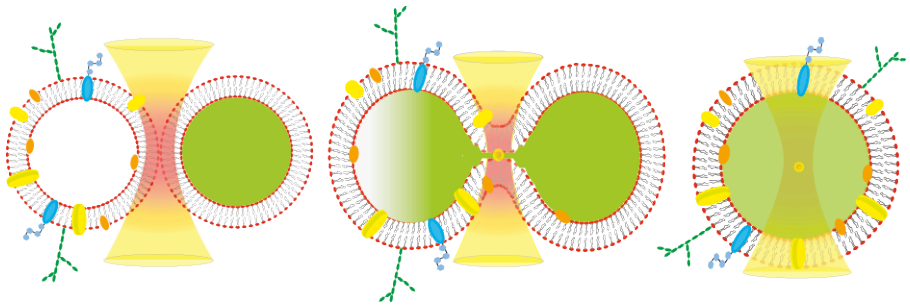
Optically trapped plasmonic nanoparticles for manipulating model lipid bilayers and biological membranes

Azra Bahadori, Andreas R. Lund[1], Guillermo M. Pescador[1], Szabolcs Semsey[2], Lene B. Oddershede[1], Poul M. Bendix[1*]

[1]Niels Bohr Institute, University of Denmark – [*]bendix@nbi.dk
[2]Department of Biology, University of Copenhagen
(Address: Blegdamsvej 17, DK-2100 Copenhagen)

Abstract

We use optically trapped plasmonic nano-heaters to facilitate efficient and controlled local heating of both model membranes and membranes of living cells. The associated effects on membranes phase behavior, membrane permeability and membrane morphology are visualized by confocal microscopy. Local heating near a gel phase membrane generates a phase transition together with an associated increased permeability of the membrane[1-4]. Trapping a plasmonic nanoparticle at an interface between two Giant Unilamellar Vesicles (GUVs) results in immediate full fusion of the apposing membranes which we verify by measuring lipid and content mixing[5]. Fusion also occurs when trapping a plasmonic nanoparticle between two cells to transform the cells into a single viable syncytium[6]. Other fusion products realized with this method include a GUV fused to a cell or a GUV fused to a giant plasma membrane vesicle (GPMV). We show how this assay can be used in biophysical research; Membrane proteins encapsulated in an inert vesicle are transferred to a vesicle composed of negative lipids by optically inducing fusion. Mixing of the two membranes results in a fused vesicle with a high affinity for the protein and we observe immediate membrane tubulation due to the tubulating activity of the protein[5,7]. Fusion of distinct membrane compartments has interesting applications in small scale chemistry for realizing pico-liter reactions and offers many exciting applications within biology which are discussed here.



[1] Andersen T, Bahadori A, Ott D, Kyrsting A, Reihani SNS, Bendix PM. Nanoscale Phase Behavior on Flat and Curved Membranes.*Nanotechnology* 2014, **25**, 505101.
[2] Andersen T, Kyrsting A, Bendix PM. Local and transient permeation events are associated with local melting of giant liposomes. *Soft Matter* 2014, **10:** 4268-4274.
[3] Jørgensen, JT, Norregaard, K,Tian P, Bendix PM, Kjaer A, Oddershede LB. Single Particle and PET-based Platform for Identifying Optimal Plasmonic Nano-Heaters for Photothermal Cancer Therapy. *Scientific Reports*, 2016, **6**:30076
[4] Bendix PM, Reihani SNS, Oddershede LB. Direct measurements of heating by electromagnetically trapped gold nanoparticles on supported lipid bilayers. *ACS Nano* 2010, **4:** 2256-2262
[5] Lund AR, Bahadori A, Semsey S, Bendix* PM, Oddershede* LB. Vesicle Fusion Triggered by Optically Heated Gold Nanoparticles. *Nano Letters*, 2015, **15**, 4183-4188.
[6] Bahadori A, Oddershede LB, Bendix PM. Hot-nanoparticle-mediated fusion of selected cells. *Nano Research*, 2017, **10**, 2034-2045.
[7] Barooji Y, Lund AR, Semsey S, Reihani SNS, Bendix PM. Dynamics of membrane nanotubes coated with I-BAR. *Scientific Reports*, 2016, **6**:30054