

PLACING COMET 81P/WILD 2 ORGANIC PARTICLES INTO CONTEXT WITH CHONDRITIC ORGANIC SOLIDS. G.D. Cody¹, H. Yabuta¹, C.M.O'D. Alexander², T. Araki³, A. L. D. Kilcoyne³, and the STARDUST PET. ¹Geophysical Laboratory and ²Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5251 Broad Branch Rd. N.W. Washington DC, 20015 USA. ³Advanced Light Source, Lawrence Berkeley Laboratory, Berkeley, Ca.
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Introduction: The successful completion of the STARDUST mission to return cometary material to Earth for in depth analysis provides an unprecedented opportunity to compare and contrast genuine cometary organic matter with insoluble organic matter (IOM) associated with chondritic meteorites.

Recent spectroscopic studies of meteoritic IOM spanning multiple classes, groups, and petrologic types reveal a number of molecular transformation pathways recorded in IOM [1,2] that can be related to either chemical oxidation or thermal metamorphism, or both. Such a clear signature of parent body processing on IOM structure defines an unambiguous path back to IOM's primitive origins. This state for chondritic organic matter is currently best represented by IOM isolated from type 1 & 2 CR chondrites, e.g., GRO95577 and EET92042, respectively.

It is anticipated that organic matter associated with Comet 81P/Wild 2, a Kuiper belt object, should provide the most primitive organic matter representative of the cold interstellar material that was the source of matter for the Solar System.

Samples: Samples studied here were provided to the STARDUST PET, Organics sub-team (S. Sandford, Lead) (Table 1). All samples analyzed were isolated and sectioned by K. Messenger at the STARDUST Curatorial facility at NASA Johnson Space Center.

Table 1

Particle Designations for Particles analyzed in this study

Sample ID	Generic	Track	Grain	Mount	Medium
1	FC12	16	1	10	epoxy
2	C2054	35	16	4	epoxy
3	C2115	22	1	5	sulfur
4	C2054	35	10	10	sulfur
5	C2054	35	8	8	sulfur
6	C2044	NA	NA	NA	sulfur
7 ^a	FC9	13	1	8	sulfur
8 ^a	FC9	13	1	8	sulfur

a: These are different slices of the same particle, with significantly different cross-sections and position on the grids.

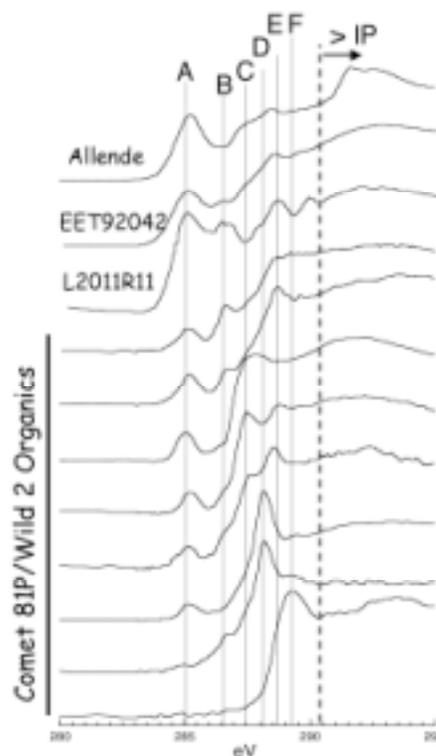


Fig. 1: C-XANES Spectra of Comet 81P/Wild 2 particles bottom (with spectra stacked such that bottom corresponds to sample # 1, Table 1 increasing to # 8 at top). Dashed lines are included highlighting characteristic absorption features for various functional groups: A) aromatic/olefinic carbon, B) enol, C) methyl, D) amidyl, E) carboxyl, and F) alcohol/ether. The approximate position of the ionization edge is designated IP and shown with a bold dashed line.

Carbon and Nitrogen X-ray Absorption Near Edge Structure (XANES) Spectroscopy: Carbon and Nitrogen XANES were acquired using the Scanning Transmission X-ray Microscope (STXM) located at beamline 5.3.2, the Advanced Light Source, Lawrence Berkeley Laboratory, Berkeley CA. Details on the specifications and operation of this instrument have been described previously [5].

Representative C-XANES spectra of eight Comet 81P/Wild 2 organic particles are presented in Fig. 1 [6] along with a spectrum of an anhydrous IDP L2011R11 [4,5] and IOM from a CR2 (EET92042) and a CV3 [Allende] presented for comparison.

It is apparent in Fig. 1 that the organic matter obtained from Comet 81P/Wild 2 varies considerably in the distribution and types of functional groups present. Whereas the C-XANES spectra of several of the particles bear similarity in the types of functional groups observed in anhydrous IDP's [4,5] and primitive IOM [2,4], other particles exhibit carbon chemistry that is considerably different than observed in IOM in any chondritic class, group, or petrologic type [2].

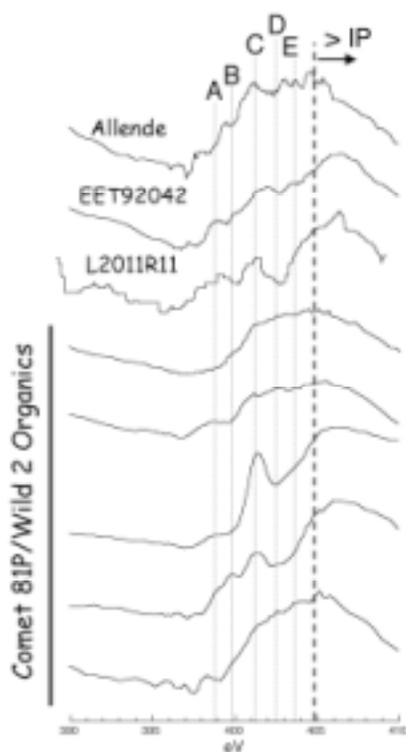


Fig. 2 N-XANES spectra of Comet 81P/Wild 2 particles (bottom). Very spectral bands are highlighted revealing the presence of A) imine, B) nitrile, C) amidyl, D) amino, and E) urea nitrogen. The approximate position of the N (1s) ionization edge is designated as **IP** and shown with a bold dashed line.

N-XANES spectra of Comet 81P/Wild 2 particles are presented in Fig. 2; along with representative N-XANES spectra from the anhydrous IDP L2011R11 [4,5] and chondritic IOM, EET92042 and Allende.

The N-XANES spectra for all of the extraterrestrial materials presented in Fig. 2 are rich, i.e., essentially all types of N-containing functional groups are represented to some extent. Notwithstanding this complexity, similar to what is observed in the C-XANES (Fig. 1), there exists considerable variation in the relative distribution of the N-containing functional groups.

Discussion: The wide range of molecular structure evident in the C- and N-XANES spectra of a relatively small set of Comet 81P/Wild 2 particles, analyzed so far, is surprising and certainly intriguing. Whereas, there exist evidence of some connection between some of the comet particles and primitive chondritic organic matter; many of the particles exhibit chemical structure completely foreign to that of primitive chondritic IOM. In other words, for some of the particles analyzed there exists no obvious chemical reaction pathway linking their chemistry and that of either the anhydrous IDP L2011R11 or the primitive chondrite IOM derived from EET92042. This high degree of variation in functional group distribution is also reflected in an enormous scatter in these particles' elemental chemistry, i.e., N/C and O/C [6].

The origin of such chemical complexity is not yet understood, but may reflect multiple origins and different synthesis mechanisms. It is possible, for example, that while there exists a subset of organic particles that constitute primitive IOM derived from pre-Solar System synthesis in the interstellar medium, some of the organic particles analyzed may represent *de novo* solids synthesized during the capture and post capture phases of the mission. The spontaneous condensation of small organic molecules into organic solids during the sublimation or thermal evaporation of cometary ices is not implausible and may provide the only rational explanation for such chemical heterogeneity if, as yet unknown, contaminants are ruled out.

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References: [1] Cody G. D. and Alexander C.M.O'D. (2005) GCA, [2] Cody, G. D, et al. in prep., [3] Flynn et al. (2003) GCA, 4791-4806, [4] Keller L. P. et al. (2004) GCA 2577-2589, [5] A. L. D. Kilcoyne et al. (2003) J. Synch Rad. 10, 125-136. [6] S. Sandford et al. (2006) Science, 34, 1727-1730.