

Aggregative Stability of Metal Particles in Solutions of Low-Molecular Surfactants

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Extended Abstract

Metal nanoparticles have a high migration activity in soil and water media and can provoke high toxicity effects on plants and bacteria (Mohammed et al., 2011). Herewith, particle size and their aggregation degree are considered to be important factors determining cytotoxicity mechanism of nanoparticles (Yamamoto et al., 2004).

When entered an aqueous solution nanoparticles form dispersions, which can be characterized both with spontaneous aggregation and high aggregative stability. The formation of unstable dispersed system is caused by high surface energy of particles as well as by the properties of the aqueous solution.

To avoid aggregation of nanoparticles different stabilizers, including the carboxylate anions (Marques, Loebenberg et al. 2011), amino acids and fulvic acids (Perdue 2013) are generally used. In this work the sodium acetate (NaAc), oxalate (Na₂Ox) and citrate (Na₃Cit) was used as a component of biological liquid to study an efficiency of this type of stabilizer for Al and Zn nanoparticles and find an optimal stabilizer concentration.

In this study we investigated stabilizer effect on the aggregative stability of aluminum and zinc nanoparticles in buffer solution. We tested Al nanoparticles, obtained by electric explosion of wire (average particle size was 100 nm, producer – Advanced Powder Technology, Tomsk, Russia) and Zn nanoparticles (average particle size –60 nm, producer – Advanced Powder Technology, Tomsk, Russia).

The aqueous solution 10⁻² M HEPES (2 - [4 - (2-hydroxyethyl)-1-piperazinyl] ethanesulfonic acid) was used to maintain pH (7..8). Ionic strength was varied from 0.001 to 10 mM and was created by the addition of surfactant in a HEPES. The pH was regulated by acid-base titration. The concentration of nanoparticles in the suspensions was 1 mM.

The particle size distribution, average size (d_{av}) and zeta potential of the particles were measured by the method of dynamic light scattering with instrument Malvern Zetasizer Nano, USA.

Comparison of the particle size calculated from the BET data and the dynamic light scattering showed that all of the exposed nanoparticle tended to aggregation in the buffer.

It was shown that in case of metal particles the citrate addition provokes disaggregation. For example, in a highly diluted solution of Na₃Cit with $I = 10^{-6}$ M size of Al particles decreased from 226 to 218 nm (pH 7), Zn - from 466 to 1252 nm (pH = 8). With a further increase of surfactant concentration up to $I = 10^{-2}$ M for aluminum nanopowder particle size is reduced to 151 nm (Al), and zinc nanopactecles are completely disaggregate (64 nm). Electrostatic stability of hydrosols formed by ionic strength of 10⁻² M SAS confirmed by a significant increase in the absolute value of zeta potential: ζ -potential decreased from -7.2 to -37.6 mV for the Al nanoparticles, and from 3.9 mV to -24 mV - nanoparticles Zn. The change of sign charge occurs at 10⁻⁶ M.

In this way, in study with the help of light dynamic scattering it has been shown that the increase of surfactant concentration 1) leads to stabilization of Al and Zn nanoparticles in sodium citrate solution, 2) has no significant effect on particles aggregation in sodium oxalate solution, and 3) provokes nanoparticles aggregation in sodium acetate solution. Experimental data allows revealing optimal conditions to create aggregation-sustainable hydrosols of biologically active nanoparticles

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