

NANOSCALE INFRARED INVESTIGATION OF ORGANICS IN CARBONACEOUS CHONDRITES

M. Yesiltas¹, T. D. Glotch², and B. Sava³. ¹Faculty of Aeronautics and Space Sciences, Kirklareli University, Kirklareli, Turkey, ²Department of Geosciences, Stony Brook University, Stony Brook, New York, USA, ³Neaspec GmbH, D-85540 Haar, Munich, Germany.
(myesiltas@knights.ucf.edu)

Introduction: Carbonaceous chondrites contain a wide range of extraterrestrial organic compounds that can provide information about the processes in the interstellar medium and early solar system. The organic content of carbonaceous chondrites includes aliphatic and aromatic hydrocarbons, carbonyls such as aldehydes, ketones, and carboxylic acids [1]. The formation regions of organics are not fully understood. Possible regions are the interstellar medium, solar nebula, or alternatively, meteorite parent bodies. To better understand the earliest processes and formation mechanisms in the Solar System, the most primitive meteorites should be considered. Dominion Range (DOM) 08006 is a petrologic type 3.0 CO chondrite. It is one of the most primitive carbonaceous chondrites, and the most primitive CO chondrite known to date [2]. The meteoritic organic matter may have contributed to the origin and evolution of life on Earth. Therefore, some of the meteoritic organic matter is of astrobiological importance. On the other hand, novel analytical techniques with nanoscale spatial resolution are required to detect and characterize meteoritic organics because of their typical sub-micron [3], or even nanoscale [4] spatial scales. It is also important to preserve the petrographic context of the considered meteorites. In this work, we present nanoscale infrared (nano-FTIR) spectra collected from the organic-rich regions of DOM 08006 with ~20 nm spatial resolution [5]. Specifically, we present spectra and petrological context of nanoglobular-like organic compounds in DOM 08006. Our results will be compared with those of other carbonaceous chondrites from different groups.

Sample: DOM 08006 was obtained from the Astromaterials Acquisition and Curation Office at NASA Johnson Space Center. It was prepared as a polished thin section by first dry-cutting the sample and then further processing using diamond paste.

Technique: Nano-FTIR spectroscopic experiments were conducted using a commercial s-SNOM nano-FTIR imaging and spectroscopy system (neaspec GmbH) equipped with mid-infrared broadband lasers. Spectra were collected within the 2000–650 cm⁻¹ spectral range with ~20 nm spatial and 12 cm⁻¹ spectral resolution. For each spectrum, 10 spectra were coadded (integration time was 10 ms/spectrum) to create the average spectrum. AFM scans were collected using a Pt coated neaspec cantilever tip (resonance frequency 250–270 kHz) that maps the surface topography. Sample drift was also monitored constantly by checking the reference points on the sample.

Results: Nano-FTIR spectra, optical, and mechanical amplitude images of the studied regions were collected from several locations on the surface of DOM 08006. Roughly spherical (~50–300 nm sized) blobs as well as many nanoglobular (100–200 nm) organic materials were detected within the matrix [5]. Some images show that organic blobs as small as ~20 nm are distributed over the matrix. Nano-FTIR spectra present several infrared bands within the 1800–1200 cm⁻¹ range due to organics. The most prominent feature is the sharp band at 1730 cm⁻¹, characteristic of C=O stretching vibrations in carbonyls. Additional bands due to C=O stretching vibrations were observed at 1580 cm⁻¹ and 1410 cm⁻¹. A doublet was observed between 1305–1250 cm⁻¹, which could be attributed to C–O stretching vibrations in aromatics. The strength of the 1730 cm⁻¹ band appears to be correlated with the band near 1580 cm⁻¹, which is also attributed to C=O stretching modes in carbonyls, or possibly carboxylic acids.

Previously, the detection of carbonyl compounds in extraterrestrial materials was carried out using destructive methods in most studies. Here, we have illustrated and confirmed that high spatial resolution nano-FTIR spectroscopy can detect and measure organic material as small as ~20 nm present within the matrix of carbonaceous chondrites, owing to the preserved petrographic context noted via nano-FTIR spectroscopy.

References: [1] M. A. Sephton, (2002) *Natural product reports*, 19,292-311. [2] J. Davidson, et al. (2019) *Geochimica et Cosmochimica Acta* 265,259-278. [3] Remusat, L. et al. (2010) *The Astrophysical Journal* 713,1048. [4] B.T. De Gregorio et al. (2013) *Meteoritics & Planetary Science*, 48,904-928. [5] Yesiltas et al. (2021) *Scientific Reports*, 11, 11656, doi.org/10.1038/s41598-021-91200-8.