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Short Communication

Development and Physico-chemical Study of the Aqueous Dispersion Silver Nanoparticles as the Basis for Creating New Nanomaterials

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The aqueous dispersion of silver nanoparticles have been obtained and studied by physicochemical methods. Maximum of size nanoparticles distribution in the aqueous dispersion determined by the small angle X-ray scattering technique was 2.5 nm. The composition on the basis of those nanoparticles can be used to create new nanomaterials, in particular for the modification of talc silver nanoparticles. The existence of nanoparticles at the talc surface is corroborated by the data of energy dispersive spectra and by X-ray diffraction spectra.

Keywords: Reverse micelles AOT, Silver nanoparticles, Aqueous dispersion, Talk, Small angle X-ray scattering, Energy-dispersive spectra.

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1. INTRODUCTION

Bactericidal properties of metal silver are dictated by its slow oxidation and a release of silver ions. In small concentrations, silver is safe for humans; however, harmful for most bacteria and viruses, which is of practical importance, including, for disinfection of water and food, especially when silver is in the nanoscale state. Silver nanoparticles in themselves have unique optical features. For example, they feature surface plasmon resonance, high developed surface, catalytic activity, high capacity of the double electric layer, etc. Antibacterial activity and maturity of nanoparticles surface facilitate their penetration through cell membranes and effect on intracellular processes [1].

In this work, silver nanoparticles are synthesized in a reverse micelle system; their aqueous dispersion is obtained that was applied for the modification of the surface.

2. EXPERIMENTAL RESULTS AND DISCUSION

Silver nanoparticles were synthesized in reverse micelles of sodium bis(2-ethylhexyl) sulfosuccinate (Aerosol OT, AOT) with mixing of two micelle systems: aqueous solution of argentic nitrate salt (AOT) isooctane and sodium borane isooctane with successive treatment by ultrasound with a frequency of 44 kHz. Concentration of silver salt was $3 \cdot 10^{-3}$ mol/l; hydration degree $w = 3.9$. Nanoparticles formed in aqueous pools of reverse micelles as a result of Ag^+ reduction with sodiumborane to atoms with a subsequent aggregation [1, 2].

The nanoparticles thus obtained, were isolated from reverse micelles into the aqueous dispersion by mixing the micelle solution with water and subsequent settling to the division of two phases (isooctane – water). In this case, the bottom (water) phase became the bright yellow color as a result of the nanoparticle transition from the reverse micelle solution. At the interphase boundary, the AOT interlayer was formed, and the adjacent water layer grew turbid a little. To conduct further study, transparent water phase layer was chosen.

The formation of silver nanoparticles was controlled by the appearance of the plasmon peak in electron spectra of the micelle solution and aqueous dispersion, which were recorded with spectrophotometer Shimadzu UV-1800 in the range of 300-600 nm. The band of the plasmon absorption for silver nanoparticles in the aqueous dispersion was 399 nm; for the micelle solution – 407 nm [3]. A small shift of the plasmon peak to the short wavelength range for the aqueous dispersion is due most likely to the change in the medium polarity near the nanoparticle surface (Fig. 1).

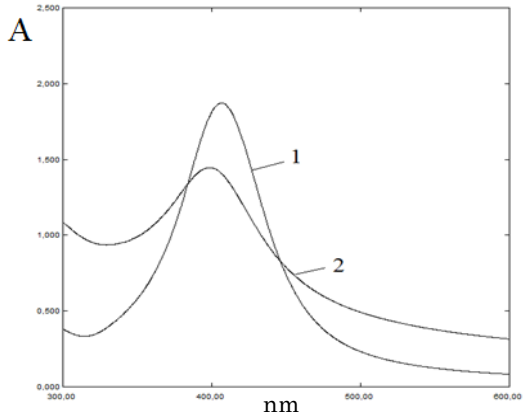

Fig. 1 – Electron spectra of plasmon absorption for silver nanoparticles in: 1 – reverse micelle solution; 2 – aqueous dispersion

The size of silver nanoparticles was measured with small-angle X-ray scattering (SAXS) technique at diffractometer SAXSessmc[2] (Anton Paar, Austria) in the linear collimation mode (CuK_α with a wavelength of

0.154 nm) in the range corresponding to the entities with sizes from 0.12 to 100 nm.

According to SAXS, the silver nanoparticle size distribution had a maximum of 2.5 nm (Fig. 2) [3, 4].

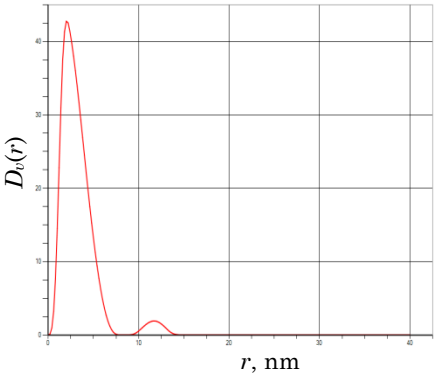

Fig. 2 – Silver nanoparticle size distribution in aqueous solution according to SAXS

The talc powder is used mainly as a neutral humidity absorber, specifically, in baby powders. However, its application is contraindicative when there are open wounds and pustular sites. Obtained and examined aqueous dispersion was used to modify the talc surface with silver nanoparticles. The nanoparticles were introduced into the talc powder with ultrasound mixing.

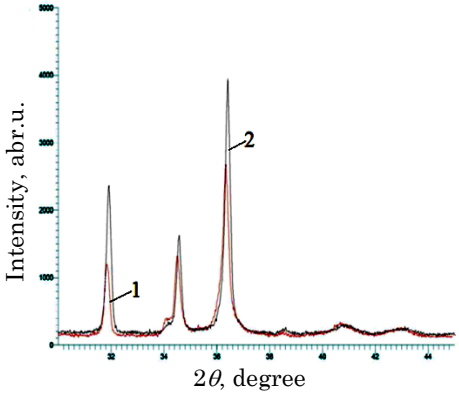

Fig. 3 – Diffractogramsof the X-ray phase analysis: 1 – original talc; 2 – talc modified by silver nanoparticles

Energy dispersive analysis done at scanning electron microscope JEOL 6610LV with an analyzer (Oxford Instruments X-Max Silicon Drift Detector 20 mm^2) corroborated theimpregnations of silver (around 1.87 %) at talc surface. Phase analysis conducted at X-ray powder diffractometer GBC EMMA revealed that in the modified talk in contradistinction to the original reflexes turned significantly wider and their intensity increased (Fig. 3).

Using changes in the diffractogram of the modified talc, according to the Debye-Scherrer formula the area of a coherent scattering (ACS) was calculated:

$$D = \frac{0.94\lambda}{\beta \cos\theta}, \qquad (1)$$

where D is the size of ACS, nm; λ is the wavelength of X-ray radiation ($\lambda = 0.154$ nm); θ is a diffraction angle, deg.; β is the line broadening, deg. The lines broaden in the diffractogram was determined according to [5, 6]:

$$\beta = B - b, \qquad (2)$$

where B is the line width (2θ), b is the standard line width (in scale 2θ).

Calculated, according to (1) and (2), the average size of silver nanoparticles was 2.7 nm, which is in accordance with the results obtained by SAXS technique.

3. CONCLUSIONS

The following conclusions can be made:

In the system of reverse micelles of AOT silver nanoparticles have been synthesized and evolved into water; they were characterized by SAXS.

The composition of talc modified by silver nanoparticles has been areas developed.

Energy dispersive analysis and the existence of the coherent scattering on X-ray patterns have supported the presence of silver particles on the talc surface.

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