Analysis of nucleic acid bases formed from simulated interstellar media

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1. Introduction
In the course of chemical evolution, it is necessary to supply nucleic acid bases which are major constituents of DNA and RNA. Since nucleic acid bases are detected in the meteorite, it is considered to be generated in space environments such as in molecular clouds.
In this study, first, we considered analytical methods for nucleic acid bases in mixtures with complicated compositions. Second, in order to verify the generation of nucleic acid bases in interstellar media, proton beam simulating cosmic ray was irradiated to the interstellar media analogs, and we investigated possible generation of nucleic acid bases and related compounds. From these experiments, we considered the possibility that nucleic acid bases essential for the generation of life could be supplied from out of the Earth.
2. Experimental
(1)Nucleic acid bases analysis
Twelve nucleic acid bases standard reagents [adenine (Ade), guanine(Gua), cytosine(Cyt), uracil (Ura), thymine(Thy), pirimidine(Pyr), hypoxanthine(Hyp), xanthine(Xan), purine(Pu), barbituric acid(BA), isoguanine(Iso-Gua), isocytsine(Iso-Cyt)] were first fractionated by gel filtration chromatography (GFC) and then each fraction was analyzed by reversed-phase HPLC (RP-HPLC), where a novel core-shell column (SunShell RP-AQUA) was used.
(2)Proton irradiation experiment
As a simulated interstellar media, a mixed gas of CO and NH_3 (350 Torr each) and 5 mL of ultrapure water were enclosed in a Pyrex glass tube, and 2 mC of 2.5 MeV proton beam was irradiated to the gas mixture by using Tandem accelerator at Tokyo Institute of Technology. The resulting product is hereafter referred to as “CAW.”
Irradiated products were injected into GFC and sorted in three compartments of retention time 15-30min (CAW1), 30-45min (CAW2), 45-60min (CAW3).
Each fractionated CAW was injected to RP-HPLC, and the nucleic acid bases were identified. For the comparison, the products were analyzed directly by RP-HPLC without fractionation by GFC.
3. Results and Discussion
(1)Nucleic acid bases analysis
In RP-HPLC, comparing the standards separation with the SunShell RP-AQUA column with a previously-used Capcell Pak C18 column, it was found that separation with SunShell RP-AQUA superior separation for each base to conventional reversed-phase columns. Therefore, in the separation / analysis of nucleic acid bases by using RP-HPLC, it was found that more accurate analysis can be performed by using SunShell RP-AQUA column.
(2)Proton irradiation experiment
BA, Cyt, Ade were detected from CAW1, Iso-Cyt was detected from CAW2, and Gua was detected from CAW3. Since Ura and Cyt were predominant in past experiments, it was suggested that Cyt and Ura are easily generated from interstellar media. In addition, BA that are considered as a candidate for non-canonical proto-RNA system, was clearly detected. It was suggested that BA is a molecule that is likely to be produced in the interstellar environment.
Compared with the RP-HPLC chromatograms of without pre-fractionation with GFC, RP-HPLC

chromatograms after fractionated with GFC looked better since huge peak of polymer-like products appeared at 1-4 min are removed, and it facilitated the identification of nucleic acid bases whose retention time was 1-4 min. In addition, it was found that nucleic acid bases with less yields could be more clearly detected. It was found that pre-fractionation of the nucleic acid bases by GFC made it possible to loaded less amount of samples on the column of RP-HPLC and the analysis of nucleic acid bases could be performed more accurately.

4. Conclusions

In this experiment, it was found that the separation using the SunShell RP-AQUA column is useful for analysis of nucleic acid bases in RP-HPLC, compared with conventional Capcell Pak C18 column. In addition, it was found that in complex mixtures, nucleic acid bases can be more accurately by pre-fractionation with GFC in the separation of nucleic acid bases.

In proton beam irradiation experiments, Ade, Gua, Cyt, Ura, which are components of RNA, were generated from simulated interstellar media, together with non-canonical bases such as Iso-Cyt and BA, which are considered to be components of proto-RNA.

From these facts, it was suggested that various nucleic acid bases and analogs whose structures were similar to them could be generated in interstellar environments.

