

The effect of chlorine on the viscosity of Na₂O-Fe₂O₃-Al₂O₃-SiO₂ melts

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ABSTRACT

The shear viscosities of Cl-bearing melts in the system Na₂O-Fe₂O₃-Al₂O₃-SiO₂ were determined at temperatures of 550–950 °C in the range of 10^{8.5} to 10^{12.0} Pa s using the micropenetration technique. The compositions are based on addition of Fe₂O₃ or FeCl₃ to aluminosilicate glasses with a fixed amount of SiO₂ (67 mol%). Although there was loss of Cl⁻ during the glass syntheses, no loss occurred during the viscometry experiments. It is to be expected that Cl⁻ takes the structural position of O²⁻, and thus reduces the polymerization of the melt structure, and therefore the viscosity of the melt; as F⁻ does. Our measurements show that the presence of Cl⁻ increases or decreases the viscosity of the melts as a function of melt composition. In the present melts, at least 10% of the Fe exists as network-modifying or charge-balancing Fe²⁺; whereas the rest exists as network-forming Fe³⁺. It is proposed here that the different effects of Cl on viscosity are due to the preferred Cl⁻-Fe²⁺_{NBO} bonding together with the different structure of peralkaline and peraluminous melts. In peralkaline aluminosilicate melts, the addition of Cl₂O₋₁ will destroy 2 NBOs and create one BO if Cl⁻ bonds primarily to the Fe²⁺ creating non-bridging O atoms. This would result in an increase in viscosity. In peraluminous melts, the addition of Cl₂O₋₁ may result in Cl⁻ bonds to the charge-balancing Fe²⁺, creating 2 new tri-clusters [assuming (Al³⁺,Fe³⁺)Si₂O₅ tri-clusters exist]. The preference of Cl⁻ to form bonds to the NBO-forming Fe²⁺ is indicated by the small amount of Cl⁻ soluble in the peraluminous melt structure in comparison to that soluble in the peralkaline structure.

Keywords: Viscosity, melt structure, micro-penetration, chlorine, iron, aluminium, peraluminous, peralkaline