

RESEARCH ARTICLE

Elucidating the significance of molecular interaction between sulphur doped zinc oxide nanoparticles and serum albumin using multispectroscopic approach

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Abstract

Ingenious nanomaterials with improved biocompatibility and multifunctional properties are gaining vital significance in biomedical applications, including advanced drug delivery and nanotheranostics. In a biological system, these nanoparticles interact with serum proteins forming a dynamic corona that affects their biological or toxicological properties producing undesirable effects. Thus, the current study focuses on the synthesis of sulphur-doped zinc oxide nanoparticles (ZnO/S NPs) and characterizing their mechanism of interaction with serum proteins using multispectroscopic approach. ZnO/S NPs were synthesized by employing a co-precipitation approach and characterized using various analytical techniques. The results of interaction studies demonstrated that ZnO/S NPs interact with serum albumins via the static quenching process. Analysis of thermodynamic parameters (ΔG , ΔH and ΔS) revealed that the binding process is spontaneous, exothermic and van der Waals force or hydrogen bonding plays a major role. The interaction of ZnO/S NPs with tyrosine residue in bovine serum albumin was established by synchronous fluorescence spectroscopy. In addition, the results of UV-visible, circular dichroism, Fourier transform infrared, Forster's resonance energy transfer theory and dynamic light scattering spectroscopic studies revealed that the ZnO/S NPs interact with albumin by inducing the conformational changes in secondary structure and reducing the α -helix content.

KEYWORDS

binding constant, binding distance, binding mode, BSA, ZnO/S NPs

1 | INTRODUCTION

The use of ingenious nanomaterials in developing novel therapeutic approaches is considered a frontier in fabricating next-generation nanosystems for biomedical applications. Nanoparticles with both imaging and target-specific therapeutic capabilities have gained significant advantages in personalized medicine, thus allowing their application in customized targeted therapy and real-time diagnosis.¹ In this regard, specific classes of metal oxide nanomaterials such as zinc oxide nanoparticles (ZnO NPs) have gained significant attention

and are promising candidates proposed for nanomedicine. However, despite their promising abilities, ZnO NPs suffer from drawbacks that could prevent their application in nanomedicine. The most critical limitation is their dose-dependent toxicity, which is attributed to the release of zinc ions as a result of nanoparticle dissolution or generation of reactive oxygen species induced by photocatalysis and damage of cell membranes caused by nanoparticle internalization.² Therefore, it is necessary to optimize the properties of ZnO NPs for achieving improved therapeutic efficacy. In order to address this limitation, doping of nanomaterials can be effectively utilized to enhance

Solid state synthesis, characterization and biological evaluation of silver doped nanosized metal oxides

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CHRONICLE

Article history:

Received December 20, 2022

Received in revised form

January 28, 2023

Accepted March 28, 2023

Available online

March 28, 2023

Keywords:

Metal Oxide

XRD

SEM

FTIR

Biological activity

ABSTRACT

Nanomaterials have attracted a great deal of attention from the scientific community due to their unique properties and applications. The small size metal oxides have opened up the door for intensive research to utilize their properties for biomedical applications. Silver nanoparticle (AgNPs) and metal oxide nanomaterials like MgO, ZnO, NiO and its silver doped nanocomposites (Ag-MgO, Ag-ZnO, Ag-NiO) have been prepared using solid state combustion method using polyvinyl alcohol (PVA) as a fuel. The structure of as prepared oxides and its silver doped nanocomposites were characterized using X-ray diffraction (XRD) tool and morphology by Scanning Electron Micrograph (SEM) tool as well as Transmission electron micrograph tool respectively. Presence of the metals in the oxides and its Ag composite was confirmed by the EDX pattern. Bonding nature in the composite is well studied by the Fourier transform infrared (FT-IR) tool. Antibacterial activity studies of the nanocomposites are carried out against various bacteria.

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1. Introduction

Nanomaterials and its technologies are enticed and magnetized in recent and upcoming research. Integration of the science and technology at nano dimension attracts the researchers due to the progressive applications¹⁻³. The latest physical properties and advanced technologies both in sample preparation and device fabrication evoke on account of the progress of nanoscience⁴⁻⁵. The man in his quest for knowledge has been conceiving and developing the physical world and its components in bigger than the biggest and smaller than the smallest dimensions of mass, length and time⁶⁻⁷. Sometimes the changes in particle size are to such an extent that completely new transpirations are dig up which helps in flowering of the world⁸⁻⁹. However, the title is about how the biological activity takes place for certain materials when it is reduced into nanoscale dimensions. In this world of elaboration nanotechnology, one of the main primary concerns should be the potential environmental impact of nanoparticles (NPs). A proper way of estimating the nanotoxicity is to monitor the response of the bacteria against these nanoparticles¹⁰⁻¹².

Inorganic nanoparticles (NPs), metal oxides are the most interesting NPs due to their applications and positive impact on pathogenic microorganisms¹³⁻¹⁵. NPs have been studied for many years because of their size-dependent physical and

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Thermal and morphological studies of chitosan and agar-agar blends

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CHRONICLE

Article history:

Received July 12, 2022

Received in revised form

August 2, 2022

Accepted November 30, 2022

Available online

December 1, 2022

Keywords:

Chitosan

Agar-agar

Blends

Compositions

Glass transition

SEM

TGA

ABSTRACT

Many researchers are attracted to Chitosan based blends due to its properties and potential applications in various fields. The advanced development of Chitosan blends integrates the science and technology of blended materials. The present experimentation is reporting the preparation of Chitosan and Agar-Agar blends (CAA) by chemical mixing of these materials at different compositions. The thermal studies of the prepared blends were studied by differential scanning calorimeter (DSC) and thermogravimetric analysis (TGA) tools. Thermal studies reveal that the lowest degradation temperatures of blends might be attributed to the partial miscibility of CAA blends at particular composition, and miscibility due to single glass transition temperature (T_g) between Chitosan and Agar-agar. Bonding nature of sample blends were carried out by Fourier transform infrared (FT-IR) instrumentation. This study reveals the interaction between Chitosan and Agar-agar is partial miscibility. Morphological study reveals that a few aggregated particles, which suggest the partial miscibility of CAA blends. Homogeneity of blend compositions and specific intermolecular interactions of hydrogen bonding type is also observed.

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1. Introduction

Generally, agar occurs as a structural carbohydrate in the cell walls of agarophytes algae, possibly existing in the form of its calcium salt or a mixture of calcium and magnesium salts. It is a complex mixture of polysaccharides composed of two major fractions namely agarose, a neutral polymer, and agarpectin, a charged sulfated polymer¹⁻². Agarose is a gelling fraction and also a neutral linear molecule essentially free of sulphates, consists chains of repeating alternate units of β -1, 3-linked- D-galactose and α -1, 4-linked 3, 6-anhydro-L-galactose. Agarpectin is a non-gelling fraction and is a sulfated polysaccharide (3% to 10% sulphate) composed of agarose and varying percentages of ester sulphate, D-glucuronic acid, and small amounts of pyruvic acid. The proportion of these two polymers varies according to the species of seaweed. In fact, Agarose normally represents at least two-thirds of the natural agar-agar. Regarding its gelling power, agar-agar is outstanding among other hydrocolloids. Agar-agar gels can be molded in very dilute solutions, containing a fraction of 0.5% to 1.0% of agar-agar. These gels are rigid, brittle and they have well defined shapes as well as sharp melting and gelling points³⁻⁶.

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Research papers

Binderless nano marigold flower like structure of nickel sulfide electrode for sustainable supercapacitor energy storage applications

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ARTICLE INFO

Keywords:

Nickel sulfide (NiS)
Binder-free electrodes
Supercapacitor
Energy density
Power density
Cyclic stability

ABSTRACT

The role of electrode materials is crucial for determining the energy storage capacity of supercapacitors. The use of active nanostructures fabricated on conducting substrates to achieve good conductivity and high surface area augments the energy storage ability of supercapacitors. The fabrication techniques for the assimilation of hierarchical nanostructures on a large electrode surface area without using binders are expected to enhance the energy and power densities of supercapacitors. The fabrication techniques should be simple, scalable, and of low-cost. In this work, a simple process for developing high-surface morphological nickel sulfide (NiS) nanostructures on commercial nickel foam at ambient temperature is developed. Further, these electrodes are used in the fabrication of supercapacitors. The surface morphological and electrochemical studies have demonstrated high energy density values of 27.58 Wh/kg and ultralong stability of 97 % even after 5000 cycles. Moreover, the fabricated electrode material exhibited properties such as quicker electron and ion transfer, a larger surface area, and superior structural integrity. The galvanostatic charge-discharge (GCD) study of the fabricated device has shown a high specific capacitance of 613 F/g. Such electrodes exhibit their suitability in supercapacitors for enhanced energy storage applications.

1. Introduction

Energy generation from non-conventional sources has gained larger importance in recent times owing to technological innovations, limitations of conventional energy sources, and encouragement by the concerned governments for energy production using renewable energy sources [1–3]. Energy storage systems play a vital role in reducing the gap between demand and production which is a major limitation of renewable energy sources [4].

Among various energy storage mechanisms, the electrochemical energy storage method is convenient, effective, modular, and reliable [5]. Battery energy storage system (BESS) and supercapacitor energy storage fall under this category. Supercapacitor energy storage is attractive because of its sustainability, superior charging and discharging capacity, augmented life cycle, excellent power density, acceptable energy density, risk-free operation, and eco-friendliness [6–8]. Nevertheless, the storage capacity and desirable electrochemical characteristics of supercapacitors strongly depend on the electrode material used [9–16]. A large surface area, rapid charge/discharge cycles, controlled

porosity, chemical stability, superior conductivity, and cost-effectiveness are some of the desirable properties of electrode materials used in supercapacitors for enhanced storage capacity [17,18].

Several materials have been reported in contemporary research articles as suitable for supercapacitor electrode preparation. These include conducting polymers and their composites [19], RuO₂ [20], MnO₂ [21], MoS₂ [22], Ni₃S₄ [23], and Ni₃S₂ [24]. However, these reported materials either suffer from certain drawbacks of noncompliance with all desirable properties or require a complex process for their synthesis. Hence, the onus is on the concerned stakeholders to fabricate the electrode materials that exhibit most of the desirable features and are produced in large quantities. The thin films of different materials on reference substrates have attracted the attention of researchers. These thin films significantly reduce the series resistance, resulting in an increased power density [25]. In addition, the fabricated electrodes should have a network with superior electrolyte accessibility for the better acceleration of ion transfer during charge-discharge cycles. A highly electrolyte-accessible network is essential to accelerate ion transport at a good rate during the charge-discharge process.

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Comparative biological evaluation of mono metallic oxides and its bimetallic (Cu, Mn) oxide nanomaterials

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Abstract

Metal oxide nanoparticles have widely attracted researchers due to their potential applications in a variety of fields, especially medical importance. In the current study, monometallic oxides like CuO and MnO₂ nanomaterials and bimetal oxide CuMn₂O₄ nanoparticles were successfully synthesized by combustion route. Doping of metal oxides nanoparticles with the specified bioactive metal dopent's results in significant improvement of essential biological properties and advanced features. Combustion derived CuO, MnO₂ and CuMn₂O₄ were subjected for antimicrobial activity studies. Obtained results reporting that, biologically active CuO and MnO₂ nanoparticles on doping that result as CuMn₂O₄ nanoparticles possess high antimicrobial activities. From the zone of inhibition studies it was evident that doping plays a key role in the enhancement of the antibacterial and antifungal activity of CuMn₂O₄ nanoparticles. As a result of this study one can predict CuMn₂O₄ nanoparticles may lead to new advanced research in biomedical applications.

Keywords: CuO, MnO₂, CuMn₂O₄, Doping, antimicrobial

1. Introduction

During the past few years, nanotechnology has been widely favored and has become the key feature growing interest on the matter at nanoscale, modifying the properties and functionalities. Field of nanomaterials and nanocomposites have been in great influence among the scientists due their unique phases, sizes, morphology, dimensionality and applications. Hence, many research efforts have been focused to control such important factors to attain the featured nanomaterials [1]. Moreover, methods of synthesizing nanoparticles and functionalizing are challenging aspects in current world for variable applications. Several real-life applications could be involved including food processing, packaging, health care, biomedical devices, surgery and implants, disinfection of hospitals, textiles, household furnishing, paints, and certain needs might have implications even in more extreme scenarios, such as germ warfare, space exploration, and in the prevention of pandemic diseases like influenza viruses, etc [2]. Nanoparticles are often prepared by conventional methods and need to be tested for biocompatibility. Thus, researchers have turned towards engineering nanoparticles and testing them for biomedical applications. Nanotechnology is currently employed as a tool to discover the advancement in the biomedical sciences as metal and metal oxide nanoparticles have shown considerable bactericidal effects. Certain metal and metal oxide nanoparticles have been used for the treatment of various applications such as diagnosis of diseases, drug delivery systems, and sun screens [3-5]. Recently,