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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 aluminate 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

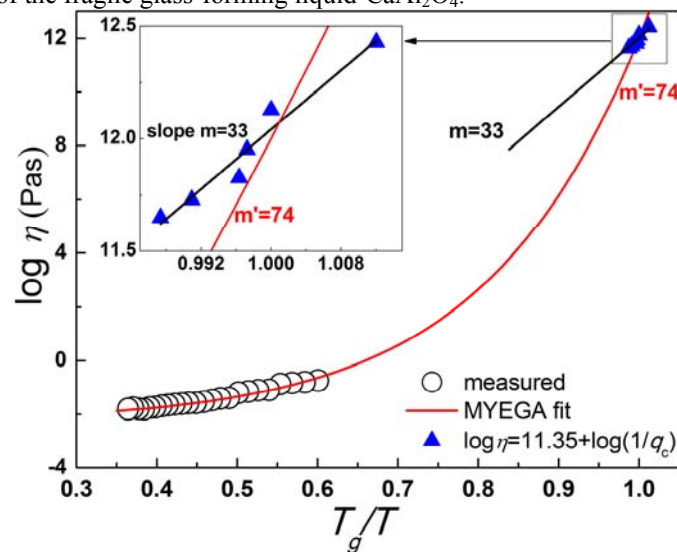


Figure 1: Viscosity η vs T_g -scaled temperature of C3A fitted to the MYEGA equation. Viscosities near T_g were determined from the relation $\log \eta = 11.35 + \log(1/q_c(T_f))$.⁷ The slope of linear fitting to $\log(1/q_c(T_f)) \sim T_g/T_f$ plots of DSC results is the fragility m .

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

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