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HIERARCHICAL ALUMINUM OXYHYDROXIDE AS NANOPARTICLES CARRIER

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The hierarchically organized aluminum oxyhydroxide with the boehmite structure has a rigid spatial shape resembling a flower with nanosheets – petals radially diverging from the center of the nanoparticles and most of the accessible surface. This allows its use as a matrix for stabilization and spatial distribution of metal nanoparticles and their oxides while maintaining their chemical activity. There are two approaches to obtain such structures: the modification by nanoparticles of previously formed hierarchical particles of oxyhydroxide or alumina and the preparation of complex hierarchical structures by hydrolysis of nanoparticles of the composition Al-M, where M is another metal, for example, Cu, Zn, Fe, Ag. The first approach is implemented in the deposition of colloidal particles, for example, in the deposition of colloidal silver on nano-sheets of hierarchical aluminum oxyhydroxide, when it is immersed in a solution of colloidal silver. Silver nanoparticles are stable, non-aggregated and firmly fixed on the surface of nanosheets due to physical adsorption. The structure of the composite hierarchical structures obtained in accordance with the second approach is determined by the nature of the second metal.

In this work, we studied the porous AlOOH-silver nanostructures obtained by both above methods. Porous AlOOH(Ag) structures were synthesized by treatment with a solution of colloidal silver of previously obtained hierarchical structures of AlOOH. The hierarchical structures of AlOOH-Ag were obtained by single-stage oxidation in water of the original two-component silver-aluminum nanoparticles obtained by the method of electric explosion of two twisted wires.

The number of silver nanoparticles deposited on the hierarchical structures of AlOOH is limited by the maximum concentration of a colloidal silver solution, in our case, 20 g/L. At a higher concentration of silver in the solution, the nanoparticles aggregate and precipitate. The use of bimetallic Al-Ag nanoparticles as precursors for the synthesis of hierarchical structures AlOOH-Ag makes it possible to introduce a large concentration of silver nanoparticles, and, therefore, increase the antimicrobial properties of hierarchical structures AlOOH-Ag in comparison with AlOOH(Ag).

The nanostructures are agglomerates up to 2 μm in size consisting of folded nanosheet structures of boehmite up to 200 nm in size and 2-5 nm thick. In the AlOOH-Ag sample, in addition to the boehmite phase, there are silver phases with a lattice parameter of 4.086 Å and $\text{Al}_{0.89}\text{Ag}_{0.11}$ solid solution. All samples are mesoporous materials with a typical hysteresis loop in the capillary condensation region, specific surface area of AlOOH is 340 m^2/g , AlOOH-Ag is 183 m^2/g , AlOOH (Ag) is 320 m^2/g . The nanostructures zeta potential is positive being 40 ± 6 mV, 26 ± 4 mV, and 34 ± 2 mV, respectively. These data indicate that the colloidal silver particles in sample AlOOH(Ag) partially block the active sites of boehmite and neutralize the positive charge.

Figure. 1. The number of living bacteria (CFU/ml) in suspension after contact with a sample of hierarchical structures

Секция 6. Иерархически организованные материалы и низкоразмерные структуры для биомедицинских приложений

Studies of the antimicrobial activity of AlOOH, AlOOH(Ag) and AlOOH-Ag on the example of Gram-positive (*E. coli*) and Gram-negative (*MRSA*) bacteria showed that AlOOH-Ag has the highest antimicrobial activity (Figure). The boehmite nanosheet structures were shown to adsorb *E. coli* bacteria effectively, but no death of adsorbed bacteria occurs, a similar effect is observed for *MRSA*. Thus, the presence of silver nanoparticles in composites gives them enhanced antimicrobial properties.

The proposed approach to stabilizing metal and oxide nanoparticles using hierarchical structures AlOOH can be extended to other applications, for example, catalysis.

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