ANALYSIS OF ORGANIC COMPOUNDS FROM STARDUST SAMPLES USING C60-TOF-SIMS.
D. Rost, T. Henkel, A. King and I. Lyon, The University of Manchester, SEAES, Williamson Bldg. Oxford Rd., Manchester, M13 9PL, UK, detlef.rost@manchester.ac.uk.

Introduction: In January 2006 the Stardust space probe brought back its sample collector for Earth based laboratory research [1–3]. During the mission, opposing sets of aerogel tiles, individually framed with Al foil, had been exposed to the particle flux from comet 81P/Wild 2 and the interstellar medium, respectively.

Impacting cometary particles produced up to millimeter long cavities or tracks in the aerogel [3]. Organic compounds (e.g., PAHs) from the comet have been identified on track walls [4] and have been putatively found in the adjacent aerogel [4,5].

The aim of this study is to investigate: (1) If direct deposition of organic compounds from the coma of Wild 2 can be identified on exposed aerogel surface. (2) If micrometer sized impact structures are present, potentially accompanied by local enrichments of cometary matter including organic compounds.

This is addressed by high resolution (~2 µm) and high mass (<2000 u) chemical mapping of aerogel surface that was exposed to the cometary particle flux as well as flight aerogel surface that was not.

Samples: C2005,2 is a ~ 10 mm × 15 mm × 5 mm aerogel chip, which was part of the top surface that fell off while tile C2005 was removed from the cometary collector tray. This sample is devoid of (visible) impact tracks.

C2052,8 is a ~ 10 mm × 10 mm × 5 mm aerogel chip dissected from the bottom of tile C2052.

These samples were allocated through the UK Stardust Consortium, a network established to guarantee most comprehensive analyses of individual samples.

The organic compound Irganox® 1010 was analyzed as a high-mass reference material for this study. It is an antioxidant of formula $C(C_{18}H_{27}O_3)_4$ and average molecular mass 1177.6 u. It was dispersed on an Al surface using chloroform ($CHCl_3$) as solvent.

Experimental: Secondary ion mass spectrometry (SIMS) and time-of-flight- or ToF-SIMS are established techniques to measure trace element concentrations and/or isotopic composition on a micrometer or even sub-micrometer scale. ToF-SIMS offers the additional advantage of almost negligible sample consumption. The typically used primary ion species (O_2^-, Ar^+, Ga^+), however, tend to fragment and hence destroy larger molecules so that organic compounds are difficult to detect. A new generation of ion guns utilizes heavier primary ions (Au_n^+, Bi_n^+, C_{60}^{n+}), resulting in a more gentle desorption of larger/organic molecules, especially when using C_{60}^{n+} [6,7].

In 2007, one of our IDLE ToF-SIMS instruments [8,9] was equipped with a 40 kV C_{60} primary ion gun from Ionoptika Ltd [10] and a 20 kV post-acceleration detector from Kore Technology Ltd was also installed to enable efficient detection of organic compounds. Measurements can be routinely performed with a lateral resolution of ~2 µm. Sub-micrometer resolution is possible although at the expense of intensity.

Preliminary results and discussion: Since the instrument upgrade was completed very recently, at this point only few measurements from C2005,2 and none from C2052,8 have been realized.

Figure 1 provides a mass spectrum of the reference substance Irganox® 1010. Although lighter hydrocarbons dominate the spectrum, characteristic peaks appear in the higher mass range; the whole molecule M^+ and MH^+ are found at m/z 1176–1179. These results demonstrate the enormous capabilities of this method.

Results from an early measurement of the aerogel surface of C2005,2 can be seen in Figure 2. The observed peaks in the high mass regime indicate organics or cluster fragments from the aerogel. However, further data collection and analysis are needed to provide a proper identification.

Outlook: We are confident that we will have more measurements, especially from the bottom aerogel, at the time of paper presentation. This will help in discriminating between the peaks omnipresent in aerogel from those of potential cometary origin.

References: [1] Brownlee D. E. et al. (2003) *JGR, 108,* 8111. [2] Tsou P. (2003) *JGR, 108,* 8113. [3] Brownlee D. et al. (2006) *Science, 314,* 1711–1716. [4] Sandford S. A. et al. (2006) *Science, 314,* 1720–1724. [5] Stephan T. et al. (2008) *Meteoritics & Planet. Sci., in press*. [6] Weibel D. et al. (2003) *Anal. Chem., 75,* 1754–1764. [7] Fletcher J. S. et al. (2006) *Anal. Chem. 78,* 1827–1831. [8] Braun R. M. et al. (1998) *Rapid Commun. Mass Spectrom. 12,* 1246–1252. [9]] Henkel T. et al. (2007) *Rev. Sci. Instrum., 78,* 055107. [10] Hill R. et al. (2006) *Appl. Surf. Sci., 252,* 7304–7307.

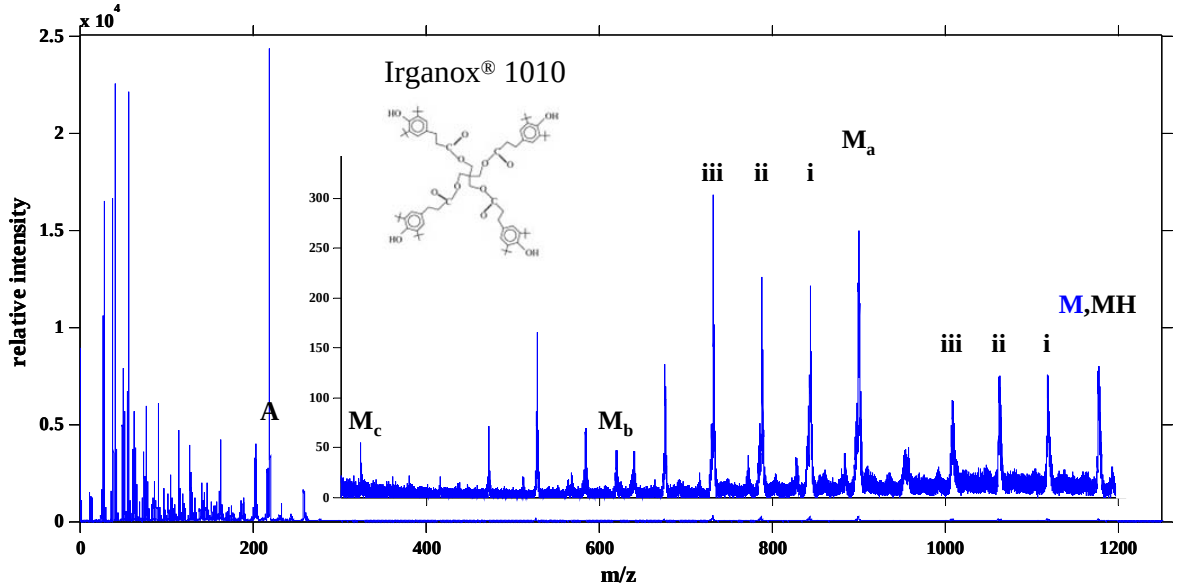

Figure 1. *Mass spectrum obtained from Irganox® 1010, $C(C_{18}H_{27}O_3)_4$. The intact molecule M and its hydride MH appear at m/z 1176–9. High mass fragments reflect sequential loss of C_4H_9 units (i, ii, iii; originally 8) and almost complete removal of ($C_{18}H_{27}O_3$)-arms from the central C atom (M_a, M_b, M_c). The most intense peak at m/z 219 (A) represents the greater part ($C_{15}H_{23}O$) of one of those arms.*

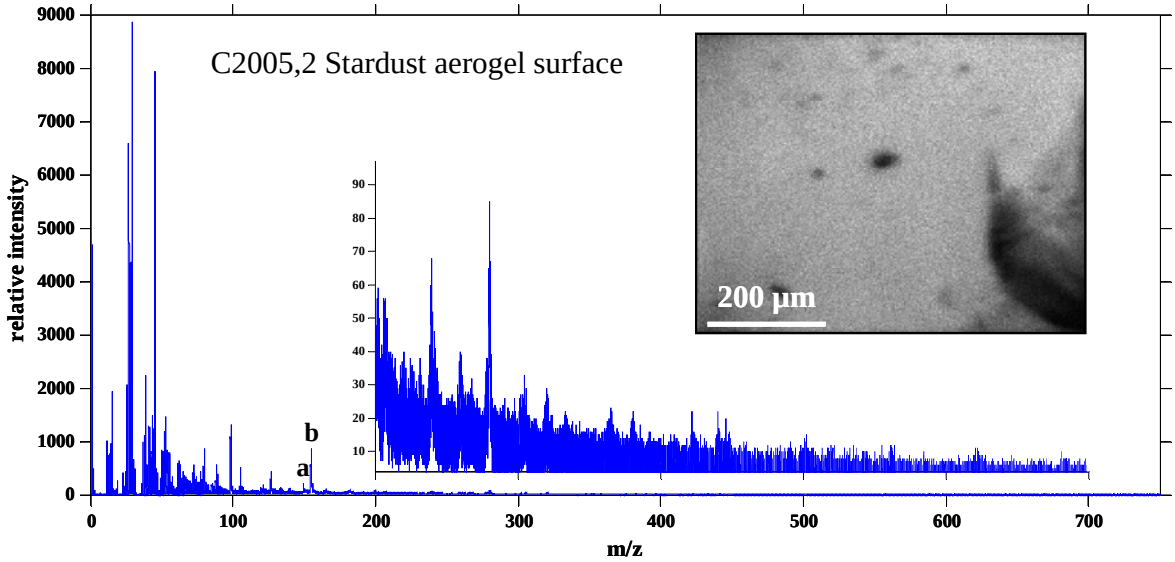

Figure 2. *Spectrum obtained from the surface of Stardust aerogel chip C2005,2 and the total secondary ion image of the analyzed area. High mass peaks can be observed up to m/z ~700. Identification of peaks >100 u proves to be problematic since most of them seem to be inconsistent with the expected PAHs or Si_iO_j-$(CH_3)_k$ clusters. A common plasticizer fragment ($C_8H_5O_3$) might be responsible for the peak at m/z 149 (a). Some peaks could be assigned to PAHs, e.g., acenaphthene ($C_{12}H_{10}$) would match the peak at m/z 154 (b), however if that were the case, the more common PAHs would have been expected to produce significant peaks and these were not observed.*

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