RADIOLYSIS TESTING OF SPHERICAL RF RESIN

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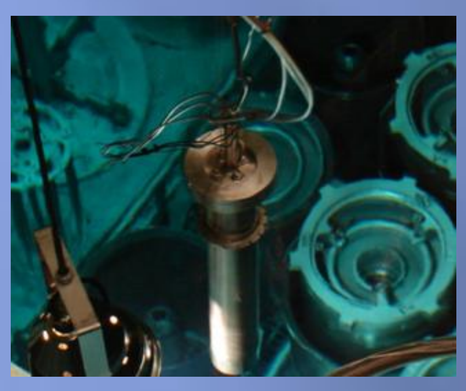
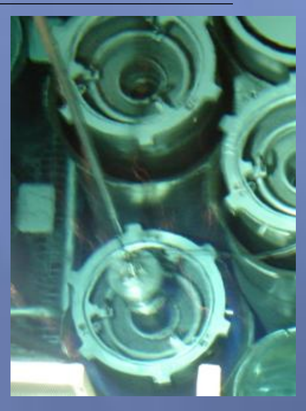
Background

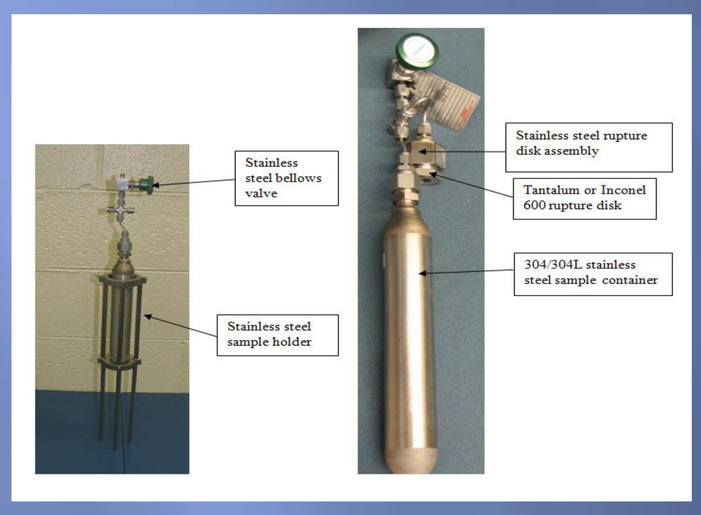
- Small Column Ion Exchange (SCIX) System proposed for cesium removal at Hanford and Savannah River
- SCIX is deployable in- or near-tank to reduce capital cost and expedite remediation
- Reported work used elutable Spherical Resorcinol Formaldehyde Resin (RF)
- Resin geometry is intended to mitigate column packing/pressure drop issues associated with granular RF and SuperLig®
- Testing was performed to obtain data for SCIX system design

Compositions of dissolved salt surrogates

Chemical compound	SRS Tanks 1, 2, and 3 (g/L)	Hanford Tank AP-101 (g/L)
$NaNO_3$	336.7	154.2
$NaNO_2$	16.6	49.0
NaOH	58.4	81.6
$NaAlO_2$	10.7	21.3
Na_2CO_3	8.5	47.7
Na_2SO_4	4.3	5.7
NaCl	0.82	2.3
NaF	1.2	0.0







Experiment

- Determine if RF degrades under radiation field
- ORNL irradiation facilities
  - High Flux Isotope Reactor (HFIR)
    - * 12.5 Mrad/hr dose rate
  - Co-60 source
    - * 24 krad/hr dose rate
- 20 samples with 15-20 g of RF irradiated at HFIR
- 3 samples with 100-120 g of RF irradiated at the Co-60 source
- Gas and liquid samples analyzed
- Resin with known oxygen exposure irradiated for comparison
- Irradiated resin used in K_d tests for comparison

Testing Conditions

HFIR testing conditions

Liquid	Type of resin	Exposures [Mrad]
Water	New	50, 100, 150, 200, 250, 300
Water	Used	50, 100
0.5 M Nitric Acid	New	150, 200, 250, 300
Hanford Simulant	New	150, 200, 250, 300
SRS Simulant	New	150, 200, 250, 300

Co-60 Source testing conditions

Liquid	Type of resin	Exposures [Mrad]
Water	New	150, 200, 250, 300
0.5 M Nitric Acid	New	150, 200, 250, 300
SRS Simulant	New	150, 200, 250, 300

- Gas, Volatile Organic Compounds (VOC), and Semi Volatile Organic Compounds (SVOC) analyzed for each HFIR Sample
- Gas and VOC samples analyzed for each Co-60 Source sample
- SVOC, Formaldehyde, and Total Organic Carbon for 300 Mrad Co-60 Source Sample

HFIR Gas Results

Gas produced during HFIR sample radiolysis[a]

HFIR samples		Number of moles generated per gram dry resin					Number of moles generated per gram dry resin per Mrad	
	Dose [Mrad]	Total	Hydrogen	Methane	Nitrogen	Oxygen	Total	Hydrogen
Nitric acid	300	2.0774E–04	3.4734E–05	2.0657E–08	4.7800E–05	–5.4401E–06	6.9247E–07	1.1578E–07
	250	8.9612E–04	6.9001E–05	8.9443E–08	1.2685E–04	–1.9257E–05	3.5845E–06	2.7601E–07
	200	1.4560E–03	3.6152E–04	2.9103E–07	3.5762E–04	–1.9358E–05	7.2800E–06	1.8076E–06
	150	7.7084E–05	5.0258E–06	1.5248E–08		–1.2742E–05	5.1389E–07	3.3505E–08
Water	300	3.5083E–04	2.8347E–04	1.4019E–07		–1.4957E–05	1.1694E–06	9.4490E–07
	250	1.6364E–04	9.6861E–05	9.8041E–08		–1.6948E–05	6.5458E–07	3.8744E–07
	200	1.7506E–04	1.7461E–08	1.2611E–04		3.1027E–05	8.7530E–07	8.7306E–11
	150	1.8119E–04	1.0237E–04	1.0857E–07		–1.7044E–05	1.2079E–06	6.8247E–07
	100 (new)[b]	1.7922E–04	2.0251E–06	1.7776E–08	7.8672E–05	1.5913E–05	1.7922E–06	2.0251E–08
	50 (new)[b]							
	100 (old)[b]	1.7292E–04	2.3794E–05	1.7146E–08	3.7984E–05	2.2761E–05	1.7292E–06	2.3794E–07
	50 (old)[b]	9.1415E–05	9.0967E–09	9.1269E–08	7.0933E–06	2.6465E–06	1.8283E–06	1.8193E–10
Hanford	300	1.2755E–04	7.3035E–05	1.2609E–08		–1.7050E–05	4.2517E–07	1.4790E–07
	250	2.2244E–04	1.5026E–04	4.4343E–08		–1.5372E–05	8.8978E–07	2.0872E–07
	200	1.5068E–04	9.0405E–05	2.9989E–08		–1.6867E–05	7.5338E–07	1.6470E–07
	150	1.7007E–04	7.4846E–05	1.2147E–09		1.6560E–05	1.1338E–06	1.2577E–07
SRS	300	3.8331E–04	1.8138E–04	7.6517E–08		7.0678E–05	1.2777E–06	1.6442E–07
	250	3.0424E–04	9.9366E–05	6.0703E–08		6.3684E–05	1.2170E–06	1.0862E–07
	200	5.1334E–05	2.1555E–05	4.9875E–09		–4.6398E–06	2.5667E–07	6.9042E–08
	150	1.8110E–04	6.3024E–05	1.4342E–08		4.4784E–05	1.2074E–06	1.0142E–07

[a]Data in this table represent cumulative gas production. The water sample with new resin that was irradiated to 50 Mrad did not have a gas sample analyzed because the gas sample was accidentally evacuated.

[b]New resin is virgin resin and has no known oxygen exposure. The 'old' resin was used in the hydraulic conductivity test loop and has a known oxygen exposure of 7 mmoles oxygen/g dry resin.

Co-60 Source Gas Results

Gas produced during Co-60 source sample radiolysis[a]

Co-60 source		Number of moles generated per gram dry resin					Number of moles generated per gram dry resin per Mrad	
	Dose [Mrad]	Total	Total	Methane	Nitrogen	Oxygen	Total	Hydrogen
Nitric acid	300			1.3069E–08	3.6302E–06	–9.4903E–06	2.6307E–06	7.7028E–07
	250	8.9537E–05	1.5400E–05	6.1833E–09	–7.9566E–06	–9.5989E–06	1.7907E–06	3.0801E–07
	200	4.7218E–05	2.4364E–06	4.6376E–09	–1.5470E–05	–6.4116E–06	9.4437E–07	4.8729E–08
	175	6.0486E–05			1.0730E–05	2.4805E–06	1.2097E–06	
	150	3.4314E–05					6.8628E–07	
Water	300	5.5560E–05	4.6948E–05	3.2311E–09	–3.7779E–05	–1.1084E–05	1.1112E–06	9.3896E–07
	250	4.3365E–05	3.1479E–05	2.9330E–09	–3.4662E–05	–1.1571E–05	8.6730E–07	6.2957E–07
SRS	300	–3.0547E–06	–5.0742E–07	–7.1380E–10	–4.6661E–05	–1.2494E–05	–6.1094E–08	–1.0148E–08
	250	–2.2209E–05	–3.3602E–06	–4.5447E–09	–5.8903E–05	–1.5116E–05	–4.4418E–07	–6.7205E–08
	200	–2.6359E–06	–1.9904E–07	–3.6645E–10	–4.6258E–05	–1.2530E–05	–5.2718E–08	–3.9809E–09
	175	2.5376E–06	3.5269E–07	–8.5095E–11	–4.3864E–05	–1.1625E–05	5.0752E–08	7.0538E–09
	150	2.8171E–05					5.6342E–07	

[a]Data in this table represent gas produced during each 50 Mrad sample.

Total organic carbon analytical results (mg/L)

Liquid	Individual aliquots					Average
Nitric acid	27.2	27.31	26.61	28.3	26.65	27.21
Water	108	104.4	104.7	110.9	112.9	108.18
SRS	1760	1711	1754	1782	1784	1758.2

Conclusions

- Irradiated resin produced gas
  - Resin covered with nitric acid produced the most gas
  - More hydrogen was generated than any other gas
  - Oxygen was consumed by the resin
  - Amount of hydrogen produced and oxygen consumed increase with higher irradiation doses
- No standard SVOC's were detected
- Discoloration of the liquid observed with higher irradiation dose
  - Discoloration does not seem to have an effect on performance

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