Hydrogen addition reactions of simple aliphatic hydrocarbons (C_2H_2 and C_2H_4) ~ clue to the formation mechanism of cometary C_2H_6~

H. Kobayashi,[1] N. Watanabe,[2] H. Hidaka,[2] T. Hama,[2] Y. Watanabe,[1] and H. Kawakita[1]

[1]*Koyama Astronomical Observatory, Kyoto Sangyo University, Japan*
[2]*Institute of Low temperature Science, Hokkaido University, Japan*

Comets are thought as remnants of planetesimals formed in the early solar nebula. Their nuclei consist of volatile ices and dust grains that were formed in the pre-solar molecular cloud and probably chemically altered in the proto-planetary disk. Although the outline of evolution from a molecular cloud to the disk is basically understood, detailed chemical processes are still in debate. To investigate the links between proto-planetary disk and the molecular cloud, we focused on cometary ethane (C2H6) which is considered to form through the hydrogen addition reactions on the cold grain surfaces. C2H6 and accetylene (C2H2), the parent molecule of the C2H6, have been observed in multiple comets since 1996 and their abundances relative to water (the major component of cometary ices) is ~0.001 with some variations [1]. Such variation might be caused by the difference in the mixing ratios between the materials originated in the molecular cloud and the disk-processed materials. C2H6 has never been detected in molecular cloud thus we evaluate experimentally the hydrogenation processes to form the C2H6 from C2H2 (C2H2 -> C2H3 -> C2H4 -> C2H5 -> C2H6). In the previous experimental studies [2], it was concluded that the reaction from C2H4 to C2H6 is considerably rapid than the reactions from C2H2 to C2H4 and it would be a reason for the absence of C2H4 in comets. To investigate those reactions quantitatively in realistic conditions of molecular clouds, we performed the laboratory measurements of hydrogen addition reactions of C2H2 and C2H4 on amorphous solid water.

The experiments were conducted by using laboratory setup for surface reaction in interstellar environment (LASSIE) at Institute of Low Temperature Science, Hokkaido University [3]. Atomic hydrogen used for the reactions were produced by the dissociation of hydrogen molecules in micro-wave induced plasma. The kinetic temperature of hydrogen atoms were ~120K and the H-atom flux was ~10^{13} $cm^{-2}s^{-1}$. The samples of pure solid C2H2, C2H4 and those on ASW were produced on the substrate located in the center of the main chamber at 10K and 20K. Infrared absorption spectra of the ices were measured by FTIR before and during the exposure of H-atom.

Although our measurements show basically the same trend as shown in the previous studies, the difference in reaction rates for C2H2 and C2H4 was found to be much less than that previously reported. We will discuss the temperature and thickness dependence of the time constant for the sample ices in the poster.

References

[1] M. J. Mumma & S. B. Charnley, 2011, Annu. Rev. Astro, Astrophys. 49, 471.
[2] K. Hiraoka, T. Takayama, A. Euchi, H. Handa, & T. Sato, 2000, ApJ, 532, 1029
[3] N. Watanabe & A. Kouchi. 2002. ApJ, 571, L173