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A Structural Connection to the Configurational Heat Capacity of Borate-Silicate Glass Forming Liquids

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When a glass-forming liquid is supercooled to the glass transition temperature (T_g), the structural degree of freedom decreases, causing a loss of the configurational heat capacity (C_{p,conf}). In borate-silicate mixed glasses, the C_{p,conf} exhibits a non-linear increase with substitution of B_2O_3 for SiO_2. However, its structural origin has not been well understood. In this work, through Raman spectroscopy measurements, we have found an implication for the intermediate range order (IRO) structural connection to the composition dependence of C_{p,conf} in a series of (75q)B_2O_3-(75(1-q))SiO_2-15Na_2O-10CaO glasses. In the silica-rich composition, the increase of the content of B-O-Si network units ([B_2Si_2O_8]^{2-}) and 6-membered borate rings causes the rapid increase of the C_{p,conf} with the addition of B_2O_3. In the boron-rich composition, the C_{p,conf} is almost constant, which is likely attributed to the counteraction between the decrease of the fraction of metaborate groups and the increase of the fraction of other borate superstructural units. As shown in Fig. 1, compared to short range order (SRO), the overall results suggest that the IRO structural change has a dominant contribution to the evolution of C_{p,conf} with composition. Furthermore, IRO is also found to govern the composition dependence of dynamic fragility, as illustrated in Fig. 2, implying that C_{p,conf} can be seen as the thermodynamic fragility in the studied system.