Did clay mould life's origins?

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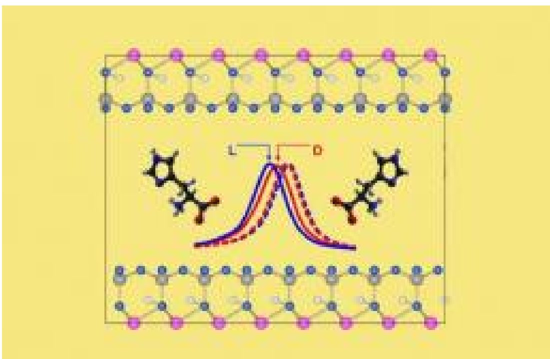

Clay's layered structure interacts differently with left- and right-handed versions of histidine, an amino acid.

(PhysOrg.com) -- An Oxford University scientist has taken our understanding of the origin of life a step further.

Professor Don Fraser from the Department of Earth Sciences has carried out neutron scattering experiments to try to find out more about the role of geochemistry in determining the origin of our amino acids – key building blocks of life on Earth – and specifically why the DNA-coded amino acids that make up our proteins are all left-handed.

There are two varieties of amino acids, known as left- or right-handed (referred to as S and R). They are mirror images of each other and both exist in nature, as shown for other substances by Louis Pasteur.

Biochemical processes in living organisms use left- and right-handed or 'chiral' receptors that template differently with these two forms. The olfactory receptors in our noses, for example, easily distinguish the distinct smells of the otherwise identical molecules (called carvones) of spearmint (R-carvone) and caraway (S-carvone).

Another example is the thalidomide tragedy that was related to the presence in the drug of both the mirror-image forms. One of these (S) was later understood to be harmful.

An important and outstanding mystery is why nature chooses only exclusively left-handed amino acids in forming proteins.

In the late 19th century, TH Huxley and Charles Darwin realised that life may have begun abiotically in a 'warm little pond' containing all the elements needed for life, 'so that a protein compound was chemically formed ready to undergo still more complex changes,' Darwin wrote.

Much later, in 1924, the Soviet scientist Alexander Oparin returned to the idea of spontaneous generation, suggesting that a 'primeval soup' of organic molecules, created by the action of sunlight in an oxygen-free environment, was the basis of all life.

Electric spark experiments subsequently carried out by Stanley Miller in model primeval atmospheres showed that amino acids form in lightning discharges. In contrast to biological systems, these show no preference for either mirror image form and are 50%:50% (racemic) mixtures.

Clay was suggested by the crystallographer John Bernal as a means of concentrating primitive biomolecules onto its surface so as to be available for further reactions. Clays again became the focus of studies more recently when James Ferris showed that they can act as catalysts for the formation of long strands of RNA, which with proteins and DNA are major compounds essential for the origin of life.

In a second paper, also published in *Physical Chemistry Chemical Physics*, Professor Fraser has extended these ideas to consider amino acids and to try to understand why all amino acids used to make proteins are left-handed.

With colleagues Professor Neal Skipper from UCL, Dr Martin Smalley from York University and Dr Chris Greenwell from Durham University he replaced the cations between the layers making up natural clay molecules with weakly bound organic cations, causing the clay layers to drift apart.
That created an extremely sensitive clay system with sufficient space to insert both left-handed and right-handed forms of the amino acid histidine between the layers.

"We found that the R- and S-histidine molecules interact differently with the clay surfaces. These clays are abiotically able to select for chirality – left- or right-handedness – as well as being implicated in the abiotic synthesis of RNA," Professor Fraser says. "Our experiments were the first to show that clay molecules could do that.

"We also found that the tiny interlayer space some 5nm wide was a very important dynamic region for studying prebiotic chemistry and that the reactions of simple chemicals there leads to the formation both of RNA oligomers and the selection of left-handed amino acids.'

Clays have also been shown by Jack Szostak and others to enable fatty acids to form primitive cells and, interestingly, clays show similar selective behaviour in space, as reported recently by the NASA scientists Glavin and Dworkin.

Amino acids contained in the meteorites Murchison and Orgueil show enrichment in S-amino acids and this correlates with the amount of intrinsic hydrous clay present in these primitive meteorites that are 4.55 billion years old. 'The amino acid studied – isovaline – cannot be a contaminant as it is not found in terrestrial living systems,' Professor Fraser explains. 'We are thus building an increasingly detailed picture of the steps that lead to the origin of life.

"We are continuing our research next month on the new NIMROD instrument at the ISIS neutron source near Oxford. This will involve amino acids enriched in deuterium, an isotope of hydrogen, and will provide a detailed atomic picture of the way amino acids interact with the layers of clay for the first time.

"In the long term, this work could have significant applications not only for our understanding of the origin of life, but also in medicine as the design of new mineral surfaces that aid the production of chiral drugs would be of great benefit to the pharmaceutical industry."

Provided by Oxford University

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