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Original Research Paper

Selecting Suitable Resin for Parting Yttrium from Leaching Solution of Saghand Uranium Mine in Yazd, Iran

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ABSTRACT

This paper gives ion exchange and influence of different types of resins for separating existing yttrium in acid leaching solution of Saghand Mine in Yazd, Iran. Firstly, after doing XRF and ICP experiments on the sample, the resultant solution was assigned out of acid leaching of the region in contact with 0.5 mL resin (based on mass percentage) from different types of anion and cation resins. In each experiment 50 mL of the sample containing 500 ppm yttrium in a column was brought into contact with different types of prevalent resins. The resins were then brought into contact for 15 minutes to different types of elusion solutions. After the analysis the resin Dow × 5ow × 8 (H^+) was selected as the optimum resin in exposure to 1 mol/L sodium acetate as the elusion solution with retrieving 93% yttrium.

INTRODUCTION

Although, rare earth elements including yttrium are not generally known, they form the greatest group of the periodic table (Takaya 2006). The, rare earth elements can be found in copious amounts in two main ores, bastnasite which is a fluoride carbonate and monazite, which is a phosphate. These elements are very important in terms of biology-environment and economy to the extent that in 2000 the value of yttrium as a metal was estimated at $ 8000 per kg. China and United States of America are the greatest producers of these elements producing 100 kt and 40 kt every year respectively. In 2005, this amount was 8000 tons in China, which is expected to reach 12300 tons in 2010 (Cox 2006).

Abundance of rare earth elements is done in two steps. The first step involves separating elements from ore, which is done by high temperature acid leaching process in mine premises; the solution contains 70 to 90 percent rare earth element oxides. The second step is ore dressing, that is, purification; in this step ratio of rare earth elements is increased.

Retrieving elements from bastnasite or monazite minerals is done by using acid leaching. The resulting solutions from acid leaching of heavy minerals in the sample of Saghand are the experimental basis of this research. Presence of these resistant minerals in the sample causes difficulty in solving rare earth elements and prevention of their entrance to water phase. In this research, attempts have been made in studying the resulting solution from leach liquor using ion exchange method with the aim of determining a suitable resin for separating yttrium.

STUDY AREA

Saghand mine is situated in the centre of Iran and in the northeastern part of Yazd city about 190 km away from it. In the study area there are four types of Metasomatit stones including:

1. Carbonate-Quartz vein
2. Albite-Termolite vein
3. Termolite-Metasomatit vein
4. Albite-Metasomatit vein

In Iran, relatively extensive researches have been conducted for identifying Protozoa regions and examining the possibility of extracting uranium and rare earth elements (Chinese Expert Group 1990). The first investigated region was Saghand area located in central Iran and its exploratory activities dates back to 50 years. On the whole, studying the results of exploratory activities along with geophysical, geological, satellite, and exploratory information and overlapping them indicates that generation of mineral substances of this region is due to hydrothermal activity in a volcanic mass. This hydrothermal mass impacts volcanic mass according to which uranium is embedded there along with rare earth elements (Memar 1994).

MATERIALS AND METHODS

Due to relative environmental complications, there is anomaly no. 5 of Saghand in this study, and since rare earth elements have relatively similar chemical properties, thus, separating them is difficult. One of the effective processes for extracting and separating rare earth elements, especially yttrium, is ion exchange process.

Using simulated solution and column method, influential factors on separating yttrium have been investigated. Optimized results were generalized after XRF and ICP experiments on the samples of Saghand anomaly region containing U, Th, Zr, Y, V, La, Cr, Ce and Fe.

This process depends on different parameters such as amount of resin, type of resin, pH of elution solution, contact time of elution solution with resin, and type of elution solution. In this paper, influential parameters on absorbing yttrium have been examined and a suitable resin is selected.

Separation by using ion exchange method: Ion exchange is a process in which a solid phase and a solution phase exchange each others' ions. Solid phase involves cation or anion and solution phase involves an electrolyte solution (McCabe & Smith 2001). Exchanging ion resins include two main parts: one polymer organic network and one ion group which enter in ion exchange reactions (Frost & Emily 2002). The primary attempts were made in 1906 for using ion exchange resins in omitting impurity from water using natural and artificial silicates; the improved properties and artificial organic resins have extensively developed for potential application of ion exchange process due to their stability and high capacity.

Ion exchange is a recommended technique for condensation and purifying uranium and rare earth elements from leach liquor sulphate acid. Researches have provided the possibility of extensive use of ion exchange method for efficient separation of rare earth elements (IAEA 1990). As a general principle, leaching process is preferred with yttrium with less than 0.5 g/L through ion exchange.

In acid leaching process, solutions have disruptive elements such as SiO_2, Ni, Cu, V, Ti, Mg, Na, Fe and Al. Some of them with iron might have very higher condensation than rare earth elements.

Column method for separating rare earth elements: The ion exchange by resins is done in two

consecutive stages. Absorption stage and efficiency stage; and when a sample is inserted into a tube (column) containing solid phase it can bypass it or through solid phase it can interact and be preserved in the column as it can be observed in Fig. 1.

In the first phase the column with 50 cm height and 1 cm diameter containing solid phase is washed by methanol and in the next stage the solution inside the column is spilled and brought into contact with resin. In the next stages valuable substances, which are specified with circles in the figure, are absorbed by resin after a certain time, and superfluous substances specified with triangle are exited from the lower part of the column. In the following stage valuable substance is extracted from washed resin using a suitable washing solution.

Sample components proportionate with their chemical properties are absorbed by solid phase in different forces and, thus, the ground is paved for the possibility of separating. After sample absorption on solid phase, it is the turn of elusion solution to start operation and elute the samples and expels them from column; the major responsibility of eluent solvent is releasing sample from solid phase and expelling it from extracting column. Thus, in fact, the chemical properties of the sample, solid phase and elusion solution determine the practical work of this technique (Salaramoli 2002).

RESULTS AND DISCUSSION

Makers of different resins use different formulations and methods for making resins. The outcome is the same type resins but with different chemical and physical properties. Also, resins are made for specific applications; and according to the type of solution which should be arranged, producing method of resin differs. Selecting resin depends on many parameters such as selectiveness of an ion to another ion, dimensions of resin particles, pH of the environment, and physical properties (Unal 2007).

For separating rare earth elements, a series of particular resins are specifically used including DOWE × 50W × 8 (H^+), DOWE × 21k (H^+), DOWEX 1 × 4 (OH^-), Amberlite IRA400 (Cl^-) and Amberlite XAD-2 (Cl^-) with the size of 100-200 mesh which are designated in Table1 according to the type of resin and influential factors on yttrium efficiency amount.

The results offered in the table indicate that in absorption stage, when the solution containing yttrium, sodium, lanthanum, uranium, etc. with 0.5 mL DOWE × 50W × 8 (H^+) resin (based on mass percentage) is in contact as substance of absorbing yttrium, after ion exchanges between the solution and resin, the solution is expelled from column and 480 ppm yttrium remains on DOWE × 50W × 8

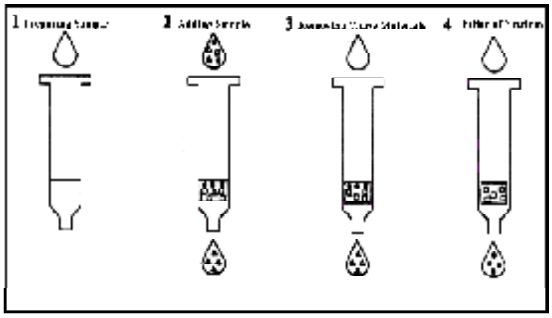

Fig. 1: Pattern of operating method of open extracting columns of solid phase (resin).

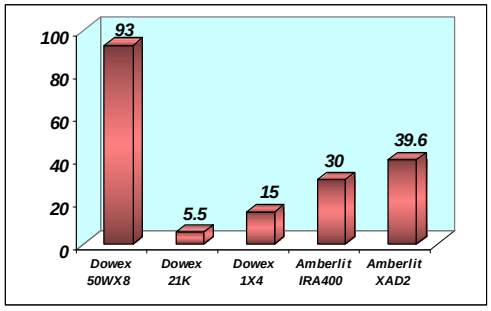

Fig. 2: Examining different types of resins for efficiency of yttrium separation.

Table 1: Investigating influential parameters on efficiency of yttrium separation.

Type of Resin	Amount of Yttrium (ppm)	Amount of Resin (mL)	Contact time of Elution Solution (min)	Type of Elution Solution	Extracted Amount of Yttrium (ppm)
DOWE × 50W × 8 (H^+)	500	0.5	15	CH_3COONa~	463
DOWE × 21K (H^+)	500	0.5	15	CH_3COONa~	27.5
DOWE × 1×4 (OH^-)	450	0.5	15	NH_4NO_3~	67.5
Amberlite IRA400 (Cl^-)	500	0.5	15	NH_4NO_3 ~	150
Amberlite × AD2 (Cl^-)	600	0.5	15	NH_4NO_3	237.6

(H^+) resin which is efficiency in the second stage. Optimizing conditions for separating yttrium emerge when there is maximum amount of yttrium in the solution; in this stage, acetate sodium (CH_3COONa) is used as a suitable elution solution. Optimum condition for using acetate sodium, pH = 5.5, and contact time of elusion solution with resin is considered 15 minutes; and out of 480 ppm in the resin, 463 ppm is extracted and the rest (17 ppm) remains on the resin. For extracting the remaining yttrium on the resin, repetition of retrieving stage (reusing acetate sodium solution) can be beneficial; of course, the repetition of this stage is acceptable in laboratory scale but it is not economical in industrial scale.

In Fig. 2, the extracted amount of yttrium is shown for different types of resins. The most amount of yttrium absorption with DOWE × 50W × 8 resin in the form of (H^+), is emerged with 100-200 mesh where yttrium absorption reaches 93%. In addition, absorption by other resins such as DOWE × 1 × 4(OH^-)15%, DOWE × 21k (H^+) 5.5%, Amberlite IRA400 (Cl^-) 30%, and Amberlite × AD2 (Cl^-) 39.6% has not been remarkable for absorbing yttrium.

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