The Effect of Quench Rate on the Toxicity Characteristic Leaching Procedures (TCLP) , PCT Durability of Environmental Waste Glass

by

C. A. Cicero

Westinghouse Savannah River Company

Savannah River Site

Aiken, South Carolina 29808

D. F. Bickford

A. R. Jurgensen

J. L. Resce

Clemson University

SC USA

B. M. Wolff

Clemson University

SC USA

A document prepared for I&EC SPECIAL SYMPOSIUM
SEVENTH ANNUAL SYMPOSIUM ON EMERGING TECHNOLOGIES IN HAZARDOUS WASTE MANAGEMENT at
Atlanta from 09/17/95 - 09/20/95.

DOE Contract No. DE-AC09-89SR18035

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Due

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P. O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161

PREPRINT EXTENDED ABSTRACT
Presented at the I&EC Special Symposium
American Chemical Society
Atlanta, GA, September 17-20, 1995

THE EFFECT OF QUENCH RATE ON THE TCLP AND PCT DURABILITY
OF ENVIRONMENTAL WASTE GLASS

J.L. Resce and B.M. Wolff
Environmental Systems Engineering Department
Clemson University, Clemson, SC 29634

A.R. Jurgensen, C.M. Cicero, and D.F. Bickford
Westinghouse Savannah River Company
Aiken, SC 29808

The effect of quench rate and the resulting devitrification on the durability of environmental waste glasses has been examined for a set of 16 model glasses. The glasses have been derived from a large glass composition space, i.e. "hyperspace glasses," which were previously developed to serve as a simplified model for studying the durability of glassy wasteforms which might result from vitrification.¹ In this study, a subset of this space has been examined for chemical durability by both the PCT and TCLP tests. This subspace is composed of six variable components Fe_2O_3 , SiO_2 , Al_2O_3 , B_2O_3 , Na_2O , and CaO and three fixed-level components BaO , PbO , and NiO . The sum of the six variable oxides always total to 95 mole percent, while, BaO and NiO levels are fixed at 2 mole percent each and PbO is 1 mole percent. The preparation and characterization of these glasses has been previously described.² Their approximate oxide composition, in mole percent, is given in Table 1. These glasses can be classified into two groups, those with low and those with higher levels of Fe_2O_3 .

The glass melts were cast into molds to produce disks, 40 mm in diameter by 6 mm in height. The disks were then quenched at two different rates. Glasses quenched at a medium rate were placed directly into a box furnace at 450° C for 30 minutes and the furnace was then turned off. The glasses then cooled to room temperature in about 2 hours. The glasses quenched at a slow rate were placed in a furnace at 650° C for 8 hours and then slowly cooled to room temperature. The crystallinity of the glasses was determined by powder x-ray diffraction so that they could be classified into three categories: (1) "amorphous," (2) "crystalline," and (3) "more crystalline."

Chemical durability testing was carried out by both the 7-Day Product Consistency Test (PCT) and the TCLP test. The sodium normalized elemental release rate (NaNRR), in $\text{g}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$, was determined from Equation 1,

$$(1) \quad \text{NaNRR} = \frac{C_{\text{Na}}}{f_{\text{Na}} \left(\frac{SA_g}{V_L} \right) t}$$

where C_{Na} is the concentration of elemental sodium in the leachate, in $\text{g}\cdot\text{m}^{-3}$; V_L is the volume of the leachate; f_{Na} is the weight fraction of sodium in the original glass; SA_g is the surface area of the glass; and t is leaching time. The SA_g/V_L ratio is assumed to be 1950 m^{-1} .

The PCT NaNRR and the TCLP releases of both Ni and Ba for both the low and high Fe_2O_3 glasses are reported in Figures 1 and 2, respectively. These results show that there is almost no devitrification with either quench rate for the low iron glasses and that there is negligible change in durability. For the high iron glasses, however, some of the slow quenched glasses are significantly more devitrified and crystalline. In some glasses, this increased crystallinity is found to lower the NaNRR and Ba TCLP durability. TCLP Ni release was negligible in both cases.

TABLE 1. Target Mole Percent Oxide Composition of Glasses^a

Glass	Target Oxide Composition of Glasses, Mole % ^a					
	SiO ₂	Al ₂ O ₃ ^b	B ₂ O ₃	Fe ₂ O ₃	Na ₂ O	CaO
2LOO	63	0	0	2	10	20
2LHO	54	0	9	2	10	20
2LOH	53	10	0	2	10	20
2LHH	44	10	9	2	10	20
2HOO	63	0	0	2	20	10
2HHO	54	0	9	2	20	10
2HOH	53	10	0	2	20	10
2HHH	44	10	9	2	20	10
4LOO	56	0	0	18	7	14
4LHO	48	0	8	18	7	14
4LOH	48.8	10	0	11.6	8.2	16.4
4LHH	39.8	10	8.3	13.2	7.9	15.8
4HOO	56	0	0	18	14	7
4HHO	48	0	8	18	14	7
4HOH	49.5	10	0	10	17	8.5
4HHH	39.5	10	8.25	14	15.5	7.75

a. BaO, PbO, and NiO target values held fixed at 2, 1, and 2 mole %, respectively.

b. Glasses contained about 0.5 % higher Al₂O₃ than targeted due to leaching from crucibles.

ACKNOWLEDGMENT

This work was supported by the U.S. Department of Energy, Office of Technology Development (Mixed Waste Integrated Program), under Contract No. DE-AC09-88R18035 and WSRC Subcontract No. AA00900T.

REFERENCES

1. Resce, J.L.; Ragsdale, R.G.; Overcamp, T.J.; Bickford, D.F.; Cicero, C.A. "The Effect of Chemical Composition on the PCT Durability of Mixed Waste Glasses from Wastewater Treatment Sludges," In *Waste Management Conference, '95 Proceedings*, Laser Options, Inc. Tucson AR. (1995).
2. Resce, J.L.; Ragsdale, R.G.; Overcamp, T.J.; Jurgensen, A.R.; Cicero, C.A.; Bickford, D.F. "XRF in Environmental Glass Analysis and Vitrification Process Control, Part 1: Sample Preparation and Measurement Precision," in *Environmental and Waste Management Issues in the Ceramic Industry II*, pp 461-472, Bickford, D.F.; Bates, S.; Jain, V.; Smith, G. (Eds.), The American Ceramic Society, Westerville, OH (1994).

Figure 1: The Effect of Devitrification on the Chemical Durability of Low Iron Glasses; (a) Sodium normalized release rate (Na-NRR) from the Product Consistency Test (PCT) in $\text{g}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$, (b) Barium TCLP release, (c) Nickel TCLP release.

Figure 2: The Effect of Devitrification on the Chemical Durability of High Iron Glasses; (a) Sodium normalized release rate (Na-NRR) from the Product Consistency Test (PCT) in $\text{g}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$, (b) Barium TCLP release, (c) Nickel TCLP release.