Characterization on Fe₃O₄ Nanoparticles by Mössbauer Studies

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Here we report a preparation of iron oxide nanoparticles and correct characterizations by Mössbauer spectroscopy and transmission electron microscope (TEM). Mössbauer studies are essential tool because the only x-ray diffractometer (XRD) patterns in nanoparticles could not distinguish iron oxides from magnetite, maghemite, and spinel oxides because of similar crystal structure.

Magnetite (Fe₃O₄) with spinel structure are made by reaction of iron(III) acetylacetonate [Fe(acac)₃] with surfactants at high temperature. We have used the phenyl ether, benzyl ether, and 1, 2-hexadecanediol as solvents [1]. Fe(acac)₃ was mixed in phenyl ether and benzyl ether for synthesis of the magnetite (Fe₃O₄). As boiling point of phenyl ether (259 °C) is lower than that of benzyl ether (298 °C), the size of maghemite nanoparticles can be controlled.

The average particle sizes of magnetite were 4 and 6 nm, narrow size distribution was convinced by HRTEM. The crystal structure was characterized by XRD patterns, but the magnetite and maghemite phase were distinguished easily. We could carry out the measurement of Mössbauer spectrum at room temperature and 4.2 K. Our iron oxide nanoparticles show superparamagnetic behavior at room temperature. At 4.2 K, Mössbauer spectra were shown the typical spectrum patterns of the magnetite [2]. The analysis parameters, for the 6 nm iron oxide nanoparticles sample, are a general sextet shape indicating ferrimagnetic behaviors. For this sample, the 4.2 K spectrum was fitted using two magnetic components of hyperfine fields \( H_d = 51.4 \) and \( 49.2 \) T, isomer shifts \( \delta = 0.35 \) and 0.73 mm/s corresponding to \( \text{Fe}^{3+} \) ions at site A and \( \text{Fe}^{2+} \) ions at site B, respectively.

The saturation magnetization \( M_s \) were 59.5 emu/g for 4 nm and 59.7 emu/g for 6 nm at room temperature (295 K) under an applied field of 10 kOe.

These samples will be used to candidate for biomedicine applications as magnetic carriers [3].

References