

Stability of Amino Acid Precursors in Simulated Extraterrestrial Environments

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In prior to the generation of life on the primitive Earth, bioorganic compounds such as amino acids should have been supplied. Since a wide variety of organics has been detected in extraterrestrial bodies like carbonaceous chondrites [1], extraterrestrial organics are probable sources for life. Amino acids in carbonaceous chondrites increased after acid-hydrolysis. Laboratory experiments simulating extraterrestrial environments showed that not free amino acids but amino acid precursors were abiotically formed [2,3]. It has not been proved, however, what kinds of amino acid precursors were formed in space and delivered to the Earth. Extraterrestrial organics are exposed to cosmic rays (protons and heavy ions), high-energy photons (UV, X-rays and gamma rays [4]) before delivered to the Earth. It is thus important to examine stability of amino acids and their precursors in space. We experimentally investigated the stability of amino acids and their precursors against heavy ions, gamma-rays, UV and soft X-rays.

Target materials were glycine (Gly) and its possible precursors (aminoacetonitrile (AAN) and hydantoin (Hyd), which are used as 5 mM solution in ammonia water (pH 9). The other material used was organic material synthesized from a mixture of CO, NH₃ and H₂O by 2.5 MeV protons from a Tandem accelerator (Tokyo Tech), whose aqueous solution was referred to as CAW. CAW contained complex amino acid precursors with large molecular weights [2].

Heavy ions irradiation, simulation of reactions in ice mantles of interstellar dusts against cosmic rays, was carried out by using 290 MeV/u carbon ions from HIMAC (NIRS, Japan), where all the targets were frozen in liquid nitrogen during irradiation of 7.5-15 kGy. In order to examine stability against gamma-rays in meteorite parent bodies, the target solution was irradiated gamma rays (5-15 kGy) from a ⁶⁰Co source (Tokyo Tech). The target materials were irradiated with VUV/UV from an excimer lamp (172 nm, Fukuoka Inst. Tech.) after dried in pits of an aluminum plate to test stability in interplanetary dusts. The other set of UV-irradiation was performed after the dried targets were covered with hexatriacontane (HTC) thin film, since HTC was used in the space exposure experiment in the Tanpopo Mission [5]. They also irradiated with soft X-rays from a synchrotron (NewSUBARU BL-6) after dried on glass plates to test stability against X-rays from the young Sun. After irradiations, all the target materials were recovered as aqueous solutions, were acid-hydrolyzed (6 M HCl, 110°C, 24 h), and amino acids in them were determined by cation-exchange HPLC and/or reversed-phase HPLC.

After acid hydrolysis of all the target materials after irradiation yielded glycine, and CAW yielded many other amino acids besides glycine. Here after glycine yields are used to discuss stability of the target materials.

In the heavy ions irradiation, CAW gave the highest recovery followed by other glycine precursors (Hyd, AAN): Gly yield was the lowest. In the case of gamma-rays irradiation, CAW and AAN were more stable than Gly and Hyd. After UV irradiation without HTC, most of Gly was decomposed while others remained much more, while Gly showed much higher recovery after UV irradiation covered with HTC thin film. Soft

X-rays-irradiated samples were now under analysis.

Generally speaking, amino acid precursors showed good stability (except Hyd against gamma-rays), and CAW showed best stability in most cases. Thus we concluded complex amino acid precursors formed in space could be safely delivered to the primitive Earth, while free amino acids were not stable during delivery if formed in space.

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