Unified Picture of Chemical Differentiation in Disk-Forming Regions of Low-Mass Protostellar Sources

*Yoko Oya[1]

1. The University of Tokyo

Disk-formation around protostars is of fundamental interest for both of astrophysics and astrochemistry, because protostellar/protoplanetary disks are the birthplaces of planets. Young (Class 0-I) low-mass protostars are known to show significant chemical diversity in their envelopes at a few 1000 au scale: specifically, hot corino (HC) chemistry and warm carbon-chain chemistry (WCCC). HC sources are rich in saturated complex organic molecules (COMs: e.g. $HCOOCH_3$), while WCCC sources in unsaturated carbon-chain molecules (e.g. C_4H). It is of great interest how the chemical diversity is inherited to chemistry of disk-forming regions.
We investigated distributions and kinematics of various molecules in the disk/envelope system for the 6 young low-mass protostar at a spatial resolution of a few 10 au with ALMA. We found that the chemical diversity at a few 1000 au scale is indeed delivered into the disk-forming regions at a 100 au scale. Moreover, the chemical composition was found to change drastically from envelopes to disks.
Such chemical diversity in disk-forming regions was totally unexpected before the ALMA observations. Most interestingly, we found hybrid sources (L483 and B335) where both the HC chemistry and WCCC are occurring in a single source. In these sources, carbon-chains are abundant in the envelope as in the case of WCCC sources, while COMs are abundant in the disk as in the case of HC sources. This result is consistent with the chemical model of collapsing cores: HC chemistry emerges with the evaporation of COMs from dust grains in a hot (>100 K) region near the protostar, while WCCC is triggered by evaporation of CH4 in a warm (>30 K) region a bit apart from the protostar. Thus, the hybrid case harbors both rich COMs and rich CH_4 on dust grains at the onset of star formation, and may be a common occurrence. In contrast, the HC and WCCC sources are regarded as distinct cases, where either COMs or CH_4 are particularly abundant, respectively. This unified view of chemistry in disk-forming regions will be an important clue to tracing the chemical evolution from protostellar cores to protoplanetary disks, and eventually the material origin in our Solar System.

Keywords: Protostellar disk, Interstellar medium, Low-mass protostars

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