# Production of Oldhamite(CaS) grains and characteristic spectra

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Carbon-rich evolved objects such as carbon-rich asymptotic giant branch (AGB) stars (C-stars), post-asymptotic giant branch objects (post-AGBs) and planetary nebulae (PNe) show a broad emission feature around 30 um. It has been considered that the'30'um feature is composed of two sub features at near 26 um and near 30 um and interests about C-rich objects. Condensation calculations and experiments predicted that candidates of the feature are sulfides; especially troilite (FeS) and ningerite (MgS, MgFeS). These substances respectively have a strong peak at 23, 32 and 28 um and also have several weak peaks. Strong features around 30-35 um were observed at post-AGBs and PNe that were difficult to be identified by these sulfides (Hony et al. 2002). In this experiment, we focused on oldhamite (CaS) that is a kind of sulfides to be founded in a lot of meteorites, because infrared (IR) spectrum of CaS is scarcely discussed as an solar abundance ratio of Ca is much smaller than that of Fe and Mg. Matthew et al. (2005) reported that the stabilities of the sulfides depended on C/O ratio. They claimed CaS and MgS are more stable than FeS when the C/O ratio is higher than 5.

In this study, CaS grains were produced by a mixed smoke of Ca and S with the gas evaporation method under three oxygen conditions; ($O_2$: 0 and Ar: 80 Torr, $O_2$: 0.1 and Ar: 79.9 Torr, $O_2$: 5 and Ar: 95 Torr) total pressure is 80 Torr. Sulfur on a tantalum boat and calcium on a tantalum conical basket were simultaneously evaporated and their smokes were mixed. Sulfur smoke was produced by a two boat method. We considered that CaS grains were produced by the reaction between calcium solid grains and sulfur liquid grains. After that, the produced samples were observed by transmission electron microscope (TEM) and measured IR spectra. In the TEM image, cubic grains with the NaCl structure were predominately produced in all conditions and small grains with the truncated cubic shape were also produced in the oxygen containing gas atmosphere. A part of the CaS and CaO grain produced in containing oxygen gas was selectively altered to $Ca(OH)_2$ phase by exposing into air. In far-IR spectra, CaS showed a large feature at 35 um and the peak shifted to short wavelength side for 1 um as the partial pressure of $O_2$ increased. This peak shift should be due to the shape effect of CaS or Ca-O vibration at 25-30 um because of the increase of CaO and $Ca(OH)_2$ phases. The CaS feature around 34-35 um corresponds to the spectral features of post-AGBs and PNe. In addition, the spectrum is also corresponded to the 35 um band, which was observed from Deep Impact to comet 9P/Tempel 1. Therefore we would like to propose that CaS should be considered a candidate at '30' um feature in addition to Fe and Mg sulfides.