

## CONTENTS

	<b>Page</b>
CONTENTS	xii
LIST OF TABLES	xv
LIST OF ILLUSTRATIONS	xvii
LIST OF ABBREVIATIONS AND SYMBOLS	xxix
1. INTRODUCTION	1
1.1 Introduction	1
1.2 Review of Literatures	3
1.3 The Objectives	21
2. EXPERIMENTAL	22
2.1 Instruments and Chemicals	22
2.2 Plant material	23
2.3 Extraction	23
2.4 Isolation and Chemical Investigation	24
2.4.1 Investigation of the CH <sub>2</sub> Cl <sub>2</sub> extract from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	24
2.4.2 Investigation of the acetone extract from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	29
2.5 Bioassay	31
2.5.1 Antibacterial assay	31
2.5.2 Cytotoxic assay	32

## CONTENTS (Continued)

	<b>Page</b>
3. RESULTS AND DISCUSSION	33
3.1 Structural elucidation of the isolated compounds from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	33
3.1.1 Compound CPH1	34
3.1.2 Compound CPH2	37
3.1.3 Compound CPH3	39
3.1.4 Compound CPH4	41
3.1.5 Compound CPH5	43
3.1.6 Compound CPH6	45
3.1.7 Compound CPH7	47
3.1.8 Compound CPH8	49
3.1.9 Compound CPH9	51
3.1.10 Compound CPH10	53
3.1.11 Compound CPH11	57
3.1.12 Compound CPH12	61
3.1.13 Compound CPH13	64
3.1.14 Compound CPH14	66
3.1.15 Compound CPH15	68
3.1.16 Compound CPH16	71
3.1.17 Compound CPH17	73

## CONTENTS (Continued)

	<b>Page</b>
3.1.18 Compound CPH18	75
3.1.19 Compound CPH19	78
3.1.20 Compound CPH20	81
3.1.21 Compounds CPH21 and CPH22	84
3.2 Biological activities of the isolated compounds from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	85
REFERENCES	88
APPENDIX	94
VITAE	180

## LIST OF TABLES

<b>Tables</b>	<b>Page</b>
1 Chemical Constituents from the <i>Cratoxylum</i> genus	4
2 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH1	36
3 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH2	38
4 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH3	40
5 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH4	42
6 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH5	44
7 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH6	46
8 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH7	48
9 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH8	50
10 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH9	52
11 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH10	55
12 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH11	60
13 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH12	63
14 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH13	65
15 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH14	67
16 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH15	70
17 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH16	72
18 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH17	74
19 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of CPH18	77

## LIST OF TABLES (Continued)

Tables	Page
20 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of <b>CPH19</b>	80
21 $^1\text{H}$ , $^{13}\text{C}$ , HMQC and HMBC spectral data of <b>CPH20</b>	83
22 Antibacterial activity of the compounds isolated from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	86
23 <i>In vitro</i> cytotoxic activity of the compounds isolated from the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	87
24 Subject $^{13}\text{C}$ NMR correlations of <b>CPH1</b>	88
25 Subject $^1\text{H}$ NMR correlations of <b>CPH1</b>	88
26 The structure of <b>CPH1</b>	88
27 Subject $^{13}\text{C}$ NMR correlations of <b>CPH2</b>	89
28 Subject $^1\text{H}$ NMR correlations of <b>CPH2</b>	89
29 The structure of <b>CPH2</b>	89
30 Subject $^{13}\text{C}$ NMR correlations of <b>CPH3</b>	90
31 Subject $^1\text{H}$ NMR correlations of <b>CPH3</b>	90
32 The structure of <b>CPH3</b>	90
33 Subject $^{13}\text{C}$ NMR correlations of <b>CPH4</b>	91
34 Subject $^1\text{H}$ NMR correlations of <b>CPH4</b>	91
35 The structure of <b>CPH4</b>	91
36 Subject $^{13}\text{C}$ NMR correlations of <b>CPH5</b>	92
37 Subject $^1\text{H}$ NMR correlations of <b>CPH5</b>	92
38 The structure of <b>CPH5</b>	92
39 Subject $^{13}\text{C}$ NMR correlations of <b>CPH6</b>	93
40 Subject $^1\text{H}$ NMR correlations of <b>CPH6</b>	93
41 The structure of <b>CPH6</b>	93
42 Subject $^{13}\text{C}$ NMR correlations of <b>CPH7</b>	94
43 Subject $^1\text{H}$ NMR correlations of <b>CPH7</b>	94
44 The structure of <b>CPH7</b>	94
45 Subject $^{13}\text{C}$ NMR correlations of <b>CPH8</b>	95
46 Subject $^1\text{H}$ NMR correlations of <b>CPH8</b>	95
47 The structure of <b>CPH8</b>	95
48 Subject $^{13}\text{C}$ NMR correlations of <b>CPH9</b>	96
49 Subject $^1\text{H}$ NMR correlations of <b>CPH9</b>	96
50 The structure of <b>CPH9</b>	96
51 Subject $^{13}\text{C}$ NMR correlations of <b>CPH10</b>	97
52 Subject $^1\text{H}$ NMR correlations of <b>CPH10</b>	97
53 The structure of <b>CPH10</b>	97
54 Subject $^{13}\text{C}$ NMR correlations of <b>CPH11</b>	98
55 Subject $^1\text{H}$ NMR correlations of <b>CPH11</b>	98
56 The structure of <b>CPH11</b>	98
57 Subject $^{13}\text{C}$ NMR correlations of <b>CPH12</b>	99
58 Subject $^1\text{H}$ NMR correlations of <b>CPH12</b>	99
59 The structure of <b>CPH12</b>	99
60 Subject $^{13}\text{C}$ NMR correlations of <b>CPH13</b>	100
61 Subject $^1\text{H}$ NMR correlations of <b>CPH13</b>	100
62 The structure of <b>CPH13</b>	100
63 Subject $^{13}\text{C}$ NMR correlations of <b>CPH14</b>	101
64 Subject $^1\text{H}$ NMR correlations of <b>CPH14</b>	101
65 The structure of <b>CPH14</b>	101
66 Subject $^{13}\text{C}$ NMR correlations of <b>CPH15</b>	102
67 Subject $^1\text{H}$ NMR correlations of <b>CPH15</b>	102
68 The structure of <b>CPH15</b>	102
69 Subject $^{13}\text{C}$ NMR correlations of <b>CPH16</b>	103
70 Subject $^1\text{H}$ NMR correlations of <b>CPH16</b>	103
71 The structure of <b>CPH16</b>	103
72 Subject $^{13}\text{C}$ NMR correlations of <b>CPH17</b>	104
73 Subject $^1\text{H}$ NMR correlations of <b>CPH17</b>	104
74 The structure of <b>CPH17</b>	104
75 Subject $^{13}\text{C}$ NMR correlations of <b>CPH18</b>	105
76 Subject $^1\text{H}$ NMR correlations of <b>CPH18</b>	105
77 The structure of <b>CPH18</b>	105
78 Subject $^{13}\text{C}$ NMR correlations of <b>CPH19</b>	106
79 Subject $^1\text{H}$ NMR correlations of <b>CPH19</b>	106
80 The structure of <b>CPH19</b>	106
81 Subject $^{13}\text{C}$ NMR correlations of <b>CPH20</b>	107
82 Subject $^1\text{H}$ NMR correlations of <b>CPH20</b>	107
83 The structure of <b>CPH20</b>	107

## LIST OF ILLUSTRATIONS

Schemes	Page
1 Extraction of the barks of <i>C. formosum</i> ssp. <i>pruniflorum</i>	23
2 Isolation of compounds <b>CPH1-5</b> , <b>CPH8-15</b> and <b>CPH18</b>	26
3 Isolation of compounds <b>CPH1-2</b> , <b>CPH6-7</b> , <b>CPH16-17</b> and <b>CPH19-22</b>	30

  

Figures	Page
1 Different parts of <i>Cratoxylum formosum</i> ssp. <i>pruniflorum</i>	2
2 Selected HMBC correlations of <b>CPH1</b>	35
3 Selected HMBC correlations of <b>CPH2</b>	38
4 The X-ray structure of <b>CPH3</b>	40
5 Selected HMBC correlations of <b>CPH4</b>	42
6 Selected HMBC correlations of <b>CPH5</b>	44
7 Selected HMBC correlations of <b>CPH6</b>	46
8 Selected HMBC correlations of <b>CPH7</b>	48
9 Selected HMBC correlations of <b>CPH8</b>	50
10 Selected HMBC correlations of <b>CPH9</b>	52
11a The structure of <b>3-O-geranylemodin anthrone</b>	54
11b Selected HMBC correlations of <b>CPH10</b>	54
12a The structure of <b>2-(3-methyl-1-butenyl)-1,8-dihydroxy-3-methoxy-6-methyl-anthrone</b>	58

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
12b The structure of <b>bivismiaquinone</b>	59
12c Selected HMBC correlations of <b>CPH11</b>	59
13 Selected HMBC correlations of <b>CPH12</b>	62
14 The X-ray structure of <b>CPH13</b>	65
15 The X-ray structure of <b>CPH14</b>	67
16 The X-ray structure of <b>CPH15</b>	69
17 Selected HMBC correlations of <b>CPH16</b>	72
18 Selected HMBC correlations of <b>CPH17</b>	74
19 Selected HMBC correlations of <b>CPH18</b>	76
20 Selected HMBC correlations of <b>CPH19</b>	79
21 The X-ray structure of <b>CPH20</b>	82
22 UV-Vis (EtOH) spectrum of <b>CPH1</b>	95
23 FT-IR (KBr) spectrum of <b>CPH1</b>	95
24 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH1</b>	96
25 2D COSY (CDCl <sub>3</sub> ) spectrum of <b>CPH1</b>	96
26 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of compound <b>CPH1</b>	97
27 DEPT 135° (CDCl <sub>3</sub> ) spectrum of compound <b>CPH1</b>	97
28 DEPT 90° (CDCl <sub>3</sub> ) spectrum of compound <b>CPH1</b>	97
29 2D HMQC (CDCl <sub>3</sub> ) spectrum of compound <b>CPH1</b>	98
30 2D HMBC (CDCl <sub>3</sub> ) spectrum of compound <b>CPH1</b>	98

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
31 UV-Vis (EtOH) spectrum of <b>CPH2</b>	99
32 FT-IR (KBr) spectrum of <b>CPH2</b>	99
33 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	100
34 2D COSY (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	100
35 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	101
36 DEPT 135° (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	101
37 DEPT 90° (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	101
38 2D HMQC (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	102
39 2D HMBC (CDCl <sub>3</sub> ) spectrum of <b>CPH2</b>	102
40 UV-Vis (EtOH) spectrum of <b>CPH3</b>	103
41 FT-IR (KBr) spectrum of <b>CPH3</b>	103
42 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	104
43 2D COSY (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	104
44 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	105
45 DEPT 135° (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	105
46 DEPT 90° (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	105
47 2D HMQC (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	106
48 2D HMBC (CDCl <sub>3</sub> ) spectrum of <b>CPH3</b>	106
49 UV-Vis (EtOH) spectrum of <b>CPH4</b>	107

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
50 FT-IR (KBr) spectrum of <b>CPH4</b>	107
51 EIMS spectrum of compound <b>CPH4</b>	108
52 HREIMS spectrum of compound <b>CPH4</b>	109
53 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	110
54 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	111
55 DEPT 135° (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	111
56 DEPT 90° (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	111
57 2D HMQC (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	112
58 2D HMBC (CDCl <sub>3</sub> ) spectrum of <b>CPH4</b>	112
59 UV-Vis (EtOH) spectrum of <b>CPH5</b>	113
60 FT-IR (KBr) spectrum of <b>CPH5</b>	113
61 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	114
62 2D COSY (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	114
63 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	115
64 DEPT 135° (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	115
65 DEPT 90° (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	115
66 2D HMQC (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	116
67 2D HMBC (CDCl <sub>3</sub> ) spectrum of <b>CPH5</b>	116
68 UV-Vis (EtOH) spectrum of <b>CPH6</b>	117

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
69 FT-IR (KBr) spectrum of <b>CPH6</b>	117
70 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	118
71 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	118
72 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	119
73 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	119
74 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	119
75 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	120
76 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH6</b>	120
77 UV-Vis (EtOH) spectrum of <b>CPH7</b>	121
78 FT-IR (KBr) spectrum of <b>CPH7</b>	121
79 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	122
80 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	122
81 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	123
82 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	123
83 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	123
84 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	124
85 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH7</b>	124
86 UV-Vis (EtOH) spectrum of <b>CPH8</b>	125
87 FT-IR (KBr) spectrum of <b>CPH8</b>	125

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
88 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	126
89 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	126
90 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	127
91 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	127
92 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	127
93 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	128
94 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH8</b>	128
95 UV-Vis (EtOH) spectrum of <b>CPH9</b>	129
96 FT-IR (KBr) spectrum of <b>CPH9</b>	129
97 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	130
98 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	130
99 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	131
100 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	131
101 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	131
102 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	132
103 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH9</b>	132
104 UV-Vis (EtOH) spectrum of <b>CPH10</b>	133
105 FT-IR (KBr) spectrum of <b>CPH10</b>	133
106 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH10</b>	134

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
107 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH10	134
108 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH10	135
109 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH10	135
110 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH10	135
111 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH10	136
112 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH10	136
113 UV-Vis (EtOH) spectrum of CPH11	137
114 FT-IR (KBr) spectrum of CPH11	137
115 EIMS spectrum of compound CPH11	138
116 HREIMS spectrum of compound CPH11	139
117 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH11	140
118 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH11	140
119 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH11	141
120 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH11	141
121 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH11	141
122 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH11	142
123 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH11	142
124 UV-Vis (EtOH) spectrum of CPH12	143
125 FT-IR (KBr) spectrum of CPH12	143

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
126 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	144
127 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	144
128 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	145
129 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	145
130 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	145
131 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	146
132 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH12</b>	146
133 UV-Vis (EtOH) spectrum of <b>CPH13</b>	147
134 FT-IR (KBr) spectrum of <b>CPH13</b>	147
135 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	148
136 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	148
137 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	149
138 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	149
139 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	149
140 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	150
141 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH13</b>	150
142 UV-Vis (EtOH) spectrum of <b>CPH14</b>	151
143 FT-IR (KBr) spectrum of <b>CPH14</b>	151
144 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH14</b>	152

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
145 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH14	152
146 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH14	153
147 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH14	153
148 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH14	153
149 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH14	154
150 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH14	154
151 UV-Vis (EtOH) spectrum of CPH15	155
152 FT-IR (KBr) spectrum of CPH15	155
153 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH15	156
154 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH15	156
155 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH15	157
156 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH15	157
157 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH15	157
158 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH15	158
159 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH15	158
160 UV-Vis (EtOH) spectrum of CPH16	159
161 FT-IR (KBr) spectrum of CPH16	159
162 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH16	160
163 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH16	160

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
164 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH16</b>	161
165 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH16</b>	161
166 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH16</b>	161
167 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH16</b>	162
168 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH16</b>	162
169 UV-Vis (EtOH) spectrum of <b>CPH17</b>	163
170 FT-IR (KBr) spectrum of <b>CPH17</b>	163
171 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	164
172 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	164
173 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	165
174 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	165
175 DEPT $90^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	165
176 2D HMQC ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	166
177 2D HMBC ( $\text{CDCl}_3$ ) spectrum of <b>CPH17</b>	166
178 FT-IR (KBr) spectrum of <b>CPH18</b>	167
179 $^1\text{H}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH18</b>	168
180 2D COSY ( $\text{CDCl}_3$ ) spectrum of <b>CPH18</b>	168
181 $^{13}\text{C}$ NMR (300 MHz) ( $\text{CDCl}_3$ ) spectrum of <b>CPH18</b>	169
182 DEPT $135^\circ$ ( $\text{CDCl}_3$ ) spectrum of <b>CPH18</b>	169

## LIST OF ILLUSTRATIONS (Continued)

Figures	Page
183 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH18	169
184 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH18	170
185 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH18	170
186 FT-IR (KBr) spectrum of CPH19	171
187 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH19	172
188 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH19	172
189 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH19	173
190 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH19	173
191 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH19	173
192 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH19	174
193 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH19	174
194 FT-IR (KBr) spectrum of CPH20	175
195 <sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH20	176
196 2D COSY (CDCl <sub>3</sub> ) spectrum of CPH20	176
197 <sup>13</sup> C NMR (300 MHz) (CDCl <sub>3</sub> ) spectrum of CPH20	177
198 DEPT 135° (CDCl <sub>3</sub> ) spectrum of CPH20	177
199 DEPT 90° (CDCl <sub>3</sub> ) spectrum of CPH20	177
200 2D HMQC (CDCl <sub>3</sub> ) spectrum of CPH20	178
201 2D HMBC (CDCl <sub>3</sub> ) spectrum of CPH20	178

## LIST OF ILLUSTRATIONS (Continued)

Figure	Caption	Page
202	<sup>1</sup> H NMR (300 MHz) (CDCl <sub>3</sub> ) spectra of CPH21 and CPH22	179

## LIST OF ABBREVIATIONS AND SYMBOLS

<i>s</i>	=	<i>singlet</i>
<i>d</i>	=	<i>doublet</i>
<i>t</i>	=	<i>triplet</i>
<i>q</i>	=	<i>quartet</i>
<i>m</i>	=	<i>multiplet</i>
<i>dd</i>	=	<i>doublet of doublet</i>
<i>dt</i>	=	<i>doublet of triplet</i>
<i>br s</i>	=	<i>broad singlet</i>
<i>g</i>	=	Gram
<i>nm</i>	=	Nanometer
<i>mp</i>	=	Melting point
$\text{cm}^{-1}$	=	Reciprocal centimeter (wave number)
$\delta$	=	Chemical shift relative to TMS
<i>J</i>	=	Coupling constant
$[\alpha]_{\text{D}}$	=	Specific rotation
$\lambda_{\text{max}}$	=	Maximum wavelength
$\nu$	=	Absorption frequencies
$\epsilon$	=	Molar extinction coefficient
<i>m/z</i>	=	A value of mass divided by charge
$^{\circ}\text{C}$	=	Degree celcius

## LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

<i>MHz</i>	=	Megahertz
ppm	=	Part per million
<i>c</i>	=	Concentration
FT-IR	=	Fourier Transform Infrared
UV-Vis	=	Ultraviolet-Visible
ESI-TOF MS	=	Electrospray Ionization Time-of-Flight Mass Spectroscopy
CIMS	=	Chemical Impact Mass Spectroscopy
HRCIMS	=	High Resolution Chemical Impact Mass Spectroscopy
EIMS	=	Electron Impact Mass Spectroscopy
HREIMS	=	High Resolution Electron Impact Mass Spectroscopy
NMR	=	Nuclear Magnetic Resonance
2D NMR	=	Two Dimensional Nuclear Magnetic Resonance
COSY	=	Correlation Spectroscopy
DEPT	=	Distortionless Enhancement by Polarization Transfer
HMBC	=	Heteronuclear Multiple Bond Correlation
HMQC	=	Heteronuclear Multiple Quantum Coherence
NOE	=	Nuclear Overhauser Effect
NOESY	=	Nuclear Overhauser Effect Correlation Spectroscopy
CC	=	Column Chromatography
QCC	=	Quick Column Chromatography

## LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

PLC	=	Preparative Thin Layer Chromatography
DCM	=	Dichloromethane
TMS	=	Tetramethylsilane
CDCl <sub>3</sub>	=	Deuteriochloroform
CD <sub>3</sub> OD	=	Deuteromethanol