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Adsorptive Removal of 2,6-Dichlorophenol from Aqueous Solution by Surfactant-modified Palygorskite Sorbents: Equilibrium, Kinetics and Thermodynamics

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Abstract

Raw palygorskite was modified by the addition of selected surfactants, viz. hexadecyltrimethylammonium bromide (CTAB), cetylpyridinium bromide (CPB) and octadecyldimethylbenzyl ammonium chloride (ODBAC). These modified clays were used as sorbents for the adsorptive removal of 2,6-dichlorophenol (2,6-DCP) from aqueous solution. Characterization of the sorbents was achieved by Fourier-transform infrared (FT-IR) analysis, nitrogen adsorption/desorption measurements and particle-size analysis. The adsorptive performance of the modified palygorskites towards the removal of 2,6-DCP from aqueous solution was studied by batch methods. In addition, the influence of contact time, pH and temperature on the adsorption process was investigated in detail.

The equilibrium data for the three modified sorbents were well fitted by the Langmuir model. It was found that the monolayer adsorption capacity increased with increasing contact time and solution temperature, respectively. Application of the pseudo-first-order and pseudo-second-order kinetic models to the kinetic data showed that the pseudo-second-order kinetic model provided an excellent fit ($R^2 > 0.99$). In addition, the film diffusion, pore diffusion and intra-particle diffusion models were also used to investigate the adsorption mechanism. Intra-particle diffusional analysis indicated that 2,6-DCP molecules diffused rapidly during the initial adsorption stage, followed by a slower stage and finally the establishment of an equilibrium condition.

Thermodynamic studies showed that the adsorption of 2,6-DCP onto the three sorbents examined occurred spontaneously and that the process was endothermic in nature. The results indicate that the surfactant-modified palygorskite exhibited a significant potential as a sorbent material for the removal of phenolic compounds from aqueous solution.

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