Synthetic cellular membrane systems

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In living systems, bio-molecules self-assemble in a predetermined fashion under specific conditions into highly organized supramolecular structures with specific functions. The constructive and synthetic approach to biological systems is an important and interesting challenge that spans across several disciplines, including physics, chemistry and biology. A closed two-dimensional surface consisting of a lipid bilayer is an essential compartment of living organisms. We have developed a synthetic membrane system that exhibits cellular functions [1].

We utilized a synthetic photosensitive amphiphile to achieve the photo-based manipulation of the opening and closing of membranes through reversible transitions between sphere and disk structures. The manipulation is based on the photo-switching of the membrane line tension, as deduced from the fluctuation of the membrane edge. Furthermore, we demonstrated the controllable capture and release of a targeted object into and from a membrane vesicle. This successful photo-manipulation of mesoscopic membrane structures in a noncontact and reversible manner may see wider application, such as in micro-reactors and smart drug-delivery systems (SDDS).

We then investigated the association of nano-particles (NPs) on a model membrane surface [3]. We found that lateral heterogeneity in the membrane mediates the partitioning of NPs in a size-dependent manner: small particles with a diameter of ≤200 nm were localized in an ordered phase, whereas large particles preferred a fluidic disordered phase. In terms of the membrane elastic energy, we present a physical model that explains this localization preference of NPs. These findings may lead to a better understanding of the basic mechanisms that underlie the association of nano-materials within a cell surface. These results help us to design proto-cell systems that take advantage of the membrane thermodynamic characteristics to recognize contacting objects.

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