Minerals and their catalytic effects on amino acid formations in environments simulating asteroids

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Extraterrestrial delivery of organic compounds including amino acids to the early Earth during the late heavy bombardment (3.8-4.5 billion years ago) may have been important for the origin of life. Recently, it is suggested that chondritic organic matter was produced through reactions of interstellar formaldehyde, followed by condensation, and carbonization probably during hydrothermal alteration on chondritic asteroids (Cody et al 2011). Furthermore, Kebukawa et al. (2013, 2015) illustrated that the presence of ammonia significantly enhances the yields of IOM from formaldehyde via formose reaction at 150 ˚C, producing amino acids. Meteorites serve as delivery systems for extraterrestrial phyllosilicate minerals to Earth. Phyllosilicates may act as absorbents and catalysts for the reactions of organic precursor molecules in the early solar system (Pearson et.al 2002). In the current research, we are studying formations of amino acid at 150 ˚C and reveal the expected role of minerals, namely, montmorillonite, olivine and serpentine for amino acid productions in water-bearing planetesimals.

We synthesized organic compounds using a mixture of water, formaldehyde and ammonia (H2O, H2CO, NH3) in a ratio of 100:7:1 with adding minerals (10 g/ L) by simulating primordial materials in comets and asteroids. Aqueous solutions were heated at 150 ˚C for 24, and 72 hours. The resulted products were divided into two parts, the first part analyzed using a FT/IR, and GFC, while the other one was acid hydrolyzed, desalted, and subjected to amino acid analysis using an HPLC.

In HPLC analysis, considerable amounts of various amino acids including glycine and alanine were detected. Moreover, presence of non-protein amino acids (β-Ala, γ-ABA) is considered as an evidence for extraterrestrial origin and against terrestrial contamination. Our preliminary results showed that the obtained amount of amino acids was elevated with the presence of minerals. FT/IR spectra of samples with minerals showed more spectral intensities than samples without minerals due to synthesis of more organic compounds. GFC showed that high molecular weight organic compounds were formed which may be characterized as amino acid precursors that maintain stable at high temperature and longer durations giving various kinds of amino acids after acid hydrolysis. These results suggested that various amino acids could be formed abiotically via a mixture of formaldehyde, ammonia, and water, as well as, the associated minerals act as catalysts to produce amino acid precursors during aqueous activities in the planetesimals.

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