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Supporting Information

# Transparent Wood Smart Windows: Polymer Electrochromic Devices Based on Poly(3,4-Ethylenedioxythiophene):Poly(Styrene Sulfonate) Electrodes

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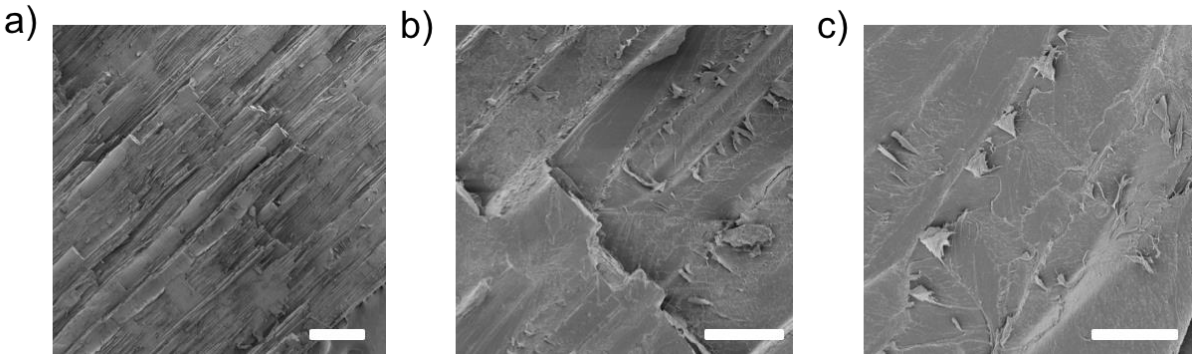


**Figure S1**. Scanning electron micrographs of the fracture surface of birch transparent wood at various magnifications. Scale bar is (a) 500 µm, (b) 20 µm, and (c) 15 µm.

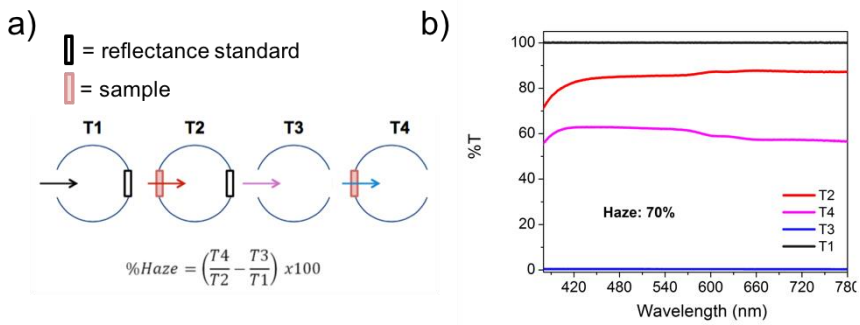


**Figure S2.** (a) Schematic illustrating sample configuration in an integrating sphere for calculating haze. The arrow indicates the light source. (b) Example of the four spectra taken from 380 to 780 nm for calculating birch transparent wood haze per ASTM D1003 (thickness = 0.6 mm).

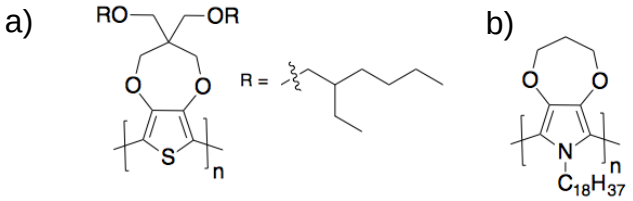


**Figure S3.** (a) ECP-Magenta structure. (b) Minimally color changing counter electrode polymer (MCCP) structure.

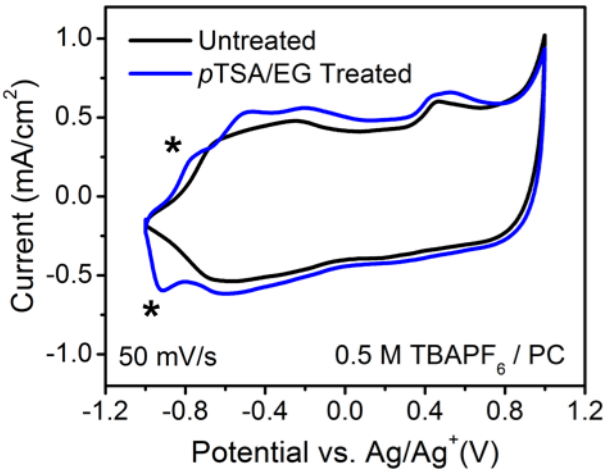


**Figure S4.** Cyclic voltammogram of acid treated and untreated PEDOT:PSS (1.6 µm thickness) on glassy carbon electrodes in 0.5 M $TBAPF_6$ / propylene carbonate at 50 mV/s. Peaks denoted with the asterisk correspond to a new redox couple apparent after the *p*TSA/EG treatment.

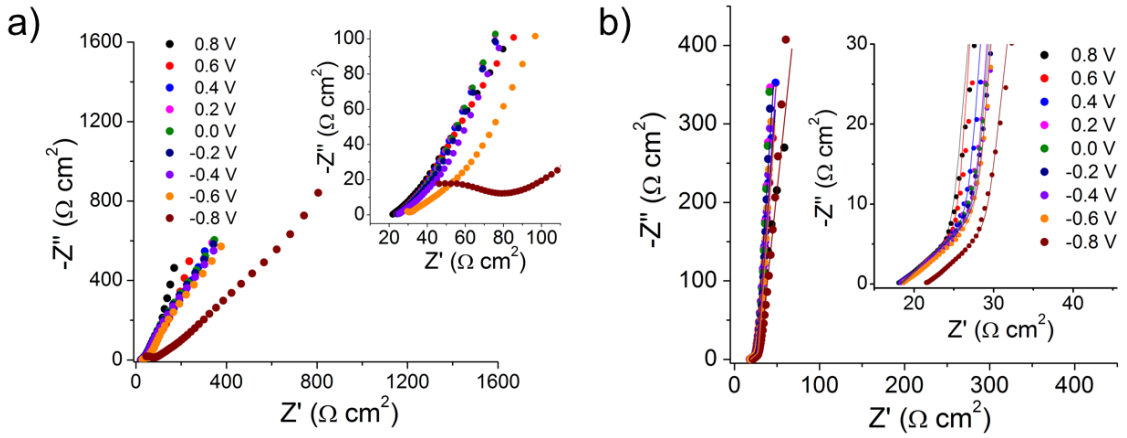


**Figure S5.** (a) Nyquist plot of *p*TSA/EG treated PEDOT:PSS on glassy carbon current collectors (thickness = 0.8 µm) at potentials from 0.8 V to -0.8 V vs. $Ag/Ag^+$. Nyquist plot of untreated PEDOT:PSS from 0.8 to -0.8V.

**Table S1**. EIS Fitted values for *p*TSA/EG Treated PEDOT:PSS electrodes. Film thickness is roughly 590 nm.

| Potential (V) | $R_s$ (Ohm) | $C_D$ (mF) | $\tau$ (s) | $\propto$ | $C_d$ (mF) | $p$ | $C_{tot}$ (mF) |
|---|---|---|---|---|---|---|---|
| 0.8 | 260 | 0.32 | 0.086 | 0.48 | 3.7 | 0.85 | 0.29 |
| 0.6 | 261 | 0.32 | 0.095 | 0.48 | 3.0 | 0.95 | 0.29 |
| 0.4 | 260 | 0.32 | 0.110 | 0.48 | 2.9 | 1 | 0.29 |
| 0.2 | 261 | 0.34 | 0.130 | 0.48 | 2.1 | 1 | 0.29 |
| 0 | 261 | 0.34 | 0.130 | 0.48 | 2.5 | 1 | 0.30 |
| -0.2 | 262 | 0.35 | 0.140 | 0.48 | 3.1 | 1 | 0.31 |
| -0.4 | 264 | 0.39 | 0.150 | 0.48 | 3.0* | 1 | 0.35 |
| -0.6 | 270 | 0.38 | 0.140 | 0.48 | 3.0* | 1 | 0.34 |
| -0.8 | 310 | 0.28 | 0.087 | 0.47 | 1.5 | 0.95 | 0.24 |

*Values fixed to allow the fitting calculation to converge

**Table S2.** Sheet resistance and corresponding conductivity of treated PEDOT:PSS films with various post-treatment conditions on glass substrates.

| Treatment | $R_s$ (Ω/sq) | Conductivity (S/cm) |
|---|---|---|
| Untreated | 50,000 | 1 |
| 1M *p*TSA / $H_2O$ | 170 ± 30 | 400 ± 100 |
| Ethylene Glycol (EG) | 80 ± 10 | 980 ± 60 |
| 1M *p*TSA / EG | 58 ± 5 | 1200 ± 100 |

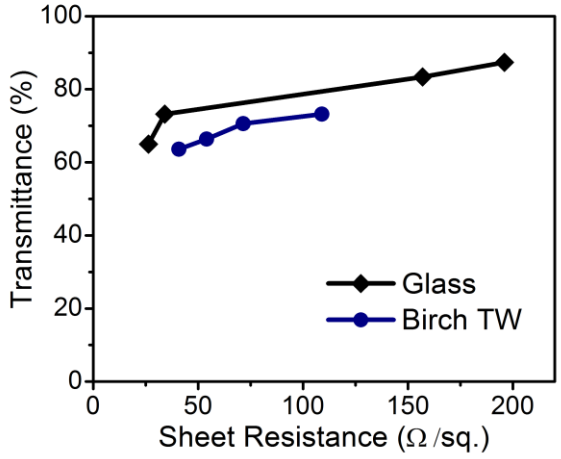


**Figure S6.** Treated PEDOT:PSS electrode transmittance at 550 nm versus sheet resistance for film coatings on glass and transparent wood.

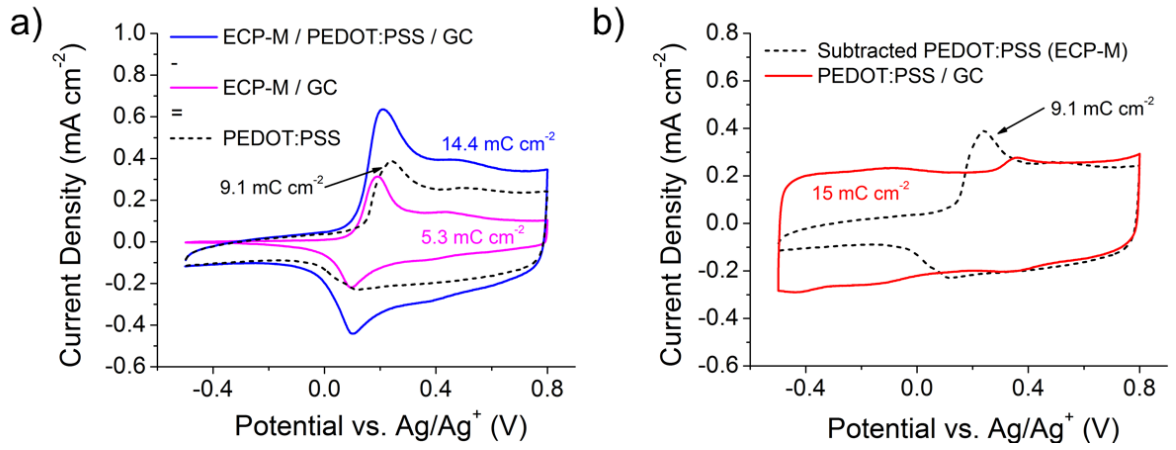


**Figure S7.** (a) Cyclic voltammograms showing the redox response of ECP-Magenta on glassy carbon and PEDOT:PSS / glassy carbon electrodes at 20 mV $s^{-1}$ (0.5 M $TBAPF_6$ / PC) . The dotted line corresponds to the current arising from the redox active PEDOT:PSS electrode. (b) Cyclic voltammograms of the subtracted current from the PEDOT:PSS / glassy carbon electrode and a PEDOT:PSS film on glassy carbon at 20 mV $s^{-1}$.

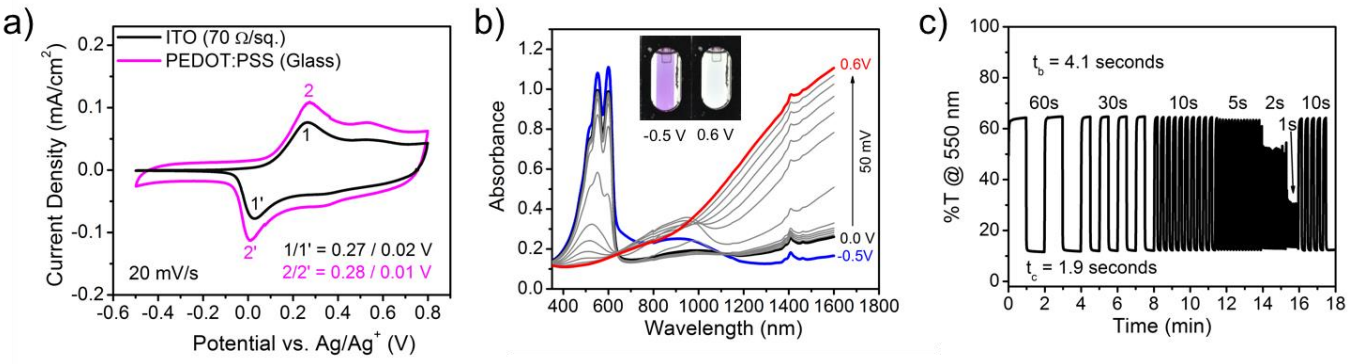


**Figure S8** (a) Cyclic voltammograms of ECP-Magenta films on PEDOT:PSS/glass and ITO/glass electrodes measured at 20 mV/s. (b) Stepwise spectral change upon electrochemical oxidation of ECP-Magenta films from -0.5 V to 0.6V on PEDOT:PSS/glass electrodes. Inset photographs show the ECP-Magenta film in its neutral (-0.5 V) and oxidized (0.6 V) state. (c) Film switching kinetics for potential square wave pulse times ranging from 60 seconds down to 1 second. Bleaching time ($t_b$) and coloring time ($t_c$) to reach 95% of full contrast are labeled.

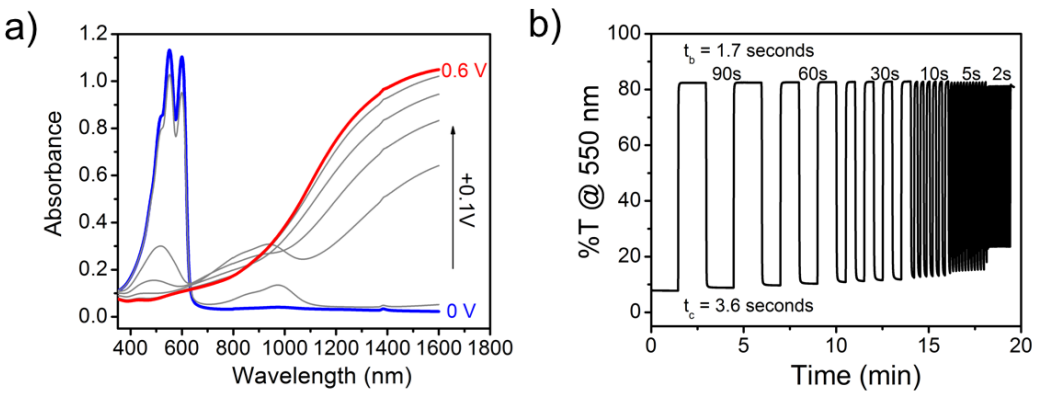


**Figure S9.** (a) Stepwise spectral change of ECP-Magenta on ITO (70 Ω $sq^{-1}$) substrates from -0.5 to 0.6 V vs. $Ag/Ag^+$ at 100 mV increments (b) ECP-Magenta film switching kinetics measured at potential pulses from -0.5 to 0.6V vs. $Ag/Ag^+$ of various lengths. Switching times are labed as $t_b$ and $t_c$ for bleaching and coloring respectively.

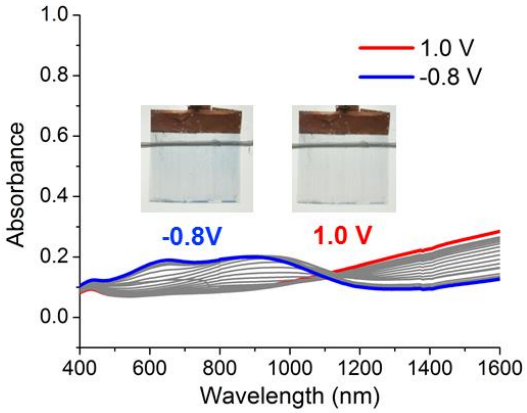


**Figure S10** Absorbance change with potential of the transparent wood electrode showing contribution of PEDOT:PSS electrochromism over a wide potential range of -0.8 V to 1.0 V (0.1 V increments). Inset photos show PEDOT:PSS coated transparent wood electrodes held at the extreme potentials.

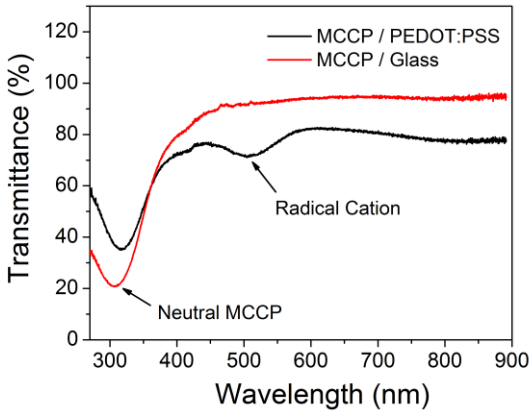


**Figure S11.** UV-Vis spectra of dried MCCP sprayed on glass vs. dried MCCP sprayed on *p*TSA/EG treated PEDOT:PSS in the absence of electrolyte the neutral and radical cation peaks for the polymer are labeled.

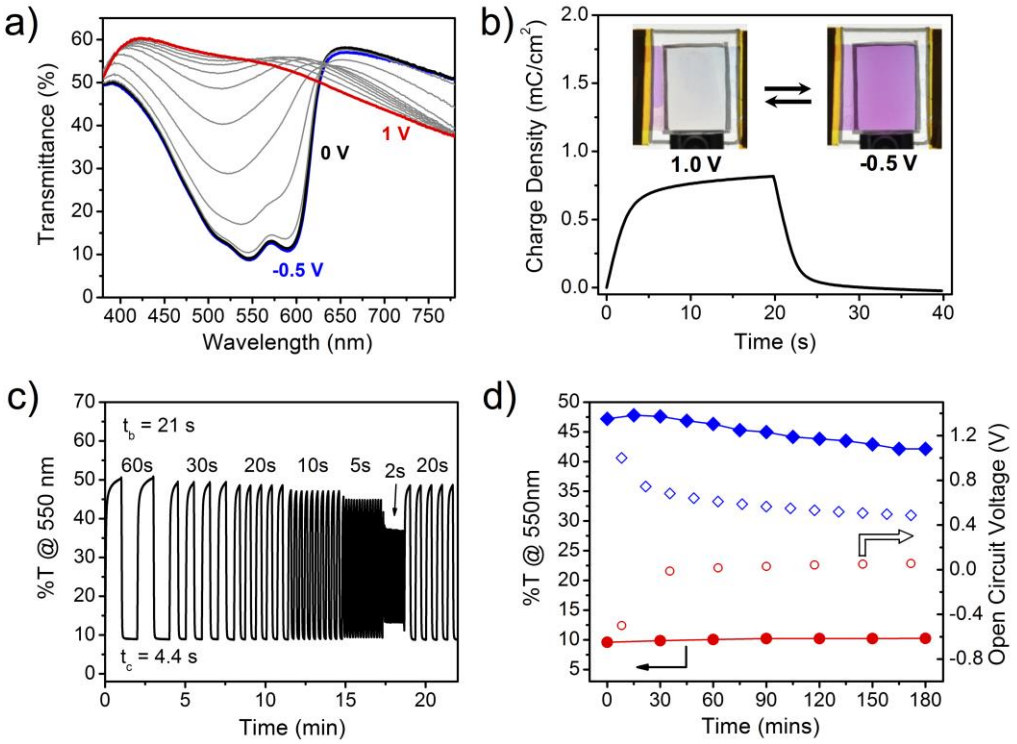


**Figure S12.** (a) Stepwise spectral change of Magenta ECD using PEDOT:PSS/glass electrodes upon oxidation from -0.5 V to 1.0 V. (b) Device charge density versus time for 20 second potential square-wave pulses. Photographs of the device in its bleached (1.0 V) and colored (-0.5 V) states. (c) Device transmittance at 550 nm for potential square wave pulses of 60 seconds down to 2 seconds. Coloration and beaching times ($t_c$ and $t_b$) are inset. (d) Optical memory for 3 $cm^2$ device constructed in inert atmosphere showing the evolution of transmittance (filled points) and open circuit voltage (open points) in both the colored and bleached state.

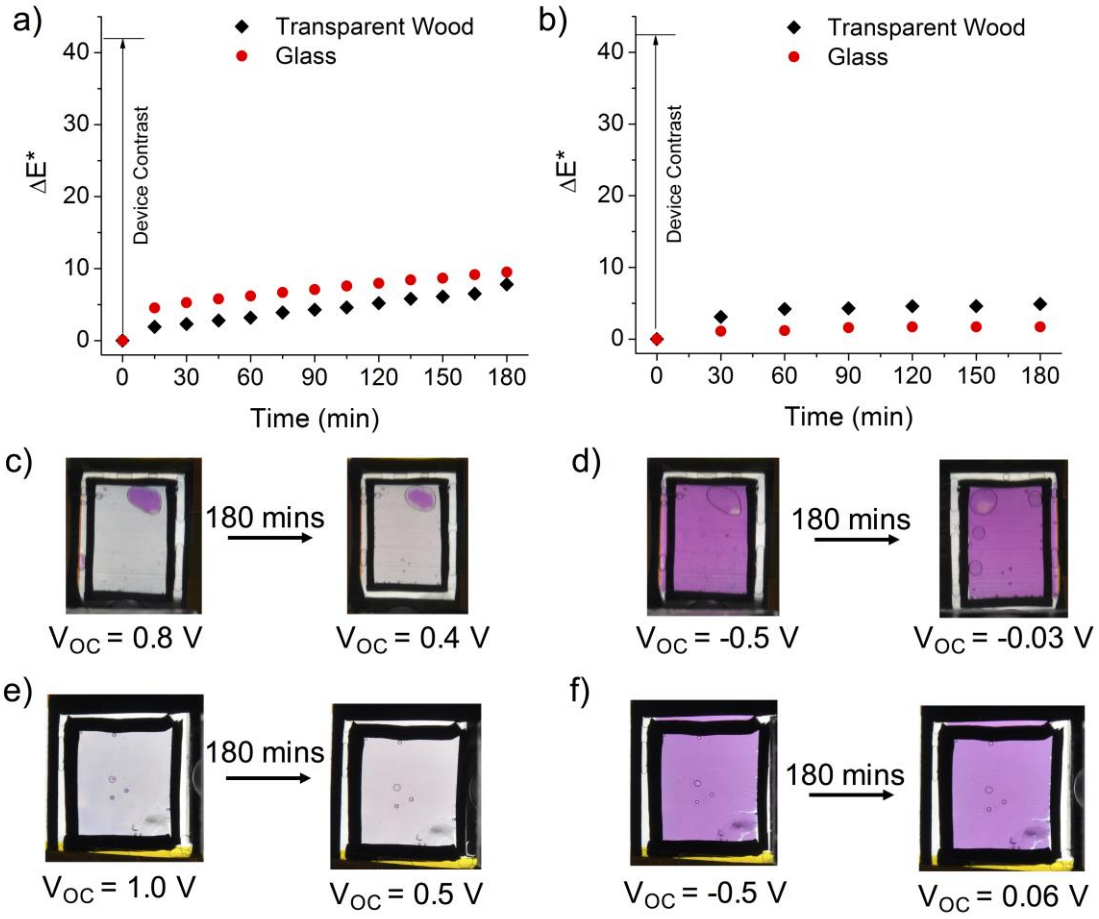


**Figure S13.** Color change versus time for a TW-ECD and a glass-based ECD set in the colorless state (a) and colored state (b) and held at open circuit for 3 hours. Photographs of TW-ECD in its bleached state (c) and colored state (d) before and after the 3-hour hold at open circuit. Photographs of glass-based ECD in its bleached state (e) and colored state (f) before and after the 3-hour hold at open circuit. Corresponding open circuit voltages are labeled for each image.