Supporting Information

Concept of Triphenylamine Side Chains with Four Electroactive Nitrogen Centers toward Record-High Stable Electrochromic Polyamides

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Table S1. Inherent Viscosity and Solubility[b] of PAs.

PA	η_{inh}(dL/g)[a]	NMP	DMAc	*o*-Chlorophenol	THF
5a	0.40	+	++	+—	+—
5b	0.32	+	+	+—	—
5c	0.45	+	+	+—	—

[a]Measured in NMP on 0.5 g/dL at 30 °C. [b]Qualitative solubility was determined using 0.01 g of polymer in 1 ml of solvent. ++ (soluble at room temperature); + (soluble on heating at 60°C); +— (partially soluble on heating at 60°C); — (insoluble in hot solvent).

Table S2. Thermal Properties of PAs.

PA	T_g (°C)[a]	T_d (°C)[b]		Char yield[c] (%)
		In Air	In N_2	
5a	178	425	467	59
5b	181	421	464	63
5c	194	421	470	65

[a]Temperature at which the middle of the heat capacity change occurred from the second DSC heating scan at a heating rate of 20°C/min. [b]Temperature at which 10% weight loss recorded by thermogravimetry at a heating rate of 20°C/min. [c]Residual weight% at 800°C in nitrogen.

Table S3. Optical and Electrochemical Data Collected for Coloration Efficiency.

Cycles[a]	△OD[b]	△T(%)[c]	Q(mC/cm^2)[d]	η(cm^2/C)[e]	decay(%)[f]
1	0.376	57.9	1.84	204	0.00
2500	0.370	57.4	1.82	203	0.49
5000	0.363	56.6	1.79	202	0.98
7500	0.357	56.0	1.78	199	2.45
10000	0.355	55.8	1.78	199	2.45
12500	0.339	54.3	1.74	194	4.90
15000	0.337	54.0	1.73	194	4.90
17500	0.329	53.1	1.71	192	5.88
20000	0.323	52.4	1.69	191	6.37
22500	0.321	52.2	1.69	190	6.86
24000	0.307	50.7	1.64	186	8.82

[a]Times of cyclic scan of **5a** by applying potential step: 0.0 V ↔ 0.5 V (V vs. Ag/AgCl). [b]Optical density change at 1404 nm. [c]Optical transmittance change at 1404 nm. [d]Ejected charge determined from in situ experiments. [e]Coloration efficiency is derived from the equation η = △OD/Q. [f]Decay of coloration efficiency after cyclic scans.

Table S4. Optical and Electrochemical Data Collected for Coloration Efficiency.

Cycles[a]	△OD[b]	△T(%)[c]	Q(mC/cm^2)[d]	η(cm^2/C)[e]	decay(%)[f]
1	0.331	53.4	2.97	111	0.00
2000	0.315	51.6	2.87	110	0.90
4000	0.310	51.0	2.86	108	2.70
6000	0.307	50.7	2.84	108	2.70
8000	0.300	49.9	2.80	107	3.60
10000	0.283	48.0	2.76	103	7.20
12000	0.281	47.7	2.75	102	8.11
14000	0.281	47.6	2.75	102	8.11
16000	0.278	47.3	2.74	101	9.01
18000	0.276	47.1	2.73	101	9.01
20000	0.267	46.0	2.68	100	9.91

[a]Times of cyclic scan of **5a** by applying potential step: 0.0 V ↔ 0.5 V (V vs. Ag/AgCl). [b]Optical density change at 440 nm. [c]Optical transmittance change at 440 nm. [d]Ejected charge determined from in situ experiments. [e]Coloration efficiency is derived from the equation: η=△OD/Q. [f]Decay of coloration efficiency after cyclic scans.

Table S5. Optical and Electrochemical Data Collected for Coloration Efficiency.

Cycles[a]	△OD[b]	△T(%)[c]	Q(mC/cm^2)[d]	η(cm^2/C)[e]	decay(%)[f]
1	1.05	91.1	7.22	145	0.00
500	1.03	90.7	7.20	144	0.69
1000	1.03	90.6	7.19	143	1.38
1500	1.02	90.4	7.17	142	2.07
2000	1.02	90.3	7.16	142	2.07
2500	1.00	90.0	7.14	140	3.45
3000	0.96	89.0	7.08	136	6.21
3500	0.95	88.7	7.06	134	7.59
4000	0.93	88.1	6.91	134	7.59
4500	0.92	88.1	6.91	134	7.59
5000	0.83	85.2	6.42	129	11.03

[a]Times of cyclic scan of **5a** by applying potential step: 0.0 V ↔ 0.7 V(V vs. Ag/AgCl). [b]Optical density change at 1404 nm. [c]Optical transmittance change at 1404 nm. [d]Ejected charge, determined from in situ experiments. [e]Coloration efficiency is derived from the equation: η=△OD/Q. [f]Decay of coloration efficiency after cyclic scans.

Table S6. NIR Absorption of Polymers at the First Stage of Oxidation.

Polymer	Potential[a] (V)	λ_{max}[b] (nm)	Absorption Range[b] (nm)
5a	0.50	1404	800-1800
P1	0.75	1062	800-1450
P2	0.40	1252	800-1700

[a]Applied potential for the first stage oxidation. [b]NIR absorption.

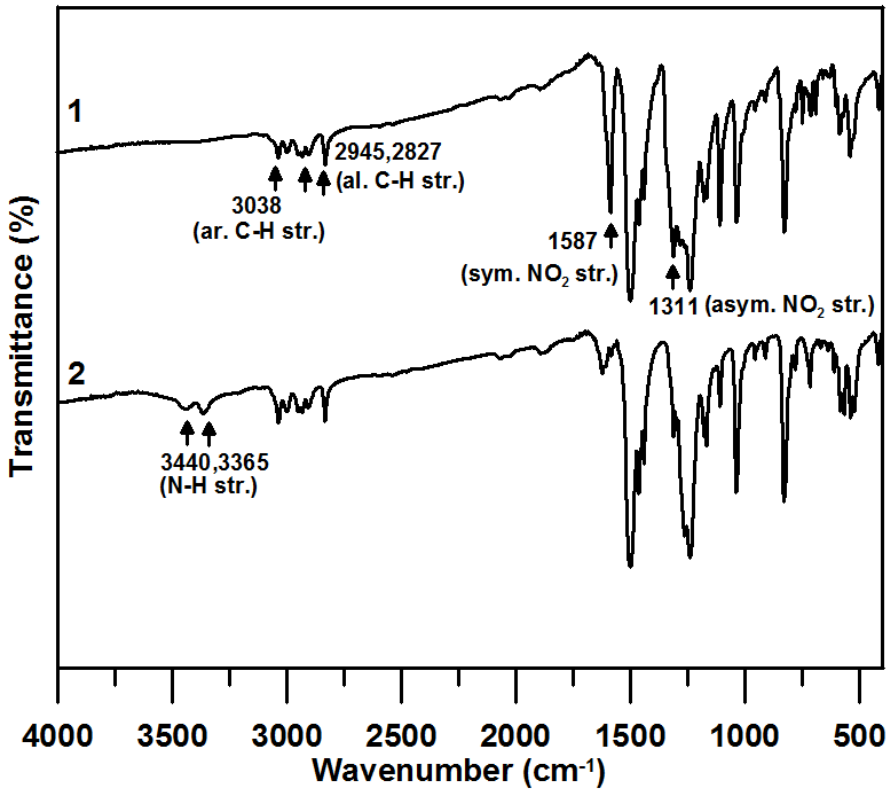

Fig. S1 FT-IR spectra of the compounds **1** and **2**.

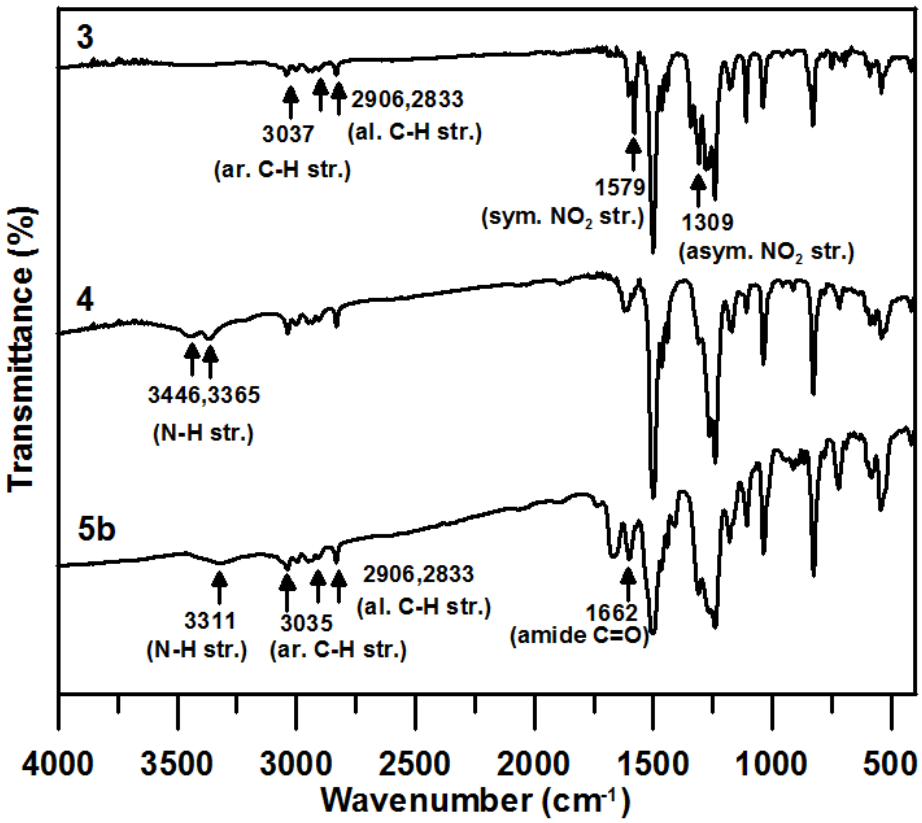

Fig. S2 FT-IR spectra of the compounds **3**, **4**, and PA **5b**.

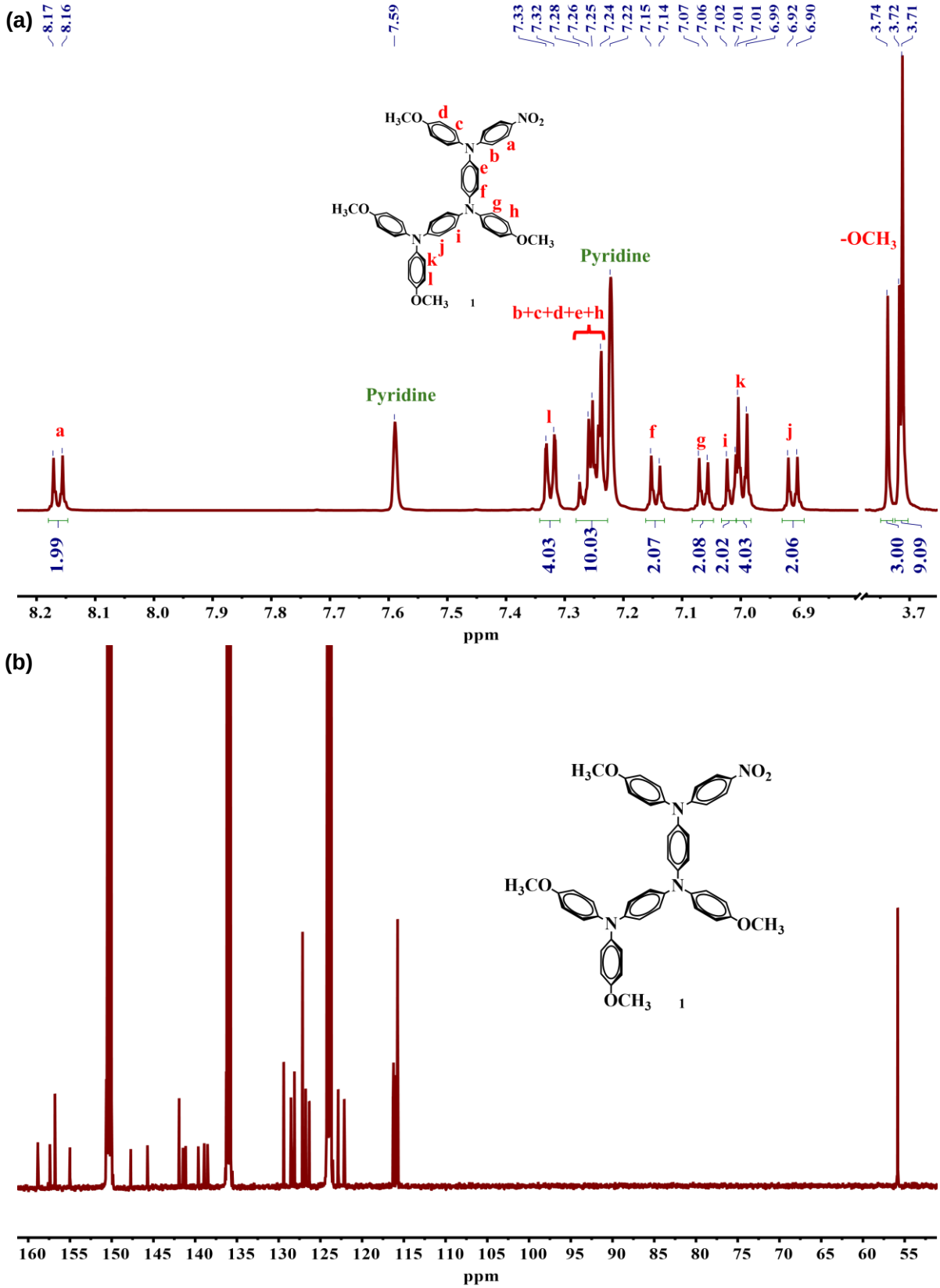

Fig. S3 (a) ^{1}H and (b) ^{13}C NMR spectra of compound **1**. (d-solvent: Pyridine-d_5)

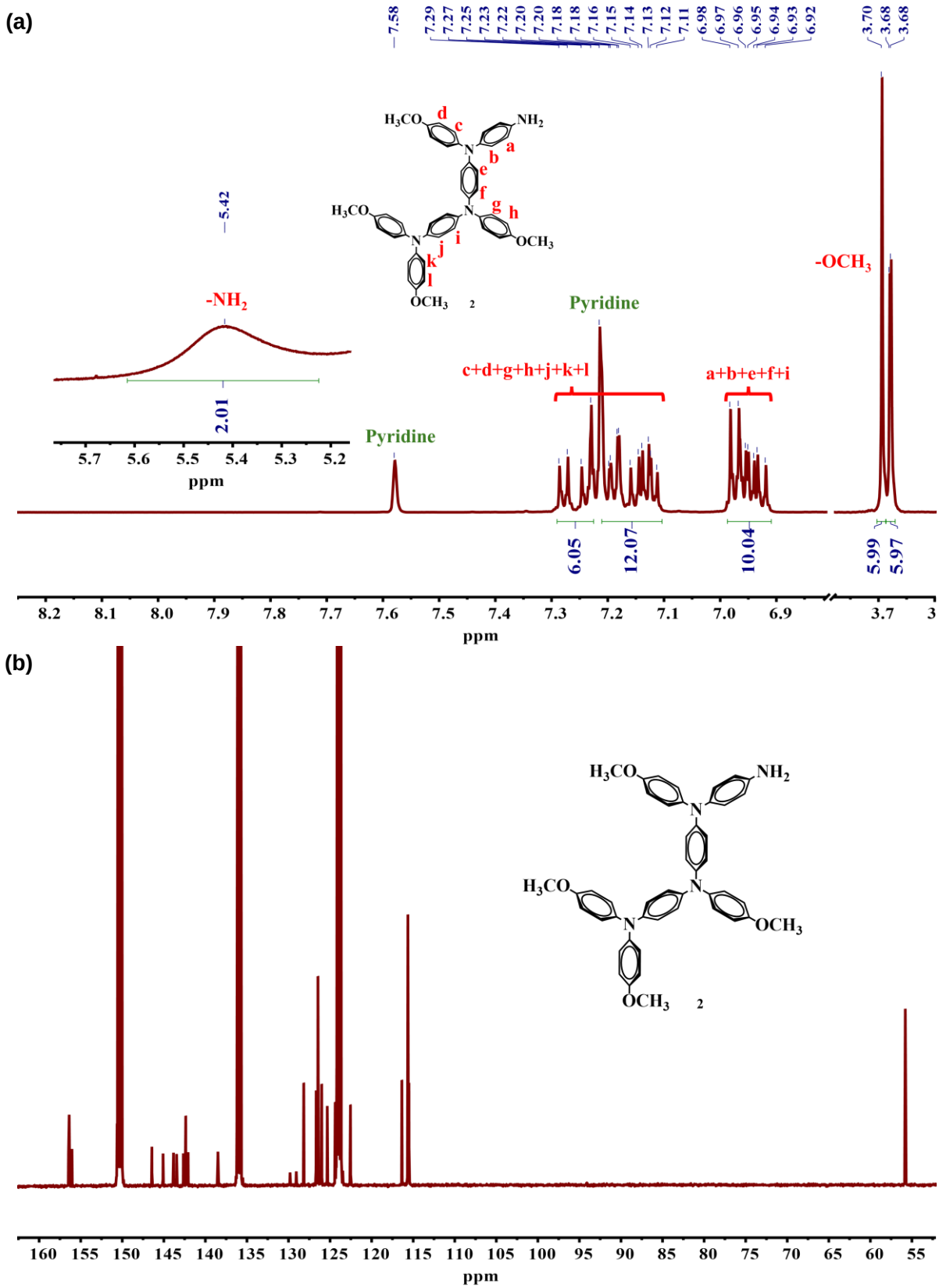

Fig. S4 (a) ^{1}H and (b) ^{13}C NMR spectra of compound **2**. (d-solvent: Pyridine-d_5)

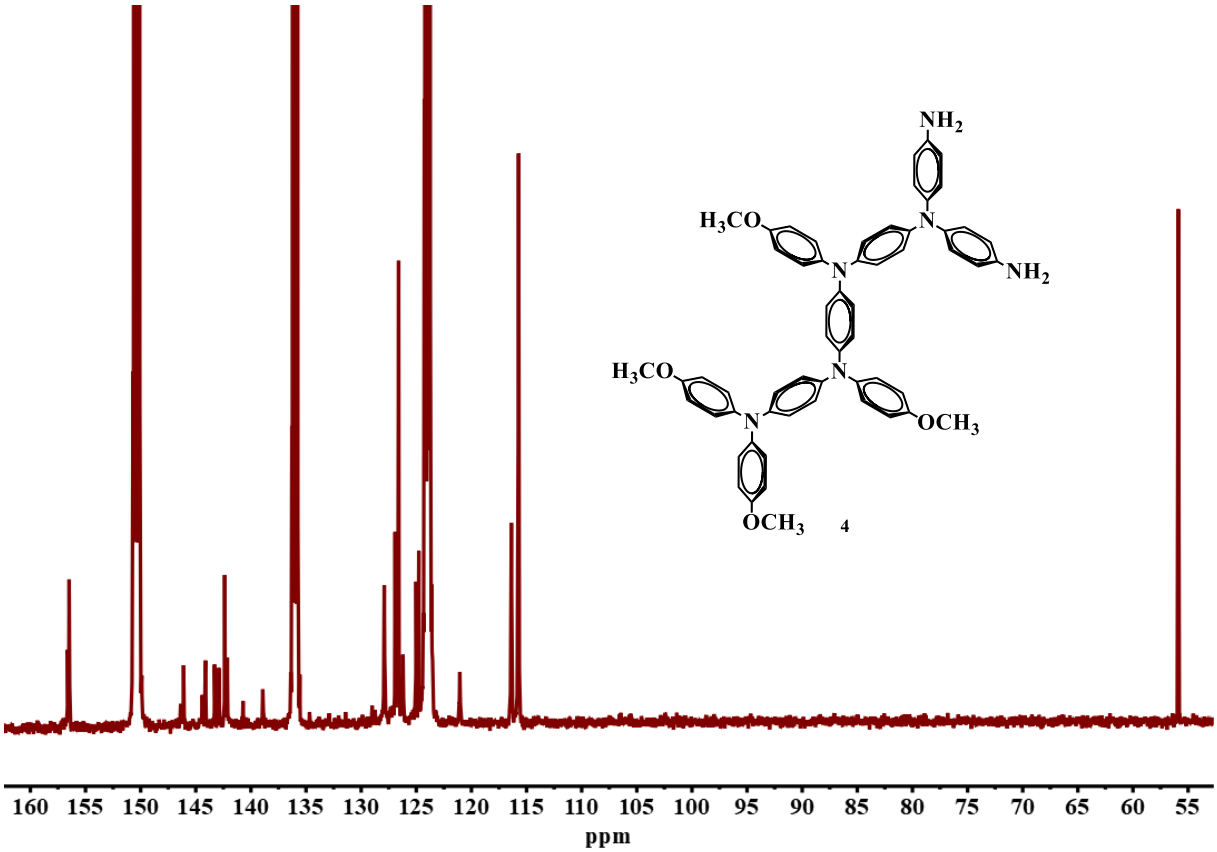

Fig. S5 ^{13}C NMR spectrum of compound **4**. (d-solvent: Pyridine-d_5)

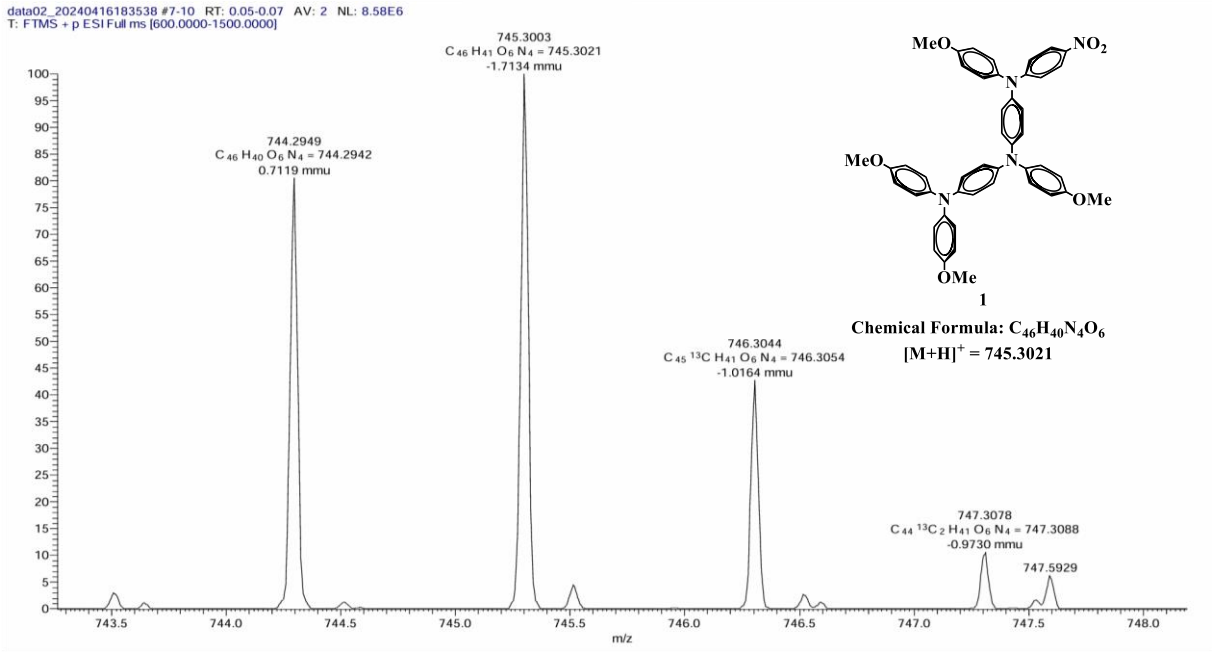

Fig. S6 ESIMS spectrum of compound **1**.

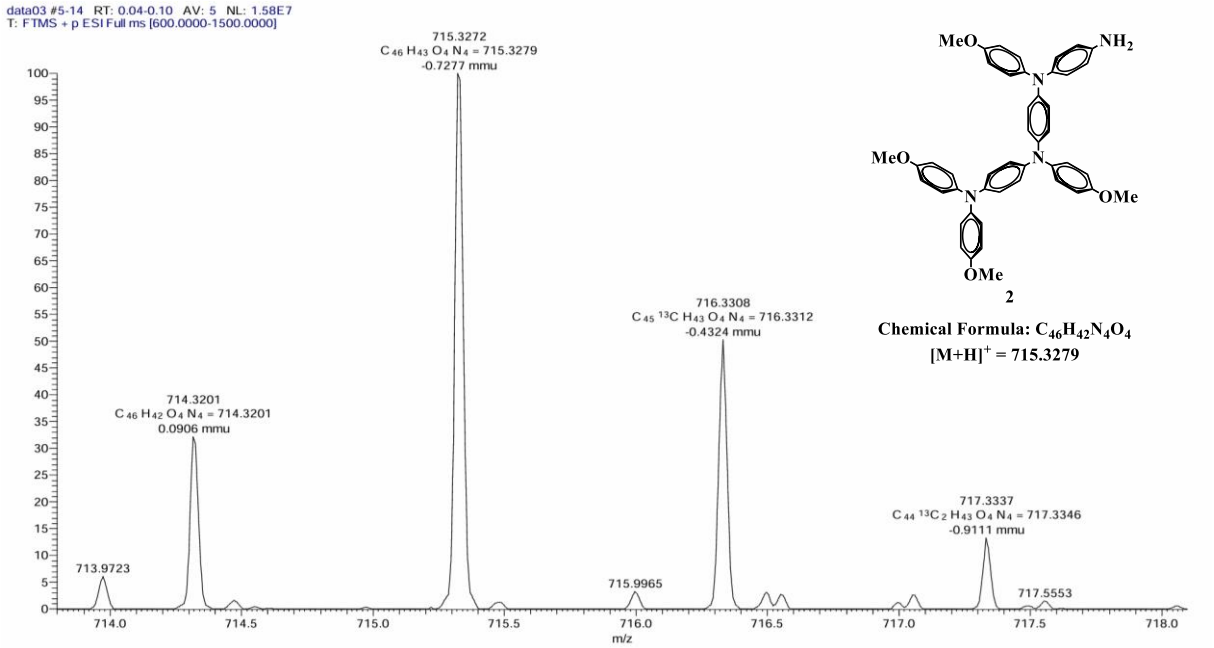

Fig. S7 ESIMS spectrum of compound **2**.

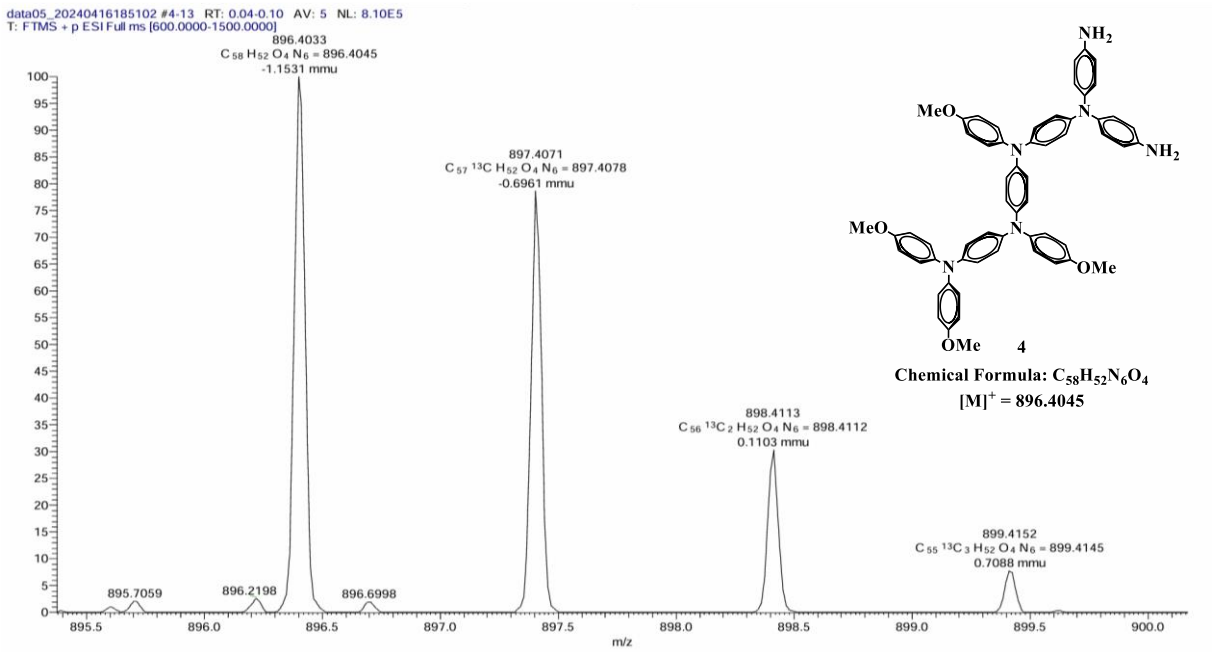

Fig. S8 ESIMS spectrum of compound **4**.

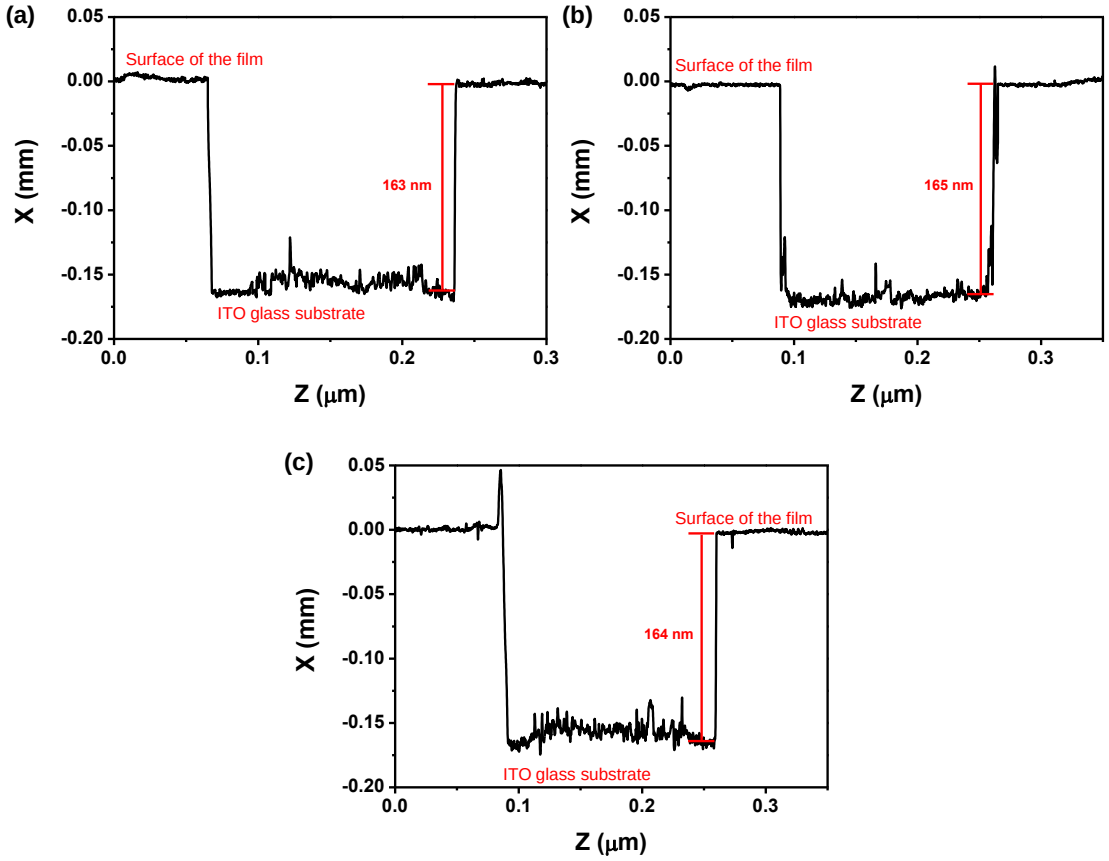

Fig. S9 Thickness and surface morphology of PAs (a) **5a**, (b) **5b**, and (c) **5c**.

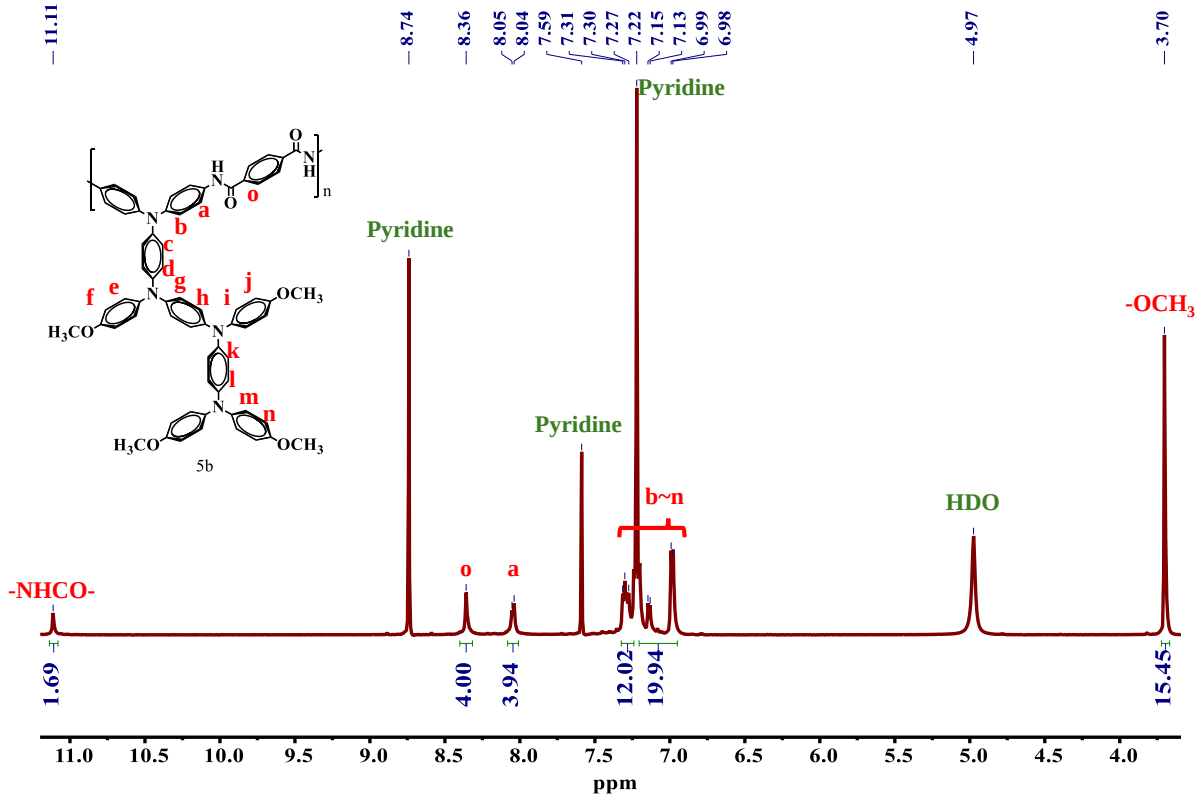

Fig. S10 ^{1}H NMR spectra of PA **5b**. (d-solvent: Pyridine-d_5)

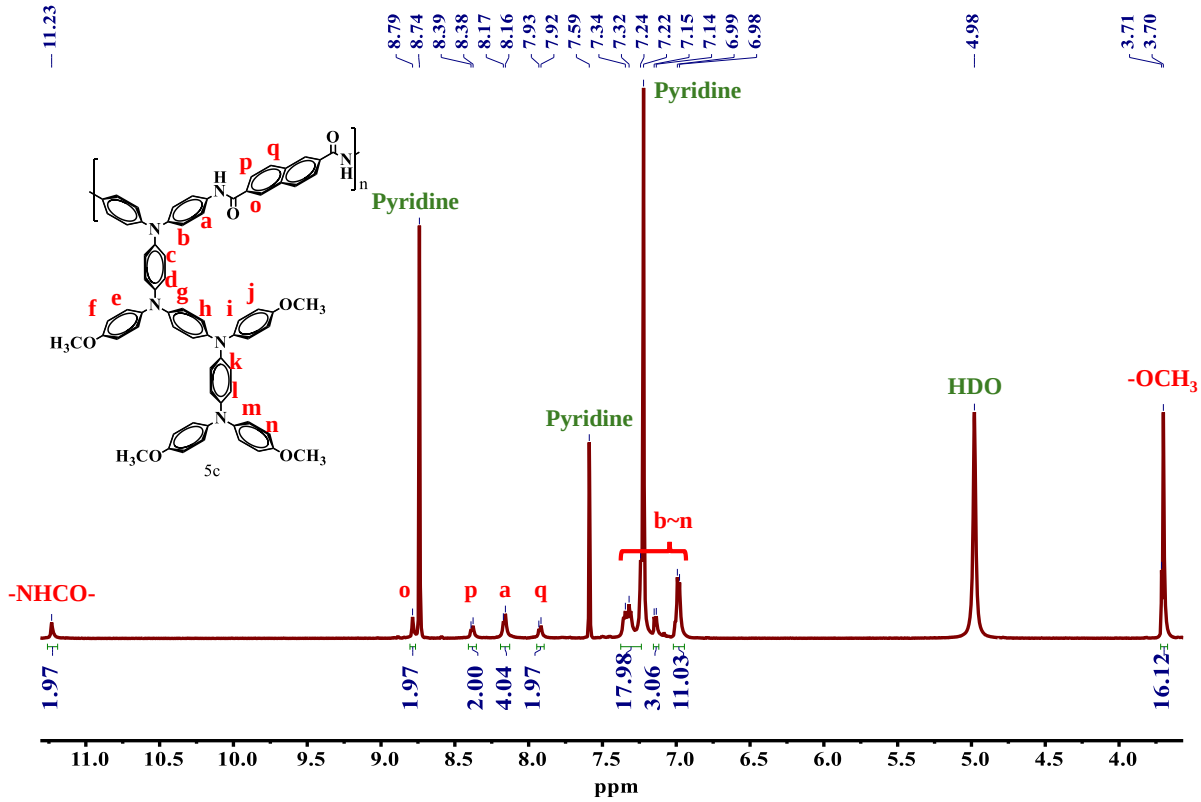

Fig. S11 ^{1}H NMR spectra of PA **5c**. (d-solvent: Pyridine-d_5)

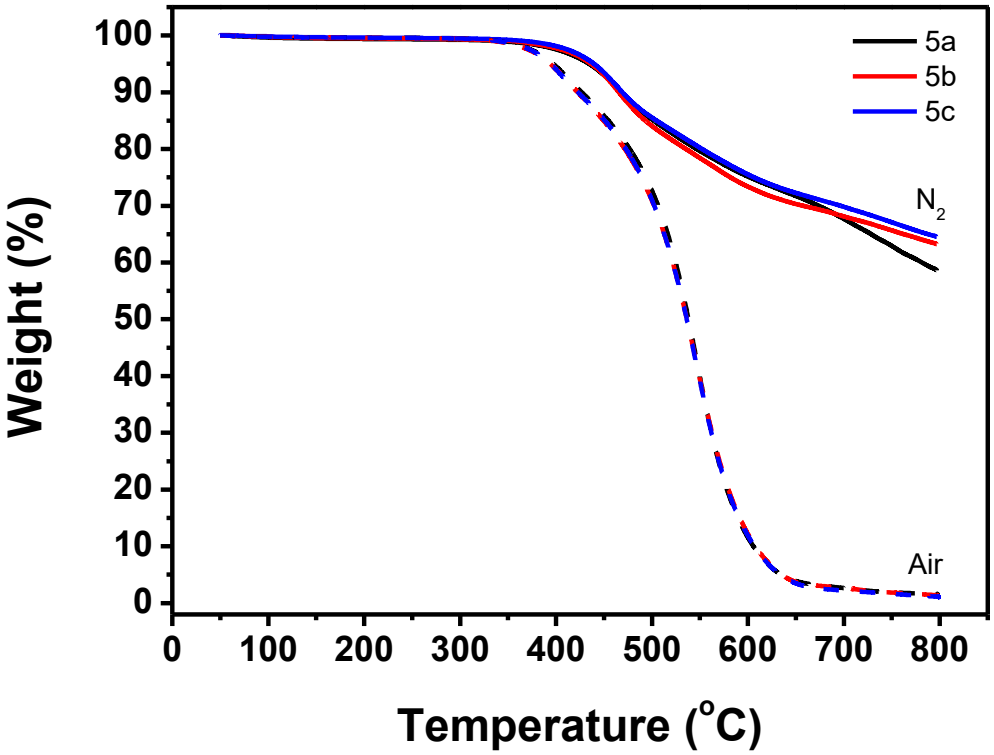

Fig. S12 TGA thermograms of PAs **5** at a heating rate of 20 °C min^{-1} from 50 to 800 °C.

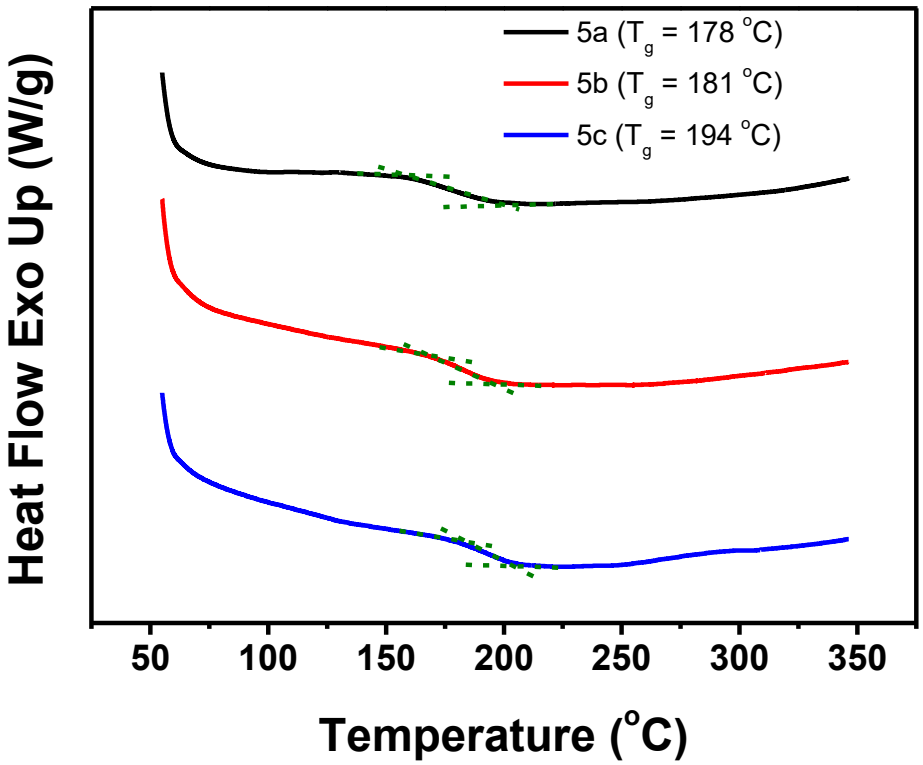

Fig. S13 DSC traces of PAs **5** at a heating rate of 20 °C min^{-1} from 50 to 350 °C.

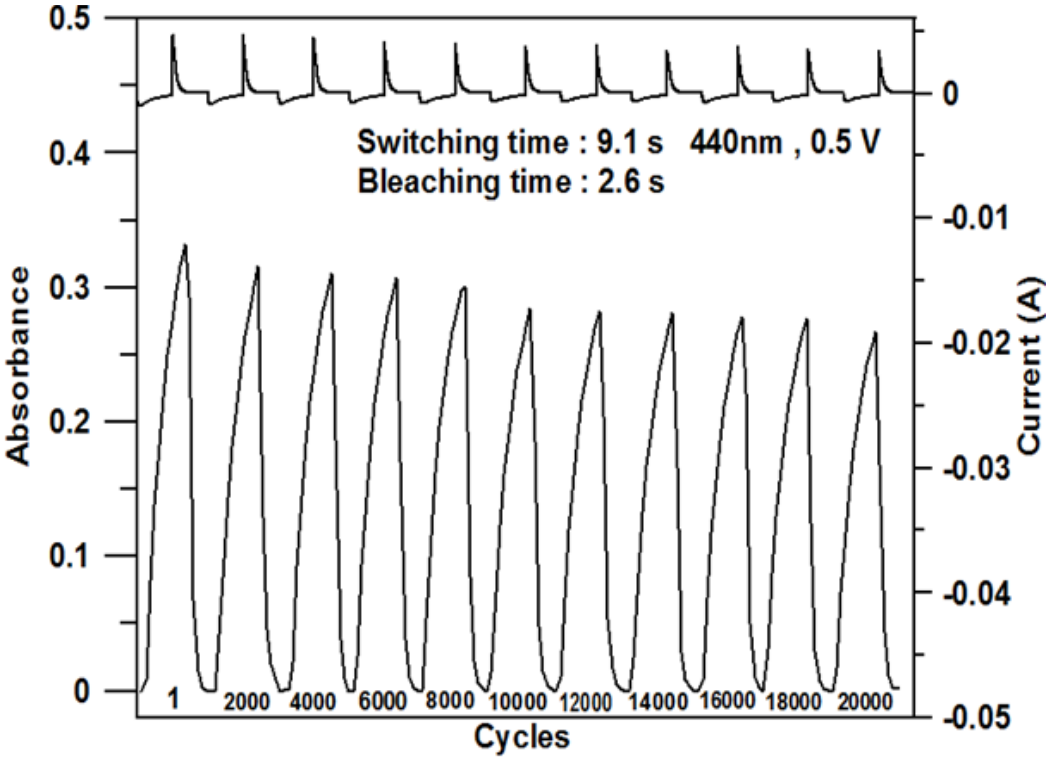

Fig. S14 Potential step absorptometry and current consumption of PA **5a** (in MeCN with 0.1 M TBAP as the supporting electrolyte) by applying a potential step 0.0 V ↔ 0.5 V, and cycle time 20 sec.

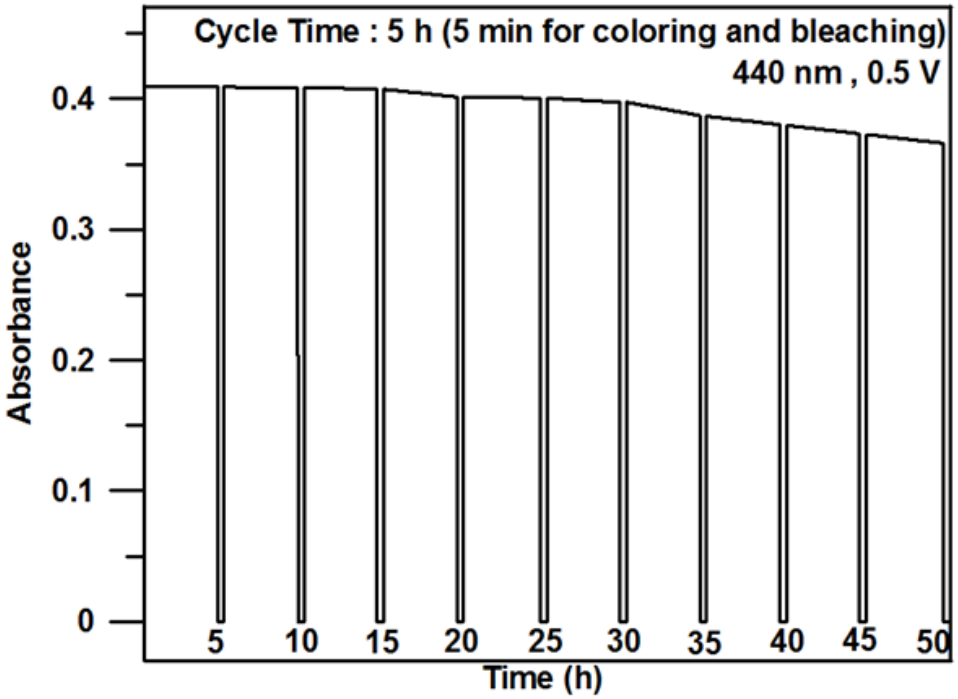

Fig. S15 Potential step absorptiometry during the continuous cycling test of PA **5a** (in MeCN with 0.1 M TBAP as the supporting electrolyte) by switching potentials step 0.00 V ↔ 0.50 V, with a cycle time of 5 h and 5 min for coloring and bleaching processes, respectively.

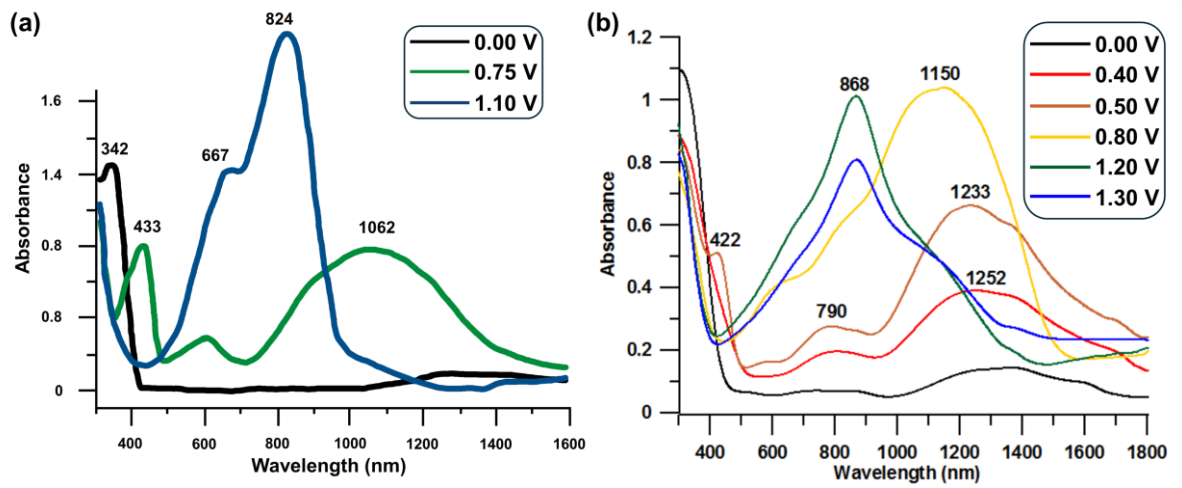

Fig. S16 Absorbance spectra of (a) **P1** and (b) **P2** thin-film electrode in 0.1 M TBAP/MeCN at different applied potentials.