Astrochemistry: Recent Successes and Current Challenges
Poster Book IAU Symposium No. 231, 2005
A. J. Markwick-Kemper, ed.

DOI: 00.0000/X000000000000000X

Reaction rates for hydrogenation and deuteration of solid CO at 15 K

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Abstract. Methanol (CH_3OH) and formaldehyde (H_2CO) are abundant organic species in ice mantle. It has been expected that surface reactions on dusts are necessary to produce the abundant H_2CO and CH_3OH molecules. Our group revealed experimentally that the successive addition of hydrogen atoms to cold solid CO, i.e., CO $\rightarrow$ HCO $\rightarrow$ H_2CO $\rightarrow$ CH_3O $\rightarrow$ CH_3OH, produces H_2CO and CH_3OH efficiently under the condition of molecular clouds. Recently, deuterium enrichments of formaldehyde and methanol were found toward the low mass protostars. It is reasonable to expect that the surface reactions play a role in producing deuterated formaldehyde and methanol as well. Using cold atomic hydrogen and deuterium beams, the relative reaction rates of hydrogenation and deuteration of solid CO were measured. The rate of hydrogenation strongly depends on the surface composition and temperature. The deuteration rate was found to be smaller than hydrogenation rate by a factor of approximately 0.12. This isotope effect can be attributed to the tunneling reaction. In conclusion, the deuterium addition to solid CO (CO + D $\rightarrow$ DCO) would not be the first step to produce the deuterated formaldehyde and methanol in molecular clouds.

Keywords. astrochemistry - atomic processes - ISM: dust, extinction - molecular processes

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Acknowledgements

This work was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture of Japan.