

CONTENTS

	Page
ACKNOWLEDGEMENT	III
ABSTRACT IN ENGLISH	IV
ABSTRACT IN THAI	VI
CONTENTS	VIII
LIST OF TABLES	XIII
LIST OF ILLUSTRATIONS	XV
ABBREVIATION	XVII
 CHAPTER1: INTRODUCTION	
1.1 Introduction to Formaldehyde and Passive Sampling	1
1.2 Formaldehyde Information	5
1.2.1 Physical and chemical properties	5
1.2.2 Source exposure	6
1.2.3 Levels in homes	7
1.2.4 Health affects	7
1.2.5 Usage	9
1.2.6 Regulations	10
1.2.7 Guidelines	11
1.2.8 Workplace indoor monitoring	12
1.3 Sampling and Analysis of formaldehydes	13
1.3.1 Passive Sampling	13
1.3.2 Formaldehyde passive samplers	23

	Page
1.3.3 Analysis method	25
1.3.4 Type of sorbent	25
1.3.5 Calibration system for passive samplers	26
1.4 Spectrophotometer for formaldehyde determination	27
1.5 Research objectives	30
 CHAPTER2: EXPERIMENTAL	
2.1 Chemicals	31
2.2 Instruments and apparatus	31
2.3 Preparation of Sampling Tubes	32
2.3.1 Adsorbent conditioning	32
2.3.2 Sorbent of formaldehyde	33
2.3.3 Passive Sampling Tube	34
2.4 Analytical methodology	36
2.4.1 Preparation of calibration curve of formaldehyde	36
2.4.2 Desorption (extraction) of filter paper	36
2.4.3 Color Development	36
2.4.4 Linear dynamic range (LDR)	37
2.4.5 Detection limit of spectrophotometry	37
2.5 Formaldehyde Exposure Chamber System	39
2.5.1 Humidifier unit	41
2.5.2 Formaldehyde generator unit	41

	Page
2.5.3 Mixing chamber	42
2.5.4 Exposure chamber	42
2.5.5 Gas collector unit	43
2.6 Determination of analyte concentration in the chamber	44
2.7 Optimization of sampler	45
2.7.1 Detection limit of sampler	45
2.7.2 Determination of total air resistance	45
2.7.3 Optimization types of impregnated paper	46
2.7.4 Optimization types of diffusion tube	47
2.7.5 Desorption efficiency and number of filter layers	47
2.7.6 Stability of sample	47
2.8 Validation of sampler	47
2.8.1 Effect of wind velocity	48
2.8.2 Effect of relative humidity	49
2.8.3 Effect of temperature	49
2.8.4 Effect of sampler orientation	49
2.8.5 Effect of reverse diffusion	50
2.8.6 Sampling time	51
2.8.7 Comparison of self constructed passive sampler and commercial passive sampler	51

	Page
CHAPTER 3: RESULTS AND DISCUSSION	
3.1 Determination of formaldehyde by spectrophotometry	53
3.1.1 Calibration curve of formaldehyde	53
3.1.2 Linearity of range	54
3.2 Detection limit of spectrophotometry	55
3.3 Optimization of passive sampler	56
3.3.1 Detection limit of passive sampler	56
3.3.2. Determination of total air resistance	68
3.3.3 Selection of types of adsorbent	60
3.3.4 Selection types of diffusion tube	62
3.3.5. Desorption efficiency and number of filter layers	64
3.3.6 Storage stability	68
3.4 Validation of sampler	69
3.4.1 Validation of wind velocity effect	69
3.4.2 Validation of relative humidity effect	74
3.4.3 Validation wind of temperature effect	78
3.4.5 Effect of orientation	82
3.4.6 Effect of reverse diffusion	86
3.5 Determination of formaldehyde indoors	88
3.5.1 Sampling duration	88

	Page
3.5.2 Comparison of Self-Constructed Sampler (SCS) with a commercial sampler	93
CHAPTER 4: CONCLUSION	99
REFERENCES	103
APPENDIX A	110
APPENDIX B	114
APPENDIX C	118
APPENDIX D	121
VITA	129

LIST OF TABLES

Table	Page
1.1 Application of passive samplers in air pollution-vegetation effects related studies.	18
1.2 Comparative characteristics of passive samplers and active (continuous) monitors for quantifying ambient air pollutant concentrations	20
2.1 Detail of adsorbent	32
2.2 Speciation of passive sampler	52
3.1 Absorbance of formaldehyde	53
3.2 Detection limit of spectrophotometry for formaldehyde	56
3.3 Data of detection limit of formaldehyde passive sampler	57
3.4 Data of detection limit of formaldehyde passive sampler (continued)	58
3.5 Dimension factor of formaldehyde passive sampler for total air resistance determination	59
3.6 Percent recovery of formaldehyde from different types of adsorbent	61
3.7 Types of diffusion tube and their percent recoveries for formaldehyde	63
3.8 Percent recoveries of formaldehyde from different number of filter layers	66
3.9 Wind velocity effect on the sampling low concentration Level	71
3.10 Validation of relative humidity effect on the sampling low concentration level	75

Table	Page
3.11 Validation of temperature effect on the sampling at low concentration level	79
3.12 Effect of sampler of orientation on absorbance formaldehyde Concentration	84
3.13 Effect the reverse diffusion on formaldehyde passive sampler	87
3.14 Effect of sampling duration on formaldehyde concentration	88
3.15 Difference of formaldehyde concentrations and exposure duration	92
3.16 Indoor formaldehyde concentrations of 8 and 24 hours	92
3.17 Comparison of indoor formaldehyde concentrations collected by Self-constructed sampler and commercial sampler (SKC) at 8 hours exposure duration	96
3.18 Comparison of indoor formaldehyde concentrations collected by Self-constructed sampler and commercial sampler (SKC) at 24 hours exposure duration	97
3.19 Comparison of indoor formaldehyde concentrations collected by Self-constructed sampler and commercial sampler (SKC) at 7 days exposure duration	98

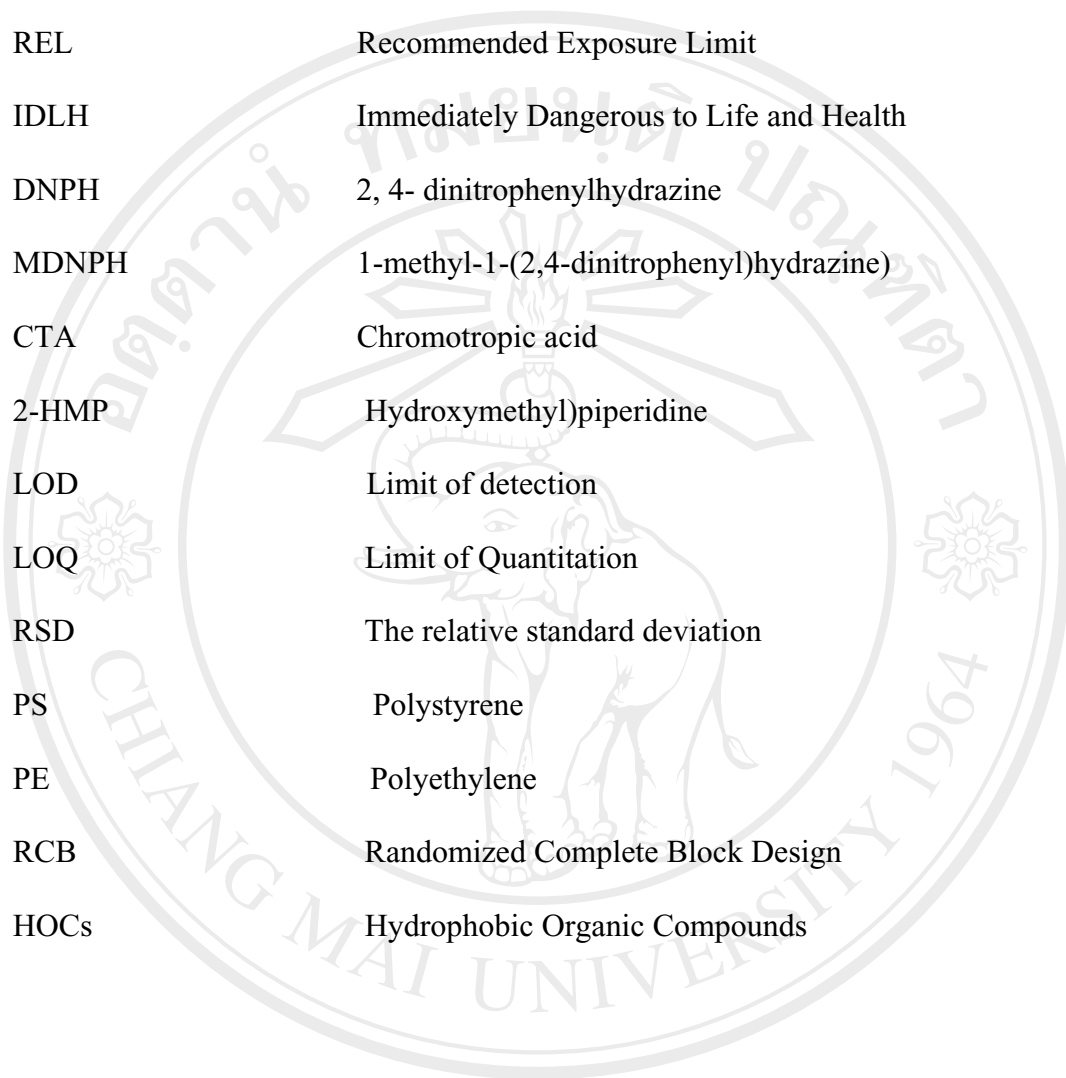
LIST OF ILLUSTRATIONS

Figure	Page
1.1 Chemical structure of Formaldehyde	6
2.1 Reaction of bisulfite adduct	33
2.2 Purple mono-cationic chromogen	34
2.3 (a) dimension of passive sampler	35
(b) Self-constructed passive sampler	35
2.4 PTFE tread seal tape	40
2.5 Diagrams of Formaldehyde Exposure Chamber System	40
2.6 Formaldehyde Exposure Chamber System	41
2.7 Humidifier units	42
2.8 Formaldehyde vapor delivery unit	43
2.9 Diagram of the exposure chamber	44
2.10 continuously gas collector	51
2.11 Formaldehyde Passive Sampler (SKC inc.)	54
3.1 Calibration curve of formaldehyde	55
3.2 Linear dynamic range of CTA method	61
3.3 Percent recovery of the formaldehyde from difference types of adsorbent	63
3.4 Types of diffusion tube and percent recovery of formaldehyde	

Figure	Page
3.5 Percent recoveries of formaldehyde from different numbers of filter layer	65
3.6 storage stability of formaldehyde passive sampler	68
3.7 Wind velocity effect on efficiency of formaldehyde sampler	70
3.8 Relative Humidity effect on capacity of formaldehyde passive sampler	74
3.9 validation of temperature effect on capacity of formaldehyde passive sampler	78
3.10 Effect of sampler of orientation on absorbance formaldehyde concentration	83
3.11 Effect of reverse diffusion on formaldehyde passive sampler	86
3.12 Formaldehyde concentrations of different sampling duration	91
3.13 Indoor formaldehyde concentrations of 8 and 24 hours	93
3.14 Comparison of indoor formaldehyde concentrations collected by SCS and commercial one	95
3.15 The slope of decreasing of concentration for 8 hours to 7 days	95

BREVIATIONS

mg/m³	microgram per cubic meter
µg /ml	microgram per milliter
nm	nanometer
ml	milliter
s	second
mit	minute
m	meter
g	gram
ppm	Part per million
m/s	meter per second
VOCs	Volatile Organic Compounds
NIOSH	National Institute for Occupational Safety and Health
PELs	permissible exposure limits
STEL	Short term exposure limit
HPLC	High Performance Liquid Chromatography
FID	Flame ionization detector
PP	Polypropylene
SCS	Self-Constructed Sampler
UFFI	Urea-formaldehyde foam insulation
TQ	Threshold Quantity
HAP	Hazardous Air Pollutant
TPQ	Threshold Planning Quantity



OSHA	the Occupational Safety and Health Administration
TLV-C	Threshold Limit Value - Ceiling
REL	Recommended Exposure Limit
IDLH	Immediately Dangerous to Life and Health
DNPH	2, 4- dinitrophenylhydrazine
MDNPH	1-methyl-1-(2,4-dinitrophenyl)hydrazine)
CTA	Chromotropic acid
2-HMP	Hydroxymethylpiperidine
LOD	Limit of detection
LOQ	Limit of Quantitation
RSD	The relative standard deviation
PS	Polystyrene
PE	Polyethylene
RCB	Randomized Complete Block Design
HOCs	Hydrophobic Organic Compounds