

In-situ analysis of sulfur speciation and isotopic compositions of organics in Murchison CM2 chondrite

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Sulfur is one of the major elements in terrestrial and extraterrestrial organics. The elemental compositions of the Murchison IOM (insoluble organic matter) are proposed to be $C_{100}H_{70}O_{22}N_3S_7$ [1] or $C_{100}H_{48}N_{1.8}O_{12}S_2$ [2]. Because sulfur shows a wide range in oxidation state (-2 to +6) with both electropositive and electronegative elements, reduced and oxidized sulfur species have been found in various carbonaceous chondrites [3, 4]. Therefore, understanding of speciation of sulfur and its distribution within organics in a carbonaceous chondrite may provide the secondary alteration processes of thermal metamorphism and aqueous alteration in the parent body.

Synchrotron based X-ray absorption near edge spectroscopy (XANES) is a powerful analytical tool to characterize and quantify chemical speciation, functional group and bonding environment of the sample. In the field of cosmochemistry, many researches were carried out to identify functional groups of C, N and O in extraterrestrial organics (i.e., IOM in carbonaceous chondrites [5], cometary returned sample [6], organics found in Hayabusa Category-3 grains [7], organics in IDPs [8], and organic component extracted from halite grain in Monahans LL chondrite [9]). However, sulfur study with XANES in the extraterrestrial organics is very rare [3, 10].

A study of sulfur isotopes for organics in meteorites were very limited [4, 11]. Orthous-Daunay and Gyngard presented a comparison of $d^{34}S$ between IOM and their surrounding sulfides measured by NanoSIMS [11]. Challenges of sulfur isotope imaging with NanoSIMS in extracted organics from CR2 chondrite were made by Hashizume and coworkers (preliminary report in the JSPS Kakenhi fund). Since lack of study for sulfur isotopes in organics, we still do not know about characteristics of sulfur isotopes in organics.

In this study, we report preliminary results of sulfur speciation measurements by L_3 -edge XANES of series sulfur bearing terrestrial organics to obtain reference spectra, and of S, N, C and O-XANES in the FIB section of the Murchison CM2 carbonaceous chondrite (147 x 187 pixels, 22 x 28 μm^2 : spatial resolution = 150 nm) using scanning transmission X-ray microscope (STXM) at Inst. Mole Sci. UVSOR BL4U. We also took a sulfur image (L_3 -edge XANES) of organics extracted from Asuka881458 CM2 chondrite for comparison in terms of sulfur distribution and speciation. For the sulfur isotopes in the same FIB section that we measured with STXM, we will use high-resolution ion imaging with NanoSIMS at Kochi Inst. Core Sample Research, JAMSTEC.

We obtained nine reference sulfur L_3 -edge spectra measured by the STXM. Reference sulfur bearing organics are sodium lauryl sulfate, sodium methanesulfonate, dibenzothiophene, thianthrene, DL-methionine, DL-methionine sulfone, L-cysteic acid, L-cystein, and L-cystine. These organics show different absorption curves which related to sulfur related chemical bond (e.g., sulfate, sulfone, thiol).

In this talk, we will present complete STXM-XANES images and spectra of S, N, C, O in the FIB section

together with NanoSIMS isotope images of H, S, N, C and O.

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