Effects of Shape and Aggregation on Infrared Spectra of Forsterite Particles

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Circumstellar and interstellar dust has been investigated by comparing between infrared spectra of astronomical observations and laboratory measurements. It is generally known that IR spectra of solid-state materials has dependencies not only on intrinsic properties, such as temperature, structure, chemical composition, but also on effects relevant to light-scattering of fine particles, such as particle size, shape, and aggregation. So far, effects of chemical composition and temperature on infrared absorption spectra of silicates have been investigated experimentally. In contrast, the shape and aggregation effects have not been well known experimentally yet. In order to examine the shape and aggregation effects on the infrared absorption spectra, we need to produce sub-micron particles by controlling of their shapes and degrees of aggregation.

In the experiments, sub-micron spherical particles of forsterite were prepared. We synthesized nano-particles of spherical amorphous silicate with the forsterite (Mg_2SiO_4) composition by RF plasma. Then, the amorphous samples were heated at various temperatures (800 - 1200^{o}C) for various durations (3 - 48hr) to obtain crystalline particles with different degrees of aggregation. The particle shape and degree of aggregation were observed under Field Emission Scanning Electron Microscope (FE-SEM). The degree of aggregation increases as heating duration or temperature increases. The IR spectra were measured by Fourier transform IR spectrometer. By comparing the measurements with calculations of IR spectra with optical constants of forterite, we estimated the shape and aggregation effects. We found systematic change in IR spectra (peak positions, intensities and half widths) corresponding to particle shapes and degrees of aggregation. Based on the results, we discuss shapes and aggregations of forsterite dust in observed IR spectrum.