Supplement Information

Electrochromic devices based on viologen derivatives with multiple color changes

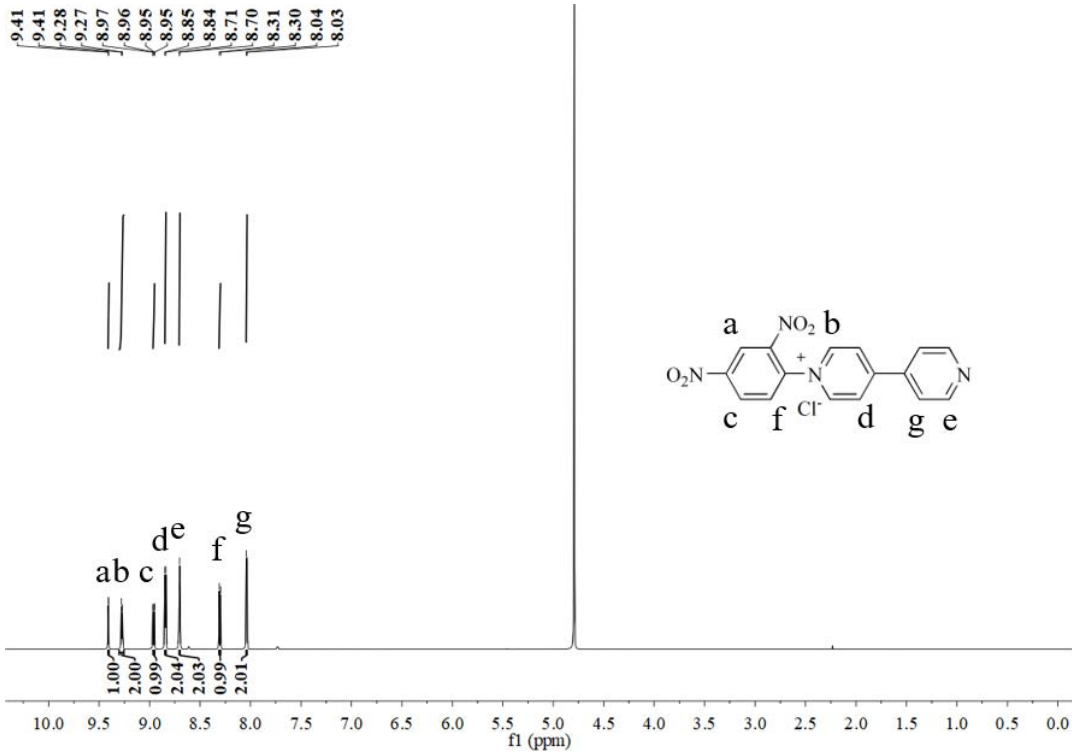

Figure S1: ^{1}H NMR spectrum of compound 1.

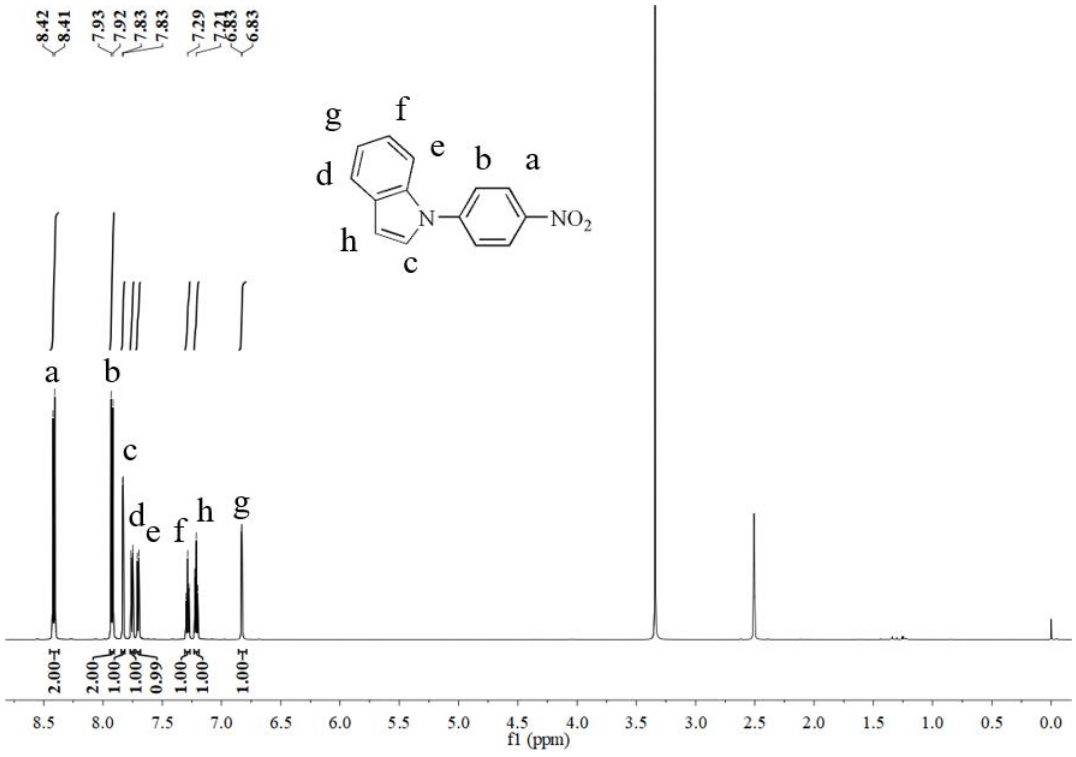

Figure S2 ^{1}H NMR spectrum of compound 2.

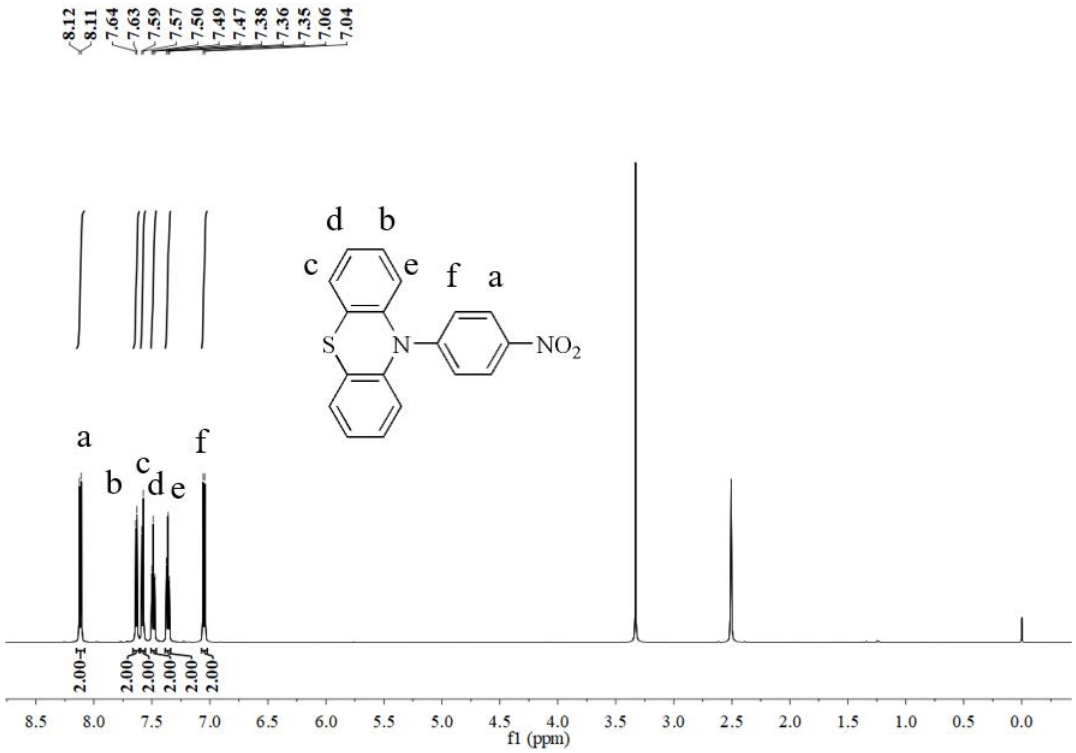

Figure S3: [1]H NMR spectrum of compound 3.

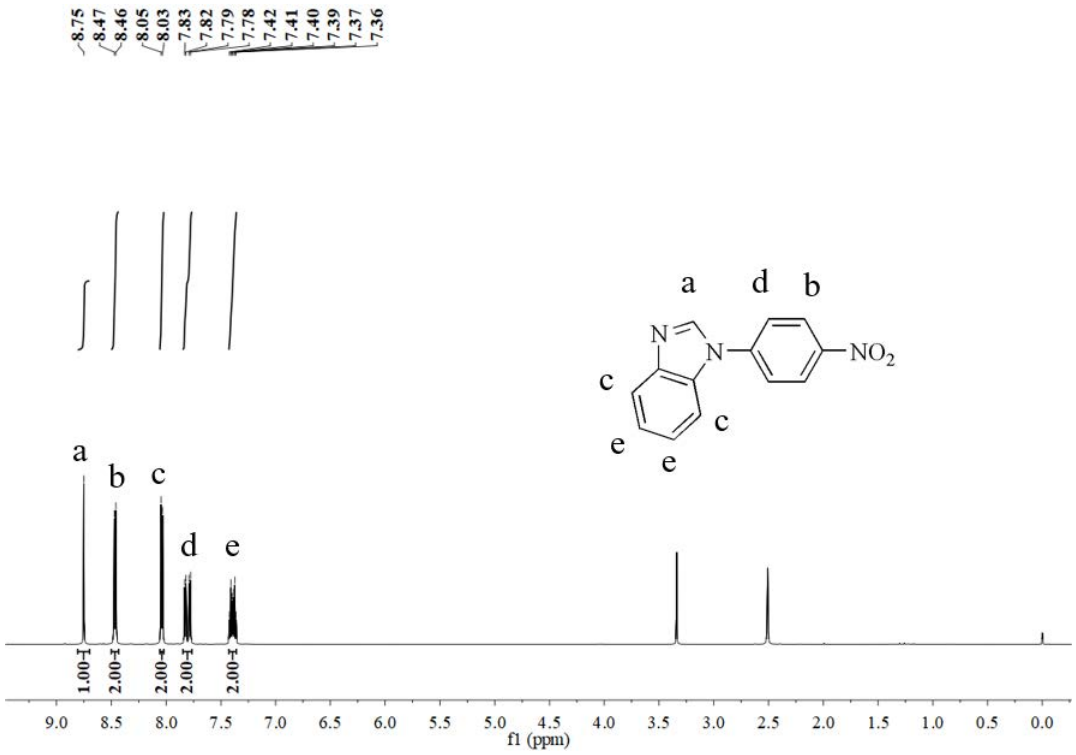

Figure S4: 1H NMR spectrum of compound 4.

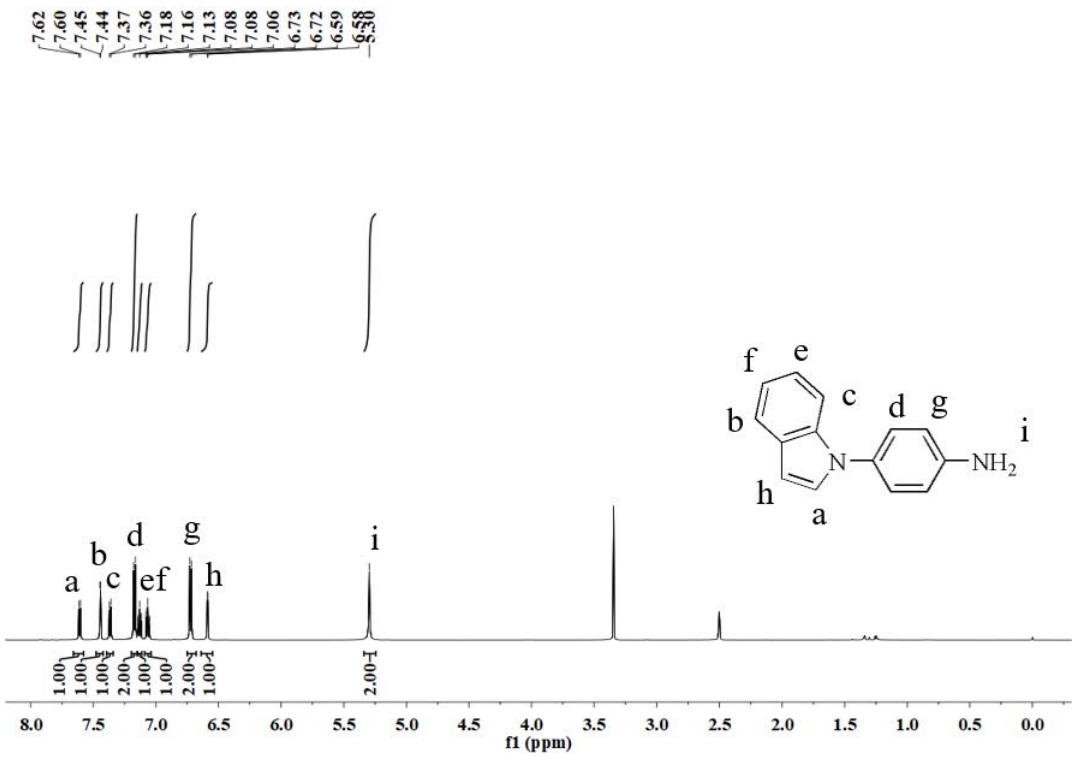

Figure S5: [1]H NMR spectrum of compound 5.

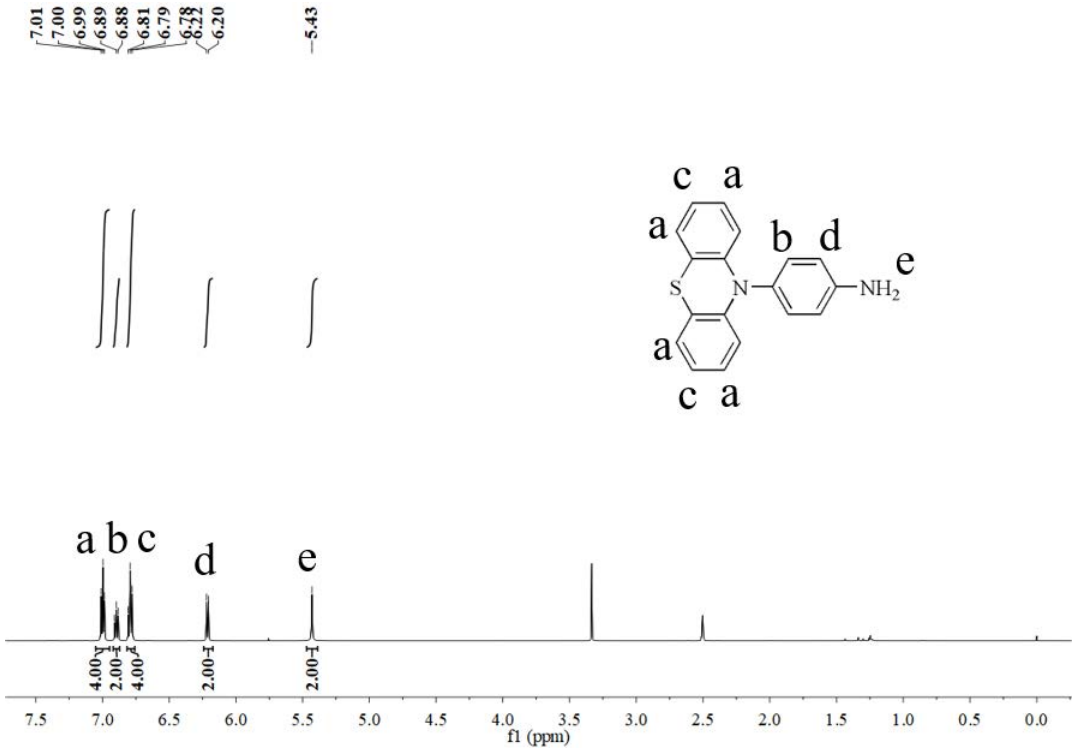

Figure S6: [1]H NMR spectrum of compound 6.

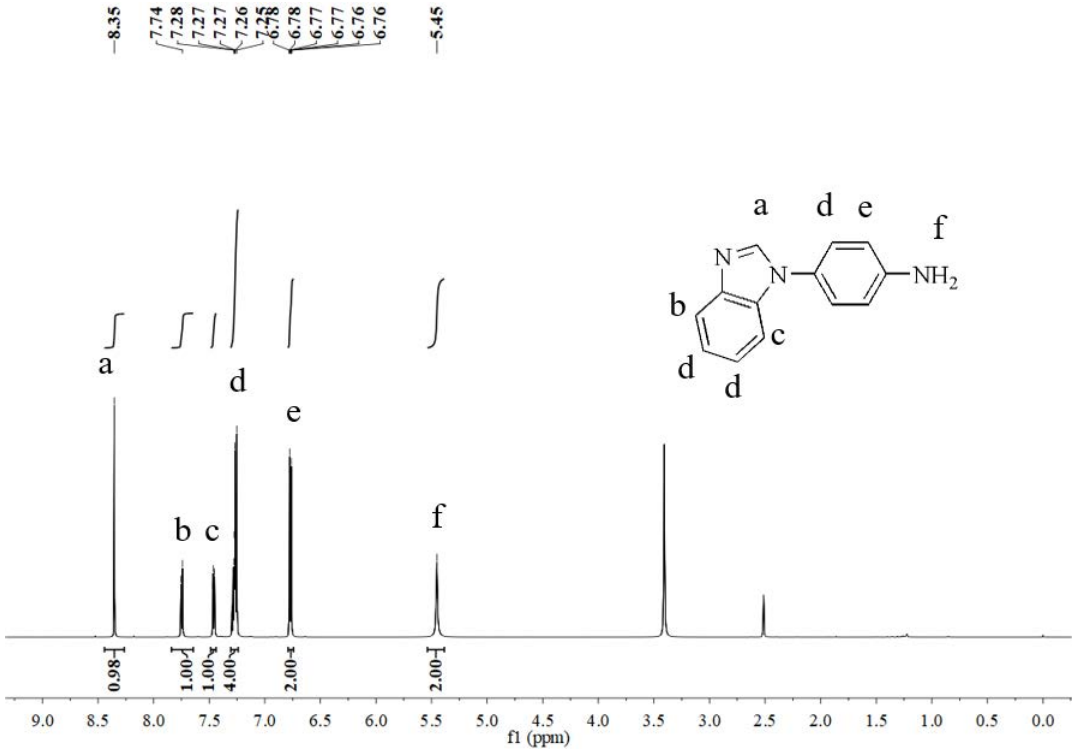

Figure S7: [1]H NMR spectrum of compound 7.

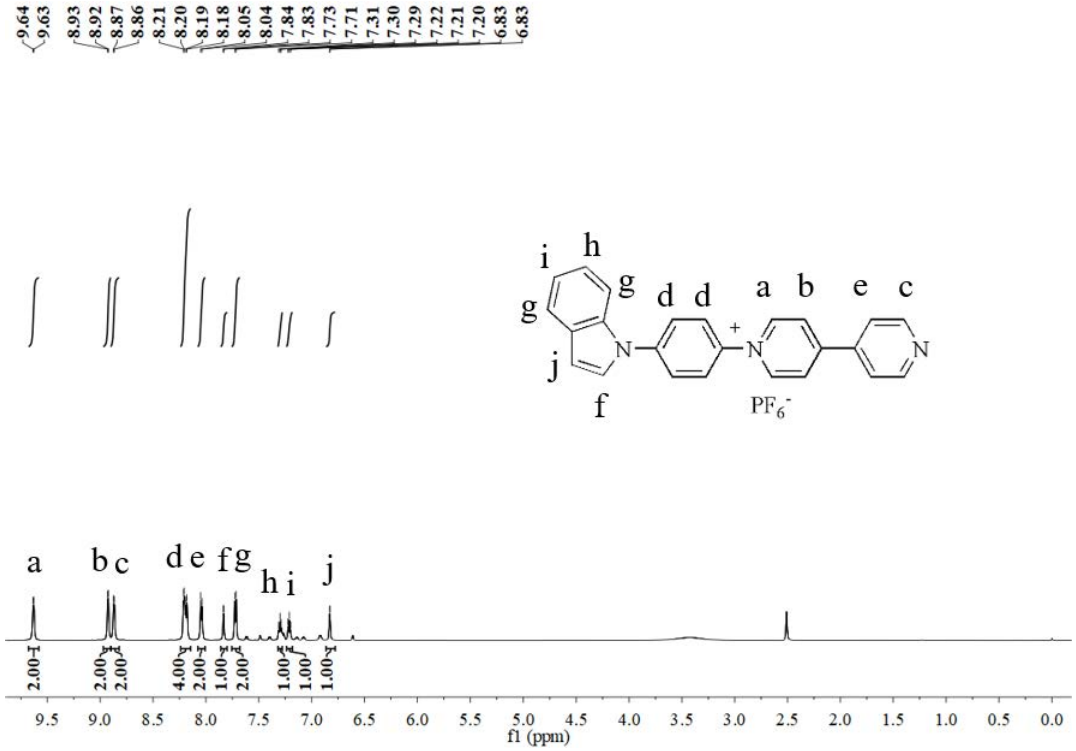

Figure S8: [1]H NMR spectrum of IV.

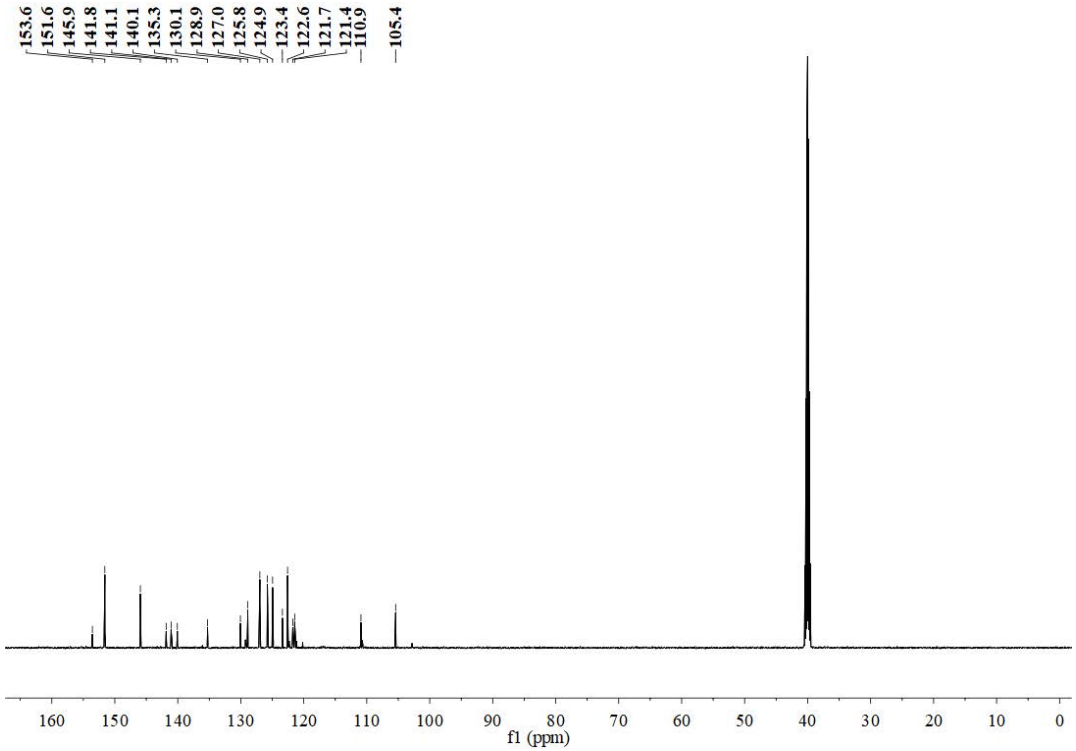

Figure S9: ^{13}C NMR spectrum of IV.

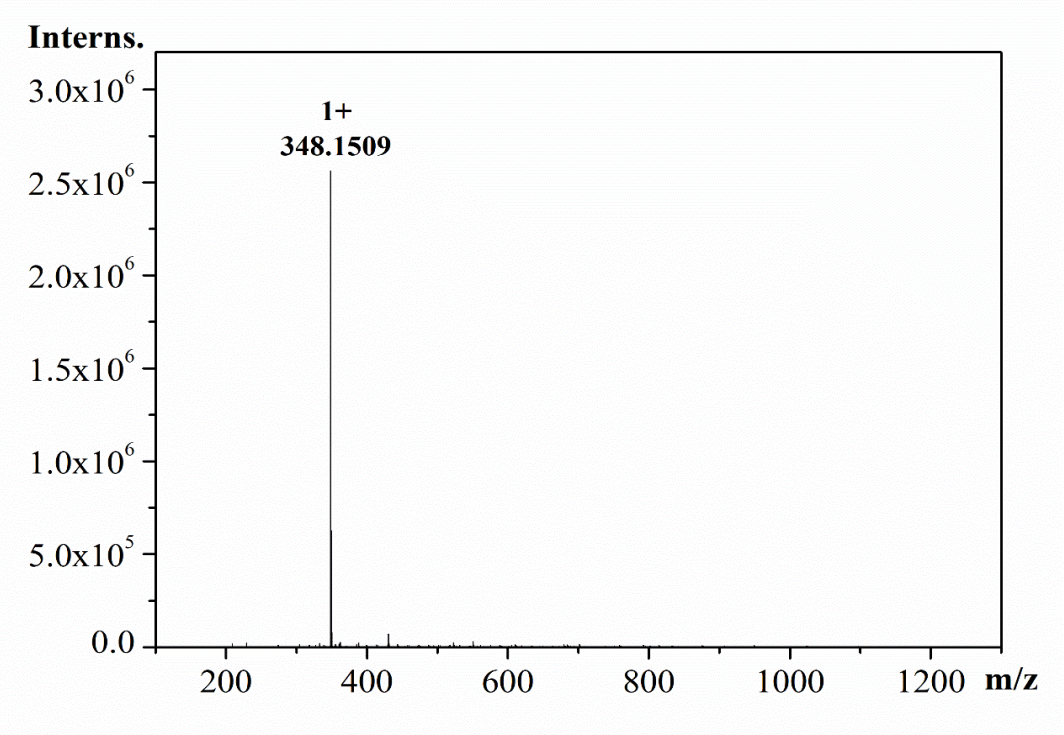

Figure S10: High Resolution Mass Spectrometry of IV.

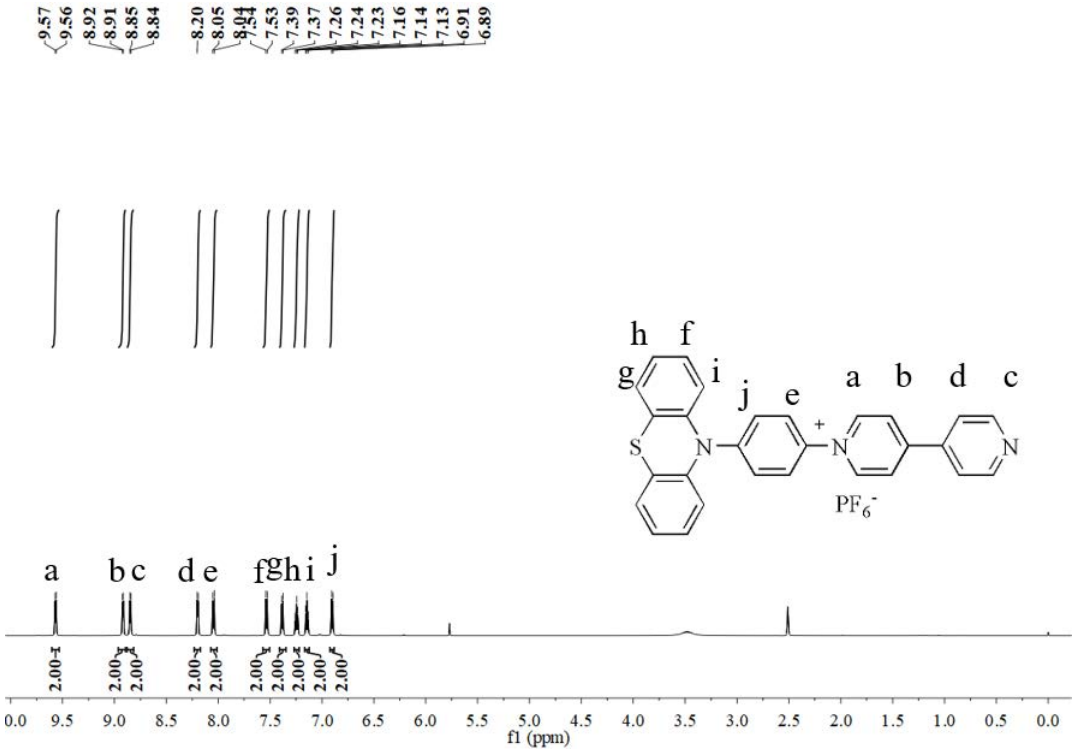

Figure S11: ^{1}H NMR spectrum of PV.

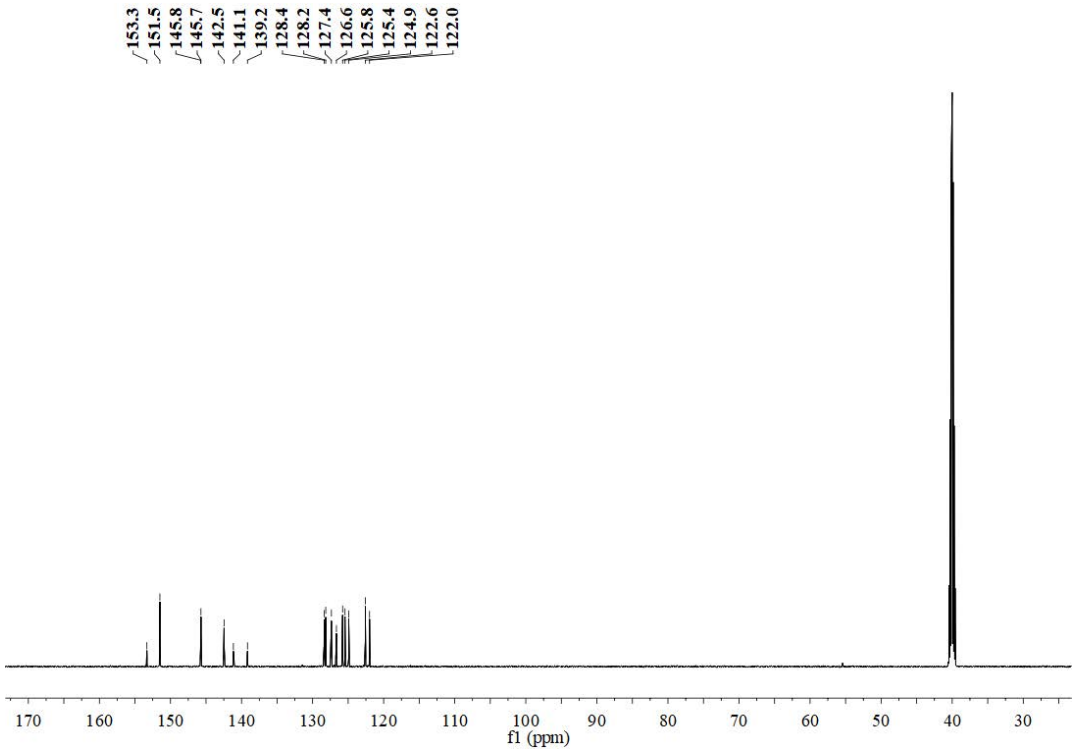

Figure S12: ^{13}C NMR spectrum of PV.

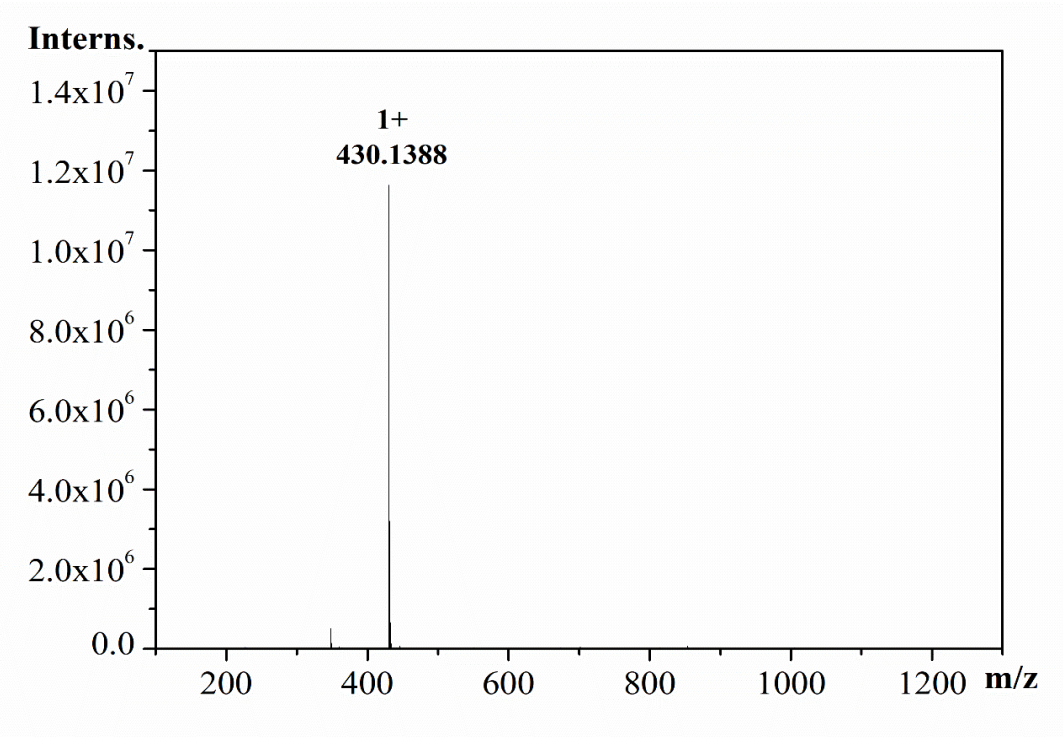

Figure S13 High Resolution Mass Spectrometry of PV.

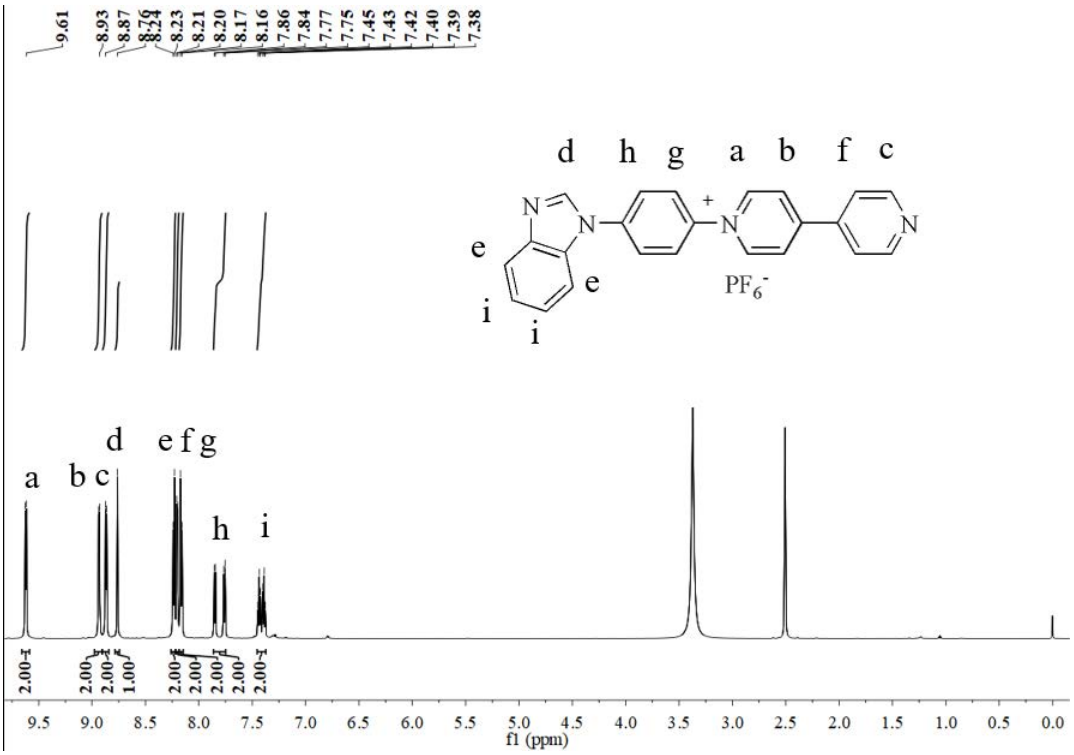

Figure S14: ^{1}H NMR spectrum of BV.

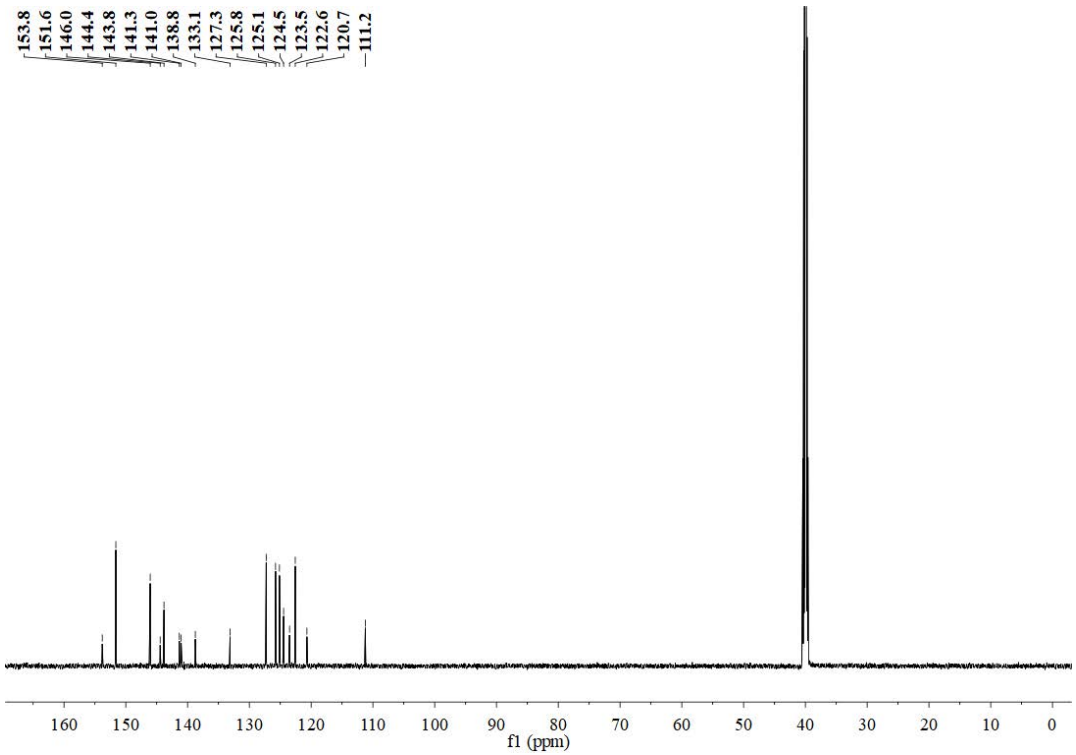

Figure S15: ^{13}C NMR spectrum of BV.

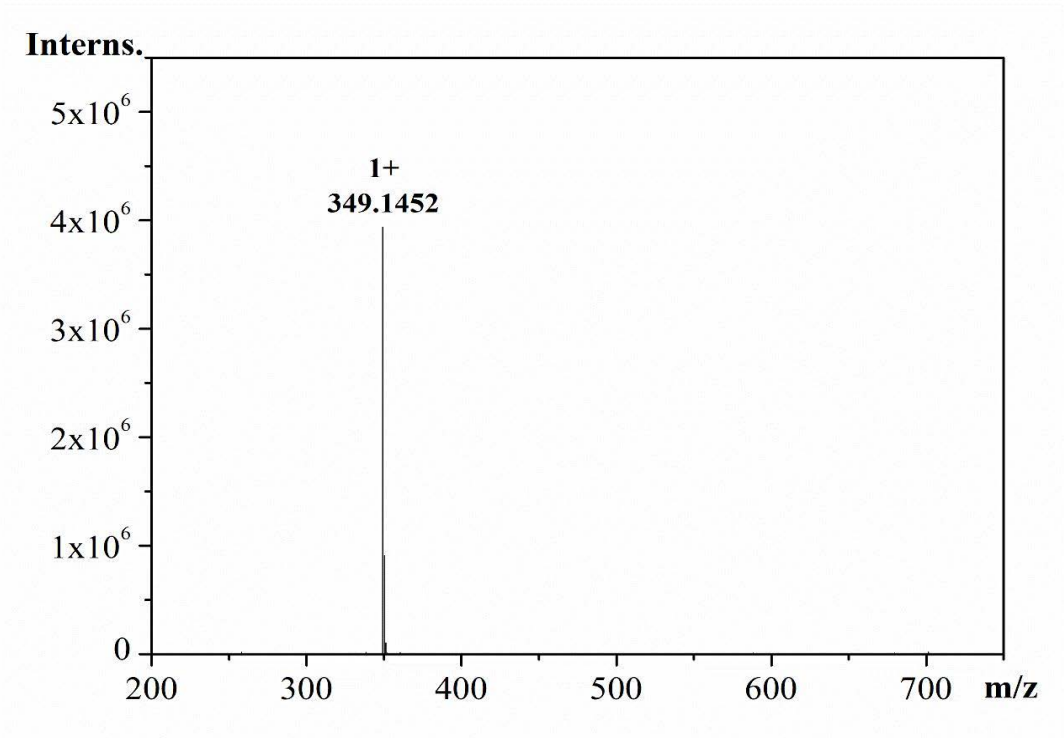

Figure S16: High Resolution Mass Spectrometry of BV.

2. Fabrication of Electrochromic device

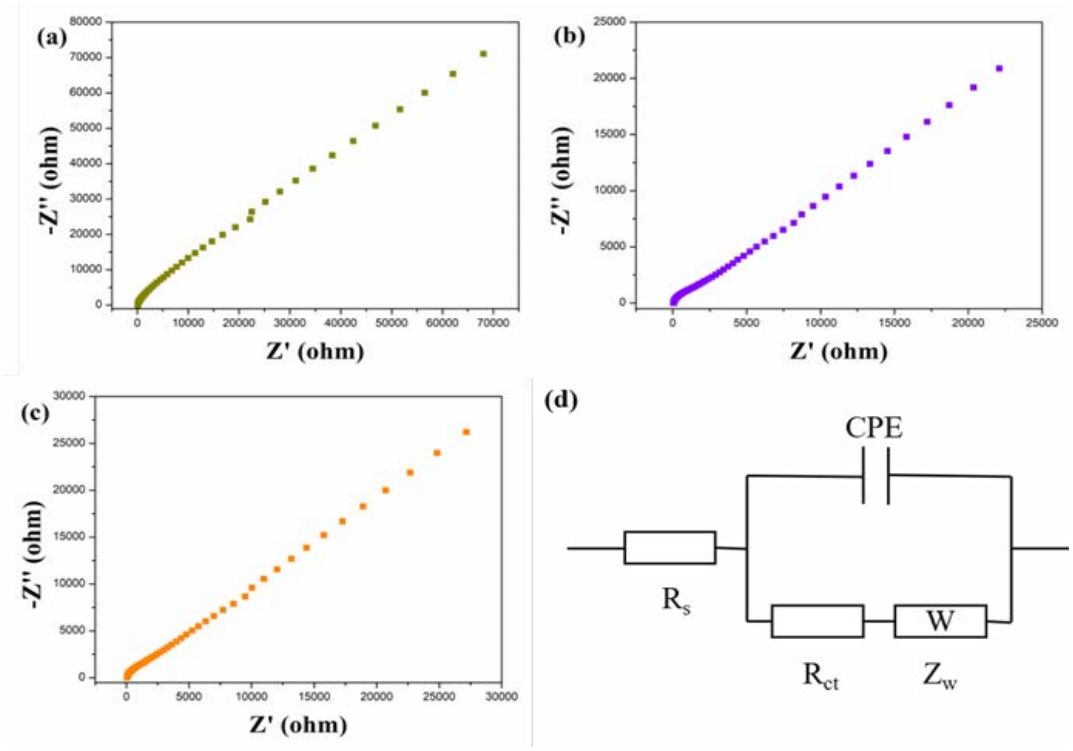

Figure S17: Electrochemical impedance spectroscopy (EIS) of (a) 2IV-based rigid ECD, (b) 2PV-based rigid ECD and (c) 2BV-based rigid ECD and (d) the corresponding analog equivalent circuit.

3. Optoelectrochemical properties of viologen derivatives

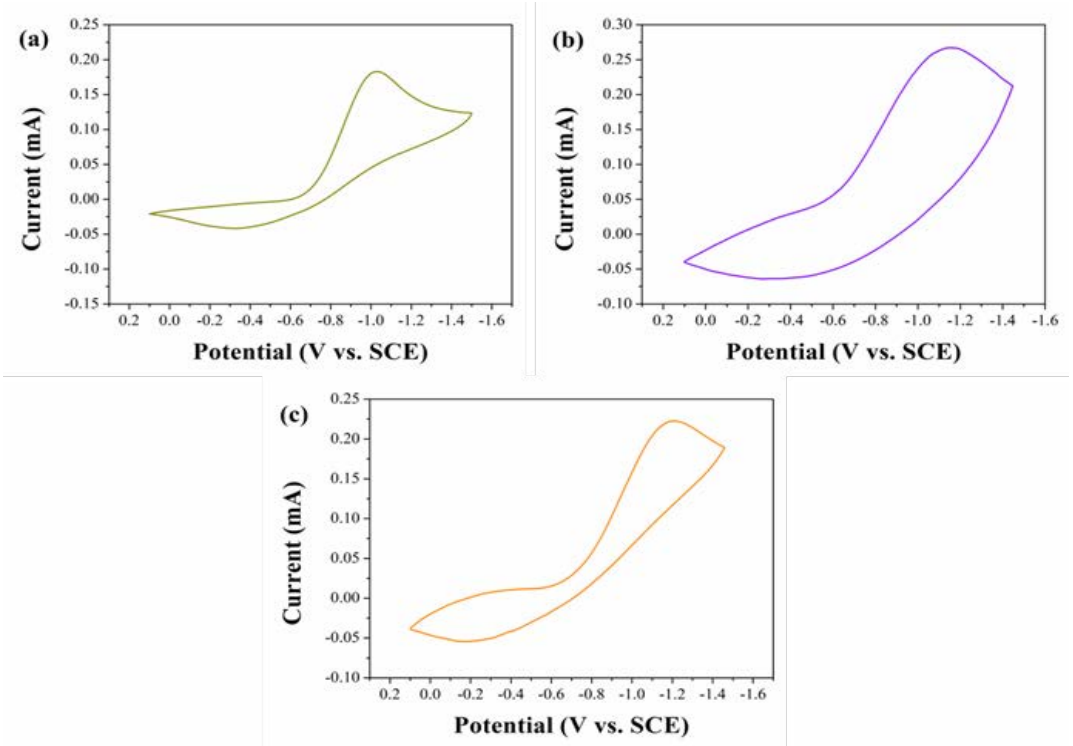

Figure S18: Cyclic voltammograms of (a) IV, (b) PV and (c) BV in PC solution containing 0.1 M TBAP at a scan rate of 50 mV/s.

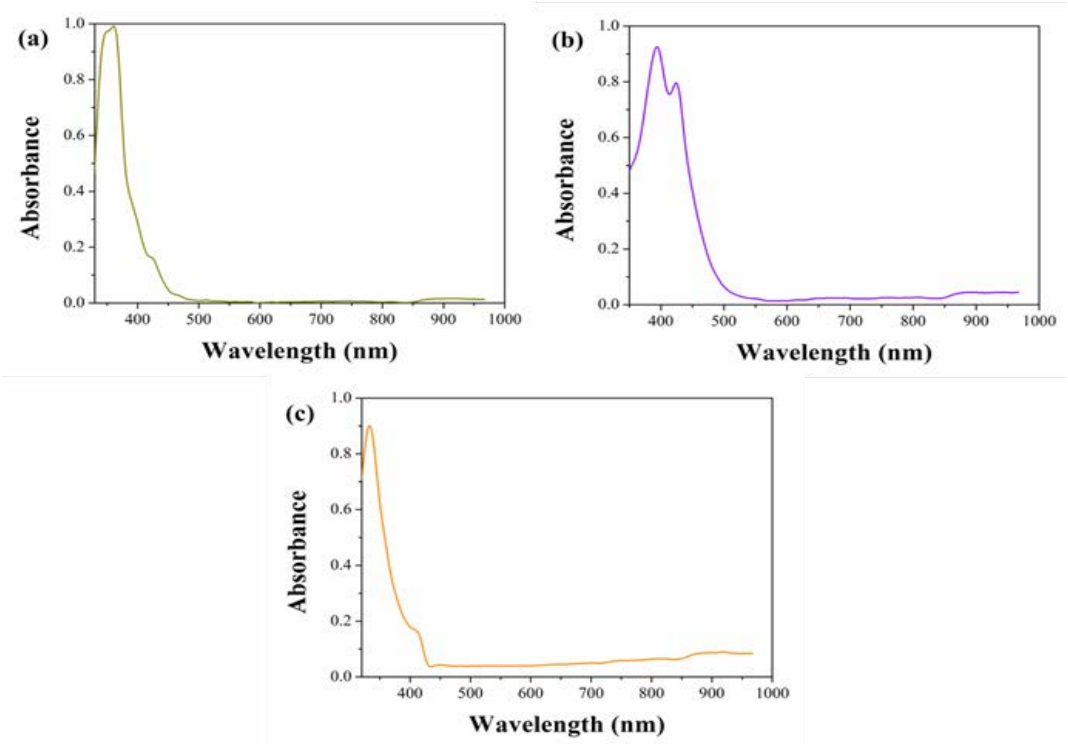

Figure S19: UV-vis absorption spectra of (a) IV, (b) PV and (c) BV in PC solution.

Table S1: Optoelectrochemical properties of viologen derivatives

Compounds	λ_{max} (nm)	λ_{edge} (nm)	E_g^{opt} (eV)	E_{red}^{onset} (V)	E_{HOMO} (eV)	E_{LUMO} (eV)
IV	361	496	2.50	-0.64	-6.26	-3.76
PV	394/424	564	2.20	-0.19	-6.41	-4.21
BV	333	433	2.86	-0.43	-6.83	-3.97

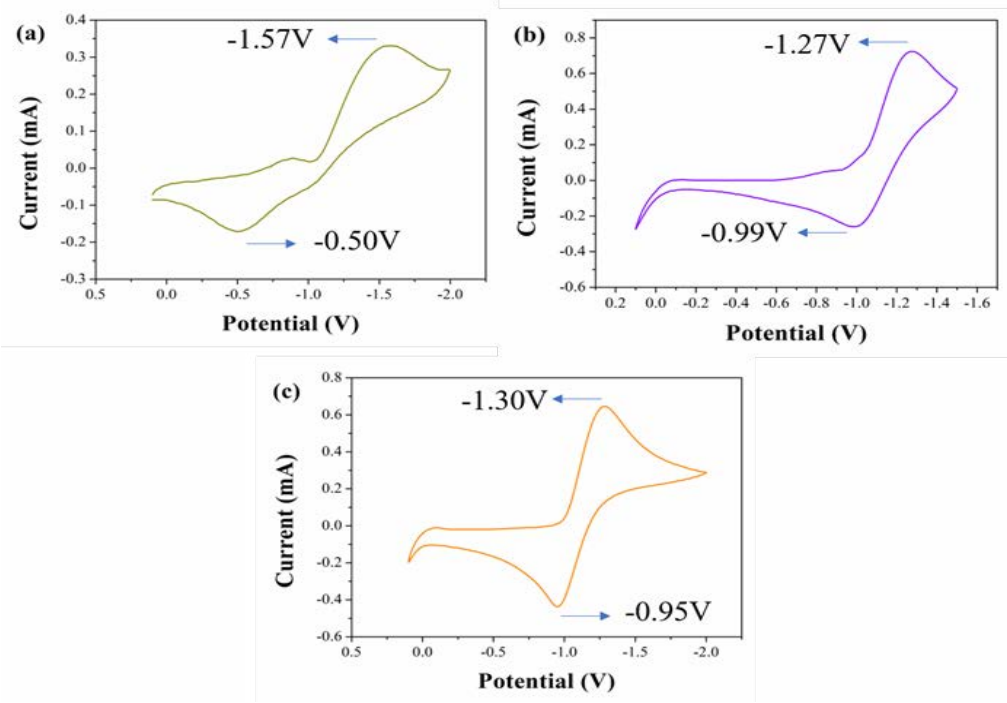

Figure S20: CVs of (a) IV-based rigid ECD, (b) PV-based rigid ECD and (c) BV-based rigid ECD at a scan rate of 50 mV/s.

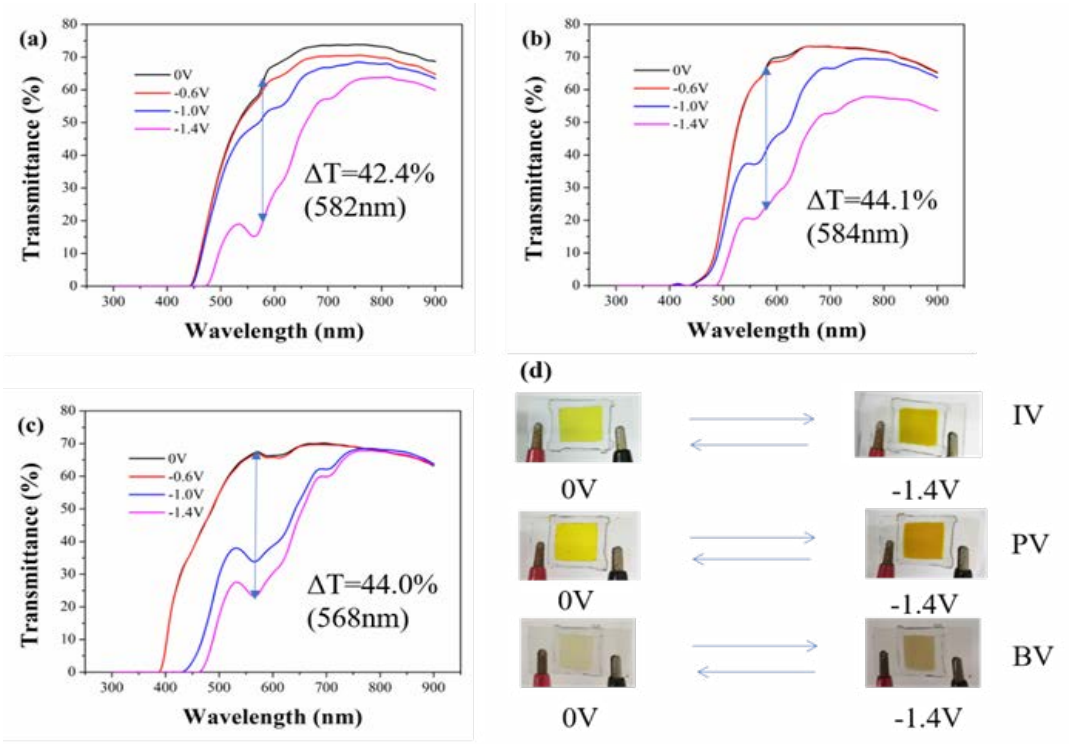

Figure S21: Spectroelectrochemistry of (a) IV-based rigid ECD, (b) PV-based rigid ECD and (c) BV-based rigid ECD under different applied voltages and the image of corresponding devices.

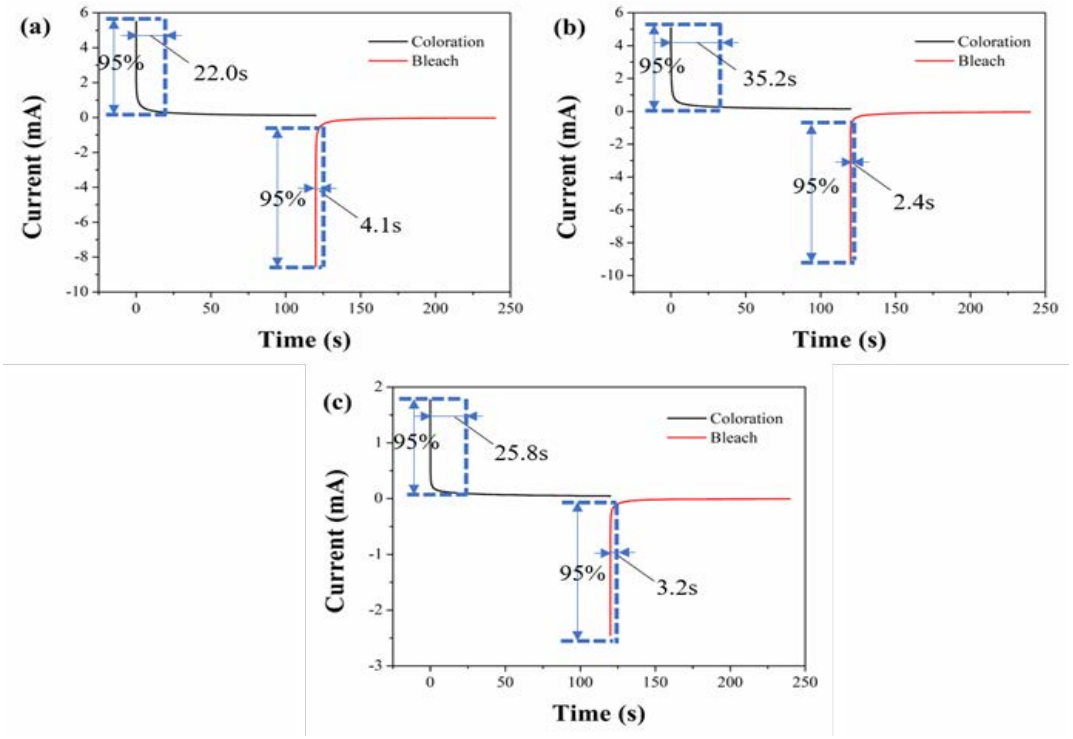

Figure S22: Current-time curves of (a) IV-based rigid ECD, (b) PV-based rigid ECD and (c) BV-based rigid ECD (switched upon voltages between 0.0 V and -1.4 V with a switching interval of 120 s).

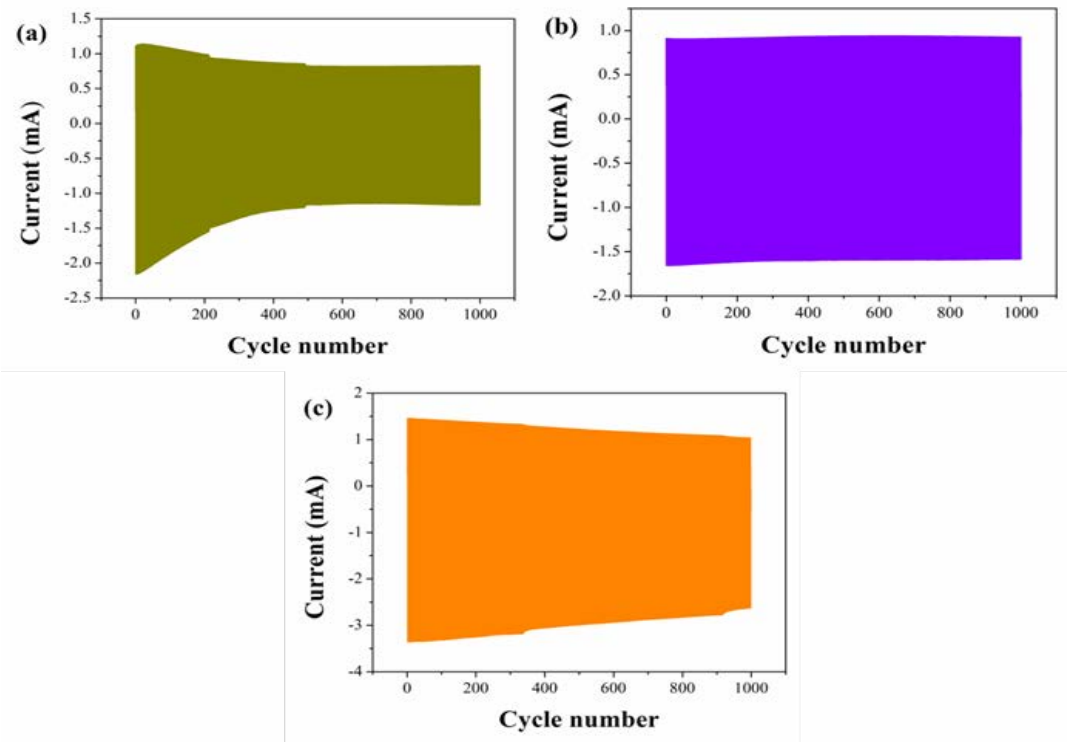

Figure S23: Properties in write-erase ability of (a) 2IV-based flexible ECD, (b) 2PV-based flexible ECD and (c) 2BV-based flexible ECD.

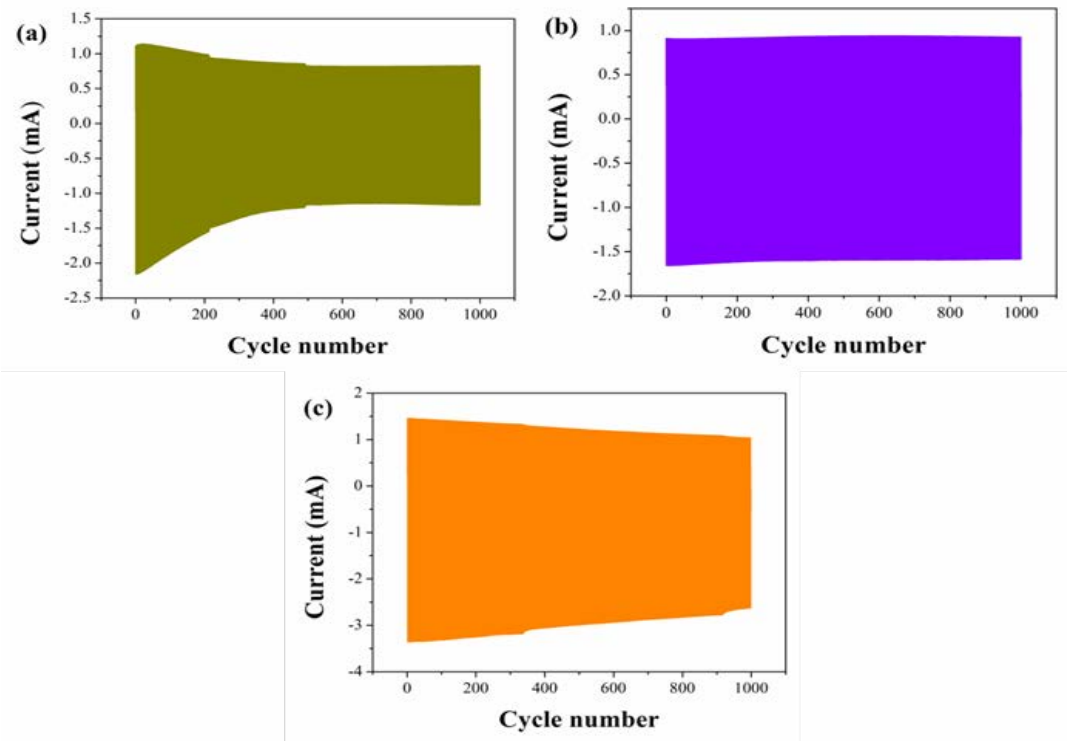

Figure S23: Properties in write-erase ability of (a) 2IV-based flexible ECD, (b) 2PV-based flexible ECD and (c) 2BV-based flexible ECD.

Table S1 Electrochromic properties of ECDs based on IV, PV and BV.

ECDs	Optical contrast (%)	Response time (s)	Coloring efficiency(cm^2/C)	Stability (%)
IV-(ITO-PET)	33.5 (564 nm)	46.0 (t_c) 4.9 (t_b)	129.67 (564nm)	51.1 (1000 cycle)
PV-(ITO-PET)	37.4 (564 nm)	84.2 (t_c) 9.9 (t_b)	87.78 (564nm)	97.6 (1000 cycle)
BV-(ITO-PET)	45.8 (466 nm)	52.9 (t_c) 7.5 (t_b)	107.22 (466nm)	72.7 (1000 cycle)
IV-(ITO-glass)	42.4 (582 nm)	22.0 (t_c) 4.1 (t_b)	197.84 (582nm)	38.9 (1000 cycle)
PV-(ITO-glass)	44.1 (584 nm)	35.2 (t_c) 2.4 (t_b)	198.70 (584nm)	91.8 (1000 cycle)
BV-(ITO-glass)	44.0 (568 nm)	25.8 (t_c) 3.2 (t_b)	201.50 (568nm)	88.8 (1000 cycle)