INVITED GUEST SPEAKER TALKS

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NANOTECHNOLOGY AS A TOOL OF DEVELOPMENTAL CHANGE IN NIGERIA

The prospect and potentials of nanotechnology to revolutionize various aspects of human endeavour cannot be underestimated. This informed the huge investment of the developed countries in research and development in order to promote innovation and commercialization of nanoproducts. It is obvious that Nigeria is currently facing challenges of rising demands for basic necessities of life such as clean and potable water, food, energy, health, security and engineering infrastructures. It is also a known fact that nanotechnology is currently generating diverse awareness and attentions as one of the foremost clean technologies of the 21st century. In spite of the essential benefits of nanotechnology for technological development, the sub-Saharan Africa region especially Nigeria is yet to key into nanotechnology initiatives as a strategy towards improving her socio-economic development and the transformations of important sectors. Trending information revealed that the benefit and opportunities that nanotechnology offers are enormous and have led to high expectations in the academics, industries and government. Because of the uniqueness of nanotechnology, quite a number of nanomaterials are now been synthesized, characterized and fabricated to solve some of the societal problems. This is possible because of the ability of nanotechnology to control properties of matter and create materials with specific properties that can be utilized for specific functions. Nanotechnology is therefore a reliable and effective approach that offers hopes of reshaping human conditions. Lack of coordination, poor funding and collaboration are some of the factors that affect nanotechnology development in Nigeria. It is therefore important that proper attention be given to the research and development of nanotechnology, its emergence and application for the growth of our nation. This will require adequate attention from policy makers, non-governmental organization, and the general public. It can be concluded that nanotechnology will serve as the viable emergent technology for socio economic growth for Nigeria.

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THE SMALL AND SMART TECHNOLOGY: WHAT FUTURE DOES IT HOLD FOR US?

The technological advancement made so far through the application of nanotechnology has necessitated the general acceptance of this nascent technology. It is a multidisciplinary area which combines efficient properties of nanomaterials in diverse applications such as biomedicine, optical devices, electronics, catalysis, textiles, energy absorption and storage. Nanomaterials are made through various ways such as physical, chemical and biological means. Some of the processes are easier and sustainable while some are not, but they all end up producing smart materials for awesome technologies. The future of nanotechnology aims at the prospects of obtaining new nanomaterials through simple preparation, low-cost, efficient, non-toxic and ecofriendly techniques. The advanced countries of the world already have nanoproducts in the market which is solving societal needs; where is Africa and Nigeria in particular in the global development of nanotechnology? Nanomaterials can exist in different sizes in as much as they are lower than 100 nm; however the quest to obtain nanoclusters, quantum dots and lower size nanoparticles with enhanced applications becomes the target of the scientists. Semiconductor quantum dots (QDs) is one class of nanomaterials that has aroused immense interest due to their quantum size effects, versatile surface chemistry, unique optical properties, easy engineering and dispersion into a variety of solvents and eventual incorporation into optoelectronic materials for various applications. Optical devices, electronics, catalysts, energy absorption and storage are interestingly getting easier, smarter and sustainable due to the latest developments in nanomaterials. Green synthesized noble metals monometallic and bimetallic nanoparticles and their composites with carbon materials, cellulose and polymers is another interesting area that is showing great promise especially in biomedicine due to less or no toxicity. On this note, several nanoparticles including silver and gold have shown great antimicrobial, anticancer, larvicidal, antioxidant and antimalarial properties. However, extensive investigations are on-going as to improve their activities probably through composites formation. The composite materials combine the properties of the individual components in an advance category for interesting applications. A whole lot of environmental, health, technological and society issues have been solved through breakthroughs in nanotechnology. The question therefore is: are we ready to imbibe this smart technology, and how do we use it to tackle our peculiar problems?

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EFFICACY OF SILVER NANOPARTICLES AGAINST MULTIDRUG RESISTANT BACTERIA

Multidrug resistant (MDR) *S. aureus* infections continue to account for excess mortality in hospital and community settings and constitute a rising global health problem. However, data on the efficacy and mechanism of actions of alternative solutions like silver nanoparticles in developing countries are lacking. This study investigated anti-staphylococcal activity of silver nanoparticles (AgNPs) against local strains from Nigeria. A total 119 clinical isolates of *S. aureus* from five Nigerian laboratories categorized as MRSA (n = 52) and MSSA (n = 67) by PCR were studied. The MIC of AgNPs produced by chemical reduction method and characterized by surface plasmon resonance absorbance and size equivalence by scanning electron microscopy was determined by microbroth dilution method. Its effect on protease activity and plasmids were also investigated. Baseline characteristics of the isolates revealed MDR phenotype of the isolates, carriage of diverse plasmids (15-32 kb) among the MDR MSSA, and mean extracellular protease activity of 24.8-55.7 U/ml. The chemically synthesized AgNPs had a peak absorbance at 400 nm with a size equivalence of 4.58 nm. The MICs of AgNPs against the isolates were 4.7 μg/ml and 4.9 μg/ml,

respectively, for MRSA and MSSA (P > 0.05). The bactericidal effect of AgNPs at 2.5-5 μg/ml on the MSSA and MRSA isolates was observed at 2.7-5.5 h post exposure *in vitro*. Further analysis revealed plasmid eviction in the MDR MSSA isolates exposed to 5 μg/ml AgNPs and dose-dependent reduction in extracellular protease activity by 84.6-93.1%. Hemolysis of human erythrocytes by AgNPs was not observed at the MIC range. This study revealed safety and efficacy of AgNPs against clinical MDR *S. aureus* isolates from Nigeria, using plasmid eviction and protease inhibition as mechanisms of action.

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GENETIC, REPRODUCTIVE AND SYSTEMIC TOXICITY OF NANOPARTICLES: COMPARISON OF INDIVIDUAL AND CO-EXPOSURE STUDIES

The last decade has witnessed a continuous increase in the use of nanotechnology. Thousands of products varying from food, cosmetics, clothes, military equipment, and personal care products are now available with nanoparticle contents. Recently, experimental and clinical usage of nanoparticles has risen exponentially because of their diverse range of biomedical applications such as in drug delivery, cell tracking and imaging. This has led to the formulation and production of different types of nanoparticles in the last two decades. Due to the numerous applications of nanoparticles in consumer products, the chances of human exposure through ingestion, inhalation and dermal contact are significantly increased. There is a growing concern about the possible adverse health effects of nanoparticles on the environment and humans. Nanoparticles may aggregate and interact in the environment in water, solids or sediments, leading to co-exposure either *via* the food chain or drinkable water, which could bio-accumulate and magnify in the 'food chain cycle', eventually leading to human exposures. Exposure of these nanoparticles in biological system may elicit novel distribution, immune responses, absorption at physiological barriers, and interaction/impairment of DNA repair processes. In general, smaller particles are thought to interact more strongly with biological systems compared to larger particles. Interestingly, some materials which are known to be inert in large quantities are in fact toxic at nanoscale, such as gold. The chemical composition of the particles themselves can be naturally toxic.

Nanoparticles have been shown to be mutagenic, carcinogenic, teratogenic, immunotoxic, hematotoxic and cytotoxic in different biological systems and *in vitro* studies. Toxicological data have shown that nanoparticles are toxic to both somatic and germ cells. Also, it has been shown that co-exposure to nanoparticles is more toxic than the individual nanoparticles. The ability of nanoparticles to damage the DNA has been suggested to be through systemic alterations. *In vivo* and *in vitro* genetic and reproductive toxicity studies of nanoparticles are very limited and the data so far reported is insufficient, hence, more experimental data are needed. Furthermore, despite the fact that humans can be exposed to a variety of nanoparticles at the same time, most studies have been limited to the toxicity of individual nanoparticles. Since the environment and humans are subjected to a complex mixture of nanoparticles, there is an urgent need for toxicological studies of co-exposure to nanoparticles, which is presently scanty in the literature. This is necessary to have a holistic data on the biocompatibility of numerous nanoparticles in consumer products.

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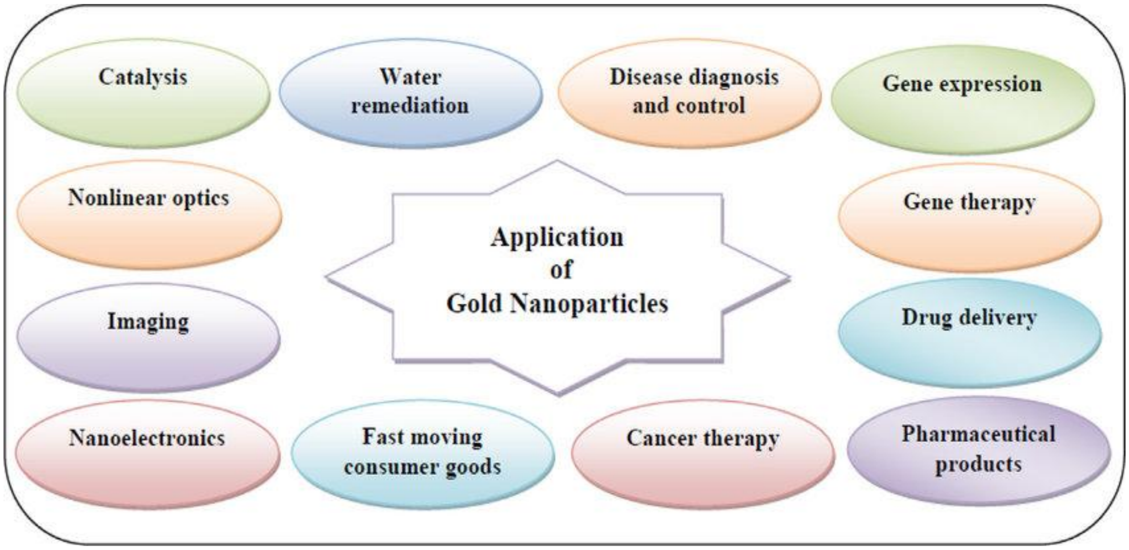
SYNTHESIS OF NANOPARTICLE AND THEIR APPLICATIONS

The knowledge of molecular biology played a lot of roles in understanding the human genome. Africa, unlike other continents did not key into the research activities in the molecular aspects at the early stage, consequent upon which the products are being purchased at very exorbitant prices. Trending now is the emerging field of Nanotechnology almost following the pattern of molecular biology era. At present African need to dwell more in the field of Nanotechnology. Hence, the call for

"Nanotechnology Applications in Africa: Opportunity and Constraint" which is the third in the series to sensitize researcher and the public. The roles of Richard Zsigmondy (first coined Nanometer), Heinrich Rohrer (Father of Nanotechnology), Richard Feynman (Father of modern Nanotechnology) and Norio Taniguchi (first to use *nanotechnology)* are crucial in the understanding of what nanotechnology and nanoparticles really means.

Nanoparticles are in the size range of 1-100 nm and can be derived from larger molecules, or synthesized by 'bottom-up' methods. Nanoparticles synthesis can be achieved through physical, chemical and biological techniques. The physical and chemical methods include laser ablation, lithography, radiolysis, aerosol technique and photochemical reduction among others. These methods are laborious and mostly involve the use of chemicals. Biological approach otherwise called green synthesis has been proved to be ecofriendly, efficient, cost effective and demands less energy. In green synthesis, microorganisms and plant materials have been used extensively as capping agents and stabilizers. The use of animal materials with such potentials is also being explored. Nanotechnology is a major scientific innovation that has changed the landscape of human endeavours. Beside the synthesis, this interaction which is to further sensitize researchers will also focus on the various applications of the nanoparticles. Metal nanoparticles produced by nanotechnology have received global attention due to their extensive applications in the health and medicine (pharmaceuticals, drug delivery, disease control/treatment, bio-imaging, anticoagulant, thrombolytic, larvicidal etc), agriculture (as insecticide, breaking of seed dormancy etc), energy applications (solar cells, light emitters, single electron transistor), food industries, chemical industries, consumer products (shampoo, soap, clothing), catalysis among others. I wish to use this opportunity to welcome you to the world of nanotechnology. It is real, endeavour to use it as a tool in your research to make a positive change. We will assist in whatever we can to accommodate you in the area of needs, since there are so "many rooms at the bottom"



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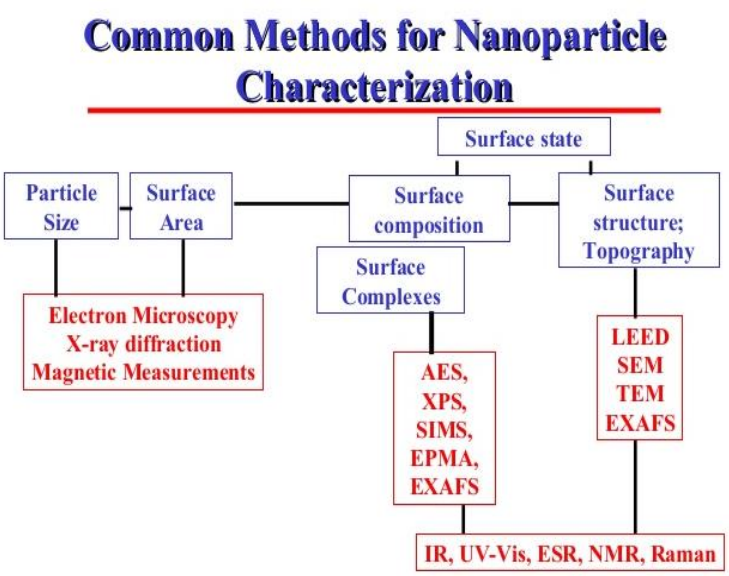
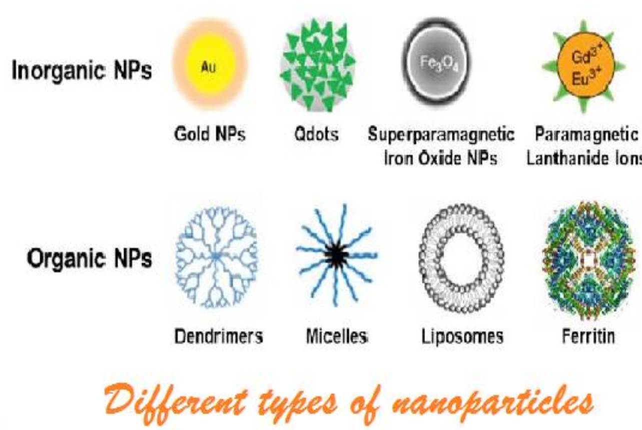
CHARACTERIZATION TECHNIQUES IN NANOTECHNOLOGY

Just as human beings are recognized and distinguished by many features such as the shapes of their body components, finger prints, blood groups, genotypes among others, materials also have different features or characteristics with which they are differentiated. These characteristic features are used to establish understanding of the material behavior, and can be tailored for desired purposes providing us the opportunity to exercise control over them. Characterization is therefore a process by which properties of materials (like composition, morphology, physical, optical, electrical, magnetic, mechanical, etc.) are measured and probed, and the method of doing this is termed characterization technique. This workshop will explore the methods of characterization often used in nanotechnology in general and nanoparticles research in particular. Therefore, the aim of the aspect of this workshop is to expose participants to a wide range of characterization techniques that are available and can be utilized for impactful nanotechnology research. The outcome will be for the attendees to confidently choose relevant characterization techniques for their works and discuss their results in professional way.

Characterization techniques will be discussed under the following categories: spectroscopy, microscopy, thermodynamic and others. Spectroscopy is the study of interaction between radiation and matters as a function of wavelength of electromagnetic waves. It reveals and identifies chemical compositions, crystal structures and photoelectric properties of materials. Some of these techniques are Raman spectroscopy, XRD, XPS, EDX, DLS, UV-VIS, IR, FTIR, AAS and NMR. Similarly, microscopy is the technique required to probe and map the surface and sub-surface structure of materials. It is used for structural and morphology analysis of nanomaterials, for measurement of thickness, surface roughness, topology and exact particles size and distribution. Common techniques are optical microscopy, SEM, TEM, AFM and STM. Unlike spectroscopy, microscopy does not depend on the wavelength of electromagnetic waves. Thermodynamic technique allows scientists to study behavior of materials with reference to change in temperature. Among available techniques are TGA, DCS, DTA and BET. The fourth category is a combination of electrical and mechanical characterization which is needed to quantify electrical mechanical properties of nanomaterials. Some of these techniques include abrasive wear measurement, nanoindentation, microhardness, impact strength, four-point probe, Hall effect among others.

Two case studies will be examined. The first has to do with the development and optimization of nanocantilever for biomedical application, while the second will be on influence of nanoparticles on physico-mechanical properties of emulsion paint. In the first case study, the lithographic procedure for manufacturing nanocantilever will be elucidated. The characterization techniques utilized included TEM, SEM, XRD, AFM, Hall effect, 4-point probe, RBS among





others. Interpretation of results obtained therefrom will also be discussed. For the second case study, approach to biosynthesis of nanoparticles will be explored. Characterization of nanoparticles which include the use of Raman spectroscopy, XRD, SEM, TEM, EDX, DLS, UV-VIS and FTIR will be discussed. Methods of characterizing mechanical properties of nanoparticles embedded paint, which include scratch resistance, weathering test, wet abrasion test, specific gravity and hiding power tests will also be elucidated.