

Production of amino acids by gamma rays during aqueous alteration process in meteorite parent body

*Shinya Asano¹, Isao Yoda², Yasuji Muramatsu³, Yoko Kebukawa¹, Kensei Kobayashi¹

1. Yokohama national university, 2. Tokyo Institute of Technology, 3. University of Hyogo

[Introduction]Organic compounds such as amino acids are necessary for the birth of life on the earth. Extraterrestrial materials such as meteorites are considered as one of the sources of these amino acids. Since most of these meteorites originated from asteroids, we need to consider the origins of organic matter in asteroids. In the early stage of solar system formation, asteroids beyond the snow line contained ice and low molecular weight organic matter derived from dust. The ice melted due to the heat generated by the radioactive decay of ²⁶Al and aqueous alteration occurred. It is pointed out the complex macromolecular organic materials (insoluble organic matter, IOM) in meteorites may have formed during aqueous alteration (approximately 0 to 150 °C.) [1]. Based on this hypothesis, experiments simulating aqueous alteration on asteroids showed that amino acids and high molecular weight organic compounds similar to IOM in meteorites was formed after heating of formaldehyde, ammonia, water [2]. In this study, we aimed to investigate effect of gamma rays generated by radioactive decay of ²⁶Al during aqueous alteration for organic synthesis.

[Experimental]⁶⁰Co gamma ray source (Tokyo Institute of Technology) was irradiated to glass tubes containing 200 μl of water: formaldehyde: ammonia = 100: 5: 5 (molar ratio). Six different irradiation conditions were applied: 3 kGy/h × 2.5 h, 3 kGy/h × 4 h, 3 kGy/h × 5 h, 1.5 kGy/h × 5 h, 1.5 kGy/h × 8 h, and 1.5 kGy/h × 10 h. For comparison, the same solutions were heated in an oven at 150 °C for 24 h. The samples after irradiation were placed on CaF₂ plate and dried, then analyzed by FT-IR. The samples after irradiation were placed on gold plate and dried, then analyzed by X-ray absorption edge near structure analysis (XANES) of Hyogo prefectural university. Also, the samples were subjected to acid hydrolysis (6 M hydrochloric acid, 24 h, 110°C) and analyzed amino acid concentrations by cation exchange HPLC.

[Results and Discussion]<Cation exchange HPLC>Various amino acids such as glycine, alanine, β-alanine were detected from the gamma-ray irradiated samples after acid hydrolysis. Relatively large amount of alanine was produced from the irradiated samples compared to the heated samples. It suggests that the formation path ways of amino acids differ between the irradiated samples and the heated samples.

[Future plan]We are planning to extrapolate the gamma-ray induced amino acid yields to the meteorite parent body environments by extending the irradiation conditions (total dose and irradiation rate) using the calculated value of total dose of gamma ray from ²⁶Al during aqueous alteration. In addition, macromolecular organic compounds will be analyzed using LC-MS.

[Reference]

[1] G.D.Cody et al., *PNAS*, 108, 19171-19176 (2011)

[2] Y.Kebukawa et al., *Astrophysical J.*, 771, 19 (2013)