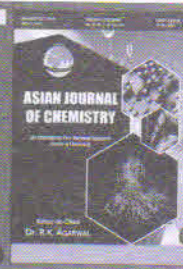


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A Dual-Strategic Approach to Synthesize Fe₂O₃ Nanoparticles with Study on their Structural, Optical and Antibacterial Properties

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In this study, iron(III) oxide (Fe₂O₃) nanoparticles were synthesized using two approaches namely a conventional chemical co-precipitation method and a green synthesis route utilizing *Azadirachta indica* leaf extract, which simultaneously functions as a reducing and stabilizing agent. Following synthesis, the nanoparticles underwent characterization to assess their optical behaviour along with structural and morphological features. Through XRD characterization, Fe₂O₃ was identified in its rhombohedral crystalline configuration, with average particle sizes measured as 42 nm for co-precipitation-derived samples and 35 nm for those synthesized *via* the green route. Scanning electron microscopy (SEM) revealed size variations between the two synthesis routes, with the green method producing relatively smaller and more uniformly dispersed nanoparticles. UV-Vis absorption spectra indicated the characteristic optical transitions with slight band gap variations, attributed to particle size and surface modifications by phytochemicals present in the neem extract. Fourier-transform infrared spectroscopy revealed characteristic Fe–O bond vibrations together with biomolecular groups in Fe₂O₃ nanoparticles produced *via* the neem-assisted route. Antimicrobial testing performed using the agar well diffusion method against *Staphylococcus aureus* and *Escherichia coli* showed that the green-synthesized particles achieved greater inhibition zones. This enhancement is associated with their nanoscale size, enlarged surface-to-volume ratio and the functional bioactive molecules originating from neem extract. Overall, the study underscores the potential of green synthesis for designing effective and biocompatible antibacterial nanomaterials.

Keywords: Fe₂O₃ nanoparticles, Green synthesis, *Azadirachta indica*, Antibacterial activity.