UNIVERSITI TEKNOLOGI MARA

TAILORING THE ELECTRICAL, ANTIBACTERIAL, DURABILITY PROPERTIES OF ELECTROACTIVE FABRIC-BASED POLYANILINE FOR POTENTIAL USES IN WEARABLE BIOELECTRONICS

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Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Science)

Faculty of Applied Sciences

June 2023

ABSTRACT

This thesis explores the development and investigation of electroactive fabric-based conducting polymer (CP), specifically polyaniline (PANI) for potential uses in wearable bioelectronics. PANI has gained substantial interest in scientific research due to its tunable structural and electrical conductivity. However, in its pristine form, PANI exhibits low conductivity values of less than 1 S cm^{-1}, which remains a challenge and limits its potential applications. Therefore, the first part of the study attempts to increase the electrical conductivity of PANI utilizing *para*-toluene sulfonic acid (*p*TSA) as a doping agent, thereby optimizing its value to fall within the acceptable range for conductive materials, particularly on human skin (~10^{-4} S cm^{-1} to 10^{2} S cm^{-1}). In addition, another comparable CP, poly(3,4-ethylenedioxythiophene): polystyrene sulfonate (PEDOT: PSS) doped with dimethyl sulfoxide (DMSO), is also examined to unveil its potential and provide a more comprehensive understanding of the electrical properties when embedded into fabric materials. The conductivity values of these CPs are critical for ensuring efficient signal transduction and smooth data transmittance when in use. After evaluating the properties of the two CPs, PANI fabric was identified as a more promising option compared to PEDOT: PSS fabric due to its ease of synthesis and superior mechanical properties, making it a better fit for wearable bioelectronics. Nevertheless, the antibacterial properties of the fabric-based CPs are also important, especially when used in contact with skin. Therefore, the second part of the thesis explores the behavior of PANI fabrics against bacterial colonisation. The study found that PANI fabric exhibits high antibacterial activities against both Gram-positive bacteria and Gram-negative bacteria, including methicillin-resistant *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Salmonella* typhi. While antibacterial properties are important, the stability and durability of the electroactive fabrics are also crucial for their practical application. The third part of the thesis proposes a novel approach to maximizing the surface adhesion and holding capability of PANI within the fabric structure. This approach improves the stability of the conductive PANI fabric, which has been found to experience instability and conductivity decay due to weak physical attachment between the conductive coating and fabric substrates. The washing evaluation, a standard test for fabrics, shows that PANI fabrics are able to retain their electrical functionalities, with conductivity values of 10^{-3} S cm^{-1}, for up to 10 washing cycles. Overall, this thesis provides a comprehensive understanding of the properties and characteristics of electroactive fabrics-based CPs, with a focus on the development of PANI-based fabrics. The findings have significant potential for future use in wearable bioelectronics, as they address the critical issues of electrical conductivity, antibacterial, and durability properties.

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

Alhamdulillah. All praises are for Allah for His blessing and mercy. Selawat dan Salam are delivered to the Prophet, Muhammad SAW, who has guided his followers to the right worldview namely Islam. I would like to thank my esteemed supervisor - Associate Professor Dr Mohd Muzamir Mahat, who has patiently trained and taught me to be a researcher, and also for believing in me. To my co-supervisors, Associate Professor Dr Zaidah Zainal Ariffin, Dr Azizi Nawawi and Dr Nur Aimi Jani for their treasured support which was really influential in shaping my experimental methods and critiquing my results.

I would like to express my gratitude to my beloved father mother and brother , who always give me moral support and inspiration. A deepest appreciation to Professor Dr Khudzir Ismail for his unwavering belief in me to pursue my studies at the Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM). Not to forget the Institute of Postgraduate Studies, UiTM Shah Alam that provides physical support and technical contribution to achieving the end task.

To Muzamir Group and Advanced Polymeric Science members who have always been there, offered me wisdom, and encouraged me; Zatul, Nazreen, Ayu, Dania, Ain, Hidayah, Adlan, Syifa, Anis, Arif, Awatif and Najiha. My mentors and friends; Dr Farish, Dr Zharfan, Mr Azrin, Syazwani, Akmal, Afiq, Puteri, and many more, thank you so much!

Major gratitude to these admirable scientists for the scientific discussion and also for getting me involved in other collaborative research projects and experiments; Dr Abid and Dr Irwan (UiTM Private Specialist Centre - Medical Project), Dr Feroz, Dr Amira, Dr Saiful, Dr Zarif, Dr Fadzli, Dr Aini, Dr Irina, Dr Awis (PETRONAS Research - Lithium Recycling Project), Dr Asyura (Institute for Medical Research - Antibacterial Testing), Dr Kishor (Qatar Grant), Dr Syakirin and Mr Herman (XPS Analysis), Dr Fauzi (chemist) and Mr Izzharif (ATR-FTIR). Their enthusiasm and unbelievable talent were crucial to my success.

A special thanks to Miss J, who patiently waiting for our big day!

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