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Ms. W. F. Perrin, Technical Information Officer
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WSRC-MS-96-0274

Treatability Studies of Actual Listed Waste Sludges from the Oak Ridge Reservation (U)

by
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DISCLAIMER

TREATABILITY STUDIES OF ACTUAL LISTED WASTE SLUDGES FROM THE OAK RIDGE RESERVATION (ORR)

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Westinghouse Savannah River Company, Aiken, SC

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ABSTRACT

Oak Ridge National Laboratory (ORNL) and Savannah River Technology Center (SRTC) are investigating vitrification for various low-level and mixed wastes on the Oak Ridge Reservation (ORR). Treatability studies have included surrogate waste formulations at the laboratory-, pilot-, and field-scales and actual waste testing at the laboratory- and pilot-scales.

The intial waste to be processing through SRTC's Tranportable Vitrification System (TVS) is the K-1407-B and K-1407-C (B/C) Pond sludge waste which is a RCRA F-listed waste. The B/C ponds at the ORR K-25 site were used as holding and settling ponds for various waste water treatment streams. Laboratory-, pilot-, and field-scale "proof-of-principle" demonstrations are providing needed operating parameters for the planned field-scale demonstration with actual B/C Pond sludge waste at ORR. This report discusses the applied systems approach to optimize glass compositions for this particular waste stream through laboratory-, pilot-, and field-scale studies with surrogate and actual B/C waste. These glass compositions will maximize glass durability and waste loading while optimizing melt properties which affect melter operation, such as melt viscosity and melter refractory corrosion. Maximum waste loadings minimize storage volume of the final waste form translating into considerable cost savings.

INTRODUCTION

Technologies are being developed by the US Department of Energy's (DOE) Nuclear Facility sites to convert low-level and mixed wastes to a solid stabilized waste form for permanent disposal. One of the alternative waste forms is vitrification. The Environmental Protection Agency (EPA) has declared vitrification the Best Demonstrated Available Technology (BDAT) for high-level radioactive waste [1] and produced a Handbook of Vitrification Technologies for Treatment of Hazardous and Radioactive Waste.[2] The DOE Office of Technology Development (OTD) has taken the position that mixed waste needs to be stabilized to the highest level reasonably possible to ensure that the resulting waste forms will meet both current and future regulatory specifications. Vitrification produces durable waste forms at volume reductions up to 97%.[3] Large reductions in volume minimize long-term storage costs making vitrification cost effective on a life cycle basis.[4]

Vitrification has been demonstrated in laboratory studies at the US DOE Savannah River Site (SRS), which is operated by Westinghouse Savannah River Company (WSRC), for (1) incinerator wastes (ash and blowdown) and (2) nickel plating line (RCRA F006) waste water sludges admixed with spent filter aid.[3, 5] Stabilization of the heavy metals in the glass was achieved by use of reactive additives such as diatomaceous earth, perlite (perflo), rice husk ash, and/or precipitated silica.[3] Maximum waste loading was achieved by tailoring the glass composition to take advantage of the common glass constituents (Si, Al, Na, and Ca) or glass forming potential existing in the waste. The process/product models developed for high level radioactive waste glass were utilized to develop glass formulations which optimize glass processability (e.g., viscosity and liquidus temperature) and product performance (e.g., durability).[6,7]

ORR has been chosen as the host site for the initial field-scale demonstration with actual waste utilizing SRTC's Transportable Vitrification System (TVS).[8,9] The initial candidate wastes for vitrification "proof-of-principle" studies are primarily waste water treatment sludges with varying types and amounts of organics. The waste water sludges were selected for the first vitrification demonstrations because (1) sludges represent over 60% by volume of all the wastes in the DOE complex, and (2) the physical characteristics of mixed waste sludges was similar to the high-level waste sludges for which vitrification was BDAT.

A developmental approach utilizing various scaled demonstrations is currently being applied to the B/C Pond sludge waste at ORR. The objective of the joint SRTC/ORNL treatability studies performed on the laboratory-scale is to develop glass formulations for actual mixed low-level waste that can be translated into successful pilot- and field-scale demonstrations. This developmental approach will provide needed data for the evaluation of the feasibility of vitrification as a stabilization option for a variety of wastes which do not currently meet RCRA/LDR (Resource Conservation and Recovery Act/Land Disposal Restrictions) requirements for storage/disposal and/or those for which treatment capacity does not presently exist.

B/C POND SLUDGE WASTE

The K-1407-B and K-1407-C ponds at the ORR K-25 site (formerly the Oak Ridge Gaseous Diffusion Plant) were used as holding and settling ponds for various waste water treatment streams, originating from coal pile runoff, steam plant boiler blowdown and ash products, raffinate from various U recovery and equipment decontamination operations, plating wastes, purge cascade blowdown, and miscellaneous laboratory wastes and chemicals.[10-11] The K-1407-B pond was operated as a flow-through settling and holding pond, whereas C pond was operated as a total containment basin, receiving dredged sludge from K-1407-B. Off-gas scrubber blowdown, ion-exchange resin, chlorides and fluorides were added primarily to C pond. Coal pile runoff and fly ash were added primarily to B pond. Initial stabilization efforts produced about 46,000 drums (89 and 96 gallon capacity) of cemented or partially cemented sludge. Final RCRA clean closure of these ponds entailed dredging up the raw sludge (intermixed with dredged clay pond liner) and storing the waste in steel drums. This produced an additional 32,000 drums of raw sludge. The current B/C pond inventory is approximately 7,000,000 gallons (935,000 ft^3).

The B/C Pond sludge wastes are reported to be primarily $Ca(OH)_2$ and SiO_2.[12] The K25 Pond sludges are RCRA listed mixed wastes; the EPA waste code is F006 (derived from plating line activities). The primary regulatory metals of concern are silver and nickel. Depleted uranium (at an average of about 0.30 wt% U-235) is the primary radioisotope of concern in this waste stream, with very low activity contributions from Tc-99.[12]

VITRIFICATION TECHNOLOGY DEMONSTRATION

The vitrification demonstration of the ORR B/C Pond sludge waste includes the following:

- Analyze actual waste
- Develop surrogate
- Surrogate "proof-of-principle" laboratory scale studies
- Actual waste "proof-of-principle" laboratory scale studies
- Surrogate waste pilot-scale demonstration
- Surrogate waste field-scale demonstration
- Actual waste field-scale demonstration

The initial surrogate and actual waste "proof-of-principle" laboratory testing is being carried out jointly between SRTC and ORNL under an Memorandum of Understanding (MOU). The pilot-scale surrogate demonstration on the B/C Pond sludge waste was performed in the SRTC's pilot-scale melter (EV-16) at the DOE/Industrial Center for Vitrification Research.[13] The SRTC EV-16 pilot-scale melter is prototypic of the SRTC TVS to be used for the field-scale demonstrations.

Both are Joule-heated melters manufactured by EnVitco, Inc. The pilot-scale melter holds 29 liters of glass and produces waste glass at a rate of 12 lbs/hour. The field-scale demonstration with surrogate B/C Pond sludge waste was performed at Clemson's Environmental Engineering Systems Engineering Department utilizing the Transportable Vitrification System (TVS). This melter holds 1515 liters of glass and produces waste glass at a rate of 300 lbs/hour. The field-scale demonstration with actual B/C Pond sludge waste is currently scheduled to begin in late FY96 at ORR with the TVS.

ANALYSIS OF ACTUAL WASTE

An archived sample of B/C Pond sludge waste was analyzed at ORR by microwave digestion with HF addition and standardless semi-quantitiative energy-dispersive X-ray spectroscopy. This sample was obtained from raw sludge that had been processed by the Chemical Waste Management thermal drying system at a reported nomimal 105°C. The two analytical techniques provide a basis for confirming/comparing the relative concentrations of various waste constituents. Another B/C Pond sludge sample from the Chemical Waste Management thermal drying system was obtained by sampling the residual, dried waste compacted on the interior of the rotary calciner. This sample should be representative of the B/C Pond sludge waste that was processed through the themal drying system. Wet chemistry analysis of this sample was performed for identification of the major inorganic cationic and anionic species.

Table I shows three compositional analyses (oxide basis) that were performed on the two B/C Pond sludge waste samples.[12,14] The elemental cation weight percentages measured in the sludge were converted to oxides. An oxide mass balance was performed because the major anion remaining in a waste after vitrification is oxygen. In addition, waste analyses given on a dry calcine (oxide only) basis forms the basis for determining the "glass forming potential" of a waste. The cation, anion, and XRD analyses were coupled together to determine if the analyses are consistent. Mass balance calculations are necessary to verify the accuracy of the waste analyses since sludge standards do not exist.

Using the elemental microwave dissolution analysis and converting to an oxide basis, an oxide sum of only 78.76 wt% was achieved. This is well below the acceptable 100 ± 5 wt% typically used as a verification tool for accuracy. A comparison of the microwave and standardless EDX spectroscopy data showed several inconsistencies between various elemental analyses for the initial B/C sample. In particular, there were extreme differences in Ca (e.g., 16,000 and 150,000 ppm from microwave and EDX, respectively). Due to the potential of Ca to complex with F (available from the HF addition during the microwave digestion), the Ca value from the microwave digestion may be biased extremely low and/or erroneous. If the Ca value from EDX spectroscopy (150,000 ppm) is used for the microwave digestion, an oxide sum of 103.19 wt% is obtained which is well within the accuracy acceptability range.

Converting the elemental values from the EDX spectroscopy data and converting to an oxide basis produces a sum of 101.90 wt%. Considering the reported thermal history of this sample (dried at a nominal 105°C) one should be considering hyrdoxides, carbonates, and sulfates in these analyses. However, sample may have been processed between 350 - 650°C leading to uncertainity in the mass balance.[14] Based on the assumptions made and reported above, mass balance calculations of 100 ± 5 wt% indicate that the B/C Pond sludge analyses determined by this study are sufficiently accurate.

Table I. Three Analyzed B/C Pond Sludge Compositions from ORR. (oxide basis)

Oxide	Microwave Digestion	Energy-Dispersive X-ray Spectroscopy	Residual Waste from Calciner
Al_2O_3	4.72	10.96	12.04
B_2O_3	0.03	-	-
BaO	0.01	-	-
CaO	20.99*	20.99	24.40
CdO	-	-	-
Cr_2O_3	0.04	-	-
CuO	0.04	-	2.71
Fe_2O_3	7.28	31.45	15.63
K_2O	1.81	4.09	2.03
MgO	0.71	1.94	-
MnO	0.56	-	-
Na_2O	0.22	-	-
NiO	0.24	-	0.65
P_2O_5	0.87	0.23	-
PbO	0.02	-	-
SiO_2	49.20	29.74	38.94
SrO	-	-	-
TiO_2	0.58	2.50	0.94
UO_3	0.12	-	-
ZnO	0.02	-	2.37
Total	103.67*	101.90	99.71

"-" indicates that the element was not detected

"*" Ca value utilized from EDX analysis due to potential complexation with F

It should be noted that the three analyses represent a high SiO_2, a high Fe_2O_3 and an "Average" case, respectively. It is assumed that these three sample analyses will bound the compositional variation expected in the B/C Pond Sludge.

GLASS FORMING POTENTIAL OF WASTE

This waste is an excellent candidate for vitrification based on the elemental analyses shown in Table I. The waste stream appears to be high Ca, Fe and/or Si and low in B, thus the glass forming system being considered is the soda-lime-silica (SLS) system due to the large known glass forming region (Figure 1). The borosilicate system is not under consideration with this waste stream due to the large known immiscibility gap in the CaO-B_2O_3-SiO_2 system.[15] However, future wastes high in B_2O_3 and/or low in CaO will preferentially be formulated into borosilicate glasses due to the larger glass forming region in this system. Compositional variation of the waste is expected but can be mitigated through proper additions of glass additives to provide a "constant" feed to the melter (assuming the three analyses shown in Table I bound the compositional space).

SLS glass waste forms have been successfully used for the In-Situ Vitrification (ISV) of contaminated soils.[16-17] The barium analog glass (Soda-Baria-Silica, SBS) was successfully used to vitrify Fernald's uranium processing ash.[18] In addition, SLS glasses have been used to stabilize high Pb wastes glasses.[19] All the above mentioned SLS and SBS glasses passed the EPA TCLP test and will meet all the Land Disposal Restrictions (LDR). The use of SLS glass for

ORR wastes has a high potential for allowing the final waste form to be delisted [20] and eliminating the need for expensive RCRA hazardous waste/mixed waste storage vaults.

Due to the glass forming potential of the B/C Pond sludge, simple ratios of three additives will be used in targeting glass formulations within the SLS family: $NaCO_3$, $LiCO_3$ and SiO_2. A maximum of three dry feed additives will be used since the SRTC TVS is designed for feeding of a maximum of three dry additives simultaneously. Additional additives could be added as a liquid or slurry and blended in the waste tank or combinations of dry additives at known ratios would have to be blended in each feed sack.

LABORATORY-SCALE STUDIES

Based on the results of the waste analyses, non-radioactive surrogates were developed for the B/C Pond waste.[11] Crucible studies with the nonradioactive surrogates and with actual waste evaluated the following parameters:

- waste loading
- melt temperatures
- varying types of alkali additives
- varying types of reactive silica additive, e.g. RASP vitrification
- melt line refractory corrosion
- general refractory corrosion
- predictability/augmentation of the SRTC process/product models developed for high-level waste vitrification [7-8]

GLASS FORMULATIONS

Over 60 glass compositions were targeted to cover the expected processing region within the SLS system (Figure 1). These compositions were based on the "average" analysis from the residual dried waste inside the rotary calciner (last column in Table I). Actual waste was vitrified at various waste loadings (ranging from 90 - 40 wt%), melt temperatures, and glass forming additives. Waste loadings on the order of 70 wt% are achievable but more conservative loadings of 50 wt% targets the "heart" of the glass forming region. Simple ratios of SiO_2, Li_2CO_3, and Na_2CO_3 were used to target glass formulations in the SLS system. Ratios of 70 wt% SiO_2, 15 wt% Li_2O, and 15 wt% Na_2O were used as well as 70 wt% SiO_2 and 30 wt% Na_2O. The usage of Li_2O preferrentially over Na_2O as a glass forming flux additive was examined due to large excesses of suspect contaminated LiOH at ORR.[21]

"PROOF-OF-PRINCIPLE" LABORATORY-SCALE TESTS

A Modified Toxicity Characteristic Leach Procedure (MTCLP) test was performed on each glass. The MTCLP is identical to the TCLP with the following exceptions: (1) the test sample-size will be reduced to produce only that quantity of leachate necessary for data acquisition (to reduce waste volume) and (2) the test sample will be size-reduced to pass through a 4.75 mm sieve rather than 9.5 mm. The MTCLP and analysis of the resulting leachates were performed at ORNL for actual waste glasses. All of the glasses were analyzed by X-ray Diffraction (XRD) for homogeneity.

Based on the chemical analyses shown in Table I, P_2O_5 possess potential problems as a minor component. To address that issue, P_2O_5 solubility stuides are currently underway with the "Average" waste composition at a waste loading of 50 wt%. Surrogate glasses were "spiked" with P_2O_5 at intervals of 0, 1, 3, 5, and 10 wt%. The solubility limit will be determined by the formation of a segragated layer on the surface of the melt.

Other laboratory-scale tests include liquidus temperature determinations and controlled cooling tests from the melt to the final product. The latter tests will provide insight into the effects (if any) of potential crystallization on product performance and processing issues. Although no results are reported in this study, laboratory-scale tests have shown that a processing window does exist for this system.

PILOT-SCALE SURROGATE RUN

Prior to field-scale tests with surrogate or actual waste, a surrogate vitrification demonstration was performed.[13] The intent of the demonstration was to determine the feasibility of vitrifying ORR B/C Pond sludge in an EnVitco type melter by identifying potential processing concerns, off-gas polluntants, and glass performance issues. The EV-16 pilot-scale melter is prototypic of the TVS EnVitco melter to be used for the field-scale demonstrations.

Details of the pilot-scale test results are described by C.A. Cicero.[13] In summary, the demonstration showed that vitrification of ORR B/C Pond sludge is viable. Approximately 700 kg of surrogate glass was produced at a 50 wt% waste loading. The glass produced was homogeneous and passed both PCT and TCLP performance criteria. No significant problems were encountered in processing during the demonstration which should translate into a successful field-scale demonstrations with the TVS.

FIELD-SCALE SURROGATE TEST

The TVS is a large-scale, fully integrated, vitrification system for the treatment of low-level and mixed wastes in the form of sludges, soils, incerator ash, and many other waste streams. The unit is designed to be easily decontaminated and transportable (equipment is primarily housed in modules that can be sealed for over-the-road transporation). The melter is a joule-heated, cold-top melter manufactured by Envitco Inc. (Toledo, Ohio) which can be either slurry or dry feed. Design and fabrication details of the TVS have been reported by Whitehouse et. al [22].

The testing of the TVS, which was performed at Clemson University under a South Carolina Iniversities Research and Education Foundation (SCUREF) contract with Clemson's Environmental Systems Engineering Department, was the culmination of two years of intensive work by SRTC personnel. Since project inception, SRTC personenel worked closely with EnVitco, Inc. and their subcontractors on the TVS design and fabrication. This effort not only included the glass formulation effort highlighted perviously in this report but also months of system check-out tests and numerous equipment modifications. Approximatley 12,500 pounds of simulated waste was processed to produce approximately 25,000 pounds of simulated waste glass.

SUMMARY

Laboratory-, pilot-, and field-scale demonstrations have been successfully integrated to show that vitrification of ORR B/C Pond sludge is a viable. Glass compositions have been formulated and processed that optimize waste loading and meet product performance requirements.

REFERENCES

1. Federal Register, **"Land Disposal Restrictions for Third Third Scheduled Wastes, Final Rule,"** 55 FR 22627 (June 1, 1990).
2. U.S. Environmental Protection Agency, **"Handbook: Vitrification Technologies for Treatment of Hazardous and Radioactive Waste,"** EPA/625/R-92/002 (May, 1992).
3. C.M. Jantzen, J.B. Pickett, and W.G. Ramsey, **"Reactive Additive Stabilization Process for Hazardous and Mixed Waste Vitrification,"** Proceedings of the Second International Symposium on Mixed Waste, Baltimore, MD, A.A. Moghissi, R.K. Blauvelt, G.A. Benda, and N.E. Rothermich (Eds.), American Society of Mechanical Engineers, 4.2.1-4.2.13 (1993).

4. C.M. Jantzen, J.B. Pickett, and W.G. Ramsey, **"Reactive Additive Stabilization Process (RASP) for Vitrification of Hazardous and Mixed Waste,"** Environmental and Waste Management Issues in the Ceramic Industry, Ceramic Transactions, Vol. 39, American Ceramic Society, Westerville, OH, 91 - 100 (1994).
5. D.F. Bickford, **"Advanced Radioactive Waste-Glass Melters,"** Nuclear Waste Management IV, G.G. Wicks, D.F. Bickford, and L.R. Bunnell (Eds.), Ceramic Transactions, V. 23, American Ceramic Society, Westerville, OH, 335-347 (1991).
6. C.M. Jantzen, **"Relationship of Glass Composition to Glass Viscosity, Resistivity, Liquidus Temperature, and Durability: First Principles Process-Product Models for Vitrification of Nuclear Waste,"** Ceramic Transactions, V. 23, American Ceramic Society, Westerville, OH, 37-51 (1991).
7. C.M. Jantzen and K.G. Brown, **"Statistical Process Control of Glass Manufactured for Nuclear Waste Disposal,"** Am. Ceram. Soc. Bull., Vol. 72, No. 5, 55-59 (1993).
8. J.C. Whitehouse, C.M. Jantzen, D.F. Bickford, A.L. Kielpinski, B.D. Helton, **"Development of a Transportable Vitrification System for Mixed Waste,"** Proceedings of Waste Management '95 (1995).
9. J.C. Whitehouse, C.M. Jantzen, F.R. Van Ryan, and D.H. Davis, **"Design and Fabrication of a Transportable Vitrification System for Mixed Waste Processing,"** Proceedings of the Third Biennial Mixed Waste Symposium, Baltimore, MD (August, 1995).
10. J.L. Shoemaker, **"Description of Stabilized Pond Sludges Stored in Drums on the K-1417 Yard,"** USDOE Report K/QT-428, Martin Marietta Energy Systems, Inc. (August, 1991).
11. J.L. Shoemaker, W.D. Bostick, C.R. Kirkpatrick, and E.W. McDaniel, **"Experience with Wasteform Delisting at the Oak Ridge Gaseous Diffusion Plant,"** USDOE Report K/QT-285, Martin Marietta Energy Systems, Inc. (April, 1989).
12. W.D. Bostick, D.P. Hoffmann, R.J. Stevenson, A.A. Richmond and D.F. Bickford, **"Surrogate Formulations for Thermal Treatment of Low-Level Mixed Waste, Part IV: Wastewater Treatment Sludges,"** USDOE Report DOE/MWIP-18, 34p (January, 1994).
13. C.A. Cicero, T.J. Overcamp, and D. Erich, **"Vitrification Demonstration with Surrogate ORR B&C Pond Sludge,"** Ceram. Trans., this volume, Amer. Ceram. Soc., Westerville, OH (1996).
14. T.M. Gilliam, Lockheed Martin Energy Systems, Oak Ridge National Laboratory, Oak Ridge, TN, personal communication.
15. M.B. Volf, **Chemical Approach to Glass**, Glass Science and Technology, 7, Elvsevier, NY (1984).
16. G.F. Piepel and J.W. Shade, **"In-Situ Vitrification and the Effects of Soil Additives: A Mixture Experiment Case Study,"** J. Am. Ceram. Soc., (in press).
17. R.A. Callow, L.E. Thompson, J.R. Weidner, C.A. Loehr, B.P. McGrail, and S.O. Bates, **"In-situ Vitrification Application to Buried Waste: Final Report of Intermediate Field Tests at Idaho National Engineering Laboratory,"** U.S. DOE Report EGG-WTD-9807, Idaho National Engineering Laboratory, Idaho Falls, ID (August, 1991).
18. D.S. Janke, C.C. Chapman, and R.A. Vogel, **"Results of Vitrifying Fernald K-65 Residue,"** Nuclear Waste Management IV, G.G. Wicks, D.F. Bickford, and L.R. Bunnell (Eds.), Ceramic Transactions, V. 23, American Ceramic Society, Westerville, OH, 53-61 (1991).

19. E.S. Shenkler, S. Graham, and V.A. Greenhut, **"Secondary Lead Smelter Slags: Minimizing Lead Release Levels,"** Nuclear Waste Management IV, G.G. Wicks, D.F. Bickford, and L.R. Bunnell (Eds.), Ceramic Transactions, V. 23, American Ceramic Society, Westerville, OH, 75-84 (1991).
20. D. Poulous, J.B. Pickett, C.M. Jantzen, **"Upfront Delisting of F006 Mixed Waste (U),"** U.S. DOE Report WSRC-TR-95-0014, Westinghouse Savannah River Company, Savannah River Company and Proceedings of Waste Management '95 (1995).
21. E.B. Munday, **"Investigation of Lithium Hydroxide Disposal Options with Cost Estimates,"** USDOE Report K/PS-1239, Martin Marietta Energy Systems, Inc. (April, 1987).
22. J.C. Whitehouse, C.M. Jantzen, F.R. Van Ryn, and D.D. Davis, **"Design and Fabrication of a Transportable Vitrification System for Mixed Waste Processing,"** Proceedings of the Third Biennial Symposium on Mixed Waste, Edited by A.A. Moghissi, B.R. Love, and R.K. Blauvelt, Baltimore, Maryland, August 7 - 10, 1995