
TABLE OF CONTENTS

List of Figures	
List of Tables	
Nomenclature	
Preface	
CHAPTER 1 INTRODUCTION	1-9
CHAPTER 2 LITERATURE REVIEW AND OBJECTIVES	11-49
2.1 Literature review	11
2.1.1 Direct alcohol fuel cell (DAFC) components	11
2.1.1.1 Electrode materials	11
2.1.1.1.1 Anode electrocatalysts	11
2.1.1.1.2 Cathode electrocatalysts	14
2.1.1.1.3 Electrochemical analysis of electrodes	15
2.1.1.1.3.1 Anode	16
2.1.1.1.3.2 Cathode	23
2.1.1.2 Type of electrolyte	28
2.1.1.2.1 Alkaline liquid electrolyte	29
2.1.1.2.2 Alkaline solid electrolyte	30
2.1.1.2.3 Membrane electrolyte characterization	36
2.1.1.2.3.1 Water uptake	36
2.1.1.2.3.2 Conductivity	37
2.1.1.2.3.3 Fourier transform infrared spectroscopy (FTIR)	38
2.1.1.2.3.4 X-ray diffraction (XRD)	39
2.1.1.2.3.5 Mechanical properties	40

2.1.1.2.3.6 Scanning electron microscopy (SEM)	41
2.1.2 Performance of membrane electrolyte in single cell	42
2.2 Objectives	48
CHAPTER 3 EXPERIMENTAL	51-66
3.1 Material	51
3.2 Experimental setup	55
3.2.1 Half cell studies	55
3.2.2 Direct alcohol fuel cell (DAFC)	56
3.3 Method	57
3.3.1 Preparation of alkaline membrane	57
3.3.2 Preparation of electrodes and membrane electrode assembly (MEA)	59
3.3.3 Membrane characterization	60
3.3.3.1 KOH/Water uptake	60
3.3.3.2 Ionic conductivity measurement	61
3.3.3.3 High resolution scanning electron microscope (HR-SEM)	62
3.3.3.4 Fourier-transform infrared spectroscopy	62
3.3.3.5 X-ray diffraction (XRD)	62
3.3.3.6 Mechanical properties	63
3.3.4 Scanning electron microscope (SEM) of electrodes	63
3.3.5 Half cell study	64
3.3.6 Single cell study	64
3.3.7 Stability test of DAFC	66
CHAPTER 4 RESULT AND DISCUSSION	67-172
4.1 Performance of alkaline membrane synthesized by physical crosslinking: Part I	68
4.1.1 Membrane characterization	68
4.1.1.1 Water uptake	68
4.1.1.2 KOH uptake	70

4.1.1.3 Ionic conductivity	71
4.1.1.4 Morphology	74
4.1.1.5 Crystal structure	77
4.1.1.6 Functional groups	78
4.1.1.7 Mechanical property	79
4.1.2 SEM of electrodes	80
4.1.2.1 SEM of anode	80
4.1.2.2 SEM of cathode	83
4.1.3 Half cell study	85
4.1.3.1 Anode	85
4.1.3.1.1 Effect of scan rate	85
4.1.3.1.2 Effect of electrocatalyst loading	88
4.1.3.1.3 Effect of fuel concentration	90
4.1.3.1.4 Effect of electrolyte concentration	93
4.1.3.1.5 Electrooxidation of methanol and ethanol mixture as fuel	95
4.1.3.2 Cathode	97
4.1.4 Single cell studies	99
4.1.4.1 Effect of KOH doping in physical crosslinked PVA membrane	99
4.1.4.2 Effect of alcohol concentration	102
4.1.4.3 Effect of electrolyte concentration	104
4.1.4.4 Effect of anode electrocatalyst loading	107
4.1.4.5 Effect of cathode electrocatalyst loading	109
4.1.4.6 Effect of electrocatalyst type	111
4.1.4.7 Effect of temperature	114
4.1.4.8 Effect of oxidant at cathode	116
4.1.4.9 Effect of membrane types	118

4.1.4.10 Effect of methanol and ethanol fuel mixture	121
4.1.4.11 Stability Test	122
4.2 Performance of alkaline membrane synthesized by chemical crosslinking: Part II	124
4.2.1 Membrane characterization	124
4.2.1.1 Water uptake	124
4.2.1.2 KOH uptake	127
4.2.1.3 Ionic conductivity	128
4.2.1.4 Morphology	132
4.2.1.5 Crystal structure	136
4.2.1.6 Functional groups	138
4.2.1.7 Mechanical property	139
4.2.2 Electrode characterization	140
4.2.3 Single cell studies	140
4.2.3.1 Effect of glutaraldehyde concentration	140
4.2.3.2 Effect of KOH doping in chemical crosslinked PVA Membrane	143
4.2.3.3 Effect of alcohol concentration	146
4.2.3.4 Effect of electrolyte concentration in	149
4.2.3.5 Effect of anode electrocatalyst loading	151
4.2.3.6 Effect of cathode electrocatalyst loading	154
4.2.3.7 Effect of electrocatalyst type	156
4.2.3.8 Effect of temperature	159
4.2.3.9 Effect of oxidant at cathode	161
4.2.3.10 Effect of membrane types	163
4.2.3.11 Effect of methanol and ethanol mixture	165
4.2.3.12 Stability test	166

4.2.4 Comparison of the performance for physical crosslinked and chemical crosslinked PVA	168
4.2.5 Efficiency of the fuel cell	171
CHAPTER 5 CONCLUSIONS	173-180
5.1 Direct alcohol fuel cell (DAFC) components and construction	173
5.2 Membrane electrolyte characterization	174
5.3 Electrode characterization	175
5.4 Performance of DAFC	176
5.5 Future scope	179
References	181
Appendix A	195
Appendix B	197
Appendix C	211