Solar Component Survey From Carbonaceous Chondrite

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Introduction: Oxygen in the solar system is believed to be formed by mixing of $^{17,18}O$-rich and ^{16}O-rich resorvoirs [1]. One candidate of $^{17,18}O$-rich end member was proposed from the magnetite in cosmic symplectite ($\delta^{17,18}O \approx +180‰$) ubiquitously distributed in the matrix of Acfer 094 cabonaceous chondrites [2]. Some potential candidates of ^{16}O-rich end member are reported from 1 chondrule [3], 5 CAIs [4,5] and the Sun [6]. However, the characteristics of ^{16}O-rich candidates are unclear. Therefore, we are investigating the ^{16}O-rich component in carbonaceous chondrites using an automatic isotope ratio mapping technique.

Automated Isotope Microscope: The automated isotope microscope system consists of a stigmatic SIMS and an ion imager SCAPS controled by LabVIEW software packages including custamized CIPS software for SIMS, SUSHI-VIEW for SCAPS and integration software CHAIN. This system allows us to obtain oxygen isotope ratio images of 1 x 1mm region having sub-micron resolution and permil precision within 2 days. Figure shows combined X-ray elemental map of solar component candidate found from the Acfer 214 CH chondrite. The candidate has similar oxygen isotopic composition of previous reports. Furture survey would clarify the characteristics of a distinct solar component.

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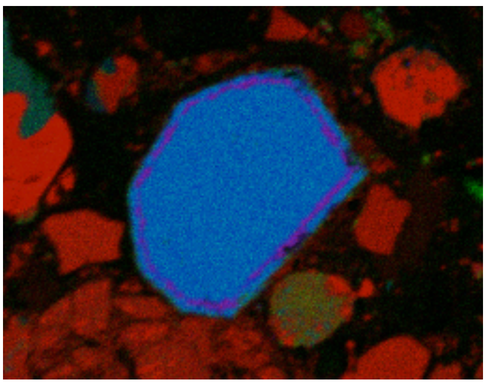

Figure Combined X-ray elemental map of solar component candidate from the Acfer 214 CH chondrite with Mg (red), Al (green), and Ca (blue).

Introduction to the Research Center for Planetary Trace Organic Compounds

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Introduction: Extraterrestrial organic compounds are essential components to understand chemical evolution in the universe. They are present in primitive meteorites in trace amounts as complex mixtures. The research center for Planetary Trace Organic Compounds (PTOC center) was founded in 2016 to develop analytical techniques of trace organic compounds under clean conditions.

High-resolution mass spectrometry: Recent high-resolution mass spectral (HRMS) analysis detected tens of thousands of different mass peaks consisting of C, H, N, O, and/or S from the Murchison meteorite [1]. Considering the structural and optical isomers, the current organic contents identified in the meteorite correspond to only approximately 1% of the total compounds present. Recently we found > 600 compounds consisting of C_nH_mN, $C_nH_mN_2$ and $C_nH_mN_4$ in elemental composition using Orbitrap HRMS coupled with HPLC [2].

High-resolution chromatography: Meteoritic organic compounds usually have suites of homologues with various functional groups. They have many structural isomers (including stereoisomers), in which the isomer distribution reflects physical and chemical conditions of the extraterrestrial environment. High-resolution chromatography analysis will be achieved to identify many isomers using a long silica capillary column using nanoLC coupled with an Orbitrap HRMS. The nanoLC and nanoESI techniques can enhance the detection sensitivity by three orders of magnitudes (*vs*. conventional HPLC).

Organic compound imaging by in-situ analysis: Trace organic compounds have been generally analyzed using the solvent extracts of powdered samples. The molecular imaging on meteorite surface has been performed using desorption electrospray ionization (DESI) coupled with an Orbitrap MS. Alkylated N-containing cyclic compounds including alkylpyridines ($C_nH_{2n-4}N^+$) and alkylimidazoles ($C_nH_{2n-1}N_2^+$) were identified on the surfaces of the Murray meteorite by in situ analysis using DESI/Orbitrap HRMS [3]. The distribution of alkylimidazoles and alkylpyridines appeared different on the surface, suggesting different their source regions or asteroidal chromatographic effect on the parent body.

Summary: The technical development will allow for the improved identification of organic compounds to study the formation pathways and origins of asteroidal organic compounds. Furthermore, the new analytical techniques will allow for the definitive identification of organic compounds in greatly reduced sample sizes (using ~⌠g of sample *vs*. current ~mg requirement), thereby contributing to the successful analysis for future sample-return missions (e.g. Hayabusa 2 and OSIRIS-REx).

References: [1] Schmitt-Kopplin P. *et al*. (2010). *Proc. Natl Acad. Sci*., **107**, 2763. [2] Yamashita Y. & Naraoka H. (2014) *Geochem. J.*, **48**, 519. [3] Naraoka H. & Hashiguchi M. (2016) *79th Ann. Meeting, Met. Soc*. #6169.