Searching for Prebiotic Organizations in Primordial Sea Medium Enriched by Transition Metals

-Mechanisms of Self-Assembly of Elastomeric Proteins by Transition Metal Chlorides-

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Summary

Molecular assembly process of tropoelastin in extracellular crevice is thought to be a key step of the elastogenesis to establish the structural basis of multiple functions of elastomeric protein as an extracellular matrix. In three major components constructing arterial wall such as vascular smooth muscle cell, collagen , and elastin, only elastin is responsible for the generation of normal internal vascular pressure. It was reported, on the other hand, that the formation of particles containing elastin-like cross-linked polypeptides are observed by prebiotic chemical experiments in primordial sea medium enriched by transition metals. These molecular self-assembly processes in extracellular space and in simulated primordial conditions can be mimicked by the temperature-dependent coacervation of elastin-related polypeptides, such as tropoelastin, α-elastin, and model polypeptides with specific repeating amino acid sequences.

Phase diagram with lower critical solution temperature characterizing the temperature-dependent coacervation of bovine neck ligamental α-elastin-water system was obtained based on the light scattering photometry and phase contrast microscopy. Hydrodynamic analysis of elastin coacervate assemblies as a scattering particle and computational particle image analysis for microcoacervate droplets demonstrated that two types of dynamic processes characterizing the critical and off-critical self-assembly processes of the elastomeric protein-water system. Temperature-dependent coacervation experiments utilizing more hydrophobic elastin model polypentapeptides and α-elastin with coexisting metal cations suggested that the fast and slow processes are based on the fundamental hydrophobic interactions and supplemental electrostatic interactions of charged amino acid residues, respectively. Effects of metal cations on the temperature-dependent coacervation of elastomeric protein-water system were examined also by CD and NMR spectroscopic investigations. Interactions between metal cations and carboxyl groups of amino acid side chains only caused simple and nonspecific effects such as salting-in and salting-out mechanisms. Highly specific and selective binding of Ca^{2+} and La^{3+} ions to peptide backbone carbonyl groups, on the contrary, induced significant effects on β-spiral structure and molecular self-assembly process. Cu^{2+} ions, incapable of binding to peptide backbone carbonyl groups, also revealed important effects on the coacervate formations probably based on the formation of coordinative complex with side chain carboxyl groups.