Dynamics of two component membranes

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1. INTRODUCTION
An increasing number of attentions have been paid to the membranes and vesicles of binary and/or ternary lipid mixtures because these systems are considered to be a simple system for understanding the behavior of real biomembranes which are intrinsically composed of many kinds of lipids and proteins. In this context, I have investigated dynamics of shape deformations coupled with intra-membrane internal degrees of freedom, such as local composition of lipids, spatial distribution of membrane proteins. In my presentation, I will talk about two topics (i) shaped deformation dynamics of vesicle coupled with intra-membrane phase separation of lipid [1] and (ii) dynamics of stimulate-induced mesoscale domain formation by GPI-anchored protein [2].

2. RESULTS OF SIMULATIONS
The dynamics of the deformation and phase separation of two-component vesicles have been studied by performing numerical simulation of a model extended from the conventional bending elastic model. We numerically investigated effects of (i) thermal noise, (ii) hydrodynamic flow and (iii) composition-dependent bending rigidity on the coarsening dynamics of a phase-separated pattern on vesicles under fixed shapes. It is found that the dynamical exponent $z (N_{DB}^{-1/2})$, the total length of the domain boundaries) of phase separation decreases from $z = 1/3$ under no thermal noise to $1/5 < z < 1/4$ when including the effects of thermal noise. We also found that the hydrodynamic effect enhances the coarsening in a bicontinuous phase separation. We also explored the dynamics of shape deformation coupled with phase separation as well, and found the composition-dependent bending rigidity crucially influences the phase separation and deformation of the vesicle. The results of simulations are in good agreement with experimentally observed behavior known as "shape convergence" [1]. Sakuma et al [1] has reported another type of shape deformation related to a distribution of lipids in two component vesicles composed of cone- and cylinder-like lipids (DHPC/DPPC), in which a single pore with a rolled rim is formed by changing of temperature. We proposed a model to describe the dynamics of shape deformations of the binary vesicle after forming a single pore. The time evolutions of the local composition of DHPC in the inner and outer leaflet are given by diffusion type equations and by a transport of lipids between the inner and outer leaflet through the capped rim. We considered an axi-symmetric spherical vesicle with a single pore and simulated shape deformations and phase separations using the model. Actually, our model well reproduced the vesicle shape with a rolled-rim.

It has been reported by Kusumi et al that, upon liganding, GPI-anchored receptors (CD59) form clusters, which in turn leads to stable assembly of special raft lipids (cholesterol and glycosphingolipids) with CD59 clusters in the outer leaflet of the plasma membrane. The raft is referred as "stimulation-induced meso-scale domains". We address to clarify the mechanism for "the stimulation induced meso-scale domain formation" by performing simulations of a hybrid model (CD59 and lipid composition). In my presentation, I will report results of our recent numerical simulations on the stimulation-induced raft formation.

REFERENCES