CARDIAC HEALTH: FROM ELECTROSTIMULATION OF CARDIOMYOCYTES

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INTRODUCTION

Cell stimulation is extremely important in cell culture to provide closer physiological culture models. These models are used for research and biomedical applications [1]. The focus of this work is to design and construct an electrostimulation platform for cardiomyocyte stimulation in culture. The aim is to design a dynamic platform to facilitate culture and experimental objectives which can be applied seamlessly to other cell lines which benefit from electrostimulation, namely myocytes and neuronal cells. To achieve the application of potential to the cells in situ this work takes advantage of bipolar electrochemical principles; whereby a conducting electrode material (bipolar electrode) is placed between two driving electrodes and a potential biased is generated between them causing a potential gradient in solution. The bipolar electrode remains at a constant potential and therefore an interfacial potential is formed between the bipolar electrode and the potential in solution. The potential different is maximal at the ends of the electrode and an anodic and cathodic pole is formed as illustrated in **Figure 1**. In order to create a suitable surface for a biological environment Fluorine Doped Tin Oxide (FTO) coated in polypyrrole – dextran sulfate – fibronectin was used. This formed a conductive polymer coating which preserved a high degree of optical transparency for microscopy applications. The electrochemical and biological properties of these conductive bipolar electrodes was then elucidated.

MATERIALS AND METHODS

Cyclic voltammetry was recorded on CH Instruments 760E potentiostat. Electrodeposition solution was formulated using Pyrrole, Dextran Sulphate, and fibronectin. CVs were used to determine the electrochemical properties of the film using a traditional three electrode cell with bipolar electrode films as the working, platinum wire electrode as the counter and 1M KCl Ag/AgCl electrode as reference. $LiClO_4$ and DPBS were used as supporting electrolyte for CVs. CVs using ferrocenemethanol were used to determine the electrochemical properties of the FTO coated in Fibronectin Gelatin coating. HL-1 cardiomyocytes were cultured on each bipolar electrode formulation for three days consecutively using supplemented Claycomb media, changed daily, as recommended by the supplier. Light microscopy images were obtained on an Olympus light microscope. All materials were purchased from Sigma-Aldrich (Ireland) and used as delivered.

RESULTS

Analysis of the electrodeposition voltammograms show that a conductive polymer film can be deposited on the FTO substrate using a potentiodynamic method. Conductivity is maintained and capacitance is also increased indicating conductive layers of PPy-DS-Fibronectin are consecutively deposited with each cycle between 0 and 0.7 V. Following deposition, CVs in $LiClO_4$ and DPBS indicate a stable electrode surface with a broad potential window. CVs of the fibronectin gelatin coated FTO indicated that a stable protein layer is coated to the electrode surface. This protein layer is not electroactive and Redox probe CVs indicate that it does not significantly alter the electrochemical properties of the electrode and remains stable over at least 50 potential cycles.

Cell culture on the presence show that all films supported traditional culture of HL-1 cardiomyocytes for a sustained 3-day culture. All electrode films and the fibronectin gelatin showed cell adhesion and continued growth over the course of the experiment.

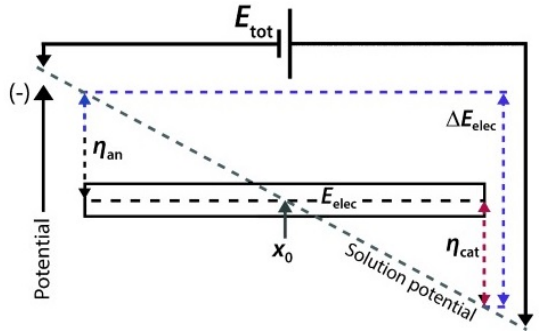

Figure 1 Schematic representation of electric field and overpotential positions on a bipolar electrode place between two appropriate driving electrodes.

DISCUSSION

The electrochemical and biological results of this study show that a suitable bipolar electrochemical surface can be achieved to allow the culture of HL-1 cardiomyocytes successfully. These results are promising with respect to the ultimate goal of in situ electrostimulation of cell lines using bipolar electrochemical techniques.

REFERENCES

1) Chen et al., Applied Materials Today volume 21 : 100804- 100813, 2020