

Stereochemical feedback with "an achiral amino acid precursor" and "a chiral amino acid": Experimental verifications

*Yoshinori Takano¹

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

To our best knowledge, the one-handedness of terrestrial amino acids and sugars is essential to the formation, structure, and function of biopolymers and is a defining molecular trait of life on the Earth. Since the time of Pasteur, the development of specific chirality in terrestrial biomolecules has remained one of the most important issues with regard to organic chemical evolution, astrochemistry, and the early Earth chemistry. Numerous hypotheses regarding the origins of homochirality have been presented, from both biogenic and abiogenic processes (e.g., Bonner, 1991; Meierhenrich, 2008). According to the former, life initially was based on achiral molecules and/or racemates and the use of specific enantiomers came about through evolution, whereas the latter theories propose that a tendency toward homochirality was inherent in prebiotic chemical evolution. When we simply imagine a coin toss chemical reaction, prebiotic enantiomers are equally racemic outcomes as 50.0 : 50.0, likewise two sides of a coin. Among these racemic reactions (e.g., the typical nucleophilic substitution reaction), enantiomer-specific isotopic analysis (ESIA) showed infinitely homogeneous components for each enantiomer (Takano et al., 2010). D, L-alpha-alanine (C3 carbon frame; potentially, including D, L-alpha-alanine precursors: Takano et al., 2007) is most abundant chiral amino acid in prebiotic chemistry, except of glycine (C2). For further information of molecular-specific homochiral verification, here we developed a stereochemical feedback reaction with an "achiral amino acid precursor" and "a chiral amino acid trigger", resulting unique and large enantiomeric excesses in the reaction products. Here, we discuss the reaction mechanism focusing on an amino acid precursor formula and a transition state inducing optically active amino acids. This research was supported in part by a grant for Scientific Research on Innovative Areas (No. 25108001; A. Kouchi & H. Yurimoto) from the Japan Society for the Promotion of Science (JSPS).

--

[References]

- Bassez, M-P., Takano, Y., and Ohkouchi, N. (2009) Organic analysis of peridotite rocks from Ashadze and Logatchev hydrothermal sites. *International Journal of Molecular Sciences*, 10, 2986-2998.
- Bonner, W.A. (1991) The origin and amplification of biomolecular chirality. *Origins of Life and Evolution of Biospheres*, 21, 59-111.
- Meierhenrich, U. (2008) *Amino Acids and the Asymmetry of Life*, Springer, 1-241.
- Takano, Y., Takahashi, J., Kaneko, T., Marumo, K. and Kobayashi, K. (2007) Asymmetric synthesis of amino acid precursors in interstellar complex organics by circularly polarized light. *Earth and Planetary Science Letters*, 254, 106-117.
- Takano, Y., Chikaraishi, Y., and Ohkouchi, N. (2010) Enantiomer-specific isotope analysis (ESIA) of D- and L-alanine: nitrogen isotopic hetero- and homogeneity by microbial process and chemical process. *Earth, Life, and Isotopes*. Kyoto University Press., pp. 387-402.

Keywords: "an achiral amino acid precursor" and "a chiral amino acid", Stereochemical feedbacks