MICRO-RAMAN SURVEY OF THE CARBONACEOUS MATTER STRUCTURE IN STRATOSPHERIC IDPS AND CARBONACEOUS CHONDRITES. P. I. Raynal, E. Quirico, J. Borg and L. d'Hendecourt. Institut d'Astrophysique Spatiale, Bâtiment 121 - Université Paris Sud, 91405 Orsay Cedex, France (e-mail: pierre-ivan.raynal@ias.fr).

Introduction. Interplanetary Dust Particles (IDPs) and carbonaceous chondrites are among the most primitive objects available for laboratory analysis, and as such are of particular interest for the study of the early Solar System. Both are noted for their high carbon content: ~4–45 wt%, average 13% for the IDPs [1], 0.1–3.5 wt% for the carbonaceous chondrites [2].

Most of the carbon in the carbonaceous chondrites resides in an insoluble fraction, in the form of either macromolecular carbon (a.k.a. m-kerogen) or pre-graphitic carbon, in varying proportions [3]. In IDPs, while previous works [e.g. 4, 5, 6, 7] point to (very) poorly graphitized carbon, the nature, structure and micro-texture of this carbonaceous material are, up today, not very well characterized.

The objective of this work is to study the carbonaceous matter in IDPs and compare it to the insoluble carbonaceous fraction in carbonaceous chondrites, using Raman microspectrometry. The Raman microprobe has proven particularly valuable for the evaluation of carbon organization [e.g. 8, 9, 10].

A better understanding of the carbonaceous matter in IDPs, as well as in carbonaceous chondrites, will help in fixing constraints on its formation and evolution in the primitive Solar System.

Samples. We investigated a sample set composed of ten stratospheric IDPs: L2021D7, -C8, -B4 and L2036G15, -I29, -A4, -E25, -D1, -D3, -D6, and matrix fragments from nine carbonaceous chondrites of different classes: Orgueil, Allais, Ivuna (CI1s), Murchison, Cold Bokkeveld, Murray (CM2s), Renazzo (CR2), Axtell and Allende (CV3s). This set was completed by two terrestrial references: graphite and type III kerogens (the most aromatic series).

Experimental

Sample preparation. The IDPs were crushed and then pressed onto KBr windows for prior IR microspectrometry analysis [11]. Similarly, small (<100µm) chips from the meteorite (and terrestrial) samples were crushed on a glass slide.

Experimental setup. The spectra acquisitions were performed on a Dilor XY confocal Raman microspectrometer, in backscattering geometry. The exciting radiation was produced by the 514.5-nm line of an Ar+ laser. The 50X objective of the microscope optics provided a 2–3 µm spot size on the sample. Laser power on the sample was kept low, typically 0.4–2 mW, for 3–6 min. The acquisition range was centered on the first-order bands of elemental carbon: the D (ca. 1360 cm⁻¹) and G (ca. 1600 cm⁻¹) peaks [8]. Several points were probed for each sample.

Data analysis. Following acquisition, the spectra (after baseline correction) were fitted with a two-lorentzian band model, in order to extract the peak parameters (position, width, intensity and area). However, for some samples (namely Allende and Axtell), the quality of the fit was significantly improved by the use of a Breit-Wigner-Fano profile [8] for the G-peak.

Main Results. A few typical spectra of the various samples are displayed on Fig. 1. All – except graphite – exhibit rather broad first-order bands, sign of a disordered carbonaceous material. Fig. 2a and 2b show the Full Width at Half Maximum versus the peak position for the D and G bands, respectively, of the extraterrestrial samples and terrestrial kerogens. These diagrams indicate several trends. Predominantly: i) The Allende and Axtell meteorites are clearly apart from the other carbonaceous chondrites. This is consistent with the previous knowledge of their carbon being mostly pregraphitic rather than macromolecular [3]. ii) According to the data presented here (Fig. 2a), Orgueil is significantly different from the other CIs and CMs. This could quite possibly be related to the fact that Orgueil is also the most altered carbonaceous chondrite [12]. iii) Carbon in IDPs appears as a distinct class of carbonaceous material, when compared to other extraterrestrial carbon. This is especially apparent in Fig. 2b.

Conclusions. Raman microspectrometry is a powerful investigation tool for the study of extraterrestrial carbon (with the added benefits of being easy to use and non-destructive). It is able to reveal differences in apparently similar materials (although the extraction of unequivocal structural information from the spectral data is not yet possible). In this case, it allows to demonstrate the specificity of IDP carbon.
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Key:
- Type III kerogen
- Allais, Ivuna
- Orgueil
- Murchison, Cold Bokkeveld, Murray
- Renazzo
- Allende, Axtell
- IDPs

Figure 1: Examples of first order Raman spectra of studied carbonaceous materials.

Figure 2a: Plot of D-peak parameters.

Figure 2b: Plot of G-peak parameters.