FTIR ANALYSES OF IDPS: COMPARISON WITH THE INFRARED SPECTRA OF THE INTERSTELLAR MEDIUM.

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1 Introduction

Interplanetary dust particles (IDPs) are extraterrestrial particles collected in the stratosphere by the high-altitude aircrafts of the collection facility established by NASA. These particles are composed of different mineral phases and by a carbonaceous material frequently forming the matrix where are distributed the mineral grains [1].

Several infrared investigations of IDPs and the comparison of their spectra to infrared astrophysical data have been done in the past [2], [3], including infrared investigation of the carbonaceous matter [4] and the silicate component [2].

Flynn et al [4] put in evidence the presence of aliphatic hydrocarbons and of a ketone group in IDPs, by detecting with FTIR the CH_2, CH_3 and C=O functional groups. Bradley et al [3] compared the infrared spectrum of glassy (GEMS) silicates to the broad 9.5 μm feature of the interstellar silicate and found there is a good match. Furthermore, Bradley et al [3] compared the infrared signature of the crystalline small silicates embedded in the GEMS to the 10 μm feature observed in the dust of the coma of comets Halley and Hale-Bopp and found again a good match. On the other hand, Keller et al [5] found a good match between pyrrhotite, a common sulfide in IDPs, and the 23.5 μm feature observed in the dust of cold clouds of the circumstellar environment.

In this work we investigate the aliphatic functional groups CH_2, CH_3 in the spectral region around 3000 cm^{-1} of several IDPs, using micro Fourier Transformed Infrared (FTIR). Then, we compare the bands observed in the IDPs with the bands observed in similar spectral regions of the Diffuse Interstellar Medium (DISM).

2 Samples and Methods

We analyzed 8 IDPs. Four of them were provided by the NASA-JSC curation facility. The remaining four were extracted from one of the collectors carried by the NASA aircrafts, the collector W7116. The collector was examined under an optical microscope in a laminar flow 10 000 class clean room. Black particles were removed using glass needles and paint brush hairs mounted in a micromanipulator. The particles were cleaned with hexane several times in order to remove the excess of silicon oil and then transfered to a mount to be further characterized by Scanning Transmission Microscopy (SEM). Energy-Dispersive X-ray (EDX) analyses were performed in each particle. The EDX data were used to select chondritic particles, since it has been determined that all stratospheric particles satisfying the chondritic composition criteria are extraterrestrial [2,3].

IDPs are dominated by silicates, which present bands in the IR that in some regions interfere with some of the organic bands. In order to diminish such interferences we have developed an etching technique at the micro-scale that removes all the silicates *in situ*, preserving the acid-insoluble organic matter. This technique, which is based in the hydrolysis by hydrofluoric acid (HF), is based in the technique used to prepare acid insoluble organic residues from meteorites (such as it has been done in Orgueil or Murchison [6], and quite similar to the technique used at micro-scale by [7] for the analysis of organics in IDPs, developed by Brownlee et al [8]. However, the main difference with the latter is that in our procedure we perform the etching *in situ* and over the entire particle, allowing therefore the analysis of the organics present in the whole volume of the particle.

The particles were crushed in a KRS-5 window, which is transparent to infrared radiation and does not dissolve with the HF. A first FTIR analysis was performed in each sample to determine the kind of silicates present in the particle and therefore its type. Then, each particle was exposed for a few hours to a micro-drop of distilled hydrofluoric acid.

3 FTIR Examination

We used Fourier Transform InfraRed spectroscopy, using a Nicolet Magna-IR 560 ESP spectrometer coupled to a Nicolet Nicplan infra-red microscope, in line with a Synchrotron Radiation Source located on line SA5 at the *Laboratoire pour l'Utilisation du Rayonnement Electromagnétique* (LURE) at the University of Paris-Sud, Orsay, France. In order to enhance the signal to noise ratio and minimize background fluctuations due to variations in the purge, 25 acquisitions of 256 scans each at the resolution of 2 cm^{-1} were made for each sample and then averaged.

We have analyzed the residue after HF treatment of all the IDPs studied and found that most of them present features in three main regions: 2800-3000 cm^{-1} typical of the CH_2 and CH_3 symmetric and asymmetric stretch vibrations of aliphatic chains; the 1500-1750 cm^{-1} typical of the COO^- antisymmetric stretch and the C=O carbonyl group; and the 3100-3600 cm^{-1} (centered at 3250) typical of the OH stretch vibration in carboxylic acids.

We have focused our interest in the 2800-3000 cm^{-1} region which is present in all but one IDP out of the 8 studied during this work. In this region four peaks are clearly present at: 2850 cm^{-1} (characteristic of the CH_2 symmetric stretch), 2865 cm^{-1} (characteristic of the CH_3 symmetric stretch), 2922 cm^{-1} (characteristic of the CH_2 asymmetric stretch), and 2958 cm^{-1} (characteristic of the CH_3 asymmetric) of the aliphatic chains. In particular, we are interested in the comparison of this region to the same region also observed in the Diffuse Interstellar Medium (DISM). Several IR observations exist on the DISM. In this study we have worked with those performed with the Infrared Space Observatory (ISO) and have chose one representative spectrum, corresponding to the IRS 7 source.

In Fig 1 is shown a typical IR spectrum of one IDP residue after HF treatment, in the region 2800-3000 cm^{-1} and its comparison to the IRS 7 source IR spectrum.

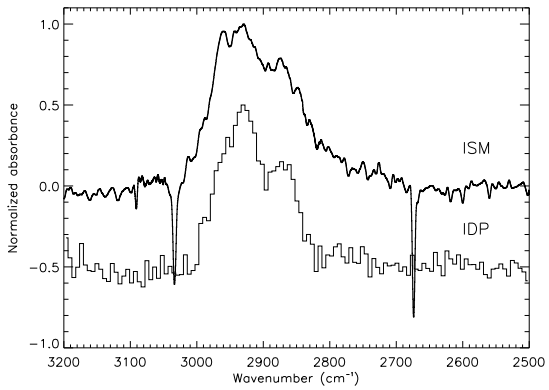

Figure 1: A comparison of the 3.4 μm region (2800-3000 cm^{-1}) of the IRS 7 source to the post HF residue of one IDP. The IRS 7 source spectrum has been obtained from the Infrared Space Observatory (ISO) Data Center.

From this comparison several remarks can be done: i) the spectra are different. ii) the four peaks are present in both objects, but in different proportions. iii) in the IRS 7 source the CH_3 peaks are higher than in the IDP, where the CH_2 peaks are prominent related to the CH_3 peaks. This suggests that the organic material present in these IDPs have longer aliphatic chains than the organic material observed in the DISM. Therefore, the organic material in the DISM is more branched and the organic material present in these IDPs is more linear.

Some IDPs also show a peak around 1700 cm^{-1}, that is attributed to the carbonyl stretch. This carbonyl group can be attributed to either a ketone or a carboxylic acid.

It could be argued that some of the organic peaks observed during these analyses are indeed contamination that could come from several sources: silicon oil, hexane used to cleaned it, the KRS-5 window, the terrestrial atmosphere. In order to investigate the possibility of contamination, we conducted analyses in several materials that we have used as blanks, to prove our methodology: i) spectra on KRS-5 but a few particle-diameters off the particle, generally on the opposite side from the region where the background was taken, and ratioed these to the original background. ii) silicon oil extracted from the same collector from where the particles where extracted. iii) a drop of hexane which rapidly evaporated. iv) as a final test, we have analysed two particles classified as terrestrial after their EDX spectrum. These particles were taken from the same collector where the IDPs were taken and they were prepared (cleaning, handling, hydrolysis, analysis) in the same manner as the IDPs. None of these materials presented features in the regions of interested, corroborating therefore that the carbonaceous organic material observed in the IDPs studied is indigenous of the IDPs.

4 Conclusions

The results obtained so far during this study show that the organic material present in these IDPs is different from the one observed in the DISM. In the past, comparisons such as this one made between the DISM and the acid-residue of meteorites was done for Murchison and Orgueil [9] and [10]. This comparison showed that the region around 3000 cm^{-1} of both meteorites and the DISM is quite similar, suggesting therefore that the carbonaceous material present in these meteorites was formed in the DISM. The present results and the comparison of the HF residue of some IDPs to the DISM show the opposite: the organic material between both types of objects is different, suggesting therefore that the organics present in IDPs were formed in a different environment of the DISM, or that this organic material in IDPs was reprocessed. Calculations of the ratio CH_2/CH_3 in these IDPs for its further comparison to the 2.5 ratio in the DISM are currently in process.

5 References

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