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グリシン前駆体、メチレンイミンの多天体探査
Survey Observations of A Glycine Precursor, Methylenimine (CH2NH)

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It is widely thought that prebiotic chemical evolution from small to large and complex molecules would have resulted in the Origin of Life. The interstellar medium (ISM), where more than 170 molecules ranging from simple linear molecules to COMs were detected, show chemically rich environment. Ehrenfreund et al. (2002) argued that exogenous delivery of COMs to the early Earth by comets and/or asteroids could be more than their terrestrial formation by two orders of magnitude; molecules delivered from the Universe might have played an important role in early Earth chemistry. From this point of view, many observations were conducted to search for prebiotic molecules in the ISM, which might turn into the " Seeds of Life " when delivered to planetary surface. Especially, great attention was paid to amino acids, essential building blocks of terrestrial life; many surveys were made unsuccessfully to search for the simplest amino acid, glycine (NH_2CH_2COOH), towards Sagittarius B2 and other high-mass star forming regions (e.g., Brown et al. 1979; Snyder et al. 1983; Combes et al. 1996, ...).

In these days, the Atacama Large Millimeter/submillimeter Array (ALMA) is expected to break through such difficulties associated with glycine survey. Garrod (2013) used her chemical reaction network simulation and argued the possibility in detecting glycine with very high spatial resolution (~0.1 ″) and the collecting power of ALMA. It would be important to know which are potential glycine-rich sources for future surveys. However, the chemical evolution of N-bearing molecules, including glycine, is poorly known. We would need to better understand formation mechanisms of N-bearing COMs including amino acids and to have carefully selected good candidate sources for amino acids before conducting searches for amino acids by ALMA.

Although the chemical evolution of interstellar N-bearing COMs is poorly known, methylamine (CH_3NH_2) has been proposed as a precursor to glycine. Theoretical and laboratory studies have demonstrated that glycine is formed on icy grain surface from CH_3NH_2 and CO_2 under UV irradiation (Holtom et al. 2005). It is suggested that CH_3NH_2 can be formed from abundant species, CH_4 and NH_3, on icy dust surface (Kim & Kaiser 2011). Further methyleneimine (CH_2NH) would be related to CH_3NH_2. Another possible route to form these species is hydrogenation to HCN on the dust surface (Dickens et al. 1997; Theule et al. 2011).

However, a source number of such precursor molecules is very limited. In order to increase the number of CH_2NH sources and to better understand formation paths to CH_2NH, we conducted survey observations of CH_2NH, with the NRO 45 m telescope and the SMT telescope towards 11 high-mass and three low-mass star-forming regions. As a result, CH_2NH was detected in eight sources, including four new sources. The estimated column densities were roughly 10^{14}-10^{15}, 10^{15}-10^{16}, and 10^{16}-10^{17} cm^{-2}, respectively, for extended, 10 ″ , and 2 ″ sources. G10.47+0.03 and Orion KL are found to be especially CH_2NH-rich sources. We used chemical reaction network simulations to investigate formation process of CH_2NH in the ISM. Under the dark cloud condition, the simulated CH_2NH abundance in the gas phase is more than 10 times lower than our observations even if we conservatively estimate the CH_2NH abundance with an extended source. On the other hand, if we include hydrogenation reaction to HCN in our model, the CH_2NH abundance increased about by two orders of magnitude, enabling us to reconcile the observed abundance of CH_2NH. We also showed that this reaction is dominant in the early, low temperature phase of cloud evolution.

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