

DOES CAPTURE IN AEROGEL CHANGE CARBONACEOUS RAMAN D AND G BANDS ? N.J. Foster^{1,2}, M.J. Burchell², A.J. Creighton², A.T. Kearsley³, and Stardust Organics PET.¹ nf40@kent.ac.uk, ²Centre for Astrophysics and Planetary Science, School of Physical Science, Univ. of Kent, Canterbury, Kent, CT2 7NH, United Kingdom, ³ Department of Mineralogy, The Natural History Museum, London, SW7 5BD, UK.

Introduction: Since the first demonstration of capture of hypervelocity particles [1] the use of aerogel to capture cosmic dust in space has become well established (see [2] for a recent review). The recent success of the NASA Stardust mission which returned cometary samples to Earth shows how fruitful this can be [3]. The particular advantage that capture and return of dust from space offers researchers lies in our ability to apply a full range of analytic tools in the laboratory to samples of known provenance. However, to obtain the full benefit from such analyses, any potential biases due to the capture method need to be understood and, if possible, corrected.

Raman and Organics: Raman spectroscopy has long been used to study the carbon content of samples, and this has been applied to dust from space since at least the early 1980s. The technique mostly relies on study of first order carbon D and G peaks, their peak position and width (and ratios thereof) to identify the presence of carbonaceous materials and to infer the history of the materials (i.e. how processed/dis-ordered is the carbon and what does that imply about the thermal history of the sample, etc.). Examples of analyses on interplanetary dust particles (IDPs) can be found in [4], meteorites in [5] and terrestrial samples in [6]. In parallel, laboratory tests have shown that Raman techniques can be used to identify the mineral [7] and organic [8, 9] content of small particles after their high speed capture in aerogel.

The Stardust mission has recently reported on studies of the organic content of dust particles captured from comet 81P/Wild 2 [10]. Raman analysis of the D and G bands for particles captured in 3 aerogel tracks was conducted, and it was found that the grains gave signals similar to the full range found with IDPs and meteorites. However, in [10] it was noted that this wide range of results could be attributable to either a large degree of heterogeneity amongst the samples or processing during capture in the aerogel.

To clarify this issue, we have carried out a range of laboratory studies looking at processing of organics in dust particles during capture in aerogel.

Method: Three meteorite samples were used in this study (Orgueil, Murchison and Allende). These were from samples provided from the collection of the Natural History Museum (London). Powdered samples of each meteorite (grain size 39 - 53 microns) were separately fired in a two stage light gas gun at the University of Kent [11] at speeds of typically 6.1 km s^{-1} (the Stardust cometary encounter speed). The targets were blocks of aerogel of density $28 - 29 \text{ kg m}^{-3}$. These blocks were not Stardust grade aerogels which had a density gradient from the front face of 5 kg m^{-3} , rising to 50 kg m^{-3} at the rear face. The density used here is thus intermediate between these two extremes. Several grains were captured in each shot.

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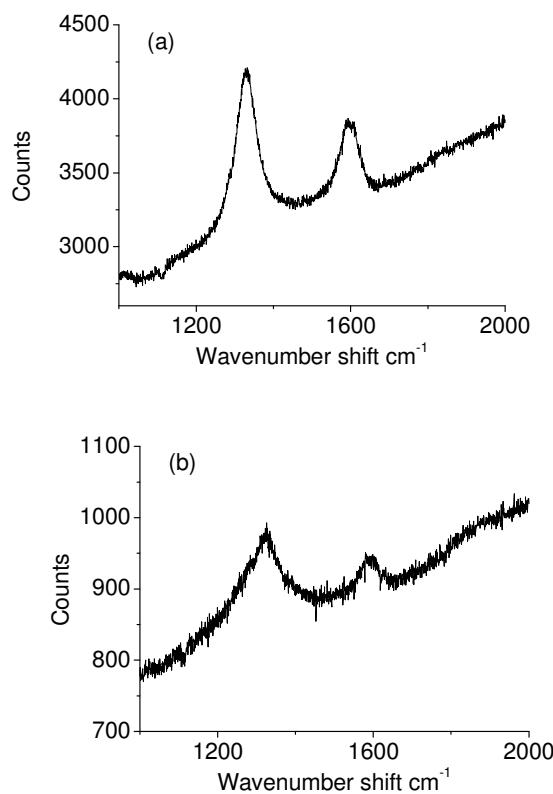


Figure 1: Raman spectra for Allende grains (a) raw grain, (b) after capture in aerogel

Raman Analysis: This was performed at the Univ. of Kent with a Jobin Yvon microRaman module attached to an Olympus microscope (BX40). The illuminating laser line was at 632.8 nm (HeNe). The spectrograph had a 1200 gr/mm grating. Data were taken on a LN₂ cooled CCD. For raw (unshot) grains the sample exposure times were typically 4x30 secs (x100 Mag). For grains measured in-situ after capture in aerogel, the illumination times were typically 8x30 sec (x50 Mag). Example spectra from Allende grains are shown in Fig. 1, with the D and G peaks at approx. 1350 and

1580 cm^{-1} respectively. After background subtraction, Gaussian curves were fit to each peak. Two programmes were used (Peaksolve and Origin) and gave compatible results. In addition, Lorentzian profiles were also fitted to the data and gave similar results for peak position and full width half maximum (FWHM). The spectra after capture in aerogel were obtained with the grains still in-situ in the aerogel.

Results: In Fig. 2 the mean and FWHM of the D and G bands for each sample are plotted.

D bands: For the D bands, in the raw grains there is a difference in peak position from Allende to Murchison to Orgueil ($1325 - 1370 - 1400\text{ cm}^{-1}$). After capture in aerogel the peak position is on average unchanged for Allende and Murchison, but shows a systematic shift to smaller values in the Orgueil sample. The FWHM varies from sample to sample in the raw grains. The low values for Allende are similar to those in [12]. After capture in aerogel, the Allende sample shows that some grains had spectra with FWHM comparable to that before, but that about half the grains had broader spectra, with in one case a peak almost 3 times wider than expected. The Murchison grains show a wider range of FWHM's, but no systematic shift has occurred. The Orgueil sample show the same range of FWHM before and after capture.

G Bands: The raw grains have a G band peak position at approx. 1585 cm^{-1} in both Murchison and Orgueil and 1595 cm^{-1} in Allende. The peak positon and FWHM for Murchison are compatible with those for carbonaceous chondrites (including Murchison samples) reported in [13]. After capture, the mean peak position in Murchison and Orgueil was unchanged, but that for Allende may have decreased slightly (at edge of statistical significance). The FWHM's were different for Allende, Murchison and Orgueil, but in each case the mean after aerogel capture was unchanged, although a larger spread was observed.

Conclusions: The range of D and G peak positions and FWHM is compatible with those reported in earlier work on meteorites and Stardust [10]. Some effects are evident due to the capture, but they are subtle and in most cases cause large scatter on the data rather than systematic shifts. The exception is the peak position for the D peak in Orgeuil, which undergoes a systematic shift to smaller wavenumbers.

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References: [1] Tsou P. et a. (1988) *LPS XIX*, 1205–1206. [2] Burchell M.J. et al. (2006) *Ann. Rev. Earth. Planet. Sci.* 34, 385 – 418. [3] Brownlee D. et al. (2006) *Science 314*, 1711 – 1716. [4] Wopenka B. (1988) *Earth and Planet Sci. Letts* 88, 221–231. [5]

Zinner E. et al. (1995) *Meteoritics* 30, 209–226. [6] Beyssac O. et al. (2003) *Spectrochimica Acta Part A* 59, 2267–2276. [7] Burchell M.J. et al. (2001) *Meteoritics and Planet. Sci.* 36, 209–221. [8] Burchell et al. (2004) *J. of Raman Spectroscopy* 35, 249– 253. [9] Burchell et al., (2006) *Meteoritics and Planet. Sci.* 41, 217–231. [10] Sandford S.A. et al. (2006) *Science* 314, 1720–1724. [11] Burchell et al. (1999) *Meas. Sci. Technol.* 10, 41–50. [12] Bonal et al. (2006) *Geochimica et Cosmochimica Acta* 70, 1849 – 1863. [13] Quirico E. et al. (2005) *Planetary & Space Science* 53, 1443 – 1448.

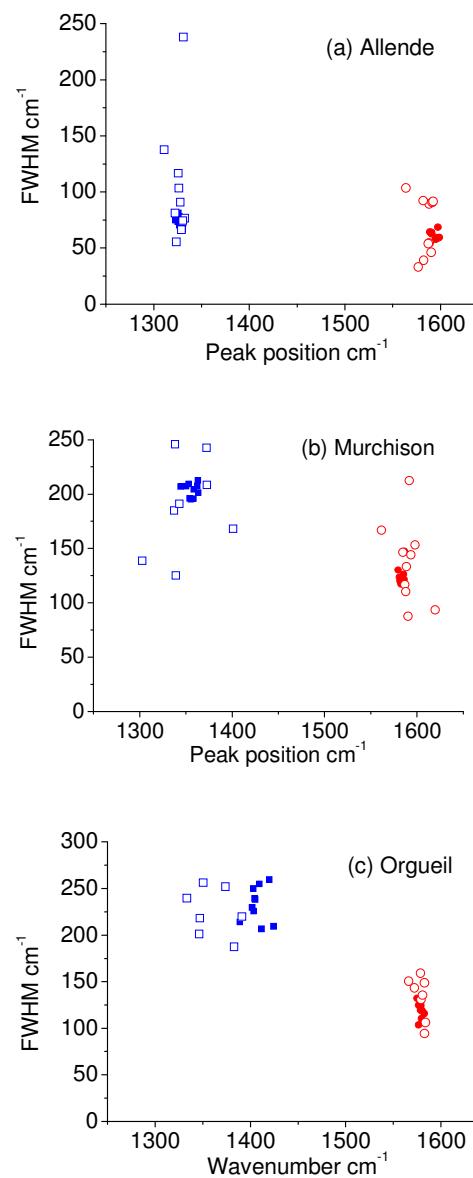


Figure 2: Peak position and width for Raman D (blue) and G (red) bands. Filled symbols are for raw grains, open symbols are for grains after capture in aerogel.