

Analytical chemistry of organic compounds in the Solar System: An attempt to link with planetary science

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Analytical chemistry of organic compounds in the Solar System small bodies is a microscopic approach for understanding of the origin and evolution of building blocks of the Solar System and life, which has a complementary relationship with macroscopic approaches such as observational and theoretical astronomy. This approach would provide a significance of considering organic compounds in the planetary formation theory, which has been constructed only by silicate and ice dusts. Indeed, significant roles of organic compounds in the early Solar System are explained by (1) high abundances of C, H, O, N in the Solar System, (2) major components of dusts in interstellar clouds, (3) high reactivity to heat, light, shock, water, and minerals (chemical indicator recording the processes in the Solar System), (4) possible contribution to accretion of dusts, due to their stickiness (Kouchi et al. 2002), and (5) possible contribution to redox imbalance in solar nebula (that determined the chemical compositions of chondrules) (Yurimoto and Kuramoto, 1998). Despite these significant roles, however, organic cosmochemistry was not a very popular field in planetary science until several years ago. One of the reasons may be because of difficulty in visualization of organic compounds, i.e., drawing of a big picture. In this point, I attempt to show a simple example. When starch-syrup is heated, how is it changed. One would tell that the color is changed from colorless to brown, the originally sticky syrup becomes less sticky candy, and water-soluble syrup becomes an insoluble solid. These descriptions are based on visibility and are easy to understand. On the other hand, if these phenomena are translated to organic analytical chemistry, the description becomes quite different from the former; hydroxyl groups of glucose changes to carbonyl groups via dehydration as well as aromaticity increases with heating. However, it should be noted that two ways of descriptions explain exactly the same phenomenon. That demonstrates that physical properties (color, stickiness, and solubility) are determined by molecular chemical structures. Likewise, analytical chemistry of organic compounds in the Solar System has a potential to reveal the molecular science that determines physics of macroscopic planetary formation, such as the color of asteroids (albedo). This will become possible by improvements of the in-situ organic analyses such as spectromicroscopy (e.g., STXM), electron microscopy (TEM), and ion probe mass spectrometry (e.g., nanoSIMS), through visualization of the distributions of organics and minerals in the Solar System materials which record the chemical evolution from dusts to planetesimals.

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