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Synthesis of α-cellulose/magnetite/polypyrrole composite for the removal of reactive black 5 dye from aqueous solutions

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ABSTRACT

A composite was obtained from α-cellulose coated with magnetite nanoparticles and conducting polypyrrole (PPy). The magnetite nanoparticles were synthesized by the coprecipitation method from $FeCl_2$ and $FeCl_3$ salts. The composite was obtained by pyrrole polymerization in the presence of a mixture of α-cellulose and magnetite nanoparticles. The magnetite nanoparticles and composite were characterized by FTIR and UV/Vis-NIR spectroscopies, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), X-ray diffraction (XRD), and thermogravimetric analyses (TGA). XRD analysis demonstrated that magnetite nanoparticles with the typical cubic structures of Fe_3O_4 were obtained. SEM analysis showed that magnetite nanoparticles had irregular morphology with average size of 13 nm, whereas the composite consisted of spherical nanoparticles of PPy coating α-cellulose fibers and magnetite nanoparticles. Batch aqueous adsorption experiments of the reactive black 5 (RB5) dye onto the synthesized material were conducted. The results showed that for the adsorption experiments set to initial pH of 3.0; the maximum adsorption capacity was 62.31 mg of dye g^{-1} of composite, while a value of 21.67 mg of dye g^{-1} of composite was obtained when the initial solution pH was set to 7.0. Adsorption isotherms for the RB5 dye were well described by the Langmuir model. The transient adsorption process of the RB5 dye onto the composite was described by a general three-resistance model; allowing the estimation of the effective diffusivity, D_0, and the adsorption rate coefficient, k_1. For the adsorption experiments with an initial pH value set to 3.0, D_0 was estimated at 4.37×10^{-11} m^2 s^{-1} while k_1 was 7.30×10^{-7} L mg^{-1}.s.

Keywords: Cellulose; Magnetite nanoparticles; Polypyrrole; Dye adsorption; Composite

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