Fabrication of poly(aniline-co-3-aminobenzoic acid) electrospun nanofiber film for simultaneously electrochemical detection of dopamine and uric acid

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Abstract

This research aimed to fabricate and investigate the electrochemical properties of poly(aniline-co-3-aminobenzoic acid) (PANI/PABA) electrospun nanofiber film for the simultaneously electrochemical detection of dopamine (DA) and uric acid (UA). The PANI/PABA was synthesized via chemical oxidative polymerization at molar ratios of aniline-to-3-aminobenzoic acid as 1:1, 1:2, and 2:1, using ammonium persulfate (APS) as the oxidizing agent. The nanofiber film of the synthesized copolymer were then prepared by electrospinning method onto a fluorine-doped tin oxide (FTO) coated glass substrate under controlled condition (an applied voltage of 15 kV, a solution flow rate of 1.0 mL/h, a solution volume of 5 mL, a needle-to-collector distance of 15 cm, and a spinning time of 15 minutes). Morphological analysis using scanning electron microscopy (SEM) revealed that the PANI/PABA nanofiber at 2:1 ratio exhibited clearer, more continuous, and more uniform fiber structures than those at ratios of 1:1 and 1:2, with an average fiber diameter of 87.228 nm. Structural characterization by attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy confirmed the copolymer formation through the presence of characteristic functional groups, including C–H, C=O, C=C, and C–N. Electrochemical properties were investigated using cyclic voltammetry (CV) in the potential range of −0.2 to 0.9 V at scan rates of 20, 40, 60, 80, 100, 200, 300, and 400 mV/s for two cycles in a phosphate buffer saline solution containing 5 mM $K_3Fe(CN)_6$ and 0.1 M KCl. The CV results clearly demonstrated that the electron transfer behavior at the electrode surface of the 2:1 ratio exhibited the highest current response, which indicated a good electrical conductivity. Furthermore, an application in electrochemical sensing using differential pulse voltammetry (DPV) showed that the fabricated electrospun nanofiber film of the synthesized PANI/PABA provided high specificity and effectively simultaneous detection of DA and UA.

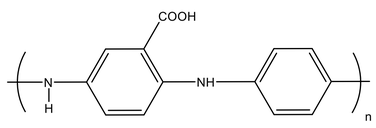
Introduction

The development of electrochemical sensors using conductive polymers has received considerable interest due to their good electrical conductivity and scalability. This research focuses on the preparation of poly(aniline-co-3-aminobenzoic acid) (PANI/PABA) nanofiber film using electrospinning under controlled condition. The obtained film is used as modified electrode for the simultaneously detection of dopamine and uric acid using differential pulse voltammetry (DPV) technique, which demonstrating high specificity for target detection.



polyaniline; PANI

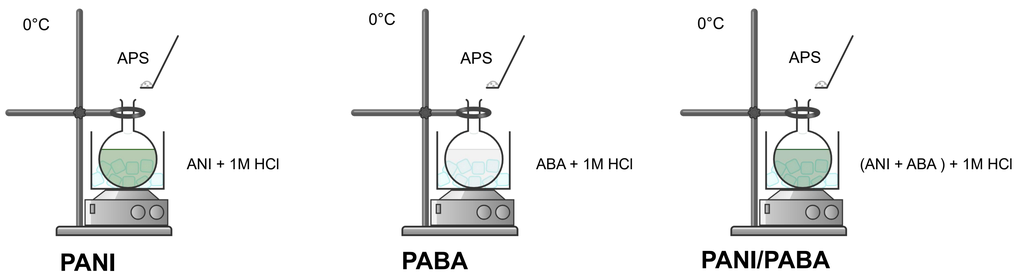
poly(3-Aminobenzoic Acid); PABA



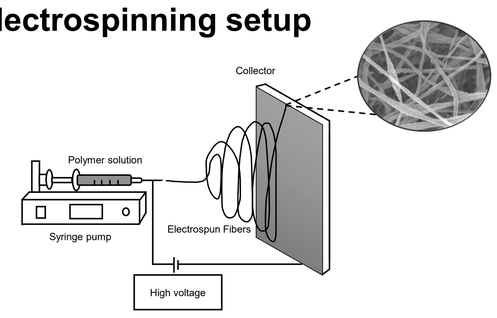
poly(aniline-co-3-Aminobenzoic Acid); PANI/PABA

Experimental

Synthesis of PANI, PABA and PANI/PABA

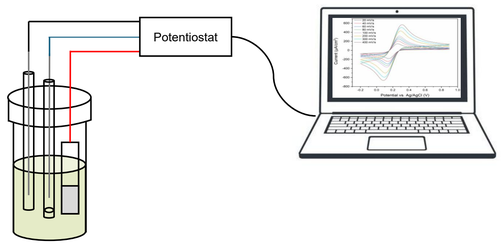


Electrospinning setup



Control variables
- The flow rate: 1.0 mL/hr.
- Volume of syringes: 5.0 mL
- Voltage: 15 kV
- Time: 5 min
- Distance between collector: 15 cm
- Room temperature

Electrochemical detection



Reference Electrode (RE) : Ag/AgCl
Counter Electrode (CE) : Platinum (Pt)
Working Electrode (WE) : PANI/PABA
Electrolyte : 5 mM $K_3Fe(CN)_6$ and 0.1 M KCl

Results and Discussion

SEM

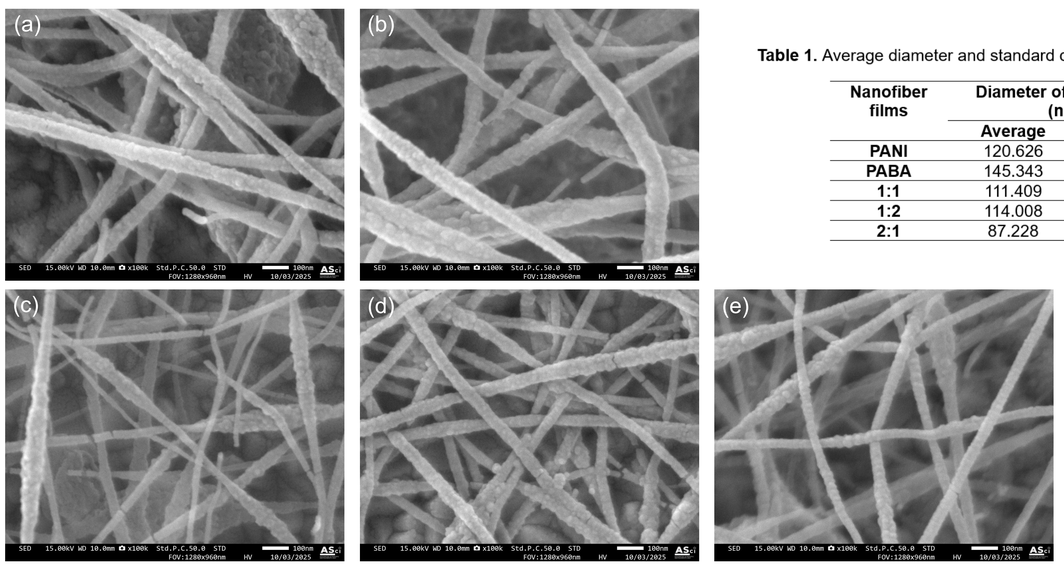


Figure 1. SEM images of the electrospun nanofiber films **(a)** PANI **(b)** PABA **(C)** PANI/PABA ratio of 1:1 **(d)** PANI/PABA ratio of 1:2 **(e)** PANI/PABA ratio of 2:1

Table 1. Average diameter and standard deviation of nanofiber films

Nanofiber films	Diameter of nanofibers (nm)	
	Average	S.D.
PANI	120.626	25.508
PABA	145.343	45.894
1:1	111.409	30.276
1:2	114.008	34.984
2:1	87.228	21.04

Electroactivity

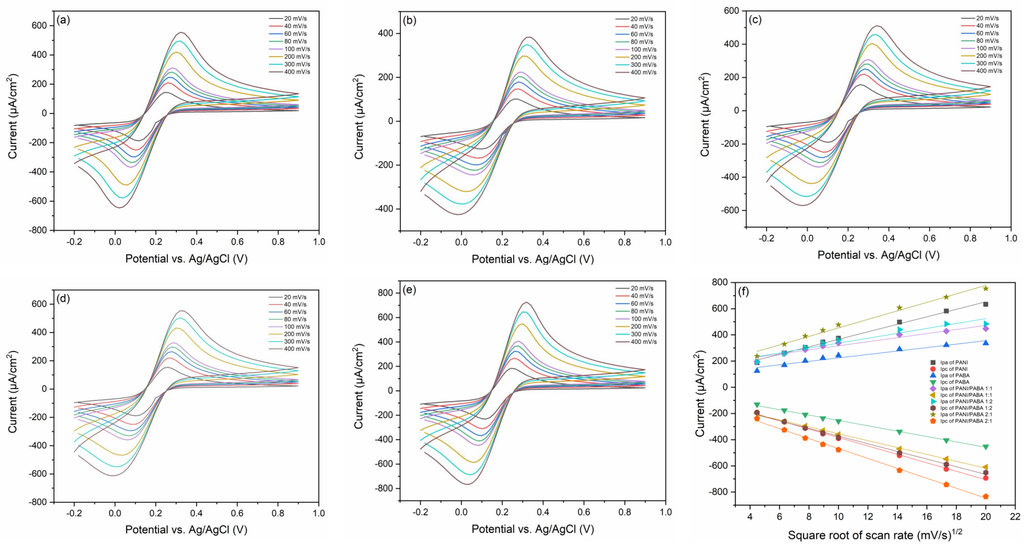


Figure 2. Cyclic voltammograms at various scan rate **(a)** PANI, **(b)** PABA and **(c)** PANI/PABA ratios of 1:1 **(d)** PANI/PABA ratios of 1:2 **(e)** PANI/PABA ratios of 2:1 with **(f)** linear plots between anodic current and cathodic current in 5 mM $K_3Fe(CN)_6$ and 0.1 M KCl.

Table 2. Redox peak current ratio: I_{pa}/I_{pc}

Nanofiber films	I_{pa}/I_{pc}
PANI	0.9583
PABA	0.8958
1:1	0.9016
1:2	0.9139
2:1	0.9744

Electrochemical detection

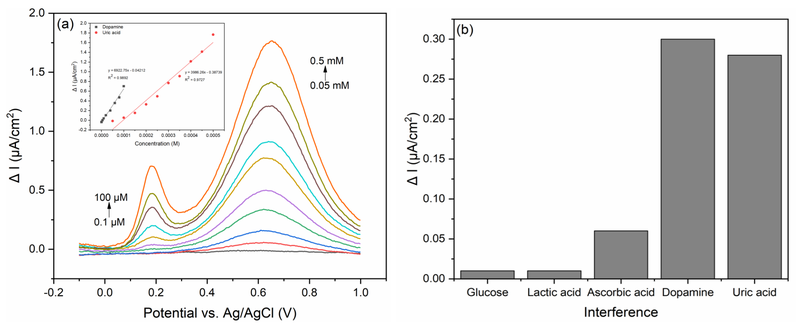


Figure 3. (a) DPV responses for simultaneously detection of DA and UA and **(b)** bar chart for selectivity study using the PANI/PABA (2:1) electrospun film.

ATR-FTIR Spectra

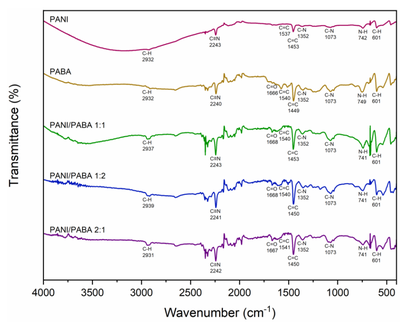


Figure 4. ATR-FTIR spectra of the fabricated electrospun nanofiber films on FTO substrate.

Acknowledgements

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References
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[2] Salavagione, H. J., Acevedo, D. F., Miras, M. C., Motheo, A. J., & Barbero, C. A. (2004).

Conclusions

- Poly(aniline-co-3-aminobenzoic acid) (PANI/PABA) nanofiber film was successfully prepared using the electrospinning technique for the simultaneously electrochemical detection of dopamine and uric acid.
- ATR-FTIR analysis confirmed the presence of key functional groups, namely C–H, C=O, C=C, and C–N indicating the formation of a copolymer structure.
- The electrospun nanofiber film of PANI/PABA exhibited high specificity for the detection of dopamine and uric acid.