IDENTIFICATION OF AROMATIC ORGANIC MATTER FROM COMET 81P/WILD 2 BY *μLTRA*-L^{2}MS.

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Introduction: Comets have escaped large-scale differentiation and mixing processes, because of the their small size, while their site of accretion in the outer reaches of the Solar System means they likely retain much of their original volatile inventory. As such cometary materials are thought to have preserved remnants of presolar and nebular organic matter from which the Solar System formed. As part of the organic sub-group of the Preliminary Examination Team (PET) for the Stardust Sample Return Mission, we have used the technique of ultrafast two-step laser mass spectrometry (*μltra*-L^{2}MS) to investigate the nature and distribution of aromatic organic matter in dust samples from Comet 81P/Wild 2 (1). The goals of this work are three-fold: [1] to explore the link between Solar System organics and that present in the interstellar medium (ISM); [2] to better understand the origin and evolution of stratospherically collected interplanetary dust particles (IDPs); and [3] to provide an improved understanding of the mass spectra collected by the Vega I & II and Giotto flyby missions to Comet 1P/Halley.

Experimental: The technique of *μltra*-L^{2}MS has been discussed in detail elsewhere (2). No specific sample preparation treatments are required for analysis other than that the sample physically fit in the vacuum chamber. Foils samples were attached directly to a stainless steel (s.s.) sample mount. Terminal particles extracted from aerogel tracks were analyzed either as a freshly cut surfaces of an epoxy bullet, or as a TEM thin-sections mounted an ultrapure polished Si wafers. Particle tracks were analyzed as cross-sections taken lengthwise along the track axis and friction mounted by sandwiching between a lower 200-Mesh Au TEM grid and an upper 50 μm (92% transmission) s.s. mesh.

Preliminary Results: We have observed the presence of aromatic organic matter in particle debris entrained along aerogel tracks and in particles at the track terminus. Although terrestrial contamination issues from the aerogel remain a concern, a substantial fraction of the observed organics appears indigenous.

The organic spectra obtained from terminal particles are generally relatively simple and dominated by low mass aromatic hydrocarbons such as benzene (78 amu; C_6H_6), phenol (94 amu; C_6H_5OH), naphthalene (128 amu; $C_{10}H_8$) and their alkylated homologs. This contrasts with more complex spectra associated with the tracks as illustrated in Fig. 1. In general, the organic composition of particles entrained on the interior track walls is diverse and gives rise to a spectrally dense mass spectrum. The predominant species are naphthalene, acenaphthylene (152 amu; $C_{12}H_8$), phenanthrene (178 amu; $C_{14}H_{10}$), pyrene (202 amu; $C_{16}H_{10}$), perylene (252 amu; $C_{20}H_{12}$) and their alkylated homologs (Ar-$(CH_2)_n$-H) extending up to at least C_4-alkyl. Interspersed within these species is a rich suite of auxiliary peaks which appear to represent the presence of O and N substitution, with the heterofunctionality being external to aromatic structure. A similar spectral complexity has been observed in several IDPs, for which a similar conclusion was drawn (3). The total concentration of organic species is highest near the track entrance and appears to decreases monotonically with track depth. The organic species observed in the track bulb also appear to have penetrated or diffused in to the adjacent aerogel. A similar effect was also observed in preflight aerogel test shots with cocoa powder coated soda-glass beads. However, since the *μltra*-L^{2}MS technique is surface sensitive and the surface area of the uncompacted aerogel is vastly greater than that of the compacted bulb, a quantitative assessment is difficult.

The presence of simple alkylated aromatic in terminal particles show some kinship to the organic composition of primitive carbonaceous chondrites such as Murchison (CM2) and Tagish Lake (CI2), while the more complex higher mass organics found in the track bulbs have similarities to stratospherically collected IDPs. In the case of IDPs, such spectra have been interpreted as the product of polymerization of smaller mass aromatics as the result of cosmic ray/solar photochemical processing and/or thermal heating experienced during atmospheric entry. By analogy thermal processing through impact heating may also explain the more complex higher mass envelopes observed in organic material along the tracks. This is consistent with the results obtained from modeling aerogel/particle impacts using a Coupled Thermodynamic and Hydrodynamic code (4). No evidence exists for the presence of C_{60} and related fullerenes, although *μltra*-L^{2}MS is not a sensitive method for detecting their presence.

References: [1] Sandford, et al. (2006) *Science*, **314**, 1720; [2] Clemett & Zare (1996) *IAU Symp. 178*; [3] Clemett, et al. (1993) Science, **262**, 721; [4] Stratton & Szydlik (1997) LPSC XXVIII, 1164.

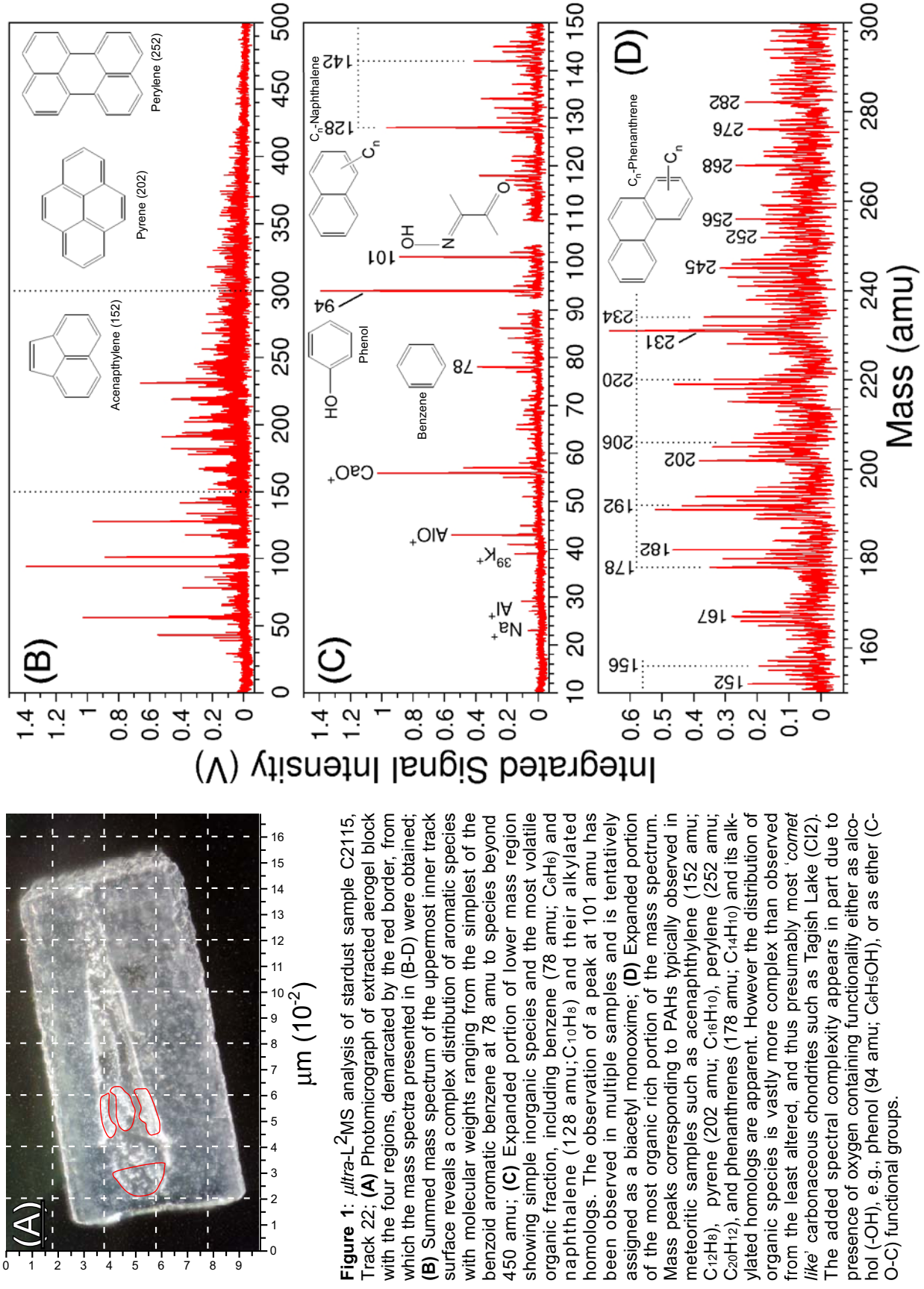

Figure 1: *ultra*-L^{2}MS analysis of stardust sample C2115, Track 22; **(A)** Photomicrograph of extracted aerogel block with the four regions, demarcated by the red border, from which the mass spectra presented in (B-D) were obtained; **(B)** Summed mass spectrum of the uppermost inner track surface reveals a complex distribution of aromatic species with molecular weights ranging from the simplest of the benzoid aromatic benzene at 78 amu to species beyond 450 amu; **(C)** Expanded portion of lower mass region showing simple inorganic species and the most volatile organic fraction, including benzene (78 amu; C_6H_6) and naphthalene (128 amu;$C_{10}H_8$) and their alkylated homologs. The observation of a peak at 101 amu has been observed in multiple samples and is tentatively assigned as a biacetyl monooxime; **(D)** Expanded portion of the most organic rich portion of the mass spectrum. Mass peaks corresponding to PAHs typically observed in meteoritic samples such as acenaphthylene (152 amu; $C_{12}H_8$), pyrene (202 amu; $C_{16}H_{10}$), perylene (252 amu; $C_{20}H_{12}$), and phenanthrenes (178 amu; $C_{14}H_{10}$) and its alkylated homologs are apparent. However the distribution of organic species is vastly more complex than observed from the least altered, and thus presumably most '*comet like*' carbonaceous chondrites such as Tagish Lake (CI2). The added spectral complexity appears in part due to presence of oxygen containing functionality either as alcohol (-OH), e.g., phenol (94 amu; C_6H_5OH), or as ether (C-O-C) functional groups.