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Advances in understanding the structure of borosilicate glasses: A Raman spectroscopy study

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ABSTRACT

This study is focused on the behavior of ternary SiO_2-Na_2O-B_2O_3 borosilicate glasses at temperatures between 298 and 1800 K. Unpolarized Raman spectra were measured up to high temperature. SiO_2-Na_2O-B_2O_3 glass samples were prepared with different values of the ratio $R = [Na_2O]/[B_2O_3]$, while the ratio $K = [SiO_2]/[B_2O_3]$ was kept constant and equal to 2.12. Spectra were measured at room temperature in samples with $0.43 \leq R \leq 1.68$, and the effect of the modifier content was clearly observed in these glasses, only in partial agreement with previous literature results. In particular, the formation in the glass of sodium-danburite units $Na_2O{\cdot}B_2O_3{\cdot}2SiO_2$ was postulated. This feature led to a new assessment of R^*, the critical value of R above which every new alkali atom added to the system breaks a Fo-O-Fo (Fo = glass former) bridge causing depolymerization of the glass. A revised formula is proposed to obtain the value of R^* as a function of K.

Raman spectra measured at high temperature yielded important information about the temperature-dependent evolution of the borosilicate system. In particular, borate and borosilicate units including tetra-coordinated boron seem to be unstable at high temperature, where the formation of metaborate chains or rings is fostered. Above 1500 °C, evaporation of borate compounds is clearly observed, stemming from the small sample size.

Keywords: Glass, borosilicate, structure, Raman spectroscopy