MODIFICATION OF SILICON OXIDE SURFACE WITH PHOSPHOLIPID BILAYERS FOR BIOSENSOR DEVELOPMENT

Anastasija Aleksandrovič[1], Aušra Valiūnienė[1], Gintaras Valinčius[2]

[1]Center for Physical Sciences and Technology, Department of Organic Chemistry, Vilnius, Lithuania
[2]Unaffiliated scientist
anastasija.aleksandrovic@ftmc.lt

Tethered phospholipid membranes (tBLMs) supported by self-assembled monolayers (SAMs) are gaining significant traction in the development of conductive biosensors. Tethered membranes offer a significant advantage over traditional black lipid membranes due to their enhanced mechanical stability and longevity. By anchoring the bilayer to the surface via silane chemistry, we create a sub-membrane space (a ”reservoir”) that mimics the aqueous environment of a cell, allowing for the potential integration of transmembrane proteins. Historically, gold has been the standard substrate for these systems, but it has some notable drawbacks: it is expensive and notoriously difficult to regenerate. As a result, metal oxides are emerging as a superior alternative. They offer a more budget-friendly foundation while providing the distinct advantage of easier membrane regeneration, making them a highly practical choice for next-generation biosensing applications [1-2].

This study explores the development and characterization of tethered bilayer lipid membranes (tBLMs) synthesized on silicon dioxide (SiO_2) substrates. By utilizing a silane-based self-assembled monolayer (SAM) as a foundational anchor, we aimed to create a robust, biomimetic platform capable of maintaining structural integrity across varying environmental conditions. The primary focus of this research was to evaluate the formation efficiency and stability of these membranes when subjected to different aqueous environments, specifically by modulating the buffer solution pH. The choice of a silicon-based substrate (specifically silicon plates coated with a precise SiO_2 layer) was strategic. This surface serves as a versatile interface that bridges the gap between solid-state electronics and biological systems. By leveraging the unique properties of SiO_2, we were able to employ a dual-mode analytical approach: electrochemical methods (used to probe the insulating properties, capacitance of the tBLM, providing insight into the ”sealing” quality of the membrane) and optical methods (utilized to monitor the thickness and viscosity ensuring a high degree of structural precision).

This multi-analytical framework not only validates the formation of the tBLM but also determines the operational limits of these sensors in varying chemical landscapes, paving the way for advanced applications in drug screening and biosensing.

[1] I. Gabriunaite, A. Valiūnienė, and G. Valincius, “Formation and properties of phospholipid bilayers on fluorine doped tin oxide electrodes,” Electrochimica Acta, vol. 283, pp. 1351–1358, May 2018, doi: 10.1016/j.electacta.2018.04.160.

[2] A. Aleksandrovic, I. Gabriunaite, G. Valincius, and A. Valiūnienė, “Regeneration of tethered bilayer lipid membrane biosensors for repetitive use in toxin detection,” Bioelectrochemistry, vol. 167, p. 109078, Aug. 2025, doi: 10.1016/j.bioelechem.2025.109078.