Mechanics of lipid nanotube networks and containers

Voinova M.V., Adams K., Karlsson R., Cans A.-S., Engelbrektsson J., Zhang B., Eves D.J., Heien M.L., Ewing G.

Chalmers University of Technology, S-412 96Gothenburg, Sweden

marina.voinova@chalmers.se

Lipid vesicle is an attractive mechanical model of cell plasmatic membrane since demonstrates similar elastic properties and global and local geometrical transformation yet contains no specific proteins responsible for the local curvature in living cells. It was found [1-3] that the application of the localized mechanical force produces lipid tethers (lipid nanotubes), water-filled cylindrical structures of radius ~0.5 μm. The peculiarities of the mechanical properties of lipid nanotubes (LNTs) originates from the fluidity of the tube wall and their mesoscopic size which makes shape fluctuations an important contribution to the membrane tension. The shape of a structure is a result of the interplay between the curvature elasticity effects maintaining the original geometry and the membrane tension which tends to reduce the nanotube radius and therefore diminish the free energy of the system. Recently, a spectacular work on formation of a microscopic network of lipid nanotubes connected with containers-vesicles has been reported in [2,3]. It was proved that lipid nanotubes can mediate an intravesicular transport of fluid and microparticles. This transportation could be induced by a mechanical perturbation of a given vesicle by causing a shape deformation [2] and a concomitant directed flow of membrane lipids. These interesting findings open perspectives towards controlled transportation of substances between lipid microcontainers-vesicles via bioorganic LNTs channels.

In this study we present a physical analysis of mechanics and transport phenomena in the system of surface-immobilized lipid bilayer vesicles (microcontainers) conjugated with a common lipid nanotube (LNT) pulled from its wall in different geometry. This work has been motivated by recent experimental precision measurements of lipid nanotube diameter utilising an artificial cell model [1] and correlations between the membrane deformation and enhanced transport of encapsulated substances between two interconnected containers-vesicles by creation of a lipid flow [2].

References

[1] Adams K.L., Engelbrektsson J., Voinova M.V., Zhang B., Eves D.J., Karlsson R., Heien M. L., Cans A.-S., Ewing G. Analytical Chemistry, **82** (2010) 1020.

[2] Karlsson, M., Davidson M., Karlsson R. ,Karlsson A., Bergenholtz J., Konkoli A., Jesorka, A., Lobovkina T., Hurtig, J., Voinova M. V., Orwar O. Ann. Rev. Phys. Chem., **55** (2004) 613.

[3] Karlsson R., Karlsson R., Karlsson M., Cans A.-S., Strömberg A., Ryttsen F., and Orwar O. Nature, 409 (2001) 150.