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Tethered lipid bilayer membranes assembly on gold by fusion of functionalized lipid vesicles

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Abstract

Lipid vesicles with functional chemical groups were designed to promote vesicle fusion on atomically flat template stripped gold (TSG) surface which is favorable for low defect density molecular assembly. Vesicles composed of 2.5 mol% 1,2-distearoyl-sn-glycero-3-phosphoethanolamine-N-poly(ethylene glycol)-2000-N-[3-(2--(pyridyldithio)propionate)] (DSPE-PEG-PDP) / 97.5 mol% POPC fused and formed tether lipid bilayer membranes (tLBMs) on TSG surfaces as determined by atomic force microscopy (AFM) topography and force spectroscopy measurements acquired under physiological conditions. The DSPE-PEG-PDP molecule containing a disulfide group is incorporated for Au-thiolate bond formation, which increases vesicle-substrate interactions and promotes vesicle fusion on TSG. As a control, vesicles composed of 100 mol% POPC did not interact with unfunctionalized hydrophobic TSG surface and only adsorbed on oxygen plasma treated hydrophilic TSG. Besides, vesicles composed of 2.5 mol% 1,2-distearoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy (poly-ethylene glycol)-2000] (DSPE-PEG) / 97.5 mol% POPC showed no indication of membrane formation on TSG, suggesting that the disulfide group in DSPE-PEG-PDP is critical for promoting vesicle fusion and membrane formation on Au. Analysis of force-distance curves for 2.5% DSPE-PEG-PDP / 97.5% POPC tLBMs on TSG yielded a breakthrough distance of 4.8 - 0.4 nm, which is about 1.7 nm thicker than that of POPC LBM formed on mica. Thus the PEG group serves as a spacer layer between the tLBM and TSG surface. Fluorescence microscopy results indicate these tLBMs also have greater mechanical stability than un-tethered LBMs made from the same vesicles on mica. Although AFM images showed incomplete tLBMs on TSG surfaces, complete surface coverage can be achieved by annealing samples in aqueous solution or during AFM scanning after exposure to functionalized vesicles. These large-scale manufacturing compatible methods introduced in this study are promising for fabricating individually electrically addressable tLBM arrays designed for high-throughput electrochemical measurements of protein-membrane interactions.