

## Possible Formation of amino acids from Titan Atmosphere by Cosmic Rays

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Titan, the largest satellite of Saturn, has a dense atmosphere containing nitrogen and methane, together with a wide variety of hydrocarbons and nitriles as minor constituents. It is hypothesized that these minor constituents are formed by ultraviolet light and high energy charged particles entrapped in magnetosphere, and cosmic rays. We performed laboratory experiments simulating reactions in Titan atmosphere by using such energy sources as high energy protons, gamma-rays, ultraviolet light and spark discharges.

A mixture of nitrogen (99%) and methane (1%) was sealed in a Pyrex tube, and one of the energies above was supplied to it. High energy protons were generated from a van de Graaff accelerator (Tokyo Institute of Technology) (hereafter referred as PI). Gamma-irradiation (GI) was performed by using a cobalt-60 sources in University of Tokyo. Spark discharges (SD) were done by using a Tesla coil. UV irradiation was performed by using a deuterium lamp: A window of the reaction tube was made of synthesized quartz. Gaseous products were analyzed by GC-FID and GC/MS. Solid products (Tholin) were recovered with liquid water, and were acid-hydrolyzed, Amino acids in the hydrolysates were determined with an amino acid analyzer (Shimadzu LC-10A).

Major gaseous products of PI and UV were saturated hydrocarbons, while those of SD were unsaturated hydrocarbons. Nitriles were also among major gaseous products of PI and SD, but UV products did not contain nitriles. These results suggest that reactions in Titan atmosphere are not caused by sole solar UV nor sole discharges.

Hydrolysates of PI, GI and SD yields various amino acids, and glycine was predominant in all of the three cases: UV yielded only trace (or contamination) level of amino acids. G-value of glycine by PI was 0.003, while that by SD was 0.00003.

Conventionally speaking, Titan has very little oxygen-containing species like water. It is probable, however, water has been delivered to Titan by comets. If the tholin produced from Titan atmosphere by cosmic ray interact with water ice on the surface of Titan, amino acids or other bioorganic compounds could be formed. These amino acids would be targets of future Titan missions.