

Tailored manganese ferrite nanoparticles with enhanced magnetic properties for effective hyperthermia cancer therapy

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Abstract

Magnetic hyperthermia, a transformative nanotechnology-based approach, has redefined cancer therapy by enabling precise and localized treatment. In this study, manganese ferrite (MnFe_2O_4) nanoparticles were synthesized via a thermal decomposition method, achieving exceptional magnetic and structural properties tailored for therapeutic applications. Advanced characterization techniques, including field emission scanning electron microscopy (FESEM), X-ray diffraction (XRD), and vibrating sample magnetometry (VSM), confirmed the nanoparticles' high crystallinity, chemical stability, and biocompatibility. Optimized synthesis conditions using 7.5 mmol of oleylamine and oleic acid surfactants produced nanoparticles with superior performance, exhibiting the lowest coercivity (15.7 Oe) and the highest saturation magnetization (33 emu/g). These features translated into remarkable magnetic hyperthermia efficiency, with a specific loss power (SLP) of 148.2 W/g in hexane media and 188.3 W/g in aqueous media, underscoring their ability to generate localized heat selectively. The thermal decomposition technique provided precise control over nanoparticle morphology and uniformity, ensuring their applicability in targeted cancer therapies. This study not only advances the understanding of MnFe_2O_4 nanoparticle synthesis and properties but also establishes their pivotal role in next-generation therapeutic technologies, emphasizing the intersection of condensed matter physics and biomedical innovation.