Chemical Engineering Journal 200–202 (2012) 59–67

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Anionic dye removal from aqueous solutions using modified zeolite: Adsorption kinetics and isotherm studies

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HIGHLIGHTS

- Zeolite is a natural, abundant and environmental friendly material.
- Zeolite has low cost and high ion exchange capacity.
- Modification of zeolite with hexamethylenediamine can be easily performed.
- The modified zeolite demonstrated a superior dye removal performance according to natural one.
- Removal efficiency of modified zeolite for both dyes is independent from solution of pH.

ARTICLE INFO

Article history:
Received 8 March 2012
Received in revised form 8 June 2012
Accepted 11 June 2012
Available online 21 June 2012

Keywords:
Zeolite
Modification
Anionic dye
Isotherm
Kinetic

ABSTRACT

The natural zeolite was modified with hexamethylenediamine (HMDA) and used as adsorbent to remove anionic dyes, namely Reactive Red 239 (RR-239) and Reactive Blue 250 (RB-250). And, the adsorption equilibrium and kinetic studies of anionic dyes were carried out. In presented work, the origin of the zeolite (Heulandite) used was in Turkey. The adsorption of reactive dyes on modified zeolite (HMDA-Z) was investigated by batch adsorption experiments. The effects of pH, temperature, sorbent dosage and the initial dyes concentrations were investigated. While the increase in temperature resulted in a higher RB-250 loading per unit weight of the modified zeolite, adsorption capacity of modified zeolite did not constitute a noticeable change for RR-239. As an additional factor effecting the removal of reactive dyes, the effects of competitive ions such as nitrate, sulfate and chloride were investigated. The adsorption results indicate that the natural zeolite had a limited adsorption capacity for reactive dyes but is substantially improved upon modifying its surfaces with HMDA. The isotherm data of both investigated dyes were analyzed by the Langmuir, Freundlich, and Redlich–Peterson isotherm model according to temperature. The most appropriate model for the equilibrium process of both dyes was the Freundlich model. The kinetic studies indicated that the adsorption of reactive dyes followed the pseudo-second-order kinetic. Thermodynamic calculations showed that the adsorption of both investigated dyes was a spontaneous and endothermic process for RB-250 and an exothermic process for RR-239.

1. Introduction

Dyes are significant pollutants causing environmental and health problems [1]. Most of them are toxic and even carcinogenic, and this constitutes a serious hazard for humans and aquatic animals [2]. A large number of dyes are commercially available and used in many industries, such as textile, printing, paper and plastics [3,4]. Dyes can be classified as anionic (direct, acid and reactive dyes), cationic (basic dyes) and non ionic (disperse dyes) [5]. However, reactive azo dyes constitute over 50% of all textile dyes used in the industry, and they are characterized by the existence of nitrogen–nitrogen double bonds (—N=N—) [6,7].

Removal of many reactive azo dyes from textile wastewater is difficult because of their highly solubility in water, complex structure and synthetic origin [8,9]. In the removal of dyes from wastewater mostly physical, chemical and biological methods such as flocculation, coagulation, precipitation, adsorption, membrane filtration, electrochemical techniques, ozonation and fungal decolorization have been used [10,11]. However, none of the methods described above have been completely successful in removing color from wastewater. In comparison with other techniques, adsorption is probably one of the simplest, low-cost and effective physical processes for the removal of dyes from wastewater [11–13]. Actived carbon is among the most effective adsorbent for the adsorption

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http://dx.doi.org/10.1016/j.cej.2012.06.038