Grain-surface reactions related to cometary hydrocarbons (ethane, ethylene, and acetylene). H. Kobayashi[1], N. Watanabe[2], H. Hidaka[2], H. Kawakita[1], [1]Koyama Astronomical Observatory, Kyoto Sangyo University (Motoyama, Kamigamo, Kita-ku, Kyoto, 6038555), [2]Institute of Low temperature Science, Hokkaido University (N19-W8, Kita-ku, Sapporo, 0600819).

Introduction: The volatiles incorporated in the comets were formed in the proto-planetary disk and/or in the pre-solar molecular cloud before the formation of proto-planetary disk. Chemistry in these stages is closely related to the physical conditions (e.g., temperatures and densities of materials) in the environments. Cometary ethane (C_2H_6) and acetylene (C_2H_2) have been detected by near-IR observations in several comets and their mixing ratios were ~10^{-3} relative to H_2O although C_2H_6 has never been detected in the ISM. The formation mechanism of C_2H_6 has been studied in laboratory. Candidates of formation reactions of C_2H_6 are the hydrogen addition reactions to C_2H_2 on the cold grains ($C_2H_2 \rightarrow C_2H_3 \rightarrow C_2H_4 \rightarrow C_2H_5 \rightarrow C_2H_6$) or dimerization of CH_3 in CH_4-rich ice by irradiation of energetic protons [1]. So existence of ethylene (C_2H_4) is a key to distinguish those hypothesizes. Hiraoka et al. (2000) [2] reported the H-atom addition reactions with pure C_2H_2 ice to form C_2H_6 and they concluded that the reactions from C_2H_4 to C_2H_6 occurred more rapidly than the reactions from C_2H_2 to C_2H_4. To investigate these reactions quantitatively in more realistic situations for ISM, we conducted the laboratory measurements of H-atom addition reactions with amorphous H_2O-C_2H_2 mixture ice. Also, photolysis may be important mechanism to destruct C_2H_6 and to form C_2H_4 and C_2H_2. In this paper, we will report on our laboratory works related to H-atom addition reactions and photolysis of hydrocarbons in comets.

Experimental details: The experiments were carried out by using laboratory setup for surface reaction in interstellar environment (LASSIE) at institute of low temperature science, Hokkaido university [3]. The experimental apparatus is shown in Fig 1. A cryogenic aluminum substrate is located in the center of the main chamber and surrounded by a large copper shroud connected to a liquid-nitrogen reservoir. Atomic hydrogen used for H-atom addition reactions were produced by the dissociation of H_2 molecules in microwave-induced plasma. The kinetic temperature of hydrogen atoms were ~130K and the H atom flux was ~10^{14} cm^{-2} s^{-1}. The sample of H_2O-C_2H_2 ice was produced on the aluminum substrate at 10K and 30K. The temperature of the ice was maintained during H-atom exposure. The UV photon source, a deuterium lamp, produces the photons of Lyman series and Lyman band. The flux was ~6×10^{13} photons cm^{-2} s^{-1}. Infrared absorption spectra of the ice were measured by the Fourier transform infrared spectrometer before and during the exposure of H-atom or UV with a spectral resolution of 4 cm^{-1}.

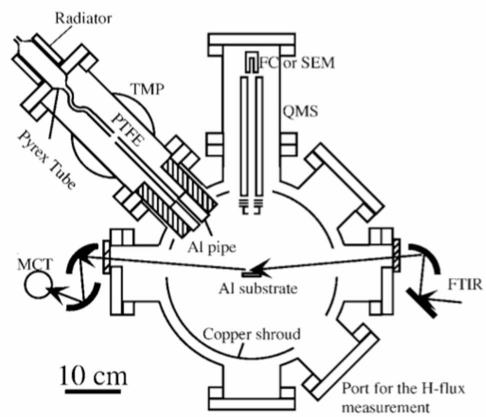

Fig 1. Diagram of experimental apparatus of LASSIE

Results and discussions: Our results of H-atom addition reactions are basically same as those in ref [3]. It is hard to detect C_2H_4 in the ice because C_2H_4 is rapidly converted to C_2H_6 by the H-atom addition reactions. This finding would explain the nondetection of C_2H_4 in comets. We will discuss the temperature dependence of H-atom addition reactions and relationship with the observations by Kawakita et al. (2011) [4]. In the case of photolysis measurements, we detected both hydrocarbons (C_2H_2 and C_2H_4) and CO-bearing molecules (CH_3OH, H_2CO, CO, CO_2). The UV radiation induces photodissociation such as $C_2H_6 \rightarrow 2CH_3$, and $H_2O \rightarrow H + OH$, and then those fragments may form methanol by $OH + CH_3 \rightarrow CH_3OH$. CH_3OH would be destroyed again by UV to H_2CO and to CO. CO_2 would be formed by $CO + OH \rightarrow CO_2 + H$. Thus, CO bearing molecules like CH_3OH, H_2CO, CO, CO_2 could be formed thorough the C_2H_6-H_2O mixture ice with UV radiation.

References: [1] Hudson R. L. and Moore M. H. (1997) *Icarus, 126,* 233-235. [2] Hiraoka K. et al. (2000) *ApJ, 532,* 1029-1037. [3] Watanabe N. and Kouchi A. (2002) *ApJ, 571,* L173–L176. [4] Kawakita H. et al. (2011) *EPSC-DPS Joint meeting,* 353.