

Solvent Extraction of Thorium and Europium using DEHPA and PC-88A

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Abstract

Objective

The object of this research is to study the ion-ligand bond during the solvent extraction process. Specifically, how many molecules of extractant bond to each ion to form the coordination complex. What – and how do – molecules interfere with or change the bonding process? These answers will lead to a broadening of the understanding of solvent extraction, and developments of new extractants. To this end the mole ratio between the extractant and the ion was varied in different trials, while the initial pH, temperature, total concentration of ligand plus metal ion, and pressure remained constant. This will lead to finding the empirical formula of the complex.

Findings

It was found that the experimental number of ligands to bond to europium was around 3.6, although more points were needed to determine this number more exactly.

While performing experiments with thorium, a clear precipitate was formed in all cases, although more prevalent in the lower ratios of ligand to thorium. In further thorium experiments, the total molar concentration will be lowered to prevent further precipitation.

Background

- Thorium is a slightly radioactive element that makes up about 0.0007 % of the earth's crust
- Thorium is primarily obtained from thorite ((Th,U)SiO₄), thorianite (ThO₂) and monazite ((RE, Th) PO₄)
- Because of its radioactivity, some rare earth deposits, if processed, would produce a hard to dispose of, radioactive gangue
- Europium is a rare earth element used in euro banknotes, nuclear reactor rods, and superconducting alloys
- The extractant used in this work is bis-(2-ethylhexyl) phosphoric acid (DEHPA)

Experimental procedure

- 1) 10 mL of organic solution was prepared with the correct molar ratio amount of extractant and the remaining in kerosene, and is shaken for five minutes to ensure dilution of extractant in kerosene
- 2) 10 mL of aqueous solution was prepared with the correct mole ratio of thorium stock solution in nitric acid, the rest being deionized water
- 3) pH is adjusted with NaOH and nitric acid until it reaches desired level, ~2 for europium samples, ~4 for thorium samples
- 4) Aqueous phase is added to organic in separatory funnel, then shaken for 15 minutes, venting pressure every five until equilibrium is reached. The shaking apparatus is shown in Figure 1.
- 5) Aqueous phase is collected and pH is measured
- 6) Inductively coupled plasma mass spectroscopy is performed on aqueous sample using model HP 4500 ICP MS
- 7) Amount in organic phase calculated to plot Job's Method of Continuous Variation



Figure 1. Photograph of the mixing system

Results

Figure 2 shows the Job's method plot for the europium DEHPA. Previous work, by Annette Hein, indicated that there were 3.6 DEHPA ligands per europium ion in the extracted complex. This is shown by the vertical, red line in Figure 2. In the Job's plot of the data in this work, the intersection of the dashed lines on both sides of the slope change. This is shown by the blue line in Figure 2. The values found by the two methods agree reasonably and indicate that more than 3 DEHPA ligands are part of the europium-DEHPA complex extracted in this work.

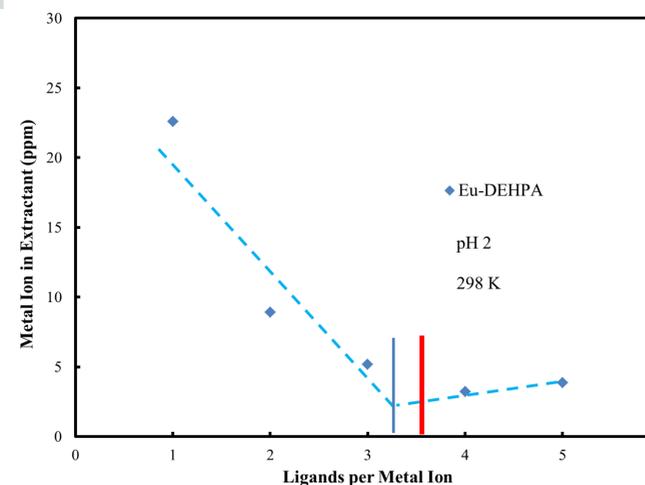


Figure 2. Job's method plot for Eu-DEHPA

Similar Job's method experiments were performed for the thorium-DEHPA system at pH 4. The initial results are shown in Figure 3. The primary result was that in many of the experiments, particularly those with about the same concentration of thorium and DEHPA a precipitate was formed. This made identifying the thorium in the organic phase difficult. Figures 4 and 5 show that similar precipitation occurred on the thorium PC-88A system.

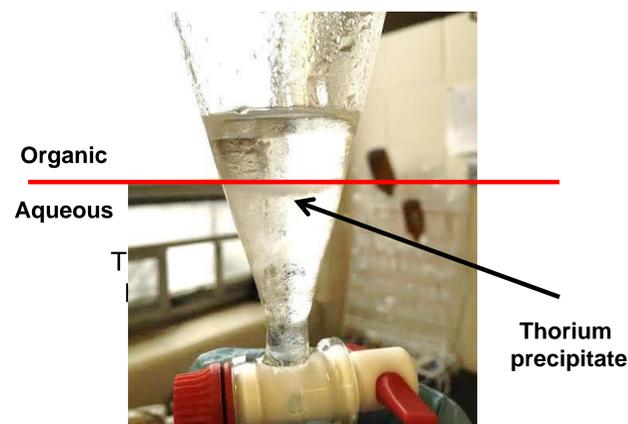


Figure 3. Thorium extraction experiment showing precipitate

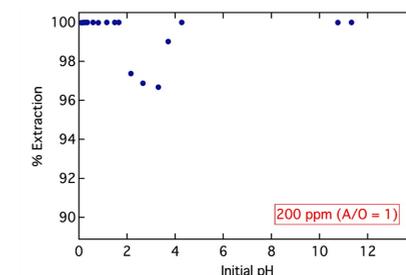


Figure 4. Extraction in the thorium-PC-88A system



Figure 5. Precipitation in the aqueous phase in the thorium-PC-88A system

Conclusions

- Conditions of thorium extraction lead to formation of precipitate; lower total molar concentration is needed
- Extraction of europium with DEHPA was successful to determine the number of ligands per europium ion

Acknowledgements

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