Colloids and Surfaces A: Physicochem. Eng. Aspects 415 (2012) 41–46

Contents lists available at SciVerse ScienceDirect

Colloids and Surfaces A: Physicochemical and Engineering Aspects

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

Efficient removal of heavy metal from aqueous solution by sulfonic acid functionalized nonporous silica microspheres

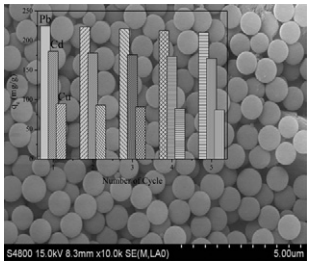
Qishu Qu*, Qian Gu, Zuli Gu, Yuqi Shen, Chengyin Wang, Xiaoya Hu

Jiangsu Key Laboratory of Environmental Materials and Environmental Engineering, College of Chemistry and Chemical Engineering, Yangzhou University, Yangzhou 225002, PR China

HIGHLIGHTS

- Nonporous thiol-functionalized silica spheres were prepared.
- The S content on the surface of particles is up to 36% (wt%).
- Sulfonic acid functionalized particles can be used to adsorb heavy metal ions.
- Adsorption capacity for Pb^{2+} was as high as 635 mg/g.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 28 June 2012
Received in revised form 25 August 2012
Accepted 30 August 2012
Available online 8 September 2012

Keywords:
Nonporous
Silica
Microspheres
Heavy metals
Sulfonic acid

ABSTRACT

Nonporous thiol-functionalized silica spheres (SiO_2—SH) were prepared by hydrolysis of 3-mercaptopropyltrimethoxysilane. Then, sulfonic acid functionalized silica microspheres (SiO_2—SO_3H) were prepared through direct oxidization of SiO_2—SH by H_2O_2 and used as adsorbent. The structure and surface of the adsorbent were investigated by field emission scanning electron microscopy, N_2 adsorption–desorption isotherm, Fourier transform infrared spectroscopy and electron diffraction spectroscope. The BET surface area of the particles is only 1.58 m^2/g. However, the content of thiol group on particle surface was as high as 36% (wt%). It was found that the SiO_2—SO_3H could effectively remove heavy metal ions (Pb^{2+}, Cd^{2+}, and Cu^{2+}) in solution through electrostatic interaction. When SiO_2—SO_3H with the particle size of 0.95 μm was used as adsorbent, the adsorption capacity for Pb^{2+}, Cd^{2+}, and Cu^{2+} reaches 635, 499, and 260 mg/g, respectively. The strong adsorption ability of SiO_2—SO_3H can be attributed to the nonporous particles with rich sulfonic group facilitating the mass transport of metal ions to the active sites. The adsorption isotherm data obey the Freundlich model. Kinetics of the metal ions removal was found to follow pseudo-second-order rate equation. pH values have only small influence on the adsorption capacity in the studied pH range. Consecutive adsorption–desorption experiments showed that SiO_2—SO_3H could be reused with only a slight loss in the adsorption capacity.

1. Introduction

Removal of heavy metals from natural and industrial wastewater has been drawing more and more attentions because of the high toxic effect of these contaminations to animals, plants, and human beings [1]. Various technologies, such as precipitation, ion exchange, reverse osmosis, membrane separation and adsorption have been developed for removing heavy metal ions from wastewater [2–5]. Among them, adsorption is the most promising and frequently used technique because of its simplicity, low cost and potential for overcoming the environmental problems. Therefore, extensive research effort has been directed toward the development of new adsorbents for the removal of heavy metals from wastewater.

* Corresponding author. Tel.: +86 514 87975590; fax: +86 514 87975244.
E-mail address: quqishu@gmail.com (Q. Qu).

0927-7757/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.colsurfa.2012.08.059