MAGNETIC PROPERTIES OF NICKEL-ZINC FERRITE NANOPARTICLES SYNTHESIZED BY COPRECIPITATION

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Nickel-zinc ferrite is a soft magnetic material having low magnetic coercivity and high resistivity values, which makes it an excellent choice as a core material for power transformers [1]. Eventhough zinc ferrite is paramagnetic, Zn substitutions on inverse spinel ferrites, e.g. nickel, cobalt or manganese ferrites, enhance the magnetic properties, being the reason of the technological importance of mixed ferrites in today's market [2].

When the particle size of the ferrite becomes very small, in the order of a few nanometers, the magnetic characteristics are strongly affected due to the influence of thermal energy over the magnetic moment ordering, originating the superparamagnetic phenomenon [3]. Wet chemical routes of synthesis can fulfill the requirements of single phase, single domain nanometer ferrite particles production, while being suitable for the synthesis of mixed ferrites [4].

The influence of zinc substitution on nickel ferrite was studied in this work. $Ni_{1-x}Zn_xFe_2O_4$ (x = 0, 0.25, 0.50 and 0.75) system was synthesized by the coprecipitation technique, using aqueous solutions of constituent ions. A digestion step at 90°C was performed to crystallize the spinel cubic phase, avoiding the sintering process, which could lead to a substantial increase in the particle size.

Single phase spinel structure was confirmed by x-ray diffraction. Transmission electron microscopy images revealed a particle size ranging from around 3 to 10 nm, increasing with the content of Zn, which is consistent with the crystallite size estimated from x-ray pattern pick width. To investigate the magnetic properties of the nickel-zinc ferrite system, hysteresis, AC susceptibility and FC/ZFC thermoremanent measurements have been made using a SQUID magnetometer. The magnetization was measured at low and room temperature, finding almost the same values at 2, 6 and 10K. All compositions showed ferromagnetic behavior at 2K, while only the sample $NiFe_2O_4$ (x=0) showed superparamagnetism at 60 and 295K.

Fig. 1 shows the FC/ZFC curves measured at a DC field of 150 Oe. This curves revealed a typical superparamagnetic behavior for samples with a low content of Zn ferrite, with broad peaks which is an indicative of a width particle size distribution. The blocking temperature (T_B) increases with the increment on Zn content. This was confirmed by the AC susceptibility measurements. The increase of T_B in samples with a larger Zn content could be related to the presence of collective switching-over regions, as a result of a broad grain size distribution or the formation of nanoparticles clusters [5]. This magnetic behavior is discussed in detail.

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Figure 1:

Figure caption: Magnetization as a function of temperature of $Ni_{1-x}Zn_xFe_2O_4$ samples. Both field cooled (FC) and zero field cooled (ZFC) modes were measured at 150 Oe.