Chemistry in a forming protoplanetary disk: main accretion phase

H. Yoneda[1], Y. Tsukamoto[2], K. Furuya[3], and Y. Aikawa[3]

[1]*Department of Planetology, Kobe University, Japan*
[2]*Riken, Japan*
[3]*Center for Computational Sciences, University of Tsukuba. Japan*

Protostellar cores harbor rich chemistry: i.e. complex organic molecules (COMs) and carbon chains. At the core center, a protostar and disk system are formed. Thus various molecules currently observed in protostellar cores will eventually be incorporated into disk. The main accretion phase, in which a protostar accretes most of its mass from the envelope via circumstellar disk, could also be an important transition phase for chemistry: from interstellar matter to disk material. Due to the high mass accretion rate, the forming disk could be much warmer than the Class II disk, and thus could enhance chemical reactions.

In this presentation, we report our numerical calculation of the molecular evolution[1] in a radiation-hydrodynamics model of star-forming core[2]. The model evolves from a cold (~ 10 K) prestellar core to the main accretion phase in ~10^5 yr, which corresponds to Class 0 objects. A rotationally-supported gravitationally unstable disk is formed around the protostar. We extract the temporal variation of physical parameters of 10^3 SPH particles which end up in the disk, and perform post-processing calculations of the gas-grain chemistry adopting a three-phase model. Inside the disk, SPH particles migrate both inward and outward. Since a significant fraction of volatiles such as CO can be trapped in the water-dominant ice in the three-phase model, ice mantle composition depends not only on the current position in the disk but also on whether the dust grain has ever migrated inside the water snow line. Stable molecules such as H_2O, CH_4, NH_3 and CH_3OH are abundantly formed in the molecular cloud before the onset of collapse and simply sublimated as the fluid parcels migrate inside the water snow line. On the other hand, various molecules such as carbon chains and complex organic molecules (COMs) are formed in the disk. COMs abundances sensitively depend on the efficiency of photodissociation and diffusion of photofragments in bulk ice mantle. As for S-bearing species, H_2S is abundant in the collapse phase. In the warm regions in the disk, H_2S is sublimated to be destroyed, while SO, H_2CS, OCS and SO_2 become abundant.

References

[1] H. Yoneda et al, in prep.
[2] Y. Tsukamoto, S.Z. Takahashi, M.N. Machida & S. Inutsuka, S. 2015, MNRAS, 446, 1175