Contribution ID: **83** Type: **Oral Presentation**

Structural, stability, and magnetic studies of polymer-coated magnesium-zinc ferrite nanoparticles synthesized via glycol-thermal route

Tuesday 8 July 2025 11:30 (20 minutes)

Magnesium-zinc ferrite (Mg1-xZnxFe2O4, for 0 ≤ x ≤1 Nanoparticles (NPs) were successfully synthesized using the glycol-thermal reaction method. The NPs were then coated with a biocompatible polymer (chitosan). The naked and coated materials were characterized for structural properties using an X-ray diffractometer (XRD), where crystallite sizes increased from an average of 12.79 nm to 14.98 nm, while the average lattice parameter reduced from 8.38 to 7.94 Å upon coating. The surface morphology of the material was evaluated using Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). TEM images reveal spherical shape particles for all NPs with an enhancement after coating, while SEM photograms reveal less agglomeration after coating. The stability of the NPs in an aqueous environment was evaluated using an Antoni par reactor (littersizer DLS 500), where the chitosan-coated NPs exhibited zeta-potential above +30 mV, which is attributed to stable particles compared to the naked particles. 57Fe Mössbauer spectroscopy, Vibrating Sample Magnetometer (VSM), and Electron Spin Resonance (ESP) techniques were used to study the magnetic properties of the as-prepared and coated NPs. Mössbauer spectra show ferrimagnetism for x ≤ 0.5 and paramagnetism for x > 0.5 at room temperature. The magnetization hysteresis loops obtained by the VSM exhibited the presence of superparamagnetic NPs in both as-prepared and coated NPs. More significant saturation magnetization and coercive field were observed in the concentration of x = 0 compared to x = 0.5 and 1.0 NPs. This was attributed to the Mg+2 magnetic ions substituting the non-magnetic Zn+2 ions. Including the chitosan on the surface of Mg-Zn ferrite NPs shows good stability, suggesting moderate results. The polymer coating shielded the magnetizations of the as-prepared NPs, which enhanced the decrease in the saturation magnetization values. Furthermore, this reduction in the saturation suggested the superparamagnetism behavior of the coated NPs, and this property is one of the essential features in the application of magnetic NPs as drug-delivery agents. Conclusively, these polymer-coated ferrites present feasible nanocarriers in magneto-targeted drug delivery.

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Session Classification: Physics of Condensed Matter and Materials 2

Track Classification: Track A - Physics of Condensed Matter and Materials