Synthesis and magnetic properties of manganese-iron spinel nanocrystals

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We have prepared a series of manganese-iron oxide $Mn_{3-x}Fe_xO_4$ (x=1.25, 1.50, 1.75) nanocrystals through polyol reduction of manganese chloride tetrahydrate ($MnCl_2{\cdot}4H_2O$) and ferric chloride hexahydrate ($FeCl_3{\cdot}6H_2O$) in the presence of oleic acid, oleylamine, and sodium hydroxide (NaOH). The as-synthesized nanocrystals have the cubic spinel structure and mean crystallite size of 4.8-5.3 nm. Their monodispersities were characterized by dynamic light scattering (DLS) and transmission electron microscopy (TEM). Magnetic measurements show that the as-synthesized magnetic nanocrystals display a superparamagnetic behavior with zero coercivity and remanence. The saturation magnetization of $Mn_{3-x}Fe_xO_4$ obtained by the plots of M against $1/H$ curve were 1.8, 5.1, and 6.8 emu/g for x = 1.25, 1.50, and 1.75, respectively. Thermal annealing induces the change of crystallite size and thus the magnetic properties of the nanocrystal assembled films. Both microstructure and magnetic behavior of the nanocrystal assembled films are very sensitive to the film composition. This controlled synthesis and assembly can be used to fabricate $Mn_{3-x}Fe_xO_4$ nanocrystal films for future nanomagnetic applications in various technological fields, such as ferrofluids, sensing elements, and recording media.

* This project is financially sponsored by National Science Council (grand no. NSC 96-2112-M-218 -001-MY3).

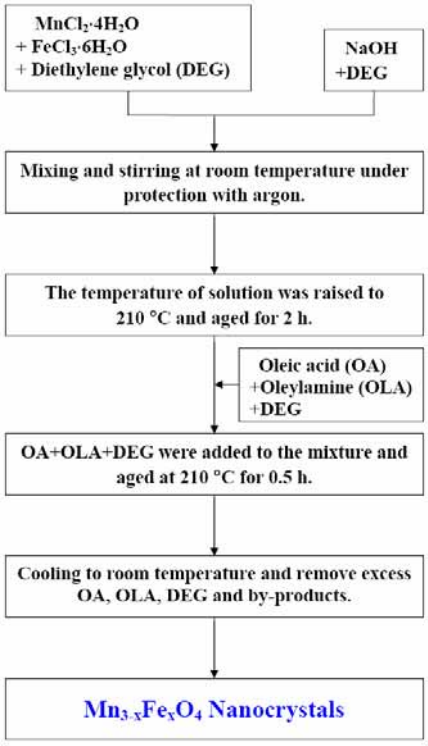

Fig. 1. Flow chart of the synthesis of $Mn_{3-x}Fe_xO_4$ nanocrystals

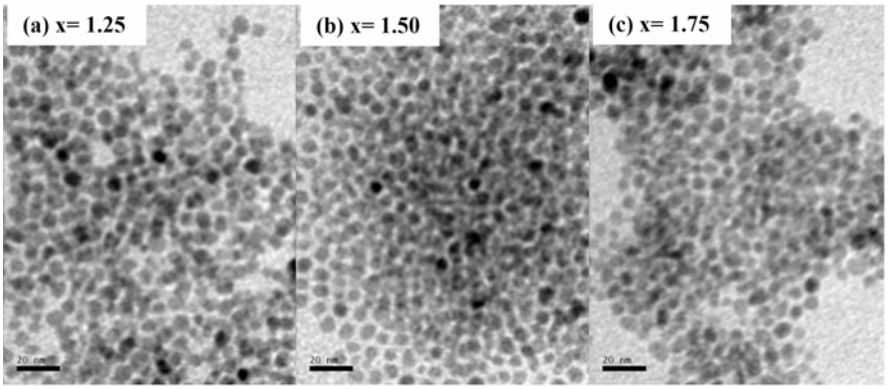

Fig. 3. TEM micrograph of $Mn_{3-x}Fe_xO_4$ nanocrystals.

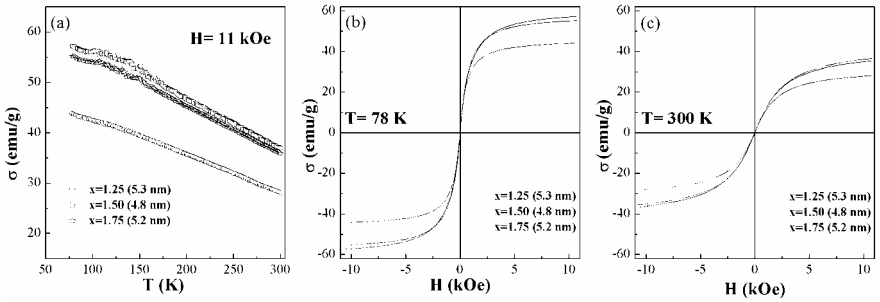

Fig. 4. (a)Temperature dependence of the ZFC and FC magnetization, and hysteresis loops measured at (b) 78 K and (c) 300 K for $Mn_{3-x}Fe_xO_4$ nanocrystals with different composition.

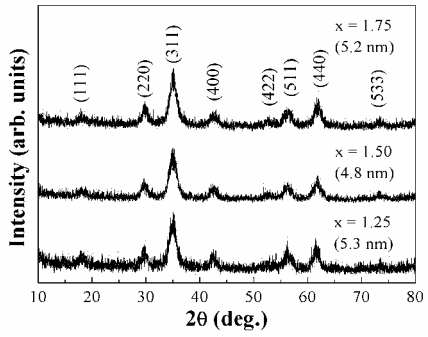

Fig. 2. XRD patterns of $Mn_{3-x}Fe_xO_4$ nanoparticles. Crystallite sizes were estimated by the Scherrer's formula.

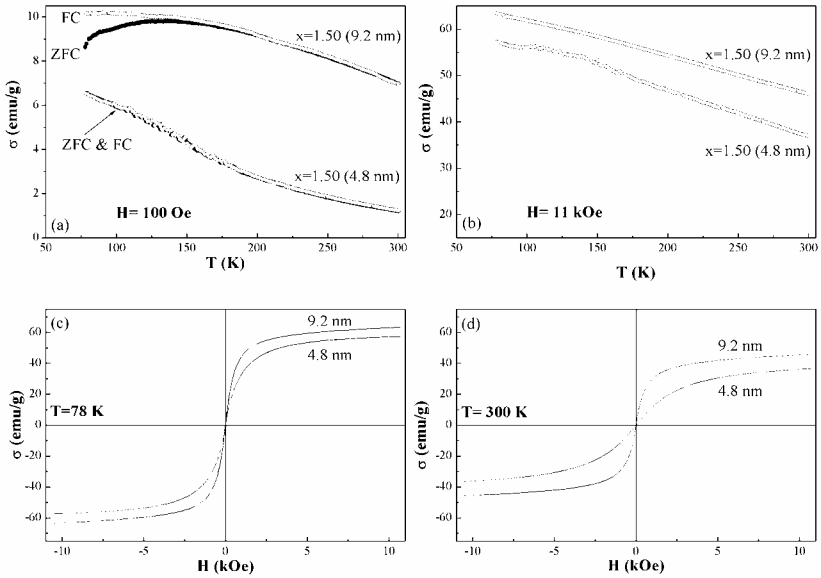

Fig. 5. Temperature dependence of the ZFC and FC magnetization, measured at applied field of (a) 100 Oe and (b) 11 kOe, for $Mn_{1.5}Fe_{1.5}O_4$ nanocrystals with various crystallite sizes. Hysteresis loops measured at (c) 78 K and (d) 300 K for $Mn_{1.5}Fe_{1.5}O_4$ nanocrystals with various crystallite sizes.

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