

TABLE OF CONTENTS

	Page
ABSTRACT (THAI).....	I
ABSTRACT (ENGLISH).....	III
ACKNOWLEDGEMENT.....	V
TABLE OF CONTENTS.....	VI
LIST OF TABLES.....	IX
LIST OF FIGURES.....	X
LIST OF ABBREVIATIONS.....	XIV
CHAPTER	
I INTRODUCTION.....	1
1.1 Introduction.....	1
1.2 Research objective	3
II LITERATURE REVIEWS.....	4
2.1 Zeolite	4
2.1.1 Zeolite A.....	9
2.1.2 Zeolite properties.....	10
2.1.3 Zeolite application.....	23
2.2 Zeolite synthesis method.....	31
2.2.1 Hydrothermal method.....	31
2.2.2 Sol-gel method.....	34
2.2.3 Microwave method.....	35
2.2.4 Ultra-sound energy method.....	37
2.2.5 Alkali-fusion and leaching method.....	37
2.3 Ball clay.....	39

TABLE OF CONTENTS (Continued)

	Page
2.4 Pressure Swing Adsorption Oxygen Concentrator.....	41
2.5 Research.....	44
2.5.1 Zeolite A synthesis.....	44
2.5.2 Ion exchange research.....	47
2.5.3 Spray drying research.....	48
2.5.4 Zeolite molecular sieve.....	49
2.5.5 Studies on adsorption-based air separation for medical-grade oxygen production.....	49
III RESEARCH METHODOLOGY.....	51
3.1 Preparation.....	51
3.1.1 Chemicals, equipment, and characterization.....	51
3.1.2 Equipment.....	53
3.1.3 Characterization techniques.....	58
3.2 Experimental flow chart.....	61
3.3 Na-A zeolite synthesis.....	62
3.4 Li-A zeolite synthesis.....	63
3.5 Spray Drying.....	64
3.6 The efficiency of Li-A zeolite synthesized as a molecular sieve in a Pressure swing adsorption (PSA) oxygen concentrator.....	64
IV RESULTS AND DISCUSSION.....	67
4.1 XRF Analysis.....	67
4.2 Thermal Analysis.....	71
4.3 X-Ray Diffraction (XRD) Analysis.....	73
4.4 Fourier Transform Infrared (FTIR) Spectrum Analysis.....	78

TABLE OF CONTENTS (Continued)

	Page
4.5 Scanning Electron Microscope (SEM), Energy Dispersive X-Ray Spectroscopy (EDS) Analyses, and X-Ray Tomographic Microscopy (XTM).....	80
4.6 Specific Surface Area of Li-A Zeolite.....	84
4.7 Zeolite molecular sieve for oxygen concentrator.....	84
4.7.1 Oxygen Purity of Different Zeolite Particle Sizes.....	85
V CONCLUSION AND RECOMMENDATION.....	90
5.1 Conclusion.....	90
5.2 Recommendation.....	91
5.2.1 Ion Exchange Exploration	91
5.2.2 Long-term Performance Testing	91
5.2.3 Scale-up and Economic Feasibility	91
REFERENCES.....	92
APPENDIX.....	103
APPENDIX A	104
BIOGRAPHY.....	111

LIST OF TABLES

Table	page
2.1 Nomenclature and specifications of important zeolites.....	6
2.2 Property of zeolites as a catalyst.....	11
2.3 Pore sizes of zeolites and molecule diameters.....	17
2.4 Chemical composition of ball clay.....	40
2.5 Literature Studies on adsorption-based air separation for medical-grade oxygen production.....	50
3.1 Chemicals and Chemical formula.....	51
3.2 Research Equipment.....	53
3.3 Characterization techniques.....	58
4.1 The chemical XRF composition of raw materials and zeolite A.....	68
4.2 Oxygen purity at different zeolite particle sizes.....	86

LIST OF FIGURES

Figure	Page
2.1 Representing of $[\text{SiO}_4]^{4-}$ or $[\text{AlO}_4]^{5-}$ tetrahedral.....	5
2.2 Features of the pores in zeolite A (IZA code LTA).....	10
2.3 Different types of hydroxyl groups and acid sites in zeolites.....	13
2.4 Shape selectivity of zeolites with examples of reactions.....	18
2.5 Sol-gel method for the synthesis of zeolite.....	35
2.6 Microwave method for the synthesis of zeolite.....	36
2.7 A schematic representation of zeolite synthesis via alkali fusion method.....	39
2.8 Ball clay.....	41
2.9 Schematics of the PSA oxygen concentrator.....	44
2.10 SEM micrographs showing the occurrence of zeolite A and associated phases obtained by hydrothermal synthesis.....	45
2.11 XRD patterns of zeolite A and associated phases obtained by hydrothermal synthesis.....	46
2.12 FT-IR spectra for Na-A (blue line) and cation-exchanged Li-A (orange line); K-A (grey line) and Rb-A (green line).....	48
3.1 Ball clay.....	51
3.2 Ranong white clay.....	51
3.3 Lampang white clay.....	52
3.4 Sodium hydroxide.....	52
3.5 Lithium hydroxide Monohydrate 99.5%.....	52
3.6 Oxygen concentrator.....	53
3.7 Oxygen gas detector.....	53
3.8 Magnetic stirrer and Magnetic bar.....	53

LIST OF FIGURES (continued)

Figure	Page
3.9 Furnace.....	54
3.10 Oven.....	54
3.11 Alumina crucible.....	54
3.12 Mortar.....	55
3.13 Spray dryer.....	55
3.14 Deionization water.....	55
3.15 Beaker.....	56
3.16 Buchner Funnel.....	56
3.17 Erlenmeyer Flask.....	56
3.18 Filter paper.....	57
3.19 litmus paper.....	57
3.20 X-ray Diffractometer: XRD (D2 PHASER).....	58
3.21 Scanning Electron Microscope/Energy Dispersive X-ray Spectroscopy: SEM-EDS (JEOL JSM-6010LV).....	58
3.22 Thermogravimetric Analyzer: TGA (Mettler Toledo TGA/DSC1).....	59
3.23 BET Surface Area Pore Size and Pore Volume Distribution Analyzer micrometric (ASAP2020P).....	59
3.24 Energy Dispersive Spectrometer X-ray Fluorescence (ED-XRF) (Horiba/XGT-5200).....	59
3.25 Fourier Transform Infrared Raman Spectrophotometry (FT-IR-Raman/Vertex 70).....	60
3.26 X-ray Tomographic Microscopy (XTM).....	60
3.27 Experimental flow chart.....	61
3.28 Flow chart for Na-A zeolite synthesis.....	62

LIST OF FIGURES (continued)

Figure	Page
3.29 Flow chart for Li-A zeolite synthesis.....	63
4.1 TGA and DTA curves of ball clay.....	73
4.2 XRD pattern of clay in Thailand.....	74
4.3 XRD pattern of ball clay and metastable phase samples calcined at a temperature range of 400 – 800 °C for 3 h.....	75
4.4 The XRD patterns of Na-A zeolite prepared by hydrothermal treatment at 100 °C in the NaOH solution at different concentrations (0.5, 1, 2, and 3 M).....	77
4.5 The XRD patterns of Na-A zeolite prepared by hydrothermal treatment at 100 °C in the NaOH solution 3M, and Li-A zeolite prepared by an ion-exchanger at room temperature in the LiOH solution 2M.....	78
4.6 Fourier transform infrared (FTIR) spectrum of Na-A zeolite 3M and Li-A zeolite 2M.....	79
4.7 Scanning electron microscope (SEM) images of clay in Thailand.....	81
4.8 Scanning electron microscope (SEM) images of Na-A zeolite after hydrothermal treatment in NaOH solution at various concentrations.....	82
4.9 Scanning electron microscope (SEM) images of (a)Li-A zeolite after a cationic exchange in LiOH solution at 2M and (b)Li-A zeolite granules prepared by a spray dryer.....	83
4.10 Cross-section of the 3D image of (a)ball clay, (b) Li-A zeolite granules and a single slice of the tomogram of (c) ball clay and (d) Li-A zeolite granules.....	83
4.11 The first cycle of the oxygen concentrator at different zeolite particle sizes.....	88

LIST OF FIGURES (continued)

Figure	Page
4.12 The second cycle of the oxygen concentrator at different zeolite particle sizes.....	88
4.13 The third cycle of the oxygen concentrator at different zeolite particle sizes.....	89