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Sorption properties of composite materials with a core-shell structure containing layered double hydroxides in the shell

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Abstract

The work is devoted to the study of the sorption properties of hierarchical composite materials with a core-shell structure. The composites contained a core of SiO_2 or Fe_3O_4@SiO_2 obtained by sol-gel synthesis, on the surface of which a layered double hydroxide (MgAlFe-LDH) was deposited. The phase composition of the obtained materials was determined, and the textural characteristics and particle morphology were studied. It was found that hierarchical materials had larger surface and demonstrated high sorption capacity towards both cationic and anionic dyes in aqueous solution in comparison with individual systems (SiO_2 and MgAlFe-LDH). It was shown that the sorption equilibrium in the system "dye solution – sorbent" for dye methylene blue was achieved faster in comparison with Congo red. The obtained kinetic data were analyzed using chemical kinetic models. The sorption of both Congo red and methylene blue on composite materials was found to be described by a pseudo-second order kinetic equation. Isotherms of sorption of Congo red and methylene blue on synthesized materials were plotted. The sorption capacity of Fe_3O_4@SiO_2@LDH and SiO_2@LDH towards Congo red were 0.19 mmol/g and 0.27 mmol/g, respectively. In the case of sorption of methylene blue, the sorption isotherms did not reach a plateau in the studied concentration range. However, it can be noted that at an initial methylene blue concentration of 0.051 mmol/L the sorption capacity of Fe_3O_4@SiO_2@LDH and SiO_2@LDH were 0.040 mmol/g and 0.033 mmol/g, respectively. The obtained data indicate that hierarchical composite materials containing LDH in their composition are effective bifunctional sorbents and can uptake both anionic and cationic forms of pollutants from a solution. An advantage of the Fe_3O_4 core system is its ability to be easily separate from a solution under the influence of an external magnetic field. It is important that the Fe_3O_4@SiO_2@LDH sample exhibits a typical superparamagnetic behavior with zero coercitivity and residual magnetic induction.

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