Amplification of enantiomeric excess in the polymerization induced by shock compression of L-alanine aqueous solution

K. MIMURA[1], R. OKADA[1], T. NISHIDA[1]

[1] Graduate school of Environmental Studies, Nagoya University, mimura@eps.nagoya-u.ac.jp

Several amino acids in meteorites show L-enantiomeric excess (L-ee) [1]. Because most of terrestrial organisms used only L-amino acids in their body, abiotic L-ee of extraterrestrial amino acids has been regarded as a possible trigger of homochirality. Comets are also thought to contain many types of organic materials including amino acids similar to meteorites [2, 3]. When extraterrestrial bodies, meteorites and comets impact against the earth, they should experience high pressure and high temperature conditions. Then, the amino acids in the bodies should be decomposed, oligomerized and racemized. Here we report the changes of chemical formation of amino acid by shock compression of L-alanine aqueous solution to simulate the comet impact.

L-alanine solution was enclosed in a reactor and was impacted by a projectile. The shocked samples were analyzed by GC-MS equipped with a chiral column after derivatization.

The shocked samples contained alanine, dialanine, and diketopiperazine. Alanine content and L-ee of the alanine moderately decreased with increasing pressure, and fell to 30% at 34 GPa. The comparison of the results between this study and previous study which performed the shock experiments of dry amino acids [4] suggests that water suppresses the decomposition of amino acids and accelerates their racemization. The suppression of decomposition is attributed to the stabilization of amino acids by the hydrogen bonding between water and the carboxyl group. The acceleration of racemization is caused by OH^- produced in the dissociation of water. The maximum yield of dialanine was 0.7 mol% at 28 GPa. Dialanine has four stereoisomers (LL-, DD-, LD-, and DL-dialanines). At 34 GPa, LL-ee of dialanine shows 45%, though L-ee of survived alanine is 30%. Our experimental results suggest that the amplification of ee occurs in the polymerization induced by shock compression. Because the ee peptides have chiral catalytic activity, the comet impact should be recognized as an important event for the homochiral evolution on the early earth.

[1] Engel and Nazy (1982) Nature 296, 837-840. [2] Bernstein et al. (2002) Nature 416, 401-403. [3] Caro et al. (2002) Nature 416, 403-406. [4] Peterson et al. (1997) Geochim. Cosmochim. Acta 61, 3937-3950.