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URANIUM SETTLING RATES IN SRS WASTE SUPERNATE

by

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1.0 Introduction

The evaporation of SRS High Level Waste supernate is accompanied by a decrease in the solubility of uranium¹, and thus uranium precipitates as the complex compound usually referred to as $\text{Na}_2\text{U}_2\text{O}_7$. The precipitated $\text{Na}_2\text{U}_2\text{O}_7$ and other precipitated solids will settle through the concentrated evaporator product at a rate determined by Stokes' Law

$$V = \frac{2g(d_s - d_l)r^2}{9\eta}$$

where the settling rate, V , is in cm/sec, g is 980 cm/sec^2 , d_s is the particle density, d_l the solution density both in g/cm^3 , r the radius of the particle in cm, and η the viscosity of the solution in poises. These quantities can all be determined from physical measurements, and settling rate thus determined for any particle size or, by extension, for a distribution of particle sizes. Reported here are the measurement of the variables in Stokes' Law for $\text{Na}_2\text{U}_2\text{O}_7$.

2.0 Summary

The particle size distributions, particle and solution densities, and solution viscosities have been determined for $\text{Na}_2\text{U}_2\text{O}_7$ precipitated from synthetic waste supernate and used to calculate the settling rates for uranium particles by Stokes' Law. In concentrated supernate ($\eta = 12.5 \text{ cP}$, $d = 1.42 \text{ g/cm}^3$) the maximum settling rate was calculated to be 3-4 ft/day and the minimum settling rate calculated as 0.25-0.5 ft/day.

3.0 Experimental Section

Synthetic waste supernate solutions³ were prepared from c.p. grade chemicals and spiked with uranium both by oversaturation (mixing a dilute acid solution with the basic components in the waste) and undersaturation (adding a concentrated uranium solution to the synthetic supernate). Particle sizes were determined on the slurry with a Microtrac II laser scattering densitometer.

The density of the solutions was determined by weighing 10 ml of the thermostatted solution in a volumetric flask. Weighings at 20, 30 and 40°C showed only a slight change with temperature.

The viscosity of the solutions was determined with a Cannon-Fenske viscometer following Walker's procedure⁴. The viscometer (#428 from Cannon Instrument Co., State College, Pa) was immersed in a thermostatted bath and the time for 6.75 mL to drain through the capillary in the viscometer measured with a stop watch. The weight of the 6.75 mL volume was determined from the density, and the solution added to the viscometer was measured by weight. The viscometer was calibrated with distilled water at 40°C to determine the viscometer constant, as

$$N = k \cdot t$$

where N = kinematic viscosity in centiStokes
 k = viscometer constant in centiStokes/sec
 t = time in seconds.

k was determined to be 0.003996 cSt/s, in agreement with Walker's value of 0.004002 cSt/s.

Kinematic viscosities were converted to dynamic viscosities by multiplying by the density

$$n = N \cdot d$$

where n = the dynamic viscosity, centipoises
 d = the solution density, g/cm³.

The solid density was determined by "wet-grading" precipitated Na₂U₂O₇. The precipitate was mixed with a synthetic waste supernate solution and allowed to settle in a 9 cm tube for 15 minutes. This fraction was removed, and the fraction that settled in 30 minutes collected next. The two fractions were each graded three times, and the particle size distribution of the two fractions measured with the Microtrac II. For the 15 minute fraction the particle size was 11 μ ; for the 30-minute fraction, 7.8 μ . Since viscosity and density of the solution had been measured, the average density of the precipitated Na₂U₂O₇ was calculated from Stokes' Law as 3.93 g/cm.

4.0 Results and Discussion

Particle size determinations found the particle size distribution of the precipitate from the oversaturation method similar to that of a solution prepared by adding 10M NaOH to a synthetic Purex High Activity Waste Concentrate (HAWC). The data is shown in Table 1.

Table 1.
Particle Size Distributions

Solution	Particle Size, μ		
	10%	50%	90%
Oversaturated Supernate	<2.3	<3.8	<13.1
Undersaturated Supernate (a)	<3.3	<18.1	<59.9
Synthetic HAWC--NaOH	<2.1	<4.3	<15.7

(a) Agitated for 16 hrs. before measurement

The results of viscosity measurements on synthetic supernate solutions are shown in Figure 1. The upper two lines on the graph are evaporations of the solution represented by the lowest line. Some additional data on viscosity and density of basic salt solutions are reported by Walker and Georgeton⁵.

With the viscosity, particle size, density of the solid and density of the solution measured, the settling rate can be calculated from Stokes' Law. Figure 2 shows the settling rate for the three solutions used in viscosity measurements vs. particle diameter. Settling rates for other solutions can be generated provided the viscosity and density of solutions are known.

An appropriate calculation is the settling rate for the particle distribution shown in Table 1 for Purex HAWC-NaOH supernate. The 10% with a particle diameter below 2μ will settle at ca. 0.6 cm/hr (6 in/day); the 40% between 2.1 and 4.3μ will settle at 1 cm/hr (1 ft/day); and the 40% between 4 and 16μ will settle at ca 10 cm/hr (10 ft/day). (Average particle size assumed to 10μ in this case; density 1.28 g/cm³, $\eta = 3.5$ cP for all).

The most important value in the calculation of the settling rate is the size of the particle; in general, Stokes' Law can be reduced to $V = k'r^2$, where k' incorporates the other constants and r is the radius of the particle. For the very concentrated supernate in Figure 2:

$$V = 0.033 * (2r)^2$$

where V has units of feet/day and $2r$ is the diameter of the particle in microns. For the particle size distribution of the Purex HAWC-NaOH supernate, the maximum settling rate is 3-4 ft/day, and the minimum is 0.25-0.5 ft/day.

5.0 References

1. D. G. Karraker, "Uranium Solubility Studies during Waste Evaporation", WSRC-TR-93-4331, August 1993.
2. G. Herdan, "Small Particle Statistics", 2nd Edition, Academic Press, New York, 1960. p.56 et seq.
3. D. D. Walker and B. A. Hamm, "Material Balance and Planned Operating Schedule for the In-Tank Process (U)", WSRC-89-1303, December 1989.
4. D. D. Walker, "Viscosity Measurements on Clear Liquids (U)", WSRC-RP-93-294, February 9, 1993.
5. D. D. Walker and G. K. Georgetown, "Viscosity and Density of Simulated Salt Solutions (U)", WSRC-RP-89-1088, October 19, 1989.

Figure 1.
Viscosity of Synthetic Supernate

Figure 2.
Settling Rate vs. Particle Diameter

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