Chemical Engineering Journal 210 (2012) 590–596

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

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

Removal of nickel(II) ions by histidine modified chitosan beads

Ahmet Eser, V. Nüket Tirtom, Tülin Aydemir *, Seda Becerik, Ayşe Dinçer

Celal Bayar University, Faculty of Arts and Sciences, Department of Chemistry, 45140 Manisa, Turkey

HIGHLIGHTS

- ▶ Chitosan was functionalized with histidine for better nickel adsorption.
- ▶ Morphology of the sorbent were discussed using FTIR, TGA and SEM analysis.
- ▶ The incorporation of chelating groups can increase the adsorption capacity.
- ▶ Langmuir and Freundlich isotherms were used to fit the equilibrium adsorption data.

ARTICLE INFO

Article history:
Received 4 June 2012
Received in revised form 31 August 2012
Accepted 10 September 2012
Available online 20 September 2012

Keywords:
Ni(II) removal
Adsorption
Waste-water treatment
Kinetic parameters
Modification

ABSTRACT

In order to increase the nickel adsorption capacity of raw chitosan beads (CB), they were chemically modified with histidine (HIS–ECH–CB) by using crosslinking agent, epichlorohydrine (ECH). The nature and morphology of the sorbent were characterized using FTIR, TGA and SEM analysis. For optimization of adsorption conditions, sorption experiments were performed by varying contact time, pH, temperature and initial nickel concentration. Based on the adsorption experiment, the HIS–ECH–CB showed the significant adsorption capacity of 55.6 mg/g under the optimal adsorption condition. Nickel adsorption isotherms data were fitted to Freundlich isotherm. Thermodynamic parameters namely $\Delta G°$, $\Delta H°$ and $\Delta S°$ of the Ni(II) adsorption process were calculated. The negative values of Gibbs free energy of adsorption ($\Delta G°$) indicated the spontaneity of the adsorption of Ni(II) ions on the histidine modified chitosan. Desorption of Ni(II) ions from HIS–ECH–CB could be done rapidly by using 0.1 M HCl, HNO_3 and EDTA solutions and the beads could be used again to adsorb Ni(II) ions.

1. Introduction

Ni(II) and its various compounds are extensively being used in various industries such as metal plating facilities, mining operations, fertilizer industries, tanneries, batteries, paper industries and pesticides, and wastewaters are directly or indirectly discharged into the environment, especially in developing countries. Removal of Ni(II) from industrial effluents has a primary importance because contamination of wastewater causes very serious health and environmental problems. Excessive accumulation of nickel might bring about serious lung and kidney problems [1,2]. Metals can be separated from other toxic pollutants, because they undergo chemically transformations. Also they are nonbiodegradable, and have great environmental, economic, and public health impacts [3,4]. Most methods which have been used to reduce metal concentration from industrial waste are chemical precipitation, ion exchange, membrane filtration, electrolytic methods, reverse osmosis, solvent extraction, and adsorption [5,6]. Some of these methods are limited by high operational cost and/or may also be inefficient in the removal of some toxic metal ions, mainly at trace level concentrations [6,8]. Adsorption techniques which have been used for metal ions removal from aquatic environment is the most frequently applied technique owing to its advantages such as variety of adsorbent materials and high efficiency at a relatively low cost. For an effective adsorption capacity, sorbents have a great importance. Biopolymers are part of a class of biosorbents used in pollutant removal from aquatic environments, and chitosan, which is the second most abundant biopolymer in nature, can be emphasized among them [9]. From the chemical point of view, chitosan is a poly (2-amine-2-deoxy-d-glucose), obtained through chitin, poly(*N*-acetyl-D-glucosamine) deacetylation in alkaline medium. This polymer is soluble in dilute organic acid solutions, such as acetic, propionic, formic and lactic acid. Chitosan has excellent properties for the adsorption of metal ions, principally due to the presence of amino groups ($-NH_2$) in the polymer matrix, which can interact with metal ions in solution chelation and complexation reactions. The high content of amino groups also makes possible many chemical modifications in polymer with the purpose of improving its features as an adsorbent, such as selectivity and adsorption capacity [10]. Therefore cross-linking process can

* Corresponding author. Tel.: +90 2362013176; fax: +90 2362412158.
E-mail addresses: ahmet.eser@cbu.edu.tr (A. Eser), aydemirt@yahoo.com (T. Aydemir).

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http://dx.doi.org/10.1016/j.cej.2012.09.020