

Effect of synthesis conditions on the physicochemical properties of lauric acid coated magnetite nanoparticles.

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Magnetic iron oxide nanoparticles have attracted broad interests in many biomedical areas, such as magnetic resonance imaging (MRI) contrast enhancement, magnetic hyperthermia, magnetic bio-sensing, and cell labeling [1]. To avoid nanoparticle aggregation and enhance their colloidal stability, carboxylate surfactants are widely used as coating materials to form steric repulsions between nanoparticles [2]. Lauric acid is one of the classical carboxylate materials, and is already approved for use in pharmaceuticals and food industry, which makes it a very promising coating material for nanoparticles in biomedical application. [3] Various methods, like mechanical milling, microemulsion, co-precipitation, thermal decomposition, etc., have been widely attempted to prepare nanoparticles. However, it is reported that the synthesis route has great impact on the properties of nanoparticle products, such as aluminium oxide nanoparticles, cobalt ferrite nanoparticles, and so on [4, 5]. Therefore, it is worthwhile to investigate the effects of different synthesis methods on the properties of lauric acid coated magnetic iron oxide nanoparticles. The research outcome can enable the synthesis of magnetic nanoparticles with desired features. Here, lauric acid coated iron oxide nanoparticles (LAIONPs) were prepared through two methods, co-precipitation and thermal decomposition. The products were characterized by using transmission electron microscopy (TEM), scanning electron microscopy (SEM), Fourier transform infrared (FT-IR), dynamic light scattering (DLS), thermo gravimetric analysis (TGA), and vibrating sample magnetometry (VSM). The iron-oxide-core average size could be tuned from 9 nm (CP-1), 11 nm (CP-2) to 13 nm (CP-3) by using different stirring speed of 1200 rpm, 800 rpm, and 400 rpm, respectively in co-precipitation experiments, while the core average size could be adjusted from 7 nm (TD-1), 11 nm (TD-2) to 17 nm (TD-3) by following different heating process in thermal decomposition experiments. (Fig. 1) The nanoparticles obtained through thermal decomposition (LAIONPs-TD) showed more uniform sizes and morphologies than the ones got from co-precipitation (LAIONPs-CP). Higher mass ratio of lauric acid in TD samples than CP samples, as indicated in TGA results (Fig. 2a and 2b), implies higher surface cover density of lauric acid surfactant on LAIONPs-TD than LAIONPs-CP. All the six LAIONPs samples exhibited superparamagnetic behavior at room temperature (Fig. 2c and 2d). The saturated magnetization (M_s) of LAIONPs increased as the particle size increased. Such a trend can be observed in the samples obtained through co-precipitation (CP-1, 54 emu/g; CP-2, 58 emu/g; and CP-3, 63 emu/g) and also in the samples obtained through thermal decomposition (TD-1, 53 emu/g; TD-2, 64 emu/g; TD-3, and 78 emu/g). For the LAIONPs with similar average core size of 11 nm, M_s value of TD-2 obtained by thermal decomposition (64 emu/g) was higher than CP-2 obtained by co-precipitation (58 emu/g). As shown in Fig. 2e, in colloidal solution with solvent of chloroform, smaller mean hydrodynamic sizes and narrower hydrodynamic size distributions were observed on IONPs-TD samples, compared with IONPs-CP samples. This work revealed the influences of two different synthesis methods on the core size, morphology, hydrodynamic size, surfactant coating mass ratio, and magnetic behavior of the final products. Our comparative study provides insights into the influence of synthesis conditions on the geometrical and magnetic properties of lauric acid coated iron oxide nanoparticles.

[1] S. Laurent, D. Forge, M. Port, A. Roch, C. Robic, L. Vander Elst, *et al.*, "Magnetic iron oxide nanoparticles: synthesis, stabilization, vectorization, physicochemical characterizations, and biological applications," *Chemical reviews*, vol. 108, pp. 2064-2110, 2008.

[2] A. K. Gupta and M. Gupta, "Synthesis and surface engineering of iron oxide nanoparticles for biomedical applications," *Biomaterials*, vol. 26, pp. 3995-4021, 2005.

[3] J. L. Kinderlerer, "Degradation of the lauric acid oils," *International Biodeterioration and Biodegradation*, vol. 33, pp. 345-354, 1994.

[4] A. Rajaeiyan and M. M. Bagheri-Mohagheghi, "Comparison of sol-gel and co-precipitation methods on the structural properties and phase transformation of γ and α -Al₂O₃ nanoparticles," *Advances in Manufacturing*, vol. 1, pp. 176-182, 2013/06/01 2013.

[5] B. G. Toksha, S. E. Shirsath, S. M. Patange, and K. M. Jadhav, "Structural investigations and magnetic properties of cobalt ferrite nanoparticles prepared by sol-gel auto combustion method," *Solid State Communications*, vol. 147, pp. 479-483, 2008.

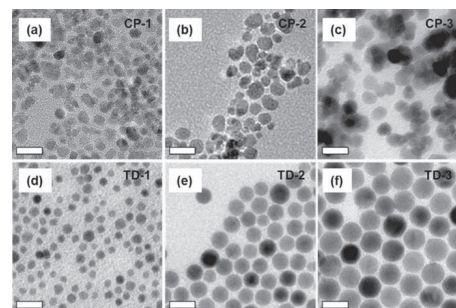


Figure 1. TEM images of lauric acid coated iron oxide nanoparticles with different core sizes obtained through (a, b, c) co-precipitation and (d, e, f) thermal decomposition. Scale bar, 20 nm.

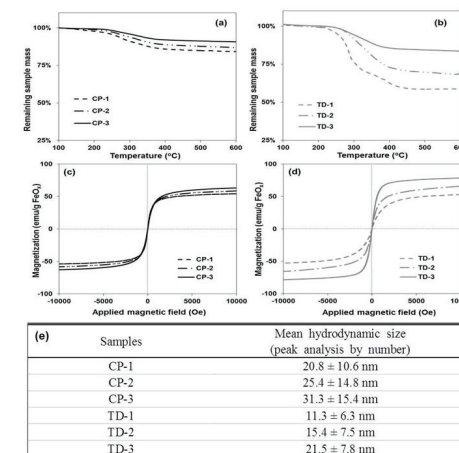


Figure 2. (a, b) TGA results and (c, d) VSM results of lauric acid coated iron oxide nanoparticles obtained from co-precipitation (CP-1, CP-2, CP-3) and thermal decomposition (TD-1, TD-2, TD-3). (e) Hydrodynamic sizes of lauric acid coated iron oxide nanoparticles in chloroform.