Chemical Engineering Journal 215–216 (2013) 461–471

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Pb(II) removal of Fe_3O_4@SiO_2–NH_2 core–shell nanomaterials prepared via a controllable sol–gel process

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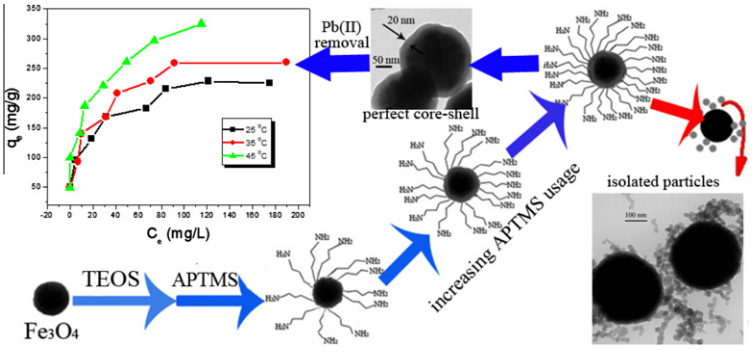
HIGHLIGHTS

- Green and facile synthesis process towards NH_2-terminal magnetic materials.
- Excellent uptake capability of adsorbent with high loading of NH_2-functionality.
- Detailed investigation of adsorption parameters on Pb(II) removal.
- Used nanomaterial can be easily separated by external magnet.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 8 August 2012
Received in revised form 7 November 2012
Accepted 8 November 2012
Available online 17 November 2012

Keywords:
Pb(II) ions
Amine-functionalization
Magnetic adsorbent
Adsorption
Kinetics

ABSTRACT

Contamination of natural water with heavy metals (especially lead ions) is a problem of major concern and thus great demand of effective adsorbents for removal of toxic ions is increasing. Due to the task-specific properties of amino groups, core–shell nanostructures of Fe_3O_4@SiO_2–NH_2 have been extensively investigated as advanced adsorbents; however, most studies on surface modification of Fe_3O_4@SiO_2 substances were of environmentally inefficient grafting methods. Herein, we demonstrated that monodispersed and spherical Fe_3O_4@SiO_2–NH_2 nanomaterials can be facilely prepared by co-condensation of TEOS with APTMS employing a green sol–gel process. The as-prepared Fe_3O_4@SiO_2–NH_2 magnetic nanoparticles (MNPs) prepared under optimum conditions possessing uniform core–shell structure (~200 nm in diameter), relatively high loading of amino-functionality (~5.45 wt%), easy recovery by external magnet and effective removal of Pb(II) (q_m = 243.9 mg/g, 25 °C). The adsorption was shown to be effective and a higher temperature was more favorable for the adsorption. The adsorption equilibrium data obeyed the Langmuir model and the kinetic data were well fitted to the pseudo-second-order model. Thermodynamic studies revealed the feasibility and endothermic nature of the system. These results demonstrated that the sol–gel produced Fe_3O_4@SiO_2–NH_2, due to its easy synthesis and recovery and eco-friendliness, can be a potential adsorbent for Pb(II) removal.

1. Introduction

With the increasingly discharged heavy metal-containing wastewater into the environment, removal of heavy metal ions from wastewater has been an extensive research topic. These pollutants are not biodegradable and tend to accumulate in living organisms and many heavy metal ions are known to be toxic or carcinogenic [1]. Lead and cadmium are regarded as two of the most hazardous substances, especially lead which can cause central nervous system damage; it can also damage the kidney, liver and reproductive system, basic cellular processes and brain

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http://dx.doi.org/10.1016/j.cej.2012.11.043