Next generation of 'Organics in Space': Toward the future small body exploration missions

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Study of organics in Space will greet nearly 50 years of history since the Murchison meteorite fall in 1969. During the first 30 years, searching for biomolecules in carbonaceous chondrites was focused on, especially amino acids, to seek a clue to life's origin in the Universe. Around 2000, this trend was gradually shifted to an extensive view that meteoritic organics record the chemical history of the early Solar System through the integration of astronomy and cosmochemistry. Relationships between the conditions of parent body processes and the molecular and isotopic variations of amino acids and insoluble organic matter (IOM) in different meteorite groups and petrologic types have been frequently studied. In 2006 when comet 81P/Wild 2 dust particles were collected and returned by Stardust, analytical techniques were remarkably improved and the application of the in-situ imaging has enabled acquisition of nano-level isotopic, molecular, and textual information. We are currently aiming to unveil more primitive records of the early Solar System by investigating less altered astromaterials than meteorites, e.g., IDPs, Antarctic micrometeorites (AMMs), and CR3 chondrites. Recently, Rosetta revealed organic-rich surface of comet 67P/Churyumov-Gerasimenko, which may have a close link with IDPs and ultracarbonaceous AMMs.

Thus, the enormous achievements have improved our understanding of the organic cosmochemical evolution, and nowadays our field has had a strong impact to more numbers of planetary scientists. However, the origin and formation pathways of organics in the Solar System have been still unresolved (and become more complicated). In order to constrain the issues, it will be important to address the following key questions; 1) Interaction of organics, minerals, and water, 2) Comprehensive organic chemical evolution without drawing a line between soluble and insoluble fractions, 3) Effects of surface processes of small bodies (e.g., space weathering and shock) on organics, 4) Non-destructive measurements of bulk compositions of organics (e.g., 3D tomography), 5) Physical properties of organic nanoglobules (e.g., deformation mechanism), 6) Drawing a true picture of IOM, 7) Chilarity of IOM, and 8) Chronology of organics. Continuous explorations of small bodies of different evolution stages such as C-, B-, and D-types, will help elcidatingthe universality and diversity of organics in Space.