Synthesis and study of exchange-bias effect of the uniform (Eu, Nd)-doped magnetite nanoparticles

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The combination of lanthanides' (Ln) and ferrites' properties through doping has been of great interest in recent decades since doping can improve the structural, electrical, and magnetic properties of ferrites, expanding their applications.[1] The exchange bias (EB) has been explored in magnetoelectronic devices, such as sensors, domain stabilizers in reading heads, magnetoresistive memories, permanent magnets, among others.[2] In this work, the modified polyol process was used to obtain neodymium and europium doped magnetite nanoparticles (NPs) in a one-pot reaction. The methodology involves adding iron(III) acetylacetonate and Ln complexes to tetraethylene glycol reducing medium. X-ray diffraction and Fourier transform infrared spectroscopy confirmed the formation of the magnetite structure and showed evidence of Fe^{3+} ion replacement for Ln^{3+} ions. Transmission electron microscopy showed spheroidal NPs with narrow size distribution and an average size of 7 nm. The presence of rare earth elements was confirmed by X-ray dispersive energy spectroscopy and by mapping with scanning-transmission electron microscopy. An optimal reaction time for doping of 3 hours resulted in better control of the nucleation and growth processes of NPs, and a critical doping value was found around 15-20%. The samples showed superparamagnetic behavior and intense EB effects consistent with the size of the NPs and the effects of structural defects induced by the formation of hydroxylated phases on the surface of the NPs and/or the presence of the dopant. The saturation magnetization values are consistent with the literature for doped and non-doped magnetite NPs. Our results showed a versatile method to obtain Ln-doped magnetite NPs and their potential use in magnetoelectronic devices due to the EB effect.

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References

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