Ultrahigh-resolution analyses of trace organic compounds for planetary materials

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Organic compounds are distributed widely in natural environment. In particular, hundreds of thousands of organic compounds with significant chemical diversity are expected to be present in extraterrestrial materials (*e.g.* meteorites) considering from their structural and optical isomers. Currently, the organic contents identified in meteorites correspond to only approx. 1% of the total compounds present. The detailed molecular distribution is required to investigate the sources and reaction mechanisms from the chemical evolution point of view.

We have started the innovative project to study trace organic compounds of planetary materials (meteorites, cosmic dusts, hydrothermal fluids, drilling samples *etc.*) using advanced chromatography and mass spectrometry with ultra-high sensitivity, resolution and separation (previously unavailable), to elucidate their history and mechanisms of formation. The following advanced analyses and development will be performed: 1) Clean room environment to avoid organic contamination; 2) Detection limit (sensitivity) down to $\sim 10^{-18}$ mol from previous $\sim 10^{-15}$ mol level; 3) Ultra-high mass resolution up to ~300,000 ($m/\Delta m$) to determine the elemental composition using exact mass; 4) Superior chromatographic separation using ultrahigh-resolution column coupled with nanoLC and/or 2-dimensional columns to determine structural and optical isomers; and 5) Development of in-situ organic compound analysis of sample surface using desorption electrospray ionization.

The technical development will allow for the improved identification of organic compounds compared to current analysis, and will advance our studies of the formation pathways and origins of planetary materials. Furthermore, the new techniques will allow for the definitive identification of organic compounds in greatly reduced sample sizes (using ~μg of sample vs. current ~mg requirement), thereby contributing to the successful analysis for future sample-return missions (e.g. Hayabusa 2 and OSIRIS-REx). The methodology will also be applicable to various types of other rare, precious, and small samples for environmental and biochemical studies.