

The adsorption of Reactive Black 5 by nanowire-synthesized nano-manganese dioxide and nano-manganese oxyhydroxide in a natural nanoclay substrate: an adsorption kinetics and isotherm study

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ABSTRACT

The compounds nano-manganese oxyhydroxide (γ -MnOOH) and nano-manganese dioxide (β -MnO₂) and their composites with montmorillonite (γ -MnOOH/M and β -MnO₂/M) were used for the first time to adsorb and remove the residual Reactive Black 5 (RB5) dye from textile industrial wastewater. The synthesis of γ -MnOOH and β -MnO₂ through the hydrothermal method resulted in the nanowire morphology of these compounds. Two new composites were synthesized by the interaction of these compounds with natural nanoclay montmorillonite. These compounds were able to penetrate montmorillonite nanolayers and intercalate them. The synthesized compounds and composites were characterized using Fourier-transform infrared spectroscopy, X-ray diffraction and scanning electron microscopy. The capacity of the compounds and composites to adsorb the RB5 was investigated in an artificial industrial wastewater. Both compounds and their composites were able to adsorb the dye and the results indicated the dependence of the adsorption capacity on different parameters, including pH, contact time, adsorbent dosage, and dye concentration. As expected, the composites showed a higher dye removal efficiency than the compounds, and the most sufficient dye adsorption (70%) was detected in the composite β -MnO₂/M for a dye concentration of 500 mg L⁻¹. The reusability of β -MnO₂ was also demonstrated for an efficient adsorption. The adsorption kinetics of compounds and composites followed the pseudo-second-order kinetic and the rate constants (k_2) of the compounds were higher than those of the composites. The adsorption isotherms of γ -MnOOH and β -MnO₂ corresponded to the Langmuir and Freundlich isotherms, respectively, and the adsorption isotherms of their composites followed the Langmuir isotherm. This study shows that nano-manganese compounds and their composites are efficient adsorbents for the removal of RB5 dye from industrial wastewater.

Keywords: Manganese oxyhydroxide; Manganese dioxide; Montmorillonite; Adsorption; Dye removal

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