Fabrication of Polyaniline and Poly(3-aminobenzoic acid) copolymer thin film by electropolymerization

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Abstract

The fabrication of thin films of polyaniline (PANI), poly(3-aminobenzoic acid) (PABA), and the PANI/PABA copolymer was carried out using the electropolymerization technique for potential applications in target biomolecule detection. The preparation of PANI and PABA thin films was conducted via cyclic voltammetry (CV) using aniline (ANI) and 3-aminobenzoic acid (3-ABA) monomer solutions, respectively, in sulfuric acid (H_2SO_4) as the electrolyte. The PANI/PABA copolymer thin film was synthesized by electropolymerization of both monomers at a 1:1 ratio onto a fluorine-doped tin oxide (FTO)-coated glass substrate, which served as the working electrode. The reference and counter electrode were Ag/AgCl and Pt wire, respectively. The electrochemical properties of the PANI, PABA, and PANI/PABA copolymer thin films were investigated using cyclic voltammetry. The results revealed that the PANI/PABA thin film exhibited a higher redox (oxidation/reduction) current than the individual PANI and PABA films, which indicating a larger active surface area and enhanced electron transfer efficiency. Furthermore, scanning electron microscopy (SEM) and ATR-FTIR (Attenuated Total Reflection Fourier Transform Infrared Spectroscopy) analyses confirmed the formation of the polymeric structures. In conclusion, the PANI/PABA thin film demonstrated promising potential for application as an electrochemical sensor for biomolecule detection, owing to its favorable electrochemical properties and high active surface area, which could further improve the sensitivity and specificity of future sensor developments.

Introduction

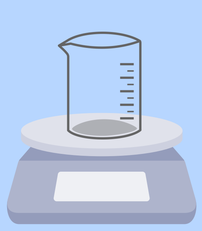
Conducting polymers had received much attention for use in biomedical and sensing applications. Among the conducting polymers, polyaniline (PANI), polypyrrole (PPy), polythiophene (PTh) and their derivatives such as poly(3-aminobenzoic acid) (PABA) or poly(3,4-ethylenedioxythiophene) (PEDOT) are the common conducting polymers for sensing applications PANI and its derivatives are one of the most studied conducting polymers because of their excellent stability and good electronic properties [1]

Objectives

1. To fabricate thin films of polyaniline (PANI) and poly(3-aminobenzoic acid) (PABA) copolymer using the electropolymerization method for the detection of target biomolecules in the future.
2. To study the electrochemical properties and amorphous of PANI, PABA, and PANI/PABA thin films.

Methodology

Preparation of ANI, 3-ABA and ANI/3-ABA solutions



ANI 0.0140g,
3-ABA 0.0209g

Dissolve in 0.5 M H_2SO_4
and adjust the volume to 10.00 mL.

Fabrication of thin films by electropolymerization

Technique : Cyclic Voltammetry
- Potential Range : 0.0 - 1.0 V
- Scan rate : 20 mV/s
- Number of scans : 10

Electode
- WE : FTO coated glass (red)
- RE : Ag/AgCl (blue)
- CE: Pt wire (black)

Electrolytes
1. ANI solution
2. 3-ABA solution
3. ANI/3-ABA

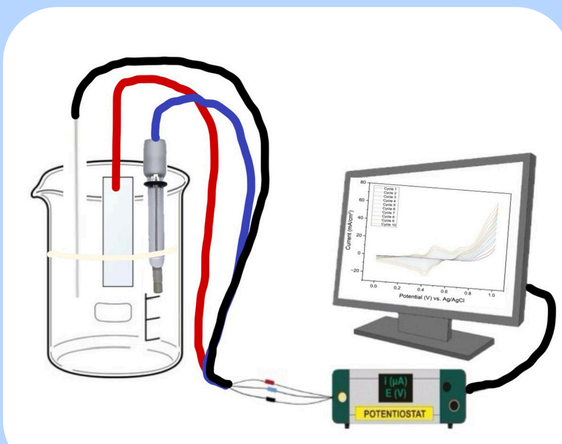


Fig 1. Equipment set up.

Results and Discussion

Fabrication of PANI, PABA and PANI/PABA copolymer thin films by electropolymerization

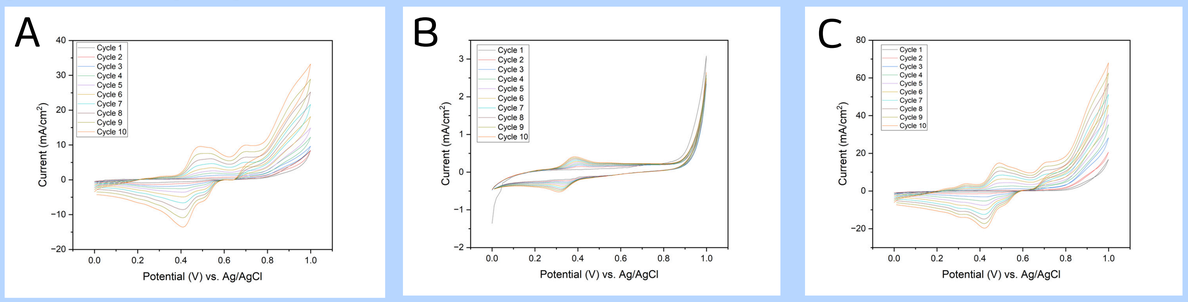


Fig 2. Cyclic voltammograms for fabrication of (A) PANI (B) PABA (C) PANI/PABA copolymer thin films

Characterization by SEM

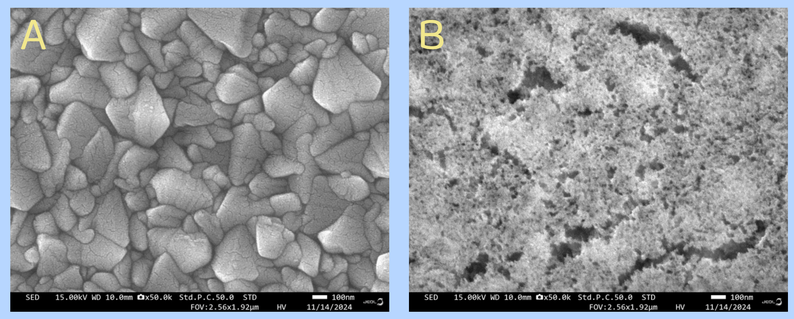


Fig 3. SEM images of (A) FTO glass (B) PANI/PABA copolymer thin film

Characterization by ATR-FTIR spectroscopy

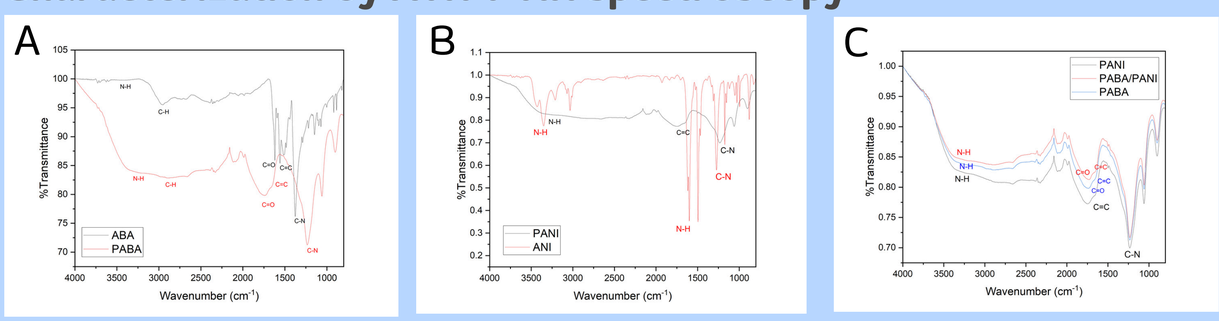


Fig 4. ATR-FTIR spectra of (A) 3-ABA and PABA thin film (B) ANI and PANI thin film (C) PANI, PABA and PANI/PABA copolymer thin films

Study of electrical properties of thin films

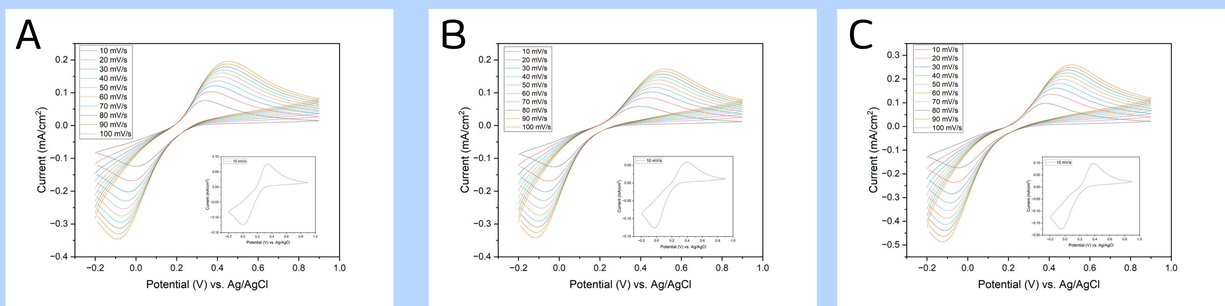


Fig 5. Cyclic voltammograms at various scan rates
in 0.5 mM $K_3Fe(CN)_6$ + 0.1 M KCl in PBS (A) PABA (B) PANI (C) PANI/PABA copolymer thin film

Conclusions

1. The electrochemical properties of the PANI, PABA, and PANI/PABA copolymer thin films were investigated using cyclic voltammetry. The results revealed that the PANI/PABA thin film exhibited a higher redox (oxidation/reduction) current than the individual PANI and PABA films, which indicating a larger active surface area and enhanced electron transfer efficiency.
2. SEM and ATR-FTIR Spectroscopy analyses confirmed the formation of the polymeric structures.
3. PANI/PABA copolymer thin film demonstrated promising potential for application as an electrochemical sensor for biomolecule detection, owing to its favorable electrochemical properties and high active surface area, which could further improve the sensitivity and specificity of future sensor developments.

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REFERENCES

[1] C. Ratlam, S. Phanichphant, S. Sriwichai, *J. Polym. Res.* 2020, 27, 183
[2] Y. Ke, M. He, J. A. L. De La Hoz Siegler, J. Liu, Y. Cheng, Y. Zhang, T. Tsuzuki, C. Yan, *Coatings.* 2019, 9, 748.