On the trail of the origins of life
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University researchers have analyzed amino acids irradiated in interstellar conditions to discover the origins of the homochirality of life

A French-German team led by researchers from the University of Nice Sophia Antiopolis, LURE/CEA/SOLEIL at Orsay/Saclay/St. Aubin, and the Center of Molecular Biophysics at Orleans have searched for the origins of homochirality in the same astrophysical conditions that were present at the time of formation and deposit on earth of the building blocks of life.

Uwe Meierhenrich (UMR CNRS – University of Nice Sophia Antipolis), Laurent Nahon (LURE/CEA/SOLEIL), and André Brack (CNRS-Orleans) suggested the following idea: the homochirality of life could be due to an irradiation of amino acids in space that would have produced an asymmetrical mix of two shapes instead of a symmetric mix (racemic). To test this hypothesis, a racemic mix of a simple amino acid, leucine, heavily present in the human organism as well as in corn, for example, was irradiated with a circularly polarized distant UV beam.

For the first time, an amino acid in the solid state was irradiated in a laboratory with a left and right circularly polarized synchrotron beam, simulating astrophysical conditions. But what do we mean by the homochirality of life?

Biology is not symmetrical. We are right-handed or left-handed, and some of our organs occupy a clearly asymmetrical position: the heart on the left side and the liver on the right side. This break in symmetry also exists at the molecular level. Bio-molecules like amino acids, those small molecules that our cells use to make proteins, or DNA sugars, are chiral molecules (from the Greek chiros, or hands) that exist a priori in two forms—called enantiomers—that are of the same chemical formula but are not superimposable (like our hands); there are the left and right enantiomers. Yet these molecules, as encountered in living organisms, display fundamental asymmetry. Amino acids are all of the left type, while DNA sugars are of the right type. **This is what is called the homochirality of life**. The molecules that we find in flavoring and perfume agents possess different odors according to whether they are of the left or right type.

More generally, in natural science, this remarkable property, discovered by Pasteur in 1847, is called bio-molecular asymmetry. Numerous manifestations of the homochirality of life have been studied intensively and in detail, but its exact origin, undoubtedly linked to the very origin of life, remains a mystery. How did the living organism select the left form of amino acids to build its proteins? Why was the right form eliminated though the synthesis of these molecules in a laboratory produces a racemic mix—meaning that it contains an equal quantity of both forms? Is this selection process due to chance, or is it of determinist origin?

According to Uwe Meierhenrich, “the breakthrough in our experiments, conducted during several sessions of intense irradiation both during the day and at night, consisted of choosing our samples, the amino acids, in the solid state. Previous experiments conducted in the United States used amino acids in solution, a liquid state that is not representative of interstellar conditions.” Laurent Nahon, manager of the LURE SU5 synchrotron line in Orsay, which provided the radiation, echoes: “SU5 is the only beamline in the world operating distant UV light containing both an intense photon flux and a state of polarization of light that is well controlled and calibrated. We are particularly anxious to continue to implement these unique techniques and to pursue this work with the 3rd generation synchrotron, SOLEIL, currently being built at St. Aubin, where SU5 will be reborn under the name DESIRS.”

The implementation of a new analytical technique has permitted developers to identify a selective degradation in the left enantiomer of leucine after irradiation with a right circularly polarized beam, leading to an enantiomeric surplus of 2.6%, from a racemic mix. These results were just published in the international edition of the journal *Angewandte Chemie*.* The results of this study are very significant with regard to the understanding of the origins of life on Earth and its evolution. They suggest that the homochirality of amino acids appeared in interstellar space, well before the origin and biological evolution of life on Earth. Subsequently, these asymmetrical amino acids were brought to earth via micro-meteorites and comets, where they caused the appearance of life.

* “Asymmetric VUV photodecomposition of the amino acid D,L-Leucine in the solid state”, U. Meierhenrich, L. Nahon, C. Alcaraz, J. Bredehöft, S. Hoffmann, B. Barbier, A. Brack, Angewandte Chemie Int. Ed. (to be published).

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