Investigating the Suitability of a Polypyrrole-Cellulose Nanofiber-Agarose Composite as a Novel Attachment Factor for Neural Organoids

Liam T. Davis[1,2], Miguel Cuevas[2,3], David Probst[1], Meghana Yeturi[2,3], Jason L. Stein[2,3]

UNC-NCSU Joint Department of Biomedical Engineering[1], UNC Neuroscience Center[2], Dept of Genetics[3]

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Introduction

Epilepsy is a complex, multifaceted condition. Implicated in its pathology, however, is a mutation leading to asynchronous neuronal firing. To study this, the Stein Lab has chosen to employ an in vitro model where organoid firing rates would be recorded using a new 3D Multi-Electrode array setup. However, previous experiments using this setup have recorded no organoid action potentials. This was thought to be due in part to the insulating coating applied to the multielectrode array to facilitate organoid attachment. In order to test this hypothesis, a novel, biodegradable, conductive attachment factor was proposed.

Experimental Design

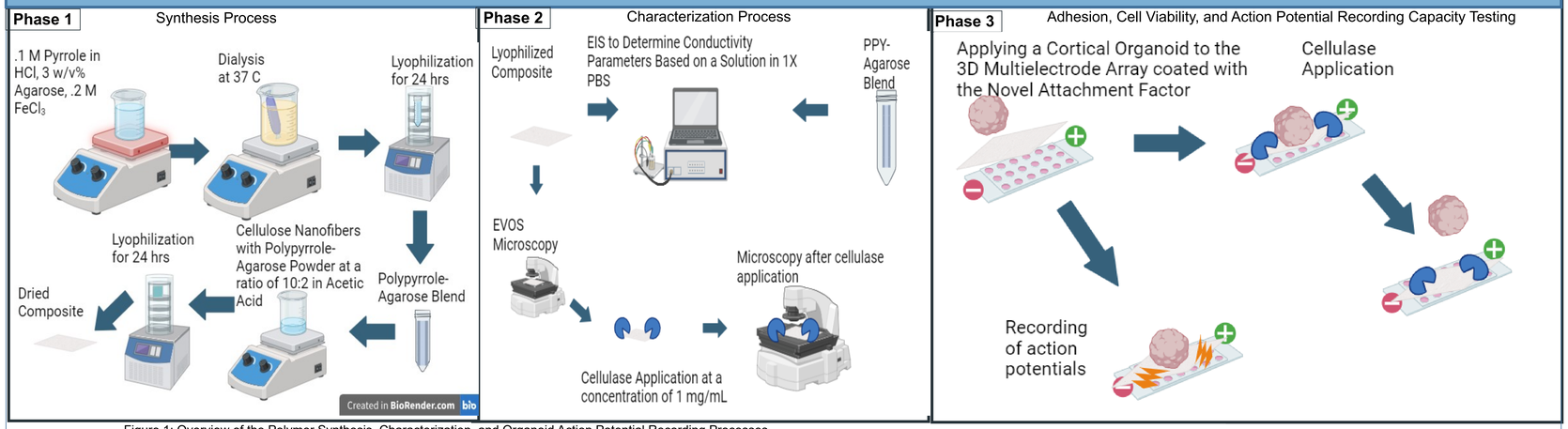
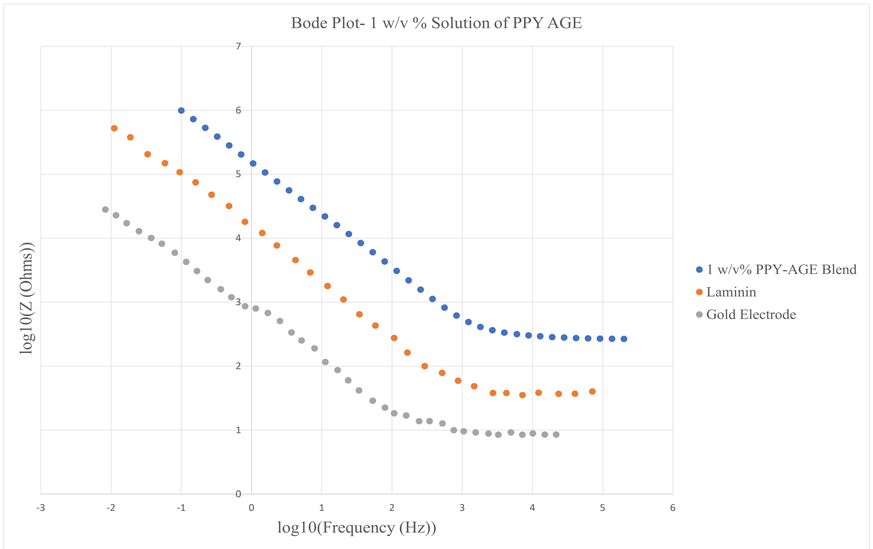


Figure 1: Overview of the Polymer Synthesis, Characterization, and Organoid Action Potential Recording Processes

EIS Results



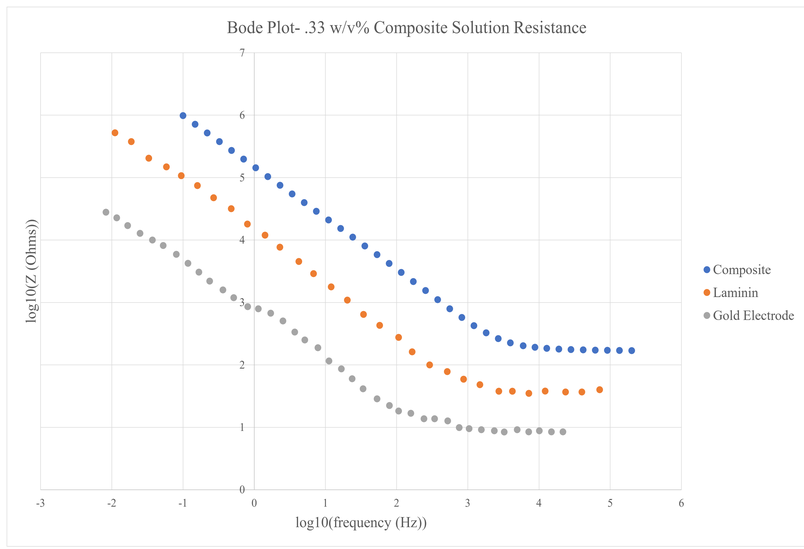


Figure 2- Bode Plots of the solution impedance of the Polypyrrole-Agarose blend (left) and the cellulose nanofiber-polypyrrole-agarose composite (right). Operating frequencies are expected to be between 10^0 and 10^2 Hz. At these frequencies, the composite is resistive. Based on this lack of observed conductance, it was deemed moot to test the cell adhesion capacities of and viability of cells in contact with the attachment factor. Also included are reference Bode plots for laminin, the current attachment factor of choice, and for a gold electrode. The laminin data was taken from Impedance characterization and modeling of electrodes for biomedical applications (Franks 2005) . The gold electrode data was taken from Carbon nanotube modified microelectrode array for neural interface (Vafaiee 2021.) Plot data was extracted via WebPlotVisualizer.

Degradation Testing

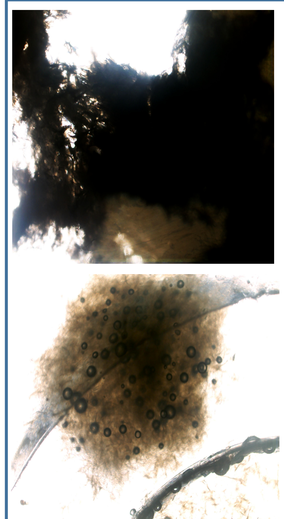


Figure 3- EVOS Microscopy Images of the composite after enzymatic degradation. Images taken at 4x Magnification of the same marked area. “After” image taken after 30 minutes of incubation in 1 mL of 1 mg/mL Cellulase Solution

Conclusions and Future Directions

1. The current approach to manufacturing the attachment factor produces a composite which can be degraded by celluase, but is resistive at operating frequencies.
2. The Stein Lab will be revisiting the manufacturing process in collaboration with the Bai Lab, in order to produce a material with the desired conductivity, allowing for phase 3 to be performed.

Acknowledgements

Funding for this project was provided from the UNC AGILE Program by the Institute for Convergent Science