Simultaneous removal of mixture of dyes aqueous solutions by magnetic nanocomposite of multi-walled carbon nanotubes: Response surface modeling and kinetic studies

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In this research work, the adsorption method was used for simultaneous removal of methylene blue (MB) and methyl orange (MO) dyes aqueous solutions. The magnetic nanocomposite of multi-walled carbon nanotube (MMWCNT) was employed as adsorbent and the removal process was optimized by the response surface modeling. The magnetic nanocomposite was prepared by the synthesis of iron oxide magnetic nanoparticles in presence of multi-walled carbon nanotubes by the chemical reduction at room temperature and was characterized by scanning electron microscopy, Fourier transform infrared spectrometry and X-ray diffraction. The experiments were conducted based on a Box-Behnken experimental design with four variables including adsorbent dosage (0.8□2 g L-1), solution pH (3□9), contact time (30□50 minutes) and ionic strength (0.02□0.1 mol L-1). Regression analysis of the experimental data resulted in the second-order models with coefficients of determination of 0.976 and 0.989, and Fisher's ratios of 22.36 and 12.38, for MB and MO, respectively. Results of the analysis of variance, lack of fit test and residual analysis validated the quality of the developed models. Based on the second-order models, the optimum conditions for simultaneous removal of the dyes by the magnetic nanocomposite was predicted as the adsorbent dosage of 2 g L-1, pH=5, contact time of 48.5 minutes and ionic strength of 0.02 mol L-1 with the responses of 98.84 and 95.65 percents for MB and MO dyes, respectively. Experimental test under the optimum conditions resulted in the removal percantage of 98.38□0.29 for MB and 94.64□0.22 for MO, which proved high accuracy of the response surface modeling method in optimizing simultaneous removal of the studied dyes aqueous solutions.

Equilibrium adsorption data in both systems of single dye and binary mixture followed Langmuir isotherm for MB and Tempkin isotherm for MO. Moreover, the experimental adsorption data of the dyes onto the magnetic nanocomposite showed good agreement with the pseudo second-order kinetic model.

Keywords : Adsorption; Response surface modeling; Multi-walled carbon nanotube; Magnetic nanocomposite; Methylene blue; Methyl orange