Functionalized Hydrogel for Adsorption and Recovery of Bismuth from Contaminated Aqueous Solutions

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Introduction

The field of adsorbent materials for metal ion adsorption has increasingly become saturated with both natural and synthetic materials, each of equally variant proposed adsorption mechanisms. Instead, focus of recent researches has shifted towards search for adsorbents that facilitate high selective adsorption of particular target metal ion substrates from competitive environments of similar ions. These adsorbents should also be able to demonstrate high extraction efficiency from both high and low concentration media. This quest has created a niche for radiation physics as alternate method for new material synthesis. Accordingly, our research explores and proposes radiation synthesized hydrogel adsorbents infused with macrocyclic groups as alternate adsorbents for high selective capture, extraction and re-usability of heavy metal polluted waste waters.

Experimental

Hydrogel synthesis involved 1:1 coupling of maleic acid and bis (chloroethyl) ether monomers under high dilution environment and temperatures (96 ºC) to facilitate condensation coupling. The obtained product, in the presence of acrylic acid, was then exposed to ^{60}Co gamma radiation source for up to 24h at constant dose rate in order to promote radical polymerization and cross-linking process, eventually resulting into a hydrogel (BCE gel). Post synthesis processing involved cutting the gel into small fractions, rinsing in water to elute all unreacted materials and drying until constant weight. The dried adsorbents were analyzed for intrinsic and functional properties and adsorbent properties tested against various sets of aqueous transition metal ion solutions for their selective removal and recovery.

Results and Discussion

The reaction conditions undertaken herein were designed to promote the coupling, condensation and eventual transformation of hitherto linear ligands into possible functionalized cyclic polymer products with multiple-denticity. Gamma radiation exposure ensured a clean polymer synthesis method with minimal chemical contamination. The hydrogels adsorbent when analyzed using FTIR, revealed the carbonyl and ester groups, insinuating successful coupling of the monomers into a 4-oxygen donor atom cyclic ring.

Against a 14-metal aqueous multi-element solution of different initial concentrations, the hydrogel adsorbent demonstrated exceptional selectivity for only Bi metal, other metals notwithstanding. The BCE gel active sites have structural specificity and inclination for only Bi.

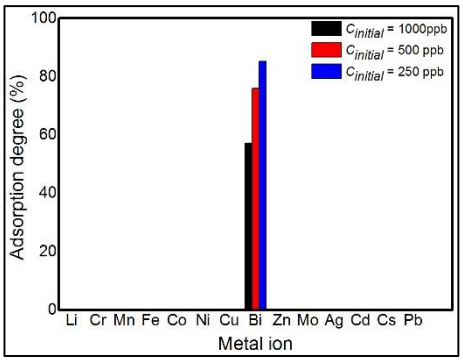

Fig. 1 competitive adsorption from 14-ion metal solution

Optimizing adsorbent parameters using sets of single ion Bi solution, a gel mass of 0.02g was found most apt for all concentrations up to 50ppm. Further, higher adsorption capacities could be achieved even at lower pollutant concentrations, showing that BCE gel can be effective for harvesting and recovery of this rare metal.

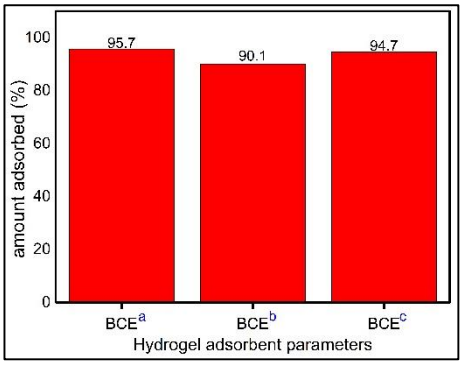

Fig. 2 Single ion Bi adsorption -a: C_0=20ppm, m = 0.02g; b: C_0 =20ppm, m = 0.04g; c: C_0 = 40ppm, m=0.04g

This gel work, demonstrating high macrocyclic effect, is important for Bi-pollution alleviation and recovery; and offers avenues for ultra-high adsorption selectivity.

Acknowledgement

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