Nanotechnology as a sized powered harbinger for a sustainable "soft future": Nigeria's status, options and challenges.

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Nanotechnology has been considered as the new millennium frontier of knowledge that would revolutionalize industry, technology and advanced materials. This new scientific concept which influences almost every facet of life is on the way to becoming the first trillion dollar market. This talk presents the rudiments underlying the concept "Nanotechnology" and its potential influences on every facet of life. There shall be a cross sectional tour of synthetic and preparation methods for nanoparticles, nanocomposites and nanomaterials, especially that which is practicable in Nigeria. Historical perspectives of Nigeria Nanotechnology Initiative (NNI 2006) shall be explained. Expanded version of this initiative is nanotechnology research in our Universities and Institutes. What led to the first nano-enabled factory ever established in Nigeria; how it came, what they did, our gain and loses? Nanotechnology education curriculum overview; what is Nigeria status? These are pertinent questions to answer.
As a leading nanotechnologist, it is necessary to cross examine my role and practices on the subject matter. In this regard, there shall be a brief talk on my contribution as I discuss few of my findings and possible suggestions for the upcoming younger scientists. How is nanotechnology related to "sustainable soft age"? What are the present options and challenges of Nanotechnology practices in Nigeria? ------ Pertinent questions to answer!

I am highly delighted about the activities of Nanotechnology Research Group (*NANO*$^+$) at LAUTECH, Ogbomoso, which were brought to my notice last year, when the head of the group, Prof. A. Lateef was in my University to examine a Master thesis on nanobiotechnology that I co-supervised. He took his time to enumerate the activities of the group and I was marveled at the achievements made by the group. I want to salute the daunting courage of the group to advance research and training in nanotechnology in this country, and I am pleased to be associated with you. I am therefore grateful to the organizers of this work, particularly, Prof. A. Lateef for counting me worthy to be part of this workshop. I wish all participants fruitful deliberations, as I hold the belief that attendance at this work would spur research in nanotechnology in our areas of specialization. Congrats *NANO*$^+$!!!, Congrats LAUTECH!!!

Nanotechnology in Drug delivery

Dr. L.G. Bakre, Department of Pharmaceutics and Pharmaceutical Technology, Olabisi Onabanjo University, Sagamu.

In recent years, nanotechnology has received a lot of attention because of its future potential that can literally revolutionize each field in which it is being exploited. Nanotechnology has emerged as a versatile platform that could provide efficient, cost-effective, and environmentally acceptable solutions to the global sustainability challenges facing society. It has been utilized to address global challenges in water purification, clean energy, greenhouse gas management, materials supply/utilization and more recently in biomedical applications. Biomedical applications of nanotherapeutics include drug delivery, molecular imaging, gene delivery, biomarker mapping, detection and diagnosis and targeted therapies.

Drug delivery is an essential part of pharmaceutical sciences that should be taken into account early in the drug discovery and development process. A drug that cannot be delivered to its site of action is essentially useless. In drug delivery applications, nanotechnology typically involves the creation of nanoparticles (5 ~ 800 nm) that are then used to package drug molecules and genes. A number of diverse nano-sized structures have been investigated for drug formulation and delivery, including small molecule and polymeric micelles, solid lipid nanoparticles, nano-sized crystalline drug and drug-antibody conjugates, dendrimers, liposomes, lipid emulsions, and solid drug-polymer nanoparticle dispersions. Engineering of these particles has produced nanomedicines that target drugs and genes to tumors and improve the brain delivery of peptides and other molecules. These particles are also capable of promoting oral drug absorption and drug transport across other biological barriers such as the cornea and the skin. These nanomaterials provide a high degree of biocompatibility before and after conjugation to biomolecules for specific function so as to translate into nanomedicines and clinical practice. Nanomaterials provide for a favorable blood half-life and physiologic behavior with minimal off-target effects, effective clearance from the human organism, and minimal or no toxicity to healthy tissues in living organisms. Nanomaterials have been used for strategic development of new drug delivery systems and reformulation of existing drugs to enhance the effectiveness, patent protection, patient-compliance, safety of drugs and decreasing the cost of health care. It is expected that the forthcoming generations of nano products will have target specificity, may carry multiple drugs and could potentially serve as carriers for the treatment and management of chronic diseases such as cancer, asthma, hypertension, HIV and diabetes.

Nanotechnology is an emerging field that is potentially changing the way diseases are treated through drug delivery. A dynamic collaboration is needed within the researchers, government, pharmaceutical - biomedical companies and educational institutions all over the world in developing the nanotechnology applications in advanced medicine and patient care. Its role in the convergence of knowledge, technology and society for achieving sustainable development cannot be overemphasized.

Biosynthesis of nanoparticles

Dr. M.A. Azeez, Member, Nanotechnology Research Group (*NANO*$^{+}$), Department of Pure and Applied Biology, LAUTECH, Ogbomoso.

Many decades of human existence have witnessed tremendous activities in knowledge based research of material science, which has resulted in the development of physical world and its components in bigger than the biggest, and smaller than the smallest dimensions of mass, length and time. During this period, man has devised several means of creating smallest particles (nanoparticles) in an innovative manner and engineered them for intended purpose – 'this is otherwise known as nanotechnology'. The novelty of nanoparticles or nanomaterials resides in the uniqueness of their properties which are often different from that of corresponding bulk materials of the same kind and are usually influenced by the particle size. Metallic nanoparticles and their alloys such as gold, silver, iron, cadmium, zinc, platinum etc., exhibit unique optical, thermal, electrical, chemical and mechanical properties which are primarily based on their small size and high surface to volume ratio. As such, they have been employed in various aspects of human endeavours including biomedical (drug delivery and pharmaceutics), energy storage (capacitance, solar cells), water treatment, catalysis, sensors, food and agriculture (nanofertilizer, nanopesticides).

Nanoparticles can be synthesized by several techniques which may be physical, chemical and biological. The physical and chemical methods include laser ablation, lithography, radiolysis, aerosol techniques and photochemical reduction. These methods are known to be cumbersome, time and energy demanding, expensive and sometimes involve the use of high pressure, hazardous chemicals such as Sodium borohydride and hydrazine, making the biological method the most preferred. Biosynthesis of nanoparticles, an emerging highlight of intersection between nanotechnology and biotechnology otherwise known as nanobiotechnology has become the major focus of the scientific community due to its simple, fast, cost effectiveness and eco-friendliness. The nature's ability to reduce metal salts to their corresponding nanoparticles has led to discovery of new natural sources of microbial, fungal, animal and plant origin that can synthesize nanoparticles.

Of all the natural sources, plant materials have been given special attention due to their eco-friendliness, non-involvement of the elaborate process of maintaining cell structures and opportunity for large scale synthesis of nanoparticles. In green chemistry, extracts and metabolites from these novel sources have been used either as reducing agents i.e. to reduce various metal salts to their corresponding nanoparticles or as stabilizing or capping agents to prevent agglomeration of nanoparticles. For the purpose of this workshop, the green methods of nanoparticle synthesis will be explored with particular emphasis on roles of plant extracts and other metabolites of natural origin. An attempt will be made to discuss the chemistry of action involved in the eventual synthesis of nanoparticles.

Characterization techniques for nanoparticles

Dr. O. Adedokun, Member, Nanotechnology Research Group (*NANO*+), Department of Pure and Applied Physics, LAUTECH, Ogbomoso.

This presentation focuses on characterization techniques employed for understanding physical and chemical properties of synthesized nanoparticle materials for various applications. The precise analysis of nanoparticles stability, size, size distribution, morphology, elemental identification, crystal structure, functional groups, thermal variation at nano level for various applications require sophisticated characterization techniques, such as particle size analyzer, electron microscopy, atomic force microscopy, x-ray diffraction, various spectroscopic and thermal analysis. Some of the challenges lie in finding the right characterization techniques that have the optimum capabilities for studying the characteristics of nanoparticles.

The properties and stability of dispersed nanoparticles can be analyzed by using dynamic light scattering (DLS) and zeta potential. An electron microscope (SEM/TEM/HRTEM) uses a beam of electrons to illuminate a sample and produce a magnified image. The morphology and size, as well as selected area electron diffraction (SAED) of the nanoparticles are commonly analyzed by transmission electron microscope (TEM). The atomic force microscopy (AFM) provides a precise three-dimensional surface profile of nanoparticle films deposited on the substrate, while X-ray diffraction analysis provides information about the structural arrangement of atoms and molecules of the nanoparticle materials. The spectroscopic techniques (XPS, EDS, FTIR, UV-Vis absorption) are good characterization tools to understand the physicochemical properties of nanoparticles. The temperature dependent measurements and glass transition temperature of the nanoparticles are analyzed by thermogravimetry analysis (TGA) and differential scanning calorimetry (DSC). Other techniques like electrical, magnetic and mechanical characterization are very essential also for proper understanding of nanoparticle behaviour. The physicochemical properties of nanoparticles always exert influences over their interactions with any given system and consequently play an important role in selection of the appropriate application. The aim of the presentation is to expose the participants to range of characterization techniques in nanotechnology.

Applications of Nanoparticles

Prof. A. Lateef (Professor of Microbiology), Head, Nanotechnology Research Group (*NANO*$^+$), & Head, Department of Pure and Applied Biology, LAUTECH, Ogbomoso.

Nanotechnology is an imperative field of modern research across the entire fields of science and technology. It deals with synthesis, strategy and manipulation of structure of particles ranging from approximately 1 to 100 nm in size. Within this size scope, all the properties (biological, chemical, electrical, and physical) are modified in fundamental ways of both individual atoms/molecules and their respective bulk. Nanotechnology has continued to attract great interests because of its extensive applications in diverse aspects of life endeavors. It is a subject matter that cuts across various fields of science and technology. Nanotechnology is rapidly gaining interest by recreating and improving the mechanisms of nanomaterials in several fields such as health care, biomedical, food and feed, cosmetics, environment, plant nutrition, chemical industries, catalysis, single electron transistors, drug-gene delivery, electronics, mechanics, light emitters, space industries, energy science, nonlinear optical devices and photo-electrochemical applications.

In this presentation, we shall take a voyage of the overview of applications of metallic nanoparticles in different areas of human endeavours. The experience of *NANO*$^+$ in the last three years would be shared with the audience, while the lecture would also dovetail into interactive discussions on how participants can introduce nanotechnology into their research activities with acceptable outcomes. The entire aim of the lecture is to stimulate the interests of participants in nanotechnology-based investigations.

Invited Presentation

Electrochemical Potential of Bioreduced Silver Nanoparticles

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Hazards and toxicity associated with the physical and chemical synthesis protocol of metal nanoparticles has recently led researchers to seek alternative routes that is eco-friendly, cheap and fast; the green chemistry approach where plant extracts and microorganism are used in the bioreduction of the metal salt or oxide is fast gaining popularity in the field of nanobiotechnology. However, controversy still trails its acceptability due to stoichiometry; furthermore, electrochemical studies on these metal nanoparticles are limited. In this study silver nitrate was reduced to its "nanoform" through a one-step synthesis protocol using the leaf extract of *Senna obtusifolia*. The usual microscopic and spectroscopic techniques such as UV-vis., FTIR, XRD, EDX, AFM and SEM (Fig. 3) were used to confirm the formation of silver nanoparticles. Electrochemical characterization using cyclic voltammetry and impedance spectroscopy further reveals the formation of silver nanoparticles via the redox reaction:

$$Ag^+ + e^- \rightleftharpoons Ag^0 \qquad \text{(Eq. 1)}$$

A formal potential value of 0.61 V vs. Ag|AgCl 3 M KCl was observed (Eq. 1 & Fig.1). Preliminary study on possible application of the nanoparticles for glucose oxidation was also carried out (Fig. 2). For the first time, we were able to establish the formal potential of bioreduced silver nanoparticles using electrochemical techniques with possible application in the fabrication of biosensor.

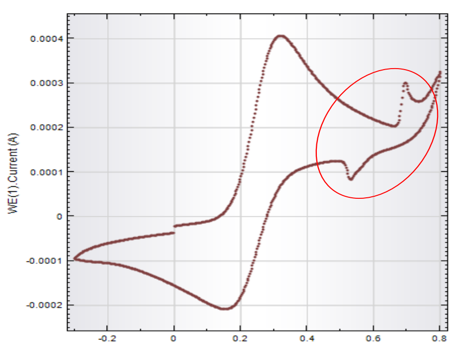

Fig. 1

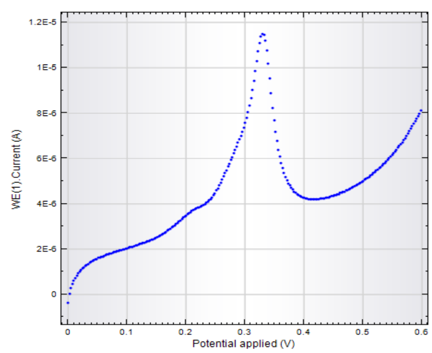

Fig. 2

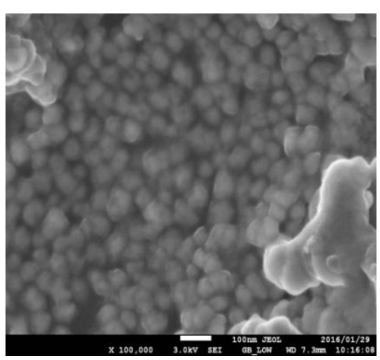

Fig. 3