Hydraulic Testing of Spherical RF Resin– Effect of Radiation and Oxygen Uptake

LINDSAY ROGERSON, KATHRYN SHPIK, AND P. A. TAYLOR

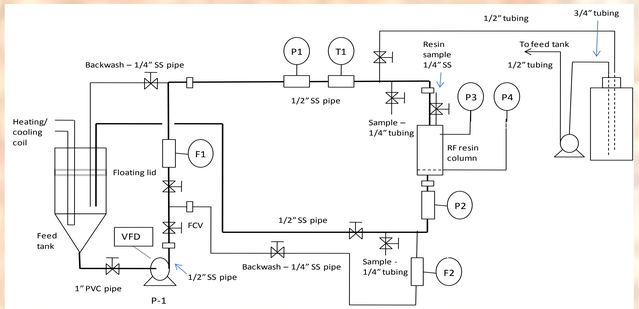
Background

Spherical resorcinol-formaldehyde (RF) resin is being evaluated for use at the Savannah River Site and at the Hanford Site to remove ^{137}Cs from high-level waste tank supernates and dissolved salt solutions. The treated solutions would be solidified for disposal as low-level waste.

Objective

Determine the hydraulic permeability of a column containing the RF resin and determine the impact of radiation exposure and oxygen uptake on the permeability. Design, fabricate and operate a test loop to measure the pressure drop through the column of RF resin at various conditions.

Photograph of test loop in operation



Flow diagram of test loop

Conclusions

- The RF resin reacts rapidly with dissolved oxygen in flowing simulant solution
- Oxygen uptake reduces the void space and the permeability of the resin
- Irradiation reduces the void space and the permeability of the resin
- Irradiation increased the toughness of the resin – less compression of resin beads for a given force
- Oxygen uptake does not change resin toughness, but does decrease the crush strength of the beads
- Irradiation and oxygen uptake decrease the cesium distribution coefficient of the resin

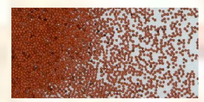
Experimental Methods

Recirculate Hanford simulant solution through a column of RF resin. Add oxygen gas to batches of simulant and measure dissolved oxygen concentration as the oxygen reacts with the resin. Determine flow rate needed to give a pressure drop through the resin bed of 9.7 psi.

Run 1 – new RF resin, temperature = 25°C
Run 2 – irradiated resin, temperature = 25°C
Run 3 – irradiated resin, temperature = 45°C

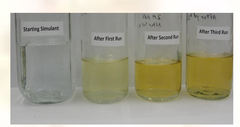
Materials

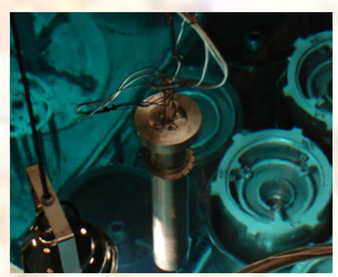
The spherical RF resin (lot #5E-370/641, manufactured by Microbeads AS, Skedsmokorset, Norway) consists of a porous polystyrene-divinyl benzene matrix, with resorcinol-formaldehyde polymerized inside the beads.



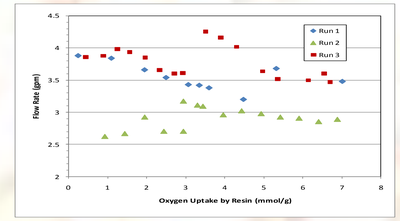
Hanford Tank Simulant Solution

Component	Conc. (*M*)
NaOH	2.0
$NaNO_3$	1.0
$NaNO_2$	0.7
$NaAlO_2$	0.3
Na_2SO_4	0.04
Na_2CO_3	0.4
NaCl	0.04
KNO_3	0.7

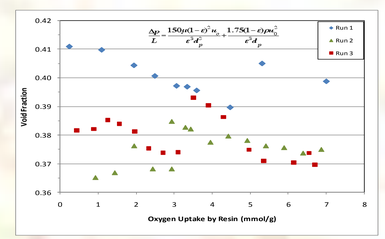




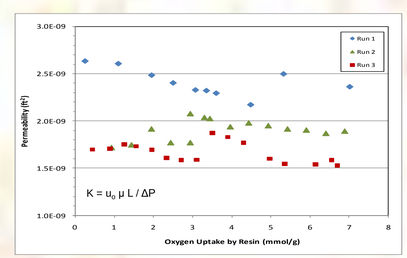
RF resin, inside sample container, being lowered into spent fuel element at the High Flux Isotope Reactor. Resin was irradiated to 177 Mrad for runs 2 and 3



Flow rate needed to give a pressure drop of 9.7 psi through The resin bed as oxygen uptake increases.

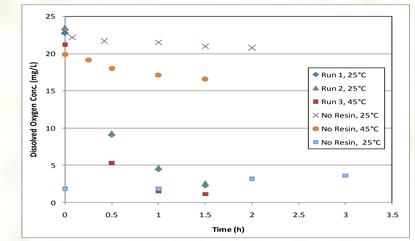


Calculated void fraction in resin beds, using Ergun's equation

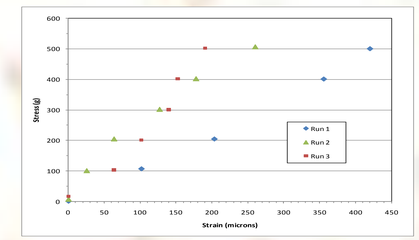


Calculated permeability of resin beds, using Darcy's equation

Results



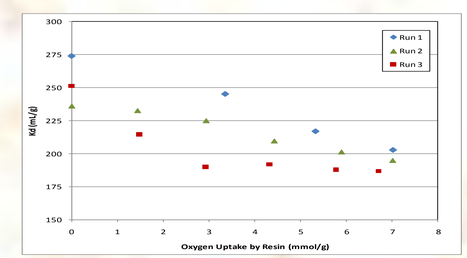
Change in DO concentration of recirculating simulant solution



Stress-versus-strain results for initial resin samples from runs 1–3, Oxygen uptake did not change the results

Crush strength of resin beads from runs 1–3

Run 1 resin samples		Run 2 resin samples		Run 3 resin samples	
O_2 uptake (mmol/g)	Crush stress (g)	O_2 uptake (mmol/g)	Crush stress (g)	O_2 uptake (mmol/g)	Crush stress (g)
0	800	0	>1000	0	>1000
3.35	350	1.44	350	1.47	680
5.32	290	2.94	405	2.92	742
7.01	260	4.43	408	4.32	574
		5.9	410	5.77	608
		7.02	365	6.7	690



Cesium uptake results for resin samples

UT-BATTELLE

OAK RIDGE National Laboratory

Print

Close