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NEW MINERAL–ORGANIC COMPOSITES BASED ON ALUMINOSILICATE MINERALS FROM UKRAINE WITH SURFACE-IMMOBILIZED POLYMER MATERIALS

The current environmental situation in Ukraine is characterized by a rapid increase in the level of surface and groundwater pollution, largely resulting from the consequences of military actions, intensive industrial activity, and the disturbance of natural ecosystems. A large number of toxic compounds enter the aquatic environment, among which heavy metal ions are particularly dangerous. Their presence is a serious threat to the environment and human health, since these elements are capable of bioaccumulation and can cause chronic intoxication even at low concentrations.

Various technologies are currently used to remove heavy metals from industrial and domestic wastewater, including ion exchange, membrane filtration, and electrochemical methods. However, adsorption has advantages over these methods due to its high efficiency, environmental safety, and simplicity of implementation.

In accordance with the principles of “Green Chemistry”, one of the current areas of modern research is the development of effective, environmentally safe, and renewable sorbents designed to replace traditional synthetic sorbents. A promising solution in this context is the use of natural aluminosilicate minerals – saponite, bentonite, vermiculite, and zeolites. These compounds have a highly developed specific surface area, layered structure, significant cation exchange capacity, and resistance to aggressive environments, which ensures their effectiveness in the processes of purifying water from inorganic contaminants.

At the same time, natural minerals in their original state often demonstrate insufficient sorption activity because of the limited number of reactive centers on their surface. In order to increase their effectiveness, surface modification is carried out, in particular, immobilization of polymers containing amino-, nitro-, azo-, or quinoline fragments in the main chain. This modification promotes the formation of functional groups on the surface of the sorbent that can act as ligands, ensuring effective binding of metal ions in complexation processes. As a result, natural aluminosilicates are transformed into hybrid sorbents that combine the structural stability of an inorganic matrix with the high reactivity of a polymer component [1-2].

The study is devoted to a comprehensive investigation of the physicochemical and sorption properties of natural aluminosilicate minerals after immobilization on their surface polymeric materials, oxyquinoline derivatives.

Composites were obtained based on natural aluminosilicate minerals – saponite (Sap), vermiculite (Ver), bentonite (Bent) using two methods of fixing the organic carrier – immobilization *in situ* and adsorption of the previously synthesized copolymer oxyquinoline derivatives and methyl methacrylate in a molar ratio of 1:3, respectively. The structural and morphological characteristics of the synthesized materials were studied using low-temperature nitrogen adsorption-desorption, thermogravimetric analysis, infrared spectroscopy, and mass spectrometry. It was found that after modification, the specific surface area of composites decreased by 4-16 times, the average pore volume decreased by 2.5-5.7 times, and the average pore diameter increased by 1.4-3.2 times compared to the original minerals. SEM analysis showed that the polymer immobilized by the *in situ* method forms directly in the pores of the mineral, partially filling them, while the copolymer fixed by adsorption evenly covers the surface with a thin layer, which helps to reduce porosity and form a more homogeneous surface structure.

A comparative analysis of the sorption properties of the synthesized hybrid materials towards Cu^{2+}, Cd^{2+}, Fe^{3+} and Pb^{2+} ions showed that the adsorption efficiency significantly depends on the modification method. It has been established that composites obtained by copolymer adsorption are characterized by higher sorption activity compared to materials synthesized by the *in situ* immobilization method, which can be attributed to the higher polymer content on the surface and the more favorable spatial arrangement of functional groups capable of complex formation. The highest sorption capacity for Cd^{2+} and Pb^{2+} ions was found in the composite based on bentonite (*in situ*). The saponite-based composite (*in situ*) showed similar effectiveness to bentonite in terms of Pb^{2+}, doubling its extraction capacity after modification. The best results for Cu^{2+} sorption were observed in the composites based on saponite (*adsorb*) and vermiculite (*adsorb*), whereas vermiculite (*adsorb*) showed a 4-fold increase in sorption capacity relative to Fe^{3+} after modification.

References:

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