

P20 Prebiotic sugar formation under mechanochemical conditions

Saskia Lamour^{1,2}, Sebastian Pallmann¹, Oliver Trapp^{1,2}

¹ Department Chemie, LMU München, ² Max-Planck-Institut für Astronomie, Heidelberg

For the origin of life several building blocks like amino acids, nucleobases, carbohydrates and phosphates are necessary. The theory of the "RNA world" considers the RNA as universal molecule which contains for example ribose as sugar.[1] A prebiotic important route for sugar molecules is the formose reaction, a base-catalyzed condensation reaction. This reaction type represents several chemical and biologically relevant transformations, which are thermo-dynamically disfavored in aqueous solution. In contrast, the proposed geochemical settings for the origin of life are, for instance, warm little ponds[2] and hydrothermal vents.[3]

As alternative, solvent-free approaches like mechanochemical reactions offer nonaqueous conditions. Prebiotic sources for mechano-chemical energy can be lithospheric activity or meteoritic impacts on earth. For the realization in bench-scale ball mills are predestinated for the investigation of mechanochemical conditions.

We report on the formation of carbohydrates under nonaqueous conditions starting from glycolaldehyde and glyceraldehyde as substrates with a catalytic base present.[4] This part of the formose reaction network was investigated with and without mechano-chemical energy input by use of a mixer ball mill. The complex product mixture was analyzed via gas chromatography-mass spectrometry.[5]

[1] O. Leslie E., Critical Reviews in Biochemistry and Molecular Biology 2004, 39, 99-123

[2] C. Darwin, The correspondence of Charles Darwin, 1871

[3] W. Martin, J. Baross, D. Kelley, M. J. Russell, Nature Reviews Microbiology 2008, 6, 805

[4] S. Lamour, S. Pallmann, O. Trapp, in preparation

[5] M. Haas, S. Lamour, O. Trapp, Journal of Chromatography A 2018

P21 Microfluidic rock-like reactors to study the synthesis of the first nucleotides

Victor Sojo¹, David Lappe¹, Thomas Matreux¹, Saidul Islam², Matt Powner², Dieter Braun¹

¹ Systems Biophysics, LMU München, ² Department of Chemistry, University College London

Amongst the many open questions in the origin of life is the origin of the first biomolecules: from lipids to amino acids to nucleotides, life exhibits a wealth of complex molecules whose pre-biotic synthetic pathways remain unclear. Whatever the answers, early biomolecules must have arisen under realistic geological boundary conditions. Recent chemical advances have shone light upon potential synthetic pathways for the production of nucleotides in the laboratory, starting from simple abiotic precursors [1]. However, and in spite of the latest progress [2], most experiments have been performed in bulk chemistry, and through independent and successive synthetic steps. Therefore, geological plausibility remains largely unexplored.

We have emulated the conditions of microfluidic flow in rock pores, to uninterruptedly drive, within one single system, the sequential reactions necessary to produce an activated nucleotide [1]. Using CAD software and finite-element-method simulations, we have designed microfluidic devices to run the nucleotide synthesis autonomously, and to recreate a scenario analogous to what could be found in porous rocks on early Earth. We produce the reactors assembled from a repertoire of modular building blocks using stereolithographic 3 D printers, allowing for many applications beyond our own. The flow can be driven by gravity, increasing the geological realism of our system. Our methods also allow us to embed rock powders into the microfluidic system, enabling the testing of

potential pre-enzymatic catalysts and further increasing geological plausibility. These results open the door to studies of any scenarios for the emergence of life, whereby chemistry is driven in a geologically realistic system to generate the earliest biologically relevant molecules.

[1] Powner, Gerland & Sutherland. Nature doi.org/10.1038/nature08013 (2009)

[2] Ritson et al. Nat. Comm. doi.org/10.1038/s41467-018-04147-2 (2018)

P22 Hypothesis, proposal and some estimates for enhanced abiogenesis experiment

Alexandr N. Andreev, Anatoliy G. Lazarenko

Laser Laboratory, Kharkiv Polytechnic Institute, National Technical University, Kharkiv

Based on the works of Prigogine and von Hayek hypothesis was proposed which allowed developing a new scheme for the origin of life experiments - the logical improvement of classic Miller's experiment in the form of „micro-planet“ installation [1]. The improvement is aimed to production of wider variety of gradients, degrees of freedom and hence possible ways of development for prebiotic chemical processes. The scheme provides cycles of wetting-drying, evaporation-condensation-solidification etc. in a small confined space along with providing the two-phase mixing and presence of fresh and „ocean“ water in conjunction with a variety of minerals, foam etc. It also supposes excitation of the system by different kinds of energy fluxes with various time periods. Different compositions and/or cycling programs can be compared by periodically monitoring of the laser light absorption and scattering spectra [2] richness, as well as by in vitro nanoparticles size measurement with correlation spectroscopy [3]. The installation basic parameters and components, as well as the possibilities of its application, are discussed.

[1] A. Lazarenko et al., Origin of life experiment enlightened by laser, [IEEE 7th Int. Conf. on Advanced Optoelectronics and Lasers], <http://ieeexplore.ieee.org/document/7851384/>, (2016)

[2] Anders, A.: Laser spectroscopy of biomolecules - in Analytical Chemistry Progress, Volume 126, Topics in Current Chemistry, pp 23-49, (1984)

[3] A. Lazarenko et al., Agitated reactor with in situ nanoparticle size control by light scattering photon correlation spectroscopy [Proceeding of 6-st International Conference on Advanced Optoelectronics and Lasers] pp. 352-354, (2013)