Effects of temperatures and molar ratios for amino acid formation from formaldehyde and ammonia simulating aqueous alteration in small bodies

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Biological-related organic substances such as amino acids may have been carried from meteorites and interplanetary dust particles to the earth. In the early stages of solar system formation, the ice containing various molecules melted due to the heat mostly generated by radioactive decay of short-lived radionuclides such as ^{26}Al in asteroids, causing aqueous alteration. In this process, macromolecular organics could be produced by simple molecules such as HCHO in the presence of liquid water [1]. It was found that amino acid precursors were also produced from HCHO and NH_3 in the hydrothermal process [2, 3]. In this study, we conducted the amino acid formation experiments from HCHO and NH_3 aqueous solutions with various molar ratios and temperatures to see the effects of these conditions for the formation of amino acids.

The starting solution with HCHO:NH_3:H_2O = 3:7:300, 5:5:300, and 7:3:300 were vacuum-sealed in glass tubes in an amount of 200 μL each, and reacted at -25℃, 5℃, 50℃, 100℃, and 150℃ for 5 days. The reaction products were acid hydrolyzed with 6 M hydrochloric acid (24h at 110℃), centrifugally dried, and then amino acids were analyzed using ultra-high performance liquid chromatography (HPLC, Nexera X2) with derivatization by o-phthalaldehyde and 9-fluorenylmethyl chloroformic acid.
As a result, glycine and alanine were mainly detected from the reaction products from HCHO and NH_3. In many cases, glycine was produced more than alanine. The higher the temperature and the higher the rate of ammonia, the more glycine was produced. On the other hand, alanine increased slightly at 100℃ and 150℃, but the effect of temperature was less than that of glycine.
Considering that the amino acids of the sample kept at -25℃ were produced in the experimental procedures, alanine was produced with the temperatures higher than 50℃, but glycine was produced even at as low as 5℃.

In our experimental conditions, we showed that amino acid yields were higher with higher temperatures and higher molar ratios of ammonia in the solutions. We will evaluate further with different starting compositions to understand the possibility of amino acid formation in small bodies with various starting compositions.

References
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Keywords: Small bodies, aqueous alteration, amino acids, formaldehyde, ammonia