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L-Methionine modified Dowex-50 ion-exchanger of reduced size for the separation and removal of Cu(II) and Ni(II) from aqueous solution

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HIGHLIGHTS

- L-Methionine functionalized reduced size Dowex-50 (RDS-50) has been prepared.
- RDS-50 had maximum sorption capacitates 83.3 and 71.4 mg g^{-1} for Ni(II) and Cu(II).
- Langmuir model and pseudo second order kinetics described the adsorption.
- The 93% and 87%, Ni(II) and Cu(II) were regenerated from used RDS-50.

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ABSTRACT

Reduced size Dowex-50 (RDS-50) ion-exchanger was developed via a simple thermal treatment of commercial Dowex-50 in presence of L-methionine. Fourier transform infrared spectroscopy, scanning electron microscopy, energy dispersive X-ray spectroscopy and N_2 adsorption/desorption isotherms studies were performed to confirm functional groups, surface morphology, BET surface area and pore size of RDS-50 ion-exchanger. RDS-50 ion-exchanger was applied for the removal of Ni(II) and Cu(II) from aqueous solution under different experimental conditions such as contact time, solution pH, initial metal ion concentration and temperature. The equilibrium adsorption data were analyzed in detail using Langmuir, Freundlich and Temkin models. Adsorption kinetic study was conducted to fit the pseudo-first-order, pseudo-second-order and the intra-particle diffusion models. The adsorption isotherm experiments revealed that adsorption of Ni(II) and Cu(II) from aqueous solution onto RDS-50 ion-exchanger was fitted for Langmuir model. The maximum adsorption of Ni(II) and Cu(II) onto the RDS-50 ion-exchanger from aqueous solution was found to be 83.33 and 71.43 mg g^{-1}. The adsorption of Ni(II) and Cu(II) onto the RDS-50 ion-exchanger followed the pseudo second order kinetic model. The 87% Cu(II) and 93% Ni(II) were desorbed in 0.10 M HCl solution.

1. Introduction

Heavy metal ions contamination in water has become a worldwide environmental concern and problem. Microelectronics, electroplating, batteries manufactures, metallurgical, and fertilizer industries are the major sources for heavy metal ions contamination in water. The releasing of heavy metal ions into streams, lakes, rivers and groundwater through the breakdown of soils due to acid rain is also responsible for the contamination of water. Heavy metal ions enter into the human body by inhalation, ingestion and skin adsorption. The heavy metal ions in excess quantity are harmful to humans, animals and plants due to their accumulation in the body and plants [1–3]. Nickel comes into water from metal plating industries, cadmium–nickel batteries, phosphate fertilizers, mining, pigments, alloy industries and sewage sludge. Ni(II) creates renal damage, emphysema, hypertension and testicular atrophy diseases [4–6]. The electroplating, and metal finishing industries are mainly responsible for Cu(II) contamination in water. The high concentration of Cu(II) is often found to be high near mines, landfills and waste disposal sites. Cu(II) in excess amount creates itching, dramatization and keratinization of hands and feet. Severe gastro-intestinal irritation and the problem in liver and kidney are occurred due to the excessive intake of Cu(II). Inhalation of copper spray increases the chance of lung cancer in exposed workers [7–9]. Therefore, the heavy metal ions contaminating wastewater must be treated before release into main stream of water. The chemical precipitation, filtration, electrochemical treatments,

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