Geo-electrochemical Decomposition of Amino Acids on Icy Planetesimals Reproduces Organics in Carbonaceous Meteorites

*LI Yamei[1], Norio Kitadai[1,2], ryuhei nakamura[1], Yasuhito Sekine[1]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Japan Agency for Marine-Earth Science and Technology

Organics in carbonaceous meteorites are the remnants of primitive solar system chemistry and parent-body processes. Amino acids are ubiquitously found in carbonaceous chondrites, and their genesis and conversion have important implications on the origin of biomolecules, the geophysical evolution and the geochemical processes that occurred in their parent bodies (icy planetesimals).

In Murchison meteorite and several reported carbonaceous meteorites, in addition to amino acids, other types of water-soluble, low molecular weight compounds make a complex suite that includes hydroxycarboxylic acid, aliphatic monoamines, monocarboxylic acids, alcohols, and others. However, the synthetic origin for their formation leading to their occurrence in meteorites remain poorly understood, becoming a long-standing enigma.

It has been largely considered that water-rock interactions cause the alteration of organic distribution and associated minerals in carbonaceous bodies, however, how does energy transduction proceed in such environment and how the chemical processes have shaped the organic distributions remain poorly understood. Here we report that geo-electrochemical processes can decompose aliphatic amino acids into monocarboxylic acids, alcohols, amines, and hydroxycarboxylic acids. Iron and nickel sulfides work as effective catalysts for the redox-mediated activation of amino acids. Such geo-electrochemical processes are driven spontaneously by the water-rock interactions, which generate steep redox, pH and chemical gradients between the interior and exterior of the icy planetesimals.

Keywords: Icy Planetesimals, Carbonaceous Meteorites, Amino Acids, Aqueous Alteration, Geo-electrochemistry