Abiotic Nitrogen Fixation and Organic Synthesis by Photochemistry on Early Mars

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Detailed studies of Mars in recent years have provided many progress on understanding the possible view of environment on early Mars. With the fact that liquid water was present on early Mars, and the discovery of organic molecules as well as nitrogen-bearing compounds on Mars, there is possibility that life could have emerged on early Mars. Thus, it is important to understand the abiotic organic synthesis and nitrogen fixation process to evaluate the possible origin of life on Mars or other terrestrial planet. Previous studies suggested that organic matters can be produced by photochemistry. Total pressure of Martian atmosphere is lower than Earth. Thus, UV may penetrated down to the surface and can directly photolyze liquid water. This suggests that UV-induced photochemistry may have been more important. However, little is known about abiotic nitrogen fixation by UV light. This experimental study examines the nitrogen photochemistry at the surface of water. In the experiment, initial gas contains N_2O or N_2 with or without CO under the presence of liquid water. The starting condition may have existed on early Mars. The results showed that NH_3, methylamine, glycine and other amino acids was produced from $N_2O + CO + H_2O$, whereas only trace amount of NH_3 was formed from $N_2 + CO + H_2O$. When gas phase do not contain CO, nitrate and nitrite were produced instead of NH_3. A numerical model including 296 photochemical reactions was constructed, and can qualitatively explain the formation of NH_3 from N_2O. However, the concentration of NH_3 in the model is order of magnitude lower than the observed amount in the experiment, suggesting that current photochemical model still lack some possible reactions to generate NH_3. The results provide important insights on chemical evolution theory that lead to the origin of life and the atmospheric evolution on Mars when the reaction pathway of NH_3 starting from N_2O and N_2 by UV light is confirmed.

Keywords: Mars, Nitrogen fixation, amino acid synthesis, UV

