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One-pot formation of non-canonical ribonucleosides and their components from aldehydes and ammonia under prebiotic Earth conditions

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The spontaneous formation of ribonucleotides and their components (sugars, nucleobases, nucleosides) is widely regarded as an essential step for the origin of life. In natural geological settings, abundant reactive molecules in the environments direct the reactions and products. Aldehydes and ammonia are reactive molecules present in considerable amounts on the prebiotic Earth (*1-3*). However, the formation of canonical nucleobases and nucleosides from aldehydes and ammonia has not been reported. Thus, this research investigated the formation of ribonucleotide components from an aldehyde-ammonia solution. The aqueous solution containing formaldehyde, glycolaldehyde, and ammonia was heated at 60–90°C in the presence of $Ca(OH)_2$ and borate. The products were analyzed with GC-MS for sugars and LC-MS/MS for nucleobases and nucleosides. GC-MS analysis showed the formation of aldopentoses, including ribose. Various N-heterocycles, including imidazole and its derivatives, were detected. Although the formation of canonical nucleobases and nucleosides was not confirmed, detailed LC-MS/MS analysis revealed the formation of ribosyl imidazole (imidazole nucleoside). Borate substantially increased the yields of ribosyl imidazole. These results indicate the new pathway for ribonucleoside via ribosyl amine. One-pot formation of ribosyl imidazole through this pathway suggests the formation of imidazole and its nucleoside more abundantly compared to canonical ones on prebiotic Earth. This further implies that Hadean environmental oligonucleotides contained imidazole bases and that primordial RNAs might have been inherited from this character.

References

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