

Nano-Spectroscopic Studies of Chemical Evolution at Interfaces – Ultimate Self-Assembly and Origins of Life –

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Abstract:

The origin of life, though it remains a mystery, is believed to have been chemical reactions at mineral surfaces on the earth during the Hadean period. Although there have been many proposals and preliminary experiments on this topic, no definitive origin has been reported yet because of a lack of nanoscopic studies. Herein, we present the first material surface observations intended to elucidate the origin of life at the molecular level. These observations were made using a combination of novel techniques, specifically, Raman spectroscopy and atomic force microscopy (AFM). Pyrite (FeS_2) is known to be one of the most common minerals that can provide condensation and reaction surfaces for chemical evolution. However, this mineral has mostly been studied from a crystallographic viewpoint or in bulk systems, and such investigations cannot fully resolve the exact mechanisms of the specific interactions that occur on this mineral. Moreover, no direct experimental evidence has been reported regarding pyrite initiating chemical evolution at the nano-scale when it is used as a reaction surface. In this study, the quantitative force analysis performed by using AFM, in which the residue of a single amino acid was mounted on AFM tips, enabled us to locate the reaction sites and to study the interaction forces between the amino acid and the pyrite surface. Our Raman spectroscopy and AFM results revealed for the first time that defective areas, with the molecular composition FeS_{2-x} , increase the adsorption probabilities of amino acid residues in chemical reactions on the surface of pyrite.

Keyword:

Nanotechnology, Scanning Probe Microscopy, Atomic Force Microscopy (AFM), Raman Spectroscopy, Self-Assembly, Bio-Interface, Chemical Evolution, and Origins of Life.

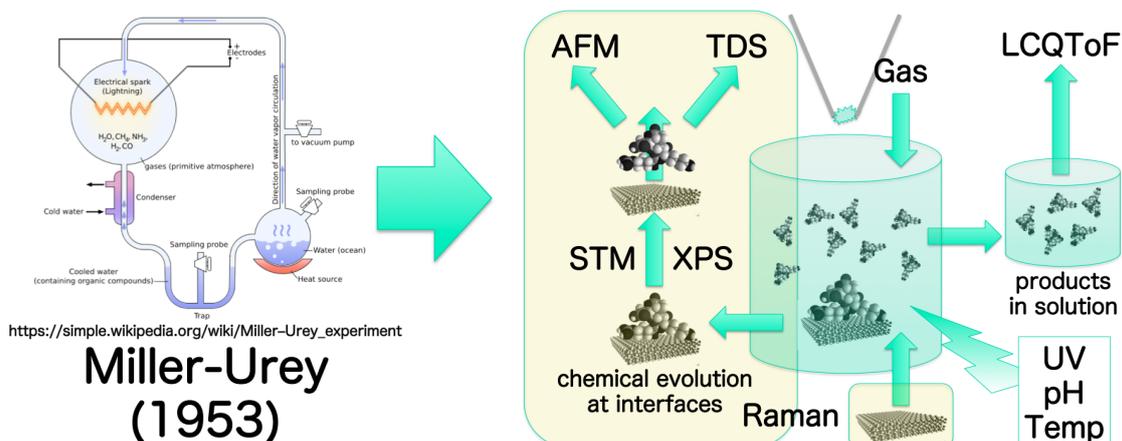


Fig. Beyond Miller-Urey Experiment at ELSI, Tokyo Tech