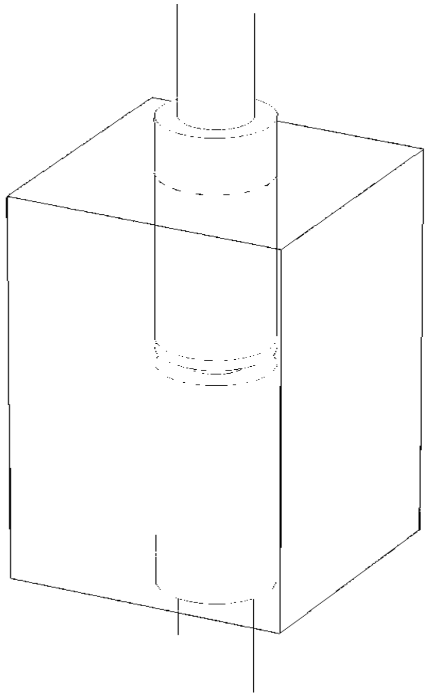
Evaluation of Composite Electronic Materials Based on Poly (3, 4 – propylenedioxythiophene/Poly – (p – Naptheleneethynylene) Wrapped Single Wall Carbon Nanotubes for Supercapacitors



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SUNFEST 2010

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NSF REU Site

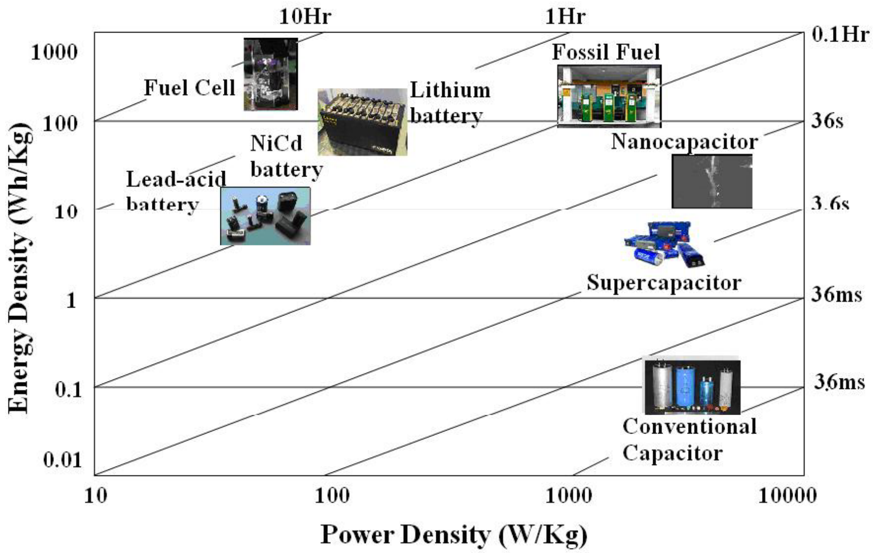
University of Pennsylvania

SUPER **CAPACITOR**

$$C = \frac{Q}{V}$$

Kinds of Energy Storage

Ragone Plot



Advantages of Supercapacitors

- Power density
- Recycle density
- Environmental friendly
- Safe
- Light weight

Types of Supercapacitors

Electrical Double Layer (EDLC)

Redox (Pseudo capacitor)

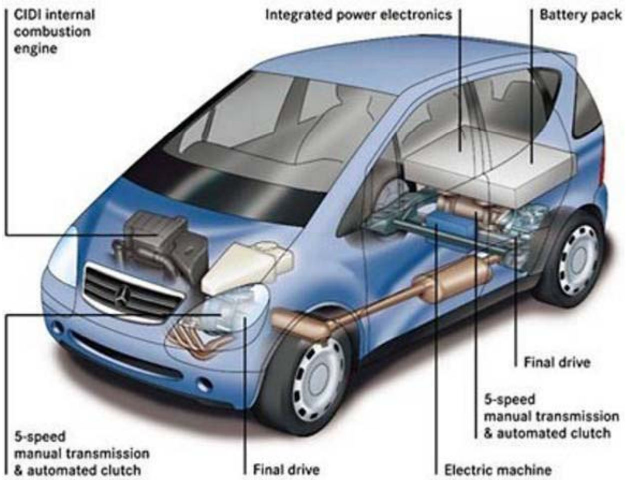
Hybrid

Reference: www2.egr.uh.edu/.../images/energy_density.jpg

Application for Supercapacitors

- ❖ Power back-up for memory functions in a wide range of consumer products such as mobile phones, laptops and radio tuners.
- ❖ To prolong battery life in products or devices using mechanical actuators such as digital cameras.
- ❖ Also used for energy storage for solar panels, and motor starters.
- ❖ Load Leveling

http://www.solar-part.com/solar/solar%20kit/solar-panels.jpg

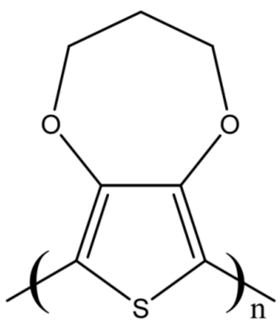


http://www.worldproutassembly.org/images/hybrid-car-hyper.jpg

http://www.vigilantpress.com/wp-content/uploads.jpg

Redox Capacitors

Active materials: metal oxides or electronically conducting polymers (ECPs)



PProDOT

Advantages of ECPs

❖Storage capacity

❖Chemical stability

❖ Reduced cost relative to noble metal oxides

❖ ECPs can provide higher capacitance and/or higher power capability than other electrodes

Symmetric	Asymmetric
Type I: same p-doping polymer	Type II: different p-doping polymers
Type III: same polymer as the p- and n-dopable material	Type IV: different polymers as the p- and n-dopable material

Experimental Procedure

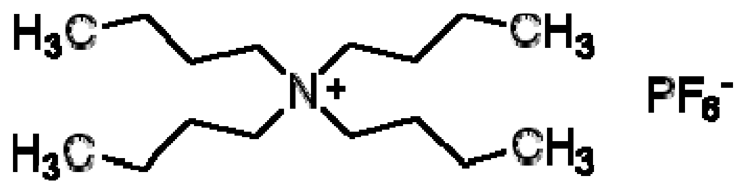
- ❖ Solutions
- ❖ Electrochemical Polymerization
- ❖ Scan Rate Tests
- ❖ Oxidizing Tests
- ❖ Doping
- ❖ Morphological Characterization
- ❖ Construction of Device
- ❖ Single Wall Carbon Nanotubes

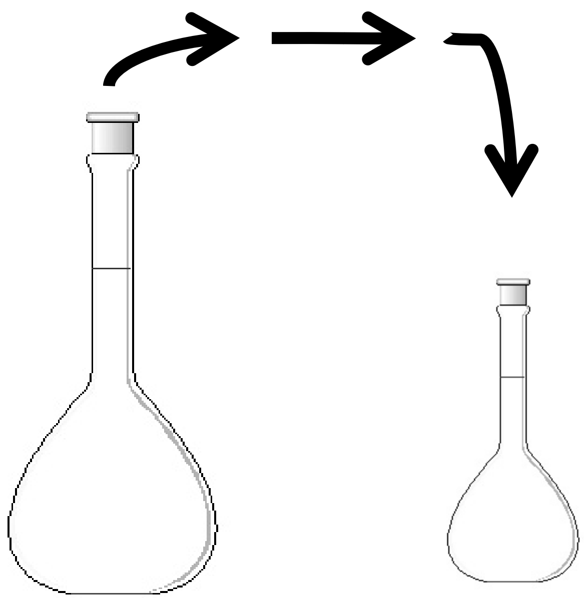
Solutions

Electrochemical Polymerization
Scan Rate Tests
Oxidizing Tests
Doping
Morphological Characterization
Construction of Device
Single Wall Carbon Nanotubes

- **25 mL $TBAPF_6$/PC solution ~ 0.1 M**

- **10 mL ProDot/$TBAPF_6$/PC**





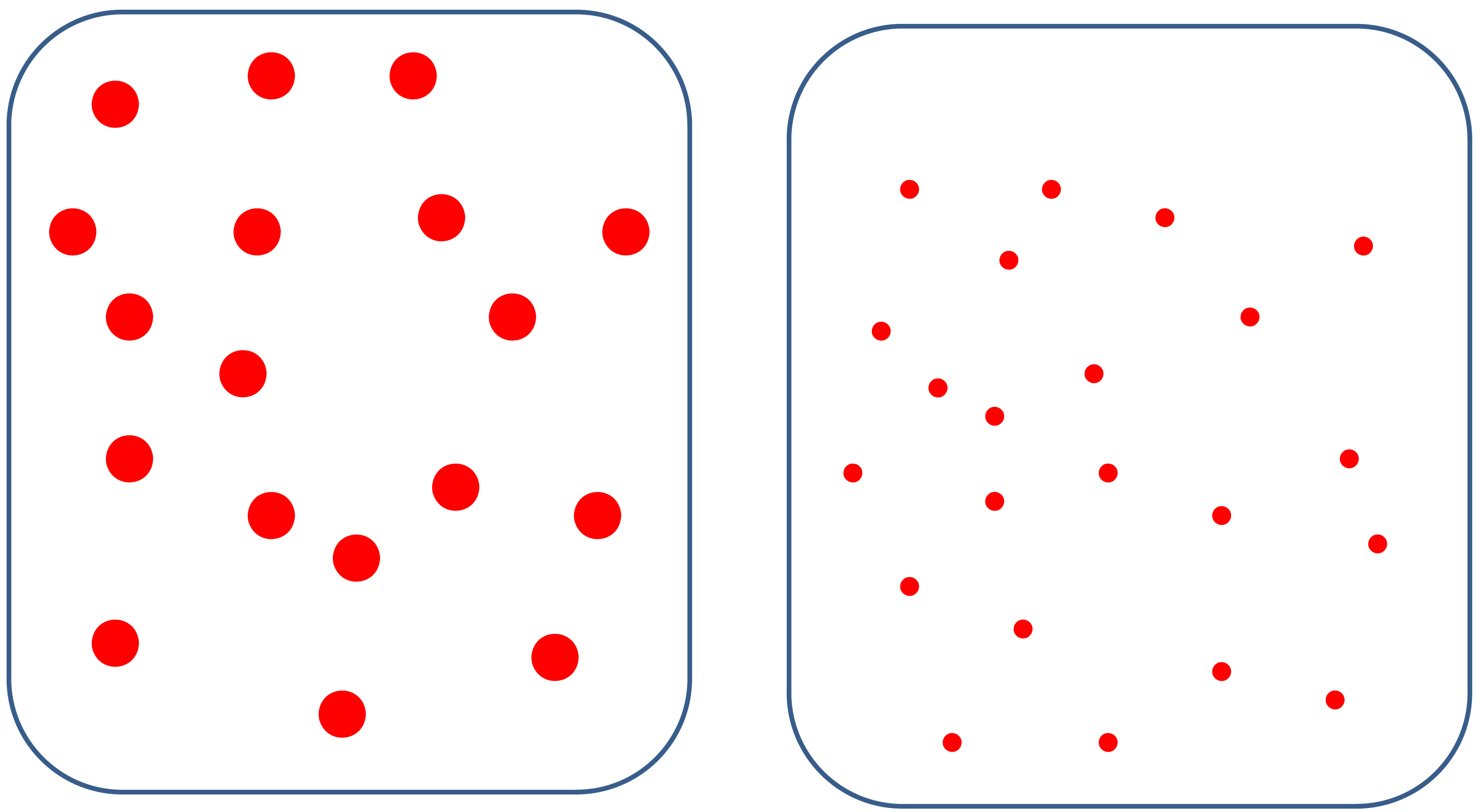
$TBAPF_6$/PC

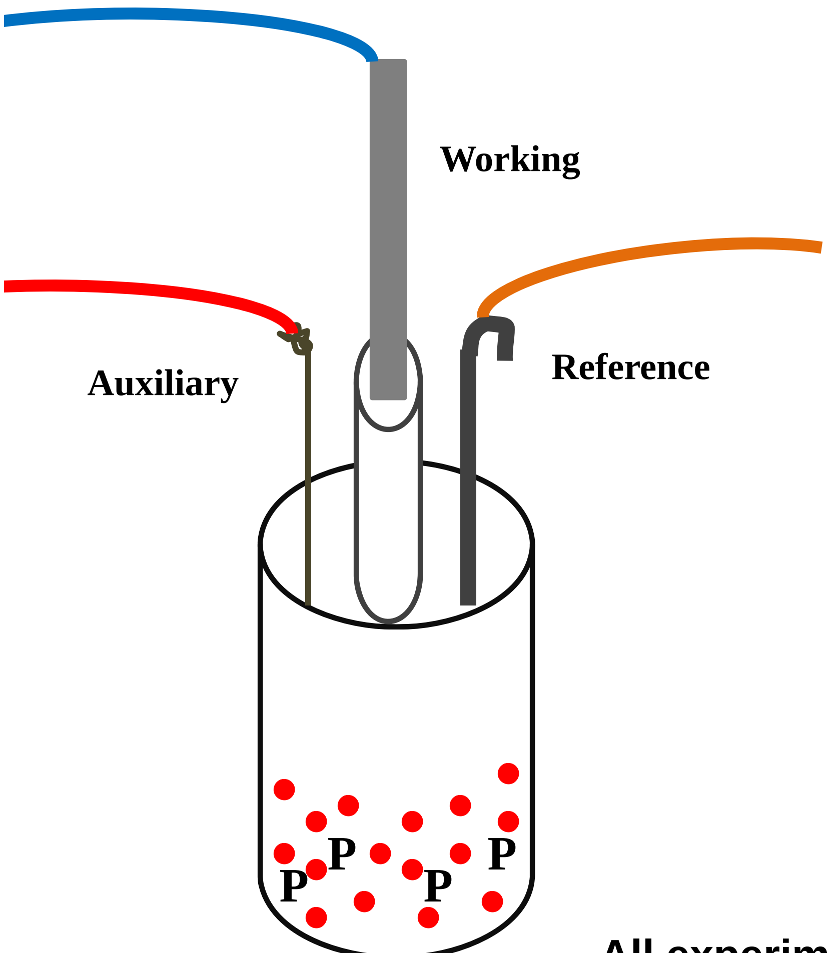
ProDot

http://www.sigmaaldrich.com

http://www.epa.gov/region3/ee/chesapeake/images/volum.gif

Why $TBAPF_6$?





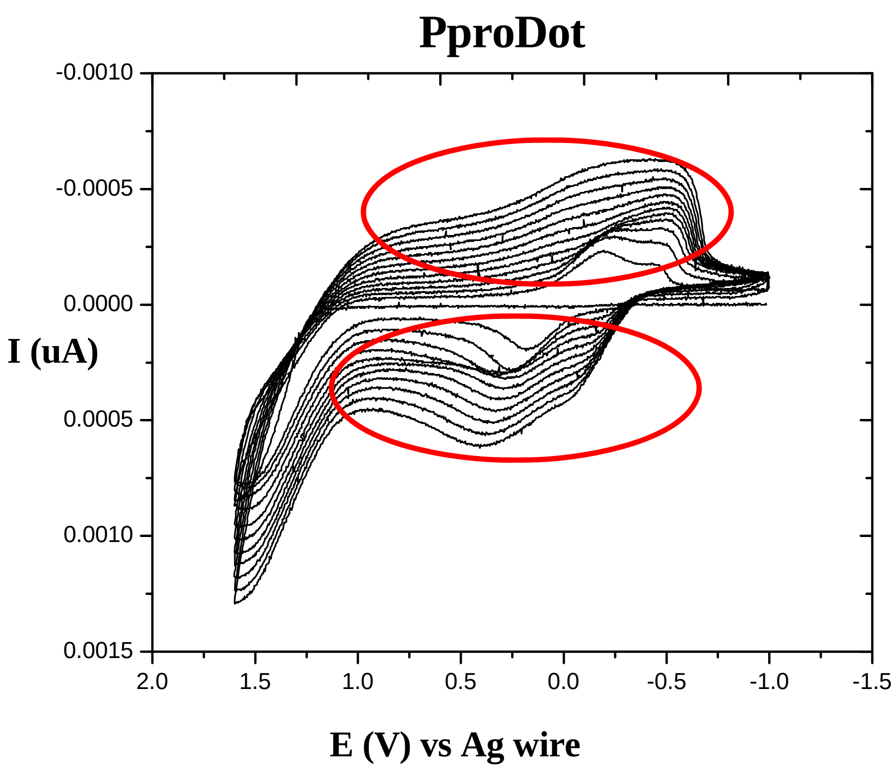
Three electrode setup

- ❖ Working electrode: Platinum (5 mm disc OD)
- ❖ Reference electrode: Silver wire
- ❖ Auxiliary /Counter electrode: Platinum wire

Parameters used

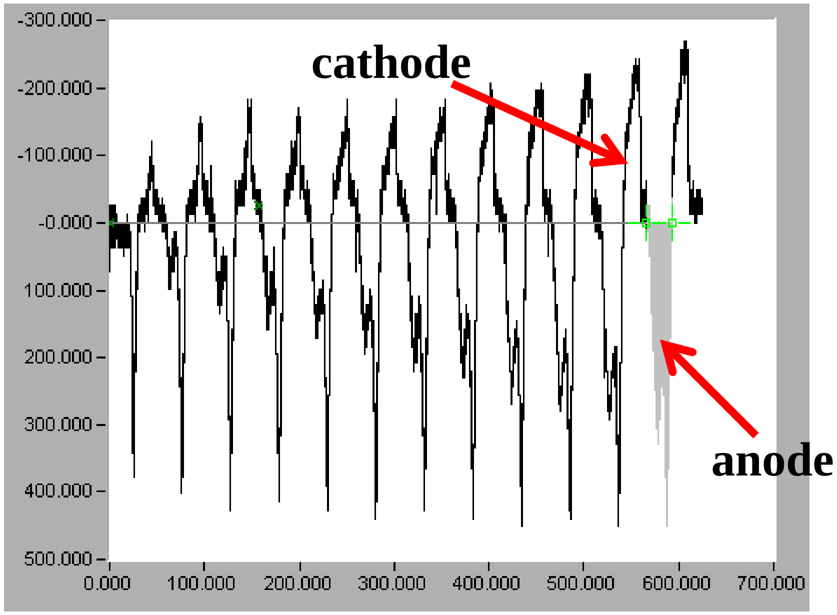
Sweep rate = 100 mV/s
Total sweep = 24
Sweep potentials = -1000 mV - 1600 mV
Color of deposition = deep purple

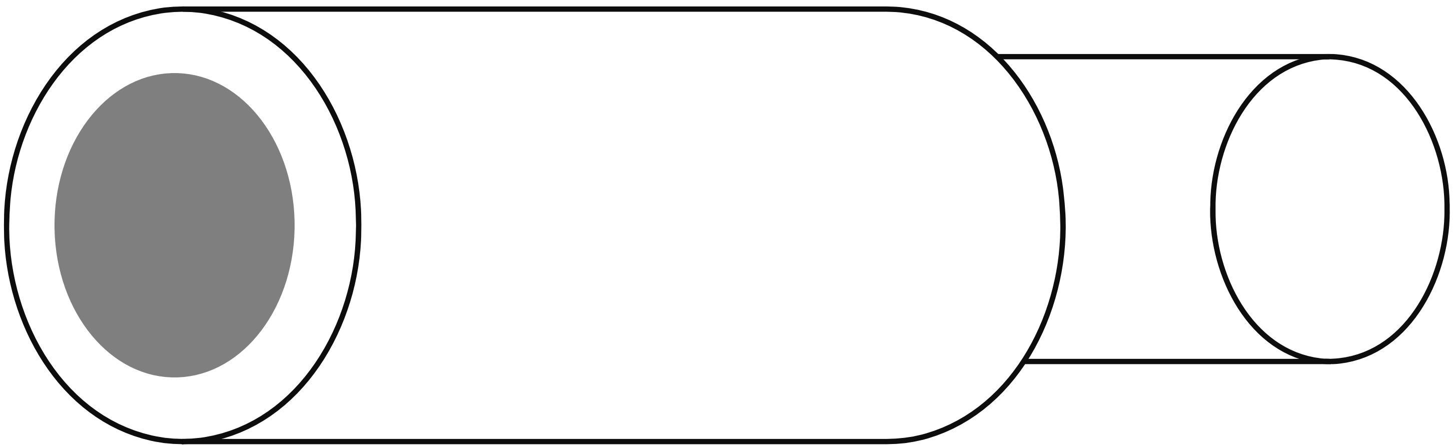
All experiments were done in a glove box in N_2 atmosphere



CV of electropolymerization

Potential charges (mC) were determined for the anode and cathode.





Electropolymerization was done to two electrodes. If the difference in potential charges exceeded the 30% limit the electropolymerization process was repeated.

Scan rate tests are done primarily to know how fast the device will work

Parameters used

Sweep rates = 25, 50, 100, 200, 250, 300, 400,500, 750, 1000, 2500, 5000, 10000 mV/s

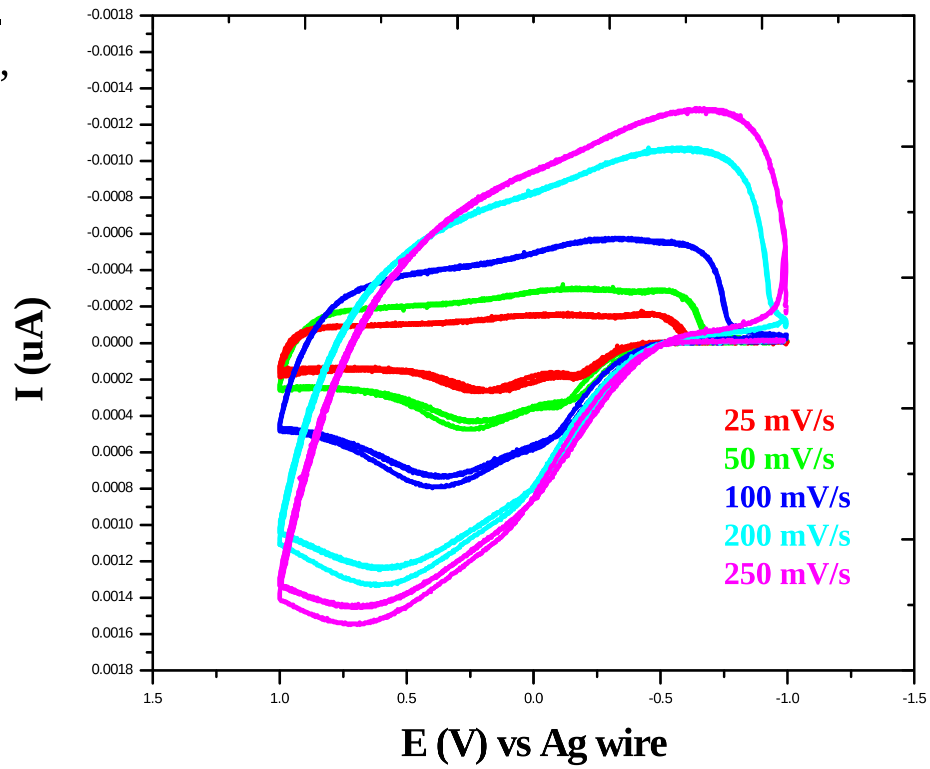
Total sweeps = 6

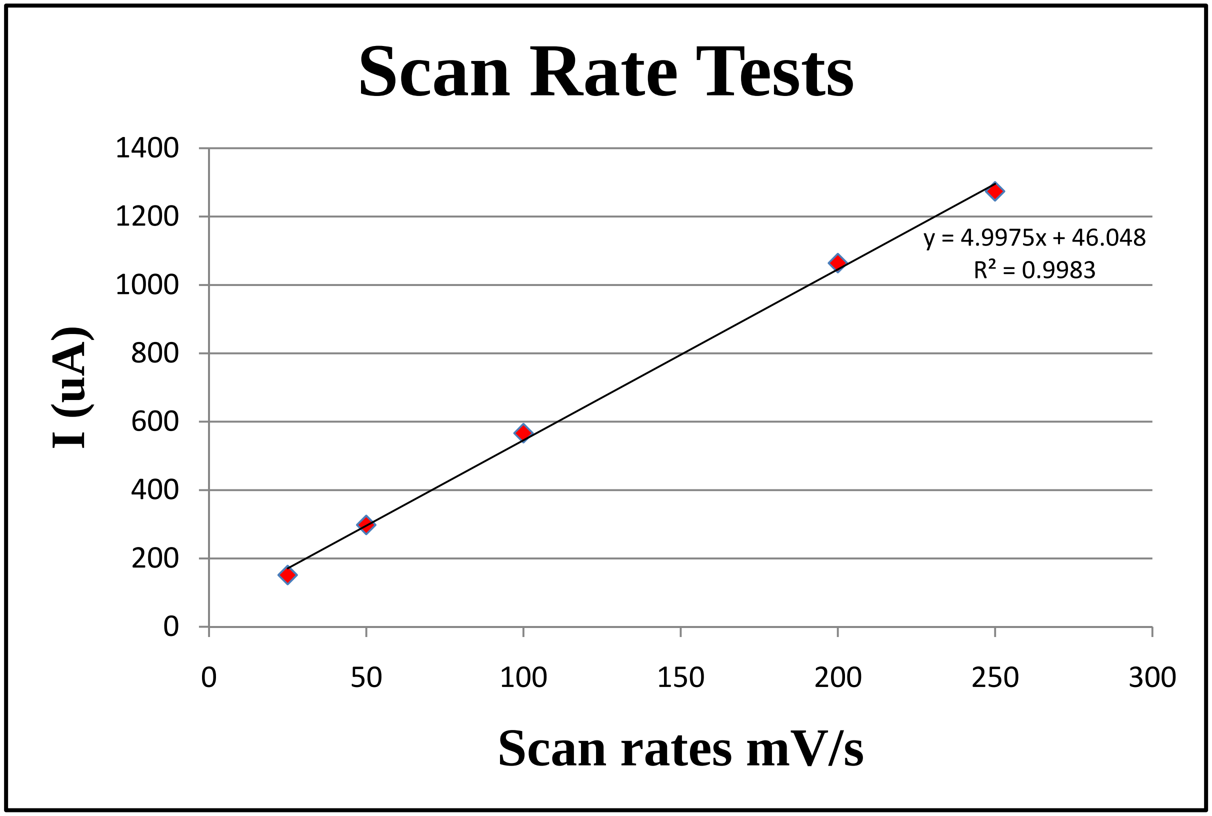
Sweep potentials = -1000 mV - 1000 mV

Solution used: TBAPF6/PC monomer free solution

Columbic efficiency = (cathode/anode x 100)%

Scan Rate Tests





Linear relation evinces a surface-immobilized film

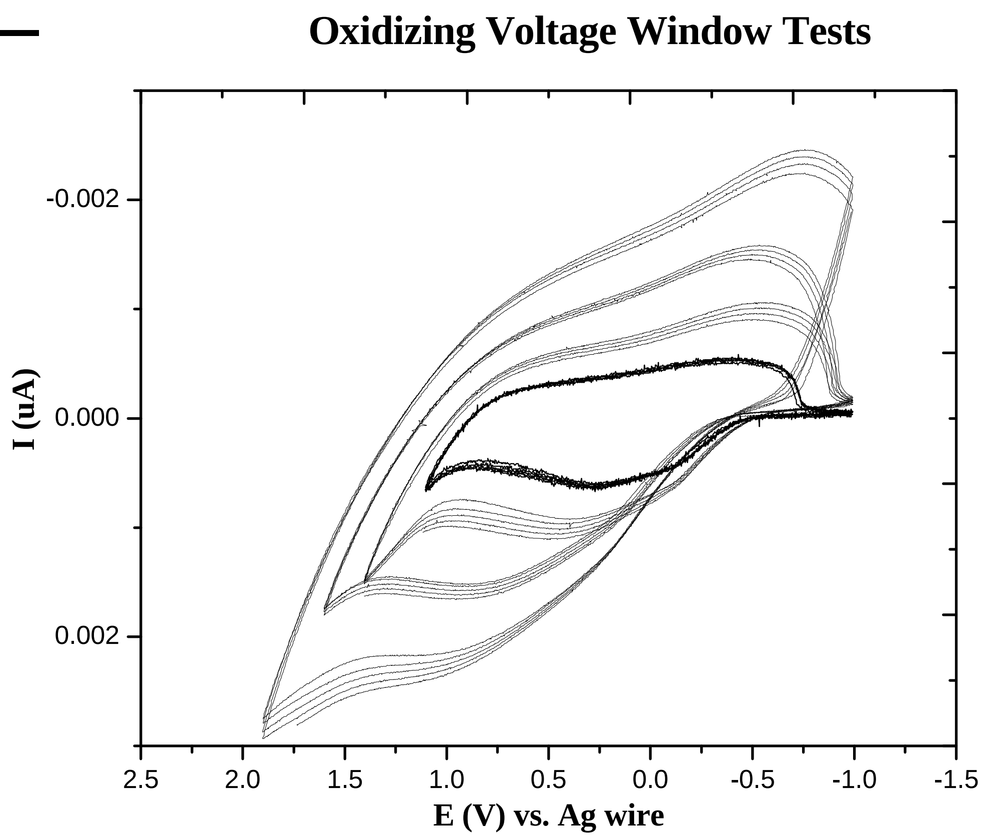
Parameters used

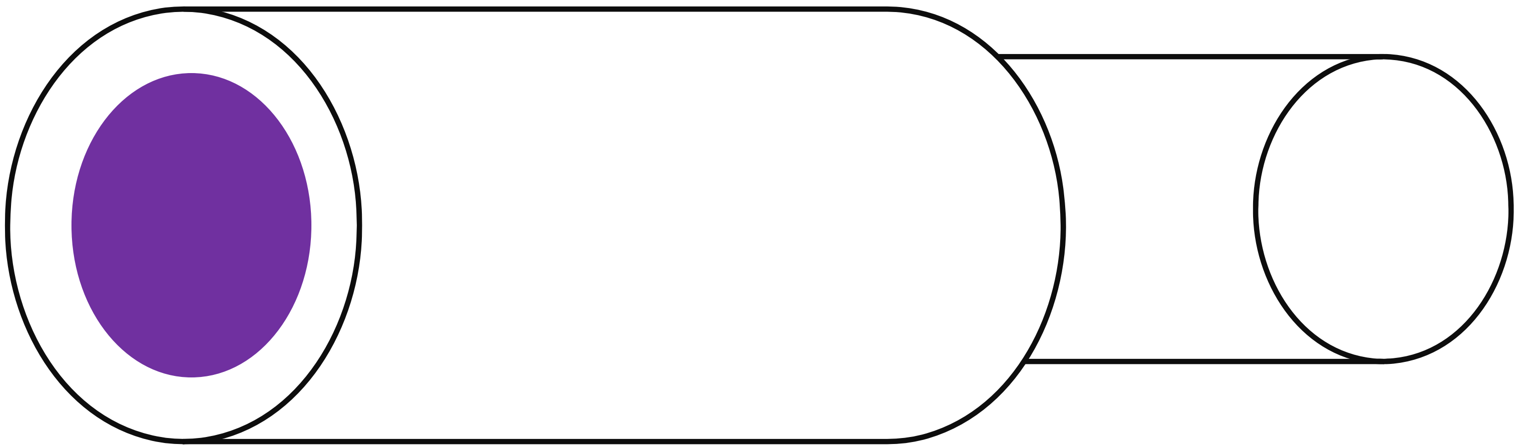
Sweep rate = 100 mV/s

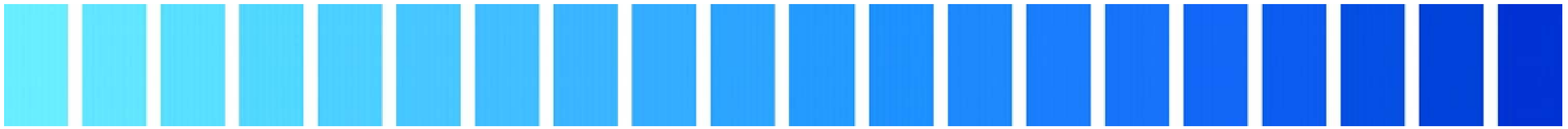
Total sweeps = 9

Sweep Potentials = Various potentials

Solution used: PproDot/TBAPF6/PC







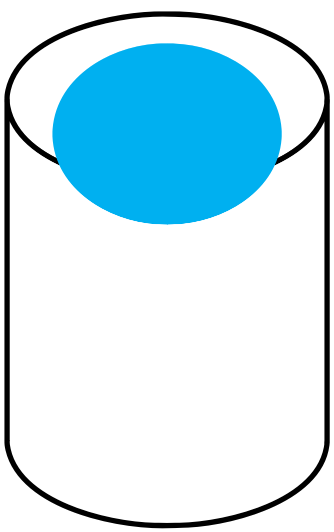
Doping polymer to oxidized state

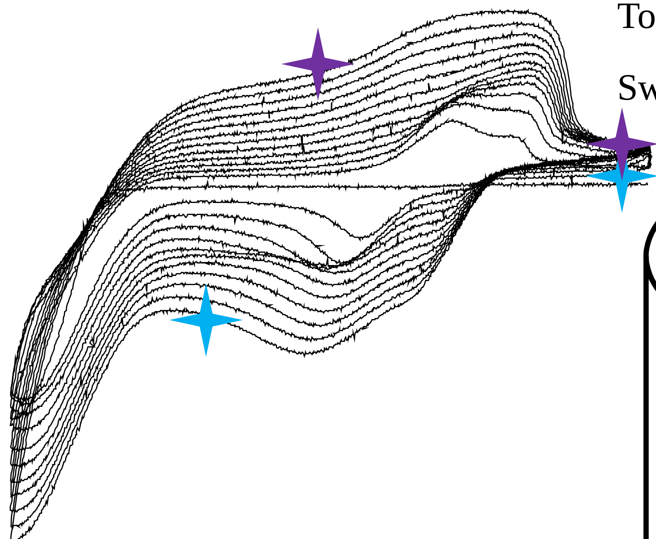
Parameters

Sweep rate = 100 mV/s

Total sweeps = 9

Sweep Potentials = Depends





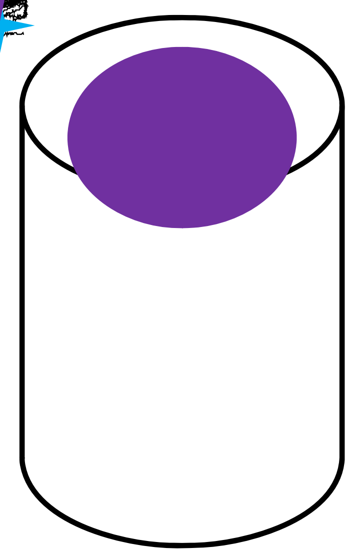
Doping polymer to neutral state

Parameters

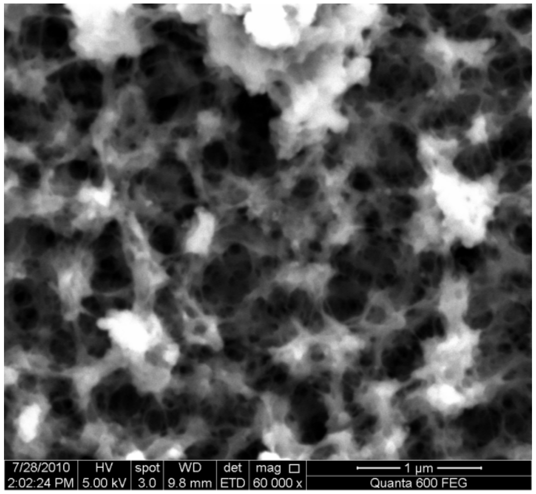
Sweep rate = 100 mV/s

Total sweeps = 9

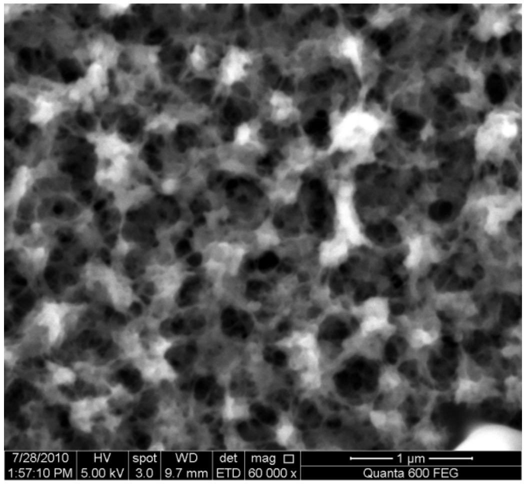
Sweep Potentials = Depends



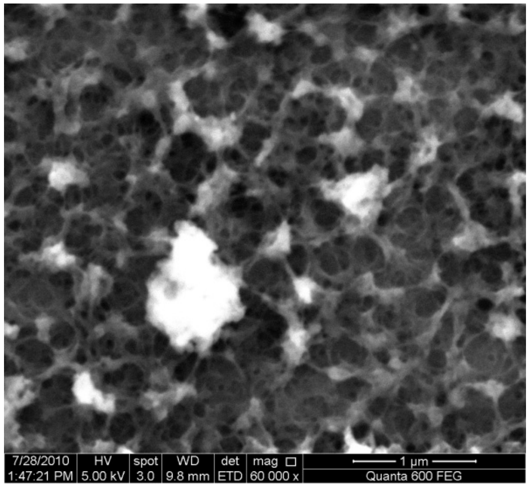
Morphological Characterization of PProDot Films



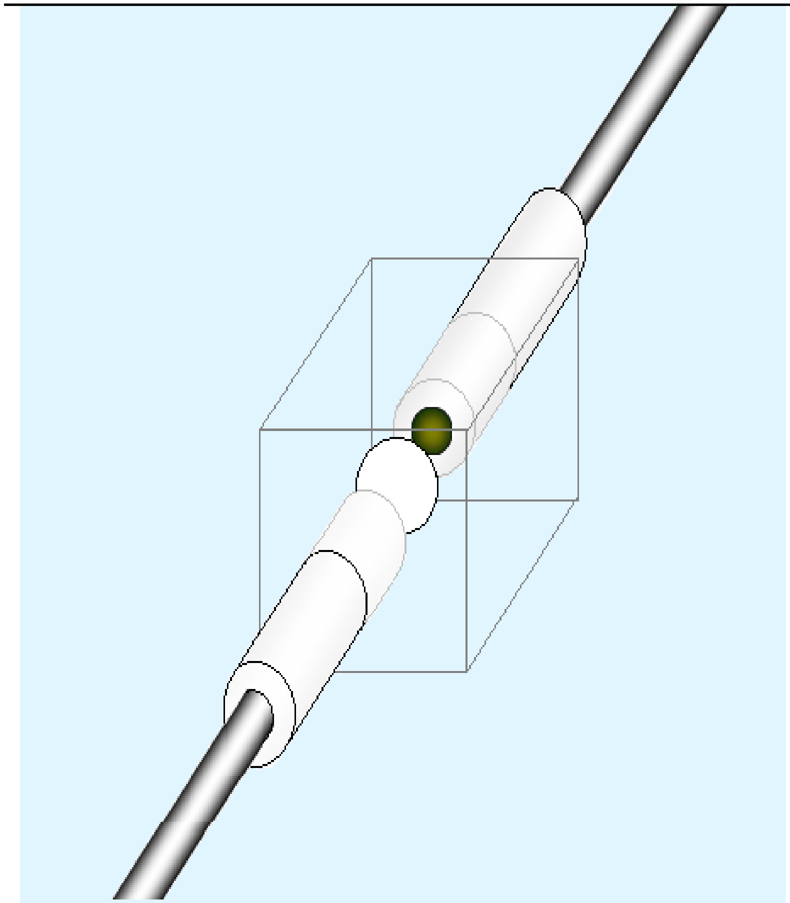
SEM of PProDot Film

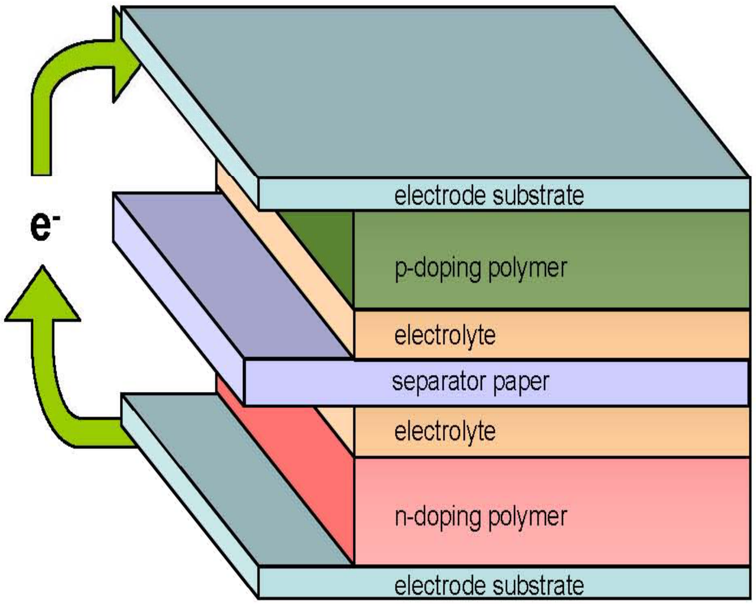


SEM of PProDot Oxidized Film

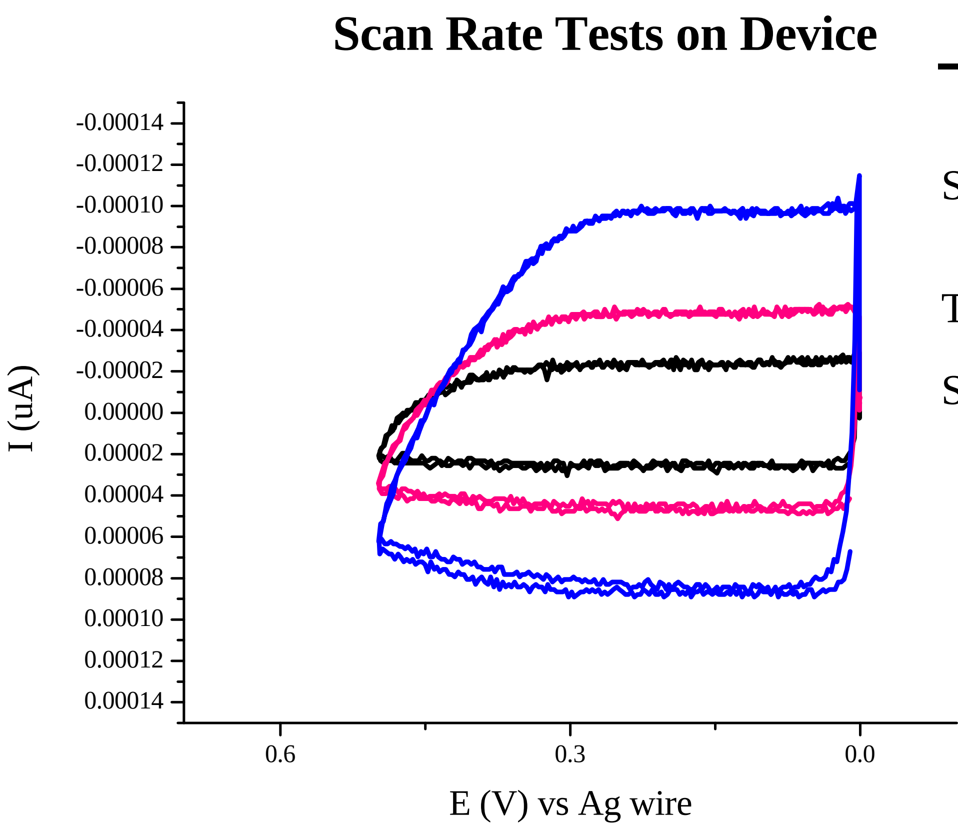


SEM of PProDot Neutral Film





Electrolyte = $TBAPF_6$/PC



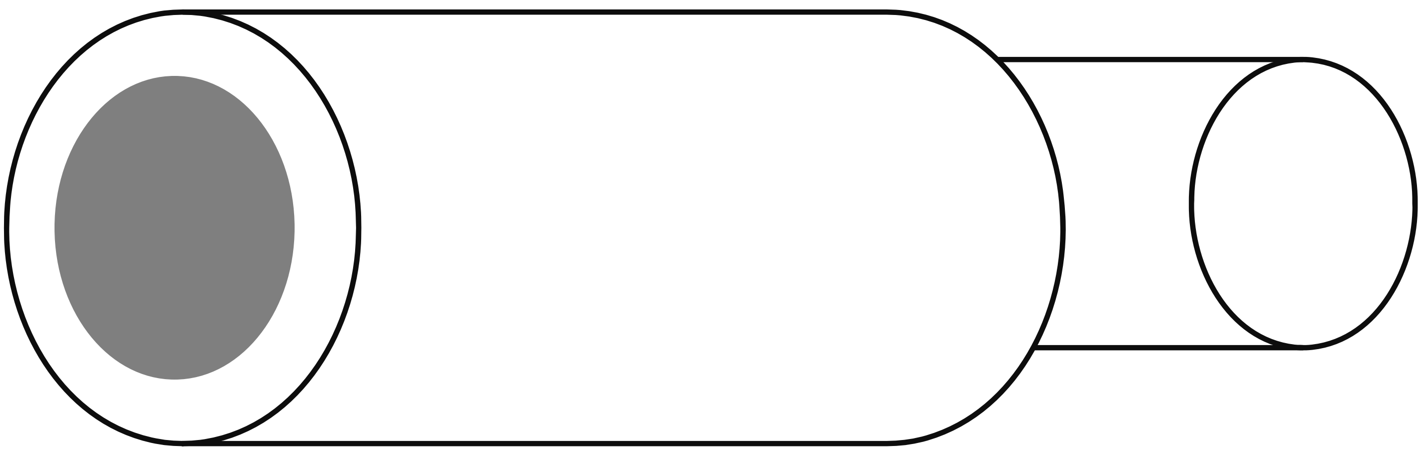
Scan Rate Tests on Device

Parameters used

Sweep rates = 25, 50, 100, 250, 500,1000, 2500, 5000, 10000 mV/s

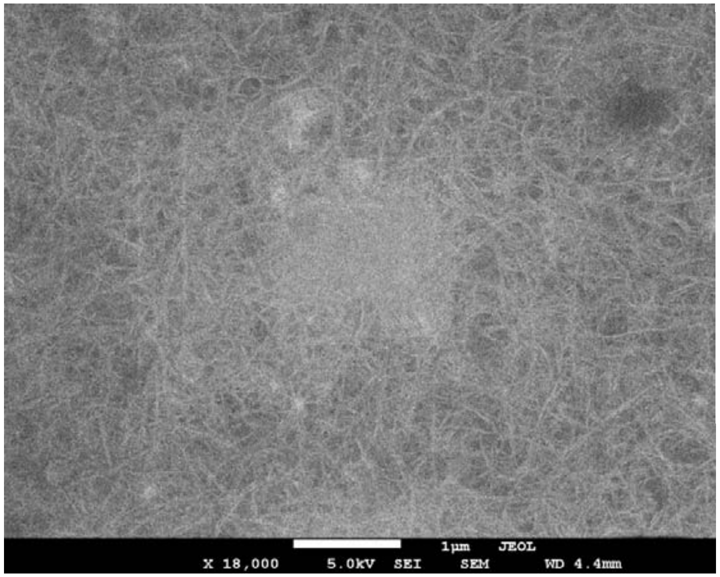
Total sweeps = 6

Sweep potentials = 0 mV - 500 mV

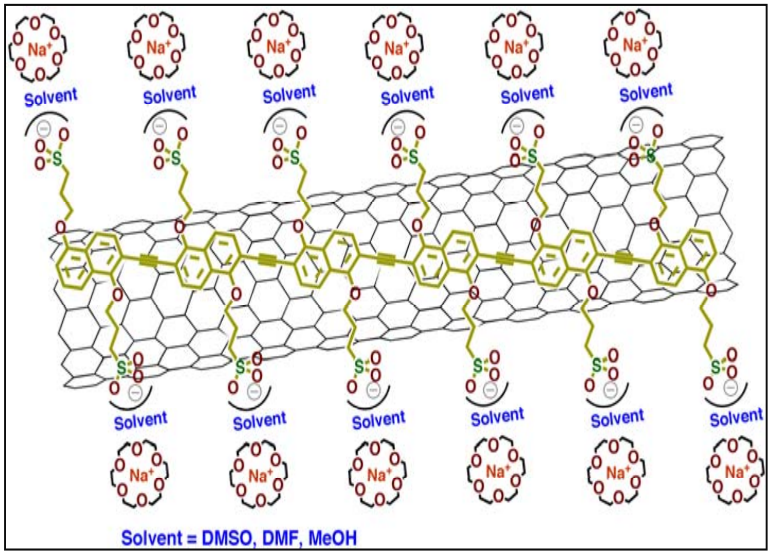


Drop cast 8 μL of PNES/SWNT

Morphological Characterization of PNES/SWNT by SEM



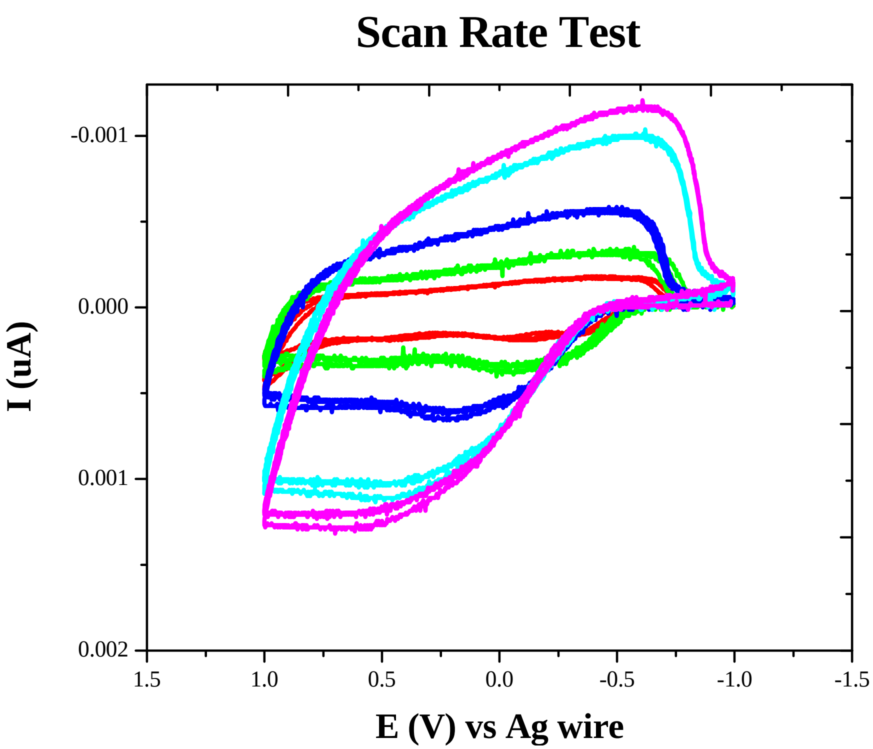
M. Rosario-Canales et al., Manuscript in Preparation

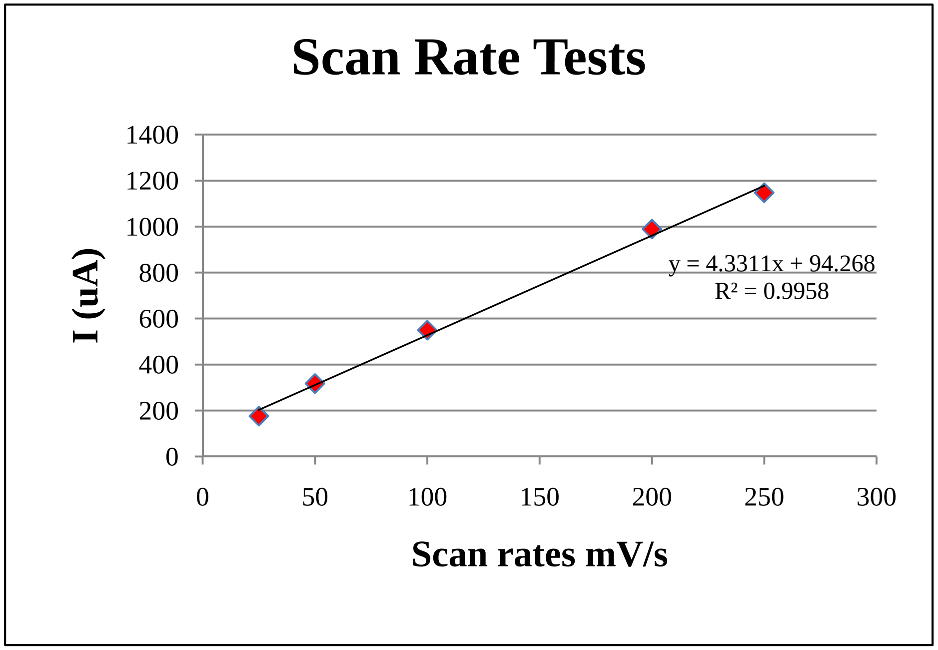


P. Deria et al., Manuscript Submitted to JACS

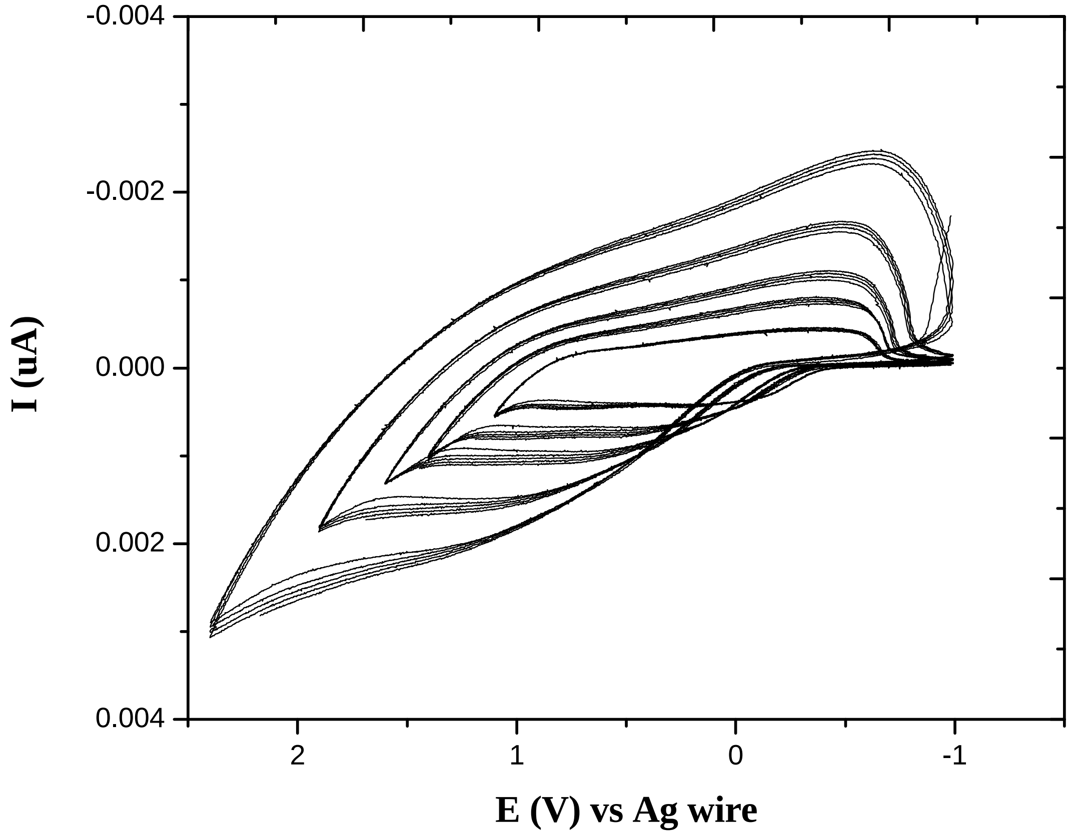
PNES: poly[2,6-{1,5-bis(3-propoxysulfonicacidsodiumsalt)}naphthylene]ethynylene

Single Wall Carbon Nanotubes





Oxidizing Voltage Window Tests



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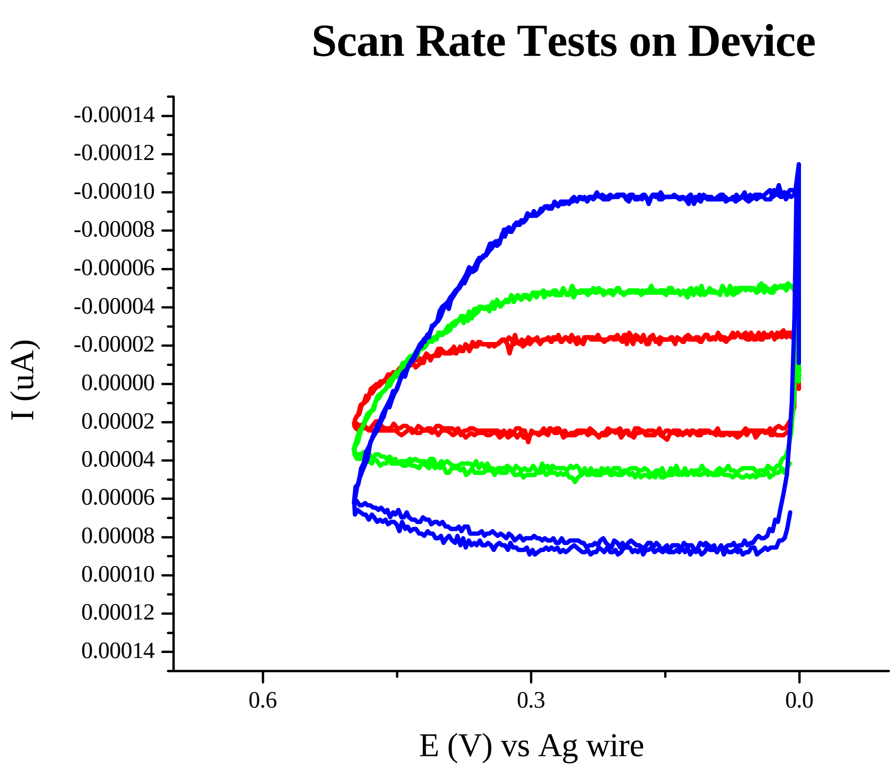
Scan Rate Tests on Device



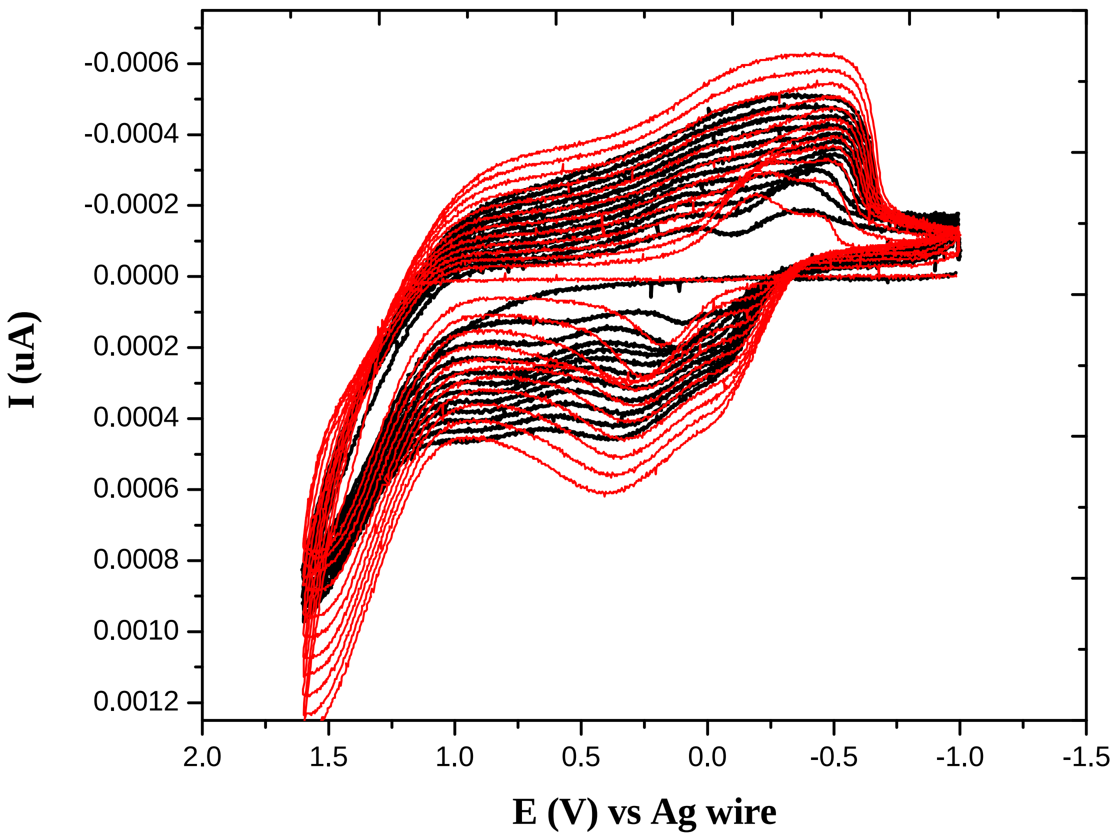
Parameters used

Sweep rates = 25, 50, 100, 250, 500,1000, 2500, 5000, 10000 mV/s

Total sweeps = 6

Sweep potentials = 0 mV - 500 mV

Results



-0.0006
-0.0004
-0.0002
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0.0010
0.0012
I (uA)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
E (V) vs Ag wire

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