Mechanism and kinetics of pore formation in membranes by water-soluble amphipathic peptides

Ming-Tao Lee, Wei-Chin Hung, Fang-Yu Chen, Huey W. Huang

1National Synchrotron Radiation Research Center, Soft matter science group, 101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu, Taiwan, 30076, Taiwan, 2Department of Physics, Chinese Military Academy, Fengshan, Kaohsiung, 83055 Taiwan, 3Department of Physics, National Central University, Chung-Li, 32054 Taiwan, 4Department of Physics & Astronomy, Rice University, Houston, Texas 77251, E-mail: mtlee@nsrrc.org.tw

How antimicrobial peptides form pores in membranes is of interest as a fundamental membrane process. However, the underlying molecular mechanism, which has potential applications in therapeutics, nonviral gene transfer and drug delivery, has been in dispute. We have resolved this mechanism by observing the time-dependent process of pore formation in individual giant unilamellar vesicles (GUVs) exposed to a melittin solution. Individual GUV first expanded its surface area at constant volume and then suddenly reversed to expanding its volume at constant area. The area expansion, the volume expansion and the point of reversal all match the results of equilibrium measurements performed on peptide-lipid mixtures. The mechanism includes a negative feedback that makes peptide-induced pores stable with a well-defined size, contrary to the suggestion that peptides disintegrate the membrane in a detergent-like manner.

Keywords: membrane, antimicrobial peptides, pore formation

Probing slow dynamics on glass transition in thin polystyrene films by X-ray reflectivity

Chunming Yang, Hikaru Terauchi, Isao Takahashi

Kwansei Gakuin University, Faculty of Science and Technology, Gakuen 2-1, Senta, Hyogo, 669-1323, Japan, E-mail: ais78403@ksc.kwansei.ac.jp

Glass transition temperature (Tg) is known to vary with heating/cooling rate for glass-forming materials. Especially for ultrathin films with thickness comparable to the length scale of cooperative rearranging region, rearrangement of the segments would be strongly influenced by the confined geometry to produce a noticeable dependence of Tg on the heating/cooling rate. It is thus interesting to observe how Tg varies in a thin glass-forming polymer under different heating/cooling conditions, which would serve us to get precious information about how dynamical behavior is hindered.

In the present study, we investigate glass transition temperature in polystyrene films spin-coated on Si substrates under different heating rates of 0.5 K/min., 0.05 K/min., and 0.01 K/min. Temperature-dependent film thickness, surface roughness, and electron density are precisely obtained by X-ray reflectivity for the films with thickness ranging from 60 nm to 3.7 nm. The thickest film comparable to ten times of radius of gyration corresponds to the maximum thickness where the reduction of Tg was observed in [1] and [2]. Dewetting phenomenon during the annealing at 430K was found to be inevitable for films less than 3.7 nm thick. Log(heating rate) vs. 1/Tg shows a slow dynamics obeying the Arrhenius behavior characterized by a decrease in activation energy with decreasing the thickness. Tg of 3.7 nm thick film was determined to be 327K (= Tg(bulk)-46 K) under the heating rate of 0.01 K/min. It almost reaches the limiting value (Tg(bulk)-51.6 K) with the infinite relaxation time predicted by WLF equation.


Keywords: glass transition, X-ray reflectivity, slow dynamics