Phosphate and borophosphate glasses: structure–properties-application

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Phosphate and borophosphate glasses present an important group of glass materials having several commercial applications. Their research is still continuing and new materials based on these glasses have been prepared. Therefore studies of their structure and properties are reported on international conferences on glasses worldwide. Special phosphate glasses show promising usefulness as fast ion conductors, waveguides, optical switches, fibres, etc. Nevertheless, the applications of these glasses are often hampered by their low chemical durability. The addition of trivalent oxides together with substitution of alkali oxides by divalent oxides can improve their chemical durability. Our studies in recent years were aimed at the stabilization of phosphate glasses with $\text{B}_2\text{O}_3$ combined with $\text{ZnO}$ or $\text{PbO}$. Such materials offer better chemical durability than alkali phosphate or borophosphate glasses. Several studies were also devoted to mixed MO-Me$_2$O borophosphate glasses with $\text{M} = \text{Pb}$ and $\text{Zn}$ and $\text{Me} = \text{Li}$, $\text{Na}$ and $\text{K}$. We studied also the modification of zinc phosphate and borophosphate glasses with higher-valent oxides, e.g. $\text{Sb}_2\text{O}_3$, $\text{Bi}_2\text{O}_3$ or $\text{TeO}_2$ and transition metal oxides $\text{TiO}_2$, $\text{Nb}_2\text{O}_5$, $\text{MoO}_3$ and $\text{WO}_3$.

For structural studies we applied Raman and infrared spectroscopy combined with $^{31}\text{P}$ and $^{11}\text{B}$ MAS NMR spectroscopy. The aim of these studies is to identify basic structural units in these glasses and to investigate structural changes with changing glass composition and to relate structural changes with changes in the properties of glasses. Study of thermal properties of glasses is is carried out using a variety of thermoanalytical techniques (DTA, DSC, dilatometry and heating microscopy thermal analysis).

The most important applications of these glasses present laser glasses, glasses for the deposition of radioactive wastes, and glass solders. Nd-doped laser glasses used in high-power systems are predominantly phosphate-based with near metaphosphate composition. These glasses are characterized by large stored energy, efficient energy extraction, resistance to laser-induced damage and mature manufacturing technology. For the storage of radioactive wastes glasses containing about 40% $\text{Fe}_2\text{O}_3$ a 60% $\text{P}_2\text{O}_5$ were proposed due to their high chemical durability and the ability to include a high content of radioactive oxides like $\text{Na}_2\text{O}$, $\text{Cs}_2\text{O}$, $\text{SrO}$, $\text{UO}_2$ or $\text{Bi}_2\text{O}_3$. These oxide dissolve in the glass melt without a significant effect on its chemical durability.

Zinc borophosphate glasses or SnO-ZnO-$\text{P}_2\text{O}_5$ glasses were proposed for the application in solders replacing lead-based solders. Both glasses reveal a sufficient chemical durability, low values of the glass transition temperature and a low coefficient of thermal expansion.