Development of Highly Light-Sensitive Film Systems for Micro-Relief Formation and Their Applications

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1. Introduction

Recently a method has been found for forming relief structures by exposing polymer films containing azobenzene molecules to patterned laser light, causing the material to migrate laterally. Our group developed a system capable of rapidly inducing mass migration within seconds by exposing a flexible liquid crystal polymer to light. In order to increase our understanding of this mass migration phenomenon and to contribute to micromachine technology, we studied the feasibility of using this system as a conveyor for other materials.

2. Development of Novel Polymers

By introducing oligo(ethylene oxide) into the polymer as a copolymer, we developed an azobenzene polymer in which mass migration is induced with high sensitivity. Using this polymer, we found that relief formations can be preserved, even at temperatures of 250 degrees celsius, by cross-linking the hydroxyl end group of the ethylene oxide. We learned it is possible to overcome properties that run counter to highly sensitive light-induced migration and the preservation of stable formations. Fig. 1 is an image taken through an atomic force microscope of a relief formed with a grid-shaped mask.

3. Photo-Conveyance of Functional Materials

Using this phenomenon of migration in film materials, we studied the inducement of migration in other functional materials (Fig. 2). This study showed us that migration is possible in dyes, conjugated polymers, and particles on the order of nanometers. This knowledge is expected to become a new elemental technology for micromachines.

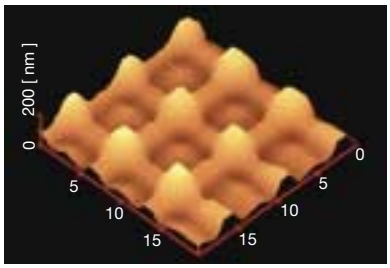

Fig. 1 An example AFM image of a relief formed by light-induced mass migration

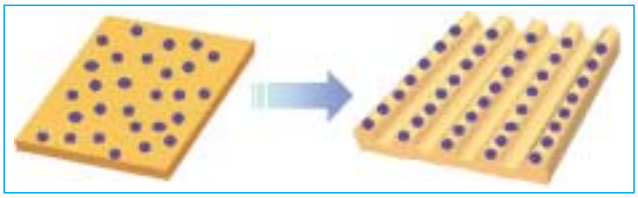

Fig. 2 A conceptual drawing showing patterning by conveyance of functional materials using light-induced migration

Electrochemical Immobilization of Engineered Protein for micro TAS

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1. Introduction

Proteins like enzymes and antibodies have specific affinities, catalytic activity, and other superior functions. Devices that make use of these functions include bioreactors and biosensors achieved through immobilized enzymes and immunosensors achieved through immobilized antibodies. We have seen many attempts to develop devices by reducing the size of these bioreactors and biosensors and employing them as micro total analysis systems(μTAS) for applications in health care or food inspection. However, various restrictions make it difficult to immobilize functional proteins on a miniaturized site. In this study, we controlled the molecular orientation of immobilized protein and attempted to develop an electrochemical immobilization method for reversibly immobilizing protein.

2. Genetical Insertion of EC-tags and Electrochemical Immobilization of Proteins

A principle of immobilization is to genetically add an EC-tag sequence (an amino acid sequence to become a divalent metal-ion coordination site) into the amino acid sequence of an immobilized protein and to configure divalent metal ions in this EC-tag site. We discovered a method of immobilization in which the coordinated metal ions are restored from two valences to zero by applying a reduction potential to the protein in this state at an electrode surface. At this time, the protein is immobilized on the surface of the electrode (Fig. 1). Protein immobilization performed according to the above process is stable even after ceasing the potential application and can be separated through a counterreaction.

Fig. 2 shows an atomic force microscope photo of an experiment using this method to immobilize a model protein on the end of a cantilever. In this example, the applied potential is focused on the radical end through an edge effect to achieve protein immobilization only around the end of the cantilever. This suggests the possibility of orientational immobilization of monomolecular proteins using the extreme radical end solid phase. Further, this method of immobilization can be used universally for many proteins by genetically inserting an EC-tag in the amino acid sequence of the protein. The potential for designing molecular orientation using this method has engendered great promise for its applications.

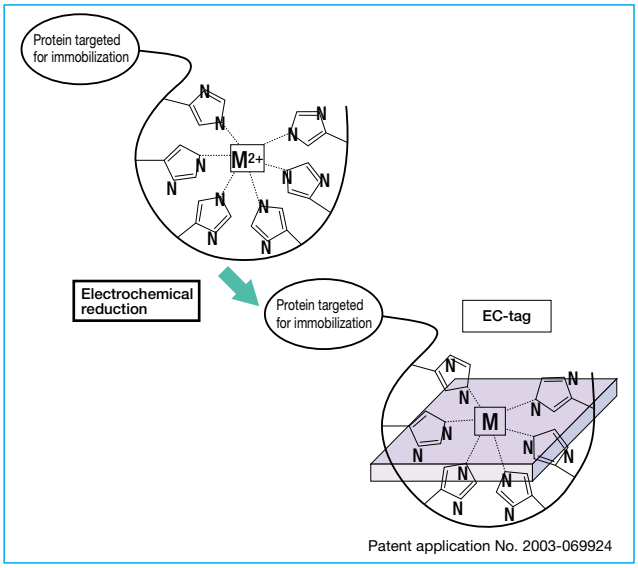

Fig. 1 Hypothetical scheme of EC tag-protein immobilization

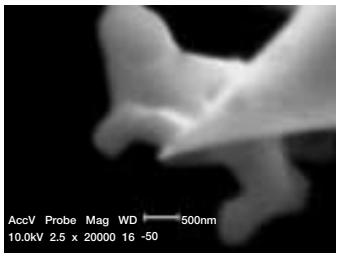

Fig. 2 SEM photograph of protein immobilized on the end of a cantilever by an EC-tag