**RELATIONSHIP BETWEEN ORGANICS AND SILICATES IN INTERPLANETARY DUST PARTICLES**

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**Introduction:** Interplanetary Dust Particles (IDPs) constitute, with the meteorites and micrometeorites, the most pristine samples originating from asteroids and comets available at the laboratory. They are mostly composed of silicates (olivine, pyroxene and layer lattice silicates) and organics [1], [2], [3]. These two major components give precious information on the origin of the IDPs [4] and on the irradiation and thermal processes they have suffered [5], [6].

We present here a systematic study carried on 10 anhydrous IDPs. In order to infer their origin and the alteration they underwent, we quantify through infrared micro-spectroscopy their silicate composition (using the 10 µm band) and we determine the length of the aliphatic chains in their organic components using their signature at 3.4 µm. We also investigate their aromatic components, sensitive to the thermal metamorphism and/or irradiation processes the IDPs have suffered [7], through Raman micro-spectroscopy.

This work, which follows the previous analyses performed on 4 IDPs [8], confirms the link between the length of the aliphatic chains and the silicate composition.

**Experiments:** We crushed the IDPs in diamond compression cells following the protocol of [9]. Transmission infrared micro-spectroscopy was performed on the SMIS beamline of the french synchrotron SOLEIL using a NicPlan microscope attached to a Fourier Transform infrared spectrometer (FTIR).

Raman spectra were acquired at SOLEIL with a spectrometer DXR from Thermo Fisher with a 532 nm laser.

**Procedure:** We applied the procedure described in [10] to determine the olivine/(olivine+pyroxene) ratio, noted "R" in the followings, for each anhydrous IDP using its mid-infrared spectrum. The ratio R gives the silicate composition of the IDP, R=0 is obtained for a 100% pyroxene composition whereas, R=1 indicates a 100% olivine composition. The length of the chains of the aliphatic component in the IDPs is determined by deconvolving the 3.4 µm infrared band with 5 gaussians (4 bands for the $CH_2$ and $CH_3$ symmetric and asymmetric stretching modes, and a fifth band that might be due to a Fermi Resonance (see [11]). The position, Full Width at Half Maximum (FWHM) and area of each band is obtained by minimizing the $\chi^2$ value during the deconvolution procedure. We deduce the $CH_2/CH_3$ ratio by using the $CH_2$ and $CH_3$ asymmetric mode to determine from their aera and the associated band strengths, the column density for each group ($CH_2$ and $CH_3$).

For each IDP, the caracteristics (positions, FWHM and intensities) of the Raman spectral features of the aromatic organic components, the so-called D and G bands, have been determined by fitting them with a 2 lorentzian bands model.

**Results and discussion:** Figure 1 gives typical infrared spectra of an olivine-rich IDP (upper spectum), and a pyroxene-rich IDP (lower spectrum). The caracteristics of each studied IDP, i.e. its $(CH_2/CH_3)_{asym}$ and olivine/(olivine+pyroxene) ratios (noted R) are given in table 1. One can note that the olivine-rich IDPs (i.e. L2036 AE4, L2071 E36 and L2021 Q3) have the longest aliphatic chains ($CH_2/CH_3$ = 5.5 in average) whereas the pyroxene-rich IDPs (i.e. L2021 D7, L2076 H1, L2036 AG1, L2036 AE3 and L2079 J1) have the shortest ones ($CH_2/CH_3$ = 3 in average). Note also that the IDPs with intermediate silicate compositions (i.e. L2021 C5 and L2083 E15) have their $CH_2/CH_3$ ratio intermediate to the value obtained for the two distinct families. This correlation could be due to thermal metamorphism: the olivine-rich IDPs assumed to originate from asteroids [4] and to be formed in the innermost part of the protoplanetary disk [12], have probably suffered a more important thermal metamorphism than pyroxene-rich IDPs (originating from comets) supposed to be formed in the outer disk. Muñoz-Caro et al. [6] showed that thermal metamorphism tends to destroy the aliphatic chains in favor of aromatics, this contradicts our observations that the longest hydrocarbon chains are associated with olivines (formed in the hotest regions) and the shortest chains are found with pyroxenes (originating from comets: cold parent body). Moreover, the comparison of the Raman G-band parameters of our IDPs does not show any correlation between thermal metamorphism and the silicate composition. This implies that other processes have to be invoked to explain the link between aliphatics chain lengths and the nature of the silicates in the IDPs, found here. This kind of contradiction has been previously observed in the Stardust samples where CAIs (refractory inclusions) where found in the cometary grains, note also the presence of olivine in the cometary stardust grains [13]. To explain the coexistence of hot and cold components in the same parent body large scale mixing in the protoplanetary disk is invoked. This mecanism could not explain our findings reported here, given that olivines (and/or pyroxenes) from both asteroids and comets are sampled, we should observe a homogeneous range of $CH_2/CH_3$ values whatever the silicate composition.

Finally, the fourth column of table 1 shows that there is no link between the amount of organics in an IDP and its silicate composition. This seems to indicate that the nature of the silicates plays a role on the nature of the organics (maybe during their formation on the silicate surface) but probably not on their quantity.

**Conclusion:** We report here a remarkable close link between the mineralogical composition and the length of the aliphatics chains on ten IDPs. Taking into account the Raman results we obtained, we showed that this relationship can not be explained by thermal metamorphism. We are now investigating the role of the nature of silicates in the photochemistry of ices and we plan to study the condensation of organics by Fischer-Tropsch type reactions on different type of silicates. This last mecanism will be studied using PRONEXT a new experiment developed in our laboratory which allows the study of gas-grain interactions and their kinetics in a "protoplanetary disk-like" environment.

**References:** [1] Sandford S.A. et al. (1985) *ApJ* 291, 838-851. [2] Messenger S. (2002) *Planetary Space Science* 50, 1221-1225. [3] Swamy K. (2005) *Word Scientific Publishing*. [4] Sandford S.A. et al. (1989) *Icarus* 82, 146-166. [5] Goto M. et al. (2003) *ApJ* 589, 419-429. [6] Muñoz-Caro G.M. et al. (2006) *A&A* 459, 147-159. [7] Busemann H. et al. (2007) *Meteoritics and Planetary Science* 42, 1387-1416. [8] Merouane S. et al. (2012) *LPI Tecnhical Report* 43, 1777. [9] Brunetto R. et al. (2011) *Icarus* 212, 896-910. [10] Merouane S. et al. (2011) *Meteoritics and Planetary Science Supplement* 74, 5146. [11] Dartois et al. (2005) *A&A* 432, 895-908. [12] Gail H.P. (2010) *Lect. Notes Phys.* 815, 61-141. [13] Zolensky M. et al. (2006) *Science* 314, 1735-1739.

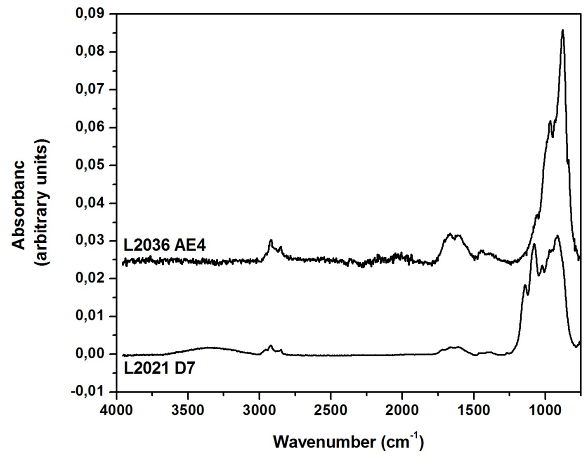


**Fig.1**. Typical IR spectrum of an olivine-rich IDP (L2036 AE4, upper spectrum) and of a pyroxene-rich IDP (L2021 D7, lower spectrum).

| IDP reference | R | $CH_2/CH_3$ | $N_{aliphatics}/N_{SiO}$ |
|---|---|---|---|
| L2036 AE4 | 1.00 ± 0.05 | 5.2 ± 0.8 | 0.14 |
| L2071 E36 | 1.00 ± 0.05 | 6.1 ± 0.9 | 0.062 |
| L2021 Q3 | 0.95 ± 0.05 | 5.7 ± 0.7 | 1.04 |
| L2021 C5 | 0.7 ± 0.05 | 3.9 ± 0.3 | 0.067 |
| L2083 E15 | 0.55 ± 0.05 | 3.5 ± 0.5 | 0.14 |
| L2079 J1 | 0.25 ± 0.05 | 3.3 ± 0.3 | 0.13 |
| L2036 AE3 | 0.15 ± 0.05 | 3.2 ± 0.2 | 0.23 |
| L2036 AG1 | 0.10 ± 0.05 | 3.3 ± 0.2 | 0.28 |
| L2076 H1 | 0.10 ± 0.05 | 2.7 ± 0.2 | 0.094 |
| L2021 D7 | 0.05 ± 0.05 | 2.7 ± 0.3 | 0.059 |

**Tab. 1.** The silicate composition is given by the Olivine/(Olivine+Pyroxene) ratio, noted R. The lengths of the aliphatic chains are given by the $CH_2/CH_3$ ratio deduced from the assymetric stretching mode of the aliphatics. The $N_{aliphatics}/N_{SiO}$ ratio gives the amount of aliphatic organics compared to silicates. The amount of each component given by its column density N is obtained by dividing the area of its corresponding IR band (the 3.4 µm band for the aliphatics and 10 µm band for the slicates) by its band strengths (8.4 x $10^{-18}$ cm.group$^{-1}$ for the assymetric stretching of $CH_2$, 1.25 x $10^{-17}$ cm.group$^{-1}$ for the assymetric stretching of $CH_3$ and 2 x $10^{-16}$ cm.group$^{-1}$ for the Si-O stretching). Note that the IR data for IDP L2021 C5 are derived from [9].