

Site specific D-H isotope exchange in amino acids during experimental hydrothermal alteration: application to carbonaceous chondrites.

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About 100 extraterrestrial amino acids have been identified in carbonaceous chondrites, with concentrations going from a few ppm to more than 300 ppm[1]. These molecules have likely been delivered to the surface of the early Earth hence they can have influenced the emergence of life [1]. Several possible synthesis routes have been discussed[2]. Isotope compositions points to precursors formed at low temperature before parent body accretion, as they show the largest D-enrichments among organic constituents in carbonaceous chondrites[3]. Nevertheless, the D/H isotope compositions of amino acids cover a large range of values; for instance, 360‰<δD<3400‰ in the Murchison CM2 chondrite[4] or 1000‰<δD<7000‰ in the EET92042 CR2 chondrite[2]. Though this could be interpreted by the occurrence of different parent bodies, the observed large isotopic range could result from the aqueous alteration that occurred during a few millions of years after the accretion. We have submitted α- and β-alanine and γ- aminobutyric acid (GABA) to hydrothermal conditions at 150°C and 4.7 bars for 1 and 10 days in presence of D₂O. Products were analyzed by gas chromatography-mass spectrometry (GC-MS) as N-ethoxycarbonyl ethyl esters allowing us to identify the site where D-H isotope exchange occurs[5]. D/H appears to be best preserved in α-alanine, with only one H-atom showing isotope exchange. In β-alanine, on the other hand, 4 H-atoms may undergo isotope exchange. Interestingly, only 2 H-atoms are prone to exchange in GABA, despite its similarity with β-alanine (one more -CH₂ group in a straight chain). In any cases, the H atoms at the α position relative to the carboxylic group are preferentially exchanged. Our experiment shows that the carbon skeleton strongly influences the tendency to exchange H-isotopes. This may indicate that some of the differences measured between amino acids and between chondrites[2,4] are the result of exchange between D-rich amino acids and D-poor water on the parent body.

[1] Elsila et al. 2016. *ACS Central Science*, doi : 10.1021/acscentsci.6b00074

[2] Elsila et al. 2012. *MAPS*, doi: 10.1111/j.1945-5100.2012.01415.x

[3] Sephton 2014. *Treatise in Geochemistry*, doi :10.1016/B978-0-08-095975-7.01002-0