A chemical link between methylamine (CH_3NH_2) and methylene imine (CH_2NH): Infrared identification of aminomethyl radical ($\bullet CH_2NH_2$) and implications for interstellar glycine formation

Joshi, P. R.,[1]* Lee, Y.-P. [1, 2]
*presenter
[1] e-mail address: prasad.nctu@gmail.com, Department of Applied Chemistry and Institute of Molecular Science, National Yang Ming Chiao Tung University, Hsinchu 30093, Taiwan
[2] Centre for Emergent Functional Matter Science, National Yang Ming Chiao Tung University, Hsinchu 300093, Taiwan

Methylamine is considered as a potential precursor for the formation of interstellar amino acid through the reaction between aminomethyl radical ($\bullet CH_2NH_2$) and HOCO. Despite of its importance in interstellar medium, direct evidence of the formation and spectral identification of $\bullet CH_2NH_2$ remains unreported. Taking advantage of unique properties associated with the *para*-hydrogen (p-H_2) matrix, we performed the reaction H + CH_3NH_2 in solid p-H_2 at 3.2 K. To generate H atoms, two methods were employed. In the first method, photolysis at 365 nm of a co-deposited mixture of CH_3NH_2/p-H_2 to produce Cl atoms and subsequent IR irradiation for promoting the Cl + H_2 ($\upsilon = 1$) → H + HCl reaction were carried out. Upon UV/IR irradiation of the Cl_2 doped CH_3NH_2/p-H_2 matrix and after maintaining this matrix in darkness, we observed formations of $\bullet CH_2NH_2$ and CH_2NH. The new IR spectrum of $\bullet CH_2NH_2$ clearly indicates that $\bullet CH_2NH_2$ can be formed from the reaction H + CH_3NH_2 in dark interstellar clouds. Isotopic experiments performed using CD_3NH_2 produced CHD_2NH_2, in addition to $\bullet CD_2NH_2$ and CD_2NH, confirming the occurrence of H addition to $\bullet CD_2NH_2$. The products observed in this study are consistent with the potential-energy schematic predicted for H + CH_3NH_2 reactions which reveal the feasibility of sequential H-abstraction and H-addition reactions. Moreover, a dual-cycle mechanism consisting of two consecutive H-abstraction and two H-addition steps chemically connects CH_3NH_2 and CH_2NH and might explain their quasi-equilibrium in the interstellar medium. In the second method, H atoms were generated upon photolysis of a H_2O_2-doped CH_3NH_2/p-H_2 matrix to generate $\bullet OH$ first to facilitate the $\bullet OH$ + CH_3NH_2 reaction; further reaction of $\bullet OH + H_2 \rightarrow H_2O + H$ might also trigger the H + CH_3NH_2 reaction. In this method, significantly more $\bullet CH_2NH_2$ was produced than in CH_3NH_2/Cl_2/p-H_2 experiments; this observation is in line with a barrier predicted for $\bullet OH$ + CH_3NH_2 much smaller than that for H + CH_3NH_2. Both $\bullet CH_2NH_2$ and CH_2NH observed herein are plausible starting materials for interstellar glycine in molecular clouds.