Supporting Information

All-in-one electrochromic fabrics with improved cycling stability via modified polyaniline towards environmental adaptive camouflage

Mingyu Ding, Wanzhong Li, Ang Li, Yuhao Wang, Jingbing Liu, Qianqian Zhang, Hao Wang**

Content of Supporting Information

1. The ratio of deposition solutions with different doping acids

Table S1. The ratio of deposition solutions with different doping acids

	SA-PANI	DBSA-PANI	pTSA-PANI
Acid	0.3 mol/L	0.05 mol/L	0.5 mol/L
Aniline	0.5 mol/L	0.01 mol/L	0.2 mol/L
Solvent	ethanol	deionized water	deionized water

2. Verification of initial oxidation potential spectrum

Comparison of spectral transmittance (350 nm - 1100 nm) modulation amplitude of PANI films in reduced state and at 0 V.

As show in Figure S1, pTSA-PANI has the biggest modulation amplitude, and SA-PANI has the smallest one. This proves that at 0 V voltage, DBSA-PANI and pTSA-PANI have already started the oxidation reaction, while SA-PANI has not yet. Based on the magnitude of the modulation amplitude, it can be inferred that pTSA-PANI has the highest degree of oxidation. The result is consistent with their E_{onset}.

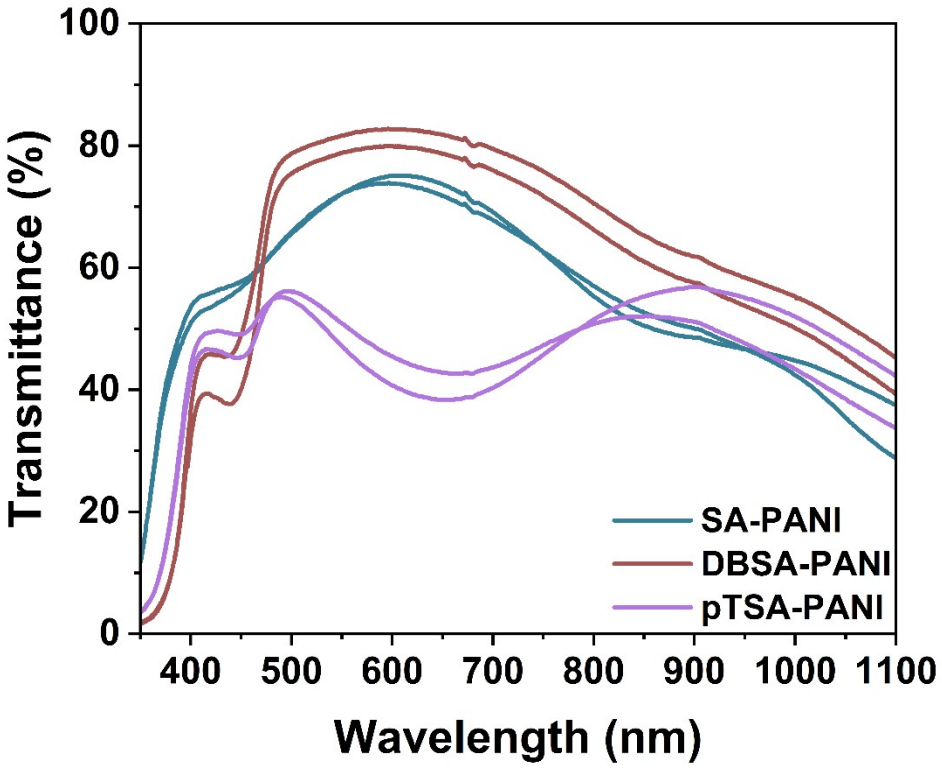

Figure. S1. Comparison of spectral transmittance (350 nm - 1100 nm) modulation amplitude of PANI films in reduced state and at 0 V.

3. Morphology of three different PANIs on ITO glass

Figure S2 shows the morphology of PANI after long-term deposition and free growth, with a deposition time of 3600 seconds, for the purpose of observing the morphology characteristics. This proves that the electrodeposition morphology of PANI doped with different anions is fixed and will not change due to different substrates.

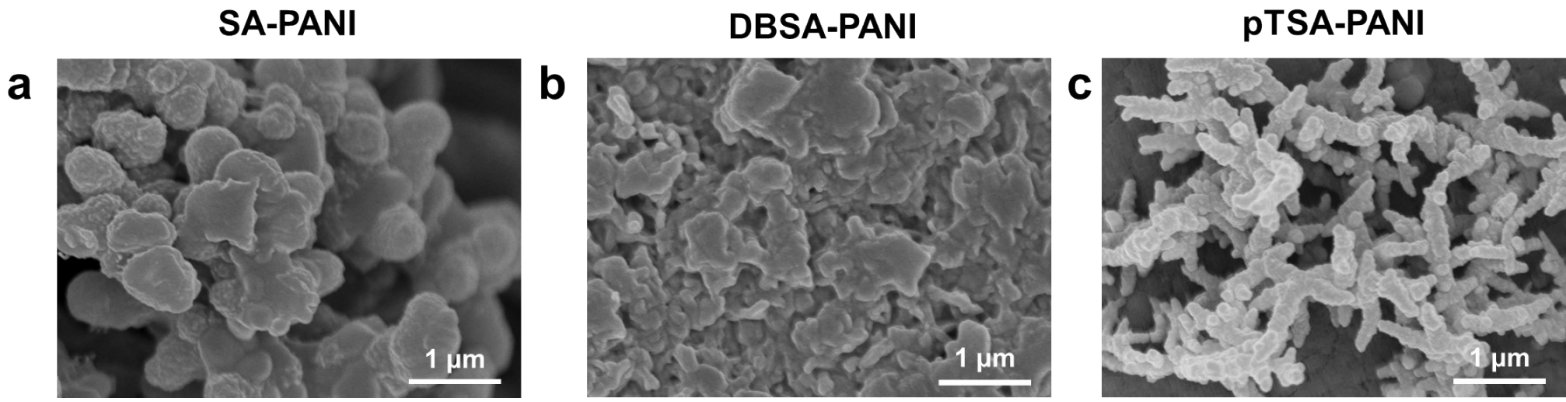

Figure. S2. SEM images of ITO growth with different doping anions.

4. Current during CV cycle process

The reduction peak potential and oxidation peak potential represent the leucoemeraldine (LE) state of PANI and emeraldine salt (ES) state. Figure. S3 shows CV curves of different anion doping PANI at different scanning speeds.

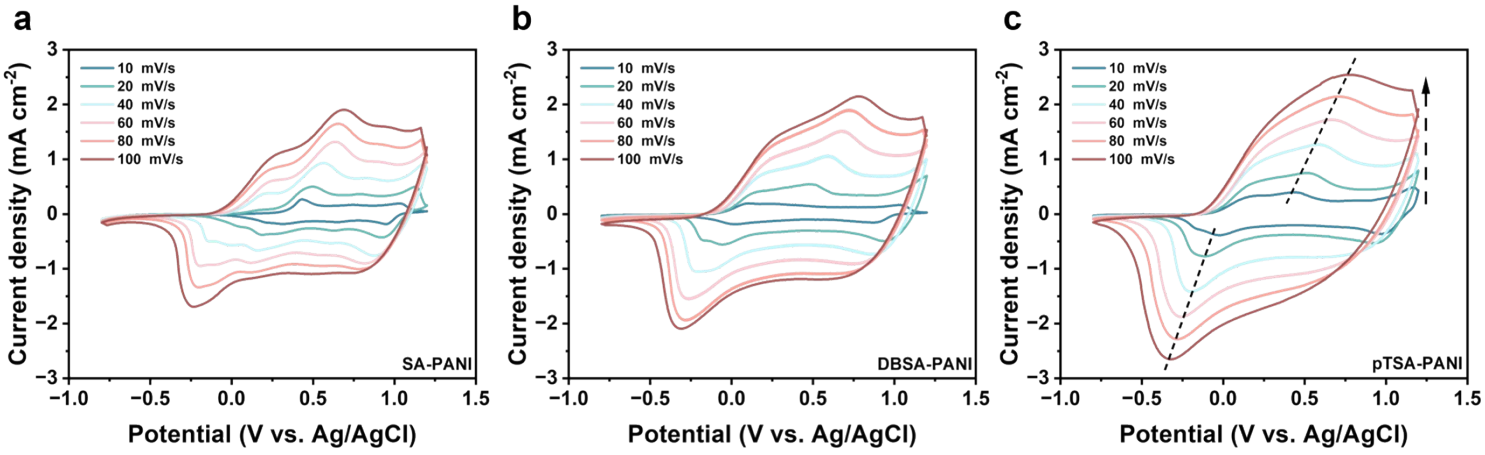

Figure. S3. CV curves of three doped PANI at different scanning rates, (a) SA-PANI (b) DBSA-PANI (c) pTSA-PANI.

5. All-in-one pTSA-PANI devices performance

As show in the Figure. S4, the device exhibited a uniform yellow green transition at ± 2V voltage, indicating that the pTSA-PANI EC fabrics exhibited consistent performance with previous studies on integrated devices on Au-nylon substrates.

As show in the Figure. S5, it respectively demonstrated the performance of EC fabrics under normal conditions, bending at 60°, bending at 120°, and folding at 180°.

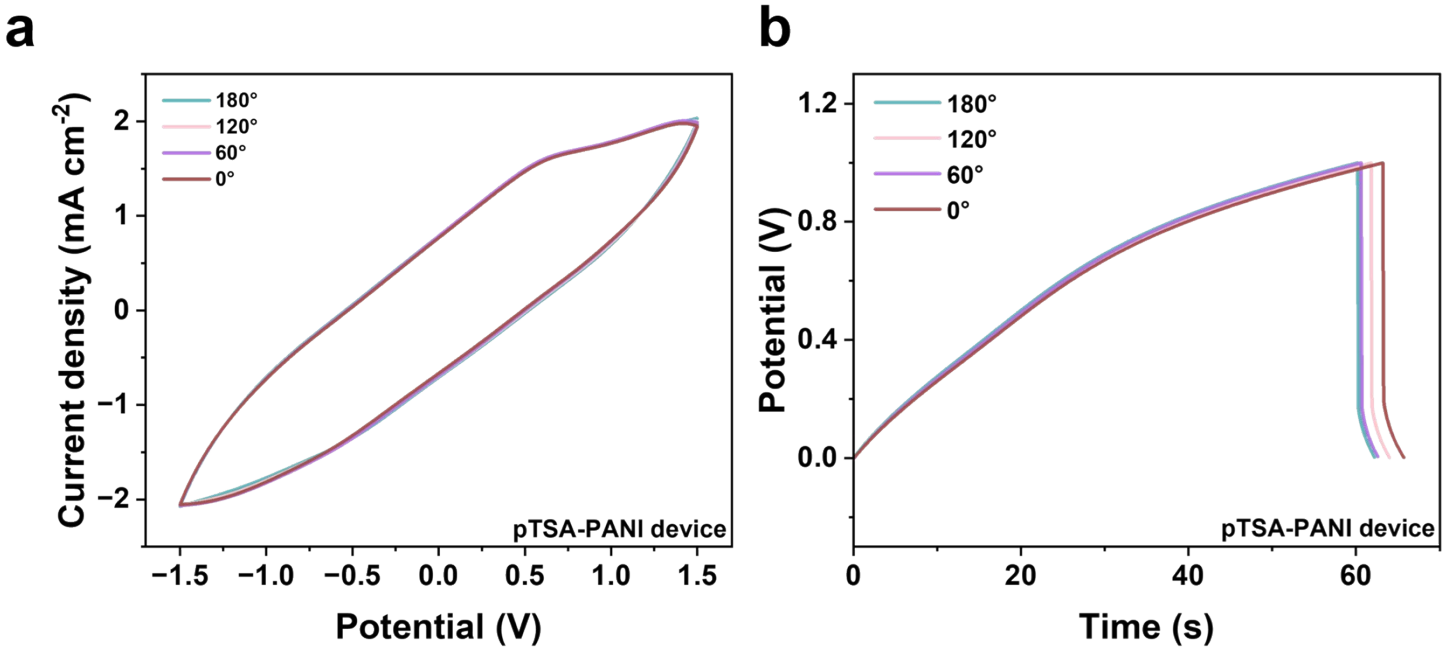

Figure. S4. Device's CV curves and GCD curves at different bending angles.

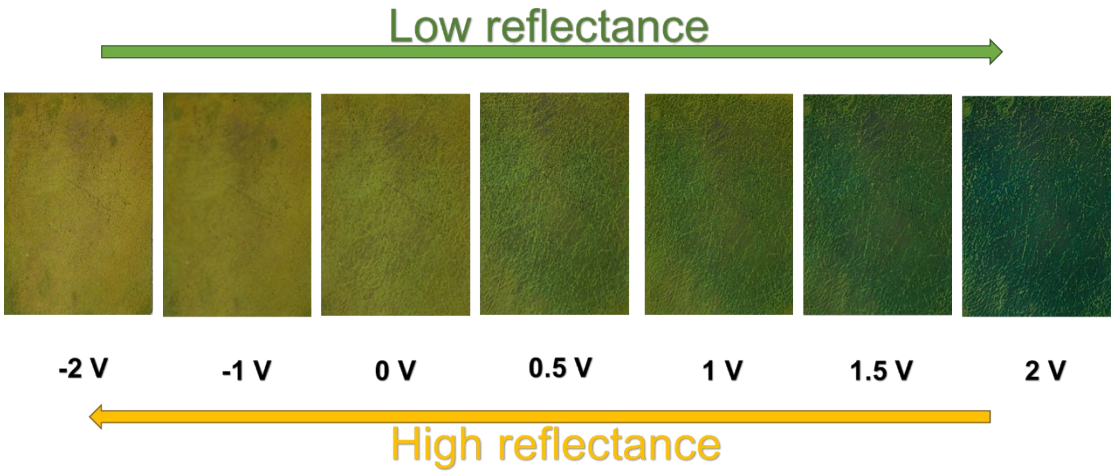

Figure. S5. Digital images of EC fabrics: uniform yellow-green transition under an applied voltage of ±2 V.

6. Performance comparison of all-in-one devices

As show in the Figure. S6, the pTSA-PANI's surface generates fine needle like structures with a larger specific surface area and higher electrochemical activity. This also indicates that the method of anionic modification is not affected by different substrates in affecting the morphology characteristics.

As show in the Figure. S7, even on a flexible substrate, pTSA-PANI still has a faster response time, indicating that in its theoretical calculations, E_{onset}, as a characteristic of the material itself, is not affected by the substrate.

As show in the Figure. S8, after calculations, we found that pTSA-PANI also exhibits better coloration efficiency in EC fabrics. This result is consistent with the performance of PANI films.

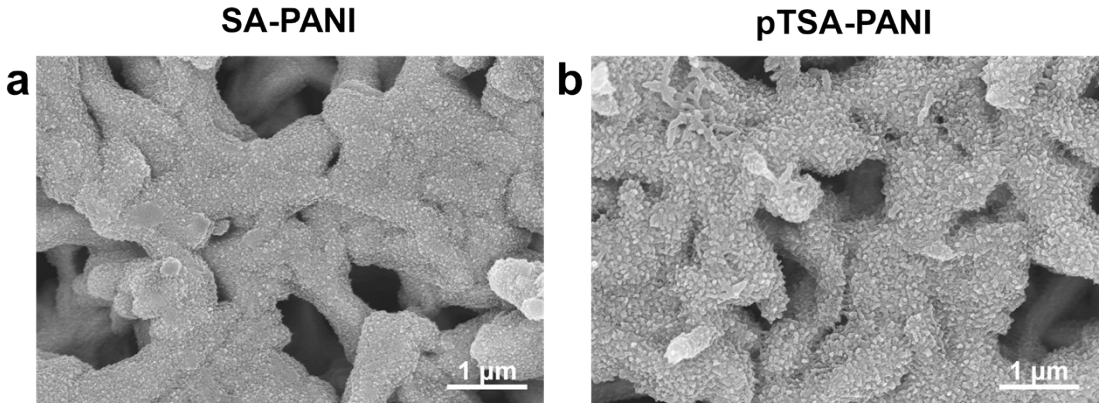

Figure. S6. Microscopic morphology of SA-PANI and pTSA-PANI all-in-one devices.

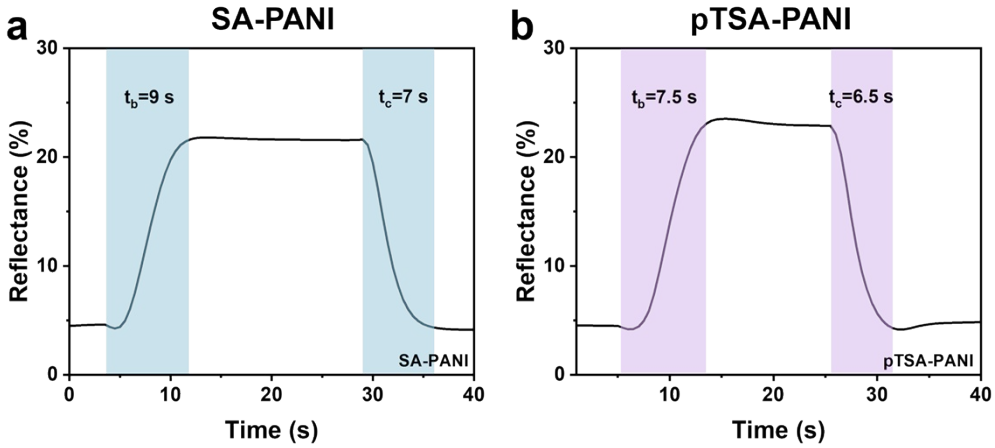

Figure. S7. Electrochromic response time of SA-PANI and pTSA-PANI all-in-one devices.

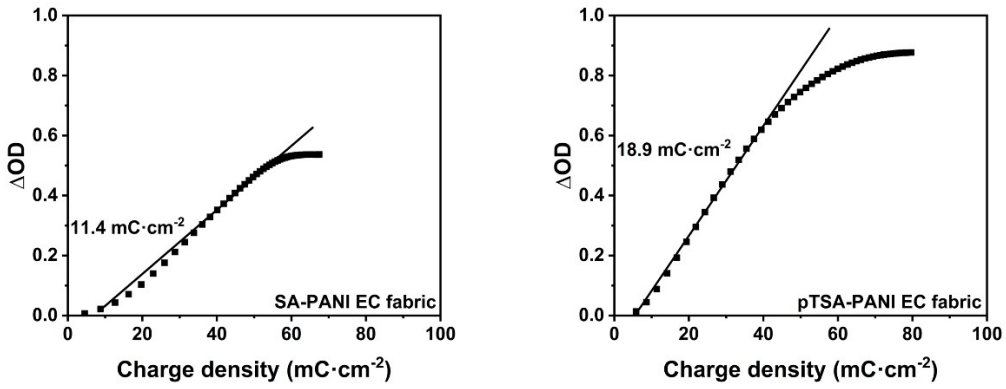

Figure. S8. The coloring efficiency of SA-PANI and pTSA-PANI applied to EC fabrics.

7. Environmental Adaptive System

Different from previous adaptive systems with larger volumes, EAS integrates various components through 3D printing technology and is powered by independent lithium batteries, allowing EAS to be independent of computers and without manual intervention, truly achieving automatic adaptation.

For EC fabrics with physical display requirements, we optimized the preparation method for large-area device preparation, such as increasing the capacity of the sedimentation tank, replacing large-area counter electrodes, and replacing working electrode clamps. The commonly used samples of our EC fabric are 2 cm × 3.5 cm, 5 cm × 5 cm, and 8 cm × 8 cm. After optimizing our preparation process, they all have significant reproducibility. The spectra of three samples of different sizes in their initial states are showed in Figure S10.

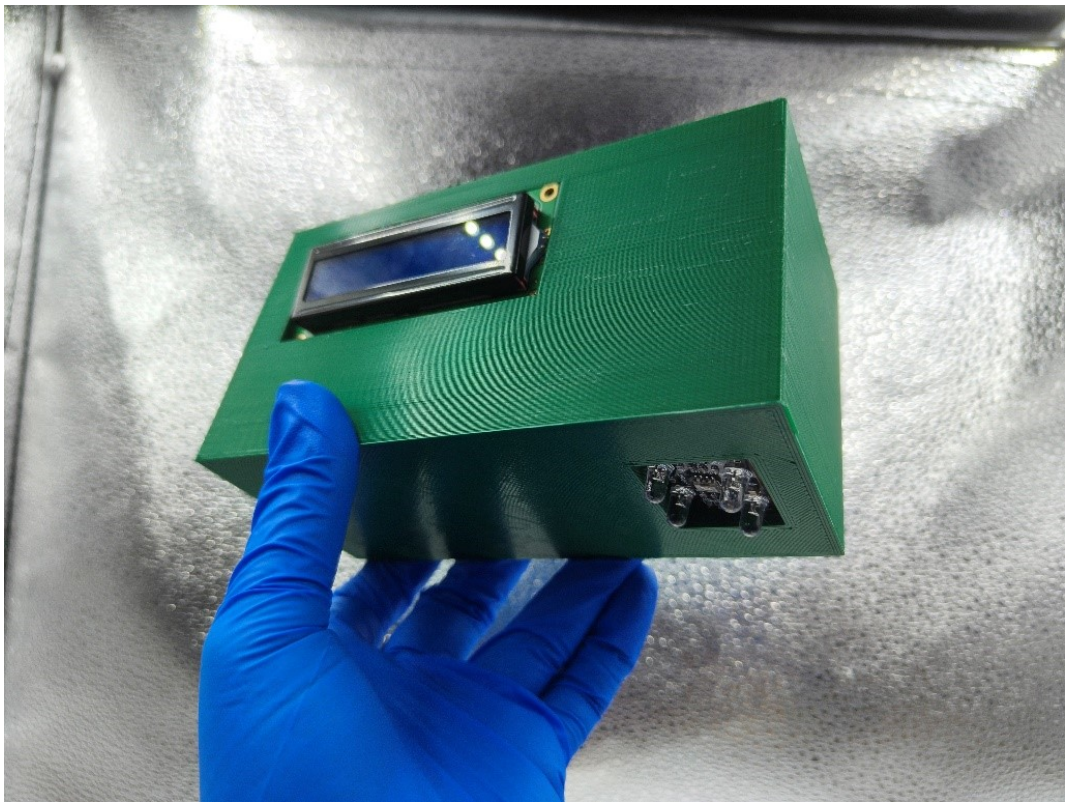

Figure. S9. The EAS system integrated into the 3D shell.

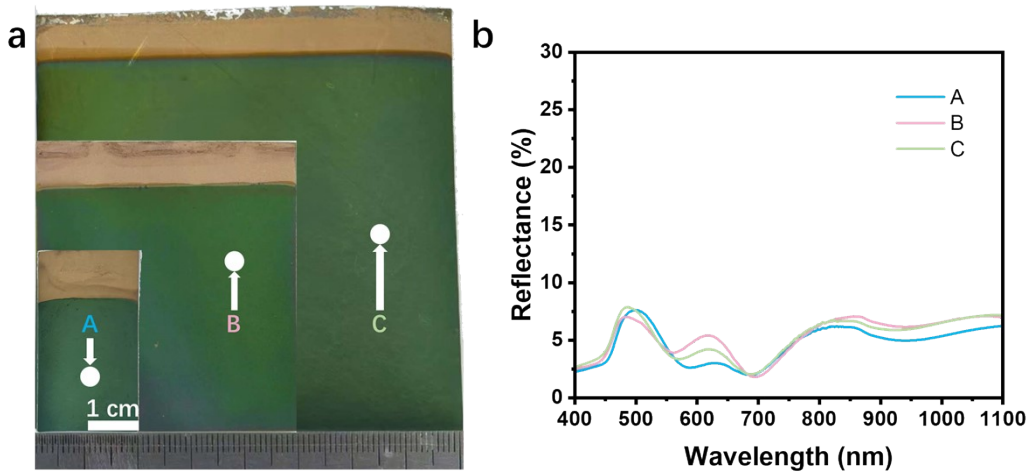

Figure S10. (a) Comparison of physical images of EC fabric samples of different sizes and random sampling for spectral measurement. (b) Randomly select points for spectral measurement at 350 nm-1100 nm.