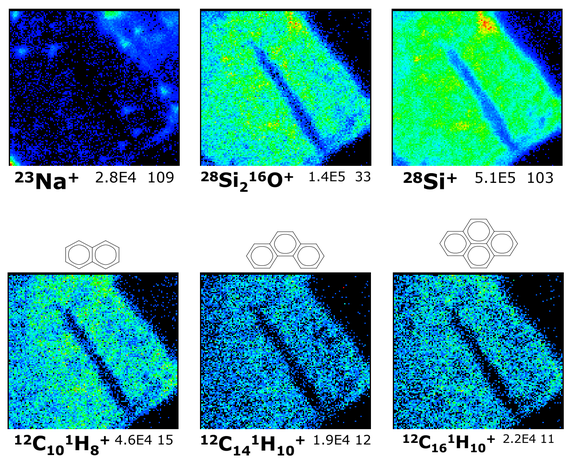
Organic Material in Aerogel Samples from the STARDUST Mission

T. Henkel and I. C. Lyon

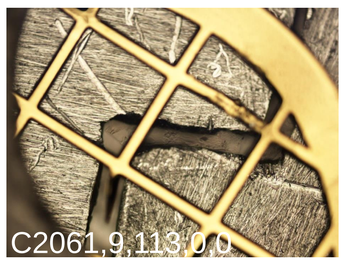
The University of Manchester, SEAES, Williamson Bldg., Oxford Road, Manchester, M13 9PL, UK
e-mail: torsten.henkel@manchester.ac.uk

Introduction:

- Organic material brought to Earth by comets is a possible source for life [1]
- Organic molecules have been found in Stardust aerogel samples [e.g. 2] and there are indications that organic material survived in craters on the Al-foil [3,4]
- Our previous study on a type A track (C2012,15,134,0,0) revealed no organic material enrichment within the track area compared to the surrounding aerogel [5] but showed the presence of several PAHs, probably contamination, in the aerogel



- We have also analysed two partial tracks of type B. These samples consisted of 100 µm long slices from cut-open tracks C2063,5,154,0,0 and C2061,9,113,0,0 [6]
  - Both samples showed contamination by Poly-Dimethyl-Siloxane which was used during mounting the aerogel tiles and is a common contaminant on plastic parts as well as a wax which was used during production of TEM-grids which have been used to hold down the samples (see images on the right)
  - A comparison of the track spectra with the spectra from the surrounding area did not reveal any significant abundance of organic material in the track area only.
  - An explanation for this could be the migration of organic material within the aerogel

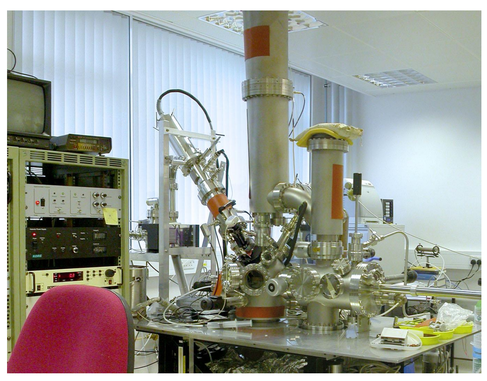


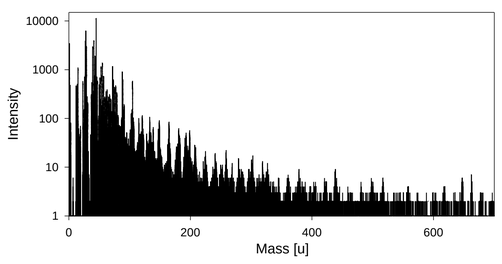
Aerogel background:

- Aerogel production included tetraethylorthosilicate and [$Si(C_2H_5O)_4$] and acetonitrile [CH_3CN] in a process of heat-treatment and super-critical drying [7]
- The aerogel batches have been baked at 300°C which reduced the organic content from initially 2.4% to around 0.5% [7]
  - Several different batches of aerogel have been used to produce the tiles and each batch might be different
  - Migration of organic material could be limited and the distribution of organic material within the aerogel could be heterogeneous
- We therefore started analyses of non-flight spares and samples from the aerogel tile backside for a blank correction

TOFSIMS using C_{60} Primary Ions:

- Time-of-Flight Secondary Ion Mass Spectrometry (TOFSIMS) analyses were acquired using the IDLE2 instrument at the University of Manchester [8]
- TOFSIMS combines complete mass spectra with high lateral resolution and high sensitivity
- C_{60} primary ions cause less fragmentation of secondary molecular ions and allow the detection of the whole molecule as well as depth-profiling of organic material
- Fragmentation patterns are like finger-prints of individual organic molecules and can help to understand the molecular structure but still need to be compared to standards
- Analyses were acquired from selected regions-of-interest which include the tracks themselves as well as surrounding aerogel



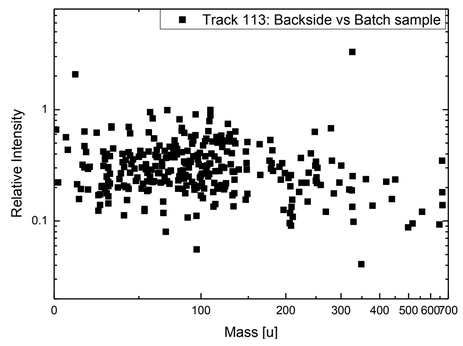


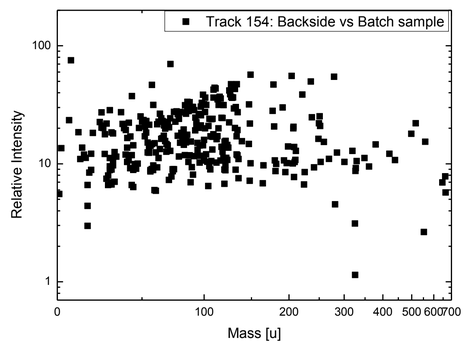
Results:

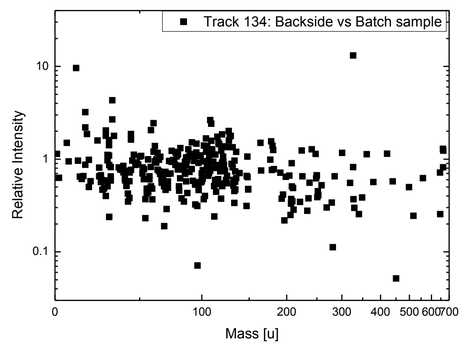
- All significant peaks in the mass spectra from the aerogel batch analyses, the tile backsides and the track areas have been marked, especially looking out for peaks in the track spectra which are not present in the backside or batch samples
- Secondary ion intensities have been normalized using the number of ionization events for each spectra
- Additional variation may exist due to different sputter rates of the uneven surfaces or slight variations in primary ion currents but these should be relatively small and affect all intensities similarly resulting in a general offset

Aerogel backsides and non-flight spares:

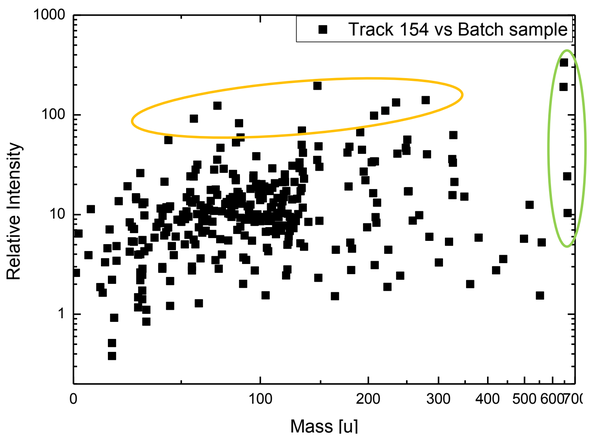
- There is quite some scatter between the aerogel tile backsides and the non-flight spares (statistical errors for each data point as similar to the marker size for almost all data points)
  - This could be from migrated cometary material or due to a heterogeneous distribution of production contaminants







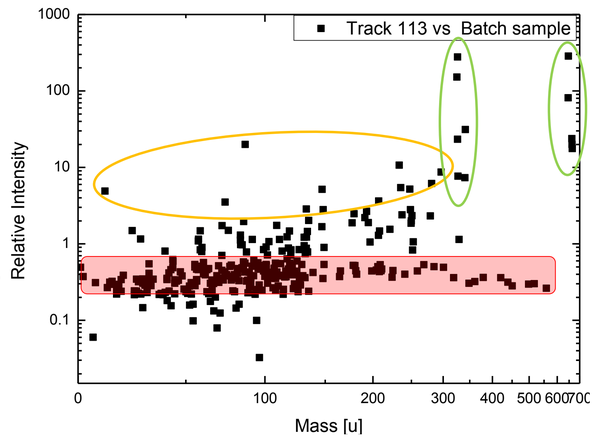
Results for track 154:



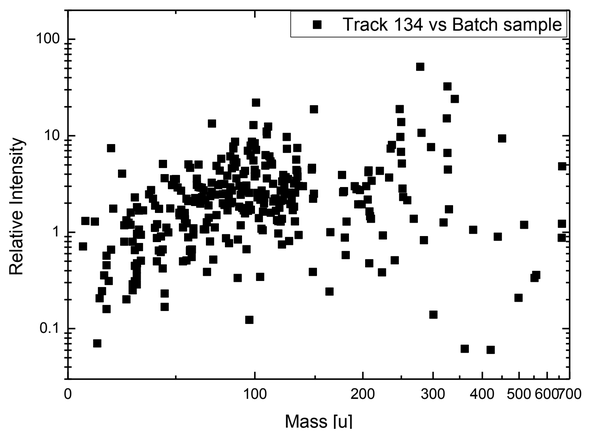
- Track 154 shows a very strong variation compared to the aerogel batch sample.
- The most significant peaks stem from PDMS (yellow circle) or the TEM-grid-wax (green circle)
- Indene and Naphthalene, which we found in the track area previously [6], are present in the aerogel batch sample already
- The large variation among the other peaks could stem from a very heterogeneous aerogel batch (E234)

Results for track 113:

- Track 113 shows the same contamination by PDMS and the TEM-grid-wax as track 154
- There is a bottom line (red area) which mainly stems from $Si_xO_yH_z$-clusters
- Peaks above the bottom line consist of SiO-clusters with attached hydrocarbons in the higher mass range and simple hydrocarbons in the lower mass range
- The aerogel tile stems from batch E236



Results for track 134:



- Track 113 was mounted differently and does not show the PDMS and wax contamination
- The scatter among the data points is similar to the previous two samples and similar to the scatter already seen in the comparison between the backside and batch sample
- The aerogel tile stems from the same batch E236 as the one above

Discussion:

- The most significant differences in tracks 154 and 113 stem from contaminations (PDMS & wax) which can be deconvoluted from any cometary contributions
- There is a significant amount of organic material already in the aerogel from production including O- and N-bearing compounds
  - Most of these seem to be bound to Si or SiO-clusters
- Previously found polycyclic aromatic hydrocarbons are already present in the aerogel batch sample
- The origin of elevated hydrocarbon contents in track 113 is unclear and could stem from the comet or be spacecraft/terrestrial contamination
  - So far no cometary organic material could be identified reliably

Acknowledgements:
We are thankful to STFC for the post for TH and NASA/JSC for supplying the samples.

References:
[1] Chyba C. and Sagan C. 1992. *Nature* 355:125-132. [2] Sandford S. A. et al. 2006. *Science* 314:1720-1724. [3] Kearsley A. T. et al. 2008. *Meteoritics & Planetary Science* 43:41-74. [4] Leitner J. et al. 2008. *Meteoritics & Planetary Science* 43:161-185. [5] Rost D. et al. 2011. *Meteoritics & Planetary Science* 46:A200. [6] Henkel T. et al. 2007. LPSC 2013, #2554. [7] Tsou P. et al. 2003. *J. of Geophys. Res.* 108(E10):8113. [8] Henkel T. et al. 2007. *Review of Scientific Instruments* 78:#055107.