Formation of Amino Acids from Simulated Interstellar Media by Radiation and Origins of Chirality

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Bioorganic compounds such as amino acids are essential for the generation of life on the primitive planets. In these days, a wide variety of bioorganic compounds including amino acids were detected in carbonaceous chondrites. Enantiomeric excess of amino acids were also reported. These observation strongly suggest that exogenous organic compounds had important roles in chemical evolution toward the origin of life.

It is suggested that organic compounds found in meteorites and comets are originally formed in interstellar dust particles (ISD) in molecular clouds. Major energy source is cosmic radiation. Here we analyzed amino acids formed from simulated interstellar media by radiation.

Simulated interstellar media (mixture of water, methanol and ammonia) was used as a starting material, which were irradiated with several types of radiation (gamma-rays, beta-rays, heavy particles bombardment).

The simulated interstellar media in a sealed tube was irradiated with gamma-rays, beta-rays and heavy particle bombardments. After irradiation, an aliquot of the irradiation product was hydrolyzed with 6M HCl at 110C for 24h. The concentration of amino acids were determined by ion-exchanged HPLC, which was composed of two high performance liquid chromatograph pumps (Shimadzu LC-6A), a cation-exchange column (Shimpak ISC-07/S1504, 4 mm i.d.x150 mm), a post column derivatization system, and a Shimadzu RF-535 fluorometric detector. The derivatized reagents used were N-acetyl-L-cystein and o-phtalaldehyde (OPA) in borate buffer.

When the simulated interstellar media was irradiated with any kinds of radiation, a wide variety of amino acids were detected in hydrolysates of the products. Glycine was always predominant amino acids. Thus, the G-value of glycine was used as an index of energy yield of bioorganic compounds. The G-value of glycine by gamma-irradiation depended on the dose rate: The lower the dose rate was, the higher the G-value of glycine was. The G-value of glycine by heavy ion bombardment was as high as that by gamma irradiation at the lowest dose rate. The present results suggest that cosmic rays, which are mainly protons and heavy ions, were essential for the formation of 'amino acid precursors' in interstellar environments. All the results support the hypothesis that exogenous amino acids had important roles in the generation of life on the Earth.

In order to investigate the origin of chirality, we irradiated 'simulated interstellar organics' with beta-rays. Preliminary results will be presented on possible appearance of eneantiomeric excess of amino acids. We thank Dr. Hidematsu Ikeda and Dr. Daisuke Hiroishi (Univ. Tokyo), Dr. Yasuyuki Muramatsu (National Institute of Radiological Science) and Dr. Vladimir Tsarev (Levedev Physical Institute) for their kind assistance in irradiation experiments. The present study was supported in part by Grant-in-Aid from MEXT, Japan (No. 14340170).