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 [JJ] Evening Poster | P (Space and Planetary Sciences) | P-PS Planetary Sciences

## [P-PS09]Origin and evolution of materials in space

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Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on observations, experiments, planetary missions, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

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## [PPS09-P05]Variation of carbon isotopic composition with formation of CO<sub>2</sub> clathrate hydrate

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In interstellar molecular clouds, various molecules such as H<sub>2</sub>O, CO, CO<sub>2</sub>, CH<sub>3</sub>OH, H<sub>2</sub>CO, and NH<sub>3</sub> are condensed onto dust grains. Water exists as amorphous ice on the dust grains and is transformed into various structures depending on thermal conditions and compositions of coexisting molecules. From the results using transmission electron microscopy and Fourier transformed infrared spectroscopy, it was found that the vapor deposited amorphous ice including CH<sub>3</sub>OH and CO<sub>2</sub> is transformed into clathrate hydrate at around 120 K [1]. This suggests that the cometary ice exists as clathrate hydrate. Clathrate hydrates are inclusion compounds consisting of water molecules and a variety of guest molecules. From infrared (IR) astronomical observation, it was found that the <sup>12</sup>C/<sup>13</sup>C isotope ratio of comets is larger than that of interstellar matter [2]. To investigate the effect of clathrate hydrate formation on <sup>12</sup>C/<sup>13</sup>C isotopic ratio, IR spectra of vapor deposited amorphous ice including <sup>12</sup>CO<sub>2</sub> and <sup>13</sup>CO<sub>2</sub> were measured. Using the spectra, the variation process of <sup>12</sup>CO<sub>2</sub>/<sup>13</sup>CO<sub>2</sub> ratio during warming was analyzed.

Amorphous ice including <sup>12</sup>CO<sub>2</sub> and <sup>13</sup>CO<sub>2</sub> was prepared with vapor deposition of mixture of <sup>12</sup>CO<sub>2</sub>, <sup>13</sup>CO<sub>2</sub> gases and distilled and degassed water on a substrate of oxygen-free copper at 42 K. In the gas mixture, the <sup>12</sup>C/<sup>13</sup>C isotopic ratio was 92, and (<sup>12</sup>CO<sub>2</sub> + <sup>13</sup>CO<sub>2</sub>)/ H<sub>2</sub>O was 1.4. The total pressure in the vacuum chamber was kept at about 3.5 × 10<sup>-5</sup> Pa during the deposition. After the deposition of amorphous ice, the substrate was warmed to 180 K at a rate of 1~4 K/min. The IR spectra were measured using a spectrometer (Shimadzu IRPrestage-21) at 2 K intervals during warming. To analyze the sublimation behaviors, the temperature programmed desorption (TPD) curves were also measured using quadrupole mass spectrometer (Pfeiffer QME220) during warming.

From the analyses of the wave numbers of the O~H stretching modes of H<sub>2</sub>O, <sup>12</sup>C=O asymmetric stretching mode of <sup>12</sup>CO<sub>2</sub>, and <sup>13</sup>C=O asymmetric stretching modes of <sup>13</sup>CO<sub>2</sub> during the warming, remarkable changes were found at around 100 K. From the TPD curve, furthermore, a remarkable gas

release was observed at this temperature. Because of the closed wave number of the  $^{12}\text{C}=\text{O}$  asymmetric stretching mode at 100 K with that of  $\text{CO}_2$  clathrate hydrate [3], the formation of  $\text{CO}_2$  clathrate hydrate at 100 K was confirmed. It was found that the  $^{12}\text{CO}_2/^{13}\text{CO}_2$  ratio increases at around 100 K. These results suggest that the formation of clathrate hydrate from amorphous ice with warming can be a cause of  $^{12}\text{C}$  condensation.

#### References

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