Nucleotide synthesis experiments by UV irradiation for "TANPOPO3"

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Abstract

1. Introduction

Nucleotides are constituents of DNA and RNA, the process of nucleotide synthesis in the primitive Earth is one of the most important processes in the origin of life.

In the atmosphere of the primitive Earth, oxygen didn't exist as molecular oxygen and ozone. This suggests that the short UV wavelength, which is interrupted at the surface of the present Earth, also worked as an important energy source for the chemical reactions at that time. Therefore, we considered that nucleotides would be synthesized by the vacuum UV irradiation in the primitive Ocean. In order to verify this hypothesis, nucleotide synthesis experiments are proposed in "TANPOPO3", the next Japanese astrobiology experiments using the International Space Station (ISS). In the experiments, samples will be exposed UV environments resembling those on the primitive Earth. In this paper, nucleotide synthesis experiments by UV irradiation were conducted as a preliminary study.

2. Experiments

Equimolar solution of nucleobases and ribose-5-phosphate were mixed and irradiated with UV (172 nm) for 4 days. This irradiation is equivalent to approximately one year of irradiation on the ISS orbit. After irradiation, irradiated solutions were analyzed by high-resolution LC/MS in order to confirm the synthesized nucleotides.

For the conformational analysis, nucleotides were separated from remaining nucleobases by the anion exchange resin utilizing the interaction between the resin and the phosphate group of nucleotides. The solution, water, and ammonium solution were sequentially eluted in the column.

3. Results

In the chromatograms of irradiated solutions, peaks of nucleobases from adenine, uracil and hypoxanthine and unknowns were found. The retention time of unknown peaks differed from those of 5'-nucleotides. However, in the mass spectra, m/z of unknown peaks were same as those of corresponding 5'-nucleotides. In addition, the MS/MS spectra of unknown peaks

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were similar to those of the 5'-nucleotides. Therefore, structural isomers of 5'-nucleotide were synthesized by UV irradiation.
Adenylate could be separated from adenine by the above anion exchange method. We will determine the conformational structure of the adenylate isomer by NMR. And we will modify the 'TANPOPO exposure apparatus' to fit for these nucleotide synthesis experiments.