Evaluation of gamma-ray effects for formation of amino acid precursors in the Solar System small bodies

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Delivery of amino acids from extraterrestrial materials such as meteorites could contribute to the emergence of life in the early Earth. Carbonaceous chondrites contain various organic matter, which mostly consists of insoluble organic matter (IOM), and also contain some soluble organic compounds including amino acids. Cody et al. [1] proposed IOM formation via formose reaction starting with formaldehyde and glycolaldehyde during aqueous activity in the small bodies. Additional hydrothermal experiments showed that ammonia enhanced the yields of IOM like organic matter [2]. The most effective heat source for melting water ice in small bodies is considered to the decay of ^{26}Al. We are focusing on the gamma-ray emission from ^{26}Al, and evaluate the effects of gamma-ray as an energy source for the formation of organic matter, specially amino acids.

Amino acids including glycine, alanine and beta-alanine were detected from the most of the irradiated and heated samples after acids hydrolysis, but little or no amino acids were detected from the solutions before acid hydrolysis. The yields of amino acids from the solutions after heating experiments were larger than these after gamma-ray irradiation with the presence of $Ca(OH)_2$, but the amino acid yields from heating were smaller than these of gamma-ray irradiation without the presence of $Ca(OH)_2$. These results indicate that $Ca(OH)_2$ was act as a catalyst to produce amino acid precursors in the heating experiments but was not in the case of gamma-ray irradiation. The solutions after heating had smaller alanine/glycine ratios than the solutions after irradiation, suggesting that heating and irradiation have different reaction mechanisms.

Insoluble fraction was only observed in the product from heating at 150 °C with ammonia. IR spectra of the insoluble fraction and soluble fraction (both dried on CaF_2 plates) revealed that soluble fraction contained amines and amides, but these bands were not significant in the IR spectra of the insoluble fraction. It suggest that the amino acids are produced from precursors containing amide bonds after braking these bonds by acid hydrolysis.

References:
[1] G. D. Cody et al., *PNAS*, 108, 19171-19176 (2011).
[2] Y. Kebukawa et al., *Astrophysical J.*, 771, 19 (2013).

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