Supporting Information

Photolithographically Patterned and Highly Stable Electrochromic Display Enabled by a Photo-assist Cross-linker

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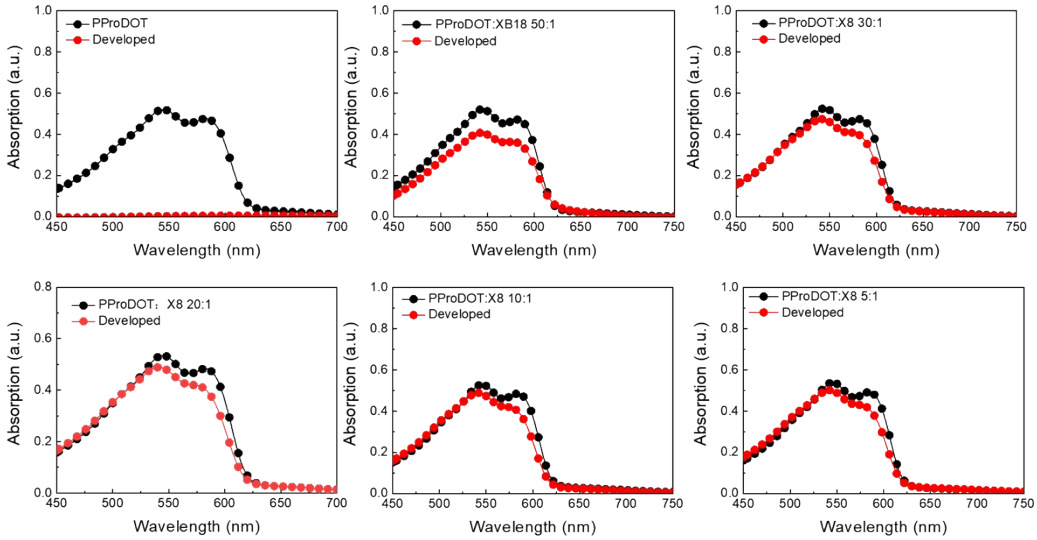


Figure S1 The absorption intensity of UV-vis spectrum before and after dissolution with dimethylbenzene of PProDOT:X8 with different ratios.

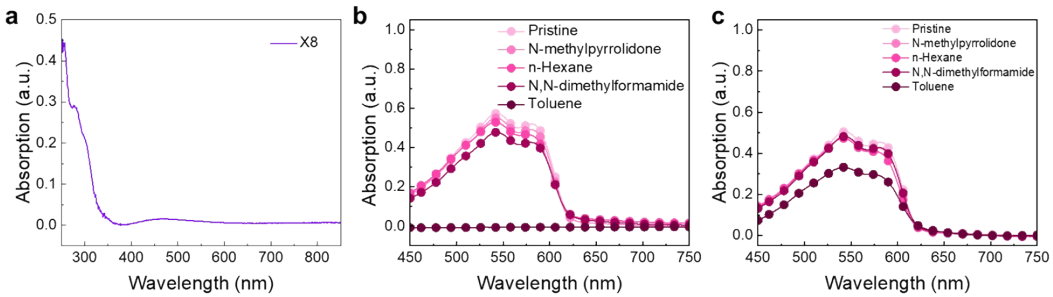


Figure S2 (a) The absorption of X8 film, (b), (c) The absorption intensity of UV-vis spectrum of PProDOT and PProDOT:X8 (w/w = 20:1) before and after dissolution with different solvents.

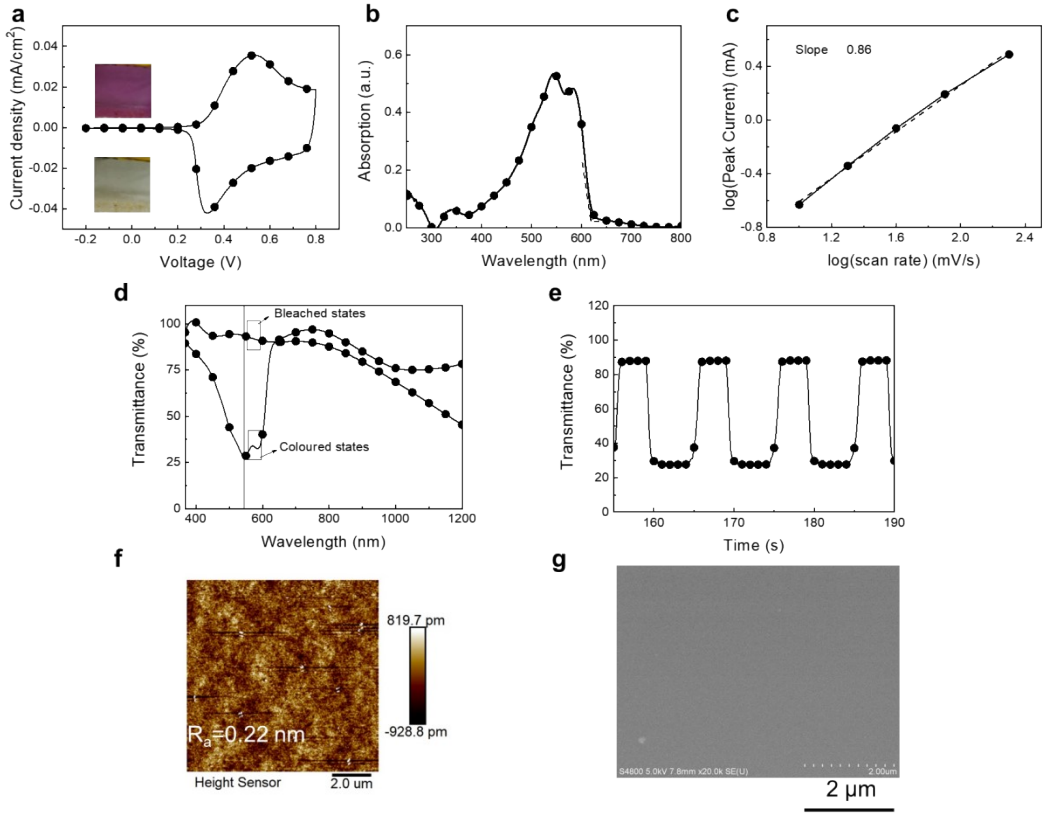


Figure S3 (a) Cyclic voltammetry analysis of crosslinked ECP films without developing (inset are digital images of the ECP films under bleached and coloured states.). (b) The absorption of the ECP Films, (c) The b-value refers to the slope of log(i) versus log(V) plot. (d) The transmittance of the ECPs under bleached and coloured states. (e) Switching speed measurements for a symmetrically (0.1 Hz cycle frequency, at +0.8 V and -0.6 V) driven measured at 550 nm. All reported potentials are relative to Ag/Ag^+.(f) AFM image. (g) SEM image.

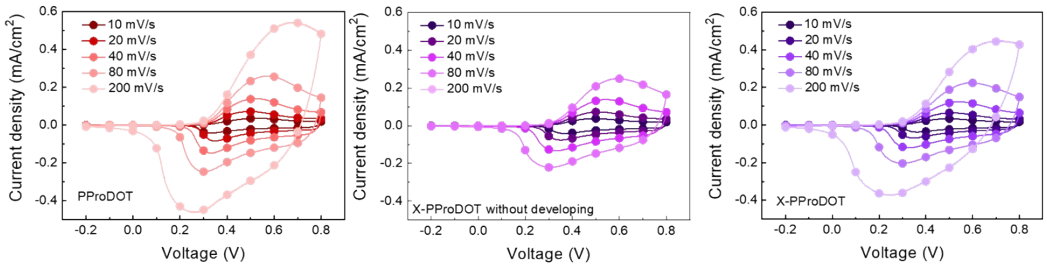


Figure S4 Cyclic voltammetry analysis of ECP films (PProDOT, X-PProDOT without develping, X-PProDOT) under different scan rates.

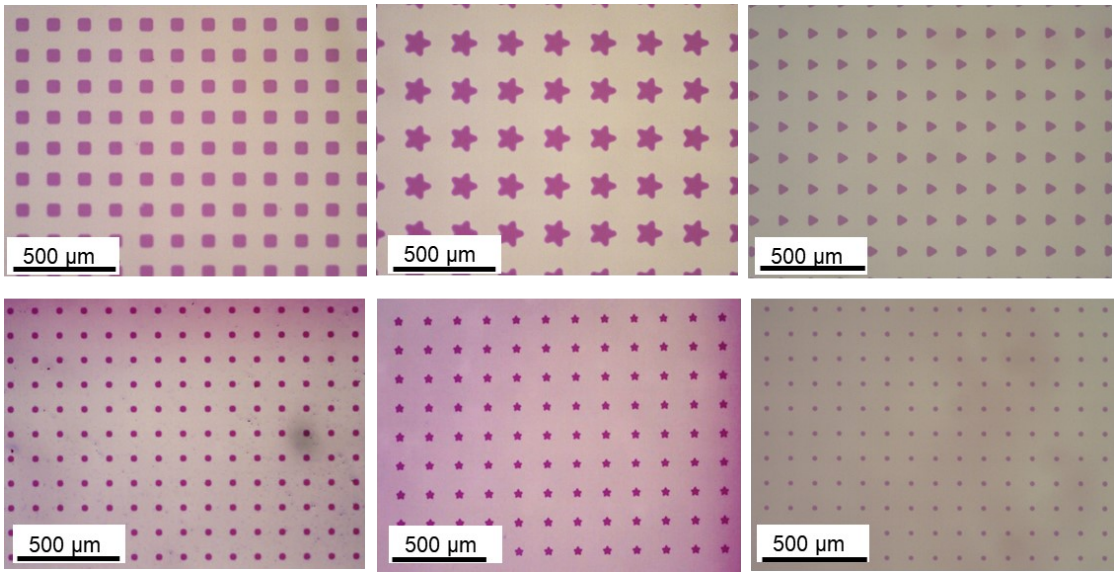


Figure S5 3D Digital microscope images of the patterned thin films of X-PProDOT.

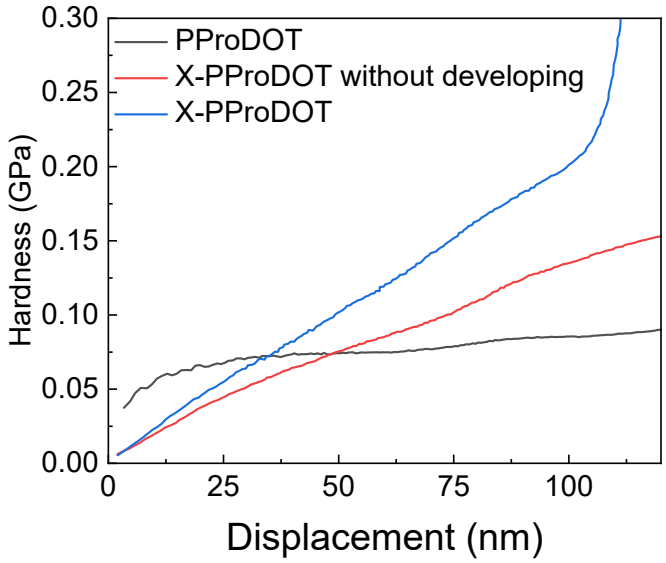


Figure S6 Indentation-depth dependence of the hardness

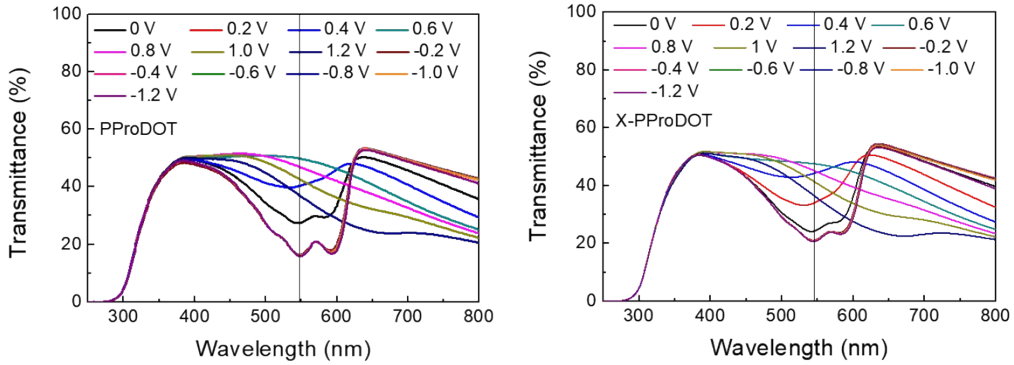


Figure S7 The transmittance change of PProDOT/X-PProDOT devices *vs.* Optical wavelength from -1.2 V to 1.2 V

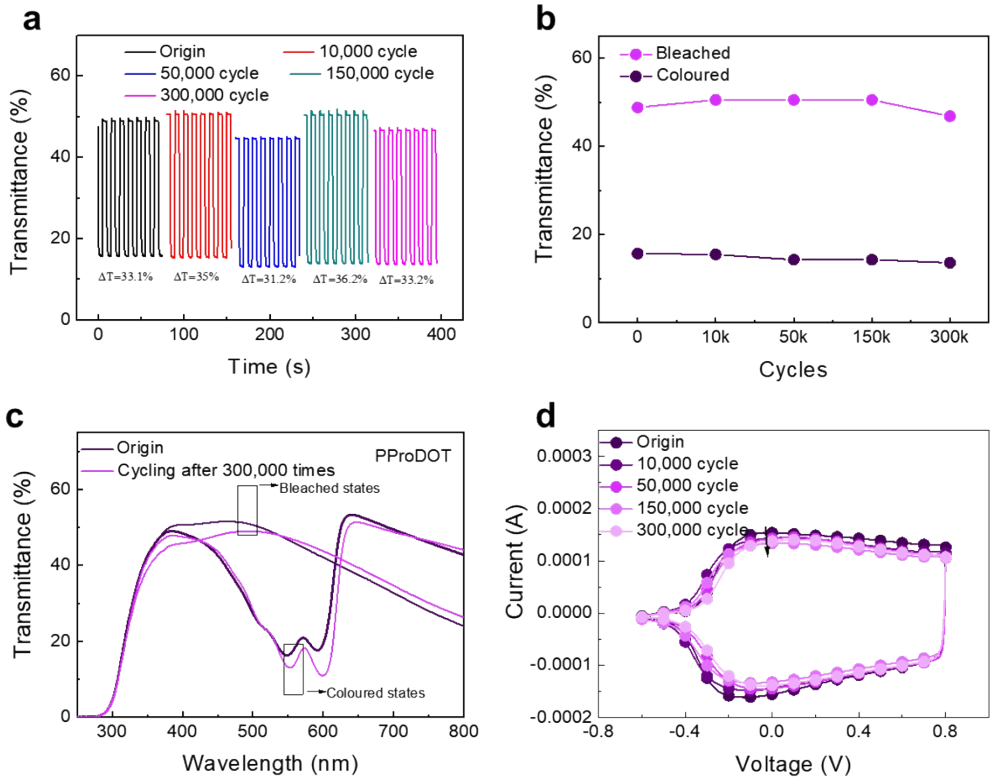


Figure S8 (a) switching speed measurements measured at 550 nm. (b), (c) the transmittance change modulation. (d) changes of CV curves during 300,000 operating cycles of the device based on PProDOT for a driven symmetrically (0.1 Hz cycle frequency, at +0.8 V and −0.6 V).

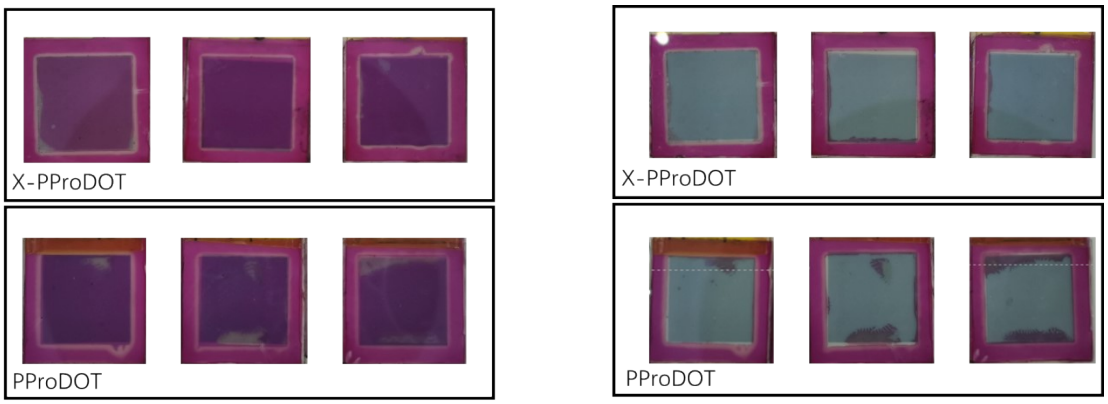
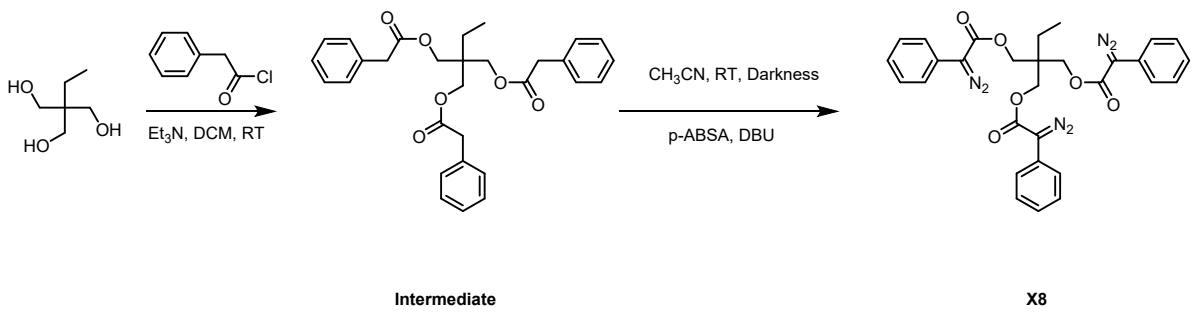
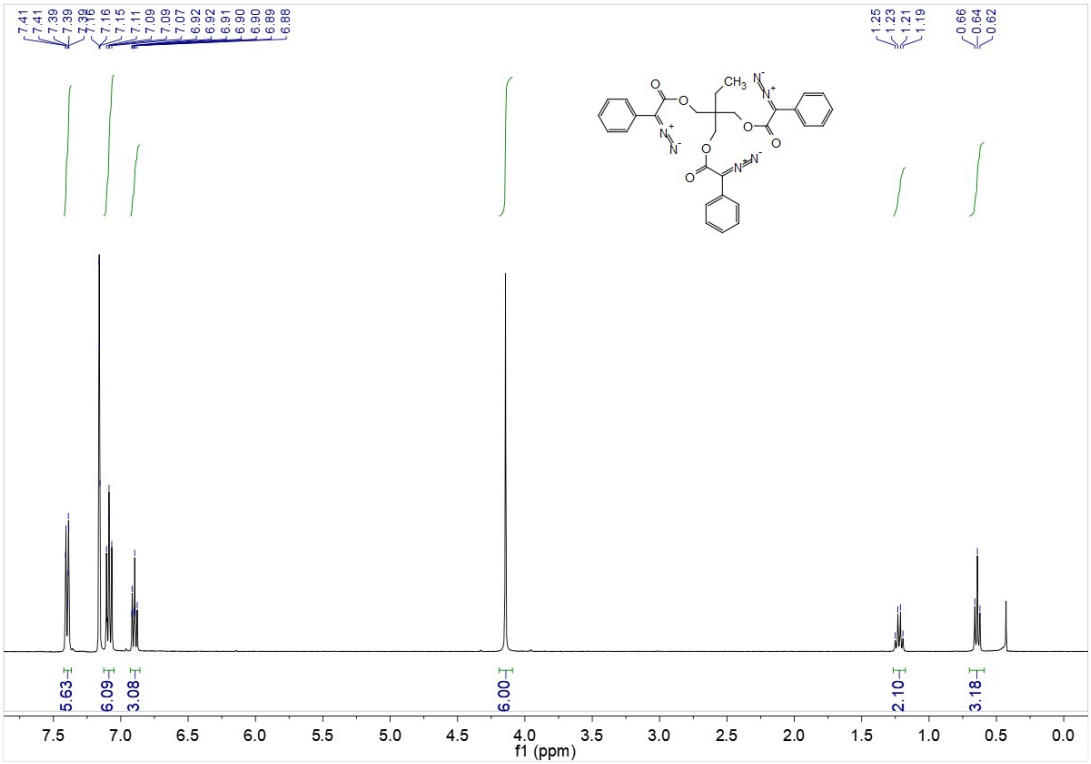


Figure S9 Bleached (left) and coloured (right) states of X-PProDOT/PProDOT devices after ~300,000 cycles with a 0.25 Hz cycle frequency, at +0.8 V and −0.6 V.

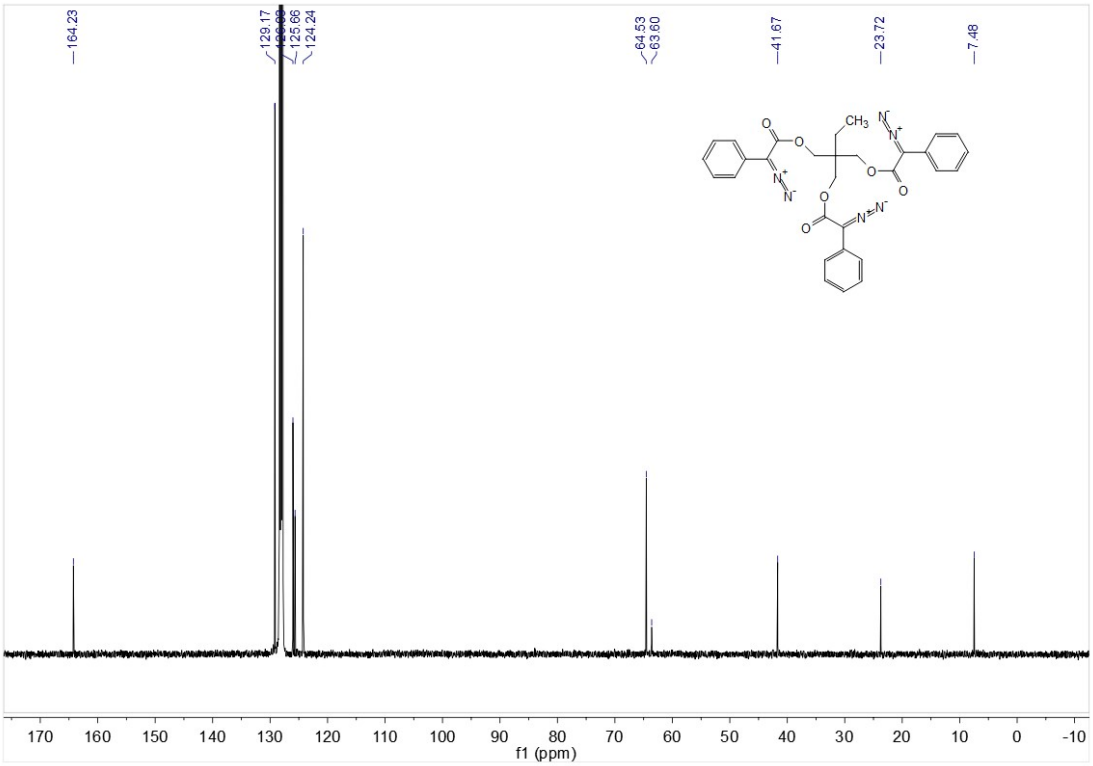


Intermediate **X8**

Scheme S1 Synthetic procedures for X8


7.41
7.41
7.39
7.39
7.18
7.16
7.15
7.11
7.09
7.09
7.07
6.92
6.92
6.91
6.90
6.90
6.89
6.88
1.25
1.23
1.21
1.19
0.66
0.64
0.62
5.63
6.09
3.08
6.00
2.10
3.18
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

^{1}H NMR of X8


164.23
129.17
128.69
125.66
124.24
64.53
63.60
41.67
23.72
7.48
CH3
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

^{13}C NMR of X8

Table S1. UV-vis absorbance of PProDOT:X8 film with different ratios before and after rinsing with xylene.

Film	Before rinsing(a.u.)	After Rinsing (a.u.)	Anti-solution(%)
PProDOT	0.52	0	0
50：1	0.52	0.40	76.9
30：1	0.53	0.47	88.7
20：1	0.53	0.49	92.5
10：1	0.53	0.49	92.5
5：1	0.54	0.49	90.7

Table S2. Solvent resistance of PProDOT and PProDOT:X8 film (w/w = 20:1).

	PProDOT	PProDOT:X8(20:1)
N-methylpyrrolidone	95.8%	95.3%
n-Hexane	91.8%	93.2%
N,N-dimethylformamide	83.3%	95.2%
Toluene	0%	65.5%
xylene	0%	92.5%

Table S3 Summary of characters of the X-PProDOT(without developing).

	E_{onset} (V) [a]	λ_{onset} (nm) [a]	λ_{max} (nm) [a]	E_g (eV) [b]	HOMO (eV) [c]	LUMO (eV) [d]	T_{min} (%)	T_{max} (%)	ΔT (%)	t_b (s) [h]	t_c (s)[i]
X-PProDOT (Without developing)	0.30	620	545	2.0	-4.90	-2.90	27.8	88	60.2	1.3	0.7

a Obtained from CV curve, b obtained from UV-vis spectrum, c Eg=1240/λ_{onset}, d obtained from CV curve of its film in 1 M $LiClO_4$ in PC solution, E_{HOMO}=-(E_{onset}+4.6), e E_{LUMO}=Eg+E_{HOMO}, g ΔT is calculated by T_{max}-T_{min}, h,I obtained from the electrochromic switching by 90%ΔT.

Table S4 Perfomance summary of PProDOT device

Cycles	$V_{bleaching}$ V	$V_{Colouring}$ V	$T_{bleaching}$ %	$T_{colouring}$ %	ΔT %	$t_{bleaching}$ s	$t_{Colouring}$ s
0	0.8	-0.6	48.8	15.7	33.1	0.4	0.7
10,000	0.8	-0.6	50.5	15.5	35	0.5	0.5
50,000	0.8	-0.6	50.5	14.3	36.2	0.6	0.8
150,000	0.8	-0.6	50.5	14.3	36.2	0.6	0.8
300,000	0.8	-0.6	46.8	13.6	33.2	0.4	0.8

Table S5 Perfomance summary of X-PProDOT device

Cycles	$V_{bleaching}$	$V_{Colouring}$	$T_{bleaching}$	$T_{colouring}$	ΔT	$t_{bleaching}$	$t_{Colouring}$
	V	**V**	**%**	**%**	**%**	**s**	**s**
0	0.8	-0.6	48.9	20.9	28	0.5	0.5
10,000	0.8	-0.6	53	19.8	34.2	0.5	0.7
50,000	0.8	-0.6	50.3	20.1	30.2	0.5	0.8
150,000	0.8	-0.6	50.3	20.1	30.2	0.5	0.8
300,000	0.8	-0.6	50.7	20.3	30.4	0.5	0.9