Chemical Engineering Journal 200–202 (2012) 426–432

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Synthesis and characterization of novel cation exchange adsorbent for the treatment of real samples for metal ions

S.A. Nabi *, A.S. Raeissi, Mohammad Shahadat, Rani Bushra, Amjad Mumtaz Khan

Analytical Research Laboratory, Department of Chemistry, Aligarh Muslim University, Aligarh, UP, India

HIGHLIGHTS

- Present work claims environmental applications of novel poly-o-toluuidineZr(IV)iodate.
- The material can be used for the treatment of Zr^{2+} ions from delta samples.
- This work describes good uptake capacity (1.5 meq g^{-1} for K^{+}) and chemical stability.
- The material has been characterized by using FTIR, TGA, XRD, SEM, TEM and UV–Visible spectrophotometry.

ARTICLE INFO

Article history:
Received 29 March 2012
Received in revised form 22 May 2012
Accepted 23 May 2012
Available online 28 June 2012

Keywords:
Synthesis
Characterization
Real samples
Heavy metal ions and analytical applications

ABSTRACT

Poly-o-toluidine based novel organic–inorganic hybrid ion exchange adsorbent has been synthesized via sol–gel process and characterized by FTIR, XRD, SEM, TEM and TGA studies. The physico-chemical properties such as ion exchange capacity, pH titration curves, chemical stability along with effect of eluent concentration and elution behavior were also carried out to exploit the ion-exchange capabilities. SEM analysis exposed that after binding inorganic precipitate with poly-o-toluidine the morphology of the composite material has been changed which is semicrystalline. The pH titration studies prove that material shows bifunctional strong cation exchange behavior. On the basis of chemical stability it can be successfully used in a number of solvent systems up to the concentration of 2 mol L^{-1}. Partition coefficients studies (K_d values) of divers metal ions were performed in some pure and mixed solvent systems by using this material. On the basis differential behavior of the material towards different metal ions it has been concluded to be selective for Ca(II), Sr(II), Zn(II), Cd(II) and Zr(IV) ions. To exploit the usefulness of the material as an adsorbent, some important quantitative binary separations of important metal ions were performed on poly-o-toluidineZr(IV)iodate columns. On the basis of good uptake capacity this composite ion exchange adsorbent has been successfully used for removal and recovery Zr(IV) and Cd(II) ions from real samples and synthetic mixture.

1. Introduction

Water pollution due to presence of heavy metal ions possesses a serious threat to living beings. These metals (Mercury, lead, cadmium, aluminum, arsenic, nickel, zinc, etc.) are detrimental to health for a variety of reasons and unfortunately are prevalent in the environment due to inconsiderable activities of modern society. They directly damage tissues which interfere with normal metabolic processes and depletion of essential nutrients leading to nutritional deficiencies and associated health concerns. Nutrition researcher Robert Goyer states that "Cadmium, lead, mercury, and aluminum are toxic metals that may interact metabolically with nutritionally essential metals" [1]. They accumulate in the food chain and water owing to high levels in particular locations. According to the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor, lead exposure affects numerous body systems and causes many forms of health impairment [2]. Cadmium tends to accumulate in the kidneys and is associated with renal damage [3], lower bone mineral density (BMD) also increased risk of fractures [4]. Other target organs for cadmium toxicity are the lungs, pulmonary oedema, and chemical pneumonitis [5]. Research has also shown cadmium play key role in thyroid hormone deficiency by interfering with the function of an important enzyme, due to free radical production and lipid peroxidation by the metal as an antioxidant [6]. To prevent the harmful effect of these metal ions it is very important to treat the contaminated water before useful purpose. Composite ion-exchangers have been found useful applications with definite advantages for the removal of metals ions from water bodies [7–11]. In our laboratory

* Corresponding author. Tel.: +91 571 2404014.
E-mail address: mdshahadat93@gmail.com (S.A. Nabi).

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http://dx.doi.org/10.1016/j.cej.2012.05.086