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Short communication

Structural, magnetic, antimicrobial and hemolysis properties of sol–gel derived iron manganese tri oxide ($FeMnO_3$) nanostructures

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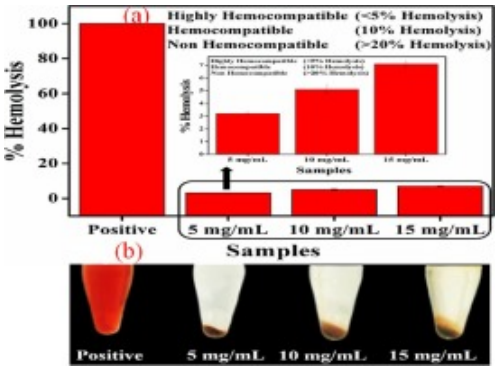
Abstract

Nanocrystalline Iron Manganese Tri Oxide ($FeMnO_3$, abbreviation name IMTO) material was attempted via colloidal solution followed by gel formation and subsequent processing at a calcined temperature of 480 °C. The above-mentioned compound was investigated for its structural characteristics, magnetic behavior, antibacterial response, and hemolysis experiment for spintronics and biomedical applications. The cubic crystal structure and weak ferromagnetic behaviour were noticed for the synthesized material from the powder X-ray diffraction (XRD) pattern and Vibrating Sample Magnetometer (VSM) studies. The surface structure of the title compound is noticed in aggregated spherical particles using Scanning Electron Microscopy (SEM) analysis. The antimicrobial activity of IMTO samples against gram-positive strains such as Streptococcus mutans (S. mutans) and Staphylococcus aureus (S. aureus) and gram-negative strains like Escherichia coli (E. coli) and Pseudomonas aeruginosa (P. aeruginosa) has been performed, followed by measurements of the zone of inhibition and their values are elucidated in detail. The hemolysis assay was carried out by taking human blood with the synthesized compound at various concentrations (5, 10, and 15 mg/mL), and the results showed its biocompatible nature.

Graphical abstract



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Introduction

Very limited literature reports are available on the development of $FeMnO_3$ (IMTO)-based compounds using various chemical synthesis routes, followed by tests on Li-ion batteries, supercapacitors, energy storage devices, electro-optics devices, waste water treatment, and biomedical applications, etc. [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18]. Further, excellent retention and cycling stability, high capacity characteristics, good dielectric properties, antiferromagnetic behaviour, good catalytic and antibacterial performance, and so on can be found in the aforementioned literature.

Various top-down approaches, such as precipitation, solvothermal, chemical oxidative, chemical solution deposition, green synthesis, pyrolysis, sol–gel, hydrothermal, self template, combustion, non-ionic surfactant assisted electrospun, mechanochemical, sol–gel auto combustion, mechanical alloying and solid state reaction methods are used to make the IMTO-based compound [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22]. The above-mentioned methods have some demerits, like the synthesis step's prolonged reaction time interval processing at high temperatures autoclave deposition steps and the chemical oxidative process.

The current work focuses on the study of the structural and surface characteristics, magnetic properties, and biological activity (antibacterial and hemolysis) of synthesized IMTO nanostructures via the sol–gel route. The VSM study revealed that the synthesized compound has weak ferromagnetic behaviour at room temperature. Antibacterial activity of synthesized IMTO nanostructures against the four bacterial strains (S. mutans, S. aureus, E. coli, and P. aeruginosa) is chosen in the experiments followed by their zone of inhibition values and response in microbial activity results, which are elaborated in detail for the first time. In addition, the synthesized compound is biocompatible nature confirmed by the hemocompatibility test.

Section snippets

Experimental

The following chemicals, such as iron (III) nitrate hydrate ($Fe(NO_3)_2{\cdot}H_2O$) (Aldrich, purity 99.9%), manganese (II) nitrate hydrate ($Mn(NO_3)_2{\cdot}2H_2O$) (Aldrich, purity 99.9%), urea (CH_4N_2O) (Aldrich, purity 99.9%), and distilled water, were used to synthesize the title compound.

In a typical synthesis, 3 mmol of $Fe(NO_3)_2{\cdot}H_2O$ and $Mn(NO_3)_2{\cdot}2H_2O$ were dissolved in 40 ml of distilled water for 30 min with magnetic stirring. Further, 3 mmol of CH_4N_2O was added to the above mixture while magnetic stirring…

Results and discussion

The XRD pattern of the title compound powder was scanned between the ranges of 20° and 70° by means of powder XRD analysis and is shown in Fig. 2. The two sharp diffraction intensity peaks were noticed at 2θ = 33.11° and 36.27°, which correspond to the miller index planes of (222) and (400), respectively [12]. Furthermore, 2θ values at 26.4°, 40.90°, 46.10°, 49.95°, 54.67°, 59.87°, and 63.67°, which correspond to planes indexed in the XRD pattern as (211), (332), (134), (125), (440), (352), and …

Conclusion

In this work, sol–gel synthesis-assisted IMTO nanostructures were fabricated, followed by investigations into their crystalline structure, surface image characterization, magnetism features, and antibacterial activity. The synthesized IMTO powder was analyzed using powder XRD, and its observed diffraction peaks resulted from the XRD pattern, which confirmed the arrangement of the cubic crystal system. With the help of high- intensity diffraction peaks from the XRD, the crystallite size of the…

CRediT authorship contribution statement

C. Vinoth: Methodology, Investigation. **J. Ramana Ramya:** Writing – review & editing. **J. Gajendiran:** Investigation, Conceptualization, Writing – review & editing. **S. Gnanam:** Conceptualization, Writing – review & editing. **S. Gokul Raj:** Writing – review & editing. **G. Ramesh Kumar:** Writing – review & editing. **M. Karthikeyan:** Formal analysis.…

Declaration of Competing Interest

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

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