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MÖSSBAUER STUDIES ON THE SUPERPARAMAGNETIC BEHAVIOR OF $COFE_2O_4$ WITH A FEW NANOMETERS

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$CoFe_2O_4$ nanoparticles with a cubic spinel structure are made by a high temperature thermal decomposition method[1-2] with iron (III) acetylacetonate [$Fe(acac)_3$] and cobalt (II) acetate [$Co(C_2H_3O_2)_2 \cdot 4H_2O$] The average particle sizes are 4.6 nm and 6.1 nm for $CoFe_2O_4$ of making with two kinds' different solvents by using a high resolution transmission electron microscopy (HRTEM). 4.6 nm particles show the superparamagnetic behavior, however, 6.1 nm particles don't show the superparamagnetic behavior at room temperature (295 K) yet. The Mössbauer spectra of samples at RT are showed in Fig. 1. Mössbauer spectra of 4.6 nm particles were displayed a superparamagnetic behavior as demonstrated by the single line with zero hyperfine fields at RT, but that of 6.1 nm particles were not. It is considered that anisotropy energy was still more superior to thermal energy because of particle size of 6.1 nm $CoFe_2O_4$. Therefore, superparamagnetic behavior was not appeared in 6.1 nm particles, even though the nanoparticles with a few nanometers. The kinds of samples can be discriminated exactly with low temperature Mössbauer spectra. From the Mössbauer spectra of samples, it is considered that samples are $CoFe_2O_4$ phase. The Mössbauer spectra were shown the typical spectrum shapes of the $CoFe_2O_4$ at 4.2 K. The spectrum at 4.2 K was fitted using two magnetic components of hyperfine fields H_{hf} = 540, 513 and isomer shifts d = 0.40, 0.30 mm/s for 4.6 nm and H_{hf} = 543, 513 and d = 0.41, 0.29 mm/s for 6.1 nm corresponding to Fe^{3+} ions at site A and site B, respectively.

In addition, the hysteresis loops of 4.6 and 6.1 nm nanoparticles were measured by vibrating sample magnetometer (VSM) in the maximum applied field of 10 kOe at RT. The magnetization curve of 4.6 nm nanoparticles shows no hysteresis area, accordingly both retentivity and coercivity are zero approximately. This behavior can be explained in terms of superparamagnetism. However, that of 6.1 nm nanoparticles has the coercivity of 93 Oe. The saturation magnetization M_S were 48.1 emu/g for 4.6 nm and 56.5 emu/g for 6.1 nm at RT.

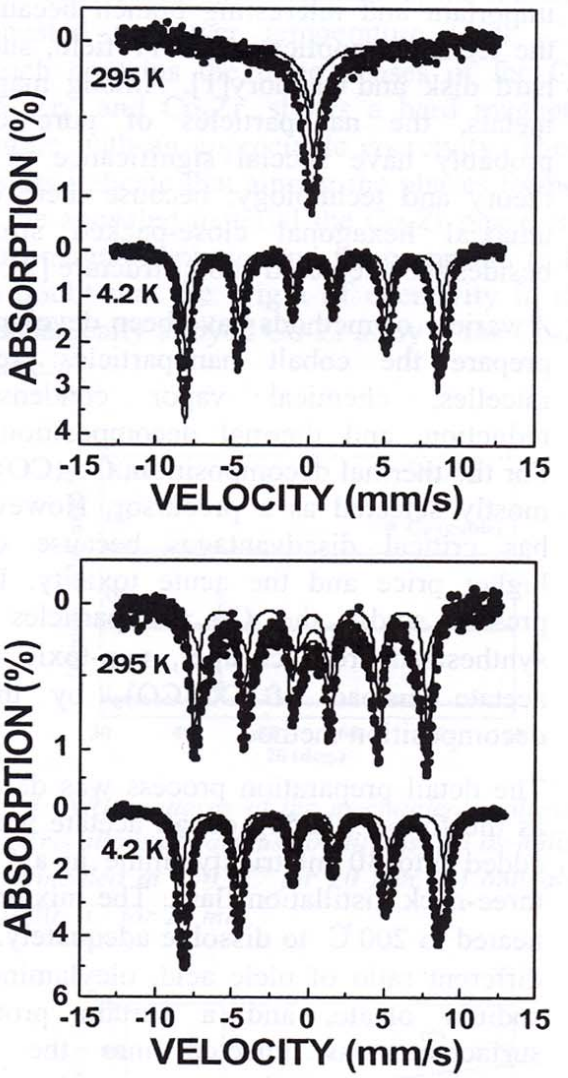

Fig. 1: Mössbauer spectra of 4.6 (up-side) and 6.1 nm (down-side) $CoFe_2O_4$ nanoparticles

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