

Enantioselectivity of Cysteine Self-assembled Monolayer on Gold for Amino Acids

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Asymmetric synthesis, optical resolution, and chiral sensing are actively investigated since bioactivities such as smell, taste, and pharmaceutical effects are often considerably different between enantiomers owing to the chiral nature of living system. For these investigations, choice or construction of chiral environment, which involves the understanding of chiral recognition, is necessary. The use of solid surface modified with chiral components provides not only adequate chiral environments for these purposes, but also a feasible approach for the study of chiral recognition. Indeed, in our previous study, enantioselectivity of the surface modified with self-assembled monolayer (SAM), on which optically active leucine (Leu) was attached with its hydrophobic side-chain facing the solution phase, was studied through crystallization of Leu with X-ray diffraction (XRD) method. As a result, on the Leu-attached SAM, only the enantiomer with same chirality as that immobilized on the SAM crystallize preferentially compared with the other enantiomer in enantiomeric solution of Leu, while racemic crystals grow in racemic solution of Leu [1].

In this study, we select an optically active amino acid, cysteine ($[\text{HSCH}_2\text{CH}(\text{NH}_2)(\text{COOH})]$; Cys), which is spontaneously chemisorbed on gold to form the SAM. As the thiol group concerns Au-S bond formation, the SAM would expose the amino acid zwitterions to solution phase at a certain range of pH. Since the dissociation state of the amino and carboxylic groups of Cys is expected to affect the structure of hydrogen bond network, which is supposed to be concerned in molecular recognition, enantioselectivity of the surface modified with Cys SAM was investigated with especially focusing on its pH dependence.

A gold substrate with predominantly (111)-oriented surface was prepared by vapor deposition on a quartz crystal. After flame annealing, the gold substrate was immersed into a 1 mM L-Cys solution to form the SAM. As the first investigation, the enantioselectivity of L-Cys SAM was examined through the crystallization of Leu with XRD as in our previous study [1]. The crystal of Leu was grown on L-Cys SAM by immersing the substrate in a solution of D- or L-Leu. For removing the excess crystallites, which are simply adsorbed and not crystallized on L-Cys SAM, the modified substrates were carefully rinsed with ethanol. As the second investigation, the enantioselectivity of L-Cys SAM was examined for an electrochemically active amino acid, 3,4-dihydroxyphenylalanine (Dopa), with cyclic voltammetry (CV). The gold electrode modified with L-Cys SAM was immersed in the D- or L-Dopa solution and its electrochemical characteristics were investigated.

As a result of the crystallization of Leu on L-Cys SAM from each Leu enantiomeric solution at a neutral pH, at which enantioselective crystallization of Leu was observed on L-Leu-attached SAM [1], XRD peaks

corresponding to the reflection of enantiomeric crystal of Leu were observed independent of the chirality of Leu solution. Thus, L-Cys SAM was suggested not to show enantioselectivity in crystallization at the neutral pH. However, considering that the intensity of the peak observed for L-Cys SAM was much greater than that for L-Leu-attached SAM (Figure 1A), the crystallization mechanism, which would influence the enantioselectivity in the crystallization, was supposed to be affected by the difference in the interfacial interaction between L-Cys SAM and the molecules in the solution. As shown in Figure 1B, the primary interaction at the solution/SAM interface is a hydrogen bonding (solid line in Figure 1B) for Cys SAM while hydrophobic one (dotted line in Figure 1B) for the Leu-attached SAM. The effect of pH on enantioselectivity of Cys SAM in the crystallization is under investigation.

From the results of the CV at an acidic pH, the double-layer capacitance of electrodes modified with L-Cys SAM depended on the chirality of Dopa contained in the solution although the redox reactions of D- and L- both Dopa, were almost completely blocked by L-Cys SAM, independent of its chirality. This difference in the double layer capacitance would be attributed to that in the adsorption behaviors of Dopa on the L-Cys SAM due to the chiral hydrogen bond network of the L-Cys SAM. It should be noted here that, interestingly, the redox reaction of Dopa was suggested to slightly but explicitly depend on the chirality of Dopa at a neutral pH. The investigation into the effect of pH on the enantioselectivity in the redox reaction and adsorption of Dopa on Cys SAM is now in progress.

Taking these results together, the effect of pH on the enantioselectivity of Cys SAM will be discussed in detail at the meeting.

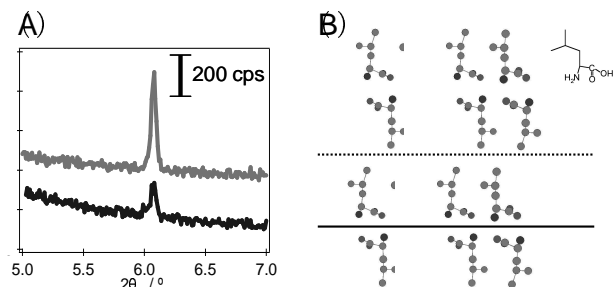


Figure 1. (A) XRD patterns of (upper) L-Cys SAM, and (lower) L-Leu-attached SAM after immersion in L-Leu solution. (B) Schematic representation of crystal structure of L-Leu.

Reference

[1] N. Banno, T. Nakanishi, M. Matsunaga, T. Asahi, T. Osaka, *J. Am. Chem. Soc.*, **126**(2), 428-429, 2004

Acknowledgement

This work was financially supported in part by a Grant-in-Aid for COE Research (Molecular Nano-Engineering) and carried out in the 21st Century COE Program (Center for Practical Nano-Chemistry) from the Ministry of Education, Culture, Sports, Science and Technology, Japan.