Glycine oligomerization up to triglycine by shock experiments simulating comet impacts

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Abiotic peptide synthesis is one of key steps in prebiotic chemistry. Peptides are building block of proteins and also play a role as a catalyst to form other biomolecules (e.g., [1]). Although varieties of mechanisms for abiotic peptide synthesis in terrestrial environments have been proposed, extraterrestrial contribution, that is, cometary and asteroidal impacts has attracted little attention. Considering that the frequency of the extraterrestrial impacts on the early Earth was greater than present day and comets and chondrites contain amino acids (e.g., [2] [3]), extraterrestrial impacts could be a candidate for peptide synthesis. In order to examine the feasibility of abiotic peptide synthesis by comet impacts, we conducted shock experiments on frozen mixtures of amino acid, water ice and silicate (forsterite) at cryogenic condition (77 K).

In the experiments, the frozen amino acid mixture was sealed into a capsule and put into a container filled with liquid nitrogen to be kept at 77 K during the shock experiments. A vertical propellant gun was used to give impact shock. The amounts of remaining amino acid and synthesized peptides in the recovered shocked samples were analyzed with gas chromatographs after the extraction and the derivatization.

The results showed that amino acid was oligomerized into peptides up to tripeptide by impact shock. Furthermore, the yield of linear dipeptide was much higher than that of cyclic diketopiperazine. These results were contrasting to the results of shock experiments at room temperature, in which they resulted in the formation of comparable amount of cyclic peptides to linear peptides [4]. These results indicate that the cryogenic condition at impact shock is a key for the formation of linear peptide. Linear peptides are more useful than cyclic peptides for further elongation of peptide chain. Thus, comet impacts might have played an important role in chemical evolution by delivering linear peptides to the early Earth.

[1] Barbier *et al.* (1993) *J. Mol. Evol.* **37**, 554-558. [2] Elsila *et al.* (2009) *Meteorit. Planet. Sci.* **44**, 1323-1330. [3] Burton *et al.* (2012) *Chem. Soc. Rev.* **41**, 5459–5472. [4] Blank *et al.* (2001) *Orig. Life Evol. Biosph.* **31**, 15-51.