Adsorption and binding dynamics of graphene-supported phospholipid membranes using the QCM-D technique

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Supported lipid membranes (SLMs) are significant as biomimetic platforms for the study of fundamental cell functions and signaling, cell-cell interactions, drug delivery and biosensing. The most common membrane lipids are phospholipids. Here we present the dynamics of adsorption and rupture of small unilamellar vesicles (SUVs) (typically <100 nm) on graphene oxide (GO) and reduced (r)GO substrates, monitored using the quartz crystal microbalance with dissipation monitoring (QCM-D) technique. The results are compared to two traditional substrates, Au and SiO_2.

We have recently demonstrated that phospholipid membranes can be produced on graphene using the dip-pen nanolithography (DPN) technique.[1] Modeling and experiments confirm that hydrophobic graphene (or rGO) results in the formation of monolayer lipid membrane in aqueous environment while hydrophilic GO results in bilayer membranes.[2]

Contact angle measurements reveal that SiO_2 is a significantly hydrophilic surface. The nature of pure Au surface is controversial; our measurements reveal a mildly hydrophilic surface. Upon GO coating, both surfaces retain their hydrophilic nature, while rGO coating renders both surfaces hydrophobic. As expected, SiO_2 and GO surfaces support the formation of a phospholipid bilayer, while we observe that Au supports vesicle absorption but not fusion to form a membrane. rGO surfaces support the formation of a phospholipid monolayer.

We additionally report on a biomolecular binding event on the graphene-supported lipid membranes, specifically the Biotin-Avidin complex which is one of the strongest known non-covalent interaction and is used for the development of robust and highly sensitive assays useful in protein detection.

References

[1] M. Hirtz, A Oikonomou, et al, Nature Communications, 4 (2013) 2591
[2] N. Willems, A. Urtizberea, et al, ACS Nano, In Press (2017)

Figures

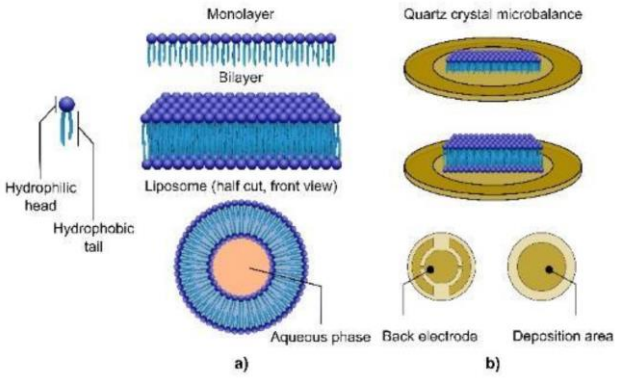

Figure 1: Schematic representation of lipid membranes from the basic lipid unit. (a) The three possible lipid structures studied and (b) Depiction of a lipid bilayer on a QCM chip.