Abstract No. Flyn0290

Infrared Analysis of Interplanetary Dust Particles: Identification of Carbonyl

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Beamline(s): U10B

Introduction: Interplanetary dust particles (IDPs), which are ~5 to 50 μm fragments from comets and asteroids, may have contributed a layer of pre-biotic organic matter, important for the development of life, to the surface of the early Earth [1]. The small mass (~1 ng) and low organic content (a few percent) makes it impossible to characterize the organic matter in IDPs by traditional laboratory techniques. We are assessing the types and abundance of organic carbon in IDPs by Fourier Transform InfraRed (FTIR) spectroscopy at beamline U10B and by carbon X-Ray Absorption Near-Edge Structure (XANES) spectroscopy at beamline X1A of the NSLS to determine the types and amount of organic carbon contributed to the early Earth by IDPs and to determine the origin of the organic matter in IDPs and meteorites. Flynn, Keller, and Miller [2] employed infrared spectroscopy, performed at beamlines U4IR and U10B of the NSLS, to detect the $C\text{-}H_2$ and $C\text{-}H_3$ stretching absorptions of aliphatic hydrocarbons in IDPs. However, in this earlier work, they were unable to detect important O and N functional groups because of interferences from the absorption features from water, and the major minerals in the IDPs (silicates, oxides, and carbonate), which obscure the weaker features from minor organic compounds.

Methods and Materials: Brownlee and co-workers [3] have developed an acid-etching technique that removes the silicates, carbonates and most oxides from the IDPs, leaving the acid-insoluble, organic-rich residue from the IDP. FTIR examination of this acid residue should allow detection of important organic features: the carbonyl absorption near 1700 cm^{-1}, PAH absorptions, and N functional groups. We have examined the acid residue from an anhydrous IDP, U2-20GCA, a hydrated IDP, W7030A-3B, and two carbonaceous meteorites, Murchison and Orgueil, as well as the silicone oil in which NASA collects the IDPs.

Results: We had detected the carbonyl (C=O) functional group in most IDPs examined by carbon XANES spectroscopy, but the XANES analyses had insufficient energy resolution to convincingly identify how the carbonyl was bonded. Figure 1 shows the infrared spectra of the five samples over the 2200 to 800 cm^{-1} range, Both IDPs show a carbonyl absorption between 1700 and 1720 cm^{-1}, consistent with a feature seen in the Murchison meteorite acid residue, indicating carbonyl bonded in a ketone. The anhydrous IDP shows a second absorption near 1770 cm^{-1}, consistent with a feature seen in the Orgueil meteorite acid residue, indicating carbonyl bonded in an ester. We also detected an absorption feature near 1575 cm^{-1}, consistent with N=O in an aliphatic hydrocarbon, in the anhydrous IDP but not in the hydrated IDP.

Conclusions: This result confirms our identification of carbonyl, an important organic building block, in IDPs using C- and O-XANES, and extends those results by determining how the carbonyl is bonded in the IDPs. We are examining other absorption features detected in the acid-etched IDPs to identify organic functional groups.

Acknowledgments: This work was supported by a NASA Exobiology research grant.

References: [1] E. Anders (1989) *Nature*, 342, 255-257. [2] Flynn, G. J. et al. (1998) *Lunar & Planetary Science XXIX*, Abs. #1157. [3] D. E. Brownlee et al. (2000) *Lunar & Planetary Science XXXI*, Abs. #1921.

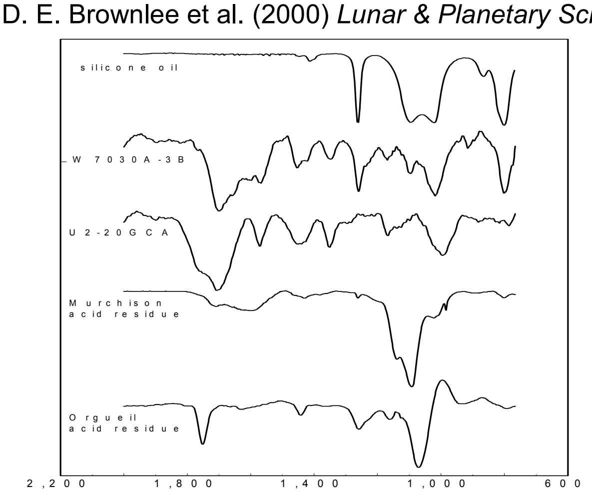

Figure 1: Infrared spectra of silicone oil, and the acid residue from two IDPs and two meteorites.