Green synthesis of gold-doped $ZnFe_2O_4$ nanoparticles using *Crataegus monogyna leaf* extract: characterization, antibacterial, and efficient degradation of methylene blue and eriochrome black T pollutants

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Abstract

In recent years, green chemistry has emerged as an efficient, environmentally friendly, and sustainable approach for nanoparticle synthesis. In this study, we employed a green chemistry method to synthesize $ZnFe_2O_4$@Au nanoparticles in the presence of a *Crataegus monogyna leaf* extract. The synthesized nanoparticles were characterized using scanning electron microscopy (SEM), energy-dispersive X-ray (EDS), transmission electron microscopy (TEM), and X-ray diffraction (XRD) analysis, demonstrating their spherical morphology and homogeneous structure. XRD analysis confirmed the purity of the $ZnFe_2O_4$@Au nanoparticles. We applied these nanoparticles as nano-catalysts for the degradation of cationic (methylene blue) and anionic (eriochrome black T) pollutants. Under UV irradiation, $ZnFe_2O_4$@Au nanoparticles exhibited high pollutant degradation efficiency, with 94.3% and 90.8% degradation of methylene blue and eriochrome black T, respectively, within 120 min. Furthermore, we investigated the antibacterial activity of the synthesized nanoparticles against Gram-positive and Gram-negative strains. Notably, the nanoparticles exhibited substantial antibacterial efficacy, with MIC values of 2.5 mg/ml for *Staphylococcus aureus* and *Escherichia coli* strains, respectively. This study highlights the multifaceted potential of $ZnFe_2O_4$@Au nanoparticles, making them a promising candidate for both environmental remediation and biological applications.