

Origin of refractory organics in chondrites: An experimental study

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Most organic matter found in chondrites occurs as insoluble organic matter (IOM). This refractory organic material has been studied through a wide range of techniques, which has provided insights in its molecular structure [1-2]. Despite these efforts, the origin, nature of precursors and synthesis of this IOM is still debated [1-3].

This study describes a Miller-Urey inspired experiment [4], designed to produce organics by condensation and polymerisation from gas molecules representative of the protosolar nebula. The experiment consists of a gas mixture (CO:N₂:noble gases = 5:0.5:0.5 + traces of H₂O) flowing at ~ 1 mbar in a quartz reactor through an electric discharge. Electrons from the plasma (average energy ~ 2 eV) initiated gas-phase chemistry by dissociating and ionizing gas molecules. At the end of the experiment, dark solids deposited on the reactor wall were recovered for ex-situ analysis by SEM, TEM, py-GC-MS, Raman and FTIR techniques. Noble gases and C, H, N content and isotopes were also measured.

TEM imaging indicates that these solids are mainly composed of amorphous carbon with small domains showing stacks of a few graphene layers. The poorly organized carbon structure was confirmed by Raman spectroscopy. Py-GC-MS, FTIR and elemental analyses indicate an aromatic material composed of small units (1-3 rings). O (carbonyl, phenol) and N (nitrile, heterocycles) functional groups were also identified. Elemental and isotopic fractionation of noble gases, similar to that observed for Q relative to Solar [4] were measured. This preliminary characterization of these synthetic organic material shares similarities with features of IOM.

Both characterization of experimental organics and the trapped noble gases suggest that ionization and dissociation of CO and N₂ in the disk, either by electrons or far-UV photons, could be a possible mechanism for formation of precursors of organics recovered in chondrites. Subsequent reaction and processing of these organic precursors during evolution of the protoplanetary disk could form the complex organic macromolecule we call IOM.

[1] L. Remusat *et al.* (2007) *CGR* **339**, 895-906, [2] S. Derenne and F. Robert (2010) *MPS* **45**, 1461-1475, [3] G. Cody *et al.* (2011) *PNAS* **108**, 19171-19176, [4] S. Miller and H. Urey (1959) *Science* **130**, 245-251. [4] R. Busemann *et al.* (2000) *MPS* **35**, 949-973

Don't forget the salty soup: Calculations for bulk marine geochemistry and radionuclide geochronology

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In reference to marine sediments I would like to add to the theme of this session: "Your data are only as good as your standards and methods!" if you remember to correct your analytical data for pore water salt.

Performing sophisticated analytics in marine geochemistry constantly aims at improving the detection limits as well as minimizing the margin of error regarding the precision and accuracy of the method. However, this holds true only if you are genuinely aware of what are you actually analyzing. The normal procedure of sample preparation for marine sediments consists of drying and grinding. Thereafter, these samples are analyzed with regards to their elementary or mineral concentrations. In the best case scenario, sampled water content data are available for calculations of physical properties, such as porosity and dry bulk density, which are both absolutely necessary for the calculation of elementary flux or geochemical budgets. In addition, based on the water content (*w*, in % of the wet weight) and a normal salinity of 3.5% (or 35 PSU), the amount of salt (*s* in mass%) in the dry sample can be determined by:

1. Calculating the mass percentage of the salty pore water (*w'*) as: $w' = w \cdot 100 / 96.5$
2. Calculate the salt as: $s = 100 \cdot (w' - w) / (100 - w)$.

This is especially important for samples with water contents above 50% (*s*=3.6%; *w*=80% *s*=14.5%), which are very common in the biogenic opal-rich, diatomaceous sediments of the Southern Ocean around Antarctica. These calculations could be improved by using known salinities, obtained through chlorine determinations, of samples or pore water directly.

Although these calculations are simple, they are often ignored, giving rise to two potential errors, sometimes greater than 14% (relative concentration). The first, greatest and often neglected mistake is a "wrong" net weight - the input is not the pure sediment but sediment + salt. For most ratios of elements, the salt content is irrelevant, but every calculation of concentrations must be corrected accordingly, also radiogenic activity calculations (e.g. ²¹⁰Pb, ²³⁰Th). Geochemists try to avoid the second error by using a salt correction when subtracting the salt related element concentrations directly from the composition analyzed.