Supplementary Material (ESI) for Chemical Communications

Supporting Information

Highly Efficient Copper-Catalyzed Cascade Synthesis of Quinazoline and Quinazolinone Derivatives

Cheng Huang,[a,b] Yuan Fu,[†] Hua Fu,[*,a] Yuyang Jiang,[*,a,b] Yufen Zhao[b]

[a] Key Laboratory of Bioorganic Phosphorus Chemistry and Chemical Biology (Ministry of Education), Department of Chemistry, Tsinghua University, Beijing 100084, P. R. China

[b] Key Laboratory of Chemical Biology (Guangdong Province), Graduate School of Shenzhen, Tsinghua University, Shenzhen 518057, P. R. China

Fax: (+86) 10-62781695

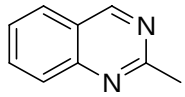
E-mail: fuhua@mail.tsinghua.edu.cn

Table of contents

General experimental procedures

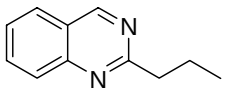
All reactions were carried out under nitrogen atmosphere. DMF was freshly distilled from CaH_2. Proton and carbon magnetic resonance spectra (^{1}H NMR and ^{13}C NMR) were recorded with tetramethylsilane or solvent resonance as the internal standard (^{1}H NMR: TMS at 0.00ppm, $CDCl_3$ at 7.26 ppm, DMSO-d_6 at 2.50 ppm; ^{13}C NMR: $CDCl_3$ at 77.0 ppm, DMSO-d_6 at 40.0 ppm).

General procedure for copper-catalyzed synthesis of quinazoline derivatives (3a-j). A flask was charged with 2-bromobenzaldehyde or 2-bromophenylketone (1 mmol), amidine hydrochloride (1.1 mmol), L-proline (46 mg, 0.4 mmol for entry 10; 23 mg, 0.2 mmol for others in Table 2), Cs_2CO_3 (978 mg, 3 mmol) and DMF (10 mL) (see Table 2), the mixture was stirred for 30 min under nitrogen atmosphere at room temperature, and then CuI (38 mg, 0.2 mmol for entry 12; 19 mg, 0.1 mmol for others in Table 2) was added. After a 30 min-stirring under the same condition, reaction temperature was raised to 110 ^{o}C. After the coupling reaction for a time as shown in Table 2, the resulting solution was cooled to room temperature and filtered, and the inorganic salts were removed. The filtrate was concentrated with the aid of a rotary evaporator, and the residue was purified by column chromatography on silica gel to provide the desired product.



3a

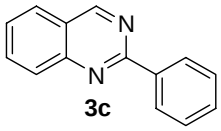
2-Methyl-quinazoline (3a).[1] Eluent: petroleum ether/ethyl acetate (from10:1 to 2:1). Brown solid, yield 75% (108 mg), mp 37-38 °C (lit.[1] mp 40 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.30 (s, 1H), 7.95-7.84 (m, 3H), 7.56 (t, J = 6.9 Hz, 1H), 2.90 (d, J = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 164.4, 160.3, 150.2, 134.1, 127.6, 127.1, 127.0, 122.8, 26.4. ESI-MS $[M+H]^+$ m/z 145.1.



3b

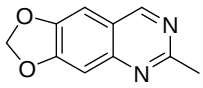
2-Propyl-quinazoline (**3b**). Eluent: petroleum ether/ethyl acetate (from 10:1 to 2:1). Brown oil, yield 82% (141 mg). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.32 (s, 1H), 7.96 (d, J = 7.6 Hz, 1H), 7.85-7.82 (m, 2H), 7.54 (t, J = 7.2 Hz, 1H), 3.11 (t, J = 7.7 Hz, 2H), 1.96 (m, 2H), 1.05 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 167.6, 160.3, 150.2, 133.8, 127.8, 127.0, 126.8,

123.0, 41.8, 22.2, 14.0. ESI-MS $[M+H]^+$ m/z 173.3.



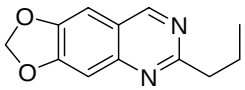
3c

2-Phenyl-quinazoline (**3c**). Eluent: petroleum ether/ethyl acetate (from 10:1 to 2:1). Yellow solid, yield 55% (115 mg), mp 230-231 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 11.34 (s, 1H), 8.33 (d, J = 7.6 Hz, 1H), 8.25-8.21 (m, 2H), 7.86-7.78 (m, 2H), 7.60-7.58 (m, 3H), 7.54-7.48 (m, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 163.7, 153.7, 151.8, 149.6, 135.0, 132.9, 131.8, 129.2, 128.1, 127.4, 126.9, 126.5. ESI-MS: $[M+H]^+$ m/z 206.1 . ESI-MS $[M+H]^+$ m/z 206.9.



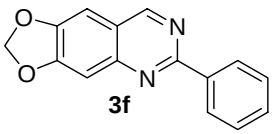
3d

6-Methyl-[1,3]dioxolo[4,5-g]quinazoline (**3d**).[2] Eluent: petroleum ether/ethyl acetate (from 10:1 to 2:1). Yellow solid, yield 92% (179 mg), mp 168-169 °C (lit.[2] 176 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.00 (s, 1H), 7.19 (s, 1H), 7.04 (s, 1H), 6.13 (s, 2H), 2.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 163.2, 157.4, 154.2, 150.0, 147.9, 119.9, 104.2, 102.2, 101.8, 26.1. ESI-MS $[M+H]^+$ m/z 189.0.



3e

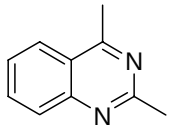
6-Propyl-[1,3]dioxolo[4,5-g]quinazoline (**3e**).[2] Eluent: petroleum ether/ethyl acetate (from 10:1 to 2:1). Yellow solid, yield 95% (205 mg), mp 82-83 °C (lit.[2] 78 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.01 (s, 1H), 7.21 (s, 1H), 7.04 (s, 1H), 6.12 (s, 2H), 3.00 (t, J = 7.6 Hz, 2H), 1.91 (m, 2H), 1.02 (t, 38 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 166.4, 157.4, 154.0, 149.9, 147.9, 120.1, 104.3, 102.1, 101.7, 41.6, 22.4, 14.0. ESI-MS $[M+H]^+$ m/z 217.1.



3f

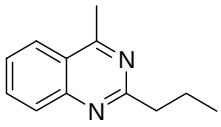
6-Phenyl-[1,3]dioxolo[4,5-g]quinazoline (**3f**). Eluent: petroleum ether/ethyl acetate (from 10:1 to 2:1). Yellow solid, yield 89% (222 mg), mp 154-155 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.14 (s, 1H), 8.53 (d*d, J_1 = 7.9 Hz, J_2 =3.0 Hz, 2H), 7.45-7.52 (m, 3H), 7.31 (s, 1H), 7.08 (s, 1H), 6.12 (s, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 160.1, 157.6, 154.2, 150.4, 148.3, 138.3,

130.3, 128.6, 128.3, 120.8, 105.1, 102.3, 101.9. ESI-MS $[M+H]^+$ m/z 251.2.



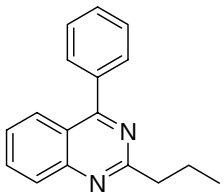
3g

2,4-Dimethyl-quinazoline (3g).[3] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). Yellow solid, yield 84% (133 mg), mp 288-290 °C (lit.[3] 300 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.98 (d, J = 8.3 Hz, 1H), 7.90 (d, J = 8.3 Hz, 1H), 7.80 (t, J = 7.2 Hz, 1H), 7.52 (t, J = 7.9 Hz, 1H), 2.88 (s, 3H), 2.84 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 168.0, 163.5, 149.8, 133.5, 128.2, 126.5, 124.8, 122.1, 26.4, 21.6. ESI-MS $[M+H]^+$ m/z 159.0.



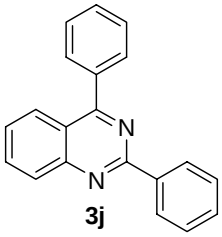
3h

4-Methyl-2-propyl-quinazoline (3h). Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). Brown solid, yield 86% (160 mg), mp 209-210 ^{o}C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.79 (t, J_1 = 7.6 Hz, J_2 = 7.9 Hz, 2H), 7.63 (t, J = 7.2 Hz, 1H), 7.33 (t, J = 7.53 Hz, 1H), 2.90 (t, J = 7.7 Hz, 2H), 2.73 (s, 3H), 1.82 (m, 2H), 0.90 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 167.8, 166.6, 149.8, 133.2, 128.3, 126.3, 124.7, 122.2, 41.9, 22.3, 21.6, 14.0. ESI-MS $[M+H]^+$ m/z 187.0.



3i

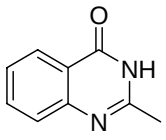
2-Propyl-4-phenylquinazoline (3i).[4] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). White solid, yield 81% (201 mg), mp 99-100°C (lit.[4] 100 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.04 (d, J = 8.6 Hz, 2H), 7.88-7.81 (m, 1H), 7.79-7.72 (m, 2H), 7.59-7.47 (m, 4H), 3.15 (t, J = 7.7 Hz, 2H), 2.01 (m, 2H), 1.07 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 168.6, 167.2, 151.5, 137.5, 133.6, 130.0, 129.9, 128.7, 128.4, 127.1, 126.7, 121.3, 42.1, 22.5, 14.2. ESI-MS $[M+H]^+$ m/z 248.8.



3j

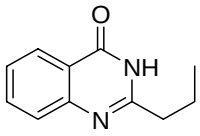
2,4-Diphenylquinazoline (3j).[5] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). Yellow solid, yield 61% (172 mg), mp 116-117°C (lit.[5] 118-120 °C). ^{1}H NMR (DMSO-d_6, 300 MHz) δ 8.23-8.05 (m, 4H), 7.78-7.21 (m, 10H). ^{13}C NMR (,DMSO-d_6, 75 MHz) δ 162.1, 155.6, 131.8, 130.8, 129.6, 129.3, 128.3, 128.0, 127.8, 127.2, 126.7, 126.4. ESI-MS $[M+H]^+$ m/z 283.2.

General procedure for copper-catalyzed synthesis of quinazolinone derivatives (5a-h) and quinazoline derivative (6b). A flask was charged with substituted methyl 2-halobenzoate (1 mmol), amidine hydrochloride (1.1 mmol), L-proline (23 mg, 0.2 mmol), Cs_2CO_3 (978 mg, 3 mmol) and DMF (10 mL) (see Table 3), the mixture was stirred for 30 min under nitrogen atmosphere at room temperature, and then CuI (19 mg, 0.1 mmol) was added. After a 30 min-stirring under the same condition, reaction temperature was raised to 80 ^{o}C. After the coupling reaction for a time as shown in Table 3, the resulting solution was cooled to room temperature and filtered, and the inorganic salts were removed. The filtrate was concentrated with the aid of a rotary evaporator, and the residue was purified by column chromatography on silica gel to provide the desired product.



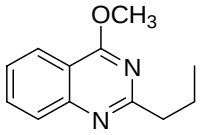
5a

2-Methyl-3H-quinazolin-4-one (5a).[6] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). White solid, Yield 91% (146 mg) using methyl 2-bromobenzoate as the substarte; 90% (144 mg) using methyl 2-chlorobenzoate as the substarte. mp 235-236 °C (lit.[6] mp 238 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.27 (d, J = 7.9 Hz, 1H), 7.83-7.43 (m, 4H), 2.60 (t, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 164.5, 153.5, 149.5, 135.0, 127.0, 126.5, 126.3, 120.3, 22.1. ESI-MS $[M+H]^+$ m/z 161.3.



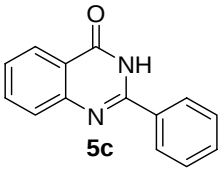
5b

2-Propyl-3H-quinazolin-4-one (5b).[6] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). White solid, yield 74% (139 mg) using methyl 2-bromobenzoate as the substarte; 77% (145 mg) using methyl 2-chlorobenzoate as the substarte. mp 208-209 °C(lit.[6] mp 207 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 12.08 (s, 1H), 8.29 (d, J = 7.9 Hz, 1H), 7.78-7.70 (m, 2H), 7.48 (t, J_1 = 6.9 Hz, J_2 = 7.5 Hz, 1H), 2.80 (t, J = 7.6 Hz, 2H), 1.95 (m, 2H), 1.09 (t, J = 7.2 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 164.5, 157.0, 149.5, 134.9, 127.3, 126.5, 126.3, 120.6, 37.8, 21.1, 13.8. ESI-MS $[M+H]^+$ m/z 189.0.



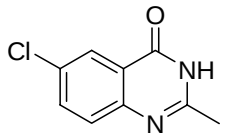
6b

4-Methoxy-2-propyl-quinazoline (6b). Eluent: petroleum ether/ethyl acetate (form 10:1 to 5:1). White solid, yield 22% (44 mg) using methyl 2-bromobenzoate as the substarte; 18% (36 mg) using methyl 2-chlorobenzoate as the substarte. mp 73-74 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.21 (d, J = 7.9 Hz, 1H), 7.68-7.57 (m, 2H), 7.39 (t, J = 6.9 Hz, 1H), 3.58 (s, 3H), 2.75 (t, J = 7.7 Hz, 2H), 1.90-1.79 (m, 2H), 1.07 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 162.4, 156.9, 147.2, 133.9, 126.8, 126.6, 126.2, 120.1, 37.5, 30.4, 20.2, 13.9. ESI-MS $[M+H]^+$ m/z 203.3.



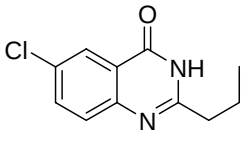
5c

2-Phenyl-3H-quinazolin-4-one (**5c**).[6] Eluent: petroleum ether/ethyl acetate (from 10:1 to 3:1). Yield 89% (198 mg) using methyl 2-bromobenzoate as the substarte; 86% (191 mg) using methyl 2-chlorobenzoate as the substarte. mp 235-236 °C (lit.[6] mp 236 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 11.77 (s, 1H), 8.35-8.27 (m, 3H), 7.84-7.75 (m, 2H), 7.60-7.50 (m, 4H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 164.0, 151.9. 149.6, 135.0, 133.0, 131.8, 129.1, 128.1, 127.5, 126.9, 126.5. ESI-MS $[M+H]^+$ m/z 223.3.



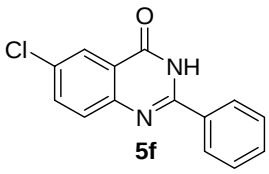
5d

6-Chloro-2-methylquinazolin-4-3H-one (**5d**). Eluent: petroleum ether/ethyl acetate (from 10:1 to 1:1). Yellow solid, yield 87% (169 mg, mp 214-215 °C. ^{1}H NMR (DMSO-d_6, 300 MHz) δ 12.40 (s, br, 1H), 7.99 (d, J = 2.4 Hz, 1H), 7.78 (dd, J_1 = 8.91 Hz, J_2 = 2.4 Hz, 1H), 7.59 (d, J = 8.9 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR (DMSO-d_6, 75 MHz) δ 161.3, 155.5. 148.1, 134.8, 130.6, 129.3, 125.2, 122.4, 22.0. ESI-MS $[M+H]^+$ m/z m/z 194.9.



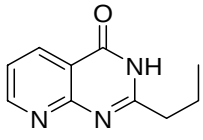
5e

6-Chloro-2-propyl-3H-quinazolin-4-one (5e). Eluent: petroleum ether/ethyl acetate (from 10:1 to 1:1). White solid, Yield 95% (211 mg), mp 230-231 °C. ^{1}H NMR (DMSO-d_6, 300 MHz) δ 12.32 (s, 1H), 7.96 (d, J = 2.4 Hz, 1H), 7.74 (dd, J_1 = 8.6 Hz, J_2 = 2.4 Hz, 1H), 7.58 (d, J = 8.6 Hz, 1H), 2.50 (t, J = 7.9 Hz, 2H), 1.70 (m, 2H), 0.89 (t, J = 7.4 Hz, 3H). ^{13}C NMR (DMSO-d_6, 75 MHz) δ 161.4, 158.5, 148.2, 134.9, 130.7, 129.6, 125.2, 122.6, 39.7, 20.7, 14.0. ESI-MS $[M+H]^+$ m/z 223.2.



5f

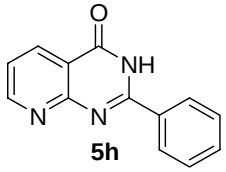
6-Chloro-2-phenyl-3H-quinazolin-4-one (5f).[7] Eluent: petroleum ether/ethyl acetate (from 10:1 to 1:1). White solid, Yield 86% (220 mg), mp 208-209 °C (lit.[7] mp 210 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.06-8.02 (m, 3H), 7.43-7.41 (t, J_1 = 3.5 Hz, J_2 = 2.7 Hz, 5H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 170.00, 133.5, 132.1, 128.7, 127.5. ESI-MS $[M+H]^+$ m/z 256.8.



5g

2-Propylpyrido[2,3-d]pyrimidin-4(3H)-one (5g). Eluent: petroleum ether/ethyl acetate (2:1)

and then ethyl acetate/methanol (8:1). White solid, Yield 82% (155 mg), mp 151-152 °C. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 13.11 (s, br., 1H), 12.09 (s, br, 1H), 8.68 (d, J = 9.30 Hz, 1H), 7.81 (d, J = 6.2 Hz, 1H), 6.65 (t, J_1 = 6.2 Hz, J_2 = 9.3 Hz, 1H), 2.85 (t, J = 7.4 Hz, 2H), 1.76 (m, 2H), 1.02 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 175.6, 163.9, 162.2, 147.4, 140.2, 120.3, 108.5, 40.4, 17.8, 13.8. ESI-MS $[M+H]^+$ m/z 190.2.



5h

2-Phenylpyrido[2,3-d]pyrimidin-4(3H)-one (5h).[8] Eluent: petroleum ether/ethyl acetate (5:1) and then ethyl acetate. Yield 76% (169 mg), mp 284-285 °C (lit.[8] mp 287-289 °C). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.27 (s, br, 1H), 8.65 (d, J = 7.9 Hz, 3H), 7.62-7.53 (m, 5H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 162.2, 155.6, 130.8, 130.7, 129.6, 129.3, 126.5. ESI-MS $[M+H]^+$ m/z 224.1.

References

1 T. Higashino, H. Kokubo, A. Goto, M. Takenoto, E. Hayashi, *Chem. Pharm. Bull.* **1984**, *32*, 3690.

2 K. Lempert, J. Fetter, J. Nyitrai, F. Bertha, *J. Chem. Soc. Perkin Trans. 1* **1986**, 269.

3 A. Motohiro, Y. Jun, K. Teruyuki, W. Yoshihisa *J. Organomet. Chem.* **1995**, *494*, 229.

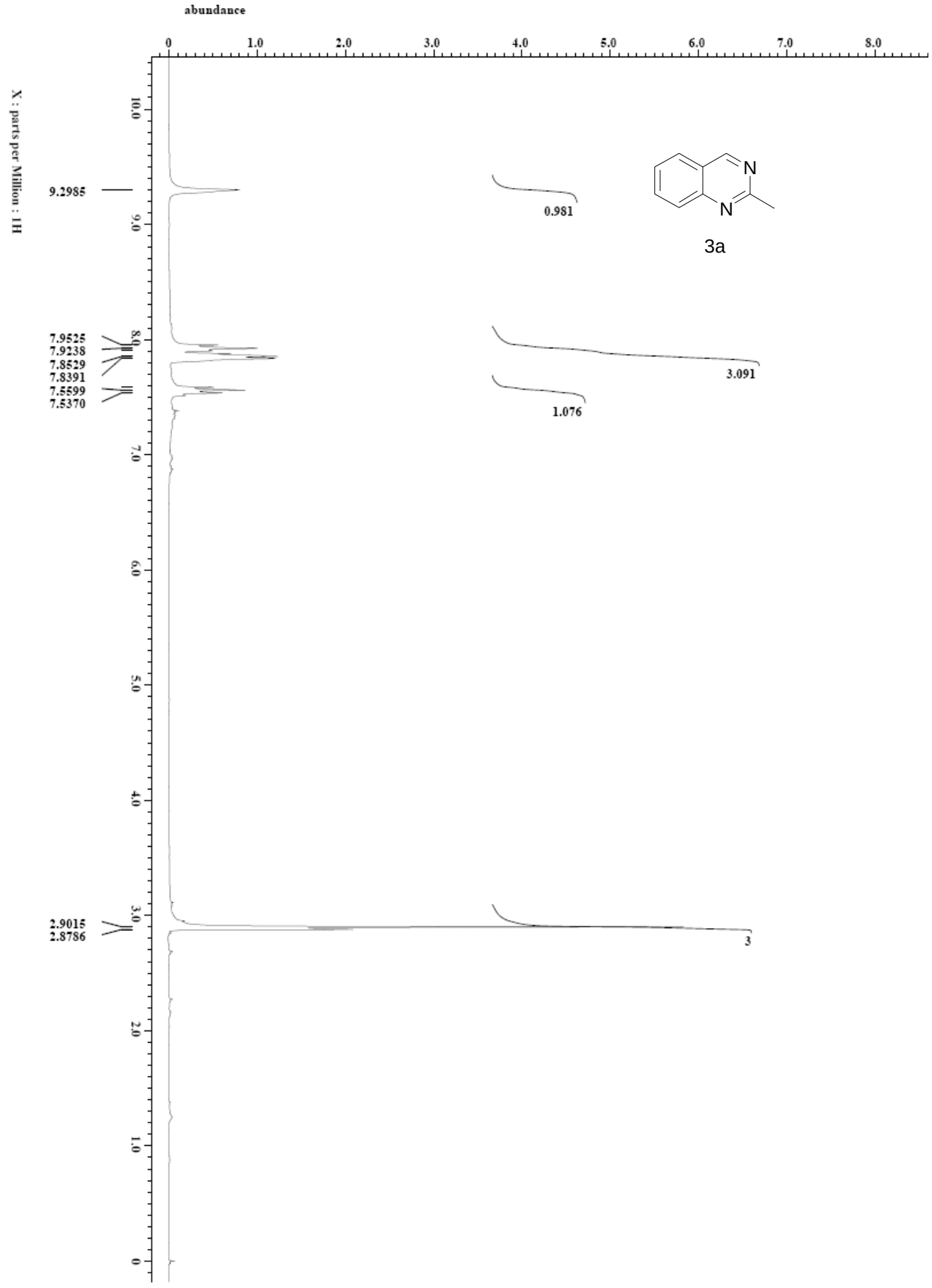
4 J. Bergman; A. Brynolf, B. Elman, E. Vuorinen, *Tetrahedron* **1986**, *42*, 3697.

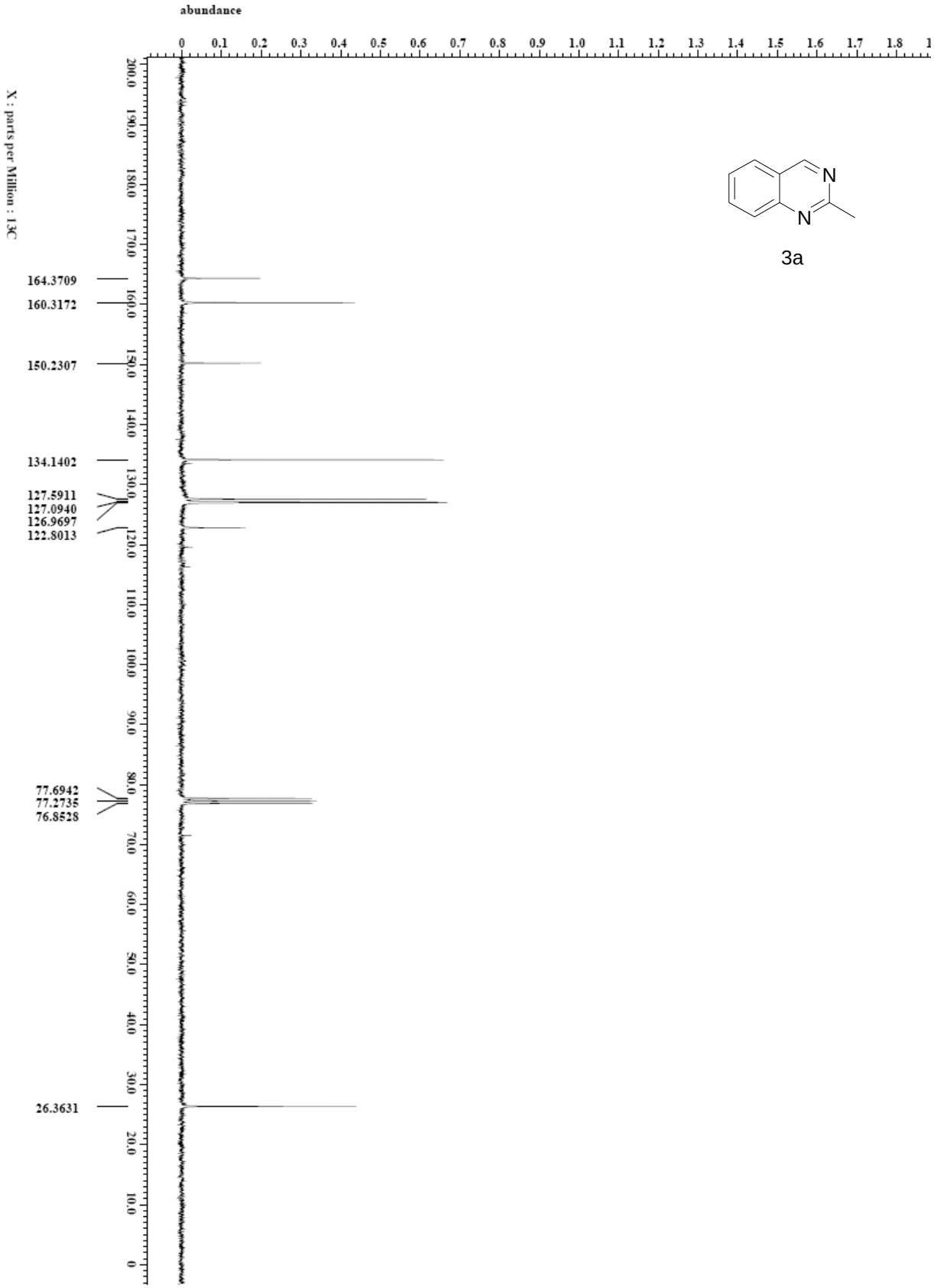
5 A. Fürstner, A. Leitner, M. Méndez, H. Krause, *J. Am. Chem. Soc*. **2002**, *124*, 13856.

6 P. Salehi, M. Dabiri, M. A. Zolfigol, M. Baghbanzadeh, *Tetrahedron Lett.* **2005**, *46*, 7051.

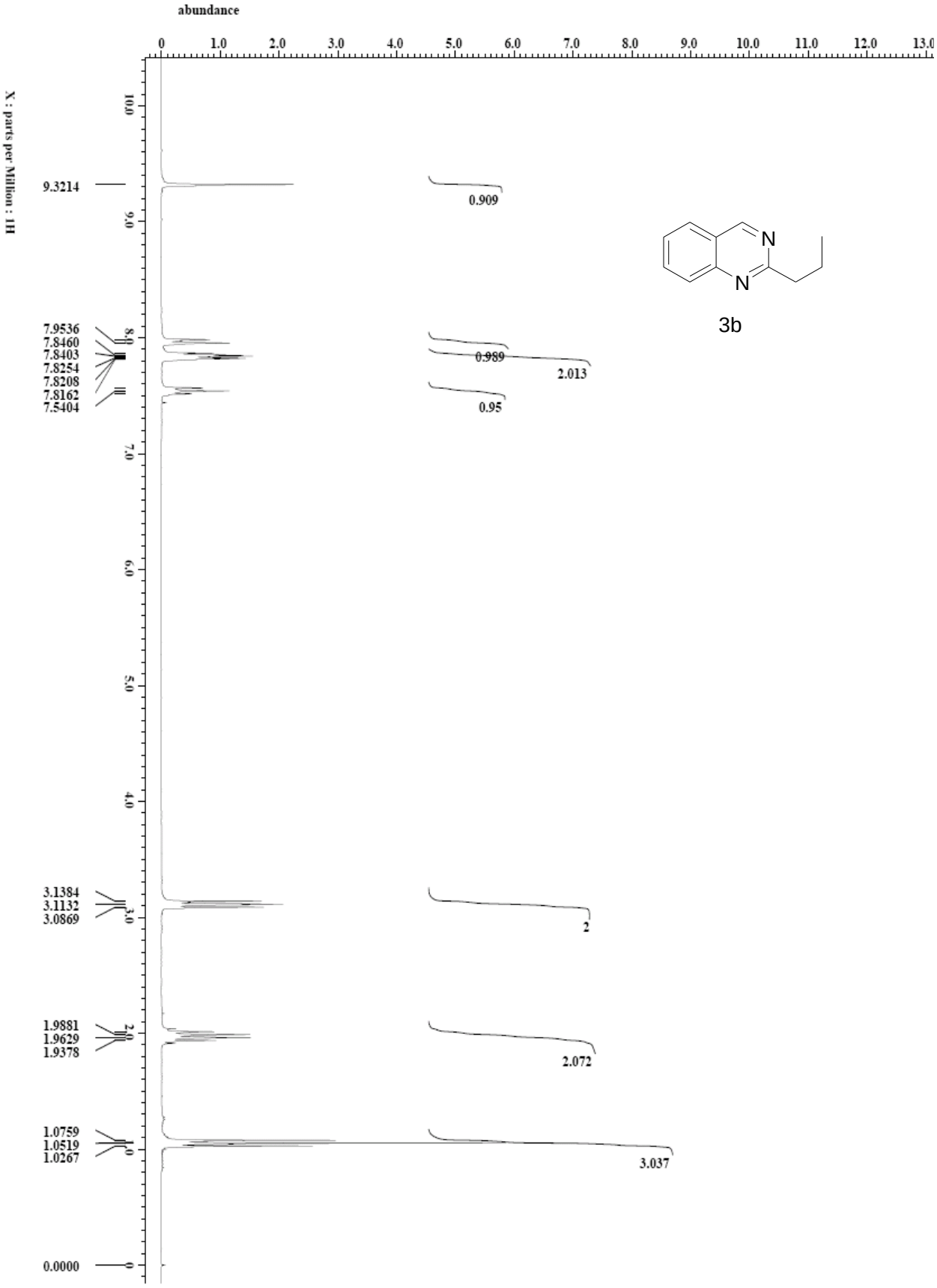
7 T. M. Potewar, R. N. Nadaf, T. Daniel, R. J. Lahoti, K. V. Srinivasan, *Synth. Commun.* **2005**, *35*, 231.

9 M. Kočevar, J. Koller, B. Stanovnik, Tišler, M. *Monatshefte Chem.* **1987**, *118*, 399.

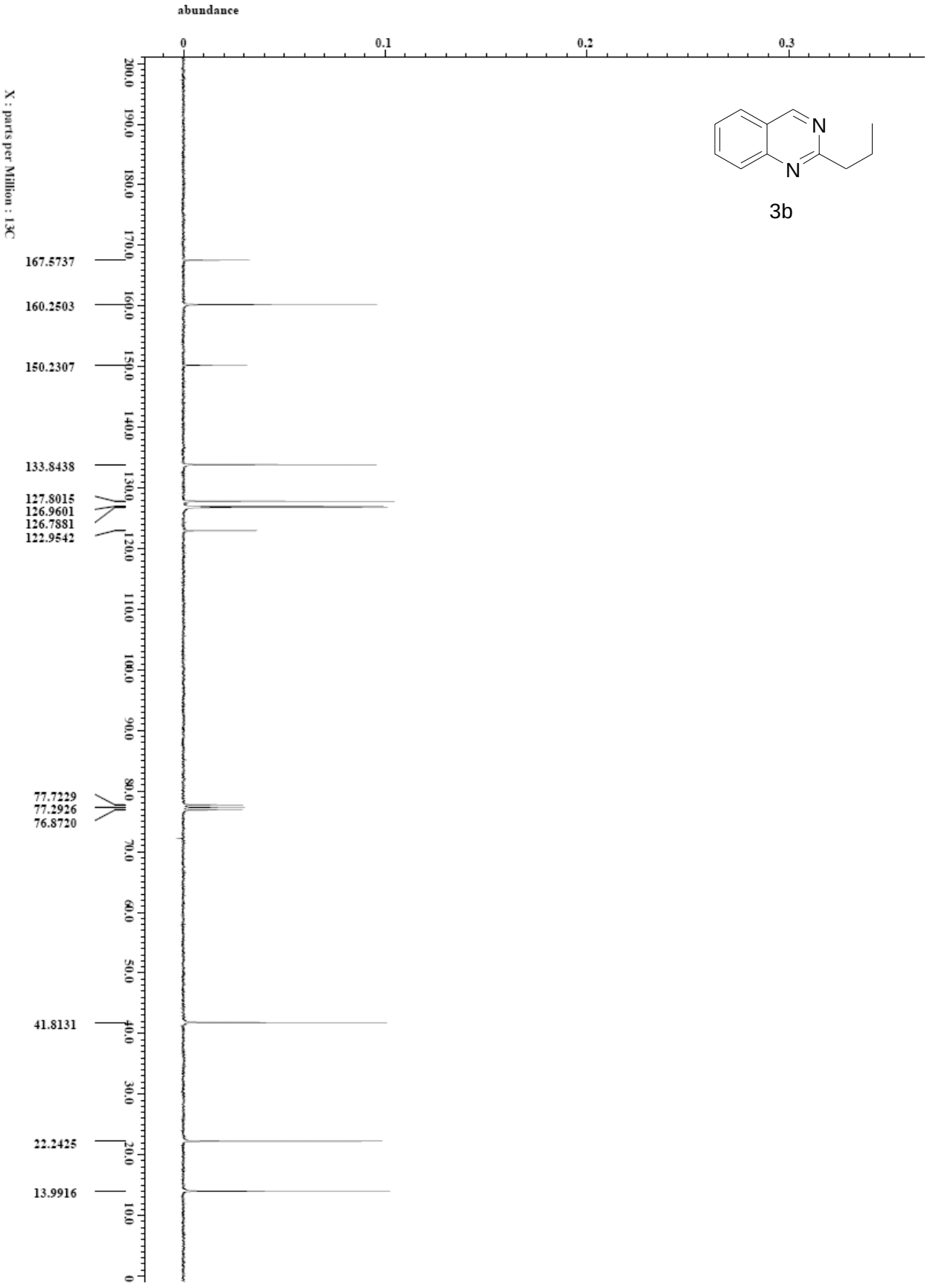

abundance
X : parts per Million : 1H
9.2985
7.9525
7.9238
7.8529
7.8391
7.5599
7.5370
2.9015
2.8786
0.981
3.091
1.076
3
N
N
3a


abundance
X : parts per Million : 13C
164.3709
160.3172
150.2307
134.1402
127.5911
127.0940
126.9697
122.8013
77.6942
77.2735
76.8528
26.3631
N
N

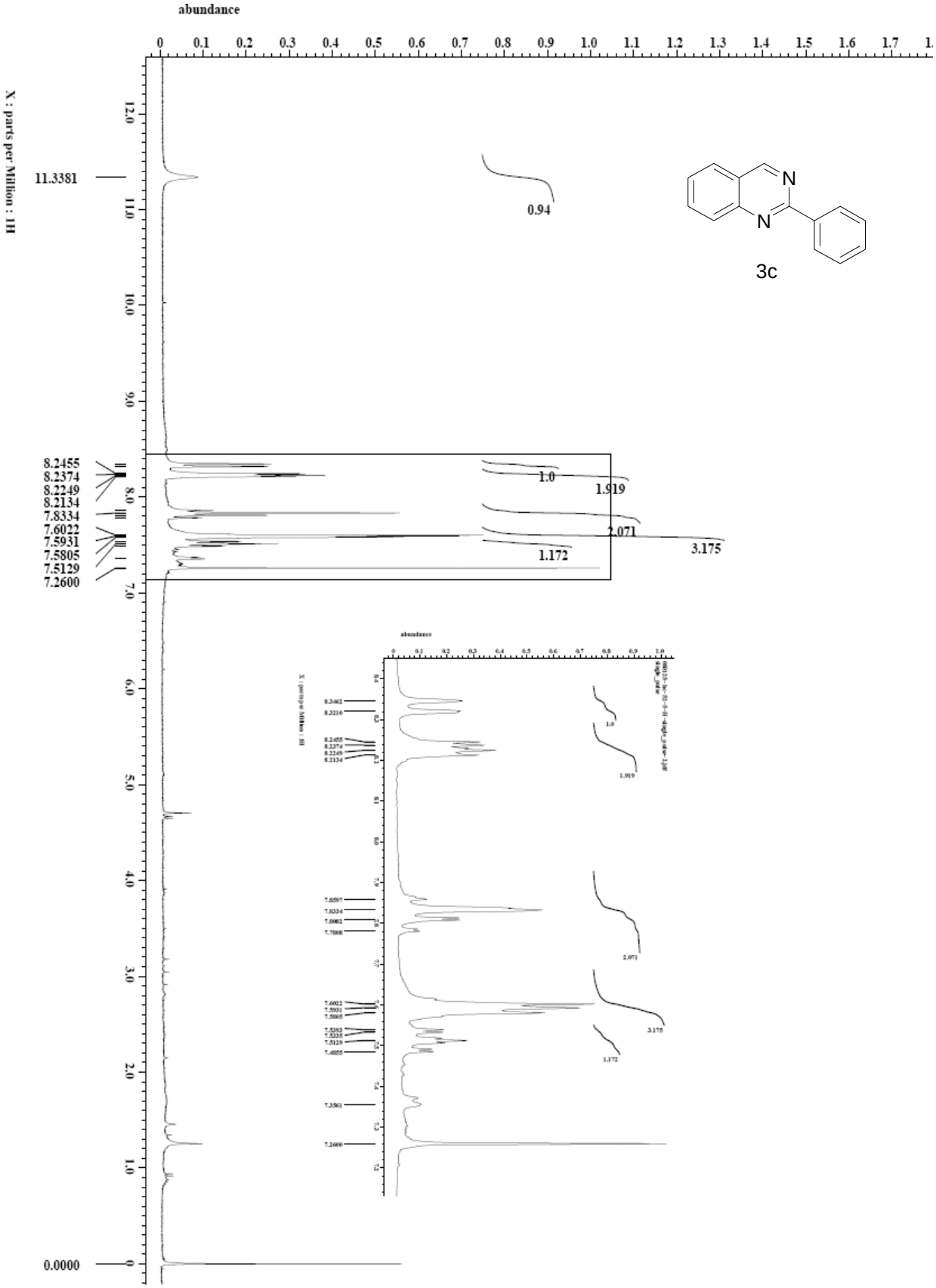
3a

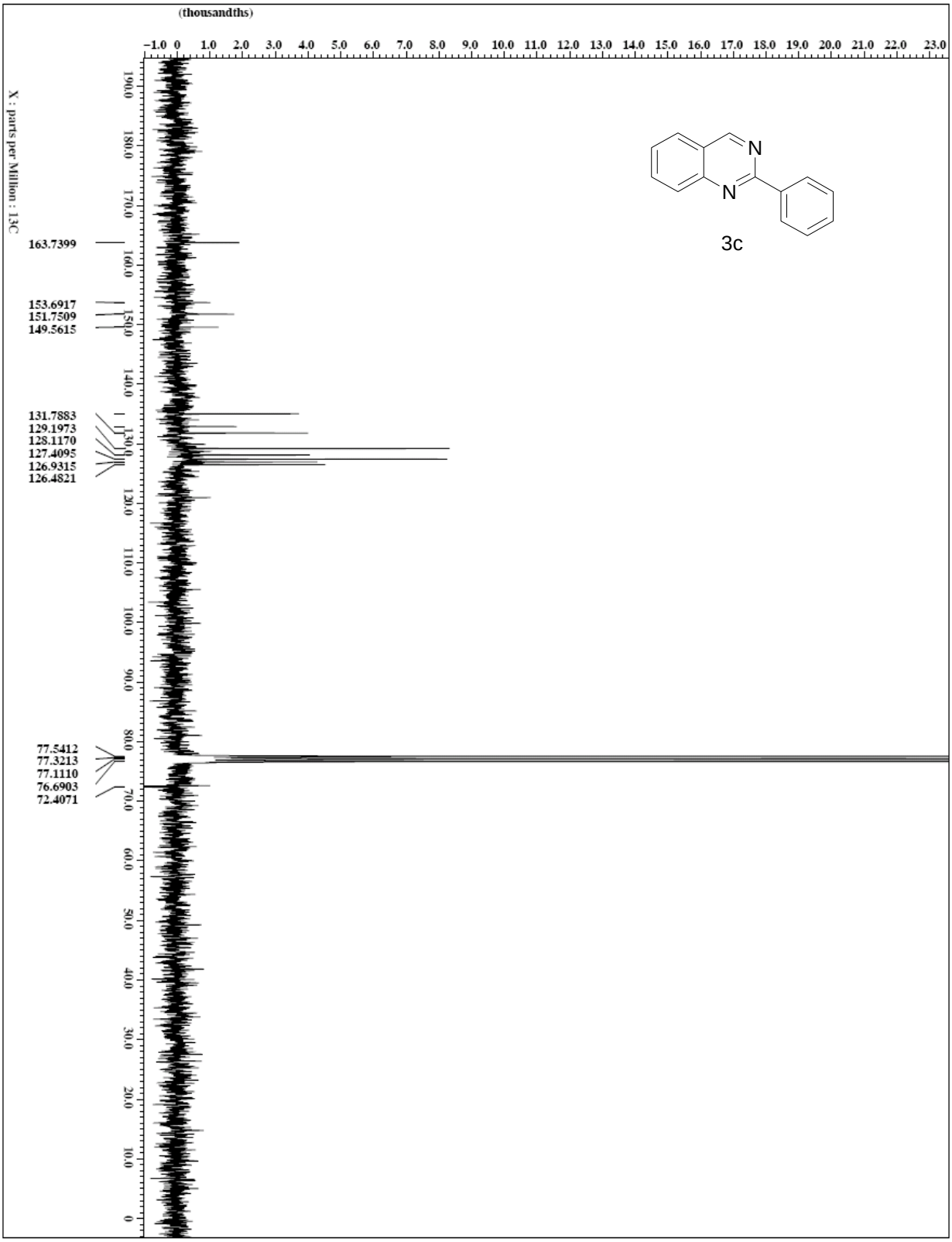

abundance
X : parts per Million : 1H
9.3214
7.9536
7.8460
7.8403
7.8254
7.8208
7.8162
7.5404
3.1384
3.1132
3.0869
1.9881
1.9629
1.9378
1.0759
1.0519
1.0267
0.0000
0.909
0.989
2.013
0.95
2
2.072
3.037
N
N

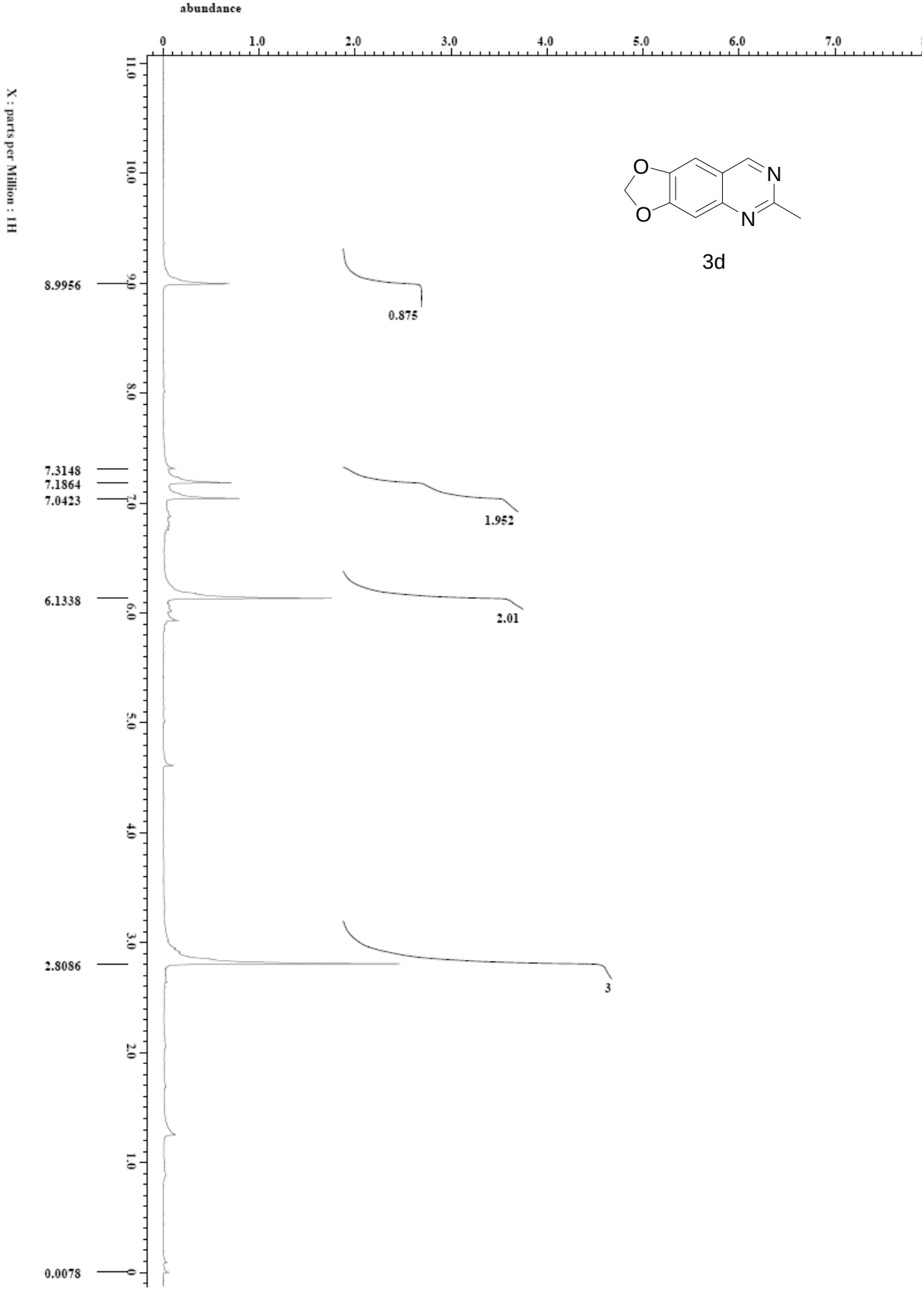
3b


abundance
0
0.1
0.2
0.3
X : parts per Million : 13C
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
167.5737
160.2503
150.2307
133.8438
127.8015
126.9601
126.7881
122.9542
77.7229
77.2926
76.8720
41.8131
22.2425
13.9916
N
N

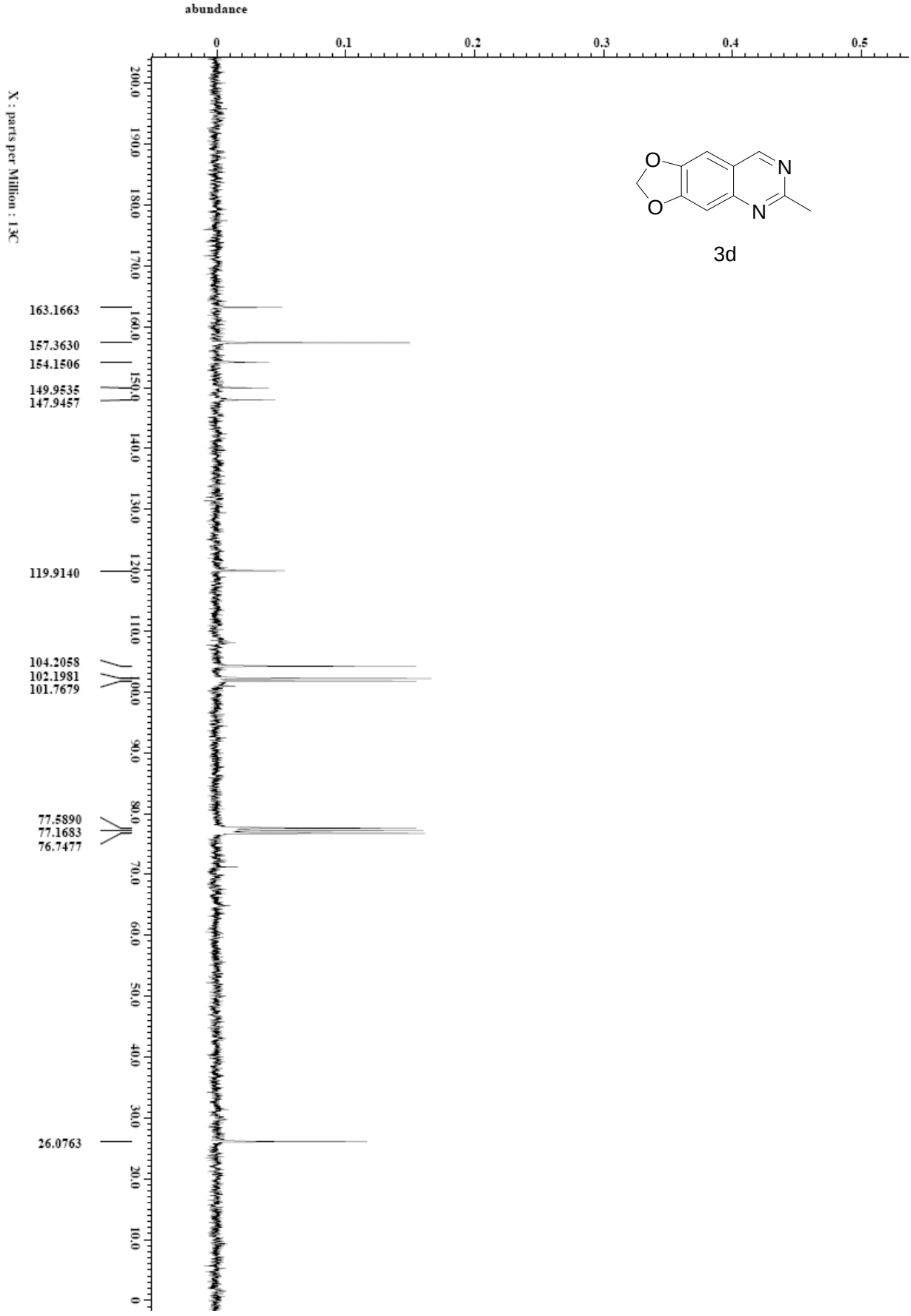
3b


abundance
X : parts per Million : 1H
11.3381
8.2455
8.2374
8.2249
8.2134
7.8334
7.6022
7.5931
7.5805
7.5129
7.2600
0.0000
0.94
1.0
1.919
2.071
3.175
1.172
N
N
3c

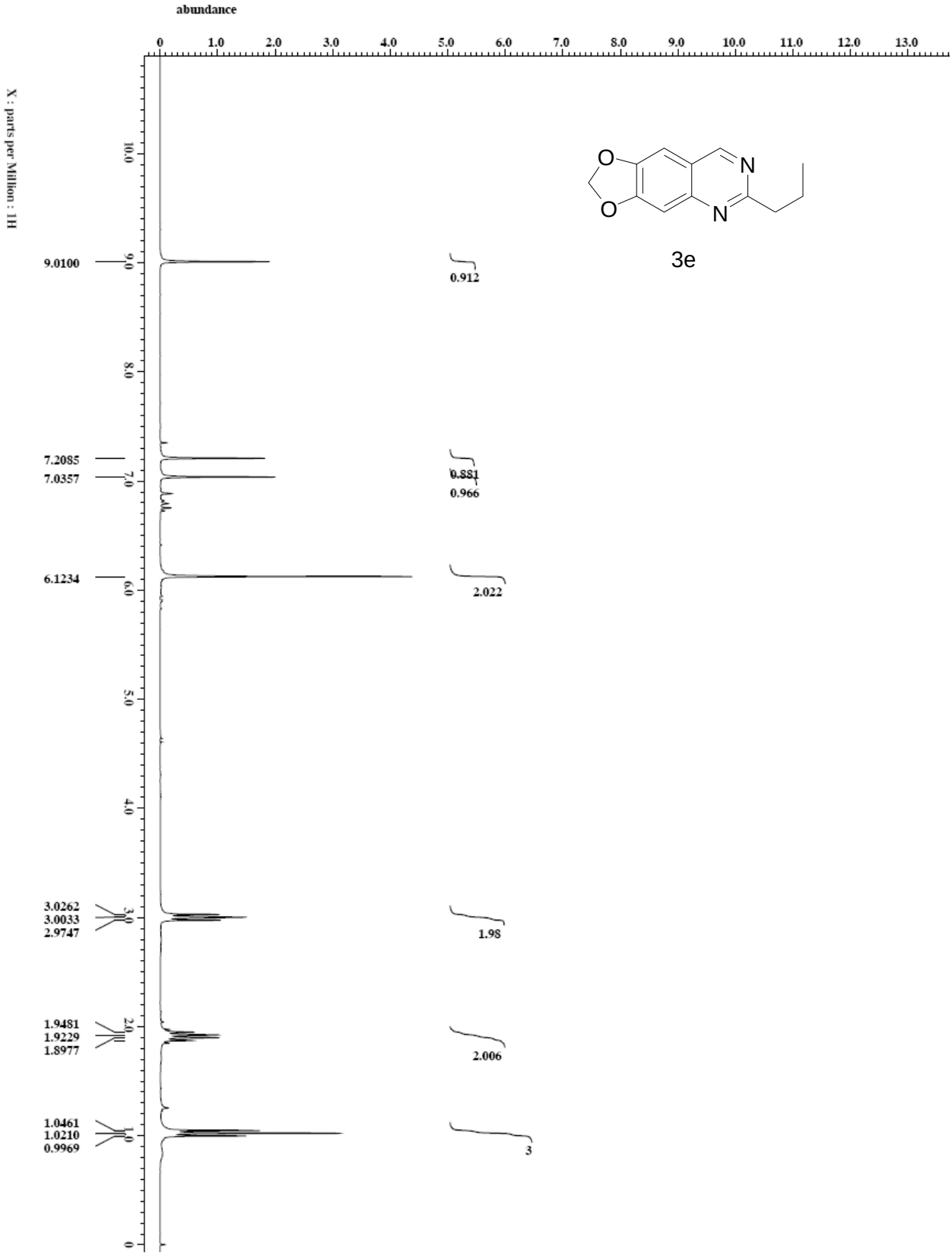

(thousandths)
X : parts per Million : 13C
163.7399
153.6917
151.7509
149.5615
131.7883
129.1973
128.1170
127.4095
126.9315
126.4821
77.5412
77.3213
77.1110
76.6903
72.4071
N
N
3c


abundance
X : parts per Million : 1H
8.9956
7.3148
7.1864
7.0423
6.1338
2.8086
0.0078
0.875
1.952
2.01
3
O
O
N
N

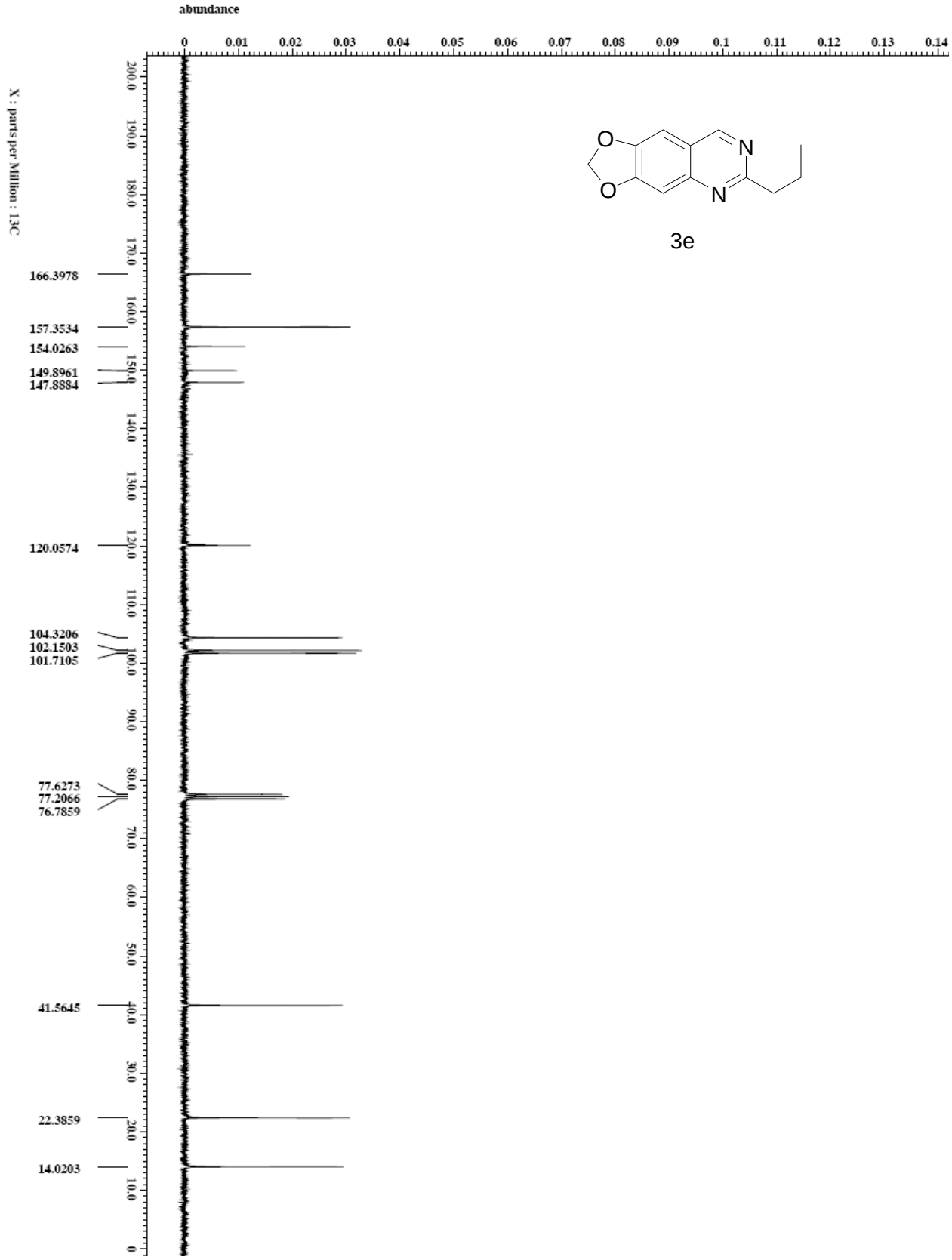
3d


abundance
0
0.1
0.2
0.3
0.4
0.5
X : parts per Million : 13C
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
163.1663
157.3630
154.1506
149.9535
147.9457
119.9140
104.2058
102.1981
101.7679
77.5890
77.1683
76.7477
26.0763
O
O
N
N

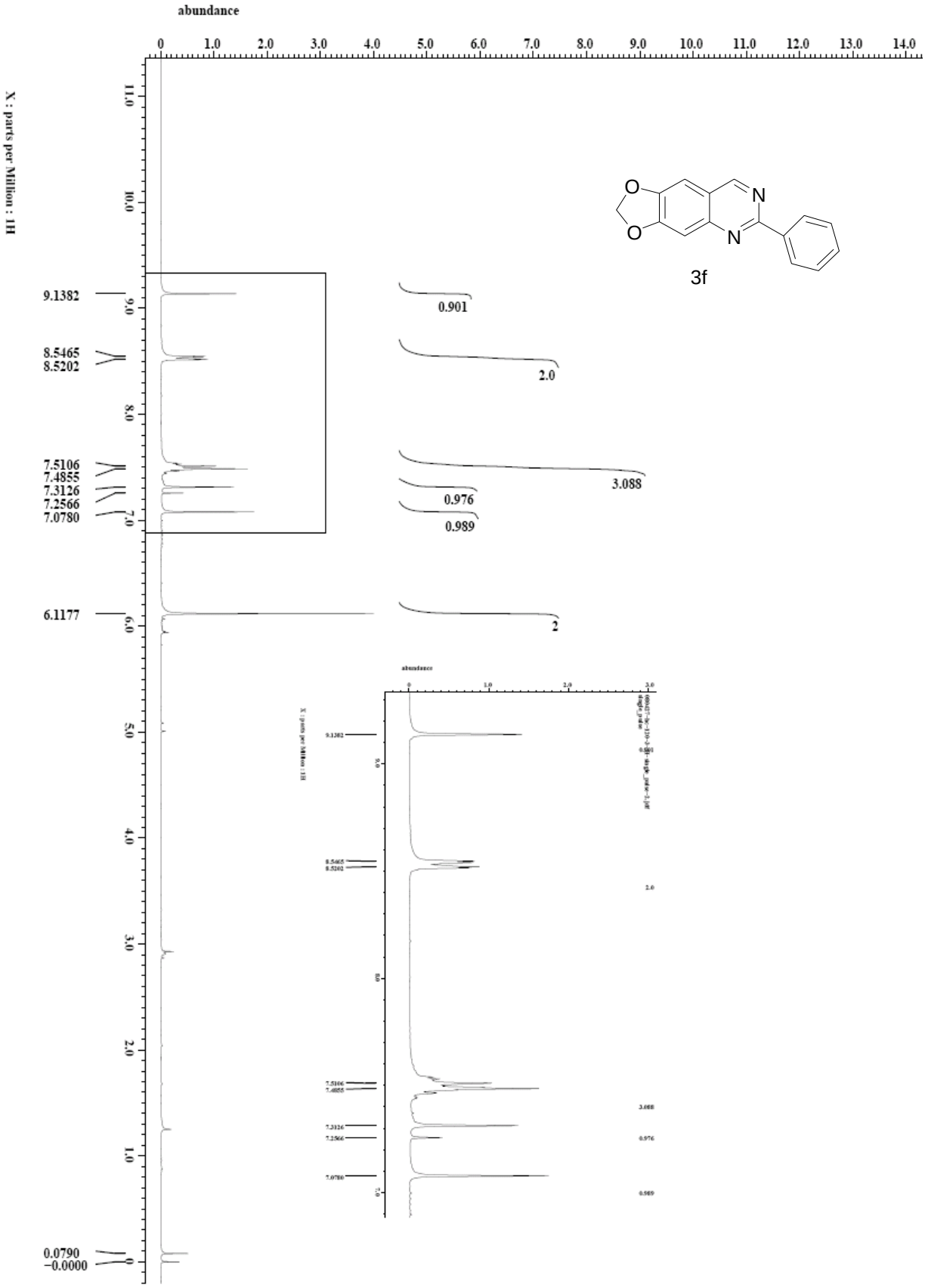
3d


abundance
0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0
X : parts per Million : 1H
9.0100
7.2085
7.0357
6.1234
3.0262
3.0033
2.9747
1.9481
1.9229
1.8977
1.0461
1.0210
0.9969
0.912
0.881
0.966
2.022
1.98
2.006
3
O
O
N
N

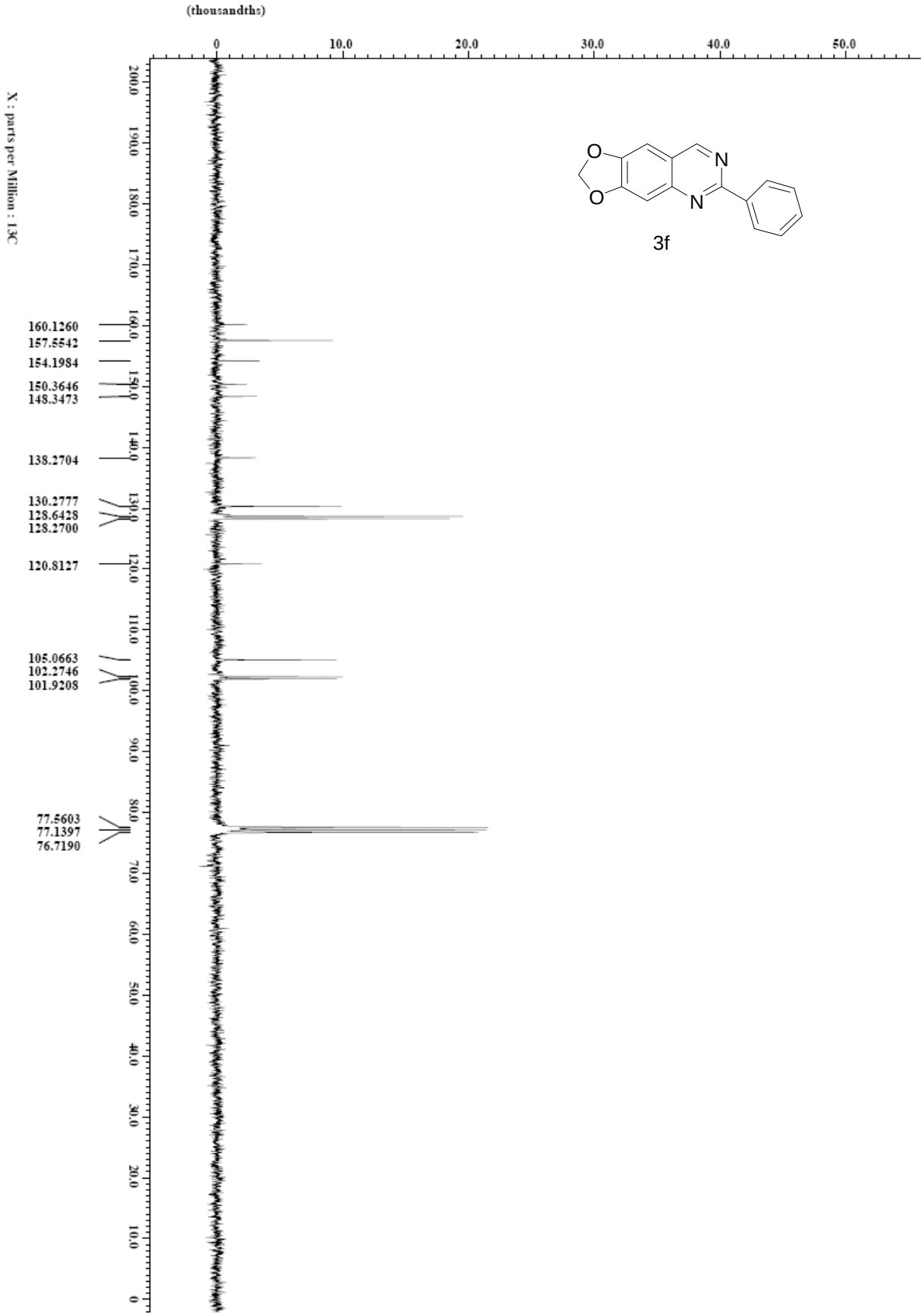
3e


abundance
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
0.13
0.14
X : parts per Million : 13C
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
166.3978
157.3534
154.0263
149.8961
147.8884
120.0574
104.3206
102.1503
101.7105
77.6273
77.2066
76.7859
41.5645
22.3859
14.0203
O
O
N
N

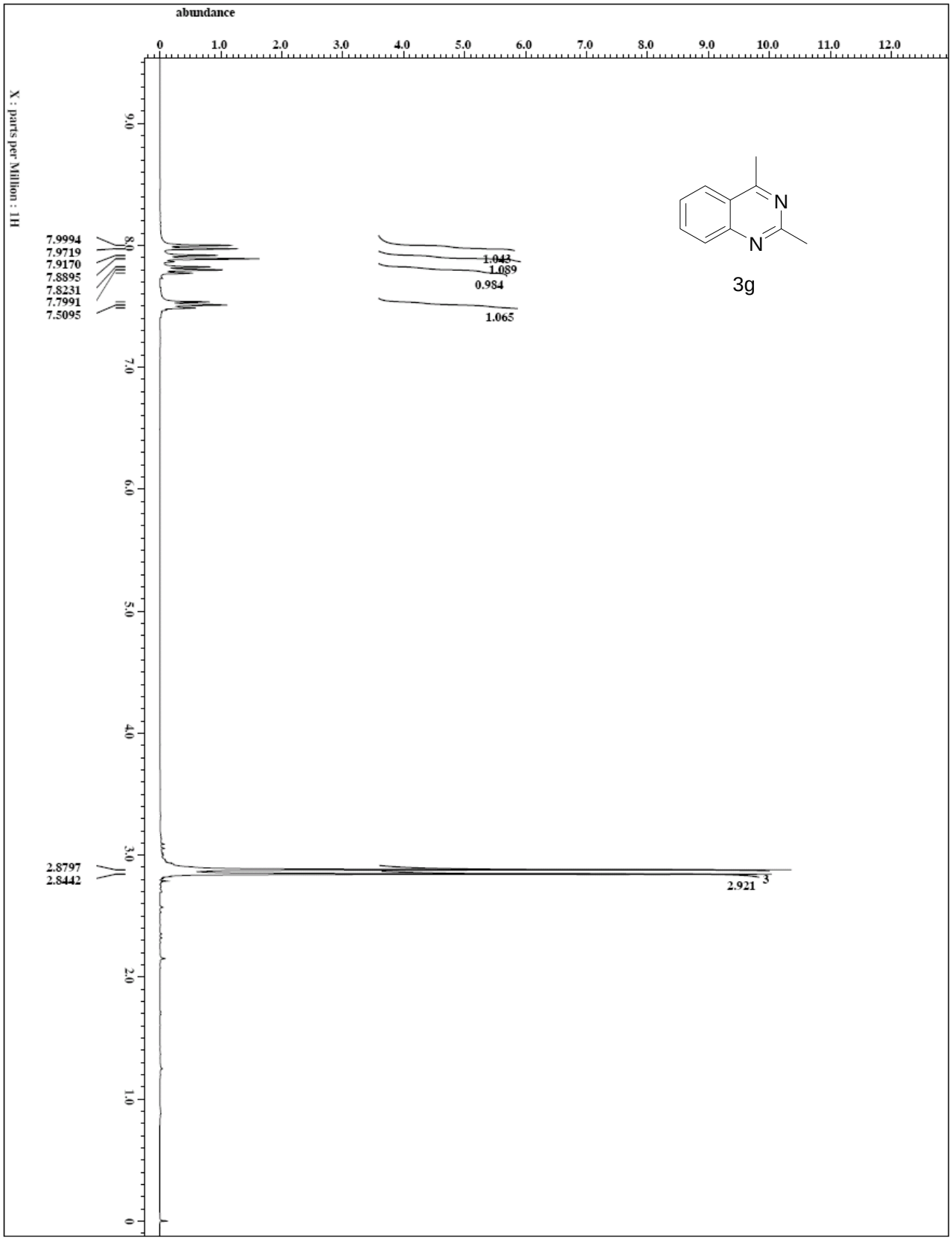
3e

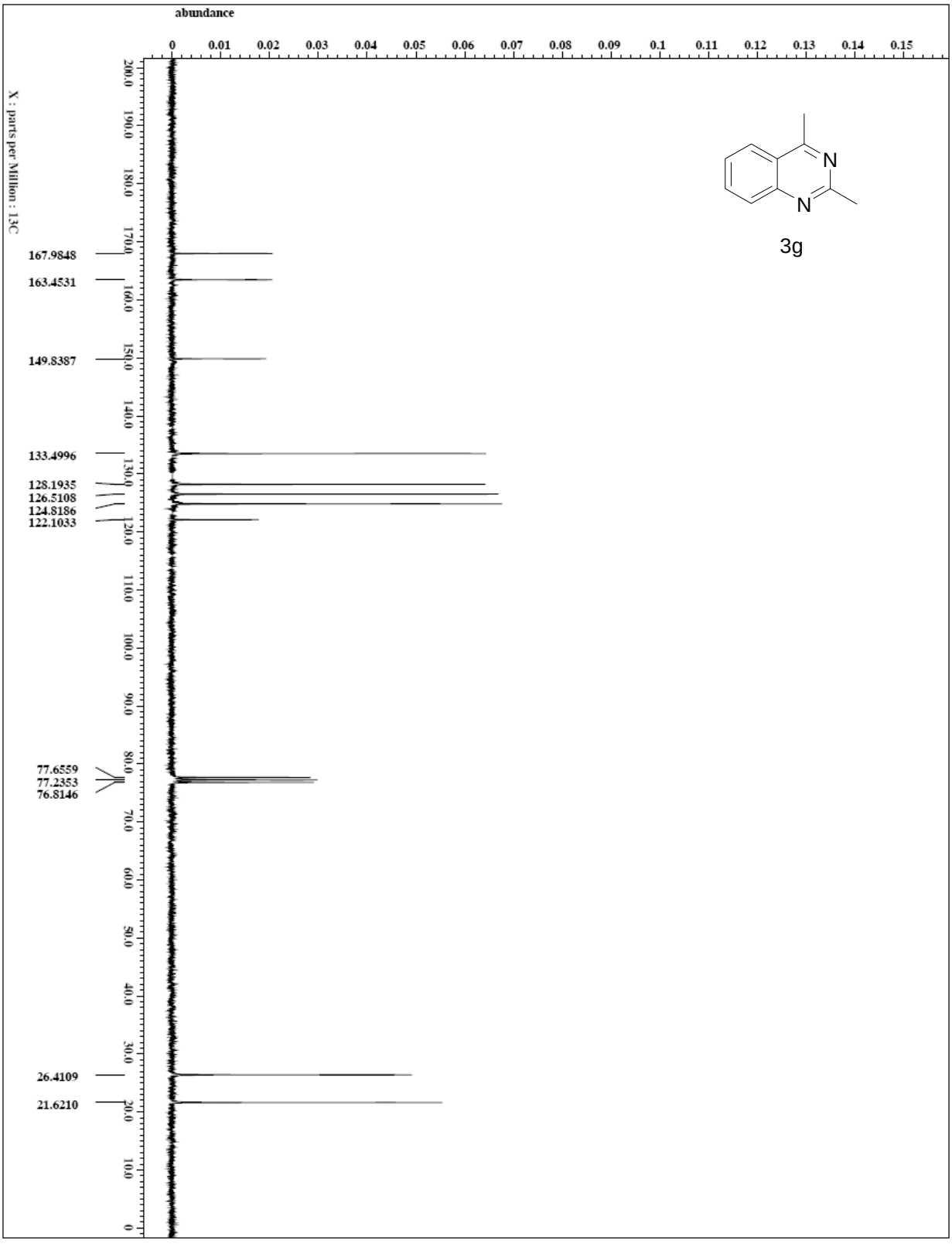

abundance
X : parts per Million : 1H
9.1382
8.5465
8.5202
7.5106
7.4855
7.3126
7.2566
7.0780
6.1177
0.0790
−0.0000
0.901
2.0
3.088
0.976
0.989
2
O
O
N
N

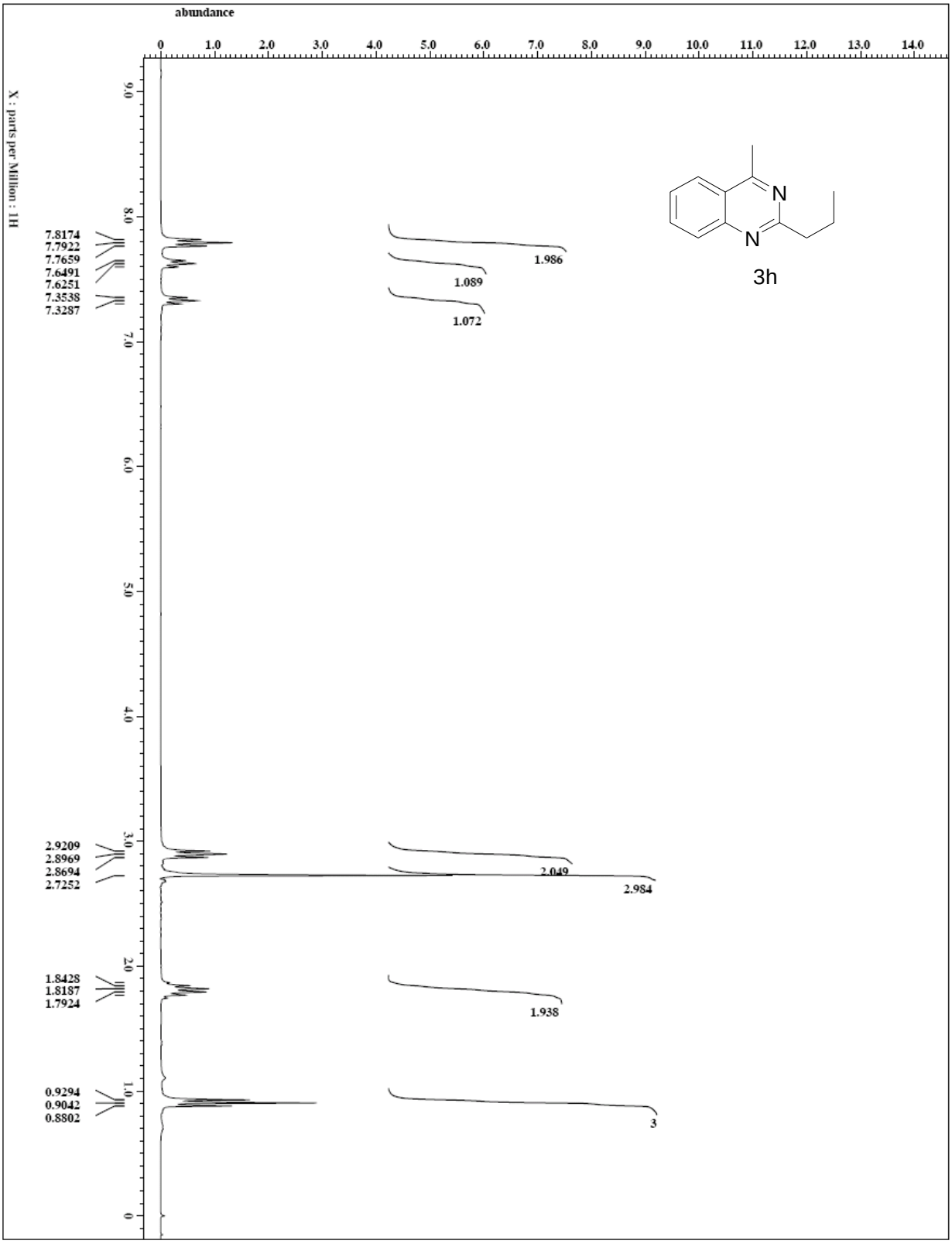
3f

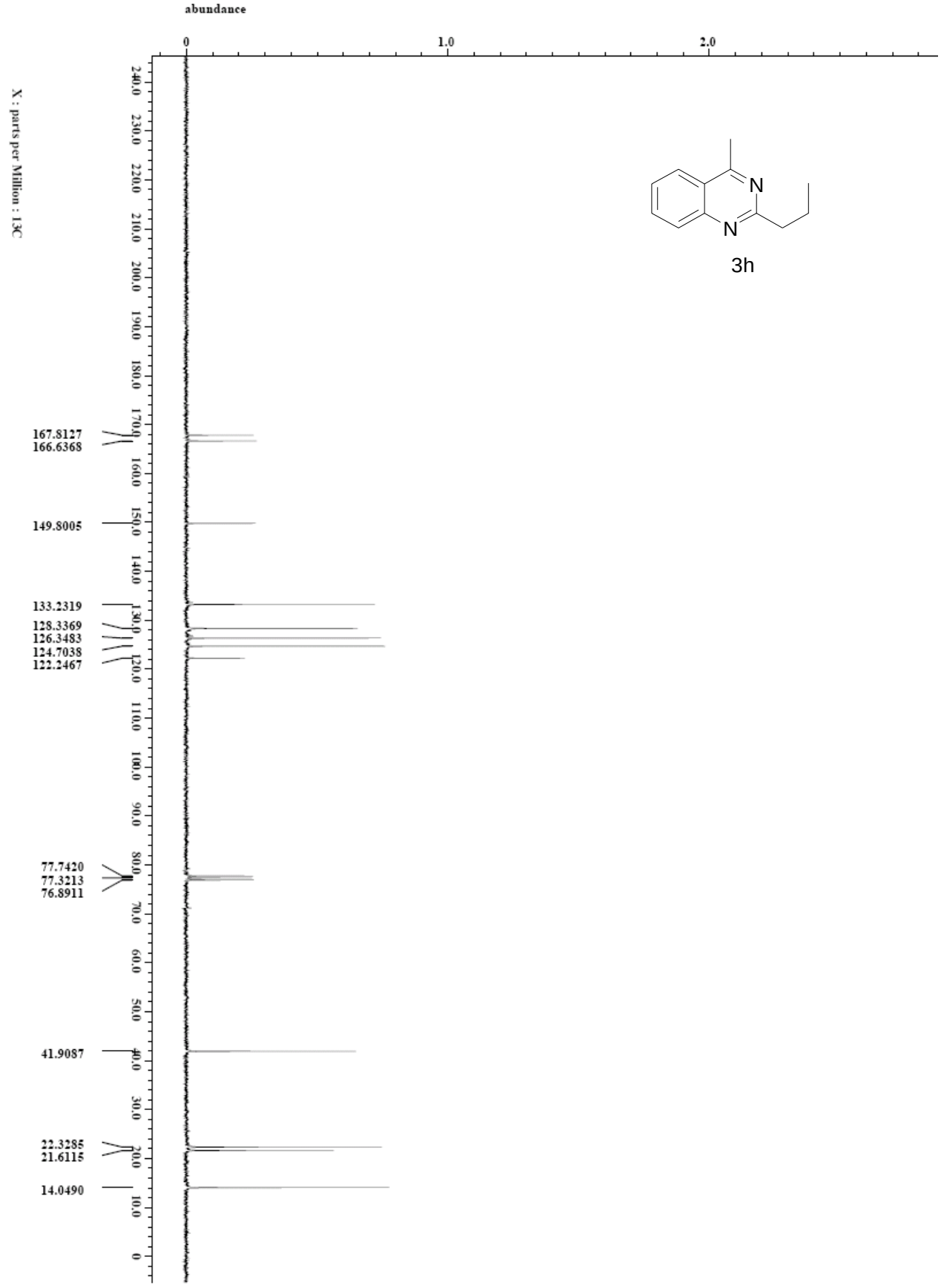

(thousandths)
0
10.0
20.0
30.0
40.0
50.0
X : parts per Million : 13C
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
160.1260
157.5542
154.1984
150.3646
148.3473
138.2704
130.2777
128.6428
128.2700
120.8127
105.0663
102.2746
101.9208
77.5603
77.1397
76.7190
O
O
N
N

3f

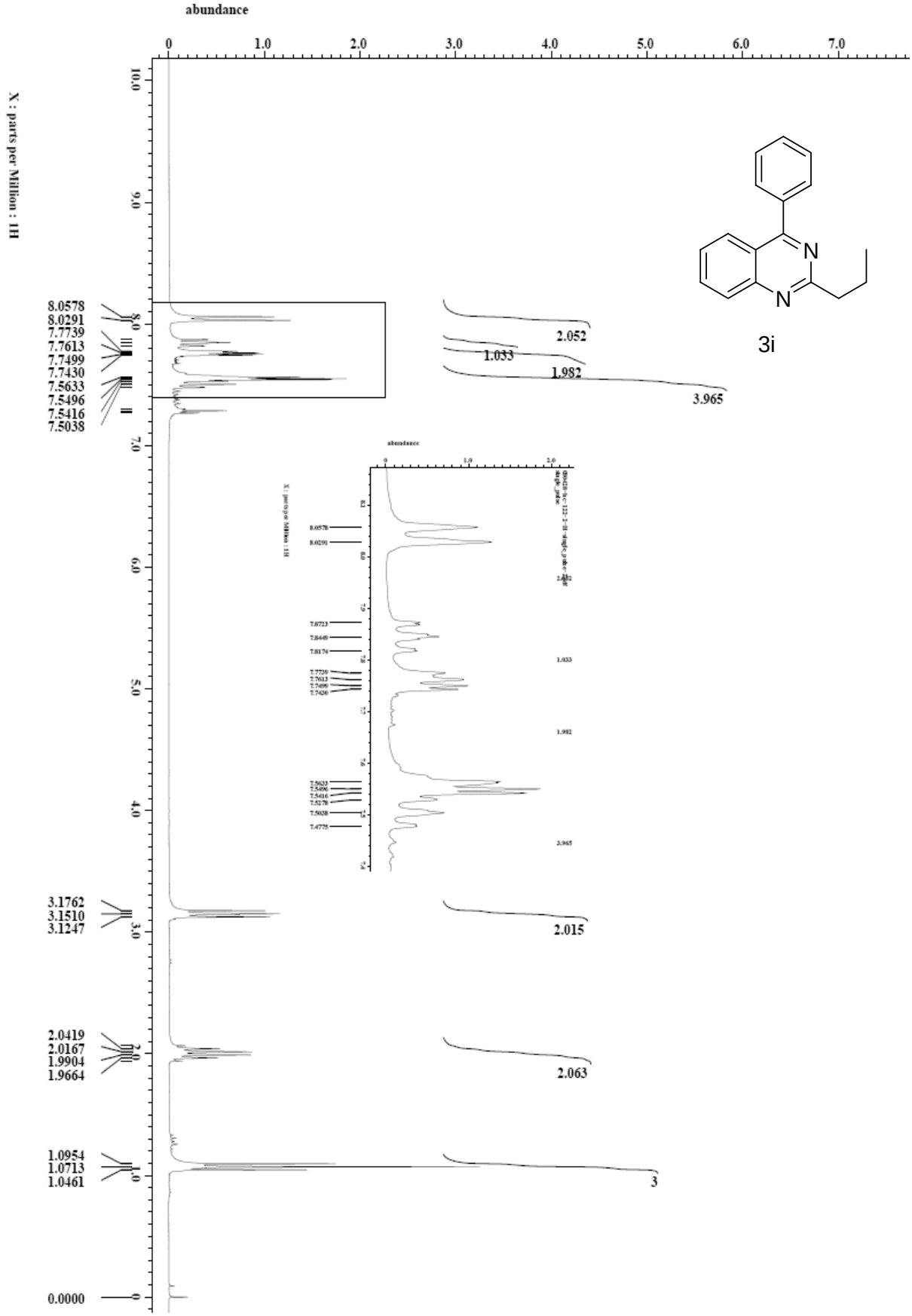

abundance
X : parts per Million : 1H
7.9994
7.9719
7.9170
7.8895
7.8231
7.7991
7.5095
1.043
1.089
0.984
1.065
2.8797
2.8442
2.921
3
N
N
3g

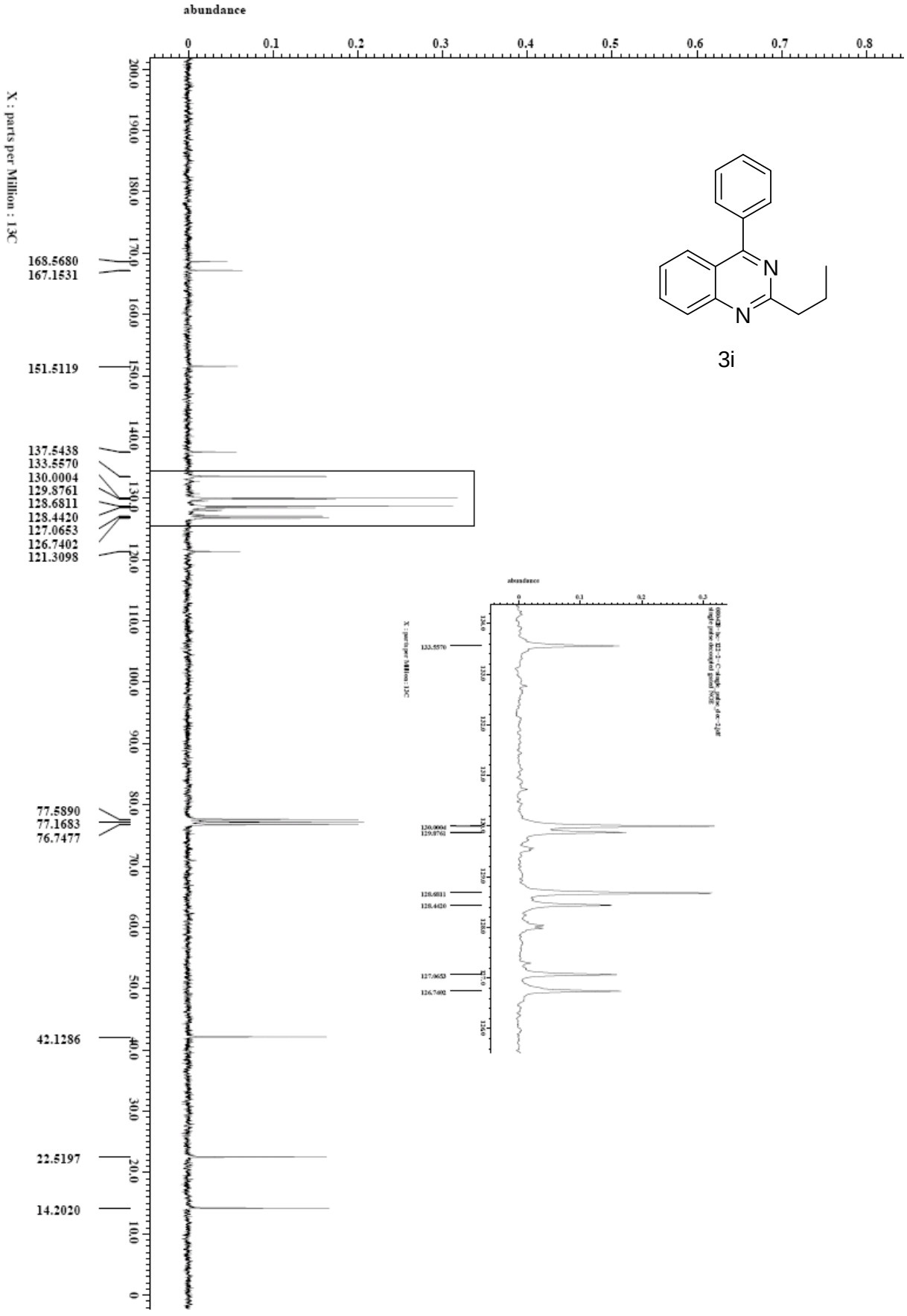

abundance
X : parts per Million : 13C
167.9848
163.4531
149.8387
133.4996
128.1935
126.5108
124.8186
122.1033
77.6559
77.2353
76.8146
26.4109
21.6210
N
N
3g


abundance
X : parts per Million : 1H
7.8174
7.7922
7.7659
7.6491
7.6251
7.3538
7.3287
2.9209
2.8969
2.8694
2.7252
1.8428
1.8187
1.7924
0.9294
0.9042
0.8802
1.986
1.089
1.072
2.049
2.984
1.938
3
N
N
3h

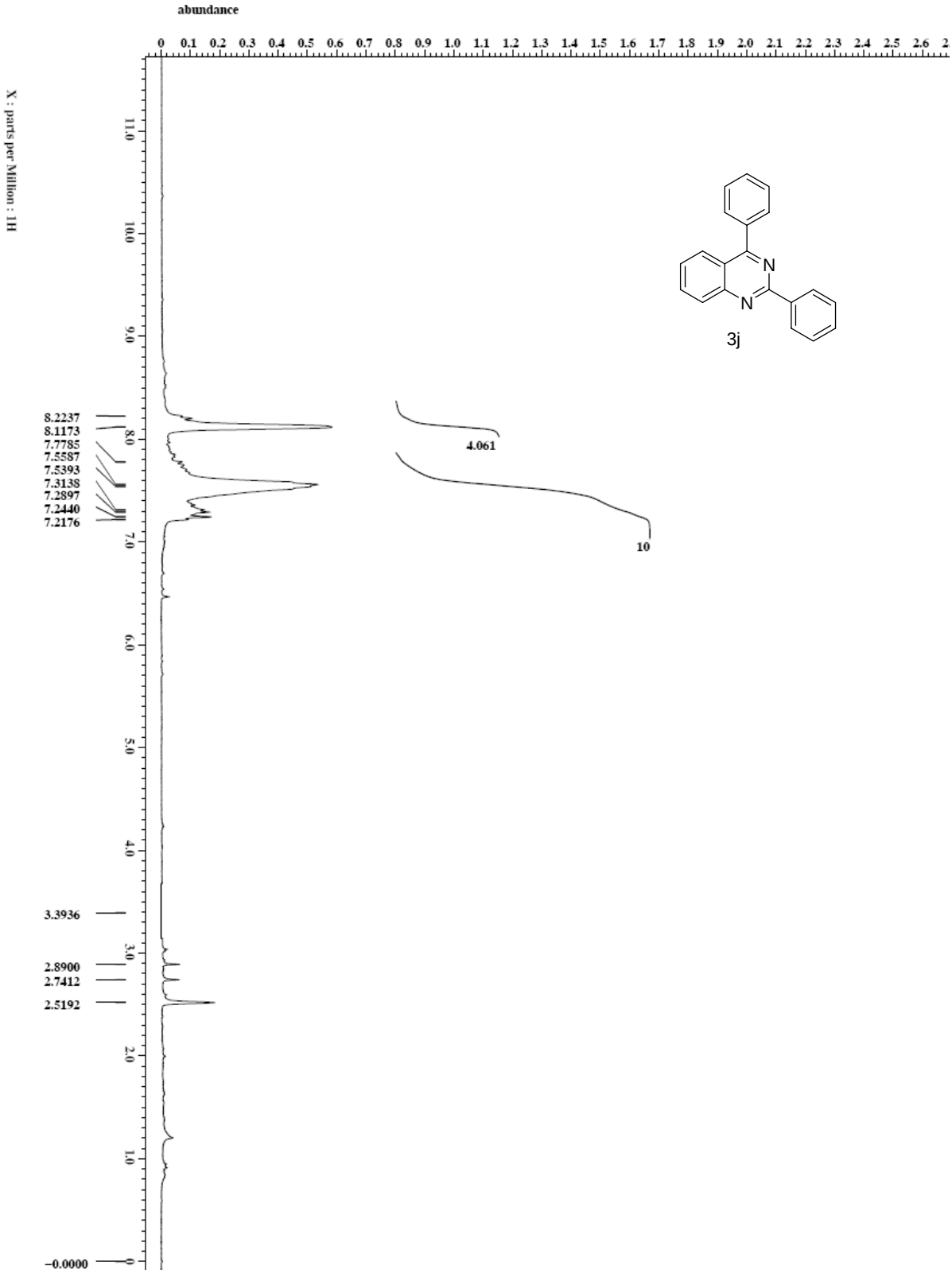

abundance
0
1.0
2.0
X : parts per Million : 13C
240.0
230.0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
167.8127
166.6368
149.8005
133.2319
128.3369
126.3483
124.7038
122.2467
77.7420
77.3213
76.8911
41.9087
22.3285
21.6115
14.0490
N
N

3h

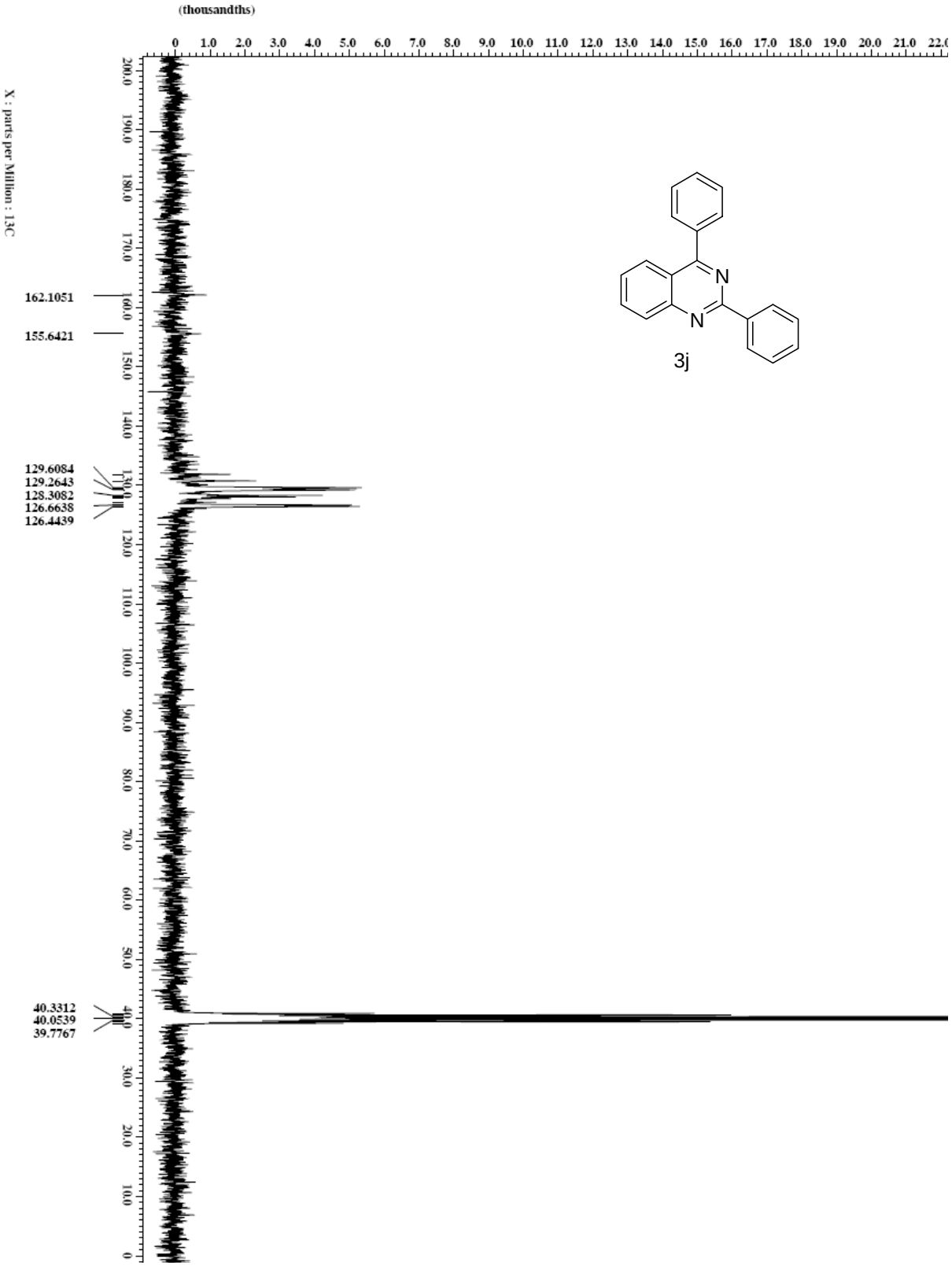

abundance
X : parts per Million : 1H
8.0578
8.0291
7.7739
7.7613
7.7499
7.7430
7.5633
7.5496
7.5416
7.5038
3.1762
3.1510
3.1247
2.0419
2.0167
1.9904
1.9664
1.0954
1.0713
1.0461
0.0000
2.052
1.033
1.982
3.965
2.015
2.063
3
N
N
3i

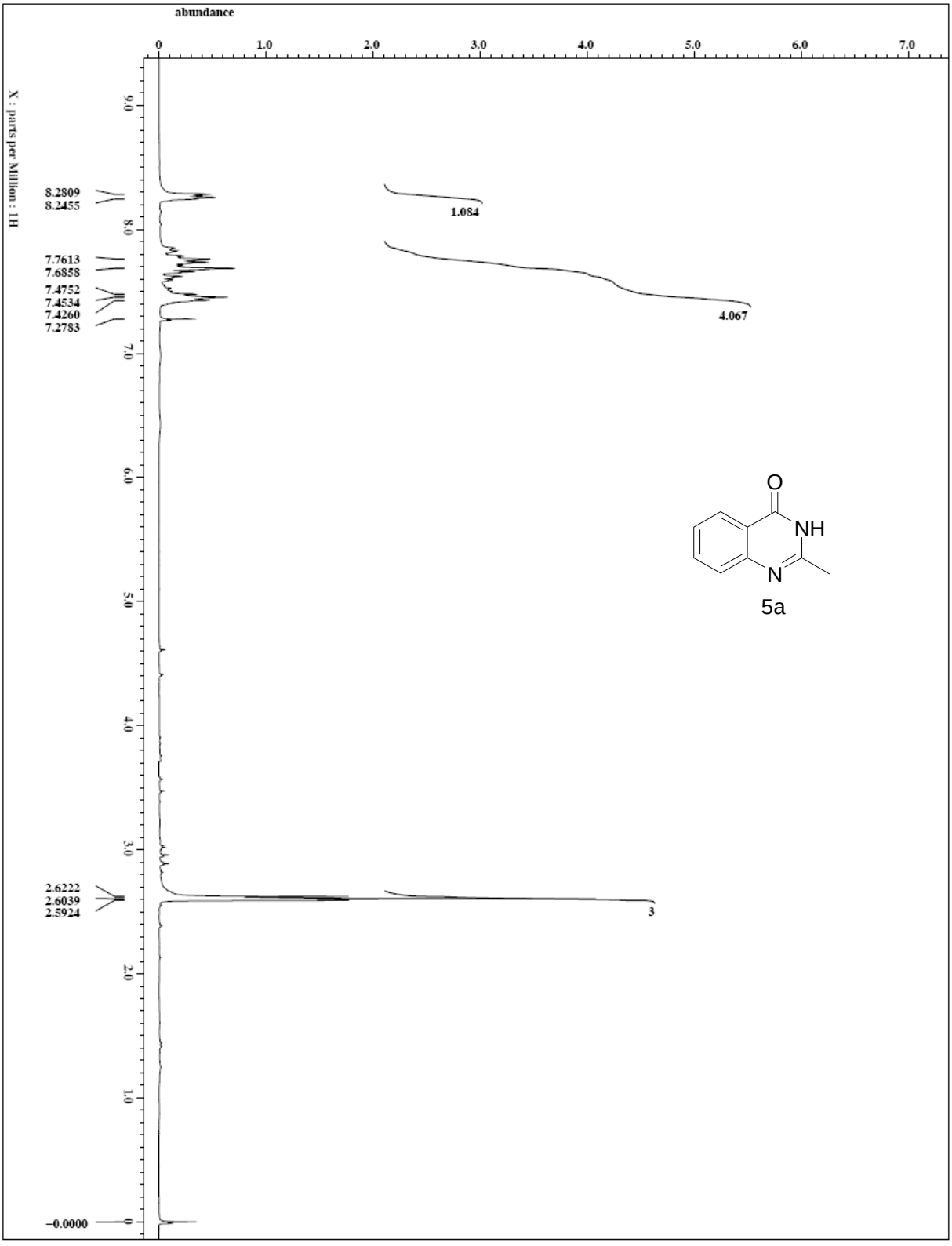

abundance
X : parts per Million : 13C
168.5680
167.1531
151.5119
137.5438
133.5570
130.0004
129.8761
128.6811
128.4420
127.0653
126.7402
121.3098
77.5890
77.1683
76.7477
42.1286
22.5197
14.2020

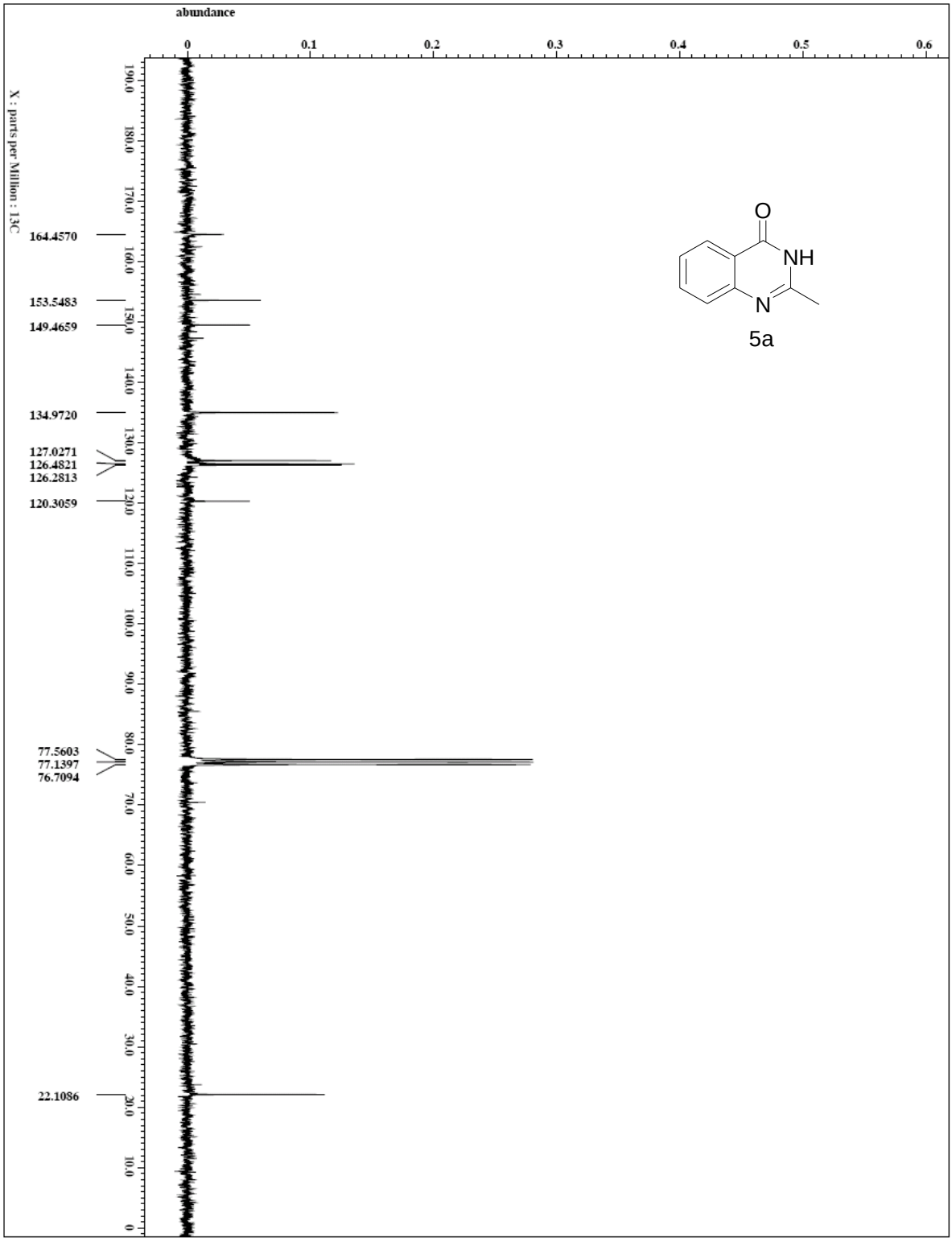
3i


abundance
X : parts per Million : 1H
8.2237
8.1173
7.7785
7.5587
7.5393
7.3138
7.2897
7.2440
7.2176
3.3936
2.8900
2.7412
2.5192
−0.0000
4.061
10
N
N

3j

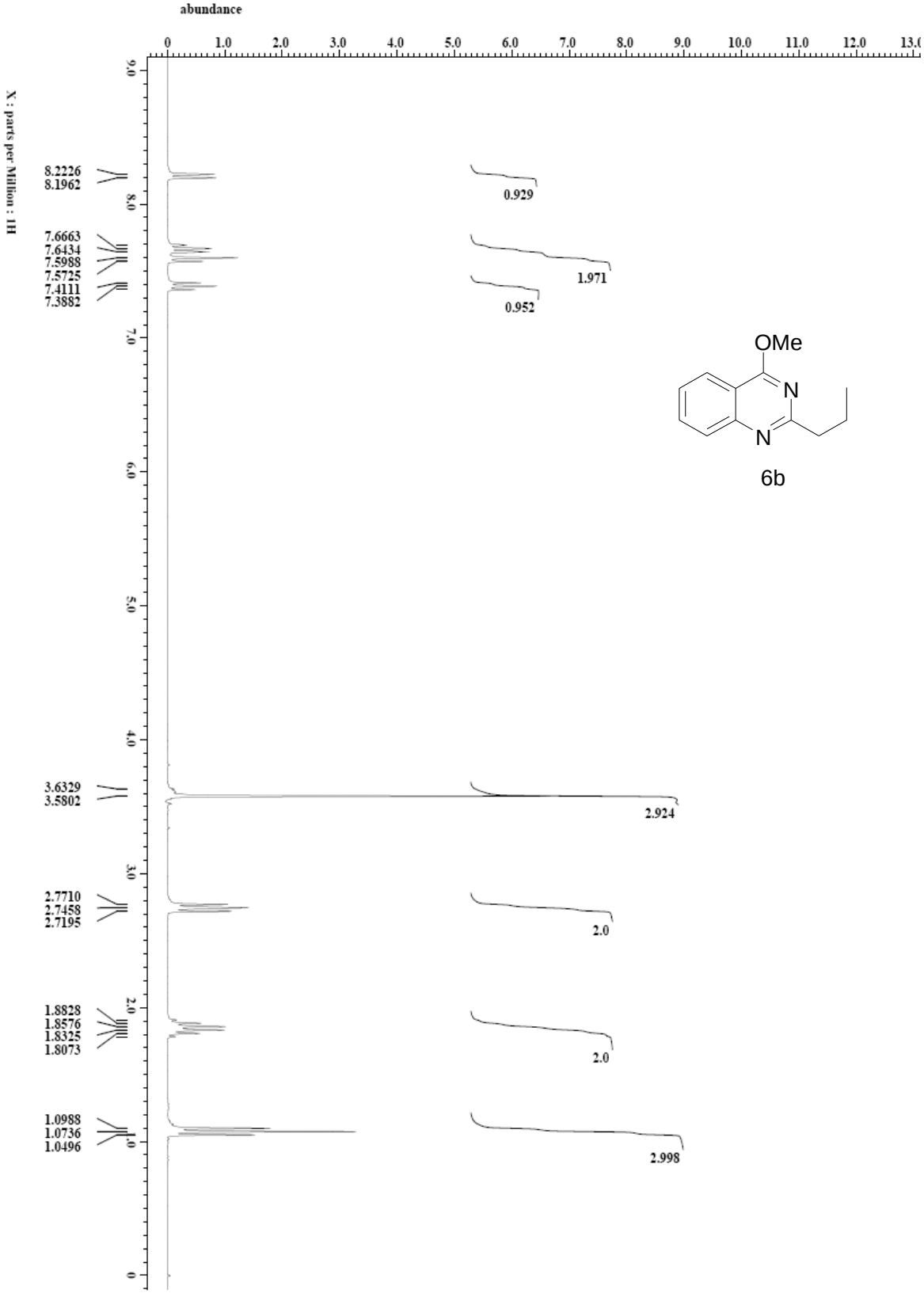

(thousandths)
X : parts per Million : 13C
162.1051
155.6421
129.6084
129.2643
128.3082
126.6638
126.4439
40.3312
40.0539
39.7767
N
N
3j

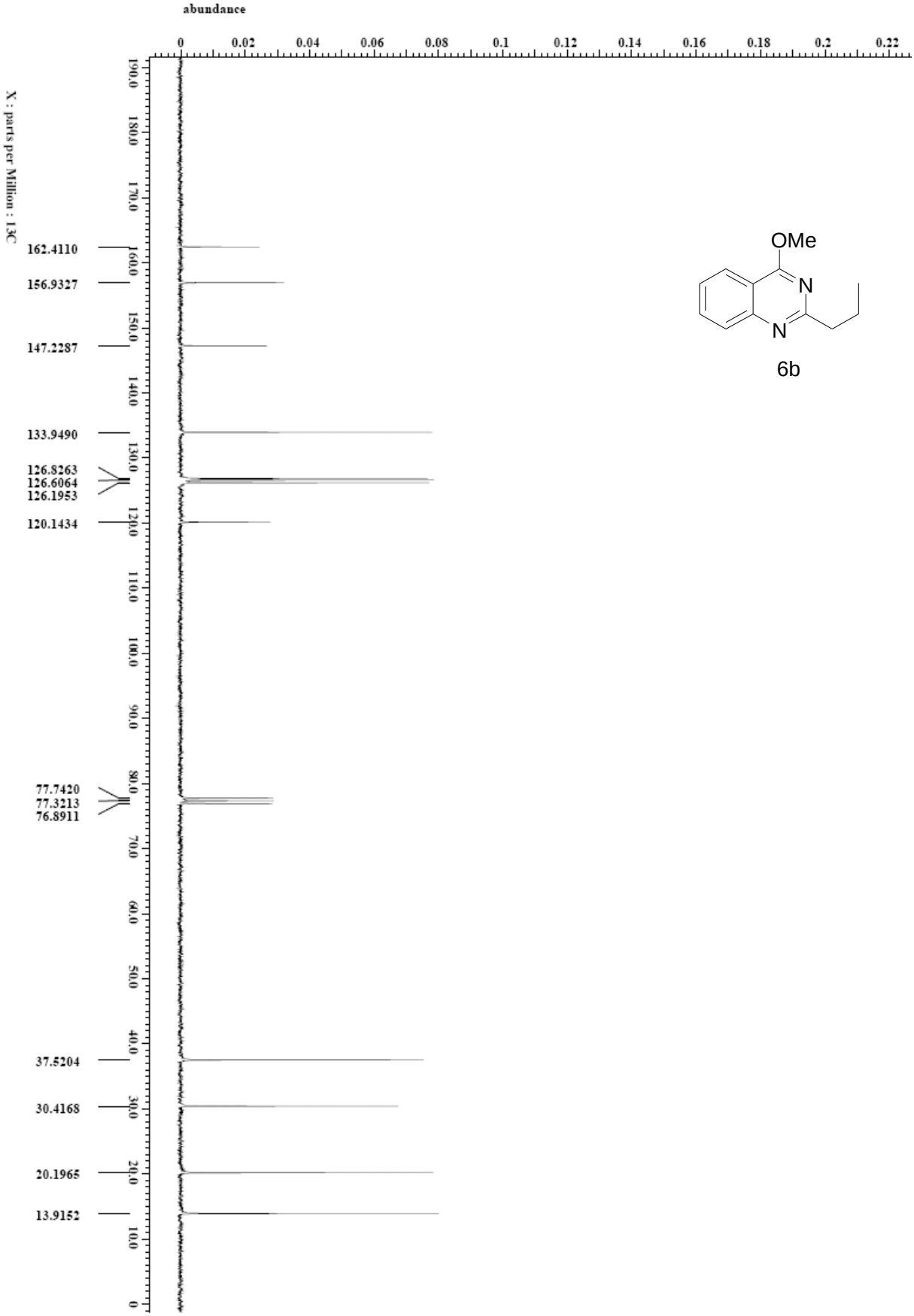

abundance
X : parts per Million : 1H
8.2809
8.2455
7.7613
7.6858
7.4752
7.4534
7.4260
7.2783
2.6222
2.6039
2.5924
−0.0000
1.084
4.067
3
O
NH
N
5a


abundance
0
0.1
0.2
0.3
0.4
0.5
0.6
X : parts per Million : 13C
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
164.4570
153.5483
149.4659
134.9720
127.0271
126.4821
126.2813
120.3059
77.5603
77.1397
76.7094
22.1086
O
NH
N
5a

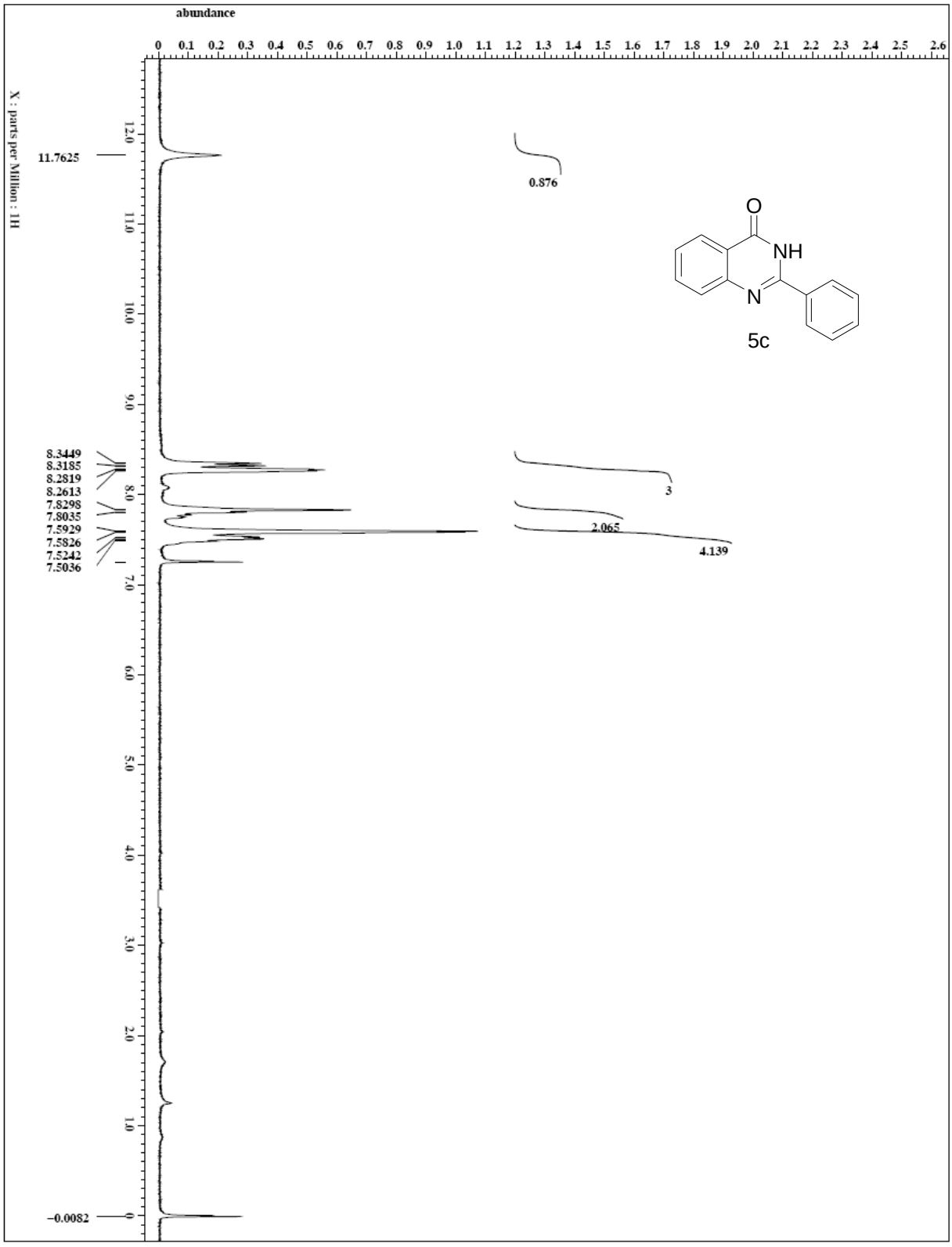

abundance
X : parts per Million : 1H
12.0832
8.3141
8.2878
7.7796
7.7567
7.7304
7.7041
7.5026
7.4797
7.4546
7.2703
2.8271
2.8030
2.7767
1.9812
1.9561
1.9309
1.1148
1.0908
1.0667
0.0000
0.82
0.947
2.007
1.11
2
2.064
2.922
O
NH
N
5b

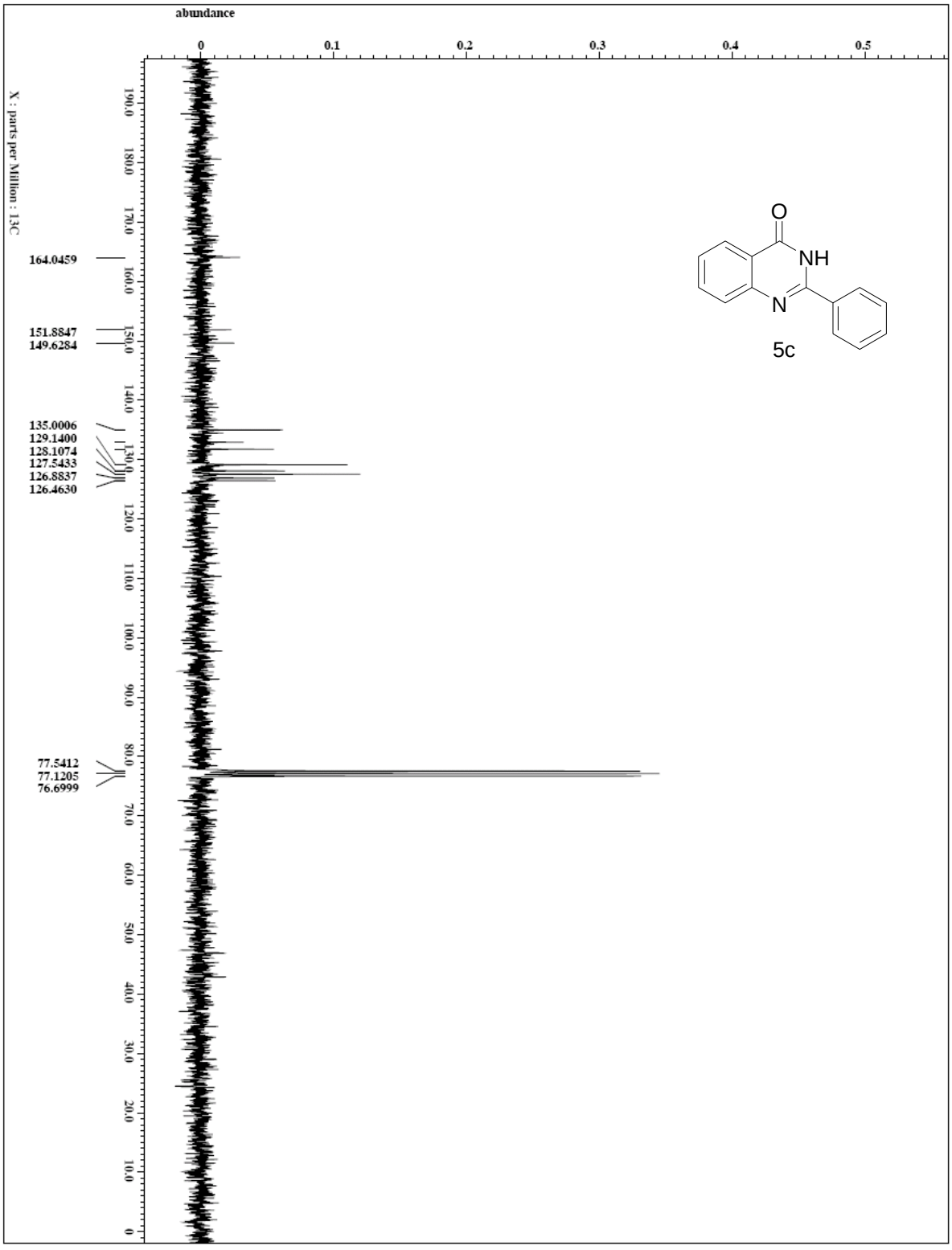

(thousandths)
X : parts per Million : 13C
164.4952
156.9614
149.5041
134.9050
127.2565
126.4534
126.3196
120.5641
77.5508
77.1301
76.6999
37.8072
21.1334
13.8482
O
NH
N
5b

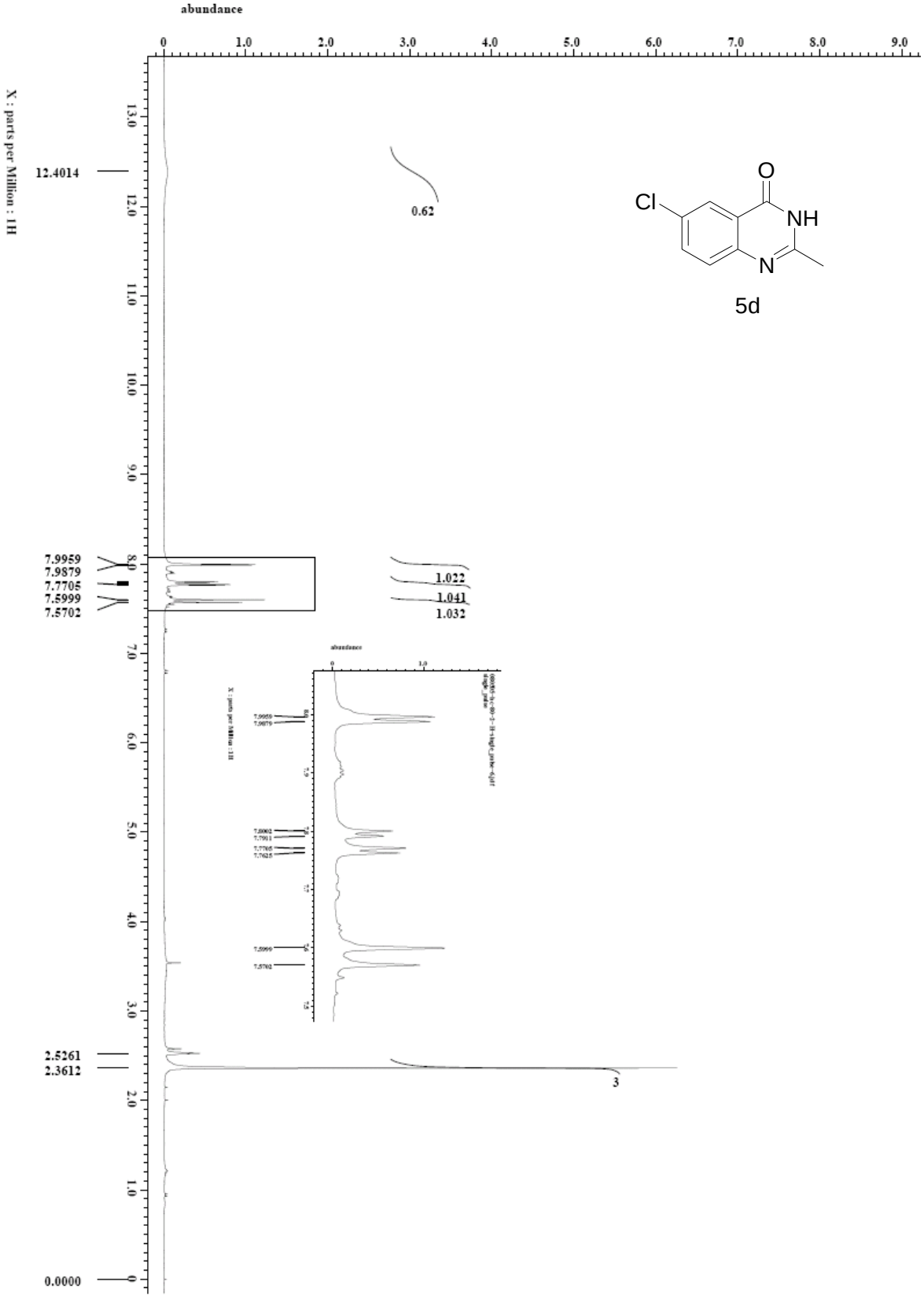


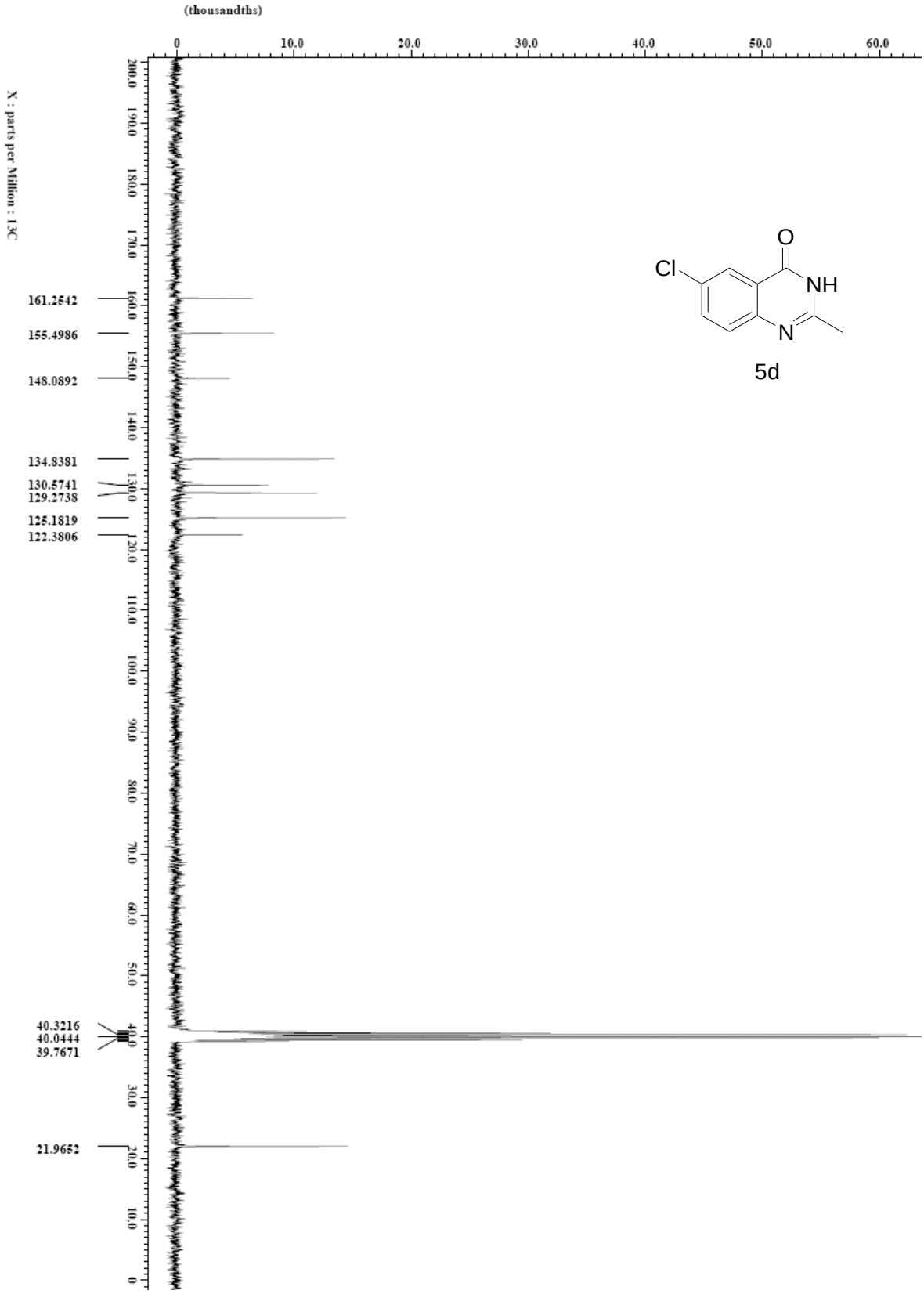

abundance
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
X : parts per Million : 13C
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
162.4110
156.9327
147.2287
133.9490
126.8263
126.6064
126.1953
120.1434
77.7420
77.3213
76.8911
37.5204
30.4168
20.1965
13.9152
OMe
N
N

6b

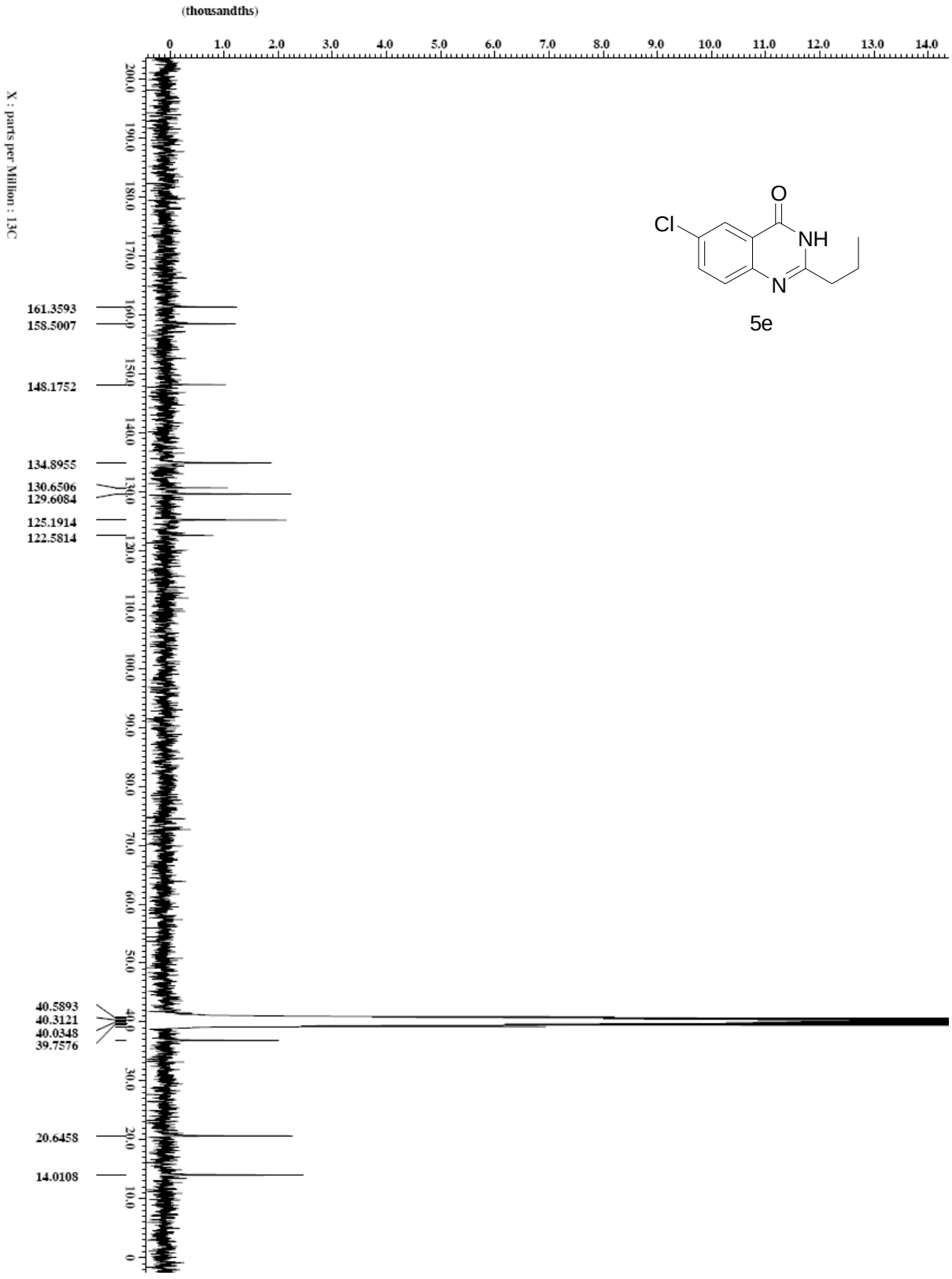

abundance
X : parts per Million : 1H
11.7625
8.3449
8.3185
8.2819
8.2613
7.8298
7.8035
7.5929
7.5826
7.5242
7.5036
−0.0082
0.876
3
2.065
4.139
O
NH
N
5c


abundance
0
0.1
0.2
0.3
0.4
0.5
X : parts per Million : 13C
190.0
180.0
170.0
164.0459
160.0
151.8847
149.6284
150.0
140.0
135.0006
129.1400
128.1074
127.5433
126.8837
126.4630
130.0
120.0
110.0
100.0
90.0
80.0
77.5412
77.1205
76.6999
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
O
NH
N
5c

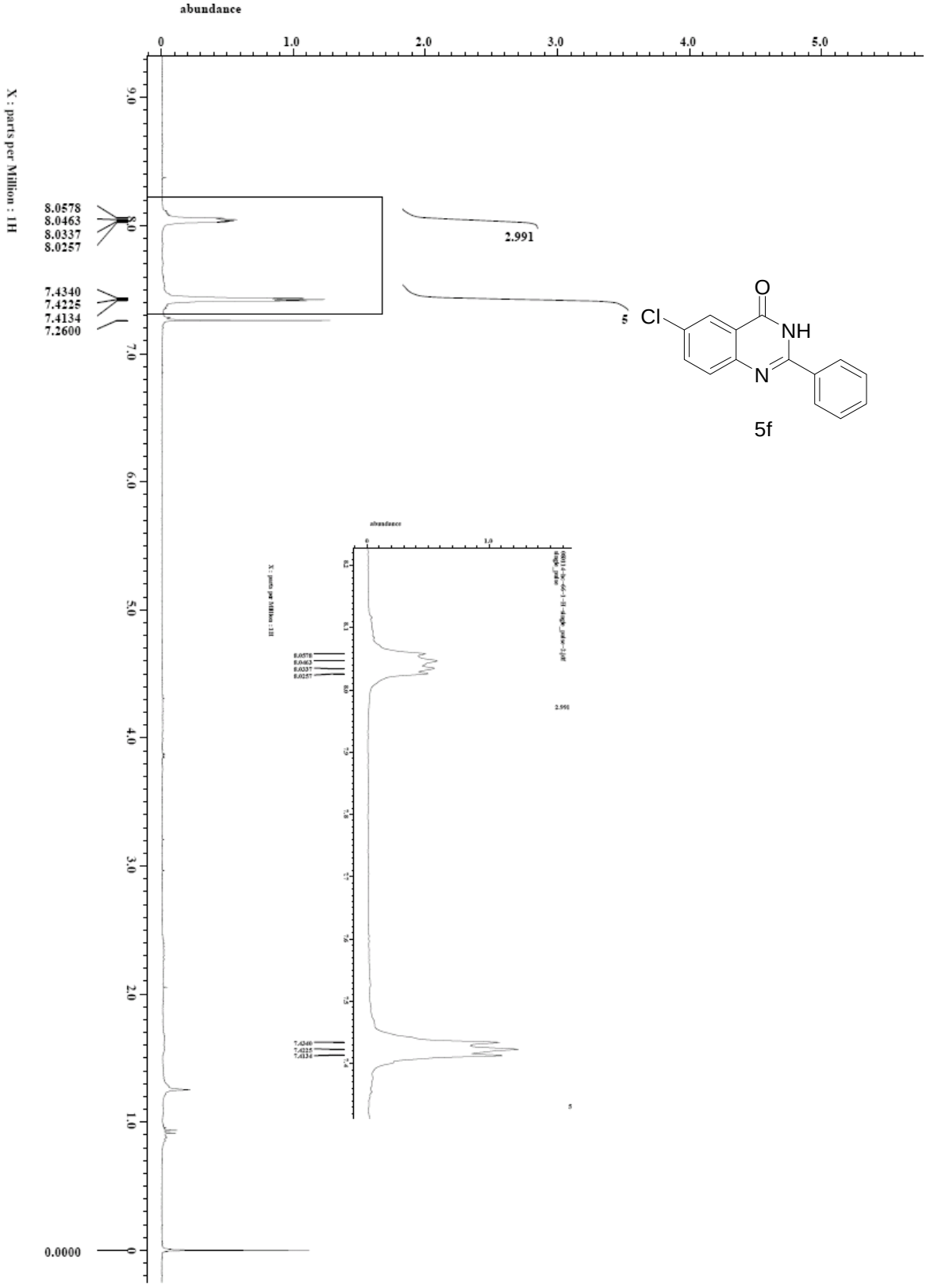

abundance
X : parts per Million : 1H
12.4014
7.9959
7.9879
7.7705
7.5999
7.5702
2.5261
2.3612
0.0000
0.62
1.022
1.041
1.032
3
Cl
O
NH
N
5d


(thousandths)
X : parts per Million : 13C
161.2542
155.4986
148.0892
134.8381
130.5741
129.2738
125.1819
122.3806
40.3216
40.0444
39.7671
21.9652
Cl
O
NH
N
5d

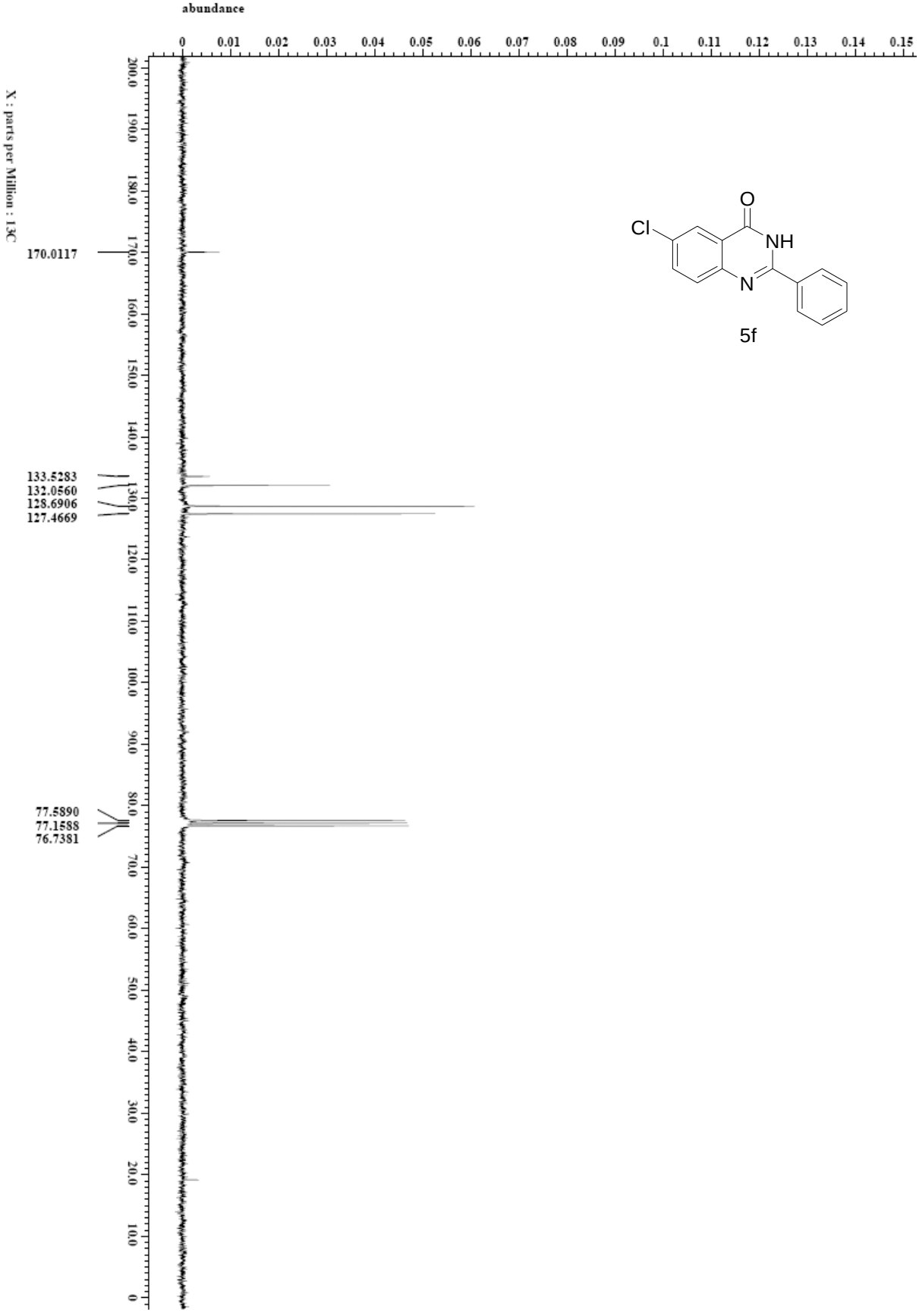

abundance
X : parts per Million : 1H
12.3177
7.9649
7.9569
7.7360
7.5883
7.5597
3.3500
3.3030
2.5316
2.5053
2.4664
1.7304
1.7052
1.6801
0.9098
0.8857
0.8605
0.802
0.978
0.946
0.98
3.082
2.034
3
Cl
O
NH
N
5e

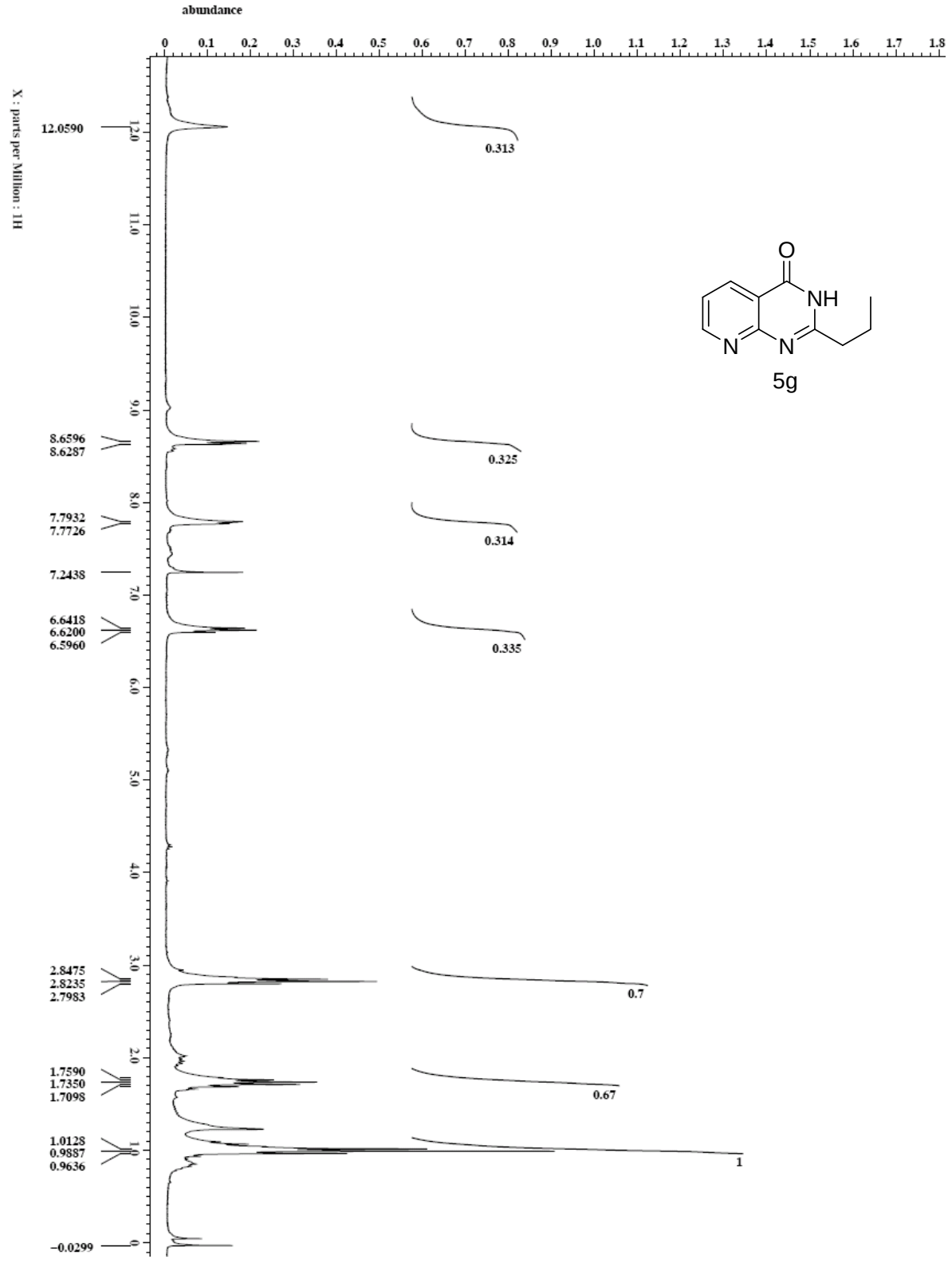

(thousandths)
X : parts per Million : 13C
161.3593
158.5007
148.1752
134.8955
130.6506
129.6084
125.1914
122.5814
40.5893
40.3121
40.0348
39.7576
20.6458
14.0108
Cl
O
NH
N

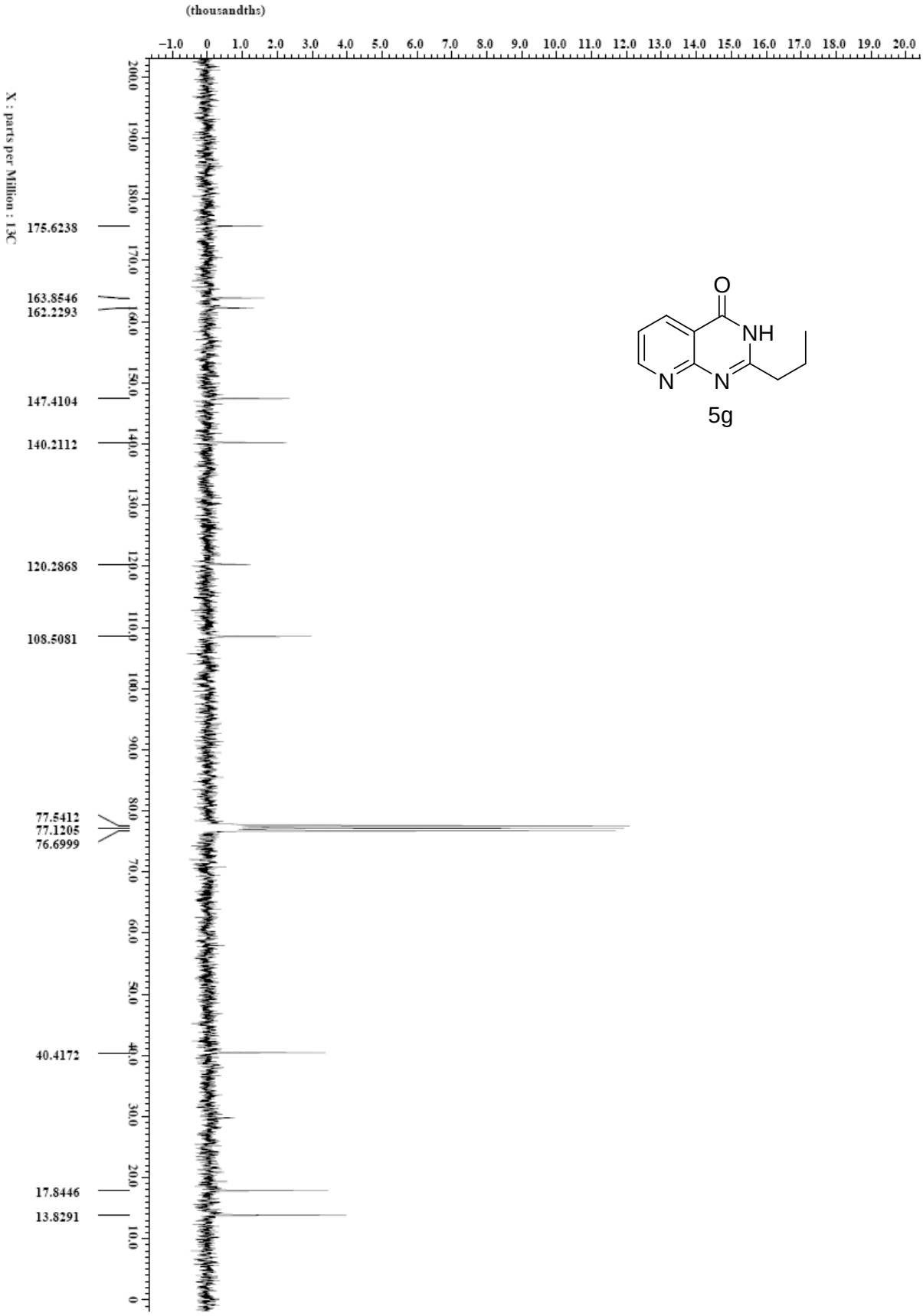
5e


abundance
X : parts per Million : 1H
8.0578
8.0463
8.0337
8.0257
7.4340
7.4225
7.4134
7.2600
0.0000
2.991
5
Cl
NH
N
O

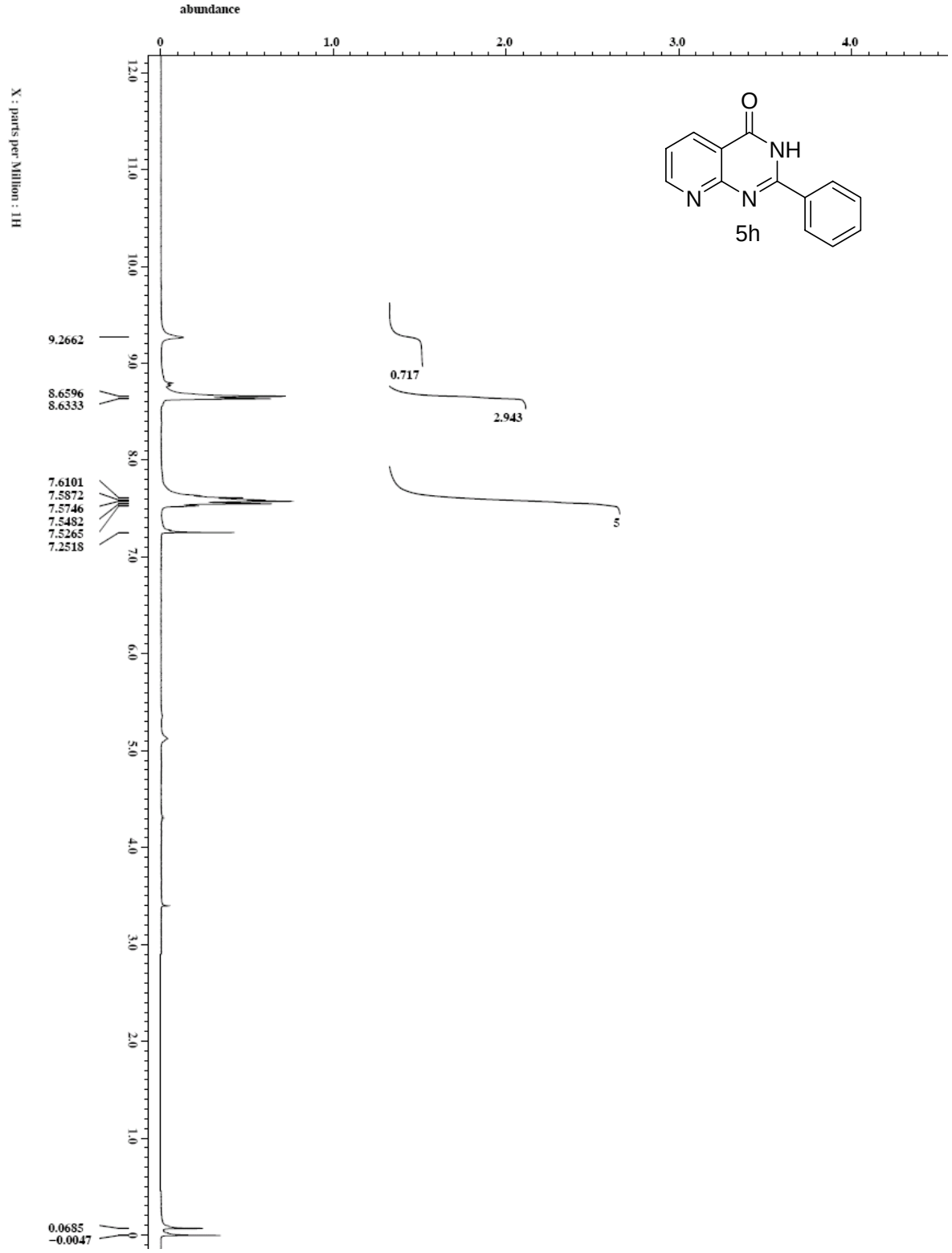
5f


abundance
X : parts per Million : 13C
170.0117
133.5283
132.0560
128.6906
127.4669
77.5890
77.1588
76.7381
Cl
O
NH
N
5f


abundance
X : parts per Million : 1H
12.0590
8.6596
8.6287
7.7932
7.7726
7.2438
6.6418
6.6200
6.5960
2.8475
2.8235
2.7983
1.7590
1.7350
1.7098
1.0128
0.9887
0.9636
−0.0299
0.313
0.325
0.314
0.335
0.7
0.67
1
O
NH
N
N
5g


(thousandths)
X : parts per Million : 13C
175.6238
163.8546
162.2293
147.4104
140.2112
120.2868
108.5081
77.5412
77.1205
76.6999
40.4172
17.8446
13.8291
O
NH
N
N

5g


abundance
X : parts per Million : 1H
9.2662
8.6596
8.6333
7.6101
7.5872
7.5746
7.5482
7.5265
7.2518
0.0685
−0.0047
0.717
2.943
5
O
NH
N
N
5h


(thousandths)
X : parts per Million : 13C
171.4075
166.5508
135.6699
132.8973
128.9870
128.8436
77.5221
77.1014
76.6807
O
NH
N
N
5h