Shape Deformation and Phase Separation Dynamics of Two component Vesicle

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Biological vesicles exhibit a wide variety of shape transformations by the change of their environment such as temperature, pH, osmotic pressure and so forth. Such transformation has been fascinating a lot of scientists. After the pioneering works by Canham and Helfrich, many researchers have investigated theoretically and experimentally in depth membrane systems and make clear shape deformations of *homogeneous* fluid membrane vesicles depending on their environments.

Recently, increasing attention has been paid to two component vesicles because such a system is consider to be a simple model system to understand the behavior of real bio-membrane that is composed of several kinds of lipids and membrane proteins. In the present work, we investigate the effect of intra-membrane heterogeneity in lipid composition on the shape deformation of two component vesicle using simple theoretical model.

We consider a two component vesicle composed of type-A and type-B amphiphiles. In such a membrane, the local bending rigidity may depend on the local composition of amphiphile ϕ *i.e.*, $\kappa(\phi)$. The total free energy functional of the vesicle is given by the sum of a bending energy and an energy coming from osmotic pressure difference p between inside and outside of the vesicle,

$$F = \int dS \left[\frac{1}{2}\kappa(\phi)H^2 + \frac{1}{2}b(\nabla\phi)^2 + f(\phi) \right] + pV \quad (1)$$

where H is the sum of two principal curvatures, V the volume of vesicle, and the sum of the second and third term in the integral denotes a mixing free energy to describe intra-membrane phase separation. Firstly, we derived equations [1] to describe dynamics of membrane shape and intra-membrane phase separation using the eq.(1). In Fig.1 we show a time evolution of phase separation on a tubular vesicle, assuming that the shape of vesicle is to be a tubular one formed by applying an large osmotic pressure difference and the time scale of shape deformation is much longer than that of phase separation. As seen from Fig.1(a), in case that the bending rigidity is constant, usual isotropic spinodal decomposition takes place. On the other hand, in case that the bending rigidity depends on local composition, a phase separation with a periodicity along the longer axis of tubular vesicle occurs and the phase separated band structure coarsens with time as seen in Fig.1(b). The formation of band-like phase separated domains comes from the coupling of the composition dependent bending rigidity and local curvature. Although in Fig.1 the shape is fixed during phase separation, we show a shape deformation coupled to the local composition in Fig.2 where red domains have a higher rigidity.

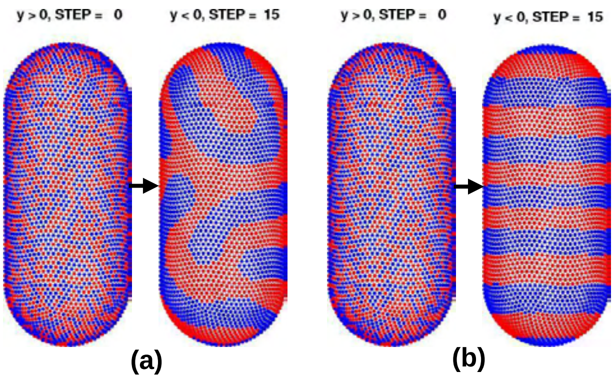

Fig.1 Time evolution of phase separation on the vesicle (a) with a constant bending rigidity, (b) with a composition dependent bending rigidity.

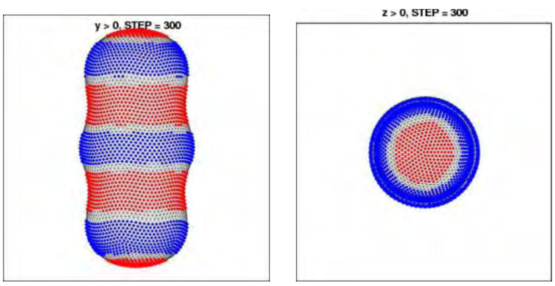

Fig.2 Shape deformation and phase separation of vesicle with a composition dependent bending rigidity. The initial shape is a tubular one.

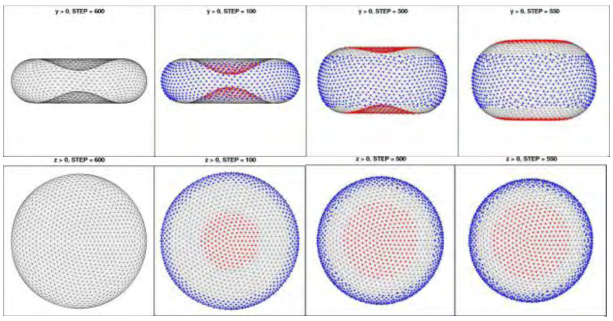

Fig.3 Time evolution of shape deformation and intra-membrane phase separation of a vesicle after obtaining a biconcave shape by imposing an osmotic pressure without phase separation.

The time evolution of shape deformation induced by the coupling of phase separation as seen in Fig.3, where the red domains have a higher bending rigidity. As seen from Fig.3, a transformation from a biconcave shape to a discocyte one occurs. In my presentation, I will illustrate a variety of shape deformation induced by couplings between shape and local heterogeneity.

References

[1] Taniguchi, T., 1996, Phys. Rev. Lett. **76**:4444-4447.