge, facts or ideas, and the technologies essential in driving the future of society and humanity. It help to position inquiries that uses acceptable scientific methodology to resolve problems, and creates new knowledge that are generally applicable. Research is also relevant in the formulation of a modern curriculum. It fosters professional excellence in the universities and it is relevant in the delivering outstanding student education and training. Research is an opportunity to make a difference and it is open to everyone and thrives on a diversity of approaches and perspectives. Research in Chemical Science is so important for both developing and developed nations. It leads to economic growth as a results of the increase in the country's Gross Domestic Product resulting from the development of new products. This makes room for the enlargement of the economics and to move from the dependent economy to the export of improved variety of raw materials of primary products. Also, it create employment and reduces brain drain. Research in the Chemical Science produce an innovative surrounding where the researchers, investors and entrepreneurs collaborations determines how successful the country becomes by translating scientific ideas into practical process and products that results to national development and sustainability.

Limitations in Research in Chemistry

Limitations in research in the chemical sciences could be described as constraints encountered by the researcher which do limit research freedom. Limitations in the chemical sciences involved poor academic foundation, availability of research supervisors in the research area of interest, quality of research supervision, unavailability of analytical equipment, inadequate knowledge of analytical equipment, lack of motivation in research, inadequate funding, the presence of religious or political dogmas, availability to gather certain experimental data (i.e., capabilities of research instruments), time needed for the research, availability of samples, and the unavailability of analytical equipment. This limitations are discussed below.

1. **Poor Academic Foundation of the Researcher**

A survey into the academic history of researchers in most Nigerian university reveals that they had poor research background that emanated from their secondary level of education. Their secondary level witnessed manipulated apparatus observing activity. This conclusion is reach when the investigator observed that most school do not plan for practical classes as stipulated in their

curriculum. They further observed that the school authorities make available to the student on examination, day analytical materials and apparatus or/and prepared analytical results during external examination, making research unattractive to the student. This observation is in correlation with the unwillingness of the student to carry out research in the undergraduate level, which correlated strongly with manipulative skills and conduct of the experiment [4], while students' attitude to research work correlated strongly with manipulation of analytical apparatus. General survey revealed that most chemistry students in the Nigeria public school has poor power of observation, measurement and experimental skills of inferring, predicting and formulating models.

2. Inadequate Laboratory Equipment in the Tertiary Institution

More than 95% of academic research in Nigeria is carried out in a private laboratory or laboratories outside the school premises. General survey reveals that researchers in the Nigerian universities collect samples and send them to private analytical laboratories for chemical analysis. This is mainly due to the facts that the laboratory of the tertiary institutions in the country are poorly equipped with these facilities [5]. It is either the few laboratory equipment available are obsolete or they are in poor working conditions or they are not available at all.

3. Inadequate Knowledge of the Use of Analytical Equipment

Most Nigerian university suffer inadequate personnel to manage available analytical equipment. The institutions lack adequate man power to train the student on the use of analytical equipment/instrument and also to conduct simple chemical analysis. These defects is still a concern in our institutions especially in the chemical sciences. Even when the various department in the institution has technologist to cover for this gap, most are trained by the university with these ill equipped laboratories. These technologist in most cases have not seen nor touch these analytical equipment until they are hired by the same institutions. Also, the institutions purchase analytical equipment without putting the specifications as well as the features of the equipment into consideration. They even don't visit the manufacturer website and to study the features and specifications of the equipment before purchase and so, they buy equipment that that requires the presence of an expatriate or the manufacturer to install before use. Thus, it is pertinent to note that the market today is flooded with different brands of laboratory equipment. It is imperative for those in charge of the purchase of laboratory equipment to deal with the right dealer to purchase the right model for use. Efficient functioning, accuracy and durability are some of factors that they should consider as they shop for laboratory equipment.

4. Inadequate Knowledge of the Use of the Right Analytical Procedure

An analytical procedure or method is the application of a technique to a specific analyte in a specific matrix. While it is mandatory that chemical analysis requires the best analytical procedures, most supervisors are not careful with standard methods or the following design criteria - accuracy, precision, sensitivity, selectivity, robustness, ruggedness, scale of operation, analysis time, availability of equipment, and cost General survey reveals that analytical procedures are not provided by the researcher thus allowing the private laboratory to use procedures available at their disposal. Sometimes, this procedures may not be adequate, coupled with the poor quality control measures employed during the analytical technique. Hence, it appears the private chemical laboratory package whatever they have and send them to the researcher and they accept them without verification. Sometimes, the required research analysis are deemed too dangerous to be conducted at a given institution or facilities. Also, the research communities especially those residence in the Nigerian academic institutions have not developed useful analytical procedures that are beneficial in the chemical sciences. And if there is any peradventure, the information is not public.

5. Inadequate Research Funding / Grant

One of the major factor affecting research in Nigeria is the ability to acquire funding or research grants either in a sufficient or partial amount to fully partially conduct all the proposed research work as seen in most developed country [5]. When a research grant is provided to a group or an individual to purchase research equipment, the facilities in use lack the desire space to install them [1]. Hence, private partners finds it difficult to invest in research in Nigeria.

6. Government Policy on Research

The Nigerian government of the day and in the past has shown no flare for research. This is shown by the number of research center in the country. This is also expressed by the amount allocated to research and the ministry of science and technology in the Nigerian budget [1]. [6] Stated that; 'not less than 60% of places shall be allocated to science and science oriented courses in the conventional universities and not less than 80% in the universities of technology'. But we are all aware that the above declaration remains only on paper. It has never been implemented not to talk of determining its functionality. [7] Stressed that the pursuit of scientific and technological education are imperative for any nation that want to maintain its independence, sovereignty, ensure growing prosperity and hold its head among civilized nations.

7. Corruption

Corruption is a culture in the Nigerian public offices. This is expressed by public office holders in all hierarchy in government. When fund is allocated for research or to purchase analytical equipment, the fund are either diverted for other purpose or, substandard equipment or analytical facilities are purchased. In the Nigerian universities and other academic institution, laboratory and maintenance fees are included in the yearly student fees and yet, these fees are technically utilized for other purpose. It has become a yearly routine and nothing is done about it.

8. The Quality of Research Supervision

The quality of research supervision is still one of the most important factor in the retention and timely completion of student research [8]. While supervision itself is often regarded as the single most important variable affecting the success of the research process, it could be described as 'probably the most responsible task undertaken by an academic' body. [9, 10] in his study, listed the role of the supervisor to be: providing the technical expertise with a general knowledge of the research area and research methods that will be used; be an active researcher who is involved in publication in peer reviewed journals, attending conferences and help students enter into academic careers; sets regular and realistic deadlines; but avoids becoming too involved in the detail of the student's work; responsive to the student; encouraging them to become an independent researcher; responding appropriate to any problems and receive, read and return work in an acceptable amount of time. [10, 11] Stated that before a supervisor is appointed a supervisor, he/she must be an authority in the field he/she is assigned to - the supervisors should have an up-to-date knowledge of the research area, have scholarly publications in the research area, maintain successful partnership with other researchers. In this part of the world, this facts are not strictly observed. Poor supervision could occur when the criteria listed above are not met and could also be as a result of too many engagement on the part of the supervisor and thereby, mortgaging supervision time [12]. [13] Reported that students who supervisors were more analytic achieved significantly higher grades for their dissertations. Hence, the quality of research could also be affected due to communication breakdown between the student and the supervisor as a fallout from faulty relationship between the supervisors an student. This mostly occur with female students than their male counterpart in Nigeria. These female student are majorly assaulted sexually. Most times, when they comply with personal demand, supervisor go ahead to carry out chemical analysis for them even to the extent of reporting the finding. Also, most supervisors in the chemical sciences engage in research for academic and promotion purpose with little or no contribution to the society. Hence, researchers and other stake holders should bear in mind that they are members of a learning institution - doing research is not just an imperative, but a need.

9. Availability of Research Supervisors

The Nigerian tertiary institutions lack the appropriate human resources to supervise certain subject areas in the chemical sciences especially in Chemistry. Some of such areas in Chemistry are organic Chemistry, atmospheric Chemistry, physical Chemistry and medicinal Chemistry. Most a time, these defect may initiate a change of supervisors thus affecting the total research time, resources and other personal investment in the research.

Prospect for Chemical Research in Nigeria

1. It Reduces Unemployment and Youth Restiveness:

Research in the chemical sciences has significant roles to play in Nigeria. Chemical research could be narrowed down to the ability to manipulate chemical molecules with certain physical properties to obtain molecules with different

physical and chemical properties. It may be sometimes, due to chemical modification or/and compounding. This process had led to the emergence of chemical industries and so, has lived to be a vital sector of the modern industrialized economy. Nigeria has a growing economy with three petroleum refinery - Warri Refinery and Petrochemical Company (WRPC); Port Harcourt Refinery and Petrochemical Company (PRPC) and Kaduna Refinery and Petrochemical Company (KRPC) and other non - petroleum chemical industry. These organizations provide massive employment opportunity for it citizens. General survey reveals that the presence and the potentials in these companies are not maximized. With effective chemical research in Nigeria, high-technology industries based companies that uses the waste generated as feeds in the petrochemicals, agricultural chemicals, electronic reagents, paints and solvents, petrochemical feedstock, pharmaceutical, soaps and detergent could spring up. The implications is that more of its citizen will be gainfully employed. More youth and other category of people are taken off the street thus, reducing crime rate, restiveness, poverty and other similar devices. It is believed that the government of Nigeria plays politics in the daily running of the government base industry which had seen then import petroleum products rather than maintaining the existing refinery, and to make them work to full capacity. With power generation at low scale, they fail to create an enabling environment for these firm to operate, coupled with small and medium scale business to grow.

2. It leads to Industrialization

Research in the chemical sciences in Nigeria if given proper attention, could leads to the springing forth of industries. They could help generate income for the host local government area, improve the state internally generated revenue and the increase of Nigeria gross domestic product (GDP). The fallout of these is improved standard of living of the masses, massive infrastructural development and improved basic amenities - good road network, electricity, pipe borne water, and quality education through scholarship to the members of the host community, among others. This amenities listed could be executed in the various communities as part of the company's social responsibility to the host community. This process helps the host communities, the state and the nation at large to grow gradually until it results to development [14].

3. Skill Development.

Research in the Chemical sciences has a significant role in the human capital development as required in the Nigerian economy. It help improve the skill of the individual or human capital thereby, promoting personal freedom or the masses dependency of the government of the day, productivity and earning power. National growth requires both middle and high level manpower for innovation and modernization in every sector of the Nigerian economy.

4. Innovation and Modernization

Technological changes and relevance is dependent on the research in the chemical sciences, because through research, new standard operational procedures, methods of production are discovered and developed to accommodate improved productivity in Nigeria. Also, research in the chemical sciences opens up motivation and widens inquisitiveness, liberating the human mind from the vestige of ignorance and superstition and makes man to be willing to accept change. Research broadens the human mode of reasoning and the way they do things, it breaks man conservatism and prepares the mind to accept modem and improved ideas and techniques [5]. Thus, without research, technological advancement and other developments could remained a fantasy. Reading, writing, observing, analyzing, coupled with social interaction facilitate an inquisitive mind's quest for knowledge, learning, and wisdom. Research serves as a bridge to achieve that goal.

5. It is a tool for Education

Chemical research introduces to young doctoral trainees, the excitement of the scientific frontier, providing experiences and skills in problem solving, information handling, organization, interpretation and presentation. It may equipped the researcher with practical skills involving the manipulation of chemicals and the use of sophisticated analytical instrumentation for the interpretation of phenomena in the Nigerian universities. Research in the chemical sciences in Nigeria will not only foster a well-trained, imaginative molecule makers, but it will also encourage and deepen our understanding of the properties of matter and of the way in which and the speed at which chemical processes occur. It is

also crucial to finding possible cures for diseases, as well as how to prevent them. Chemical research in Nigeria could help people nurture their potential and achieve goals through various opportunities. These can be in the form of securing employment, scholarships, training grants, project funding, and business collaboration among others. Research entails both reading and writing. These two literacy functions help enable computation and comprehension. Without these skills, it is less likely for anyone to appreciate and get involved in research. Reading opens the mind to a vast horizon of knowledge, while writing helps a reader use her/his own perspective and transform this into a more concrete idea that she understands. It could help Nigerian researchers to develop critical reasoning skills, such principle that use this thinking process is food for the brain, allowing creativity and logic to remain active. It also helps prevent mental illnesses like Alzheimer's. Hence, research in the chemical sciences in Nigeria is a must to ascertain if the ideas of the researcher are supported by previous studies or if these ideas still need proof to be considered as knowledge.

Ways to Improve Research Skills

It is modest to note that the human quest to seek knowledge, satisfy one's sense of wonder, develop abilities, connect with others and understand society is integral to research [15]. Research skills in the chemical sciences could be improved through the following means

- Read hard copy and electronic books on research especially research in the chemical sciences.
- Attend academic training such as seminars, workshops, and conferences aimed at deepening your knowledge and honing your skills in carrying out research.
- Search for reputable researcher or research mentor in your field of interest and identify with them.

Conclusion

Chemical analysis is key in the development of any society. Chemical Sciences has many roles to play in meeting the Nigerian challenges from soil chemistry to pollution monitoring, from creation of better methods of plant crop protection to helping develop new, more productive and more improved and resistant varieties. Chemists need to work with their learned societies, professional bodies and funding agencies to seek innovative solutions that will maximize access to published material for those working in resource - poor settings. Nigeria has all it takes to be ranked as one of the biggest economy in the world. The federal government of Nigeria should have a “rethink” on her position in the funding of research in the chemical sciences by creating the enabling environment for private individuals, non – governmental organizations and possible foreign partners to invest in research and development in Nigeria. In the longer term, research in the chemical sciences may create materials with extraordinary properties - as yet undreamed of, which may dramatically improve communication technology in Nigeria, healthcare, environmental monitoring and transport. Hence, it is pertinent that, it is from this base that new research in areas of strategic importance, and in areas that we cannot presently imagine, will spring.

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