Chemical Engineering Journal 220 (2013) 237–243

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Electrospun nanofiber membrane of PEO/Chitosan for the adsorption of nickel, cadmium, lead and copper ions from aqueous solution

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HIGHLIGHTS

- The selectivity adsorption of nanofiber membrane was in order of Pb(II)<Cd(II)<Cu(II)<Ni(II).
- The prepared nanofiber membrane was mesoporous.
- The mechanism of adsorption metal ions by the nanofiber membrane was physically.
- The metals adsorption capacity did not change after five sorption–desorption cycles.

ARTICLE INFO

Article history:
Received 16 October 2012
Received in revised form 3 January 2013
Accepted 5 January 2013
Available online 11 January 2013

Keywords:
PEO/Chitosan
Electrospinning
Nanofiber
Heavy metal
Adsorption

ABSTRACT

Poly ethylene oxide (PEO)/Chitosan nanofiber membrane was prepared by the electrospinning technique; afterward, the potential of the prepared nanofiber membrane for adsorption of nickel (Ni), cadmium (Cd), lead (Pb) and copper (Cu) from aqueous solution was investigated. The applied voltage, tip-collector distance and solution flow rate of electrospinning process were 20 kV, 13.5 cm and 0.5 mL h^{-1} respectively. The prepared nanofibers were characterized by Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM) and Brunauer–Emmert–Teller (BET) analysis. Based on results, the homogeneous electrospun nanofibers with the average diameter and surface area of 98 nm and 312.2 $m^2 g^{-1}$ were obtained respectively. Then, the adsorption experiments were carried out to investigate the effect of different adsorption parameters such as contact time, initial concentration and temperature in a batch system. The sorption selectivity of lead, copper, cadmium and nickel onto the membrane was in order of Pb(II)<Cd(II)<Cu(II)<Ni(II). The kinetic data of metal ions were analyzed by pseudo-first-order and pseudo-second-order kinetic models. Three isotherm models namely Freundlich, Langmuir and Dubinin–Radushkevich were applied to describe the equilibrium data of metal ions. The calculated thermodynamic parameters (ΔG°, ΔH° and ΔS°) showed that the adsorption of metal ions onto the PEO/Chitosan nanofiber membrane was feasible, spontaneous and endothermic. The reusability of nanofiber membrane for the removal of different metal ions was also determined after five sorption–desorption cycles.

1. Introduction

Removal of heavy metals from wastewater is a very important factor with respect to human's health and environmental considerations [1]. Several methods used for the removal of heavy metal ions from aqueous solutions include chemical precipitation, electrodialysis, membrane process and solvent extraction [2–5]. However, these techniques are associated with problems such as excessive time requirements, high costs and high energy consumption. In this way, adsorption method can be considered as an effective and widely used process due to its simplicity, moderate operational conditions and economical feasibility [6–8].

The most important property of any adsorbent is the surface area and structure. Furthermore, the chemical nature and polarity of the adsorbent surface can influence the attractive forces between the adsorbent and adsorbate. The nanofiber membranes prepared by the electrospinning method have unique properties such as high specific surface area and high porosity with fine pores. These properties caused to use electrospun nanofiber membranes for the removal of heavy metal ions [9–14]. In recent years, researchers used nanofiber membranes such as polyvinylpyrrolidone (PVP)/SiO_2 [15], PVA/SiO_2 [16] and PAN-oxime [17] for the removal of heavy metal ions.

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http://dx.doi.org/10.1016/j.cej.2013.01.021