

MOLECULAR DISTRIBUTION OF ORGANIC MATTER AND MINERAL RELATIONSHIPS IN METEORITES AND INTERPLANETARY DUST.

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Introduction: Bulk chemical analysis of carbonaceous meteorites using chromatographic and mass spectrometric techniques has revealed the presence of a wide diversity of organic species. This includes aliphatic and aromatic hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, amino acids, amines, amides, *N*-heterocycles, phosphonic acids, sulfonic acids, sugar-related compounds and a poorly defined macromolecular phase [1]. This diversity is a product of the many environments and synthetic pathways contributing to the formation and chemical evolution of meteoritic organics -- from interstellar processes (ion-molecule reactions) and gas-grain chemistry in the early Solar nebula (Fischer-Tropsch & Miller-Urey reactions) through to hydrothermal and shock alteration on meteorite parent bodies. Elucidating the contribution and influence such processes requires an understanding of the exact *in situ* spatial distribution of individual organic species and their relationships to the local host mineralogy (e.g., [2]). However technological and analytical challenges have previously severely limited such investigations.

Approach: We have applied ultrafast two-step laser mass spectrometry (ultra-L²MS) [3] to map the molecular distribution of trace organic species ($< 10^{-15}$ mol.) at μm spatial resolution in the matrix of carbonaceous chondrites and individual interplanetary dust particles (IDPs). Samples were prepared by embedding in *N*-free epoxy potted butts. A diamond knife ultramicrotome is then used to expose a fresh surface and provide e^- transparent thin sections of the same surface for subsequent mineralogical and/or isotopic characterization. Organic molecules are non-thermally desorbed as neutral species from the exposed sample surface using a pulsed IR laser beam spatially filtered and focused to a diffraction limited $\sim 5 \mu\text{m}$ spot using a Schwarzschild reflecting objective. Desorbed neutrals are subsequently selectively photoionized using a pulsed UV and identified using a time-of-flight mass spectrometer. Spatial mapping is achieved by rastering the sample stage under the desorption laser.

Preliminary Results: Matrix containing fragments of the two carbonaceous chondrites Tagish Lake (CI1) and Bells (CM2), both known to contain ¹⁵N-rich organic globules [4], as well as two large IDP fragments (L2009O14 cluster 13 & L2036AA7*4) have been investigated. The distribution of aromatic and unsaturated hydrocarbons is heterogeneous down to the mapping resolution of the ultra-L²MS instrument; both in terms of the absolute spatial distribution and in the relative ratio between different species including homologous alkylation series (i.e., X-H ... X-(CH₂)_n-H). There is no evidence of surface smearing of organics by the diamond microtome knife, and no interferences from the epoxy mount since such an extensively polymerized cross-linked structures cannot undergo desorption under the neutral conditions employed. The presence of organic-rich hot-spots suggests specific binding of some organics to mineral phases.

References: [1] Sephton M.A. (2002) *Nat. Prod. Rep.* **19**:292-311. [2] Pearson V.K. et. al (2002) *MAPS* **37**:1829-1833. [3] Clemett S. J. & Zare R. N. (1997) *Int. Astron. Union Symp.* **178**: 305–320. [4] Nakamura-Messenger K. et al. (2006) *Science* **314**: 1439-1442.