Journal of
Nanoscience and Nanotechnology
Vol. 11, 6241–6244, 2011

Effect of Proton Irradiation on the Magnetic Properties of Manganese Ferrite

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Cubic-spinel $MnFe_2O_4$ magnetic nanoparticles (NPs) were prepared, with an average particle size of about 4 nm determined from a high-resolution transmission electron microscope. When the NPs were proton-irradiated, the lattice constants decreased with increasing proton irradiation. Before the proton irradiation, the NPs exhibited 36.2 ± 0.1 emu/g magnetization (M_S) and 11.1 ± 0.1 Oe coercivity (H_C). After the irradiation of the samples with 5 and 10 pC/μm^2 doses, the M_S changed to 35.6 and 35.1 ± 0.1 emu/g, and the H_C to 11.3 and 12.9 ± 0.1 Oe, respectively. The room-temperature Mössbauer spectra of the NPs showed superparamagnetic characteristics, with the single-absorption line of two sites and a large relaxation frequency. During the proton irradiation, the relaxation frequency decreased to 156.02 and 134.29 ± 0.01 $\Gamma/\hbar$ from the unirradiated sample's 164.02 ± 0.01 $\Gamma/\hbar$. It is suggested that the proton irradiation induced the increase in the anisotropy energy of the $MnFe_2O_4$ NPs. Moreover, from the external-field-induced Mössbauer spectra at 4.2 K, an increase in the canted angle of the hyperfine field between sites A (tetrahedral) and B (octahedral) was observed with proton irradiation.

Keywords: $MnFe_2O_4$, Mössbauer, Proton Irradiation, Relaxation Effect.

RESEARCH ARTICLE