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Physical, spectroscopic and antibacterial investigation of $Mg_{0.3}Zn_{0.5}Mn_{0.2}Fe_2O_4$ via temperature dependent hydrothermal approach

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ABSTRACT

$Mg_{0.3}Zn_{0.5}Mn_{0.2}Fe_2O_4$ spinel ferrite magnetic nanoparticles (MNPs) were synthesized with sealing temperatures of 160 °C, 180 °C, and 200 °C by hydrothermal route. The physicochemical parameters of synthesized MNPs were investigated by XRD, FTIR and VSM. The X-ray diffraction reveals the more crystallinity with temperature hence crystallite size (12 nm-18 nm). The functional group analysis by two strong absorptions within 400–600 cm^{-1} of FTIR and elemental analysis (EDS) confirms spinel ferrite MNPs. The M-H loop with minimal saturation Magnetization M_S (15.90, 22.96, 21.96 emu/g), Coercivity H_C (21.04, 22.69, and 20.63 O_e) and remnant magnetization M_r (0.64, 0.81, and 0.78 emu/g) as recorded by VSM. Particle size obtained by TEM signifies superparamagnetic nature of MNPs. The dielectric properties of MNPs with frequency were recorded using Impedance spectroscopy which were found to be influenced by crystallization. The dielectric constant of all samples decreases with rise in frequency, indicating dielectric dispersion at lower frequencies, possibly due to interfacial polarization. The antibacterial efficacy of MNPs against different gram positive and gram-negative bacteria was demonstrated by Zones of inhibition.

1. Introduction

The nanostructured magnetic materials are in the recent trend of nano science and nano technology field due to their application potential in the wide range from industrial to biomedical field [1]. Ferrites are the magnetic material with Iron Oxide as a Key Component and show outstanding properties due to their good chemical stability, high resistivity, low dielectric losses, and tuneable magnetic properties. Out of various types of ferrites, spinel ferrite is soft magnetic material with chemical composition AB_2O_4, where *A* and *B* refer to divalent and trivalent metal ions respectively. The spinel ferrite displays exceptional properties with multifunctional nature applicable in drug delivery, bioseparation, absorbent materials, data processing devices, magnetic refrigeration systems, gas sensing, ultrahigh density(UHD) recording, magnetic resonance imaging (MRI), multilayer chip inductor(MLCI), microwave - radio frequency devices and electromagnetic interference (EMI) suppression [2]. The wide application area of spinel ferrite MNPs mainly depends on various structural, spectroscopic and magnetic parameters [3]. The spinel ferrite MNPs is synthesized by various effective bottom-up chemical routes. Some of them are hydrothermal/solvothermal, sol–gel auto-combustion, Co-precipitation and many others [4]. The physical and chemical properties of synthesized MNPs will decide the application area greatly affected by synthesis method, cation distribution and processing temperature [5].

The spinel ferrite MNPs, especially Mg-Zn ferrites have attained substantial recognition because of their adequate significance for applications in technology that includes biomedical diagnosis, MLCI, magneto calorific refrigeration, and information storage system due to their superior qualities like high electrical resistivity, low power losses, moderate saturation magnetization, high initial permeability [6].

H. Mohseni et al. [7] highlighted magnetic and structural studies of the Mn substituted Mg–Zn ferrite nanoparticles synthesized by the glycine nitrate process. They summarized the increasing content of Mn^{2+} results in increasing crystallite size which also tends to reduce coercivity.

T.A. Nhlapo et al. [8] studies Magnetic properties of $Mn_{0.1}Mg_{0.2}TM$

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