Prebiotic Reaction Vessels – RNA Formation in Nanoconfinements of water

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Abstract

In the science field of the origin of life one of the biggest questions is how life could develop from the prebiotic world that was present on early Earth. One of the big challenges in theories on the origin of life is the so called "water problem". It addresses the paradox that several reactions needed to develop biomolecules, like RNA and DNA, only proceed under water free conditions, though that most theories suppose that life developed in water, with RNA as a first genetic molecule. So far, one of the most discussed ideas which aim to solve this paradox is based on drying and wetting cycles of little ponds, to get rid of the hydrolysing water.
However, biology has had to find a completely different way to overcome the hydrolysis problem as all biochemical reactions occur within cells – an environment full of water – what is basically managed by enzymes, like the RNA-Polymerase. Regarding the aspect of evolutionary conservation it is feasible to assume that during the chemical evolution towards the origin of life the same physicochemical phenomena were tapped to overcome the hydrolysis problem as they are used by modern organisms.

Here we show that there is a possibility of reducing water activity for enabling condensation reactions within water. This possibility emerges from nanofluidic effects on confined water: when water-dispersed particles come in temporal proximity to each other, temporal nanoconfinements of water are formed. Such confinements can reduce the activity of water – amongst other properties – and thus can act as prebiotic reactions vessels for condensation reactions.

This talk presents results on investigations of nucleotides within nanoconfinements of water formed in aqueous particle dispersions of e.g. polycyclic aromatic heterocycle particles and inorganic mineral particles such as graphite, silica or iron oxides.

We found a spontaneous polymerization of nucleotides creating RNA within temporal nanoconfinements of water. We discuss how the nanoconfinements are formed, how they overcome the hydrolysis problem and present different yield of formed RNA, regarding to different experimental settings and ambient conditions.
Regarding the fact that active sites of numerous enzymes reduce water activity and thus

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prevent hydrolysis during polymerization reactions by forming pockets of nanoconfined water our findings may contribute to solve the "water problem" in two ways: our model both consider the aspect of conservation in evolution and solves the water problem paradox within an aqueous environment in the form of suspensions – ubiquitous in the prebiotic world.