Origin of cometary and chondritic refractory organics: Ion irradiation experiments

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Refractory organic matter (ROM) – termed Insoluble Organic Matter (IOM) in chondrites – is a polyaromatic carbonaceous solid ubiquitous in cometary dust and primitive chondrites. The origin of this material is still a debated issue. While the high D/H fractionation points to a formation step in low-T conditions, the polyaromatic structure might require an energetic input as thermal processing and/or ions irradiation [1-4]. We report here experimental simulations in order to test both these processes for producing kerogen-like materials from various precursors: polyethylene glycol (PEG1450), sucrose, lignine, cellulose and a Me-OH soluble extract of lignite. Thermal degradation experiment were run at IPAG with a tubular furnace maintained under secondary vacuum, over the range 300-1000 °C. Low-energy (LE-) irradiations were performed on the IRMA beamline at CSNSM (Orsay-France) with fluences up to 4.10^{14} ions/cm^2 [C 40 keV, Ne 170 keV], and high-energy (HE-)irradiation at GANIL (Caen-France) [Zn 590 MeV, C 12 MeV, Ni 12 MeV]. Infrared spectra were collected *in situ* during irradiation. Raman spectroscopy (514 and 244 nm) was performed *ex situ* to characterize the polyaromatic structure of the samples. These experiments provide new insights into the origin of IOM and cometary ROM. Heating processes provide fair IOM-like polyaromatic solids, and kinetics and precursor effects might even improve these analogs. In contrast, LE-irradiation leads to almost amorphous carbonaceous materials, irrelevant to IOM/ROM. HE-irradiation appears as a possible chemical root to transform simple species into an insoluble solid, but with final structure and composition dissimilar from IOM. Nebular heating might then appear as an essential process. However, the contribution of HE-ionic irradiation cannot be excluded at this point, for instance in the first step of precursors formation.

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On the origin of interplanetary organics at the surface of icy bodies

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Introduction: The origin of interplanetary organic matter (OM) is still debated considering either a direct heritage from the parent molecular cloud or processes in the solar protoplanetary disk itself. However, formation of organics at later stages of the solar system evolution, when small bodies such as asteroids or comets were already formed, should be considered to explain the formation of organics components observed in interplanetary dust.

Irradiation of N-rich ices: It is possible to recover from Antarctic ice and snow ultracarbonaceous micrometeorites (UCAMMs) that exhibit exceptional OM concentrations [1, 2]. This OM is N-rich and show extreme Deuterium excesses [3, 4]. The OM components observed in UCAMMs are substantially different from that of insoluble OM extracted from chondrites, requiring an alternative synthesis. Large reservoirs of N_2-CH_4 rich ices occur at the surface of trans-Neptunian icy objects, as recently imaged by the New-Horizon space probe [5]. These ices endure substantial irradiation by Galactic cosmic rays [6]. Recent experiments demonstrated that irradiation of N_2-CH_4 ices by high-energy ions produce an N-rich refractory organic residue that can be the precursor of the OM observed in UCAMMs [7]. We will review the results obtained by analyzing primitive OM in interplanetary dust and Antarctic micrometeorites and compare it to the recent results of the Rosetta mission that confirmed the presence of abundant OM at the surface of comet 67P/Churyumov-Gerasimenko [8, 9].

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