
[EE] Evening Poster | B (Biogeosciences) | B-AO Astrobiology & the Origin of Life

[B-AO01]Astrobiology

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Twenty years have passed since when the field of Astrobiology, which aims to unveil the origins, evolution, and habitability of life by integrating multidisciplinary fields, was established. Origins of Life are currently being re-conceptualized via expansion of prebiotic chemistry to systems chemistry and chemical space. Besides their relationship to life's building blocks, it is expected to demonstrate the significant roles of organic molecules in the history of planetary formation. The linkages among the variations in chemical compositions of deep-sea hydrothermal environments, geological settings, and ecological systems were systematically investigated. Cassini, which accomplished in the long-term explorations of the planets bearing liquid, had "Grand Finale" this year. Discoveries of extrasolar planets have been dramatically increased to date.

Originally, Astrobiology does not need a specific science category. We therefore aim to make this session so that Earth and Planetary scientists from all the categories join for discussing 'where we came from and where we are going' and for making novel integrated researches.

For the next stage of Astrobiology, presentations on the instrument development in space explorations, comparative studies of solar system and exoplanets, etc, will be very much welcome.

[BAO01-P05]The formation of Amino acids and Organic acids from simulated mildly-reducing primitive atmosphere

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Since 1950s, a large number of laboratory experiments have been performed to examine possible formation of bioorganic compounds such as amino acids in primitive Earth atmosphere. Earlier experiments with strongly reducing gas mixtures containing large molar ratio of methane and ammonia, and it was reported that efficient production of amino acids and other important organics were formed in it by spark discharges and other energy sources. It is now estimated, however, that the early Earth atmosphere was only slightly reducing [1]: N₂ and CO₂ were the major atmospheric constituents, together with some small amount of reducing carbon species like CH₄ and/or CO. Simulation experiments suggested, however, that amino acid formation was restricted under these conditions [2]. We reported that cosmic rays could facilitate chemical reactions with less reducing model of primitive atmosphere such as a mixture of CO₂, CO, N₂ and H₂O [3]. However these energy sources have been ignored in experiments with initiation of prebiotic chemistry [4]. Here, we examine possible formation of amino acids from slightly reducing gas mixtures by applying high-energy protons to simulate the action of cosmic rays.

We conducted three sets of laboratory experiments using energetic particles, spark discharge and UV light as dominant energy sources. In these sets of experiments we used 400 mL of gas mixture of N₂, CO₂

and CH₄ introduced to a Pyrex tube together with 5 mL of pure water under 350 Torr of N₂ and 350 Torr of mixtures with varied mixing ratios of CH₄ and CO₂. In order to simulate possible roles of cosmic rays, the gas mixture was irradiated with 2.5 MeV proton beam produced in the Tandem accelerator at Tokyo Tech, Japan. We also exposed the same composition of gas mixtures to spark discharges by using a Tesla coil to simulate lightning. The gas mixtures were also irradiated with UV light (λ ; >190 nm) from a xenon lamp. Each product was acid-hydrolyzed and was subjected to amino acid analysis by HPLC and GC/MS, both after derivatization. Carboxylic acids were determined by GC/MS after derivatization. Starting and resulting gas mixtures were analyzed with a quadrupole mass spectrometer.

Amino acids were detected in the hydrolyzed products when gas mixtures of N₂, CO₂, CH₄ and H₂O were irradiated with 2.5 MeV protons at the initial the molar ratio of methane (r_{CH_4}) in the starting gas mixture as low as 0.5 %. On the other hand, amino acids were detected only when r_{CH_4} was greater than 15 % in the case of spark discharges. The experiments with UV irradiation source did not yield amino acids or their precursors even when r_{CH_4} was 50 %. Very little amino acids were detected in all the products before hydrolysis. It was shown that not free amino acids but amino acid precursors were formed in selected experiments.

Carboxylic acids including formic acid, oxalic acid and glyoxylic acid were detected from unhydrolyzed products derived from N₂-CO₂ gas mixtures exposed to spark discharges and proton irradiation. We show that some free carboxylic acids could be formed in non-reducing atmospheres as well as slightly reducing atmospheres either by proton irradiation or by spark discharges. It was suggested that the mechanism of formation of amino acid precursors from N₂-CO₂-CH₄-H₂O mixtures was quite different from that of carboxylic acids.

Lightning and solar UV have been considered important energy sources for prebiotic synthesis in primitive Earth atmosphere. We here showed that lightning and solar UV could not singularly synthesize important N-containing organics such as amino acids from slightly reducing primitive Earth atmosphere. On the other hand, cosmic ray could have been an important energy source to synthesize amino acid precursors even if primitive Earth atmosphere was only slightly reducing. It would be of interest to examine whether there are synergetic effects among cosmic rays, UV and thundering.

References:

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