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Chemical evolutions and the early Earth's atmosphere

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The composition of the early Earth's atmosphere when life originated remains uncertain. A half century ago, S. L. Miller successfully synthesized amino acids from a spark discharge in a gas mixture of methane, ammonia, hydrogen, and water. After this experiment, it has been suggested that the early Earth's atmosphere when life originated may not have been that of strong reducing conditions, and rather a more oxidized atmosphere containing carbon dioxide and nitrogen. Subsequent spark discharge experiments have shown that bioorganic compounds are not efficiently produced from CO2-N2-H2O atmospheres, prompting the investigation of other synthetic pathways for bioorganic compounds.

Recently, several hypotheses regarding the origins of bioorganic compounds have been proposed:

(1) Formation of bioorganic compounds from a CO2-N2-H2O atmosphere containing less CH4.
(2) Formation of bioorganic compounds under hydrothermal conditions.
(3) Delivery of bioorganic compounds by meteorites and comets.

Although each of these hypotheses is supported by experimental data, observations or theoretical calculations, remaining problems must be addressed.

We have experimentally shown that bioorganic compounds, such as amino acids and nucleic acid bases, are efficiently synthesized from a gas mixture of carbon monoxide, nitrogen and water using proton irradiation and high-temperature plasma discharges.1-3) Based on these results, we have proposed that a CO-dominant atmosphere may have been present when life originated.3)

Here we discuss the possibility of a CO-dominant atmosphere when life originated, and show the efficiency of synthesis in this atmosphere when compared to other proposed pathways.

1) K. Kobayashi, T. Kaneko, T. Saito, and T. Oshima, Origins Life Evol. Biosphere 28 (1998) 155-165.
2) S. Miyakawa, K. Murasawa, K. Kobayashi, and A. B. Sawaoka, J. Am. Chem. Soc. 121 (1999) 8144-8145.
3) S. Miyakawa, H. Yamanashi, K. Kobayashi, H. J. Cleaves, and S. L. Miller, Proc. Natl. Acad. Sci. USA 99 (2002) 14628-14631.