Condensation Experiments in the System of Mg-Si-O and Its Application to Dust-formation in Mass-loss Winds from Evolved Stars

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Magnesian silicates exist in circumstellar environments as one of the dominant dust components in the form of amorphous or crystals such as forsterite (Mg_2SiO_4) and enstatite ($MgSiO_3$). Thus, it is important to understand formation mechanisms of different forms of magnesian silicates in order to understand evolution of solid in space and estimate physical conditions in circumstellar environments.

In this study, in order to understand condensation behaviors of magnesium silicates at pressures as low as in mass-loss winds from evolved stars, we performed condensation experiments in the system of Mg-Si-O using an infrared vacuum furnace. The furnace consists of a silica glass tube connecting to a turbo molecular pumping system, two infrared heating systems, and a quadrupole mass spectrometer. A single crystal of forsterite, used as a gas source of Mg, Si, and O, was heated at ~1800 K by focusing infrared light from halogen lumps. A substrate of molybdenum plate was put at various distances from the gas source to change condensation temperatures from 1420 to 750 K. Condensation experiments were carried out for 24-72 hours at a pressure of $\sim 10^{-5}$ Pa.

Neither Mg, Si, nor O condensed on the substrate at 1420 and 1310 K. No silicate condensed at 1130 K either, but Si condensed as Mo-Si alloy. Amorphous silicates condensed at 840 and 750 K. Such condensates found in the present study are different from those formed in the Mg-Si-O system in previous studies [1, 2], where crystalline forsterite and enstatite and amorphous silicate condensed on substrates depending on temperatures, which may be because smaller gas fluxes of Mg, Si, and O in the present study than in [1, 2] reduced chances of encounter of three different molecules containing Mg, Si, and O on the substrate.

The present study indicates that crystalline forsterite cannot condense at ~850 K at pressures as low as in circumstellar conditions around evolved stars, but amorphous magnesian silicates condense.

Keywords: condensation; kinetics; crystalline silicate; amorphous silicate

References

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