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Mineral-Mediated Chemical Evolution of RNA and Related Molecules Compatible with the Hadean Environments

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RNA world under the Hadean environments: Before the RNA-based or RNA-protein-based life-like systems towards the last universal common ancestor of the present organisms, RNA-like and protein-like molecules should have accumulated by chemical evolution processes from these monomeric materials under the primitive Earth conditions. It is reasonable that different types of naturally-occurring minerals could have played important roles, such as the catalytic formation, selection, and concentration of these biomolecules since these processes should have occurred in aqueous medium or water-rich environments. Extensive studies, such as prebiotic RNA formation in the presence of montmorillonite clay [1,2], have continuously supported experimentally this assumption. Nevertheless, it is also essential to verify whether the Hadean environments were compatible with chemical-physical plausibility of these processes.

Hydrothermal verifications: These chemical evolution experiments have been carried out somewhat or much more mild conditions as comparing with the plausible Hadean environments. We have developed a series of hydrothermal micro-flow reactor systems which enable to analyze chemical evolution processes at temperatures up to 400 ºC, pressures up to 35 MPa within the millisecond to second time scale (0.002 – 200 sec) [3]. On the other hand, a large diversity of the early Earth environments is taken into account. Thus, improvements for in situ monitoring of UV-visible absorption spectra and reactions in the presence of mineral particles were achieved [4,5]. These hydrothermal micro-flow reactor systems are useful for kinetic analysis of the stability and prebiotic formation of nucleotides, RNA, amino acids, peptides, and proteins, and thermodynamic investigation of interaction of biomolecules at high temperatures. By using these systems, we found efficient elongation of alanine peptide from $(Ala)_4$ to $(Ala)_5$ under the hydrothermal conditions, and this is enhanced with carbonate minerals, for instance [5,6]. In addition, we showed a possibility of RNA elongation at temperatures over 100 ºC in the presence of clay mineral [7] and the behavior of a ribozyme [8]. Further improvements of the hydrothermal flow systems are currently investigated [9].

Recently, we focused whether the elongation from $(Ala)_4$ to $(Ala)_5$ occur with or without hydrothermal conditions, and the roles of minerals of clay minerals for this elongation processes.

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