

Synthesis of an amino acid from carboxylic acid and ammonia with shock wave

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Proteins are composed of twenty kinds of amino acids and are essential biomolecules for life on the Earth. Therefore, origins of amino acids on the early Earth have been an important concern. Many previous studies indicate that the late heavy bombardment (LHB) of extraterrestrial objects had occurred during 3.8-4.0 billion years ago. These impacts might have delivered and produced prebiotic organic compounds including amino acids, amines, and carboxylic acids as well as ammonia (Cronin and Pizzarello et al., 1988; Furukawa et al. 2009). However, the number of biomolecule by these processes was limited number of amino acids among protein-constituent amino acids. The organic compounds supplied by the impacts of extraterrestrial objects to the oceans must have experienced further impacts, because the LHB is a successive impact event. In this study, we demonstrated shock-recovery experiments on a solution of formic acid and ammonia to investigate whether amino acids form from low molecular weight organic compounds by oceanic impacts on the early Earth.

Shock-recovery experiments were performed with a single-stage propellant gun using an improved sample container. Starting material is a mixture of ¹³C-formic acid and ammonia. After the impact experiments, soluble organic compounds were extracted into water and then amines and amino acids were analyzed with liquid chromatography-mass spectrometer (LC/MS). Glycine, methylamine and ethylamine whose carbons are composed of ¹³C were identified in all of the samples. The amounts of glycine were almost constant regardless of the impact velocity (0.7-0.8 km/s). The amounts of produced amines increased depending on the impact velocity. The present results suggest that shock wave converts a low molecular weight organic compound to larger molecular weight organic compounds. The successive impacts might have contributed to chemical evolution providing variety in biomolecules on the prebiotic Earth.