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Effects of borate on the stability of ribose

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RNA is considered an important biomolecule for the origin of life, with its abilities as the carrier of genetic information and catalysts for biological reactions. RNA is composed of phosphoric acid, nucleic acid bases, and ribose. Among them, ribose is the most unstable component. Therefore, accumulation of ribose on the early Earth is an important step for the origin of RNA. Ribose as well as other aldopentoses can be abiotically synthesized by formose reaction in which formaldehyde oligomerize under alkaline conditions. Previous studies showed a stabilization of pentoses in the formose reaction by borate. In this study, we have investigated the effects of borate on the stability of aldopentoses.

Incubation experiments of each four aldopentoses were conducted at approximately 45 degree C with sodium tetraborate decahydrate of three concentrations. The pH of the experimental solution was buffered with calcium hydroxide. The experimental solution was collected at a fixed interval and analyzed with liquid chromatography-mass spectrometry.

In the borate-free experiments, all aldopentoses showed high decrease rates. In borate-containing experiments, formations of pentose-borate complexes were observed. The decrease rates for all aldopentoses were reduced with the concentration of borate. These results indicate that borate can stabilize all aldopentoses. Therefore, borate might have stabilized aldopentoses including ribose and contributed to the formation of primordial RNA on the early Earth.

Keywords: ribose, RNA, borate, origin of life