Hydrothermal Interactions between RNA Molecules and Phosphate Minerals

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Transmission of genetic information is an essential factor for life, and it is presumed that RNA played a primary role in the first primitive life. However, formation processes of RNA in the chemical evolution have not been well understood. RNA is made of nucleosides (composed of sugars and bases) and phosphoric acids bound by phosphodiester linkages between sugar parts of nucleosides and phosphoric acids. Thus phosphorylation of nucleosides was an important step in prebiotic evolution. It is possible that phosphate minerals served as a phosphate source. In order to evaluate this possibility, hydrothermal experiments have been conducted using hydroxyapatite(HAP) as a phosphate mineral and adenosine as a nucleoside.

In our experiments, 4 different types of starting mixtures were heated in an electric oven at 140 degrees C for 1-8 days, 10 ml of 10 mM adenosine, 10 ml of 10 mM adenosine with 0.1 g HAP powder, and 10 ml of 10 mM adenosine with 1 g HAP powder. The 4th type is 10 mM adenosine solution containing dissolved phosphate and calcium. Obtained solutions were analyzed by UV-Visible spectroscopy and ATR-IR spectroscopy and HPLC. Ortho-phosphate and calcium concentration of obtained solutions was measured by colorimetric methods. Product precipitates were observed by SEM microscopy and analyzed by FT-IR spectroscopy with the KBr pellet method.

As a result, adenosine completely lost by this hydrothermal heating. Adenine (base) was first formed, and then decomposed. Hypoxanthine was also produced. No phosphorylated nucleoside (AMP, ADP, ATP) was detected. The decomposition rate of adenosine increased in the following order: adenosine only, with dissolved phosphate and calcium, with 0.1 g HAP powder, with 1 g HAP powder. The concentration of phosphate in the obtained solution with 1 g HAP powder was about 3 times larger than those of other solutions. Product precipitates were needle-like crystals.

These results indicate that the phosphate mineral accelerated the thermal decomposition rate of adenosine at 140degrees C. This temperature condition is considered to be not favorable for the chemical evolution to RNA, because of unstability of the nucleoside and no phosphorylation.