Synthesis, characterisation and applications of conducting polymer coated textiles

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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
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


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

µ micro
° C degree Celsius
A− anion
ABS absorbance
Ag/AgCl silver/silver chloride reference electrode
CEP conducting electroactive polymer
cm centimeter
CV cyclic voltammetry
ΔE potential difference
E potential
Ep(a) anodic peak potential
Ep(c) cathodic peak potential
EB emeraldine base
ES emeraldine salt
g gram
HPLC high performance liquid chromatography
I current
ITO Indium-tin oxide
K Kelvin
LB leucoemeraldine base
M molar
mA millampere(s)
mV millivolt
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>number of electron</td>
</tr>
<tr>
<td>NDSA</td>
<td>1,5-naphthalenedisulfonic acid tetrahydrate</td>
</tr>
<tr>
<td>PAN</td>
<td>polyaniline</td>
</tr>
<tr>
<td>PB</td>
<td>pernigraniline base</td>
</tr>
<tr>
<td>PMAS</td>
<td>poly(2-methoxyaniline-5-sulfonic acid)</td>
</tr>
<tr>
<td>PPy</td>
<td>polypyrrole</td>
</tr>
<tr>
<td>PS</td>
<td>pernigraniline salt</td>
</tr>
<tr>
<td>Pt</td>
<td>platinum</td>
</tr>
<tr>
<td>R</td>
<td>resistance</td>
</tr>
<tr>
<td>RVC</td>
<td>reticulated vitreous carbon</td>
</tr>
<tr>
<td>sec</td>
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</tr>
<tr>
<td>SPAN</td>
<td>sulfonated polyaniline</td>
</tr>
<tr>
<td>SEM</td>
<td>scanning electron microscopy</td>
</tr>
<tr>
<td>TGA</td>
<td>Thermogravimetry analysis</td>
</tr>
<tr>
<td>UV-Vis</td>
<td>ultraviolet-visible</td>
</tr>
</tbody>
</table>
LIST OF FIGURES AND TABLES

1. Figures

Figure 1.1. Schematic of conducting polymers

Figure 1.2. Polypyrrole polymerisation initiation and polymer growth

Figure 1.3. Interconversions between different forms of polyaniline

Figure 1.4. Chemical polymerisation of aniline

Figure 1.5. Structures of some fully sulfonated polyanilines

Figure 1.6. Assignment of electronic absorption bands of emeraldine salt

Figure 1.7. UV-Vis spectra of (a) initial emeraldine salt PAn.(+)-HCSA film and (b) leucoemeraldine base film derived by reduction with PhNHNH₂

Figure 1.8. UV-Vis spectra of (a) initial emeraldine salt PAn.(+)-HCSA film and (b) pernigraniline base film derived by oxidation with ceric ammonium sulfate [93].

Figure 1.9. UV-Vis spectra of PMAS solution during oxidation in 0.1 M (NH₂)S₂O₈, pH 1

Figure 1.10. UV-Vis spectra of PMAS solution during reduction in 0.08 M hydrazine, pH 9

Figure 1.11. Classification of fibres

Figure 1.12. The morphological diagram of a wool fibre

Figure 1.13. The general formula of amino acid

Figure 1.14. Poly (ethylene terephthalate) polymerisation

Figure 1.15. Polymerisation steps used to produce Nylon 66 and Nylon 6 fibres

Figure 1.16. Photomicrograph of Lycra Spandex fibre in a cross-section

Figure 1.17. Photomicrograph of Lycra Spandex fibre in a longitudinal view

Figure 1.18. The repeat unit of a polyether based Spandex used in Lycra fabric
Figure 1.19. (a) The unstretched or amorphous state of the polymer system of an elastomeric fibre; (b) The stretched or more crystalline state of the polymer system of an elastomeric fibre

Figure 1.20. Woven fabrics: plain weave

Figure 1.21. 1/1 rib weft knitted fabric

Figure 1.22. Simple warp knit

Figure 1.23. Face side of the locknit fabric

Figure 1.24. Surface resistivity of various textile products

Figure 2.1. In-situ (chemical oxidation) polymerisation method used to coat fabrics

Figure 2.2. (a) Dyeing process of fabric (b) Top view of the fabric secured onto the spindle

Figure 2.3. Template polymerisation of conducting polyaniline on the PMAS-treated fabric.

Figure 2.4. Vapour-phase polymerisation method

Figure 2.5. Cyclic voltammetry cell for conducting polymer coated fabric

Figure 2.6. Cyclic voltammogram of PPy/NDSA coated nylon Lycra in 1.0 M NaNO₃ at a scan rate of 100 mVs⁻¹

Figure 2.7. Top view of the ASTM four-point probe method for the measurement of the electrical conductivity of a piece of conductive fabric. The distance between the two inner electrodes is 0.2 cm. The sample is sandwiched with another connector. A constant current is applied between the two outer electrodes

Figure 2.8. Top view of the AATCC-76 two-point probe method for the measurement of the electrical conductivity of a piece of conductive fabric. The distance between the two parallel electrodes is 1.5 cm. The sample is measured with a standard ohmmeter
Figure 2.9. UV-Visible spectra of PMAS solution before and after dyeing the wool nylon Lycra fabric

Figure 2.10. SEM image of a polypyrrole-NDSA coated nylon Lycra

Figure 2.11. Wheatstone bridge electrical resistance vs. strain testing circuit

Figure 2.12. Resistance vs Strain of polypyrrole coated nylon Lycra fabric when stretched to 50%

Figure 2.13. Force vs Strain of polypyrrole coated nylon Lycra fabric when stretched to 50%

Figure 2.14. Dynamic calibration apparatus

Figure 3.1. Both sides of PPy-coated nylon Lycra prepared at a current density of 2.0 mAcm⁻² for 4 hours using electrochemical polymerisation

Figure 3.2. SEM of PPy-coated nylon Lycra prepared at a current density of 2.0 mAcm⁻² for 4 hours using electrochemical polymerisation

Figure 3.3. SEM of PPy-coated nylon Lycra using the vapour polymerisation

Figure 3.4. Typical strain-resistance responses of PPy-coated nylon Lycra fabric under different cycles when stretched to 50%

Figure 3.5. PPy-coated Taffeta polyester after different polymerisation times

Figure 3.6. Resistance change of PPy-coated polyester versus strain

Figure 3.7. The surface resistivity (Ω/□) of PPy-coated nylon Lycra at different areas of the A4 fabric

Figure 3.8. The surface resistivity (Ω/□) of PPy-coated nylon Lycra at different areas of coated fabric (7.4 cm x 10.5 cm).

Figure 3.9. The changes of surface resistivity vs storage time of PPy-coated nylon Lycra. Broken line: stored in the open air, bold line: stored in a desiccator
Figure 3.10. Cyclic voltammogram of PPy/NDSA film (ca. 0.1 µm thickness) in 1.0 M NaNO₃ at a scan rate of 100 mV s⁻¹

Figure 3.11. Cyclic voltammogram of PPy/NDSA coated nylon Lycra in 1.0 M NaNO₃ at a scan rate of 100 mVs⁻¹

Figure 3.12. Scanning electron micrograph of uncoated nylon Lycra fibre

Figure 3.13. Scanning electron micrograph of PPy-coated nylon Lycra fibre

Figure 3.14. UV-Vis spectra of uncoated and PPy-coated nylon Lycra fabrics

Figure 3.15. TGA (60-600 °C) of PPy/NDSA powder under nitrogen gas

Figure 3.16. TGA (60-600 °C) of dopant NDSA under nitrogen gas

Figure 3.17. TGA (50-500 °C) of uncoated and PPy-coated nylon Lycra fabrics under nitrogen gas

Figure 4.1. Branched structures of the traditional ortho-para directed enzymatic polymerisation of aniline that results in an electrically inactive form of aniline vs enzymatic polymerization in the presence of SPS

Figure 4.2. Poly (2-methoxyaniline-5 sulfonic acid) (PMAS) structure

Figure 4.3. Thermobath with temperature control used in the dyeing process

Figure 4.4. The spindle with wool fabric before (a) and after (b) dyeing with PMAS

Figure 4.5. Beer’s Law plot for aqueous PMAS solution

Figure 4.6. Surface resistivity vs. storage time for PMAS-treated wool nylon Lycra

Broken line: stored in the open air, bold line: stored in a sealed plastic bag.

Figure 4.7. Changes in surface resistivity vs. time for wool nylon Lycra coated with PMAS then coated with PAn prepared at room temperature. Broken line: stored in the open air, bold line: stored in a sealed plastic bag.
Figure 4.8. Changes in surface resistivity vs. time. PMAS templated polyaniline wool nylon Lycra prepared at lower temperature (2-3 °C). Broken line: stored in the open air, bold line: stored in a sealed plastic bag.

Figure 4.9. Cyclic voltammogram of polyaniline (HCl) on a glassy carbon electrode in 1 M HCl at a scan rate of 50 mV/s

Figure 4.10. Cyclic voltammogram (CV) obtained using PMAS-treated wool nylon Lycra as the working electrode in 1 M HCl at a scan rate of 10 mV/s

Figure 4.11. Cyclic voltammogram (CV) obtained using PMAS templated polyaniline coated wool nylon Lycra as working electrode in 1 M HCl at a scan rate of 10 mV/s

Figure 4.12. Cyclic voltammograms (CV) obtained using PMAS templated polyaniline coated wool nylon Lycra as working electrode in 1 M HCl at a scan rate of 10 mV/s. Pink line: stored in the open air for 55 days, blue line: stored in a sealed plastic bag for 55 days.

Figure 4.13. UV-Visible spectra of uncoated, PMAS & in-situ templating coated wool nylon Lycra using ortho-dichlorobenzene as a solvent

Figure 4.14. UV-Visible spectra of PMAS templated PAn coated wool nylon Lycra under different storage conditions for 55 days

Figure 4.15. UV-Visible spectra of oxidised / reduced forms of PMAS templated PAn-coated wool nylon Lycra

Figure 4.16. UV-Visible spectra of coated wool nylon Lycra before and after heating at 100 °C and 210 °C for 2 hours

Figure 4.17. Scanning electron micrograph of uncoated wool nylon Lycra fibre.

Figure 4.18. Scanning electron micrograph of PMAS-treated wool nylon Lycra fibre.

Figure 4.19. Scanning electron micrograph PMAS templated PAn-coated wool nylon

Figure 4.20. TGA (60-500 °C) PMAS powder
Figure 4.21. TGA (60-600 °C) of templated PAn powder (PMAS+PAn copolymer)

Figure 4.22. TGA (60-600 °C) of uncoated, PMAS-treated and templated PAn coated wool nylon Lycra fabrics

Figure 5.1. Stress-strain responses of uncoated nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.2. Stress-strain responses of uncoated nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.3. Stress-strain responses of PPy-coated nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.4. Stress-strain responses of PPy-coated nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.5. Stress-strain of uncoated and PPy-coated nylon Lycra fabrics in the wale direction at different strains

Figure 5.6. Stress-strain responses of uncoated wool nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.7. Stress-strain responses of uncoated wool nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.8. Stress-strain responses of PMAS-treated wool nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.9. Stress-strain responses of PMAS-treated wool nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.10. Stress-strain responses of PMAS templated PAn-coated wool nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.11. Stress-strain responses of PMAS templated PAn-coated wool nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%
Figure 5.12. Stress-strain of uncoated, PMAS-treated and PMAS templated PAn-coated wool nylon Lycra fabrics in the wale direction at different strains

Figure 5.13. Resistance/Strain relationship for nylon Lycra in the wale and course direction

Figure 5.14. Resistance-strain of PPy-coated nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.15. Resistance-strain of PPy-coated nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.16. Resistance-strain on PPy-coated nylon Lycra fabric in the wale direction at different strains

Figure 5.17. Resistance-strain of PMAS templated PAn-coated wool nylon Lycra fabric for the first two cycles when stretched to 50%

Figure 5.18. Resistance-strain responses of PMAS templated PAn-coated wool nylon Lycra fabric for the fifth and the sixth cycles when stretched to 50%

Figure 5.19. Resistance-strain responses for PMAS templated PAn-coated wool nylon Lycra 7010 fabric in the wale direction at different strain

Figure 5.20. Ratio of change in resistance to initial resistance ($\Delta R/R_i$) of PPy-coated nylon Lycra when stretched to 50%

Figure 5.21. Ratio of change in resistance to initial resistance ($\Delta R/R_i$) of PMAS templated PAn-coated wool nylon Lycra when stretched to 70%

Figure 5.22. Electronic signal of resistance response on PPy-coated nylon Lycra at 1 Hz when stretched to 50%

Figure 5.23. Changes in resistance of PPy-coated nylon Lycra fabric in the wale direction at 1 Hz under different strains
Figure 5.24. Changes in resistance of PPy-coated nylon Lycra fabric in the wale direction at different frequencies under different strains

Figure 5.25. Electronic signal of resistance responses on PMAS templated PAn-coated wool nylon Lycra at strain=50%

Figure 5.26. Changes of resistance on PMAS templated PAn-coated wool nylon Lycra fabric in the wale direction at different strain

Figure 5.27. Ratio of change in resistance to initial resistance (ΔR/Ri) of PPy-coated nylon Lycra when stretched from 10% to 50%

Figure 5.28. Ratio of change in resistance to initial resistance (ΔR/Ri) of PMAS templated PAn-coated wool nylon Lycra when stretched from 10% to 70%

Figure 6.1. The joint angle, φ, for the knee

Figure 6.2. “Intelligent Elbow Strain Gauge”

Figure 6.3. Changes in resistance of PPy-coated nylon Lycra strip on the “Intelligent Elbow Strain Gauge” under different strain ranges

Figure 6.4. Knee sleeve system

Figure 6.5. Intelligent Knee Sleeve

Figure 6.6. Football player wearing the “intelligent knee sleeve” and training to land correctly to protect his knee from potential ligament damage

Figure 6.7. The rehabilitation glove with PPy-coated fabric sensor strips on each finger

2. Tables

Table 1.1. Techniques used for characterisation of conducting polymers.

Table 3.1. Optimisation of molar concentrations of pyrrole/FeCl₃/NDSA

Table 3.2. Optimisation of molar concentrations of pyrrole/FeCl₃/NDSA

Table 3.3. Optimisation of molar concentrations of pyrrole/FeCl₃/NDSA
Table 3.4. Summary of electrochemical polymerisation for PPy-coated nylon Lycra at different current densities

Table 3.5. Summary of electrochemical polymerisation for PPy-coated nylon Lycra at different polymerisation times

Table 3.6. The surface resistivity of PPy-coated nylon Lycra using different concentrations of FeCl₃ in ethanol for soaking the fabric prior to monomer exposure

Table 3.7. The surface resistivity of PPy-coated nylon Lycra using different solvents for oxidant uptake into the textile

Table 3.8. The surface resistivity of PPy-coated nylon Lycra using different temperature for vapour generation

Table 3.9. The surface resistivity and strain gauge factors for PPy-coated nylon Lycra – effect of pyrrole monomer concentrations

Table 3.10. The surface resistivity and gauge factors of PPy-coated nylon Lycra produced under different oxidant FeCl₃ concentrations

Table 3.11. The surface resistivity and gauge factors of PPy-coated nylon Lycra obtained using different dopant concentrations

Table 3.12. The surface resistivity and gauge factor of PPy-coated nylon Lycra obtained by using different reaction times

Table 3.13. The surface resistivity and gauge factors of PPy-coated nylon Lycra produced at different polymerisation temperatures

Table 3.14. The surface resistivity of PPy-coated Taffeta polyester after different polymerisation times

Table 4.1. Summary of wool nylon Lycra washed with and without Sandoclean PC Liquid

Table 4.2. Effect of variation of pH on the application of PMAS
Table 4.3. The effect of variation of temperatures on the application of PMAS

Table 4.4. The surface resistivity of the PMAS templated PAn-coated wool nylon Lycra produced under different PMAS:Aniline ratios

Table 4.5. The surface resistivity of the PMAS templated PAn-coated wool nylon Lycra fabrics produced using different Aniline:APS ratios

Table 4.6. Surface resistivity of the PMAS templated PAn - coated wool nylon Lycra prepared using different temperatures for aniline oxidation

Table 4.7. Consumption of aniline monomer during polymerisation in the presence of PMAS templated wool nylon Lycra using different reaction temperatures
CONTENTS

DEDICATION 1
CERTIFICATION II
ACKNOWLEDGMENTS III
PUBLICATIONS IV
ABSTRACT V
ABBREVIATIONS VII
LIST OF FIGURES AND TABLES IX

CHAPTER 1 1
GENERAL INTRODUCTION 1
1.1 CONDUCING POLYMERS 2
   1.1.1. The Development of Conducting Polymer 2
   1.1.2. Polypyrrole 3
   1.1.3. Polyaniline 6
       1.1.3.1. Unsubstituted Polyaniline (PAn) 7
       1.1.3.2. Sulfonated Polyaniline 11
   1.1.4. Characterisation of Conducting Polymers 15
1.2 FIBRE STRUCTURE & TEXTILE SUBSTRATE 16
   1.2.1. Fibre Structure 18
       1.2.1.1. Wool Fibre 18
       1.2.1.2. Polyester Fibre 21
       1.2.1.3. Nylon Fibre 24
       1.2.1.4. Spandex Fibre – Lycra Fibre 26
1.2.2. Fabric Textile Structure
   1.2.2.1. Woven Fabrics
   1.2.2.2. Knitted Fabrics

1.3. ELECTRICALLY CONDUCTING TEXTILES
   1.3.1. Carbon Fibres and Carbon-filled Materials
   1.3.2. Metallic Fibres
   1.3.3. Metal Coated Materials
   1.3.4. Conducting Polymer Coated Textiles
      1.3.4.1. Polypyrrole Coated Textiles
      1.3.4.2. Polyaniline Coated Textiles
      1.3.4.3. Properties of Conductive Textiles

1.4. AIMS OF THE PROJECT

1.5. REFERENCES

CHAPTER 2

GENERAL EXPERIMENTAL TECHNIQUES

2.1. INTRODUCTION

2.2. PREPARATION OF CONDUCTIVE POLYMER COATED TEXTILES

2.2.1. Chemical Polymerisation
   2.2.1.1. In-situ Polymerisation (Chemical Oxidation) Process
   2.2.1.2. Template Polymerisation Process
   2.2.1.3. Chemical oxidation Using Vapour Phase Monomer

2.2.2. Electrochemical Polymerisation
2.3. CHARACTERISATION METHODS FOR CONDUCTIVE POLYMER COATED TEXTILE

2.3.1. Cyclic Voltammetry (CV)

2.3.2. Electrical Conductivity

2.3.3. UV-Vis Spectroscopy

2.3.4. Scanning Electron Microscopy (SEM)

2.3.5. Thermogravimetric Analysis

2.3.6. High Performance Liquid Chromatography (HPLC)

2.3.7. Instron Testing to Determine Stress/strain Curves

2.3.8. Use of SmartMotor to Determine Strain Gauge Characteristics at Different Frequencies

2.4. REFERENCES

CHAPTER 3

PREPARATION AND CHARACTERISATION OF POLYPYRROLE COATED FABRICS

3.1. INTRODUCTION

3.2. EXPERIMENTAL

3.2.1. Reagents and Materials

3.2.2. Instrumentation

3.2.3. Preparation of PPy-coated Fabrics Using Different Techniques

3.2.3.1. Electrochemical Polymerisation

3.2.3.2. Chemical Oxidation Using Vapour-phase Monomer

3.2.3.3. In-situ Chemical Oxidation

3.2.3.3.1. Preparation of PPy-coated Nylon Lycra Fabric
3.2.3.2. Preparation of PPy-coated Polyester Taffeta Fabric 91

3.2.4. Characterisation of PPy-coated Nylon Lycra Fabric 91

3.2.4.1. Surface Resistivity 92

3.2.4.2. Cyclic Voltammetry 92

3.2.4.3. Morphology Analysis 92

3.2.4.4. UV-Vis Spectra 93

3.2.4.5. Thermogravimetric Analysis 93

3.2.4.6. Strain & Stress Testing by Instron 4302 Tensile Tester 93

3.3. RESULTS AND DISCUSSION 94

3.3.1. Effect of Reaction Conditions on Surface Resistivity of PPy-coated Nylon Lycra Coated Using Electrochemical Polymerisation 94

3.3.2. Effect of Reaction Conditions on Surface Resistivity of PPy-coated Nylon Lycra Coated Using Chemical Oxidation of Monomer from Vapour Phase 98

3.3.3. Effect of Reaction Conditions on Surface Resistivity and Gauge Factor of PPy-coated Nylon Lycra Coated Using Chemical Oxidation 101

3.3.3.1. Effect of Pyrrole Monomer Concentration 101

3.3.3.2. Effect of Oxidant Concentration 104

3.3.3.3. Effect of Dopant Concentration 105

3.3.3.4. Effect of Reaction Time 106

3.3.3.5. Effect of Reaction Temperature 108

3.3.4. Effect of Reaction Conditions on Surface Resistivity and Gauge Factor of PPy-coated Polyester Taffeta 109
CHAPTER 4

PREPARATION AND CHARACTERISATION OF POLYANILINE COATED FABRICS

4.1. INTRODUCTION

4.2. EXPERIMENTAL

4.2.1. Reagents and Materials

4.2.2. Instrumentation

4.2.3. Preparation of PMAS Templated PAn-coated Fabric

4.2.3.1. Integration of the Molecular Template-PMAS (Step One)

4.2.3.2. Integration of Cationic Inherently Conducting Polymers (Step Two)

4.2.4. Characterisation of PMAS Templated PAn-coated Wool Fabric

4.2.4.1. Surface Resistivity

4.2.4.2. Cyclic Voltammetry
4.3. RESULTS AND DISCUSSION

4.3.1. Effect of Reaction Conditions on Integration of the Molecular Template- PMAS

4.3.2. Effect of Reaction Conditions on Coating of Templated Textile with Polyaniline

4.3.2.1. Effect of Aniline to PMAS Ratio

4.3.2.2. Effect of Oxidant Concentration

4.3.2.3. Polymerisation Temperature

4.3.2.4. Aniline Monomer Consumption at Different Temperatures

4.3.3. Characterisation of PMAS Templated PAn-coated Fabrics

4.3.3.1. Surface Resistivity Change vs Time of PMAS-treated Wool Fabrics

4.3.3.2. Surface Resistivity Change vs Time of PMAS Templated PAn-coated Wool Fabrics

4.3.3.3. Cyclic Voltammetry

4.3.3.4. UV-Vis Spectra

4.3.3.5. SEM

4.3.3.6. Thermogravimetry

4.4. CONCLUSION

4.5. REFERENCES
CHAPTER 5

CONDUCTIVE POLYMER COATED TEXTILES AND THEIR STRAIN GAUGE CHARACTERISTICS

5.1. INTRODUCTION

5.2. EXPERIMENTAL

5.2.1. Materials

5.2.2. Instrumentation

5.3. RESULTS AND DISCUSSION

5.3.1. Mechanical Properties of Uncoated and Polymer-coated Fabrics by Instron 4320 Tensile Tester

5.3.1.1. PPy-coated Nylon Lycra

5.3.1.2. Templated PAn-coated Wool Nylon Lycra

5.3.2. Strain Gauge Response of Polymer-coated Fabrics

5.3.2.1. PPy-coated Nylon Lycra

5.3.2.2. Templated PAn-coated Wool Nylon Lycra

5.3.3. Strain Gauge Response of Polymer-coated Fabrics at Different Frequencies

5.3.3.1. PPy-coated Nylon Lycra

5.3.3.2. Templated PAn-coated Wool Nylon Lycra

5.4. CONCLUSION

5.5. REFERENCES

CHAPTER 6

APPLICATION OF CONDUCTING POLYMER COATED FABRICS

6.1. INTRODUCTION
6.2. DEVELOPMENT OF STRETCHABLE CONDUCTIVE TEXTILES 217
  6.2.1. Strain Gauge Performance in Sport Training 217
  6.2.2. Conductive Stretchable Textiles for Sensors and Actuators 223
  6.2.3. Further Potential Applications 225

6.3. CONCLUSIONS 226

6.4. REFERENCES 228

CHAPTER 7 230

GENERAL CONCLUSIONS 230