INTERPLANETARY DUST PARTICLES: ORGANIC MATTER STUDIED BY RAMAN SPECTROSCOPY AND LASER INDUCED FLUORESCENCE. L. Bonal¹, E. Quirico¹, G. Montagnac² and B. Reynard² ¹Laboratoire de Planétologie de Grenoble, Université Joseph Fourier Bât. D de Physique 38041 Grenoble Cedex 9 FRANCE (mailto: lydie.bonal@obs.ujf-grenoble.fr), ²Laboratoire de Sciences de la Terre, ENS Lyon, 46, allée d’Italie, 69007 Lyon FRANCE.

Introduction: We are developing a micro-manipulation line and a spectroscopic method for providing chemical imagery data on Organic Matter (OM) trapped in micrometric grains (Interplanetary Dust Particles, matrix grains extracted from pristine chondrites, STARDUST samples, etc.) The general framework of our approach is based on the complementarity of Multi Wavelength Raman spectroscopy (including the 244 nm UV excitation), and of Laser-Induced Fluorescence (LIF). We report in this abstract preliminary results obtained on 5 IDPs, which were studied in situ in silicon oil prior extraction. The study will be extended to 15 other IDPs.

Samples and experiments: A set of 5 stratospheric IDPs from NASA collector L2008 had been provided to us by the JSC Astromaterials Curation Center: L2008X1 cluster#3, L2008X2 cluster#4, L2008X3 cluster#8, L2008X4 cluster#9, L2008X5 cluster#11. Preliminary results have been obtained without any preparation of the samples. Raman and fluorescence spectra have been obtained through the glass slide (components at ~490 cm⁻¹, ~570 cm⁻¹ and 1080 cm⁻¹) and silicon oil (characterised by narrow bands at ~2905 cm⁻¹, 2964 cm⁻¹).

Raman experiments and LIF measurements were performed at Laboratoire de Sciences de la Terre (ENS-Lyon, France) using a Raman spectrometer (Labram HR800, Jobin Yvon) coupled to an argon ion and helium-neon lasers (457.9, 514.5 and 632.8 nm excitations). Raman spectra have been acquired using a single wavelength excitation source at 514.5nm of a Spectra Physics Ar⁺ laser. Power at the sample surface was ~ 100µW. Typical time irradiation was 270 seconds. To record the luminescence signal a 150 l/mm grating was used. The covered spectral range was 400-1000 nm. Photo-instability of the materials due to chemical reactions with atmospheric oxygen induces large variations of the intensity of the fluorescence signal [1]. Therefore, experiments were carried out under an inert atmosphere (Ar) in a dedicated cell. In that manner, the signal was relatively stable and the individual subscans were stitched together without applying a gain factor. Laser Induced Fluorescence is a non-destructive technique, as long as the photon flow is sufficiently low. Thus, care was taken to irradiate the sample with low power fluxes (typically 100µW on the surface), to prevent modifications of the structure.

Preliminary results: Among the studied IDPs, only 3 contained OM. Raman spectra of the both others reveal olivine (fine bands at ~825 and 856 cm⁻¹) and hematite (fine bands at ~226, 246, 292, 410, 1316 cm⁻¹). Typical Raman spectra of cluster #4, #8, #11 are shown on figure 1.


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Numerical treatment of the Raman spectra of so disordered carbon material is not easy due to the slope of the fluorescence background influencing the shape of the broad D and G bands. In this case, the fluorescence spectra may help to reveal differences between the samples. Indeed, the use of LIF to characterize OM has been suggested by numerous papers in the geochemistry field, mainly in order to determine weak maturation grade [3]. Though it
perturbs the Raman signal, the fluorescence provides information about the chemical composition and about the structure of OM [4]. Each IDP are characterised by a different fluorescence spectra (Fig. 2): cluster#11 is characterised by the highest intensity and cluster#8 by the lowest, both centered around 630nm; spectra of the cluster#4 is centered around 750nm. In comparison, fluorescence spectra of Orgueil (divided for convenience by 1.9 on Fig. 2) is characterised by a higher maximum intensity but by a comparable spectral shape. The fluorophores in IDP #11 and Orgueil may therefore be comparable.

![Figure 2: fluorescence spectra of L2008 cluster#4, # 8, #11 and Orgueil CI chondrite using green excitation wavelength (514nm). Differences in intensity and in wavelength of the maximum characterised these 3 IDPs.](image)

**Discussion:** the presence of the 1st order carbon bands in the Raman spectra shows that the OM in the IDPs #4, #8 and #11 is polyaromatic. Moreover, the G and D bands provide information on the degree of structural order. The visual observation of the spectra suggests that in all the 3 IDPs, the carbon material is disordered, as both bands are very broad and unstructured. But, their visual profiles appear variable from one spectrum to another.

The source of the fluorescence signal can be located in minerals, insoluble or soluble OM. As no mineral feature is detected in the spectra (except olivine in the IDP #11), it is likely that the fluorophores are located in the OM, where the fluorescence is essentially due to its sp² bonds. Preliminary results demonstrate that the technique is sensitive to the chemical and structural composition of OM [4]. Indeed, the increase of the relative concentration of the fluorophores, as well as their condensation, with the aromatization leads to a progressive change of the fluorescence emission [5]; decrease of the maximum intensity and red shift and broadening with an increasing ordering. Thus, fluorescence spectra (Fig. 2) may reveal differences in ordering of the aromatic network inside these IDPs.

UV-Raman spectra are fluorescence-free and allows collection of a Raman spectrum of the mainly sp²-bonded solid [6]. Moreover, some vibrational modes are UV-resonant and cannot be observed using visible excitations [7]. Typically it is the case for the CN sp³ bond at 2200 cm⁻¹ and the sp³ T peak around 1000cm⁻¹. This technique could therefore provide clues on the speciation of nitrogen. Some IDPs can locally exhibit N abundances as high as 10wt% [8], which is enough for UV-Raman detection [7, 9].

**Conclusion:** The goal of our study was to investigate in-situ in silicone oil, prior extraction, the heterogeneity of OM among a significant number of IDPs and possibly to classify them into different groups and to get clues on their origin. Without any sample preparation, the preliminary results reveal differences between the 3 IDPs containing OM. This study shows that it is possible to get information on OM without extracting the samples, and might be of help for classifying the particles, with possible implications for curation.

This study is being pursued by performing UV Raman and LIF spectroscopies on extracted IDPs and by multiplying the studied samples.

**References**


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