**Importance of Pressure for Prebiotic Peptide Formation: Implication to Origin of Life on the Early Earth**

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**Introduction:** Prebiotic peptide formation is the essential process to promote chemical evolution for origin of life. Polymerization of amino acids, thus peptide formation, is accompanied with dehydration reactions. Such dehydrating nature on peptide formation questions if submarine hydrothermal conditions, i.e., more hydrated conditions, were suitable for prebiotic peptide formations. Peptide formation is often promoted by addition of heat energy in a reaction system. However, thermal weakness is present among amino acids, limiting the reaction temperature of peptide formation. On the other hand, a pressure effect is expected to compensate such thermal weakness, and expand the reaction temperature range of peptide formation.

Those lead to a new hypothesis that the prebiotic peptides may have formed under high-temperature and high-pressure environments accompanied with dehydrating (water-poor) conditions. The main purpose of the present study is, therefore, set to examine the above hypothesis experimentally.

**Experimental:** In order to examine pressure, temperature and dehydration effects on peptide formation, series of autoclave experiments were performed. Purified powders (100mg) of alanine, glycine, valine, aspartic acid and methionine were used in experiments. Water was not added to starting materials to realize dry and dehydrating conditions. The amino acid powders were sealed in individual gold tubes and, then, placed into a test-tube type autoclave. Experiments were performed for 1 to 30 days under various pressure (1-175 MPa) and temperature (100-200 C) conditions. The products were analyzed using HPLC and LC-MS at Tohoku University. In particular, degree of peptide polymerization was carefully examined using peptide standards for LC-MS analyses. Analytical conditions of the LC-MS are described elsewhere [1, 2].

**Results and Discussion:** Results indicate that: (1) glycine was polymerized up to 11-mer (combination of 11 glycine molecules), which was not formed in any previous experiments without catalyses [3]; (2) valine was polymerized up to 3-mer, which was considered to be difficult to be formed; (3) aspartic acid was polymerized to 4-mer, accompanied with production of tyrosine, glycine and alanine; and (4) methionine 2-mer was formed. Surprisingly many peptides in the present study are stable even in high temperature conditions exceeding 100 C degree. This suggests that thermal stability of pepides is significantly enlarged in pressurized conditions. It is also found that pressure has a role to limit the production of DKP and cyclic amino acids, which are inhibitors for elongation of peptides. Production of ammonia was also limited in high-pressure conditions. All results indicate that heat energy was effectively utilized to convert individual amino acids into highly elongated peptides under high-pressure conditions.

Those results further imply that prebiotic peptide formation could happen inside of deep oceanic crusts of the early Earth where pressure and temperature were available. Pressurized crustal conditions also promote dehydrating reactions, thus favoring for peptide formation. In addition, “thermally“ stable peptides under pressurized conditions are useful to understand the unknown ecosystem of deep subsurface biosphere of the modern Earth.

**References:**

[1] Furukawa Y. et al. (2009) *Nature Geoscience*, *2,*62–66. [2] Schouten et al. (2009) G-cube, vol.10., Q03012. [3] Ohara S. et. al. (2007) *Orig. Life and Ear. Evol., 37,* 215–223.