Cationic and anionic dye removal from aqueous solution using montmorillonite clay: evaluation of adsorption parameters and mechanism

Ponchami Sharmaa, Dipankar J. Boraha, Pankaj Dasb, Manash R. Dasca,

aMaterials Science Division, CSIR-North East Institute of Science and Technology, Jorhat 785006, Assam, India, Tel. +91 9864550510; email: ponchi.du@gmail.com (P. Sharma), Tel. +91 9706408960; email: dipankarjyotibora@gmail.com (D.J. Borah), Tel. +91 9957178399; Fax: +91 376 2370011; emails: mrdas@rrljorhat.res.in, mnshrdas@yahoo.com (M.R. Das)
bDepartment of Chemistry, Dibrugarh University, Dibrugarh 786004, Assam, India, Tel. +91 9435394373; email: pankajd29@yahoo.com

Received 22 May 2014; Accepted 12 February 2015

ABSTRACT

This paper deals with the removal of methyl green, a cationic dye, and methyl blue, an anionic dye, from aqueous system by adsorption onto the montmorillonite clay. The effect of different experimental conditions such as time, adsorbate concentrations, pH, temperature, and presence of other ions has been investigated. In order to understand the adsorption behavior of the dye molecules onto montmorillonite, the kinetics of the adsorption data were analyzed using different models such as pseudo-first-order, pseudo-second-order, intraparticle diffusion, Boyd, Elovich, Richi, and Bajpai model. This study shows that the adsorption maximum reached at 60 min and follows the pseudo-second-order kinetics. The adsorption isotherm has been investigated in the pH range of 4–9 at 25°C and analyzed with different models namely Langmuir, Freundlich, Sips, Toth, Temkin, Scatchard, and Dubinin and Raduskevich (D–R) models. The thermodynamic parameters such as the Gibbs free energy (ΔG°), enthalpy (ΔH°), and entropy (ΔS°) changes were calculated. The interaction of dye molecules onto montmorillonite has been investigated by X-ray diffraction analysis which indicates that adsorption takes place mainly into the interlayer region of the clay. Maximum removal of methyl green and methyl blue dye molecules up to 68.35 and 95.95%, respectively was achieved by adsorption of the dye molecules onto montmorillonite clay at pH 5 and 35°C.

Keywords: Montmorillonite clay; Adsorption; Kinetics; Isotherm; Thermodynamics

*Corresponding author.

1944-3994/1944-3986 © 2015 Balaban Desalination Publications. All rights reserved.