

A PRELIMINARY ASSESSMENT OF THE ORGANIC CONTENT OF INTERPLANETARY DUST PARTICLES. G. J. Flynn,¹ L. P. Keller,² S. Wirick³ and C. Jacobsen³ ¹Dept. of Physics, SUNY-Plattsburgh, 101 Broad St., Plattsburgh, NY 12901 (george.flynn@plattsburgh.edu), ²NASA Johnson Space Center, Houston, TX 77051, ³Dept. of Physics, SUNY-Stony Brook, Stony Brook, NY 11794.

Introduction: Interplanetary dust particles (IDPs) collected from the Earth's stratosphere by NASA have been shown to contain significant quantities of organic matter [1]. Anders [2] suggested that organic matter contributed by IDPs to the surface of the Earth may have been important for the origin of life. As part of our ongoing effort to characterize the organic carbon in IDPs, we have now compared the absorption strengths of organic features in IDPs to their strengths in meteorites and standards to estimate the concentration of each organic functional group in IDPs.

Samples: We performed C-XANES spectroscopy on the carbon-rich areas of 13 IDPs, 8 anhydrous and 5 hydrated. We performed FTIR spectroscopy on 19 IDPs, including 14 anhydrous IDPs and 5 hydrated IDPs, 6 of which were also analyzed by C-XANES.

Results: We previously detected the carbon-ring and carbonyl (C=O) functional groups in IDPs using carbon X-ray Absorption Near-Edge Structure (XANES) spectroscopy and the aliphatic C-H₂ and C-H₃ functional groups by Fourier Transform InfraRed (FTIR) spectroscopy [1].

C-XANES Examination. The C-XANES spectra of an anhydrous IDP, a hydrated IDP, and a carbon-rich spot on an ultramicrotome section of the carbonaceous chondrite meteorite Murchison are shown in Figure 1. Each of these C-XANES spectra shows two strong absorptions:

- 1) at ~285 eV, characteristic of the C-ring, and,
- 2) at ~288.5 eV, characteristic of the C=O bond.

The C-ring structure occurs in both elemental (graphitic or amorphous) carbon and organic carbon (e.g., PAHs). *The detection of the carbonyl absorption indicates that the IDPs contain some organic carbon.*

Carbonyl Abundance. The height of the C-edge, i.e., the increase in absorption from 282 to 300 eV, is a measure of the total mass of carbon in the analysis beam while the area of the C=O absorption is proportional to the abundance of that functional group. Thus, in each sample, the ratio of the C=O area to the C-edge height is proportional to the fraction of the total carbon that is present in the C=O functional group. Table 1 shows the C=O area/C-edge height for the 13 IDPs and Murchison samples. By comparing the area of the C=O absorption peak to the height of the C-edge, we estimate that the anhydrous and the hydrated IDPs each have, on average, about the same C=O to total carbon and that this is also comparable to our bulk Murchison sample but about twice that of the

Murchison acid residue. Nuclear magnetic resonance analysis of the acid insoluble organic extract from Murchison indicates that it contains about 9 wt-% carbonyl [3]. Since the mean IDP carbon content is ~12 wt-% [4], we estimate that at least ~1 to 2% of the total particle mass is bound in the C=O functional group.

FTIR Examination. Most of the IDPs examined to date show large silicate absorptions (consistent with the mineralogy of IDPs examined by analytical TEM), and much smaller absorptions consistent with the C-H₂ and C-H₃ stretching vibrations of aliphatic hydrocarbons. These aliphatic stretching features are quite distinct from the single, large C-H₃ absorption of the silicone oil in which the IDPs are collected.

Aliphatic Hydrocarbon Abundance: We prepared a mixture of 1% paraffin and 99% clay, for comparison with the hydrated IDPs. Since silicate is the major phase in most IDPs, we scaled the IDP spectra to equal depths of the 10 μm silicate absorption, and then compared the depth of the aliphatic absorption. Because of the possibility of a contribution from silicone oil to the C-H₃ absorption, Table 2 shows the depth of the C-H₂ absorption, relative to an Si-O absorption depth of 1, for the hydrated and the anhydrous IDPs. The depth of the Si-O scaled C-H₂ absorption feature varies by about an order of magnitude among the particles, suggesting that (if the silicate content of the particles is similar) the aliphatic hydrocarbon content is highly variable from one IDP to the next.

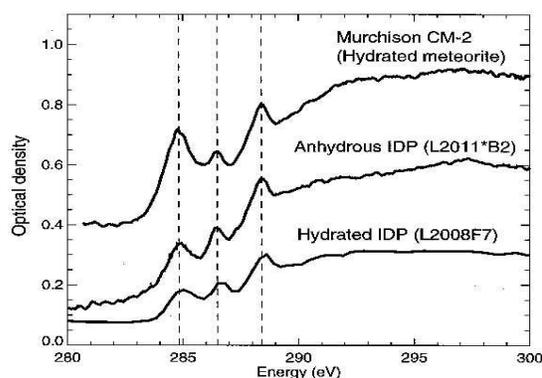


Figure 1: C-XANES spectra of the carbon-rich regions of two IDPs, one hydrated and the other anhydrous compared to the Murchison carbonaceous meteorite.

Table 1
Peak Heights in C-XANES Spectra

Sample	C=O Area C-edge Height
<i>Anhydrous IDPs</i>	
L2011R11	2.03
L2005*A3	1.46
L2009D11	5.71
L2009H9	3.84
L2008G12	1.48
L2009E6	5.94
L2011B6	5.65
L2011*B2	2.23
<i>Average Anhydrous IDPs</i>	3.54
<i>Hydrated IDPs</i>	
L2009H11	2.46
L2008U13	2.05
L2008R15	4.20
L2009J5	1.79
L2008F7	5.47
<i>Average Hydrated IDPs</i>	3.19
<i>Murchison (CM2)</i>	
Microtome Section	4.36
<u>Acid Residue</u>	<u>1.43</u>

Comparison of the hydrated IDPs to the mixture of clay and paraffin is straightforward because the silicate absorption feature is similar in both. Four of the five hydrated IDPs show an aliphatic C-H₂ absorption depth greater than that of the 1% paraffin - 99% clay mixture, indicating the hydrated IDPs contain aliphatic hydrocarbons at the percent-level.

We are in the process of measuring paraffin-olivine and paraffin-pyroxene mixtures for comparison with the anhydrous IDPs. However, in the raw spectra the aliphatic hydrocarbon absorption features are, on average, roughly similar in depth to those in the hydrated IDPs, indicating that the anhydrous IDPs also contain aliphatic hydrocarbon at the percent-level.

Conclusions: Comparison of the C=O absorption measured by C-XANES with that in Murchison acid residue suggests that, on average, both the anhydrous and the hydrated IDPs contain percent-level carbonyl. Comparison of the depth of the aliphatic C-H₂ absorption to that in mixtures of paraffin and clay demonstrates that, on average, the hydrated IDPs contain aliphatic hydrocarbon at the percent-level, and the anhydrous IDPs seem to be similar. Thus, the C=O and aliphatic hydrocarbon functional groups together constitute several percent of the total mass of IDPs, and other organic functional groups can only increase the organic content of IDPs.

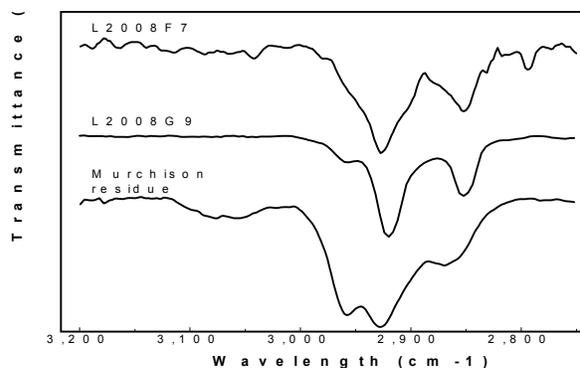


Figure 2: FTIR spectra in the C-H stretching region of a hydrated IDP, L2008F7, an anhydrous IDP, L2008G9, and Murchison acid residue.

Table 2:
C-H₂ Absorption Depths in IDPs

Sample	C-H ₂ Depth (for Si-O Depth =1)
<i>Anhydrous IDPs</i>	
L2021C4	0.10
L2036I18	0.28
L2021D10	0.25
L2008V42A	0.03
L2008G9	0.32
L2009J4	0.31
L2011*B2	0.04
L2008G12	0.17
L2008H9	0.13
L2011R11	0.05
L2011*B5	0.32
<i>Average Anhydrous IDPs</i>	0.18
<i>Hydrated IDPs</i>	
L2008F16	0.16
L2021C10	0.09
L2008U13	0.04
L2009H11	0.01
L2008F7	0.21
<i>Average Hydrated IDPs</i>	0.10
<i>Standard Mixture</i>	
<u>1% paraffin and 99% clay</u>	<u>0.035</u>

References: [1] Flynn, G. J., L. P. Keller, S. Wirick and C. Jacobsen (2000) in *A New Era in Bioastronomy*, ASP Conf. Series, **V. 213**, 191-194. [2] Anders, E. (1989) *Nature*, **342**, 255-257. [3] Cody, G. D., C. M. O. Alexander, and F. Tera (2002) *Geochim. Cosmochim. Acta*, **66**, 1851-1865. [4] Thomas, K. L., L. P. Keller, G. E. Blanford, and D. S. McKay (1994) in *Analysis of Interplanetary Dust*, AIP Conf. Proc., **V. 310**, 165-174.