Applications of infrared nano-spectroscopy for carbonaceous chondrites: To understand organic-mineral interactions during aqueous alteration

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Organic matter in carbonaceous chondrites is distributed in fine grained matrix. Although 100 nm to <1 μm "nanoglobules" are often found in chondritic meteorites, these are ~10% of OM in chondrites [1], and the rest is smaller than nanoglobules. In order to understand pre- and post-accretion history of organic matter and its association with surrounding minerals, microscopic techniques are mandatory. Scanning transmission X-ray microscopy (STXM) combined with X-ray absorption near-edge structure (XANES) spectroscopy is so far the most suitable method in this purpose, that allows molecular structure information in ~40-nm spatial resolution. Infrared (IR) spectroscopy could be a complementary to XANES. However, the spatial resolution of IR is limited to a few micrometer, due to diffraction limit. Use of near-field light is one possibility to overcome the limitation of the spatial resolution. We have applied near-field IR spectroscopy to carbonaceous chondrites [2, 3]. However, the near-field signals are very low thus the intensity of IR light from a typical ceramic IR light source in a bench-top FTIR seems not large enough. Here, we applied two methods of high spatial resolution IR to carbonaceous chondrites, one is synchrotron infrared nanospectroscopy (SINS) using near-field IR with atomic force microscope (AFM) that is installed at Advances Light Source (ALS) beamline 5.4 [4, 5], other is AFM with its tip detecting thermal expansion of a sample resulting from absorption of infrared radiation (NanoIR2, Anasys Instruments) [e.g., 6].

We prepared ultramicrotomed thin sections of Murchison and Bells meteorites, as well as antigorite that was baked at 500 °C for 4 hours as a contamination control, since the IR absorption spectroscopy is susceptible to contamination from volatile organic matter [7]. We confirmed that both methods have at least 50-nm special resolutions. In the IR imaging, we observed that overlapping of regions that absorb 3400 cm^{-1} corresponding to OH and 2920 cm^{-1} corresponding to aliphatic CH, indicating association of organic matter with phyllosilicates. Such association is well known previously but in ~1 μm spatial resolutions [2, 3, 8]. We will further discuss parent body processes inferred from nano-scale IR imaging of Murchison and Bells meteorites.

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