

Manipulation of Biomolecules on Solid Substrate Using Artificial Cell Membrane

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The development of biofunctional devices requires a biointerface for maintaining biomolecules on a substrate without interfering with their structure or biological functions. By using an artificial membrane biointerface, we can control the position, density and arrangement of biomolecules, leading to the design of various bio devices such as highly sensitive biosensors or implant-type biochips. Here we produced artificial cell membranes on a substrate that enable proteins to be adsorbed or transported to a desired position, and thus realized a novel molecular manipulation technique for use at the biointerfaces [1].

A cell membrane is essentially composed of phospholipids (lipids). The fluidity of an artificial cell membrane is controlled by the choice of lipid components. We selectively fabricated artificial cell membranes with high/low fluidity that contained nickel-chelating lipids (Ni-lipid). The Ni-lipid is capable of specific binding with terminal modified proteins. Fig. 1 (a) and (b) show AFM images of an artificial cell membrane consisting of DSPC (low fluid lipid) and Ni-lipid. The image of a 50/50 mol% of DSPC/Ni-lipid reveals a hetero-geneous membrane structure with round DSPC-rich domains distributed in a Ni-lipid-rich fluid-phase domain. The DSPC domains were slightly thicker (1.0 nm) than the surrounding Ni-lipid domain. The area of each domain was controlled by controlling the molar ratio of the lipid components. When histidine-tagged green fluorescent proteins (His-tagged GFPs) were added to the membrane, the fluorescent pattern was evidently based on the specific adsorption of His-GFPs only in the Ni-lipid domain (Fig. 1 (c) and (d)). While the membrane produced by DOPC (high fluid lipid) and Ni-lipid formed a homogeneous structure with high fluidity. The membrane exhibited a self-spreading ability in buffer solution whereby a single lipid membrane (5 nm high) grows on a substrate surface by self-organization [2]. By employing the self-spreading nature, we demonstrated protein transport along the micro-pattern. Fig. 2 shows the time evolution of the molecular transport of His-GFPs tethered on the membrane. The transport property agreed well with the existing self-spreading model of an artificial membrane [velocity (v) = (β /time (t))^{1/2}] where the kinetic spreading coefficient (β) was 10.4 $\mu\text{m}^2/\text{s}$.

The biointerface produced by lipids can also employ a cell membrane model to analyze biomolecular interactions or signal transmission events. Therefore, the biointerface will be beneficial for bioscience as well as providing a framework for building biofunctional devices.

[1] H. Nakashima et al., *Langmuir* **26** (2010) 12716.

[2] K. Furukawa et al., *Lab Chip* **6** (2006) 1001.

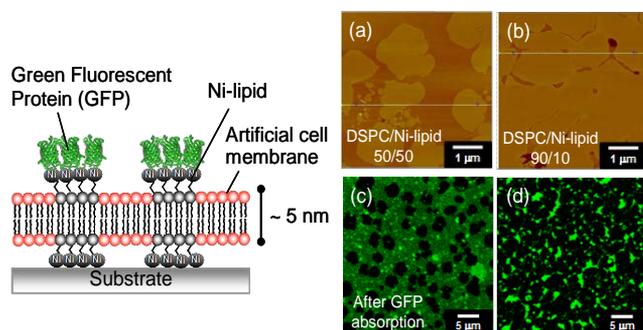


Fig. 1. Pattern formation of artificial cell membrane and absorption of proteins at specific location on

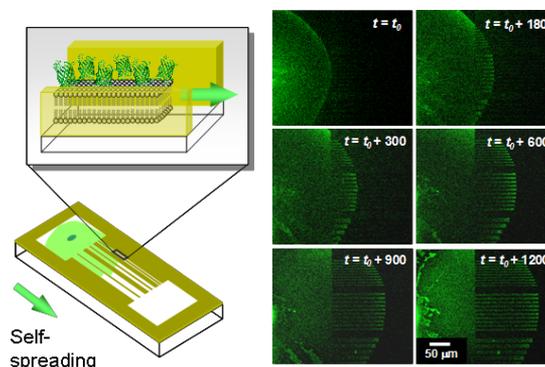


Fig. 2. Protein transport through self-spreading of artificial cell membrane