INFLUENCE OF THE ADDITION OF INTERMEDIATE OXIDES ON THE GLASS TRANSITION TEMPERATURE AND COEFFICIENT OF THERMAL EXPANSION OF LEAD BORATE GLASSES

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Low-melting glasses based on the lead borate system have a wide range of applications, including electrical engineering, electronics, nuclear, and solar energy. The lead borate system is an essential source for synthesizing new materials with valuable and particular properties such as high refractive index, low melting point, chemical resistance, wide glass-formation region and strong radiation shielding for γ-rays.

The lowest melting point eutectic in the binary $PbO–B_2O_3$ binary system with a melting point of 493 °C contains 70 mol.% PbO and 30 mol.% B_2O_3. Despite the low melting point of this glass, its use as sealing and solder glass is limited by its high coefficient of thermal expansion and tendency to devitrification. It is well known that the addition of a small number of intermediate oxides, especially Al_2O_3, TiO_2 and ZnO, improves the glass-forming ability, structure, thermal and dielectric properties of the heavy metal borate glasses. In order to realize the full potential of these unique glasses, it is critical to understand composition-structure-property relationships. These motivated us to study the influence of adding Al_2O_3, ZnO and TiO_2 on the changes in the glass transition temperature and the coefficient of thermal expansion of $70PbO–30B_2O_3$ glass.

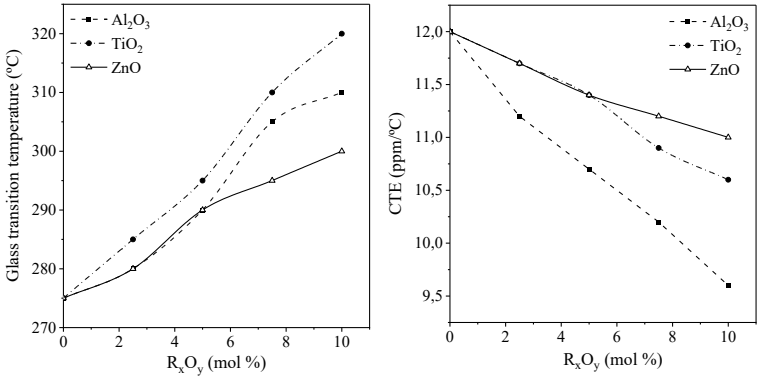

Fig. 1. Effect of the addition of intermediate oxides on the glass transition temperature and the coefficient of thermal expansion (CTE) of lead borate glasses

The coefficient of thermal expansion (CTE) in the range from 20 to 200 °C and glass transition temperature (T_g) of the glass samples were determined using a dilatometer (Dilatometer1300 L, Italy). The results of the dilatometry analysis are presented in Fig. 1.

The dilatometry results show that with equimolar substitution of PbO by Al_2O_3, ZnO, or TiO_2, the glass transition temperature (280–320 °C) increased while the coefficient of thermal expansion (9.6–12.0 ppm/°C) decreased. The observed decrease in CTE values and an increase in T_g values can be attributed to the substitution of the weaker and more flexible Pb–O (101 kJ/mol) bonds by the strong and rigid Zn–O (151 kJ/mol), Al–O (377 kJ/mol) and Ti–O (305 kJ/mol) bonds.