

Synthesis and magnetic properties of Nickel Ferrite nanoparticles for biomedical applications

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Magnetic nanoparticles and their corresponding specific properties are becoming an important investigation area in last years. The size confinement to nanometer scale in magnetic materials changes the properties from those of the bulk ferro and ferrimagnetic counterparts, the remainder magnetization disappears keeping the magnetic moment. These properties are interesting for some biomedical applications, such as drug delivery, MRI contrast and magnetic hyperthermia. In order to enhance magnetic hyperthermia, nanoparticle average sizes, crystalline anisotropy and magnetic moment are important factors to be considered. The most usual materials for such applications are superparamagnetic iron oxide (SPIO) compounds.

A good approach to increase the magnetic moment is to introduce paramagnetic atoms in the crystal structure, replacing some of Fe(II) cations in octahedral holes [1]. These cations cause a decompensation of ferrimagnetic structure increasing the net magnetic moment and magnetic permeability. What's more, changes in crystalline anisotropy are also expected [2].

In this work we report the preparation and characterization of nickel ferrites varying nickel composition in the 3 – 20% range, in order to study the effects in magnetic behavior. The nickel ferrite nanoparticles have been synthesized by polyol method, using nickel(II) and iron(III) acetylacetonates as precursors, 1,2-hexadecanediol as dispersant, benzyl ether as solvent and oleic acid and oleylamine as coating agents. For one of the samples, seed mediated growth process was performed to evaluate changes in magnetic properties with nanoparticle size [3].

X Ray Diffraction (XRD) technique was used to corroborate the inverse spinel structure without impurities for synthesized samples. Dynamic Light Scattering (DLS) and Transmission Electron Microscopy (TEM) studies have shown that the diameter of ferrite nanoparticles is around 10-14 nanometers for non-grown particles. Inductively Coupled Plasma (ICP) spectroscopy has been used to determine the exact percentage of Nickel on samples. Finally, the mass percentage of organic material was obtained by thermogravimetric (TG) measurements under Argon atmosphere.

In order to study the magnetic behavior of the different samples, magnetization measurements were carried out in function of magnetic field at 300 K, as well as Electron Magnetic Resonance Spectroscopy (EPR) measurements at room temperature in noninteracting dispersed particles. This characterization, has led us to understand the relationship between magnetic response and nickel percentage in the ferrite inverse spinel structure and EMR signals have been related to the size of the nanoparticles. In this sense, a displacement of the signal to higher g_{eff} values have been observed for increasing sizes.

References

- [1] Shouheng Sun, Hao Zeng, David B. Robinson, Simone Raoux, Philip M. Rice, Shan X. Wang, Guaxiong Li, J. Am. Chem. Soc, **126** (2004) 273-279.
- [2] Seung-hyun Noh, Wonjun Na, Jung-tak Jang, Jae-Hyun Lee, Eun Jung Lee, Seung Ho Moon, Yongjun Lim, Jeon-Soo Shin, Jinwoo Cheonn, Nano Lett., **12** (2012) 3716-3721.
- [3] Jongnam Park, Eunwoong Lee, Nong-Moon Hwang, Misun Kang, Sung Chul Kim, Yosun Hwang, Je-Geun Park, Han-Jin Noh, Jae-Young Kim, Jae-Hoon Park, Taeghwan Hyeon, Angew. Chem, **117** (2005) 2932-2937.