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Control of the Magnetic Properties of $Co_XFe_{3-X}O_4$ Nanoparticles for Performance Optimization in Magnetic Fluid Hyperthermia to Activate Magnetoliposomes for Remote Controlled Drug Release

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The study of magnetic nanoparticles for medical applications has been growing in recent years. Among the different approaches, some studies focus on magnetic nanoparticles (MNPs) incorporated into liposomes, to serve as vectors for drug delivery and thermal remote activation using an alternating magnetic field [1]. To reach that goal, the particles need to be smaller than a certain size, reach 42-45 ºC under a specific alternating magnetic field configuration, and reverse their magnetization by Néel relaxation mechanism. In this work, we studied a near 10 nm cobalt-ferrite MNPs that match the mentioned requirements when a magnetic field of 575 kHz and 20 mT is applied. Full morphological and magnetic properties of different CoXFe3-XO4 MNPs were correlated to understand the magnetic fluid hyperthermia (MFH) response. We analyzed the specific power absorption (SPA) of the nanoparticles, determined by the magnetic, morphological and rheological properties of dispersed MNPs. The MNPs were synthesized by high-temperature thermal decomposition of organometallic precursors. By controlling the size and the composition of these samples, we were able to tune the effective magnetic anisotropy and the saturation magnetization, which allow us to optimize the SPA of our material in MFH experiments [2]. The crystal structure and morphology of the nanoparticles were determined by X-ray Diffraction (XRD), Transmission Electron Microscopy (TEM) and the magnetic properties were determined by magnetization measurements. The SPA was obtained for different MNP concentrations dispersions (in two different rheological conditions i.e different fluid viscosities) with frequencies between 100kHz and 575kHz and magnetic field amplitude up to 56mT. The resulting SPA values were analyzed in terms of the different possible mechanisms that determine the magnetic losses, and indeed the Néel relaxation mechanism was dominant, allowing for greater temperature control and safer and more reliable application of the technology.

[1] K. Ulbrich et al. Chem. Rev. 116 (2016) 5338–5431
[2] T. E. Torres et al. Journal of Applied Physics 118 (2015) 183902