Condensation experiments in the Mg-Si-O system for understanding of circumstellar dust formation: dependence on the Mg/Si ratio.

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Silicates are major dust species around young and evolved stars, and in the interstellar medium. Experimental and theoretical studies on solid formation are crucial for understanding the origin of precursor materials of chondrites and dust formation around stars. Condensation experiments of silicates were performed in various systems, where most of the studies evaporated starting materials with compositions of $(Mg_x, Fe_{1-x})_2SiO_4$, SiO_2, and MgO [1-7]. Condensation from vapors with different Mg/Si ratio, however, has not been studied systematically. In this study, we performed condensation experiments of silicates from vapors with various Mg/Si ratios to examine the condensation sequence in different circumstellar environments.

Condensation experiments were carried out in a vacuum chamber. We produced Mg-Si-O gases by evaporation of (1) melts with Mg/Si~1 (Exp02 and 03) and (2) SiO_2 and MgO powders separately filled in Knudsen cells (Exp04-06) placed on the bottom of the crucible of 90 mm in depth. Here, the Mg/Si ratio was controlled by changing the size of the hole on the rids of the Knudsen cells to be 0.9, 1.6, and 20.0, respectively. The vapors condense onto Pt (Exp02-05) and Ir (Exp06) wires of 50-80 mm in length hung from the top of the crucible. The temperature gradient on the wire was measured by thermocouples before the experiments.

A mixture of SiO_2 and MgO powders were heated as a gas source at 1650 (Exp02) and 1580˚C (Exp03), which are higher than the melting temperature. We obtained condensates on the Pt-wires. In Exp02, forsterite was obtained at ~1570˚C and clino-enstatite at lower temperature regions. In Exp03, ortho- (or proto-) enstatite was observed at the highest temperature region (~1520˚C) and forsterite was not confirmed. Clino-enstatite covered the Pt-wire at lower temperatures than 1510˚C.

Quartz and periclase powders were put into Ir Knudsen cells separately and heated at 1580˚C (Exp03-06). No condensate was observed at >1360˚C. Forsterite covered the wires at <1350˚C and enstatite was not condensed at lower temperatures. No clear difference was observed between the three experiments with different Mg/Si ratio of 0.9-20.0.

Fractional evaporation may have occurred from Mg-Si-O melts, and the gas composition gradually enriched in Si compared to Mg during the experiments. We did not use Knudsen cells for the experiments Exp02 and 03. Therefore, the differences between the condensation experiments from gases evaporated from melts and powders may be the Mg/Si ratio and gas fluxes. As future works, we plan to perform experiments with much lower Mg/Si ratios and with higher gas fluxes (higher supersaturation ratios) to determine the condition to form clino- and proto-enstatite from gas phases.

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