Chemical Engineering Journal 200–202 (2012) 149–157

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Heavy metal interactions with phosphatic clay: Kinetic and equilibrium studies

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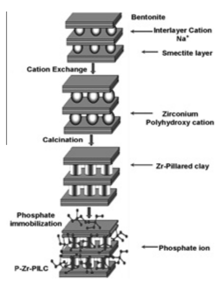
HIGHLIGHTS

- ▶ P—Zr-PILC was prepared by pillaring bentonite clay with Zr-polyhydroxy cations followed by phosphate immobilization.
- ▶ P—Zr-PILC characterized by means of FTIR, XRD, TG, SEM, and potentiometric titrations.
- ▶ P—Zr-PILC with increased surface negative charge be used for the adsorption of Hg(II), Cd(II) and Co(II).

GRAPHICAL ABSTRACT

Schematic representation for P—Zr-PILC preparation.



ARTICLE INFO

Article history:
Received 5 March 2012
Received in revised form 7 June 2012
Accepted 7 June 2012
Available online 16 June 2012

Keywords:
Zirconium pillared clay
Heavy metals
Adsorption
Isotherm
Desorption

ABSTRACT

A novel adsorbent, phosphate-immobilized zirconium pillared clay (P—Zr-PILC) was prepared by pillaring bentonite clay with Zr-polyhydroxy cations followed by phosphate immobilization using a batch reactor at pH 3.0. P—Zr-PILC was characterized by means of FTIR, XRD, TG, SEM, and potentiometric titrations. Adsorbent with increased surface negative charge can be used for the adsorption of Hg(II), Cd(II) and Co(II) from water and industry effluents. The effects of pH, contact time, initial concentration, adsorbent dose, and adsorption isotherm on Hg(II), Cd(II) and Co(II) adsorption onto P—Zr-PILC were evaluated using batch experiments. Maximum removal of 99.5%, 98.0%, and 97.2% for Hg(II), Cd(II), and Co(II) respectively was observed for an initial concentration of 5.0 mg L^{-1} at pH 6.0 and at an adsorbent dose of 2 g L^{-1}. Equilibrium was achieved in 4 h. The equilibrium data were fitted to the Redlich–Peterson isotherm model when compared with Langmuir and Freundlich isotherm models. The experimental kinetic data were analyzed using pseudo-first-order and pseudo-second-order kinetic models and film-diffusion process was found to be the rate limiting step for the adsorption of Hg(II), Cd(II) and Co(II) ions onto P—Zr-PILC. Desorption experiments showed that 0.2 M HCl can effectively desorb the adsorbed heavy metal ions and reusability of the adsorbent was tested by several cycles of adsorption–desorption experiments.

1. Introduction

Heavy metal pollution is spreading throughout the world with the expansion of industrial activities. It is well recognized that the presence of heavy metals in the environment can be detrimental to a variety of living species including man. Mercury(II) is one of the heavy metals of concern and has been found in the wastewaters coming from chlor-alkali manufacturing industry, oil refinery, paint, pharmaceutical, paper and pulp and battery manufacturing industries. The major effects of mercury(II) poisoning manifest as neurological and renal disturbances as it can easily pass the blood–brain carrier and affect the fetal brain. The carcinogenic potential of cadmium(II) in human beings and laboratory animals have been documented. Cobalt(II) intoxication causes paralysis, diarrhea, low blood pressure, lung irritations and bone defects. Unlike organic pollutants, heavy metals are non-biodegradable, hence removal of heavy metal ions from water and effluents become essential.

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http://dx.doi.org/10.1016/j.cej.2012.06.024