

Sorption efficiency of a new sorbent towards uranyl: phosphonic acid grafted Merrifield resin

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Abstract A novel sorbent resin consisting of a Phosphonic Acid grafted on Merrifield Resin (PA-MR) for the extraction of uranyl from nitrate media is described. The sorption behaviour of uranyl cation on PA-MR was investigated using batch equilibrium technique. The effects of parameters such as shaking speed, pH levels, contact time, metal concentrations, ionic strength and temperature were reported. The results show that the sorption capacity increases with increasing both initial uranyl ion concentration and temperature and decreases with increasing ionic strength. Therefore, the optimum condition for the present study should be using 6.6 mg adsorbent per 1.0 mg uranyl in solution with pH 3.6 and shaking at 250 rpm for 180 min. The adsorption behavior of the system was also investigated and found to be in line with Langmuir isotherm. The kinetic data was well described by the pseudo second-order. Thermodynamics data leads to endothermic process $\Delta H = + 31.03 \text{ kJ mol}^{-1}$, $\Delta S = + 146.64 \text{ J mol}^{-1} \text{ K}^{-1}$ and $\Delta G = -11.96 \text{ kJ mol}^{-1}$ at 20 K. ΔG decreased to negatives values with increasing temperature indicating that the process was more favoured at high temperature.

Keywords Uranyl sorption · Phosphonic acid grafted Merrifield resin · Kinetics · Thermodynamics · Diffusion

Introduction

Uranium and its compounds are potential toxic and radioactive environmental pollutants [1–3], especially in mining and nuclear industry, so the migration of uranium in nature is important in this context [4]. In the aim to eliminate and separate this pollutant from wastewater, many papers were reported separation and recovery of uranium from aqueous solutions [5, 6]. Various kinds of organophosphorous acids and esters liquids have been widely used for the separation and purification of uranium [7]. However, even with this extractants, a large number of separation steps are necessary and a high solvent consumption. Therefore, many types of adsorbents have been developed and studied for the recovery and separation of uranium from aqueous media such as impregnated silica [1], Amberlite XAD resins [8] and other materials [9–11]. But these methods usually give a reduced yield of extraction and necessities high dosage sorbent. Solid phase extraction (SPE) is the most common technique used for metal preconcentration in aqueous phase because of its advantages of high enrichment factor, high recovery, rapid phase separation, low cost, reversible process and low consumption of organic solvents [12, 13]. In SPE procedure, the choice of appropriate chelating agent is a critical factor to obtain full recovery and high enrichment factor. For this reason, the modification of resins with the organophosphorous reagents have been extensively carried out in several papers [14, 15].

In the present paper, a novel grafted polymer for extraction of uranium from nitrate aqueous media has been developed by grafting Merrifield chloromethylated resin with phosphonic acid (PA-MR). The grafting process is well characterized using FT-IR spectroscopy, ^{31}P and ^{13}C CP-MAS (cross-polarized magic angle spin) NMR spectroscopy and CHP elemental analysis. Various physicochemical

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