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TECHNICAL NOTE

Use of Weak-Acid Cation-Exchange Resins Purolite C105 (H^+) and Purolite C106 (H^+) for the Adsorption of UO_2^{2+}

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ABSTRACT

The polyacrylic weak-acid cation-exchangers Purolite C105 (H^+) and Purolite C106 (H^+) have been used in batchwise adsorption of UO_2^{2+} from nitrate solutions containing 0.01 M of UO_2^{2+} at pH 3.2. The two resins, which have a saturation capacity up to about 1.24 mmol UO_2^{2+} g^{-1} resin, showed rapid exchange kinetics. In addition, the resin Purolite C105 (H^+) displayed high UO_2^{2+} loading in small-scale column operations and retained its capacity after five cycles. Adsorbed UO_2^{2+} was rapidly and quantitatively eluted from this resin with 0.1 N H_2SO_4.

INTRODUCTION

The weak-acid cation-exchange resins have displayed several advantages for uranium recovery (1, 2). Probably the most important advantage in using weak-acid resins is that they are not prone to fouling or poisoning. Also, the carboxylic functional group of weak-acid resins is very stable, with little site deterioration over time. In addition to these factors, weak-acid resins retain their capacity almost indefinitely (3).

The primary objective of this paper is to provide experimental evidence with regard to the possibility of removing UO_2^{2+} by weak-acid cation-exchangers Purolite C105 (H^+) and Purolite C106 (H^+). Furthermore, experimental data for the adsorption of uranium in acidic medium will be provided.

EXPERIMENTAL

The resins used were Purolite C105 (H^+) and Purolite C106 (H^+), from Purolite International Ltd., acrylic-type weak-acid cation-exchangers (4). The commercial resin Dowex 50W (H^+), a strongly acidic cation exchanger, was supplied by Sigma Chemical. The resin Purolite C106 (H^+) was reacted with 1 M Na_2CO_3 to obtain the resin in the Na^+ form. Batch extractions were performed with 50 mg of each resin by reaction with a solution (20 mL) containing 0.01 M UO_2^{2+} as its nitrate, generally at pH 3.2 and 30°C. The determination of the UO_2^{2+} content of the supernatant was made colorimetrically according to the sodium salicylate method. The amount of UO_2^{2+} adsorbed was calculated as mmol UO_2^{2+} g^{-1} resin.

The columns employed for column extractions were made of glass tubing with an internal diameter of 0.7 cm. Each column was packed with 0.5 g wet-settled resin. The UO_2^{2+} nitrate solutions were delivered downflow to the column at a flow rate of 1 mL·min^{-1}. Each resin was loaded using a 50 mL UO_2^{2+} nitrate solution with a concentration of 0.01 M. Each column loaded with UO_2^{2+} was eluted with 0.25 M H_2SO_4 at a flow rate of 0.5 mL·min^{-1} (downflow). Stripping of resins loaded with UO_2^{2+} was performed using a variety of acid concentrations: 0.1, 0.25, 0.5, 1.0, and 2.0 N.

RESULTS AND DISCUSSION

Batchwise Adsorption of UO_2^{2+}

The details of the two resins used in this work, Purolite C105 (H^+) and Purolite C106 (H^+), are given in Table 1. Each resin was used in a batch process with a solution containing 0.01 M UO_2^{2+} as its nitrate, generally at pH 3.2 and 30°C. In order to obtain the relative performance of these two resins in kinetic terms, the adsorption of UO_2^{2+} was monitored with time, taking samples at 15 and 30 minutes, and at 1, 4, 8, and 24 hours. The loading profiles for Purolite C 105 (H^+) and Purolite C106 (H^+) are shown in Fig. 1. Purolite C106 (H^+) achieved full UO_2^{2+} loading more quickly than Purolite C105 (H^+). Even after 4 hours, Purolite C106 (H^+) was ~80% loaded. The value for Purolite C105 (H^+) was ~69%. The higher full loading capacity of Purolite C105 (H^+) can be attributed to its higher wet volume.

Subsequent kinetic performance tests were performed for Purolite C105 (H^+) and Purolite C106 (H^+) using UO_2^{2+} solutions with concentrations

TABLE 1
The Characteristics of Purolite C105 (H^+) and Purolite C106 (H^+)[a]

Resin	Structure	Type	Particle size (mesh size)	Water retention (%)	Total wet volume capacity (equiv./L)
Purolite C105 (H^+)	Gel	Weak acid, cation, acrylic	14–52	45–53	4.2
Purolite C106 (H^+)	Gel	Weak acid, cation, acrylic	14–52	48–53	3.0

[a] See Reference 4.

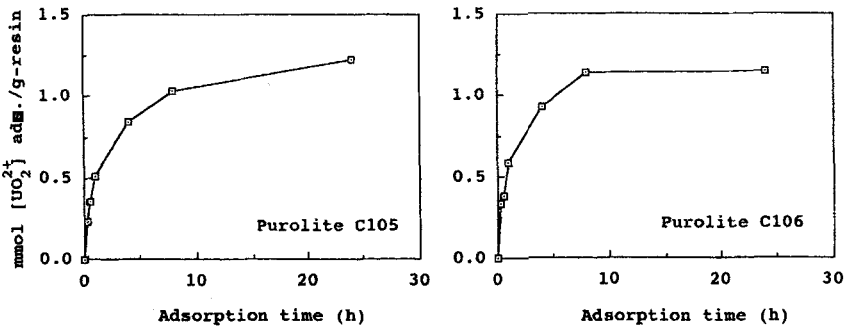

FIG. 1 Loading of resins using 0.01 M UO_2^{2+}, pH 3.2, and 30°C as a function of time.

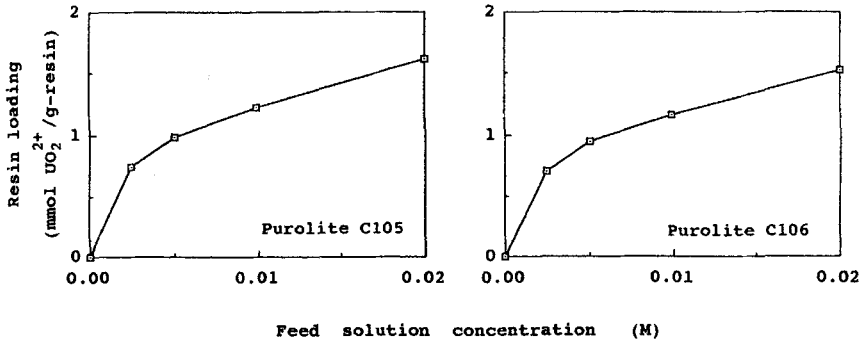

FIG. 2 UO_2^{2+} loading concentration isotherms, pH 3.2, 30°C, 24 hours.

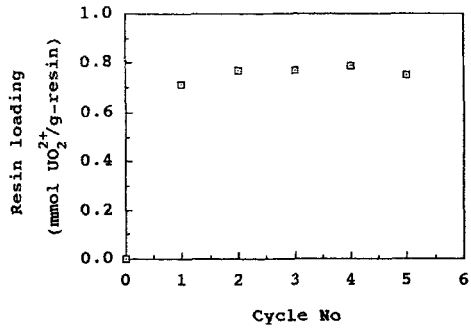

FIG. 3 Columnar UO_2^{2+} loading–elution cycles with the resin Purolite C105.

of 0.0025, 0.005, 0.01, and 0.02 M. The UO_2^{2+} loading capacities obtained were dependent upon the concentration of the feed solution. The two resins barely reached saturation even with a solution of 0.02 M (Fig. 2).

Columnar Adsorption of UO_2^{2+}

The recycling of the resin Purolite C105 (H^+) in terms of columnar adsorption of UO_2^{2+} was performed with high efficiency. After five loading–stripping–washing cycles, the resin capacity remained almost stable. Figure 3 shows the results. The data in Table 2 confirm that elution of UO_2^{2+} from Purolite C105 (H^+) was efficient with H_2SO_4 solutions. Elution was shown to be achieved by acid as low as 0.1 N in concentration (Table 2). The resin Purolite C105 (H^+) provided fast elution kinetics even with 0.1 N H_2SO_4.

A different approach to UO_2^{2+} loading is the use of the resins Purolite C106 (H^+) and Purolite C106 (Na^+) in sulfuric acid media. For compari-

TABLE 2
Stripping of Resins Loaded with UO_2^{2+} Using a Variety of Acid Concentrations

H_2SO_4 strip solution concentration (N)	mmol [UO_2^{2+}] adsorbed[a]	mmol [UO_2^{2+}] eluted[b]
2.00	0.311	0.240
1.00	0.273	0.210
0.50	0.316	0.257
0.25	0.330	0.254
0.10	0.400	0.317

[a] Adsorption: Resin, 0.5 g; columnar (downflow), 1 mL/min; 50 mL 0.01 M UO_2^{2+}.
[b] Elution: Columnar (downflow), 0.5 mL/min.

TABLE 3
The UO_2^{2+} Loading of Cation-Exchange Resins in H_2SO_4 Medium

Resin type	H_2SO_4 load solution concentration (N)	mmol $[UO_2^{2+}]$ adsorbed/mL resin[a]
Dowex 50 W (H^+),	1.0	0.036
strongly acidic	0.5	0.057
cation-exchanger	0.1	0.089
Purolite C106 (H^+)	0.1	0.007
Purolite C106 (Na^+)	0.1	0.014

[a] Adsorption: Resin 1 mL; 25 mL 1000 ppm UO_2^{2+} solution; columnar (downflow), 1 mL/min.

son, the strongly acidic cation-exchanger Dowex 50W (H^+) was used for UO_2^{2+} loading with a variety of acid concentrations. As summarized in Table 3, the strongly acidic cation-exchanger Dowex 50W (H^+) provided a significant advantage over the weak-acid cation-exchangers Purolite C106 (H^+) and Purolite C106 (Na^+). In a 0.1 N H_2SO_4 medium, the resin Dowex 50W (H^+) was ~96% loaded. In contrast, the performance of the weak-acid resins was poor due to their high affinity for hydrogen ion (Table 3).

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