Amino acid analysis of the Murchison meteorite irradiated by circular-polarized UV light

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1. Introduction

Terrestrial life is composed of L-form amino acids. It has been a challenging issue how the molecular chirality was developed during chemical evolution prior to origins of life. As the non-proteineous alpha-methylated amino acids such as 2-amino-2,3-dimethylpentanoic acid and isovaline, which seem resistant to racemization during degradation, was observed as L-form excess in the Murchison meteorite (Cronin and Pizzarello, 1997), one hypothesis has been proposed that the excess of some meteoritic L-amino acids could affect influence on an optical selectivity on the primitive earth as well as in the primitive solar nebula. Subsequently, it is suggested that the L-form enrichment may be induced by circularly polarized light in a molecular cloud (Bailey et al., 1998). Recently, Takano et al. (2007) have performed a UV radiation experiment on artificial interstellar high-molecular organic matter, where left-circular polarized light (L-CPL) and right-circular polarized light (R-CPL) can make enrichment of L-alanine and D-alanine, respectively. In contrast, not only circular-polarized but also non-polarized UV irradiation has never been conducted on meteoritic organic matter with respect to its alteration. In this study, we have performed UV irradiation on the Murchison meteorite powder with L-CPL, R-CPL and non-polarized light to analyze amino acids.

2.Experimental

The Murchison meteorite powder (10-15 mg) was sealed in a synthetic quartz tube under vacuum to be irradiated by defocused 217nm L-CPL and R-CPL with 100 mJ for 1h using free electron laser at ultraviolet synchrotron orbital radiation (UVSOR) facility of the Institute for Molecular Science (IMS). Similarly, the meteorite powder was irradiated by defocused 213nm Nd-YAG laser. After irradiation, the meteorite sample was extracted with water followed by acid hydrolysis. The resultant amino acid was derivatized with Boc-L-Cys and o-diphthalaldehyde for amino acid analysis by fluorescence detection using HPLC.

3. Results and discussion

Concentration of abundant amino acids reported in Murchison such as glycine (Gly), alanine (Ala), glutamic acid (Glu), aspartic acid (Asp) and valine (Val) as well as non-proteineous beta-alanine (beta-Ala), aminoisobutyric acid (AIB) and gamma-aminobutyric acid (GABA) decreased by up to 40% after irradiation. As relative abundance of amino acids did not change much, the conversion between amino acids during irradiation was the least. In addition, alpha-methylated AIB was degraded similarly relative to beta-alanine, suggesting that the alpha-substituted structure was not an important factor for stability against the UV photolysis. The wavelength used in this study (213 and 217 nm) could induce decarboxylation of carbonyl and carboxyl groups in meteoritic organic matter. The optically active amino acids such as Ala and Asp resulted in racemization through degradation by either L-CPL or R-CPL. In the presence of meteorite matrix (i.e. inorganic minerals), the circularly polarized light could not induce effectively asymmetric reaction. Further studies such as CPL irradiation on organic matter extracted from meteorites are needed.