

Evolution of H-isotope signature of amino acids during asteroidal aqueous alteration

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Over 100 amino acids have been detected in carbonaceous chondrites and comets. They are of prime interest to disentangle the evolution of organic materials in the early solar system and on the parent bodies that were subjected to physical and chemical evolution over the past 4.5 billion years [1, 2]. Distribution of amino acids may relate to the synthetic processes and secondary processes that have affected parent bodies (aqueous alteration or thermal metamorphism). Isotope compositions point to precursors formed at low temperatures in cold interstellar or nebular environment 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 spread over 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 [5]. This difference is often interpreted as the consequence of isotope equilibration with water during the aqueous alteration that affected CI, CM and CR chondrite parent bodies. The δD values of amino acids tend to increase with the increasing carbon number for the α -H, α -NH₂ amino acids. This may relate to their precursors and synthesis route, or to a better preservation of their isotope signature during parent body evolution [5]. To explore the later hypothesis, a better understanding of the evolution of the δD of amino acids under asteroidal conditions is required. We present here an experimental investigation of the kinetics of isotope exchange between water and amino acids at 150°C. We can also identify which molecular sites are more prone to D-H exchange to interpret how molecular structure influence preservation of δD values.

In this contribution, the H-isotope evolution of glycine, alanine and isovaline under aqueous alteration conditions have been investigated with experiments at 150 °C for 1, 10 and 21 days with the presence of water at different δD values. The preferential sites for H-D isotope exchange were identified through experiments in the presence of D₂O and using gas-chromatography and mass spectrometry (GC-MS). Our results showed that the hydrogen at α -position of amino acids is prone to faster exchange; the amino acids without α -hydrogen show no significant exchange, *e.g.*, glycine with 2 H-atoms shows significant exchange, in contrast to isovaline (no α -hydrogen).

Kinetics of isotope exchange was investigated thanks to experiments with D-poor water (SLAP2, $\delta D = -427$ ‰) and D-rich water (IAEA 605, D = 6000 ‰) and analysis by GC-irMS (Elementar VisION isotopic interfaced with an Agilent Technologies 7890B GC). Our data show that the shorter the carbon chain, the higher the exchange efficiency. Therefore, long-chain amino acids and branched-amino acids without α -hydrogen should better preserve their D/H than short ones. The different behavior of amino acids under aqueous alteration may partly explain the large range of isotope compositions reported within single meteorites.

Références

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