

MOLECULAR STUDY OF THE INSOLUBLE ORGANIC MATTER OF KAINSAZ CO3 CARBONACEOUS CHONDRITE: COMPARISON WITH CI AND CM IOM. J.-N. Rouzaud¹, L. Remusat^{2,3}, C. Le Guillou¹, L. Binet⁴, S. Derenne³, F. Robert⁵, ¹Lab. de Géologie, ENS-CNRS, Paris, France, ²GPS division, Caltech, Pasadena, USA (remusat@gps.caltech.edu), ³LCBOP, CNRS, Paris, France, ⁴LCMCP, ENSCP-CNRS, Paris, France, ⁵LEME, MNHN-CNRS, Paris, France.

Introduction: Insoluble Organic Matter (IOM) in carbonaceous chondrites has been studied for decades to understand the origin and the chemical evolution of organic compounds in these primitive objects. A main challenge lies in deciphering the effect of the physical and chemical processes that have occurred on the parent bodies of these meteorites. One goal of these studies is to determine the molecular composition of the organic macromolecule available in the early solar system. Indeed, if CI and CM chondrites are known to have been subjected to an hydrothermal event, other classes of carbonaceous chondrites have experienced moderate to intense thermal alteration. The occurrence of an unique organic precursor is still a matter of debate.

The efforts to study the molecular structure of IOM have mainly concentrated on CI and CM chondrites, that is the aqueously altered carbonaceous chondrites. Hence, IOM in these objects, often considered as the most primitive ones, is known to be constituted by rather small aromatic units linked to each other by short and branched aliphatic chains [1-3]. Moreover, these aliphatic moieties exhibit oxidized functions (ether and ester) possibly partly inherited from the aqueous alteration on the parent body.

Few molecular data are available on thermally processed carbonaceous chondrites, as CO or CV chondrites. Raman studies of IOM in CO and CV chondrites reveal a higher level of organization [4, 5], but the molecular structure of these IOM cannot be directly compared to that of CI and CM chondrites. The purpose of the present study is to bring new molecular data on IOM of thermal processed chondrites.

Experimental: the IOM of Kainsaz (CO3) was extracted by classical HF/HCl treatment [2] and then it has been studied by pyrolysis, Electron Paramagnetic Resonance (EPR) and High Resolution Transmission Electron Microscopy (HRTEM) [6]. The above methods are identical to those already applied to Orgueil or Murchison IOM [3, 7, 8]. HRTEM images were analysed in the same way it was performed for Orgueil and Murchison IOMs [8]

The organic content of Kainsaz is about 0.7 wt%, with a global atomic H/C ratio of 0.16, much lower than CI and CM chondrites.

Results and Discussion: As expected, Kainsaz IOM reveals some remarkable differences with Orgueil and Murchison IOMs.

Pyrolysis: very few products are released by pyrolysis at 650°C. They are mainly alkylbenzenes and naphthalene. This is consistent with previous pyrolysis experiment [9] and in agreement with a more refractory structure [5] with very few thermally labile products. Moreover, no oxygen containing product was detected, in good agreement with the absence of any substantial hydrothermal alteration.

EPR: EPR reveals that Kainsaz IOM contains one to two orders of magnitude less organic radicals than in CI and CM IOMs. Moreover, the number of radicals in Kainsaz IOM is not dependent on the temperature (fig. 1), in contrast with Orgueil and Murchison IOM [10], indicating that no diradicaloid occur in Kainsaz IOM. The differences between CI and CM IOMs and Kainsaz IOM are consistent with the effect of a thermal stress more important for Kainsaz IOM. Indeed high temperatures are known to destroy radicals in organic samples.

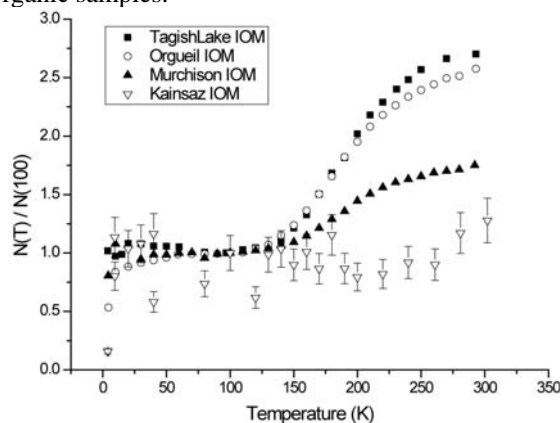


Figure 1 : temperature evolution of the radical concentration (normalized to the concentration at 100K). In contrast with CI and CM IOMs, radical concentration in Kainsaz IOM does not increase above 100K. Kainsaz IOM does not contain any moieties with thermally accessible triplet states (e.g. diradicaloids).

HRTEM: HRTEM reveals a very heterogeneous nanostructural organization (fig. 2), with poorly organized regions exhibiting nano- and meso-porosity, and well organized areas showing graphite occurrence.

Small onion like structures (fig. 2d) are observed and could be related to the thermal destabilisation of nanodiamonds [11]. These features, and especially the presence of graphitized carbons, are consistent with a thermal effect experienced by the IOM.

Image analysis offers quantification of some key parameters on the physical structure of IOMs. Inter-layer spacing, aromatic unit extension and number of stacked layers were determined in different areas of poorly organized carbons (*a priori* the most representative of the primitive organic matter) and compared to the estimations of the same parameters for Orgueil and Murchison IOMs. Surprisingly, fringe length, that represents the extension of aromatic units, and the number of stacked layers in Kainsaz poorly organized organic matter are close to those of Orgueil and Murchison, showing that the level of organization of these regions is equivalent. Nevertheless, the interlayer spacing is smaller in Kainsaz, indicating that aromatic layers are closer than in CI and CM IOMs, consistent with a lack of heteroelements and branched aliphatic chains. It then appears that the thermal evolution begins by a reduction of interlayer spacing instead of an extension of the aromatic layers. Moreover, it must be

noted that pyrolysis, EPR and elemental analyses were performed on the global IOM, i.e. including more ordered carbons characterized by larger layers and consequently lower H/C.

Conclusions: All these observations are consistent with a higher thermal stress experienced by the IOM of Kainsaz compared to CI and CM chondrites. This stress could have been experienced on the parent body and/or in the solar nebula prior to accretion of the parent body.

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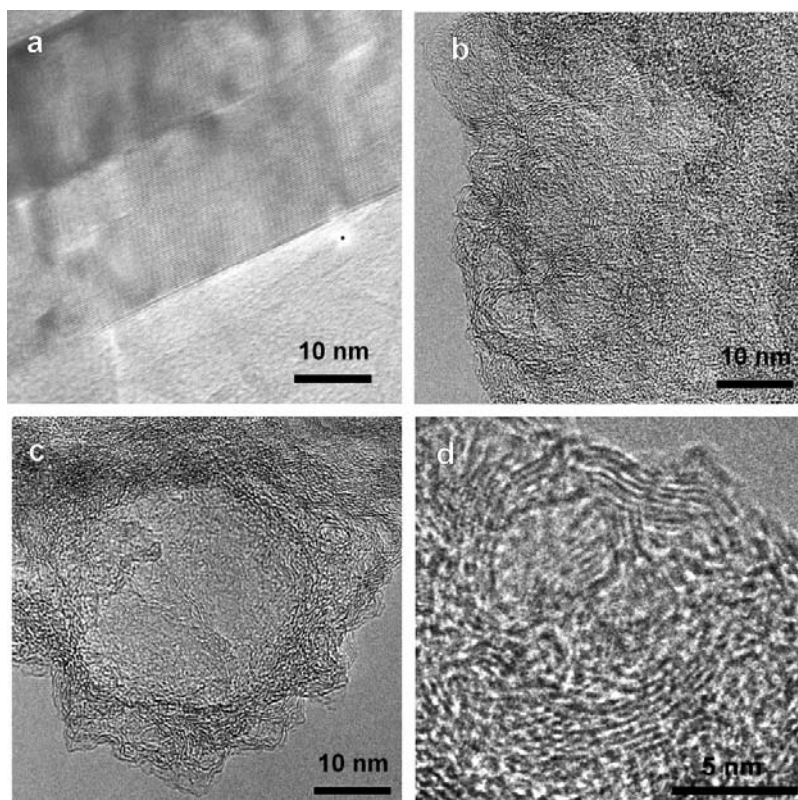


Figure 2 : HRTEM images of Kainsaz IOM. It exhibits very heterogeneous nanostructures, with occurrence of graphite (a) or poorly organized microporous organic matter (b). It also exhibits meso (c) and onion-like features similar to those obtained by thermal destabilisation of nanodiamonds (d).