Removal of methylene blue from aqueous solution by mesoporous silicalite-1 synthesized using carboxymethyl cellulose as template

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Abstract

In the present work, we have developed a mesoporous silicalite-1 using CMC as a template for the removal of MB from aqueous solution. The synthesized silicalite-1 were characterised using scanning electron microscopy (SEM), transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD), thermogravimetric analysis (TGA), Energy-dispersive X-ray spectroscopy (EDX) and N₂ adsorption-desorption isotherm (BET). XRD and FTIR analysis confirmed the formation of crystallinity and development of MFI structure in the mesoporous silicalite-1. The adsorption of MB dye on mesoporous silicalite-1 was conducted by batch adsorption method. The effect of various parameters such as adsorbent dosage, initial dye concentration, contact time and temperature on the dye uptake ability of silicalite-1 was investigated. The operating parameters for the maximum adsorption are silicalite-1 dosage (0.1 wt%), contact time (240 min), initial dye concentration (10 ppm) and temperature (30°C). The MB dye removal onto mesoporous silicalite-1 followed pseudo-second-order kinetic and Freundlich isotherm. The silicalite-1 exhibits 86% removal efficiency even after six adsorption-desorption cycle. Therefore, the developed mesoporous silicalite-1 is an effective eco-friendly adsorbent for MB dye removal from aqueous environment.

Full Text

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Figures

Figure 1

Structural formula of methylene blue

Figure 2

Powder XRD patterns and FTIR spectra of conventional and mesoporous silicalite-1

Figure 3

SEM micrographs of (a & b) conventional and (c & d) mesoporous silicalite-1

Figure 4

TEM images of mesoporous silicalite-1

Figure 5

(I) N₂ adsorption isotherms of: a) conventional b) mesoporous silicalite-1; (II) pore size distribution of: a) conventional b) mesoporous silicalite-1

Figure 6

TGA curves of conventional and mesoporous silicalite-1 and the corresponding DTG curves are given at the inset

Figure 7

EDS image of mesoporous silicalite-1

Figure 8

Effect of various parameters on the adsorption of MB onto mesoporous silicalite-1 a) silicalite-1 dosage b) initial dye concentration c) contact time d) temperature on the adsorption process (adsorbent dosage = 0.10 wt%, initial MO concentration = 10 ppm, contact time = 240 min and temperature = 30°C)

Figure 9

a) pseudo-first-order b) pseudo-second-order models for the adsorption of MB dye onto mesoporous silicalite-1

Figure 10

Isotherm model plots for the adsorption of MB a) Langmuir isotherm b) Freundlich isotherm

Figure 11

Reusability performance of adsorption of MB onto mesoporous silicalite-1