Astrochemistry in planetary system formation: from molecular clouds to protoplanetary disks and planetary system material

*Yuri Aikawa[1]

1. Department of Astronomy, Graduate School of Science, University of Tokyo

Earth-like planets are formed via coagulation of solid material in protoplanetary disks. Since volatiles are one of the essential ingredients of habitable planets, the distribution of volatiles between the solids and the gas phase in the raw material of planetary systems are of special importance. In this presentation, I will review astrocchemistry of volatiles in planetary system formation.

Sun-like starts and protoplanetary disks are formed by the gravitational collapse of molecular cloud cores. In the central region of a cloud core, most of the volatile species, except for H2 and He, are frozen onto dust grains due to low temperature (\sim 10 K) and high density (\gt 10^5 cm^{-3}). As collapse proceeds, the temperature rises, and various molecules sublimate to be observed around a forming protostar: e.g. water and organic molecules such as CH_3OH. Since radio observations of gaseous molecular are more sensitive and have more diagnosing power than infrared observations of solid material, molecular line observations have been performed towards several protostars to constrain the raw material for planetary system formation. Towards the protostar IRAS 16293 and FU Ori star V883 Ori, the molecular composition of the sublimates is found to be similar to that of comet 67P/C-G. It suggests that the raw material of other planetary systems is as rich in volatiles and organic molecules as that of Solar system.

When the parental molecular cloud dissipates, a protostar evolves to a T Tauri star, and its circumstellar disk is called a protoplanetary disk. ALMA found ring-gap structures in many protoplanetary disks. While various mechanisms are proposed for the ring-gap structures, one of the promising mechanisms is the disk-planet interaction; i.e. the disks may already harbor planets. Observations also suggest radial migration of large dust grains. Since grains are covered with ice mantles, volatiles could also be enriched in inner radii and ring regions. The snow line of CO is now spatially resolved in a few disks, while water snow line is hard to resolve even with ALMA, except for disks in outburst.

Keywords: astrochemistry, planetary system formation