ICAM2009
11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

Synthesis and Characterization of $MeFe_2O_4$ (Me=Ni,Co) Nanoparticles Obtained by a Gelatin-Based Sol-Gel Method

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Abstract – Magnetic nanoparticles of nickel and cobalt ferrite, $MeFe_2O_4$ (Me=Ni,Co), were synthesized by a gelatin-based sol-gel method. The solution resulting from mixing of components was dried at temperature 100°C to obtain a resin which was calcined at 400°C, 600°C, 800°C, and 1000°C. The material was characterized by x-ray diffraction, Mössbauer spectroscopy, and magnetic measurements. Average particle sizes depend on calcination temperature and range from 10nm to 80nm. Mössbauer measurements show that Ni ferrite sample calcined at 400°C is superparamagnetic, consistent with the small particle size. Superparamagnetic effect is not found in the Co ferrite sample with particle size similar to that of Ni ferrite.

Nanostructured materials receive a great deal of attention due to interesting unique optical, electrical, chemical, and magnetic properties. Unique magnetic properties make these materials suitable for applications in medicine, electronics, and disk storage technologies, depending on nanoparticles' size, shape, and magnetic stability. For this work, magnetic nanoparticles of nickel and cobalt ferrite, $MeFe_2O_4$ (Me=Ni,Co), were synthesized by a gelatin-based sol-gel method using gelatin and iron, nickel and cobalt salts. This preparation method is viable owing to its simplicity and low cost. The solution resulting from mixing of components was dried at temperature 100°C to obtain a resin which was calcined at 400°C, 600°C, 800°C, and 1000°C. The final product of this process was the desired ferrite nanoparticles.

The material was characterized by x-ray diffraction, Mössbauer spectroscopy, and magnetic measurements. Particle sizes were calculated from the line broadening of x-ray powder peaks through the Rietveld method of refinement using Scherrer equation. Residual microstrain values were estimated through the Williamson-Hall plot. Average particle size ranges from about 10nm for samples calcined at 400°C to about 80nm for samples calcined at 1000°C. The Mössbauer spectrum for the Ni ferrite sample calcined at 400°C presents a central doublet indicative of a superparamagnetic behavior, consistent with the small particle average size. A doublet is not present in the Mössbauer spectrum for the Co ferrite calcined at 400°C indicating that this sample is not in superparamagnetic state despite the small particle size. Spectra for the remaining samples present two sextets associated with octahedral and tetrahedral-coordinated iron sites characteristic of ferrites' spinel structure. Magnetic subspectra linewidths decrease with increasing calcination temperatures consistent with increasing particle average sizes observed by x-ray diffraction. Magnetic properties were measured using a vibrating sample magnetometer and will also be presented.

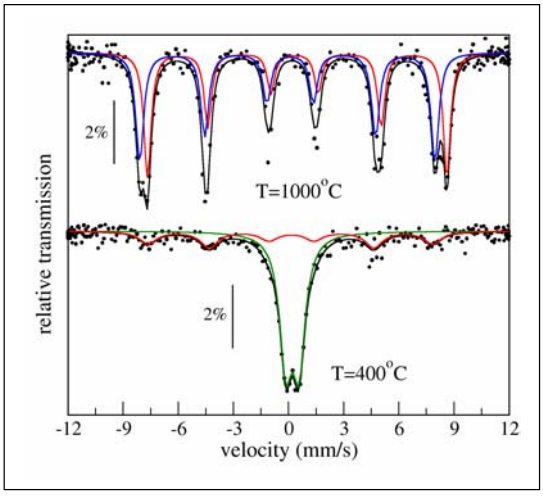

Figure 1: Mössbauer spectra of $NiFe_2O_4$ calcined at 400°C and 1000°C

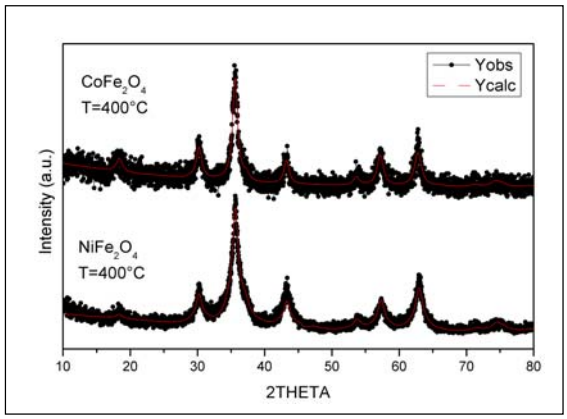

Figure 2: X-ray diffraction patterns of $NiFe_2O_4$ e $CoFe_2O_4$ calcined at 400°C.