Electrochemical detection of glucose using a PEDOT/CNT functionalized platinum electrode with integrated Glucose Oxidase

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Introduction

- Bodily metabolism of Glucose is essential to the maintenance and regulation of internal conditions to allow life. The concentration of dissolved glucose therefore must remain at a specific range to optimally conserve energy, while also producing enough ATP for bodily processes
- Application of Functionalized Carbon Nanotubes (CNT's) with poly-3,4-ethylenedioxythiophene (EDOT) to an electrode surface has been shown to drastically increase electrode sensitivity to analyte in solution by increasing surface area
- This study aims to see if the application of organic glucose oxidase into a conductive polymer nanocomposite coating on electrodes will serve as a reliable method for accurate and sensitive glucose detection.

Materials & Methods

The experiment occurred in 3 main phases:

- Optimization of the procedure for coating PEDOT/CNT onto the carbon/platinum electrodes
- Incorporation of Glucose Oxidase into the polymerization mixture and determining functionality after polymerization
- Electrochemical detection of ß-D-Glucose in an Artificial Cerebrospinal Fluid solution

Optimization Conditions

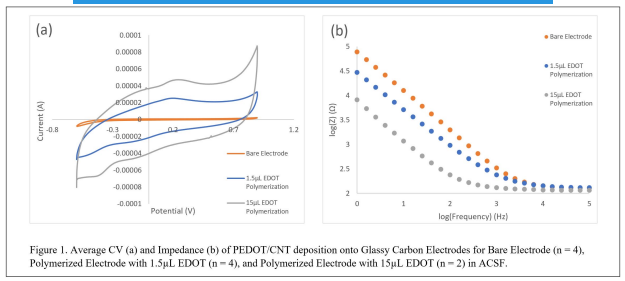

Figure 1. Average CV (a) and Impedance (b) of PEDOT/CNT deposition onto Glassy Carbon Electrodes for Bare Electrode (n = 4), Polymerized Electrode with 1.5µL EDOT (n = 4), and Polymerized Electrode with 15µL EDOT (n = 2) in ACSF.

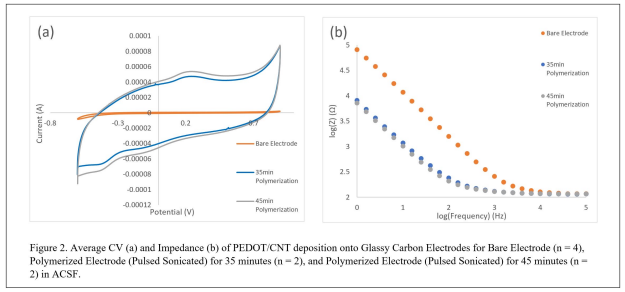

Figure 2. Average CV (a) and Impedance (b) of PEDOT/CNT deposition onto Glassy Carbon Electrodes for Bare Electrode (n = 4), Polymerized Electrode (Pulsed Sonicated) for 35 minutes (n = 2), and Polymerized Electrode (Pulsed Sonicated) for 45 minutes (n = 2) in ACSF.

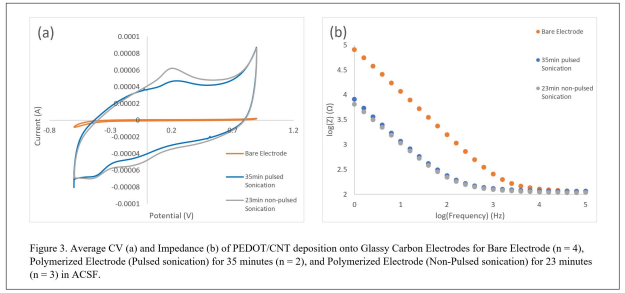

Figure 3. Average CV (a) and Impedance (b) of PEDOT/CNT deposition onto Glassy Carbon Electrodes for Bare Electrode (n = 4), Polymerized Electrode (Pulsed sonication) for 35 minutes (n = 2), and Polymerized Electrode (Non-Pulsed sonication) for 23 minutes (n = 3) in ACSF.

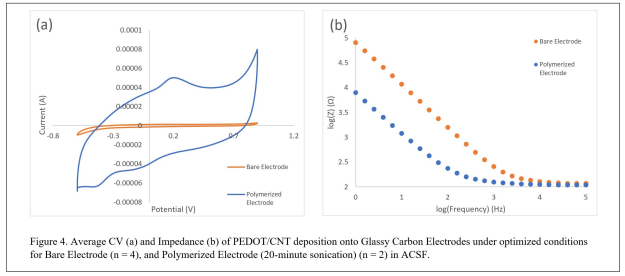

Figure 4. Average CV (a) and Impedance (b) of PEDOT/CNT deposition onto Glassy Carbon Electrodes under optimized conditions for Bare Electrode (n = 4), and Polymerized Electrode (20-minute sonication) (n = 2) in ACSF.

Glucose Detection

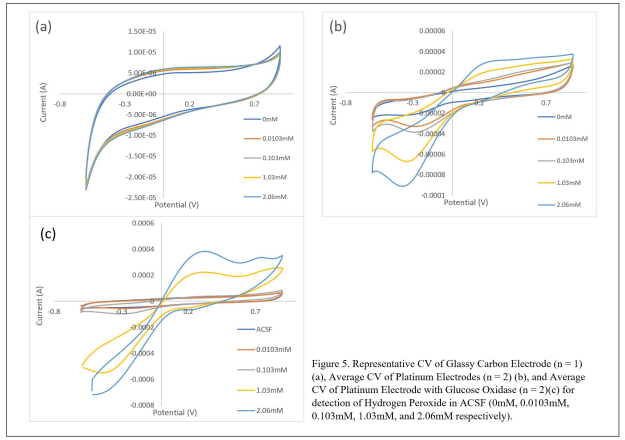

Figure 5. Representative CV of Glassy Carbon Electrode (n = 1) (a), Average CV of Platinum Electrodes (n = 2) (b), and Average CV of Platinum Electrode with Glucose Oxidase (n = 2)(c) for detection of Hydrogen Peroxide in ACSF (0mM, 0.0103mM, 0.103mM, 1.03mM, and 2.06mM respectively).

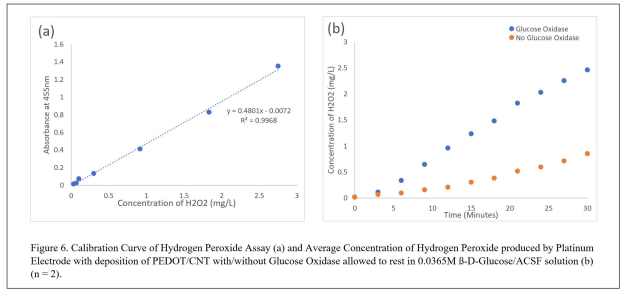

Figure 6. Calibration Curve of Hydrogen Peroxide Assay (a) and Average Concentration of Hydrogen Peroxide produced by Platinum Electrode with deposition of PEDOT/CNT with/without Glucose Oxidase allowed to rest in 0.0365M ß-D-Glucose/ACSF solution (b) (n = 2).

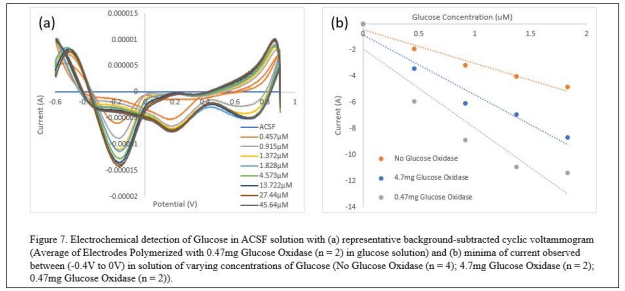

Figure 7. Electrochemical detection of Glucose in ACSF solution with (a) representative background-subtracted cyclic voltammogram (Average of Electrodes Polymerized with 0.47mg Glucose Oxidase (n = 2) in glucose solution) and (b) minima of current observed between (-0.4V to 0V) in solution of varying concentrations of Glucose (No Glucose Oxidase (n = 4); 4.7mg Glucose Oxidase (n = 2); 0.47mg Glucose Oxidase (n = 2)).

Results and Discussion

- It was determined that optimal polymerization conditions included: 15µL EDOT + 1.5mL DI H_2O + 1.5mg CNT
  sonicated for 20min (non-pulsed)
- Carbon Electrodes provided too little differentiation in Peroxide Detection and therefore Procedures were altered for Platinum Electrodes which are better suited for hydrogen peroxide detection
- Through Spectroquant® colorimetric analysis it was determined that glucose oxidase is being incorporated into the electrode matrixes
- Electrochemical detection provided positive feedback in detection of Glucose utilizing 4.7mg (n = 2) and 0.47mg (n = 2) of Glucose Oxidase, respectively. Increased signal was also detected in experimental blank without glucose oxidase, with inconsistent results (n = 4)

Conclusion

We have successfully optimized the procedure for polymerization of PEDOT/CNT nanocomposite coatings onto the electrode surface. We have also successfully incorporated Glucose Oxidase into the matrixes of the coating with retained functionality to catalyze the reaction of glucose to produce hydrogen peroxide for detection. This application shows promise, but further research must occur to increase detection using this system.

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