

Photo-Induced Deuterium Enrichment in Residues Produced from the UV Irradiation of Pyrimidine in H₂O and H₂O+NH₃ Ices

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Organic compounds found in meteorites often show isotopic signatures of their interstellar/protosolar heritage as enrichments in D and ¹⁵N. Meteoritic organics found to be enriched in D include amino acids, hydroxy and dicarboxylic acids, as well as polycyclic aromatic hydrocarbons (PAHs). Processes that can produce isotopic enrichments in presolar/protosolar materials include gas-phase ion-molecule reactions, gas-grain surface reactions, and unimolecular photo-dissociation reactions involving PAHs. Because many molecules in interstellar clouds are enriched in D, the presence of D anomalies in meteorites is thought to originate from preserved or slightly altered interstellar/protostellar materials. However, the link between isotopic enrichments seen in space and those in meteoritic compounds and their relationship remain unclear.

In this work, we present results of hydrogen isotopic fractionation for compounds in organic residues produced from the UV irradiation using an H₂-discharge UV lamp of H₂O:pyrimidine = 20:1 and H₂O:NH₃:pyrimidine = 20:2:1 ice mixtures at low temperature (<20 K). After irradiation, the resulting residues are dissolved in H₂O and analyzed with gas chromatography–mass spectrometry coupled with isotope ratio mass spectrometry (GC-MS/IRMS) [1], following a protocol similar to that used for previous analyses of comparable samples [2,3]. We used this technique to measure compound-specific D/H isotopic ratios for the initial pyrimidine and for two photo-products present in the residues, namely, 2,2'-bipyrimidine and an unidentified bipyrimidine isomer [2–4]. Measuring D enrichments in bipyrimidines has the advantage that the H atoms on these molecules are not easily exchangeable with other compounds, in particular the H₂O and NH₃ present in the ices or the solvents used to extract the samples for GC-MS/IRMS measurements.

The δD value for the initial pyrimidine, measured with a high-temperature conversion elemental analyzer connected to the IRMS, was found to be –30‰. Preliminary measurements made on a residue produced from the UV irradiation of an H₂O:NH₃:pyrimidine = 20:2:1 ice mixture indicate δD values of +118‰ for 2,2'-bipyrimidine and +92‰ for the other bipyrimidine isomer, and therefore show a significant D enrichment during the photo-processing and warm-up that lead to their formation [5]. New measurements are currently being performed on a number of residues produced from simpler H₂O:pyrimidine = 20:1 ice mixtures under different experimental conditions and will be presented here.

References: [1] Elsila, J.E. et al. (2012) *Meteorit. Planet. Sci.*, **47**, 1517. [2] Nuevo, M. et al. (2009) *Astrobiology*, **9**, 683. [3] Nuevo, M. et al. (2012) *Astrobiology*, **12**, 295. [4] Bera, P.P. et al. (2010) *J. Chem. Phys.*, **133**, 104303. [5] Sandford, S.A. et al. (2013) 76th Annual Meteoritical Society Meeting, Abstract #5137.