Microfluidic platform for bilayer membrane formation

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Keywords Nanofluidics, Liposomes, Drug Encapsulation, MEMS

Context

Liposomes are nano-scale phospholipid bilayer vesicles used as carrier in enhanced drug delivery. Conventional formation methods give little control over the content of the liposomes and often suffer from poor encapsulation efficiencies. A mechanism is proposed whereby liposomes are individually formed and physically loaded with the active agent.

Objectives & Methods

The objective of this project is to establish a microfluidic platform for externally controlled on-chip planar bilayer formation, enabling subsequent deformation of the bilayer into a spherical conformation. Controlling the direction of the deformation and the molecular environment in the vicinity of the bilayer should enable an automated and scalable ideal encapsulation process. The bilayer formation process could be confirmed by using optical and electrical characterization. The bilayer is formed in a planar nozzle at the junction of water-filled microchannels supplying the continuous/disperse phase and an oil-filled nanochannel supplying the self-assembling material. The microchannels are etched in glass and the nanochannel is fabricated out of LPCVD-deposited silicon nitride on a silicon chip, which is anodically bonded on both sides to the glass microchannel chips.

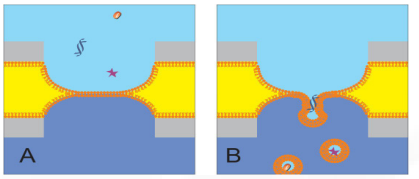

Fig. 1. Formation scheme: A) a bilayer formed in a planar nozzle between two water phases supported by an infinite phospholipid-in-oil reservoir. B) Deformation of the bilayer, enveloping the disperse phase (above) while continuously separating the continuous phase (below).

Results

Chips were successfully fabricated at MESA+ Institute for Nanotechnology in The Netherlands. A setup was built to deliver water and oil selectively to regions of interest in the chip with local control over pressure in individual channels. Phospholipid material was transported to the nozzle through the nanochannel and monolayer-coated oil droplets were formed reproducibly. Although bilayer formation has not yet been confirmed, we consider that remodeling of the aspect ratio of the planar nozzle would help producing the planar bilayer.

Fig. 2. Bottom-up view of the injection of a femtoliter oil droplet in the water reservoir through the planar nozzle. The device is about 200 µm long