

TABLE OF CONTENTS

ABSTRAK	i
ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
1. INTRODUCTION	1
1.1 Conducting Polymers	1
1.2 The Electrical Properties of Conducting Polymers	2
1.3 Conducting Polymers and their Electrolyte Composites	3
1.4 Practical Applications of Conducting Polymers	3
1.5 Polypyrrole	4
1.6 The Mechanism of Polypyrrole Formation	5
1.7 Conductivity Measurement by the Four Point Probe Method	6
1.8 Applications of Polypyrrole	8
1.9 Cyclic Voltammetry	9
1.10 Wastewater Treatment	9
1.11 Ion Exchange	10
1.12 ESCA for Surface Analysis of Polypyrrole	11
1.13 Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS)	12
2 EXPERIMENTAL	13
2.1 Chemicals used	13
2.2 Apparatus	14
2.2.1 Glassware and Cleaning	14
2.2.2 Sample Bottles (Polyethylene)	14
2.3 Instruments and Equipment	14
2.4 Cleaning Process for Working Electrode	15

2.5	Solutions Preparations	15
2.6	Cyclic Voltammetry	17
2.7	Conducting Polymer Preparation	18
2.8	Conductivity Measurement	20
2.9	Ion Exchange	22
2.10	Optical Study of Surface Morphology	23
2.11	Surface Analysis	23
	2.11.1 Electron Spectroscopy for Chemical Analysis (ESCA)	23
	2.11.2 Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS)	24
3	RESULTS AND DISCUSSION	26
3.1	Cyclic Voltammetry (Qualitative Observation)	26
	3.1.1 Electropolymerization of Pyrrole in Aqueous NaPSS Solutions	26
	3.1.2 Electropolymerization of Pyrrole in the presence of PVS	27
	3.1.3 Electropolymerization of Pyrrole in the presence of PTS	29
	3.1.4 Electrochemical Incorporation/Release of Copper Ions into/from the PPy/PSS Film	30
	3.1.5 Electrochemical Incorporation/Release of Copper Ions into/from the PPy/PVS Film	30
	3.1.6 Electrochemical Incorporation/Release of Copper Ions into/from the PPy/PTS Film	32
	3.1.7 Electrochemical Incorporation/Release of Nickel Ions into/from the PPy/PSS Film	33
	3.1.8 Electrochemical Incorporation/Release of Nickel Ions	33

	into/from the PPy/PVS Film	
3.1.9	Electrochemical Incorporation/Release of Nickel Ions into/from the PPy/PTS Film	35
3.1.10	Electrochemical Incorporation/Release of Cobalt Ions into/from the PPy/PSS Film	36
3.1.11	Electrochemical Incorporation/Release of Cobalt Ions into/from the PPy/PVS Film	36
3.1.12	Electrochemical Incorporation/Release of Cobalt Ions into/from the PPy/PTS Film	38
3.2	Conductivity of PPy/PVS Films	39
3.2.1	Surface Conductivity as a function of concentration of Pyrrole used in the preparation of the film	40
3.2.2	Calculation of Surface Conductivity	40
3.2.3	Effect of Concentration of Pyrrole on the Surface Conductivity or Bulk Conductivity of the composite PPy-PVS Films	42
3.2.4	The Relationship between Density and Concentration of PPy monomer used	42
3.3	Metal Ion Removal using Polypyrrole- Dopant Films	45
3.3.1	Copper Removal by alternately depositing/ ion-exchange and stripping using PVS-PPy Film	45
3.3.2	Nickel Removal by alternately depositing/ ion-exchange and stripping using PSS-PPy and PVS-PPy Films	50
3.3.3	Cobalt Removal by alternately depositing/ ion-exchange and stripping using PSS-PPy and PVS-PPy Films	55

4	SURFACE CHARACTERISTIC STUDY	60
4.1	Polypyrrole/ Poly (Vinylsulfonic Acid, Sodium Salt) (PPy/PVS) Oxidised and reduced films	60
4.1.1	Surface Characteristic Study of Polypyrrole-dopants Films	60
4.1.2	The C 1s core-level ESCA spectra for PPy/PVS oxidised and reduced films	61
4.1.3	TOF-SIMS results for PPy/PVS oxidised and reduced films	64
4.1.4	The N 1s core-level ESCA spectra for PPy/PVS oxidised and reduced films	67
4.1.5	Morphology of the PPy-PVS oxidised and reduced films	70
4.1.6	Secondary Ion Images for PPy/PVS oxidised and reduced film	73
4.2	Polypyrrole/ p-Toluenesulfonic Acid (PPy/PTS) Oxidised and reduced films	76
4.2.1	The C 1s core-level ESCA spectra for PPy/PTS oxidised and reduced films	76
4.2.2	TOF-SIMS spectra for PPy/PTS reduced film	79
4.2.3	The N 1s core-level ESCA spectra for PPy/PTS oxidised and reduced films	81
4.2.4	Morphology of the PPy-PTS oxidised film	84
4.2.5	Morphology of the PPy-PTS reduced film	84
4.2.6	Secondary Ion Images for PPy/PTS oxidised and reduced films	87
4.3	Copper Ions Reduction/ Insertion On Polypyrrole-Dopants Films	90

4.3.1	The reduction of Copper ions at Polypyrrole-Dopants films	90
4.4	Nickel Ions Insertion/ Reduction At Polypyrrole-Dopants Films	92
4.4.1	The reduction of Nickel ions at Polypyrrole-Dopants films	92
4.4.2	TOF-SIMS spectra for Polypyrrole-Dopants films reduced in the presence of Nickel ions	94
4.4.3	Secondary Ions Images (Ion Mapping) for Polypyrrole -Dopants films reduced in the presence of Nickel ions	97
4.5	The Polypyrrole-Dopants films reduced in Cobalt ion solutions	99
4.5.1	The reduction of Cobalt ions at Polypyrrole-Dopants films electrodes	99
4.5.2	TOF-SIMS spectra for Polypyrrole-Dopants films reduced in solutions of Cobalt ions	101
4.5.3	Secondary ion images for Polypyrrole-Dopants composite films reduced in solutions of Cobalt ions	105
5	CONCLUSION	110
6	REFERENCES	112
7	APPENDICES	119