Contribution ID: **137** Type: **Poster Presentation**

Structural and Magnetic Properties of $Ni_{0.5}M_{0.5}Al_{0.1}Fe_{1.9}O_4$ (M = Zn, Mn, Mg) Ferrites

This study explores the structural and magnetic properties of $Ni_{0.5}M_{0.5}Al_{0.1}Fe_{1.9}O_4$ (M = Zn, Mn, Mg) spinel ferrites synthesized using a modified glycolothermal method tailored for enhanced control over particle sizes, crystallinity, and tuning of magnetic parameters. Additionally, the study aims to optimize magnetic hyperthermia parameters and leverage biodegradable elemental compositions. By systematically substituting Zn, Mg, and Mn, we tuned key magnetic parameters such as saturation magnetization, coercivity, and effective magnetic anisotropy through their distinct site preferences and spin interactions. Zn^{2+} was chosen to enhance magnetization for soft magnetic applications, Mg^{2+} to promote low-loss behaviour for power electronics, and Mn^{2+} to induce spin canting for tuneable responses; Al^{3+} was incorporated to reduce cell volume and drive Fe redistribution, thereby enhancing superexchange interactions.

Preliminary results from X-ray diffraction and Rietveld refinement confirmed phase purity and single-phase formation. Crystallite sizes from 9–11 nm were determined using the modified Scherrer method, while the lattice parameters followed Vegard's law, indicating the successful formation of a continuous solid solution. The unit cell volume reduced at each substitution level, resulting in a more stable structure. SEM-EDX analysis showed good agreement between experimental and theoretical compositions. Electron spin resonance (ESR) measurements were conducted. The Zn-substituted spinel ferrites exhibited the lowest resonance field at 2747.6 Oe, while the Mg-substituted samples showed the highest resonance field, with the Mn-substituted ferrite falling in between. These shifts in resonance fields are attributed to differences in magnetocrystalline anisotropy. The decrease in g-values from 2.5 to 2.3 indicates significant variation in the electronic structure and spin-orbital coupling due to cation distribution. An increased resonance field was associated with more significant magnetic anisotropy, lower g-values, and enhanced anisotropic behaviour. Vibrating sample magnetometer measurements showed saturation magnetizations ranging from approximately 23 to 55 emu/g and extremely low coercivitiy between 16 and 21 Oe, characteristic of superparamagnetic behaviour. The net magnetic moments deduced from the experimental data were in good agreement with theoretical estimates from cation distribution.

This work elucidates the fundamental structure-property relationships in spinel ferrites and opens avenues for the development of advanced materials synthesized by a modified glycol thermal method with potential applications in magnetic hyperthermia therapy whilst leveraging South Africa's abundant transitional metals. Further investigations include measuring the materials'magnetic properties at low temperatures and using Mössbauer spectroscopy to examine Fe^{3+} oxidation states, site occupancy, magnetic ordering of the materials, and measurement of magnetic hyperthermia measurements such as specific loss power (SLP).

Apply for student award at which level:

None

Consent on use of personal information: Abstract Submission

Yes, I ACCEPT

Primary author: DLAMINI, Sanele (University of Mpumalanga)

Presenter: DLAMINI, Sanele (University of Mpumalanga)

Session Classification: Poster Session

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