種々の模擬宇宙環境におけるアミノ酸前駆体の安定性評価
Stability of Amino Acid Precursors in Simulated Extraterestrial Environments

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Since a wide variety of organic compounds have been detected in extraterrestrial bodies like carbonaceous chondrites [1] and comets [2], extraterrestrial organics could be essential sources for the first life on the Earth. Amino acids in carbonaceous chondrites increased after acid-hydrolysis, which suggested that not only free amino acids but also amino acid precursors were present in them. Laboratory experiments simulating extraterrestrial environments showed that not free amino acids but amino acid precursors were mainly formed [3, 4]. Though amino acid precursors in meteorites and products of laboratory simulations have not been well identified, aminonitriles and hydantoins could be candidates. On the other hands, proton irradiation of a mixture of CO, NH_3 and H_2O, which simulated possible reactions among interstellar media, gave complex amino acid precursors with large molecular weights [5]. Such amino acids and amino acid precursors that were formed abiotically in space environments would be exposed to various energy sources in prior to delivery to the primitive Earth. For example, organics in molecular clouds were exposed to galactic cosmic rays (protons and heavy ions). Interstellar organic compounds were irradiated with strong VUV/X-rays from the young Sun. Organic compounds in small bodies were irradiated with gamma rays from such nuclides as ^{26}Al in the earlier stage of the solar system. Organic compounds in interplanetary dust particles were exposed to solar UV/VUV before delivery to Earth atmosphere. Thus it is important to examine stability of amino acids and their precursors against energetic particles and photons. We experimentally investigated the stability of amino acids and their precursors against heavy ions, gamma-rays, UV and soft X-rays.

Target molecules used in the present study were (i) glycine (Gly), (ii) hydantoin (Hyd; a precursor of Gly), and (iii) aminoacetonitrile (AAN; the Strecker-type precursor of Gly). They are used as 5 mM solutions in ammonia water (pH 9). In addition to them, we chose (iv) organic material synthesized from a mixture of CO, NH_3 and H_2O by 2.5 MeV protons from a Tandem accelerator (Tokyo Tech). We will call them CAW. CAW contained complex amino acid precursors with large molecular weights [3].

Experimental: *Heavy ions irradiation*: Aqueous solution of each target molecule was frozen in liquid nitrogen, and was irradiated with 290 MeV/u carbon ions from HIMAC (NIRS, Japan) at 7.5-15 kGy. *Gamma-rays irradiation*: Aqueous solution of each target molecule was irradiated with gamma rays (5-10 kGy) from a ^{60}Co source (Tokyo Tech, Japan). *UV irradiation*: Each target molecule was irradiated with UV from a xenon lamp after dried in pits of an aluminum plate. *Soft X-rays irradiation*: Each target molecule was irradiated with soft X-rays from a synchrotron (NewSUBARU BL-6) for 10 min after dried on aluminum plates. Amino acid analysis: all the target materials were recovered as aqueous solutions, were acid-hydrolyzed (6 M HCl, 110℃, 24 h), and amino acids in them were determined by reversed-phase HPLC after pre-column derivatization with *o*-phthalaldehyde and mercaptoethanol.

Results and Discussion: Since glycine was always major amino acids after acid hydrolysis of all the target materials after irradiation yielded glycine, we will discuss stability of target molecules by using the glycine yields.

Heavy ions irradiation: Recoveries at 15 kGy were as follows. CAW (95.1%), Hyd (93.6%), Gly (91.8%) and AAN (77.5%). AAN was least stable among all. *Gamma-rays irradiation*: Decomposition of AAN, CAW and Hyd at 10 kGy was not detected, while recovery of Gly was 79.5%. *Soft X-rays irradiation*: recovery ratios were less than 10 % in the case of Gly, Hyd and AAN, while that of CAW was 51.1%. UV-irradiated samples were now under analysis.

Free amino acid (glycine) was generally less stable than amino acid precursors (CAW and Hyd), and CAW was most stable among 4 compounds tested against all the energies. Thus it was suggested that complex amino acid precursors were robust molecules in space, while free amino acids were easy to decompose even if they were formed from their precursors in space.

References

[1] K. Kvenvolden *et al.*, *Nature*, **228**, 923-926 (1970).

[2] J. Kissel and F. R. Krueger, *Nature*, **326**, 755-760 (1987).

[3] Y. Takano *et al.*, *Appl. Phys. Lett.*, **84**, 1410-1412 (2004).

[4] Y. Kebukawa et al., *Sci. Adv.*, **3**, e1602093 (2017).

[5] S. Kuramoto *et al., 2019 JpGU Meeting*, Chiba (2019).

[6] S. Iglesias-Groth et al., *Mon. Not. R. Astron. Soc.,* **410**, 1447-1453 (2011).

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