2D NMR: Example 1: HSQC + COSY

Assignment of Menthol

Step 1: 1D proton and C-13 spectra.

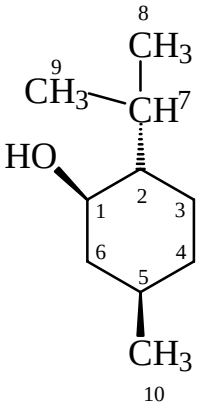
- Account for all protons. Integration gives 20.5. There are 8.6 protons between 0.8 - 1 ppm, overlap including some impurity or incorrect integration.
- number all carbons by chemical shift. Correct number of C.
- DEPT-135: 3 CH_2, 7 CH/CH_3. The three C at lowest shift most likely CH_3 groups.
- HSQC: connect protons to carbons.
  - Identify the pairs of CH_2 protons, these will also show a cross peak in the COSY ($^2J_{HH}$)
  - 1-3 are indeed methyl groups as only then the integrations make sense
  - there are a total of 8 menthol protons between 0.8-1 ppm
  - OH does not give a cross peak
- COSY: connect neighboring CH groups
  - assign most downfield shift 10 to C-1.
  - assign methyl groups: 1 and 2 both connected to 5, 3-6 => 1 and 2 are CH_3-8 and CH_3-9, 5 => C-7, 2 => CH_3-10, 6 => C-5
  - Connect 1-OH, 1-8-6-7-4-9-1, 9-5. Note that 7/6 shows up only on one side of diagonal. The 8A/7A cross peak might be due to HC^4-C-C^6H long range coupling

- INADEQUATE: alternative to obtain C-C connectivity
  - less overlap and no dihedral angle dependence of coupling ($^1J_{CC}$)
  - sensitivity problem: required 0.5 g material

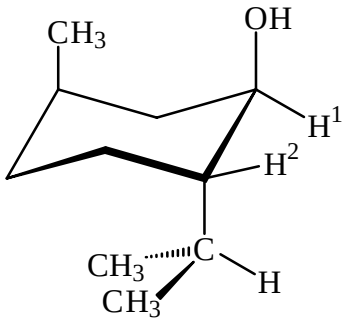
final assignment:

shift	assignment	shift	assignment
1,2	C-8 & C-9	6	C-5
3	C-10	7	C-4
4	C-3	8	C-6
5	C-7	9	C-2

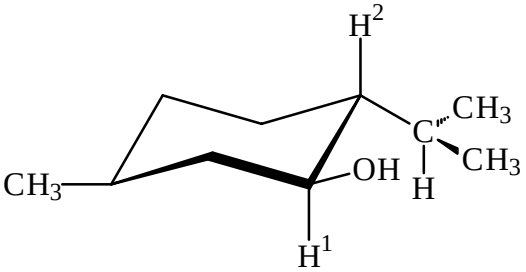
10 C-1



1

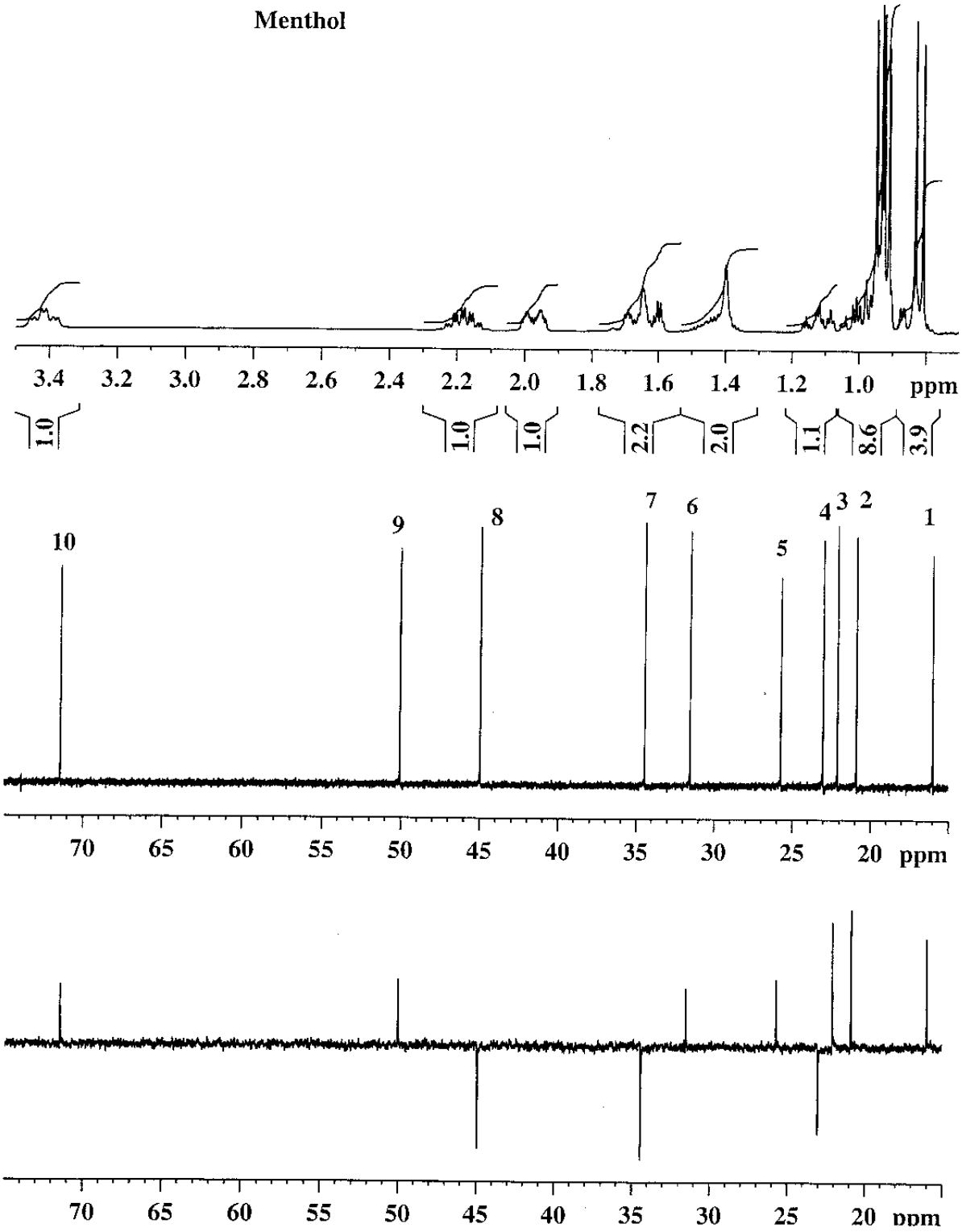


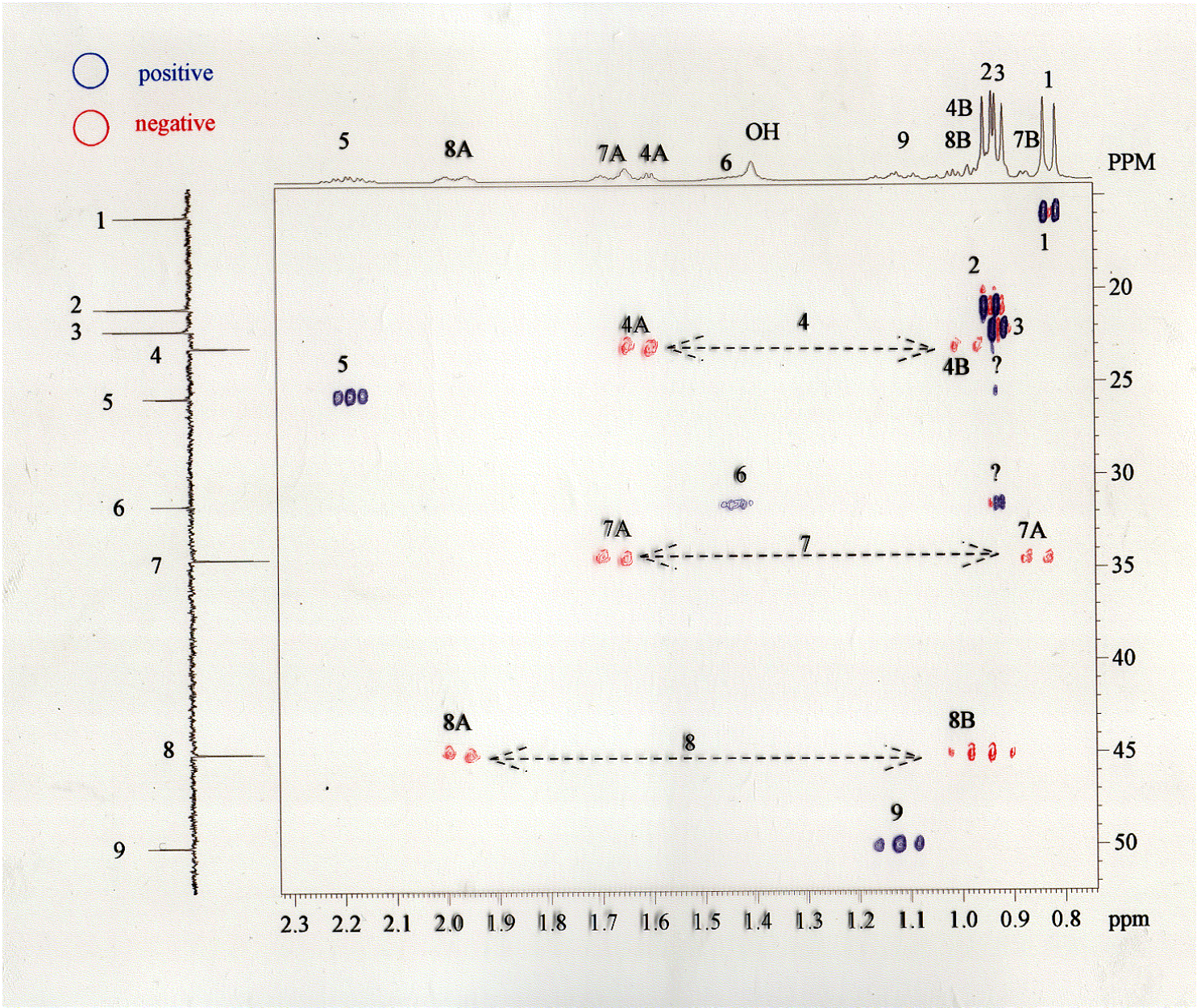
1a

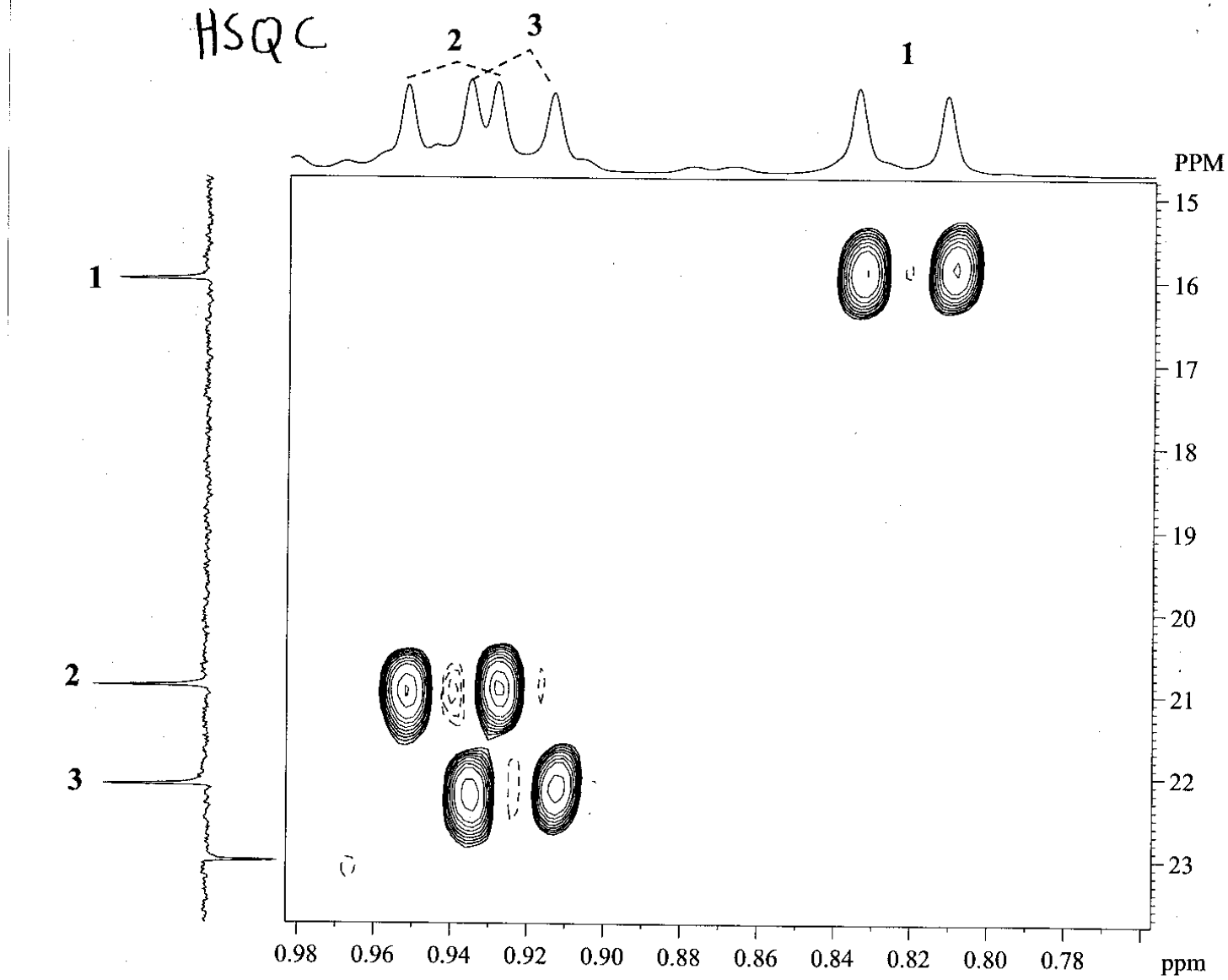


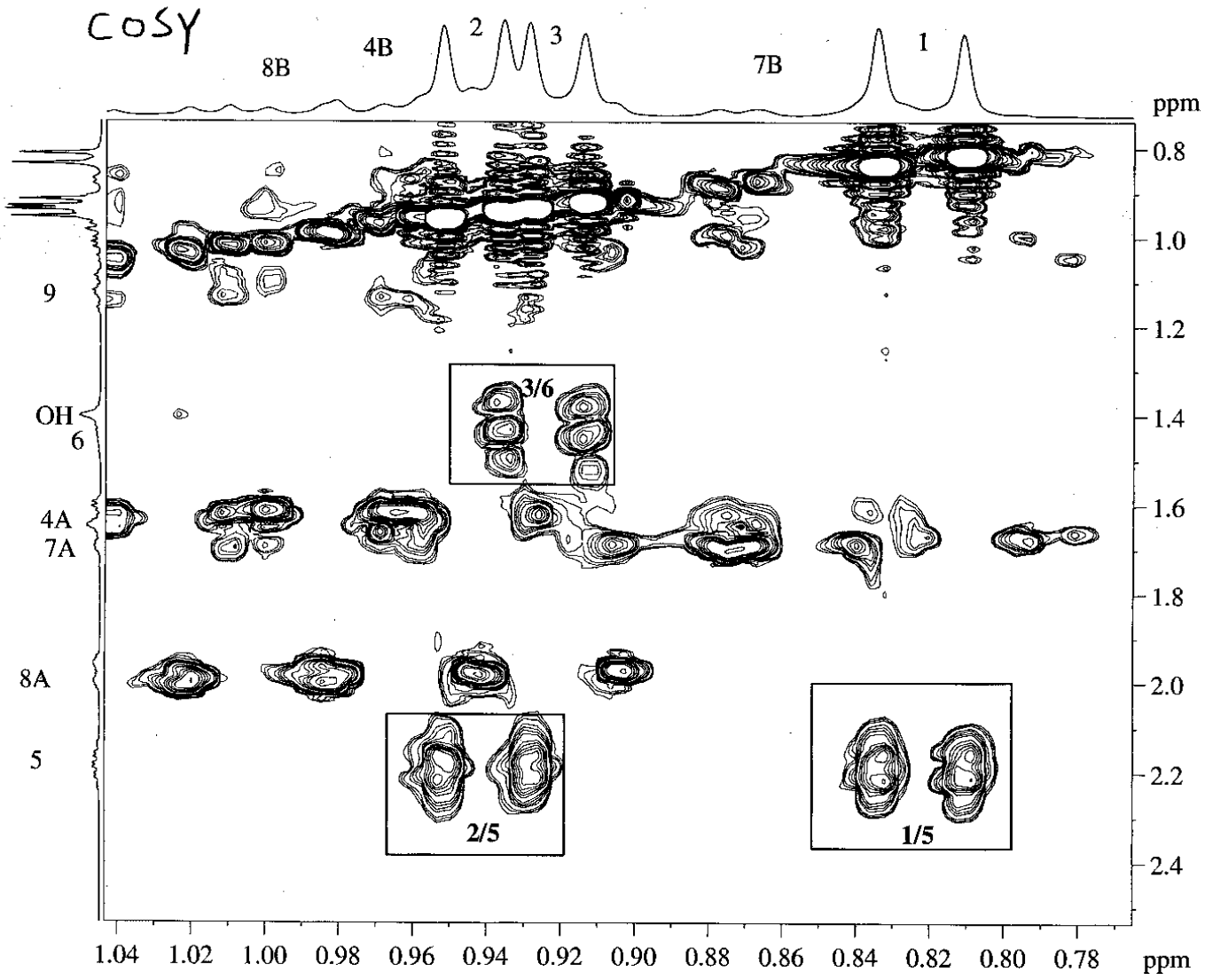
1b

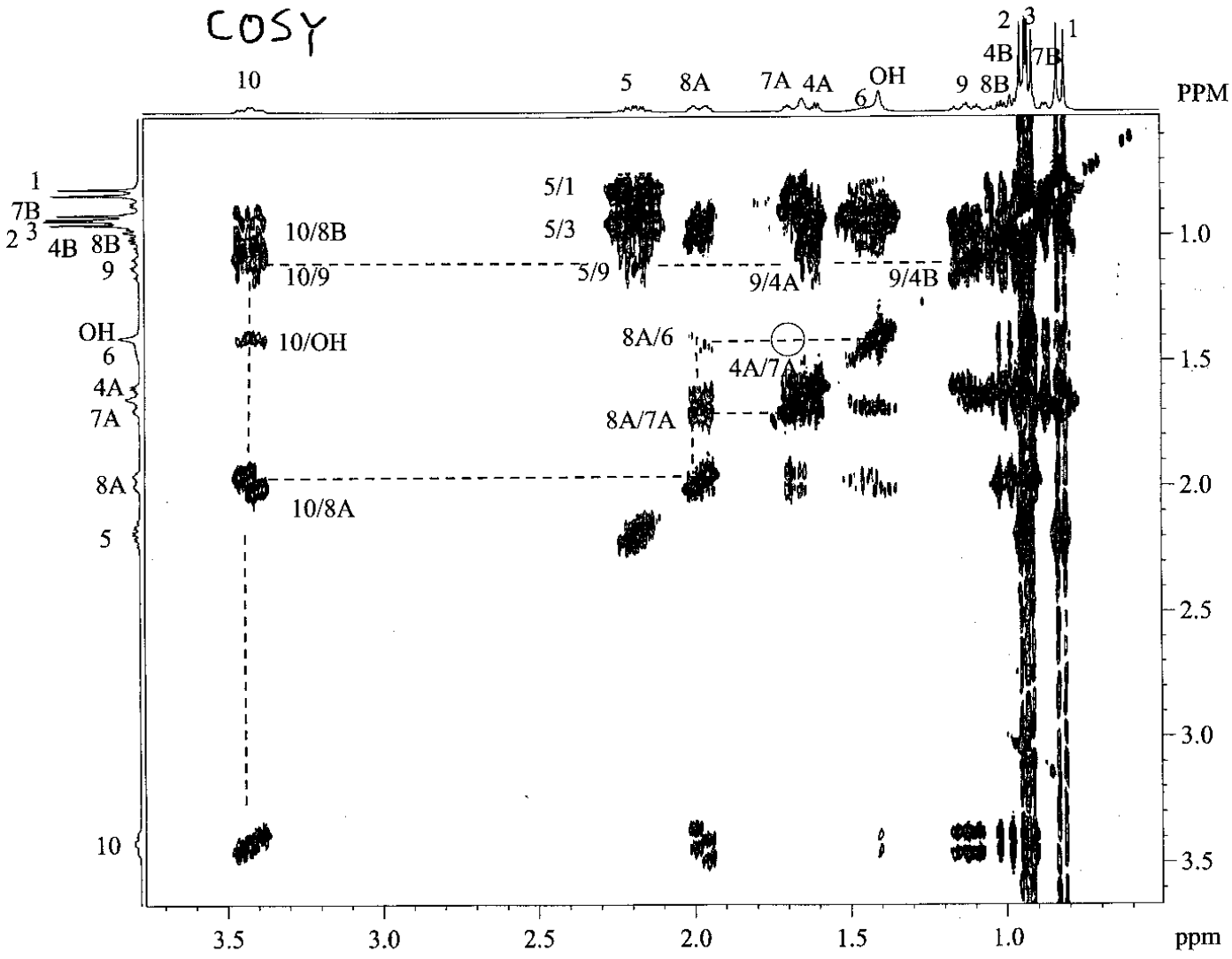
Menthol

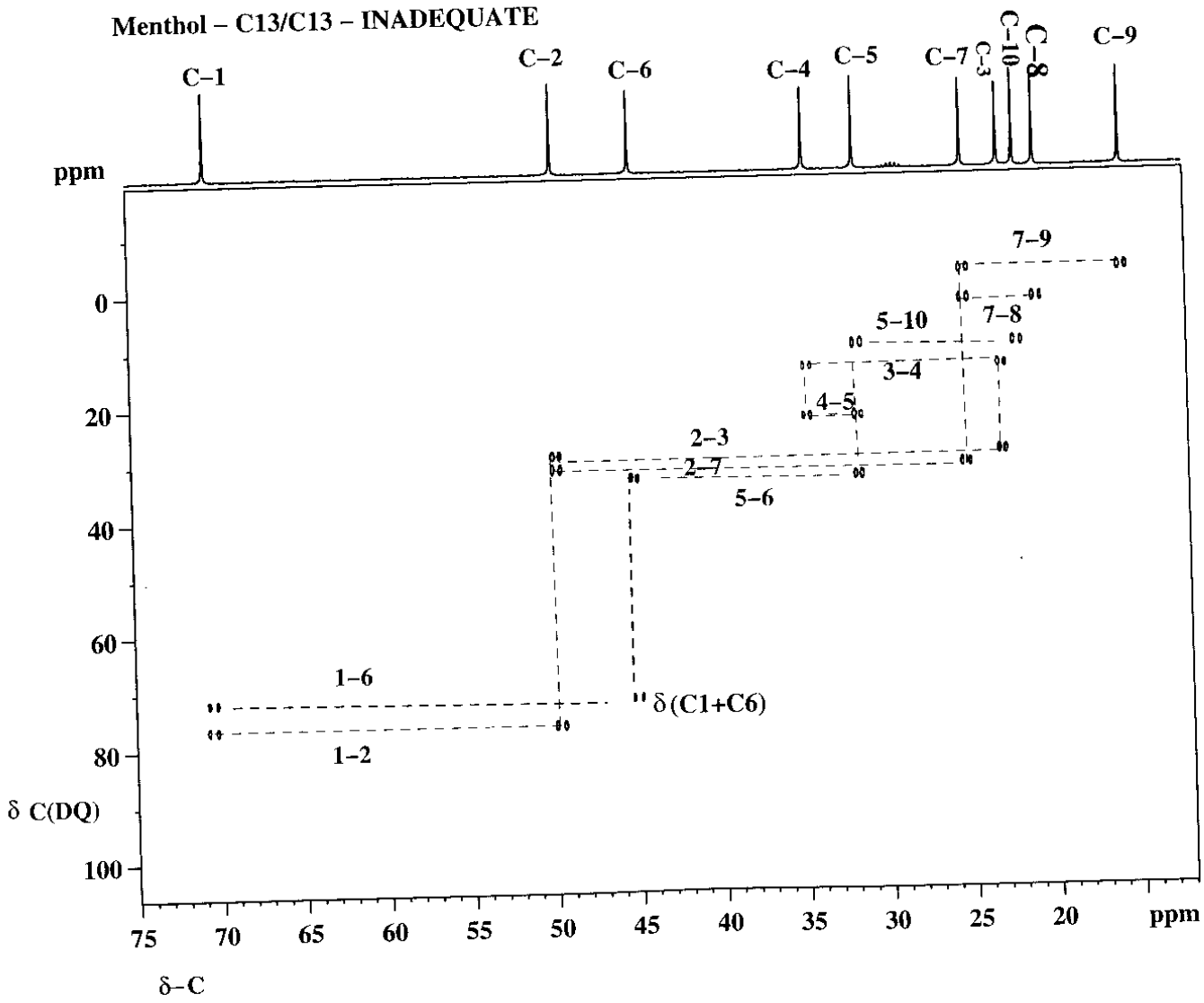

3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
ppm
1.0
1.0
1.0
2.2
2.0
1.1
8.6
3.9
10
9
8
7
6
5
4
3
2
1
70
65
60
55
50
45
40
35
30
25
20
ppm
70
65
60
55
50
45
40
35
30
25
20
ppm


positive
negative
5
8A
7A
4A
OH
6
9
8B
4B
23
7B
1
PPM
1
2
3
4
5
6
7
8
9
20
25
30
35
40
45
50
4A
4
4B
?
7A
7
8
8B
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
ppm


HSQC
2
3
1
PPM
15
16
17
18
19
20
21
22
23
1
2
3
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
ppm


COSY
8B
4B
2
3
7B
1
ppm
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
9
OH
6
4A
7A
8A
5
3/6
2/5
1/5
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
ppm


COSY
10
5
8A
7A
4A
OH
6
9
8B
4B
7B
2
3
1
PPM
1
7B
2 3
4B
8B
9
OH
6
4A
7A
8A
5
10
10/8B
10/9
10/OH
10/8A
5/1
5/3
5/9
9/4A
9/4B
8A/6
4A/7A
8A/7A
1.0
1.5
2.0
2.5
3.0
3.5
3.5
3.0
2.5
2.0
1.5
1.0
ppm


Menthol – C13/C13 – INADEQUATE
C–1
C–2
C–6
C–4
C–5
C–7
C–3
C–10
C–8
C–9
ppm
7–9
7–8
5–10
3–4
4–5
2–3
2–7
5–6
1–6
δ(C1+C6)
1–2
δ C(DQ)
0
20
40
60
80
100
75
70
65
60
55
50
45
40
35
30
25
20
ppm
δ–C