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Evaluation of the efficacy of halloysite nanotubes in the removal of acidic and basic dyes from aqueous solution

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Abstract

The present work describes the removal of Direct Red 81, Methyl Orange, Methylene Blue and Crystal Violet from aqueous solution using halloysite nanotubes. The clay mineral was physicochemically characterized using various methods. The influences of pH, interaction time, initial dye concentration, adsorbent amount and temperature on adsorption were monitored and interpreted. Although previous work has shown that acidic pH conditions favour the adsorption of pollutants from aqueous systems by clay materials, in this study maximum removal was possible over a wide range of pH conditions (pH ≥2–12). Adsorption was very rapid, and equilibrium was attained within 30 min. For all four dyes studied, chemical reaction seemed significant in the rate-controlling step, and the pseudo-second-order chemical reaction kinetics provided the best correlation of the experimental data. Thermodynamically, the process was spontaneous, with Gibbs energy decreasing with increasing temperature. Halloysite would be suitable for removing dyes from aqueous solution. This was further tested by using the halloysite nanotubes for the removal of complex dyes from printing and ink industry effluents.