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Analysis of Amino Acid Precursors Formed by Particles Irradiation of Possible Interstellar Media

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A wide variety of organic compounds including amino acids have been detected in extraterrestrial bodies such as carbonaceous chondrites and comets. Since it was suggested that complex organics found in the extraterrestrial bodies were formed in extreme cold environments, one of the possible sites for the formation of the organics was in interstellar dusts in molecular clouds. We reported that amino acid precursors could be easily formed from possible interstellar media (H_2O, NH_3, CO, CH_4 and/or CH_3OH) by irradiation with protons or heavy ions. In the present paper, possible interstellar media with various mixing ratios were irradiated with high energy particles, and determined amino acids after acid hydrolysis of the products. We also characterized the products by FT-IR.

Gaseous mixtures of CO, CH_4 and NH_3 with various ratios (total pressure: 700 Torr) with 5 mL of liquid water were introduced in Pyrex tubes with Havar foils. Each Pyrex tube was irradiated with 2.5 MeV protons from a Tandem accelerator (TIT): Total electric quantity was 2 mC each. Liquid mixtures of CH_3OH, NH_3 and H_2O with various ratios were irradiated with 290 MeV/u carbon ions from the HIMAC accelerator (NIRS) for up to 4 hours at the dose rate of 3.75 kGy/h. Amino acids were determined by cation exchange HPLC before and after acid hydrolysis. Products, both before and after acid hydrolysis, were analyzed FT-IR for characterization.

Proton irradiation of the gaseous mixtures yielded only trace of amino acids before hydrolysis, but wide variety of amino acids were detected after hydrolysis. G-value of glycine from 1:1 a mixture of CO and NH_3 with water (CAW) was as high as ca. 0.3. When CH_4 was added to the gas mixture (CMAW), glycine yield was largely decreased, but alanine yield was drastically increased, which was sometimes more than glycine. FT-IR spectra of both CAW and CMAW (before hydrolysis) showed peaks at 1670 cm^{-1} (amide C=O), and those of CMAW showed peaks at 1750 cm^{-1}(carboxylic acid or ester C=O). The amide C=O peaks were disappeared after hydrolysis.

Heavy ion irradiation of the liquid mixtures also yielded amino acids after hydrolysis. When ratio of CH_3OH and NH_3 to H_2O were decreased, amino acid yield decreased, but even in the case of CH_3OH: NH_3: H_2O = 10: 1: 37, amino acids were detected. In the HIMAC experiment, the energy of heavy ions were quite high and pass through the target mixtures with only small part of energy was deposited to the target, which is the same situation as what happens in dense clouds. The present results suggested that amino acid precursors can be formed in water-rich ice mantles of interstellar dust particles (ISDs) by the action of cosmic rays.

We are planning to irradiate ice (solid) mixtures simulated interstellar ices with heavy ions, and to compare amino acid yields and structures of the complex organic products with liquid phase irradiation. Characterization of the products will be extended to LC/ESI-MS and XANES.