Lipid nanotubes from freestanding lipid membranes

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Structures such as lipid nanotubes play an important structural role in different cellular organelles such as the Golgi apparatus, endoplasmic reticulum and mitochondria, but also in inter and intracellular exchanges and cellular migration. The study of their properties and biophysics is often carried on vesicles, supported lipid bilayers or living cells. In these approaches, it is challenging to achieve asymmetric lipid distribution, dynamic buffer control and zero curvature. In contrast, the use of a freestanding lipid bilayer on a microfluidic device present additional advantages such as easy access to both sides of the membrane, possibility to create several membranes in a same device, possibility to circulate different solutions, and full compatibility with optical techniques.
We show a novel and versatile method to study lipid nanotubes by combining optical tweezers with freestanding lipid membranes formed inside a microfluidic chip. The bilayers were assembled over a hole inside a microfluidic device and lipid nanotubes were formed via two methods: 1) by pulling a lipid patch anchored to bead by streptavidin-biotin interactions or 2) by pushing the bead across the membrane. The tension, bending rigidity and the force required to pull the nanotubes will be discussed.
Our method of forming tubes from freestanding bilayers provides a robust platform, not only for nanotubes studies, but also for further study of protein-membrane interactions under controlled conditions on each side of the membrane, and modulated membrane complexity.