MÖSSBAUER SPECTROSCOPY STUDY OF γ-Fe_2O_3 NANOPARTICLES MODIFIED BY HUMIC ACIDS

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In recent years, water-soluble magnetic nanoparticles have been actively studied because of their attractive properties for biomedical applications. They are used in drug delivery as carriers for magnetic drug targeting, in hyperthermia, protein separation, etc.

For *in vivo* applications the magnetic particles have to be coated with a biocompatible shells to prevent aggregation during or after the synthesis process and biodegradation when exposed to the biological system. Humic acids (HA) are inexpensive natural surfactants which can be used as protective/stabilizing shells for nanoparticles [1].

In our work magnetic nanoparticles of γ-Fe_2O_3 was obtained by aerosol spray pyrolysis (ASP) method [2]. Humic acids of leonardite were used as stabilizing agents.

Preparation of modified γ-Fe_2O_3 nanoparticles using HA as surfactant leads to formation of slightly associated groups of magnetite nanoparticles [3], which penetrate between branches of the HA as shown in Figure 1.

The Mössbauer spectra of the sample γ-Fe_2O_3 stabilized by the HA are given in Figure 2 and the corresponding fitted parameters are listed in Table 1.

The spectra correspond to a magnetic oxide with a superparamagnetic behaviour. Indeed, lowering temperature gives "paramagnetic" signals from Fe^{3+} ions (a doublet and a monoline at 300 K), which turn into three sets of hyperfine structure lines (HFS). Two of which are described presence of γ-Fe_2O_3 nanoclusters of two characteristic sizes in a magnetically ordered state ($16 < T < 180$ K) denoted in Table 1 as γ-Fe_2O_3-1 and γ-Fe_2O_3-2, respectively [2], and the third can be described as new spectral component ((δ = 0,43 ± 0,03 mm/s, ε = 0,00 ± 0,03 mm/s and H_{in} = 39,9 ± 0,5T (21%±5%)) related to an interaction of HA with the surface of hyperfine magnetic phase.

Using humic acids as new non-toxic agent permits to obtain stable during long time suspensions of magnetic nanoparticles for future medical applications.

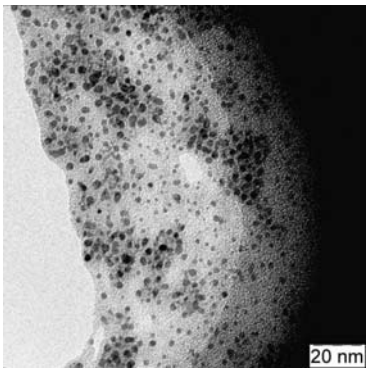

Figure 1. TEM image of modified mahemite nanoparticles.

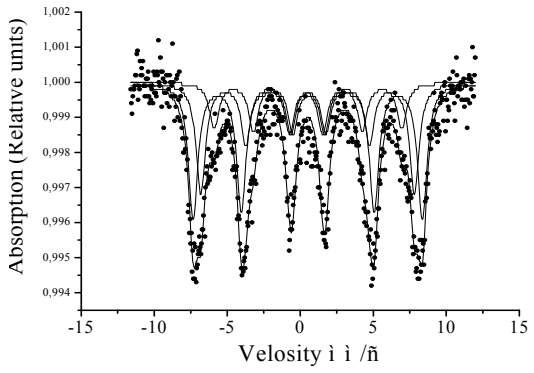

Figure 2. Mössbauer spectra of the γ-Fe_2O_3 stabilized by HA at 77K.

Table I: Mössbauer parameters of the γ-Fe_2O_3 stabilized by HA at 77K.

Comp.	δ	E	Γ	H_{in}, ±0.5 T	Relative content (%), ±0.05%
	±0.03 mm s^{-1}				
γ-Fe_2O_3 - 1	0.41	0.00	0.78	45.4	33
γ-Fe_2O_3 - 2	0.42	0.00	0.78	48.7	46
γ-Fe_2O_3 - 3	0.43	0.00	0.78	39.9	21

[1] E. Illés, E. Tombácz, Journal of Colloid and Interface Science, 295 (2006) p. 115

[2] A.E. Chekanova, A.L. Dubov, E.A. Goodilin, et.al. Mendeleev Commun., 19 (2009) p. 4

[3] A.E. Chekanova, T.A. Sorkina, A.L. Dubov, et.al. Mendeleev Commun., 19 (2009) p. 72