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Deposition-Time Dependence of the Electrochemical Response of Polyaniline Films Co-electrodeposited with Carbon Black

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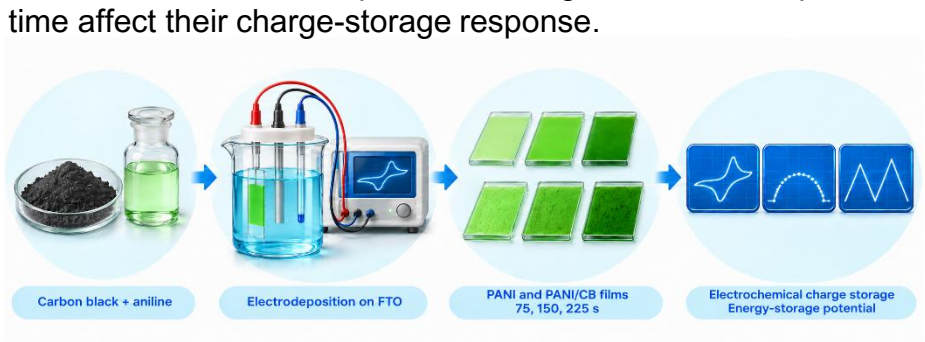
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Introduction

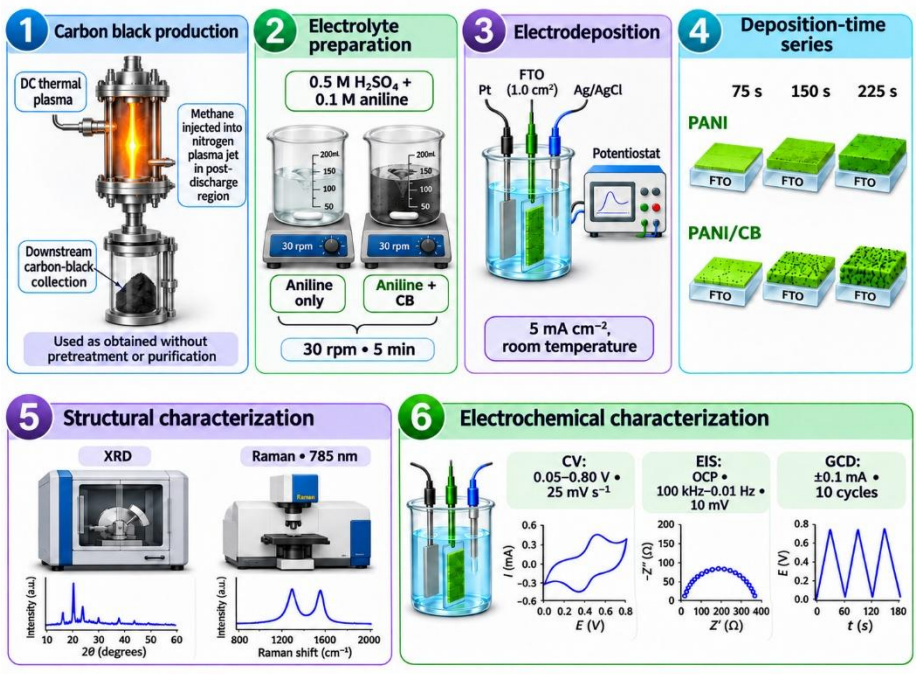
Polyaniline (PANI) is a redox-active conducting polymer used in electrochemical charge-storage electrodes, and its morphology and electrochemical response are influenced by electrodeposition conditions [1]. Carbon black (CB) has also been incorporated into PANI-based composites, with recent studies reporting composition- and morphology-dependent electrochemical behavior [2,3]. In this work, pristine PANI and PANI/CB thin films were galvanostatically deposited on fluorine-doped tin oxide (FTO) for 75, 150, and 225 s. Their electrochemical responses were compared using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge–discharge (GCD).

Goals

To assess the potential of pristine PANI and PANI/CB thin films as electrochemical energy-storage electrodes by determining how carbon black incorporation and galvanostatic deposition time affect their charge-storage response.



Methodology



Results

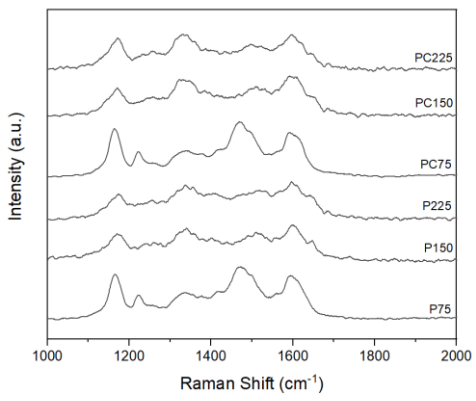


Figure 1: Raman spectra of pristine PANI (P75, P150, and P225) and PANI/CB composite films (PC75, PC150, and PC225) electrodeposited on FTO for 75, 150, and 225 s, respectively. Spectra were acquired using 785 nm excitation and vertically offset for clarity. Intensity is reported in arbitrary units.

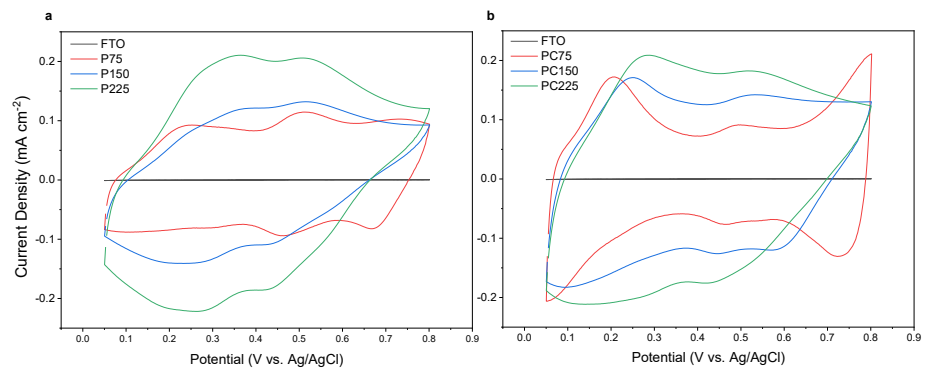


Figure 2: Cyclic voltammograms of (a) PANI and (b) PANI/CB electrodes prepared at deposition times of 75, 150, and 225 s, together with bare FTO. Measurements were performed in 1.0 M H_2SO_4 at 25 mV s^{-1} over 0.05–0.80 V vs Ag/AgCl.

Table 1. CV-derived apparent areal capacitance and estimated areal energy and power densities for bare FTO, PANI, and PANI/CB electrodes. Measurements were performed in 1.0 M H_2SO_4 at 25 mV s^{-1} over 0.05–0.80 V vs Ag/AgCl.

Sample	$C_{A,CV}$ (mF cm^{-2})	E_A (µWh cm^{-2})	P_A (µW cm^{-2})
FTO	0.0118	0.000923	0.111
P75	3.19	0.249	29.9
P150	3.60	0.282	33.8
P225	5.80	0.453	54.3
PC75	4.05	0.317	38.0
PC150	4.85	0.379	45.5
PC225	5.88	0.459	55.1

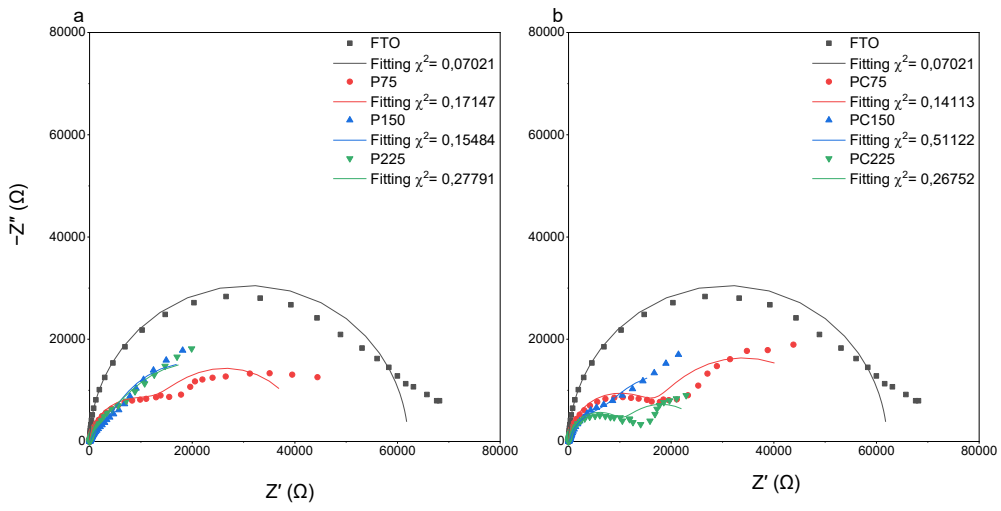


Figure 3: Nyquist plots and equivalent-circuit fits for (a) bare FTO and pristine PANI electrodes and (b) bare FTO and PANI/CB electrodes. Symbols denote experimental data and lines denote fitted responses; χ^2 values are indicated in the panels. EIS measurements were performed at each electrode's OCP in 1.0 M H_2SO_4.

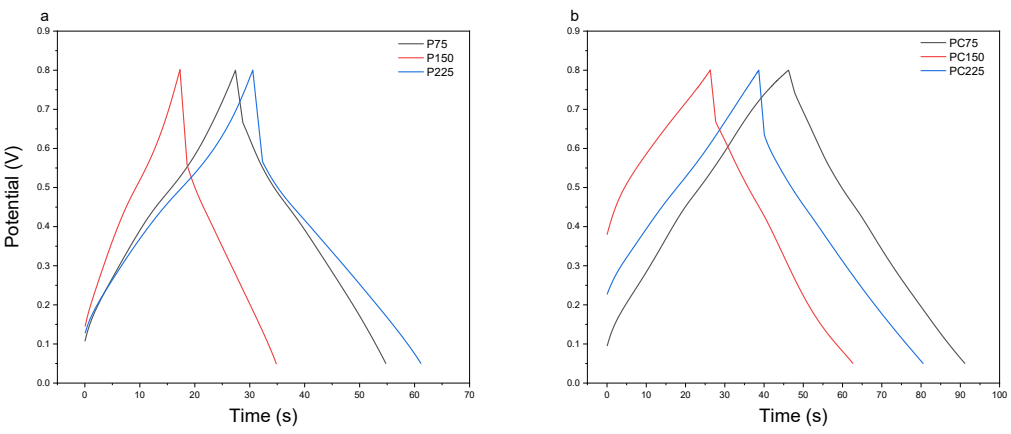


Figure 4: Galvanostatic charge–discharge profiles of (a) pristine PANI electrodes (P75, P150, and P225) and (b) PANI/CB electrodes (PC75, PC150, and PC225). Measurements were performed in 1.0 mol L^{-1} H_2SO_4 using charge and discharge currents of +0.1 and −0.1 mA, respectively ($|j|$ = 0.1 mA cm^{-2}), within the 0.05–0.80 V potential window vs. Ag/AgCl. The acquisition interval was 0.05 s.

Conclusions

Raman spectra showed PANI-associated vibrational features, while electrochemical measurements revealed that the effect of carbon black depended on deposition time. PANI/CB films showed higher apparent capacitance at 75 and 150 s, but values were similar to pristine PANI at 225 s. These results support further evaluation of PANI/CB films for electrochemical energy storage.

References and Acknowledgments

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