彗星衝突を模擬した衝撃実験によって合成されたLL過剰ペプチド
LL-excess peptides synthesized by shock experiments simulating comet impacts

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Terrestrial organisms have the biological homochirality that uses L-amino acids and D-sugars selectively in biomolecules. Because the homochirality is essential for organisms to form higher-order structures of proteins and to activate enzymes, the homochirality is considered to be an inherent feature also in primitive organisms on the early earth. Therefore, to examine the origin of life, it is necessary to comprehensively discuss the evolution of homochirality as well as the chemical evolution. Because abiotic L-enantiomeric excess (L-ee) amino acids were reported only from carbonaceous meteorites in nature, the L-ee amino acids have been thought as triggers of the evolution of homochirality.

In order to examine the behavior of L-ee amino acids under the impact of bodies on the early earth, we performed the shock experiments of L-alanine solution simulating the impact of comets, which are thought to contain many organic materials similar to that of carbonaceous chondrites. Shock pressure (6.5-34 GPa) and shock temperature (500-887 K) were calculated using one-dimensional impedance matching method. Recovered samples were derivatized (esterification and acylation) and analyzed with GC-FID and GC-MS.

Alanine and dialanine were detected in shocked samples. With increasing shock temperature, while abundance and L-ee ({(L-D) / (L+D)} * 100 (%)) of survived alanine were decreased, LL-ee dialanine were produced. LL-peptides have been considered to be important in the evolution processes for the origin of life since they act as catalysts for polymerization of biomaterials and selective synthesis of D-sugars. Furthermore, interestingly, LL-ee ({(LL-DD) / (LL+DD)} * 100 (%)) shows greater values than L-ee at same shock conditions. The ee amplification process of amino acids by recrystallization has been proposed, but there is no report of the ee amplification of peptides during polymerization process. The results of this study suggest that comet impacts had been important process for origin of life because the chemical evolution to form peptides and the development of homochirality to amplify the ee are occurred simultaneously.

Considering the frequency distribution of impact velocity of comets in nature, about 10% of all comet impact numbers experienced the shock conditions of this experiments. Also, considering the deceleration of impact velocity by Earth’s atmosphere, the shock conditions of this experiments would have occurred sufficiently even in nature. From these results, comet impacts have not only supplied L-ee amino acids and LL-ee peptides, which are important for the origin of life, to the early earth, but also important events that could resolve simultaneously the homochirality and the chemical evolution.

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