Abiotic synthesis of organic matters in environments simulating asteroids and the catalytic effect of minerals on amino acid formation

*Walaa Elmasry[1], Yoko Kebukawa[1], Kensei Kobayashi[1]

1. Yokohama National University

Solar system materials, such as comets, meteorites, and interplanetary dust particles are known to contain extraterrestrial molecules, which might have a heritage from interstellar, nebular, and/or parent body processing. Delivery of these molecules including amino acids to the early Earth may have been important for the origin of life as they are the building blocks of proteins and enzymes. It is suggested that chondritic organic matter was produced through condensation of interstellar formaldehyde, which is an abundant component of the interstellar medium (ISM) organic inventory and, presumably, the solar nebula followed by condensation and carbonization probably during hydrothermal alteration on chondritic asteroids (Cody et al 2011). According to Kebukawa et al. (2013, 2015), the presence of ammonia significantly enhances the formation of organic solids similar to chondritic insoluble organic matter (IOM) from formaldehyde via the formose reaction at 150°C and could produce amino acids. Carbonaceous chondrites contain abundant clay minerals. Clays may act as absorbents and catalysts for the polymerization of organic interstellar precursor molecules in the early solar system (Pearson et.al 2002).

In this research, we are studying amino acid formation from formaldehyde and ammonia at 150°C and reveal the expected effect of minerals, namely, montmorillonite clay, olivine and serpentine to simulate the processes of amino acid productions in water-bearing planetesimals.

We synthesized organic compounds using a mixture of water, formaldehyde and ammonia (H_2O, H_2CO, NH_3) in a ratio of 100:7:1 (mol) with adding minerals (6 mg/ 0.6 mL solution) by simulating primordial materials in comets and asteroids. Aqueous solutions were heated at 150°C for 24 hours. The resulted products were divided into two parts, the first analyzed using a FT/IR and the other part was acid hydrolyzed, desalted, and subjected to amino acid analysis using a HPLC.

FT/IR spectra indicated that the differences in the spectral intensities are due to synthesis of more organic compounds. In HPLC analysis, various amino acids including glycine and alanine were detected. Presence of non-protein amino acids (β-Ala, γ-ABA) is considered as evidence against terrestrial contamination. Our preliminary results showed that the obtained amount of amino acids was elevated with the presence of minerals. These results suggested that the associated minerals act as catalysts to produce amino acid precursors during aqueous activities in the planetesimals.

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