Molecular separation by a free-standing and nanometer-thick membrane

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Biological lipid bilayer membrane is an ideal example for precise and efficient molecular separation. One of its characteristics is free-standing property with molecular thickness, and molecular scale phenomena become dominant in the direction of the membrane thickness. Thus, artificial membrane with a free standing properties and nanometer thickness would be a unique property different from conventional membrane. Based on this idea, we have developed functional free-standing nanomembranes with a centimeter-scale of lateral size (Fig.1).[1],[2] These membrane are manipulable macroscopically, event its thickness is a few tens nanometers.

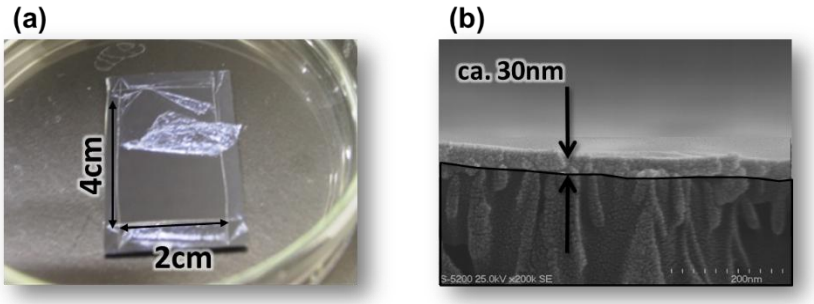

Figure 1. Free-standing nanomembrane (a) and the cross sectional image on a porous support (b)

We have succeeded to prepare a free-standing and ultrathin membrane with precise molecular filtration ability by designing nanochannels structures across a membrane. Our next target is to separate further small molecules, including CO_2 and gaseous molecules, because membrane separation of CO_2 is one of promising CO_2 capture technologies. In this scope, we have developed membranes composed of polymer and inorganic materials.
In polymeric nanomembranes, we have investigated cross linkable materials, such as an epoxy resin, urea and melamine derivatives, for the preparation of nanomembrane. In all case, we have succeeded to prepare free-standing membrane with a few tens nanometer thick, and the gas permeance of each membrane was investigated.
In inorganic membrane, we employed the composite materials composed of titanium alkoxide carboxylic derivatives, such as phthalic acid, to control the gas selectivity of the membrane. Based on a spin-coating process, titania composite membrane with the thickness of 100 nm or less was prepared on a PDMS support. Some composite membrane, show preferential CO_2 permeation over nitrogen.

In membrane separation, the thickness plays an important role for the efficient separation. Further thinning to reach the thickness of a biological lipid membrane is our challenge to create ideal membrane separation based on molecular dynamics.

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Fields of Research

Surface nanostructure, nanometer-thick membrane, nanofabrication

Publications

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