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Production of Energy from Na^+ Ion Transport utilising Nanostructured Biomimetic Membranes

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The application of biomimetically inspired nano-fabrication techniques has the potential for the construction of novel devices [1]. Such biomimetically inspired techniques involve the incorporation of biological membrane transport proteins into lipid bilayers, but currently the construction of such devices has the significant limitations of *(i)* the short lifetime of systems that only use liposomes or Black Lipid Membranes (BLM), and *(ii)* the difficulty in obtaining purified membrane transport proteins using cell-based overexpression systems. We overcame these limitations by developing a biomimetic membrane system with a very long stable lifetime, and utilizing cell-free techniques to purify membrane transport proteins [2]. Such biomimetic membrane systems can also be used as *(i)* a biosensor by monitoring the change in gating of the incorporated ion channels [3], and *(ii)* a "smart" biomimetic microcapsular delivery system tuned for the selective therapeutic delivery and targeting of drugs [4].

In this report we describe the reconstruction of biological membrane transport proteins in an artificial biomimetic membrane system to fabricate a novel method to produce energy. An optimized cell-free protocol [2] was used to purify the biological membrane transport proteins which were incorporated into the lipid bilayer of the biomimetic membrane system to provide a functional capability to control Na^+ ion transport. The lipid bilayer was supported by a free-standing planar polyelectrolyte multilayer film, which we formed in a novel way using a sacrificial substrate of low melting point agarose. Our method provides additional stability to the free-standing planar polyelectrolyte multilayer film by the inclusion of a proportion of the agarose during the fabrication of the film in order to create an interpenetrating polyelectrolyte/hydrogel. The sacrificial agarose substrate is first pre-coated with a layer of poly(ethyleneimine) (PEI) which acts as a precursor to enhance the stability of the subsequent alternating polyelectrolyte multilayers. The required number of layers of poly(sodium 4-styrenesulfonate) (PSS) and poly(allylamine hydrochloride) (PAH) are then deposited onto the agarose substrate using the layer-by-layer technique. The sacrificial substrate provided strength during manipulation and allowed the easy transferral of the interpenetrating polyelectrolyte/hydrogel onto a range of other substrates, without the need to dip these substrates in polyelectrolyte. That was important for the ultimate use of the biomimetic membrane system in a diffusion chamber.

We report the characterisation of our novel interpenetrating polyelectrolyte/hydrogel from the results of our studies using an elemental analysis, ellipsometry and differential scanning calorimetry. We confirmed the permeability of this material using a tracer diffusion experiments. The complete biomimetic system was characterized using impedance spectroscopy which demonstrated that the interpenetrating polyelectrolyte/hydrogel supported a lipid bilayer in the diffusion chamber. Finally, after incorporating membrane transport proteins in the supported lipid bilayer to control Na^+ ion transport, our results from impedance spectroscopy measurements indicated that the complete system generated an electrical potential of 100mV utilizing a gradient of Na^+ ions as the only fuel in the diffusion chamber.

Références

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