Effect of pH on the polymerization rate of an amino acid

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In the chemical evolution of life, amino acids should be polymerized into peptides. Therefore, it is necessary to evaluate quantitatively amino acid polymerization processes. Although it is known that solution pH significantly influences polymerization rates, quantitative effects of pH have not yet been investigated. In this study, the pH effects on the polymerization rate of an amino acid (glycine: Gly) were quantitatively evaluated.

8.0ml of 100mM Gly solutions, having pH from 6 to 9, were put into Teflon bottles and heated at 140 degree C from 1 to 14 days. After heating, concentrations of glycine (Gly), glycylglycine (GlyGly) and diketopiperazine (DKP) were measured by liquid chromatography (LC). In the same way, 8.0ml of 50mM GlyGly solutions, having pH from 6 to 9, were put into Teflon bottles and heated at 140 degree C from 1 to 4 days. Concentrations of Gly, GlyGly and DKP after the reaction were measured by LC.

In this study, the reaction pathways are assumed to be the following: Gly to GlyGly (the second order reaction), GlyGly to DKP (the first order reaction), DKP to GlyGly (the first order reaction), GlyGly to Gly (the first order reaction). Results of heating experiments on Gly and GlyGly solutions were fitted by the above four reactions to obtain corresponding rate constants.

As a result, GlyGly formation rate constants increased for increasing pH. Dissociated species of amino acids are known to change from zweitterion to anion with increasing pH. The deprotonated anionic amino group is considered to have higher reactivity than zweitterions and is favorable for peptide formation. Therefore, the polymerization process of amino acid can be favored for alkaline conditions.