# TABLE OF CONTENTS

**Abstract**

**Chapter 1.0 Introduction**

1.1 Definition of electrodeposition 1

1.2 Principle 1

1.3 Factor affecting the electrodeposition process 4

1.4 Types of electrodeposits 6

1.5 Application of electrodeposition 6

1.6 Definition of alloys 7

1.7 Electro deposited alloy 8

1.8 Factor affecting the alloy deposition 8

1.9 Health and environmental effects of using hexavalent chromium electrodeposition 11

1.10 Hexavalent chromium electroplating alternatives 13

1.11 Trivalent chromium electroplating 15

1.12 Electroplating in non-aqueous solution 18

1.13 Ionic liquids 20

1.14 Deep eutectic solvents 23

1.15 Applications of deep eutectic solvents 26

1.16 References 29

**Chapter 2.0 Literature review**

2.1 Chromium electrodeposition from Cr(VI) electrolyte 36
2.2 Decorative and hard chromium electrodeposition using hexavalent chromium 37

2.3 Problems and developments in functional electrodeposition using trivalent chromium 43

2.4 References 59

Chapter 3.0 Experimental procedure

3.1 Electrolyte preparation 65
3.2 DES preparation 65
3.3 Preparation of substrate 66
3.4 Electrodeposition methods 66
3.5 Characterization of electrodeposited metals and alloys 71
3.6 References 81

Chapter 4.0 Aim and scope of the research

4.1 Scope of research work 90
4.2 Methodology 91
4.3 References 93

Chapter 5.0 Electrodeposition of Fe-Ni-Cr alloy from deep eutectic system containing choline chloride and ethylene glycol

5.1 Introduction 94
5.2 Experimental 95
5.3 Results and discussion 97
5.4 Conclusions 101
5.5 References 103
Chapter 6.0 Pulsed electrodeposition of microcrystalline chromium from trivalent Cr–DMF bath

6. 1 Introduction 112
6.2 Experimental 113
6.3 Results and discussion 114
6.4 Conclusions 118
6.5 References 120

Chapter 7.0 Structure, current efficiency and corrosion properties of brush electrodeposited (BED) Cr from Cr(III)–dimethylformamide (DMF) bath

7.1 Introduction 128
7.2 Experimental 129
7.3 Results and discussion 130
7.4 Conclusions 134
7.5 References 135

Chapter 8.0 Electrodeposition of Fe-Ni-Cr alloy from deep eutectic system containing choline chloride and ethylene glycol

8.1 Introduction 145
8.2 Experimental section 146
8.3 Results and discussion 147
8.4 Conclusions 152
8.5 References 154

Chapter 9.0 Conclusions 159

List of publications 162