CHARACTERIZATION OF 81P/WILD 2 PARTICLES C2103,1,98,1,0, C2103,1,98,2,0, and C2065,1,97,1,0

Introduction: Analyses of cometary materials provide information about the inventories of carbon, nitrogen, and other elements in the regions where comets formed [1-3]. We report studies of three Stardust fragments made using nuclear reaction analysis (NRA) to measure C, N, O, and Si; FTIR to characterize organic matter; synchrotron-induced x-ray fluorescence (SXRF) to determine Fe and certain element/Fe ratios; and SEM/EDAX to image sample morphology. We also had three technical goals. 1) Previously we made blank corrections to C and N based on analyses of aerogel samples not flown on Stardust [4]. For this work, we obtained particle-free, Stardust aerogel from a portion of the cell that contained cometary particles studied by [4]. 2) To assess the compositional variability of possibly comet-like extraterrestrial material, we examined several grains taken from the CI chondrites Orgueil and Alais. 3) We undertook a study of grains of Illinois coal fired at high velocity into aerogel as possible analogs for captured Stardust grains.

Samples: L. Keller and K. Messenger extracted particles C2103,1,98,1,0 (C2103,1), C2103,1,98,2,0 (C2103,2) and C2065,1,97,1,0 (C2065). After FTIR analyses, the grains were pressed into high-purity indium foils. Fred Hörz furnished samples of newly made and thoroughly baked aerogel for bombardment with Illinois coal. The bombardment was done using a two stage light gas gun at the University of Kent. B. Zanda supplied samples of Alais and Orgueil. The instrumental methods used are described in [4].

Results: Aerogel blanks - Table 1 shows elemental concentrations of aerogel measured by NRA. Signals were stable over time, ruling out significant deposition of C and N during irradiation. The O/Si atom ratios exceed the expected value of 2.0 by ~25% as a result of unavoidable cross section and data processing uncertainties. The average concentration of C measured for a large scanned area (0.1 mm²) of C2054 is 5 wt%, 10× and 3× the values of 0.5 wt% from [5] and 1.4 wt% from [4], respectively. The newly made aerogel supplied by F. Hörz contains ~3.5 wt% C. Concentrations of N were below the detection limit, ~1×10⁹ atom N/μm² for an irradiation of 1 μC.

Stardust fragments - Figure 1 shows SEM/EDAX images of three Stardust fragments taken without C coating. Each fragment is ~10 μm across. No peaks from Fe or Ni were evident in the EDAX x-ray spectra. Only the EDAX x-ray spectrum of C2103,2 had a Mg K-α peak. Evidently, the samples are rich in aerogel.

Characteristic infrared absorptions resulting from CH and C=O stretches were observed in the FTIR spectra of all three Stardust fragments. The spectrum of C2065 shows the highest C-H/Si-O peak ratio. As the Si-O content is high, we infer that this fragment contains abundant organics. The spectrum of C2103,1 exhibits a comparable ratio. In comparison, C2103,2 has far weaker but readily detectable organic features.

Figure 2 shows carbon maps for the Stardust fragments. Like C21 [4], fragments 2103,2 and 2065 both contain large concentrations of elemental carbon, ~20 wt%; The C concentration of fragment 2103,1, 3.6 wt%, is below the C2054 blank level, 5 wt%. All fragments contained less than 0.5 wt% N.

Table 1. Atom fractions

<table>
<thead>
<tr>
<th></th>
<th>Si</th>
<th>O</th>
<th>C</th>
<th>N</th>
</tr>
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<tbody>
<tr>
<td>Aerogel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>0.27</td>
<td>0.67</td>
<td>0.055</td>
<td>&lt;0.005</td>
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<tr>
<td>C2054BL1</td>
<td>0.27</td>
<td>0.68</td>
<td>0.081</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>C2054BL2</td>
<td>0.27</td>
<td>0.68</td>
<td>0.081</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>C2054BL3</td>
<td>0.27</td>
<td>0.68</td>
<td>0.081</td>
<td>&lt;0.005</td>
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<tr>
<td>Stardust</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>C2103,1</td>
<td>0.27</td>
<td>0.67</td>
<td>0.057</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>C2103,2</td>
<td>0.28</td>
<td>0.45</td>
<td>0.31</td>
<td>~0.005</td>
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<tr>
<td>C2065</td>
<td>0.20</td>
<td>0.49</td>
<td>0.30</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

Figure 3 shows CI-normalized elemental ratios from SXRF. For comparison, means and 1-σ confidence limits are plotted for several whole tracks [6,7]; the ranges of the many individual analyses taken along these tracks are larger than the 1-σ limits.
**Discussion:** The 3 Stardust fragments analyzed contain compressed or partially melted aerogel and must be associated with the capture of Wild 2 material. The Ni concentrations of C2065a, C2065b, C2103.1 and C2103.2 show the presence of cometary material. Remarkably, none of the new fragments contains detectable nitrogen. Although C concentrations in ultra-thin sections of Stardust fragments vary widely sub micron scale [10], C/N atom ratios for 8 organic-rich samples occupy a narrow range, from 4 to 14 [11]. The new, high C/N ratios of Stardust fragments implied in Table 1 may be artifacts of the aerogel capture process, resulting perhaps from the processing of organic carbon present in the aerogel.

**Conclusions:** Some particle-free aerogel used to capture Stardust particles contains 5 wt% C, about 10 times the expected value [5]. Either carbon concentrations in the flight aerogel varied from place to place or the aerogel picked up additional carbon over time. Stardust fragments C2103.2 and C2065 contain high concentrations of C, but no detectable N. Such high concentrations of C are uncommon in micrometeorites. Detailed petrography of a carbon-rich Stardust fragment would be desirable. A shot of Illinois coal fired into high-purity aerogel produced a track with no detectable terminal particles. The coal may have disaggregated to submicron, carbon-rich grains and/or vaporized during deceleration. Vaporization would be consistent with observations of labile organics in the Stardust samples [12]. Analyses of random grains of CI chondrites agree well enough with accepted CI abundances to suggest that 15-20 random analyses of C and N in ‘bulk’ Stardust grains will give representative results.


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**Figure 3**

**Figure 4**

**Figure 5**

**References:**