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**SELECTIVE PARTITIONING OF MERCURY FROM
CO-EXTRACTED ACTINIDES IN A SIMULATED
ACIDIC ICPP WASTE STREAM¹**

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ABSTRACT

The TRUEX process is being evaluated at the Idaho Chemical Processing Plant (ICPP) as a means to partition the actinides from acidic sodium-bearing waste (SBW). The mercury content of this waste averages 1 g/l. Because the chemistry of mercury has not been extensively evaluated in the TRUEX process, mercury was singled out as an element of interest. Radioactive mercury, ²⁰³Hg, was spiked into a simulated solution of SBW containing 1 g/l mercury. Successive extraction batch contacts with the mercury spiked waste simulant and successive scrubbing and stripping batch contacts of the mercury loaded TRUEX solvent (0.2 M CMPO-1.4 M TBP in dodecane) show that mercury will extract into and strip from the solvent. The extraction distribution coefficient for mercury, as HgCl₂, from SBW having a nitric acid concentration of 1.4 M and a chloride concentration of 0.035 M was found to be 3. The stripping distribution coefficient was found to be 0.5 with 5 M HNO₃ and 0.077 with 0.25 M Na₂CO₃. An experimental flowsheet was designed from the batch contact tests and tested counter-currently using 5.5 cm centrifugal contactors. Results from the counter-current test show that mercury can be removed from the acidic mixed SBW simulant and recovered separately from the actinides.

INTRODUCTION

The Idaho Chemical Processing Plant (ICPP), located at the Idaho National Engineering Laboratory (INEL) in Southeastern Idaho, is owned by the DOE and currently operated by Lockheed Idaho Technologies Co., Inc (LITCO). The mission of the ICPP at one time was to reprocess special DOE and naval fuels. The majority of the reprocessed fuels were either zirconium or aluminum clad. The headend dissolution completely dissolved the cladding, heavy metals, and fission products. In order to enhance the dissolution rate of the aluminum clad fuels, mercury was added as a catalyst.

Following uranium recovery via a combination of REDOX and PUREX type processes, the highly radioactive raffinate streams were sent to temporary underground storage tanks. The liquid raffinates were eventually solidified by calcining in a fluidized bed operated at 500°C.

During the calcination process, mercury was volatilized and scrubbed out of the off-gas using nitric acid [1]. The nitric acid scrub solutions, which in essence concentrated the mercury, were sent back to temporary storage where they were blended with decontamination, solvent wash, and other solutions, most of which are high in sodium. This waste is referred to as sodium-bearing waste (SBW).

Unlike the liquid reprocessing raffinates, SBW solutions are not calcinable directly and must be blended with non-radioactive aluminum nitrate or other first cycle raffinates prior to calcination (as of November 1993 all raffinates were calcined). Approximately 1.5 million gallons of SBW, containing a total of 2 metric tons of mercury, are in temporary storage at the ICPP.

If the SBW is eventually blended and calcined, the mercury will most likely report back to the calciner nitric acid off-gas scrub solution and be sent back to temporary underground storage, thus resulting in mercury recycle throughout the ICPP waste treatment process.

Due to the growing environmental awareness of the public and DOE laboratories, a safe and

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efficient process to remove mercury from radioactive and non-radioactive waste streams may prove to be advantageous. Mercury partitioning may result in hazardous waste volume reductions and provide a mercury waste form suitable for final disposition or reuse.

Therefore, the scope of this work was to: 1) determine mercury extraction, scrub, and stripping distribution coefficients (D_{Hg}) in a typical TRUEX flowsheet using simulated sodium waste, and 2) develop a flowsheet that would either allow mercury to be partitioned from the co-extracted actinides or selectively extracted from them. Actinide separations from ICPP SBW will most likely be a gross separation rather than selective actinide partitioning. Therefore, the TRUEX flowsheet used for these tests deviates slightly in the stripping section from the TRUEX flowsheet developed by ANL [2].

EXPERIMENTAL

Commercially purchased octyl(phenyl) N,N -diisobutyl-carbamoylmethyl-phosphine oxide (CMPO) obtained from Elf Atochem and having a purity of >97% was sent to Argonne National Laboratory and further purified by Vandegrift and co-workers. It should be noted that previous CMPO purity tests show that the Elf Atochem CMPO is pure enough for use as received and that further purification steps are probably not necessary [3]. The TRUEX solvent was made up using this CMPO by LITCO's Quality Control Laboratory to contain 0.2 M CMPO and 1.4 M TBP in dodecane. The solvent was washed three times with 0.25 M Na_2CO_3 ($O/A = 5$) [4] and filtered through Whatman 542 filter paper prior to contact with the sodium waste simulant. To ascertain the purity and concentration of the CMPO in this solvent, the solvent was contacted with nitric acid solutions, ranging in acid concentrations between 0.01 - 8 M , containing ^{241}Am . Americium distribution coefficients using this solvent agree favorably with those found in literature [4] thereby establishing the suitability of this solvent for use in this study.

A NIST traceable ^{203}Hg standard in HCl was purchased from Amersham. One milliliter of this standard was diluted to 100 mL with 2 M HNO_3 . The resulting activity of ^{203}Hg in this solution was 14,864 dps/mL at $T_0 = \text{December 1, 1993}$ and contained 163 ppm Cl^- . Because of the short ^{203}Hg half-life (46.8 days), all ^{203}Hg results were decay corrected back to T_0 . Aliquots of the stock ^{203}Hg solution were spiked into the sodium waste simulant. The spike was allowed to equilibrate with the sodium waste for approximately 24 hours prior to contacting with the TRUEX solvent.

The TRUEX solvent was pre-equilibrated with non-spiked sodium waste simulant prior to contact with the spiked simulant. The composition of the non-spiked sodium waste simulant is presented in Table 1. Mercury is expected to predominantly exist as HgCl_2 in the waste simulant because of the high acidity and low chloride concentrations [5]. Pre-equilibrating the solvent has the effect of loading it with all extractable species (HNO_3 , Zr^{+4} , etc), including non-radioactive mercury, so that when the spiked sodium waste was contacted with the solvent, only the species of interest, ^{203}Hg , was extracted. Kinetic studies [6] show that the ^{203}Hg should come to equilibrium with stable mercury quickly. The distribution coefficient of stable mercury was assumed to be that determined for ^{203}Hg . To verify ^{203}Hg distribution coefficients obtained from TRUEX solvent pre-equilibrated with sodium waste simulant containing stable mercury, extractions were repeated using TRUEX solvent pre-equilibrated with sodium waste simulant that did not contain mercury. This pre-equilibrated solvent was then contacted with the ^{203}Hg spiked simulant which did contain stable mercury.

Solvent pre-equilibration was performed by contacting the solvent three times with the simulated waste at an $O/A = 1$ [7]. Pre-equilibration contacts were performed by mixing the two phases in a glass test tube on a vortex mixer for one minute. Phase disengagements were achieved by centrifuging the two phases for 5 minutes at 3500 rpm.

The ability to strip mercury from the TRUEX solvent using 0.25 M Na_2CO_3 was evaluated according to the flowsheet shown in Figure 1. A 0.04 M HEDPA contact was performed prior to contacts with 0.25 M Na_2CO_3 to remove any extracted metals, such as zirconium.

A second experimental procedure, shown in Figure 2, was used to evaluate solutions that

might selectively strip mercury from the TRUEX solvent. Following solvent pre-equilibration, sodium waste spiked with ^{203}Hg was contacted once with the TRUEX solvent. The mercury loaded solvent was then contacted six times with 5 M HNO_3 to strip mercury. Based on previous tests conducted to determine D_{Hg} as a function of nitric acid concentration [6], 5 M HNO_3 was chosen as a suitable mercury stripping solution. The experimental procedure shown in Figure 2 was repeated using 0.01 M and 5 M HCl .

Mercury extraction distribution ratios were also evaluated in a series of contacts, with fresh, pre-equilibrated TRUEX solvent being used for each contact. The solvent was subsequently scrubbed and stripped. This series of extraction, scrub and strip contacts, shown in Figure 3, was designed to simulate and evaluate mercury behavior in a TRUEX flowsheet. Mercury stripping behavior from the scrubbed TRUEX solvent was evaluated with 0.01 M HNO_3 , 0.25 M HEDPA, and 0.01-0.1 M $\text{H}_2\text{C}_2\text{O}_4$. All contacts, including solvent pre-equilibration, shown in Figures 1-3 were conducted at ambient laboratory temperatures ($27 \pm 2^\circ\text{C}$). All contacts were performed for 1 minute on a vortex mixer.

One milliliter of the initial spiked sodium waste feed and 1 ml of each phase after contact and centrifuging was sampled and placed in a 5 dram glass vial having a calibrated geometry. The 5 dram vials were centered against a High Purity Germanium detector having a relative efficiency of 73%. The ^{203}Hg primary photopeak at 279.2 keV was used to determine mercury activities in each phase.

Mercury distribution coefficients were determined by:

$$D_{\text{Hg}-203} = \frac{[\text{Activity } \text{Hg}_{\text{org}}]}{[\text{Activity } \text{Hg}_{\text{aq}}]} \quad (1)$$

Material balances were calculated by dividing the total activity of the feed (organic or aqueous) by the sum of the total activities of both phase after contact:

$$\% \text{ Material Balance} = \frac{\text{Total Activity In}}{\text{Total Activity Out}} \times 100 \% \quad (2)$$

where the total activity in and out is:

$$\frac{\text{Total Activity In}}{\text{Total Activity Out}} = \frac{(\text{dps/mL feed}) (\text{mL feed})}{(\text{dps/mL aq. phase}) (\text{mL aq. phase}) + (\text{dps/mL org. phase}) (\text{mL org. phase})} \quad (3)$$

Percent material balances were typically $100 \pm 5\%$.

Aliquots of each aqueous phase were titrated after extraction and phase separation with a standardized solution of 0.1002 M NaOH to a phenolphthalein endpoint. Acid results from this titration were taken to be the equilibrium acid concentration. To prevent metal hydrolysis from occurring and resulting in erroneous equilibrium acid concentrations, the aliquots were added to a solution of sodium oxalate ($\text{pH} = 5.2$) that had been previously titrated to the same phenolphthalein endpoint.

RESULTS AND DISCUSSION

Mercury Stripping With 0.25 Molar Sodium Carbonate

Sodium carbonate was tested as a possible mercury stripping reagent according to the flowsheet shown in Figure 1. The TRUEX solvent was loaded with mercury by contacting it three times with spiked SBW simulant, followed by three 0.2 M HNO_3 scrub contacts, one 0.04 M HEDPA strip to remove extracted zirconium, and three 0.25 M Na_2CO_3 strip contacts. Mercury activities in the organic and aqueous phase for each contact is shown in Table 2.

Sodium carbonate stripped 93% of the mercury from the TRUEX solvent in the first strip

contact (SR2). Little, if any, mercury was stripped in the subsequent two sodium carbonate strips (SR3 & SR4). Reasons for mercury not being stripped from the solvent in the final two 0.25 Na_2CO_3 strip contents are unclear at this time. Trace amounts of impurities in the CMPO or TBP may be preventing the complete removal of mercury from the solvent, or the Na_2CO_3 may be ineffective in completely removing mercury from the solvent.

The ability of sodium carbonate to strip mercury from the TRUEX solvent does allow for mercury removal during solvent clean-up operations; however, mercury precipitations, as HgO , have been observed in contacts with sodium carbonate. The occurrence of the HgO precipitation appears to be dependent upon the stripping solution used prior to 0.25 M Na_2CO_3 contacts. This precipitate was observed when the solvent was stripped with 0.01 M HNO_3 ; however, when the solvent was stripped with 0.25 to 0.04 M HEDPA, HgO precipitation did not occur during the 0.25 M Na_2CO_3 contacts. Reasons for this precipitate behavior are unclear at this time since neither dilute nitric acid nor HEDPA strip mercury from the solvent.

Mercury Stripping With 5 Molar Nitric Acid

Results from the series of contacts using the experimental procedure described in Figure 2 are shown in Table 3. Contacting the ^{203}Hg spiked simulated sodium waste with pre-equilibrated TRUEX solvent results in an extraction $D_{\text{Hg}} = 3$. This distribution coefficient agrees favorably with extraction mercury distribution coefficients shown in Table 2. Contacting the mercury loaded TRUEX solvent with 5 M HNO_3 resulted in a $D_{\text{Hg}} = 0.66$ for the first strip contact. Similarly, small mercury distributions were observed for the second through sixth strip contacts. After 6 stripping contacts, 99.5% of the mercury extracted into the TRUEX solvent had been stripped out. This data indicates that 5 M HNO_3 is a more efficient mercury stripping reagent than 0.25 M Na_2CO_3 .

The ^{203}Hg activity in the loaded solvent decreased from 1.11E3 dps/mL after the initial forward extraction to 5.11 dps/mL after six strip contacts. A low material balance is seen for the fifth strip contact which cannot be explained at this time. No interfacial crud or precipitate was observed in the fifth or fourth contacts. Unfortunately, the aqueous phase from the fourth contact was inadvertently disposed prior to sampling.

To verify the accuracy of Hg distributions shown in Table 3, the experimental procedure shown in Figure 2 was repeated using TRUEX solvent that was pre-equilibrated with a sodium waste simulant that did not contain mercury. This allowed for the concomitant extraction of both stable and radioactive mercury into the organic phase. Results from this test are also shown in Table 3. Extraction and stripping mercury distribution coefficients agree favorably with those obtained from TRUEX solvent pre-equilibrated with sodium waste containing stable mercury (Table 3).

Stripping distribution coefficients for mercury shown in Tables 2 and 3 indicate that removing mercury from the TRUEX solvent does not appear to be difficult and alleviates the concern of mercury build-up in the CMPO which could lead to reduced actinide extraction distribution coefficients. Mercury stripping will most likely be necessary if the TRUEX process is applied to ICPP sodium bearing waste in order to keep the pristine characteristics of the solvent.

Mercury Extraction from SBW Simulant

Tests were performed to determine the path of mercury during actinide separation conditions. The experimental procedure shown in Figure 3 was followed for this set of contacts. Three successive contacts of the aqueous sodium waste feed were performed with fresh pre-equilibrated TRUEX solvent. After the feed had been contacted three times with the TRUEX solvent, 99.7% of the original mercury concentration in the spiked sodium waste simulant had been extracted. Results of D_{Hg} for the extraction contacts are shown in Table 4. The extraction of Hg from acidic chloride solutions containing HgCl_2 as the predominant species into solvents containing only CMPO or TBP has been shown to be (unpublished data):



The two reactions shown in equations 4 and 5 are believed to be the primary reactions between the TRUEX solvent and the SBW simulant.

Mercury Stripping with Dilute Nitric Acid, Oxalic Acid, HEDPA, and HCl

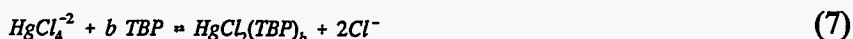
The organic feed resulting from the first contact with the sodium waste (E1-O) was contacted three times with 0.2 M HNO_3 , followed by three contacts with 0.01 M HNO_3 . Fresh scrub and strip solutions were used for each contact. The loaded solvent resulting from the second feed contact (E2-O) in the actinide separation flowsheet was also scrubbed three times with 0.2 M HNO_3 . The scrubbed solvent was then divided into two equal volume aliquots. One aliquot was stripped with 0.01 M $\text{H}_2\text{C}_2\text{O}_4$ the other aliquot was stripped with 0.1 M $\text{H}_2\text{C}_2\text{O}_4$. D_{Hg} for the scrub and strip contacts are shown in Table 4.

HEDPA was also tested to strip mercury from the TRUEX solvent. HEDPA is a member of the thermally unstable complexants (TUCS) and has been reported to be an effective actinide stripping agent [8]. If HEDPA were to strip mercury, there exists the possibility of stripping mercury in conjunction with the actinides, and perhaps simplifying some mercury separation flowsheets. A solution of 0.25 M HEDPA in 0.05 M HNO_3 was substituted for 0.01 M HNO_3 in the experimental procedure shown in Figure 3. Mercury extraction, scrub, and stripping distribution coefficients are also shown in Table 4.

Results from the experiments conducted using the experimental procedure shown in Figure 3, show that dilute nitric acid, oxalic acid and HEDPA are ineffective at stripping mercury from the TRUEX solvent.

The experimental procedure shown in Figure 2 was repeated using 0.01 M and 5M HCl as the stripping solutions. These contacts were performed to determine if the stripping behavior of mercury in a chloride system is analogous to the stripping behavior of americium in the nitrate system. In the nitrate system, americium has been shown to extract as a nitrate species, however, americium is also stripped from the TRUEX solvent in dilute nitric acid [9]. Horwitz, et. al., have also shown that the actinides will extract into and strip from the TRUEX solvent using HCl (TRUEX-Chloride Process) [10]. Stripping mercury with dilute HCl after the actinides have been stripped with an alternative stripping solution, that is immune to mercury, may offer an alternative to the 5 M HNO_3 and 0.25 M Na_2CO_3 Hg separation schemes. Results from this test are shown in Table 4.

A comparison of the 5 M HCl stripping distribution values with distribution values obtained with 0.01 M HCl does show a decrease in D_{Hg} . A possible explanation for the D_{Hg} decrease may be attributed to the increase in chloride concentration causing the formation of HgCl_4^{-2} . This is the predominant Hg species in acidic solutions containing $> 0.1 \text{ M Cl}^-$ [5]. The extraction of mercury from solutions where the dominant species is HgCl_4^{-2} into solvents containing only CMPO or TBP, has been shown to decrease as the chloride concentration increases (unpublished data). The reaction of HgCl_4^{-2} is postulated to be:



The CMPO and TBP stoichiometries have not been confirmed and reactions shown in Equations 6 and 7 have not been proven to be reversible. Equations 6 and 7 show how increasing the chloride concentration will drive the reactions to the left, causing a decrease in D_{Hg} . Stripping D_{Hg} observed with 0.01 M HCl are substantially larger than those observed with 5 M HCl because the formation of HgCl_4^{-2} is unfavorable at the lower chloride concentration.

The HCl stripping data indicates that extracted HgCl_2 does not strip from the TRUEX solvent with dilute or fairly concentrated HCl. This behavior seems to be inconsistent with that of americium in the nitrate system and with the behavior of the actinides in the TRUEX-Chloride system. A possible reason for HgCl_2 behavior is its covalent nature, as opposed to the ionic nature of the actinide-nitrates and chlorides. The covalent nature of mercuric chloride probably contributes to its solubility in the organic phase.

Flowsheet Development

A TRUEX flowsheet has been developed for treating ICPP SBW from actinide and mercury tracer tests using the SBW simulant [11-12]. This flowsheet was tested counter-currently using 5.5 cm centrifugal contactors and an SBW simulant containing Nd as an Am surrogate and non-radioactive Hg. Greater than 98 % of the Hg and >99.9% of the Nd in the simulant was extracted after 8 stages (O/A=0.33). The Nd/Hg loaded TRUEX solvent was then scrubbed with 0.07 M HNO_3 (4 stages O/A=1.5) and stripped with 4 stages of 0.04 M HEDPA (O/A=0.75). Neodymium was quantitatively recovered from the solvent with the HEDPA. The Hg loaded solvent was then washed with 0.25 M Na_2CO_3 (4 stages O/A=1). Greater than 99% of the extracted Hg was recovered. The tested flowsheet and results are shown in Figure 4.

CONCLUSIONS

A process flowsheet capable of partitioning mercury from the co-extracted actinides using the TRUEX process has been developed. The process has been demonstrated counter-currently with simulated acidic sodium waste similar to that currently being stored at the ICPP. Greater than 98% of the Hg in the SBW simulant was extracted into the TRUEX solvent. The extracted Hg was quantitatively recovered from the solvent with 0.25 M Na_2CO_3 . Nitric acid concentrations ≥ 5 M, have also been shown to quantitatively strip Hg from the TRUEX solvent in batch contact tests. Other stripping solutions (0.01 M HNO_3 , 0.01 M HCl, 0.25 M HEDPA, 0.04 M HEDPA and 0.01-0.1 M $\text{H}_2\text{C}_2\text{O}_4$), were ineffective in stripping mercury from the TRUEX solvent.

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Table 1. Non-spiked Sodium Waste Simulant Concentrations.

Component	<u>M</u>	Component	<u>M</u>
H ⁺	1.35	K	1.43E-1
Al	6.48E-1	Mn	1.42E-2
B	1.71E-2	Mo	1.49E-3
Cd	2.29E-3	Na	1.26
Ca	3.91E-2	NO ₃	4.46
Ce	3.88E-4	Ni	2.20E-3
Cl	3.52E-2	Pb	1.08E-3
Cs	7.52E-5	PO ₄	<9.18E-3
Cr	6.56E-3	Sr	1.70E-4
F	9.66E-2	SO ₄	3.86E-2
Fe	3.10E-2	Zr	1.00E-3
Hg	2.88E-3		

Table 2. Stripping D_{Hg} using 0.25 M Na_2CO_3 .

Contact	Organic Activity dps/mL	Aqueous Activity dps/mL	D_{Hg}	Material Balance In/Out
Feed	NA	$1.59E3 \pm 8.71E1$	NA	NA
E1	$1.30E3 \pm 5.56E1$	$3.59E2 \pm 1.69E1$	3.6	96%
E2	$2.43E3 \pm 1.19E2$	$5.96E2 \pm 3.14E1$	4.1	95%
E3	$3.04E3 \pm 1.53E2$	$7.61E2 \pm 4.20E1$	4.0	105%
SC1	$3.06E3 \pm 1.64E2$	$1.16E2 \pm 6.46E0$	26	96%
SC2	$2.98E3 \pm 1.52E2$	$6.03E1 \pm 3.64E0$	49	101%
SC3	$3.00E3 \pm 1.56E2$	$4.65E1 \pm 3.11E0$	64	98%
SR1 HEDPA	$3.01E3 \pm 1.70E2$	$2.72E1 \pm 1.96E0$	110	99%
SR2	$2.10E2 \pm 1.31E1$	$2.71E3 \pm 1.48E2$	0.077	103%
SR3	$2.24E2 \pm 1.38E1$	ND	†	93%
SR4	$2.15E2 \pm 1.15E1$	ND	†	104%

Sample Codes: E = forward extraction, SC#, scrub number, SR# = strip number,
 ND = No activity detected NA = Not applicable † = Can't calculate D_{Hg}

Table 3. Mercury stripping distributions from Hg-203 spiked SBW, the TRUEX solvent, and 5 M HNO_3 .

Contact	TRUEX Pre-equilibrated with SBW Containing Hg		TRUEX Pre-equilibrated with SBW Containing no Hg	
	[HNO_3]	D_{Hg}	[HNO_3]	D_{Hg}
E1	1.52	3.1	1.57	2.98
SR1	4.68	0.66	4.78	0.72
SR2	4.97	0.62	4.88	0.62
SR3	4.91	0.53	5.00	0.57
SR4	5.08	ND	5.17	0.60
SR5	ND	0.33	5.05	0.81
SR6	5.22	0.84	5.08	0.62

ND = No data

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Table 4. Mercury distribution coefficients using Hg-203 spiked SBW simulant, the TRUEX solvent, and various stripping reagents.

Contact	Strip Reagent 0.01 M HNO ₃ (Figure 3)		Strip Reagent Oxalic Acid (Figure 3)		Strip Reagent 0.25 M HEDPA (Figure 3)		Strip Reagent 0.01 M HCl (Figure 2)		Strip Reagent 5.0 M HCl (Figure 2)	
	[HNO ₃] _{aq}	D _{Hg}	[HNO ₃] _{aq}	D _{Hg}	[H ⁺] _{aq}	D _{Hg}	[H ⁺] _{aq}	D _{Hg}	[H ⁺] _{aq}	D _{Hg}
E1	1.47	3.0	1.47	3.0	1.51 [†]	3.1	1.52 [†]	3.2	1.53 [†]	3.1
E2	1.45	3.1	1.45	3.1	NC	NC	NC	NC	NC	NC
E3	1.47	3.1	1.47	3.1	NC	NC	NC	NC	NC	NC
SC1	0.85 ¹	23.7	0.84 ²	25.5	0.85 [†]	27.5	NC	NC	NC	NC
SC2	0.39 ¹	46.7	0.40 ²	42.6	0.41 [†]	53.3	NC	NC	NC	NC
SC3	0.26 ¹	55.7	0.25 ²	57.8	0.27 [†]	65.6	NC	NC	NC	NC
SR1	0.068 ¹	71.4	ND ²	53.7 ³ (SR0.1)	0.78	114	0.68	35	5.16	1.08
SR2	0.017 ¹	67.7	ND ²	67.3 ⁴ (SR0.01)	0.72	129	0.20	68	5.42	3.13
SR3	0.0095 ¹	67.2	NC	NC	0.70	133	0.046	79	5.18	5.80
SR4	NC	NC	NC	NC	0.71	130	0.012	76	5.18	8.14
SR5	NC	NC	NC	NC	NC	NC	0.01	77	5.01	10.13
SR6	NC	NC	NC	NC	NC	NC	ND	68	NC	NC

1 = scrubbed and stripped TRUEX from E1 contact

2 = scrubbed and stripped TRUEX from E2 contact

3 = 0.1 M oxalic acid strip solution

4 = 0.01 M oxalic acid strip solution

NC = No contact performed

ND = No data

† = acid as HNO₃

Figure 1. Procedure for evaluating mercury stripping behavior with sodium carbonate.

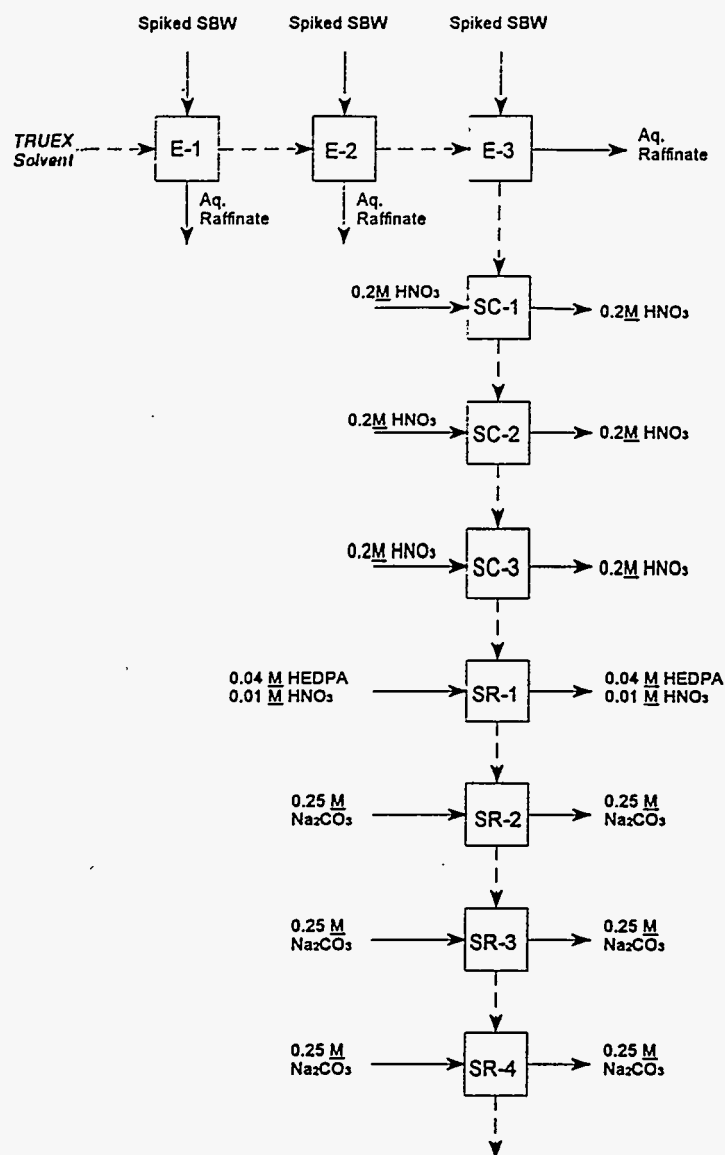


Figure 2. Schematic of experimental procedure.

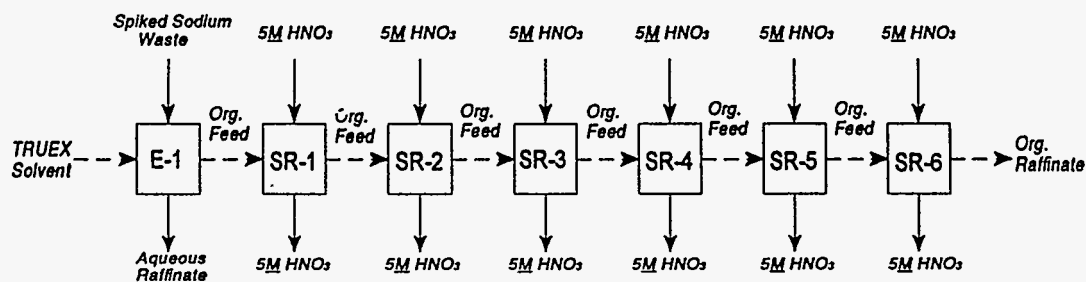


Figure 3. Procedure for evaluating mercury in a simulated TRUEX process flowsheet.

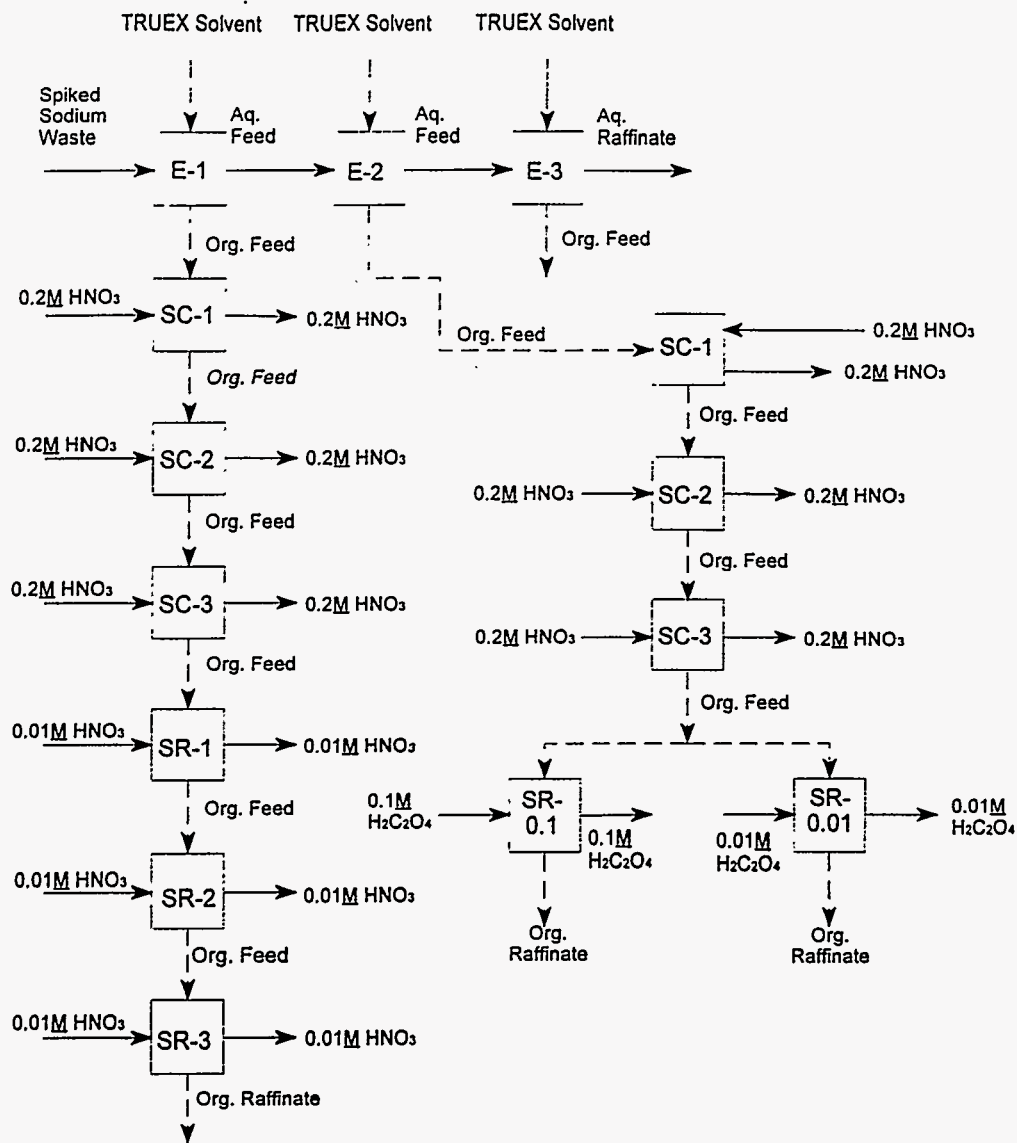
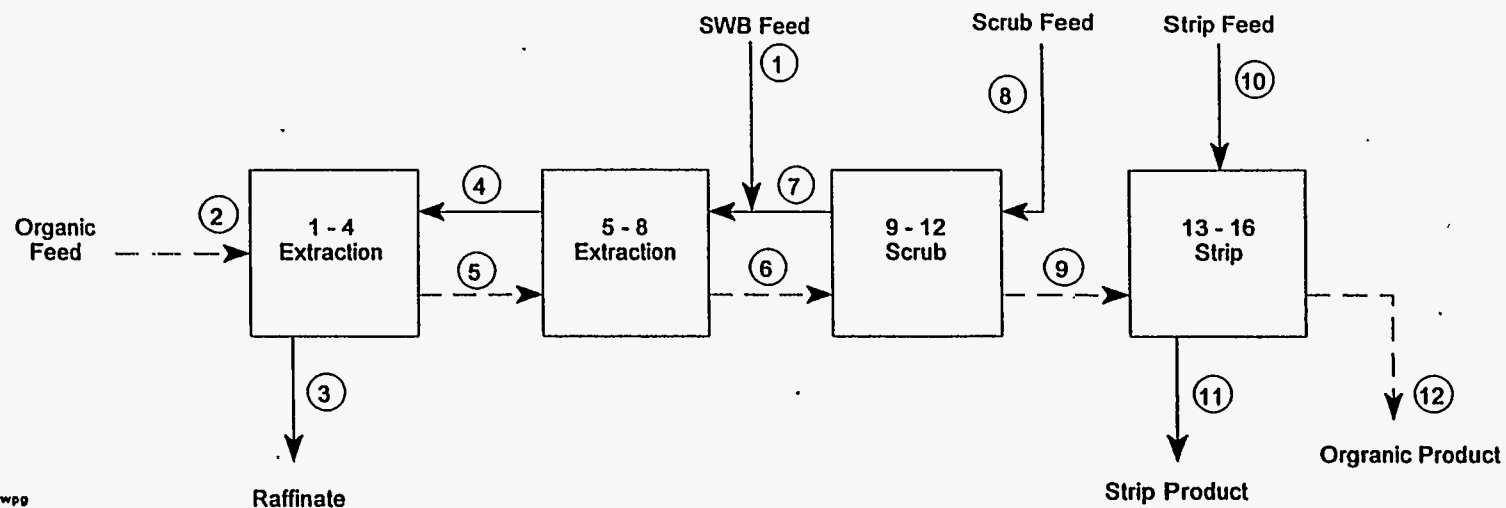


Figure 4. TRUEX flowsheet tested in 5.5 cm centrifugal contactors.



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	SBW Feed 1	Organic Feed 2	LAW Raff. 3	Stage 5 Aqueous 4	Stage 4 Organic 5	Stage 8 Organic 6	Stage 9 Aqueous 7	Scrub Feed 8	Stage 12 Organic 9	Strip Feed 10	Strip Product 11	Organic Product 12
H ⁺ M	1.31	0.0142	1.00	1.28	0.84	0.82	1.21	0.072	0.108	0.01	0.18	0.007
TUCS										0.04	0.04	
Nd M	3.79E-03		<2.1E-06	<2.1E-06	<5.2E-06	8.98E-03	9.36E-04		9.64E-03		7.14E-03	<5.2E-06
Hg M	1.17E-03		1.19E-05	1.20E-04	2.02E-03	1.57E-03	1.90E-04		1.91E-03		1.35E-05	1.76E-03
Fe M	0.0245		0.0184	0.0204	8.28E-03	0.0107	0.0112		3.04E-03		2.45E-03	1.68E-05
Zr M	7.7E-05		3.46E-05	3.04E-05	1.67E-05	1.11E-04	1.62E-05		1.11E-04		8.47E-05	<1.9E-06
Flow LPH	0.706	0.30	0.905	0.905	0.30	0.30	0.199	0.199	0.30	0.39	0.39	0.30