Multiplexed Biomimetic Lipid Membranes on Graphene by Dip-Pen Nanolithography

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The application of graphene in sensor devices or as an interface to biological systems crucially depends on the ability to appropriately functionalize the pristine graphene. Here we show the direct writing of tailored phospholipid membranes on graphene using dip-pen nanolithography (DPN). Phospholipids exhibit higher mobility on graphene compared to the commonly used silicon dioxide substrate, leading to well-spread uniform membranes. DPN allows for multiplexed assembly of phospholipid membranes of different functionalities in close proximity to each other. The membranes are stable in aqueous environments and we observe electronic doping of graphene by charged phospholipids. Based on these results, we propose phospholipid membranes as a route for non-covalent immobilization of various functional groups on the graphene for applications in biosensing and biocatalysis. As proof of principle, we demonstrate the specific binding of streptavidin to biotin functionalized membranes. The combination of atomic force microscopy in air and fluid and binding experiments yields new insights towards a consistent model for the layer organization within phospholipid stacks on graphene.