Experimental studies on formation of complex amino acid precursors in molecular clouds by cosmic rays

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We have been studying chemical evolution toward origins of life by irradiating simulated planetary atmospheres and simulated interstellar media with high-energy particles to simulate the action of cosmic rays. It was shown that complex precursors of amino acids and nucleic acid bases could be formed in such simulation experiments. Here we compared the energy yield of amino acids by irradiation of possible interstellar media with various kinds of high-energy ions.

A mixture of methanol, ammonia and water (molar ratio was 1:1:2.8) was irradiated with protons from a Tandem accelerator (TIARA, QuBS, IAEA, Japan) or heavy ions from a heavy ion accelerator (HIMAC, NIRS, Japan). Heavy ions used and their radiation dosages were He (150 MeV/u) 840Gy, C (290 MeV/u) 14000Gy, Ne (400 MeV/u) 12000Gy, Ar (500 MeV/u) 2000Gy and Fe (500 MeV/u) 2500Gy. The irradiation products were acid-hydrolyzed, and amino acids were determined by HPLC (Shimadzu LC-10A).

Glycine was predominant amino acid product in the hydrolysates, followed by alanine, beta-alanine, alpha-aminobutyric acid (ABA), beta-aminoisobutyric acid (AIBA) and gamma-ABA. Neon beam irradiation gave the largest G-value of glycine among all the heavy ions and proton irradiation. The present order from H through Ne depended on their LET (linear energy transfer), but Ar and Fe did not fit the tendency.

In the present irradiation systems, formation of amino acid precursors and destruction of them seemed to occur at the same time. Thus we studied the possible destruction of the formed amino acid precursors by further irradiation. The irradiation product was once dried to remove starting materials (methanol, ammonia and water), and was dissolved in pure water, and then was irradiated with heavy ions. However, amino acid yield (as measured after hydrolysis) was not decreased but increased by the further irradiation. Further research should be required to find the reason.

The irradiation products including amino acid precursors were quite hydrophilic and easy to dissolve in water, but complex organics found in meteorites and comets were hydrophobic and highly aromatic. It is said that carbon particles (graphite, amorphous carbon, etc.) are present in interstellar clouds, so we add graphite to the mixture of methanol, ammonia and water) and the mixture were irradiated with heavy ions. Some preliminary results will be reported.