SILICATE CONDENSATION EXPERIMENTS IN A HYDROGEN DOMINANT GAS AND ITS THERMAL HISTORY

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Introduction: The thermal evolution of silicates is an important process in the solar nebula, because most interstellar silicates are initially in an amorphous state. Since amorphous silicates gradually crystallize via thermal annealing in the hot inner solar nebula over time, observations of their spectra as they change from amorphous to crystalline (forsterite) via thermal annealing have been performed [1], and the chronology and formation age of comets in the early Solar System has been discussed based on these laboratory experiments [2]. In the scenario where crystalline silicates form only by annealing, there are difficulties. For example, thermal annealing will not produce forsterite unless the chemical composition of the precursor particles is of olivine composition. In addition, the oxygen isotopic composition of crystalline silicates in IDPs and Wild-2/Stardust samples is indistinguishable from solar [3,4]. The abundant presolar crystalline silicates, determined from oxygen isotopic anomalies, are much less abundant than presolar amorphous silicates, which are thought to be GEMS [5].

In contrast to simple condensation in an outflow from an evolved star, solar silicate grains are a result of complex experiences, such as annealing of presolar grains, evaporation and recondensation of amorphous grains in the nebula, epitaxial growth of large crystalline grains, condensation of amorphous grains followed by annealing and oxidation of metallic precursors such as magnesium silicide (Mg_2Si). Solar system silicates may be a result of all of these processes, i.e., the degree of each contribution should be elucidated. Here, we will show results of condensation experiments in hydrogen dominant gas and thermal alteration of the resultant amorphous magnesiosilica particles using differential scanning calorimetry (DSC).

Laboratory study: Refractory magnesiosilica and Mg_2Si particles were produced by vapor phase condensation from O_2, SiH_4, and Mg in a H_2 bulk flow [6]. Formation of Mg_2Si suggests that Mg_2Si grains can be formed in outflows from evolved stars in addition to amorphous oxide minerals and that they might possibly contribute to solar silicates. They might also condense from hot vapors in the solar nebula. Exothermic reactions during the annealing of the samples were detected by DSC. With IR spectroscopy and transmission electron microscopy, we show that cosmic dust could possibly undergo fusion to larger particles, with oxidation of magnesium silicide and crystallization of forsterite as exothermic reactions in the early solar system. During the crystallization of forsterite particles, the spectral evolution of the 10 μm feature from amorphous to crystalline was observed to begin at lower temperature than the crystallization temperature of 1003 K. We propose that metallic Mg_2Si grains could have been the seeds that grew via oxidation to form some fraction of the forsterite observed in the Solar System.

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