TABLE OF CONTENTS	
	Page
ACKNOWLEDGEMENTS	iii
ABSTRACT (in English)	v
ABSTRACT (in Thai)	vii
TABLE OF CONTENTS	ix
LIST OF TABLES	xvi
LIST OF FIGURES	XX
LIST OF SCHEMES	xxiv
ABBREVIATIONS AND SYMBOLS	xxviii

1.1 Asymmet	The synthesis				1	
1.1.1 Prin	ciple of asymmetric synthes	sis			1	
1.1.2 Ana	lytical methods				3	
1.1.	2.1 Polarimeter				4	
	2.2 Nuclear Magnetic Reso	nance Sp	pectroscor	by by	6	
	2.3 Chromatography				11	
1.2 TADDOI	s and their derivatives				13	
1.3 Literature	reviews				14	
1.3.1 Moo	lified TADDOLs				14	

	1.3.1.1 Amino TADDOLs	14
	1.3.1.2 Titanium TADDOLates	17
	1.3.1.3 TADDOLs derived hydroperoxide	18
	1.3.1.4 TADDOLs-derived chiral phosphorus	21
	1.3.1.5 TADDOL-derived lithium aluminium hydride	23
	1.3.2 TADDOLs as chiral catalysts in asymmetric syntheses	27
	1.3.2.1 Addition to carbonyl compounds	22
	1.3.2.2 Reduction reactions	30
	1.3.2.3 Oxidation reactions	32
	1.3.2.4 Rearrangements	34
1.4	Stereochemistry	36
1.5	Aims and research objectives	36
CHAPT	ER 2 EXPERIMENTAL	
2.1	Resolution of enantiomeric dimethyl itaconate-anthracene adducts	
	(+)-(11 <i>S</i>)- 66 and (-)-(11 <i>R</i>)- 66	40
	2.1.1 Synthesis of (±)-11-carbomethoxy-11-carboxylmethyl-9,10-	
	dihydro-9,10-ethanoanthracene [(±)- 76]	40
	2.1.2 (-)-11-Carbomethoxy-11-[(-)-menthoxyacetyl]-9,10-dihydro-	
	9,10-ethanoanthracenes [(-)-(11 <i>S</i>)- 67 and (-)-(11 <i>R</i>)- 68]	43
	2.1.3 Preparation of optically active 11-carbomethoxy-11-methoxy-	
	acetyl-9,10-dihydro-9,10-ethanoanthracene [(+)-(11S)-66]	47
	2.1.4 Preparation of optically active 11-carbomethoxy-11-methoxy-	
	acetyl-9,10-dihydro-9,10-ethanoanthracene [(–)-(11 <i>R</i>)- 66]	⁵⁰ e o

2.2 Syntheses of both enantiomerically pure forms of tetrahydro-4'carbomethoxy-5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10-ethanoanthracenes and derivatives [(4'S,11R)-69a, (4'R,11R)-77, (4'R,11S)-69a and (4'S,11S)-77] 50 2.2.1 Synthesis of enantiomeric tetrahydro-4'-carbomethoxy-5'diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10ethanoanthracenes [(4'S,11R)-69a, (4'R,11R)-77] 50 2.2.2 Synthesis of enantiomeric tetrahydro-4'-carbomethoxy-5'diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10ethanoanthracenes [(4'R, 11S)-69a, (4'S, 11S)-77]55 Syntheses of both enantiomerically pure forms of tetrahydro-4'-2.3carbomethoxy-5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10-ethanoanthracenes derivatives [(4'S,11R)-69b, (4'S,11R)-69c, (4'*R*,11*S*)-**69b** and (4'*R*,11*S*)-**69c**] 56 2.3.1 Synthesis of enantiomeric of tetrahydro-4'-carbomethoxymethyl-5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10ethanoanthracenes [(4'S,11R)-69b] 56 2.3.2 Synthesis of enantiomeric of tetrahydro-4'-carbomethoxyethyl-5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10ethanoanthracenes [(4'S,11R)-69c] 59 2.3.3 Synthesis of enantiomeric of tetrahydro-4'-carbomethoxymethyl-5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10ethanoanthracenes [(4'*R*,11*S*)-**69b**] 61

	2.3.4 Synthesis of enantiomeric of tetrahydro-4'-carbomethoxyethyl-	
	5'-diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10-	
	ethanoanthracenes [(4'R,11S)-69c]	62
2.4	Syntheses of both enantiomerically pure forms of 11-hydroxymethy-	
	lene-11-(2'-(1',3'-dihydroxy-1',1'-diphenylpropyl))-9,10-dihydro-9,10-	
	ethano anthracenes [(2'S,11R)-70a and (2'R,11S)-70a]	63
	2.4.1 Synthesis of optically active of 11-hydroxymethylene-11-(2'-	
	(1',3'-dihydroxy-1',1'-diphenylpropyl))-9,10-dihydro-9,10-	
	ethanoanthracene [(2'S,11R)- 70a]	63
	2.4.2 Synthesis of optically active of 11-hydroxymethylene-11-(2'-	
	(1',3'-dihydroxy-1',1'-diphenylpropyl))-9,10-dihydro-9,10-	
	ethanoanthracene [(2'R,11S)-70a]	67
2.5	Study the effect of the triol TADDOL-anthracene catalysts	
	(2'S,11R)- 70a and (2'R,11S)- 70a for reduction reaction of	
	11-carbo-methoxy-11-(1'-benzoyl)methoxyacetyl-9,10-dihydro-	
	9,10-ethanoanthracene [(±)- 71]	68
	2.5.1 Reduction of β -keto ester (±)- 71 in the presence of TADDOL–	
	anthracene catalyst (2'S,11R)-70a	68
	2.5.1.1 1 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
	70a	68
	2.5.1.2 1 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
	70a in THF:H ₂ O (4:0.5)	72

2.5.1.3 5 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
70a 2 2 2 6 6	72
2.5.1.4 10 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
70a	73
2.5.1.5 15 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
70a	73
2.5.1.6 20 mol% of TADDOL–anthracene catalyst (2'S,11R)-	
70a	74
2.5.2 Reduction of β -keto ester (±)- 71 in the presence of TADDOL–	
anthracene catalyst [(2'R,11S)-70a]	74
2.5.2.1 1 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
70a	74
2.5.2.2 1 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
70a in THF:H ₂ O (4:0.5)	74
2.5.2.3 5 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
70a	75
2.5.2.4 10 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
70a	75
2.5.2.5 15 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
	76
2.5.2.6 20 mol% of TADDOL–anthracene catalyst (2'R,11S)-	
ights reser	76

СН	APT	ER 3 RESULTS AND DISCUSSION	
	3.1	Preparation of optically active dimethyl itaconate-anthracene adducts	
		(+)-(11 <i>S</i>)- 66 and (-)-(11 <i>R</i>)- 66	77
	3.2	Syntheses both of enantiomerically pure forms tetrahydro-4'-	
		carbomethoxy-5'-diphenyl-2'-hydroxy-2'-phenyl-furanone-3'-spiro-	
		11-9,10-dihydro-9,10-ethanoanthracenes [(4'S,11R)- 69a , (4'R,(11R)-	
		77 , (4' <i>R</i> ,11 <i>S</i>)- 69b and (4' <i>S</i> ,11 <i>S</i>)- 77]	79
	3.3	Syntheses both forms of optically active 11-hydroxymethylene-11-	
		(2'-(1',3'-dihydroxy-1',1'-diphenylpropyl))-9,10-dihydro-9,10-	
		ethanoanthracene $[(2'S,11R)-70a \text{ and } (2'R,11S)-70a]$	86
	3.4	Synthesis of optically active 11-hydroxymethylene-11-(2'-(1',3'-	
		dihydroxy-1',1'-diphenylpropyl))-9,10-dihydro-9,10-	
		ethanoanthracene derivatives [(2'S,11R)-89 and (2'S,11R)-90]	98
		3.4.1 Synthesis of 11-(1"-hydroxymethylphenyl)-11-([1'-hydroxy-	
		diphenylmethyl]-methoxyacetyl)-9,10-dihydro-9,10-ethano	
		anthracene [(2'S,11R)- 89]	99
		3.4.2 Protection of 11-hydroxymethylene-11-(2'-(1',3'-dihydroxy-	
		1',1'-diphenylpropyl))-9,10-dihydro-9,10-ethanoanthracene	
		[(2'S,11R)-90]	100
	3.5	Synthesis of enantiomeric of tetrahydro-4'-alkylcarbomethoxy-5'-	
		diphenyl-2'-furanone-3'-spiro-11-9,10-dihydro-9,10-ethano	
		anthracenes [(4'S,11R)- 69b and (4'S,11R)- 69b]	102

3.6	Reduction of tetrahydro-4'-alkylcarbomethoxy-5'-diphenyl-2'-	
	furanone-3'-spiro-11-9,10-dihydro-9,10-ethanoanthracenes	
	[(2'S,11R)- 69b and (2'S,11R)- 69c]	109
3.7	Study the effect of the triol TADDOL-anthracene catalysts for	
	1,2-addition reaction of ethyl magnesium bromide to benzaldehyde	110
3.8	Study the effect of the triol TADDOL-anthracene catalysts for	
	reduction reaction of 11-carbomethoxy-11-(1'-benzoyl)methoxy-	
	acetyl-9,10-dihydro-9,10-ethanoanthracene [(±)-71]	112
СНАРТ	FR 4 CONCLUSION	126
REFERI	ENCES	120
APPENI	DIX	133
CURRIC	CULUM VITAE	176

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

LIST OF TABLES

Table		Page
1	Common chiral lanthanide shift reagents	8
2	Enantioselective addition of diethylzinc to aromatic aldehydes	
	catalyzed by amino-TADDOL	15
3	Enantioselective addition of diethylzinc to aldehydes catalyzed	
	by 20	16
4	Catalysis by BINOLate/TADDOLate-Ti Complexe 22a	17
5	3,3'-Modified BIPOLate/TADDOLate-Ti COmplexe 22	18
6	Catalytic oxidation of mesitylol 25 by the various transition-	
	metal-substituted polyoxometalates with the racemic	
	hydroperoxide 24	19
7	Catalytic enantioselective epoxidationa of the primary allylic	
	alcohols 28 by $[ZnW(VO)_2(ZNW_9O_{34})_2]^{-12}$ with TADOOH 23	20
8	[Rh(nbd)Cl] ₂ -catalyzed hydroboration of 4-chlorostyrene using	
	TADDOL-phosphite and phosphoamidite ligands, L	22
9	Asymmetric reduction of alkyl aryl ketones 44a-f with aluminium	
	hydride reagents 42 ($M^+ = Na^+$) and 43 in THF giving rise to	
	alcohols 45a-f	24

xvii

LIST OF TABLES (CONTINUED)

Table		Page
10	Asymmetric reduction of N-(triphenylphosphinyl)acetophenone-	
	imine (46) with aluminium hydride reagents 42 ($M^+ = Na^+$) and 43	
	in THF	26
11	Reactions of methyl ketones with reagents derived from	
	TADDOLs 49 or 50	28
12	Asymmetric hydrogenation of prochiral olefins with	
	$[Rh(nbd)_2BF_4]$ and ligands 53a-d	31
13	Epoxidation of 1,3-diphenylprop-2-en-1-one and of other	
	enones with hydroperoxy alcohol 54	33
14	Oxidation of MeSPh by the hydrogenperoxy alcohol 54	34
15	The reaction of Brassard's diene with aldehydes catalyzed by 60	35
16	Data of the monoacid adduct (±)-76	41
17	Data of monomenthyl adduct (–)-(11S)-67	44
18	Data of monomenthyl adduct (-)-(11R)-68	45
19	Data of optically active dimethyl itaconate-anthracene adduct	
	(+)-(11 <i>S</i>)- 66	48
20	Data of major spiro–lactone diastereomer (4'S,11R)-69a	52
21	Data of minor spiro–lactone diastereomer (4'R,11R)-77	53
22	Data of methyl spiro–lactone adduct (4'S,11R)-69b	57

LIST OF TABLES (CONTINUED)

Table		Page
23	Data of ethyl spiro–lactone adduct (4'S,11R)-69c	59
24	Data of triol TADDOL–anthracene adduct (2'S,11R)-70a	64
25	Data of reduced compound (4'R,11S)-78	65
26	Data of <i>trans</i> -isomer 72	69
27	Data of <i>cis</i> -isomer 73	71
28	¹ H-NMR data of both enantiomeric major and minor spiro–	
	lactone adducts 69a and 77	85
29	¹ H-NMR data of TADDOL–anthracene adducts and byproducts	
	(2'S,11R)- 70a and (2'R,11S)- 70a , (4'R,11S)- 78 and (4'S,11R)- 78 ,	
	(11 <i>R</i>)- 79 and (11 <i>S</i>)- 79 and (11 <i>S</i>)- 80 and (11 <i>R</i>)- 80	97
30	Synthesis of TADDOL-anthracene adduct in the diol form	100
31	Synthesis of the TADDOL-anthracene adduct in the protected form	101
32	Optimization of synthesizing methyl spiro-lactone	
	(4'S,11R)- 69b	102
33	¹ H-NMR data of optically active spiro–lactone derivatives	
	(69b and 69c)	108
34	Effect of the triol TADDOL-anthracene adduct (2'S,11R)-70a	
	in 1,2-addition	111

LIST OF TABLES (CONTINUED)

Table Page 35 Reduction of β-keto ester (±)-71 by NaBH₄ in the presence of (2'S, 11R)-70a and (2'R,11S)-70a 113

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

LIST OF FIGURES

Figure		Page
1	Structure of carvones	1
2	Components of polarimeter	4
3	Structure of Mosher's acid	7
1 A	Common chiral derivatizing agents for ¹ H NMR and ¹⁹ F NMR	8
5 5	Structure of 1-(9-anthryl)-2,2,2-trifluoroethanol (8)	10
6	Common chiral solvating agents and some classes of compounds	
	which have been used with	10
7	Structures of TADDOLs	13
8	Amino-TADDOL derivatives	15
9	Structure of TADOOH (23)	18
10	TADDOLate reagents	27
11	TADOOH reagent 54	32
12	TADDOL catalyst 60 for asymmetric hetero-Diels-Alder reaction	34
13	3D structural conformations of both forms of major spiro-lactone	
	adducts $(4'S,11R)$ -69a and $(4'R,11S)$ -69a were generated by	
	MM2 force field calculations for energy minimization from	
	modeling program Chem3D Ultra 11.0 and GaussView 3.09	
	program	82

LIST OF FIGURES (CONTINUED)

Figure		Page
14	¹ H-NMR spectral data of major spiro–lactone adduct	
	(4'S,11R)- 69a and (4'R,11S)- 69a	83
15	3D structural conformations of both forms of minor	
	spiro–lactone adducts (4'R,11R)-77 and (4'S,11S)-77 were	
	generated by MM2 force field calculations for energy minimization	
	from modeling program Chem3D Ultra 11.0 and GaussView	
	3.09 program	84
16	¹ H-NMR spectral data of minor spiro–lactone adduct	
	(4'R,11R)-77 and (4'S,11S)-77	85
17	3D structural conformations of triol TADDOL-anthracene adducts	
	(2'S,11R)- 70a and (2'R,11S)- 70a were generated by MM2 force	
	field calculations for energy minimization from modeling program	
	Chem3D Ultra 11.0 and GaussView 3.09 program with	
	the observed NOE correlations (arrows)	91
18	¹ H-NMR spectral data of triol TADDOL–anthracene adducts	
	(2'S,11R)- 70a and (2'R,11S)- 70a (dash arrows were COSY	
	correlation)	92

LIST OF FIGURES (CONTINUED)

Figure		Page
19	3D structural conformations of reduced compounds $(4'R, 11S)$ -	
	78 and (4' <i>S</i> ,11 <i>R</i>)- 78 were generated by MM2 force field	
	calculations for energy minimization from modeling program	
	Chem3D Ultra 11.0 and GaussView 3.09 program with the	
	observed NOE correlations (arrows)	93
20	¹ H-NMR spectral data of reduced compounds $(4'R, 11S)$ -78 and	
	(4'S,11R)-78 (dash arrows were COSY and NOE correlation,	
	respectively)	94
21	¹ H-NMR spectral data of by-products $(11R)$ - 79 and $(11S)$ - 79	
	(Dash arrows and plain arrows were COSY, NOE and HMBC	
	correlation, respectively)	95
22	¹ H-NMR spectral data of by-products (11 <i>S</i>)- 80 and (11 <i>R</i>)- 80	96
23	3D structural conformations of methyl spiro-lactone adducts	
	(4'R,11S)-69b and (4'S,11R)-69b were generated by MM2	
	force field calculations for energy minimization from modeling	
	program Chem3D Ultra 11.0 and GaussView 3.09 program	105
Copyrig241t	¹ H-NMR spectral data of methyl spiro–lactone adduct	
	(4' <i>S</i> ,11 <i>R</i>)- 69b and (4' <i>R</i> ,11 <i>S</i>)- 69b	106

LIST OF FIGURES (CONTINUED)

Figure

25

26

Page

3D structural conformations of ethyl spiro–lactone adducts (4'R,11S)-**69c** and (4'S,11R)-**69c** were generated by MM2 force field calculations for energy minimization from modeling program Chem3D Ultra 11.0 and GaussView 3.09 program 107 ¹H-NMR spectral data of ethyl spiro–lactone adduct (4'S,11R)-**69c** and (4'R,11S)-**69c** 108

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

xxiv

LIST OF SCHEMES

Schei	ne	Page
1	Enantioselective decarboxylation of brucine and 2-ethyl-2-	
	methylmalonic acid (1)	2
2	The possibilities of alkylation to chiral enolate 4	3
3	Retrosynthesis of TADDOLs	14
4	Synthesis of chiral BIPOLate/TADDOLate–Ti catalyst 22	17
5	TADDOL-containing hydride reagents	23
6	Synthesis of chiral calix[4]arene-based diphosphites 53a-d	30
7	One-step synthesis of (S)-(+)-dihydrokawain 61	35
8	Schematic represents the Felkin-Anh model	36
9	Syntheses of TADDOL–anthracene analogues $(2'S, 11R)$ -70 and	
	(2'R,11S)- 70	37
10	Studied the 1,2-addition reaction of ethyl magnesium bromide to	
	benzaldehyde with TADDOL–anthracene adduct (2'S,11R)-70a	
	and (2' <i>R</i> ,11 <i>S</i>)- 70a	38
11	Applied of the novel TADDOL–anthracene catalysts (2'S,11R)-	
	70a and $(2'R,11S)$ - 70a in the reduction of β -keto ester (±)- 71	
	using NaBH ₄ as reducing agent	38
18 ₁₂	Retrosynthesis of TADDOL–anthracene catalysts 79	77

LIST OF SCHEMES (CONTINUED)

Scheme	Scheme	
13	Resolution of dimethyl itaconate–anthracene adducts (+)-(11S)-	
	66 and (–)-(11 <i>R</i>)- 66	79
14	Synthesis both of enantiomeric spiro-lactone adducts	
	69a and 77	80
15	Schematic represents the proposed mechanism of tandem	
	aldol-lactonization of the spiro-lactone adducts	81
16	Reduction of the major spiro-lactone adducts (4'S,11R)-69a	
	and (4' <i>R</i> ,11 <i>S</i>)- 69a by an excess lithium aluminium hydride	87
17	Proposed mechanism of the spiro-lactone reducing by LAH	89
18	The target TADDOL-anthracene catalysts in diol and protected	
	forms	99
19	Synthesis of TADDOL-anthracene adduct derivatives	
	70b and 70c	101
20	Synthesis both of enantiomeric spiro-lactone derivatives	
	69b and 69c	103
21	Proposed mechanism of synthesis spiro-lactone derivatives	
	69b and 69c	104
22	Reducing of methyl and ethyl spiro-lactone adducts by an excess	
	LAH NTS RESER	110 e

LIST OF SCHEMES (CONTINUED)

Scheme		Page
23	23 Proposed mechanism of β -keto ester reduction by	
	Jongkol, R <i>et al</i> .	115
24	The asymmetric reduction of prochiral aromatic ketones by	
	chirally modified NaBH ₄	116
25	Mechanism of $NaBH_4$ and carboxylic acid with chiral diol	117
26	Transition state model for reduction of propiophenone by chirally	
	modified NaBH ₄	117
27	Proposed transition state models for the triol TADDOL-anthracene	
	adducts (2'S,11R)-70a via Felkin-anh model	118
28	Proposed transition state models for the triol TADDOL-anthracene	
	adducts (2'S,11R)-70a via Anti-Felkin-anh model	119
29	Proposed mechanism for the triol TADDOL-anthracene	
	adduct (2'S,11R)-70a. (a) Mechanism for <i>cis</i> -isomer.	
	(b) Mechanism model for <i>trans</i> -isomer	120
30	Proposed transition state models for the triol TADDOL-anthracene	
	adduct (2' <i>R</i> ,11 <i>S</i>)- 70a via Felkin-anh model	122
31	Proposed transition state models for the triol TADDOL-anthracene	
	adduct (2'R,11S)-70a via Anti-Felkin-anh model	123

xxvi

LIST OF SCHEMES (CONTINUED)

Scheme

Scheme		Page
32	Proposed mechanism for the triol TADDOL-anthracene	
	adduct (2' <i>R</i> ,11 <i>S</i>)- 70a . (a) Mechanism for <i>cis</i> -isomer.	
	(b) Mechanism model for <i>trans</i> -isomer	124
33	Total synthesis of TADDOL–anthracene adducts (2'S,11R)-70a	
	and (2' <i>R</i> ,11 <i>S</i>)- 70a	126
34	1,2-addition of benzaldehyde and EtMgBr with 1 mol%	
35	of TADDOL–anthracene adducts $(2'S,11R)$ -70a and Ti $(^{i}OPr)_{4}$	127
	The β -keto ester reduction with 1 mol% of TADDOL–anthracene	
	adducts (2'R,11S)-70a	128

ABBREVIATIONS AND SYMBOLS

b.p.	boiling point
n-BuLi	<i>n</i> -butyllithium
°C	degrees celcius
compd	compound
calcd	calculated
cat.	catalyst
conc	concentration
COSY	correlation spectroscopy
δ	chemical shift in parts per million downfield from
	tetramethylsilane
d	doublet (spectral)
d	density
dd	double of doublet (spectral)
ddd	double of doublet (spectral)
dt	double of triplet (spectral)
d.e.	diastereomeric excess
DCC	N,N'-dicyclohexylcarbodiimide
DEPT	distortionless enhancement by polarization transfer
DMAP	4-(<i>N</i> , <i>N</i> -dimethylamino)pyridine
ee. r i g	enantiomeric excess

xxix

ESI-MS	electrospray ionization mass spectrometry
Et	ethyl
EtOAc	ethyl acetate
equiv	equivalent
FT-IR	fourier-transform infrared
g	gram
НМВС	heteronuclear multiple bond correlation
НМРА	hexamethylphospharamide
НМQС	heteronuclear multiple quantum correlation
Hz	hertz
hr	hour (s)
IR	infrared
J	coupling constant
LAH	lithium aluminium hydride
LDA	lithium diisopropylamide
Lit.	literature
Ме	methyl
MHz	megahertz
MW, mol wt	molecular weight
m	multiplet (spectral)
min	minute (s)
mL	millilitre nang Mal University
mmol	milimole reserved
mol	mole

m.p.	melting point
m/z	mass to charge ratio
NMR	nuclear magnetic resonance
NOE	nuclear overhauser effect
Ph	phenyl
PhLi	phenyl lithium
PLC	preparative layer chromatography
ppm	parts per million (in NMR)
<i>i</i> -Pr	isopropyl
rt	room temperature (°C)
S	singlet (spectral)
THF	tetrahydrofuran
TMS	tetramethylsilane
TMEDA	tetramethylenediamine
t	triplet (spectral)
UV	ultraviolet
%	percent
[<i>a</i>]	specific optically rotation
ν	wave number (cm ⁻¹)

All rights reserved

XXX