DIAL

Salt Cake Dissolution Flow Module

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Background

A large portion of the waste contained in the storage tanks at Hanford and at the Savannah River Site (SRS) is in the form of salt cake. The dissolution of the waste is the first stage in reducing the inventory and eventually closing the tanks. The wastes vary in composition and contain a number of different salts including sodium nitrate, sodium nitrite, sodium carbonate, and sodium phosphate. Addition of a diluent, such as water or caustic, to the tank results in dissolution and permits transfer of an aqueous stream to downstream processing facilities. Mobilization of the waste depends on the thermodynamics of the waste constituents as well as on the inherent porosity and permeability of the salt matrix. The later two properties reflect the ability of a fluid to flow through, and potentially interact with, a material of varying particle sizes, arrangements, and packing density.

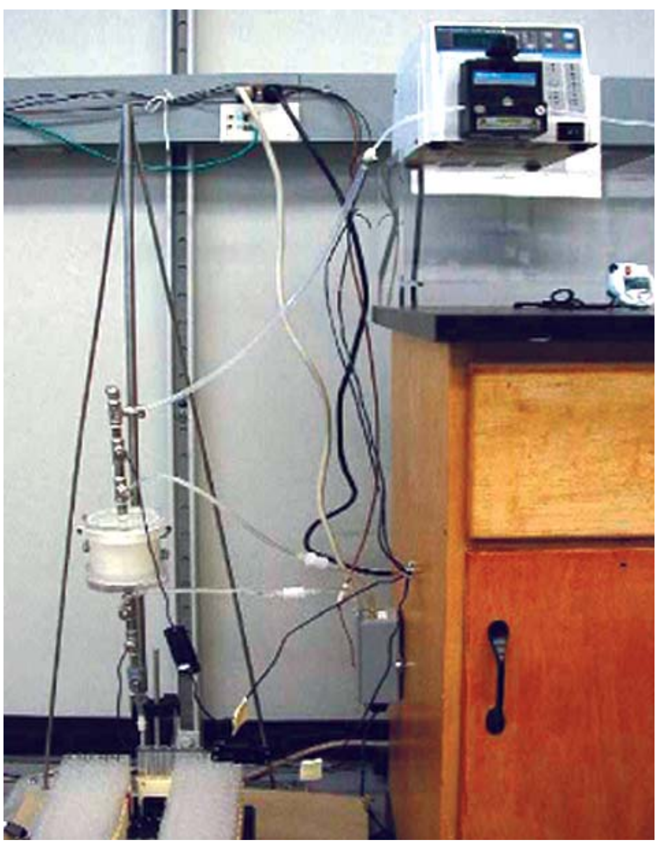

Figure 1. The flow through configuration of the SDFM consists of an acrylic column, a peristaltic pump for diluent addition, and a fraction collector.

Figure 2. All operations in the DASR configuration of the SDFM are performed through a salt well.

Previous estimates of void fraction and fluid flow through salt cakes have relied on limited laboratory experiments, tank recharge rates, and the general similarity of salt cakes to sand. Work in these laboratories has resulted in a laboratory-scale system capable of quantifying salt mixture physical properties and dissolution chemistry. Site engineers are using these results to validate flow sheets, establish retrieval time lines, select diluents, and investigate downstream process impacts.

The salt cake dissolution flow module (SDFM) can be operated in two different configurations. Flow through experiments, Figure 1, permit the determination of porosity, based on the Blake–Kozeny equation, and permeability, from Darcy's Law.

The second manifestation of the system more fully accounts for tank configurations, where a well has been bored into the salt bed, Figure 2. This arrangement is referred to as drain, add, sit, and remove (DASR) and follows from operations at the Savannah River Site (SRS). This experiment allows for the determination of the fraction of interstitial liquor that can be removed from the salt bed and the permeability of diluent into the matrix.

Anion and cation profiles will differ with the two experiments. In the flow through configuration the pressure initially above the salt matrix is insufficient for significant displacement of the interstitial liquid lodged within the pores. Dissolution of the salt proceeds from the top to the bottom of the column and diluent and dissolved salt compositions can interact with the high ionic strength interstitial liquid. This tends to result in the mixing of low and high ionic strength liquids giving rise to solids re-precipitation. The DASR configuration initially removes the majority of the interstitial liquid and minimizes solids formation from this source.

A number of different experimental tools and methods are used during the column experiment and in analyzing the dissolution process.

METHOD	ANALYSIS
DIAL Imaging System	Salt cake and diluent level heights, channeling
Thermocouples	Temperature
IC(1)	NO_2^{-1}, NO_3^{-1}, SO_4^{-2}, PO_4^{-3}, Cl^{-1}, F^{-1}, $C_2O_4^{-2}$
ICP(2)	Al^{+3}, Si^{+4}
TIC/TOC(3)	CO_3^{-2}
Rotational Viscometer	Absolute viscosity, shear rate dependence
PLM(4)	Solids identification and size
SEM/X-ray, XRD	Solids composition and size
Polymer Impregnation/ LCM(5)	Dry salt cake porosity
Thermal Gravimetric Analyzer (TGA)	Supernatant and salt cake water loading

1) ion chromatography
2) inductively coupled plasma spectroscopy
3) total inorganic carbon, total organic carbon instrument
4) polarized light microscope
5) laser confocal microscope

Application and Results

Three different salt cakes, two from the Hanford site and one from SRS have been evaluated using the flow through column configuration. ESP model predictions for the original solids in the salt cake surrogates and the determined porosity and permeabilities are given in Figure 3.

The SRS simulant was found to have the largest porosity and permeability of the three compositions. Model predictions indicate that 80% of the solids in the SRS salt cake are sodium nitrate. These crystals form rhombs of regular shape thereby leading to a greater packing regularity in the bed. NaPHOH is sodium phosphate dodecahydrate and these crystals are thin and

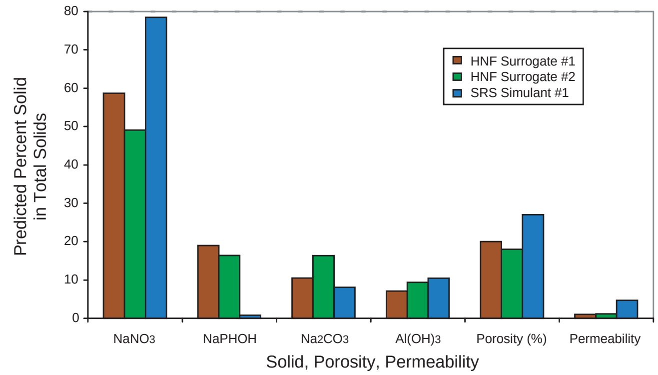

Figure 3. Thermodynamic model predictions and measured salt cake physical properties show correlations with solids weight fractions.

rod-like structure that, in combination with the regular shapes, reduces the effective pore diameter.

Chemical data have been obtained for both types of experiments and follow the model predictions for nitrate, nitrite, carbonate, chloride, and oxalate anions and for aluminum cation. Some differences were found with the partitioning of the given anions between the solid and liquid phases, particularly for fluoride, sulfate and phosphate. These differences are under evaluation in connection with efforts to develop the double salt database.

Availability and Future Work

The SDFM is currently being used to evaluate simulants for SRS. Additional experiments are in progress to ascertain the possibility of forming gibbsite ($Al(OH)_3$) layers within site tanks. Layer formation has previously been observed with one of the Hanford simulants. The potential presence of layers within the tank drastically altered the permeability of the material and reduced the effectiveness of dissolution thereby increasing the time required for waste retrieval. Means for minimizing this effect range from the use of caustic as a diluent to the incorporation of past practice sluicing.

For further information on the SDFM and salt cake dissolution experiments, you may contact:

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