CNMS Staff Science Highlight

Evaporation-Induced Buckling and Fission of Microscale Droplet Interface Bilayers

Scientific Achievement

Microscale droplet interface bilayers (µDIBs) were formed between femtoliter-volume water droplets in a lipid-oil microchannel. The water-oil interface of each droplet consisted of a lipid monolayer while the interface between the droplets was a planar lipid bilayer. As the droplets evaporated, the lipid bilayer was observed to buckle and eventually fission a small vesicle to regulate its shape.

Significance

Droplet interface bilayers (DIBs) are a robust platform for studying synthetic cellular membranes. However, to date no DIBs have been created at cellular length scales. The µDIBs produced here display bilayer dynamics reminiscent of endo- and exocytosis in cells.

Research Details

- µDIBs were generated by bringing together femtoliter-volume aqueous droplets in a lipid-oil microchannel .
- The 5-10 µm initial diameters of the droplets resulted in dramatic evaporation effects that reveal the dynamics of µDIBs undergoing shape change.
- The evaporation of the droplets forces a "conveyor-belt" effect, where lipids in the shrinking monolayer interfaces are forced to pair together and slide into the growing bilayer area to conserve mass.

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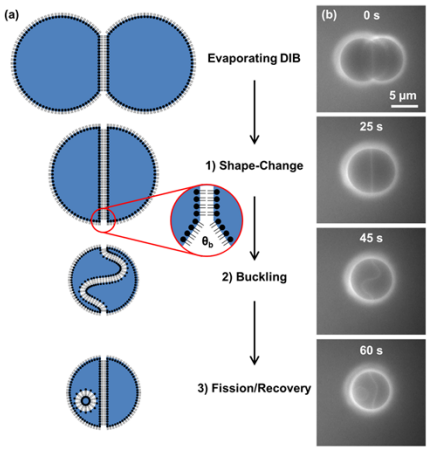

(a) Schematic and (b) fluorescent imaging of the progressing regimes of an evaporating µDIB. The cross-sectional length of the bilayer is continuously fed by lipids from the shrinking monolayers, resulting in buckling and fission at a critical bending moment.

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Highlight Narrative Text

Droplet interface bilayers (DIBs) are a robust platform for studying synthetic cellular membranes; however, to date no DIBs have been produced at cellular length scales. Here, we create microscale droplet interface bilayers (µDIBs) at the interface between aqueous femtoliter-volume droplets within an oil-filled microfluidic channel. The uniquely large area-to-volume ratio of the droplets results in strong evaporation effects, causing the system to transition through three distinct regimes. First, the two adjacent droplets shrink into the shape of a single spherical droplet, where an augmented lipid bilayer partitions two hemi-spherical volumes. In the second regime, the combined effects of the shrinking monolayers and growing bilayer force the confined bilayer to buckle to conserve its mass. Finally, at a critical bending moment, the buckling bilayer fissions a vesicle to regulate its shape and mass. The µDIBs produced here enable evaporation-induced bilayer dynamics reminiscent of endo- and exocytosis in cells.

Fig. 1 (a) Schematic and (b) fluorescent imaging of the progressing regimes of an evaporating µDIB. The cross-sectional length of the bilayer is continuously fed by lipids from the shrinking monolayers, resulting in buckling and fission at a critical bending moment.

Reference

"Evaporation-Induced Buckling and Fission of Microscale Droplet Interface Bilayers"

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