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Microfluidic Device Development to study Electric Field Effect on Planar Lipid Bilayers

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Abstract

Various membrane models replicate essential features of biological membranes, including elasticity and fluidity. Planar bilayers have been created using traditional methods, such as the black lipid membrane technique. Recently, micro-fabricated devices featuring horizontally oriented planar lipid bilayers have been developed with combined optical and electrical outputs. Electric fields play important roles in various biological processes, including embryonic development, wound healing, and cancer metastasis. Disruption of epithelial layers can generate lateral electric fields that promote electrotaxis, aiding in tissue repair. Strong electric pulses can induce electroporation, creating temporary membrane pores that facilitate drug delivery. In this study, we designed a microfluidic device using PDMS polymer. We optimized both the bilayer reconstitution method and the aperture design. The optimized 3D–microchip consists of a bottom channel connected to a micromachined upper cone. The capacitance of the bilayer(350 µm diameter) was found to be 500 pF by measuring the impedance. The nonlinear response of the system impedance was studied for different frequencies (100-500 kHz) of the applied voltages. Furthermore, we observed that the membrane's lifespan with a composition of DOPC/DOPS/DOPE (60:10:30) is influenced by the frequency and intensity of the electric field. The bilayer was destroyed by increasing the applied voltage and reducing frequency.

Keywords: Electric field; Microfluidic device; Planar lipid bilayers; Capacitance