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# Synthesis, characterisation and applications of conducting polymer coated textiles

Jian Wu

*University of Wollongong*

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**SYNTHESIS, CHARACTERISATION AND  
APPLICATIONS OF CONDUCTING POLYMER  
COATED TEXTILES**

**A thesis submitted in fulfillment of the requirements  
for the award of the degree**

**DOCTOR OF PHILOSOPHY**

**from**

**UNIVERSITY OF WOLLONGONG**

**by**

**JIAN WU, B.Sc.**

**Department of Chemistry**

**May 2004**

*To my parents for their encouragement,  
especially in memory of my father*

*To my husband Xifa Yang and my daughter Wenxin Yang  
for their support and patience*

## THESIS CERTIFICATION

I, Jian WU, declare that this thesis, submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in the Department of Chemistry, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Jian WU

May 2004

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## PUBLICATIONS

- 1 J. Wu, D. Zhou, C. Too and G. G. Wallace, “Conducting Polymers Coated Textile” ICSM 2004 and *Synthetic Metals* (Submitted).
- 2 “Electromechanical actuators based on fibre and fabrics” G. G. Wallace, J. Wu, V. Aboutanos, G. M. Spinks and D. Zhou, SPIE (2001) [4329-55].
- 3 G.G. Wallace, G. M. Spinks, J. Wu and D. Zhou, “Electrofunctional materials: strain gauges and actuators in fabric structures (Invited paper), SPIE, Smart Materials and MEMS (2000) [4234-4235].

## ABSTRACT

This thesis describes preparation and characterisation of a range of novel conducting polymer coated textiles, which have potential in applications such as static dissipation, EMI shielding, heating elements, composite structures and many military applications.

Conducting polypyrrole coated textiles such as nylon Lycra and polyester fabrics have been synthesised using different approaches (Chapter 3). The present study concentrates on preparation of conducting polypyrrole coated textile using an *in-situ* polymerisation method. A range of characterisation techniques for the inherently conducting polymer (ICP) coated fabrics were used: the stability of the surface resistivity, cyclic voltammetry, Scanning Electron Microscopy (SEM), UV-Vis spectroscopy and Thermogravimetric analysis (TGA). It was found that the PPy-coated nylon Lycra fabric could be used as a wearable strain gauge. The strain gauge characteristics have been investigated using both an Instron machine and a “SmartMotor”.

The use of molecular templates to facilitate the polymerisation and the integration of inherently conducting polymers (ICPs) into textiles has been investigated (Chapter 4). Poly(2-methoxyaniline-5 sulfonic acid) or [PMAS] is a water-soluble, fully sulfonated polyaniline that has been used as molecular template. In the first step – “dyeing” of PMAS into the textile, the effect of fabric pre-treatment, solution pH as well as solution temperature have been investigated. In the second step the effects of the ratio of PMAS to aniline, the ratio of aniline to ammonium persulfate and the polymerisation temperature on the polymerisation reaction have also been studied. Characterisation of the templated polyaniline coated fabric prepared using the above “Two step” process



has been undertaken (Chapter 4). The stability of the conductivity, cyclic voltammetry, UV-Vis spectra, SEM studies, TGA analysis and strain gauge characteristics have been determined. Results indicate that templated PAN-coated wool nylon Lycra can be used as the strain gauge as tested with either the Instron machine or “SmartMotor”.

Conducting polymer coated textile fabrics are easily prepared and integrated into truly wearable clothing and garments to create strain sensors with a wide dynamic range. Functional wearable textile sensing systems can monitor human motion, provide immediate bio-feedback to the wearer without changing the properties and functions of the fabric material and with no interference to normal human body motion. This innovative technique can be widely used for injury prevention, rehabilitation, sport technique modification and medical treatment. It will have a number of further potential applications to be used for daily living, work and recreation in the future.

**ABBREVIATIONS**

<b><math>\mu</math></b>	micro
<b><math>^{\circ}\text{C}</math></b>	degree Celsius
<b><math>\text{A}^{-}</math></b>	anion
<b>ABS</b>	absorbance
<b>Ag/AgCl</b>	silver/silver chloride reference electrode
<b>CEP</b>	conducting electroactive polymer
<b>cm</b>	centimeter
<b>CV</b>	cyclic voltammetry
<b><math>\Delta\text{E}</math></b>	potential difference
<b>E</b>	potential
<b><math>\text{E}_{\text{p(a)}}</math></b>	anodic peak potential
<b><math>\text{E}_{\text{p(c)}}</math></b>	cathodic peak potential
<b>EB</b>	emeraldine base
<b>ES</b>	emeraldine salt
<b>g</b>	gram
<b>HPLC</b>	high performance liquid chromatography
<b>I</b>	current
<b>ITO</b>	Indium-tin oxide
<b>K</b>	Kelvin
<b>LB</b>	leucoemeraldine base
<b>M</b>	molar
<b>mA</b>	milliampere(s)
<b>mV</b>	millivolt

<b>n</b>	number of electron
<b>NDSA</b>	1,5-naphthalenedisulfonic acid tetrahydrate
<b>PAn</b>	polyaniline
<b>PB</b>	pernigraniline base
<b>PMAS</b>	poly(2-methoxyaniline-5-sulfonic acid)
<b>PPy</b>	polypyrrole
<b>PS</b>	pernigraniline salt
<b>Pt</b>	platinum
<b>R</b>	resistance
<b>RVC</b>	reticulated vitreous carbon
<b>sec</b>	second
<b>SPAN</b>	sulfonated polyaniline
<b>SEM</b>	scanning electron microscopy
<b>TGA</b>	Thermogravimetry analysis
<b>UV-Vis</b>	ultraviolet-visible

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