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Valine peptide formation under high temperature and high pressure conditions

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Peptide formation on the early Earth is an essential process for the origin of life. Heating experiments of compressed solid valine, one of the simplest amino acid having an alkyl side chain, were performed under various temperature (150-200^{o}C) and pressure (50-150 MPa) conditions up to 384 hours, in order to investigate how temperature and pressure affect the stability of valine and reaction rates of the peptide formation from valine monomers. The samples were enclosed in a gold tube and pressurized with a test-tube type autoclave using water as pressure medium. Produced peptides were analyzed by liquid chromatography-mass spectrometry (LC/MS). The recovered valine and decomposition products having amino groups were analyzed with a high performance liquid chromatography (HPLC) after the derivatization with a florescent reagent.

The run products contained linear peptides from dimmer to hexamer, cyclic dimmer, other amino acids, ammonia, and amines. The decomposition rates of starting valine at three different temperatures showed that the decomposition of the starting valine was very sensitive to the temperature change. Increasing temperature also accelerate the rates of both formation and decomposition of the linear peptides. On the other hand, the decomposition rates of valine and its peptides decreased with increasing pressure. The effect of pressure on production rates of valine peptides were very small, compared to that of temperature. Because the major decomposition products were ammonia and carbon dioxide, which were vapor or supercritical phase at the experimental conditions, pressure could suppress the degradation of valine and peptides by inhibiting their degassing reactions. The results of our experiments support a hypothesis that peptides were formed through diagenesis and suggest that pressure expand the stability of valine and the peptides under high temperature conditions. The present study also suggests that the typical diagenetic condition (up to 100^{o}C) is suitable for the high yield peptide formation in geological time scale. Polymerization of other amino acids, such as glycine and alanine, were also confirmed at different series of anhydrous experiments, suggesting a general importance of pressurized deep sediments for prebiotic peptide formations.

Keywords: amino acid, polymerization, protein, origin of life, early Earth, pressure