CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Attendance at the 102nd Annual meeting & Exposition of the American Ceramic Society
Charge Number 20.01403.102

DATE/PLACE: April 30–May 3, 2000, St. Louis, MO

AUTHORS: V. Jain, Center for Nuclear Waste Regulatory Analyses (CNWRA)
Y.-M. Pan, Center for Nuclear Waste Regulatory Analyses (CNWRA)

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PERSONS PRESENT: V. Jain, CNWRA; Y.-M. Pan, CNWRA

BACKGROUND AND PURPOSE OF TRIP:

The 102nd Annual meeting & Exposition of the American Ceramic Society, was held April 30–May 3, 2000, at the America's Center in St. Louis, Missouri. Conference attracted about 2,000 delegates and more than 1,800 technical papers were presented.

The International Symposiums on "Waste Management Science and Technology in the Ceramic and Nuclear Industries" and "Science and Technology in Addressing Environmental Issues in the Ceramic Industry" at the meeting were devoted to presentations and discussions on the environmental issues, recycling, air emissions, and nuclear waste management. The nuclear waste management symposium focused on high-level waste (HLW) processing, low-level waste (LLW) or low-activity waste (LAW) processing, Plutonium Immobilization Program (PIP), waste vitrification technologies, waste form properties and characterization, leaching behavior of the vitrified waste, and modeling of vitrification processes. Sixty eight papers were presented in two symposiums. The proceedings will be published as Ceramic Transactions by the American Ceramic Society.

Since several parallel sessions were held, the summary provided in this report is based on the authors' attendance at selected sessions and brief notes taken during presentations on topics relevant to environmental issues, sulfur solubility in glass, vitrification of wastes, the Tank Waste Remediation System-Privatization (TWRS-P) project, and chemical durability of glasses.

SUMMARY OF PERTINENT POINTS:

Environmental Issues

Robert Eagan (Sandia National Laboratory), presented an invited lecture on Power for Peace, Prosperity and the Environment. The presentation discussed the need for nuclear energy to meet carbon emission levels set forth by the Kyoto agreement. He addressed the need for reestablishing the leadership in the nuclear energy

and development of nuclear power reactors. In addition, he indicated that Center for Strategies and International Studies and Presidents Committee of Advisors on Science and Technology are looking into preserving and enhancing nuclear power.

Karyn Wiemers [Pacific Northwest National Laboratory (PNNL)], presented an invited lecture on Application of Hazardous Waste Management Regulations to Defense Nuclear Waste Treatment and Disposal Status of Evolving Process at Hanford. The presentation provided an overview of the TWRS-P program. She discussed challenges involved in the solidification of Hanford wastes, for example de-listing of the current Hanford tank waste. If de-listing can not be obtained the project cost will significantly increase. She indicated that overall no volume reduction is anticipated between current volume of liquid waste and vitrified product. This is in contrast to the established opinion that one of the advantages of vitrification is volume reduction. Responding to Author's question on NRC regulation, she indicated that Office of River Protection (ORP) has no regulatory role. Regulatory Unit has the current regulatory responsibility and is independent of ORP.

Sulfur in Glasses

Several papers were presented on this topic. A brief summary of the papers relevant to TWRS-P program is provided.

K. Lu [Catholic University of America (CUA)], presented a paper titled, Kinetic Constraints in the Incorporation of Sulfur into Glass Melts. Presenter indicated that sulfur salt phase formation occurs early in the cold-cap formation. They studied sulfur solubility by either bubbling SO_2 in the glass melt or following the diffusion of sodium sulfate salt into glass melt. In both cases they showed that sulfur incorporation rate depends upon the melting rate and diffusion coefficients. Different glasses show different SO_3 solubility, and higher solubility can be obtained by using proper composition.

D. McKeown (CUA), presented a paper titled, Sulfur Environment in Borosilicate Waste Glasses: Characterization by Raman Spectroscopy. He used Raman spectroscopy to characterize the structural environment of sulfur in a series of borosilicate glasses and indicated that irrespective of the glass composition, sulfur was present in glasses as isolated units of SO_4 tetrahedra.

Hong Li (PNNL), presented a paper titled, Sulfate Retention and Segregation in Simulated Radioactive Waste Borosilicate glasses. Based on experiments and literature data , he developed a relationship for sulfur retention based on non-bridging oxygen concentration in the melt. Results indicated that as the concentration of alkali increases, the sulfur retention in the glass increases. Sulfur retention of more than of 1 percent SO_3 is possible. He also indicated that phosphates significantly increase sulfur retention. However, the data could not explain the sulfur segregation tendency. Because sulfur segregation is a kinetic process that occurs during batch to glass conversion, initial reactions of the batch materials seem to have a stronger effect on the sulfur segregation tendency.

All papers in this area indicated the need for fundamental study to gain understanding.

Vitrification and Process Technology Session

A brief summary of the papers relevant to the TWRS-P program is provided.

D. Davis (COGEMA/TECO), presented two papers titled, Development of Durable Glasses from Fernald Silos 1 and 2 Surrogates, and Control of Batch Redox to Permit Practical Manufacturing of Fernald Surrogate Glass. These two papers summarized the results of the proof-of-principle demonstration study for Fernald Silo 1 and 2 wastes containing high-sulfate and high-lead. The papers discussed development of glass composition for wastes containing up to 9.5 percent PbO and 3.8 percent SO_3. The glasses developed were boron-free glasses based on lithia-soda-lime-silica glass composition. The glass composition was developed using a proprietary additive that provided significant reduction in Pb release. In addition, a redox model was developed that used sugar as a reductant and bounded separation of salt layer and precipitation of metal. The study indicated that by the use of a proper reductant to decompose sulfate as SO_2 during early stages of melting was useful in reducing formation of sulfate layer in the melt. The glass composition adjustment provided sulfur solubility > 1.2 percent.

Dr. Ron Palmer [West Valley Demonstration Project (WVDP)], gave an overview presentation of the WVDP program. As of April 30, 2000, WVDP has produced 246 canisters (compared to 238 in April 1999). To date, >99% Sr-90, >95% Cs-137, and >99% TRU have been processed into glass. Presently one batch requires more than 30 transfers from the tank farm. Currently WVDP is focused on developing plans for cleaning HLW tanks and HLW vitrification facility closure.

Sharon Marra [Savannah River Site (SRS)], gave an overview presentation on the waste qualification requirements for the immobilized plutonium waste form. She indicated that the requirements for the plutonium waste form are similar to the HLW glass waste form. As an update to the Defense Waste Processing Plant (DWPF), she indicated that DWPF is processing 2nd macro batch. To date, 930 canisters have been filled with glass and 3rd macro batch is being prepared. The 2nd macro batch is expected to last one more year.

G. Chandler (SRS) presented a paper on behalf of K. Imrich titled, Metallurgical Evaluation of Inconel 690 Components from a Pilot Scale Demonstration Melter System. This paper reported performance of Inconel 690 components after 7-years of operations in a joule-heated pilot scale melter. The components that were included in this evaluation were lid heaters, level probes, melt pool thermowells, feed tubes, and vent lines. Melt pool thermowells showed extensive corrosion at the glass/air interface, feed tubes showed inter-granular attack near melter lid, film cooler and vent tubes showed chlorination attack. Even though, several components showed corrosion, they all performed as expected.

X. D. Lu (CUA) presented a paper titled, Corrosion Mechanism of K-3 Refractory in Waste Glass Melts. In this paper, the presenter showed that by modifying the waste glass composition that leads to the formation of a passive layer on the refractory surface results in reduced refractory corrosion. Presenter declined to provide the changes that were made to the base composition, citing them as proprietary (trade secret).

John Pickett (SRS), presented a paper titled, Vitrification and Privatization Success. In this paper, John discussed the successful completion of the M-Area vitrification process. After the replacement of the 1st melter due to corrosion, the process worked smoothly meeting all regulatory and process requirements. The project costed DOE <$14 million and saved DOE almost 44 million. This project, was not a fully privatized project. GTS Duratek was reimbursed at certain hold points. The waste, in the form of vitrified gems, is currently waiting de-listing prior to disposal as a LLW. The keys to the successful project were: preparing a very tight contract specification and scope of work; utilizing commercial construction standards, when appropriate for LLW treatment; and eliminating the very costly DOE Order project 4700.1 oversight, which reduced final design and construction costs by 70-80%.

Glass Durability

Y-M. Pan and V. Jain (CNWRA), co-authored a paper titled, Effect of Iron Chlorides on Simulated HLW Glasses. The test conditions were selected to simulate an internal WP environment containing steel corrosion products and oxidized by radiolysis. The modified product consistency test (PCT), with regular solution exchanges, was used to determine the leaching rates of simulated HLW glasses (WVDP Ref. 6 and DWPF Blend 1) in the presence of aqueous solutions of $FeCl_2$ and $FeCl_3$ at 90°C. Substantially high initial boron and alkali release rates, approximately a factor of 50 to 70 times greater than those in deionized water were measured in 0.25 M $FeCl_3$ solutions. The initial leaching rate for boron was found to be pH-dependent and decreased as the leachate pH was increased. The slope of the regression of log leaching rate with pH was linear and almost identical for the two simulated waste glasses. The preliminary leaching results suggest that both solution pH and the presence of corrosion species such as iron chloride are significant contributing factors for enhanced glass dissolution. The regression of pH dependence from this study in consideration of the internal WP environment may provide a useful model parameter for assessing glass durability.

Dr. Carol Jantzen, Westinghouse Savannah River Company, Aiken, SC presented two papers titled, Impact of Phase Separation on Durability in Phosphate Containing Borosilicate Waste Glasses for INEEL, and Phase Separation in Borosilicate Waste Glasses: Scale, Kinetics and Effects on Durability. The first paper discussed the impact of phase separation on durability in phosphate containing HLW glasses, and the second addressed the kinetics of phase separation. High concentrations of P_2O_5 added to the HLW at the INEEL during preprocessing caused phase separation in the waste glasses. However, high P_2O_5 containing glasses with crystalline phase separation are more durable than low P_2O_5 containing glasses, even though phase separation has been known to have an adverse effect on durability of borosilicate waste glasses. Mathematical analysis of glass durability data shows that high Al_2O_3 stabilized the glass matrix and made the glasses durable.

A. Jiricka (PNNL), presented a paper titled, Vapor Hydration Test (VHT) Testing of Hanford LAW Glasses: Preliminary Results. In this paper, using optical microscopy and SEM/EDS showed progression of reaction and formation of secondary phases in the samples. Data will be used for Hanford LAW Performance Assessment (PA). VHT is an aggressive test that is conducted at 200 °C.

Andy Buechele (CUA), presented a paper titled, Aqueous Corrosion of High-Sodium Low Activity Waste Glasses. In this paper he questioned the ability to predict glass durability under changing regulatory requirements for the Hanford LAW PA. Initially data was required at 25 °C using PCT, then it was changed to 40 °C PCT, followed by 75 °C PCT and now 90 °C PCT and VHT. He showed that data obtained from under different conditions can not be correlated with each other.

SUMMARY OF ACTIVITIES:

In addition to presenting paper, the author, V. Jain, was elected Trustee for the Nuclear and Environmental Technology Division for a three year term (2000–2003). He was one of the symposium chair for the Waste Management Science and Technology in the Ceramic and Nuclear Industries that was responsible for soliciting papers and session chairs. In addition, the author chaired the session on Alternative and Innovative Waste Forms.

CONCLUSIONS:

The meeting was very useful in keeping current with the ongoing worldwide advancements in the vitrification science and technology. The participation at the meeting was a good opportunity to gather information and generate discussion on the nuclear waste processing technologies.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

None.

SIGNATURES:

Vijay Jain
Senior Research Engineer

5-10-00
Date

Yi-Ming Pan
Senior Research Engineer

5-11-00
Date

CONCURRENCE:

Narasi Sridhar, Manager
Corrosion Science & Process Engineering, Element

5/10/00
Date

Budhi Sagar
Technical Director

5/12/2000
Date

VJ:jg