



APPENDICES

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่

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APPENDIX A

Results of TLC analysis of distilled lime oil before and after fermentation

Table 4.11 R_f values from TLC chromatogram of Figure 4.2 A

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
1.(1S)-(-)- α -pinene	1	greenish yellow	absent	grey	0.16
	2	greenish yellow	absent	grey	0.18
	3	greenish yellow	absent	violet	0.22
	4	dull	absent	dark grey	0.26
	5	greenish yellow	absent	violet	0.30
	6	greenish yellow	absent	greyish violet	0.37
	7	greenish yellow	absent	violet	0.57
2. fresh peel lime oil	1	greenish yellow	absent	dark blue	0.20
	2	greenish yellow	bright blue	violet blue	0.26
	3	dull	absent	dark grey	0.32
	4	greenish yellow	absent	violet	0.38
	5	dull	absent	bluish violet	0.45
	6	greenish yellow	absent	violet	0.48
	7	dull	absent	violet grey	0.53
	8	greenish yellow	absent	violet blue	0.67
	9	greenish yellow	violet	violet	0.72
	10	dull	absent	dark violet	0.91
3. Pressed peel lime oil	1	greenish yellow	absent	dark blue	0.20

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
	2	greenish yellow	violet	violet blue	0.26
	3	dull	absent	dark grey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	violet	0.39
	6	greenish yellow	absent	brownish grey	0.43
	7	greenish yellow	absent	bright violet	0.48
	8	greenish yellow	absent	violet grey	0.53
	9	greenish yellow	absent	light blue	0.56
	10	dull	absent	pale violet	0.58
	11	greenish yellow	absent	violet	0.62
	12	greenish yellow	absent	pale violet	0.69
	13	greenish yellow	absent	pale violet	0.77
	14	dull	absent	violet	0.91
4. lime oil 15 days	1	greenish yellow	absent	blue	0.20
	2	greenish yellow	absent	violet blue	0.26
	3	dull	absent	darkgrey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	violet	0.39
	6	greenish yellow	absent	brownish grey	0.44
	7	greenish yellow	absent	bright violet	0.48
	8	greenish yellow	absent	violet grey	0.53
	9	greenish yellow	absent	light blue	0.57
	10	dull	absent	pale violet	0.60
	11	greenish yellow	absent	pale violet	0.63
	12	greenish yellow	absent	pale violet	0.69
	13	greenish yellow	absent	pale violet	0.77

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
5. lime oil 30 days	14	dull	absent	pale violet	0.92
	1	greenish yellow	absent	blue	0.20
	2	greenish yellow	absent	violet blue	0.26
	3	dull	absent	dark grey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	violet	0.40
	6	greenish yellow	absent	pale brownish grey	0.44
	7	greenish yellow	absent	pale violet	0.48
	8	greenish yellow	absent	greyish blue	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.64
	11	greenish yellow	absent	pale violet	0.70
	12	greenish yellow	absent	pale violet	0.80
6. lime oil 45 days	13	dull	absent	pale violet	0.92
	1	greenish yellow	absent	dark blue	0.21
	2	greenish yellow	violet	violet blue	0.26
	3	dull	absent	dark grey	0.32
	4	greenish yellow	absent	bluish grey	0.37
	5	greenish yellow	absent	violet	0.40
	6	greenish yellow	absent	brownish grey	0.45
	7	greenish yellow	absent	pale violet	0.49
	8	greenish yellow	absent	greyish blue	0.55
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.64
	11	greenish yellow	absent	pale violet	0.71
12	greenish yellow	absent	pale violet	0.77	

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 n		
7. lime oil 60 days	13	dull	absent	pale violet	0.92
	1	greenish yellow	absent	dark blue	0.20
	2	greenish yellow	violet	violet blue	0.26
	3	dull	absent	dark grey	0.32
	4	greenish yellow	absent	bluish grey	0.37
	5	greenish yellow	absent	violet	0.40
	6	greenish yellow	absent	brownish grey	0.44
	7	greenish yellow	absent	pale violet	0.49
	8	greenish yellow	absent	greyish blue	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.64
	11	greenish yellow	absent	pale violet	0.70
	12	greenish yellow	absent	violet	0.77
8. lime oil 90 days	13	dull	absent	pale violet	0.92
	1	greenish yellow	absent	dark blue	0.20
	2	greenish yellow	absent	violet blue	0.26
	3	dull	absent	dark grey	0.32
	4	greenish yellow	absent	bluish grey	0.37
	5	greenish yellow	absent	violet	0.40
	6	greenish yellow	absent	pale brownish grey	0.44
	7	greenish yellow	absent	pale violet	0.49
	8	greenish yellow	absent	greyish light blue	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	violet	0.64
11	greenish yellow	absent	pale violet	0.70	

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
9. (+)-limonene	12	greenish yellow	absent	violet	0.77
	13	dull	absent	pale violet	0.92
	1	greenish yellow	absent	light blue	0.26
	2	greenish yellow	absent	violet	0.30
	3	greenish yellow	absent	grey	0.36
	4	greenish yellow	absent	light blue	0.54
	5	dull	absent	violet	0.59

Table 4.12 R_f values from TLC chromatogram of Figure 4.2 B

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
1. α -terpineol	1	greenish yellow	absent	red brown, dark blue rim	0.32
2. fresh peel lime oil	1	greenish yellow	absent	dark blue	0.21
	2	greenish yellow	bright blue	violet	0.26
	3	dull	absent	dark grey	0.33
	4	greenish yellow	absent	pale violet	0.38
	5	dull	absent	bluish grey	0.46
	6	greenish yellow	absent	violet	0.50
	7	dull	absent	grey	0.54
	8	greenish yellow	absent	violet dark blue	0.69

Substance	Spot no.	Color under UV light at		Color after use spraying reagent	R _f
		254 nm	365 nm		
3. pressed peel lime oil	9	greenish yellow	violet	violet	0.73
	10	dull	absent	dark violet	0.93
	1	greenish yellow	absent	dark blue	0.21
	2	greenish yellow	violet	violet	0.26
	3	dull	absent	grey	0.32
	4	greenish yellow	absent	bluish grey	0.37
	5	greenish yellow	absent	pale violet	0.40
	6	greenish yellow	absent	brownish grey	0.45
	7	greenish yellow	absent	bright violet	0.49
	8	greenish yellow	absent	light bluish grey	0.55
	9	greenish yellow	absent	light blue	0.58
	10	dull	absent	pale violet	0.61
	11	greenish yellow	absent	pale violet	0.65
	12	greenish yellow	absent	pale violet	0.71
13	greenish yellow	absent	pale violet	0.78	
14	dull	absent	violet	0.93	
4. Lime oil 15 days	1	greenish yellow	absent	blue	0.20
	2	greenish yellow	absent	violet	0.25
	3	dull	absent	grey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	pale violet	0.40
	6	greenish yellow	absent	brownish grey	0.44
	7	greenish yellow	absent	bright violet	0.49
	8	greenish yellow	absent	pale light bluish grey	0.54
	9	greenish yellow	absent	light blue	0.58

Substance	Spot no.	Color under UV light at		Color use spraying reagent	R _f
		254 nm	365 nm		
	10	dull	absent	pale violet	0.61
	11	greenish yellow	absent	pale violet	0.64
	12	greenish yellow	absent	pale violet	0.71
	13	greenish yellow	absent	pale violet	0.78
	14	dull	absent	pale violet	0.93
5. 30 day fermented peel lime oil	1	greenish yellow	absent	blue	0.20
	2	greenish yellow	absent	violet	0.26
	3	dull	absent	grey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	pale violet	0.40
	6	greenish yellow	absent	pale brownish grey	0.44
	7	greenish yellow	absent	pale violet	0.49
	8	greenish yellow	absent	light bluish grey	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.64
	11	greenish yellow	absent	pale violet	0.70
	12	greenish yellow	absent	violet	0.78
	13	dull	absent	pale violet	0.93
6. 45 day fermented peel lime oil	1	greenish yellow	absent	dark blue	0.20
	2	greenish yellow	violet	violet	0.26
	3	dull	absent	dark grey	0.32
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	violet	0.40

Substance	Spot no.	Color under UV light at		Color spraying reagent	R _f
		254 nm	365 nm		
	6	greenish yellow	absent	brownish grey	0.44
	7	greenish yellow	absent	pale violet	0.48
	8	greenish yellow	absent	light bluish grey	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.63
	11	greenish yellow	absent	pale violet	0.70
	12	greenish yellow	absent	violet	0.77
	13	dull	absent	pale violet	0.93
7. 60 day fermented peel lime oil	1	greenish yellow	absent	dark blue	0.20
	2	greenish yellow	violet	violet	0.25
	3	dull	absent	dark grey	0.31
	4	greenish yellow	absent	bluish grey	0.36
	5	greenish yellow	absent	pale violet	0.40
	6	greenish yellow	absent	brownish grey	0.43
	7	greenish yellow	absent	pale violet	0.48
	8	greenish yellow	absent	light bluish grey	0.54
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.62
	11	greenish yellow	absent	pale violet	0.69
	12	greenish yellow	absent	violet	0.76
	13	dull	absent	pale violet	0.93
8. 90 day fermented peel lime oil	1	greenish yellow	absent	dark blue	0.19
	2	greenish yellow	absent	violet	0.24

Substance	Spot no.	Color under UV light at		Color after spraying reagent	R _f
		254 nm	365 nm		
	3	dull	absent	dark grey	0.31
	4	greenish yellow	absent	bluish grey	0.35
	5	greenish yellow	absent	pale violet	0.40
	6	greenish yellow	absent	pale brownish grey	0.43
	7	greenish yellow	absent	pale violet	0.47
	8	greenish yellow	absent	pale greyish light blue	0.53
	9	dull	absent	pale violet	0.60
	10	greenish yellow	absent	pale violet	0.62
	11	greenish yellow	absent	pale violet	0.69
	12	greenish yellow	absent	violet	0.77
	13	dull	absent	pale violet	0.93
9. β -myrcene	1	dull	absent	reddish violet	0.93

Table 4.13 R_f values from TLC chromatogram of Figure 4.3

Substance	Spot no.	Color under UV light at		Color after spraying reagent	R _f
		254 nm	365 nm		
1. α -terpineol	1	greenish yellow	absent	reddish brown, dark bluish rim	0.36
	2	greenish yellow	absent	pale grey	0.17
2. β -myrcene	1	dull	absent	reddish violet	0.93

Substance	Spot no.	Color under UV light at		Color after spraying reagent	R _f
		254 nm	365 nm		
3. lemon oil	1	greenish yellow	absent	violet	0.13
	2	greenish yellow	absent	violet	0.18
	3	greenish yellow	absent	violet	0.26
	4	greenish yellow	violet pale	grey	0.39
	5	greenish yellow	bright	bluish pale grey	0.44
	6	dull	absent	pale grey	0.52
	7	dull	absent	dark red, violet blue rim	0.77
4. fresh peel lime oil	1	greenish yellow	absent	violet	0.12
	2	greenish yellow	absent	bluish violet	0.27
	3	dull	absent	bluish violet	0.30
	4	greenish yellow	absent	light blue	0.32
	5	greenish yellow	bright blue	pale grey	0.35
	6	greenish yellow	absent	violet	0.40
	7	greenish yellow	pale violet	light bluish grey	0.44
	8	greenish yellow	absent	violet	0.48
	9	dull	absent	bluish violet	0.56
	10	dull	absent	violet light blue	0.61
	11	greenish yellow	absent	bluish violet	0.75
	12	dull	absent	absent	0.78
	13	dull	absent	violet	0.93
5. pressed peel lime oil	1	greenish yellow	absent	violet	0.14
	2	greenish yellow	absent	violet	0.26

Substance	Spot no.	Color under UV light at		Color after spraying reagent	R _f
		254 nm	365 nm		
	3	greenish yellow	pale violet	light bluish grey	0.34
	4	greenish yellow	absent	violet	0.40
	5	greenish yellow	absent	light bluish grey	0.44
	6	greenish yellow	absent	pale grey	0.55
	7	greenish yellow	absent	bright violet	0.59
	8	greenish yellow	absent	light blue	0.63
	9	dull	absent	light blue	0.68
	10	greenish yellow	absent	grey	0.82
	11	dull	absent	violet	0.93
6. 45 day fermented peel lime oil	1	greenish yellow	absent	violet	0.14
	2	greenish yellow	absent	bluish violet	0.27
	3	greenish yellow	violet	light blue	0.34
	4	greenish yellow	absent	violet	0.40
	5	greenish yellow	absent	light bluish grey	0.45
	6	greenish yellow	absent	pale grey	0.55
	7	greenish yellow	absent	light blue	0.63
	8	dull	absent	light blue	0.68
7. (+)-limonene	1	greenish yellow	absent	light blue	0.33
	2	greenish yellow	absent	greyish light blue	0.37
	3	greenish yellow	absent	light bluish violet	0.43

Substance	Spot no.	Color under UV light at		Color after spraying reagent	R _f
		254 nm	365 nm		
8. (1S)-(-)- α -pinene	4	greenish yellow	absent	pale light blue	0.63
	5	greenish yellow	absent	pale violet	0.67
	1	greenish yellow	absent	pale grey	0.23
	2	greenish yellow	absent	pale grey	0.26
	3	greenish yellow	absent	pale grey	0.30
	4	dull	absent	grey	0.36
	5	greenish yellow	absent	grey	0.39
	6	greenish yellow	absent	grey	0.46
7	greenish yellow	absent	pale grey	0.69	

APPENDIX B

GC Chromatograms of Standards

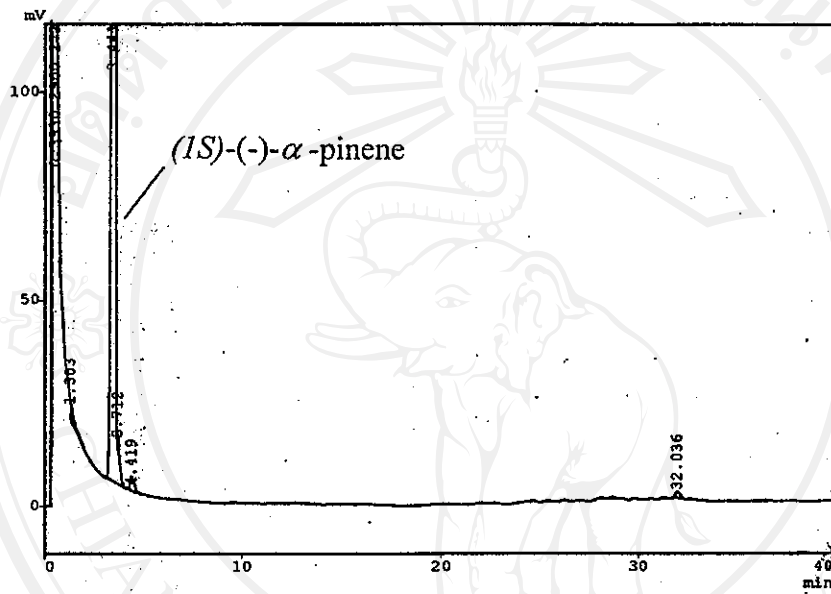


Figure 4.14 GC Chromatogram of (1S)-(-)-α-pinene

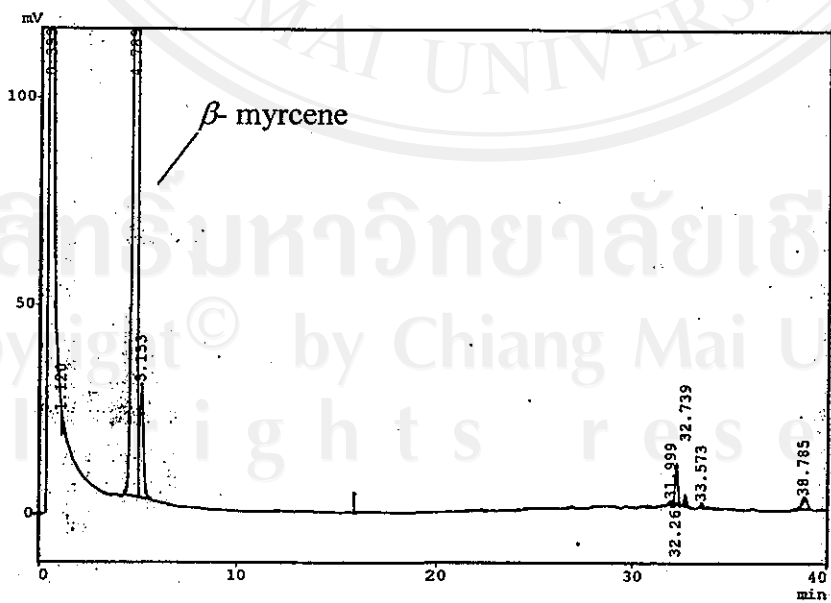


Figure 4.15 GC Chromatogram of β-myrcene

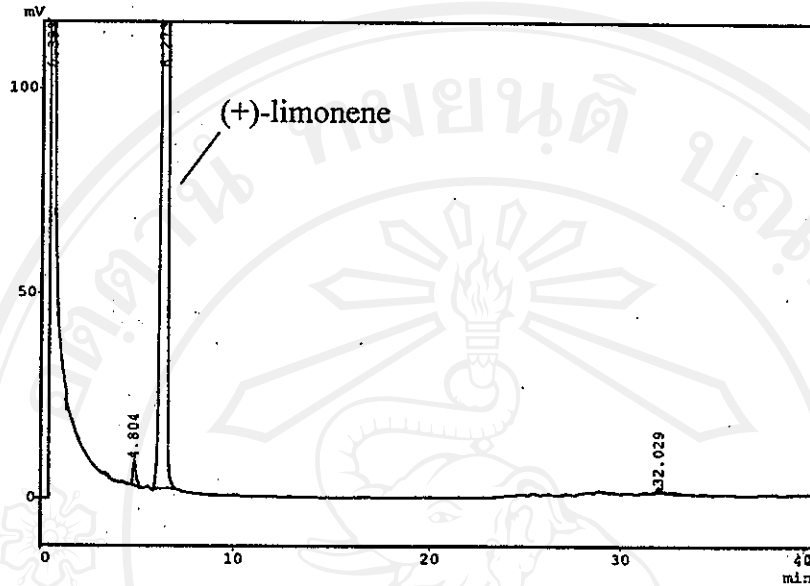


Figure 4.16 GC Chromatogram of (+)-limonene

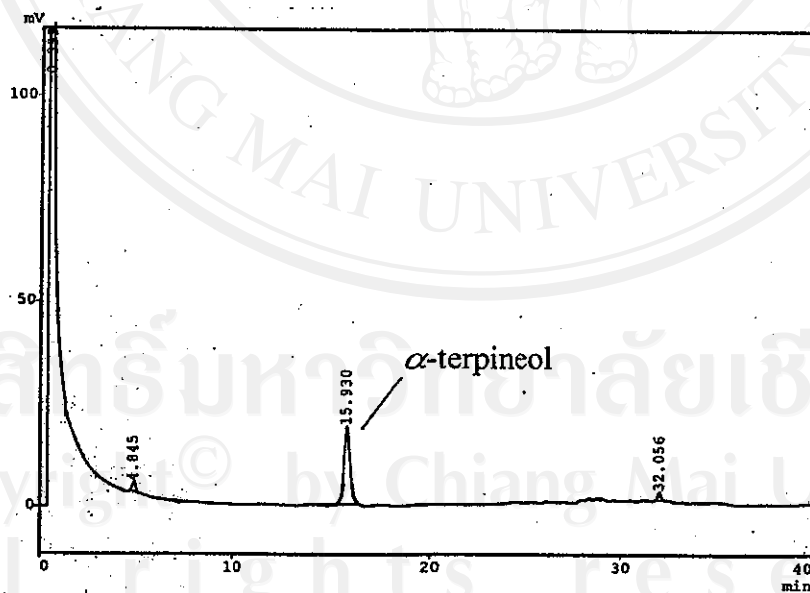


Figure 4.17 GC Chromatogram of α -terpineol

APPENDIX C

Mass spectrum of major component of distilled lime oil from GC/MS analysis by search libraries: WILEY275.L and NIST98.L

1. Mass spectrum of major component of distilled lime oil before fermentation

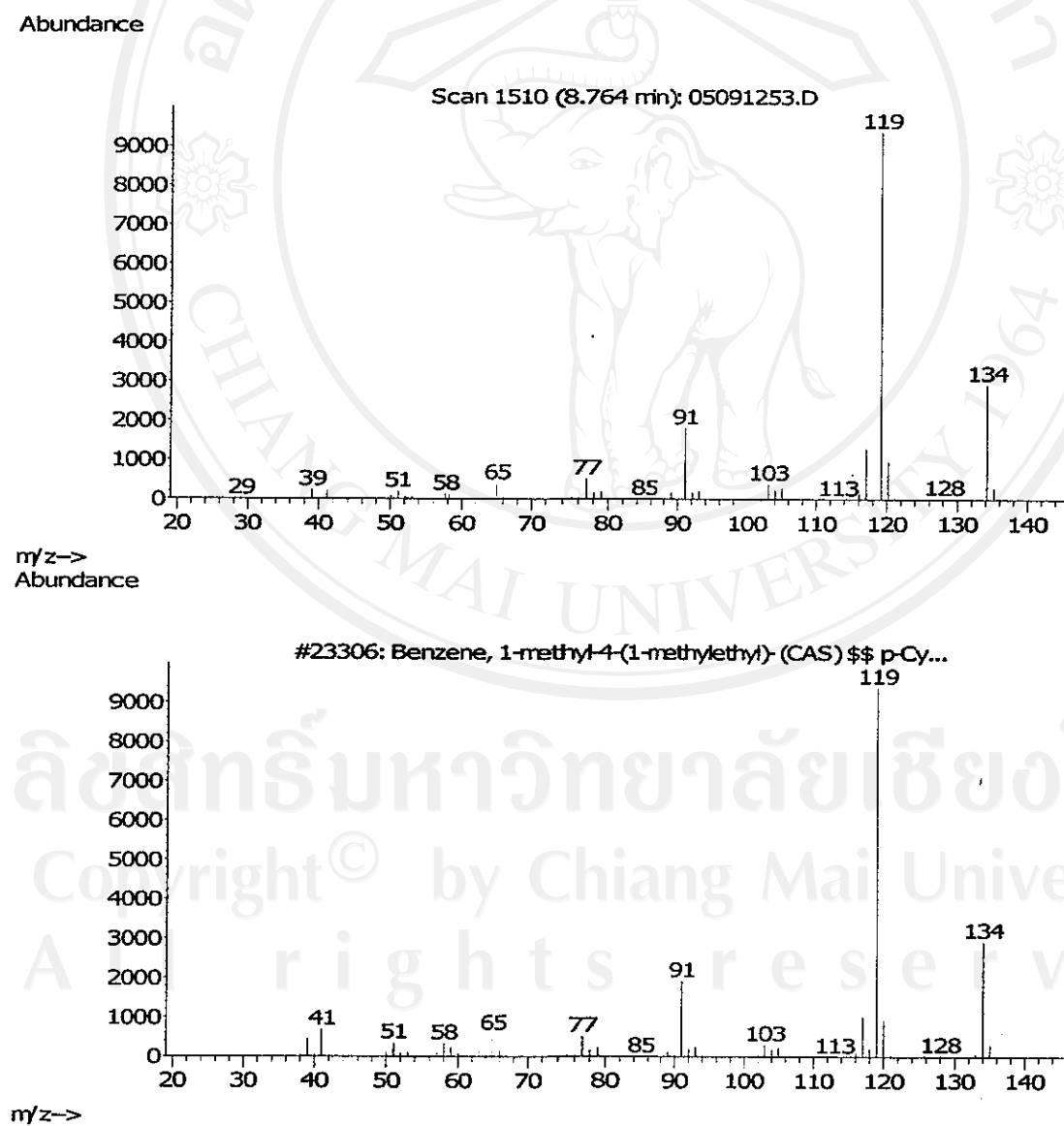


Figure 4.18 Mass spectrum of *p*-cymene of distilled lime oil before fermentation

Abundance

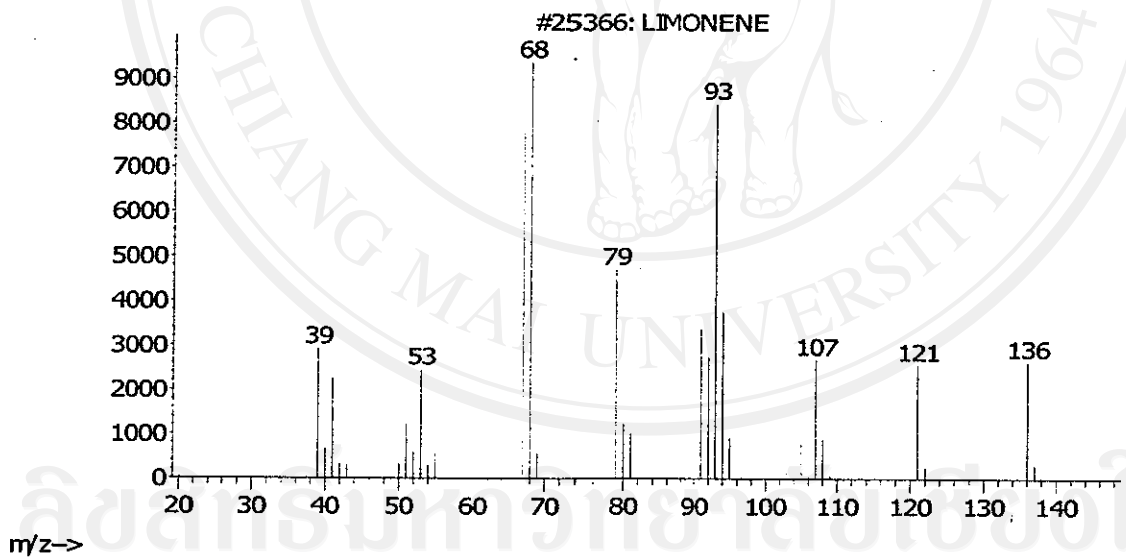
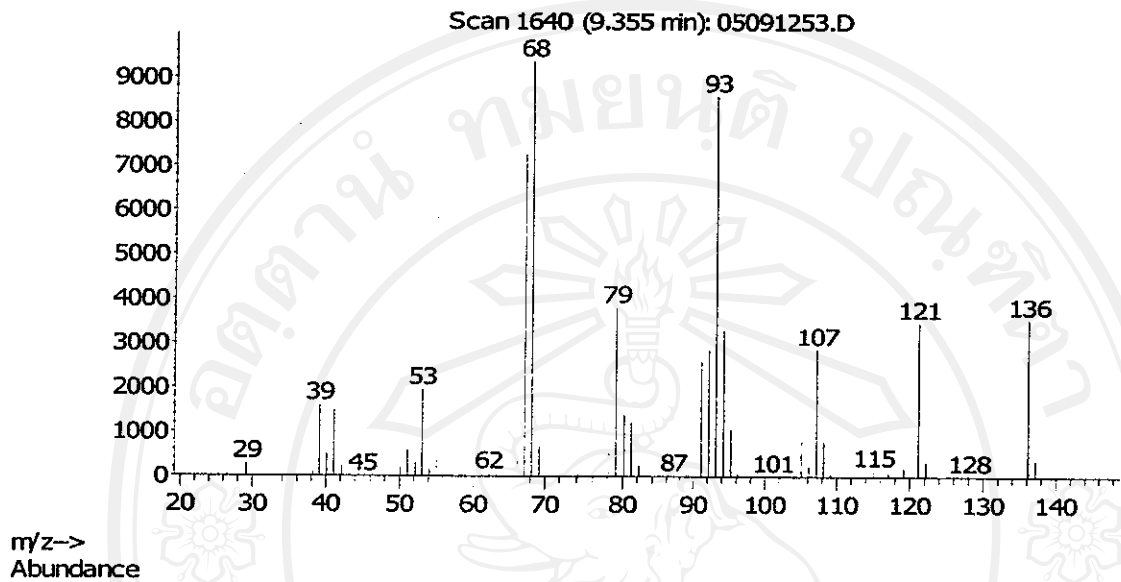


Figure 4.19 Mass spectrum of limonene of distilled lime oil before fermentation

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Abundance

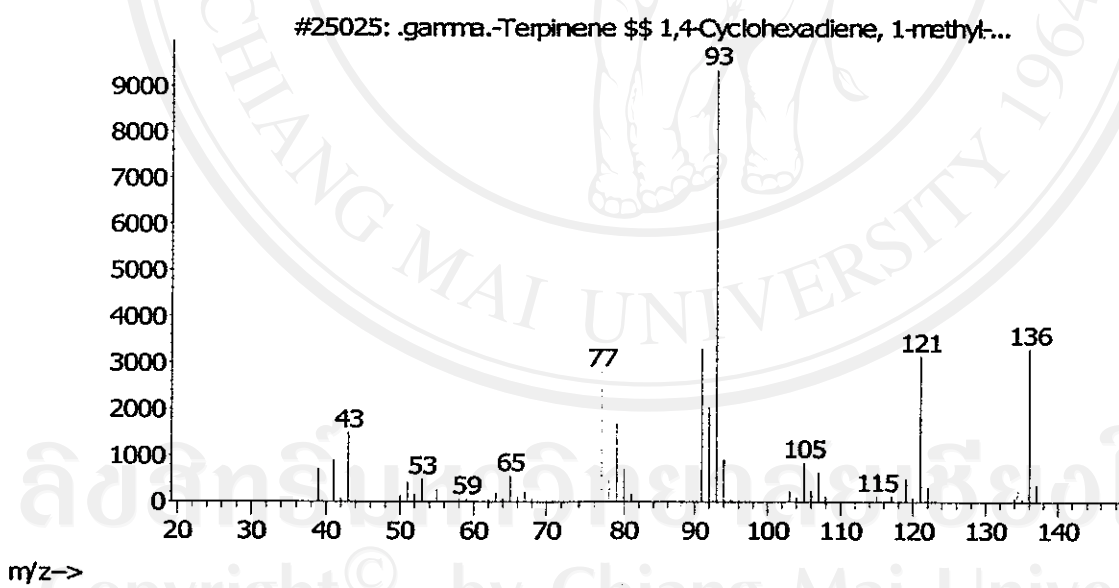
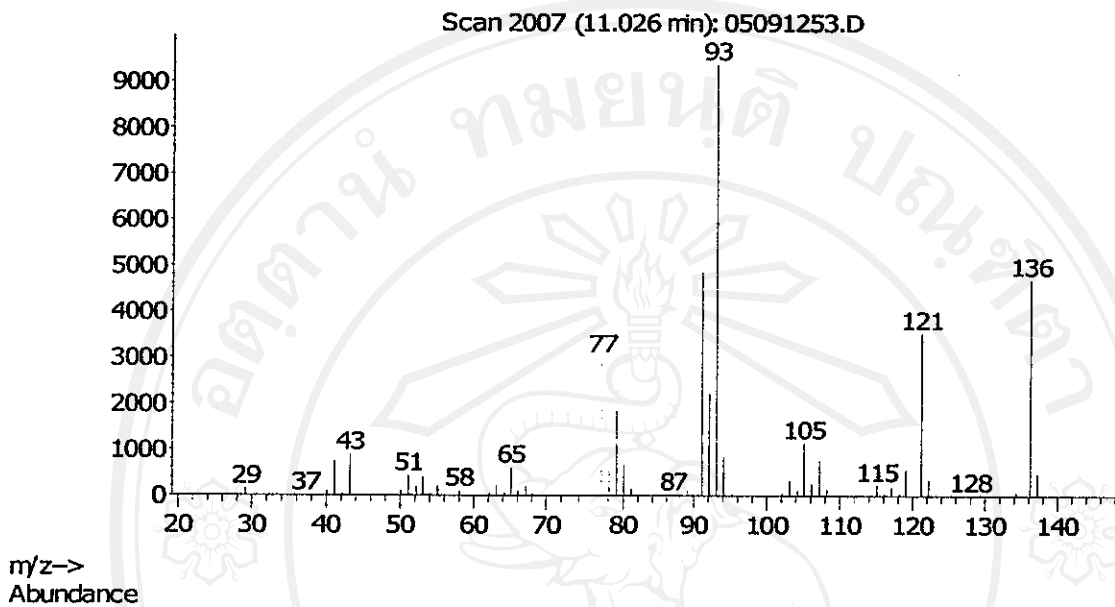


Figure 4.20 Mass spectrum of γ -terpinene of distilled lime oil before fermentation

Abundance

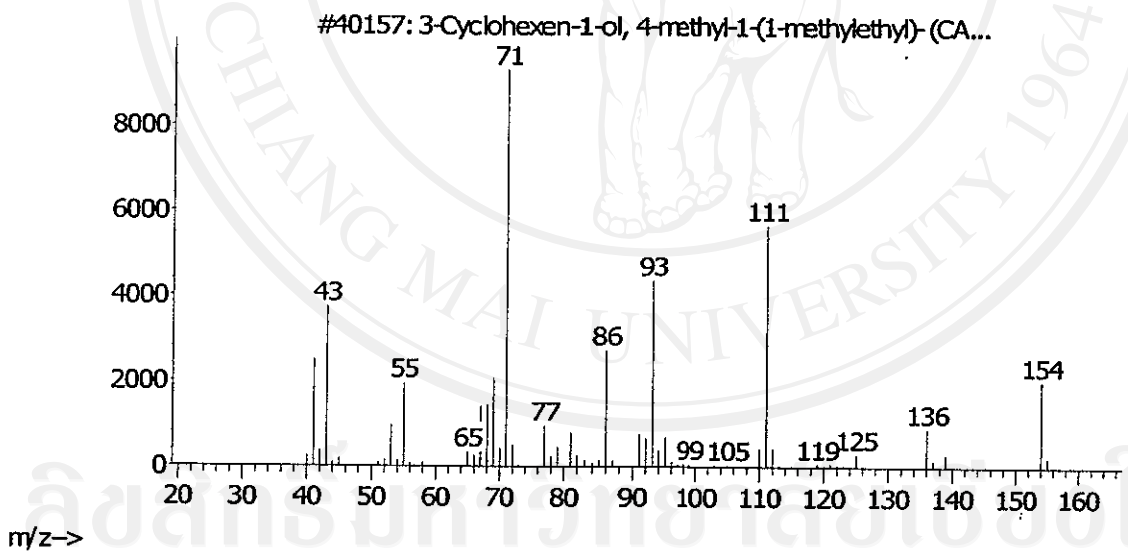
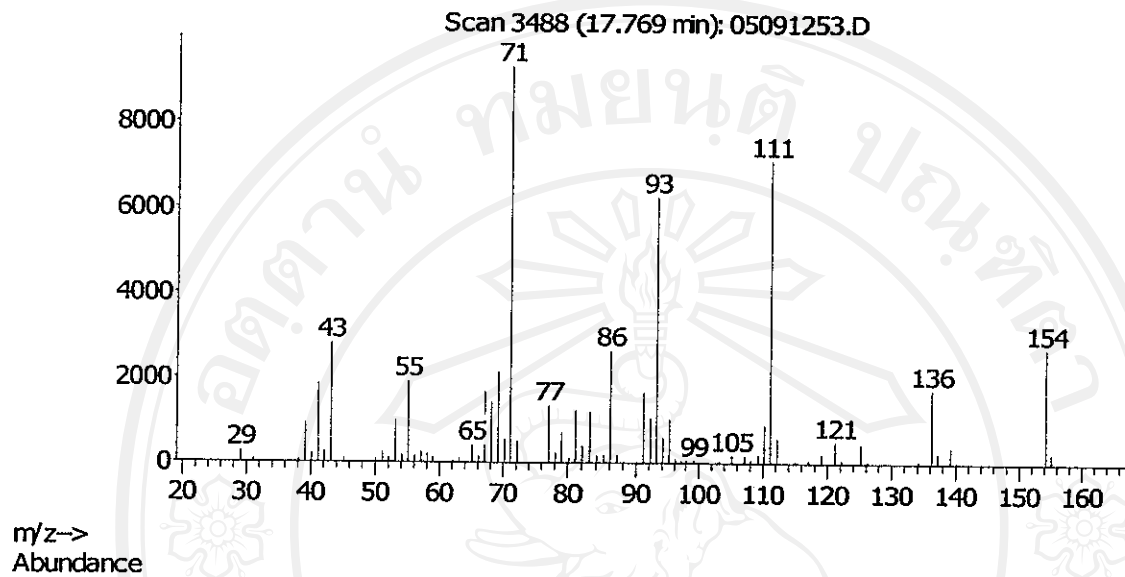


Figure 4.21 Mass spectrum of terpinen-4-ol of distilled lime oil before fermentation

Abundance

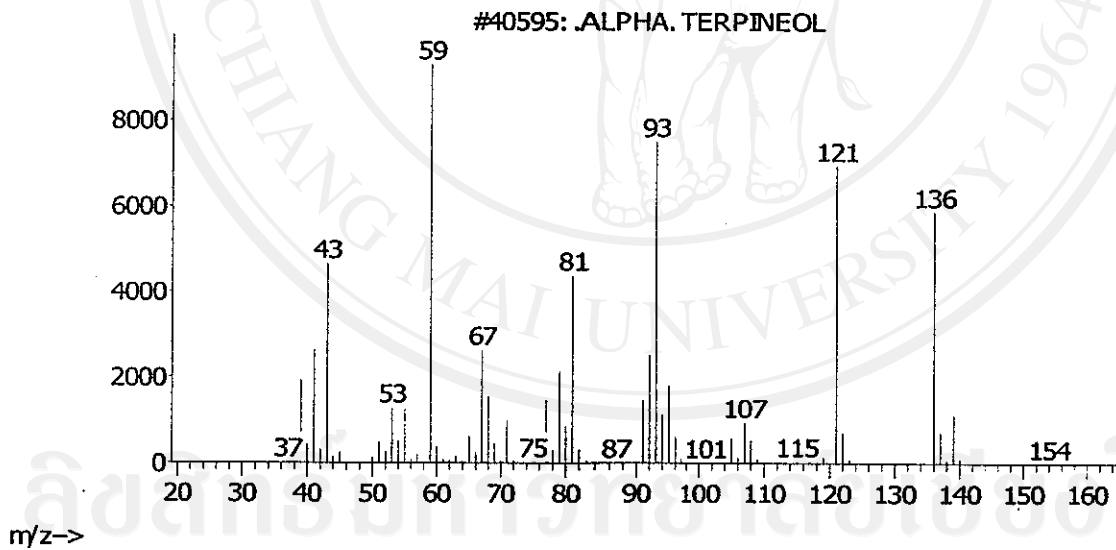
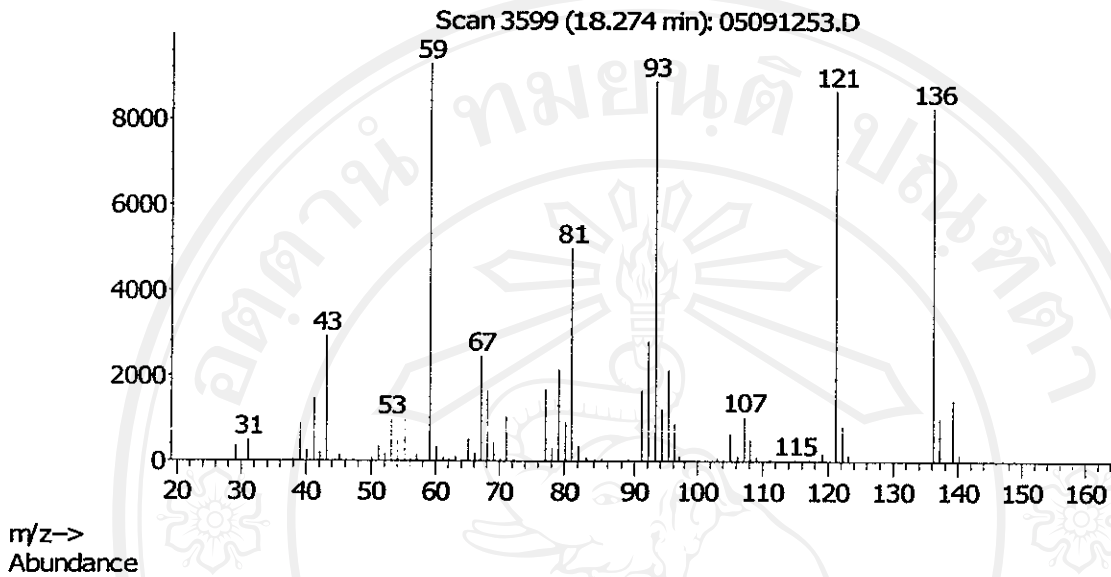


Figure 4.22 Mass spectrum of α -terpineol of distilled lime oil before fermentation

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Abundance

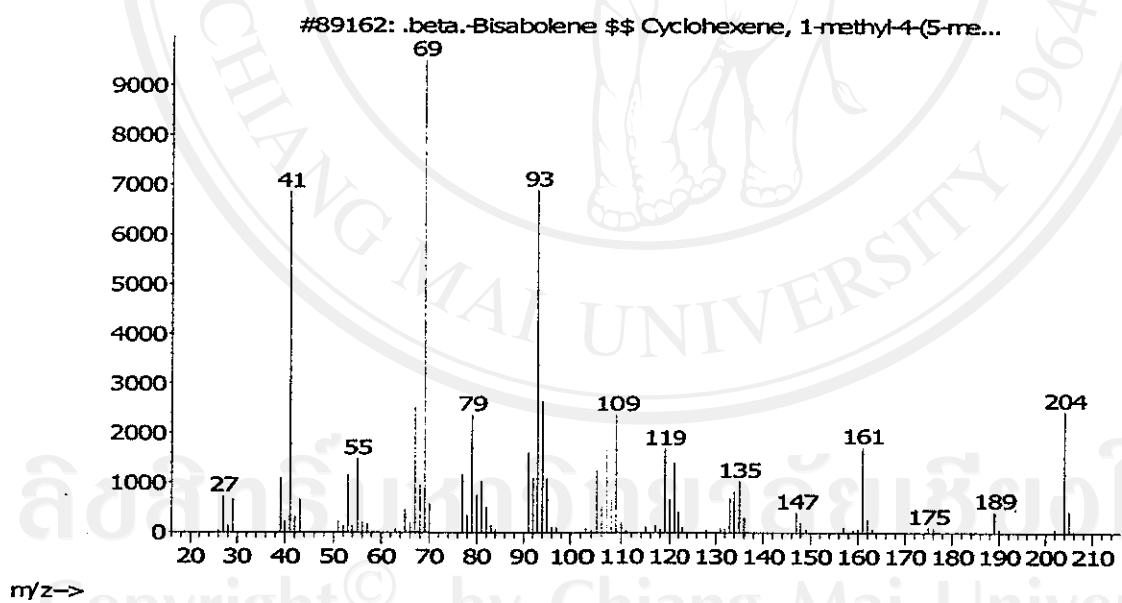
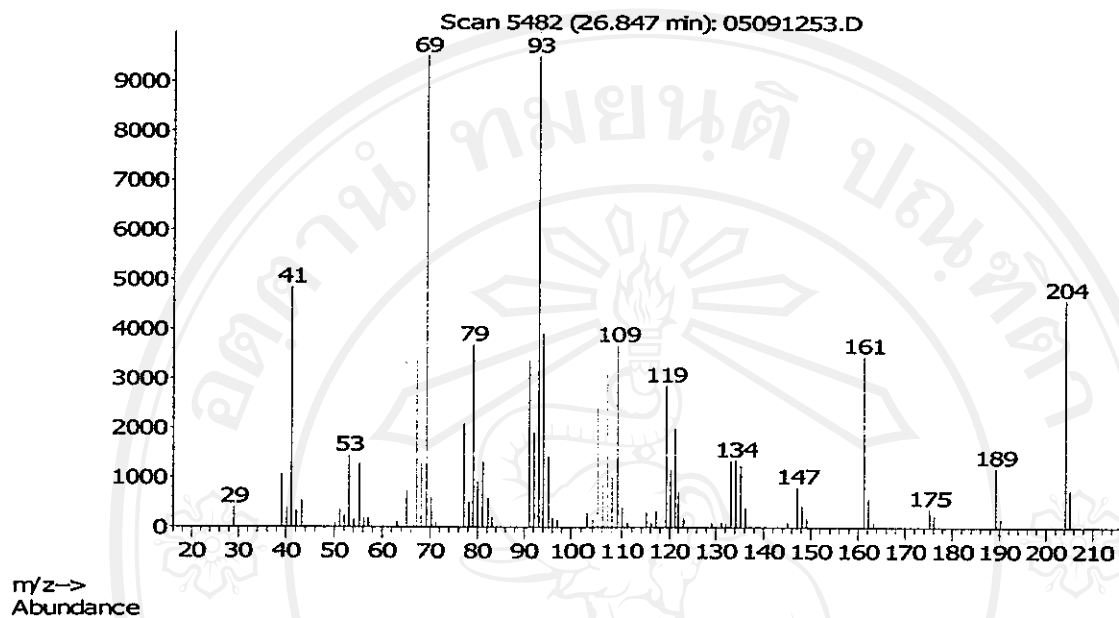


Figure 4.23 Mass spectrum of β -bisabolene of distilled lime oil before fermentation

2. Mass spectrum of major component of distilled lime oil after fermentation

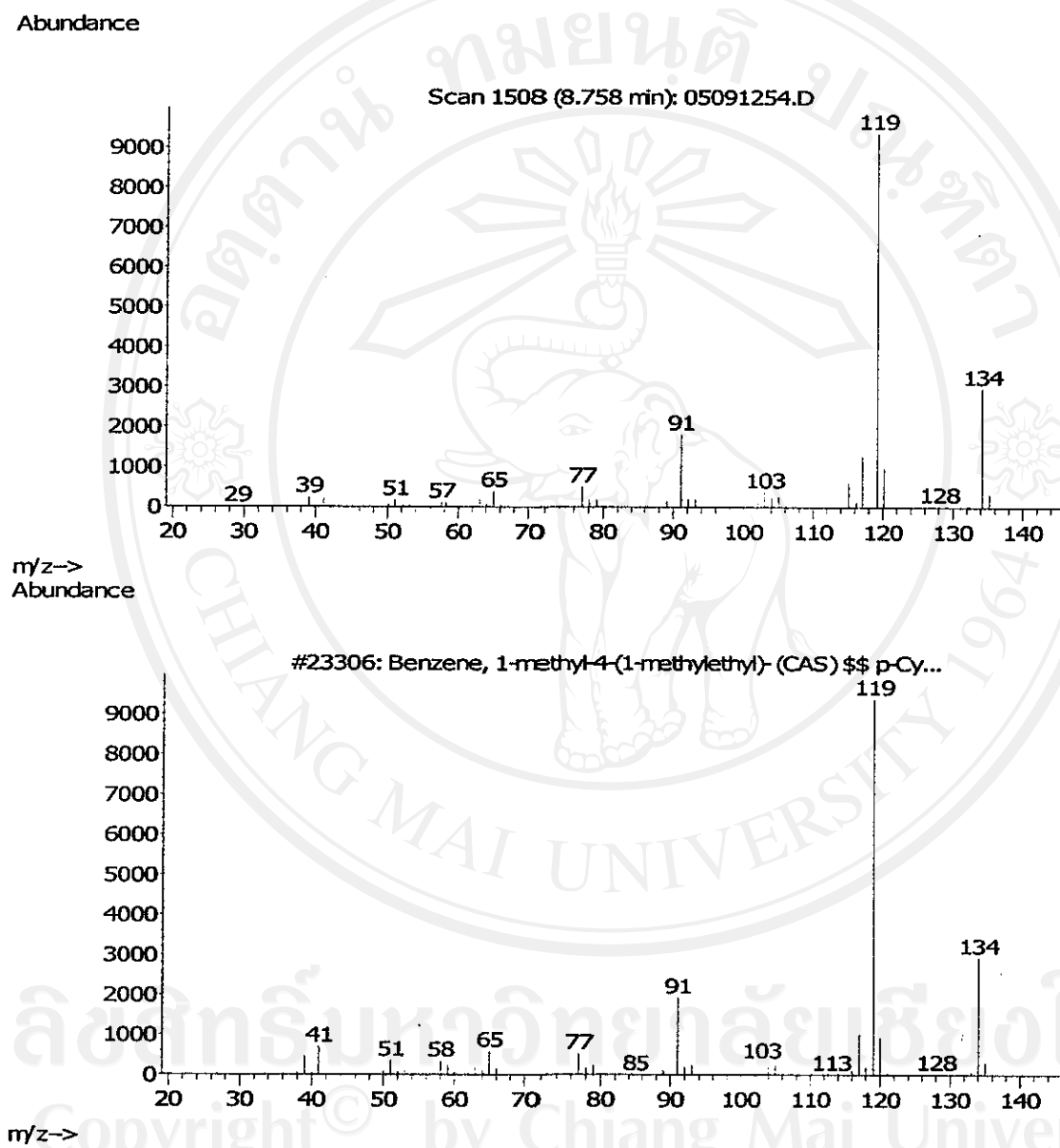


Figure 4.24 Mass spectrum of *p*-cymene of distilled lime oil after fermentation

Abundance

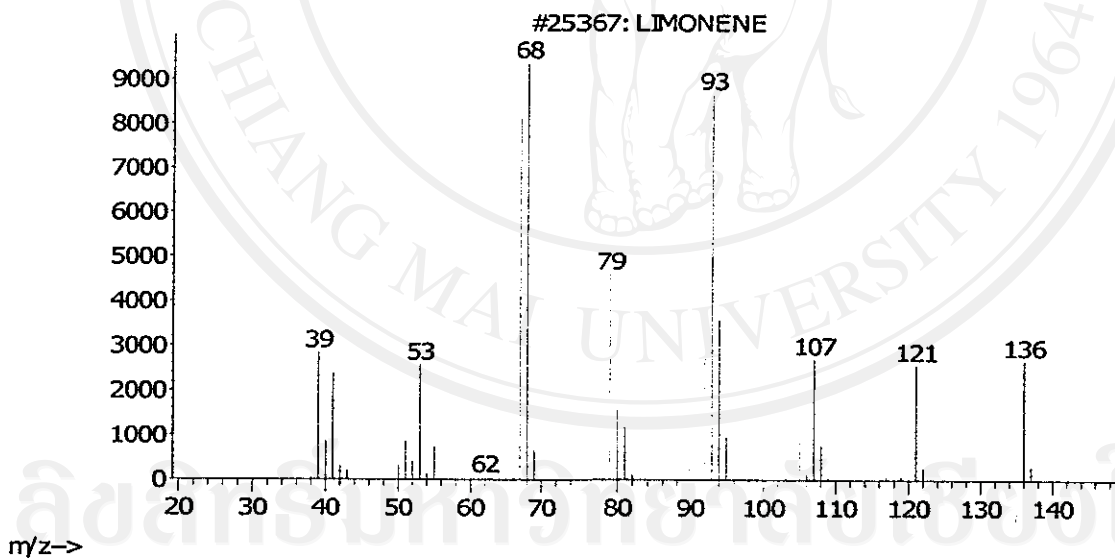
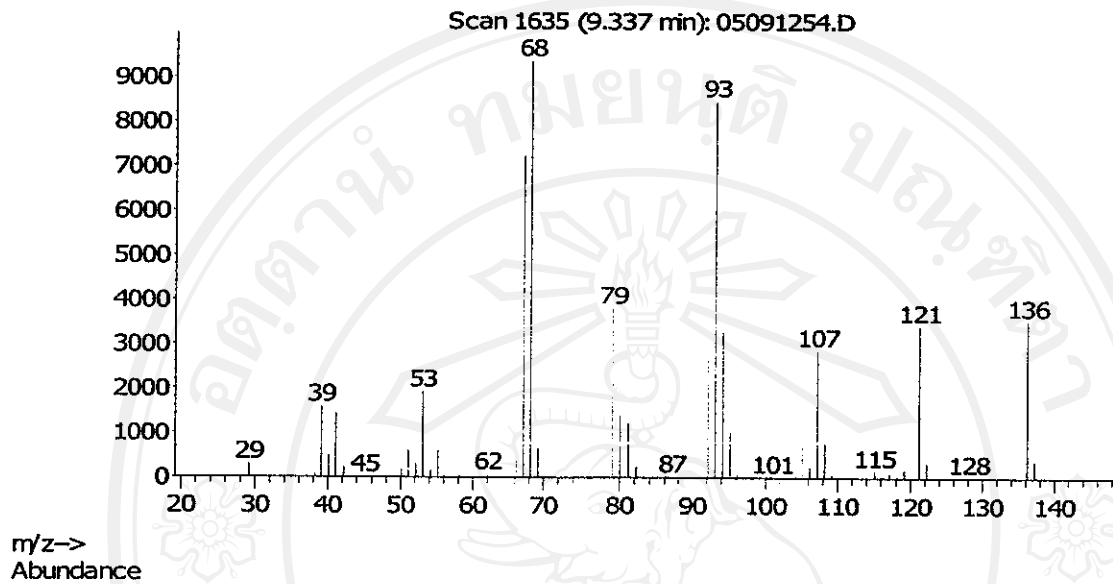
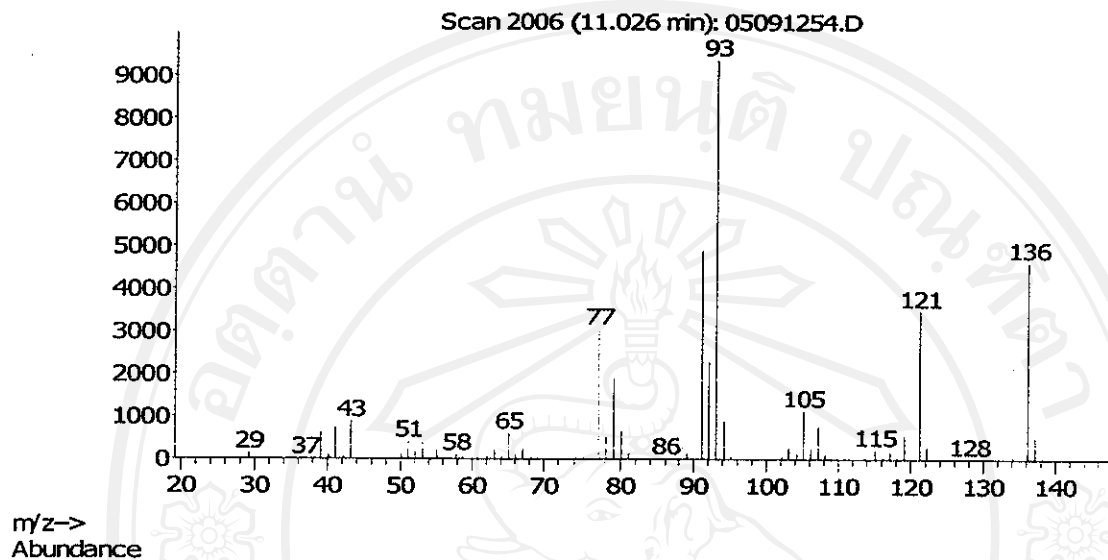
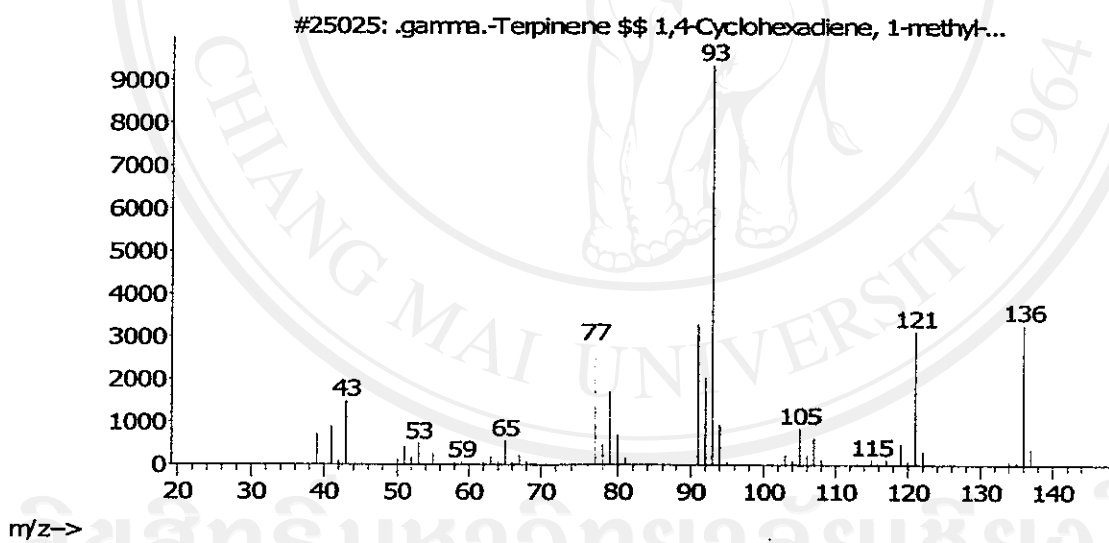


Figure 4.25 Mass spectrum of limonene of distilled lime oil after fermentation

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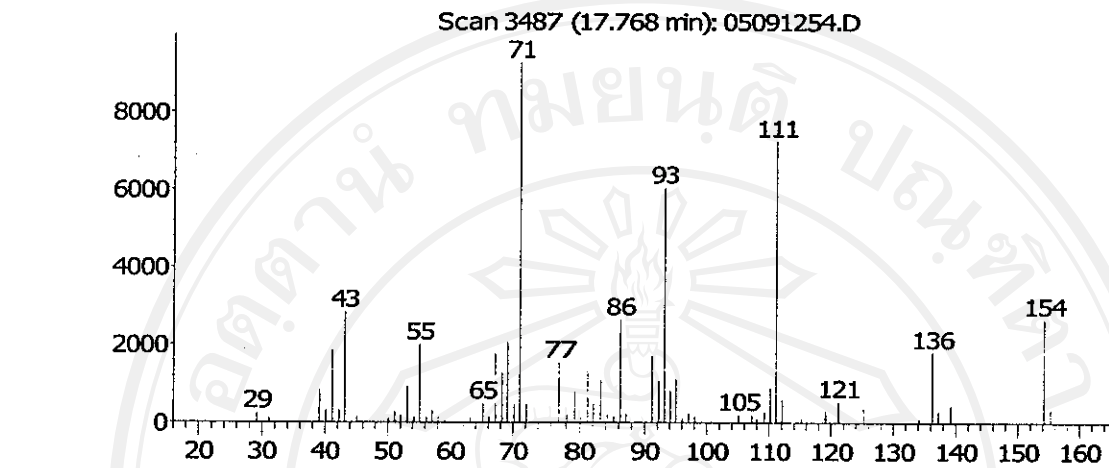
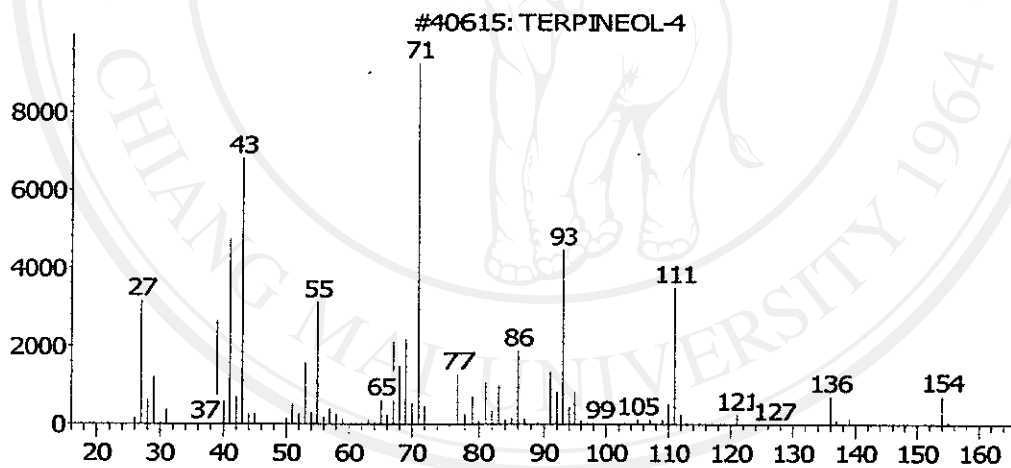
m/z->
Abundance

m/z->

Figure 4.26 Mass spectrum of γ -terpinene of distilled lime oil after fermentation

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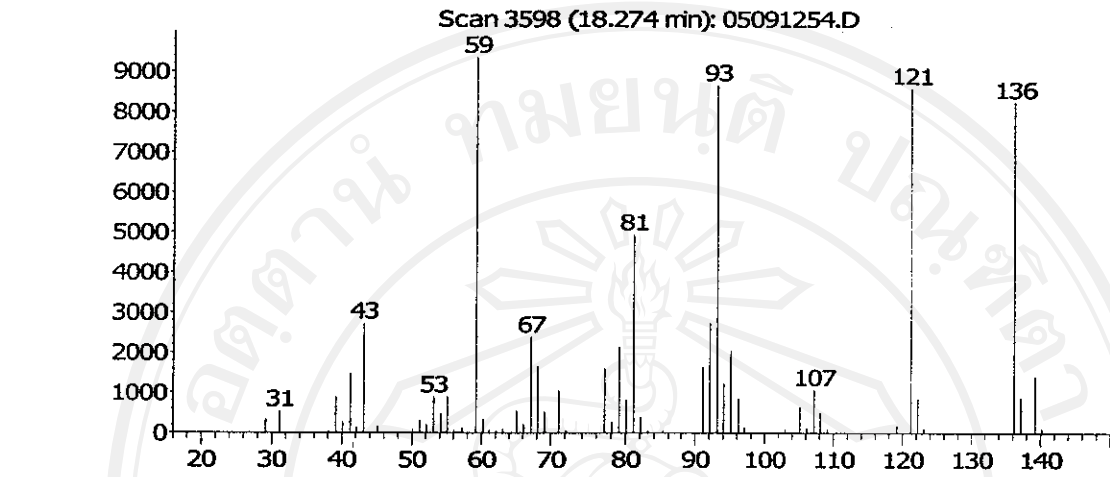
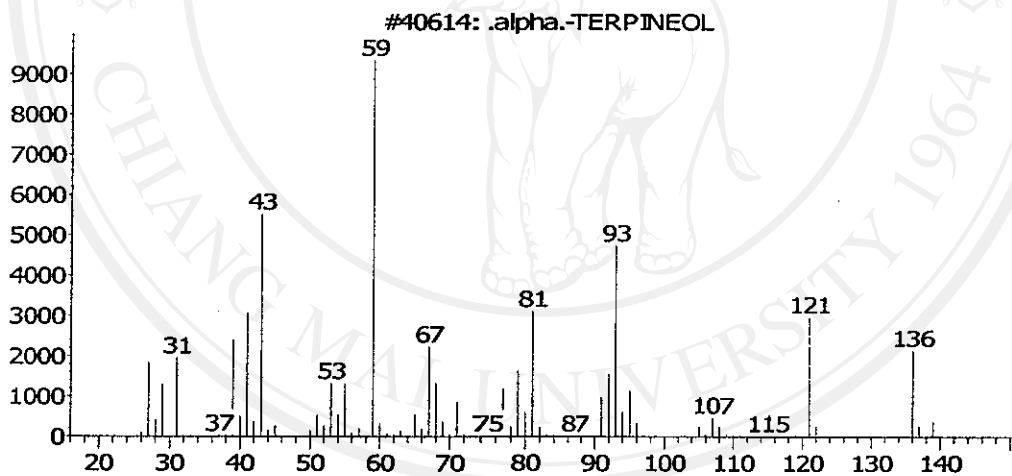
m/z->
Abundance

m/z->

Figure 4.27 Mass spectrum of terpinen-4-ol of distilled lime oil after fermentation

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Abundance

m/z->
Abundance

m/z->

Figure 4.28 Mass spectrum of α -terpineol of distilled lime oil after fermentation

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Abundance

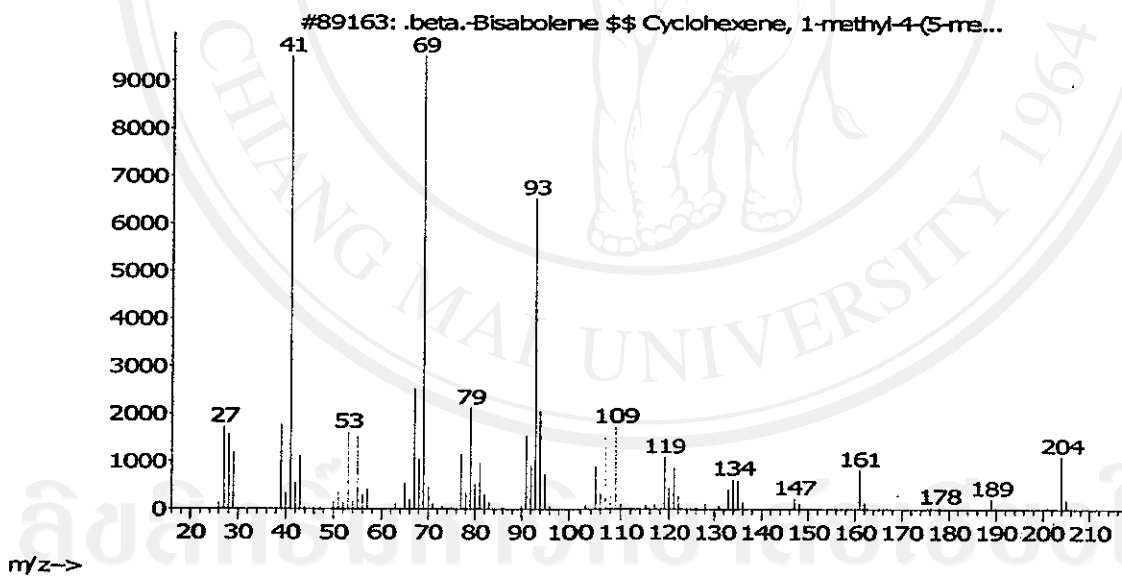
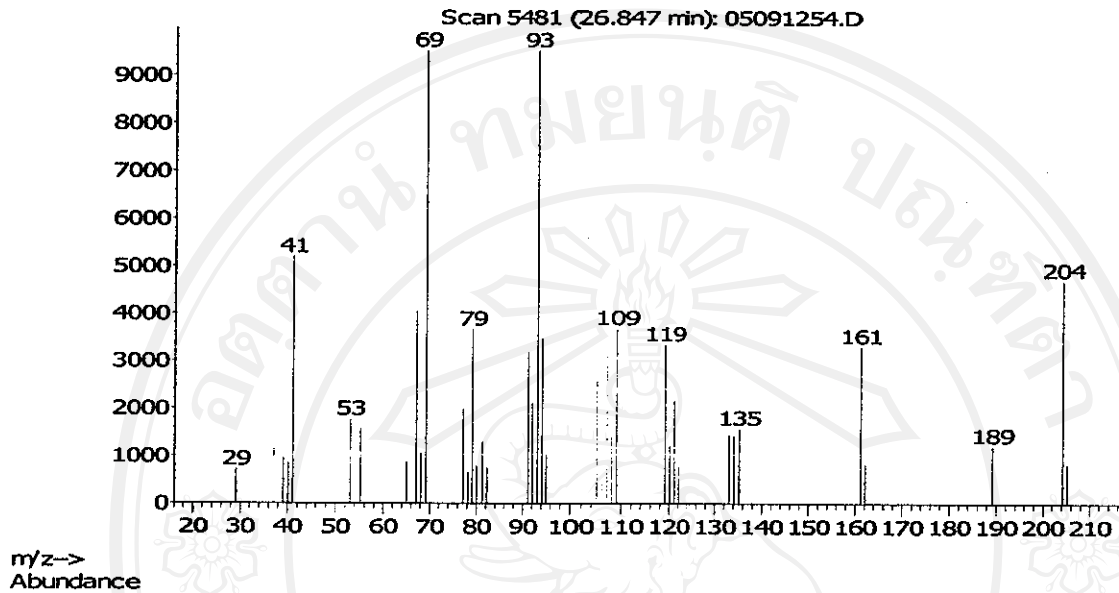


Figure 4.29 Mass spectrum of β -bisabolene of distilled lime oil after fermentation

Curriculum Vitae

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Education Bachelor of Science (Chemistry)
Faculty of Science, Chiang Mai University (1982)
Master of Science (Pharmaceutical Sciences)
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Professional Experience

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1996-1999 NGO in Organic farming, Bangkok

1993-1995 Cooperative and Community Member, Teacher, Shampoo Factory
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1990-1992 Sales Executive (Export)
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