

Molecular Evolution in Star-Forming Cores: From Prestellar Cores to Protostellar Cores

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We investigate the molecular abundances in protostellar cores by solving the gas-grain chemical reaction network[1]. As a physical model of the core, we adopt a result of one-dimensional radiation-hydrodynamics calculation, which follows the contraction of an initially hydrostatic prestellar core to form a protostellar core. Temporal variation of molecular abundances is solved in multiple infalling shells, which enable us to investigate the spatial distribution of molecules in the evolving core. The shells pass through the warm region of $T=10-100$ K in several 10^4 yr and falls onto the central star in ~ 100 yr after they enter the region of $T > 100$ K. We found that the complex organic species such as HCOOCH_3 are formed mainly via grain-surface reactions at $T \sim 20-40$ K, and then sublimated to the gas phase when the shell temperature reaches their sublimation temperatures ($T \geq 100$ K). Carbon-chain species are re-generated from sublimated CH_4 via gas-phase and grain-surface reactions [1][2]. HCO_2^+ , which is recently detected towards L1527[3], are abundant at $r=100-2000$ AU, and its column density reaches 10^{11} cm^{-2} in our model[1]. If a core is isolated and irradiated by interstellar UV radiation, photo-dissociation of water ice could produce higher abundance of CO_2 , while complex species become less abundant, compared with the case of embedded core in ambient clouds.

We are now extending the above model to multiply-deuterated species. Preliminary results would be reported on the deuterated species.

References

- [1] Y. Aikawa, V. Wakelam, E. Herbst & R.T. Garrod 2008, ApJ, 674, 984
- [2] N. Sakai, T. Sakai, T. Hirota & S. Yamamoto 2008, ApJ, 672, 371
- [3] N. Sakai, T. Sakai, Y. Aikawa & S. Yamamoto 2008, ApJ, 675, L89