Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Capacitive Studies of Electrodeposited PEDOT-maleimide

*Yuhang Wu,[a] Samadhan S. Nagane,[a] Peter Sitarik,[a] Shrirang Chhatre,[a] Junghyun Lee,[a] and David C. Martin[a,b]**

[a] Department of Materials Science and Engineering, University of Delaware, Newark, Delaware 19716, United States

[b] Department of Biomedical Engineering, University of Delaware, Newark, Delaware, 19716, United States.

Corresponding Author

* Email-address: milty@udel.edu (David C. Martin)

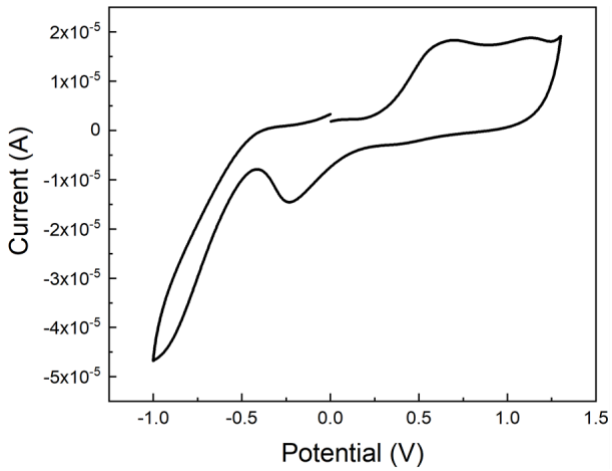

Fig. S1 Staircase CV of monomer free 0.02 M lithium perchlorate acetonitrile solution at 100 mVs^{-1}. The curve is the 5^{th} cycle.

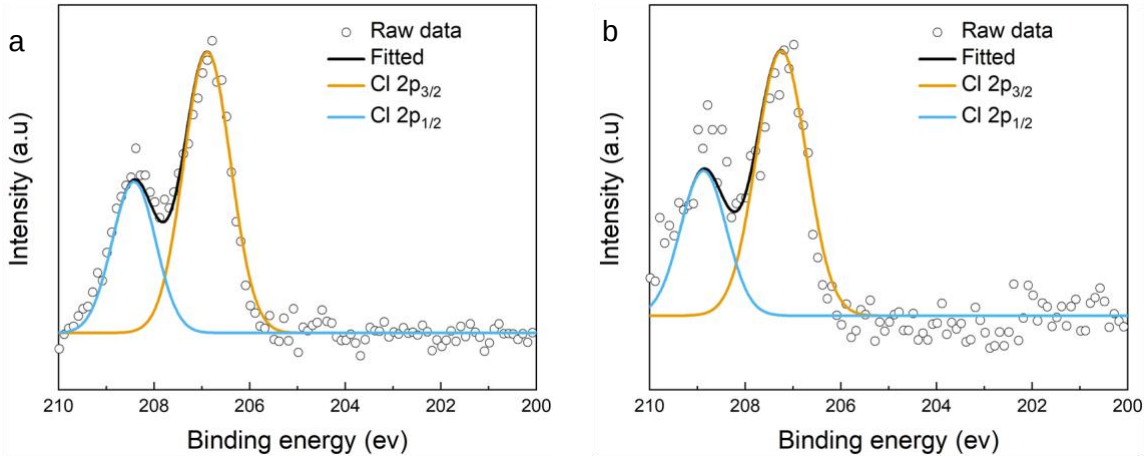

Fig. S2 Cl 2p of (a) PEDOT and (b) PEDOT-maleimide.

Table S1 Deconvoluted chlorine peak positions and doping levels of PEDOT and PEDOT-maleimide

Sample	Cl $2p_{3/2}$ (eV)	Cl $2p_{1/2}$ (eV)	Doping level
PEDOT	206.9	208.4	0.20
PEDOT-maleimide	207.2	208.7	0.16

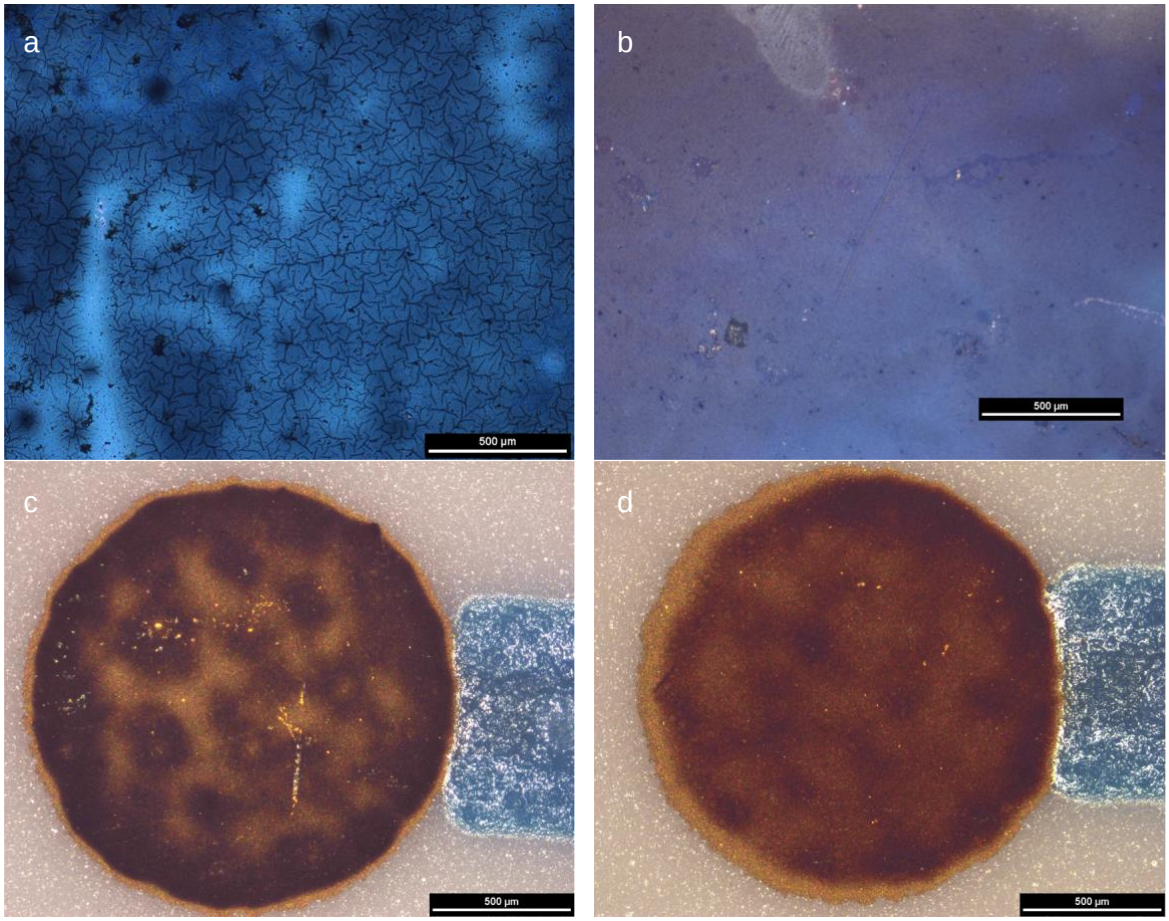

Fig. S3 OM of (a) PEDOT and (b) PEDOT-maleimide ITO samples. OM of (c) PEDOT and (d) PEDOT-maleimide coated working electrodes of C223BT.

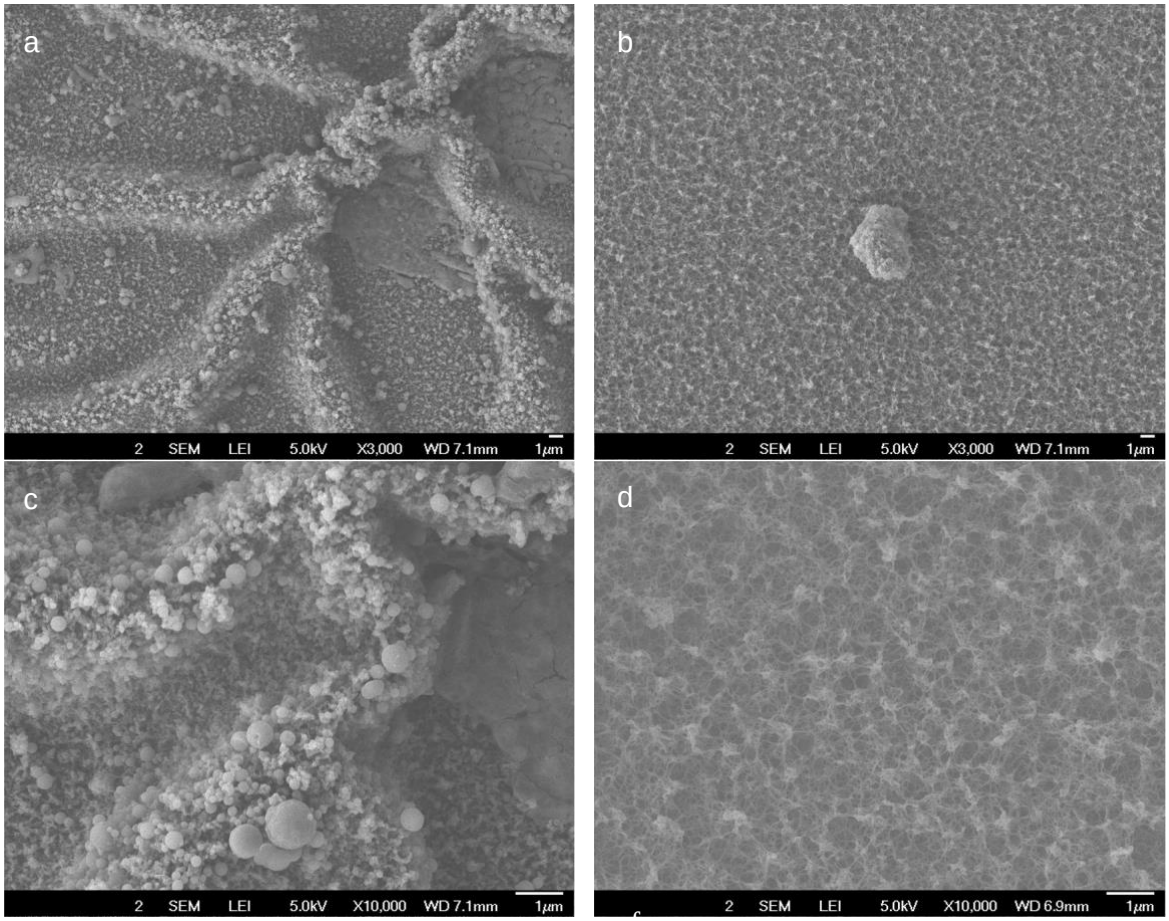

Fig. S4 SEM of PEDOT at (a) low magnification, (c) high magnification and PEDOT-maleimide at (b) low magnification, (d) high magnification.

Table S2 Thickness of PEDOT and PEDOT-maleimide coated ITO samples

Thickness (nm)	PEDOT-1	PEDOT-2	PEDOT-3	PEDOT-maleimide-1	PEDOT-maleimide-2	PEDOT-maleimide-3
Line1	455.6	438.5	486.9	444.2	436.0	447.3
Line2	470.8	410.7	466.1	438.7	437.6	435.1
Line3	431.0	447.6	453.5	458.6	471.4	426.2
Average	451.2			443.9		
Deviation	22.7			13.7		

Table S3 Resistance measured by the Keithley 2400 source meter and the converted sheet resistance

	PEDOT-1	PEDOT-2	PEDOT-3	PEDOT-maleimide-1	PEDOT-maleimide-2	PEDOT-maleimide-3
R_r (Ω)	1.82E3	1.84E3	1.84E3	9.90E3	1.07E4	1.16E4
Sheet resistance (Ω/sq)	6.60E3	6.67E3	6.67E3	3.59E4	3.87E4	4.20E4
Average	6.65E3			3.89E4		
Deviation	4.04E1			3.05E3		

Table S4 Conductivities of PEDOT and PEDOT-maleimide coated ITO samples

Conductivity (Scm^{-1})	PEDOT-1	PEDOT-2	PEDOT-3	PEDOT-maleimide-1	PEDOT-maleimide-2	PEDOT-maleimide-3
Line1	3.33	3.42	3.08	0.63	0.59	0.53
Line2	3.22	3.65	3.22	0.63	0.59	0.55
Line3	3.52	3.35	3.31	0.61	0.55	0.56
Average	3.34			0.58		
Deviation	0.17			0.04		

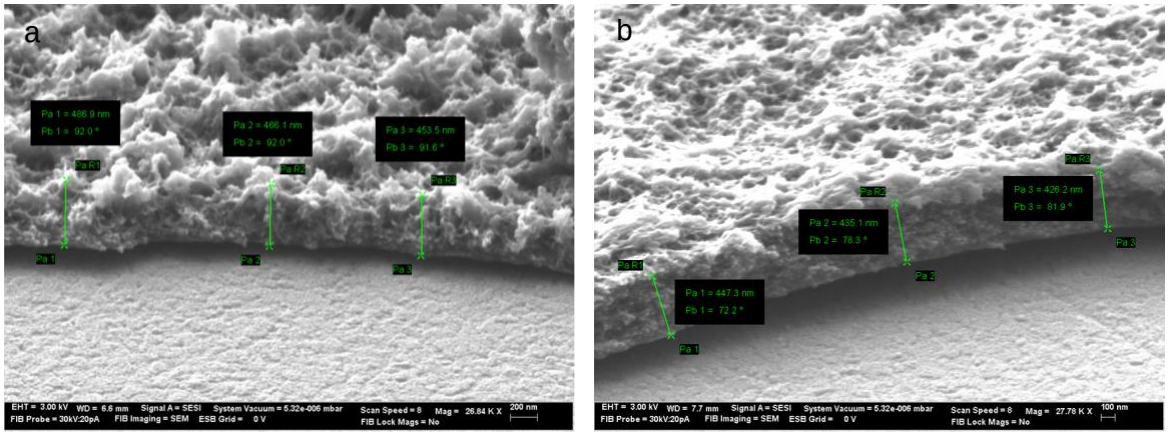

Fig. S5 Representative Cross-section images of (a) PEDOT and (b) PEDOT-maleimide.

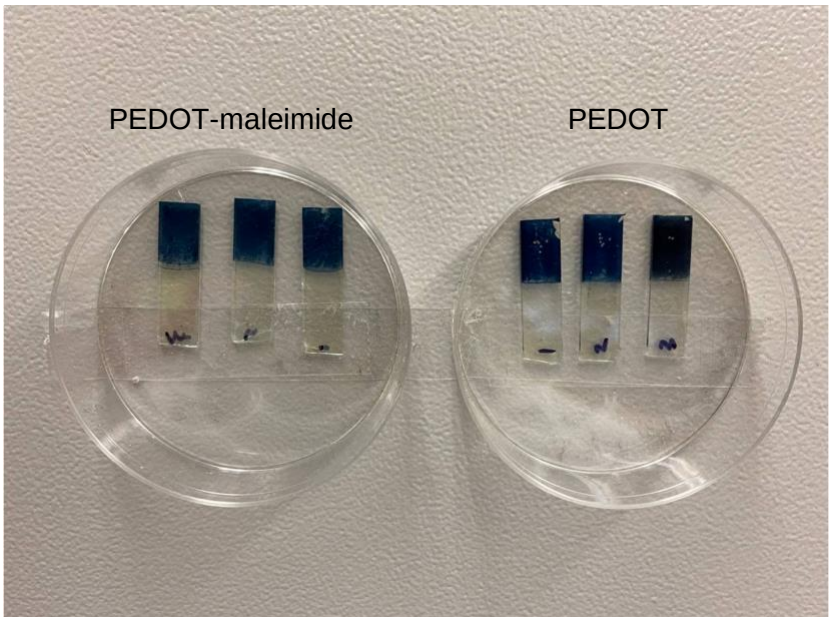

Fig. S6 PEDOT and PEDOT-maleimide coated ITO samples after characterized by four-point probe.

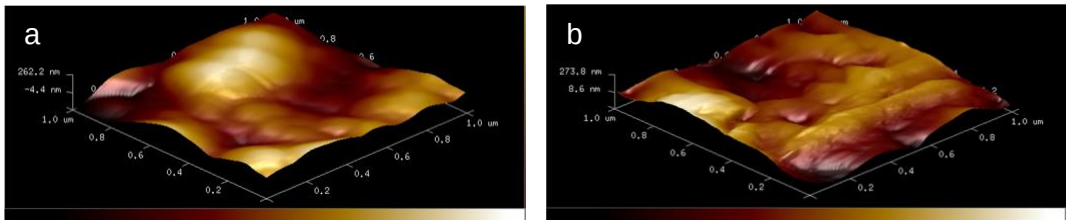

Fig. S7 Topographies of 1×1 μm mapping areas for nanoindentation. (a) PEDOT and (b) PEDOT-maleimide.

Table S5. Results of Z-test: Two samples for means

Sample	PEDOT	PEDOT-maleimide
Mean	1.75	4.54
Known Variance	1.17	8.73
Observations	2154	1813
Hypothesized Mean Difference	0	
z	-38.10	
P(Z≤z) one-tail	0.00	
z Critical one-tail	1.64	
P(Z≤z) two-tail	0.00	
z Critical two-tail	1.96	

Table S6. Results of F-test: Two samples for variances

Sample	PEDOT	PEDOT-maleimide
Mean	1.75	4.54
Variance	1.17	8.73
Observations	2154	1813
df	2153	1812
F	0.13	
P(F≤f) one-tail	0.00	
F Critical one-tail	0.93	

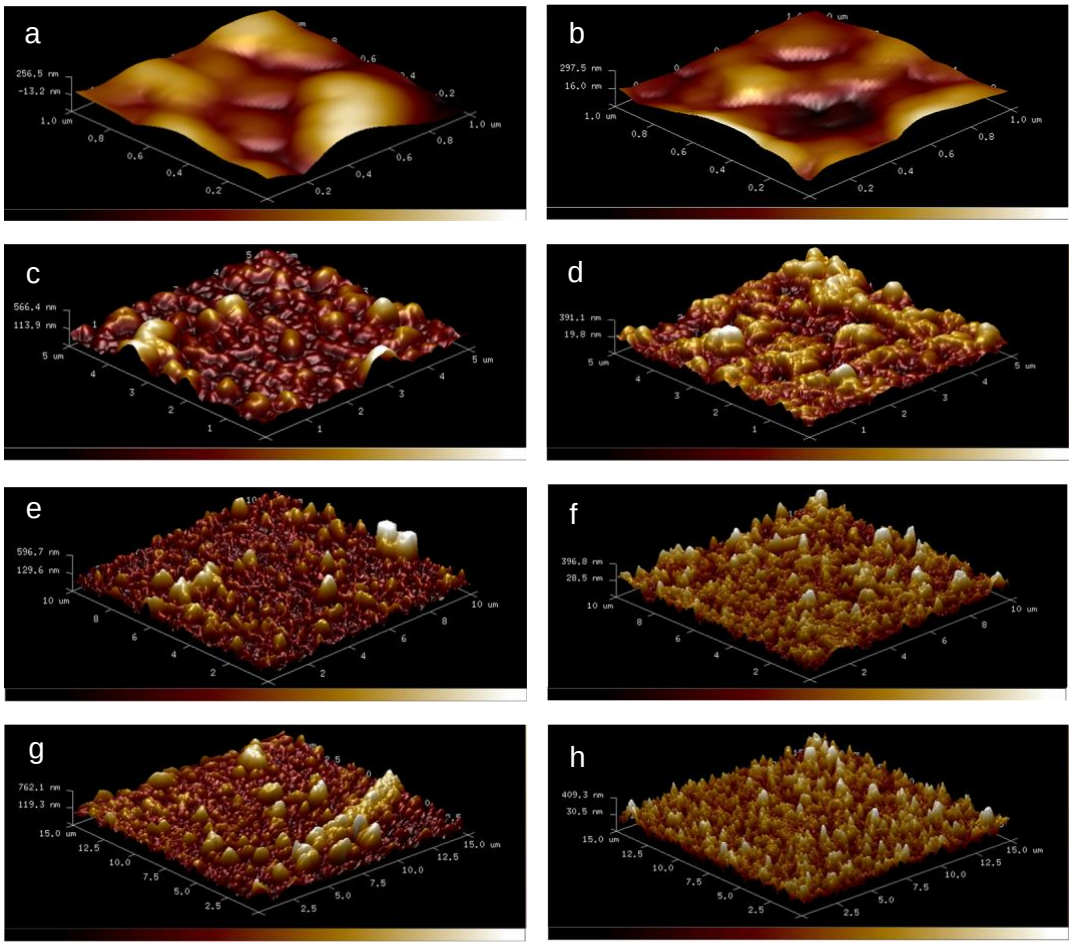

Fig. S8 Topographies of PEDOT over (a) 1×1, (c) 5×5, (e)10×10, and (g) 15×15 μm^2 areas as well as PEDOT-maleimide over (b) 1×1, (d) 5×5, (f)10×10, and (h) 15×15 μm^2 areas.

Table S7. Effective surface areas of PEDOT and PEDOT-maleimide at different probed length scales

Sample	1×1 μm²		5×5 μm²		10×10 μm²		15×15 μm²	
	Mean (μm²)	Deviation (μm²)	Mean (μm²)	Deviation (μm²)	Mean (μm²)	Deviation (μm²)	Mean (μm²)	Deviation (μm²)
PEDOT	1.30	0.10	33.33	1.70	137.00	6.24	322.67	6.81
PEDOT-maleimide	1.39	0.05	33.78	2.04	143.33	14.57	345.33	17.21

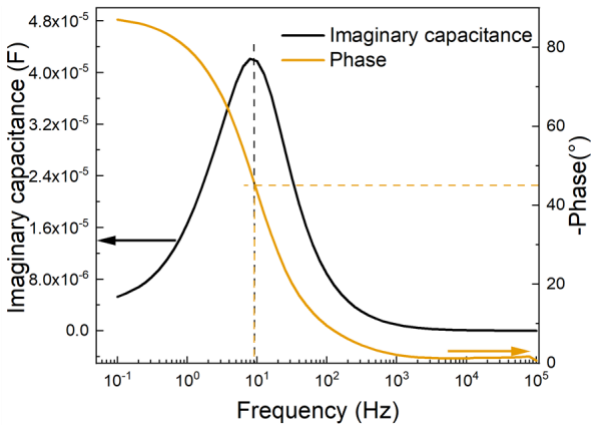

Fig. S9 Evolution of imaginary capacitance and phase angle of PEDOT.

Table S8. Extracted relaxation time constants from PEDOT and PEDOT-maleimide samples from imaginary capacitance and phase curves built against the frequency

Strategy	Sample 1 (ms)	Sample 2 (ms)	Sample 3 (ms)	Average (ms)	Standard deviation (ms)
PEDOT phase	108.1	108.1	108.1	108.1	0.0
PEDOT-maleimide Phase	90.0	106.3	74.9	90.4	15.7
PEDOT imaginary capacitance	118.6	118.6	130.2	122.5	6.7
sPEDOT-maleimide imaginary capacitance	93.3	104.2	79.0	92.2	12.6