BIOMIMETIC TEMPLATE-GUIDED FABRICATION OF TUBULAR LIPID MEMBRANES FOR ARTIFICIAL PRIMARY CILIA

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ABSTRACT

We firstly present a simple and robust method to fabricate vertically grown tubular lipid membrane array via template-guided thin film gentle hydration using nano/micro-sized porous membranes. In this approach, we update the common gentle hydration method using micro- or nanoporous membrane as a template to guide vertical growth of lipid tubes. During hydration of dried lipid film with a proper buffer solution, tubular lipid structures are vertically grown at each pore by structural guiding force instead of hydrodynamic or electric force.

KEYWORDS: Primary cilia, Biomimetics, Tubular lipid membranes, porous membrane, gentle hydration

INTRODUCTION

The purpose of this research is to mimic the function of primary cilia which protrude from cell's plasma membrane. The primary cilium is slender and tubular organelle composed of lipid bilayer membrane and plays a key role as cell's antennae to sense extracellular signals because of increased surface area, enriched signal receptors and compartmentalized reaction chamber.

There are several attempts to mimic the function of cilia using ferrofluid-PDMS composites, magnetic bead assemble or light-sensitive polymers. Despite the successful demonstration of cilia biomimicking, they still focused only the motile function of cilia due to the limitation of materials they used [1, 2]. Therefore, for the first step, the construction of artificial tubular lipid membrane is highly required to mimic the primary function of cilia.

In order to fabricate the tubular lipid structures, usually hydrodynamic and electric forces have been adopted. For example, lipid structures extruded from microfabricated apertures or nozzles are elongated by hydraulic pressure, and pre-existed GUVs are pulled by point electrical force with a pipet or by an electric field between two electrodes. However, these methods simply demonstrated the fabrication of tubular lipid structures and are not efficient to extend for the artificial primary cilia [3, 4].

Here, we present an easy and novel method to fabricate vertically grown tubular lipid membrane arrays via template-guided gentle hydration of dried lipid film for mimicking the primary function of cilia.

EXPERIMENTAL

Briefly describing, a lipid coated porous membrane is carefully placed on UV-curable polymer dropped glass substrate. After UV curing, the lipid coated porous membrane is tightly bonded to the glass substrate. If a proper buffer is introduced to the lipid coated porous membrane, then the backside dried lipid film is hydrated and simultaneously form vertically grown tubular lipid structures guided by tunnel-like apertures of the porous membrane. Our method is very similar with simple germination process and highly compatible with integration of membrane proteins and electrode arrays for further application to cilia-based biomimetic sensing platform.

RESULTS AND DISCUSSION

In order to determine the optimized condition for fabricating uniform and stable lipid tubes, we investigated various variables such as lipid composition, template dimension, and buffer composition. For the lipid materials effect, we tested different lipids include DMPC (zwitterionic), DOPS (negatively

charged), DOTAP (positively charged), DMPC+DOPS (8:2), DMPC+DOTAP (8:2). And for the effect of template dimension, we used commercially available transwell porous membrane and on-demand fabricated uniform porous membrane according to aperture diameter and thickness of porous membrane (i.e., aperture aspect ratio). As a result, we observed well-organized tubular lipid structures in case of DMPC+DOPS (8:2), 0.4 μm apertures with 10 μm pore length and PBS 10X buffer with chitosan among the experiments we tested.

CONCLUSION

We developed an easy and novel method to fabricate tubular lipid membranes using template-guided thin film gently hydration. It would be worthwhile for a novel biomolecule sensing platform that mimic the primary function of cilia.

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