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TECHNICAL DIVISION

SOLVENT EXTRACTION RECOVERY OF URANIUM FROM METAL WASTE

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[redacted] Date: June 1, 1949

To: F. L. Steahly

From: C. V. Ellison, D. E. Ferguson, T. C. Runion

Subject: Solvent Extraction Recovery of Uranium from Metal Waste

A simple and feasible solvent extraction process has been developed through the laboratory stage at ORNL for the recovery of uranium from metal waste. The procedure involves the solution of waste sludge to 3.0-5.0 N HNO_3, solvent extraction with 15% tributyl phosphate* - 85% hexane, and subsequent stripping of uranium from the solvent with water.

Uranium from ORNL waste sludge, Hanford supernatant and Hanford metal sludge has been recovered in one counter-current batch solvent extraction cycle with a decontamination of the uranium to 3-7% of the natural uranium beta activity and to 20-40% of the natural uranium gamma activity. The uranium losses were 0.1% for ORNL sludge and Hanford supernatant. For Hanford sludge the uranium loss was 0.7% in the initial experiments.

The mechanical operability of this process in a 1 inch laboratory column has been demonstrated with ORNL waste sludge. The uranium losses obtained were comparable with those obtained in the laboratory batch work. It is planned to determine optimum column operating conditions using ORNL sludge within the next few weeks. Later, the process will be demonstrated

* Tributyl phosphate has been used previously by Iowa State College for purifying thorium from ore contaminates and later by Battelle Memorial Institute for separating thorium and uranium from low grade ores.

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with full Hanford activity.

The high extractive power of tributyl phosphate for uranyl ion indicates the formation of a compound between uranium and the tributyl phosphate. The complex apparently involves two moles of the solvent and approximately two moles of nitric acid per mole of uranium. The extraction of fission products is at a minimum as the solvent nears saturation in uranium. This condition must be carefully controlled.

Chemical Studies

The solvent extraction of uranium by tributyl phosphate (Bu_3PO_4) has been studied in laboratory batch experiments. The results are summarized as follows:

(1) The saturation solubility of nitric acid and uranium in Bu_3PO_4 is one-half mole of uranium and one mole of nitric acid per mole of Bu_3PO_4. At this concentration of uranium in the solvent, uranium distribution coefficients were not influenced by changes of acidity in the range of 0.1 to 5.0 N, temperature in the range of 10-50°C., or salt ($NaNO_3$) concentration in the range of 0-3 molar. Equilibrium time between the solvent and aqueous phases was too fast to measure (i.e. less than 10 seconds).

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(2) At uranium concentrations below the saturation value of the solvent, uranium extraction by Bu_3PO_4 was markedly improved by increasing acid (HNO_3) and salt ($NaNO_3$) concentrations, and was markedly reduced by the presence of sulfates and by temperature increases. However, the deleterious effect of sulfates and phosphates was easily overcome by increasing nitric acid concentration up to 5.0 N.

The following results were obtained using a 20% Bu_3PO_4 - 80% hexane mixture as a solvent:

(a) Uranium distribution coefficients (org/aq) were increased from 0.25 at a nitric acid concentration of 0.02 M to 20.5 at 5.46 M (all other variables remaining constant). Complexing by $SO_4^{=}$ and $PO_4^{=}$ was at a minimum in 5.0 N HNO_3.

(b) Upon varying the concentration of uranium in the aqueous phase, the distribution coefficient reached a maximum of 0.65 when the aqueous feed was approximately 0.4 M in uranium.

(c) When the $NaNO_3$ concentration of the aqueous phase was varied from 0 to 5 molar, the distribution coefficients increased from 0.24 to greater than 300.

The results obtained in counter-current batch extraction runs are summarized in Table I.

Table I

Tributyl Phosphate Extraction of Uranium from Metal Waste - Counter-Current Batch Runs

Feed: 3.0 to 4.5 N HNO_3 solution of waste
Solvent: 85% hexane - 15% tributyl phosphate
Scrub: 3.0 N HNO_3
Strip: Water
Equilibrated three minutes in counter-current batch tubes: 5 extraction stages, 4 scrub stages, 5 strip stages.

Source of Uranium Processed	Uranium Loss %	Beta Activity of Product β c/m/mg U	γ Activity of Product Mv/mg U	Beta Decontamination Factor
ORNL Sludge	0.1	2	0.001	1.5×10^4
HW Supernatant	0.1	2	0.001	3×10^4
HW Sludge	0.7	5	0.002	3×10^5
Activity of natural U		70	0.005	

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