Molecules that came in handy for first life on Earth

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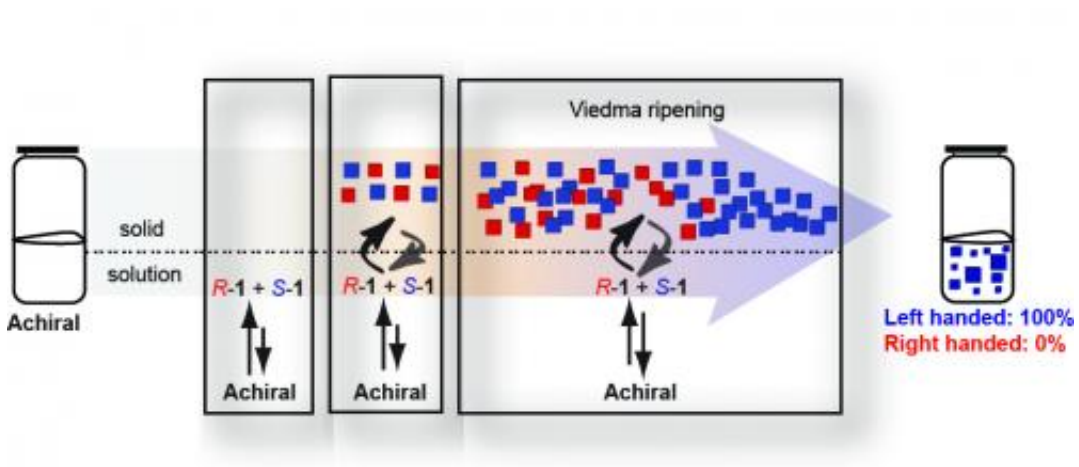

The experiment starts with achiral reactants, without any handedness. These react into both left- (S, blue) and right-handed products (R, red). After crystallization, a process called Viedma ripening converts all molecules to the same handedness.

For the first time, chemists have successfully produced amino acid-like molecules that all have the same 'handedness', from simple building blocks and in a single test tube. Could this be how life started. On earth? Or in space, as the Philae lander is currently exploring? René Steendam researcher in Astrochemistry at Radboud University, the Netherlands has published the findings in *Nature Communications*.

Some molecules are found in two chiral variants that, just like hands, are

mirror images of one another. Nature, however, makes use of only one variant; for example, DNA is made of a right-handed helix and the most common sugar – glucose – is also right-handed. Why nature does this, and how it all started, remains an intriguing puzzle. After all, whenever chemists make the same molecules they obtain a mix of both variants.

Although the molecules are chemically identical, the biological effect of the two mirror images can differ enormously. Due to different interactions with the molecules in our bodies such as DNA and sugars, this can mean a difference between a toxin and a medicine. Thalidomide (trade name Softenon), originally produced as a mix of both mirror images, is the most dramatic example of this. It is therefore very important for the pharmaceutical industry to produce the correct versions of molecules, and a range of chemical methods have been developed to be able to do this selectively. Even so, this does not explain the preference for just one of the mirror images in the early days of the earth...

The article in Nature Communications describes how Radboud chemists produced an amino acid-like molecule with a single handedness from a solution of a ketone and an amine. Their method may be similar to the processes that took place in the primordial soup. The feasibility of this scenario was first proposed by the physicist F.C. Frank in 1953, which he coined'spontaneous asymmetric synthesis'.

An article by Kenso Soai in Nature in 1995 described the experimental realization for the first time, but this only worked after addition of a pinch of the left-handed or right-handed product to start with. The Radboud chemists however took it an important step further: they updated Frank's concept and discovered a spontaneous asymmetric synthesis method which takes place in the absence of left- or right-handed molecules. René Steendam: "The first left-handed amino acids could have been produced in this way, no matter whether this happened

on earth or somewhere else in the universe".

"No-one has done this before, no-one has achieved – in a single, simple reaction, in a single beaker with no chirality present – an end situation that is 100 % left-handed or 100 % right-handed" says Elias Vlieg, Professor of Solid State Chemistry. "This really is a fantastic example of how we go about things here in the Institute for Molecules and Materials. The molecules that we used came from Floris Rutjes' Synthetic Organic Chemistry group, who is René's other supervisor. There they understand reactions, and we understand crystals." The researchers applied a method during the reaction that was invented a few years ago at Radboud University allowing crystals to repeatedly dissolve and grow through continuous grinding and stirring. "All this does is accelerate the process, but if you have enough time – as you do during evolution – it will work without using this trick."

More information: "Emergence of single molecular chirality from achiral reactants," Rene R.E. Steendam, Jorge M.M. Verkade, Tim J.B. van Benthem, Hugo Meekes, Willem J.P. van Enckevort, Jan Raap, Floris P.J.T. Rutjes & Elias Vlieg, *Nature Communications* November 21. DOI: 10.1038/NCOMMS6543

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