Highly efficient ultrasonic-assisted removal of methylene blue from aqueous media by magnetic mesoporous silica: experimental design methodology, kinetic and equilibrium studies

Somaye Nourozi, Rouholah Zare-Dorabei*

Research Laboratory of Spectrometry & Micro and Nano Extraction, Department of Chemistry, Iran University of Science and Technology, Tehran 16846-13114, Iran, Tel. +98 21 77240646; Fax: +98 21 77491204; emails: zaredorabei@iust.ac.ir (R. Zare-Dorabei), somayenorooezi37@gmail.com (S. Nourozi)

Received 1 August 2016; Accepted 14 July 2017

ABSTRACT

In the present study, a magnetic mesoporous silica (SBA-15-HESI-Fe₃O₄) was used as adsorbent for removal of methylene blue from aqueous solution. Ultrasound irradiation was employed to accelerate chemical process. In this study, influence of different parameters such as pH, initial dye concentration (mg L⁻¹), adsorbent dose (mg) and sonication time (min) on adsorption process were investigated. Central composite design was performed to obtain the optimum levels of parameters using response surface methodology and to investigate the possible interaction between variables. Under the best condition (pH = 9, dye concentration = 25 mg L⁻¹, adsorbent dose = 10 mg and sonication time = 2.2 min), the experimental equilibrium data were fitted to various isotherm models such as Langmuir, Freundlich and Tempkin. The results revealed the suitability and applicability of the Langmuir model. Different kinetic models including pseudo-first-order and pseudo-second-order were assessed and it was found that removal process followed pseudo-second-order kinetics. Ultrasonic power had important role in shortening the adsorption time of ions by enhancing the dispersion of adsorbent in solution. Overall, the as-synthesized adsorbent showed high adsorbent capacity (qe = 172.3 mg g⁻¹) for successful dye uptake on the real wastewaters in a short time (2.2 min).

Keywords: Methylene blue; Magnetic mesoporous adsorbent; Wastewater; Sonication; Experimental design; Kinetic and equilibrium isotherms

* Corresponding author.