Stability of amino acid precursors in various space environments

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Amino acids have been detected in such extraterrestrial bodies as carbonaceous chondrites [1]. There have been number of studies to synthesize amino acids in simulated extraterrestrial environments [2]. It seems, however, that most extraterrestrial amino acids are present as precursors or combined forms rather than in free forms, since (i) amino acids in carbonaceous chondrites greatly increased after acid hydrolysis [1], and (ii) laboratory experiments suggested that not free amino acids but amino acid precursors were formed from possible interstellar media by the action of cosmic rays [2]. If these compounds carried to the primitive Earth, we should consider their stability in various extraterrestrial environments including in proto-solar nebula, asteroids, comets and cosmic dusts. For example, organic compounds would have altered in aqueous solution in asteroids by gamma rays from ^{26}Al [3]. High energy particles (cosmic rays) are another possible energy source for alteration of extraterrestrial organics in the solar system. Here we examine the stability of amino acids and amino acid precursors against gamma rays and heavy particles.
Experimental: Target molecules are (i) glycine (Gly, free amino acid), (ii) aminoacetonitrile (AAN; glycine precursor), (iii) hydantoin (Hyd, glycine precursor detected in carbonaceous chondrites [4]), and (iv) complex amino acid precursors “CAW” synthesized from carbon monoxide, ammonia and water by irradiation of 2.5 MeV protons from a Tandem accelerator (Tokyo Tech, Japan). CAW is a model of complex interstellar organics [4].
Aqueous solution of each molecule was sealed in a Pyrex tube, and subjected to 290 MeV/u carbon ions irradiation (HIMAC, NIRS, Japan) or to gamma ray irradiation (^{60}CO source, Tokyo Tech, Japan). Irradiated samples were acid-hydrolyzed (6 M HCl, 110℃, 24 h), and amino acids in the hydrolysates were determined by cation-exchange HPLC (Shimadzu LC-20A).
Results and Discussion: Glycine was determined in both irradiation products from Gly, AAN and Hyd. In the case of CAW, various amino acids were detected in the hydrolysates of the irradiation products, but glycine was predominant. Hereafter we will mainly discuss the relative recovery of glycine in the irradiated samples to reference samples without irradiation.
In the case of carbon ions irradiation, decrease of glycine was limited, but Gly, AAN and hydantoin was largely decomposed after irradiation.
After 5 kGy of gamma irradiation of Gly and Hyd, glycine recoveries from them were 68% and 46%, respectively, but AAN and CAW were hardly decomposed. Hydantoin was less stable than others against gamma irradiation, but still some hydantoin in liquid phase of asteroids could survive in their early stages.
After 15 kGy of carbon ions irradiation, recovery of CAW was highest among all (recovery: 98.5%), followed by glycine (35%) and aminoacetonitrile (18%). Hydantoin was mostly decomposed under the same condition.
It is concluded that complex amino acid precursors (CAW) was more stable than free amino acid (glycine) and small amino acid precursors (hydantoin) against space radiation environments. Aminoacetonitirele

was stable against gamma rays, but not stable against heavy ions.

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Keywords: origins of life, amino acid, stability

