Chemical comparison of STARDUST organics from Comet Wild 2 with organic matter in chondritic meteorites

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Introduction The STARDUST Organics Preliminary Examination Team (PET) have analyzed Comet Wild 2 stardust samples using Two-step Laser Desorption-Laser Ionization Mass Spectrometry (L^2MS), Liquid Chromatography coupled with Time of Flight Mass Spectrometry (LC-FD/TOF-MS), Scanning Transmission X-ray Microscopy (STXM) - X-ray Absorption Near Edge Spectroscopy (XANES), Infrared and Raman microscopy, Ion chromatography with conductivity detection, Secondary Ion Mass Spectrometry (SIMS), and Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS). The results by STXM-XANES and Raman will be mainly presented.

Methods [XANES] The principle of XANES is the absorption in soft X-ray region in response to K-shell excitation of light elements. Absorption edge is observed at different photon energy for different electronic structure, which enables the identification and quantification of functional groups in organic molecules. Absorption contrast images of the samples were taken by scanning through the focus by STXM, and XANES spectra of the focused area were obtained by scanning the range of 280-330eV for C, 390-420eV for N, and 520-580eV for O. Data for 15 particles of the stardusts were acquired at beamline 5.3.2. at the Advanced Light Source, Lawrence Berkeley Laboratory.

[Raman] The degree of thermal metamorphism which the stardust organics experienced was evaluated by the peak sizes, positions and widths of the band centered at ˜1360 cm^{-1} derived from disordred carbonaceous material (D-band) and the band at ˜1580 cm^{-1} derived from graphite-like carbon (G-band) in the form of condensed rings. Twelve particles of the stardusts were measured by Raman at 5 laboratories. The results by WiTec alpha-SNOM including near-field optical microscopy, atomic force microscopy, and confocal imaging Raman microscopy (532 nm frequency-doubled Nd: YAG laser) at Carnegie Institution of Washington will be mainly presented.

Results and discussion [XANES] C, N, O-XANES analyses detected the transitions from 1s to pi^{Λ} consistent with variable abundances of a variety of functional groups, such as aromatic (˜285.2 eV), ketone/aldehyde (˜287.5 eV), carboxyl (288.6 eV), ether/alcohol (289.5 eV), amide (288.2, 401.4 eV), and nitrile (399.9 eV). The analyses revealed that the structural characteristics of stardust organics were, 1) poor in aromatic carbon, 2) rich in N and O, and 3) more heterogeneous, compared to those of organic matter in chondritic meteorites, suggesting that stardust organics appear to be more primitive in terms of thermal processing. Furthermore, a portion of the stardust organics appeared to be relatively labile and/or soluble, since a part of the organics disappeared or diffused out of the original particle and into the surrounding epoxy.

[Raman] D- and G- band ratios of the Raman spectra of the stardust organics were similar to those of IDP and primitive chondritic meteorites, indicating the presence of non-metamorphosed organic matter, that is, the molecular structure that contains not only condensed aromatic rings but substantial amounts of hetero atoms suh as O, N, and S. Also, one stardust sample showed unusually a low G-band position, suggesting amorphized carbon caused from particle irradiation.