

## Origin and evolution of the aromatic organic matter in carbonaceous chondrites

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Carbonaceous chondrites are often considered as reservoirs of the first organic molecules delivered to the prebiotic Earth. They can contain up to 4 wt% of organic matter, most of it being rich in aromatic moieties [1]. Indeed; the main organic fraction is an insoluble macromolecule (IOM) constituted by small aromatic units interconnected by short and branched aliphatic chains, and chondrites also contain a diverse suite of soluble polyaromatic hydrocarbons (PAHs). In the meantime, PAHs are emblematic molecules of the interstellar medium and molecular clouds [2]. The relationships between PAHs in the ISM and aromatic moieties in carbonaceous chondrites remains unresolved. Carbon and hydrogen isotopes constitute a valuable tool to decipher the origin of organic compounds in small bodies but their evolution during the parent body evolution still needs to be constrained. We have investigated soluble PAHs and the IOM of Mukundpura, Aguas Zarcas and Kolang, CM carbonaceous chondrites showing increasing degrees of aqueous alteration. They are expected to originate from the same parent body as the Murchison and Paris chondrites. We have also subjected these organic components to experimental hydrothermal conditions to investigate how asteroidal processes, here the aqueous alteration, may affect molecular and isotope features of aromatic organic materials.

A diverse suite of up to 35 ppm of soluble PAHs can be detected in CM chondrites, going from 1 to 7 aromatic rings [3]. Their C-isotope composition are consistent with pre-accretion synthesis in the gas phase, either in the parent molecular cloud or the protosolar nebula [4]. However, their H-isotope composition shows significant D-depletion compared to other molecules in the same chondrites, likely influenced by the D-depleted water stored in hydrated minerals. Experiments at 150°C show that PAHs are stable and their C-isotope signature is not modified during aqueous alteration on the parent bodies whereas H-isotope compositions are strongly influenced by the D/H of circulating water.

The IOM isolated from the same meteorites show similar molecular structure as in the Paris and Murchison chondrites although the relative content of aromatic carbon increases at the expense of aliphatic moieties upon aqueous alteration [5]. The diversity of N, S and O containing moieties is also reduced with increasing degree of alteration, showing the loss of heteroelements through aqueous alteration. In the meantime, the IOM H-isotope signature is only slightly affected by aqueous alteration. This is confirmed by experiments performed in hydrothermal conditions at 150°C [6].

Overall, the molecular structure of aromatic moieties in CM chondrites is poorly affected by aqueous alteration on the parent body. However, soluble PAHs are severely influenced by the H-isotope composition of the circulating fluid, hence losing the pre-accretion signature. In the meantime, the IOM constitute a more robust recording of the H-isotope signature of its precursors as a likely consequence of its hydrophobic nature. Both aromatic-rich components are likely inherited from gas phase synthesis, in the molecular cloud or during the first events of the formation of our solar system.

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