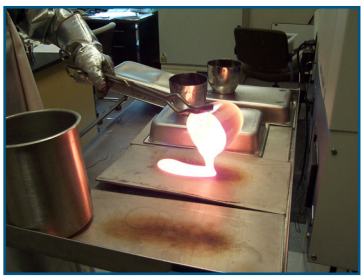
Incorporation of TiO_2 in High Level Waste Glass

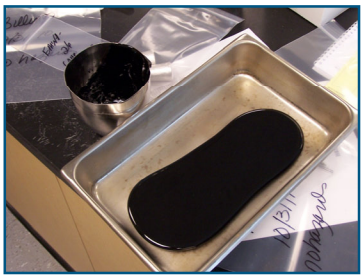
K.M. Fox, F.C. Johnson, and T.B. Edwards

Background

- **The Savannah River Site Tank Farm plans to implement Small Column Ion Exchange (SCIX) to disposition salt solution**
- **Monosodium Titanate (MST) will be used to remove actinides and strontium in waste tanks**
- **Filtered solution will be passed through Crystalline Silicotitanate (CST) resin to remove cesium**
  - Decontaminated solution will be immobilized in grout
- **MST and ground, ^{137}Cs-laden CST will be immobilized with sludge in high level waste (HLW) glass**
- **MST and CST from SCIX will increase concentrations of Nb_2O_5, TiO_2, and ZrO_2 in Defense Waste Processing Facility (DWPF) glass**
  - Impacts of these increases on glass properties (behavior in melter) and performance (repository requirements) must be understood
- **DWPF uses models for process control that predict glass properties and performance from composition**
  - Models must be validated for these increases



Pouring simulated high level waste glass after melting at 1150 °C.



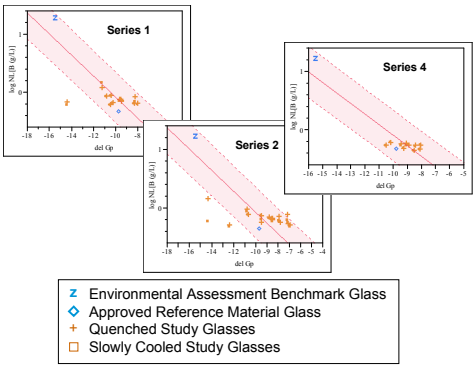
Patty of simulated high level waste glass after cooling.

Outline – Present Study

- **Paper studies**
  - Projected waste compositions with SCIX streams incorporated evaluated using potential glass frit compositions and the current process control models
  - Results showed good ability to accommodate the SCIX streams in glass
  - Several assumptions made in using the current models:
    - Current TiO_2 limit of 2 wt % in glass must be increased
    - Compositional region of applicability for models must be extended
- **Experimental program**
  - Provide data to support the incorporation of SCIX streams (address the above assumptions)
    - Extend model validation or re-fit models as necessary
- **Fabricating and characterizing glasses to determine impacts of higher Nb_2O_5, TiO_2, and ZrO_2 concentrations**
  - Bounding TiO_2 concentrations of 4 to 8 wt % in glass
- **Glass compositions have been selected to allow for the study of:**
  - Individual component effects on the incorporoation of TiO_2
  - Sludge batch specific glasses
  - Variation in sludge composition
  - Crystallization
  - Impacts of noble metals
  - Impacts of uranium and thorium

Durability Impacts

- **37 glasses have been fabricated to date for durability testing**
  - Air quenched and slowly cooled versions
- **Used the ASTM Product Consistency Test (PCT), Method A**
- **Ground samples of each glass sealed in stainless steel vessels with water for 7 days at 90 °C**
  - Samples run in triplicate
- **Results compared with predicted values from the current DWPF durability models**



- **Measured versus predicted PCT response for boron**
  - All glasses are well predicted except for those with high K_2O concentrations
  - High K_2O concentrations unrealistic for actual processing, although somewhat beneficial for TiO_2 retention

Stainless steel vessels used for the ASTM Product Consistency Test.

Print

Close

SRNL-STI-2010-00683

We Put Science To Work™

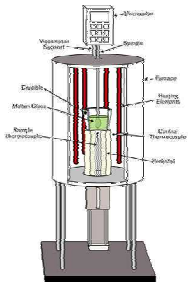
SRNL is managed and operated for the U.S. Department of Energy by Savannah River Nuclear Solutions, LLC

Incorporation of TiO_2 in High Level Waste Glass

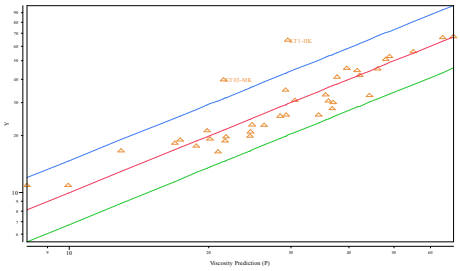
K.M. Fox, F.C. Johnson, and T.B. Edwards

Viscosity Impacts

- **Viscosity of 37 glasses measured using rotating spindle technique**
  - Temperature range of 1050 to 1250 °C
  - Data fit to Fulcher equations to determine measured values at 1150 °C
- **Results compared with predicted values from the current DWPF viscosity model**



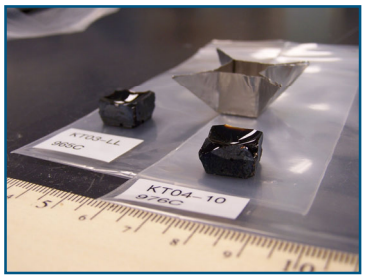
http://www.ortonceramic.com



Y-axis:
- Predicted viscosity (Poise)
- Upper 95% Confidence Interval Bound
- Lower 95% Confidence Interval Bound
- Measured Viscosity

- **All glasses are well predicted at 1150 °C except for those with high K_2O concentrations**
  - High K_2O concentrations unrealistic for actual processing, although somewhat beneficial for TiO_2 retention

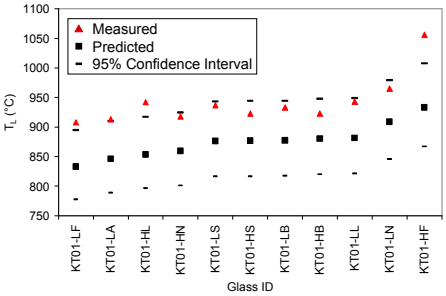
High temperature, rotating spindle viscometer.



Heat treated glass samples and platinum boat for liquidus temperature determinations.

Liquidus Temperature Impacts

- **Measurements completed for 11 glass compositions using an isothermal hold technique**
- **Specimens heat treated for 24 hours**
  - Then cut and polished for transmitted light optical microscopy
  - Samples observed for the presence of bulk crystallization
- **Results compared with the predicted liquidus temperatures from the current DWPF model**

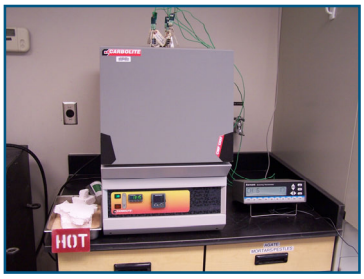


- **Most glasses predictable using current liquidus temperature model**
- **Additional measurements are in progress**

Summary – Results to Date

- **Work-in-progress study of the impacts of higher concentrations of Nb_2O_5, TiO_2, and ZrO_2 in HLW glass**
  - Results showing good ability to accommodate the SCIX streams in glass
- **Preliminary results show good predictability of chemical durability and viscosity**
- **Liquidus temperature model may need to be adjusted to incorporate these components**
  - However, no new crystalline phases have been identified
- **Experimental work is continuing to provide the data necessary to support model validation or revision**

The authors would like to thank the researchers and laboratory technicians who have contributed to this work, including Irene Reamer, Phyllis Workman, Whitney Riley, David Missimer, David Best, Pat Simmons, David Peeler, and David Koopman.



Instrumented, isothermal furnace for liquidus temperature determinations.

Print

SRNL-STI-2010-00683

Close

We Put Science To Work™

SRNL is managed and operated for the U.S. Department of Energy by Savannah River Nuclear Solutions, LLC