Racemization of L-alanine by impact shock

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Several amino acids in meteorites show enantiomeric excess (ee), especially the L-ee [1]. Because most of organisms in the earth produce and consume only L-amino acids, the ee of extraterrestrial amino acids have been studied for the elucidation of origin of life. When meteorites impact on the earth, the meteorites experience high pressure and high temperature conditions generated by shock compression. Then, amino acids should be decomposed and undergo racemization in the meteorites. Peterson et al. (1997) performed shock recovery experiments of amino acids and reported the racemization by shock compression [2]. Comets also have been acknowledged as extraterrestrial materials including many types of organic materials. Some amino acids were formed by experimental simulation of ultraviolet photolysis of interstellar ice analogues [3, 4]. Here we report shock recovery experiments of L-alanine aqueous solution and the chemical and racemic changes of alanine.

L-alanine aqueous solution was enclosed in a reactor and was impacted by a projectile. After recovery of the shocked sample, the recovered sample was derivatized and analyzed by GC-FID with a Chrasil-L-Val capillary column.

The shocked samples contained alanine (Ala), Ala-Ala, and Ala-diketopiperazine. The survival rate of Ala gradually decreased to 40 wt% at 30 GPa. The maximum yields of products were approximately 3 wt% around 20 GPa. The ee of Ala in the shocked samples decreased with increasing pressure. The racemization was not completed at 30 GPa, the ee of Ala showed 20%. Peterson et al. (1997) reported that six amino acids were drastically decomposed between 15 GPa and 20 GPa, and the survival rates fell into 0.1 wt% at 30 GPa. The ee of survived amino acids at 30 GPa showed from 20% to 40%. Regarding the ee of survived amino acids, the results of Peterson et al. (1997) are consistent with our results. However, the survival rate in our study was higher than that of Peterson et al. (1997). The significant difference between our study and Peterson et al. (1997) is supposed to be the matrix of starting materials. As the matrix, water was used in our study, but powdered meteorite in Peterson et al. (1997). Water may inhibit the decomposition of amino acids by shock compression.

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