Simulation of chemical evolution in submarine hydrothermal systems with flow reactor

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Many submarine hydrothermal systems (SHSs) has been discovered since their first discovery in the late 1970s. It is suggested that SHSs is promising environments for the chemical reaction toward the generation of life in the Earth. They keep reducing environments where organic compounds are easily formed and stored stably. Concentrations of metal ions there are 10,000 times larger than those in surrounding seawater: Some metal ions have many catalytic activities. Therefore, it was possible that the organic compounds generated in the Earth or supplied from space are altered to the molecular systems with biological functions in the SHSs. In addition to that, novel biospheres were discovered near SHSs. There have been many laboratory simulations of SHSs. In most of them, however, closed systems were used. In the present study, possible organic reactions in simulated hydrothermal systems was examined by using a flow system. We examined the formation of amino acids with Strecker-type reactions by using a supercritical water flow reactor (SCWFR). Possible roles of metal ions are also examined. A aqueous solution of KCN (0.1 M), HCHO (0.1 M), and (NH4)HCO3 (0.05 M) was used as a standard starting material (hereafter referred as Sample A).

Experiment 1: The sample A was heated at 200 - 400 C for 2 minutes 25 MPa.

Experiment 2: Zn2+ (1 mM, 5 mM, 10 mM) and Mn2+ (1 mM, 5 mM, 10 mM) was added to the Sample A, and heated at 200 - 400 C for 2 minutes at 25 MPa.

Experiment 3: The sample A was diluted to 10 times, 20 times, and 100 times, and then heated at 200 - 300 C for 2 minutes 25 MPa.

After reactions, amino acids in the resulting products were analyzed with an amino acid analyzer after acid hydrolysis (6 M HCl, 110 C, 24 h) and Desalting with AG 50W-X8 Resin.

The sample A gave several amino acids: Gly was predominant, followed by alanine in all the tempertures. Beta-alanine and gamma-aminobutyric acid were also detected in small amount. No amino acids was not detected when heating at 400 C. When 1 mM of Zn2+ was added, more amino acids were obtained at all the temperatures examined. On the other hands, 5 or 10 mM of Zn2+ or Mn2+ was added to the Sample A, amino acid yields were decreased. When the Sample A was used after dilution, amino acids were still detected. Further works will be done to examine possible roles of submarine hydrothermal systems and metal ions existing there in chemical evolution toward the generation of life in the Earth.