Chemical Engineering Journal 200–202 (2012) 192–201

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Removal of cadmium from aqueous solution using mesoporous PVA/TEOS/APTES composite nanofiber prepared by sol–gel/electrospinning

Mohammad Irani [a,*], Ali Reza Keshtkar [b,*], Mohammad Ali Moosavian [a]

[a] Department of Chemical Engineering, Faculty of Engineering, University of Tehran, Tehran, Iran
[b] Nuclear Fuel Cycle School, Nuclear Science and Technology Research Institute, Tehran, Iran

HIGHLIGHTS

- The synthesized membranes were characterized by FTIR, SEM and BET analyses.
- The structure of PVA/TEOS/APTES composite nanofiber was mesoporous.
- The maximum adsorption capacity of cadmium adsorption was 327.3 mg g^{-1}.
- The mechanism of cadmium sorption onto the nanofiber is chemisorption.
- The cadmium sorption onto the composite nanofiber did not change after 8 cycles.

ARTICLE INFO

Article history:
Received 28 April 2012
Received in revised form 12 June 2012
Accepted 13 June 2012
Available online 23 June 2012

Keywords:
PVA/TEOS/APTES
Nanofiber
Sol–gel
Electrospinning
Removal
Cadmium

ABSTRACT

The novel poly (vinyl alcohol)/tetraethylorthosilicate/aminopropyl triethoxysilane (PVA/TEOS/APTES) composite nanofiber was prepared by the sol–gel/electrospinning method and its application for the removal of cadmium from aqueous solution was investigated. The parameters of electrospinning process such as flow rate of spinning solution, applied voltage and tip–collector distance (TCD) were optimized for fabrication of homogeneous and fine fibers. As results, the fibers with the smallest average diameter of about 196.70 nm were obtained at the flow rate of 0.3 mL h^{-1}, applied voltage of 17.5 kV and TCD of 12.5 cm. Fourier Transform Infrared (FTIR) revealed the presence of amine groups in the structure of PVA/TEOS/APTES composite nanofiber. The result of pore volume calculation by BJH model showed that the structure of PVA/TEOS/APTES nanofiber was mesoporous. Experimental parameters affecting cadmium sorption onto the PVA/TEOS/APTES nanofiber such as pH, contact time, initial concentration and temperature were studied. The kinetic data were analyzed by the pseudo-first-order, pseudo-second-order and double-exponential kinetic models. The Langmuir, Freundlich and Redlich–Peterson isotherm models were applied to describe the equilibrium data of cadmium sorption onto the composite nanofiber. Thermodynamic parameters indicated that the cadmium adsorption onto the composite nanofiber was endothermic and spontaneous process. The reusability of the composite nanofiber was also determined after eight sorption–desorption cycles.

1. Introduction

Sol–gel technique is a suitable method for the preparation of organic–inorganic hybrids from precursors containing alkoxysilyl groups through steps of hydrolysis and condensation [1]. The silica-based adsorbents such as TEOS due to the large specific surface area were used widely in the removal of heavy metal ions [2,3]. Furthermore, the removal efficiency of metal ions increases remarkably in the wake of the adsorbent surface modification by the functional groups such as —NH_2, —SH and —S— groups [2,3] On the other hand, electrospinning technique is an efficient method for fabrication of sub-micron or nanoscale fibers [4–7]. Nanoscale fibers of silica materials prepared by sol–gel/electrospinnig technique have a large surface area and high porosity which these properties provide high separation efficiency. In recent years, researchers used from polyvinylpyrrolidone (PVP)/SiO_2 [8], PVA/SiO_2 nanofiber membrane [9] and amidoxime-modified polyacrylonitrile (PAN-oxime) [10] for adsorption of heavy metals from aqueous solutions.

In electrospinning technique, high voltage is applied between a nozzle and a collector where an electrically charged jet of polymer

* Corresponding authors. Tel.: +98 021 88765937 (M. Irani), +98 021 82064399 (A.R. Keshtkar).
E-mail addresses: irani_mo@ut.ac.ir (M. Irani), akeshtkar@aeoi.org.ir (A.R. Keshtkar).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.06.054