Condensation of Silicon Monoxide at Cryogenic Temperatures

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We have recently started the experimental study of silicate condensation at very low temperature. This project is motivated by two facts. First, silicates are the main components of cosmic dust. Second, the estimated amount of silicate dust formed at high temperature in stellar environments, considering the lifetime of the grains, cannot account for the comparatively large quantity of silicate dust that is osberved in the interstellar medium (ISM). Thus the formation and growth of silicate grains must occur in the ISM, more specifically in dense clouds where temperatures in the range 10–50 K prevail.

As the first stage of our project, we have studied the condensation of SiO molecules, which we can reasonably expect to be among the main building blocks of interstellar silicates.

A first set of experiments has been carried out at 0.37 K in superfluid He droplets with a technique that makes use of mass spectrometry. After seeding the droplets with two to four SiO molecules, the formation of $(SiO)_x$ (x = 2–4) clusters has been observed despite the extremely low temperature. Hence it is concluded that there is no energy barrier that could prevent the condensation of SiO molecules at the temperatures found in the ISM.

In a second set of experiments, we have deposited SiO molecules in Ne matrices at 6 K, using UV absorption spectroscopy to monitor the process. After annealing of the matrices at 10–12 K and after their evaporation, we have found that white grains had been formed. Images obtained by transmission electron microscopy show that the grains are fluffy, amorphous, and $\sim$10 nm to $\sim$10 μm in size. Chemical analysis by energy-dispersive X-ray spectroscopy gives SiO as their formula. Thus SiO grains can be formed at low temperature and can survive to room temperature.

These experiments and their results will be presented in detail before introducing the latest progresses of this ongoing project.