Evolution of molecules in space: from interstellar clouds to proto-planetary nebula

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Our understanding of the origin and evolution of planetary systems has been mostly limited to the dynamics. The importance of chemistry has been emphasized, however, systematic studies about chemical evolution have not yet been performed. We have thus started research project on “Evolution of molecules in space” supported by Grant-in-Aid for Scientific Research on Innovative Areas from MEXT, Japan from 2013.
We focus our attention on the most abundant solid materials in space: ices and organic materials. How do these molecules evolve in space? We aim at answering this question by interdisciplinary approaches including laboratory and theoretical studies about surface processes, observation of young stellar objects, modeling of molecular cloud and protoplanetary-disk chemistry, and analyses of extraterrestrial materials.

We are now investigating the evolution of molecules by following groups; (1) Experimental studies about surface reactions of atoms and molecules and photochemical reactions of solids at low temperatures to mimic phenomena occurring in molecular clouds (PI: A. Kouchi, Hokkaido Univ.), (2) Heating experiments of molecular-cloud organics and Fischer-Tropsh type surface reaction experiments to mimic phenomena occurring in proto-planetary nebulae (PI: H. Nagahara, Univ. of Tokyo), (3) Observation of young stellar objects by radio telescopes (ALMA, ASTE etc.) to understand the evolution and variety of organic molecules (PI: S. Yamamoto Univ. of Tokyo), (4) Modeling of surface processes and developing of chemical network model (PI: T. Fukazawa, Meiji Univ.), and (5) Analyses of chemical and isotopic composition of organic molecules in meteorites and cometary dust (PI: H. Yurimoto, Hokkaido Univ.). I will introduce some important achievements of respective groups.

Our project will contribute to not only the understanding of origin and evolution of molecules in space but also the analysis of returned samples by Hayabusa 2 and OSIRIS-REx. We have developed some new analytical setups: High-resolution imaging-type soft X-ray microscope/spectrometer, two-dimensional HPLC-MS for amino acids analysis, high-sensitive HPLC-MS for organic material analysis, etc.

Keywords: Evolution of molecules, Ices, Organic materials, Interstellar molecular clouds, Proto-planetary disk

