Theoretical analysis of the adsorption properties of methyl violet dye on iron-doped mesoporous silica microspheres

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ABSTRACT

The optimum adsorption conditions of methyl violet (MV) dye from aqueous solutions by iron-doped mesoporous silica microspheres (Fe-MSM) were investigated through adsorption experiments to improve the effect of advanced treatment of dye wastewater. The novel adsorbents were characterized by X-ray diffraction, Fourier transform infrared spectroscopy, N₂ adsorption–desorption isotherms, and scanning electron microscopy. The effects of adsorbent dosage, adsorption time, initial dye concentration, and pH on the adsorption performance were analyzed. Given these effects, the kinetics equation, related parameters, and the adsorption mechanisms were obtained. Results indicate that the different Fe contents had a slight influence on the adsorption capacity of the samples. The adsorption efficiency reached 98% for an MV solution with an initial concentration of 50 mg/L, adsorbent dosage of 10 mg, equilibrium time for adsorption of 30 min, and an alkaline pH. The adsorption process followed the pseudo-second-order kinetic model. The intra-particle diffusion of dye molecules into interior surface was achieved through rate-controlled process, and further adsorption mechanisms were involved except for ion exchange. Fe-MSM could be an ideal material for the treatment of dyestuff wastewater because of its relatively high performance and rapid sorption velocity.

Keywords: Adsorption kinetics; Characterization; Fe-MSM; Methyl violet; Theoretical analysis