Humic Substances as Stabilizing Agents for Superparamagnetic Nanoparticles

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Keywords: humic, biocompatible magnetic nanoparticles, γ-Fe_2O_3

1. INTRODUCTION

Magnetic fluids are stable colloidal suspensions usually containing ferrite-based (MFe_2O_4) magnetic nanoparticles dispersed in organic or inorganic liquid carriers. Magnetic fluids stable under physiological conditions are of great interest for potential biomedical applications as contrast agents for magnetic resonance imaging (MRI) or colloidal mediators for cancer magnetic hyperthermia. However, magnetic nanoparticles without additional coating often tend to aggregate in water or tissue fluid limiting the range of their applications (1). To prevent nanoparticles aggregation, modification of iron-oxide nanoparticles by humic acids has been studied in the proposed research for the first time.

2. MATERIALS AND METHODS

Humic acids (HA) of brown coal derived from commercially available potassium humate of leonardite were used for stabilization of oxide nanoparticles. The composite of γ-Fe_2O_3-NaCl was obtained using aerosol spray pyrolysis method (ASP) as described in (2). Sodium chloride was used to encapsulate nanoparticles. The aerosol stream was burned in furnace at 650°-700°C. The as-prepared samples were examined by XRD, TEM, Mössbauer spectrometry, magnetic measurements and dynamic light scattering (DLS). For modification with HA, 2% solution of composite was prepared in 100 ppm HA solution at pH 7 using ultrasonic bath. Stability of colloid obtained was monitored using DLS measurements. Iron content in precipitate and fractions of different particle size was determined using spectrophotometry analysis with o-phenantroline after oxidative digestion of organic matter.

3. RESULTS AND DISCUSSION

The composite particles of γ-Fe_2O_3-NaCl obtained by ASP represent hollow nanostructured microspheres consisting of ~50 nm nanoparticles. Mössbauer spectra measured in the range of 300-16K proved the presence of metastable phase of maghemite γ-Fe_2O_3. The isomer shift relative to α-Fe and quadruple splitting at 16K were 0.46 and 0.04 mm/s, respectively. The magnetic measurements illustrate the superparamagnetic behavior of the particles. According to DLS results, the obtained humic-composite colloid was composed of particles with a peak size at 145±60 nm preserved within ten days of observation. According to the chemical analysis iron content exceeds 4 mg per liter for the refined fraction of modified nanoparticles after ten days of ageing.

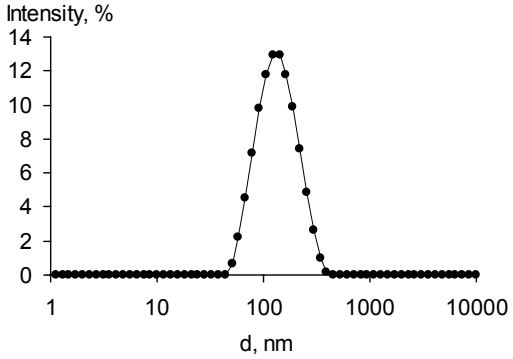

Figure.1 Particles size distribution for magnetic nanoparticles obtained at 650°C and stabilized by HA as measured by dynamic light scattering (DLS); (D=145±60 nm).

4. CONCLUSIONS

The prospects of novel applications of humic substances as stabilizing agents for γ-Fe_2O_3 superparamagnetic nanoparticles in aqueous solutions were demonstrated.

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