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A new sorbent for europium nitrate extraction: phosphonic acid grafted on polystyrene resin

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Abstract A new chelating polymeric sorbent has been developed using polystyrene resin grafted with phosphonic acid. After characterization by FTIR and elementary analysis, the new resin has been investigated in liquid–solid extraction of europium(III). The results indicated that phosphonic resin could adsorb Eu(III) ion effectively from aqueous solution. The adsorption was strongly dependent on pH of the medium with enhanced adsorption as the pH value of 6.5. The influence of other analytical parameters including contact time, amount of resin, metal ion concentration, and ionic strength were investigated. The maximum uptake capacity of Eu(III) ions was 122.6 mg/g grafted resin at ambient temperature, at an initial pH value of 6.50. The overall adsorption process was best described by pseudo first-order kinetic. When Freundlich and Langmuir isotherms were tested, the latter had a better fit with the experimental data. Furthermore, Eu(III) could be eluted by using 1.0 mol/L H_2SO_4 solution and the grafted resin could be regenerated and reused.

Keywords Solid phase extraction · Ion exchange resin · Europium(III) · Supported phosphonic acid

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Introduction

One of the important processes in the management of nuclear wastes is the intra- and inter-group separation of lanthanides and actinides. For this goal, it is pertinent to search for new extraction system in addition to using familiar ones.

The most used methods for separation and pre-concentration of lanthanides include solvent extraction [1], ion exchange [2], adsorption [3], flotation [4], precipitation [5], co-precipitation [6], membrane dialysis [7], Cloud point extraction [8] and chromatographic extraction [9]. Most of these methods suffer from technical, economic and health problems related to selectivity, long time of extraction and large quantity of hazardous materials used.

One of the promising methods is the use of solid phase extraction by functionalized resins that have suitable functional groups capable of interaction with metal ions. The use of solid phase extraction have been proved to be more advantageous in view of their total insolubility in aqueous phase, low rate of physical degradation, high sorption capacity for metal ions, low organic solvent inventory and good flexibility in working conditions [10]. The organic extractant can be grafted to an inert polymeric support like polystyrene, and recently extraction of europium(III) ions from aqueous solutions was carried out using chelating resin with imino diacetate group (Tulsion CH-90 resin) [11], Amberlyst A-15 [12], resin containing bis(2,4,4-trimethylpentyl)dithiophosphinic [13], dipicolinic derivative coordination cages in styrene-based polymeric material [14], Amberlite XAD-7HP resin containing 1 wt% of the Kläui ligand [15], octyl(phenyl)-*N*,*N*′-diisobutyl carbamoylmethylphosphine oxide and polyacrylonitrile [16], phosphinic acid polystyrene resin [17] and di-(2-ethylhexyl) phosphoric acid (HDEHP)-Levextrel resin [18].