

Molecular and isotope constraints on the formation of the insoluble organic matter of carbonaceous meteorites

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The origin of the insoluble organic matter (IOM) of the carbonaceous meteorites remains an unsolved issue despite major achievements in the knowledge of its chemical structure. The latter led us to propose a model for its molecular structure. Based on the relationship between the aromatic moieties of the macromolecular structure and their aliphatic linkages, it was recently suggested that, its synthesis has taken place in the gas phase of the disk surrounding the Sun in its early T-Tauri phase and that organic radicals have played a central role in this organo-synthesis.

To test experimentally this pathway, we submitted short hydrocarbons (methane, pentane, octane) to a microwave plasma discharge so as to produce in situ CH_x radicals. The black organic residue deposited contained both soluble and insoluble OM. The comparison at the molecular level between the thus synthesized IOM and that of meteorite led to strong similarities thus supporting the proposed pathway for its organo-synthesis.

Moreover, in the meteorite IOM, systematic deuterium enrichment relative to the protosolar value is observed at the bulk sample scale and micrometer-sized grains exhibit dramatic enrichments in deuterium interpreted as a heritage of the interstellar medium or resulting from ion-molecule reactions taking place in the diffuse part of the solar disk. In the aforementioned synthesized IOM, NanoSIMS analyses revealed large variations at a sub-micrometric spatial resolution. They likely reflect the differences in the D/H ratios of the CH_x radicals whose polymerization is at the origin of the IOM. These isotopic heterogeneities are commensurable with those observed in meteorite IOM. As a consequence, the appearance of organic radicals in the ionized regions of the T-Tauri solar disk may have triggered the formation of organic compounds. This laboratory synthesis thus shed a new light on the formation conditions and pathways of the IOM of carbonaceous chondrites.