The effects of ion particle radiation on amino acids in a serpentine matrix

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Abstract:
On a planet or moon, the absence of a sufficiently strong global magnetic field leads to large radiation exposure. Charged particles reach, for example, the surfaces of Mars, Enceladus and the objects in the asteroid belt. If such particles hit biomolecules, complete decomposition or at least significant chemical structure alterations can occur. This has not only to be considered in the search for extraterrestrial life (e.g., on Mars and Enceladus), but also in the chemical analyses of meteorites because the meteorite parent bodies, the asteroids, are also exposed to this particle radiation. The organic substances formed in the asteroids during the aqueous alteration phase will also be affected to some extent. The degree to which they are affected depends on their distance from the asteroid's surface.
Carbonaceous chondrites are of special interest because they contain various organic compounds, including amino acids, such as alanine and isovaline. The latter is known to be resistant against racemization [Gadamer 1914]. In some meteorites, an L-enantiomeric excess of isovaline was surprisingly detected [Pizzarello et al. 2003] indicating some chiral influence on amino acid synthesis in asteroids (or earlier in interstellar clouds). Four billion years ago, meteorites were exogenous sources that extended the terrestrial chemical inventory and probably also brought this enantiomeric excess to Earth. This is of great interest concerning the origin of biological homochirality.
In our experiments, we prepared a mixture of L-amino acids (alanine and isovaline) and serpentine, a phyllosilicate dominating in CI and CM chondrites [e.g., Beck et al. 2010]. These mineral–amino acid mixtures were irradiated with different doses (e.g., 250 Gy) of helium ions (He 150 MeV n^{-1}; LET: 2.2 keV μm^{-1}) and iron ions (Fe 500 MeV n^{-1}; LET: 200 keV μm^{-1}). After extraction from the mineral matrix, the amino acids and their remnants were analyzed with chiral GC-MS and HPLC. Prior to analyses, derivatization was necessary, firstly for GC-MS to obtain the volatile N-trifluoroacetyl-O-methyl esters of the amino acids [Fox et al. 2015] and secondly for HPLC to produce 1-fluoro-2,4-dinitrobenzene (Sanger's reagent) derivatives with a strong absorption near 340 nm. Racemization of the amino acids and the degree and nature of their decomposition will provide insight into processes related to the origin of biological homochirality.

References

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