Formation of ice mantle by hydrogen atom addition reaction with solid oxygen at low temperatures

Naoya Miyauchi[1]; Hiroshi Hidaka[2]; Takeshi Chigai[3]; Akihiro Nagaoka[2]; Naoki Watanabe[4]; Akira Kouchi[5]

[1] Inst. Low Temp. Sci. Hokkaido Univ.; [2] Inst. Low Temp. Sci., Hokkaido Univ.; [3] ILTS, Hokkaido Univ.; [4] Inst. of Low Temp. Sci., Hokkaido Univ.; [5] Inst. Low Temp. Sci., Hokkaido Univ

http://risu.lowtem.hokudai.ac.jp

Water is the most abundant solid molecule in space, and has been observed in various astrophysical environments, such as outer planets, satellites, comets, and interstellar clouds. However, the formation mechanism of water molecules has not been understood to date.

Experiments were performed using the Apparatus for SUrface Reaction in Astrophysics (ASURA) system described previously. Briefly, solid O_2 with an 8 monolayer thickness was produced by vapor deposition on an aluminum substrate at 10 K. The atomic beams could be cooled to 70 K in the aluminum tube that was connected to an He refrigerator. Infrared absorption spectra of the sample solid during irradiation by atoms were measured in-situ by Fourier transform infrared spectroscopy.

The formation of H_2O_2 (D_2O_2) and H_2O(D_2O) were also observed when solid O_2 was exposed to an H(D) beam at temperatures at 10 K. We found that the reaction proceeds very efficiently and obtained the effective reaction rates. The formation of H_2O_2 and H_2O is very rapid and efficient; H_2O_2 and H_2O are observed even after exposure for 5 s. When H atoms are irradiated onto solid CO at 10 K, the production of H_2CO and CH_3OH are observed after 30 s and 1 min, respectively.

Based on the experimental results, we discuss the reaction mechanism and astrophysical implications.