Removal of anionic dyes from aqueous solution by adsorption onto amino-functionalized magnetic nanoadsorbent

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ABSTRACT

The amino-functionalized magnetic nanoadsorbent Fe₃O₄@SiO₂-NH₂ was prepared and it was characterized by X-ray powder diffraction, transmission electron microscopy, Fourier transform infrared (FT-IR) spectroscopy, and thermogravimetric analysis (TGA). The adsorption of anionic dyes including Acid Orange II (AO II) and Reactive Brilliant Red X-3B (X-3B) onto Fe₃O₄@SiO₂-NH₂ was investigated. The results showed that Fe₃O₄@SiO₂-NH₂ exhibited efficient adsorption for these anionic dyes under acidic conditions, and it was proposed to proceed via electrostatic attraction and hydrogen bonding between the positively charged protonated amino groups (–NH₃⁺) on the adsorbent surface and the negatively charged sulfonate groups (–SO₃⁻) of the dyes. The mechanism was supported by density functional theory (DFT) calculations. The adsorption kinetics for AO II and X-3B on Fe₃O₄@SiO₂-NH₂ followed the pseudo-second-order kinetic model, and the adsorption equilibrium data fitted well with Langmuir isotherm model. The maximum adsorption capacities for AO II and X-3B at pH 2 under room temperature were 132.2 and 233.1 mg g⁻¹, respectively. Desorption of dyes and regeneration of the adsorbent were carried out using aqueous solution at pH 10. The adsorbent Fe₃O₄@SiO₂-NH₂ could be easily recovered by external magnet and it exhibited good recyclability and reusability for three cycles use.

Keywords: Anionic dye removal; Adsorption; Wastewater treatment; Magnetic silica; Amino-functionalized nanoparticles

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