

## **Evaporator Neutralization Experiments**

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## Evaporator Neutralization Experiments

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### Summary

The chemistry of uranium and effects of mixing during neutralization of the acidic waste from chemical cleaning operations of the 242-16H Evaporator pot has been investigated. The following conclusions are derived from these scoping experiments.

- Neutralizations were done with nonradioactive simulants and scaled air sparge rates of 0, 20 and 1200 ml/min. The simulants contained aluminum nitrate, sodium silicate, and 1.5 M free nitric acid. The 50 wt% caustic formed a heavy bottom layer at the 0 and 20 ml/min rates. At the air sparge rate of 1200 mL/min, neutralization was complete within 2 hours. pH data and indicator color as well showed adequacy of the 2 hour duration to neutralize the bulk acid solution to a pH of 7 to 10.
- Neutralization in the nonradioactive acid solution without mixing resulted in the formation of a gel that contained sodium nitrate with some carbonate and hydrous aluminum as well. Temperature rise was localized to the caustic-acid interface and did not exceed 20 °C.
- The presence of uranium at a concentration of 290 g/L (radioactive simulant) significantly increases the time required to complete neutralization over the time seen in the 1200 ml/min nonradioactive test. The time was about 8 hours. Floating uranium solids prevented good mixing (mass transfer) and appeared to hold the caustic in the solid layer. The pH in the uranium solid layer was higher than the bulk liquid phase. Bulk solids mixing did not occur after 48 additional hours of sparging.
- Uranium solids formed from the onset of caustic addition. The solids were layered and paste-like. At the present loading of depleted uranium, the amount of solids formed during neutralization in the 242-16H Evaporator pot presents a formidable engineering challenge to pump the solids out of the pot.
- Rheological data for the uranium precipitate showed a viscosity of 20 centipoise, approximately 5 times higher than previous testing with much lower uranium concentrations. Yield stress data continues to indicate the precipitate is pumpable.

## Introduction

The 242-16H High Level Waste Evaporator processes radioactive waste from the feed tank (Tank 43H), concentrates the waste, and discharges to the concentrate receipt tank (Tank 38H). During this processing the waste typically concentrates by 30-40 vol %. However, during processing of Defense Waste Processing Facility Recycle stream, the concentration approaches 90 vol %. Flow difficulties in the Gravity Drain Line (GDL) occurred in July 1997. Video inspection indicated solid deposits were present in the Gravity Drain Line.<sup>1</sup> Laboratory experiments showed that compounds of the general formula,  $\text{Na}_8\text{Al}_6\text{Si}_6\text{O}_{24}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ , form readily under the evaporator conditions.<sup>2,3,4</sup> During November 1999 a sample of solids removed from the Evaporator cone contained mostly sodium aluminosilicate.<sup>5</sup>

The material from the Evaporator cone<sup>5</sup> showed ~ 7 wt % uranium with a 3 %  $^{235}\text{U}$  enrichment. After estimating the amount of solids present, High Level Waste Engineering declared a Potential Inadequacy in the Safety Analysis (PISA)<sup>6</sup> because of the accumulation of uranium in the 242-16H Evaporator pot. SRTC personnel have developed a cleaning methodology to remove the deposits from the Evaporator pot using dilute nitric acid containing depleted uranium as a neutron absorber.<sup>7,8,9</sup> CST Engineering requested SRTC perform scoping tests to examine the neutralization of the spent nitric acid prior to discharging to Tank 42H. The results of the scoping work is presented here. CST Engineering requested follow-on task level work.<sup>10</sup> The follow-on neutralization work is covered in a task plan.<sup>11</sup>

## Experimental

### I. Non-Radioactive Experiments

Initial experiments used a 4-liter quartz beaker and a liquid simulant with the composition found in Table 1. Nitric acid solution (1.5 M) were prepared with dissolved silicon from sodium meta-silicate and aluminum from aluminum nitrate. The version of the simulant for the 1200 ml/min sparge rate had a trace of phenolphthalien added as a tracer for the extent of neutralization.

Table 1. Acid Component Concentrations

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Free Acid = 1.5M
Al (added as $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ ) = 0.096M
Si (added as $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ ) = 0.036M

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The following items were secured at various positions in the beaker: one 0.25-inch OD stainless steel air sparge tube with its opening at the bottom center of the beaker, four thermocouples, four pH probes, and two small diameter transparent plastic tubes from the caustic syringe pumps.

The experiment was performed by filling the beaker with 3 liters of acid solution to be neutralized, setting the air sparge rate, and initiating caustic flow from the syringe pump. Concentrated sodium hydroxide solution (50 wt % - 18.9 M) was added to the quartz vessel using a dual syringe pump equipped with two 100 mL syringes. 350 ml of the 50 wt% caustic was delivered at a total rate of 2.8 ml/min (1.4 ml/min from each syringe), so that caustic delivery took just over two hours. There was a short delay time while the syringes were refilled during the delivery period.

Temperature, pH, and appearance were recorded in notes, still, and video photography. Records were made until after the caustic flow stopped. For the 20 ml/min air sparge rate the sparger was left on overnight so that the effect of mixing over a longer time period could be noted the next day.

## II. Experiments with Uranium-bearing solution

Nitric acid solution (1.5 M) was prepared with dissolved silicon from sodium meta-silicate and aluminum from aluminum nitrate. The silicon and aluminum concentrations were each 0.04 M for this simulant. Uranium trioxide ( $\text{UO}_3$ ) was dissolved in nitric acid and added to nitric acid solution containing Si and Al until the concentrations shown in Table 2 were achieved.

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Table 2. Acid Component Concentrations

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U = 290 g/L
Free Acid = 1.5M
Al (added as $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ ) = 0.04M
Si (added as $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ ) = 0.04M

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A 4-L quartz beaker was fabricated into which was placed approximately 3 liters of acid solution. Concentrated sodium hydroxide solution (50 wt % - 18.9 M) was added to the quartz vessel using a dual syringe pump equipped with two 100 mL syringes. Thermocouples measured the temperature of the liquid phase at two locations. Additionally, pH probes were installed to measure pH at similar locations in the quartz vessel. Photographs were taken during the neutralizations.

The experiment was performed by filling the beaker with 3 liters of acid solution to be neutralized, setting the air sparge rate, and initiating caustic flow from the syringe pump. Concentrated sodium hydroxide solution (50 wt % - 18.9 M) was added to the quartz vessel using a dual syringe pump equipped with two 100 mL syringes. 510 ml of the 50 wt% caustic was delivered at a total rate of 2.8 ml/min (1.4 ml/min from each syringe), so that

caustic delivery took just over four hours. There were short delay times while the syringes were refilled during the delivery period. The extra caustic was used because it was needed to neutralize the uranyl nitrate.

### *Air Sparge Rate Scaling*

The 242-16H Evaporator pot is an 8 foot diameter cylindrical vessel with a conical bottom. The evaporator vessel will be cleaned with a uranium-bearing nitric acid solution. Prior to discharging spent acid to a nearby carbon steel waste tank, the cleaning solution will be neutralized with 50 wt% sodium hydroxide solution. Initial process flowsheet options called for this neutralization to occur in the evaporator pot with an air lance available to provide some mixing. SRTC has been investigating this process in laboratory-scale experiments. The experiments were scaled by matching the injected air superficial velocity in the experimental vessel to the injected air superficial velocity in the 242-16H Evaporator pot. The superficial velocity is calculated with equation [1]

$$v_s = Q/A \quad [1]$$

Where  $v_s$  is the air superficial velocity,  $Q$  is the air flow rate, and  $A$  is the vessel cross section area. Table 3 shows the dimensions of the 242-16H Evaporator pot and the experimental vessel, along with the calculated superficial velocity. cfm is cubic feet per minute.

Table 3. 242-16H Evaporator Pot Dimensions and Air Flow

Parameter	242-16H Evaporator Pot	Experimental Vessel
Tank Diameter	96 in	6.5 in
Area	46,700 cm <sup>2</sup>	214 cm <sup>2</sup>
Air Flow Rate	10 cfm	1300 cc/min
Superficial Velocity	6.06 cm/s	6.06 cm/s

Therefore, the recommended air injection rate in the experiments is 1300 ml/min. This was reduced to 1200 ml/min in the experiments for conservatism.

Laboratory notebook WSRC-NB-2000-00031 contains data obtained during these tests and the procedures used.<sup>12</sup> Personnel used routine analytical protocol for the samples in this report.<sup>13</sup>

## **Results and Discussion**

### Non-Radioactive Experiments

#### *No Air Sparge*

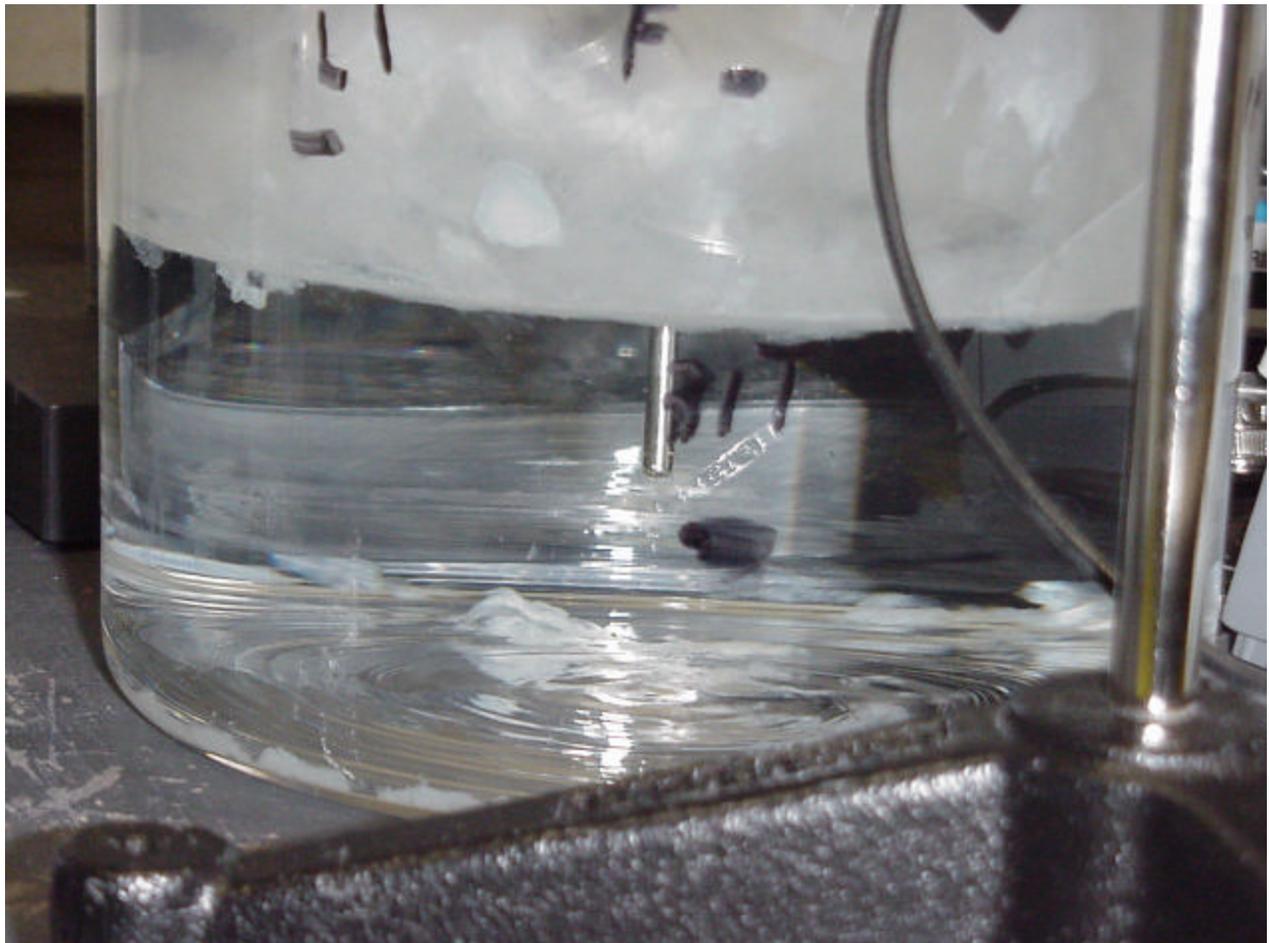
The first experiment was performed without mixing. Concentrated sodium hydroxide was added to a simulated nonradioactive nitric acid solution containing Si and Al at a rate of 2.8 mL/min. The caustic solution, being denser than the simulated spent nitric acid solution, sank to the bottom of the vessel. Within 30 minutes of beginning caustic flow, a white gel-like fluffy precipitate started to form at the interface of the acid and caustic solutions. At its largest extent, the solid precipitate extended to 25 % of the vessel height.

Figure 1 shows the vessel during the test conducted without mixing. During the 130 minute test, the pH readings in the bulk liquid did not exceed 2.9. The maximum temperature rise observed during the tests was 20 ° C and this was measured at the 80 minute point near the bottom of the vessel. Figure 2 shows the appearance of the vessel at the end of the run. A clear caustic layer remained at the bottom of the vessel.

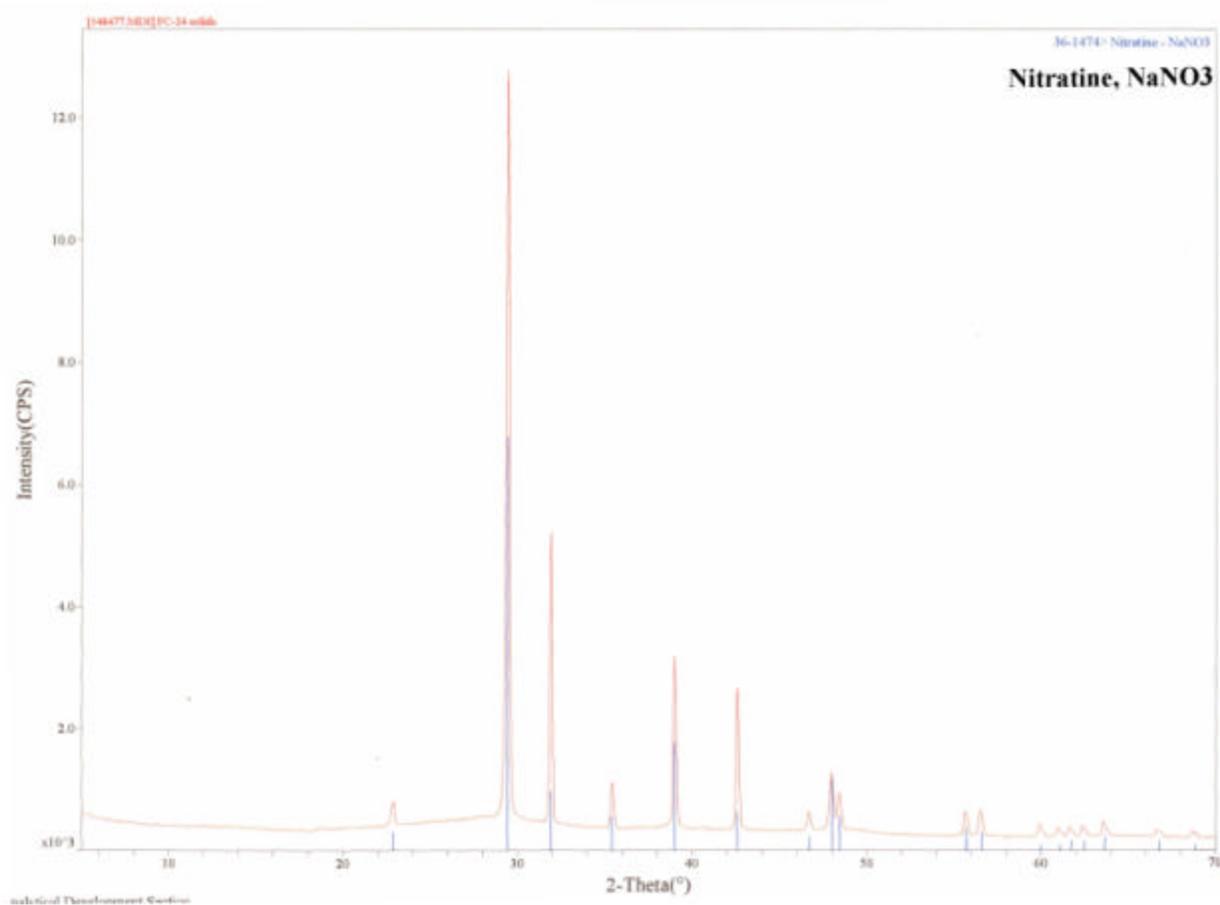
The gel-like solids above the caustic layer were collected and sent for solid-state characterization using X-ray diffraction and energy dispersive X-ray analysis. Figure 3 shows the X-ray diffraction results. Sodium nitrate was the only crystalline species that was found.



**Figure 1. Neutralization without Mixing**



**Figure 2. Caustic Stratification at the End of the No Mixing Run**



**Figure 3. X-Ray Powder Pattern for Solids from Test without Mixing**

Solids from this work were also examined by electron microscopy and energy dispersive X-ray analysis for elements. Sodium, oxygen, carbon, and aluminum were found. Carbonates and aluminate were likely present. Carbonate probably formed from carbon dioxide in the air used to sparge the vessel. Similar carbonate formation would occur in the 242-16H Evaporator pot if air is used to sparge its contents. The aluminum would have been detected by this method but not by X-ray powder diffraction if the aluminum was not in a crystalline material. Nitrogen (from sodium nitrate) was not seen with the energy dispersive X-ray method but the analyst pointed out that the method is weak in its detection of nitrogen.

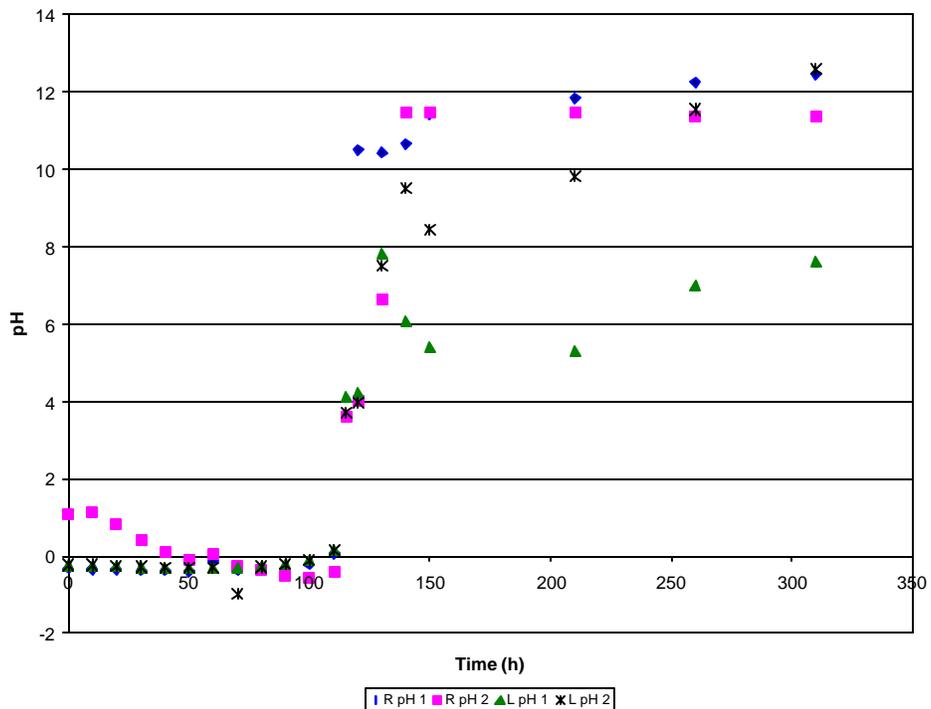
#### *20 mL/min Air Sparge*

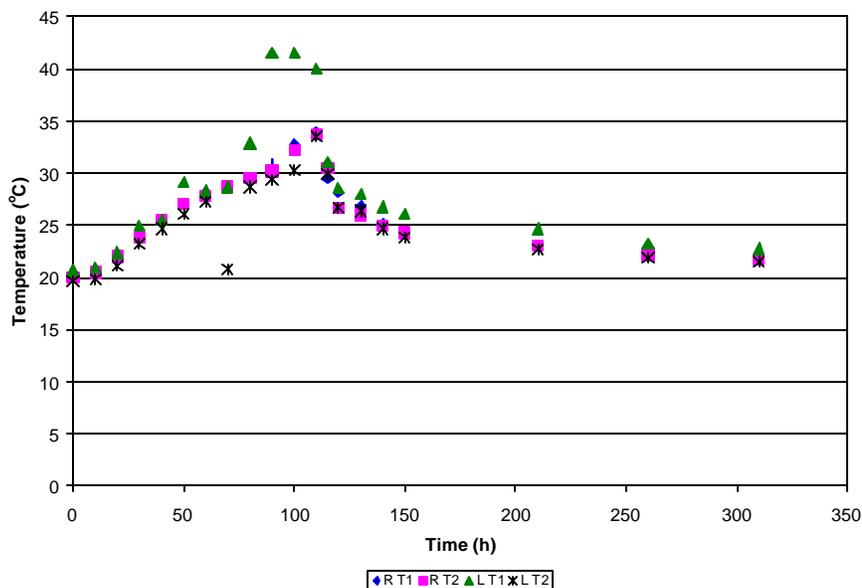
The second experiment used an air sparge of 20 mL/min to simulate mixing in the 242-16H Evaporator pot. The air flowrate was far below what is normally used in scaling the mixing, but was an attempt to see if gentle mixing was adequate. This 20 mL/min air flowrate has about the same inverse time

(flowrate/pot volume) as the 242-16H Evaporator pot if the evaporator lance was operated at 10 cfm. Figure 4 shows the solids formed during the test. The solids were very fine and free flowing.



Figure 4. Neutralization with 20 mL/min Air Sparge



**Figure 5. pH Measurements for 20 mL/min Test****Figure 6. Temperature Measurements for 20 mL/min Test**

Figures 5 and 6 show the pH and temperature profiles measured during the 20 mL/min test. The pH measurements depict a titration curve that would be expected for neutralizing a strong monoprotic acid with base. There was little shift in the pH initially during caustic addition. The caustic addition was complete at the 110-minute point. As the air sparge mixed the acid and base, the pH begins to rise very sharply. By 150 minutes, the bulk of the solution is neutralized. The only exception is the pH data measured with probe L (left) pH1. This probe was located near the bottom of the vessel. The temperature profile (Figure 6) shows a steady rise of about 0.1 °C/min and a spike at the point the pH changes very rapidly. The maximum temperature rise was 23 °C.

### *1200 mL/min Air Sparge*

Shown in Figure 7 is a photograph of the neutralization experiment conducted with an air sparge rate of 1200 mL/min. This air flowrate would provide the same average superficial velocity as the 242-16H Evaporator pot air lance operating at its standard 10 cfm. Engineering judgement considered this to be the best scaling method overall. Solids were again formed during this test but it appeared the amount is substantially less than in the two previous tests.

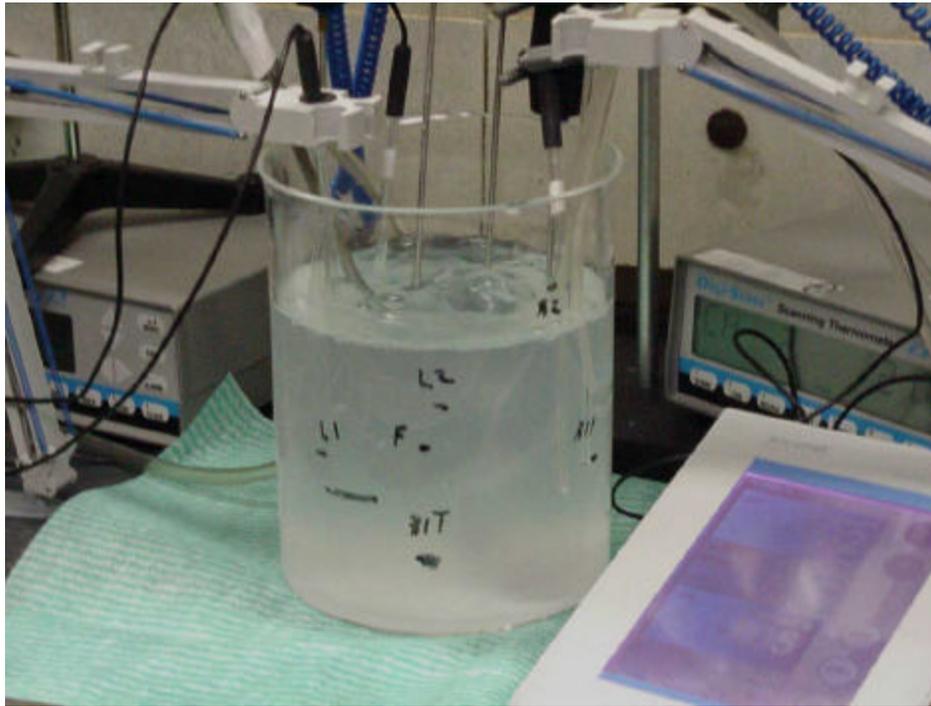
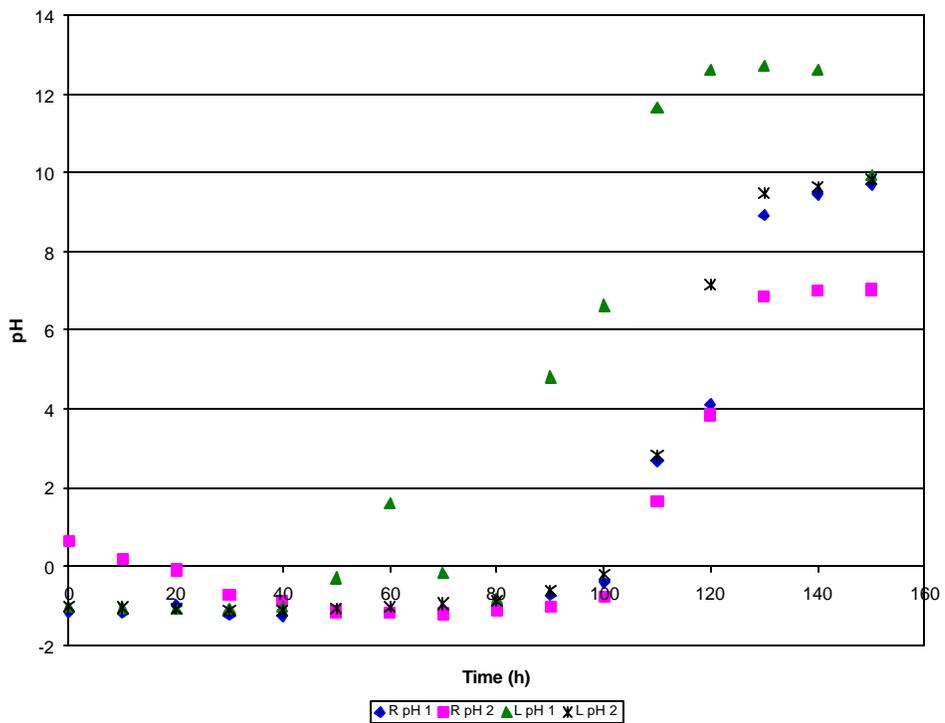
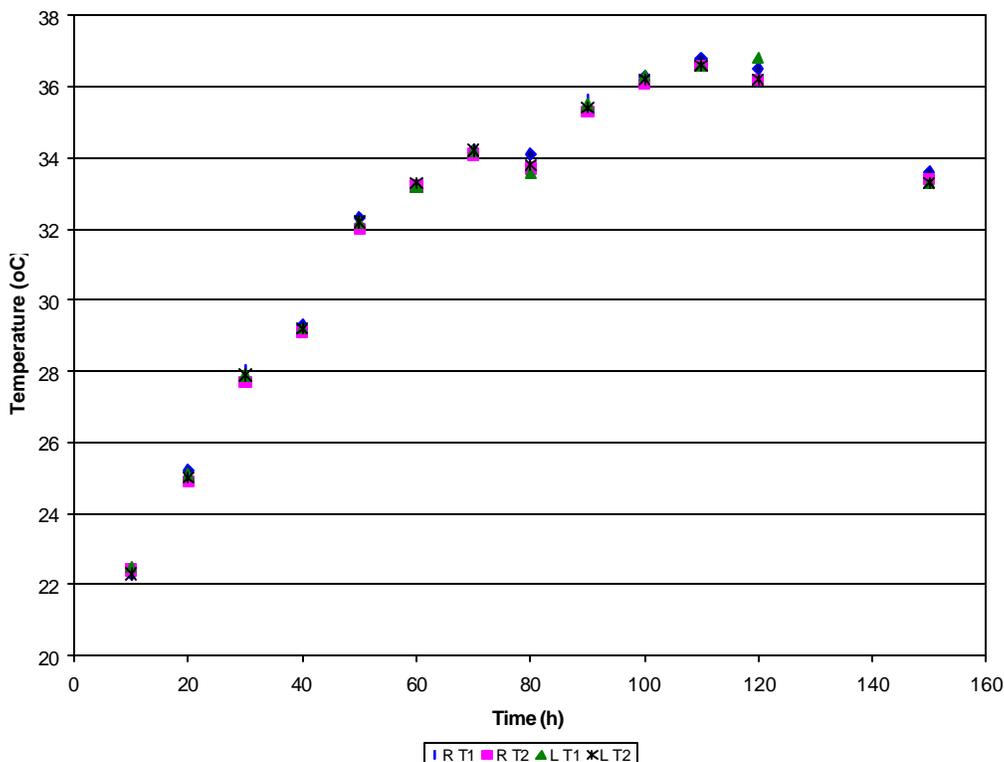


Figure 7. Neutralization at 1200 mL/min Air Sparge

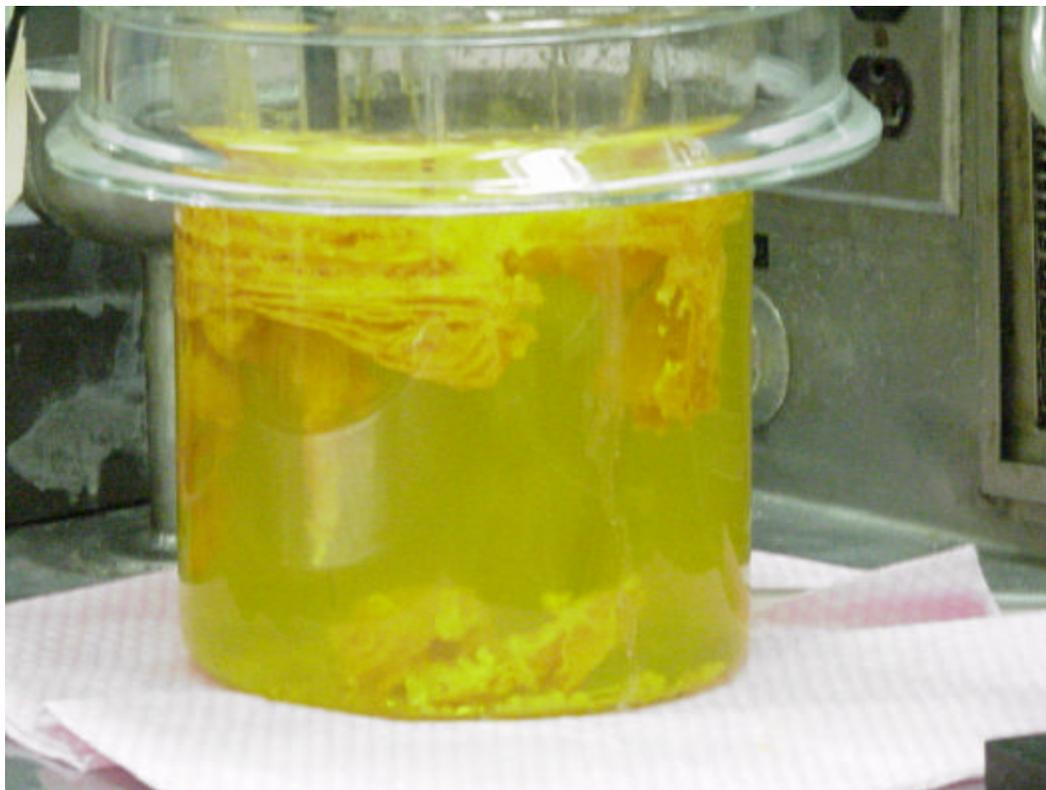


**Figure 8. pH Measurements from 1200 mL/min Test****Figure 9. Temperature Measurements from 1200 mL/min Test**

Figures 8 and 9 show the pH and temperature profiles measured during the 1200 mL/min test. The pH measurements depict a titration curve that would be expected for neutralizing a strong monoprotic acid with base. There was little shift in the pH initially during caustic addition. The caustic addition was complete at the 110-minute point. As the air sparge mixes the acid and base, the pH begins to rise very sharply. By 150 minutes, the bulk of the solution is neutralized. The only exception is the pH data measured with probe L pH1. This probe was located near the bottom of the vessel and fairly close to the caustic addition. This may explain why the readings were higher than the data from the other pH probes. The temperature profile (Figure 7) shows a steady rise of about 0.16 °C/min. The rise is uniform across the entire vessel indicating very good mixing. There is no “spike” in the temperature profile. The maximum temperature rise was 16.5 °C much less than the rise in the 20 mL/min sparging test. The phenolphthalein indicator turned pink uniformly at the end of 2 hours showing that the bulk of the solution exceeded pH 8.2.

### *Uranium Test*

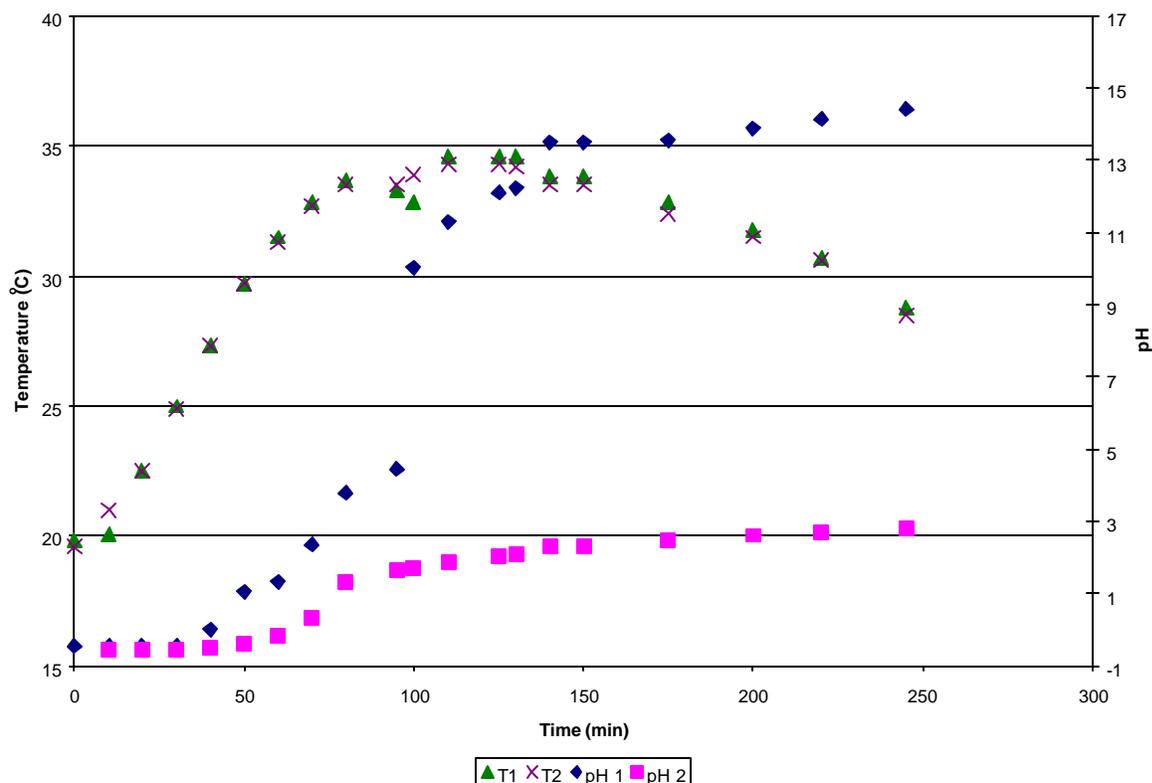
The final planned test was to examine the neutralization of a largely depleted uranium solution that contained approximately 0.04 M aluminum and silicon. All other aspects of the experiment were the same including the 1200 ml/min air sparge rate and 2.8 ml/min caustic addition rate. Additional volume of caustic was needed to complete the uranyl nitrate neutralization (raise pH above 12); therefore, a total of 510 mL of caustic was added. Uranium precipitate formed as soon as the caustic solution exited the feed addition lines. An orangish, yellow precipitate formed layers in the upper region shown in Figure 10.



**Figure 10. Uranium Solution Neutralization**

The temperature and pH were measured throughout the experiment, though only two pH and two temperature probes were used. Figure 11 contains a graphical display of the data obtained for the first 250 minutes of the experiment. Data were collected for an additional 260 minutes with little or no change from the data measured at 245 minutes. The temperature behavior of the uranium system was very similar to the simulant test. Temperature rise was slight with maximum temperature reaching 34.6 °C after approximately 100 minutes. The highest rate of increase is 10 °C /hr. The temperature drops after 140 minutes reaching 25 °C after 300 minutes.

The pH profiles are, however, quite different from the simulant experiment with the same air sparge rate. The two pH probes, labeled pH1 and pH2, were located top and bottom of the vessel, respectively. The pH probe at the top of the vessel, pH1, measured a very rapid rise through neutrality and to a measured pH of 11.7 after 110 minutes. The pH reached a maximum of 14.6 after approximately 450 minutes. Sporadic measurements were taken a later times. At 800 and 1315 minutes, the pH measured 14.35 and 14.07, respectively. The pH probe in the bottom of the vessel measured pH readings from the start (-0.5) to a pH of 3.3 after 500 minutes. Two days later, a researcher removed the pH probe from the vessel bottom. The probe was actually submerged in uranium solids. The probe was response checked and placed in the bulk liquid. The pH at that time read 11.7.



**Figure 11. Temperature and pH Measurements from Uranium Test**

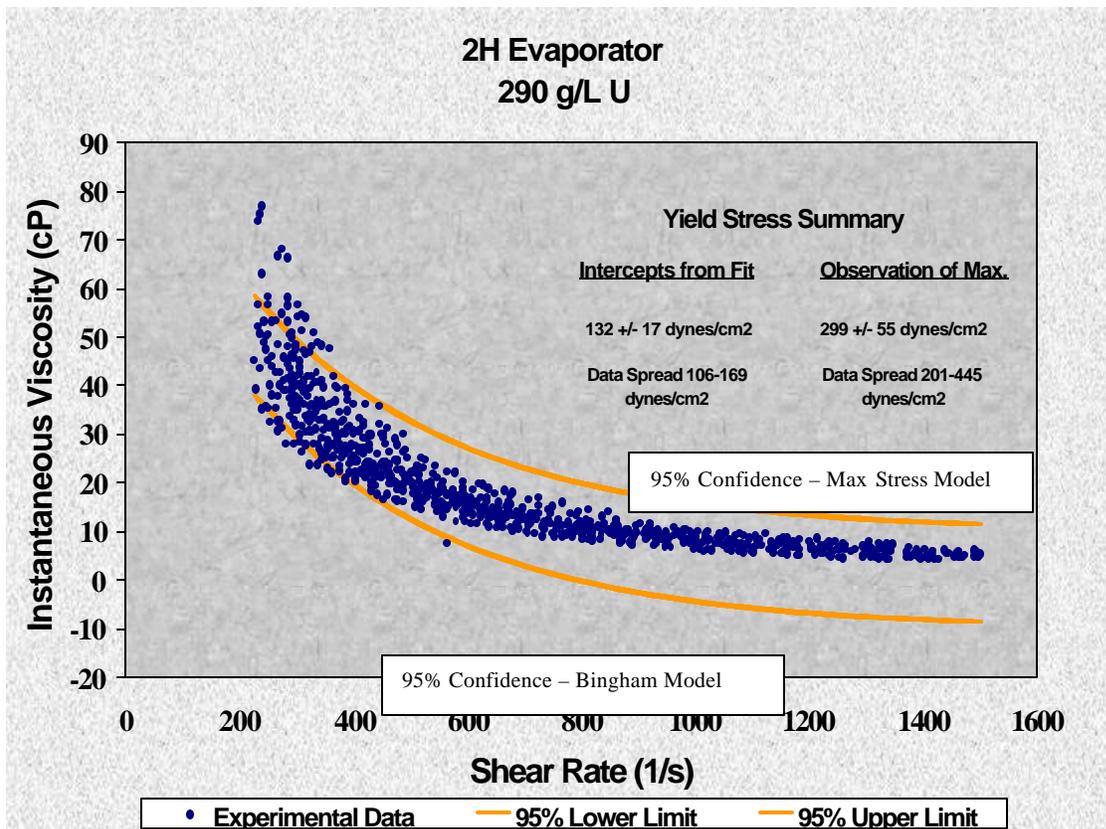
### *Rheology Measurements of Uranium Precipitate*

Rheological data were collected in the SRTC shielded cells using a Haake RV30/M5 system and a NV rotor. Shown in Figure 12 is a plot of the instantaneous viscosity as a function of the shear rate with the accompanying 95% confidence intervals for nine replicate runs.

Clearly the fluid is somewhat thixotropic (thins as the shear rate increases). It is important to note that in the higher shear rate range, of more practical interest for maintaining fluid flow, that the instantaneous viscosity is much less dependent on the shear rate than in the lower shear rate regime. In the higher shear rate range the instantaneous viscosity is less than 20 cP. The confidence intervals are slightly tighter in the noisier low shear rate range. This attribute is directly related to the logarithmically distributed data point intervals used to acquire the data.

Two different approaches were used to evaluate the yield stress for fluid flow initiation. This dual approach was an attempt to provide a bounding perspective on the actual yield stress. The methods yielded different yield stress results. This should be reviewed realizing the non-Newtonian character of the data was not directly fit. Rather the yield stress was approximated given the quick turn around time for the sample and the fact that the appropriate model to describe these by non-Newtonian rheology curves was not intuitively obvious. The resulting approach is an attempt to bound the yield stress. This would help mitigate technical risk associated with the yield stress of the slurry.

The first approach was to fit the stress-strain curve in the shear rate range of process interest using a Bingham plastic model.<sup>14</sup> The shear stress was extrapolated to the point of initial flow for each of the nine runs, averaged, and the associated 95% confidence interval is reported. As a result of



**Figure 12. Rheology Data from Uranium Precipitate**

this method of evaluation the yield stress is  $132 \pm 17$  dynes/cm<sup>2</sup>. Note that the data ranged from as low as 106 dynes/cm<sup>2</sup> to as high as 169 dynes/cm<sup>2</sup> using this method of analysis. This approach is the less conservative of the two approaches used to extract a yield stress value from the data.

The second approach used to evaluate the yield stress of the precipitated slurry is clearly the more conservative of the two methods and results in a yield stress value which is most likely the worst case scenario. In this method the stress recorded during each of nine replicate runs in the very low shear rate range (0-10 1/s) was evaluated and the one point maximum was recorded as the yield stress. These values were averaged to supply a value of  $299 \pm 55$  dynes/cm<sup>2</sup> at 95% confidence. The individual responses ranged from as low as 201 to as high as 445. The most likely yield stress is somewhere between the results of the two methods.

The stress-strain curves demonstrated some unexpected trends in the very low shear rate range (10-50 1/s) which could be attributable to particle effects. These observations could be related to a number of phenomena including settling and bridging. The results reported are meant as a qualitative guide. These unexpected characteristics are not expected to grossly alter the presented results but should be considered in an assessment of the technical risk associated with use of this data for design. Further work would be necessary to assist in understanding the origin of these spectral features.

*Chemistry of Uranium Precipitate*

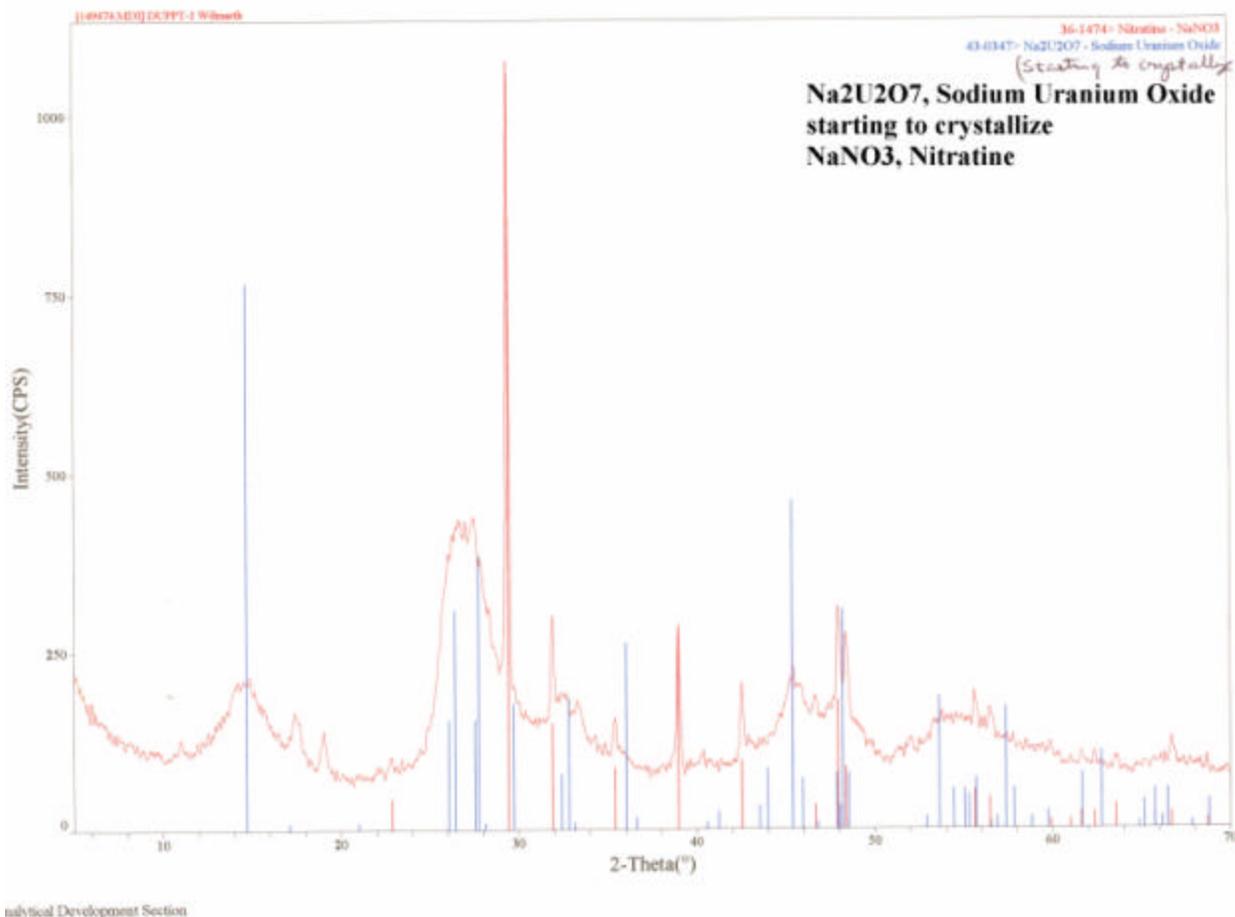
The uranium-sodium hydroxide-water system is complex and can produce a wide variety of solid phases.<sup>15</sup> The system contains polymeric oxide-hydroxides that are partly nitrated when nitrate is present, plus uranates with a variety of sodium to uranium molar ratios.<sup>16</sup>

General observations from the references above agree with those made in the experiment with uranium. Ricci and Lopriest observed an orange solid phase at high sodium to uranium ratios, a condition similar to local regions where 50 wt% caustic was added to the evaporator pot simulant.<sup>14</sup> As the sodium hydroxide diffused or was mixed into the bulk liquid the local sodium to uranium ratio would drop, shifting the color from orange to yellow as Ricci and Lopriest report. The solids were identified as solid solutions with various proportions of hydrated sodium oxide and uranium oxide. Ricci and Lopriest also reported a pink phase at sodium levels so high that sodium formed a monohydrate with water, but this phase was not observed in the current experiment.

Maly and Vesely found that titration of uranyl nitrate with sodium hydroxide first created anionic uranium hydroxide polymer which would take on nitrate. With further addition of caustic and time the polymer would convert to sodium diuranate ( $\text{Na}_2\text{U}_2\text{O}_7$ ).<sup>15</sup>

In the current work, solid state characterization by X-ray diffraction and energy dispersive X-ray analysis (EDX) – scanning electron microscopy was performed on two different samples removed from the neutralization vessel. The first sample was taken shortly after the end of the caustic addition and represented the orange material observed in Figure 10. The second sample was taken after 2 days had transpired and was yellow in color.

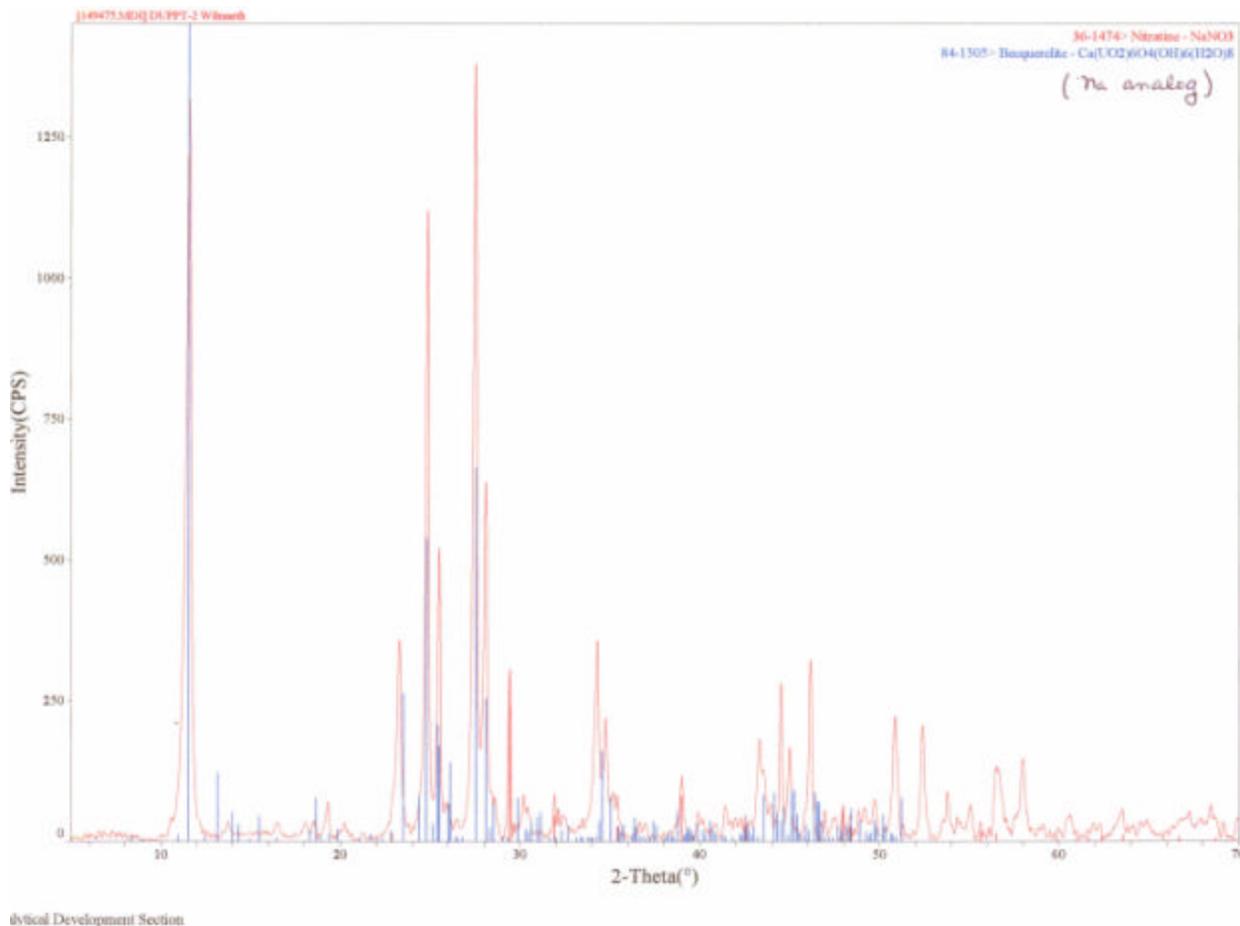
Figure 13 shows the X-ray diffraction powder pattern obtained from the orange-colored solid sample. The sample is comprised of sharp diffraction peaks from sodium nitrate and broad diffraction peaks of sodium diuranate. The breadth of the diffraction peaks indicates poor long range order, i. e., poor crystallinity. An accompanying EDX spectrum shows peaks from sodium and uranium. The EDX spectrum did not show any signs of Al or Si that would exist if the aluminosilicate had re-precipitated.



**Figure 13. Powder Diffraction Pattern of Orange Solids**

Figure 14 shows the X-ray diffraction powder pattern obtained from the yellow-colored solid sample. The sample is comprised of sharp diffraction peaks from sodium nitrate and sodium uranyl hydroxide,

$\text{Na}_2(\text{UO}_2)_6(\text{OH})_6 \cdot 8 \text{H}_2\text{O}$ . An accompanying EDX spectrum shows peaks from sodium and uranium with the sodium peak more intense than the peak in the orange material. The EDX spectrum, again, did not show any signs of Al or Si that would exist if the aluminosilicate had re-precipitated.



**Figure 14. Powder Pattern from Yellow Solids**

### Video Data

Experiments were recorded by video camera and a video Compact Disk (CD) accompanies this report. Discussions of the five separate experiments follow.

#### I. Injection Of 50 Wt% Caustic into Sparged Uranium-Acid Solution

This clip shows the beaker, the startup of the air sparge at 1200 ml/min, and closeups of the tubes where the caustic is introduced. Gel is seen to form initially at the mouths of the caustic tubes and some of it appears to float. A half hour later an orange layer entrapping bubbles has formed at the top of the

solution. Solids are found to sink when disturbed with a glass rod. About 9 hours later the orange layer is still in place and the solution is milky and yellow.

The solids clearly form quickly and do not appear to be amenable to good pumping or other transport out of the vessel.

## II. Pumpout Test

A peristaltic pump was used to draw beaker contents up and out using a glass eductor tube. Closeup video of the glass tube shows very little solid transported in the stream. The fluid is mostly the milky yellow portion of the neutralized material. At the end of the test most of the solids that formed during neutralization are still in the neutralization vessel. The solids are chunky as if they had set up somewhat. They also stuck to metal coupons placed in the beaker. The chunks and sticky nature of the solids are indicators that the acid/neutralization strategy may not work well for the 242-16H Evaporator pot.

## III. Acid exposure of a solid chunk

A chunk of solids from the main neutralization test was dropped into 1.5 M nitric acid to gauge its tendency to dissolve. This video clip shows that there is no immediate tendency to dissolve or break up with gentle agitation. It was noted over 48 hours later that the solids did break up on standing.

## IV. Dropwise Addition of Caustic with Good Mixing

Acidified uranium solution was placed into a beaker and stirred well while caustic was added drop by drop. Each drop formed a corpuscle that remained intact during the mixing. The initial gel that was formed lacked significant color but attained a bright orange color as time went on. The solids seemed to form larger masses with time. They were also tacky and adhered to a probe in the beaker. Given additional mixing time it was found that the solids broke up and dissolved, adding a yellow haze to the liquid. The well mixed solution was easy to pump.

## V. Reverse Strike Neutralization

This test examined the scenario where the uranium acid solution is dropped directly into Tank 42 to neutralize it. The simulant of Tank 42 liquid contained the following anions, where sodium was the only cation:

ANION	MOLARITY
Nitrate, NO <sub>3</sub> <sup>-</sup>	1.45
Nitrite, NO <sub>2</sub> <sup>-</sup>	1.53
Free Hydroxide, OH <sup>-</sup>	4.37
Aluminate, Al(OH) <sub>4</sub> <sup>-</sup>	0.22
Carbonate, CO <sub>3</sub> <sup>--</sup>	0.06

Sinking orange solids formed immediately. They appeared to be cohesive and did not break up much when moved with a spatula. The pH of those solids was measured as 4.4. After the vessel was stirred the solids were accumulated and their pH was 12.95. This indicates that the solids are basic in nature and that their initial low pH was due to entrained acid. Stirring subsequently neutralized acid in the solids by the bulk solution of higher pH.

### **Conclusions**

The effects of mixing and of uranium during neutralization of the acidic waste from chemical cleaning operations of the 242-16H Evaporator pot has been measured on a 3-liter scale. Experiments with simulants lacking uranium found that neutralizations without mixing resulted in the formation of a gel that contained sodium nitrate with some carbonate and hydrous aluminum as well. The temperature rise was localized to the caustic-acid interface and did not exceed 20 °C.

Tests examining air sparging during neutralization showed significantly reduced the time required to neutralize the bulk solution to a pH of 7 – 10. At sparge rates of 1200 mL/min, neutralization was complete within 2 hours.

The presence of uranium at a concentration of 290 g/L significantly increased the time required to complete neutralization. Floating uranium solids prevented good mixing (mass transfer) and appeared to hold the caustic in the solid layer. The pH in the uranium solid layer was higher than the bulk liquid phase.

Uranium solids formed from the onset of caustic addition. The solids were layered and paste-like. At the present loading of depleted uranium, the amount of solids formed during neutralization in the 242-16H Evaporator pot with air sparge mixing presents a formidable engineering challenge to pump the solids out of the pot. At the same time beaker tests with stirring bars provided evidence that pumpable slurry could be made by mechanical agitation rather than by air sparging.

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B. Morrell, E. Pearson, J. Clark, K. Klapper

Shielded Cells

D. Sanders

Analytical Development

R. Rutherford, J. Durden, A. Jurgensen, M. Summer

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Waste Processing Technology	

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R. A. Peterson	Date
Waste Processing Technology	

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W. A. Crooks	Date
Actinide Technology	

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R. A. Pierce	Date
Actinide Technology	

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S. W. Rosencrance	Date
Waste Processing Technology	

**Design Check**

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	Date
Waste Processing Technology	

**Management**

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W. B. Van Pelt	Date
Waste Processing Technology	

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B. L. Lewis

Date

Concentrate Storage and Transfer

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