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浸透圧変化によって誘起される架橋脂質二分子膜の出芽変形

Osmotically induced budding transition in a suspended lipid bilayer

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We have developed nano-bio devices for optical and electrophysiological analysis of biomaterials on a microfabricated substrate covered with suspended lipid bilayers. Here, we describes the behavior of a lipid bilayer suspended over a microfabricated substrate under varying osmotic pressure. The substrate, named “pepper shaker” substrate, consists of an etched chamber in a Si chip that is covered by a SiO_2 layer containing an array of holes, typically ~ 100 nm in diameter (Figure 1). The cavity was sealed with a lipid bilayer by rupturing a giant unilamellar vesicle on the substrate. The fluorescent probe calcein was enclosed in the cavity along with glucose and/or $CaCl_2$ to induce and vary osmotic pressure.

Osmotic pressure was induced by varying the concentration of the species in the solution above the bilayer (Figure 2). Upon diluting the external solution, a phenomenon akin to blebbing in apoptosing cells was observed (Figure 2 (b)): a bud formed in the bilayer to compensate for the increased osmotic pressure inside the cavity. In some cases budding off from the bilayer was observed, forming a small vesicle containing the internal solution from the cavity (Figure 2 (c)). Upon increasing the external concentration more than the internal one, osmotic pressure towards the interior of the cavity induced the inverse budding formation (Figure 2 (d)). In this case, the budding from the bilayer was found to protrude into the cavity, which brought about formation of a vesicle containing the external solution in a process akin to endocytosis in cells.

By varying the concentration of the external solution it was therefore possible to finely control the direction and extent of bilayer budding. In future, we think this concept may find application in mimicking and studying the behavior of biological systems such as bleb formation in apoptosis, synaptic vesicle formation, and endosome formation in endocytosis.

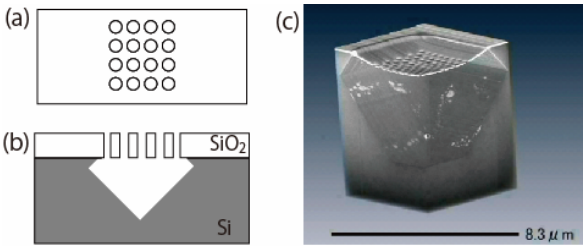

Figure 1. Schematic illustration of pepper shaker substrate. (a) Overhead view. (b) Cross sectional view. (c) Scanning electron microscope image of the pepper shaker substrate.

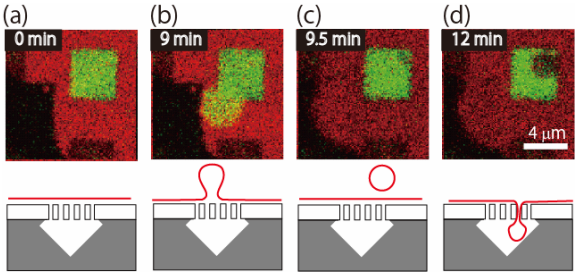

Figure 2. Time lapse images of the budding transition upon varying the external concentration. (a) Flat lipid bilayer. (b) Budding transition akin to blebbing. (c) Budding off/vesicle formation. (d) Budding transition akin to endocytosis.