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Life time of hydrogen atom on amorphous CO ice

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Hydrogen is most abundant element in space and widely used as a component of complex molecules. In a molecular cloud, various molecules are produced in or on an ice mantle, which formed on nanometer-sized inorganic grains at low temperatures, rather than in gas phase. For example, although hydrogen molecules can form in gas phase via sequence reaction of radiative attachment and associative detachment of H- and H, the formation rate is insufficient to explain the observed amount of hydrogen molecules (Gould & Salpeter, 1963). To understand formation of not only hydrogen but also complex molecules, therefore, physical and chemical properties, such as sticking coefficients, diffusion constants, sublimation probability, rate constants and energy barriers, of atoms on cold surfaces must be clarified. After 1990s, although several experiments were performed and provided effective rates concerning surface reactions relevant to astrochemistry (e.g., Pirronello et al. 1997; 1999; Vidali et al. 2004; Watanabe et al. 2006; Watanabe 2006), those data for the above-mentioned properties of hydrogen atom are totally lacking.

In the case of hydrogen atoms landed on the grain surface, it migrates on the grain surface and removed by desorption or reactions with another atoms or molecules. In order to clarify such processes, we started a series of experiments using hydrogen atoms on cold substrates. Not only water ice (H2O), but also CO, carbon dioxide (CO2), formaldehyde (H2CO), methanol (CH3OH), ammonia (NH3) and so forth construct the ice mantle as main components (Gibb et al., 2004). In particular, the abundance of CO ice is roughly tens of percent of an ice mantle. In addition, some fractions of CO was found to exist in CO-solid form on the ice mantle. Accordingly, behavior of hydrogen atoms on CO ice solid is important to understand the chemical evolution on a grain surface. We show first experimental results of life time of hydrogen atoms on CO solid ice. We found that the life time is very long and the diffusion constants would be much smaller than normally expected.