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Mechanical properties of $PbO–ZnO–P_2O_5$ glasses

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Three ternary lead zinc phosphate glasses with different atomic ratio have been prepared in order to study their structure and mechanical properties. All of them showed high expansion coefficient and weak mechanical properties. Though experimental errors are relatively high, the Young's modulus and modulus of rupture seem to indicate higher values with higher P_2O_5 content. Surprisingly, the $30P_2O_5$.50PbO.20ZnO (mol%) glass shows a relatively high fatigue susceptibility (n=56.8±2.0), much higher than that of the other two compositions examined and of that of soda–lime–silica glass (n=20)

Phosphate glasses are of technological interest owing to properties such as high thermal expansion coefficients and low melting and softening temperatures, that make feasible applications in low temperature glass-to-metal seals.[1] Commonly, however, such low melting glasses exhibit poor chemical durability and, in general, their hygroscopic nature makes them unsuitable for practical applications.

Ternary $PbO–ZnO–P_2O_5$ glasses, unlike binary $PbO–P_2O_5$ and $ZnO–P_2O_5$ glasses, show significant improvement in durability while maintaining low glass transformation and softening temperatures.[2] Achieving excellent chemical durability close to that of soda–lime–silica glasses and having large refraction indices that are adjustable by composition, these glasses have potential applications in sealing as well as for optical purposes.[3] Lead zinc phosphate glasses are also being considered for vitrifying certain nuclear wastes that are poorly suited for borosilicate glasses.[4] Because of the mechanical and thermal stresses occurring in some of these applications, the knowledge of their strength is important. There is little information for the mechanical properties of lead zinc phosphate glasses compared to commercial silicate glasses.

In the present study we have investigated structural properties by means of FT-IR analysis and mechanical properties of three different ternary Pb–Zn phosphate glasses, in mol%: $40P_2O_5$.50PbO.10ZnO, $30P_2O_5$.50PbO.20ZnO and $30P_2O_5$.40PbO.30ZnO, respectively, labelled as 451, 352 and 343. The three digit codes indicate the mol% divided by ten of P_2O_5, PbO and ZnO. For example, No. 451 indicates 40 mol% P_2O_5, 50 mol% PbO and 10 mol% ZnO.

Experimental Procedure

Preparation of glasses

A series of lead zinc phosphate glasses was prepared by thoroughly mixing and melting appropriate amounts of analytical reagent grade trilead tetroxide (Pb_3O_4), zinc oxide (ZnO), and ammonium dihydrogen phosphate ($NH_4H_2PO_4$). The composition of the glasses studied is given in Table 1. $NH_4H_2PO_4$, which decomposes at about 450°C, was used in place of P_2O_5. The well-mixed powders were preheated slowly to 450°C in an alumina crucible to remove H_2O and NH_3 prior to melting, and were then melted at 1000°C for 2 h. The crucible was then removed from the furnace and the melt was cast into a stainless-slab of 8×8×80 mm. To prevent cracking, the slab was kept for 2 h at a temperature of 50°C above T_g immediately after casting, and then cooled overnight in an electric furnace. The samples were stored in a desiccator to protect from possible attack by moisture.

The compositions studied, their density (Micromeritics AccuPyc 1330) and glass transition tem-

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