Effect of a third network former on the properties of aluminosilicate glasses

Thilo Grammes*†[1], Alina Nizamutdinova[2], Jonathan Massera[3], Dominique De Ligny[4], Leo Van Wüllen[2], and Delia S. Brauer‡[1]

[1]Otto Schott Institute of Materials Research – Fraunhoferstr. 6, 07743 Jena, Germany
[2]Institute of Physics, Augsburg University – Universitätsstr. 1, 86159 Augsburg, Germany
[3]BioMediTech and Faculty of Biomedical Sciences and Engineering, Tampere University of Technology – Korkeakoulunkatu 3, 33720 Tampere, Finland
[4]Institute of Glass and Ceramics, Department of Materials Science and Engineering, Friedrich Alexander University Erlangen Nuremberg – Martensstr. 5, 91058 Erlangen, Germany

Abstract

In this study the properties of metaluminous aluminosilicate glasses have been investigated as well as changes upon the addition of phosphate. Glasses in the system SiO2-Al2O3-Na2O-P2O5 were prepared with a variation of the P2O5 content (up to 7.5 mol%) and of the SiO2 content (between 50 and 70 mol%). MAS NMR experiments confirmed that aluminium is present in four-fold coordination mostly as shown in Figure 1. Aluminium is thus charge-balanced by sodium ions and incorporated into the silicate network. Glass density was found to decrease with phosphate addition, possibly owing to reduced cross-linking of the glass network upon phosphate incorporation. Another possibility is an interaction between phosphate groups and [AlO4]- tetrahedra, which may lead to formation of non-bridging oxygens by sodium ions, which are no longer needed for charge-compensation. Glass transition temperature showed a trend similar to that of the density for phosphate addition; however, it decreased in glasses with fixed 7.5 mol% phosphate when the silica content was increased. This unexpected trend points towards a complex interplay between the three network formers (Si, Al and P). The two different roles of sodium (network modifying or charge-balancing) may also affect the glass properties. Raman spectra showed changes in band intensities which are in agreement with an observed decrease in hardness with phosphate addition. For some features of the Raman spectra, interestingly, the increase of phosphate content had a similar effect as an increase in silica content. Thus the underlying changes in the glass network may also be similar. In summary, the incorporation of phosphate as a third network former affects the thermal and mechanical properties of aluminosilicate glasses in a way which points at complex, non-linear structural changes.

Keywords: aluminosilicate glass, mechanical properties, structure property relationships, three network formers

*Speaker
†Corresponding author: thilo.grammes@uni-jena.de
‡Corresponding author: delia.brauer@uni-jena.de