

## Investigation of magnetic and structural properties of $\text{CoFe}_2\text{O}_4$ nanoparticles by measuring hyperfine interactions with $^{111}\text{Cd}$

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Because their ability of magnetic nanoparticles (MNP) to become magnetized when exposed to an external magnetic field, which make them good candidates for biomedical applications [1]. The investigation of the magnetic and structural properties by techniques with atomic resolution, such as those based on hyperfine interactions, is, therefore, greatly useful in the study of MNP. In this work, hyperfine interactions in nanoparticles of  $\text{CoFe}_2\text{O}_4$  were investigated by perturbed  $\gamma$ - $\gamma$  angular correlation (PAC) spectroscopy using  $^{111}\text{Cd}$  as probe nuclei in the temperature range from 50 K to 850 K. Samples of  $\text{CoFe}_2\text{O}_4$  were prepared by thermal decomposition [2]. Magnetic measurements results show a blocking temperature of 210 K and a superparamagnetic behavior at 300 K. MET measurements show that particles present well-monodispersed spherical shape with average size of 7 nm. XRD results show that samples crystallize in a single phase with the expected spinel structure. PAC spectra were fitted by a model considering two site fractions occupied by the probe nuclei. One were characterized by a single well-defined Larmor frequency with site fraction population of 47%, which was assigned to probe nuclei substituting cation sites in the core region of the particles. The other was characterized by a broad distribution quadrupole frequency with population of 53% corresponding to probe nuclei at distorted cation sites in the shell region of the particles. This assignment agrees with an expected shell/core volume ratio for particles with a diameter of 7 nm. Hyperfine measurements also show that the magnetic hyperfine field ( $B_{\text{hf}}$ ) is 12.6 T at 10 K in the saturated region and the temperature dependence of  $B_{\text{hf}}$  indicate that the transition temperature is around 900 K.

[1] H. Nemala, J. Thakur, V. Naik, P. Vaishnava, G. Lawes, R. Naik, *J. Appl. Phys.*, **2014**, *116*, 034309.

[2] S. Sun, H. Zeng, *Journal of the American Chemical Society*, 2002, *124*, 8204.