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Solvent Extraction Separation of Some Actinides and Lanthanides with Sulfoxides

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NOTE

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Abstract

Studies have been made on the extraction of some actinides [Th(IV), Pa(V), and U(VI)] and lanthanides [La(III), Ce(III), Pm(III), Eu(III), and Tb(III)] from hydrochloric acid medium by dialkyl sulfoxides. The actinides have extraction maxima at 7.0 *M* HCl while the lanthanides practically do not get extracted. Thus the extraction separation of these two groups can be effected by the preferential extraction of the actinides by the sulfoxides.

GENERAL PROCEDURE

The lanthanide solution (^{140}La, ^{141}Ce, ^{147}Pm, $^{152-154}$Eu, ^{160}Tb) at tracer level was mixed with an appropriate volume of preequilibrated hydrochloric acid to get the required acid concentration. The aqueous phase was then contacted with an equal volume of 0.25 *M* di-*n*-pentyl sulfoxide (DPSO) in CCl_4 for 24 hr in a thermostat at 30 ± 1 °C. One milliliter aliquots of both phases were pipetted out for the estimation of the metal by the radiometric method.

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RESULTS AND DISCUSSIONS

Effect of Acid and DPSO Concentration

The extraction studies were made from pH level to 9.0 *M* hydrochloric acid solutions at different sulfoxide concentrations (0.01 to 1.0 *M*). The lanthanides are not extracted within this range. Even an increase in the total chloride ion concentration by the addition of alkali halides does not initiate the extraction of the lanthanides. On the other hand, the extraction of actinides from halide solutions at a given strength of DPSO concentration increases initially steeply with increase in the concentration of the acid (*1–3*) (Fig. 1) and with increase in the concentration of the extractant (Fig. 2). A considerable enhancement in the distribution coefficient, *D* (the ratio of the metal concentration in the organic phase to that present in the aqueous phase), is effected by the addition of salting-out agents (*1*, *2*).

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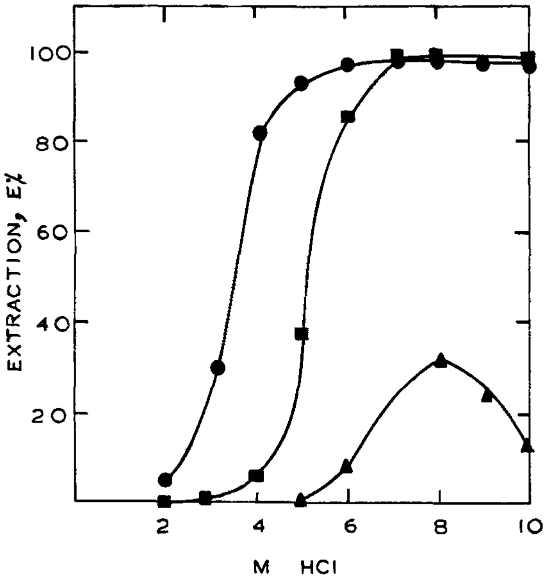

FIG. 1. Extraction as a function of acidity: (●) uranium, (■) protactinium, and (▲) thorium.

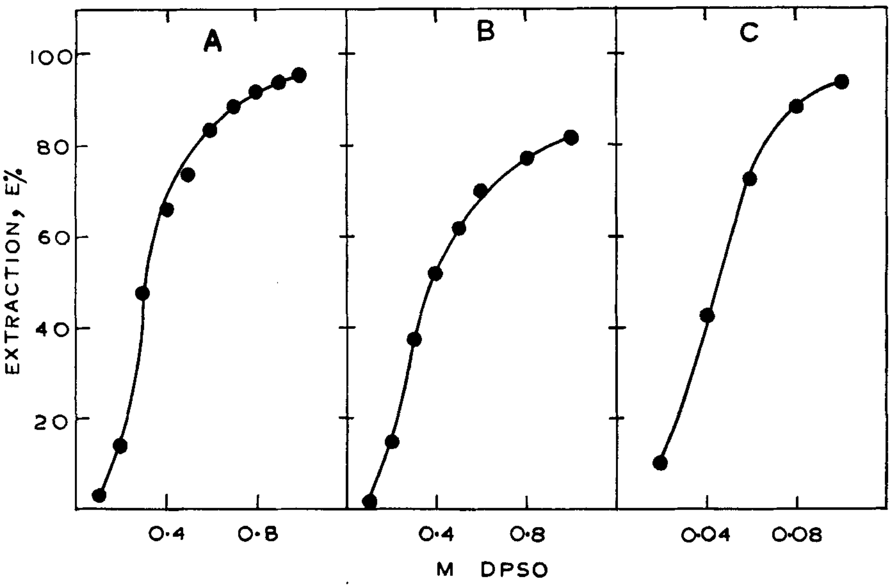

FIG. 2. Extraction as a function of di-*n*-pentyl sulfoxide concentration: (A) uranium, (B) thorium, and (C) protactinium.

Application

It is seen from the foregoing account of the solvent extraction of actinides [Th(IV), Pa(V), and U(VI)] and lanthanides that a clean separation of the two groups can be achieved. The possibility of separation was verified. A solution containing actinides [Th(IV) 0.02 *M* and U(VI) 0.02 *M*] and lanthanides (tracers ^{141}Ce, $^{152-154}$Eu, and ^{160}Tb) was prepared in 4.0 *M* HCl. The aqueous phase was then equilibrated with an equal volume of 0.25 *M* DPSO in carbon tetrachloride repeatedly for 5 times, extracting uranium using a fresh solution of the extractant every time. The organic phase fractions collected were stripped with slightly basic aqueous phase, and the uranium content was estimated gravimetrically using oxine method (*4*). Uranium was extracted quantitatively (within ±0.2%).

After the removal of uranium the concentration of the acid in the aqueous phase and that of the extractant in the diluent were then raised to

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7.0 and 1.0 *M*, respectively; and the solvent extraction procedure was repeated for 5 times as before to remove thorium. The extracted thorium was estimated as the oxalate (*5*, *6*) and found to be quantitatively extracted (within ±0.8%). The lanthanides remained nonextracted in the aqueous phase.

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