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# HCN production by chemical reactions between impact-induced hot CN and a neutral atmosphere

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Hydrogen cyanide (HCN) is one of the most important molecules in the origin of life, because it can help forming amino acids and nuclear bases. The processes of HCN production and organic supply on pre-biotic Earth have been widely studied. A meteoritic impact is a particularly important process because it produces a large amount of HCN in a short period time, allowing to have high concentration of HCN on Earth. Previous studies show that a large amount of HCN is formed by pure gas-phase chemical reactions due to impact shocks in a strongly reducing atmosphere (i.e., H2-CH4-NH3-rich). However, the widely accepted composition of the early Earth's atmosphere range from mildly reducing (mostly CO and CO2 and small amounts of H2 and CH4) to neutral (N2-CO2 dominated). In such atmosphere, HCN production efficiency is greatly reduced. Thus, if there is a more efficient mechanism to produce HCN in a mildly reducing or neutral atmosphere, it would play a very important role in the origin of life.

Recent impact experiments by Sugita and Schultz, (2000) show that a large amount of CN radicals may be produced by chemical reaction between carbon-rich meteoritic material and an ambient nitrogen-rich atmosphere. Although it was inferred that the impact-generated CN radicals may react with water vapor in an ambient atmosphere to form HCN, this possibility has not been investigated experimentally. Thus, in this study, we conducted laser ablation experiments within gas mixtures using a GCMS and a high-speed optical spectrometer to investigate chemical reactions between impact-induced hot CN radicals and a neutral atmosphere.

A graphite target and N2-CO2-H2O gas mixtures were used in this experiments. A Nd:YAG laser was used to generate high-temperature CN radicals. Band optical emission of CN was observed to estimate the total amount and temperature of laser-induced CN radicals. The final product gas was analyzed with GCMS after laser irradiation to measure the total amount of HCN.

The results of spectroscopic observations show that the thermal and chemical state of laser-induced hot vapor is similar to impact-induced one. The temperature and column number density of hot CN radicals are 6500 - 6800 K and 10 - 50 nmol/cm2 in neutral atmosphere, respectively.

The results of mass-spectrometry show that the chemical composition of final product gas is depends rather strongly on that of the ambient atmosphere. The HCN production decreases as the partial pressure of CO2 increases. The HCN production are 9.8 and 2.8 nmol within 0 and 200 Torr of CO2, respectively. The conversion ratio from hot CN to HCN in neutral atmosphere is 19 - 5 % for 0 - 300 Torr of CO2 partial pressure.

The above two sets of experiments strongly suggest that hot CN radicals produced by a hypervelocity impact of carbon-rich asteroid would chemically react with water vapor in an ambient atmosphere and produce a large amount of HCN. Although HCN production decreases as the partial pressure of CO2, 1 -100 ppm of HCN would be formed in ambient atmospheres that contain as much as a few hundred Torr of CO2. Thus, this HCN production mechanism may have worked efficiently on early Earth and played an important role in the chemical evolution during the origin of life.