

Effect of UV Irradiation on the Soluble Organic Matter extract from the Murchison Chondrite. F. R. Orthous-Daunay¹, L. Flandinet¹, R. Thissen¹, V. Vuitton¹, F. Moynier², L. Piani³, S. Tachibana³. frod@ujf-grenoble.fr. ¹IPAG, CNRS Univ. Grenoble Alpes, IPAG, F-38000 Grenoble, France, ²Institut de Physique du Globe de Paris, France ³Department of Natural History Sciences, Hokkaido University, Japan.

Introduction: The Soluble Organic Matter (SOM) consists of thousands of compounds varying in mass up to 2000 Da [1], [2]. These compounds size is in-between the molecules detected in space environments (tens of atoms) and larger macromolecules found only in meteorites. Their size distribution can be related to their synthesis process with the help of high resolution mass spectrometry [3], [4]. The carbonaceous chains have kept track of molecular growth as well as cyclization and photolytic contribution in their size distributions. This is consistent with an interstellar origin as recent studies reported efficient aliphatic chains growth in hot corinos [5] and simulated photolysis occurring in Photon Dominated Regions [6]. An experimental test of this origin hypothesis for the SOM would be to expose it to photolytic condition and to monitor any chemical change with high resolution MS.

Method: Sixty-five g of Murchison were washed with water and freeze-thaw disaggregated before being macerated in methanol and toluene (1:2) for 1 week in a dark room. Extracts were recovered after centrifugation and stored in glass tubes. Thin films of extract were deposited on sapphire glasses and exposed to UV (115 to 165 nm) deuterium lamps under $\sim 10^{-6}$ Pa vacuum inside the PICACHU apparatus at Hokkaido University. Samples received various fluencies of photons, reaching 10^{20} photons/cm² in 500 hours of exposure. Photolytic outgassing was monitored by unity-resolved (quadrupole) mass spectrometry. Chemical modification of the whole mixture was checked by measuring high resolution mass spectra before and after exposure with a Thermo LTQ Orbitrap XL coupled with an Electrospray ionization (ESI) source, at Univ. Grenoble Alpes.

Results and discussion: Concerning the high-resolution spectrometry, detected ions are in the 150-750 Da range. In particular, cations have an average mass of ~ 350 Da. In this mass range, the Orbitrap resolution is high enough not to compromise stoichiometry computation for each exact mass. Each mass detected bears at least NH, consistently with the ESI ionization bias for amines in positive polarity. We interpret the periodicity in mass as a repetition of stoichiometric patterns. CH₂ is one of the most frequent patterns. Molecules varying only by a given number of CH₂ all exhibit a lognormal distribution. This is characteristic of the molecular growth depending on chains transfer polymerization. After exposure, we still observe a lognormal distribution but with a slightly smaller width than for the experiment without exposure. Our observations may help to understand the survivability of such large molecules in both space and on planetary surfaces.

References: [1]Schmitt-Kopplin P. et al. (2010) *Proc. Natl. Acad. Sci. U. S. A.*, 107, 7 pp. 2763–8.[2]Yamashita Y. and Naraoka H. (2014) *Geochem. J.*, 48 pp. 519–525.[3]Wesslau H. (1956) *Makromol. Chem.*, 20 p. 111.[4]Somogyi Á. et al. (2016) *Int. J. Mol. Sci.*, 17, 439.[5]Belloche A. et al. (2014) *Science (80-.)*, 345, 6204 p. 15841587.[6]Alata I. et al. (2015) *Astron. Astrophys.*, 123 pp. 1–9.

DEUTERATION OF INSOLUBLE ORGANIC MATTER AND SILICATES BY IONIZING IRRADIATION IN THE SOLAR NEBULA. M. ROSKOSZ¹, B. LAURENT², L. GAVILAN³, L. REMUSAT¹, N. CARRASCO³, H. LEROUX⁴, ¹IMPMC, UMR CNRS 7590, SORBONNE UNIVERSITÉ, UPMC, IRD, MNHN, PARIS, FRANCE (MATHIEU.ROSKOSZ@MNHN.FR). ²DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES, UNIVERSITY OF ST. ANDREWS, ST. ANDREWS. ³LATMOS, UNIVERSITÉ VERSAILLES ST-QUENTIN, FRANCE. ⁴UMET, UNIVERSITÉ LILLE 1, FRANCE.

Introduction: Organic matter found in carbonaceous chondrites is highly enriched in deuterium, relative to H₂ in the protosolar nebula (PSN) and compared to the bulk “chondritic water” mainly adsorbed on or dissolved in silicate and oxide grains. Ion-molecule or gas-grain reactions could lead to such D-enrichment of organics. The ionizing irradiations in the PSN potentially enhanced these mechanisms. In this context, we conducted electron and X-ray irradiation experiments on a large array of well-characterized analogues of the IOM and of hydrous silicates.

Results: These irradiations affect the structures of organic precursors. A strong correlation between the structural, compositional and isotopic evolutions is observed. As the dose increases, the δD of each precursor increases until it reaches a plateau value that depends on the nature of the sample. This is a consequence of the nature and the relative proportions of the different CH groups present in the starting material. Concerning silicates, a large deviation from the initial isotopic signature was found. The magnitude of this fractionation is highly correlated to the drop of the water content.

Discussion: Concerning organics, intramolecular fractionation factors were derived and found remarkably consistent with factors determined from the IOM of the Orgueil meteorite. Data collected on silicates can be modeled by a Rayleigh-type distillation equation. The fit to the data is consistent with a pure kinetic effect. A quantitative model is derived, that accounts for both structural and isotopic evolutions of the IOM and silicates. Starting from a similar D/H signature, the deuteration of silicate grains larger than about 100 nm is very limited. Conversely, the deuteration of micron-size particles of IOM is very efficient for a comparable irradiation dose. This new fractionating process could explain the systematic D-enrichment measured in the IOM relative to the water present in carbonaceous chondrites.