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Amino acid formation from simulaed mildly-reducing primitive atmospheres by spark discharges and proton irradiation

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Miller (1953) reported that amino acids were abiotically formed in a gas mixture of methane, ammonia, hydrogen and water. However, It is suggested that the primitive Earth atmosphere was less reducing, and its major components were carbon dioxide and nitrogen. It is quite difficult to form amino acids from such non-reducing gas mixtures. If it is mildly reducing, i.e. it contained some carbon monoxide or methane, amino acid production could be expected.

We examined possible formation of amino acids from mildly reducing gas mixtures by spark discharges or by proton irradiation. A mixture of carbon dioxide and methane (total 50 %) and nitrogen (50 %) was introduced into a glass tube with liquid water. Spark discharges in the gas mixtures were performed with a Tesla coil for 12 hours. Proton beams (2.5 MeV, 2 mC) were irradiated to the gas mixtures from a Tandem accelerator (TIT). The resulting products were acid-hydrolyzed, and amino acids were determined by ion-exchange HPLC with post-derivatization with o-phthalaldehyde and N-acetyl-L-cystein.

A mixture of methane and nitrogen gave amino acids in high yields by either spark discharges or proton irradiation. When carbon dioxide was added to the gas mixture, amino acid yields decreased. In the case of spark discharges, amino acids could not be detected when methane ratio in total carbon sources (carbon dioxide + methane) was less than 30 %. In the case of proton irradiation, the mixture with the methane ratio was 5 % still gave amino acids. Thus, it was suggested that, in the case that the primitive Earth atmosphere was only slightly reducing, a major energy source for the production of amino acids was not thundering but cosmic rays.

Keywords: mildly-reducing primitive atmospheres, spark discharge, proton irradiation, origins of life, amino acids