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The adsorption behabior on montmorillonite under hydrothermal condition

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Amino acids comprising protains are the most fundamental substances of life. Stability and polymerization of amino acids are essentially important to succeed the life on the primitive earth. Thermal energy of submarine hydrothermal systems might be the driving force of amino acid polymerization, although the amino acids can easily be decomposed by heat. Clay minerals in the system would protect the amino acids from thermal decomposition (Imai, 2004). In this study, the role of clay minerals to form peptides at hydrothermal condition was examined by two different approaches from the point of views of laboratory experiment.

First, 1 mmol/L glycine solution was heated with 1g montmorillonite or amorphous silica at pH 2, at which the maximum concentration of adsorbed glycine was observed at room temperature, and 150 degrees for 168 hours. After the reaction, amount of adsorbed glycine onto montmorillonite and amorphous silica were 2046 nmol/g and 307 nmol/g, respectively. The glycine concentration in the solution was the same for the solution after the reaction. Peptide formation was not observed in the set conditions.

Second, pH dependence on the peptide formation was examined. 1 mmol/L glycine solution with 1g montmorillonite was heated changing pH from 2 to 12 at 150 degrees for 168 hours. The glycine adsorbed was 101.54 nnol/g, 76.65 nnol/g, 88.56 nnol/g, 46.47nnol/g, 48.87nnol/g, and 28.50nmol/g at pH 2, 4, 6, 8, 10 and 12, respectively. In the solurion, remaining glycine was 0.74 mmol/L, 0.42mmol/L, 0.40mmol/L, 0.54mmol/L, 0.80mmol/L, 0.80mmol/L at pH 2, 4, 6, 8, 10 and 12, respectively. Peptide was not observed in the series of this experiments, similar to the results of above experiment. Since the glicyne is dominant cation below pH 5.97 (isoelectric point) and surface of montmollilonite is charged negative, the montmorillonite adsorbs glycine easily in the acidic solution below that pH. The remaining amount of glycine is small at around neutral pH, probably because the glycine is nonpolar molecule which has small affinity to be adsorbed.

Those experiments suggest that the montmollilonite preserves more glycine via adsorption at acidic condition in high temperature hydrothermal solution. Montmollilonite may maintain the stability of glycine in the solution at around neutral pH. Peptide formation was not observed at any conditions of this study. Since the peptide formation is dehydration reaction, it would rarely occur in the aqueous solution. Thus, the peptide formation would be favorable under dry conditions.Thus, the clay minerals would work to condence the amino acid, and dry condition would be needed for further reaction for peptide formation.

Keywords: hydrothermal condition, glycine, montmorillonite, adsorption, pH