HYBRID LIPID BILAYERS ON SILICON AS A PLATFORM FOR STUDYING PORE-FORMING TOXINS

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Research on phospholipid membranes is an essential subject for advancing the understanding of biological processes. The phospholipid bilayer is responsible for many crucial cell functions, including selective transport and protection against external agents. In this context, pore-forming toxins are of particular interest, as they directly compromise membrane integrity and serve as model systems for studying membrane disruption mechanisms [1] relevant to both pathology and antimicrobial activity. Phospholipid membrane models have been widely investigated on functionalized metal [2, 3] and metal oxide [4] surfaces. Silicon offers a well-defined and chemically versatile alternative, combining surface stability with tunable electrochemical properties. Its compatibility with controlled surface functionalization and semiconductor-based analysis enables systematic investigation of interfacial processes occurring at lipid membrane-solid interfaces.

The objective of this study was to form and characterize hybrid bilayer lipid membranes (hBLMs) composed of 1,2-dioleoyl-sn-glycero-3-phosphocholin (DOPC) on oxidized n-type silicon surfaces modified with an octadecyltrichlorosilane (OTS) self-assembled monolayer (SAM), and to investigate the concentration-dependent interaction of the pore-forming peptide, melittin, with these membranes.

Oxidized silicon wafers were functionalized with an OTS monolayer subsequently coated with a DOPC hBLM using the vesicle fusion technique [2]. Surface modification was evaluated using contact angle (CA) measurements and electrochemical impedance spectroscopy (EIS). EIS measurements were performed over a range of DC potentials to probe the change in interfacial resistance and capacitance of the surface after each modification step. The effect of melittin, the principal pore-forming component of bee venom [5], was assessed by exposing hBLMs to increasing peptide concentrations and monitoring the resulting changes in electrochemical response.

Successful formation of the silane-based SAM allowed for DOPC hBLM assembly and significantly altered both the surface chemistry and the electrochemical behavior of the semiconductor interface. EIS revealed characteristic impedance changes following monolayer and hBLM formation as well as disruption upon exposure to melittin. Melittin-induced defect formation led to a decrease in membrane resistance and changes in capacitance indicating increased ionic permeability. A clear correlation between the extent of membrane disruption and melittin concentration was observed.

These results demonstrate that oxidized n-type silicon functionalized with OTS provides a robust and reproducible platform for electrochemical studies of lipid membranes. The system enables sensitive detection of melittin-induced membrane damage and represents a promising approach for developing membrane-based sensing platforms relevant to toxin detection and membrane-active compound characterization.

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