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Enhanced adsorptive degradation of Congo red in aqueous solutions using polyaniline/Fe^0 composite nanofibers

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Abstract

In this study, a simple approach was described for the fabrication of composite nanofibers (CNFs) of polyaniline/Fe^0 (PANI/Fe^0) using a template-free method for the reductive degradation and removal of Congo red (CR) from aqueous solutions. The PANI/Fe^0 CNFs were prepared via rapid mixing polymerization of aniline monomers with Fe(III) chloride as an oxidant, followed by reduction of polymerization by products (Fe(II)/Fe(III)) as the Fe precursor. The PANI/Fe^0 CNFs were characterized by Field Emission-Scanning Electron Microscopy (FE-SEM), High Resolution-Transmission Electron Microscopy (HR-TEM), Brunauer–Emmett–Teller (BET) method, X-ray Diffraction (XRD), Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR), X-ray Photoelectron Spectroscopy (XPS) and Vibrating Sample Magnetometry (VSM). These CNFs exhibited enhanced performance relevant to the adsorptive degradation/decolourization of CR, compared to PANI NFs and Fe^0 nanoparticle counterparts. Batch experiments with a minimum dosage (1 g/L) of PANI/Fe^0 CNFs showed complete degradation of 50 mg/L CR after 5 min of reaction. The CR degradation efficiency increased with decrease in initial concentration and solution pH, whereas it decreased with decrease in dosage of the CNFs. The CR degradation rate followed a pseudo-first-order kinetic model. Identification of the CR degradation products using liquid chromatography–mass spectrometry (LC–MS) revealed that the degradation mechanism proceeds through reductive cleavage of the azo linkage, resulting in the formation of 4-aminonaphthalenesulfonate ions and surface-adsorbed aromatic species, all being adsorbed on the CNFs surface at higher dosage. Six consecutive CR removal experiments using the same CNFs demonstrated that the CNFs retained the original CR removal efficiency up to 5th cycle, confirming their high recycling ability. Finally, the CNFs could be separated from the degradation fluid by exploiting external magnetic field.