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MÖSSBAUER STUDIES ON THE SUPERPARAMAGNETIC BEHAVIOR OF COFe₂O₄ WITH A FEW NANOMETERS

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CoFe₂O₄ nanoparticles with a cubic spinel structure are made by a high temperature thermal decomposition method with iron (III) acetylacetonate [Fe(acac)₃] and cobalt (II) acetate [Co(C₂H₃O₂)₂ · 4H₂O]. The average particle sizes are 4.6 nm and 6.1 nm for CoFe₂O₄ 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 CoFe₂O₄. 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 CoFe₂O₄ phase. The Mössbauer spectra were shown the typical spectrum shapes of the CoFe₂O₄ 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 Fe³⁺ 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) CoFe₂O₄ nanoparticles