New in-situ micro-characterization methods for organic materials from carbonaceous chondrites

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Detailed characterization of high molecular weight organic materials in carbonaceous chondrites has been limited except for the recent studies by Nakamura et al., (2002, 2003), because of the lack of organic rich areas devoid of coexisting mineral matrices.

Firstly, we conducted in-situ kinetic heating experiments in air under an infrared (IR) microscope for organic components from carbonaceous chondrites (Murchison and Orgueil). The decrease rates of C-H and C=O bands were measured and the activation energies were determined. The same type of experiments were also conducted for some analogue organic compounds. These results were compared together with our data on in-situ thermal decomposition kinetics on aqueous humic substances by using ultraviolet-visible spectroscopy, in order to discuss their organic structures and thermal history.

Secondly, we are developing a new type of IR spectrometer by using near-field optics (we can call it Nano-IR) enabling characterization of organics in submicron scales. This system can measure 3-dimensional (3D) topography of the sample surface like an atomic force microscope and obtain IR spectra at the same time. In order to test the capability of the instrument, we conducted spectral mapping of polystyrene deposited on an Al mirror with 200 nm steps in a 1x1 micrometer area. Near-field IR spectra showed three distinct C-H stretching peaks in the 2850-3200 cm$^{-1}$ region. The area intensity of this region is used to present a 3D distribution map of C-H. The 3D map indicates clearly heterogeneous distribution of polystyrene with a spatial resolution of about 200 nm, which is ten times higher spatial resolution than that of conventional IR microspectroscopy. This new apparatus is expected to be able to characterize IR signatures of organic components in nanoscale and so that provide precious information on organic-rich areas in carbonaceous chondrites and cosmic dusts and their relevance to life in the universe.

References
