CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Attendance at the 106th Annual meeting & Exposition of the American Ceramic Society
Charge Number 20.06002.01.081; AI Number 06002.081.324

DATE/PLACE: April 19–21, 2004, Indianapolis, Indiana

AUTHOR: V. Jain

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PERSONS PRESENT: V. Jain, CNWRA

BACKGROUND AND PURPOSE OF TRIP:

The 106th Annual Meeting & Exposition of the American Ceramic Society was held April 19–21, 2004, Indianapolis, Indiana. This conference attracted about 1,700 delegates and more than 1,200 technical papers were presented. The conference was organized under the leadership of CNWRA staff, Vijay Jain. In addition, Dr. Jain was the lead organizer of the symposium on Materials for Homeland Defense. Rustom Roy Lecture on Frontiers of Science was delivered by Dr. Jane A. Alexander, Deputy Director of Homeland Security Advanced Research Projects Agency. During her presentation, among other security issues she stressed the need to enhance our understanding on dirty bombs. In the symposium on homeland security materials eight papers were presented.

A symposium on Ceramic Science and Technology for the Nuclear Industry was devoted to the presentations and discussions on the nuclear waste forms—processing and technology; glass waste forms—modeling, properties, and testing; nuclear fuels—processing and technology; ceramic waste forms—formulation, and testing. Approximately 40 papers were presented in the symposium. The proceedings will be published as Ceramic Transactions by the American Ceramic Society.

The summary provided in this report is based on authors' attendance at selected sessions and brief notes taken during presentations on topics relevant to the Nuclear Regulatory Commission.

SUMMARY OF PERTINENT POINTS:

Glass Waste Forms—Modeling, Properties, and Testing

Han (Catholic University of America) presented a paper that discussed formation of spinels at the near-liquidus temperature range in a vitrification melter. In glass waste forms, the waste loading limited by crystallization of spinel phases. While the presence of such phases rarely affects the quality of the glass product, it presents a significant processing concern because these phases can sediment on the melter floor, and ultimately limit melter life. The results showed that the near-liquidus spinel crystallization usually occurs in multiple stages that lead to a complex relationship between the temperature and amount of the crystalline phase. Furthermore, the data showed that the presence of noble metals increase the liquidus temperature.

T. M. Bessmann (Oak Ridge National Laboratory) provided an overview of a software that could be used for calculating formation of phases in the waste glass compositions. A modified associate species thermochemical model for the liquid/glass phases in nuclear waste glass systems was presented. The modification of the methodology was required to address the presence of two immiscible liquids. This approach has been extended to include spinel-forming constituents together with the base glass system.

Sulfur in glasses was a major topic of discussion in this session. I. Vidensky (Catholic University of America) used a square wave voltammetry (SWV) to monitor formation of sulfate phases in waste glasses. In addition, SWV technique was used to characterize sulfur redox species coexisting with other salt phases. Voltammograms indicated well-defined peaks that showed reduction of sulfur. The sulfur reduction potentials in the glass melts showed a good agreement with the corresponding salt phases. The potential application of SWV as an in situ real-time monitoring system for sulfur was explored. C. Jantzen (Savannah River Technology Center) presented a paper focused on studies aimed to increase the sulfur limit currently imposed on waste glasses. Sulfate salts have limited solubility in waste glasses. If the sulfate concentration exceeds solubility limit, inclusions including a water-soluble surface layer (gall) on the glass surface, and/or a molten salt layer on the melt pool surface can form. Study showed that sulfate solubility can be increased to 0.5 wt% without significant impact on waste glass performance. S.K. Sundaram (Pacific Northwest National Laboratory) discussed the use of a millimeter wave (MMW) detection technology to measure sulfur content in a pilot scale melter. In the presence of a sulfate layer, the emissivity of the melt surface decreased by about 30 percent from the original emissivity of the glass melt. The data demonstrated the viability of the MMW technology for waste melter diagnostics.

F.Y. Yueh (Mississippi State University) presented a paper that discussed direct compositional analysis using laser induced breakdown spectroscopy (LIBS) for dried sludge or glass in shielded cell facilities. This work demonstrated a rapid on-site determination of waste and frit composition. The results of LIBS analysis were compared with the simulated samples using inductively coupled plasma analysis to determine the accuracy of the measurement.

Nuclear Fuels—Processing and Technology

In this session, papers discussing advanced gas reactor fuel were presented. R.A. Lowden (Oak Ridge National Laboratory) presented an overview of the U.S. Department of Energy's Advanced Gas Reactor Fuel Development and Qualification Program to support deployment of a high temperature gas-cooled reactor (HTR) technology, and to establish a basis for the development of fuels suitable for very high temperature gas-cooled reactors. Currently, this program is focused on the re-establishment and improvement of U.S. capability to produce high quality SiC-based TRIstructural ISOtropic (TRISO) fuel. TRISO particle fuel consists of a kernel of fissile/fertile material surrounded by layers of polymeric carbon and silicon carbide ceramic for protection and containment. Coatings provide primary barrier to fission product release from the fuel. F. Charollais (Commissariat a l'Energie Atomique) provided an overview of the French program. The goals of their program are to restore coated and fissile kernels manufacturing knowledge including innovative technology perspectives, and develop modern characterization methods that are able to satisfy future nuclear industrial needs. The fabrication of UO_2 fissile kernels requires spherical specificity. Method is being developed, for producing spherical kernels, uses a process based on sol-gel technique called Gel Supported Precipitation. J. Fourcade (Purdue University) presented a paper on polymeric ceramic precursors to

consolidate dispersions of fuels, target actinides or waste particles. The Polymer Impregnation and Pyrolysis (PIP) method was used to generate a beta-SiC phase. Thermal modeling data showed a significant reduction in fuel centerline temperatures with beta-SiC as the second phase. S.P. Wilson (Los Alamos National Laboratory) provided status of the program on the development of the mixed nitride fuels under the Advanced Fuel Cycle Initiative. These fuels will be tested for power production and the burning of minor actinides. G.W. Hollenberg (Pacific Northwest National Laboratory) presented results of manufacturing thin-walled, high-density lithium aluminate pellets. These are used as annular pellets in the tritium producing burnable absorber rods. A triple spray drying process was developed that included a unique-feedstock blend cycle, a post-calcination grinding cycle, and a high pH final cycle with high solids loading slurry. Currently the pilot plant is capable of producing more than 400,000 pellets per year.

Materials for Homeland Security

J.J. Thomas (Northwestern University) discussed development of a safety concrete for use in security walls. This concrete would disintegrate into small fragments when subjected to sudden and severe loading. Investigations of terrorist bombings have concluded that concrete security walls adjacent to an explosion tend to break into large chunks with enough kinetic energy to cause significant damage and loss of life. Safety concrete is formed by processing a cement based material with microcracks distributed throughout its volume. On loading, the microcracks result in complete fragmentation that is similar to the fragmentation of safety glass used in automobile glasses.

Q. Luo (U. S. Army) presented development of a lightweight polymer/glass-ceramic face-shield that provides NIJ Type IIIA level protection. Face shields could reduce death and injury rates, but currently available polymeric/glass-type laminate devices weigh more than 3.5 pounds and are not suitable for continuous wear. Luo and his coauthors investigated three potential glass-ceramics for use as hard face materials, and determined that a heat treatment temperature of 850 °C was optimal for maximizing hardness without degrading transparency. A lamination process was developed to enhance energy dissipation and absorption during ballistic impact.

D. Kim (Korea Advanced Institute of Science and Technology, Korea) discussed a new method of synthesizing in-situ B_4C with Al and Ti composites. The processing consists of dipping the preform of B_4C into molten aluminum (Dipping Exothermic Reaction Process—DERP) to fabricate a B_4C reinforced Al and Ti matrix composite for lightweight armor applications.

Q. Zhao (Drexel University) discussed development of piezoelectric cantilever sensors to detect cells, bacteria, and protein molecules in solutions. A nerve gas sensor was developed by coating the sensing tip with selective gas adsorbents such SiO_2 as the adsorbent for detecting nerve gas simulant dimethyl methylphosphonate (DMMP).

V. Dravid (Northwestern University) discussed concept of electronic nano-nose. This involves an array of sensors providing differential signals from varied analytes, followed by an intricate pattern recognition and artificial intelligence analysis. They used two different approaches to sensor array, as an essential part of an integrated electronic nano-nose system. The first approach is based on dip-pen nanolithography (DPN), which uses a atomic force microscope (AFM) tip as a nanoscale dip-pen to site-specifically deposit inorganic and organic sensor elements between prefabricated electrodes. The second approach, microcantilevers were

embedded with metal-oxide-semiconductor field-effect-transistor (MOSFET) to provide an electronic transduction scheme. Study showed that toxic gases and biological entities (DNA, proteins) can be detected with high sensitivity.

M. Lee (Yeungnam University) presented an improved room temperature fluxgate-type magnetometer with a sensitivity of 50–100 fT. They showed excellent resolution of 50–100 fT at the sampling rate of direct current to 5 kHz, which are comparable to a superconducting quantum interference device (SQUID) sensor. This new magnetometer is good for the passive magnetic security screening systems.

American Ceramic Society Activities

Dr. Jain completed his term as the Technical Program Chair for the 2004 Annual Meeting of the American Ceramic Society and was elected by the Board of Directors to Chair, the American Ceramic Society Meetings Committee for 2004–2005. In this role, Dr. Jain will work with the Materials Society and ASM International to develop joint meetings. In addition, Dr. Jain will be responsible for all meetings that are organized and supported by the American Ceramic Society.

CONCLUSIONS:

The meeting was very useful in keeping current with the ongoing worldwide advancements in waste forms for the disposal of radioactive wastes. The participation at the meeting was a good opportunity to gather information and generate discussion on the nuclear waste forms and processing technologies. Leadership roles in the professional societies contribute to the visibility and recognition among peers.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Participation in future meetings is highly recommended.

SIGNATURES:

Vijay Jain
Corrosion Science & Process Engineering, Element

4/30/04
Date

CONCURRENCE:

Budhi Sagar
Technical Director

04/30/2004
Date

VJ:BS:jg