

Nitrogen isotope fractionation during synchrotron light irradiation of solar-like gases

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The isotopic composition of the two stable isotopes of nitrogen (¹⁴N and ¹⁵N) in the solar system shows enormous variations, the origin of which is debated (see [1]). Since other isotopic systems, such as carbon and noble gases, do not show such marked variations, nucleosynthetic heterogeneities have been excluded, and alternative explanations involving ionization or photochemical processes within the molecular cloud or in less transparent regions of the evolving disk have been proposed [2]. Plasma ionization of gas mixtures (H₂, CO, N₂, and noble gases) produces carbon-rich residues that show similarities to organic matter found in primitive meteorites. In addition, the trapped noble gases show elemental and isotopic fractionation reminiscent of those found chondrites [2]. However, nitrogen trapped in such residues shows only modest isotopic variations [2,3]. Chakraborty et al [4] successfully produced large ¹⁵N enrichments in photochemical experiments, where synchrotron photons irradiated a 50:50 H₂-N₂ mixture. These authors attributed these ¹⁵N excesses to the predissociation of N₂, which favored ¹⁵N over ¹⁴N. However, self-shielding effects could also have occurred [5]. Here, we report a novel photochemistry experiment aimed at synthesizing organic molecules – potential precursors of primitive organic compounds harboring volatile elements in meteorites. A 90 nm synchrotron light beam passed through a membrane in a closed chamber filled with either H₂-CO-N₂ or N₂-H₂ mixtures, under pressures of 0.25 mbar and 1 mbar, respectively, thereby eliminating self-shielding effects. The organic products were cryogenically trapped in different fractions and analyzed at CRPG by static mass spectrometry. The results show variable enrichments in ¹⁵N, reaching up to 600 ‰, opening the way to the production of primitive organic compounds containing both trapped noble gases and isotopically fractionated nitrogen.

[1] Füri E. & Marty B. 2015. *Nature Geosci.* DOI: 10.1038/NGEO2451; [2] Kuga M. et al. 2015. *PNAS* 112, 7129; [3] Bekaert D.V. et al. 2018. *APJ* 859, 142; [4] Chakraborty S. et al *PNAS* 111,14704-14709; [5] Shi X. et al 2017. *ApJ*. 850, 48.