ScienceDirect

Journal of Molecular Structure

Volume 1292, 15 November 2023, 136154

Structural, magnetic, and antibacterial activity of the pure, Zn-doped, and Zn-doped/sugar-assisted coprecipitation synthesized semicrystalline Co_3O_4 compound

P. Prameela [a], J. Ramana Ramya [b], J. Gajendiran [a], S. Gnanam [c], K. Ramachandran [d], S. Gokul Raj [e], G. Ramesh Kumar [f]

Show more

https://doi.org/10.1016/j.molstruc.2023.136154

Get rights and content

Highlights

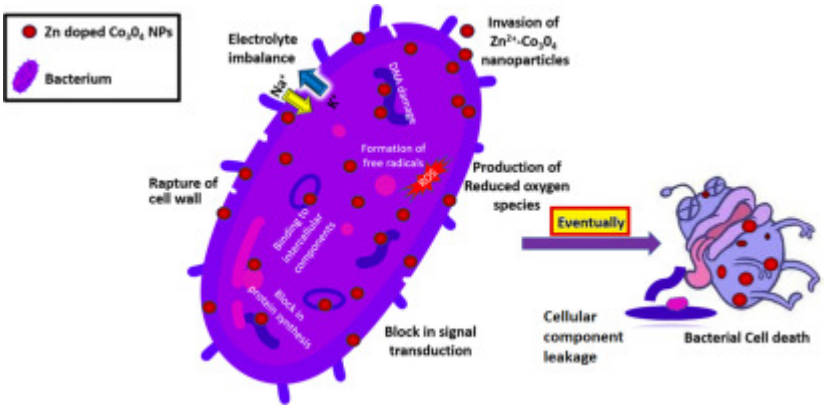
- Pure, Zn-doped, and Zn-doped/sugar-assisted Co_3O_4 were made by precipitation route.
- Synthesized compounds were tested for surface, magnetic and antibacterial activity.
- XRD analysis confirmed semi-crystalline behavior and spinel structure formation.
- Synthesized compounds were confirmed a weak ferromagnetic behavior via VSM study.

- The diameter inhibition zone values of synthesized compounds are discussed in detail.

Abstract

Undoped, Zn-doped, and Zn-doped/sugar-assisted semi-crystalline structures of Co_3O_4 were made by introducing a facile precipitation approach. The synthesized compounds were tested for surface characteristics, magnetic properties, and antibacterial activity. Powder X-ray diffraction (XRD) analysis confirmed semi-crystalline behavior and spinel structure formation in all synthesized compounds. Using scanning electron microscopy (SEM) characterization, microstructure formation along with the large agglomeration of spherical particles, uniform distribution of spherical particles, and spherical-flake-like particle structures were noticed for the pure, Zn-doped, and Zn-doped/sugar-assisted Co_3O_4 samples, respectively. From the vibration sample magnetometry (VSM), Zn-doped/sugar-assisted Co_3O_4 was found to have relatively lower saturation magnetization when compared to pure Co_3O_4 and Zn-doped Co_3O_4 material. The antibacterial performance of the synthesized compounds against the bacteria Escherichia coli (E.coli) and Staphylococcus aureus (S. aureus) has been tested. The above-mentioned germicidal responses showed a relatively larger inhibition zone for the Zn-doped and Zn-doped/sugar-assisted Co_3O_4 compared to the undoped Co_3O_4 sample. The obtained diameter inhibition zone values of all synthesised compounds are comparable to the standard positive and negative control.

Graphical abstract



Download: Download high-res image (210KB)

Download: Download full-size image

Introduction

Many researchers have been focusing on attempting the various nanostructures of pure and metal ions doped Co_3O_4 by several chemical synthesis routes (co-precipitation, hydrothermal, ultrasonic spray pyrolysis, surfactant assisted precipitation, microwave, thermal decomposition, sucrose assisted precipitation, conventional, oxygenating, green synthesis) for potential applications in spintronics devices and the biomedical field [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25]. They reported that the nanocrystalline formation of Co_3O_4 produced important results such as weak ferromagnetism, uncompensated surface spins, moderate coercivity, retentivity, and magnetic saturation when measured with a vibrating sample magnetometer (VSM) [[1], [2], [3], [4], [5], [6], [7], [8], [9], [10],[22], [23], [24], [25]]. In addition, they reported that Co_3O_4 material is non-toxic, and has a good response against bacterial cell death from an antibacterial experiment [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21].

Furthermore, the bulk form of the Co_3O_4 material showed antiferromagnetic behavior. The above literature reported only crystalline formations of Co_3O_4 particles that were synthesized. In addition, most of the above-mentioned chemical synthesis methods are used, including the autoclave, high temperature process, special reagents and conditions, and tedious steps to produce Co_3O_4 particles. However, in this work, facile precipitation methods have been implemented to develop semi-crystalline Co_3O_4 particles. The intention of the present work is to synthesize semi-crystalline Co_3O_4 particles using a pure, Zn-doped, and Zn-doped/sugar-assisted precipitation route, and followed by investigation of their magnetic features, and antibacterial performance versus *Staphylococcus aureus* (*S. aureus*) and Escherichia coli (*E.coli)* for the first time. The resulting synthesized Co_3O_4 particles crystalline behavior, surface particle shape, room temperature magnetism behavior, and antibacterial responses versus gram negative bacteria *E. coli* (E.coli), and gram positive bacteria Staphylococcus aureus (S. aureus) are comparatively discussed in detail.

Section snippets

Experimental

2.49 g of $Co(CH_3COO)_2 .4H_2O$ was dispersed in 40 mL of distilled water under magnetic stirring for 1 h to make a pink-coloured cobalt acetate aqueous solution. 0.219 g of $Zn(CH_3COO)_2{\cdot}2H_2O$, and 1 g of sugar were mixed into the cobalt acetate aqueous solution under magnetic stirring, and consequently a precipitating agent like 3.99 g of NaOH pellets was added. The precipitate formation step was allowed to age for 24 h, and consequently, the above precipitation was taken to be filtered and washed…

Results and discussion

Pure Co_3O_4, Zn-doped Co_3O_4, and Zn-doped/sugar-assisted Co_3O_4 compounds are allowed to be 0.02°/*sec* scanned for the diffraction pattern in the range of 10°–70° through an assessed powder XRD instrument, and XRD graphs results are presented in Fig. 1(a–c). The collected strong X-ray diffraction peaks were marked to the respective planes based on the reported JCPDS Card No. 42-1467 of the Co_3O_4 material [4]. It is confirmed that the synthesized compounds have formed the spinel cubic structure.

For …

Conclusion

The pure Co_3O_4, Zn-doped Co_3O_4, and Zn-doped/sugar-assisted Co_3O_4 compounds were synthesized by the precipitation method. Powder XRD, SEM/EDX, TEM/HR-TEM, VSM, and antibacterial analysis were performed on the aforementioned compounds. Based on the observed strong intensity peaks in the XRD graphs for the pure Co_3O_4, Zn-doped Co_3O_4, and Zn-doped/sugar-assisted Co_3O_4 compounds, there is solid evidence for the formation of a spinel crystal structure with a semi-crystalline nature. Using EDX…

CRediT authorship contribution statement

P. Prameela: Methodology, Investigation, Writing – original draft, Writing – review & editing. **J. Ramana Ramya:** Writing – review & editing. **J. Gajendiran:** Writing – original draft, Conceptualization, Writing – review & editing. **S. Gnanam:** Writing – original draft, Conceptualization, Writing – review & editing. **K. Ramachandran:** Writing – review & editing. **S. Gokul Raj:** Writing – review & editing. **G. Ramesh Kumar:** Writing – review & editing.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interest or personal relationship that could have appeared to influence the work reported in this paper.…

Recommended articles

References (26)

M. Salavati-Niasari *et al.*
Synthesis and characterization of Co_3O_4 nanorods by thermal decomposition of cobalt oxalate
J. Phys. Chem. Solids (2009)

A.K.M. Atique Ullah *et al.*
Tailoring surface morphology and magnetic property by precipitants concentrations dependent synthesis of Co_3O_4 nanoparticles
Ceram. Int. (2020)

N.K. Yetim
Hydrothermal synthesis of Co_3O_4 with different morphology: investigation of magnetic and electrochemical properties
J. Mol. Struct. (2021)

C. Ramamoorthy *et al.*
Effect of surfactants assisted Co_3O_4 nanoparticles and its structural, optical, magnetic and electrochemical properties
Optik (2017)

D.E. Zhang *et al.*
A facile synthesis of Co_3O_4 nanoflakes: magnetic and catalytic properties
Solid State Sci. (2011)

R.J.S. Lima *et al.*
Influence of organic precursor on the structural and magnetic properties of Co_3O_4 nanoparticles
Phys. B Condens. Matter (2012)

Z. Dong *et al.*

Novel magnetic properties of Co_3O_4 nanowires

Solid State Commun. (2009)

C.T. Anuradha *et al.*

Facile-synthesis and characterization of cobalt oxide (Co_3O_4) nanoparticles by using Arishta leaves assisted biological molecules and its antibacterial and antifungal activities

J. Mol. Struct. (2022)

T. Kavitha *et al.*

Thermal decomposition of metal complex precursor as route to the synthesis of Co_3O_4 nanoparticles: antibacterial activity and mechanism

J. Alloy. Compd. (2017)

D. Das *et al.*

Synthesis, characterization and biological applications of cobalt oxide (Co_3O_4) nanoparticles

Chem. Phy. Impact (2023)

View more references

Cited by (2)

Eco-friendly synthesis of Co<inf>3</inf>O<inf>4</inf> nanoparticles using Millettia pinnata towards increased anti-oxidant, anti-biofilm and cytocompatibility properties against biofilm producing bacteria and human pulmonary alveolar basal cells

2024, Journal of Drug Delivery Science and Technology

Show abstract

Low-concentration detection of H<inf>2</inf>S using temperature-dependent Cr-doped cobalt-oxide gas sensors

2024, Journal of Environmental Chemical Engineering

Show abstract

View full text