Magnetic properties of Er-doped Fe_3O_4 nanoparticles studied by perturbed angular spectroscopy

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Iron oxide nanoparticles have numerous applications in biomedicine; however, the saturation magnetization of iron oxide is substantially reduced from that of pure iron, due to oxygen mediation the exchange interaction between the iron atoms. To try to improve the saturation magnetization, we have examined the magnetic properties of rare-earth doped iron oxide.

Here, we investigate the magnetic properties of Er-doped Fe_3O_4 nanoparticles. All the samples were prepared by co-precipitation. For the doped material, Er^{+3} atoms were chosen in order to replace the Fe^{+3} in the $(Fe^{+2})(Fe^{+3})_2O_4$ structure. Structural characterization was determined by X-ray diffraction and transmission electron microscopy to confirm this structure. Hysteresis loops as a function of temperature were used to probe the magnetic properties. In addition, hyperfine interaction parameters as a function of temperature (300 K to 873 K) were obtained by perturbed angular γ-γ correlation (PAC) spectroscopy using $^{111}In(^{111}Cd)$ as probe nuclei.

To fit the PAC spectra (FIG. 1), the ^{111}Cd probes were considered to occupy three sites: tetrahedral, octahedral, and a third site where the probes are located at the nanoparticle surface [1]. The hyperfine magnetic field B_{hf} was calculated using the Larmor equation, $\omega_L = \mu_N g B_{hf}/\hbar$, and its behavior as a function of temperature follows a Brillouin-type transition. The Curie temperature obtained for 5% Er-doped was approx. 845 K (FIG. 2), which is higher than the expected Curie temperature for pure Fe_3O_4 (approx. 722 K) [2]. Current work is focused on correlating this shift in Curie temperature with the magnetic properties and determining if it is concentration dependent.

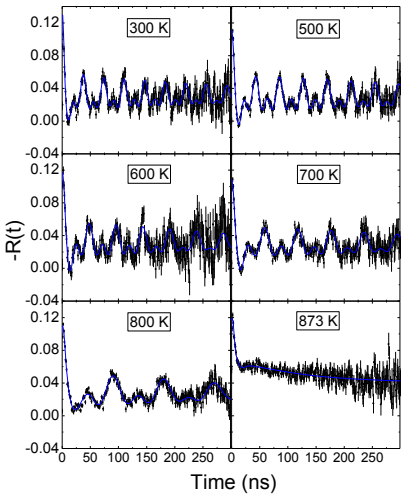

FIG. 1 – PAC spectra of 5% Er-doped Fe_3O_4 samples measured in different temperatures.

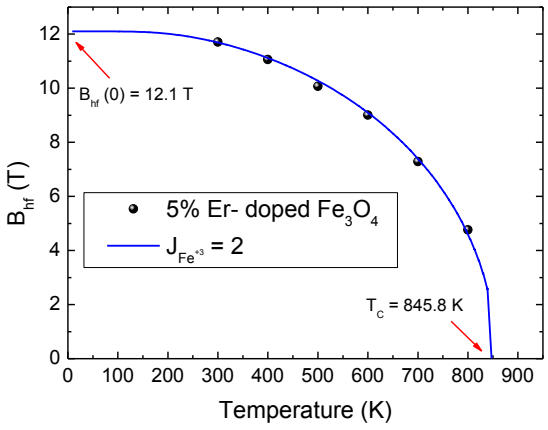

FIG. 2 – Hyperfine magnetic field as a function of temperature for 5% Er-doped Fe_3O_4 nanoparticle.

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References

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