

In-situ analysis of organic compounds in the Murchison meteorite using desorption electrospray ionization coupled with an Orbitrap mass spectrometer.

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[INTRODUCTION] Primitive meteorites contain a wide variety of organic species. Recent studies using high-resolution mass spectrometry equipped with liquid chromatography revealed presence of various CHO, CHNO, CHNOS [1] and CHN species in solvent extracts from Murchison meteorite [2, 3]. The organic compounds would be synthesized and evolved through oxidation and reduction processes during aqueous alteration on the parent body [3]. To understand the chemical evolution of the organic compounds in primitive meteorites, investigation of their spatial distribution and relationship with minerals is very important.

Two-dimensional (2D) analysis using desorption electrospray ionization (DESI) coupled with mass spectrometry can achieve non-destructive and ambient in-situ analysis to reveal the spatial distribution of organic molecules [6, 7]. This technique is effective for analysis of polar organic species (e.g. CHN and CHNO compounds) compared to laser based ionization technique. In this study, we performed the 2D DESI-MS imaging using high-resolution mass spectrometry (HRMS) on surface of Murchison meteorite.

[EXPERIMENTAL] The fragments with flat surface (~ a few mm) of Murchison meteorite were obtained by chipping and were pressed in Indium. The 2D DESI-HRMS imaging was performed on surface using a DESI ion source (Omni Spray Source 2D, Prosolia) equipped with a hybrid quadrupole-Orbitrap mass spectrometer (Q-Exactive Plus, Thermo Scientific). Methanol (LCMS grade) was sprayed on the sample surface with 1–2 $\mu\text{l}/\text{min}$ of flow rate. The DESI-HRMS (~140,000@ m/z 200) imaging was performed in a clean room (class 1000) at the Research Center for Planetary Trace Organic Compounds of Kyushu University. After the imaging, the sample was subsequently observed using FE-SEM (JEOL JSM-7001F) equipped with an EDS (Oxford INCA Energy). The FE-SEM observation was carried out with no coating on the sample.

[RESULTS AND DISCUSSION] Numerous ion peaks with m/z 70-700 were detected from sample surface. Among the peaks, alkylated homologues of $\text{C}_n\text{H}_{2n-1}\text{N}_2^+$ ($n=9-14$) and $\text{C}_n\text{H}_{2n}\text{NO}^+$ ($n=6-9$) were detected in the Murchison meteorite distinguishing from surrounding metal. Both compounds could be assigned within < 3 ppm in mass precision. Our previous study using HPLC/HPMS analyses revealed that alkylated homologues of imidazole ($\text{C}_n\text{H}_{2n-1}\text{N}_2^+$) were dominant in the MeOH extract of the Murchison meteorite [2, 3]. Although the detailed structures of these compounds could not be defined in this experiment, the $\text{C}_n\text{H}_{2n-1}\text{N}_2^+$ compounds detected through DESI-HRMS imaging could correspond to the alkyimidazole homologues. Our results suggest usefulness of the DESI-MS analysis for understanding of spatial distribution of polar organic species in primitive meteorites. The $\text{C}_n\text{H}_{2n-2}\text{N}_2$ compounds were mainly distributed in matrix region of Murchison. Homologues of $\text{C}_n\text{H}_{2n}\text{NO}^+$ except $\text{C}_6\text{H}_{12}\text{NO}^+$ showed roughly homogeneous distribution in the matrix region. On the other hand, distribution of $\text{C}_6\text{H}_{12}\text{NO}^+$ was clearly different from other homologues and it was concentrated in the edge of the fragment. The compound distribution could have a relationship to secondary altered minerals (phosphates associated with clay minerals, which may be PCP) in Murchison. The observation would indicate that $\text{C}_6\text{H}_{12}\text{NO}^+$ experienced

different chemical evolution from other homologues of $C_nH_{2n}NO^+$, and possible processes would be oxidation and/or chromatographic effect during hydrothermal processes on the parent body of Murchison. Further analysis will be performed to determine the mineral phases in the fragment in near future.

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