

ZnO Nanoparticles Synthesis and Characterization by Hydrothermal Process for Biological Applications

Supamas Wirunchit and Wantana Koetniryom*

This research is interested in the development of zinc oxide (ZnO) nanoparticle synthesis by hydrothermal precipitation solutions for biological applications. The synthesis of ZnO nanoparticles study from zinc nitrate ($Zn(NO_3)_2$) precursor under the three precipitator solutions consists of potassium hydroxide (KOH), sodium hydroxide (NaOH), and ammonium hydroxide (NH_4OH), respectively. The synthesis of ZnO nanoparticles is investigated using the following techniques: X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), and Raman spectroscopy techniques. The structure and size of the ZnO nanoparticles are analyzed by using a field emission scanning electron microscope (FE-SEM), and finally, the antibacterial efficacy of the ZnO nanoparticles is studied. The hydrothermal synthesis condition realizes that the smallest ZnO nanoparticles come from the zinc nitrate ($Zn(NO_3)_2$) precursor reacted with sodium hydroxide (NaOH) precipitator at 120 °C for 4 h.

1. Introduction

The well-known nanoparticles are ZnO metal oxide semiconductor materials because they have large excitation binding energy (60 meV) and direct wide bandgap (3.37 eV).^[1] Many applications of ZnO, e.g., catalysts,^[2] solar cells,^[3] gas sensors,^[4] light emitting diodes,^[5] rubber additive,^[6] and pigments.^[7] Due to the advantage of ZnO nanoparticles with good UV absorbance, it is widely used in the cosmetics and sunscreen industries.^[8] In addition, its unique physical properties are characterized by its photocatalytic and photo-oxidizing ability, chemical resistance, and inhibition of the growth of fungi and microorganisms and bacteria effectively. ZnO is acceptable for its benefit in biological applications as an antibacterial material.^[9] Due to the ability of zinc oxide

nanoparticles to inhibit bacteria due to the photocatalytic reaction, the electron holes of the zinc oxide nanoparticles will react with water. It can break down water into free radicals in the form of hydroxyl radicals ($\cdot OH$) and hydrogen ions (hydrogen ion; H^+). Conduction band (CB) electrons react with oxygen in the air to form superoxide radical anion: O_2^- . The free radicals of the superoxide ions continuously react with the hydrogen ions until they form hydrogen peroxide (H_2O_2). Hydrogen peroxide free radicals of superoxide ions and hydroxyl free radicals are reactive oxygen species (ROS) that affect cell wall damage by permeating bacterial cell membranes thus causing the deterioration of bacterial cells.^[10] There are also other physical and chemical factors that affect bacteria inhibition of zinc oxide nanoparticles

such as the UV illumination effect, the impact of ZnO morphology, the surface modification by thermal annealing, the influence of ZnO particle size and concentration, and the surface defect.^[11–14] Synthesis of ZnO nanoparticles for inhibition of bacteria that are the main cause of disease. Synthesized ZnO nano-materials to a specific size and morphological shape suitable for inhibiting bacteria must important consider the synthesis process.

There are several methods for creating ZnO nanostructures such as sol-gel,^[15,16] combustion,^[17,18] co-precipitation,^[19] and hydrothermal process.^[20] Most commonly used is hydrothermal process, which is interesting and popular recently because of its cost-effectiveness. It is easy to implement and an environmentally friendly approach that can be controlled and replicated. Hydrothermal technique is a chemical synthesis process that is a bottom-up process under the influence of zinc precursor and the type of precipitant agents that affect the ZnO nanoparticles. Hydrothermal techniques use high temperatures and pressures in the reaction. The temperature is usually close to the boiling point and the critical temperature of water (374 °C), and the pressure used is in the range of ≈ 20 MPa, therefore it must be prepared in an autoclave. From the literature review, it was found that the use of precursor as zinc nitrate reacts with base sodium hydroxide showed a trend of zinc oxide size tending to increase when the reaction temperature is increased.^[21] A study of differential morphological preparation of zinc oxide nanoparticles through pH control reveals that at pH 8, 9, and 10, the synthesized zinc oxide nanoparticles exhibited nanorod, nanowire, and nanosheet morphology, and at pH 11, 12, and 13, the synthesized zinc oxide nanoparticles exhibited spherical morphology. It was found that zinc oxide nanoparticles with rod morphology will be able to suppress bacteria better than spherical.^[22]

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Synthesis And Characterization Of Zno Nanoparticles

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Synthesis And Characterization Of Zno Nanoparticles:

Synthesis and Characterization of ZnO Nanoparticles Isibhakhomen U. Abhulimen,2005 **Synthesis and Characterization of Zinc Oxide Nanoparticles** Zewdu Weldemichael Zena,Girma Goro Gonfa,2013 This book reports study on the synthesis and characterization of ZnO nanoparticles by a two step synthesis procedure The first step is the solution free mechanochemical synthesis of zinc tartarate followed by thermal decomposition The synthesized ZnO nanoparticles were characterized by XRD Uv Vis spectrophotometer Transmission electron microscope Scanning electron microscope Energy dispersive x ray spectroscopy and Elemental mapping analysis techniques and the corresponding results were clearly described in this work I confidently recommend that this book can be used as a reference for physicists chemists and university students concerning to the fields of Nanoscience and Nanotechnology **Synthesis and Characterization of ZnO Nanoparticles** ,2012 **Synthesis & Characterization of ZnO Nanoparticles Hydrothermal Route** M. Latha Muthumani,2013-08-12 **Synthesis and Characterization of Zno Nanoparticles and Nanorods** ,2011-06-16

Nanotechnology is now associated with all the branches of research in science due to its ability to provide materials with new and amendable properties We start the book with the general ideas in nanotechnology and present here the synthesis of ZnO nano materials of two different morphologies prepared by very simple methods and their characterization by various different methods like Absorption spectroscopy Fluorescence spectroscopy X ray diffractometry Scanning electron microscopy and Fourier transform infrared spectroscopy Internal architectures of these instruments are also given which we think required to understand the outcomes This book can be much helpful for those who are starting with the research in the field of nanotechnology A Novel Approach to Synthesis and Characterization of Zinc Oxide (ZnO) Nanoparticles for Biomedical Applications Nandita Nag,2009 ZnO nanoparticles being biocompatible and chemically stable have much potential for biomedical applications that include anti bacterial and mold prevention air ventilation and purification water purification photosynthesis and disease detection Therefore the fabrication of ZnO nanoparticles and their binding to biomolecules would be a notable contribution to this field This research is aimed at the fabrication of ZnO nanoparticles using a safe cost effective and easy to handle technique that is capable of producing nanoparticles free of any contamination and functionalization of those particles with biomolecules ZnO nanoparticles have been fabricated at room temperature by laser ablation of ZnO thin film prepared with a pulsed laser deposition PLD technique Characterization of the nanoparticles has been done using UV Visible UV Vis spectroscopy fluorescence spectroscopy dynamic light scattering DLS and transmission electron microscopy TEM UV Vis absorption and fluorescence emission peaks at 280 and 410 nm respectively validate the exact nature of ZnO nanoparticles Size determination of these particles by DLS and TEM have demonstrated that majority of the particles are in the range of 80 to 90 nm which authenticates the presence of nanoparticles Effects of the laser parameters on the growth of the nanoparticles have been investigated Enhanced homogeneity and stability of these

ZnO nanoparticles have been observed when produced in presence of 0.2 % glucose solution. Functionalization of these nanoparticles has been successfully established by assemblage with protein molecules. These results could play a significant role in future development of antibiotic free approach for treating microbial infection where antimicrobial enzymes attached to nanoparticles could be used.

Synthesis and Characterization of ZnO/Graphene Nanostructures for Electronics and Photocatalysis Seyed Ebrahim Chalangar, 2021-04-08

Recent rapid development of electronics and electro optical devices demands affordable and reliable materials with enhanced performance. Forming nanocomposites of already well known materials is one possible route towards novel functional materials with desirable synergistic enhanced properties. Incompatible chemical properties, mismatched crystal structures and weak bonding interactions between the substances however often limit the number of possible nanocomposites. Moreover, using an inexpensive facile large area and flexible fabrication technique is crucial to employ the new composites in industrially viable applications. This thesis focuses on the synthesis and characterization of different zinc oxide/graphene (ZnO/GR) nanocomposites well suited for optoelectronics and photocatalysis applications. Two different approaches of i) substrate free random synthesis and ii) template assisted selective area synthesis were studied in detail. In the first approach ZnO nanoparticles/rods were grown on GR. The obtained nanocomposites were investigated for better GR dispersity, electrical conductivity and optical properties. Besides, by adding silver iodide to the nanocomposite, an enhanced plasmonic solar driven photocatalyst was synthesized and analyzed. In the second approach, arrays of single vertically aligned ZnO nanorods were synthesized using a colloidal lithography patterned sol-gel ZnO seed layer. Our demonstrated nanofabrication technique with simple substrate independent and large wafer scale area compatibility improved the alignment and surface density of ZnO nanorods over large selective growth areas. Eventually, we found a novel method to further enhance the vertical alignment of the ZnO nanorods by introducing a GR buffer layer between the Si substrate and the ZnO seed layer together with the mentioned patterning technique. The synthesized nanocomposites were analyzed using a large variety of experimental techniques including electron microscopy, photoelectron spectroscopy, x-ray diffraction, photoluminescence and cathodoluminescence spectroscopy for in-depth studies of their morphology, chemical and optical properties. Our findings show that the designed ZnO/GR nanocomposites with vertically aligned ZnO nanorods of high crystalline quality synthesized with the developed low cost nanofabrication technique can lead to novel devices offering higher performance at a significantly lower fabrication cost.

Interfacial Phenomena on Biological Membranes Manoranjan Arakha, Suman Jha, 2018-01-10

This book focuses on important interfacial phenomena such as interfacial potential and interfacial multi-functionality responsible for determining the fate of nanoparticles inside the biological milieu. Additionally, this book explores the role of surface defects in photocatalytic nanoparticles in defining the nanoparticle interaction to biological membrane and cytotoxic propensity. The authors describe the interfacial assembly of peptide/protein on conformational/functional dynamics of the peptide/protein which may be adopted as an approach to

moderate the protein misfolding diseases *Nanotechnology Driven Herbal Medicine for Burns: From Concept to Application* Md. Abul Barkat, 2021-12-29 Burns can cause life threatening injury and the lengthy hospitalization and rehabilitations required in burn therapy lead to higher healthcare costs The risk of infection has also been one of the important concerns of burn wound management The purpose of the burn wound care management is speedy wound healing and epithelization to limit the infection The topical application of therapeutic agents is quintessential for the longevity of patients having significant burns In recent times research on herbal medicine for burn wound management has been vastly increased because of their safer toxicological profiles in contrast to synthetic medicines Despite the promising therapeutic potential of herbal medicines in this area herbal medications have some limitations which include low pharmacological activity solubility and stability Nanotechnology based smart drug delivery approaches which involve the use of small molecules as nanocarriers however can help to overcome these biopharmaceutical challenges This book provides an overview of plant mediated metallic nanoparticulate systems and nanophytomedicine based therapeutic treatment modalities for burn wound lesions Nine chapters deliver updated information about nanomedicines for burn wound therapy Contributions are written by experts in nanomedicine and phytomedicine and collectively cover the pathophysiology of wound lesions current and future outlook of nanomedicine based treatments for burn wound lesions the role of biocompatible nanomaterials in burn wound management plant mediated synthesis of metal nanoparticles for treating burn wound sepsis phytomedicine based nanoformulations and the phyto informatics models involved in the wound healing process which are used to select appropriate nanotherapeutic agents This reference serves as an accessible source of information on the topic of nanomedicine for burn treatments for all healthcare professionals medical doctors nurses students trainees and researchers in allied fields pharmacology phytomedicine who are interested in this area of medicine Antimicrobial Nanosystems Kabali Vijai Anand, Shadpour Mallakpour, Chaudhery Mustansar Hussain, 2023-03-29 Antimicrobial Nanosystems Fabrication and Development provides an in depth review of nanotechnological advancements in the fields of biotechnology and pharmaceutical industries to counteract bacterial infections and related health issues Functionalized nanomaterials and their processes are covered along with the theory and fabrication of antimicrobial nanosystems The potential applications of antimicrobial nanosystems are also discussed along with their challenges and commercialization This book discusses the most frequent problems caused by resistant microorganisms and difficult to treat bacteria and highlights the impact of recently developed antimicrobial nanosystems Various methods to obtain efficient nanomaterials with antimicrobial properties are described along with their advantages challenges and main applications The design of targeting antimicrobial therapeutics able to specifically detect pathogenic microorganisms and to act in a very specific manner is thoroughly investigated Discusses the most frequent problems caused by resistant microorganisms and difficult to treat bacteria Includes various methods to obtain efficient nanomaterials with antimicrobial properties that are described along with their

advantages challenges and main applications Covers the ability of microbes to adapt and select resistance a major challenge in the design of alternative antimicrobial agents Provides various sections that illustrate the fabrication and development of antimicrobial nanosystems

Nanostructures for Antimicrobial Therapy Anton Fikai,Alexandru Mihai Grumezescu,2017-05-29 Nanostructures for Antimicrobial Therapy discusses the pros and cons of the use of nanostructured materials in the prevention and eradication of infections highlighting the efficient microbicidal effect of nanoparticles against antibiotic resistant pathogens and biofilms Conventional antibiotics are becoming ineffective towards microorganisms due to their widespread and often inappropriate use As a result the development of antibiotic resistance in microorganisms is increasingly being reported New approaches are needed to confront the rising issues related to infectious diseases The merging of biomaterials such as chitosan carrageenan gelatin poly lactic co glycolic acid with nanotechnology provides a promising platform for antimicrobial therapy as it provides a controlled way to target cells and induce the desired response without the adverse effects common to many traditional treatments Nanoparticles represent one of the most promising therapeutic treatments to the problem caused by infectious micro organisms resistant to traditional therapies This volume discusses this promise in detail and also discusses what challenges the greater use of nanoparticles might pose to medical professionals The unique physiochemical properties of nanoparticles combined with their growth inhibitory capacity against microbes has led to the upsurge in the research on nanoparticles as antimicrobials The importance of bactericidal nanobiomaterials study will likely increase as development of resistant strains of bacteria against most potent antibiotics continues Shows how nanoantibiotics can be used to more effectively treat disease Discusses the advantages and issues of a variety of different nanoantibiotics enabling medics to select which best meets their needs Provides a cogent summary of recent developments in this field allowing readers to quickly familiarize themselves with this topic area

High-Quality Materials Khairul Fikri bin Tamrin,Charles Bong Hin Joo,2021-09-08 Special topic volume with invited peer reviewed papers only

Technological strategies to improve animal health and production Daniel Hernandez-Patlan,Bruno Solis-Cruz,Guillermo Tellez-Isaias,2023-06-27

Nano-Dimensional Zinc Oxide for Energy Harvesting, Sensing, and Environmental Remediation Nupur Aggarwal,Naveen Kumar,Shivani Singla,2025-07-15 Zinc oxide ZnO nanostructures have gained significant attention in recent years due to their applications in various fields The book provides a comprehensive overview of the recent advances in ZnO based nanostructures for energy harvesting sensing and environmental remediation applications It covers advanced aspects of application based research on ZnO nanostructures The book also includes biosynthesized ZnO nanostructures and their role in targeted drug delivery Features Explores various synthesis techniques for ZnO nanostructures detailing their impact on material properties and applications in emerging technologies Discusses the role of ZnO based nanostructures in solar cells photocatalysis and environmental remediation including heavy metal detection and removal Highlights ZnO nanostructures potential in electrochemical sensors for medical diagnostics

antimicrobial applications and gas sensing technologies ZnO s piezoelectric properties ultraviolet photodetectors and its integration into next generation electronic and optoelectronic devices are discussed in depth Provides insights into ZnO nanostructures role in plant growth enhancement along with discussions on future research directions and technological advancements in the field This is a reference book for academicians and researchers interested in the potential of nano dimensional zinc oxide *Journal of Nano Research Vol. 52* Efstathios I. Meletis,2018-05-11 The 52nd volume of the Journal of Nano Research contains peer reviewed papers by the results of the research from the field of synthesis and the use of various nanomaterials and nanostructures We hope that this volume of the journal will be useful and interesting for a wide range of engineers scientists and students whose activity is related with the creation and using of nanomaterials and nanotechnologies in different branches of human activity *Green Synthesis and Characterization of ZnO Nanoparticles for Photocatalytic Degradation of Anthracene* ,2015 *Green Polymer Composites Technology 0* Inamuddin,2016-11-03 This book is a comprehensive introduction to green or environmentally friendly polymer composites developed using renewable polymers of natural origin such as starch lignin cellulose acetate poly lactic acid PLA polyhydroxylalkanoates PHA polyhydroxylbutyrate PHB etc and the development of modern technologies for preparing green composites with various applications The book also discusses major applications of green polymer composites in industries such as medicine biotechnology fine chemicals and engineering *Photocatalysts. Part I* Juan Manuel Peralta-Hernández,Stanislav Kolisnychenko,2023-05-17 Aggregated Book [Synthesis and Characterization of Zinc Oxide Based Nanostructures and Composites for Energy Related Applications](#) Ahmed Salah Mahdi Al-Asadi,2016 The main objective of this communication is to report the synthesis and characterization of zinc oxide ZnO based nanostructures and composites for energy related applications using a simple and cost effective chemical bath deposition CBD technique Highly crystalline zinc oxide ZnO nanowires NWs were synthesized through CBD method using a simple seeding technique This seeding process includes dispersion of commercially available ZnO nanoparticles through spraying on a desired substrate prior to the CBD growth A typical growth period of 16 h produced ZnO NW assemblies with an average diameter of 45 nm and lengths of 1 1 3 m with an optical band gap of 3 61 eV The NWs growth was successfully achieved on various substrates e g silicon dioxide plastic sheets copper grid and carbon nanotube buckypaper The as prepared ZnO NWs were found to be photoactive under ultra violet UV illumination UV photosensor devices fabricated using these NW assemblies demonstrated a high photodetection abilities at room temperature under moderate UV illumination power of 250 W cm² These findings indicate the possibility of using ZnO NWs grown using the same seeding method for various opto electronic applications The same seeding technique was also used to grow ZnO NWs onto aligned multi wall carbon nanotubes MWCNTs which were synthesized by using air assisted chemical vapor deposition CVD onto a SiO₂ Si substrate This ZnO NW MWCNT hybrid structure was characterized by scanning electron microscopy SEM energy dispersive spectroscopy EDS and Raman spectroscopy The fabricated structure

was used as an electrode for supercapacitor SC measurements Good electrochemical performance was accomplished with a specific capacitance of 192 F g along with a maximum energy density of 3.8 Wh kg and a high power density of 28 kW kg The fabricated device showed high stability and it retained over 99% of its initial specific capacitance value after 2000 cycles In addition we report on the synthesis electrochemical characterization of two dimensional Zinc Aluminum ZnAl layered double hydroxides LDHs directly grown on Al substrate by using CBD method After details structural characterization by SEM Raman spectroscopy EDS elemental mapping and X ray powder diffraction XRD the electrochemical performances of an electrode fabricated based on this material were evaluated via cyclic voltammetry and galvanostatic charge discharge using various electrolytes The ionic electrolyte device showed a maximum specific capacitance of 120 F g along with a maximum energy density of 5.17 Wh Kg and a high power density of 8.4 kW h Additionally we found that a high specific capacitance value of 358 F g was achieved using an aqueous electrolyte

Nanomaterials, Environmentally Friendly and Construction Materials and Technologies Alan Kin Tak Lau, 2025-12-02 Special topic volume with invited peer reviewed papers only

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Table of Contents Synthesis And Characterization Of Zno Nanoparticles

1. Understanding the eBook Synthesis And Characterization Of Zno Nanoparticles
 - The Rise of Digital Reading Synthesis And Characterization Of Zno Nanoparticles
 - Advantages of eBooks Over Traditional Books
2. Identifying Synthesis And Characterization Of Zno Nanoparticles
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Synthesis And Characterization Of Zno Nanoparticles
 - User-Friendly Interface
4. Exploring eBook Recommendations from Synthesis And Characterization Of Zno Nanoparticles
 - Personalized Recommendations
 - Synthesis And Characterization Of Zno Nanoparticles User Reviews and Ratings

- Synthesis And Characterization Of Zno Nanoparticles and Bestseller Lists
- 5. Accessing Synthesis And Characterization Of Zno Nanoparticles Free and Paid eBooks
 - Synthesis And Characterization Of Zno Nanoparticles Public Domain eBooks
 - Synthesis And Characterization Of Zno Nanoparticles eBook Subscription Services
 - Synthesis And Characterization Of Zno Nanoparticles Budget-Friendly Options
- 6. Navigating Synthesis And Characterization Of Zno Nanoparticles eBook Formats
 - ePub, PDF, MOBI, and More
 - Synthesis And Characterization Of Zno Nanoparticles Compatibility with Devices
 - Synthesis And Characterization Of Zno Nanoparticles Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Synthesis And Characterization Of Zno Nanoparticles
 - Highlighting and Note-Taking Synthesis And Characterization Of Zno Nanoparticles
 - Interactive Elements Synthesis And Characterization Of Zno Nanoparticles
- 8. Staying Engaged with Synthesis And Characterization Of Zno Nanoparticles
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Synthesis And Characterization Of Zno Nanoparticles
- 9. Balancing eBooks and Physical Books Synthesis And Characterization Of Zno Nanoparticles
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Synthesis And Characterization Of Zno Nanoparticles
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Synthesis And Characterization Of Zno Nanoparticles
 - Setting Reading Goals Synthesis And Characterization Of Zno Nanoparticles
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Synthesis And Characterization Of Zno Nanoparticles
 - Fact-Checking eBook Content of Synthesis And Characterization Of Zno Nanoparticles
 - Distinguishing Credible Sources

13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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