

**Theoretical Investigation on Chirality Transfer for Optical D/L  
Acetic Acid-Substituted Isomers Based on the Scaled  
Hypersphere Search Method**

Graduate School of Science, Tohoku University  
Xia Yang, Satoshi Maeda, and Koichi Ohno

Molecular chirality is one of the fundamental characteristics of molecules, and it plays an important role in stereochemistry and biochemistry. Specifically, the homo-chirality of biological molecules (the use of only left-handed L-configuration amino acids and only right-handed D-configuration sugars) has long been known to be an important characteristic of life. Alanine ( $\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$ ), is the first *chiral* amino acid having distinct enantiomeric structures; thus provide significant prototypes for developing our understanding of this important class of molecule. Although it might then appear that the study of isolated molecules in the gas phase would be more straightforward, such investigations have been very limited. Notable problems endure regarding the molecular evolution. How was Nature's selection of these stereochemical structures, a random one, or were determinate processes involved? Conversion reactions between optical isomers have not been elucidated hitherto. All these questions urged us to investigate their reaction pathways on potential energy surface (PES), which is a fascinating research goal.

The scaled hypersphere search (SHS) method [1-3] makes it possible to explore unknown reaction pathways on PES. This method enables us to make a global analysis of the potential energy surface by detecting the anharmonic downward distortions of PES as energy minima on a hyper surface which would have a constant energy if the potentials are harmonic. In this study, intramolecular D-L conversion pathways of substituted acetic acids ( $\text{XYZC}^*\text{CO}_2\text{H}$ , X, Y, and Z are substituents) have been discovered by the application of the SHS method to exploring potential energy surfaces at the level of CCSD(T)/aug-cc-pVDZ//B3LYP/aug-cc-pVDZ based on the Gaussian03 program package.

The present results show D-L conversion pathways for some optical isomers are favorable with respect to its isomerization and dissociation, while for other systems, it is easier to dissociate into fragments other than conversion to its optical isomers due to less dissociation energy. NBO analysis and effect of intramolecular hydrogen bond on

formation of mechanism were further investigated.

In general, the stability order for conformers of this class of molecule depends on the intramolecular hydrogen bond (HB). The conformer with the bifurcated acceptor of the HB is the most stable. The conformers with the O-H...N HB are less stable, but stay lower than those with the N-H...O(-H) HB. Moreover, the gauche conformers are more stable than the anti ones.

Fig.1 shows D-L conversion pathways between optical isomers of alanine and lactic acid inclusive of the lowest dissociation channel and favorable isomerization toward amide. Starting from one of the most stable isomer with point chirality, reaction pathways leading to neighboring transition state were searched systematically from its equilibrium structure. As can be seen in Fig.1 (a), four conversion channels, (A), (B), (C), and (D), were discovered between D and L isomers.

The present results show D-L conversion pathways between optical isomers of alanine are favorable with respect to its isomerization and dissociation. Lactic acid is easier to dissociate into fragments other than conversion to its optical isomers due to less dissociation energy.

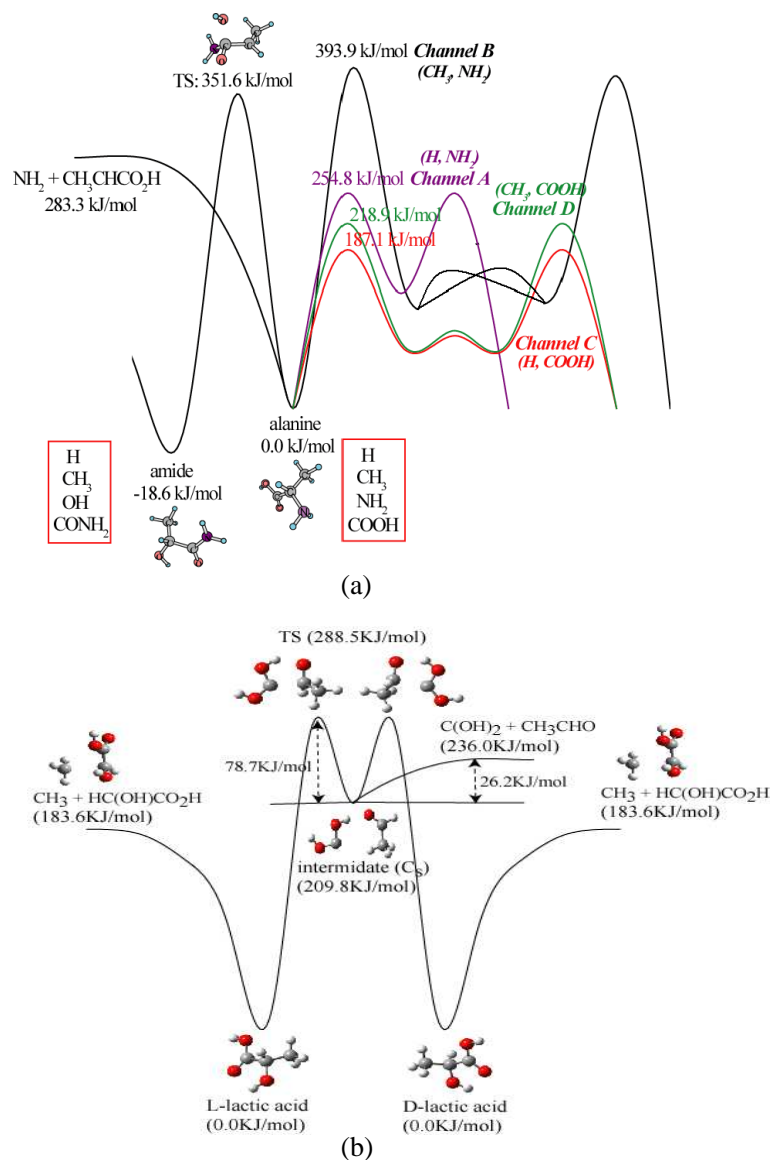


Fig1. D-L Conversion pathways between optical isomers of alanine (a) and lactic acid (b) inclusive of the lowest dissociation channel and favorable isomerization toward amide.

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- [2] S. Maeda, K. Ohno, J. Phys. Chem, A 109, 5742 (2005).
- [3] K. Ohno, S. Maeda, J. Phys. Chem, A 110, 8933 (2006).