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

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

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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. 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\textsubscript{2}O\textsubscript{3}, SiO\textsubscript{2}, Al\textsubscript{2}O\textsubscript{3}, B\textsubscript{2}O\textsubscript{3}, Na\textsubscript{2}O, 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. 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\textsubscript{2}O\textsubscript{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 g·m\textsuperscript{-2}·d\textsuperscript{-1}, was determined from Equation 1,

\begin{equation}
\text{NaNRR} = \frac{C_{\text{Na}}}{f_{\text{Na}}(S\Delta g/V_L)t}
\end{equation}

where $C_{\text{Na}}$ is the concentration of elemental sodium in the leachate, in g·m\textsuperscript{-2}; $V_L$ is the volume of the leachate; $f_{\text{Na}}$ is the weight fraction of sodium in the original glass; $S\Delta g$ is the surface area of the glass; and $t$ is leaching time. The $S\Delta g/V_L$ ratio is assumed to be 1950 m\textsuperscript{-1}.

The PCT NaNRR and the TCLP releases of both Ni and Ba for both the low and high Fe\textsubscript{2}O\textsubscript{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

<table>
<thead>
<tr>
<th>Glass</th>
<th>Target Oxide Composition of Glasses, Mole %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SiO₂</td>
</tr>
<tr>
<td>2LOO</td>
<td>63</td>
</tr>
<tr>
<td>2LHO</td>
<td>54</td>
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<tr>
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<td>4LHO</td>
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<td>4HOO</td>
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<td>4HHO</td>
<td>48</td>
</tr>
<tr>
<td>4HOH</td>
<td>49.5</td>
</tr>
<tr>
<td>4HHH</td>
<td>39.5</td>
</tr>
</tbody>
</table>

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
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REFERENCES

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 g-m²-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 g·m⁻²·d⁻¹, (b) Barium TCLP release, (c) Nickel TCLP release.