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Dynamic behavior of the 3CaO-1Al2O3 liquid

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Calcium aluminates (CaO)x(Al2O3)1-x are main components in the Earth’s mantle and also in the aluminates cement, which have been studied by many researchers.1,2) Calcium aluminates are very fragile glass formers and do not contain typical network-forming cations. The structure of (CaO)x(Al2O3)1-x with x=0.33, 0.5 and 0.75 was investigated in a laser heated aerodynamic levitation (ADL) furnace.3,4) The ADL technique enables vitrifying calcium aluminates in the composition range of 0.37 < x < 0.75, whereas the conventional melt-quenching method can vitrify only those in a much narrower x range (0.6 < x < 0.7).3) Kargl et al studied the viscous behavior of the CaAl2O4 liquid in the temperature range of 2000 to 2800 K by using ADL.5) Hennet et al studied the structural evolution of the fragile glass-forming liquid-CaAl2O4.6)

Figure 1: Viscosity $\eta$ vs $T_g$-scaled temperature of C3A fitted to the MYEGA equation. Viscosities near $T_g$ were determined from the relation $\log \eta = 11.35 + \log (1/q(T_f))$.7) The slope of linear fitting to $\log (1/q(T_f))$ vs $T_g/T_f$ plots of DSC results is the fragility $m$.

The 3CaO-1Al2O3 (C3A) bulk glass was prepared using the ADL technique. The viscosities at high temperatures (1773~2923 K) of the C3A liquid were measured using the ADL technique as shown in Figure 1. By conducting differential scanning calorimetric (DSC) measurements, we determined the glass transition temperature ($T_g=1092$ K) and the dependence of fictive temperature ($T_f$) on cooling rate ($q_c$). The temperature dependence of viscosity was fitted to the Mauro-Yue-Ellison-Gupta-Allan (MYEGA) equation.8) The fragility parameter $m'$ of the C3A liquid was determined to be about 74 by extrapolating the MYEGA fitting curve to the $T_g$, while $m$ was determined using DSC to be about 33. This implies that the fragile-to-strong liquid transition occurs in the C3A liquid upon cooling.9)