NANO 2018B001

Antibacterial and algacidal activities of silver nanoparticles synthesized from aqueous extract of ginger (*Zingiber officinale*) rhizome

Adelere, I.A[1]*., Lateef, A[2]., Adams H.O[1]., Adabara, N.U.[1], Oyewole, O.A[1]., and Bala, J.D[1]

[1]Department of Microbiology, Federal University of Technology, PMB 65, Minna, Nigeria, [2]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: isiaka.ade@futminna.edu.ng

Biosynthesis of nanoparticles using microbial metabolites and plant extracts have been extensively researched in recent times owing to their advantages such as simplicity, cheapness, eco-friendliness, biocompatibility and wide applications over the common physical and chemical methods. This study aimed to synthesize AgNPs from aqueous extract of ginger rhizome and to evaluate the antibacterial and algacidal activities of the synthesized AgNPs. The synthesis was carried out by mixing 1mM silver nitrate with the aqueous extract of ginger rhizomes (10:1) under ambient conditions. The synthesized AgNPs were characterized by UV-visible spectroscopy, Fourier transform infrared spectroscopy (FTIR) and Scanning Electron Microscopy (SEM). The particles were investigated for possible antibacterial activity against some clinical bacterial isolates and algacidal activity against a strain of cyanobacteria. The synthesized AgNPs are yellowish brown in color and exhibited maximum absorbance at 429 nm. FTIR spectrum showed strong and distinct peak at 3356, 2855, 2129, and 1636 cm^{-1}, indicating the involvement of protein molecules in the capping and stabilization of the particles. They are spherical in shape with size ranging from 10-55 nm. The particles demonstrated very potent antibacterial activity against the clinical isolates of *Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Escherichia coli*, while appreciable algacidal activity against the tested strain of cyanobacteria was observed. This study therefore, suggests the application of the synthesized AgNPs in the manufacturing of a new antibacterial drug and also in water treatment to inhibit pathogenic bacterial and algal growth.

Keywords: Biosynthesis, silver nanoparticles, ginger rhizome; antibacterial drug, algacidal activity

NANO 2018P002

Biomedical instrumentation techniques: a review

Hassan, M.I[1*]., Haruna, M[1]., Yahaya, S.M[1]., Kabiru, H[2]., Safiyanu, I[1]., Sale, A.I[1]., Hayatu, L.W[1]., and Abdullahi, J[1]

[1]Department of Biology, Kano University of Science and Technology, Wudil, Kano State, Nigeria,
[2]Department of Physics, University of Abuja, FCT, Nigeria.

*Corresponding author: hmisaigodiya@gmail.com; +2348099991632

This review focuses on Radiation Physics and Modern Trends in Health Care Devices. Biomedical sciences rely heavily on devices to acquire and analyze the physiological data needed to understand and model the biological processes of human being. A thin piezoresistive effect provides an observable resistance change that is linear function of pressure and is observable at low stress levels. A diaphragm is used as a stress magnifying devices; where its magnification is proportional to the square of the ratio of the diaphragm diameter to its thickness. There was a descriptional development of a surface-enhanced Raman scattering (SERS) method and instrument for use in biomedical and genomics analysis. The Multi-Spectral Imaging (MSI) concept allows recording the entire SERS spectrum for every pixel on the two dimensional hybridization platforms in the field of view with the use of a raid-scanning solid-state device, such as the acousto-optic tunable filter (AOTF). The SERS is a detective method that uses nanostructured metallic substrate as SERS-active Platforms. The SERGen (SERS Gene) probes can be used to detect DNA targets by means of hybridization to DNA Sequence complementary to that of the

probes. Optical coherence tomography (OCT) can be determined by optical scattering and it is up to 2-3 mm in tissue. It functions as a type of optical biopsy, to provide cross-sectional images of tissue structure on micron-scale. Intraesophageal pressure monitoring can be practiced by the use of solid state technology in an entire circadian cycle. Finally, fluorescence spectroscopy is a widely used research tool in biochemistry and molecular biology. Therefore, there is an increasing application of techniques in radiation physics in quality healthcare.

Keywords: Piezoresistive, biomedical instrumentation, diaphragm, waves, X-ray, IA, SERS, MSI, AOTF

NANO 2018P003

Investigation of thermal properties of some frequently used ceiling tiles sold in Kaura-Namoda

Hassan, A.B*., Lawal, M., and Ibrahim, U

Physics Unit, Department of Science Laboratory Technology, Federal Polytechnic, Kaura-Namoda Zamfara State.

*Corresponding author: hassaniadebayobamidele@gmail.com; 08034269002

In this study, comparison of thermal properties of some selected materials frequently used as ceiling tiles in building design was investigated. The material investigated include: POP (sample A), Asbestos (Sample B), Suspended (Sample C), plywood (Sample D), Cardboard (Sample E), and PVC (Sample F). The investigation was carried out using modified Lee disc thermal conductivity apparatus. The result show that the six samples A, B, C, D, E and F analyzed in terms of their thermal properties can be thermally characterized into two major groups: Samples A, B and E with higher thermal absorptivities and samples C, D and F with lower thermal absorptivities. Based on their molecular point of view of thermal absorptivities, samples C, D and F are recommended as the best materials with high thermal insulation efficiency. Sample C appear to have the highest thermal resistivity of 19.0153 KmW^{-1} which suggests it to be the best material among the list in the study, while asbestos has 3.783771 KmW^{-1} as the least in the group. The result of the materials investigated in this study fit favorably well within the range of other existing industrial insulator.

Keywords: Thermal insulators, ceiling tiles, thermal conductivity, absorptivities

NANO 2018B004

Formulation development of 5-fluorouracil microspheres by solid dispersion for therapeutic management of colorectal cancer (CRC)

Oyeniyi, Y.J[1*]., and Nnamani, N.D[2]

[1]Department of Pharmaceutics and Pharmaceutical Microbiology, Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University, Sokoto, [2]Department of Pharmaceutics and Pharmaceutical Technology, College of Pharmacy, Igbinedion University, Okada, Edo state.

*Corresponding author: drjimioyeniyi@gmail.com

Solid dispersion technology (SD) involves dispersion of poor water soluble active pharmaceutical ingredients (API) in a solubility-enhancing polymer with the uttermost goal of improving oral bioavailability of the API. This is study is aimed at production and evaluation of 5- Fluorouracil (5-FU) microspheres for colon delivery using solid dispersion method (SD). The solid dispersions of 5-FU were prepared by hot melting method. The SD formulations were characterized using a scanning electron microscopy, USP dissolution apparatus type 2, and MTT assay. The produced SD formulations were spherically shaped with size ranging between 98 and 112 μm. FTIR spectral show no chemical interactions between the excipients and 5 FU. The yield (PY), drug entrapment efficiency (DEE) and the drug loading (DL) values were high enough to support commercial scale up of the technique. SD2 had the

highest DEE, cumulative drug released and DL values. This may be responsive for the improved cytotoxicity against HT115 cells. The release of 5-FU in all the formulations follow both Fickian's and non-Fickian's kinetics which are also pH responsive with no sign of dose dumping. This study demonstrated successful production of pH responsive 5-FU solid dispersions, by hot melt technique. The release follows Korymeyer-Peppas kinetic models and selectively delivered 5-FU to the colon and improved cytotoxicity against CRC**.**

Key words: Solid dispersion, colorectal cancer, 5-Fluorouracil, MTT assay, pharmaceuticals, cytotoxicity

NANO 2018B005

Fungal xylanases-mediated synthesis of silver nanoparticles for catalytic and biomedical applications

Elegbede, J.A[1*]., and Lateef, A[1,2]

[1]Laboratory of Industrial Microbiology and Nanobiotechnology, Department of Pure and Applied Biology
[2]Nanotechnology Research Group (*NANO*$^{+}$), Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.
*Corresponding author: josephadetunji18@gmail.com

Green synthesis of nanoparticles has fuelled the use of biomaterials to synthesize of a variety of metallic nanoparticles. The current study investigates the use of xylanases of *Aspergillus niger* L3 (NEA) and *Trichoderma longibrachiatum* L2 (TEA) to synthesize silver nanoparticles (AgNPs). Characterization of AgNPs was carried out using UV-vis spectroscopy, Fourier transform infrared spectroscopy (FTIR), and transmission electron microscopy (TEM), while their effectiveness as antimicrobial, antioxidant, catalytic, anticoagulant and thrombolytic agents were determined. The colloidal AgNPs was brownish with surface plasmon resonance at 402.5 and 410 nm for NEA-AgNPs and TEA-AgNPs respectively; while FTIR indicated that protein molecules were responsible for the capping and stabilization of the nanoparticles. The spherical nanoparticles had size of 15.21-77.49 nm. The nanoparticles significantly inhibited the growth of tested bacteria (63.20-88.10 %) and fungi (82.20-86.10 %), and also scavenged DPPH (37.48-79.42 %) and hydrogen peroxide (20.50-96.50 %). In addition, the AgNPs degraded malachite green (78.97 %) and methylene blue (25.30 %). Furthermore, the AgNPs displayed excellent anticoagulant and thrombolytic activities using human blood. This study has demonstrated the potential of xylanases to synthesize AgNPs which is to the best of our knowledge the first record of its kind such. The present study underscores the relevance of xylanases in nanobiotechnology.

Keywords: Xylanases, fungi, silver nanoparticles, green synthesis, biomedical applications, dye degradation

NANO 2018B006

Pycnanthus angolensis sap: Biosynthesis of silver and sodium nanoparticles and antimicrobial activities

Alabi, K.A*., Adeoye, M.D., Musa I.J., and Akin-Bashiru, B.F

Department of Chemical Sciences, Industrial and Environmental Unit, Fountain University, P.M.B 4491 Osogbo.
Corresponding author: qasimade@gmail.com; 08034705605

The traditional healers add sodium chloride (common salt) to *Pycnanthus angolensis* sap before using it as cough-inhibitory drug without formal evidence. Therefore, this research work has chosen to identify the chemical constituents in the sap and as well prepare silver and sodium nanoparticles of the sap for comparison. The sample was tapped into an air-tight bottle. Silver and sodium chloride salts were added

separately and homogenized. Gas-chromatograph mass spectrometer (GC-MS) was used to identify the content of the sap. The samples (silver and sodium nanoparticles) were screened against one bacterium (*Staphylococcus aureus*) and one fungus (*Aspergillus niger*). The estimated HOMO-LUMO energy gap and associated global parameters: global hardness and softness, chemical potential, electrophilicity, electronegativity, ionization potential, electron affinity and polarizability of the optimized structures of the two identified compounds were determined by Density Function Theory (DFT) using Becke-3-Lee Yankpar function (DFT-B3LY 631G*). The chromatogram showed that sap contains only two compounds: 2-(4-hydroxy-3-methoxyphenyl) propanamide (73.05 %) and 4,4'-[(2R,3S)-2,3-dimethylbutane-1,4-diyl)bis(2-methoxyphenol] (26.95 %). Sodium nanoparticles inhibited *Staphylococcus* at 19 mm and silver nanoparticles at 10 mm. Both did not have effect on *Aspergillus niger* mycelia growth. Hence, the traditional healers are justified by the addition of sodium chloride (common salt) before use. The compound 4,4'-[(2R,3S)-2,3-dimethylbutane-1,4-diyl)bis(2-methoxyphenol)] is more potent than the major 2-(4-hydroxy-3-methoxyphenyl) propanamide according to the calculated values. According to our search this work is the first to report the chemical constituents of *Pycnanthus angolensis* sap and to justify why traditional healers add sodium chloride (common salt) to the sap before use as cough-drug.

Keywords: *Pycnanthus angolensis*, sap, *Staphylococcus aureus*, *Aspergillus niger*¸ cough, herbal medicine, nanoparticles

NANO 2018P007

Silver nanoparticles (AgNPs) of *Tridax procumbens* and *Phyllanthus amarus* leaf extracts: corrosion inhibition and antimicrobial potentials

Adeoye, M.D[1*]., Alabi, K.A[1]., Adeyemo, J.A[1]., and Ojo, O.O[2]

[1]Department of Chemical Sciences, Fountain University, Osogbo, Osun State. Nigeria, [2]Department of Chemical Sciences, Mountain Top University, Makogi, Oba, Ogun State.Nigeria.

*****Corresponding author**:** dasoladeoye@yahoo.com**;** adeoye.mariam@fuo.edu.ng; +2348028944246

Plant systems and their extracts have been described as green and eco-friendly materials for metal nanoparticles synthesis and applications. Metals of nano-scales have been discovered to perform specific functions better than the bulk forms of metals and their plant extracts. This study was designed to compare the corrosion inhibition efficiencies of *Tridax procumbens* (TPE) and *Phyllanthus amarus* (PAE) leaf extracts; and their synthesized silver nanoparticles (AgNPs) on aluminium in 1M HCl using weight loss method. The corrosion inhibitory efficiencies (% IE), degree of surface coverage (ɵ) and corrosion rates at varying temperature, contact time and concentration of the synthesized AgNPs of TPE (AgNPs-TPE) and PAE (AgNPs-PAE) were determined, with their ɵ subjected to different adsorption models. The antimicrobial and antifungal activities were also tested against the *Escherichia coli*, *Staphylococcus aureus*, *Aspergillus niger* and *Candida albicans* strains using a spread plate method. The % IE and **ɵ** follow the trend: PAE < TPE < AgNPs-TPE < AgNPs-PAE. These actions increase with increasing concentration and time but decreases with increasing temperature. The adsorption of the inhibitors conforms to Langmuir isotherm. The AgNPs exhibited higher inhibition activities against the tested strains of the fungi and bacteria than their corresponding leaf extracts. The Scanning Electron Microscopy analysis also revealed the possible interactions, with the formation of a protective layer on the aluminum by the inhibitors.

Keywords: Nano-scales, isotherm, anticorrosion, adsorption, inhibitory efficiency, surface coverage, green synthesis, silver nanoparticles

NANO 2018P008

Production, characterization, mechanical properties and biodegradability study of a nano fiber reinforced thermoplastic starch polymer

Adeyi, A.J*., and Durowoju, M.O
Department of Mechanical Engineering, Ladoke Akintola University of Technology Ogbomoso, Oyo State, Nigeria.
*Corresponding author: adeyi.abiola@yahoo.com; modurowoju@lautech.edu.ng

Nowadays, the clamor for biodegradable polymer-based material is very high due to its many environmental preservation advantage and other benefits. Therefore, development of alternative green packaging materials is of utmost importance. Although, scientific exploits have developed thermoplastic starch-based materials as a promising alternative, a lot still has to be done in taming the poor mechanical and moisture uptake tendencies of starch-based material. It has however been established that nano-cellulose reinforcement can significantly reduce the hydrophilic tendencies and also improve the mechanical properties of thermoplastic starch polymer. In this study, nanoscale *Momordica charantia* fiber was used to improve the properties of plasticized starch-based film. Raw *Momordica* fiber's alkalization was first optimized with Response Surface Methodology and Genetic Algorithm. Thereafter, the optimally alkalized fiber was further bleached and nanofibre was extracted through acid hydrolysis followed by homogenization. The nanofiber possesses improved crystallinity and cellulose concentration as established by FTIR analysis. TEM analysis showed that nano fibers produced have an average diameter of 5 - 10 nm size. Reinforced thermoplastic starch film also show improved mechanical and moisture absorption properties. The produced films show significant decrease in weight after five (5) days of soil burial test, signifying high rate of biodegradability. It can be concluded from the results that the *Momordica* reinforced biodegradable plastic starch film can be used to replace non-biodegradable polymers presently applied in ready-to-eat food and grocery packing materials.
Keywords: *Momordica charantia,* biodegradable polymer, nanofibre, reinforced thermoplastic starch film, mechanical properties

NANO 2018B009

Synthesis of silver nanoparticles from *Adansonia digitata* leaf extract and its antimicrobial properties

***Akintola, A.O[1]., Azeez, M.A[2]., Kehinde, B.D[3]., and Oladipo, I.C[1]**
[1]Department of Science Laboratory Technology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [2]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [3]Department of Biochemistry, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
*Corresponding author: aoakintola@lautech.edu.ng

Silver nanoparticles (AgNPs) were green synthesized using *Adansonia digitata* leaf extract. The synthesized AgNPs were characterized in terms of synthesis, size, shape, morphology and capping functionalities by UV-visible Spectroscopy, Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). Antimicrobial activity of the AgNPs was investigated by well diffusion method. The antibacterial activity of the nanoparticles was studied against *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Salmonella typhi* and *Klebsiella pneumoniae*, while the antifungal activity was studied against *Candida albicans*, *Aspergillus niger*, *Penicillium notatum* and *Rhizopus stolonifer*. The dark yellowish brown colloidal AgNPs were spherical in shape, 40-50 nm in size and absorbed maximally at 418 nm. The AgNPs was active against all the studied microorganisms. *Staphylococcus aureus* was the most susceptible bacterium (inhibition zones

ranging from 12.00 to 28.00 mm, MIC: 30 µl, MBC: 50 µl), while *Aspergillus niger* was the most susceptible fungus (inhibition zones ranging from 10.00 to 18.00 mm, MIC: 90 µl, MFC: 120 µl). In conclusion, the synthesized silver nanoparticles was found to have antimicrobial activity against the pathogenic bacteria and fungi tested and hence has a great potential in biomedical application for the treatment of microbial infections.

Keywords: Silver nanoparticles; *Adansonia digitata;* antimicrobial activity; nanoparticles; methanolic extract

NANO 2018P010

Adsorptive and modulating properties of zero-valent silver nanoparticles for heavy metals and heavy metals-induced free radicals in *Moringa oleifera*

Azeez, L[1*]., Lateef, A[2]., Adejumo, A[1]., Rasheed, A[1]., Sulaimon, A[3]., and Samuel, O[1]

[1]Department of Pure and Applied Chemistry, Osun State University, Osogbo, Nigeria, [2]Nanotechnology Research Group (*NANO*[+]), Laboratory of Industrial Microbiology and Nanobiotechnology, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria

[3]Department of Microbiology, Osun State University, Osogbo, Nigeria

* Corresponding author: luqman.azeez@uniosun.edu.ng; +2348061538999

Abilities of zero-valent silver nanoparticles (AgNPs) as nano-adsorbent for heavy metal sequestration and for modulating antioxidant activity as well as inducing phytochemical boost to scavenge free radicals induced by heavy metal toxicity on *Moringa oleifera* were investigated. Soil in 40 buckets were spiked with 0.2 mg AgNPs/g soil (group B), 0.5 mg Cd/g soil (group C), 0.5 mg Pb/ g soil (group D), 0.5 mg Cd/g soil (group E), 0.5 mg Pb/ g soil (group F), 0.2 mg AgNPs + 0.5 mg Cd/g soil (group G) and 0.2 mg AgNPs + 0.5 mg Pb/g soil (group H), while the control (water) is A. These buckets were wetted for three weeks with water for group A, 250 mg/L Cd for group C, 250 mg/L Pb for group D and 75 mg/L AgNPs for groups B, E, F, G and H. Significant ($p < 0.05$) reductions were obtained for number of leaves, lengths of shoots and roots, percentage germination, vigour and growth tolerance indices, moisture content, photosynthetic pigments, total carotenoids, total flavonoids, total phenolic contents, ferric reducing ability, free radical scavenging activity as well as hydrogen-peroxide activity with concomitant significant ($p < 0.05$) increase in malondialdehyde and hydrogen peroxide levels for *M. oleifera* grown on Cd and Pb treated soil compared to control with Pb having the worse effects. Interestingly, AgNPs wetted Cd and Pb treated soil and co-additions had significant ($p < 0.05$) positive impacts on these parameters over control by increasing their levels. It can therefore be inferred that AgNPs attenuated the deleterious effects of Cd and Pb on *M. oleifera*, and can therefore be useful in bioremediation strategies.

Keywords: Adsorption, *Moringa oleifera,* silver nanoparticles, free-radicals, phytochemicals, bioremediation

NANO 2018B011

Applications of nanotechnology in biomedical engineering and medicine: a review

Banigo, A.T*., Azeez, T.O., Ejeta, K.O., and Egbuchulam, M[1]

Department of Biomedical Technology, Federal University of Technology, P. M. B. 1526, Owerri, Imo State, Nigeria.

*Corresponding author: almabanigo2@gmail.com

Nanotechnology (NT) is a convergent field that brings together physics, chemistry, material science and engineering at a scale ranging from 1 to 100 nanometres usually known as nanoscale. NT has been employed in the design, fabrication, production, characterization and utilization of many materials

including biomaterials and devices whereby at least one dimension that affects the functional behaviour of the products is on the nanoscale and eventually interacts with the human body at sub-cellular level. In this work, synthesis and applications of nanotechnology and nanomaterials in Biomedical Engineering and Medicine (BME) and Medicine was studied. NT is highly effective and efficient in vast applications of BME, particularly in areas of drug and gene delivery, biosensors, imaging, biomaterial artificial implants and tissue engineering, nanorobots for surgery, cancer therapy, diagnostic tools and many more for drastic improvement. The synthesized nanomaterials are categorized into zero, one, two and three dimensional nanostructures nanomaterials and are used for different healthcare delivery. Nanomaterials such as quantum dots, rods, dendrimers and nanotubes exist in nature and the challenges faced by the traditional methods in quite a slow rate can be overcome by NT. The potential of normal drug reduces as better understanding of nanotechnology pops up. Thus, nanotechnology and nanomaterials improves tissue regeneration, gene replacement, nanosurgeries and drug delivery in developing medicine and BME fields, and can create tremendous effects in the future.
Keywords: Nanotechnology, biomedical engineering, medicine, application, nanosurgeries, biomaterials

NANO 2018B012

Biosynthesis and antimicrobial activities of *Allium cepa*-mediated silver nanoparticles (AgNPs) against some clinical bacterial isolates

Senbadejo, T.Y*., and Muhammad, A.B
Department of Biological Sciences, College of Natural and Applied Sciences, Fountain University Osogbo, Osun State, Nigeria.
*Corresponding author: tosinoble@yahoo.com; Tel +234 8058109442

The synthesis of metal and semiconductor nanoparticles is an expanding research area due to the potential applications for the development of novel technologies. This study revealed the convenient and extracellular method for the synthesis of AgNPs with the use of onion (*Allium cepa*) extract. Onions were obtained from the open market in Osogbo, Osun state. The synthesized AgNPs were characterized using UV-vis spectroscopy and Fourier-transform infrared spectroscopy (FTIR). The antimicrobial effect of each of aqueous, methanolic and fresh extract of *Allium cepa* combined with synthesized AgNPs were assessed using clinical isolates of *Staphylococcus aureus* and *Escherichia coli* by agar well diffusion method. It was observed that the extract and silver nitrate solution changed from light yellow to dark brown in color after 3 h of incubation in the dark. The biosynthesized AgNPs had maximum absorbance at the wavelength of 535 nm. From the experiment, it was observed that the AgNPs has antimicrobial potential as it inhibited the growth of *S. aureus* and *E. coli* with zones of inhibition ranging from 18-26 mm at concentrations of 100 µg/ml. The FTIR spectrum showed peaks at 1662, 1357, 1165, and 110 cm^{-1} which indicates the possible biomolecules in onion extract responsible for capping leading to efficient stabilization of the AgNPs.
Keywords: Silver nanoparticles, green synthesis, *Allium cepa*, *Staphylococcus aureus*, *Escherichia coli*

NANO 2018B013

Chitosan nanoparticles: a review of applications in drug-delivery

Fajingbesi, A.O
Department of Biological Sciences, Fountain University, Osogbo, Osun State, Nigeria.
Corresponding author: glamorousammie@gmail.com; 07038545105

Chitosan is a biodegradable biocompatible polymer that is generally regarded as safe for human dietary use and approved for wound dressing applications. Chitosan has been used as a carrier in polymeric nanoparticles for drug delivery through various routes of administration. Chitosan has chemical functional groups that can be modified to achieve specific goals, making it a polymer with a tremendous range of potential applications. Nanoparticles (NPs) prepared with chitosan and chitosan derivatives typically possess a positive charge having a selective adsorption, neutralizing effect and muco-adhesive properties such that can adhere to mucus membranes and release drug payload in a sustained or controlled release manner. Chitosan-based NPs have various applications in non-parental drug delivery for the treatment of cancer, gastrointestinal diseases, drug delivery to the brain and ocular infections. Chitosan and its derivatives have potential for a wider application as chitosan nanoparticles have shown low toxicity both *in vitro* and some *in vivo* models.
Keywords: Chitosan, nanoparticles, drugs, drug-delivery, biocompatible polymers

NANO 2018P014

Influence of XL-terrasoil nano-chemical on geotechnical properties of weak laterite

Olaniyan, O.S., Ajileye, V.O*., Adewusi, M.O., and Anifowose, O.I
Department of Civil Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.
*Corresponding author: osolaniyan@lautech.edu.ng; ajileyevictoroluwaseun@gmail.com

Laterite is a major material in road construction. However, there is paucity of information on effect of X-Terrasoil on geotechnical properties of weak laterite. This study investigates the geotechnical properties of weak laterites stabilized with a Nanochemical (XL-Terrasoil). Laterite soil samples were collected from two different burrow pits Sample A and B at ($8^{\circ}08'$N, $4^{\circ}15'$E) and ($8^{\circ}25'$N, $4^{\circ}.3'$E) and their geotechnical properties at natural state were determined. XL-Terrasoil was measured in weight to stabilize the laterites at 5, 10, 15, and 20 %, respectively. Geotechnical properties which include Liquid Limit (LL), Plastic Limit (PL), Plastic Index (PI) Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR), and sieve analysis of stabilized and unstabilized samples were determined. The CBR, MDD, PI and percentage passing sieve number 200 of samples A and B were (2 %, 1700 kg/m^3, 45.6 %, 50.1 %) and (3 %, 1840 kg/m^3, 30.6 %, 46.1 %), respectively. Using AASHTO classification system, the soils fall into A-5 - A-7 soils. The LL, PI, MDD and OMC for XL-Terrasoil stabilized samples A ranged (36-52) %, (8-32) %, (1.7 -2.34) g/cm^3 and (7.20-10.8) %. The corresponding values for sample B were (36-58) %, (15-34) %, (1.8-2.63) g/cm^3, (10.5-14.0) %. The average CBR (soaked and unsoaked) for stabilized samples varied from (5-6) %, (13-17) % and (4-8) %, (20-25) %, respectively. The optimum percentage of the nanomaterial that gave the highest compressive strength was 15 %, and it can be concluded that XL-Terrasoil enhanced the geotechnical properties of weak lateritic soil, and may have application in road construction**.**
Keywords: Laterite, XL-Terrasoil, geotechnical properties, nanomaterial, soil

NANO 2018P015

Green nanotechnology: novel source of nano-products

Ejeta, K.O[1*]., Azeez, T.O[2]., Dolor, G.A[3]., and Banigo, A[4]

[1,2,4]Department of Biomedical Technology, Federal University of Technology, Owerri, Nigeria,
[3]Department of Mechanical Engineering, Delta State Polytechnic, Oghara, Nigeria.
[*]Corresponding author: koejeta@yahoo.co.uk; +2348038795184

Green nanotechnology has three main goals which include producing nanomaterials or products without harming human health or the environment, enhancing the properties of the products with composites and producing nano-products that provide solutions to environmental problems such as biodegradation or corrosion of products. This work is aimed to synthesize nanomaterials from three common Nigerian grasses/herbs (elephant grass, bermuda grass, and carpet grass). Samples of grasses/herbs were obtained, converted to carbon black by burning in close compartment of Muffle furnace and then bioreduced to nanoforms using plant extracts. Microscopic and spectroscopic techniques were used to confirm the formation of nanomaterials. This study established potential renewable source of nanomaterials that are novel, eco-friendly and cheap.

Keywords: Green nanotechnology, nanoproducts, novel, eco-friendly, cheap materials, renewable materials

NANO 2018B016

Effect of injection of magnesium nanoparticles (MgONPs) on selected tissue enzymes in broiler chicks

Ogunbode, S.M[1*]., Abubakar, K.T[1]., Salau, A.K[1]., and Majolagbe, H.O[2].

[1]Department of Chemical Sciences, Fountain University, Osogbo [2]Adeniran Ogunsanya College of Education Otto-Ijanikin, Lagos Nigeria.
*Corresponding author: sammy16_ogunbode@yahoo.com; 08038278441

This research was conducted to investigate the effect of injection of biogenically synthesized magnesium nanoparticles (240 µg/ml; < 100 nm) on selected tissue enzymes in broiler chicks. A total of 105 day-old broiler chicks were wing-tagged, weighed and randomly distributed into seven treatments (T1-T7) with three replicates of five birds per replicate. Each treatment was injected subcutaneously with the following: T1 (Without injection (control group), T2 (Injected with 0.5 ml of deionized water (sham group), T3 (Injected with 100 mg of glucose dissolved in 0.5 ml of deionized water), T4 (Injected with 100 mg of glucose dissolved in 0.5ml of deionized water plus 4 mg of magnesium sulphate ($MgSO_4$) dissolved in 0.5 ml of deionized water), T5 (Injected with 100 mg glucose dissolved in 0.5 ml of deionized water plus 4 ml magnesium nanoparticles solution in 0.5 ml of deionized water), T6 (Injected with 4 mg of magnesium sulphate ($MgSO_4$) dissolved in 0.5 ml of deionized water) and T7 (Injected with 4 ml of magnesium nanoparticles solution in 0.5 ml of deionized water). At the end of the study, two birds per replicate were randomly selected and sacrificed. Blood samples were collected for serum alkaline phosphatase (ALP) analysis. Tissues (liver and kidney) were assayed for superoxide dismutase (SOD) and malondialdehyde (MDA) activities. The results of this study showed that *in vivo* administration of magnesium nanoparticles to broiler chicks had no deleterious effect ($p > 0.05$) on the enzyme activities in the various tissues studied when compared with birds on the control diets. ALP activities of birds on the control diet and those injected with MgONPs was 54.29 and 54.21 $ULmg^{-1}$ protein respectively. Hence, magnesium nanoparticles can be said to be safe for poultry use.

Keywords: Magnesium nanoparticles, broiler chicks, alkaline phosphatase, superoxide dismutase, malondialdehyde

NANO 2018B017

Green synthesis and antimicrobial activities of silver nanoparticles of *Vernonia amygdalina*

Ganiyu, O.T*., and Adeleke, M.A

Department of Biological Sciences, College of Natural and Applied Sciences, Fountain University, Osogbo, Osun State, Nigeria.

*Corresponding author: tajudunni@yahoo.com; Tel +234 7034650862

This study was carried out to synthesize silver nanoparticles (AgNPs) using leaf extract of *Vernonia amygdalina*. The synthesized AgNPs were characterized using UV-vis spectroscopy and Fourier-transform infrared spectroscopy (FTIR). The antimicrobial effects of the aqueous extract and synthesized AgNPs were assessed against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Aspergillus niger* and *Aspergillus flavus* using agar well diffusion method. It was observed that the AgNPs has antimicrobial potential as it showed varied degrees of inhibition against *S. aureus* (24.00 mm), *E. coli* (16.00 mm), *P. aeruginosa* (12.00 mm), *A. niger* (15.00 mm) and *A. flavus* (17.00 mm). The leaf extract alone has no inhibitory effect on any of the organisms. The FTIR spectrum showed prominent peaks at 1413, 1716 cm^{-1} and may be as a result of C=O stretching vibrations and strong band at 3405 cm^{-1} which may result from N-H stretching vibration. They are derived from water soluble compounds such as flavonoids, alkaloids and polyphenols present in leaves. These biochemicals are known to interact with metal salts via these functional groups and mediate their reduction to nanoparticles. The synthesized nanoparticles have better radical scavenging activity at low concentration but low activity at high concentration.

Keywords: *Vernonia amygdalina*, Silver nanoparticles, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*

NANO 2018B18

Biosynthesis of silver, gold and alloy nanoparticles using *Persea americana* fruit peel aqueous extract for their biomedical properties

***Oke, A.M[1]., Adebayo, A.E[1,2]., Oyatokun, A.A[1]., Abisoye, O.D[1]., Adiji, I.P[1]., Fagbenro, D.O[1]., Amusan, T.V[1]**

[1]Department of Pure and Applied Biology, [2]Nanotechnology Research Group (*NANO*$^{+}$), Ladoke Akintola University of Technology, PMB 4000, Ogbomoso Nigeria.

*Corresponding author: okemorenikejiabel@gmail.com

While several green biomolecules have been used to synthesize functional and biologically compatible nanoparticles, little attention has been paid to *Persea americana* (Avocado) fruit extract as a potential reducing agent. This study used Avocado fruit peel aqueous extracts to synthesize silver nanoparticles (AgNPs), gold nanoparticles (AuNPs) and bimetallic alloy nanoparticles (Ag-AuNPs). The particles were characterized using UV-vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), selected area electron diffraction (SAED), Energy Dispersive X-ray spectroscopy (EDX) and X-ray diffraction (XRD) among others. They were assessed for their antibacterial, antifungal and antioxidant properties. The UV-vis spectroscopy showed AgNPs, AuNPs and Ag-AuNPs with surface plasmon resonance at 429.5, 535 and 523.5 nm respectively. TEM results indicated spherical, anisotropic, rod and hexagon particles with size range of 18-80 nm for AgNPs and 16-71 nm for AuNPs. The energy dispersive X-ray spectra showed silver, gold and silver-gold as conspicuous metals in AgNPs, AuNPs and Ag-AuNPs colloids, respectively. SAED showed ring shaped nanoparticles. The nanoparticles effectively inhibited growth of tested bacteria (11-94 %) for AgNPs, (10-77 %) for AuNPs and (20-85 %) for Ag-AuNPs. The effectiveness of the biosynthesized nanoparticles

can be placed as Ag-AuNPs > AgNPs >AuNPs. The fungal inhibition performances are 33-76 %, 50-82 % and 27-88 % for AgNPs, AuNPs and Ag-AuNPs, respectively while DPPH scavenging activities were 57.82-63.25 %, 15.28-54.50 % and 53.05-54.26 %, which were dose-dependent at the tested concentrations of 20–100 µg/ml with good antioxidant activities compared to standard BHA (41.46-84.57 %) and ascorbic acid (43.56–91.10 %). The bleaching inhibition assay of ABTS showed activities of 56.15-85.43 % (AgNPs), 34.67-50.93 % (AuNPs) and 45.31-94.01 % (Ag-AuNPs). The lower concentrations of EC_{50} were obtained in nanoparticles (24.45-58.33 µg/ml) compared with the standards (38.42-69.04 µg/ml) indicating that the nanoparticles could suffice as good agents in drug consignment. This study has demonstrated the potential of *P. americana* fruit peel aqueous extracts to synthesize AgNPs, AuNPs and Ag-AuNPs for antibacterial, antifungal and antioxidants applications. The current work, to our knowledge, is the first to use avocado peel extract to synthesis nanoparticles.

Keywords: Biosynthesis, silver nanoparticles, gold nanoparticles, silver-gold alloy nanoparticles, *Persea americana*, antioxidant, antimicrobial activities

NANO 2018B019

Biogenic synthesis of titanium oxide nanoparticles using seed extract of *Cola nitida* for biomedical and catalytic applications

***Akinola, P.O.,[1*] and Lateef, A[1,2]**

[1]Laboratory of Industrial Microbiology and Nanobiotechnology, Department of Pure and Applied Biology, [2]Nanotechnology Research Group (*NANO*$^{+}$), Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: dammy_realvision@yahoo.com

Phyto-synthesis of transition metal nanoparticles is gaining importance due to their biocompatibility, low toxicity, green approach and environmental-friendly nature. In this study, seed extract of *Cola nitida* was investigated for the biogenic synthesis of titanium oxide nanoparticles (TiO_2 NPs) and studied for their biomedical applications. The biosynthesized TiO_2 NPs was characterized by UV-vis spectroscopy, FTIR, TEM, FESEM, SAED, EDX and XRD. The antibacterial and antifungal activities of the nanoparticles, catalytic, antioxidant and anticoagulant activities of the nanoparticles were examined. The kola seed mediated-titanium oxide nanoparticles (KS-TiO_2 NPs) synthesized was orange in colour with maximum absorbance at 272.5 nm. The FTIR spectrum confirmed the involvement of proteins in the bioreduction and stabilization. The particle sizes ranged from 79.44-133 nm as revealed by TEM. FESEM images showed particles were spongy shaped with agglomeration. The particles were crystalline in form. EDX analysis revealed titanium as the most noticeable element in TiO_2 NPs. The XRD proved the anatase phase of titanium oxide. The antibacterial activity of nanoparticles was tested against *Staphylococcus aureus, E. coli, Klebsiella pneumoniae* and *Pseudomonas aeruginosa.* Maximum percentage inhibition obtained was 68 % against *Klebsiella pneumoniae*. The nanoparticles effectively inhibited the growth of *Aspergillus flavus* and *Fusarium solani*. Catalytic degradation of malachite green was 91.93 % at 80 µg/ml. TiO_2 NPs are highly antioxidant in nature scavenging DPPH (1,1-diphenyl-2-picrylhydrazyl) and H_2O_2. The nanoparticles also displayed an excellent anticoagulant activity against fresh blood collected from a healthy individual. The nanoparticles displayed potent antibacterial, antifungal, catalytic, antioxidant and anticoagulant activities.

Keywords: *Cola nitida*, titanium oxide nanoparticles, biomedical applications, TEM, antioxidant, thrombolysis

NANO 2018B020

Antioxidant and antifungal potentials of silver, gold and silver-gold alloy nanoparticles of *Opuntia ficus-indica*

Ibikunle, J.B[1,3*]., Adebayo, A.E[1,2]., Olajide, O.O[1]., Okunlola, O.C[1]., Olowoporoku, B.T[1]., Ajala, V.A[1]., and Ogundele, O[1]

[1]Department of Pure and Applied Biology, [2]Nanotechnology Research Group (*NANO*$^{+}$), Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo State Nigeria, [3]Department of Science Laboratory Technology, Federal Polytechnic, P.M.B 420, Offa, Kwara State, Nigeria

*Corresponding author: ibikunlejelilat@gmail.com

Nanoparticles have a huge share in nanotechnology, which offers numerous benefits, including eco-friendliness and compatibility for biomedical applications. This study used *Opuntia ficus-indica* aqueous extracts to synthesize silver (AgNPs), gold (AuNPs) and bimetallic alloy (Ag-AuNPs) nanoparticles. The particles were characterized using UV-vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), selected area electron diffraction (SAED), Energy Dispersive X-ray signal (EDX) and X-ray diffraction (XRD). The assessments of their antioxidant and antifungal activities were done. The UV-vis spectroscopy showed AgNPs, AuNPs and Ag-AuNPs with surface plasmon resonance at 464, 547 and 538 nm respectively. The spherical, anisotropic, rod and hexagon nanoparticles had size of 27-38 nm for AgNPs and 11-28 nm for AuNPs. The energy dispersive X-ray spectra showed silver, gold and silver-gold as conspicuous metals in AgNPs, AuNPs and Ag-AuNPs colloids respectively. Selected area electron diffraction (SAED) showed the nanoparticles as ring shaped pattern crystal structures. The fungal inhibition of 44-70 % for AgNPs, 42-79 % for AuNPs and 52-92 % for Ag-AuNPs were obtained. DPPH scavenging activities were obtained as follows; AgNPs (52.9-58.0 %), AuNPs (37.9-58.7 %) and Ag-AuNPs (37.1-63.0 %), which were dose-dependent at the tested concentrations of 20-100 µg/ml with good antioxidant activities compared to standard BHA (43.6-91.1 %) and ascorbic acid (52.2-84.4 %). The bleaching inhibition assay of ABTS showed activities of 41.8-62.7% (AgNPs), 27.2-50.1 % (AuNPs) and 33.3-49.1 % (Ag-AuNPs). The lower concentrations of EC_{50} were obtained in nanoparticles (18.0-60.0 µg/ml) compared with the standards (18.0-110.0 µg/ml), which is an indication that the nanoparticles could suffice as good agents in drug consignment. This study has showed the potential of *Opuntia ficus-indica* aqueous extracts to synthesize AgNPs, AuNPs and Ag-AuNPs which have antifungal and antioxidants activities.

Keywords: Green synthesis, *Opuntia ficus-indica*, AgNPs, AuNPs, Ag-AuNPs, nanoparticles, biomedical applications

NANO 2018B021

Characterization and release kinetics of metronidazole loaded silver nanoparticles prepared from *Carica papaya* leaf extract

Jackson, T.C., and Ifekpolugo, N.L

Department of Pharmaceutics and Pharmaceutical Technology, University of Uyo, Uyo, Nigeria

*Corresponding author: clementjackson@uniuyo.edu.ng

Silver nanoparticles were synthesized using ecofriendly method with extract of *Carica papaya* as reducing and stabilizing agent. Metronidazole (200 mg) was loaded as model drug to the silver nanoparticles. The percentage yield of the metronidazole nanoparticles was high (96.00 %). The entrapment efficiency 85.60 % while the loading capacity was 8.90 %. Differential scanning calorimetry showed there was no interaction between the reducing agent and model drug. Characterization of the metronidazole nanoparticles using UV-vis spectroscopy, zeta sizer, scanning electron microscopy (SEM) was performed. The UV-vis spectroscopy showed surface plasmon resonance of 435 nm for the silver

nanoparticles. The mean particle size was 250 nm while the polydispersity index was 0.22. The metronidazole nanoparticles showed extended and controlled release profile. The kinetics of release was zero order (R^2 = 0.9931) for the metronidazole nanoparticles, while the metronidazole normal release tablet followed Higuchi kinetics (R^2 = 0.9745).

Keywords: Metronidazole, silver nanoparticles, *Carica papaya*, drug release, Higuchi kinetics

NANO 2018B022

Characterization, antimicrobial, antioxidant, and anticoagulant activities of silver nanoparticles synthesized from *Petiveria alliacea* L. leaf extract

Lateef, A[1]., Folarin, B.I[1]., Oladejo, S.M[1]., Akinola, P.O*[1]., Beukes, L.S[2] and Gueguim-Kana, E.B[3]

[1]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria; [2]Microscopy and Microanalysis Unit, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa; [3]Department of Microbiology, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Corresponding author: dammy_realvision@yahoo.com

Phytosynthesis of silver nanoparticles (AgNPs) using leaf extract of *Petiveria alliacea* (PA) was the focus of this research work. The PA-AgNPs were characterized by UV-vis spectroscopy, Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), and selected area electron diffraction (SAED) study. Studies were made on the AgNPs for antibacterial, antifungal, anticoagulant, free-radical scavenging, and hydrogen peroxide scavenging activities. The crystalline PA-AgNPs were monodispersed, with a size range of 16.70-33.74 nm and maximum absorption at 410 nm. FTIR analysis displayed prominent peaks at 3430.6, 1711.8, and 1165.9 cm^{-1}, which showed the existence of phenolic compounds and proteins in the synthesis of AgNPs. PA-AgNPs was active against *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*, with 100 % inhibition. The PA-AgNPs also displayed good antifungal properties, as the concentrations of 100 and 150 mg/ml had 100 % inhibition toward *Aspergillus fumigatus* and *Aspergillus flavus*. However, there was 66.67 % inhibition of *Aspergillus niger*. It scavenged both DPPH and H_2O_2 by 70.69 and 89.02 %, respectively. PA-AgNPs also prevented the coagulation of human blood. This study, being the first of its kind to use the leaf extract of PA for the synthesis of AgNPs has shown that PA-AgNPs can find biomedical applications.

Keywords: Anticoagulant; antimicrobial activity; antioxidant activity; *Petiveria alliacea*; phytosynthesis; silver nanoparticles

NANO 2018B023

Effects of cocoa pod husk extract-mediated silver nanoparticles on selected tissues of albino rats

Salau, A.K*[1]., Osineye, S.O[2]., and Lateef, A[3]

[1]Antioxidants, Toxicology and Phytomedicine Research Laboratory, Biochemistry and Nutrition Unit, [2]Plant Biochemistry Research Laboratory, Biochemistry and Nutrition Unit, Department of Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria, [3]Nanotechnology Research Group (*NANO*$^+$), Laboratory of Industrial Microbiology and Nanobiotechnology, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: ka.salaudeen@gmail.com

In spite of the various applications of silver nanoparticles in household and biomedical products, not much is known about the effects of these nanoparticles on the living system, especially the biogenic nanoparticles. This work investigated the effects of cocoa pod husk extract-mediated silver nanoparticles (CPHE-AgNPs) on selected tissues of albino rats. Twelve female albino rats weighing 188.61±19.15 were

randomly assigned into three groups of four rats each and treated once daily with 0.5 ml of distilled water, 50 µg/mL, and 100 µg/mL of the nanoparticles intraperitoneally for fourteen days. Activities of selected enzymes were monitored in the serum, liver, kidney and heart. Hepatic and renal function indices, lipid profile, organ-body weight ratios and organ histoarchitectural examination were also carried out. There were significant ($p < 0.05$) elevations in the heart ALP, liver GGT and AST, and serum K^+at 100 µg/mL, as well as serum albumin, creatinine and Na^+ at 50 and 100 µg/mL. There were also significant ($p < 0.05$) reductions in serum AST (at 50 µg/mL), direct bilirubin (at 100 µg/mL), and serum ALP and CK, and liver ALP and ALT. However, there were no significant ($p > 0.05$) changes in serum GGT, ALT, AST (at 100 µg/mL), liver GGT and AST (both at 50 µg/mL), kidney ALP, ALT and AST, heart ALP (at 50 µg/mL), ALT, CK, and AST. Also, not significantly ($p > 0.05$) affected were direct bilirubin (at 50 µg/mL), protein, total bilirubin, lipid profile, uric acid and Cl^-. The computed liver-, kidney- and heart-body weight ratios and histoarchitecture were also not affected by the nanoparticles. The results show mild hepatic, renal and cardiac toxicities, with functional toxicity of the liver and kidney. There were no evidences of organ structural damages. The intraperitoneal use of CPHE-AgNPs for fourteen days exhibited mild toxicity in female rats at 50 and 100 µg/mL.
Keywords: Cocoa pod extract, silver nanoparticles, toxicology, organs, albino rats, functional toxicity

NANO 2018P024

Determining biomechanical properties of cells and tissues at nanoscale: techniques and applications

Adedayo, S.A[1*]., Omisanya, I[2]., Adedayo, A.A[3]., Atoyebi, E.O[4]., Asafa, T.B[5]

[1,4]Biomedical Engineering Option, Department of Mechanical Engineering, University of Ibadan, Ibadan, Nigeria, [2]School of Mechanical Engineering, Tianjin University, Tianjin 300350, China, [3]Department of Pure and Applied Biology, LAUTECH, Ogbomoso, Nigeria, [5]Department of Mechanical Engineering, LAUTECH, Ogbomoso, Nigeria.

*Corresponding author: adedayoas91@gmail.com

Cellular proliferation, gene expression and other cellular metabolisms are key areas in which the mechanical properties of cells are required. These derived mechanical properties such as viscoelasticity, Young's modulus, and mechanical vibrations among others can be monitored to track changes and behaviour of the cells to detect disease symptoms such as cancer, osteoarthritis, asthma, inflammation and many others. Experimental conditions like tip geometry and mechanical models used, often influence the relative mechanical properties of the cells. Tumor or cancerous cell usually express a certain biochemical protein at its membrane which makes it very hard for antibodies to identify, but a cell mechanical approach has shown that the elasticity of such cell is quite different from that of a normal cell, thus rendering the adoption of nanobiomechanics (same as bionanomechanics) a worthwhile approach. This review therefore presents an insight into some of the existing techniques used in testing for the various mechanical properties of cells which include; magnetic twisting cytometry, optical tweezers, microscale or nanoscale indentation, and micropipette aspiration, and their various applications in biomedical engineering.
Keywords: biomechanical properties, techniques, nanomechanics, nanoindentatation, bionanomechanics, cell mechanics

NANO 2018B025

Biological synthesis of nanoparticles from *Cola nitida* and its applications

Taiwo, M[1*]., Adedayo, S.A[2]., Adedayo, A.A[3]., Lateef, A[4]

[1]Department of Microbiology, University of Ibadan, Ibadan, Nigeria, [2]Biomedical Engineering Option, Department of Mechanical Engineering, University of Ibadan, Ibadan, Nigeria [3,4]Department of Pure and Applied Biology, LAUTECH, Ogbomoso, Nigeria.

*Corresponding author: dammymariam001@gmail.com

Cola nitida seed extracts were used to synthesize metallic Ag-Au alloy nanoparticles. Stable Ag-Au nanoparticles were formed in a ratio of 80:20 respectively, by adding 2 mL of $HAuCl_4$ to 8 mL of $AgNO_3$ with the seed extract as reducing agent of Au^{3+} to Au^0 and Ag^+ to Ag^0. UV-visible spectroscopy was used to monitor the quantitative formation of alloy and the particles. The synthesized alloy nanoparticles were characterized with Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectroscopy (EDX) and Fourier Transform Infrared Spectroscopy (FTIR). In the larvicidal assay, varying concentrations of Ag-Au alloy nanoparticles were prepared (60, 80, and 100 µg/mL) by dispersing the nanoparticles in sterile distilled water. Methylene blue, malachite green and congo red dyes were used in the dye degradation assay, while in the antioxidant assay, DPPH was used by reacting 1 mL of synthesized alloy nanoparticles of different concentrations with the test reagents. This environmentally friendly method of biological production of alloy nanoparticles provides rate of synthesis faster to those of chemical methods and can potentially be used in various human contacting areas such as food and medical applications.
Keywords: Nanoparticles, biological synthesis, plant extract, *Cola nitida*, green synthesis, Ag-Au (alloy) metal.

NANO 2018P026

Solid state refrigeration potentials in $Ni_{42.5}E_{0.5}Mn_{46}Sn_{11}$ (E = Fe, Co, Ni, Cu) Heusler alloys

Ezekiel, I.P*[1]., and Moyo, T[2]

[1,2]National Centre for Technology Management, North West Office, 7th Floor, Federal Secretariat, Katsina Road, Kano, Kano State, Nigeria, [2]School of Chemistry and Physics, Westville Campus, University of KwaZulu-Natal, Durban, South Africa.

*Corresponding author: itegbeyogene@gmail.com

The increasing world population and its associated human activities have placed a high demand on energy consumption, coupled with damage to the ecosystem. An example is the use of conventional refrigerators which make use of gas compressors that requires high energy for ambient cooling. The chlorofluorocarbons and hydrochlorofluorocarbons gases that are used as refrigerants contribute to global warming by depleting the ozone layer when the gases escape into the environment. The quest for alternatives for efficient cooling, low energy consumption, economic viability and device compatibility has necessitated the research into solid-state refrigeration technology which relies on the magnetocaloric effect (MCE) that is obtainable from bulk or nano magnetic materials. Intermetallic alloys are examples of materials that have gained attention for MCE research. The magnitude of the magnetic entropy, ΔS_M the refrigerant capacity *RC*, and the operating temperature at which the maximum ΔS_M can be obtained, are important determinants for application purposes. This work examines the effect of Fe, Co and Cu substitutions of Ni on the MCE properties in $Ni_{43}Mn_{46}Sn_{11}$ Heusler alloy. The results show a first-order magnetic transition (FOM) at low temperatures while a second-order magnetic transition (SOM) was observed near room temperature. Our investigations revealed that the inclusions of Fe, Co and Cu atoms caused lattice expansion. The substitution of Ni by Fe, Co, and Cu produced $Ni_{42.5}$(Fe, Co, Ni, Cu)$_{0.5}Mn_{46}Sn_{11}$ alloys which have higher working temperatures from 221 K to 241 K in the FOM regions.

An increase from 282 K to 289 K was observed in the SOM regions, with a more significant increase to 294 K by Co substitution. The unsubstituted sample, $Ni_{43}Mn_{46}Sn_{11}$, has the highest value of $\Delta S_M \approx 29$ J kg^{-1} K^{-1} in the FOM regions. The ΔS_M operates over a wide temperature range in the SOM region. The $Ni_{43}Mn_{46}Sn_{11}$ sample also showed the most efficient *RC* compared to the substituted samples. The inclusions of the transition metals act as pinning centers of the magnetic domain walls which lead to a significant enhancement of the coercivity H_C and exchange bias field H_{EX}. An unusual temperature dependence of H_C is reported here for the first time, with a strong correlation obtained between the temperature T_{MC} at which the maximum H_C was observed and the temperature T_0 obtained from the exponential fit to the H_{EX} data.

Keywords: Refrigerant, Heusler alloy, energy efficiency, magnetocaloric effect, magnetic entropy

NANO 2018IP027

Sustainable nanotechnology development in Nigeria – Hazards and policy directions

Ezekiel, I.P*., Adebudo, O.G., Aodu, A.B., Mainasara, A., and Musa, Z.M

National Centre for Technology Management, North West Office, 7th Floor, Federal Secretariat, Katsina Road, Kano, Kano State.

*Corresponding author: itegbeyogene@gmail.com

Science and technology (S&T) have been the bedrock of industrial revolutions. Innovation has, however, played a significant role in advancing S&T from the first industrial revolution that is characterized by uneconomically large and heavy machinery to the fourth industrial revolution where miniaturization of machinery and electronic devices is predominant. This has been largely made possible in the 21st century by the diverse potentials in nanotechnology. The technology shows promising prospects in enhancing service delivery and finds applications in diverse sectors of our society. Nevertheless, like every other technological revolution of the past, there are negative impacts both on humans and the environment that could arise from the use of nanomaterials and irresponsible disposal of nanowastes. Nanoscale materials behave very differently from their bulk counterparts. Their very fine particle size nature allows possible penetration of pores. Due to data gaps, leading nations on nanotechnology development are initiating precautionary measures to address the challenges of possible exposures to nanomaterials and the management of nanowastes. For example, REACH (registration, evaluation, authorization, and restriction of chemicals) is a framework developed under the NANoREG project by the European Union to address nano-hazards. The USA through the Environmental Protection Agency and the National Institute for Occupational Safety and Health (NIOSH) are similarly making efforts to address the health concerns associated with nanotechnology development. Most Asian countries and developing nations like Brazil have adopted some of the EU and USA frameworks. This study elucidates some laboratory pieces of evidence on the toxicity of some nanomaterials. We used scientific nano-publications, country investments in nanotechnology, patents, and nano-products commercialization as possible indicators for an overview of the expected level of nanomaterials consumption and the amount of nanowastes that could be generated. The current chemical and environmental protection laws in Nigeria are not sufficient to manage the importation, production, exposure, and disposal of engineered nanomaterials. We propose a nano-safety protocol and policy directions for incorporation into the roadmap for nanotechnology development in Nigeria, with peculiar domestic factors taken into considerations.

Keywords: Industrialization, nanotechnology, nanowastes, nanotoxicity, nano-safety protocols

NANO 2018P28

Optical Studies of Natural Dyes and Green Synthesized Silver Nanoparticles Embedded in Titanium (IV) Oxide for Application in Dye Sensitized Solar Cells

Alamu, G. A.[1]., Adedokun, O[1, 2 *]., Atere, D.A[1]., Oyeshola, H.O[1]., Fajinmi, G.R[1]., and Sanusi, Y.K[1, 2]

[1]Department of Pure and Applied Physics, [2]Nanotechnology Research Group (*NANO*$^+$), Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: oadedokun@lautech.edu.ng

Solar energy is unlimited in quantity and is becoming one of the most promising alternative energy sources. Dye sensitized solar cell (DSSC) emerged as a new class of low cost energy conversion device with simple manufacturing procedures. This research focuses on the optical characteristics of natural dyes and green synthesized silver nanoparticles incorporated into Titanium (IV) Oxide (TiO_2) for application in dye sensitized solar cells. Natural dyes were extracted from air dried neem (*Azadirachta indica*) and henna (*Lawsonia inermis*) leaves. Henna leaf broth extract was prepared and added to silver nitrate ($AgNO_3$) solution for reduction of silver ions into silver nanoparticles. TiO_2 pastes were prepared and deposited on glass substrates as thin films by doctor blade technique. The coated substrates were dried and annealed at 450 ^oC. The samples were soaked in dye solution for sensitization. The optical characterizations were carried out using UV-vis Avantes spectrophotometer. The neem and henna dye extracts both from ethanol showed intense Soret and Q absorption bands in the visible region. The optical absorption band obtained at about 425 nm confirmed the presence of the AgNPs. Incorporating the silver nanoparticles into TiO_2 increased the absorbance in the visible region. The absorbance significantly increased in the wavelength region from 420 nm to 750 nm after dye loading. From this research, it has shown that optical properties of natural dyes and green synthesized silver nanoparticles are good materials for application in dye sensitized solar cells with outstanding environmental friendliness.

Keywords: Solar energy, dye sensitized solar cell, TiO_2, silver nanoparticles, *Azadirachta indica*, *Lawsonia inermis*

NANO 2018P029

Effect of fluorine doping on sol-gel spin coated tin oxide thin films for solar cell applications

Odebunmi, V. M[1,2]., Adedokun, O[1,4*]., Atanda, O.S[1]., Babalola, K.K.[1,3]., Fajinmi, G.R[1]., and Sanusi, Y.K[1,4]

[1]Department of Pure and Applied Physics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [2] Department of Physics, Emmanuel Alayande College of Education,Oyo, Nigeria, [3]Department of Physics, Osun State College of Education, Ila-Orangun, Nigeria, [4]Nanotechnology Research Group (*NANO*$^+$), Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: oadedokun@lautech.edu.ng

Transparent Conducting Oxide (TCO) thin films are class of materials of importance because of their applications in optoelectronics and solar cells. Indium Tin Oxide (ITO) is the most common and effective one but the abundant use of ITO as TCO thin films has several drawbacks such as scarcity, highly toxic, and expensive source of indium itself. Fluorine doped Tin Oxide (FTO) is an alternative material in the development of TCO thin film due to the availability, non-toxicity and inexpensive source of fluorine. In this research, effects of fluorine doping on structural and optical characteristics of tin oxide (SnO_2) were investigated. SnO_2 and FTO thin films were synthesized using sol-gel spin coating technique. SnO_2 film was prepared using stannous chloride as the metal source, 2-methoxyethanol as the solvent, di-ethanolamine as the stabilizer and FTO films were prepared by addition of ammonium fluoride as the dopant source at 5, 10, 15 and 20 % at a deposition speed of 2000 rpm for 40 seconds and later annealed at temperature of 600 ^oC. The structural and optical characteristics of prepared thin films were

characterized using X-ray diffraction (XRD) analysis and UV-visible spectroscopy, respectively. The doping concentration reduces the transparency of the film, which is probably due to the increase in fundamental absorption as photon striking increases with increase in carrier concentration, while there is increase in conductivity as dopant increases. This study indicates that sol-gel spin coated FTO films prepared under the optimized operating conditions could be a potential n-type material for solar cell application.

Keywords: Solar energy, tin-oxide, thin films, sol-gel spin technique, fluorine doping

NANO 2018B030

Biochar ameliorates acidity and improves organic carbon in an acid soil for enhanced maize performance

Oyeyiola, Y.B[1*]., Omueti, J.A.I[2]., Kolawole, G.O[1]., and Ewetola, E.A[1]

[1]Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [2]Department of Agronomy, University of Ibadan, Nigeria.

[*]Corresponding author: yboyeyiola@lautech.edu.ng; Tel.: +2348028216790.

Acidity and declining organic carbon (OC) are major bottle necks to profitable crop production in the tropical soils. Ameliorating soil acidity with conventional liming materials is costly and leads to soil OC depletion. Use of biochar, the solid product of pyrolysis of plant biomass has not been well documented in the management of tropical acid soil. Three biochar types prepared from underutilized plants: *Gliricidia sepium* (GLB), *Imperata cylindrica* (ICB) and *Tithonia diversifolia* (TDB) leaves applied at 10 t/ha with or without chemical fertilizer (50 % CF) at 60 kg N/ha were studied for their immediate and residual effects in 500 g acid soil. Sole lime (SL) applied at 1 t/ha, sole chemical fertilizer (100 %CF) at 120 Kg N/ha and unamended soils (control) were compared for two maize croppings in completely randomized design with three replications. Results indicated that biochar with or without CF significantly ($p < 0.05$) enhanced soil pH and OC above SL and control with comparable exchangeable Al and acidity values with SL during the two croppings. Biochar exhibited positive residual effects with soil pH, OC, exchangeable acidity and fresh root weight of maize compared to immediate effects with highest improving values of 15 (TLB+50 %CF), 21 (GLB+50 %CF), 100 (GLB, TLB and TLB+50 %CF) and 1700 % (GLB+50 %CF) respectively. Spiking biochar with 50 %CF generally enhanced biochar activity in ameliorating the acid soil studied. Biochar of these underutilized plants should therefore be exploited for reclamation, management of acidity and reduced usage of chemical fertilizers in organic carbon depleted tropical soils.

Keywords: Biochar, *Gliricidia sepium*, *Imperata cylindrica*, *Tithonia diversifolia*, soil acidity, soil organic carbon management

NANO 2018P031

Effect of rice husk ash and graphene nanoplatelets on morphological and mechanical properties of recycled aluminium cans hybrid composites

Yekinni, A.A*[1,2]., Durowoju, M.O[2]., Agunsoye, J.O[3]., and Mudashiru, L.O[2]

[1]Department of Mechanical Engineering, Lagos State Polytechnic, Ikorodu, Nigeria, [2]Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [3]Department of Metallurgical and Materials Engineering, University of Lagos, Akoka, Nigeria.

[*]Corresponding author: kunleyk2003@yahoo.com

The paper presents results of the studies of creating new lightweight aluminium matrix composite materials from 150 µm sized rice husk ash (RHA) and graphene (G) nanoplatelets by stir cast technique.

The method for synthesizing aluminium-based matrix composite materials with low concentration (0.4 % wt) graphene and low concentration RHA (0.8 % to 1.2 % and 1.6 % wt.), such that RHA provides additional carbon and also acts as a carrier to disperse graphene in aluminium (Al) matrix is entirely new. The composite melt was poured into a preheated cavity die steel mould to produce rectangular and circular bars. The bars were machined to standard samples for morphological, mechanical, and physical property investigations. Microstructural/chemical composition analyses of reinforcements, control sample and composites were carried out with the aid of optical and scanning electron microscopes (SEM) with attached energy dispersive X-ray spectroscopy (EDS). Phases were identified using an X-ray diffractometer (XRD). The optical and SEM/EDS micrographs showed reasonably uniform distribution of RHA and graphene nanoplatelets in the matrix of aluminium alloy. The increase in carbon content of Al/RHA/G composites as revealed in the EDS when compared to composites of Al/RHA confirmed the presence of graphene nanoplatelets (nCP). The XRD of all composites did not reveal formation of second phase particle like Al_4C_3. Rather, formation of carbon-metal and carbon-metal-oxygen atomic bonds was revealed in the XRD, which led to increase in the ultimate tensile, hardness and fatigue properties of the composites from 63.45 to 132.50 MPa, 75.50 to 115.60 HV and 0.72 x 10^6 to 2.46 x 10^6 cycles respectively. However, there was a noticeable decrease in impact energy and density as percent weight fraction of RHA increases from 13.60 to 8.14 J and 2.85 x 10^3 to 2.62 x 10^3 Kg/m^3 respectively. Therefore, the developed composites are suitable for operations in very hard dynamical, thermal and mechanical conditions where light weights are a necessity.
Keywords: Rice husk ash, graphene nanoplatelets, recycled aluminium cans, stir cast, composites

NANO 2018B032

Optimization of staminate and pistillate *Carica papaya* leaf extracts for green synthesis of silver nanoparticles

Olabode, A.D[1,2*]., Salawudeen, T.O[1,3]., Aworanti, O.A[1]., Latinwo, G.K[1]., Aremu, M.O[1]., Babatunde, K.A[1]., and Alade, A.O[1,2,3]*

[1]Department of Chemical Engineering, [2]Bioenvironmental, Water and Engineering Research Group (BWERG), [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; olamilekanawesome@yahoo.com

This study investigated green synthesis of silver nanoparticles using the blends of extracts of male (staminate) and female (pistillate) pawpaw (*Carica papaya*) leaves. Dry and almost fallen stems of male and female pawpaw plants were carefully collected and the leaves were trimmed, and then air-dried before being extracted with water at room temperature. I-Optimal Design (IOD) under the Combined Methodology of the Design Expert (11.0.4.0) was used to mix varying composition (0-100 % v/v) of the staminate and pistillate pawpaw leaves extracts at varying ratios (1:4-10 ml of extract mixture: ml of $AgNO_3$) as factor. The fifteen experimental runs were generated for the green synthesis were carefully conducted and optical density of the synthesized material was examined with UV-Vis spectrophotometer and Fourier transform infrared (FTIR) spectroscopy of the sample with highest absorbance was investigated. Experimental run with mixed ratio of 13.9/86.1 % staminate/pistillate pawpaw leaves extracts and ratio 1:5.5 ml of extract mixture: ml of $AgNO_3$ gave the highest optical density of 0.942. The coefficient of determination (R^2), Adjusted R^2 and Predicted R^2 of the cubic-Linear model developed for the data were 0.9225, 0.8450 and 0.42098, respectively. The study suggests that mixtures of leaves of male and female pawpaw (*Carica papaya*) are resourceful biomass for green synthesis of silver nanoparticles.
Keywords: *Carica papaya*, combined methodology, silver nanoparticles, pistillate, staminate

NANO 2018B033

Synthesis of silver nanoparticles from Ackee apple and shear butter shells biocomposite: combine methodology optimization

Iyanda, D.O[1,2*]., Salawudeen, T.O[1,3]., Salam, K.K[1]., Agarry, S.E[1]., Araromi, D.O[1,]., Ogunleye, O.O[1]., and Alade, A.O[1,2,3]*

[1]Department of Chemical Engineering, [2]Bioenvironmental, Water and Engineering Research Group (BWERG), [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; oladuntaniyanda@gmail.com

Optimization of silver nanoparticles synthesis involving mixture of Ackee apple and Shear butter shells extracts was investigated in this study. The Ackee apple and shear butter shells were hygienically processed, ground to powder and subjected to aqueous extraction. Extracts of the precursors were combined in different percentage (0-100 %) compositions and mixed with standard solution of silver nitrate at various volumetric ratios (1:4-10 ml). The I-Optimal Design under the Combined Methodology of the Design Expert (11.0.4) software was used to optimise the combination of the components (extracts) and factor (silver solution). Seventeen experimental runs were generated and optical density of the synthesized nanoparticles was used as response and Fourier transform infrared (FTIR) spectroscopy of the sample with highest absorbance was investigated. Statistical analysis of the data obtained was conducted to determine the suitability of the optimization tool used and models developed. The mixture of Ackee apple/Shear butter shells (71/29 % v/v) with volumetric ratios (1:4-10 ml) gave the optimum Optical Density of 0.50. The correlation coefficient (R^2) of the data gotten was 0.9956 and the adjusted R^2 was 0.9795, while the predicted R^2 was 0.8699. The results gotten from this study exhibited Ackee apple and shear butter shells as potential biomass for the synthesis of silver nanoparticles and the I-Optimal design is an effective optimization tool for nanoparticles synthesis.

Keywords: Ackee apple shell, biosynthesis, optimization, shear butter shell, silver nanoparticles

NANO 2018B034

I-Optimal optimization of green synthesis of silver nanoparticles using *Parkia biglobosa* biocomposite

Azeez, A.I[1,2*]., Salawudeen, T.O[1,3]., Arinkoola, A.O[1,]., Osuolale, F.N[1]., Afolabi, T.J[1,2]., Oyekunle, O.S[1]., and Alade, A.O[1,2,3]*

[1]Department of Chemical Engineering, [2]Bioenvironmental, Water and Engineering Research Group (BWERG), [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; aji42cool@yahoo.com

This study investigated green synthesis of silver nanoparticles using biocomposite of *Parkia biglobosa* pod and the inflorescence extracts. I-Optimal Design (IOD) under the Combined Methodology of the Design Expert (11.0.4.0) was used to mix *Parkia biglobosa* pod (0-100 %) and *Parkia biglobosa* inflorescence (0-100 %) extracts as well as 4-10 ml of $AgNO_3$ as factor. Fifteen experimental runs were generated and were mixed accordingly for the green synthesis. The absorbance capacity of the synthesized material was conducted using UV-vis spectrophotometer and Fourier transform infrared (FTIR) spectroscopy of the sample with highest absorbance was investigated. The best biocomposite gotten from a mix of inflorescence extract (71.6 %) and pod extract (28.4 %) synthesized with 7 ml of silver nitrate ($AgNO_3$) giving an absorbance spectra of 1.074 mg/g and wavelength of 415 nm. The coefficient of determination (R^2), Adjusted R^2 and Predicted R^2 of the quadratic-Linear model gotten for

the data were 0.7608, 0.6279 and 0.4828, respectively. The result showed a biocomposite of *Parkia biglobosa* pod and the inflorescence extracts are good biomaterial for green synthesis of silver nanoparticles.

Keywords: I-Optimal design, optimization, *Parkia biglobosa*, silver nanoparticles

NANO 2018B035

Optimization study of silver nanoparticles production from blends of extracts obtained from agricultural wastes

Olatunbosun, K.B[1,2]., Salawudeen, T.O[1,3]., Ajani, A.O[1]., Agbede, O.O[1]., Olu-Arotiowa, A.O[1]., Jimoh, M.O[1]., and Alade, A.O[1,2,3]*

[1]Department of Chemical Engineering, [2]Bioenvironmental, Water and Engineering Research Group (BWERG), [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; kunlebosun7@gmail.com

The aim of the study is to optimize the synthesis of nanoparticles from the blends of aqueous extracts obtained from Coconut Shaft and Rice Husk. The I-Optimal Design under the Combined Methodology of the Design Expert (11.0.4) was employed as the optimization tool and seventeen experimental runs were generated at random. The percentage composition of the extracts ranged from 0-100 % and the ratio of extract to silver solution, which is the factor, ranged from 1:4-1:10. Optical densities of the synthesized nanoparticles were measured with UV-vis Spectrophotometer and Fourier transform infrared (FTIR) spectroscopy of the sample with highest absorbance was investigated. The optimum blend composition, 71.1 % coconut shaft and 28.9 % rice husk with the ratio 1:4.0, which gave highest optical density of 1.57 was gotten from the fifth experimental run. Statistical analysis of this experiment showed a good fit of 0.8930, 0.8662 and 0.8160 for the correlation coefficient (R^2), adjusted R^2 and predicted R^2, respectively. The results gotten from this investigation showed that the application of I-Optimal Design under the Combined Methodology is a suitable optimization tool for the synthesis of silver nanoparticles using blends of extracts from agricultural wastes such as coconut shaft and rice husk.

Keywords: Coconut shaft, silver nanoparticles, rice husk, optimization

NANO 2018B036

Optimization of silver nanoparticles biosynthesis from agrowaste shells using combined methodology

Olawale, O.N[1,2*]., Salawudeen, T.O[1,3]., Adeyi, V.A[1,2]., Adebayo, G.A[1]., Dada, E.O[1]., Jimoda, L.A[1]., and Alade, A.O[1,2,3]*

[1]Department of Chemical Engineering, [2]Bioenvironmental, Water and Engineering Research Group (BWERG), [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; deejaynifty@gmail.com

Biosynthesis of silver-based nanoparticles using the mixtures of extracts obtained from agrowastes such as melon seed and groundnut shells was investigated in this study. Samples of the melon seed and groundnut shells were carefully precleaned, air-dried and ground to uniform particle sizes before being subjected to aqueous extraction at room temperature. I-Optimal Design (IOD) under the Combined Methodology of the Design Expert (11.0.4.0) was used to mix varying volume (0-100 % v/v) of the melon seed and groundnut shells extracts at different ratios of the extract mixture/$AgNO_3$ solution in the ranges 1:4-1:10 ml (v/v). The mixing volumes were observed as components while the varying volume of

the $AgNO_3$ solution was observed as factor. The seventeen experimental runs generated were carefully executed and optical density of the synthesized material was examined with UV-Vis spectrophotometer. Experimental Run with mixed ratio of 86.1/13.9 % staminate/ pistillate pawpaw leaves extracts and ratio 1:5.5 ml of extract mixture: ml of $AgNO_3$ gave the highest optical density (OD) of 0.942. The model equation developed is $OD^3 = +0.5106A + 0.2445B - 0.0450AC - 0.5813BC - 0.0038AC^2 + 0.5489BC^2$ for the study is highly significant ($p < 0.0001$). The coefficient of determination (R^2), Adjusted R^2 and Predicted R^2 of the Cubic x Quadratic model developed for the data were 0.9651, 0.9433 and 0.9044, respectively. The study suggests that agrowastes such as melon seed and groundnut shells can be employed as renewable raw materials for biotechnology purposes particular biosynthesis of nanoparticles.

Keywords: Combined methodology, groundnut shell, melon seed shells, silver nanoparticles

NANO 2018P037

Shea butter oil bleaching with biosynthesized gold-silver-*Cola-nitida* nanoparticles modified Nigerian clay

Oriola, K.O[1]., Yusuf, R.O[1*]., and Alade, A.O[1,2,3]*

[1]Department of Agricultural Engineering, [2]Department of Chemical Engineering, [3]Science and Engineering Research Group, Ladoke Akintola University of Technology Ogbomoso, Nigeria.

*Corresponding author: aoalade@lautech.edu.ng; roysformi@yahoo.com

Shea butter oil is one of the important oils used in the oleochemical industries to produce various by-products such as cosmetics. Therefore, quality of this oil is desired to be of high industrial grade in order to improve the quality of the by-product and its safe application by humans. Bleaching is a major and critical unit operation involved in the manufacture of quality, particularly, good color and odor of the Shea butter oil. Bleaching is embedded in adsorption process involving application of clay material modified with inorganic acid and base. Oil bleaching with inorganic acid and base treated clays has been very efficient with satisfactory results, but the traces of these compounds are very detrimental to the equipment and safe application of the oil by humans. The major purpose of this research is to give cost effective, efficient and safe method for the modification (activation) procedure of the clay samples. Thus, biosynthesized gold-silver nanoparticles (Au-AgNPs) from *Cola nitida* is proposed as potential environmental-friendly material for the modification of the clay for effective bleaching of Shea butter oil to improve quality and operations in the oleochemical industry.

Keywords: Adsorption, clay, *Cola nitida*, nanoparticles, Shea butter oil

NANO 2018B038

Nanotechnology: applications in pharmaceutical sciences

Bello, S.I[1*]., and Kola-Mustapha, A.T[2]

[1]Department of Clinical Pharmacy and Pharmacy Practice, [2]Department of Pharmaceutics and Industrial Pharmacy, Faculty of Pharmaceutical Sciences, University of Ilorin, Ilorin, Nigeria.

*Corresponding author: sibello10@yahoo.com; +2348035675609

Tremendous efforts have been directed towards nanotechnology research in recent years. Nanotechnology produces important subsets such as nanomaterials which include nanostructured and nanomaterials with average particle size within the nanometer size range (1 to 100 nm). The material-based nanotechnologies include solid lipid nanoparticles, liposomes, niosomes, pegylated nanoparticles, coated nanoparticles, polysaccharides, polymers, polyesters, nanosphere, micelles among others. Their significantly reduced sizes confer unique properties on nanomaterials in terms of relatively significant improvement in functionality, physical, chemical and biological properties; thus, enhancing researches on their specific

applications. The potential applications of nanotechnology in pharmaceutical sciences include drug delivery, diagnostics, nutraceuticals and manufacture of products with improved compatibility. Other applications of nanotechnology in drug delivery include its high specificity towards the target site, ability to reduce toxic effects of drugs to normal cells, decreases plasma fluctuation of drugs, improves solubility, increases drug bioavailability, lessens dose required, rapid onset of therapeutic action, reduces cost of drug products, decreases patient to patient variability and enhances patients' adherence to drugs. The commercially available nanodrugs have been approved by Food and Drug Administration of US for a variety of indications, including cancer, while many more are in the early stages of development or clinical trials. Most of the approved nanodrugs have exhibited improved efficacy and reduced toxicity when compared to conventional drugs. The nanosized drug delivery systems are therefore being explored, to improve drug targeting and release at the desired site of action and time it is required.

Keywords: Nanoparticles, pharmaceutical sciences, drug delivery system, nanodrugs, applications

NANO 2018P039

Theoretical examination of efficiency of some anthocyanidins as sensitizers in dye-sensitized solar cells

Abdulsalami I.O*[1]., Semire B[2]., and Bello I.A[2].

[1]Department of Chemical Sciences, Fountain University, Osogbo, Nigeria, [2]Department of Pure and Applied Chemistry, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: aiboldkip@gmail.com

Dye-sensitized solar cells (DSSCs) are photovoltaic devices that convert solar energy into electrical energy using organic dyes as sensitizers. Several metal free organic compounds have been designed, synthesized and applied as sensitizers in DSSCs, including anthocyanidins. However, some drawbacks concerning these applications are low efficiency and stability of the DSSCs. Thorough understanding of the electronic factors that contribute to light absorption is necessary to select chromophores whose structural characteristics maximize the overall performance of the DSSCs. This study investigated structural effects and electronic contributions of anthocyanidins to improve the efficiency of DSSCs. Equilibrium geometries of the anthocyanidin dyes, semiconductor and dye-semiconductor couples were fully optimized at DFT level of theory with the standard 6-31G (d,p) basis set. The calculations were carried out with the density functionals: B3LYP. Frontier molecular parameters i.e. Highest Occupied Molecular Orbital (HOMO) and Lowest Unoccupied Molecular Orbitals (LUMO) levels and energies were calculated. All calculations were performed by the Spartan '14 and Gaussian '03 softwares implemented on an Intel® Core(TM) i5-5200U CPU @ 2.20GHz, 8G RAM computer. Quantum chemical method, the DFT, have been used to calculate parameters such as frontier molecular orbitals, band gap energies, reactivity descriptors. Molecular orbitals (MOs) surface showed that TiO_2 orbital was susceptible to nucleophilic attack. The HOMO of terminal hydroxyl groups in dye were susceptible to nucleophilic attacks at different degrees. MOs of dye-semiconductor showed intramolecular charge transfer from dye to TiO_2 upon photoexcitation of dye. Electronic properties of dyes showed maximum absorption transitions in this order Mv < Dp < Pg < Cy. Reactivity descriptors revealed relationship between light-harvesting-efficiency (LHE) and chemical hardness (η) for dye molecules in the order Cy < Pg < Dp < Mv. In conclusion, Cy-sensitized solar cell has the highest efficiency among anthocyanidins and this is in agreement with reported empirical report.

Keywords: DSSCs, HOMO, LUMO, anthocyanidins, dyes

NANO 2018B040

Synthesis, identification and antioxidant activity of silver nanoparticles from *Psidium guajava* leaf extract

Salau, A. K*[1]., Ajenikoko, S.O[1]., Ogunbode, S.M[2]., and Tijani, K.O[3]

[1]Antioxidants, Toxicology and Phytomedicine Research Laboratory, Biochemistry and Nutrition Unit, Department of Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria, [2]Agricultural and Nutritional Biochemistry Research Laboratory, Biochemistry and Nutrition Unit, Department of Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria, [3]Chemistry Laboratory, Department of Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria.

*Corresponding author: ka.salaudeen@gmail.com

Nanotechnology is currently a flourishing field that provides a novel way to fabricate nanoparticles exploring biological sources. This study focuses on the green synthesis of silver nanoparticles using components of *Psidium guajava* leaf extract as reducing, capping and stabilizing agents. Aqueous extract of *P. guajava* leaves was reacted with 1 mM silver nitrate at ambient temperature which resulted in a colour change indicating the formation of silver nanoparticles. The synthesized silver nanoparticles were identified by UV-visible spectrophotometer and Fourier Transform Infra-Red Spectroscopy (FTIR). The UV-vis spectra showed peak at 440 nm; FTIR spectroscopic analysis showed absorbance bands around 3209-3429 cm^{-1} [N-H stretching (amine group)], 2868 cm^{-1} [C-H (sym/asym) aliphatic], 2364-2426 cm^{-1} (cyano group), 1616 cm^{-1} (amide group), 1384 cm^{-1} (methyl group) and 763 cm^{-1} (methylene group). The nanoparticles also scavenged 2, 2-diphenyl-1-picrylhydrazyl radical at a range of 60.5 % (0.2 mg/ml) to 74.1 % (at 0.8 mg/ml) and also reduced ferric ions in solution. This study has shown that silver nanoparticles can be synthesized from aqueous *P. guajava* leaf extract and the nanoparticles also exhibited considerable free radical scavenging and ferric ion reducing activities. This can be explored in scaled-up green synthesis of silver nanoparticles with various potential applications.

Keywords: *Psidium guajava*, green synthesis, antioxidant activity, DPPH, silver nanoparticles

NANO 2018B041

Green synthesis and antimicrobial activity of *Vernonia amygdalina* leaf extract-mediated silver nanoparticles

Salau, A.K*[1]., Durojaiye, O.G[1]., Ganiyu, O.T[2]., and Afolabi-Balogun, N.B[3]

[1]Antioxidants, Toxicology and Phytomedicine Research Laboratory, Biochemistry and Nutrition Unit, Department of Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria, [2]Microbiology and Biotechnology Unit, Department of Biological Sciences, Fountain University, PMB 4491, Osogbo, Nigeria, [3]Molecular Biology and Genetic Engineering Research Laboratory, Biochemistry Unit, Departmentof Chemical Sciences, Fountain University, PMB 4491, Osogbo, Nigeria.

*Corresponding author: ka.salaudeen@gmail.com

The present investigation reports the use of *Vernonia amygdalina* for the synthesis of silver nanoparticles. Silver nanoparticles were synthesized biogenically from aqueous *V. amygdalina* leaf extract and silver nitrate solution. The identification of the silver nanoparticles was carried out by UV-visible spectrophotometry and Fourier Transform Infra-Red (FTIR) spectroscopy. The antimicrobial activity of the silver nanoparticles was also evaluated. The UV-Vis absorption spectra of silver nanoparticles showed an absorbance peak at 480 nm, while the FTIR spectrum for *V. amygdalina* leaf extract AgNPs peaked at 3448.84, 1635.69 and 1384.94 cm^{-1}, showing the involvement of proteins and phenolic compounds in reduction, capping and stabilization of the silver ions and silver nanoparticles. The nanoparticles exhibited antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus* with 0.1 and 0.2 cm

zones of inhibition, respectively at 100 µl, but ineffective against *Aspergillus niger* and *A. flavus.* Our results have shown that silver nanoparticles can be synthesized from plant extracts in an eco-friendly, cheap, and less toxic environment. These silver nanoparticles can also have the potentials to behave like the chemically synthesized nanoparticles in their numerous applications.

Keywords: Green synthesis, silver nanoparticles, antimicrobial activity, *Vernonia amygdalina*

NANO 2018B042

Antimicrobial, antioxidant, anticoagulant and thrombolytic activities of gold nanoparticles synthesized from *Bisghia sapida* husk

Oladipo, I.C[1,2]., Lateef, A[2,3]., Ogunsona, S.B[1]*., Azeez, M.A[2, 3]., Asafa, T. B[2, 4]., and Yekeen, T.A[2,3]

[1]Department of Science Laboratory Technology, [2]Nanotechnology Research Group (*NANO*$^{+}$), [3]Department of Pure and Applied Biology, [4]Department of Mechanical Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: sbogunsona@lautech.edu.ng

The biosynthesis of gold nanoparticles (AuNPs) using extract of *Bisghia sapida* husk was investigated in this work. The AuNPs was characterized by UV-vis spectroscopy, Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) and evaluated for antifungal, antioxidant, anticoagulant and thrombolytic activities. The AgNPs were nearly spherical, and crystalline in nature with size of 64-95 nm. Energy dispersive X-ray (EDX) analysis showed that gold (Au) was the prominent metal present, while the selected area electron diffraction pattern conformed to the face-centred crystalline nature of AuNPs. The UV-visible spectrum of the AuNPs synthesized displayed clear peak at 549 nm. The prominent FTIR peaks obtained at 3296.35-3747.69, 2243.21-2411.02, 1197.79-1637.56 cm^{-1}, alluded to the fact that proteins were involved in the biofabrication and capping of AuNPs. The AuNPs synthesized showed potent antifungal activities through mycelial inhibitions of 58.9 %, 61.4 %, 63.4 % and 50 % against *Fusarium solani, Aspergillus fumigatus, A. flavus* and *A. niger* at 200 µg/ml respectively. The AuNPs showed great free radical scavenging properties (62.152 %) against 2,2-diphenyl-1-picrylhydrazyl at 100 µg/ml. The AuNPs prevented coagulation of blood and also achieved 52 % lysis of blood clot showing potential nanomedical applications. This study has presented an eco-friendly and economical synthesis of AuNPs from *B. sapida* husk for various nanobiotechnological applications.

Keywords: *Bisghia sapida,* gold nanoparticles, biomedical applications, green synthesis

NANO 2018B043

Phytosynthesis of silver nanoparticles using *Morinda lucida* and its antibacterial and antifungal activities

Raimi, O.R*., and Oyewumi, A.B

Department of Science Laboratory Technology, Osun State Polytechnic, P.M.B 301, Iree.

*Corresponding author: allahuli2009@yahoo.com; abdulazeezoyewumi45@gmail.com

The biosynthesis of silver nanoparticles (AgNPs) is ecofriendly and cost effective. The aim of the present study is to synthesize AgNPs using leaf extract of *Morinda lucida*, to characterize the synthesized nanoparticles and to test the antimicrobial activities on *Escherichia coli, Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa, Aspergillus niger, Fusarium solani, Aspergillus fumigatus* and *Candida albicans.* The synthesized nanoparticles were characterized by visual observation for colour change and UV-vis spectrophotometry. The antimicrobial activities were performed using agar well diffusion method. The UV-visible spectroscopy of AgNPs showed a prominent peak maximally at 410

nm. The final stable colour change was brownish-black from pale white aqueous silver solution. The AgNPs showed antibacterial activity to all the bacterial tested. The zone of inhibition obtained were *E. coli* (10 mm) using 200 µl and 600 µl of AgNPs, *S. aureus* (10 mm) using 600 µl and 800 µl of AgNPs, *P. aeruginosa* (9 mm) using 400 µl and 800 µl AgNPs, and *B. subtilis* (8.5 mm) using 200 µl AgNPs. Equally, it showed appreciable fungicidal activity to *A. niger* (57.5 %), *F. solani* (54.3 %), *A. fumigatus* (48.5 %), and *Candida albicans* (48.2 %). The efficacy of the synthesized AgNPs was demonstrated in this study as a promising alternative to antibiotics in the treatment of bacterial and fungal diseases.

Keywords: Silver nanoparticles, *Morinda lucida*, phytosynthesis, antimicrobial activity

NANO 2018B044

Biological activities and cytogenotoxicity of green synthesized corn-silk mediated silver nanoparticles

Akintayo, G.O[1]., Yekeen, T.A[1,7*]., Lateef, A[2,7]., Azeez, M.A[1,7]., Asafa, T.B[3,7]., Oladipo, I.C[4,7]., Gueguim-Kana, E.B[5]., and Beukes, L.S[6]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, [3]Department of Mechanical Engineering, [4]Department of Science Laboratory Technology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.
[5]Department of Microbiology, [6]Microscopy and Microanalysis Unit, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa
[7]Nanotechnology Research Group (*NANO*$^{+}$) (www.nanotech.lautech.edu.ng)
*Corresponding author: tayekeen@lautech.edu.ng

Nanotechnology has been found to be relevant in all areas of human endeavours but not without fear of possible hazards to environment and human health. This study synthesized corn-silk mediated silver nanoparticles (CS-AgNPs), and evaluated its biological activities and cytogenotoxicity using *Allium cepa* assay. Corn-silk (1g) was heated in distilled water at 60 ^{o}C for 1 h, cooled and centrifuged at 4000 rpm for 30 min to obtain the extract. CS-AgNPs was synthesized by reacting extract (1ml) with 1mM $AgNO_3$ (40ml) at 30±2 ^{o}C for 30 min. CS-AgNPs was characterized using UV–Vis, Fourier-trans-form infrared (FTIR) spectroscopy, and Transmission electron microscopy (TEM). Larvicidal and antioxidant properties as well as anti-coagulation and thrombolysis of human blood clot by CS-AgNPs were investigated. Cytogenotoxic effects of CS-AgNPs and $AgNO_3$ were evaluated by exposing twenty onion bulbs to 0.01, 0.10, 1.0, 10.0 and 100.0 µg/ml of their solution. CS-AgNPs formed was dark brown with maximum absorbance at 436 nm. FTIR peaks at 3271, 1635, 1454 and 416 cm^{-1} indicated proteins as capping and stabilization molecules. Selected Area Electron Diffraction (SAED) of CS-AgNPs yielded ring pattern while the Energy-Dispersive-X-ray (EDX) spectra showed Ag as prominent metal. TEM showed size range 8.48-45.78 nm. About 66-100 % mortality was obtained for anopheles mosquito larvae exposed to CS-AgNPs in 12 h. CS-AgNPs had antioxidant potentials, indicating its scavenging ability. Its anticoagulant and thrombolytic potency could be deployed in management of blood coagulation disorders. Mitotic index of CS-AgNPs in almost all concentrations throughout exposure periods was less than one half the values of the control. Fragmentation and C-mitosis were among aberrations observed. CS-AgNPs could be employed in biomedical activities but caution is required in its usage due to cytogenotoxicity potential.

Keywords: Corn-silk, green synthesis, silver nanoparticles, biomedical applications, cytogenotoxicity

NANO 2018B045

Synthesis, characterization, biological activities and safety evaluation of egg shell-mediated silver nanoparticles

Akintayo, G.O[1]., Yekeen, T.A[1,8*]., Lateef, A[2,8]., Azeez, M.A[1,8]., Asafa, T.B[3,8]., Oladipo, I.C[4,8]., Badmus, J.A[5,8]., Ojo, S.A[2]., Gueguim-Kana, E.B[6]., and Beukes, L.S[7]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, [3]Department of Mechanical Engineering, [4]Department of Science Laboratory Technology, [5] Department of Biochemistry, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria. [6]Department of Microbiology, [7]Microscopy and Microanalysis Unit, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa. [8]Nanotechnology Research Group (*NANO*$^+$) (www.nanotech.lautech.edu.ng)

*Corresponding author: tayekeen@lautech.edu.ng

Unlike plants and microbes, waste materials from higher animals are rarely used in the synthesis of nanoparticles. This study investigates synthesis, potential biological activities and safety of egg shell mediated silver nanoparticles (EG-AgNPs). Eggshell extract was prepared by heating 1 g in 100 ml of distilled water at 60°C for 1 h, cooled and centrifuged at 4000 rpm for 30 min. EG-AgNPs was produced by adding extract (1 ml) to 1 mM $AgNO_3$ (40 ml) to reduce Ag^+ to its nanoparticles. Characterization of EG-AgNPs was via UV-vis spectroscopy, Fourier-transform-infrared spectroscopy (FTIR) and transmission electron microscopy (TEM). Larvicidal, antioxidant, anticoagulant and thrombolytic potentials of EG-AgNPs were tested. Cytogenotoxicity was evaluated by exposing twenty onion bulbs to 0.01, 0.10, 1.0, 10.0 and 100.0 µg/ml of EG-AgNPs, and $AgNO_3$ solution with distilled water used as control. Chromosomal aberrations were observed at 24, 48 and 72 h, while growth inhibition was recorded at 72 h. The colloidal EG-AgNPs was greyish with surface plasmon resonance at 465 nm, while FTIR indicated protein molecules were used as capping and stabilization agents. The spherical EG-AgNPs had size of 9.61-27.17 nm, caused 66-100 % mortality of exposed *Anopheles* mosquito larvae in 12 h, and scavenged DPPH (39-69 %) and hydrogen peroxide (81-94 %). It also displayed excellent anticoagulant and thrombolytic activities on human blood with 21 % lysis. EG-AgNPs displayed potential for cytogenotoxicity with mitotic index less than half the values of the control in almost all concentrations and also induced chromosomal aberrations. This study revealed that egg shell extract could be used for green synthesis of EG-AgNPs, which has high biological activities. However, safety should be further investigated.

Keywords: Egg shell, green synthesis, silver nanoparticles, biomedical applications, cytogenotoxicity

NANO 2018B046

Green synthesis and antibacterial activities of coconut husk extract-mediated silver nanoparticles

Aina, D.A[1]*., Owolo, O[1]., Adeoye-Isijola, M[1]., Olukanni, O.D[3]., Lateef, A[4,6]., Aina, F.O[2]., and Asafa, T.B[5,6]

[1]Department of Microbiology, [2]Department of Maternal and Child Health, Babcock University, PMB 21244, Ikeja, Lagos, Nigeria, [3]Department of Chemical Sciences, Redeemer's University, Ede 232001. [4]Department of Pure and Applied Biology, [5]Department of Mechanical Engineering, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria, [6]Nanotechnology Research Group (*NANO*$^+$), LAUTECH, Ogbomoso, Nigeria

*Corresponding author: ainaa@babcock.edu.ng

This work reports the synthesis of silver nanoparticles (AgNPs) using coconut husk extract. Antibacterial activity of the biosynthesized AgNPs was evaluated against some selected pathogenic microorganisms. The biosynthesized AgNPs were characterized using UV-visible and field emission Scanning electron

microscope. The synthesized AgNPs inhibited distinctly the growth of the selected microorganisms with zones ranging from 9-13 mm. The absorption spectrum of the synthesized AgNPs showed a maximum spectrum of 448 nm, while FTIR analysis showed different functional groups present on the surface of the AgNPs with broad peak between 839 and 3454 cm^{-1}. The AgNPs have phytochemicals as capping agents on their surfaces adding to the available drugs that could be used in combating multidrug resistant pathogens. This study showed that coconut husk can be used for the synthesis of AgNPs with high antibacterial properties. This is the first report of using coconut husk to biosynthesize nanoparticles to the best of our knowledge.

Keywords: Coconut husk, antibacterial activities, silver nanoparticles, green synthesis

NANO 2018P047

Impact of post-deposition annealing on the properties of zinc oxide nanoparticles thin film as anode buffer layer for polymer solar cells

Babalola K.K[1,2]., Sanusi Y.K[1,3]., Adio A.B[1]., and Adedokun, O[1,3*]

[1]Department of Pure and Applied Physics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, [2]Department of Physics, Osun State College of Education, Ila-Orangun, Nigeria, [3]Nanotechnology Research Group (*NANO*$^{+}$), Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

[*]Corresponding author: oadedokun@lautech.edu.ng

Today, polymer solar cells (PSCs) dominate modern age research in renewable solar energy and the ultimate goal is to improve the general performance of the PSCs to enable them to compete on an equal footing basis with conventional silicon photovoltaic cells. However, there are several fundamental parameters that have been reported to improve the general performance of PSC devices. This present work aims at examining the impact of post-deposition heat treatment on the optical and morphological properties of zinc oxide nanoparticles thin film for anode buffer layer of polymer solar cells. Depositions were done by spin coating of sol-gel solution of zinc oxide onto pre-cleaned glass substrate at 4000 rpm for 30 s using spin-coater at room temperature. Post-deposition thermal annealing at different range of temperatures from 150 °C to 600 °C with steps of 50 °C were carried out on the films. The impacts of thermal annealing on optical and morphological properties of the deposited thin films were investigated using UV-vis spectrophotometer and scanning electron microscope, respectively. The optical transparency increases with increase in annealing temperature in the visible region and lower reflectance also observed with increase in temperature. It was observed that band gap energy reduces as annealing temperature is increased from 150 °C to 600 °C. And the samples surface roughness increases as the temperature increases as observed from the SEM analysis. This shows that thermal treatment may improve the optical stability and efficiency of zinc oxide nanoparticles thin film as anode buffer layer for polymer solar cells.

Keywords: Polymer solar cells, zinc oxide, thin film, thermal annealing, optical stability

NANO 2018B048

Evaluation of biological activities and cytogenotoxic potentials of silver nanoparticles synthesized from human hair extract

Akintayo, G.O[1]., Yekeen, T.A[1,8*]., Lateef, A[2,8]., Azeez, M.A[1,8]., Asafa, T.B[3,8]., Oladipo, I.C[4,8]., Badmus, J.A[5,8]., Ojo, S.A[2]., Gueguim-Kana, E.B[6]., and Beukes, L.S[7]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, [3]Department of Mechanical Engineering, [4]Department of Science Laboratory Technology, [5] Department of Biochemistry, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria, [6]Department of Microbiology, [7]Microscopy and Microanalysis Unit, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa, [8]Nanotechnology Research Group (*NANO*$^+$) (www.nanotech.lautech.edu.ng)

*Corresponding author: tayekeen@lautech.edu.ng

Human hair is regarded as a kind of waste without value thus dumped indiscriminately. This study evaluated the biological activities and cytogenotoxic potentials of silver nanoparticles synthesized from human hair extract (HH-AgNPs) and its cytogenotoxicity using *Allium cepa* assay. Human hair (1 g) was extracted by hydrolyzing in 0.1 M NaOH at 90 ºC for 1 h, cooled and centrifuged at 4000 rpm for 30 min. The synthesis was carried out with 1ml extract added to 40 ml of 1 mM $AgNO_3$ solution for reduction of Ag^+ to nanoparticles. HH-AgNPs was characterized using UV-vis, Fourier-trans-form infrared (FTIR) spectroscopy, and Transmission-electron-microscopy (TEM). The potential of HH-AgNPs as larvicidal, antioxidant, anticoagulant and thrombolytic agent were evaluated. The cytogenotoxicity of HH-AgNPs and $AgNO_3$were investigated by exposing 20 onions to 0.01, 0.10, 1.0,10 and 100 µg/ml. Cell division and chromosomal aberrations were assessed at 24, 48 and 72 h. A greyish colour was observed for HH-AgNPs with absorbance peak at 409 nm and FTIR indicated proteins as capping and stabilizing molecules. TEM also showed a size range of 11.76-31.59 nm with characteristics ring patterns as revealed by Selected Area Electron Diffraction. The larvicidal activity displayed 56-100 % mortality in 48 h with excellent antioxidant activities for both DPPH and H_2O_2. Its anticoagulation and thrombolytic activities on fresh human blood showed dispersed red blood cells indicating its usefulness in the management of blood disorder. Significant root inhibition was observed at all concentrations of HH-AgNPs and $AgNO_3$ compared to the control while chromosomal aberrations induced were higher in all $AgNO_3$ compared to the corresponding concentration of HH-AgNPs except at 0.1 µg/ml at 24 h which indicates amelioration. HH-AgNPs can be of use in the biomedical application but with care due to its cytogenotoxicity potential.

Keywords: Human hair, green synthesis, AgNPs, cytogenotoxicity, biomedical applications

NANO 2018P049

Influence of nanosilica on the workability and compressive strength of wood ash cement concrete

Raheem, A.A[1]., Lateef, A[2,3]., Akinola, P.O[2]., Adeniyi, A.A[1]., and Yusuf, S.O[1*]

[1]Department of Civil Engineering, [2]Department of Pure and Applied Biology, [3]Nanotechnology Research Group (*NANO*$^+$), Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: soyusuf38@student.lautech.edu.ng

Studies have revealed that wood ash cement concrete just like other pozzolanic cement concrete have lower early strength compared to plain cement concrete. Nanoparticles have been found to improve the early strength of concrete due to its small size and large surface area. This paper reports the influence of nanosilica on the workability and compressive strength of wood ash cement concrete. Wood ash was obtained as a waste product from Ladoke Akintola University of Technology bread bakery, Ogbomoso. Biological synthesis of nanosilica using kola pod extract and silica precursor (1:5) was conducted at

Laboratory of Industrial Microbiology and Nanobiotechnology, Ladoke Akintola University of Technology, Ogbomoso. The chemical composition, specific gravity and particle size distribution of wood ash were determined. Particle size distribution of fine and coarse aggregate was determined. Concrete with 10 % wood ash replacement for cement was produced using 1:2:4 mix proportion and water to binder ratio of 0.5. Nanosilica was added at 0.5, 1.0, 1.5 and 2.0 % levels. Concrete with no wood ash and nanosilica served as the control. Workability and compressive strength of the concrete were determined. The compressive strength was determined at 3, 7, 28 and 56 days. The results showed that concrete workability was enhanced with introduction of nanosilica. The compressive strength increased with the addition of nanosilica. Maximum compressive strength of 24.96 N/mm^2 was achieved at 56-day curing age. It was concluded that nanosilica improved early strength development in concrete with 1.5 % as the optimum addition.

Keywords: Wood ash cement, concrete, nanosilica, workability, compressive strength

NANO 2018P050

Synthesis of nanomagnetite for the removal of malachite green from wastewater

Fakorede, O. K[1]., Giwa, A. A[1,2*]., Abdulsalam, K. A[3]., and Wewers, F[2]

[1]Department of Pure and Applied Chemistry, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso 210214, Nigeria, [2]Department of Chemistry, Cape Peninsula University of Technology, Bellville 7535, South Africa, [3]Department of Chemistry, Adeleke University, Ede, Nigeria.

*Corresponding author: giwa1010@gmail.com

Water pollution is a serious problem all over the world as a result of increased industrialization, urbanization and population. The use of metal oxide nanoparticles as adsorbents has received great attention in water/wastewater treatment due to their exclusive properties. This study is on synthesis and characterization of magnetite, and its application in the remediation of wastewater. Particles of magnetite were synthesized by co-precipitation of solutions of iron (III) chloride and iron (II) chloride in basic medium. The precipitate obtained was washed, dried and characterized using Ultraviolet-Visible and Fourier Transform Infrared Spectrophotometric techniques, and Scanning Electron Microscopy. Batch adsorption experiments were conducted to study the removal of malachite green dye from aqueous solution by the synthesized iron oxide. The effects of initial dye concentration, temperature, contact time and pH on the sorption process were investigated. The experimental data obtained were fitted to different kinetics (Pseudo-first order and Pseudo-second order) and isotherm (Langmuir, Freundlich, and Temkin) models. The thermodynamics and kinetics parameters for the process were also determined. The adsorption capacity of magnetite for malachite green was 78.47 mg/g at pH 5.6 and temperature of 30 ^oC. The adsorption process could best be described by Freundlich isotherm (R^2 = 0.968) and pseudo-second order kinetics (R^2 = 0.995). It was thermodynamically feasible (ΔG = - 7.74 to -12.59 kJ/mol) and endothermic (ΔH = 39.67 kJ). The study suggests that magnetite could be a promising material for use as an adsorbent for effective removal of malachite green and other dyes from wastewater.

Keywords: Magnetite, nanomaterials, wastewater, malachite green, dyes, adsorption

NANO 2018P051

Investigation of silver nanoparticles (AgNPs) as modifier to enhance the physical and flow properties of Agbabu natural bitumen

Olabemiwo, O.M., Bakare, H.O., and Adebayo, E.O*

Department of Pure and Applied Chemistry, Faculty of Pure and Applied Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: aelizabethomolola@yahoo.com

Roads are considered to be germane to the development in all countries of the world and are equally important and essential elements of infrastructure which play a vital role in our daily lives. The basic components of the asphalt concrete pavement are bitumen and aggregate. Bituminous road performances depend on the flow properties of bitumen which in turn is controlled by the composition of bitumen. The composition of bitumen is however vulnerable to environmental factors such as sunlight, heat and moisture. These environmental factors coupled with other factors such as traffic density and poor maintenance services lead to road defects such as rutting and fatigue cracking. To militate against bitumen deterioration, the conventional bitumen needs to be improved with regards to performance related properties in order to minimise the damage of pavement surface and increase its durability. The modification of bitumen has been explored over the past years as a means of improving road pavement performance properties. This study attempted a Fourier Transform Infrared (FTIR) investigation of the suitability of silver nanoparticles (AgNPs) as bitumen modifier for improving the physical and flow properties of Agbabu natural bitumen (ANB). The AgNPs was mixed with the ANB at five different modification levels (3, 6, 9,12 and 15 v/w) of bitumen using melt blend technique, after which the cooled modified ANB samples were characterized for their physical and flow properties such as softening point, penetration, and kinematic viscosity. Change in the temperature susceptibility of AgNPs modified ANB was also investigated by calculating the Penetration Index (PI). FTIR measurements were also performed on both the unmodified and AgNPs-modified ANB samples in order to determine the variation in the chemical structure of ANB before and after the modification. The results showed a decrease in penetration, increase in softening point and kinematic viscosity of AgNPs-modified ANB samples compared with neat ANB. These results can bring about an improvement in rutting resistance and fatigue cracking when AgNPs is used as binder in asphalt concrete pavement.

Keywords: Bitumen, nanoparticles, modifiers, rutting resistance, fatigue cracking, flow and physical properties, FTIR

NANO 2018P052

Numerical simulation of sandwiched Perovskite-based solar cell using solar cell capacitance simulator (SCAPS-1D)

Bello, I.T*., Adedokun, O., Odedumoye, Y.A., and Awodugba, A.O

Department of Pure and Applied Physics, LadokeAkintola University of Technology, P.M.B. 4000, Ogbomoso, Nigeria.

*Corresponding authors: itbello13@pgschool.lautech.edu.ng; oadedokun@lautech.edu.ng

Due to the superb characteristics of its light-harvesting, the Perovskite sensitizer ABX_3 (A = CH_3NH_3, B = Pb, Sn, and X = Cl, Br, I) has recently attracted great attention. Perovskite is composed of inexpensive and earth abundant materials. It is processable at low temperature preferably via the printing techniques. In addition, the charges in the bulk material after light absorption that enhances low loss in energy charge generation and collection were generated freely. In this research work, solar cell capacitance simulator (SCAPS-1D) was used to harness the real device hybrid Perovskite (PSC) solar cell with material parameters obtained from literatures and experiments used in the definition panel and the arrangement of

an hybrid (FTO/ZnO/CZTS/Pscs/CZTS/HTM) model in the SCAPS-1D simulator. From the simulated results obtained, the band gap diagram and other curves were constructed. The efficiency greater than twenty percent (>20 %) was achieved, which shows that having a combination of two different absorber were achievable and calling for great attention from the researchers.

Keywords: Perovskite sensitizer, solar cell, SCAPS-1D, band gap, hybrid Perovskite solar cell

NANO 2018P053

Thermal properties of nano-based termite mound clay

Oriola, K.O., and Saheed O.L*

Department of Agricultural Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: kooriola@lautech.edu.ng; kayce64@gmail.com

A major factor influencing crop deterioration during storage is temperature because grains are biologically active, giving off heat during respiration. In essence, any action taken to ensure a cool internal environment within storage structures such as silos tends to reduce the rate of respiration thereby increasing the storage life of the stored produce. Moreover, at lower temperatures and moisture content, the growth of fungus, insect and mites is reduced thus the need for the use of locally available materials that will eliminate the problem of moisture condensation. Termite mound clay (TMC), a material available in abundance all over Nigeria has been investigated as a potential construction material for storage structure, but it was found suitable for only short time storage. This is probably due to its high thermal property values. AgNPs has been reported to exhibit antifungal and antimicrobial properties, which if incorporated with TMC for silo construction might elongate the shelf life of produce stored. Thus, this research investigated the influence of different AgNPs inclusion on the thermal properties of TMC. TMC was collected from Ladoke Akintola University Technology Ogbomoso, Oyo State. It was ground and sieved using a 500 µm sieve to remove coarse particles and foreign materials. The TMC powder obtained was mixed with water using 1:5 water to clay ratio by weight and also mixed with different percentage of nanoparticles (0.1, 0.3, 0.5, 0.7, and 0.9 %) dry weight. Five replicates of each sample were moulded. After thorough mixing, the TMC was fed into mould to form a cylindrical shape of length 5 cm and diameter 3.5 cm. This was done in other to accommodate the whole length of the KD2 pro needle used for determining the thermal properties of the samples. The cylindrically shape TMC was left to air-dry for 5 days after which the samples were dried in the oven at 105 ^{o}C for 48 h to remove all moisture. The results obtained from the experiment revealed that the mean values of the thermal conductivities of different percentage of nanoparticles in addition to the TMC were found to increase from 0.712 W/mK to 0.806 W/mK, while control was 0.514 W/mK. The mean values of specific heat capacities of TMC samples were found to increase from 1.036 J/kgK to 1.817 J/kgK, while the control was 0.769 J/kgK. The thermal diffusivity of TMC ranges from 3.54×10^{-7} m^2/s to 6.24×10^{-7} m^2/s, while that of the control was 5.86×10^{-7} m^2/s. The addition of AgNPs to enhance the thermal properties showed increase in the thermal conductivity which is not good for grain storage because low values indicate the material is a poor conductor of heat, specific heat capacity was found to increase and materials with high specific capacity are desirable. Thermal diffusivity was found to decrease which is good for grain storage because materials with high thermal diffusivity adjust rapidly to ambient temperature because heat is quickly connected. Agricultural storage materials should possesses less thermal conductivity properties to avoid heat transfer to the product being stored.

Keywords: Silver nanoparticles, thermal properties, nano-clay mound, grain storage, silo

NANO 2018P054

A plasmonic effect of algal based-silver nanoparticles embedded in TiO_2 photoanode for dye sensitized solar cells

Adenigba, V.O[1*]., Oloke, J.K[2]., Omomowo, I.O[2]., and Sanusi, Y.K[3]

[1]Department of Science Laboratory Technology, [2]Department of Pure and Applied Biology, [3]Department of Pure and Applied Physics, Ladoke Akintola University of Technology, Ogbomoso, P.M.B 4000, Oyo State, Nigeria.

*Corresponding author: laidede4ever@yahoo.com

Semiconductor oxide layer like ZnO and TiO_2 coated FTO glass act as photoelectrode for dye sensitized solar cells, and efficiency of DSSCs can be increased by selecting the optimum value of different parameters for fabrication process. A plasmonic effect of algal-based AgNPs embedded in TiO_2 photoanode was studied for the performance improvement. Algal based-AgNPs were synthesized using the cell free extracts of *Neodesmus pupukensis* MG257914, the nanoparticles were characterized using transmission electron microscopy (TEM), X-ray diffraction (XRD), Fourier transform infrared microscopy (FTIR) and energy-dispersive X-ray. The influence of the nanoparticles embedded at different concentrations and different deposition thickness on optical properties of the modified photoanode were carried out using UV-vis spectroscopy. Electrical characterization with and without the presence of nanoparticles were analyzed using I.V characterization to observe the plasmonic effects on the performance of the modified photoanode. The optimum concentration of AgNPs to TiO_2 was 1:1, while the best thickness was 98 nm. The modified AgNPs photoanode had a maximum open circuit voltage of 1.275 V compared to photoanode without AgNPs of 0.479 V. This represents 60 % appreciable improvement in photovoltage of DSSCs.

Keywords: Dye sensitized solar cells, *Neodesmus pupukensis*, plasmonic effects, TiO_2 photoanode, silver nanoparticles

NANO 2018B055

Effects of Neem plant dye-mediated silver nanoparticles on *Corchorus olitorius* seed germination and chlorophyll quality

Durodola, F.A[1.]., Adubi, A.O[1]., Azeez, M.A[1*]., Lateef, A[2]., and Yekeen, T.A[1]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria

*Corresponding author: maazeez@lautech.edu.ng

Green synthesis, in recent years has increased tremendously due to its various advantages and applications. This study reveals synthesis of silver nanoparticles using Neem plant (*Azadirachta indica*) dye extract as the reducing agent, and its effects on seed germination and chlorophyll quality of *Corchorus olitorius*. In extracting the dye, 100 ml of distilled water was added to 1 g powder of the Neem leaves at 60 ^{o}C for 20 min. Silver nanoparticles were synthesized using 2 ml of the aqueous plant extract with 78 ml of 1 x 10^{-3} M silver nitrate solution and left to incubate for 24 h. The synthesized nanoparticles (AZI-AgNPs) were characterized by UV-visible spectrophotometer and Fourier transform infrared spectroscopy (FTIR). Seeds of *C. olitorius* were treated with different concentrations (20, 40, 60, 80, and 100 %) of the AZI-AgNPs, while distilled water served as control. After soaking for 2 h, the treated seeds were planted on Petri plates lined with Whatman filter paper with each treatment replicated thrice. Data were taken on the parameters such as; Germination Percentage (GP), Root Length (RL), Shoot Length (SL), Germination Index (GI), Vigor Index (VI), Tolerance index (TI), chlorophylls A and B, total

carotenoid and total chlorophyll. There was a positive effect of the particles on GP at 80 % concentration, which was highest (79.17 %) and significant in comparison with other treatments, while highest GI (7.99) was at 0 % AgNPs. Tolerance index was found to be decreasing as the concentration increases. There was an inhibitory effect of the AZI-AgNPs on shoot length when compared with the control which was significantly higher 2.41 cm, though 40 % AZI-AgNPs induced better root elongation (1.25 cm). Chlorophyll A and B, carotenoid and total chlorophyll were found to be enhanced (3.60, 1.48, 23.84 and 5.08, respectively) at 80 % AZI-AgNPs. Thus, the synthesized AZI-AgNPs promoted seed germination and chlorophyll quality at high concentration of 80 %. This is indicative of possible application of biosynthesized AZI-AgNPs in plant improvement.

Keywords: Green synthesis, silver nanoparticles, *Azadirachta indica*, *Corchorus olitorius*, seed germination, chlorophyll quality

NANO 2018B056

Impact of plant dye extract biosynthesized silver nanoparticles on germinability and chlorophyll quality of *Albemoschus esculentus*

Adubi, A.O[1]., Durodola, F.A[1.]., Azeez, M.A[1*]., Lateef, A[2]., and Yekeen, T.A[1]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit,
[2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria
*Corresponding author: maazeez@lautech.edu.ng

Silver nanoparticles were synthesized using dye extracted from *Indigo feratinctoria* (IF) plant leaves and its impacts on *Albemoschus esculentus* seeds germinability and chlorophyll quality were investigated. Silver nanoparticles was synthesized using dye extracted from *I. feratinctoria* plant leaves and its phyto-toxicity effects on seed germination of *A. esculentus* was investigated. Aqueous extract of *I. feratinctoria* was prepared from 1 g of dry leaf in 100 ml of distilled water at 60 ^{o}C for 20 min, the solution was filtered when cooled. AgNPs synthesis was carried out with a ratio of 1:39 of the filtrate plant and 1 mM of silver nitrate solution. The particles were characterized using UV-visible spectrophotometer and Fourier transform infrared spectroscopy (FTIR). Dry seeds of *A. esculentus* were soaked in different dilutions (20, 40, 60, 80 and 100 %) of the nanoparticles for two hours while distilled water served as control, the treated seeds were planted on Petri plates lined with Whatman filter paper (10 seeds per plate) and each treatment replicated three times. Data were taken on the following seedling parameters (Germination percentage (GP), Root length (RL), Shoot length (SL), Germination index (GI), Vigor index (VI), Tolerance index (TI)). Chlorophyll quality (chlorophyll a, b, carotenoid and total chlorophyll) was also determined by soaking 0.03 g of the leaf in 7 ml of 90 % Methanol and absorbance read at 470, 646 and 663 nm after 72 h in the dark. Synthesized IF-AgNPs at 80 % enhanced seed germination (89 %), the highest RL and VI (1.95 cm, 213) was recorded at 20 % AgNPs. TI was found to be decreasing as concentration of the IF-AgNPs increases from 0-40 % but increased from 60-100 % AgNPs, while there was an inhibition on shoot length across all the IF-AgNPs levels. Chlorophyll quality (chlorophyll a and total chlorophyll) of the plant was found to be improved at 60 % IF-AgNPs with values (0.63 mg/ml and 0.84 mg/ml) while chlorophyll b was significantly higher than the control at 100 % IF-AgNPs. The synthesized IF-AgNPs had beneficial effects on seed germination and chlorophyll quality of *A. esculentus*, even at high concentrations. However, there is need for field study on the effect of the particles on yield parameters and biochemical compositions of the fruits.

Keywords: *A. esculentus, Indigo feratinctoria*, green synthesis, silver nanoparticles, plant physiology, chlorophyll

NANO 2018P057

Effect of annealing temperature on green synthesized zinc-oxide nanoparticles for solar cell application

Oyeshola, H.O*., Fajinmi, G.R., Sanusi, Y.K., Adedokun, O., and Adejumo, B.K.
Department of Pure and Applied Physics, Ladoke Akintola University of Technology Ogbomoso, Nigeria
*Corresponding author: oyesholahak89@gmail.com

Today with the growing population, the energy demand is rapidly increasing. The present energy resources are fossil fuel which may not last longer than few decades; thereby necessitating search for renewable sources of energy. Nanocrystal solar cells have attracted increasing attention due to their high efficiency for energy conversion and low production cost compared with silicon solar cells. In this work, green synthesized ZnONPs were prepared, crystal structure was investigated and the effect of annealing temperature on its optical properties was also determined. Zinc-oxide nanoparticles were synthesized with addition of ethanolic extract of neem leaves (*Azadirachta indica*) into zinc nitrate as precursor. The synthesized nanoparticles paste was prepared and thin films were deposited on a glass substrate using doctor blade techniques. The samples were dried and annealed at 100, 200, 300 and 400 ^{o}C. The optical/structural characterization was done using UV-vis spectrophotometer and X-ray diffractometer (XRD). The deposited films revealed the absorption in the visible region, with lower optical absorption within 500-600 nm at 300 ^{o}C. The optical transmittance spectrum indicates the average transmittance higher than 80 % in the visible region. The optical band gap decreases as the annealing temperature increases and average grain size of the particles from XRD result was estimated to be 13.7 nm, from the highest diffraction peak obtained. The result shows that the green synthesized ZnONPs would have good properties in solar cell application, which are environmental benign and user-friendly in nature.
Keywords: Green synthesis, solar energy, ZnONPs, optical characterization, thin film, solar cells, semiconductor

NANO 2018B058

Green Chemistry and potential for plant improvement: A perspective

Azeez, M.A[1,8]., Yekeen, T.A[1,8*]., Lateef, A[2,8]., Asafa, T.B[3,8]., Oladipo, I.C[4,8]., Badmus, J.A[5,8]., Gueguim-Kana, E.B[6]., and Beukes, L.S[7]
[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, [3]Department of Mechanical Engineering, [4]Department of Science Laboratory Technology, [5]Department of Biochemistry, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria, [6]Department of Microbiology, [7]Microscopy and Microanalysis Unit, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa, [8]Nanotechnology Research Group (*NANO*$^{+}$) (www.nanotech.lautech.edu.ng)
*Corresponding authors: maazeez@lautech.edu.ng

Activities in nanotechnology have been going on for decades with tremendous potential for its applications in virtually different fields. Until recently, most approaches employed in the synthesis of nanoparticles and nanomaterials have been either physical or chemical methods, which are generally adjudged to be expensive, cumbersome, with high energy requirements, and use of hazardous and toxic chemicals. The popular demand for cheap, very easy and cost effective, less energy demanding environmental friendly technology led to the development of green technology, otherwise termed 'Green Chemistry'. Advent of green chemistry has provided pathways for numerous scientists to use biological

materials of various origins for synthesis of metallic nanoparticles. Many of the research efforts have been directed towards the use of metallic nanoparticles synthesized in medical and industrial applications with very little on its exploitation in a sustainable way to bring about crop improvement. Most studies on nanoparticles interaction with plants have been directed towards toxicity, with few on mechanisms of interference with plant growth and development that may probably be adapted to bring about plant improvement. Unraveling the physiological, biochemical and molecular mechanisms of nanoparticles in plant become very important with a view to produce better plant growth and development. Therefore, this work explores green synthesis of metallic nanoparticles, its various applications in plants, with issues and challenges raised to provide direction for future endeavours that will translate to better plant products and resources for the benefit of humanity.

Keywords: Green chemistry, nanoparticles, crop improvement, agriculture, plant physiology, sustainable agriculture

NANO 2018P059

Harnessing the potentials of computational modelling for Nanotechnology researches in Nigeria

Ibrahim, D.M
Department of Mechanical Engineering, University of Abuja, Nigeria
d.ibrahim@uniabuja.edu.ng

Nanotechnology is beyond doubt a multidisciplinary field, that cut across several basic physical sciences and engineering areas. This involves conducting research on some physical, chemical, mechanical and structural properties of materials for conceptualization, characterization, development and prototyping of nanoscale materials. Research and development in nanotechnology is directed toward understanding and creating improved materials, devices, and systems that exploit these new properties for novel applications in various aspects of human life. Despite the enormous achievements globally, there are a lot of challenges facing researches and applications of nanotechnology in Nigeria which have been attributed to several factors such as lack of adequate and well trained manpower, high cost of equipment and maintenance of required laboratories/facilities, poor academic and industry linkage, improper implementation of the national policy on nanotechnology and others. This paper highlights the potentials of computational nanotechnology as an enabling tool to improve the scope and spread of researches for nanotechnology in Nigeria in order to attain the desired local and global beneficial targets.

Keywords: Nano-scale; nanotechnology; computational modelling, R&D

NANO 2018P060

Synthesis, optimization and characterization of Titanium (IV) oxide-loaded silver nanoparticles thin films

Balogun, S.W[1*]., Abdulhamid, A.B[2]., Sanusi, Y.K[3]., and Adedokun, O[3]
[1]Department of Physics and Materials Science, Kwara State University, Malete, Ilorin, Nigeria,
[2]Department of Physics, School of Science, Kwara State College of Education, Ilorin, Nigeria,
[3]Department of Pure and Applied Physics, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
*Corresponding author: sbalogun94@gmail.com; oadedokun@lautech.edu.ng

Today's solar cells are simply not efficient enough and are currently too expensive to manufacture for large-scale electricity generation. However, potential advancements in nanotechnology may open the door to the production of cheaper and slightly more efficient solar cells. This research investigates effect of annealing temperature on the optical properties of titanium (IV) oxide loaded with silver nanoparticles

(TiO_2:AgNPs) thin films deposited on glass substrate by spin-coating technique. Silver nanoparticles was prepared using *Gliricidia sepium* leaf extract as a reducing agent for silver nitrate. Deposition of TiO_2:AgNPs blend solution was done in different volume ratio. The blend solution volume ratio of (1:0.2) was deposited with different speed of revolution per minutes (rpm) for 30 seconds. The optical properties of thin films were evaluated using UV-vis spectrophotometer. The samples were annealed at temperature range of 50-425 ^oC with 10 ^oC interval in a tubular furnace. It is observed from the results that the peak absorption of photon energy occurred at 375 ^oC in the visible range of the spectrum. Optimal thickness for peak absorbance of the TiO_2:AgNPs blend layer occurred at 115 nm in the visible range and at the corresponding spin speed of 1000 rpm. Optimized fabrication process with blend layer thickness of 115 nm yielded the best absorbance at annealed temperature of 375 ^oC in the visible region. The band gap energy of the blend thin film is 3.58eV at 375 ^oC in the visible range of the spectrum. It is revealed from the result that the light absorption, broadened absorption spectral and thermal stability of titanium (IV) oxide films was enhanced using silver nanoparticles. The results could serve as a guideline for improving the design and fabrication of organic solar cells.

Keywords: Organic thin film, silver nanoparticles, titanium (IV) oxide, annealing, blend, AgNPs:TiO_2, optical properties

NANO 2018B061

Effect of biosynthesized silver nanoparticles on the development of *Anopheles gambiae* sensu stricto

Ajala, O.O., and Balogun, H*

Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

*Corresponding author: hassan46@gmail.com; ooajala@lautech.edu.ng

Female *Anopheles gambiae* sensu stricto, is a vector of *Plasmodium falciparum* responsible for malaria infection in man. This research focused on how the developmental stages of the vector can be hindered using silver nanoparticles synthesized with extracts of *Moringa oleifera* leaf, spider cobweb, and king of bitters. Silver nanoparticles were synthesized by standard methods, and applied at different concentrations on larvae and pupae of *A. gambiae.* Deionized water was used for the control experiment. Observations of larvae and pupae developments, and mortality at different concentrations were recorded. Data obtained were analyzed using analysis of variance (ANOVA) to detect significance ($p = 0.05$) between means of larvae and pupae still alive at different concentrations after the control had developed to next stage. Ultraviolet spectra of synthesized nanoparticles showed peak at 535.00, 413.5 nm, and 424 nm for the extract of *M. oleifera*, spider's cobweb, and king of bitters respectively. Development of more than 50 % larvae to pupae were inhibited at different concentrations (42.5 µg/ml and 21.25 µg/ml, *M. oleifera* extract; 42.5 µg/ml, 21.25 µg/ml and 10.63 µg/ml, spider cobweb; 10.63 µg/ml, king of bitters), when the control had metamorphosed to pupae. All inhibited larvae were still alive. Spider's cobweb nanoparticles was the most effective at inhibiting development of larva to pupa followed by *M. oleifera*, and lastly king of bitters. Synthesized silver nanoparticles of *M. oleifera* leaf, spider cobweb and king of bitters extracts inhibited the development and also resulted in mortality in the larval and pupa stages of *Anopheles gambiae*.

Keywords: King of bitters, metamorphosis, *Moringa oleifera*, silver nanoparticles, biosynthesis, spider cobweb, *Anopheles gambiae*

NANO 2018B062

Haematological, histopathological and genotoxicity assessment of *Cola nitida*-pod mediated silver, gold and silver-gold alloy nanoparticles using *Clarias gariepinus*

Yekeen, T.A[1,7*]., Lateef, A[2,7]., Azeez, M.A[1,7]., Asafa, T.B[3,7]., Oladipo, I.C[4,7]., Badmus, J.A[5,7]., and Fawole, O.O[6]

[1]Laboratory of Ecotoxicology, Genetics and Nanobiotechnology, Environmental Biology Unit, [2]Laboratory of Industrial Microbiology and Nanobiotechnology, Microbiology Unit, Department of Pure and Applied Biology, [3]Department of Mechanical Engineering, [4]Department of Science Laboratory Technology, [5]Department of Biochemistry, [6]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria, [7]Nanotechnology Research Group (*NANO*$^{+}$) (www.nanotech.lautech.edu.ng).

*Corresponding author: tayekeen@lautech.edu.ng

Applications of nanoparticles in almost all areas of human endeavour and associated effects call for toxicological evaluation. Toxic effects of three *Cola nitida* pod mediated silver (CP-AgNPs), gold (CP-AuNPs) and alloy (CP-Ag-AuNPs) nanoparticles on the haematological parameters of *Clarias gariepinus* was assessed. Fish (20) were exposed to 5, 100 and 250 ng/ml with blood samples and micronuclei induced were evaluated on days 14, 28 and 42, while histopathology was on day 42. Distilled water and metallic salt solutions (Ag^{+} and Au^{+2}) were used as controls. The biosynthesized nanoparticles were dark brown with size range 12-91 nm obtained. No significant difference was observed in mean weight among the fish treated with different concentrations of different nanoparticles and control at day 14, but elevation in weight was observed at day 28 and 42 compared to control. Reduction trend was observed in haematological parameters as exposure period increases with significance difference observed in packed cell volume, red blood cell, and haemoglobin on days 28 and 42. Increase observed in MCV and MCH with slight variation in MCHC indicate microcysticanaemia. Mild hepatocellular degeneration was observed at all concentrations of CP-Ag-NPs, 250 ng of CP-AuNPs and 5 ng of alloy, while mild epithelial vacuolar degeneration and necrosis were observed for kidney of 100 ng CP-Ag-AuNPs and CP-AgNPs. Gills in higher concentrations of the nanoparticles were characterized by moderate lamellae hyperplasia. Micronucleus and other aberrations induced by the nanoparticles were not significantly different from the controls for all exposure periods. This study revealed variations in haematological parameters of the treated fish, mild alterations in organs evaluated and no significant induction of aberrations.

Keywords: *Cola nitida*, nanoparticles, haematology, genotoxicity, fish, *Clarias gariepinus*

NANO 2018P063

Development of a single walled carbon nanotube (SWNT) based nanosensor for measuring the electrical and electromagnetic properties of cells

Emuoyibofarhe, O.J[1]., and Alamu, F.O[2*]

[1]Department of Computer Science and Engineering, Faculty of Engineering and Technology, Ladoke Akintola University of Technology, P M B 4000, Ogbomoso, Nigeria, [2]Department of Computer Science, University of Lagos, Akoka, Lagos

*Corresponding author: eojustice@gmail.com; femialamu@gmail.com

The study of biochemical interaction has been the basis for explaining cellular functions and diseases diagnosis and hence medical treatment became largely based on drug therapy. This act directed all research in medicine to be directed towards understanding the chemistry of the body and the effects that drugs have on altering that chemistry. Yet most of the problems of the body cannot be traced exclusively to biochemical explanation without roles of endogenously crated electromagnetic fields and electrical

currents in the body. The rapid pace of miniaturization in the semiconductor industry has resulted in faster and more powerful computing and instrumentation, which has begun to revolutionize medical diagnosis and therapy in the area of the use of nanotechnology. Recent advances in nanomedicine offer ground-breaking methods for the prevention, diagnosis and treatment of some fatal diseases. A nanosensor is an ultra sensitive sensor that can detect single virus particles or even ultra-low concentrations of a substance that could be potentially harmful to the human body or a system built by some sequence of nanotechnology on the nanoscale, whose purpose is mainly to obtain data on the atomic scale and transfer it into data that can be easily analyzed. This research work takes a look at the effect of the roles of endogenously crated electromagnetic fields and electrical currents in disease condition diagnosis and treatment of same using a single walled carbon nanosensor.

Keywords: Nanosensor, nanomedicine, electromagnetic fields, electrical currents, miniaturization

NANO 2018B064

Applications of nanotechnology in healthcare delivery

Emuoyibofarhe, J.O., and Ogunniyi, J.O*

Department of Computer Science and Engineering, Faculty of Engineering and Technology, Ladoke Akintola University of Technology, P M B 4000, Ogbomoso, Nigeria.

*Corresponding author: eojustice@gmail.com; juliusolasunmibo321@gmail.com

Nanotechnologies are technologies based on tiny things mostly comprising of nanostructures, atoms and molecules. Its scale of measurement is nanometer scale, which is one billionth of a meter which is smaller than wavelength of visible light or hundred thousand width of a human hair. Presently, health care delivery pledges to have a lot of benefits from Nanotechnology. It is appropriate to say Nanotechnology now has a branch in medicine called nanomedicine. Though, Nanotechnology is relatively new but it applications in medicine are especially promising, and areas such as disease diagnosis, drug delivery targeted at specific sites in the body, and molecular imaging are being intensively investigated and some products undergoing clinical trials. One area of interest is creating nanomaterials that are not only efficient, but also well tolerated by the human body. Another area of application of nanomedicine is the creation of new body parts to replace the damaged body parts via 3D printing. The aim of this article is to outline the potential uses of nanotechnology in health care delivery.

Keywords: Nanotechnology, healthcare, telehealth, telemedicine, nanomedicine

NANO 2018B065

Trends and future prospects of nanodelivered phytopharmaceuticals for diseases of public health importance

Ajala. T.O

Department of Pharmaceutics and Industrial Pharmacy, University of Ibadan, Ibadan

tolulola1721@gmail.com; +2348022171674

The use of plants for healing forms the origin of modern medicine and had existed before human history. Phytopharmaceuticals which are formulations of bioactive plant agents have gained immense attention not just because of therapeutic activity against diverse diseases, but due to cultural acceptability and perceived safety. The formulation pharmacist however faces challenges such as poor solubility of bioactive agents which culminates in poor bioavailability and low oral absorption. In addition, instability of bioactive herbal agents and impulsive toxicity pose limitation to their use. One approach that has proved helpful is the delivery of phytoactives as nanoparticulate systems and improved outcomes have

been observed. The current efforts on the delivery of phytoactives using nanoparticles, its outcomes, challenges and future prospects are the aims of this study. The study examined past reports of phytoactive agents designed as nanoparticulate systems. Their usefulness in solving the challenges encountered with conventional dosage forms was carefully observed. The different diseases of public health significance addressed by the nanoparticulate formulations were also determined. Hydrophobic and hydrophilic phytoactive agents like extracts, isolates, plant powders and oils have been delivered as nanoparticles. Most of them have shown activity as anti-anxiety, antioxidant, antidiabetic, anti-malarial, anticancer and for cardiovascular problems.

Keywords: Phytopharmaceuticals, nanoparticulate systems, bioavailability, nano-delivery, bioactives

NANO 2018P066

Modification and pore distribution in cast Al A356 alloy using tungsten carbide (WC) nanoparticles

Mudashiru, L.O[1]., Adeaga, O.A[2]., Adegbola, A.A[1*]., and Sanusi, W.O[1]

[1]Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso Nigeria, [2]First Technical University, Ibadan, Nigeria.

*Corresponding author: aaadegbola59@lautech.edu.ng

Porosity formation and distribution in eutectic Al-Si alloy A356 modified with tungsten carbide (WC) nanoparticles was investigated using fractal analysis. WC nanoparticles added in an amount of 0.1 wt. % to the molting melts yield fine microstructure with porosity level lower than the as-cast sample. Porosity levels of average sphericity 0.12 % attained in the modified sample indicates the near-net shape forming capability of WC nanoparticles of the disintegrated pores in Al A356 alloy.

Keywords: Al 356 alloy, WC nanoparticles, fractal analysis, sphericity, porosity

NANO 2018P067

Thermophysical properties of copper oxide and aluminium oxide water-based nanofluids in a rotating system

Akinpelu, F.O[1]., Alabison, R.M[2]*., Oyekunle, J.O[2]., and Olaleye, O.A[2]

[1]Department of Pure and Applied Mathematics, LAUTECH, Ogbomoso, [2]Department of Statistics, Federal Polytechnic, Ede.

*Corresponding author: ralabison@yahoo.com; 0803 575 4996

This work intends to investigate the heat transfer enhancement of CuO and Al_2O_3 water-based nanofluids in a rotating system with internal heat generation and radiation absorption. It is assumed that the porous plate in a rotating frame oscillates with constant frequency in time. The fluid is water-based nanofluid containing CuO and Al_2O_3 nanoparticles which are assumed to be in thermal equilibrium with no slip occurring between them. The dimensionless governing differential equations obtained are solved analytically using perturbation method. The effects of various dimensionless governing parameters such as radiation absorption parameter, heat generation parameter, volume fraction of the nanoparticles on velocity, temperature and concentration profiles were studied. Thermal capabilities of the nanoparticles were compared.

Keywords: Thermophysical properties, nanofluid, rotating system, porous medium, nanoparticles

NANO 2018B068

Biomedical potentials of biosynthesized silver nanoparticles (AgNPs) from *Pleurotus pulmonarius* aqueous extract

Adebayo, E.A., Ogundun, O.S*., Oloyede, B., Afolabi, T., Ilesanmi, O., Oladipo, Y., Odewumi, E., and Oke, M.A

Department of Pure and Applied Biology, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Nigeria.

*Corresponding author: eaadebayo@lautech.edu.ng; osogundun@student.lautech.edu.ng

In recent years, silver (AgNPs) nanoparticles have attracted the attention of scientific community in the field of nanotechnology due to their unique properties and biological applications. The extracellular and intracellular mushroom extracts are being investigated for biosynthesis of nanoparticles and biological applications. The current study aimed at determining biomedical potential of biosynthesized silver nanoparticles (AgNPs) using *P. pulmonarius* aqueous extract. The antibacterial assay was carried out using the following test organisms; *Escherichia coli* (stool), *Escherichia coli* (ATCC 25922), *Bacillus subtilis* (ATCC 6633), *Klebsiella pneumoniae* (Urine), *Listeria monocytogenes* (ATCC 19111), *Pseudomonas aeruginosa* (ATCC 27853), *Staphylococcus aureus* (ATCC 25923), *Staphylococcus aureus* (Ear), *Streptococcus pyogenes* (Sputum), while the antifungal was tested on the following organisms: *Aspergillus niger*, *Aspergillus fumigatus*, *Fusarium solani*, *Aspergillus flavus* and *Candida albicans*. The antioxidant, anticoagulant and thrombolytic assays were also carried out. The percentage growth inhibition of the silver nanoparticles at 20 µg/ml, 40 µg/ml, 60 µg/ml and 80 µg/m varied between 19 to 87 % with highest percentage inhibition of 87 % obtained at 80 µg/ml and the lowest percentage inhibition of 19 % obtained at 40 µg/ml. The fungal inhibition performances range from 29 to 75 %, while the nanoparticles showed an excellent performance in antioxidant, anticoagulant and thrombolytic activities. The result strongly showed that silver nanoparticles have higher antibacterial and antifungal, antioxidant, anticoagulant and thrombolytic properties than that of the aqueous extract of *P. pulmonarius*. The end result suffice that biosynthesized AgNPs can be useful in drug delivery for treating ailments.

Keywords: Biosynthesis, *Pleurotus pulmonarius*, silver nanoparticles, antimicrobial activities, biomedical applications

NANO 2018B069

Inhibition of lipid peroxidation and anti-hemolytic effects of *Citrus sinensis* and *Chrysophyllum africanum* aqueous seeds extract inspired silver nanoparticles

Badmus, J.A[1,3,4*]., Adebayo, E.A[2,3]., Yekeen, T.A[2.3]., Azeez, M.A[2,3]., and Lateef, A[2,3]

[1]Department of Biochemistry, [2]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Nigeria, [3]Nanotechnology Research Group (*NANO*$^{+}$), [4]Department of Biomedical Sciences, Oxidative Stress Research Unit, Cape Peninsula University of Technology, Cape Town, South Africa.

*Corresponding author: jabadmus@lautech.edu.ng

Natural products from plant leaves, seeds, and stems are frequently used for green nanoparticles synthesis. These agents contain various nontoxic and biodegradable phytochemicals that act as both reducing and capping agents for the formation of stable nanoparticles. The present work investigated the synthesis of silver nanoparticles, inhibition of lipid peroxidation in egg yolk and rat liver and anti-hemolytic activity using *Citrus sinensis* and *Chrysophyllum africanum* seeds aqueous extracts. The synthesis of AgNPs with aqueous seed extracts was visually monitored using changes in color and confirmed with UV-vis spectroscopic scanning. Statistical analysis was carried out using the student t-test

and level of significance was set at $P<0.05$. The color of the reaction between silver nitrate solutions (1 mM) with aqueous seed extracts changes from colorless to reddish brown, which absorb at a wavelength range of 412-420 nm. *C. sinensis*-AgNPs showed significant inhibition of lipid peroxidation in both egg yolk and liver, while *C. africanum*-AgNPs activity did not show significant difference when compared with their respective extract. Both AgNPs and extracts of both seeds showed remarkable anti-hemolytic activity against H_2O_2 induced hemolysis at all tested concentrations. However, both nanoparticles significantly ($P<0.05$) had higher anti-hemolytic activity when compared with their respective extracts ($P<0.005$).
This study shows that both *C. sinensis* and *C. africanum* seeds can be of benefit for the synthesis of nanoparticles that can be used for biomedical applications.
Keywords: *Citrus sinensis*, *Chrysophyllum africanum*, seeds, nanoparticles, silver, hemolysis, lipid peroxidation

NANO 2018P070

Carbon materials derived from renewable pine biomass for high voltage supercapacitor with excellent stability

Bello, A[1, 2*]., Barzegar, F[3]., Khaleed, A.A[3]., Momodu, D.Y[3]., Dangbegnon, J. K[3]., and Manyala, N[3]
[1]Department of Physics, [2]Department of Materials Science and Engineering, African University of Science and Technology (AUST), Abuja, Nigeria, [3]Department of Physics, Institute of Applied Materials, SARCHI Chair in Carbon Technology and Materials, University of Pretoria, Pretoria 0028, South Africa.
*Corresponding author: abello@aust.edu.ng

As the world demand for energy continue to increase at a rapid rate, it is critical to improve on the sustainable technologies which produce, convert and store energy efficiently and adequately. Electrode materials are key to improving performance in a number of important energy storage technologies such as supercapacitors and batteries. Supercapacitors are nowadays attractive and play a dominant role in energy storage applications as they can supply higher power density than batteries and higher energy density than conventional capacitors. Biomass materials are potential sources of carbon materials for supercapacitors and have become attractive because they are readily available, abundant, low-cost, pose no threat to the environment and meet the requirement for green and sustainable carbon sources for developments of electrode materials for next generation of supercapacitors. Herein, we explore the synthesis of high surface area carbon from coniferous pines by hydrothermal treatment followed by physical activation and carbonization, and have investigated its potential properties for supercapacitor application. The symmetric device fabricated from this carbon material could achieve a wide operational voltage of 2 V in neutral aqueous electrolyte exhibiting good charge propagation with a specific capacitance of 137 F g^{-1}, energy density of 19 Wh kg^{-1} and long cyclability with 10,000 cycles. The results obtained show that the carbon material produced exhibits very good electrochemical performance and can be easily regenerated.
Keywords: Biomass, pine cones, microporous carbon, aqueous electrolyte, supercapacitors