

TABLE OF CONTENTS

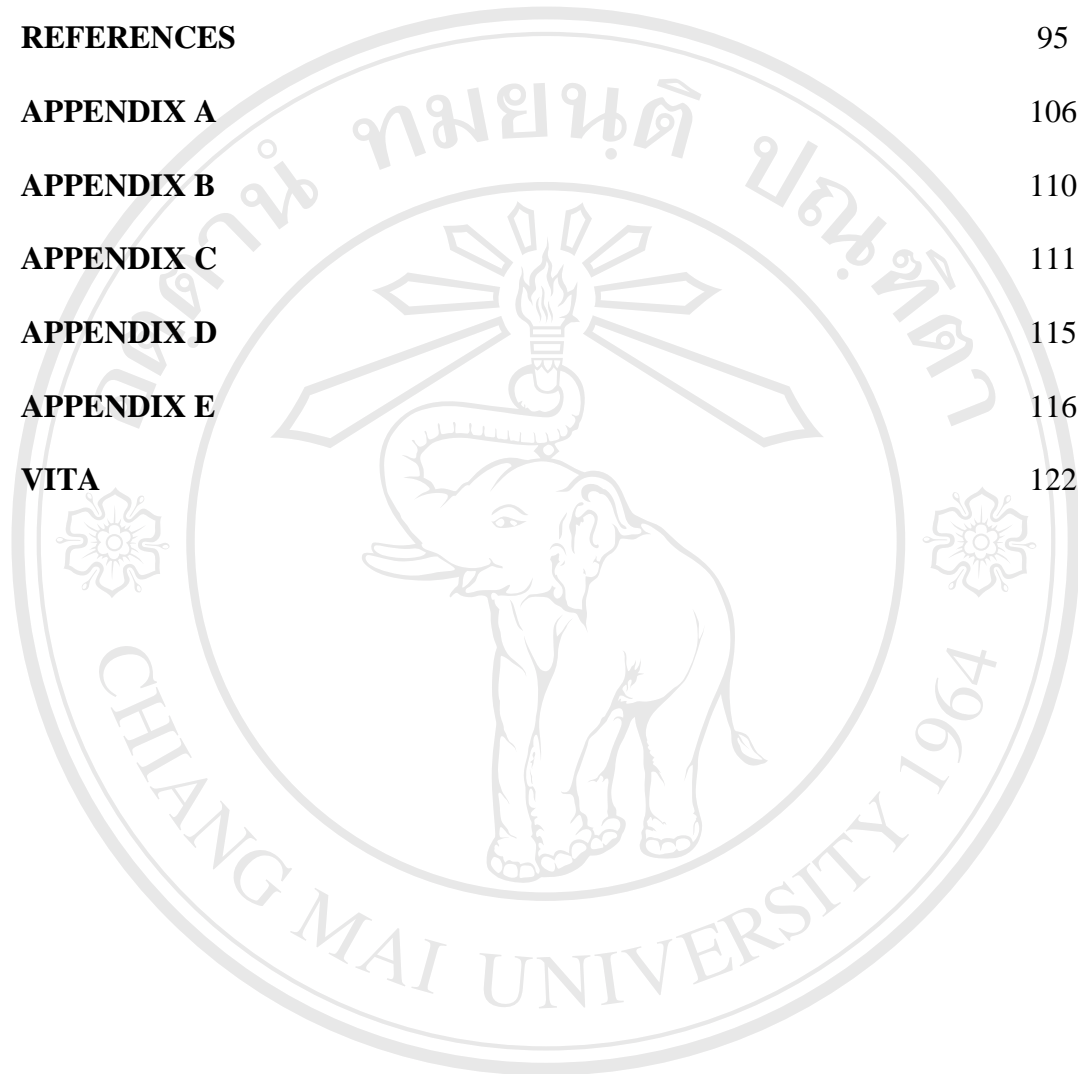
	Page
ACKNOWLEDGEMENT	III
ABSTRACT	IV
TABLE OF CONTENTS	VIII
LIST OF TABLES	XII
LIST OF FIGURES	XIII
ABBREVIATIONS AND SYMBOLS	XIV
CHAPTER 1: INTRODUCTION	1
1.1 Air pollution	1
1.2 Nitrogen dioxide (NO ₂)	2
1.2.1 Health and environmental effect of NO ₂	2
1.2.2 Atmospheric reaction of nitrogen	5
1.3 Study site “Chiang Mai Province”	8
1.3.1 Geographical background, population and economic structure	8
1.3.2 Traffic structure	12
1.4 Passive sampling of air	13
1.4.1 Operating principle	14
1.5 Literature Review	18
1.6 NO ₂ Test Kit	22
1.7 Spectrophotometry	24
1.8 Research Objectives	25

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright © by Chiang Mai University
All rights reserved

	Page
CHAPTER 2 EXPERIMENTAL	26
2.1 Apparatus	26
2.2 Chemicals	26
2.3 Instruments	27
2.4 Preparation of solutions	27
2.4.1 Absorbing solution (20% v/v of Triethanolamine, TEA)	27
2.4.2 Sulfanilamide solution	27
2.4.3 N-(1Naphyl) ethylenediamine dihydrochloride (NEDA) solution	27
2.4.4 Saltzmann reagent	27
2.4.5 Nitrite standard stock solution (1000 mg/L)	28
2.5 Analytical characteristics	28
2.5.1 Linear dynamic rang	28
2.5.2 Calibration curve	28
2.5.3 Limit of Detection (LOD) and Limit of Quantitation (LOQ)	28
2.5.4 Repeatability and Reproducibility	29
2.6 NO ₂ test kit and its user instruction	29
2.7 Passive sampler for NO ₂ determination	32
2.7.1 Preparation of diffusion tube	32
2.7.2 Exposure of diffusion tube	33
2.7.3 Extraction of sample	35
2.7.4 Analysis of sample	35
2.7.5 NO ₂ determination from incense burning	35

	Page
2.8 Sampling site	36
2.8.1 Land – use pattern	36
2.8.2 Location of sampling site and sampling period	39
2.8.3 Sampling site description	44
CHAPTER 3 RESULTS AND DISCUSSION	55
3.1 Analytical Characteristics of Spectrophotometry	55
3.1.1 Linear range	55
3.1.2 Calibration curve of nitrogen dioxide	55
3.1.3 Limit of detection and limit of quantification	58
3.1.4 Repeatability and reproducibility	59
3.2 Application of NO ₂ test kit in field study	60
3.2.1 Correlation of NO ₂ concentrations determination by the test kit and spectrophotometry	60
3.3 Comparison of urban NO ₂ concentrations from spectrophotometry and chemiluminescence	62
3.4 NO ₂ concentrations from passive sampling	66
3.4.1 NO ₂ concentrations in urban, sub-urban and rural areas	66
3.4.2 Contribution of NO ₂ from incense burning	74
3.4.3 Temporal variation of NO ₂ concentrations	78
3.4.4 Geographic distribution of NO ₂ in Chiang Mai	82

	Page
CHAPTER 4 CONCLUSION	92
REFERENCES	95
APPENDIX A	106
APPENDIX B	110
APPENDIX C	111
APPENDIX D	115
APPENDIX E	116
VITA	122



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
 Copyright© by Chiang Mai University
 All rights reserved

LIST OF TABLES

Table	Page
1.1 Standard of nitrogen dioxide in ambient air prescribed by various organizations	4
1.2 Population and population density in Chiang Mai Province	11
2.1 Land – use pattern of Chiang Mai province in 2006	37
2.2 The surrounding of sampling site	40
2.3 The Geographical Position System in Chiang Mai Province	41
3.1 Linear dynamic ranges of nitrite standard	56
3.2 Absorbance of nitrite standard solution	57
3.3 Limit of detection and limit of quantification of spectrophotometry for nitrite	59
3.4 Repeatability and reproducibility of spectrophotometry	60
3.5 Nitrogen dioxide concentrations from passive samplers in comparison with reference values	64
3.6 Comparison of NO ₂ concentrations in ambient air of urban areas of Chiang Mai Province obtained from spectrophotometry and chemiluminescence	65
3.7 The concentrations of NO ₂ in ambient air samples measured by spectrophotometry	69
3.8 NO ₂ concentrations from testing of incense burning in laboratory	76
3.9 NO ₂ concentrations from U3 site (shrine)	77
3.10 Classification of NO ₂ concentrations based on measurement data	82
3.11 Adjustment of NO ₂ concentrations from passive sampling	85

LIST OF FIGURES

Figure	Page
1.1 Sources of nitrogen oxide (NO _x) emission in Germany in the year 2000	3
1.2 Map of Thailand, including location of Chiang Mai	9
1.3 Changes in the population and the number of the registered vehicles in Chiang Mai Province from 2001 to 2006	12
1.4 The NO ₂ formation for determined by spectrophotometry	16
1.5 Examples of different sampler configurations	19
1.6 Spectrophotometry	23
1.7 Schematic diagram of a spectrophotometer	24
2.1 Standard color chart of nitrogen dioxide in mg/L and ppbv (based on 3 day exposure) adapted from Chalermrom, 2008	31
2.2 Passive sampling of NO ₂ and sample analysis by NO ₂ test kit	32
2.3 Polypropylene tubes	33
2.4 The configuration of passive samplers (a) and a gas diffusion pathway (b)	34
2.5 Land – use pattern of in Chiang Mai Province in 2006	38
2.6 Location of the study sites in Chiang Mai Province	43
2.7 U1; Maharaj Nakorn Chiang Mai Hospital, Muang District	45
2.8 U2; Yupparaj Wittayalai School, Muang District	45
2.9 U3; Waroros Market, Muang District	45
2.10 U4; Chiang Mai Regional Police Traffic Center, Muang District	47
2.11 U5; Pee Nong Dormitory, Muang District	47
2.12 U6; Soi 7 Muen Dam Phra Khot Road, Back of CMRU	47

Figure	Page
2.13 U7; Muen San Temple, Muang District	49
2.14 U8; Yu Pin House (small real-estate), Muang District	49
2.15 SU1; San Sai Market; San Sai District	49
2.16 SU2; Ban San Sai Noi, San Sai District	50
2.17 SU3; Thanawan home-estate	50
2.18 SU4; Ban Tam Nuk, Muang District	50
2.19 SU5; Ban Tan Pin, Muang District	51
2.20 SU6; Ban Muang Kung, Hang Dong District	51
2.21 R1; Ban Rong Bon, Doi Saket District	51
2.22 R2; Ban Pha Yak Don Kaew, Doi Saket District	53
2.23 R3; Ban Rong Khi Lek, Doi saket District	53
2.24 R4; Ban Rai, Hang Dong District	53
2.25 R5; Aeranthawan Temple, Hang Dong District	54
2.26 R6; Ban Num Phrae, Hang Dong District	54
3.1 Linear dynamic range of nitrite standard	57
3.2 Calibration curve of nitrite standard solution	58
3.3 Correlation of NO ₂ concentrations determined by NO ₂ test kit and spectrophotometry	61
3.4 (a) Concentrations of NO ₂ in ambient air of urban area November 2007 to April 2008 measured by spectrophotometry	71
3.4 (b) Concentrations of NO ₂ in ambient air of sub-urban area November 2007 to April 2008 measured by spectrophotometry	72
3.4 (c) Concentrations of NO ₂ in ambient air of rural area November 2007	73

Figure	Page
to April 2008 measured by spectrophotometry	
3.5 Concentrations of NO ₂ in November 2007 to April 2008 measured by spectrophotometry a. November 2007, b. December 2007, c. January 2008, d. February 2008, e. March 2008 and f. April 2008	79
3.6 (a) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in November 2007	86
3.6 (b) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in December 2007	87
3.6 (c) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in January 2008	88
3.6 (d) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in February 2008	89
3.6 (e) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in March 2008	90
3.6 (f) Ambient NO ₂ concentrations and wind rose of Chiang Mai Province in April 2008	91

ABBREVIATION AND SYMBOLS

ANOVA	Analysis of Variance
CO	Carbon monoxide
EU	Eupean union
H ₂ S	Hydrogen sulfide
LDR	Linear Dynamic Range
LOD	Limit of detection
LOQ	Limit of Quantification
LSD	Least significant difference
NE	Northeast
NH ₃	Ammonia
NMHCs	Non-methane hydrocarbons
NO _x	Nitrogen oxide
NO	Nitric oxide
NO ₂	Nitrogen dioxide
NO ₂ ⁻	Nitrite
N ₂ O	Nitrous oxide
NW	Northwest
mg/L	Milligrams per liter
µg/m ³	Micrograms per cubic meter
µl	Microliters
ml	Milliliters

PAHs	Particulate polycyclic aromatic hydrocarbons
PAN	Peroxyacetyl nitrate
PCD	Pollution Control Department, Thailand
PP	Polypropylene
ppbv	part per billion volume
ppm	part per million
RSD	Relative Standard Deviation
s	second
SE	Southeast
SD	Standard Deviation
SO ₂	Sulfur dioxide
SW	Southwest
TEA	Triethanolamine
US-EPA	United State-Environmental Protection Agency
WHO	World Health Organization

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved