Supporting Information

Carbene-catalyzed desymmetrization of 1,3-diols: access to optically enriched tertiary alkyl chlorides

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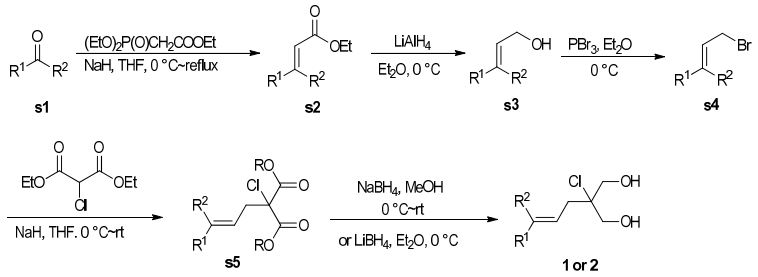
1. General Information

All reactions were carried out under standard conditions using N_2 as shielding gas with magnetic stirring. Analytical thin layer chromatography (TLC) was performed with TLC plates. All reactions and column chromatography were monitored by thin layer chromatography with UV light at 254 nm and colorized with ethanol solution of phosphomolybdic acid, followed by heating using a heat gun. All products could be purified by column chromatography using ethyl acetate and hexane as eluent. Organic solutions were concentrated by rotary evaporation. All solvents were freshly distilled before use. ^1H and ^{13}C NMR chemical shifts are reported in $CDCl_3$ solution of the compound by Bruker AV-300 MHz or Bruker AV-400 MHz instruments and marked in ppm relative to tetramethylsilane (TMS) (0) and $CDCl_3$ (77.0 ppm) as standard. The following abbreviations are used to describe peak patterns where appropriate: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. Coupling constants (*J*) are reported in Hertz (Hz). High resolution mass spectral analysis (HRMS) was performed on Waters Q-TOF Premier mass spectrometer. The determination of *ee* was performed *via* chiral phase HPLC analysis using Shimadzu LC-20AD HPLC workstation. Optical rotations were measured using a 1 mL cell with a 1 cm path length on a Jasco P1030 digital polarimeter and are reported as follows: $[\alpha]^D_{20}$. The dr values of the products were determined by the corresponding ^1H NMR spectra. The absolute configuration of products could be confirmed according to the optical rotations of known compounds.

2. General procedure for preparation of substrates 1 and 2

All substrates were prepared according to literature[1] (**1j**) or following general procedure (**1a-1i** and **2a-2p**) from different starting materials (the specific starting material, please see the related data part of substrate).



Under nitrogen atmosphere, to a suspension of sodium hydride (60% suspension in oil, 1.5 equiv) in THF (0.3mmol/mL) was added triethyl phosphonoacetate (1.8 equiv) dropwise at 0 °C, then the resulting mixture was stirred for 30 min at 0 °C. Ketone **s1** (1 equiv, 1 M in THF solution) was added dropwise to the resulting mixture and the reaction was allowed to reflux overnight. After cooling to room temperature, the reaction was quenched with saturated NH_4Cl, the organic phase was separated and the aqueous solution was extracted with Et_2O. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford the corresponding (*E*)-isomer **s2**.

To a stirred suspension of $LiAlH_4$ (1.2 equiv) in Et_2O (3 ml per mmol) was added (*E*)-isomer **s2** (1 equiv, 1 M in Et_2O solution) dropwise at 0 °C, then the resulting mixture was stirred for 30 min at 0 °C. The reaction was then cautiously quenched with ethyl acetate at

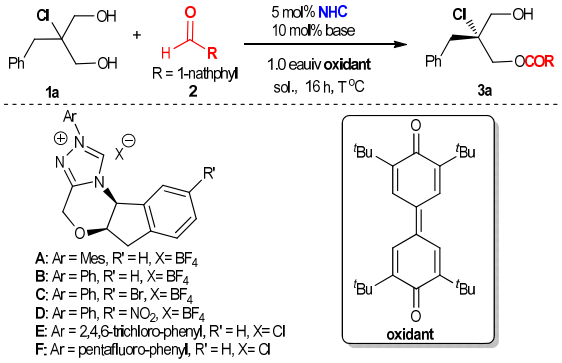
0 °C, then 15% NaOH solution (1 ml per gram of $LiAlH_4$) was added follow by the addition of another portion of water (1 ml per gram of $LiAlH_4$). The resulting mixture was allowed to stir for 1 h to form a white suspension. Anhydrous $MgSO_4$ was added and the suspension was stirred for another 30 min. The solid was removed by filtration using celite and the filtrate was concentrated to give the corresponding alcohol **s3** that was used without further purification.

To a stirred solution of alcohol **s3** (1 equiv) in Et_2O (1.0 mmol/mL) was added PBr_3 (0.5 equiv) dropwise at 0 °C, then the reaction was allowed to warm to room temperature and stirred. After the reaction was completed, it was cautiously treated with 20% NaOH (2 M) at 0 °C. The organic layer containing the corresponding bromide compound **s4** was separated, washed with brine, dried over anhydrous Na_2SO_4 and kept over solid sodium hydrate for the next step.

To a dried flask with a magnetic stir bar was added dimethyl chloromalonate (1 equiv) and dried THF (0.3 M). The solution was cooled to 0 °C follow by the addition of sodium hydride (60% suspension in oil, 1 equiv). The resulting mixture was allowed to stir at rt for 30 min. Then bromide **s4** (1.1 equiv) was added and the reaction mixture was allowed to stir overnight at rt. The reaction mixture was quenched by saturated NH_4Cl solution, the organic phase was separated and the aqueous phase was extracted with Et_2O three times. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford diester **s5**.

To a stirred solution of diester **s5** (1 equiv) in MeOH (0.25 M) was added $NaBH_4$ (4 equiv), the resulting mixture of which was stirred at 0 °C for 15 min and then allowed to warm to room temperature and stirred for 6 h. After the reaction was completed, the mixture was quenched with saturated NH_4Cl, the solvent was evaporated and the aqueous solution was extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford the corresponding diol.

3. Screening of conditions and general procedure for syntheses of products 3

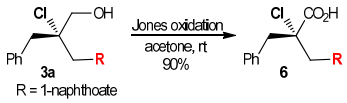


entry[a]	Sol.	T (°C)	base	Lewis acid	**3a** yield (%)	**3a** er (%)[c]
1	THF	0	Cs_2CO_3	-	95	81:19
2	$CHCl_3$	0	Cs_2CO_3	-	94	65:35
3	DCM	0	Cs_2CO_3	-	92	68:32
4	Tol.	0	Cs_2CO_3	-	86	84:16
5	Dioxane	0	Cs_2CO_3	-	70	67:33
6	1,2-DCM	0	Cs_2CO_3	-	88	69:31
7	Et_2O	0	Cs_2CO_3	-	92	77:23
8	THF	0	K_2CO_3	-	<20%	-
9	THF	0	DBU	-	<20%	-
10	THF	0	Et_3N	-	86	50:50
11	THF	r.t.	Cs_2CO_3		>90	75:25
12	THF	-20	Cs_2CO_3		>90	90:10
13	THF	-25	Cs_2CO_3		>90	92:8
14	THF	-30	Cs_2CO_3		>90	92.5:7.5
15	THF	-35	Cs_2CO_3		>90	92.5:7.5
15	**THF**	**-45**	**Cs_2CO_3**		**>90**	**95:5**
16	THF	-55	Cs_2CO_3		>90[b]	93.5:6.5
18	THF	-65	Cs_2CO_3		>90[b]	87.5:12.5
19	THF	-70	Cs_2CO_3		>90[b]	90:10
20	THF	-45	Cs_2CO_3	LiCl	75	79:21
21	THF	-45	Cs_2CO_3	$Sc(OTf)_3$	90	82:28
22	THF	-45	Cs_2CO_3	$Yb(OTf)_3$	92	88:26
23	THF	-45	Cs_2CO_3	$Cu(OTf)_2$	85	72:28
24	THF	-45	Cs_2CO_3	$Mg(OTf)_2$	87	87:13
25	THF	-45	Cs_2CO_3	$Zn(OTf)_2$	93	87:13

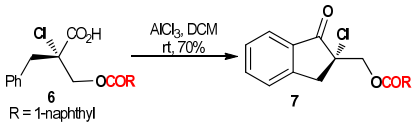
[a]All reactions of **1a** (0.10 mmol, 20.1 mg) with aldehyde **2** (0.2 mmol, 31.2 mg) were carried out in presence of catalyst of 5 mol% **E** and Cs_2CO_3 of 10 mol% in THF (1.0 mL) for 16 h. [b]Catalyst **E** of 2 mol% and Cs_2CO_3 of 5 were used (48 h). [c]Isolated yield. [d]Er of **3a** was determined by chiral HPLC analysis.

General procedure for synthesis of product 3: Under N_2 atmosphere, oxidant (0.1 mmol), triazolium salt **A-F** (0.01 mmol) and Cs_2CO_3 (0.015 mmol, 4.9 mg) were dissolved in freshly distilled THF stirred at room temperature for 5 minutes. Then, the yellow solution was slowly added into a solution of the 1,3-diol **1** (0.10 mmol, 0.10 M) and 1-naphthaldehyde (0.15 mmol) in THF at the specified temperature (-45 °C) as shown in Chart 1 and Chart 2 in the text. The resulting mixture was stirred under constant temperature for 12 h. The solvent was removed under reduced pressure and the crude residue was purified *via* column chromatography on silica gel to afford the desired *mono*-esterification product **3**.

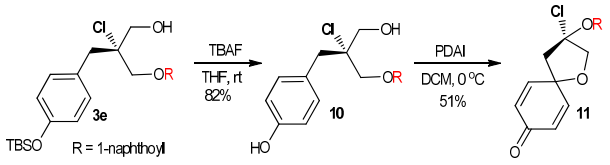
4. General procedure for the synthetic applicability



The procedure for synthesis of 6: The solution of **3a** (2.0 mmol, 1.0 equive) in acetone was cooled to 0 °C. Jones reagent (1.6 mL, 1.67 M in water) was added dropwise and the reaction mixture was stirred at 0 °C for 2h. Then the water was added and the mixture was extracted with ether. The combined organic layers were dried with Na_2SO_4. The resulting solution was concentrated by vacuum pump. The acid **6** could be obtained in 90% yield through isolation by silica gel column chromatography.



The procedure for synthesis of 7: Under a nitrogen atmosphere, a solution of **6** (0.3 mmol, 110 mg, 1.0 equiv) in DCM (4.0 mL, 0.05 M) was added to $AlCl_3$ (0.6 mmol, 79 mg, 2.0 equiv) at 0 °C. After the full conversion of **6**, the reaction was quenched with H_2O. Then the organic phase was separated, and the aqueous phase was extracted with Et_2O three times. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford product **7** in 70% yield.



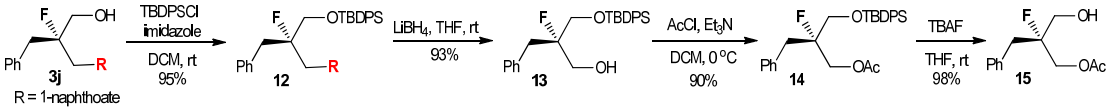
The procedure for synthesis of 11: To the solution of crude product **3e** (0.4 mmol, 194 mg, 1.0 equiv) in THF was added TBAF (105 mg, 1.0 equiv) and the reaction was treated with H_2O after full conversion of reaction by TLC monitoring. The organic phase was separated, and the aqueous phase was extracted with DCM three times. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford phenol product **10**.

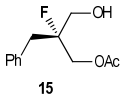
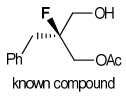
To a solution of phenol **10** in DCM (0.1 M) was added PDAI (130 mg, 1 equiv) at 0 °C. After the reaction was stirred at 0 °C for 1h, the saturated $Na_2S_2O_3$ was added to quench reaction. The final system was quenched with ethyl acetate three times. The combined organic layers were

concentrated under vacuum and the product **11** could be obtained in 40% total yield for two steps by column chromatography.

5. Determination of the absolute configuration of the products 3 and 4

The absolute configuration of the products **3** and **4** was determined by correlation with a known compound as follows.[1]



 15	 known compound
$[\alpha]^{20}_D$ = +6 (*c* = 14.0 mg/mL, $CHCl_3$)	$[\alpha]_D$ = -8.8 (*c* = 0.98 mg/mL, $CHCl_3$, 95% ee)

According to the optical rotations of our synthetic compounds and the known compound, the absolute configuration of our synthetic compounds could be confirmed.

The procedure for synthesis of 12: To a stirred solution of **3j** (0.7 mmol, 236 mg, 1 equiv) in DCM (0.5 mmol/ml) was added imidazole (, 2.2 equiv, 104.7 mg) at 0 °C. Then, TBDPSCl was added to the reaction system and the reaction was stirred for 2 h. The reaction was subsequently quenched with H_2O, the organic layer was separated and the aqueous phase was extracted with DCM. The combined organic layers were washed with brine, dried over anh. Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to give product **12** in 95% yield.

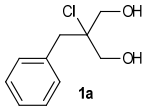
Under a nitrogen atmosphere, to a stirred solution of **12** (0.4 mmol, 230 mg, 1 equiv) in THF (0.25 mmol/ml) was added $LiBH_4$ (2 N in THF solution, 2.2 equiv) dropwise at 0 °C, and the reaction mixture was allowed to stir at that temperature for 12 h. Subsequently, the reaction was quenched by sat. NH_4Cl, the organic phase was separated, and the aqueous phase was extracted with Et_2O three times. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford product **13** in 89% yield.

Under a nitrogen atmosphere, to a stirred solution of **13** (0.2 mmol, 84 mg, 1 equiv) in DCM (0. 5 mmol/ml) was added AcCl (2.0 equiv) dropwise at 0 °C. Subsequently, Et_3N was added to stir at that temperature for 1 h. After that, the reaction was quenched with H_2O, the organic phase was separated, and the aqueous phase extracted with DCM three times. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure to afford the residue **14**.

To the solution of crude product **14** (1.0 equiv) in THF was added TBAF (1.0 equiv,) and the reaction was treated with H_2O after full conversion of reaction by TLC monitoring. The organic phase was separated, and the aqueous phase was extracted with DCM three times. The combined organic layers were washed with brine, dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography to afford product **15** in 81% total yield for two steps.

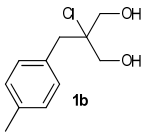
6. Characterization of key compounds 1, 2 and 3

2-benzyl-2-chloropropane-1,3-diol (1a)



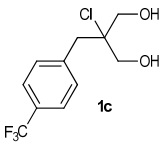
According to general procedure, the title compound (1.61 g) could be obtained in 80% yield for two steps from diethyl chloromalonate (10 mmol, 1.94 g). White solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.31-7.27 (m, 5H), 3.73 (s, 2H), 3.14 (s, 2H), 2.87 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 135.0, 130.8, 128.2, 127.1, 76.6, 65.9, 41.1; HRMS (ESI) calcd. For $C_{10}H_{14}ClO_2$ $[M+H]^+$: 201.0677, Found: 201.0679. IR ν (cm^{-1}) 3269, 2947, 1455, 1119, 1074, 701.

2-chloro-2-(4-methylbenzyl)propane-1,3-diol (1b)



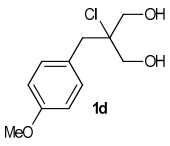
According to general procedure, the title compound (1.76 g) could be obtained in 82% yield for two steps from diethyl chloromalonate (10 mmol, 1.94 g). White solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.12 (d, J = 7.6 Hz, 2H), 7.20 (d, J = 7.6 Hz, 2H), 3.74 (s, 4H), 3.14 (s, 2H), 2.34 (s, 3H), 2.29 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 136.8, 132.0, 130.6, 128.9, 66.2, 40.8, 21.1; HRMS (ESI) calcd. For $C_{11}H_{16}ClO_2$ $[M+H]^+$: 215.0833, Found: 215.0840. IR ν (cm^{-1}) 3222, 1452, 1118, 1066, 767, 699.

2-chloro-2-(4-(trifluoromethyl)benzyl)propane-1,3-diol (1c)



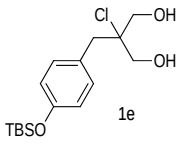
According to general procedure, the title compound (1.88 g) could be obtained in 70% yield for two steps from diethyl chloromalonate (10 mmol, 1.94 g). White solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.57 (d, *J* = 8.4 Hz, 2H), 7.54 (d, *J* = 8.0 Hz, 2H), 3.77-3.68 (m, 4H), 3.20 (s, 2H), 3.13 (s, 2H), 2.87 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 139.1, 131.3, 129.5, 129.2, 125.5, 125.1, 125.0, 125.0, 125.0, 122.8, 75.7, 65.7, 40.5; HRMS (ESI) calcd. For $C_{11}H_{13}ClF_3O_2$ $[M+H]^+$: 269.0551, Found: 269.0556. IR ν (cm^{-1}) 2923, 1746, 1437, 1325.

2-chloro-2-(4-methoxybenzyl)propane-1,3-diol (1d)



According to general procedure, the title compound (1.71 g) could be obtained in 74% yield for two steps from diethyl chloromalonate (10 mmol, 1.94 g). White solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.22 (d, *J* = 8.4 Hz, 2H), 6.83 (d, *J* = 8.8 Hz, 2H), 3.77 (s, 3H), 3.71 (d, *J* = 3.6 Hz, 2H), 3.13 (s, 2H), 3.07 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.5, 131.8, 127.0, 113.5, 65.7, 55.1, 40.1; HRMS (ESI) calcd. For $C_{11}H_{16}ClO_3$ $[M+H]^+$: 231.0782, Found: 231.0789. IR ν (cm^{-1}) 3303, 2931, 1614, 1250, 1085, 849.

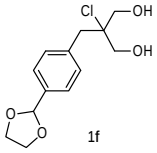
2-(4-((tert-butyldimethylsilyl)oxy)benzyl)-2-chloropropane-1,3-diol (1e)



Following the literature procedure[2], the corresponding (bromomethyl)benzene could be obtained. According to the general procedure, the title compound could be obtained as a white solid in 73% overall yield from (bromomethyl)benzene compound. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.16 (d, *J* = 8.5 Hz, 2H), 6.78 (d, *J* = 8.5 Hz, 2H), 3.72 (d, *J* = 6.0 Hz, 2H), 3.71 (d, *J* = 6.7 Hz, 2H), 3.10 (s, 2H), 2.41 (t, *J* = 6.5 Hz, 2H), 0.98 (s, 9H), 0.19 (s, 6H); ^{13}C NMR

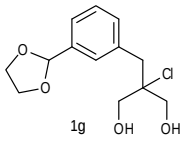
(100 MHz, $CDCl_3$): δ 154.9, 131.9, 127.8, 119.9, 77.6, 66.2, 40.6, 25.8, 18.3, −4.3. HRMS (ESI) calcd. For $C_{16}H_{28}ClO_3Si$ $[M+H]^+$: 331.1491, Found: 331.1497. IR ν (cm^{-1}) 2954, 1472, 1254, 1059, 778.

2-(4-(1,3-dioxolan-2-yl)benzyl)-2-chloropropane-1,3-diol (1f)



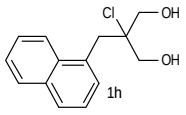
Following the literature procedure[3], the corresponding (bromomethyl)benzene could be obtained. According to the general procedure, the title compound could be obtained as a white solid in 78% overall yield from the bromomethylbenzene compound. ^1H NMR (400 MHz, $CDCl_3$): δ 7.43 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 5.80 (s, 1H), 4.18-4.10 (m, 2H), 4.08-4.00 (m, 2H), 3.73 (d, *J* = 6.0 Hz, 2H), 3.71 (d, *J* = 6.6 Hz, 2H), 3.19 (s, 2H), 2.17 (t, *J* = 6.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 136.8, 136.4, 131.0, 126.5, 103.7, 77.0, 66.2, 65.5, 41.0. HRMS (ESI) calcd. For $C_{13}H_{18}ClO_4$ $[M+H]^+$: 273.0888, Found: 273.0886. IR ν (cm^{-1}) 3308, 2931, 1696, 1389, 1090, 854.

2-(3-(1,3-dioxolan-2-yl)benzyl)-2-chloropropane-1,3-diol (1g)



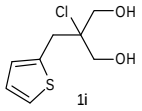
According to the procedure of **1f**, the title compound could be obtained as a white solid in 15% overall yield from the bromomethylbenzene compound. ^1H NMR (400 MHz, $CDCl_3$): δ 7.43-7.38 (m, 2H), 7.36-7.32 (m, 2H), 5.80 (s, 1H), 4.18-4.09 (m, 2H), 4.08-3.99 (m, 2H), 3.72 (d, *J* = 6.0 Hz, 2H), 3.71 (d, *J* = 6.8 Hz, 2H), 3.18 (s, 2H), 2.48 (t, *J* = 6.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ137.9, 135.5, 131.9, 129.0, 128.4, 125.4, 103.8, 66.3, 65.5, 41.1. HRMS (ESI) calcd. For $C_{13}H_{18}ClO_4$ $[M+H]^+$: 273.0888, Found: 273.0884. IR ν (cm^{-1}) 2926, 1694, 1386, 1087, 708, 583.

2-chloro-2-(naphthalen-1-ylmethyl)propane-1,3-diol (1h)



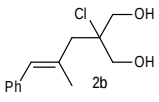
According to the general procedure, the title compound could be obtained as a white solid in 85% overall yield. ^1H NMR (400 MHz, $CDCl_3$): δ 7.84-7.77 (m, 4H), 7.48-7.46 (m, 3H), 3.79-3.77 (m, 4H), 3.53 (s, 2H), 2.19 (t, *J* = 2.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.9, 133.3, 132.7, 132.5, 129.6, 128.9, 127.7, 127.6, 126.1, 125.8, 77.4, 66.3, 41.2; HRMS (ESI) calcd. For $C_{14}H_{16}ClO_2$ $[M+H]^+$: 251.0833, Found: 251.0842. IR ν (cm^{-1}) 3291, 2917, 1266, 1066, 1017, 754.

2-chloro-2-(thiophen-2-ylmethyl)propane-1,3-diol (1i)



The diol was obtained in 86% yield over two steps as a white solid from the bromide compound. ^1H NMR (400 MHz, $CDCl_3$): δ 7.22 (t, *J* = 3.3 Hz, 1H), 6.97 (d, *J* = 3.4 Hz, 2H), 3.83-3.73 (m, 4H), 3.40 (s, 2H), 2.44 (t, *J* = 6.5 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 136.5, 128.3, 126.9, 125.3, 76.1, 66.3, 35.6. HRMS (ESI) calcd. For $C_8H_{12}ClO_2S$ $[M+H]^+$: 207.0241, Found: 207.0247. IR ν (cm^{-1}) 3323, 1438, 1118, 1062, 710, 695.

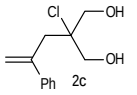
(E)-2-chloro-2-(2-methyl-3-phenylallyl)propane-1,3-diol (2b)



Following the literature procedure[4], the corresponding

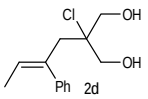
(E)-(3-bromo-2-methylprop-1-en-1-yl)benzene could be obtained. Then according to the general procedure, the diol was obtained in 81% overall yield as a white solid from bromide compound. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36-7.31 (m, 2H), 7.28-7.21 (m, 3H), 6.44 (s, 1H), 3.86 (d, *J* = 3.8 Hz, 4H); 2.76 (s, 2H), s.45 (brs, 2H), 2.04 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 137.7, 133.3, 131.2, 129.1, 128.3, 126.7, 77.0, 66.9, 46.1, 20.6. HRMS (ESI) calcd. For $C_{13}H_{18}ClO_2$ $[M+H]^+$: 241.0990, Found: 241.0990. IR ν (cm^{-1}) 3319, 1494, 1124, 961,679, 671.

2-chloro-2-(2-phenylallyl)propane-1,3-diol (2c)



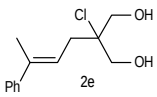
The preparation of allyl bromide followed the literature procedure[5]. The residue was purified by column chromatography to afford diol as a white solid in 76% overall yield from the allyl bromide compound. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43-7.38 (m, 2H), 3.37-3.27 (m, 3H), 5.42 (d, *J* = 1.4 Hz, 1H), 5.31 (s, 1H), 3.64 (d, *J* = 6.4 Hz, 1H), 3.63 (d, *J* = 7.0 Hz, 1H), 3.12 (s, 2H), 2.07 (t, *J* = 6.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143, 142.1, 128.8, 128.0, 126.5, 119.7, 40.8, 77.1, 66.8. HRMS (ESI) calcd. For $C_{12}H_{15}ClO_2$ $[M+H]^+$: 226.0750, Found: 226.0755. IR ν (cm^{-1}) 2933, 1624, 1431, 1071, 904, 697.

(Z)-2-chloro-2-(2-phenylbut-2-en-1-yl)propane-1,3-diol (2d)



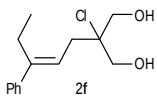
Following the literature procedure,[5] the allyl alcohol could be obtained. According to general procedure, the diol was obtained in 78% overall yield as a white solid form the allyl bromide. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.38-7.36 (m, 2H), 7.29-7.26 (m, 1H), 7.25-7.21 (m, 2H), 5.80 (q, *J* = 7.0 Hz, 1H), 3.57 (s, 4H), 2.98 (s, 2H), 2.08 (brs, 2H), 1.66 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 140.5, 135.2, 128.8, 128.6, 128.5, 127.2, 77.6, 66.9, 44.4, 15.1. HRMS (ESI) calcd. For $C_{13}H_{18}ClO_2$ $[M+H]^+$: 241.0990, Found: 241.0998. IR ν (cm^{-1}) 3293, 2931, 1439, 1267, 1062, 703.

(E)-2-chloro-2-(3-phenylbut-2-en-1-yl)propane-1,3-diol (2e)



Following the literature procedure[6], the allyl bromide could be obtained. Then according to general procedure the diol was obtained in 74% overall yield as a white solid from the allyl bromide. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43-7.37 (m, 2H), 7.36-7.30 (m, 2H), 7.29-7.24 (m, 1H), 5.88 (t, *J* = 7.1 Hz, 1H), 3.84 (d, *J* = 4.6 Hz, 4H), 2.77 (d, *J* = 7.4 Hz, 2H), 2.47 (t, *J* = 6.1 Hz, 2H), 2.09 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.6, 139.1, 128.4, 127.2, 125.9, 121.2, 77.5, 66.9, 34.7, 16.5. HRMS (ESI) calcd. For $C_{13}H_{18}ClO_2$ $[M+H]^+$: 241.0990, Found: 241.0998. IR ν (cm^{-1}) 3345, 2929, 1419, 1069, 734, 695.

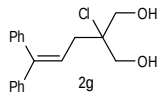
(E)-2-chloro-2-(3-phenylpent-2-en-1-yl)propane-1,3-diol (2f)



Following the literature procedure,[7] the allyl alcohol could be obtained. Then the allyl bromide could be prepared following general procedure A. Following the general procedure B, the diol could be obtained in 72% yield overall yield as a white solid from allyl bromide. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.40-7.22 (m, 5H), 5.76-5.68 (m, 1H), 3.85 (s, 4H), 2.77 (d, *J* = 6.6

Hz, 2H), 2.60-2.50 (m, 2H), 2.24 (brs, 2H), 1.02-0.92 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.8, 142.6, 128.4, 127.2, 126.6, 120.7, 77.2, 66.9, 34.3, 23.3, 13.4. HRMS (ESI) calcd. For $C_{14}H_{20}ClO_2$ $[M+H]^+$: 255.1146, Found: 255.1144. IR ν (cm^{-1}) 3303, 2931, 1614, 1250, 1085, 849.

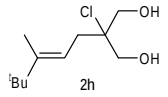
2-chloro-2-(3,3-diphenylallyl)propane-1,3-diol (2g)



2g

Following the literature procedure,[8] the allyl bromide could be obtained. According to the general procedure B the diol could be obtained in 76% overall yield as a white solid from allyl bromide. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.42-7.32 (m, 5H), 7.30-7.22 (s, 3H), 7.21-7.17 (m, 2H), 6.26 (t, *J* = 7.4 Hz, 1H), 3.74 (d, *J* = 6.6 Hz, 4H), 2.67 (d, *J* = 7.3 Hz, 2H), 2.10 (t, *J* = 6.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.3, 142.2, 139.7, 129.8, 128.7, 128.4, 127.6, 127.4, 122.6, 76.8, 67.2, 35.0. HRMS (ESI) calcd. For $C_{18}H_{20}ClO_2$ $[M+H]^+$: 303.1146, Found: 303.1148. IR ν (cm^{-1}) 3100, 1480, 1289, 1072, 923, 626.

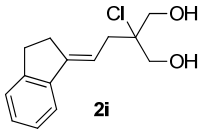
(E)-2-chloro-2-(3,4,4-trimethylpent-2-en-1-yl)propane-1,3-diol (2h)



2h

Following the general procedure, the diol could be obtained in 11% overall yield as a white solid from the corresponding ketone. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.33 (t, *J* = 7.2 Hz, 1H), 3.77 (d, *J* = 6.5 Hz, 4H), 2.56 (d, *J* = 7.3 Hz, 2H), 2.25 (t, *J* = 6.5 Hz, 2H), 1.05 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 147.8, 114.2, 78.1, 67.1, 36.7, 34.3, 29.2, 13.3. HRMS (ESI) calcd. For $C_{11}H_{22}ClO_2$ $[M+H]^+$: 221.1303, Found: 221.1308. IR ν (cm^{-1}) 3389, 1423, 1112, 1049, 827, 652.

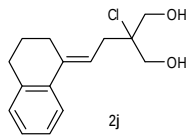
(E)-2-chloro-2-(2-(2,3-dihydro-1H-inden-1-ylidene)ethyl)propane-1,3-diol (2i)



2i

Following the general procedure, the diol could be obtained in 15% overall yield as a white solid from the corresponding ketone. δ 7.50-7.48 (m, 1H), 7.27-7.18 (m, 3H), 6.04-5.99 (m, 1H), 3.86-3.84 (m, 4H), 3.03-2.99 (m, 2H), 2.80-2.75 (m, 4H), 2.17-2.14 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 146.5, 141.1, 128.2, 126.6, 125.5, 120.3, 111.9, 77.8, 67.1, 35.7, 30.1, 28.3. HRMS (ESI) calcd. For $C_{14}H_{18}ClO_2$ $[M+H]^+$: 253.0990, Found: 253.0998. IR ν (cm^{-1}) 3295, 2954, 1480, 1283, 1032, 692.

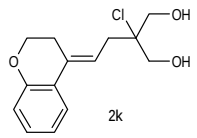
(E)-2-chloro-2-(2-(3,4-dihydronaphthalen-1(2H)-ylidene)ethyl)propane-1,3-diol (2j)



2j

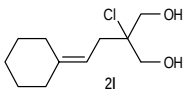
Following the general procedure, the diol was obtained in 18% overall yield as a white solid from the corresponding ketone. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.61-7.56 (m, 1H), 7.19-7.14 (m, 2H), 7.12-7.08 (m, 2H), 6.10 (t, *J* = 7.4 Hz, 1H), 3.84 (d, *J* = 5.6 Hz, 4H), 2.82-2.75 (m, 4H), 2.54 (t, *J* = 5.6 Hz, 2H), 2.22-2.12 (m, 2H), 1.88-1.80 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.3, 137.7, 136.0, 129.0, 127.2, 126.2, 124.1, 117.0, 77.5, 66.9, 34.1, 30.5, 27.0, 23.3. HRMS (ESI) calcd. For $C_{15}H_{20}ClO_2$ $[M+H]^+$: 267.1146, Found: 267.1147. IR ν (cm^{-1}) 3290, 2935, 1483, 1263, 1032, 672.

(E)-2-chloro-2-(2-(chroman-4-ylidene)ethyl)propane-1,3-diol (2k)



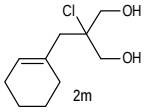
Following the general procedure, the diol was obtained in 12% overall yield as a white solid from the corresponding ketone. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.55 (d, *J* = 7.7 Hz, 1H), 7.15 (t, *J* = 7.5 Hz, 1H), 6.90 (t, *J* = 7.5 Hz, 1H), 6.84 (d, *J* = 7.9 Hz, 1H), 6.14 (t, *J* = 7.4 Hz, 1H), 4.21 (d, *J* = 5.4 Hz, 2H), 3.84 (d, *J* = 11.8 Hz, 2H), 3.80 (d, *J* = 11.8 Hz, 2H), 2.76 (d, *J* = 7.7 Hz, 2H), 2.71 (t, *J* = 4.7 Hz, 2H), 2.05 (brs, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 154.5, 132.5, 129.1, 124.1, 122.5, 120.9, 117.6, 115.1, 77.3, 66.7, 66.4, 33.5, 26.2. HRMS (ESI) calcd. For $C_{14}H_{18}ClO_3$ $[M+H]^+$: 269.0939, Found: 269.0935. IR ν (cm^{-1}) 3398, 1578, 1208, 1106, 905, 744.

2-chloro-2-(2-cyclohexylideneethyl)propane-1,3-diol (2l)



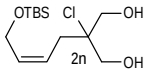
Following the general procedure, the diol was obtained in 12% overall yield as a white solid from the corresponding ketone. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.18 (t, *J* = 7.5 Hz, 1H), 3.77 (d, *J* = 5.8 Hz, 4H), 2.56 (d, *J* = 7.6 Hz, 2H), 2.21-2.18 (m, 6H), 1.57-1.49 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 144.5, 114.1, 77.8, 67.0, 37.6, 33.4, 29.2, 28.7, 27.8, 26.9. HRMS (ESI) calcd. For $C_{11}H_{20}ClO_2$ $[M+H]^+$: 219.1146, Found: 219.1140. IR ν (cm^{-1}) 3304, 2958, 1458, 1274, 1065, 654.

2-chloro-2-(cyclohex-1-en-1-ylmethyl)propane-1,3-diol (2m)



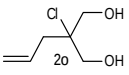
Following the general procedure, with commercially available methyl 1-cyclohexene-1-carboxylate as the starting material, the diol was obtained in 19% overall yield as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.61-5.57 (m, 1H), 3.77 (d, *J* = 6.5 Hz, 4H), 2.51 (s, 2H), 2.29 (t, *J* = 6.7 Hz, 2H), 2.13-2.08 (m, 2H), 2.06-2.00 (m, 2H), 1.65-1.51 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.0, 128.0, 77.4, 67.2, 44.1, 30.8, 25.6, 23.2, 22.2. HRMS (ESI) calcd. For $C_{10}H_{18}ClO_2$ $[M+H]^+$: 205.0990, Found: 205.0996. IR ν (cm^{-1}) 3283, 2924, 1424, 1268, 1075, 720.

(Z)-2-(4-((tert-butyldimethylsilyl)oxy)but-2-en-1-yl)-2-chloropropane-1,3-diol (2n)



Following the general procedure, the diol product was obtained in 21% yield over four steps as a white solid from the corresponding known allyl bromide. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.93-5.78 (m, 2H), 4.19 (d, *J* = 6.9 Hz, 2H), 3.77 (d, *J* = 7.3 Hz, 2H), 3.76 (d, *J* = 7.0 Hz, 2H), 3.26 (t, *J* = 7.1 Hz, 2H), 2.74 (d, *J* = 7.2 Hz, 2H), 0.90 (s, 9H), 0.11 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 131.1, 128.8, 75.3, 67.2, 58.5, 32.1, 26.0, 18.5, −5.1. HRMS (ESI) calcd. For $C_{13}H_{28}ClO_3Si_2$ $[M+H]^+$: 295.1491, Found: 295.1497. IR ν (cm^{-1}) 3337, 2954, 1510, 1250, 921, 643.

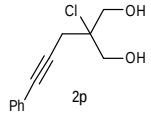
2-allyl-2-chloropropane-1,3-diol (2o)



Following the general procedure, the diol could be obtained from the corresponding allyl bromide in 30% total yield as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.95-5.85 (m, 1H), 5.23 (d, *J* = 14.4 Hz, 1H), 5.18 (d, *J* = 4.4 Hz, 1H), 3.53 (s, 2H), 3.79-3.72 (dd, *J* = 12.0 Hz, 16.0 Hz, 4H), 3.42 (s, 2H), 2.57 (d, *J* = 11.2 Hz, 1H); ^{13}C

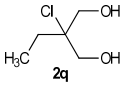
NMR (100 MHz, $CDCl_3$): δ131.8, 119.5, 75.2, 66.1, 39.7; HRMS (ESI) calcd. For $C_6H_{12}ClO_2$ $[M+H]^+$: 151.0520, Found: 151.0527. IR ν (cm^{-1}) 2936, 1642, 1433, 1058, 924, 655.

2-chloro-2-(3-phenylprop-2-yn-1-yl)propane-1,3-diol (2p)



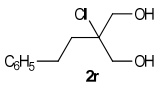
Following the general procedure, using 3-phenyl-2-propyl-1-ol as the starting material, the diol was obtained in 26% overall yield as a white solid. ^1H NMR (400 MHz, $CDCl_3$): δ 7.45-7.39 (m, 2H), 7.33-7.27 (m, 2H), 3.77 (d, *J* = 4.8 Hz, 4H), 3.03 (s, 2H), 2.38 (brs, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 131.8, 128.4, 128.4, 123.0, 84.0, 83.9, 74.8, 66.8, 27.5. HRMS (ESI) calcd. For $C_{12}H_{14}ClO_2$ $[M+H]^+$: 225.0677, Found: 225.0679. IR ν (cm^{-1}) 3306, 2930, 1489, 1270, 1058, 692.

2-chloro-2-ethylpropane-1,3-diol (2q)



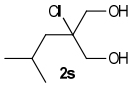
Following the general procedure, using 3-phenyl-2-propyl-1-ol as the starting material, the diol was obtained in 18% overall yield as a white solid. ^1H NMR (400 MHz, $CDCl_3$): δ 3.82-3.74 (m, 4H), 2.78 (s, 2H), 1.88-1.82 (dd, *J* = 7.2 Hz, 14.8 Hz, 2H), 1.06-1.02 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 177.5, 77.3, 77.0, 76.7, 66.3, 28.1, 8.0. HRMS (ESI) calcd. For $C_5H_{12}ClO_2$ $[M+H]^+$: 139.0520, Found: 139.0526. IR ν (cm^{-1}) 3304, 2958, 1274, 1065, 754.

2-chloro-2-phenethylpropane-1,3-diol (2r)



Following the general procedure, using 3-phenyl-2-propyl-1-ol as the starting material, the diol was obtained in 20% overall yield as a white solid. ^1H NMR (400 MHz, $CDCl_3$): δ 7.32-7.28 (m, 2H), 7.23-7.19 (m, 3H), 3.89-3.80 (m, 4H), 2.84-2.80 (m, 2H), 2.17-2.08 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.3, 128.6, 128.4, 77.2, 67.0, 37.3, 30.2. HRMS (ESI) calcd. For $C_{11}H_{16}ClO_2$ $[M+H]^+$: 215.0833, Found: 215.0838. IR ν (cm^{-1}) 3316, 2928, 1488, 1260, 1058, 690.

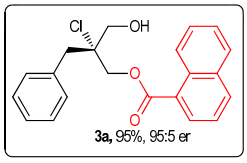
2-chloro-2-isobutylpropane-1,3-diol (2s)



Following the general procedure, using 3-phenyl-2-propyl-1-ol as the starting material, the diol was obtained in 18% overall yield as a white solid. ^1H NMR (400 MHz, $CDCl_3$): δ 3.82-3.74 (dd, *J* = 7.6 Hz, 14.8 Hz, 2H), 2.83 (s, 2H), 1.97-1.88 (m, 1H), 1.74 (d, *J* = 7.6 Hz, 2H), 1.01 (d, *J* = 6.4 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 77.2, 66.8, 43.7, 24.7, 24.1. HRMS (ESI) calcd. For $C_7H_{16}ClO_2$ $[M+H]^+$: 167.0833, Found: 167.0838. IR ν (cm^{-1}) 3308, 2988, 1276, 1065, 756.

6. Characterization of products 3 and 4

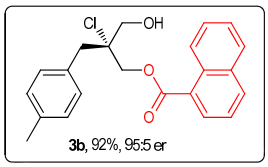
2-benzyl-2-chloro-3-hydroxypropyl 1-naphthoate (3a)



Yellow oil. ^1H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, *J* = 8.8 Hz, 1H), 8.26 (d, *J* = 7.2 Hz, 1H), 8.08 (d, *J* = 8.4 Hz, 1H), 7.91 (d, *J* = 8.0 Hz, 1H), 6.67-6.30 (m, 1H), 7.59-7.52 (m, 2H), 7.36-7.26 (m, 5H), 4.65 (d, *J* = 12.0 Hz, 1H), 4.59 (t, *J* = 11.6 Hz, 1H), 3.77 (d, *J* = 7.2 Hz, 2H),

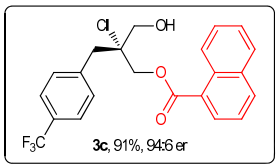
3.28 (s, 2H), 2.63 (t, J = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 134.6, 134.1, 133.9, 131.5, 130.9, 130.7, 128.7, 128.3, 128.1, 127.3, 126.4, 126.1, 125.7, 124.5, 73.5, 66.2, 65.7, 41.7; HRMS (ESI) calcd. For $C_{21}H_{20}ClO_3$ $[M+H]^+$: 355.1095, Found: 355.1090. $[\alpha]^{20}_D$ = 14.0 (c = 13.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 34755, 2932, 1743, 1554, 1256, 1042. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 11.1 min, t_2 = 13.5 min.

2-chloro-3-hydroxy-2-(4-methylbenzyl)propyl 1-naphthoate (3b)



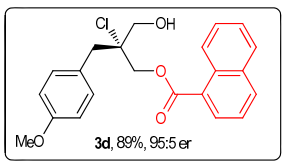
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.94 (d, J = 8.4 Hz, 1H), 8.25 (d, J = 1.2 Hz, 1H), 8.23 (d, J = 1.2 Hz, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.93-7.62 (m, 1H), 7.57-7.50 (m, 2H), 7.24-7.21 (m, 2H), 7.13-7.11 (d, J = 7.6 Hz, 2H), 4.63 (d, J = 11.6 Hz, 1H), 4.49 (d, J = 12.0 Hz, 1H), 3.77 (d, J = 6.0 Hz, 2H), 3.23 (s, 2H), 2.56 (t, J = 7.2 Hz, 1H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.20, 136.9, 134.0, 133.9, 131.4, 130.7, 130.6, 129.0, 128.6, 128.1, 126.4, 126.1, 125.7, 124.5, 73.7, 66.2, 65.7, 41.3; HRMS (ESI) calcd. For $C_{22}H_{22}ClO_3$ $[M+H]^+$: 369.1252, Found: 369.1257. $[\alpha]^{20}_D$ = 60.0 (c = 18.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3447, 2920, 1718, 1511, 1278, 1017. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 11.6 min, t_2 = 13.8 min.

2-chloro-3-hydroxy-2-(4-(trifluoromethyl)benzyl)propyl 1-naphthoate (3c)



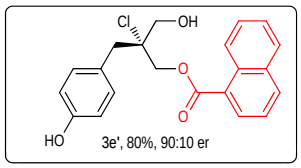
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, J = 8.4 Hz, 1H), 8.23 (d, J = 2.4 Hz, 1H), 8.08 (d, J = 1.2 Hz, 1H), 7.91 (d, J = 8.4 Hz, 1H), 7.67-7.25 (m, 7H), 4.66 (d, J = 11.6 Hz, 2H), 4.49 (d, J = 12.0 Hz, 2H), 3.79-3.70 (m, 2H), 3.30 (s, 2H), 2.74 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 138.6, 134.3, 133.9, 131.4, 131.3, 130.7, 128.7, 128.2, 126.5, 125.8, 125.6, 125.2, 125.2, 124.5, 72.7, 66.2, 65.4, 41.2; HRMS (ESI) calcd. For $C_{22}H_{19}ClF_3O_3$ $[M+H]^+$: 423.0969, Found: 423.0960. $[\alpha]^{20}_D$ = 40.0 (c = 11.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3592, 1721, 1334, 1110, 1017, 784. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 12.3 min, t_2 = 15.3 min.

2-chloro-3-hydroxy-2-(4-methoxybenzyl)propyl 1-naphthoate (3d)



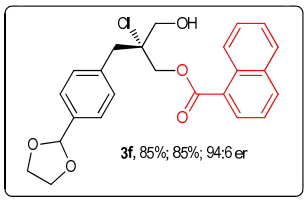
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, J = 8.4 Hz, 1H), 8.26 (d, 0.8 Hz, 1H), 8.24 (d, J = 0.8 Hz, 1H), 8.07 (d, J = 8.0 Hz, 1H), 7.66-7.62 (m, 1H), 7.58-7.26 (m, 2H), 7.25 (d, J = 4.8 Hz, 2H), 6.85 (d, J = 8.8 Hz, 2H), 4.63 (d, J = 12.0 Hz, 1H), 4.49 (d, J = 12.0 Hz, 1H), 3.79 (s, 3H), 3.76 (d, J = 8.4 Hz, 2H), 3.21 (s, 2H), 2.66 (*t*, J = 5.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 158.9, 134.1, 133.9, 131.9, 131.4, 130.6, 128.7, 128.1, 126.5, 126.4, 126.1, 125.7, 124.5, 113.7, 73.9, 66.2, 65.6, 55.2, 40.8; HRMS (ESI) calcd. For $C_{22}H_{22}ClO_4$ $[M+H]^+$: 385.1201, Found: 385.1208. $[\alpha]^{20}_D$ = 30.0 (c = 15.0 mg/mL, $CHCl_3$). The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 15.6 min, t_2 = 18.3 min.

2-(4-((tert-butyldimethylsilyl)oxy)benzyl)-2-chloro-3-hydroxypropyl 1-naphthoate (3e)



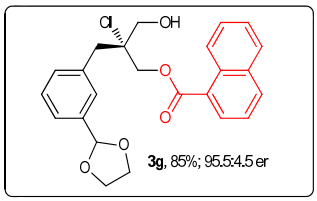
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, *J* = 8.8 Hz, 1H), 8.25 (d, *J* = 1.2 Hz, 1H), 8.23 (d, *J* = 1.2 Hz, 1H), 8.02 (d, *J* = 8.0 Hz, 1H), 7.88-7.59 (m, 1H), 7.54-7.47 (m, 2H), 7.18 (d, *J* = 8.8 Hz, 6H), 6.79 (d, *J* = 8.4 Hz, 2H), 4.60 (d, *J* = 12.0 Hz, 1H), 4.47 (d, *J* = 12.0 Hz, 1H), 3.74 (s, 2H), 3.18 (s, 2H), 0.98 (s, 9H), 0.19 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.1, 154.8, 134.0, 133.8, 131.8, 131.4, 130.6, 128.6, 128.0, 127.1, 126.3, 126.0, 125.6, 124.5, 119.8, 73.7, 66.2, 65.6, 40.8, 25.6, 18.1; HRMS (ESI) calcd. For $C_{27}H_{34}ClO_4Si$ $[M+H]^+$: 485.1909, Found: 485.1908. $[\alpha]^{20}_D$ = 20.0 (*c* = 4.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1721, 1511, 1242, 1195, 1016, 782. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 28.1 min, t_2 = 28.6 min.

2-(4-(1,3-dioxolan-2-yl)benzyl)-2-chloro-3-hydroxypropyl 1-naphthoate (3f)



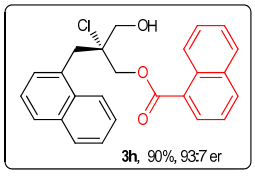
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.94 (d, *J* = 8.4 Hz, 1H), 8.25 (d, *J* = 0.8 Hz, 1H), 8.24 (d, *J* = 0.8 Hz, 1H), 8.07 (d, *J* = 8.0 Hz, 1H), 7.92-7.63 (m, 1H), 7.58-7.52 (m, 2H), 7.45 (d, *J* = 8.0 Hz, 1H), 7.36 (d, *J* =8.0 Hz, 1H), 5.80 (s, 1H), 4.64 (d, *J* = 12.0 Hz, 1H), 4.49 (d, *J* = 12.0 Hz, 1H), 4.15-4.05 (m, 2H), 3.75 (s, 2H), 3.28 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 137.0, 135.6, 134.1, 133.9, 131.4, 131.0, 130.7, 128.7, 128.1, 126.5, 126.4, 126.0, 125.6, 124.5, 103.5, 73.3, 66.2, 65.5, 65.3, 41.4; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_5$ $[M+H]^+$: 427.1307, Found: 427.1307. $[\alpha]^{20}_D$ = 36.0 (*c* = 8.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2919, 1714, 1511, 1240, 1077, 781. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 24.9 min, t_2 = 38.4 min.

2-(3-(1,3-dioxolan-2-yl)benzyl)-2-chloro-3-hydroxypropyl 1-naphthoate (3g)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, *J* = 8.4 Hz, 1H), 8.26 (d, *J* = 7.2 Hz, 1H), 8.10 (d, *J* = 4.0 Hz, 1H), 7.89 (d, *J* = 11.6 Hz, 1H), 7.67-7.63 (m, 1H), 7.60-7.51 (m, 2H), 7.47-7.26 (m, 1H), 5.79 (s, 1H), 4.69-4.61 (m, 1H), 4.54-4.49 (m, 1H), 4.09-4.00 (m, 4H), 3.99-3.74 (m, 2H), 3.79 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 138.1, 134.7, 134.1, 133.9, 131.8, 131.5, 130.7, 128.9, 128.7, 128.4, 128.1, 126.4, 126.0, 125.7, 125.5, 124.5, 103.5, 73.4, 66.2, 65.7, 65.3, 41.6; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_5$ $[M+H]^+$: 427.1307, Found: 427.1305. $[\alpha]^{20}_D$ = 36.0 (*c* = 9.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2919, 1719, 1241, 1133, 1016, 782. The er value was determined by HPLC (Chiralcel ID, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 43.7 min, t_2 = 52.2 min.

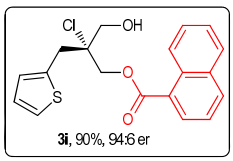
2-chloro-3-hydroxy-2-(naphthalen-1-ylmethyl)propyl 1-naphthoate (3h)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, *J* = 8.8 Hz, 1H), 8.24 (d, *J* = 0.8 Hz, 1H), 8.22 (d, *J* = 0.8 Hz, 1H), 8.05 (d, *J* = 8.4 Hz, 1H), 7.91-7.78 (m, 4H), 7.66-7.44 (m, 6H), 4.69 (d, *J* = 11.6 Hz, 1H),

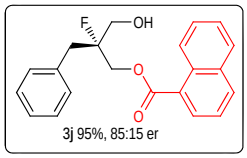
4.52 (t, J = 12.0 Hz, 1H), 3.80 (d, J = 7.2 Hz, 2H), 3.43 (s, 2H), 2.72-2.68 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.3, 134.1, 133.9, 133.2, 132.6, 132.2, 131.4, 130.7, 129.8, 128.9, 128.7, 128.1, 127.8, 127.8, 127.6, 126.4, 126.1, 126.0, 125.9, 125.7, 124.5, 77.3, 77.0, 76.7, 73.7, 66.4, 65.7, 41.8; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_5$ $[M+H]^+$: 427.1307, Found: 427.1304. $[\alpha]^{20}_D$ = 35.0 (c = 6.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2923, 1510, 1241, 1195, 1133, 781. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 15.7 min, t_2 = 18.4 min.

2-chloro-3-hydroxy-2-(thiophen-2-ylmethyl)propyl 1-naphthoate (3i)



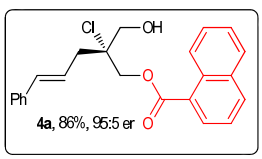
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.94 (d, J = 8.8 Hz, 1H), 8.27 (d, J = 0.8 Hz, 1H), 8.25 (d, J = 0.8 Hz, 1H), 8.06 (d, J = 8.4 Hz, 1H), 7.91-7.62 (m, 3H), 7.57-7.51 (m, 2H), 7.25-7.01 (m, 1H), 7.00-6.97 (m, 2H), 4.65 (d, J = 11.6. Hz, 1H), 4.54 (d, J = 11.6 Hz, 1H), 3.81 (d, J = 7.6 Hz, 2H), 3.54-3.46 (m, 1H), 2.64 (t, J = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.1, 135.8, 134.1, 133.9, 131.4, 130.7, 128.6, 128.4, 128.1, 126.9, 126.4, 126.0, 125.6, 125.3, 124.5, 72.8, 66.1, 65.8, 36.1; HRMS (ESI) calcd. For $C_{19}H_{18}ClO_3S$ $[M+H]^+$: 361.0660, Found: 361.0660. $[\alpha]^{20}_D$ = 30.0 (c = 18.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1719, 1510, 1195, 1132, 1014, 781. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 13.3 min, t_2 = 16.4 min.

2-benzyl-2-fluoro-3-hydroxypropyl 1-naphthoate (3j)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.91 (d, J = 8.8 Hz, 1H), 8.22 (d, J = 7.2 Hz, 1H), 8.05 (d, J = 8.0 Hz, 1H), 7.89 (d, J = 8.0 Hz, 1H), 7.65-7.49 (m, 3H), 7.49-7.25 (m, 5H), 4.63-4.55 (dd, J = 12.0 Hz, 19.2 1H), 4.49-4.42 (dd, J = 12.4 Hz, 19.2 1H), 3.75 (d, J = 19.2 Hz, 2H), 3.20 (d, J = 19.2 Hz, 2H), 2.23 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.3, 134.6, 134.5, 134.0, 133.9, 131.4, 130.6, 130.4, 128.6, 128.5, 128.1, 127.1, 126.4, 126.2, 125.6, 124.4, 97.3, 95.5, 64.5, 64.2, 63.4, 63.1, 38.9, 38.6; HRMS (ESI) calcd. For $C_{21}H_{20}FO_3$ $[M+H]^+$: 339.1391, Found: 339.1390. $[\alpha]^{20}_D$ = 4.8 (c = 14.0 mg/mL, $CHCl_3$), IR ν (cm^{-1}) 3067, 1751, 1690, 1275, 1160, 695. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 24.7 min, t_2 = 29.2 min.

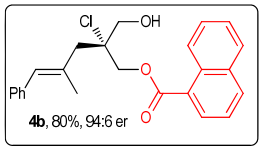
(E)-2-chloro-2-(hydroxymethyl)-5-phenylpent-4-en-1-yl 1-naphthoate (4a)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, J = 8.4 Hz, 1H), 8.25 (d, J = 7.6 Hz, 1H), 8.07 (d, J = 8.0 Hz, 1H), 7.90 (d, J = 8.0 Hz, 1H), 7.66-7.49 (m, 3H), 7.38-7.22 (m, 5H), 6.56 (d, J = 16.0 Hz, 1H), 4.74 (d, J = 12.0 Hz, 1H), 4.62 (d, J = 12.0 Hz, 1H), 3.84 (d, J = 7.2 Hz, 2H), 2.87 (d, J = 7.6 Hz, 2H), 2.56 (t, J = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.2，136.8，134.9，134.0，133.8，131.4，130.7，128.6，128.6，128.1，127.6，126.4，126.3，126.0，125.6，124.5，122.8，73.3，66.5，66.2，39.6; HRMS (ESI) calcd. For $C_{23}H_{22}ClO_3$ $[M+H]^+$: 381.1252, Found: 381.1252. $[\alpha]^{20}_D$ = 26.0 (c = 5.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3453, 2949, 1718, 1195, 1015, 782. The er value was determined

by HPLC (Chiralcel IA, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 21.7 min, t_2 = 25.6 min.

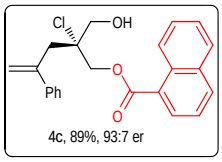
(E)-2-chloro-2-(hydroxymethyl)-4-methyl-5-phenylpent-4-en-1-yl1-naphthoate (4b)



4b, 80%, 94:6 er

Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.92 (d, *J* = 8.8 Hz, 1H), 8.26 (d, *J* = 0.8 Hz, 1H), 8.24 (d, *J* = 0.8 Hz, 1H), 8.05 (d, *J* = 8.0 Hz, 1H), 7.91-7.49 (m, 3H), 7.34-7.21 (m, 5H), 6.47 (s, 1H), 4.76 (d, *J* = 12.0 Hz, 1H), 4.63 (d, *J* = 11.6 Hz, 1H), 3.87-3.85 (dd, *J* = 2.8 Hz, 8.0 Hz, 2H), 2.90-2.81 (m, 2H), 2.66 (t, *J* = 7.2 Hz, 1H), 2.08 (d, *J* = 1.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.3, 137.5, 134.0, 133.9, 132.6, 131.6, 131.4, 130.6, 128.9, 128.6, 128.1, 128.1, 126.6, 126.4, 126.1, 125.7, 124.5, 73.5, 66.6, 66.4, 46.4, 20.6; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_3$ $[M+H]^+$: 395.1408, Found: 395.1408. $[\alpha]^{20}_D$ = 22.0 (*c* = 4.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3453, 2921, 1510, 1241, 1016, 782. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 10.6 min, t_2 = 11.8 min.

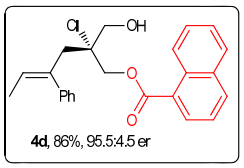
2-chloro-2-(hydroxymethyl)-4-phenylpent-4-en-1-yl 1-naphthoate (4c)



4c, 89%, 93:7 er

Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.87 (d, *J* = 8.4 Hz, 1H), 8.16 (d, *J* = 0.8 Hz, 1H), 8.14 (d, *J* = 0.8 Hz, 1H), 8.03 (d, *J* = 8.4 Hz, 1H), 7.61-7.47 (m, 3H), 7.40-7.37 (m, 2H), 7.28-7.22 (m, 3H), 5.44 (d, *J* = 1.2. Hz, 1H), 5.33 (s, 1H), 4.50 (d, *J* = 11.6.0 Hz, 1H), 4.41 (d, *J* = 11.6 Hz, 1H), 3.70 (s, 1H), 3.27-3.18 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.9, 142.9, 141.7, 133.9, 133.8, 131.6, 131.4, 130.6, 128.6, 128.5, 128.0, 127.8, 126.4, 126.3, 125.7, 124.4, 119.8, 73.5, 66.4, 66.3, 41.1; HRMS (ESI) calcd. For $C_{23}H_{22}ClO_3$ $[M+H]^+$: 381.1252, Found: 381.1255. $[\alpha]^{20}_D$ = 165.0 (*c* = 24.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3482, 2920, 1718, 1195, 1016, 782. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 11.1 min, t_2 = 12.6 min.

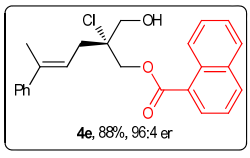
(Z)-2-chloro-2-(hydroxymethyl)-4-phenylhex-4-en-1-yl 1-naphthoate (4d)



4d, 86%, 95.5:4.5 er

Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.87 (d, *J* = 8.4 Hz, 1H), 8.11 (d, *J* = 7.2 Hz, 1H), 8.04 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.64-7.48 (m, 3H), 7.30-7.17 (m, 6H), 5.83-5.80 (dd, J = 7.2 Hz, 13.6 Hz, 1H), 4.45-4.37 (dd, *J* = 11.6 Hz, 22.0 Hz, 2H), 3.64 (d, *J* = 8.8 Hz, 1H), 3.10 (d, *J* = 3.2 Hz, 2H), 2.22 (t, *J* = 7.6 Hz, 1H), 1.65 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ166.8, 140.1, 134.9, 133.8, 131.4, 130.6, 128.8, 128.7, 128.6, 128.3, 127.9, 127.0, 126.3, 126.2, 125.8, 124.4,74.2, 66.5, 66.5, 44.7, 15.0; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_3$ $[M+H]^+$: 395.1408, Found: 395.1404. $[\alpha]^{20}_D$ = 94.0 (*c* = 12.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1719, 1241, 1132, 780, 702. The er value was determined by HPLC (Chiralcel OD, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 22.2 min, t_2 = 25.3 min.

(E)-2-chloro-2-(hydroxymethyl)-5-phenylhex-4-en-1-yl 1-naphthoate (4e)

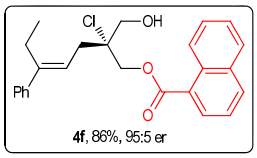


4e, 88%, 96:4 er

Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, *J* = 8.8 Hz, 1H),

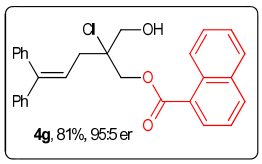
8.23 (d, J = 7.2 Hz, 1H), 8.05 (d, J = 8.0 Hz, 1H), 7.89 (d, J = 8.0 Hz, 1H), 7.65-7.47 (m, 3H), 7.40-7.23 (m, 5H), 5.96 (t, J = 7.6 Hz, 1H), 4.47 (d, J = 12.0 Hz, 1H), 4.62 (d, J = 12.0 Hz, 1H), 3.85 (d, J = 6.0 Hz, 2H), 2.89-2.85 (m, 1H), 2.08 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 143.4, 139.3, 134.0, 133.9, 131.4, 130.6, 128.6, 128.2, 128.1, 127.1, 126.4, 126.1, 125.8, 125.6, 124.5, 120.6, 74.0, 66.5, 66.4, 35.1, 16.5; HRMS (ESI) calcd. For $C_{24}H_{24}ClO_3$ $[M+H]^+$: 395.1408, Found: 395.1409. $[\alpha]^{20}_D$ = 74.0 (c = 15.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3485, 2944, 1733, 1165, 1017, 782. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 19.0 min, t_2 = 20.1 min.

(E)-2-chloro-2-(hydroxymethyl)-5-phenylhept-4-en-1-yl 1-naphthoate (4f)



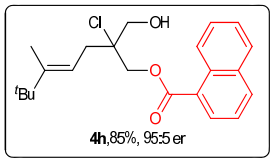
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, J = 8.8 Hz, 1H), 8.24 (d, J = 7.2 Hz, 1H), 8.05 (d, J = 8.4 Hz, 1H), 7.90 (d, J = 8.0 Hz, 1H), 7.65-7.48 (m, 3H), 7.37-7.25 (m, 6H), 5.80 (t, J = 7.6 Hz, 1H), 4.63 (d, J = 11.6 Hz, 1H), 3.85 (d, J = 7.2 Hz, 1H), 2.90-2.87 (dd, J = 3.2 Hz, 7.6 Hz, 2H), 2.61-2.52 (m, 3H), 0.95 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.3, 146.1, 142.4, 134.0, 133.9, 131.4, 130.7, 128.6, 128.3, 128.1, 127.1, 126.5, 126.4, 126.1, 125.6, 124.5, 120.1, 73.8, 66.6, 66.3, 34.7, 23.3, 13.3; HRMS (ESI) calcd. For $C_{25}H_{26}ClO_3$ $[M+H]^+$: 409.1565, Found: 409.1560. $[\alpha]^{20}_D$ = 58.0 (c = 13.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3451, 2965, 1719, 1277, 1132, 781. The er value was determined by HPLC (Chiralcel OD-H, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 50.8 min, t_2 = 57.6 min.

2-chloro-2-(hydroxymethyl)-5,5-diphenylpent-4-en-1-yl 1-naphthoate (4g)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.90 (d, J = 8.4 Hz, 1H), 8.03 (d, J = 8.4 Hz, 1H), 7.95 (d, J = 7.2 Hz, 1H), 7.89 (d, J = 11.6 Hz, 1H), 7.63-7.52 (m, 2H), 7.44-7.40 (m, 1H), 7.29-7.15 (m, 10H), 6.34 (t, J = 7.2 Hz, 1H), 4.59 (S, 1H), 3.78 (d, J = 6.8 Hz, 1H), 2.82 (d, J = 6.8 Hz, 2H), 2.82 (d, J = 7.6 Hz, 3H), 2.32 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 166.9, 145.7, 142.0, 139.5, 133.9, 133.8, 131.4, 130.6, 129.7, 128.6, 128.4, 128.2, 128.0, 127.5, 127.3, 126.3, 125.8, 125.7, 124.4, 121.8, 73.7, 66.5, 66.2, 35.6; HRMS (ESI) calcd. For $C_{29}H_{26}ClO_3$ $[M+H]^+$: 457.1565, Found: 457.1565. $[\alpha]^{20}_D$ = 46.0 (c = 9.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1720, 1242, 1195, 1139, 780. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 29.8 min, t_2 = 33.5 min.

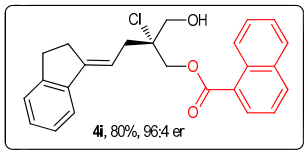
(E)-2-chloro-2-(hydroxymethyl)-5,6,6-trimethylhept-4-en-1-yl 1-naphthoate (4h)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, J = 8.8 Hz, 1H), 8.24 (d, J = 7.2 Hz, 1H), 8.06 (d, J = 8.0 Hz, 1H), 7.90 (d, J = 8.0 Hz, 1H), 7.65-7.50 (m, 2H), 5.42 (d, J = 7.2 Hz, 1H), 4.67 (d, J = 11.6 Hz, 1H), 4.56 (d, J = 11.6 Hz, 1H), 3.81 (d, J = 7.2 Hz, 2H), 2.70-2.67 (m, 2H), 2.51 (t, J = 7.2 Hz, 3H), 1.65 (s, 3H), 1.06 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 148.1, 134.0, 133.9, 131.4, 130.6, 128.6, 128.0, 126.4, 126.2, 125.7, 124.5, 113.7, 74.5, 66.5, 66.4, 36.6, 34.6, 29.0, 13.3; HRMS (ESI) calcd. For $C_{22}H_{28}ClO_3$ $[M+H]^+$:

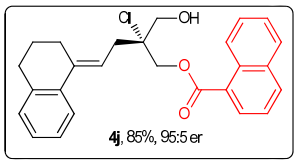
375.1721, Found: 375.1728. $[\alpha]^{20}_{D}$ = 31.0 (*c* = 10.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2988, 1722, 1241, 781. The er value was determined by HPLC (Chiralcel ID, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 14.0 min, t_2 = 15.7 min.

(E)-2-chloro-4-(2,3-dihydro-1H-inden-1-ylidene)-2-(hydroxymethyl)butyl 1-naphthoate (4i)



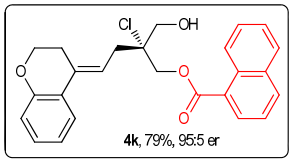
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.97 (d, *J* = 8.8 Hz, 1H), 8.29 (d, *J* = 7.6 Hz, 1H), 8.19 (d, *J* = 8.0 Hz, 1H), 7.94 (d, *J* = 8.4 Hz, 1H), 7.69-7.53 (m, 4H), 7.29-7.22 (m, 3H), 6.16-6.13 (m, 1H), 4.80 (d, *J* = 11.6 Hz, 1H), 4.68 (d, *J* = 11.6 Hz, 1H), 3.90 (d, *J* = 10.8 Hz, 2H), 3.03-2.96 (m, 2H), 2.91 (d, *J* = 7.2 Hz, 2H), 2.81 (d, *J* = 5.6 Hz, 2H), 2.65-2.62 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.3, 146.6, 146.3, 140.9, 134.0, 133.9, 131.4, 130.6, 128.6, 128.1, 128.1, 126.5, 126.4, 126.1, 125.6, 125.3, 124.7, 124.5, 120.3, 111.3, 74.2, 66.7, 66.3, 36.1, 29.9, 28.2; HRMS (ESI) calcd. For $C_{25}H_{24}ClO_3$ $[M+H]^+$: 407.1408, Found: 407.1400. $[\alpha]^{20}_{D}$ = 81.0 (*c* = 9.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1719, 1459, 1241, 1194, 1132, 781. The er value was determined by HPLC (Chiralcel OD-H, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 30.6 min, t_2 = 42.5 min.

(E)-2-chloro-4-(3,4-dihydronaphthalen-1(2H)-ylidene)-2-(hydroxymethyl)butyl 1-naphthoate (4j)



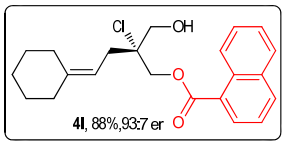
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.97 (d, *J* = 8.8 Hz, 1H), 8.29 (d, *J* = 1.2 Hz, 1H), 8.27 (d, *J* = 1.2 Hz, 1H), 8.10 (d, *J* = 8.0 Hz, 1H), 7.95-7.20 (m, 4H), 7.15-7.12 (m, 3H), 6.23 (t, *J* = 7.6 Hz, 1H), 4.77 (d, *J* = 12.0 Hz, 1H), 4.67 (d, *J* = 11.6 Hz, 1H), 3.91-3.89 (m, 2H), 2.95-2.92 (m, 2H), 2.82-2.79 (m, 2H), 2.64-2.56 (m, 2H), 1.86-1.83 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 138.6, 137.5, 135.8, 134.0, 133.9, 131.4, 130.6, 128.9, 128.6, 128.1, 127.2, 126.4, 126.1, 125.6, 124.5, 124.0, 116.3, 74.2, 66.6, 66.4, 34.5, 30.3, 26.9, 23.2; HRMS (ESI) calcd. For $C_{26}H_{26}ClO_3$ $[M+H]^+$: 421.1565, Found: 421.1563. $[\alpha]^{20}_{D}$ = 80.0 (*c* = 13.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2987, 1720, 1510, 1240, 1133, 780. The er value was determined by HPLC (Chiralcel ODH, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 88.9 min, t_2 = 99.3 min.

(E)-2-chloro-4-(chroman-4-ylidene)-2-(hydroxymethyl)butyl 1-naphthoate (4k)



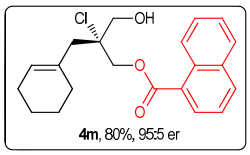
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.92 (d, *J* = 8.4 Hz, 1H), 8.25 (d, *J* = 0.8 Hz, 1H), 8.15 (d, *J* = 6.0 Hz, 1H), 7.99 (d, *J* = 5.6 Hz, 1H), 7.17-7.13 (m, 1H), 6.91-6.83 (m, 2H), 6.22 (t, *J* = 7.6 Hz, 1H), 4.74 (d, *J* = 12.0 Hz, 1H), 4.60 (d, *J* = 12.0 Hz, 1H), 4.16 (t, *J* = 5.6 Hz, 2H), 2.69 (t, *J* = 5.6 Hz, 2H), 2.61 (t, *J* = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.3, 154.4, 134.2, 133.9, 132.8, 131.4, 130.7, 129.1, 128.7, 126.5, 126.0, 125.6, 124.5, 124.0, 120.8, 117.5, 114.4, 66.6, 66.2, 35.9, 26.1; HRMS (ESI) calcd. For $C_{25}H_{24}ClO_4$ $[M+H]^+$: 423.1358, Found: 423.1359. $[\alpha]^{20}_{D}$ = 40.0 (*c* = 5.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2962, 1719, 1450, 1096, 1019, 801. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 51.8 min, t_2 = 58.3 min.

2-chloro-4-cyclohexylidene-2-(hydroxymethyl)butyl 1-naphthoate (4l)



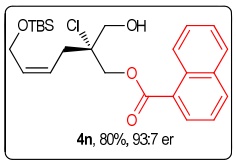
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, *J* = 9.6 Hz, 1H), 8.24 (d, *J* = 7.2 Hz, 1H), 8.06 (d, *J* = 8.0 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.65-7.45 (m, 3H), 5.27 (t, *J* = 7.6 Hz, 1H), 4.65 (d, *J* = 11.6 Hz, 1H), 4.58 (d, *J* = 11.6 Hz, 1H), 3.81 (d, *J* = 6.8 Hz, 2H), 2.74-2.62 (m, 2H), 2.48 (t, *J* = 7.2 Hz, 3H), 2.17-2.14 (m, 4H), 1.57-1.48 (m, 7H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 144.8, 134.0, 133.9, 131.4, 130.6, 128.6, 128.0, 126.4, 126.2, 125.7, 124.5, 113.6, 74.3, 66.5, 66.4, 37.4, 33.6, 29.1, 28.6, 27.7, 26.7; HRMS (ESI) calcd. For $C_{22}H_{26}ClO_3$ $[M+H]^+$: 373.1565, Found: 373.1561. $[\alpha]^{20}_D$ = 35.0 (*c* = 6.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 2918, 1718, 1446, 1195, 1015, 781. The er value was determined by HPLC (Chiralcel ID, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 19.6 min, t_2 = 27.5 min.

2-chloro-3-(cyclohex-1-en-1-yl)-2-(hydroxymethyl)propyl 1-naphthoate (4m)



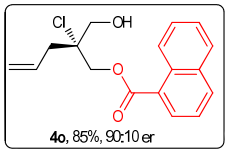
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.94 (d, *J* = 8.4 Hz, 1H), 8.24 (d, *J* = 7.6 Hz, 1H), 8.06 (d, *J* = 8.0 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.57-7.26 (m, 2H), 5.63 (s, 1H), 4.68 (d, *J* = 12.0 Hz, 1H), 4.56 (d, *J* = 11.6 Hz, 1H), 3.80-3.78 (m, 2H), 2.67-2.54 (m, 3H), 2.18-2.15 (m, 2H), 2.04 (m, 2H), 1.64-1.55 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 134.0, 133.9, 132.1, 131.4, 130.6, 128.6, 128.4, 128.0, 126.4, 126.2, 125.7, 124.5, 73.6, 66.6, 66.5, 44.2, 30.8, 25.5, 23.0, 22.0; HRMS (ESI) calcd. For $C_{21}H_{24}ClO_3$ $[M+H]^+$: 359.1408, Found: 359.1405. $[\alpha]^{20}_D$ = 88.0 (*c* = 18.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3474, 1719, 1511, 1241, 1133, 1017. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 21.6 min, t_2 = 25.9 min.

(Z)-6-((tert-butyldimethylsilyl)oxy)-2-chloro-2-(hydroxymethyl)hex-4-en-1-yl 1-naphthoate (4n)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.95 (d, *J* = 8.4 Hz, 1H), 8.26 (d, *J* = 7.2 Hz, 1H), 8.05 (d, *J* = 8.0 Hz, 1H), 7.89 (dd, *J* = 12.0 Hz, 15.2 Hz, 1H), 4.32-4.27 (dd, *J* = 11.6 Hz, 15.2 Hz, 1H), 4.15-4.10 (dd, *J* = 12.4 Hz, 6.0 Hz, 1H), 3.78-3.73 (m, 2H), 3.68-3.64 (m, 1H), 2.95-2.90 (dd, *J* = 8.8 Hz, 14.4 Hz, 1H), 2.66-2.61 (dd, *J* = 6.4 Hz, 14.4 Hz, 3H), 0.89 (s, 9H), 0.08 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.0, 133.8, 132.4, 131.5, 130.6, 128.6, 128.0, 126.4, 126.3, 126.2, 125.8, 124.5, 72.6, 67.5, 64.9, 58.7, 33.0, 25.8, 18.3; HRMS (ESI) calcd. For $C_{24}H_{34}ClO_4Si$ $[M+H]^+$: 449.1909, Found: 449.1900. $[\alpha]^{20}_D$ = 146.0 (*c* = 13.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3418, 2954, 1721, 1462, 1242, 837. The er value was determined by HPLC (Chiralcel OD-H, hexane/isopropanol = 90:10, flow rate = 0.75 mL/min), retention time: t_1 = 17.4 min, t_2 = 22.7 min.

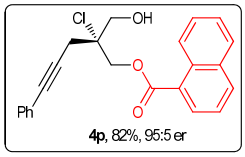
2-chloro-2-(hydroxymethyl)pent-4-en-1-yl 1-naphthoate (4o)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 6.4 Hz, 1H), 8.05 (d, *J* = 8.4 Hz, 1H), 7.99 (d, *J* = 8.4 Hz, 1H), 7.65 (d, *J* = 1.2 Hz, 1H),

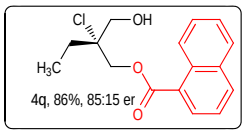
7.64-7.61 (m, 1H), 7.57-7.50 (m, 2H), 6.03-5.92 (m, 1H), 3.79 (d, *J* = 6.8 Hz, 2H), 2.71 (d, *J* = 7.2 Hz, 2H), 2.57 (t, *J* = 6.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.2, 134.0, 133.9, 131.4, 130.6, 128.6, 128.1, 126.4, 126.1, 125.6, 124.5, 120.2, 72.7, 66.3, 66.2, 40.3; HRMS (ESI) calcd. For $C_{17}H_{18}ClO_3$ $[M+H]^+$: 305.0939, Found: 305.0934. $[\alpha]^{20}_D$ = 170.0 (*c* = 15.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3500, 2948, 1542, 1462, 1015, 778. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 14.4 min, t_2 = 16.2 min.

2-chloro-2-(hydroxymethyl)-5-phenylpent-4-yn-1-yl 1-naphthoate (4p)



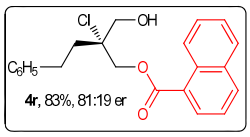
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.94 (d, *J* = 8.4 Hz, 1H), 8.26 (d, *J* = 7.2 Hz, 1H), 8.05 (d, *J* = 8.0 Hz, 1H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.65-7.48 (m, 3H), 7.43-7.41 (m, 2H), 7.32-7.25 (m, 3H), 4.85 (d, *J* = 12.0 Hz, 1H), 4.76 (d, *J* = 12.0 Hz, 1H), 3.97 (d, *J* = 6.8 Hz, 2H), 3.02-3.11 (dd, *J* = 17.6 Hz, 20.0 Hz, 2H), 2.56 (t, *J* = 7.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.1, 134.0, 133.9, 131.7, 131.4, 130.7, 128.6, 128.3, 128.1, 126.4, 126.1, 125.7, 124.5, 122.8, 84.3, 83.2, 71.6, 66.6, 66.3, 28.2; HRMS (ESI) calcd. For $C_{23}H_{20}ClO_3$ $[M+H]^+$: 379.1095, Found: 379.1099. $[\alpha]^{20}_D$ = 104.0 (*c* = 12.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1718, 1490, 1241, 1132, 1016, 781. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 97:3, flow rate = 0.75 mL/min), retention time: t_1 = 32.8 min, t_2 = 36.0 min.

(R)-2-chloro-2-(hydroxymethyl)butyl 1-naphthoate (4q)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.92 (d, *J* = 8.8 Hz, 1H), 8.23-8.21 (dd, *J* = 1.2 Hz, 7.2 Hz, 1H), 8.05 (d, *J* = 8.0 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.66-7.62 (m, 1H), 7.57-7.49 (m, 2H), 4.68 (d, *J* = 15.6 Hz, 1H), 4.59 (d, *J* = 15.6 Hz, 1H), 3.80 (t, *J* = 1.2 Hz, 2H), 2.58-2.55 (m, 1H), 2.04-1.92 (m, 2H), 1.14-1.11 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.3, 134.0, 133.9, 131.4, 130.6, 128.6, 128.1, 126.4, 126.1, 125.6, 124.5, 74.2, 66.6, 66.4, 44.1, 24.7, 24.2; HRMS (ESI) calcd. For $C_{16}H_{18}ClO_3$ $[M+H]^+$: 293.0939, Found: 293.0938. $[\alpha]^{20}_D$ = 28.0 (*c* = 12.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3420, 2964, 1728, 1442, 1245, 837. The er value was determined by HPLC (Chiralcel ID, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 21.1 min, t_2 = 25.9.0 min.

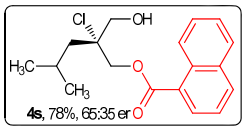
(R)-2-chloro-2-(hydroxymethyl)-4-phenylbutyl 1-naphthoate (4r)



Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.92 (d, *J* = 8.8 Hz, 1H), 8.21 (d, *J* = 6.6 Hz, 1H), 8.04 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.64-7.60 (m, 1H), 7.56-7.48 (m, 2H), 7.30-7.17 (m, 5H), 4.73 (d, *J* = 15.6 Hz, 1H), 4.63 (d, *J* = 15.6 Hz, 1H), 3.83 (s, 2H), 2.92-2.88 (dd, *J* = 7.6 Hz, 9.2 Hz, 2H), 2.25-2.19 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 167.2, 141.0, 134.3, 134.1, 133.8, 131.4, 130.6, 128.6, 128.6, 128.4, 128.1, 128.0, 126.3, 126.2, 126.2, 126.0, 125.9, 125.6, 124.5, 73.5, 66.2, 66.1, 37.7, 30.0; HRMS (ESI) calcd. For $C_{22}H_{22}ClO_3$ $[M+H]^+$: 369.1252, Found: 369.1256. $[\alpha]^{20}_D$ = 24.0 (*c* = 18.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 1718, 1470, 1261, 1156, 1043, 781. The er value was determined by HPLC (Chiralcel IA, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 21.2 min, t_2 = 23.0

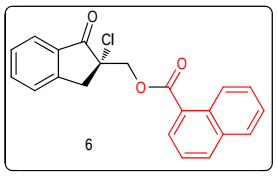
min.

(R)-2-chloro-2-(hydroxymethyl)-4-methylpentyl 1-naphthoate (4s)



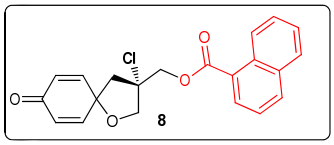
Yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.22 (d, *J* = 1.2 Hz, 1H), 8.21 (d, *J* = 1.2 Hz, 1H), 8.06 (d, *J* = 8.0 Hz, 1H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.65-7.61 (m, 1H), 7.57-7.50 (m, 2H), 4.68 (d, *J* = 12.0 Hz, 1H), 4.61 (d, *J* = 12.0 Hz, 1H), 3.78 (d, *J* = 7.2 Hz, 2H), 2.59 (t, *J* = 7.2 Hz, 1H), 2.01-1.99 (m, 1H), 1.86 (d, *J* = 5.6 Hz, 2H), 1.66-1.04 (dd, *J* = 3.6 Hz, 6.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ167.3, 134.0, 133.9, 131.4,130.6, 128.6, 128.1, 126.4, 126.1, 125.6, 124.5, 74.2, 66.6, 66.4, 44.1, 24.7, 24.2; HRMS (ESI) calcd. For $C_{18}H_{22}ClO_3$ $[M+H]^+$: 321.1252, Found: 321.1258. $[\alpha]^{20}_D$ = 18.0 (*c* = 10.0 mg/mL, $CHCl_3$). IR ν (cm^{-1}) 3418, 2954, 1721, 1462, 1242, 837. The er value was determined by HPLC (Chiralcel ID, hexane/isopropanol = 95:5, flow rate = 0.75 mL/min), retention time: t_1 = 13.7 min, t_2 = 15.4 min.

(S)-(2-chloro-1-oxo-2,3-dihydro-1H-inden-2-yl)methyl 1-naphthoate (6)



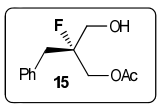
Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.80 (d, *J* = 8.0 Hz, 1H), 7.98 (d, *J* = 8.0 Hz, 1H), 7.91 (d, *J* = 7.6 Hz, 1H), 7.87-7.83 (m, 2H), 7.56-7.46 (m, 4H), 7.36 (t, *J* = 7.6 Hz, 4H), 4.96-4.79 (dd, *J* = 11.2 Hz, 32.8 Hz, 1H), 3.82 (d, *J* = 11.8 Hz, 1H), 3.63 (d, *J* = 18.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.3, 166.2, 150.2, 136.4, 133.9, 133.7, 133.5, 131.3, 130.6, 128.5, 128.4, 128.0, 126.5, 126.3, 125.6, 125.5,124.4, 66.9, 66.0, 41.1; HRMS (ESI) calcd. For $C_{21}H_{16}ClO_3$, $[M+H]^+$: 351.0782, Found: 351.0788.

(3-chloro-8-oxo-1-oxaspiro[4.5]deca-6,9-dien-3-yl)methyl 1-naphthoate (8)



Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.93 (d, *J* = 8.4 Hz, 1H), 8.24 (d, *J* = 7.2 Hz, 1H), 8.10 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 1H), 7.67-7.53 (m, 3H), 7.34-7.26 (m, 1H), 6.80-6.77 (dd, *J* = 2.8 Hz, 10.0 Hz, 1H), 6.22-6.17 (m, 2H), 4.77 (d, *J* = 11.6 Hz, 1H), 4.70 (d, *J* = 12.0 Hz, 1H), 4.43-4.36 (dd, *J* = 7.6 Hz, 16.0 Hz, 2H), 2.70-2.61 (dd, *J* = 14.8 Hz, 20.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ185.0，166.5，148.0，147.6，134.3，133.9，131.4，130.6，128.7，128.2，128.1，127.4，126.5，125.7，125.5，124.5，78.2，78.0，72.6，67.8，48.8; HRMS (ESI) calcd. For $C_{21}H_{18}ClO_4$ $[M+H]^+$: 369.0888, Found: 369.0889. $[\alpha]^{20}_D$ = 20.0 (*c* = 4.0 mg/mL, $CHCl_3$).

(R)-2-benzyl-2-fluoro-3-hydroxypropyl acetate (15)



Colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.33-7.23 (m, 5H), 4.28-4.09 (m, 2H), 3.64-3.59 (dd, *J* = 3.6 Hz, 12.4 Hz, 1H), 3.05 (d, *J* = 21.2 Hz, 2H), 2.13 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 1171.0, 134.5, 134.5, 130.3, 128.4, 127.0, 97.0, 95.3, 64.1, 63.8, 63.1, 62.8, 38.57, 38.4, 20.7; HRMS (ESI) calcd. For $C_{11}H_{14}ClO_3$ $[M+H]^+$: 229.0626, Found: 229.0629. $[\alpha]^{20}_D$ = 6.0 (*c* = 14.0 mg/mL, $CHCl_3$).

7. References

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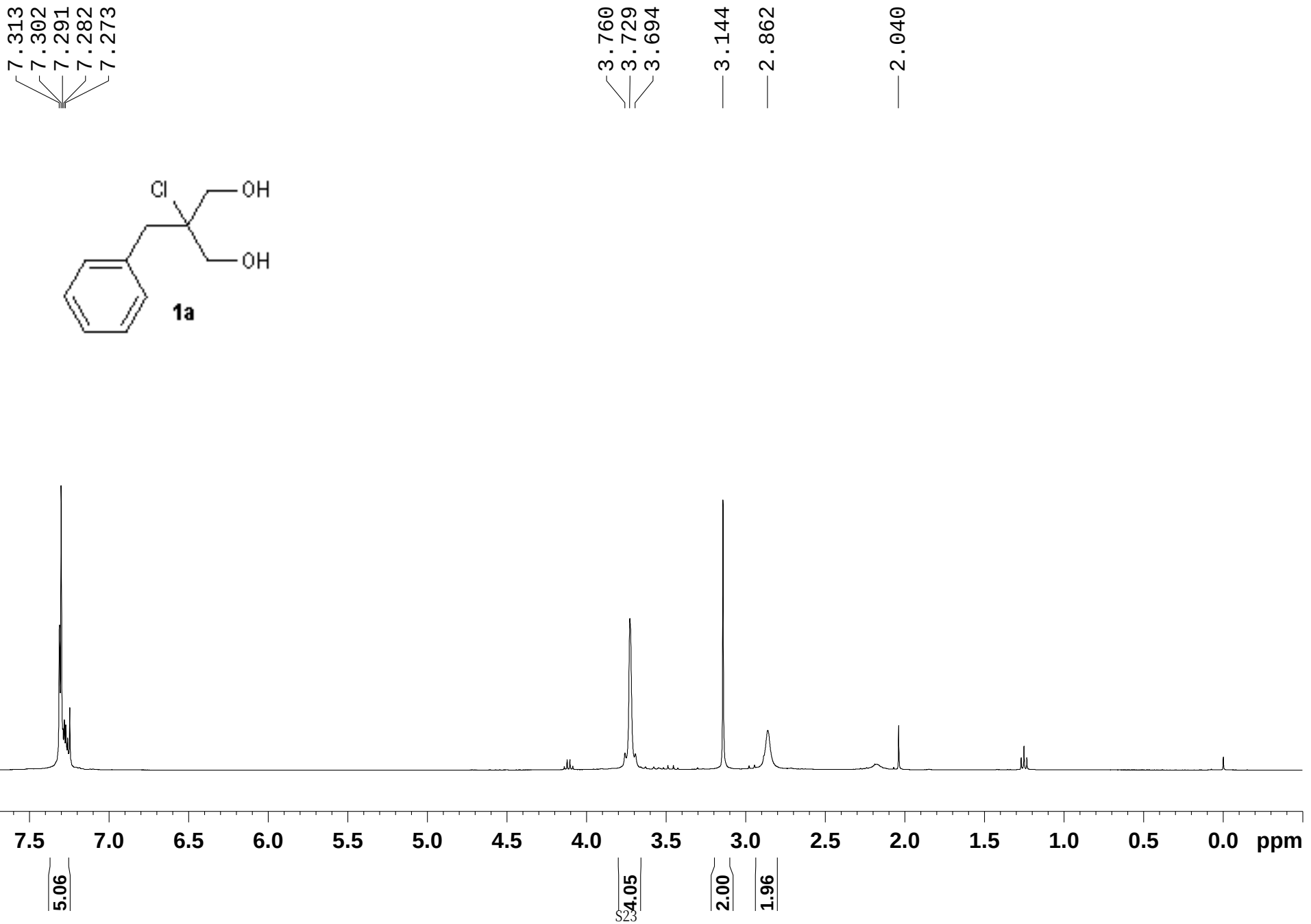
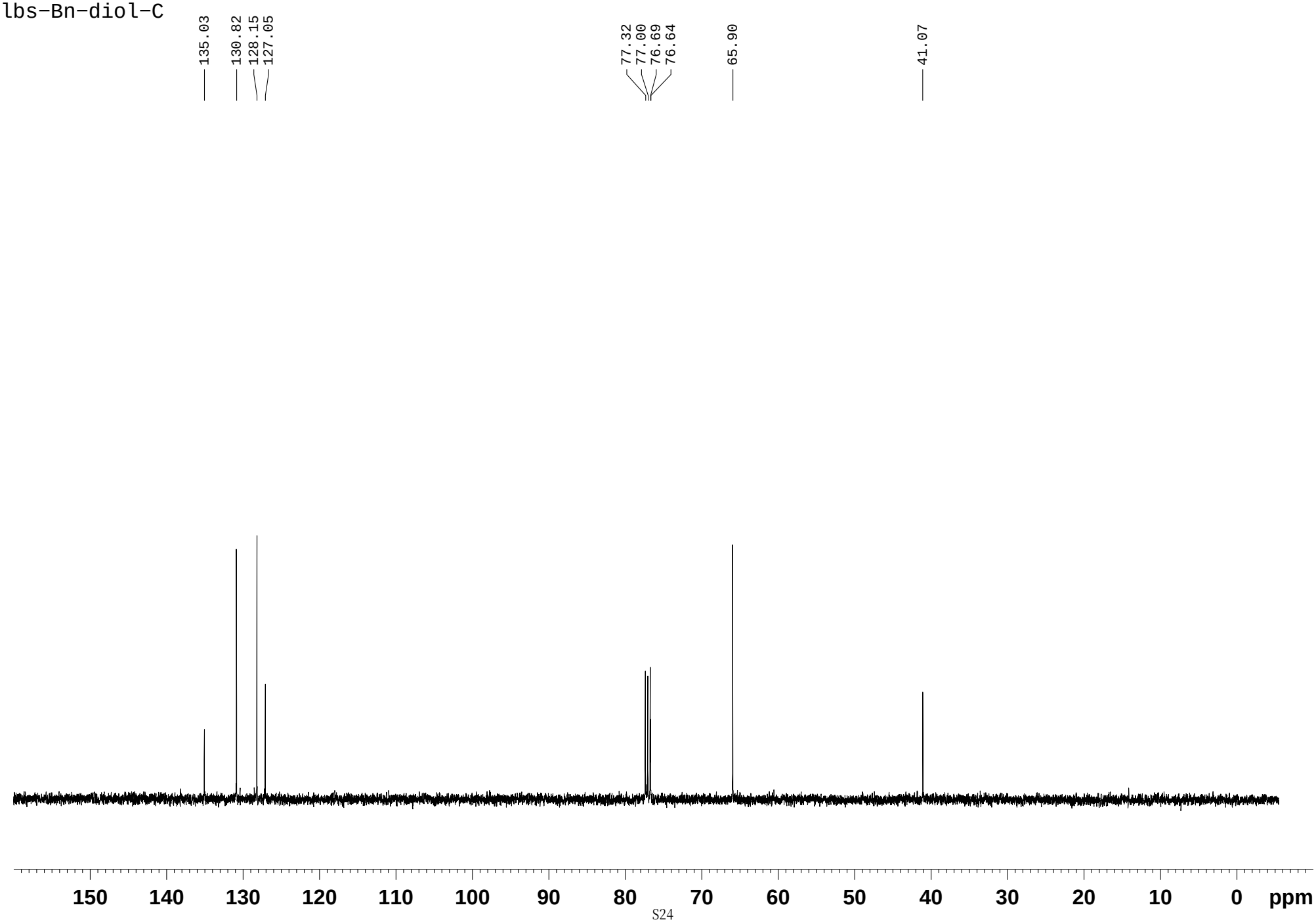
lbs-Bn-diol-H1



lbs-Bn-diol-C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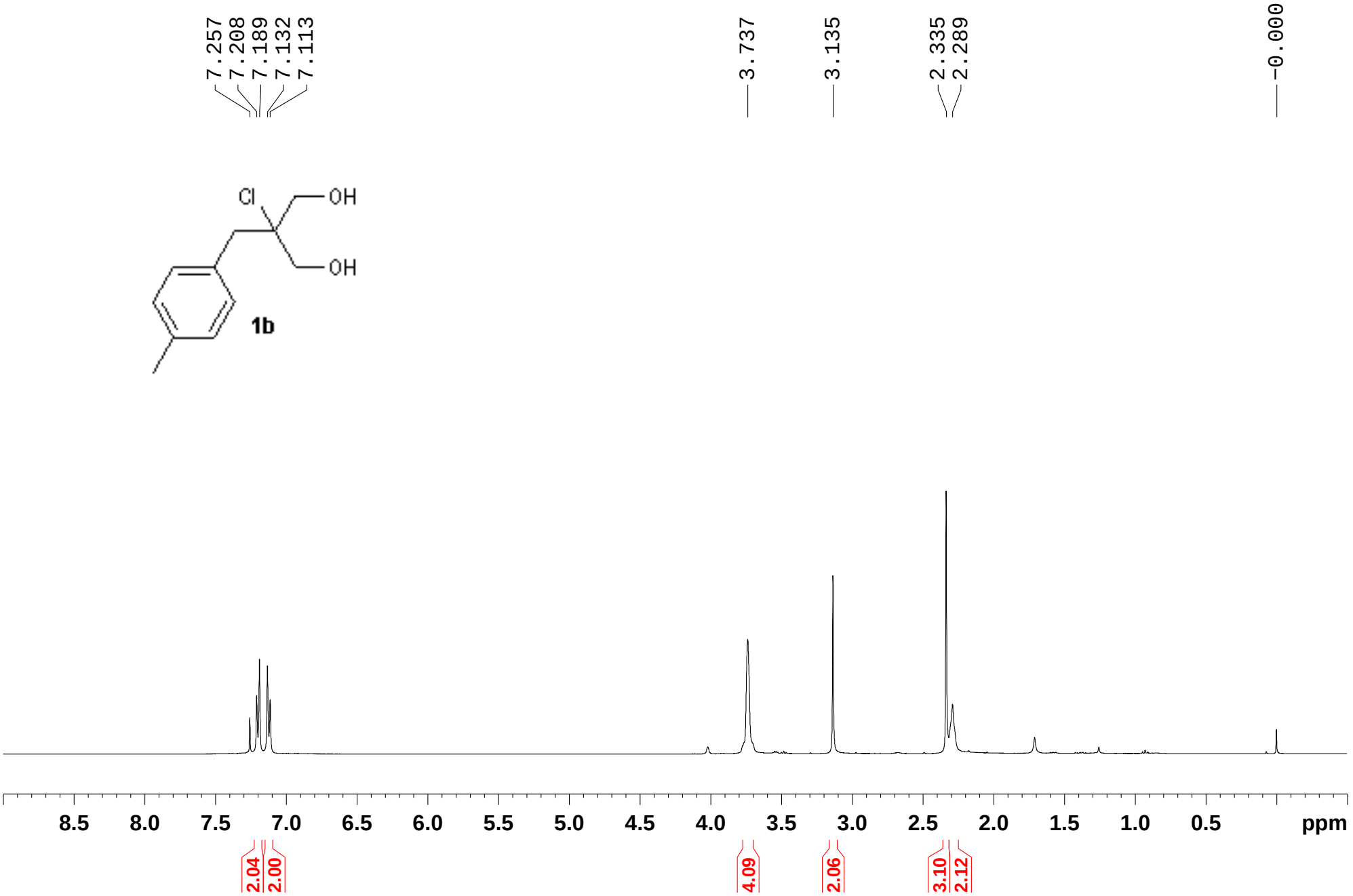
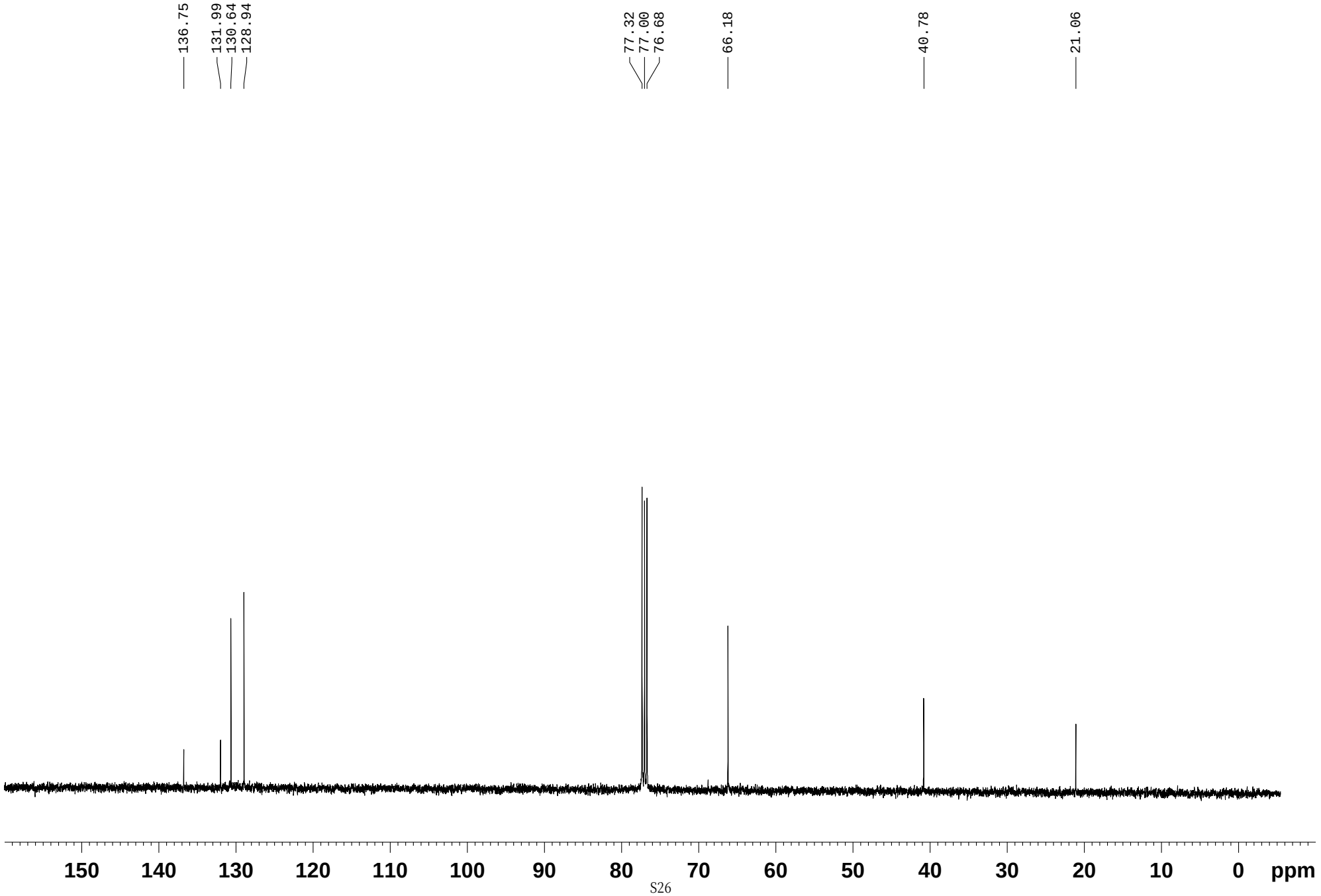
77.00
76.69
76.64
65.90
41.07
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

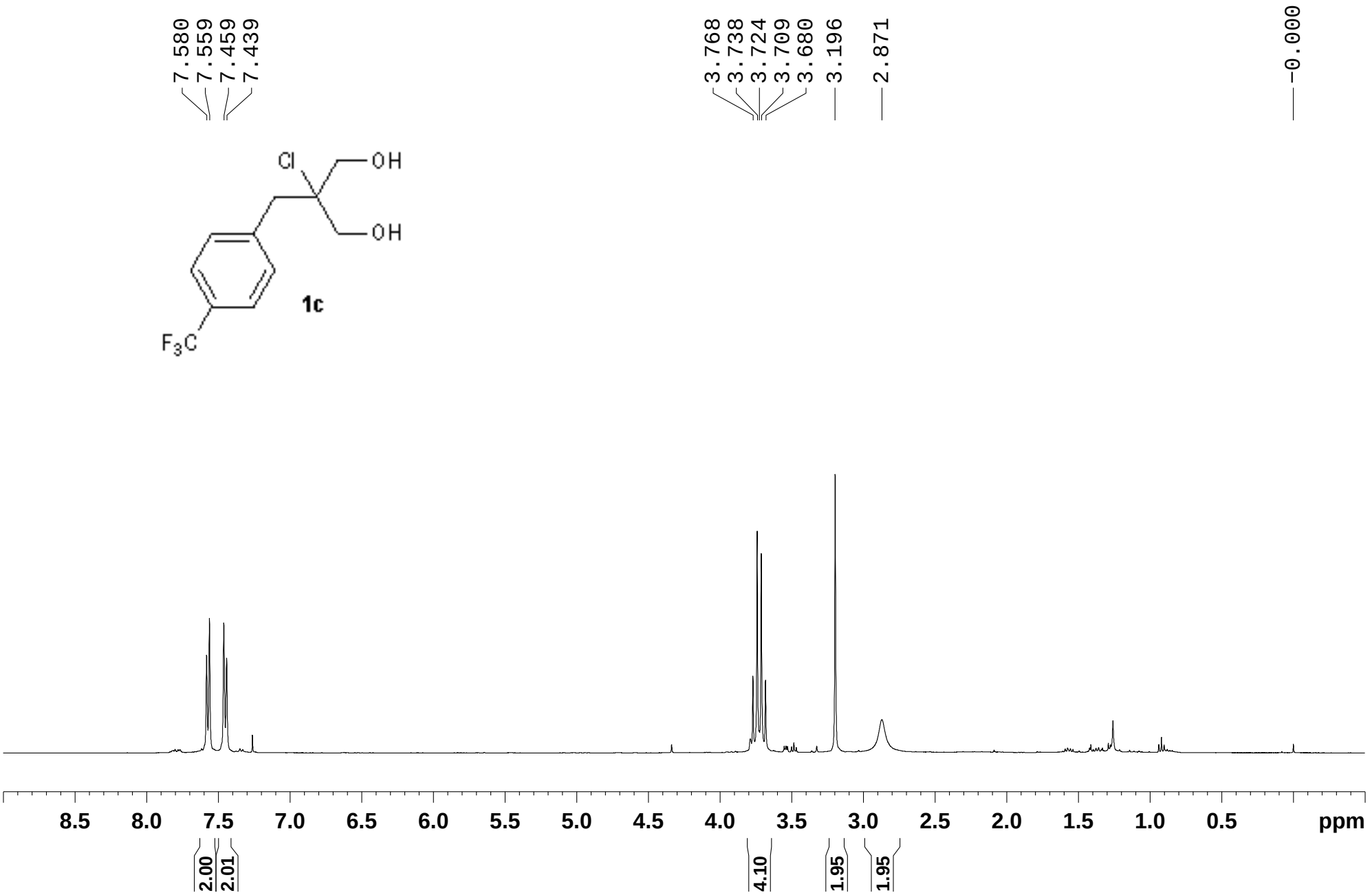
lbs-4-Me-diol-H



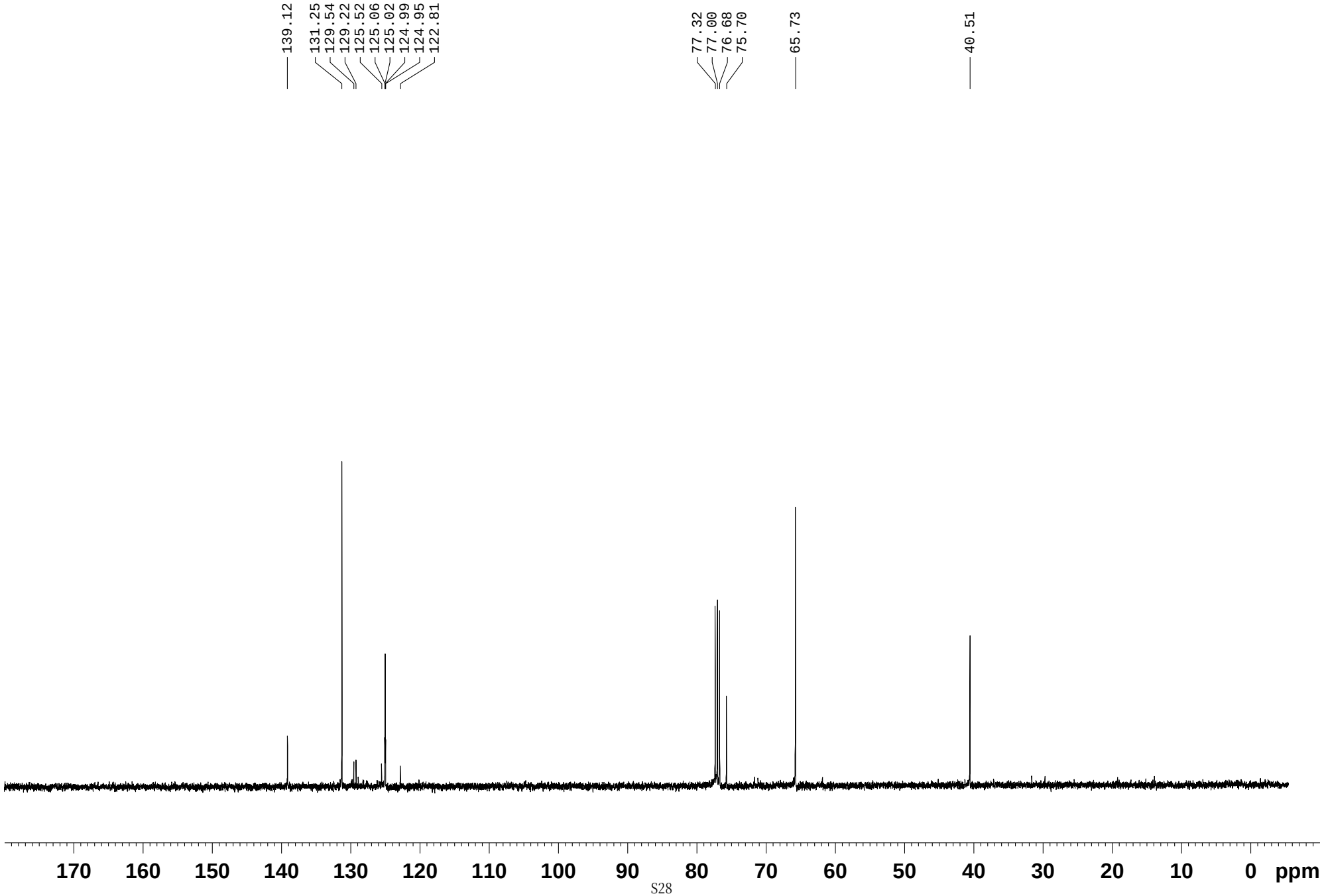
lbs-4-Me-diol-C



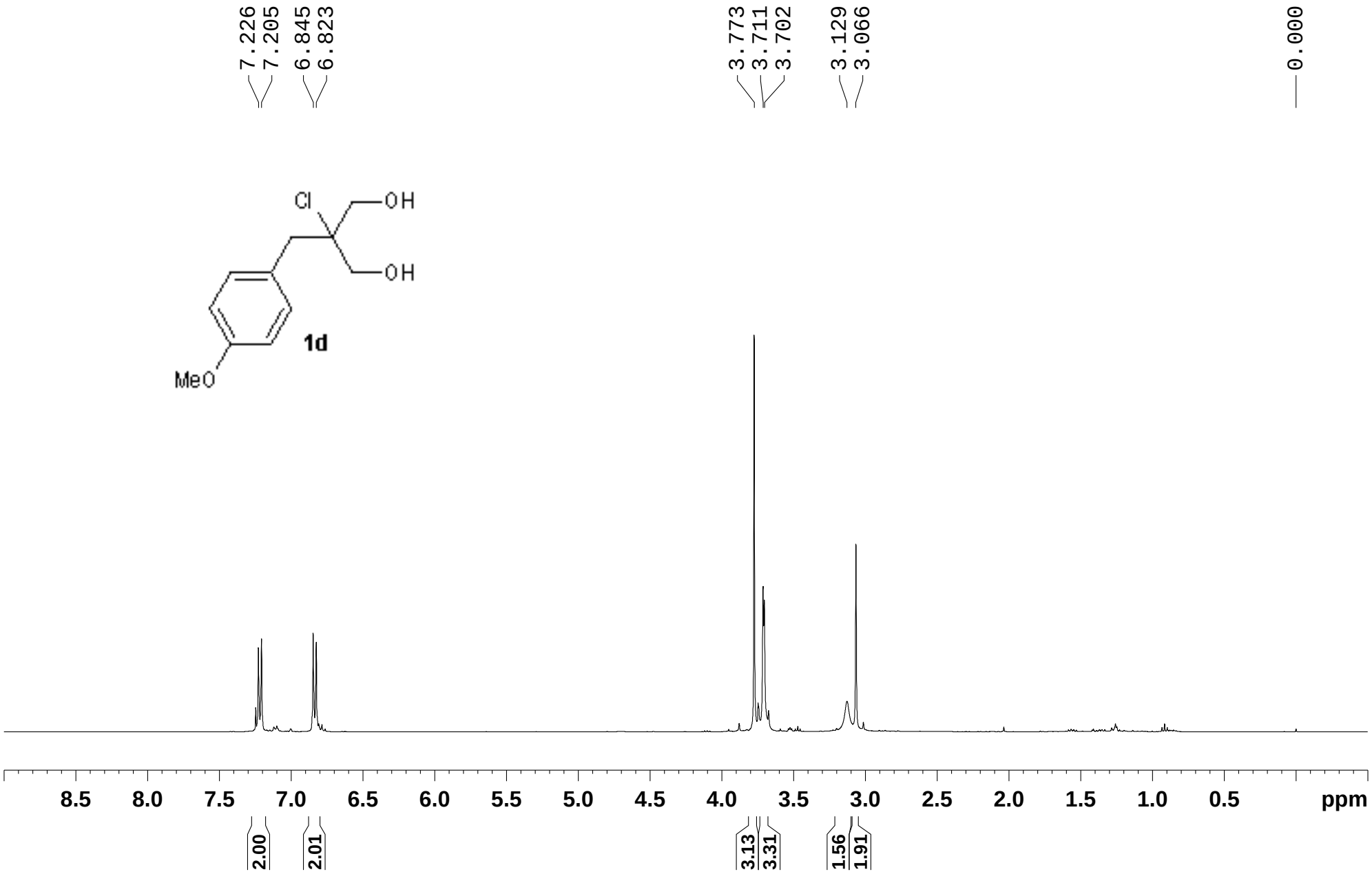
lbs-4-CF3-diol-H



lbs-4-CF3-diol-C



lbs-4-MeO-diol-H



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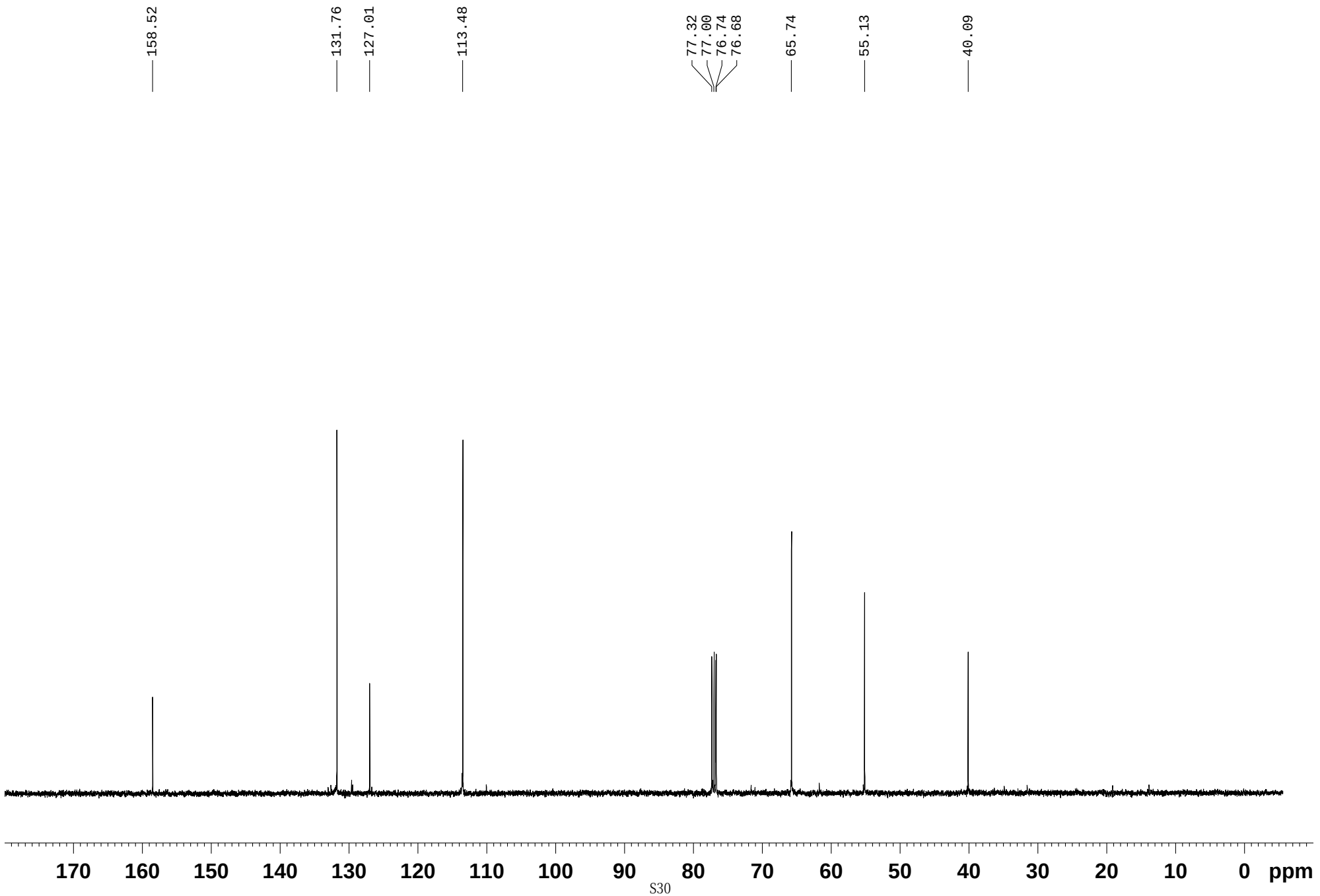

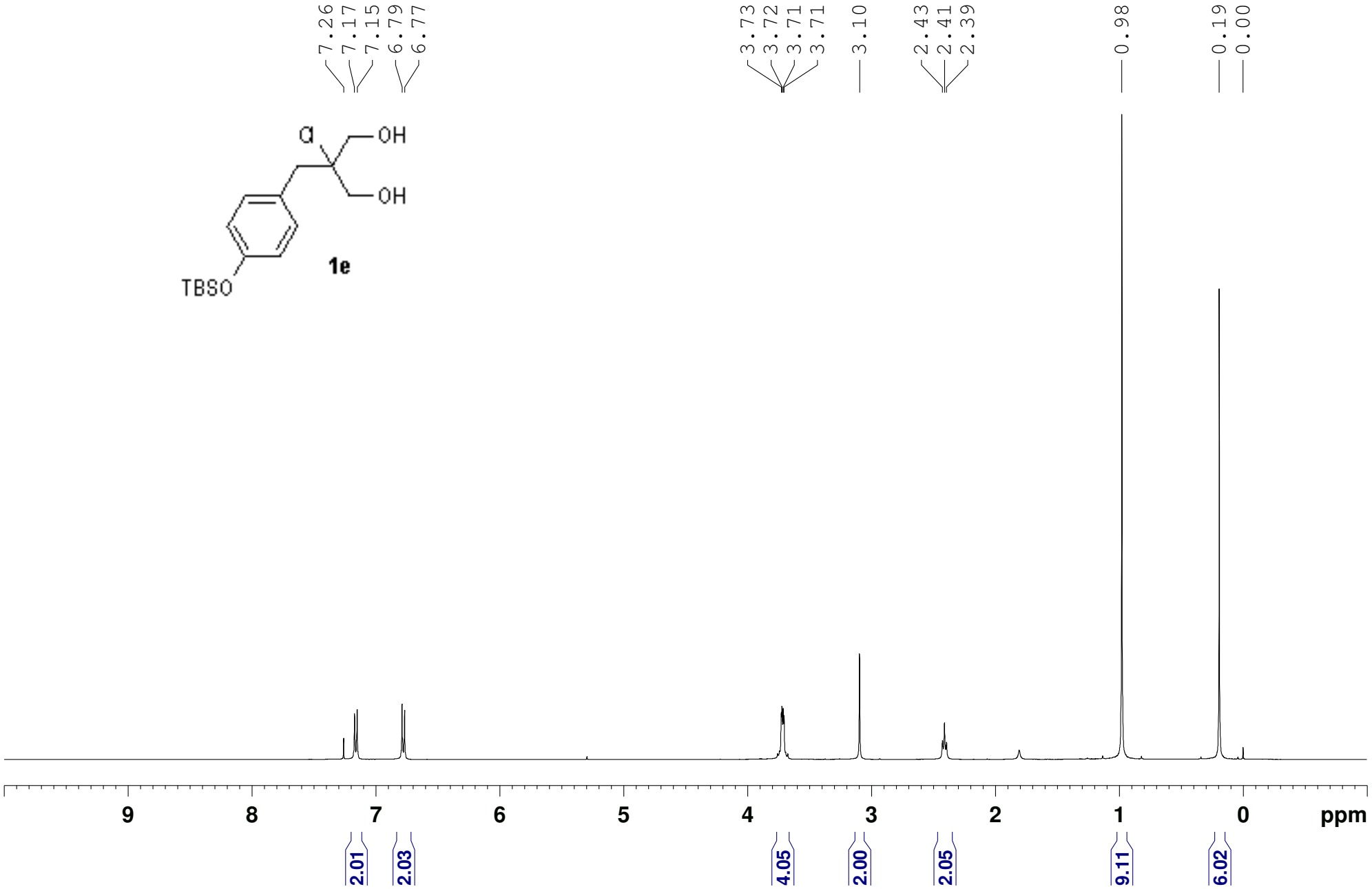
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3.73
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3.71
3.71
3.10
2.43
2.41
2.39
0.98
0.19
0.00
Cl
OH
OH
TBSO
1e
9
8
7
6
5
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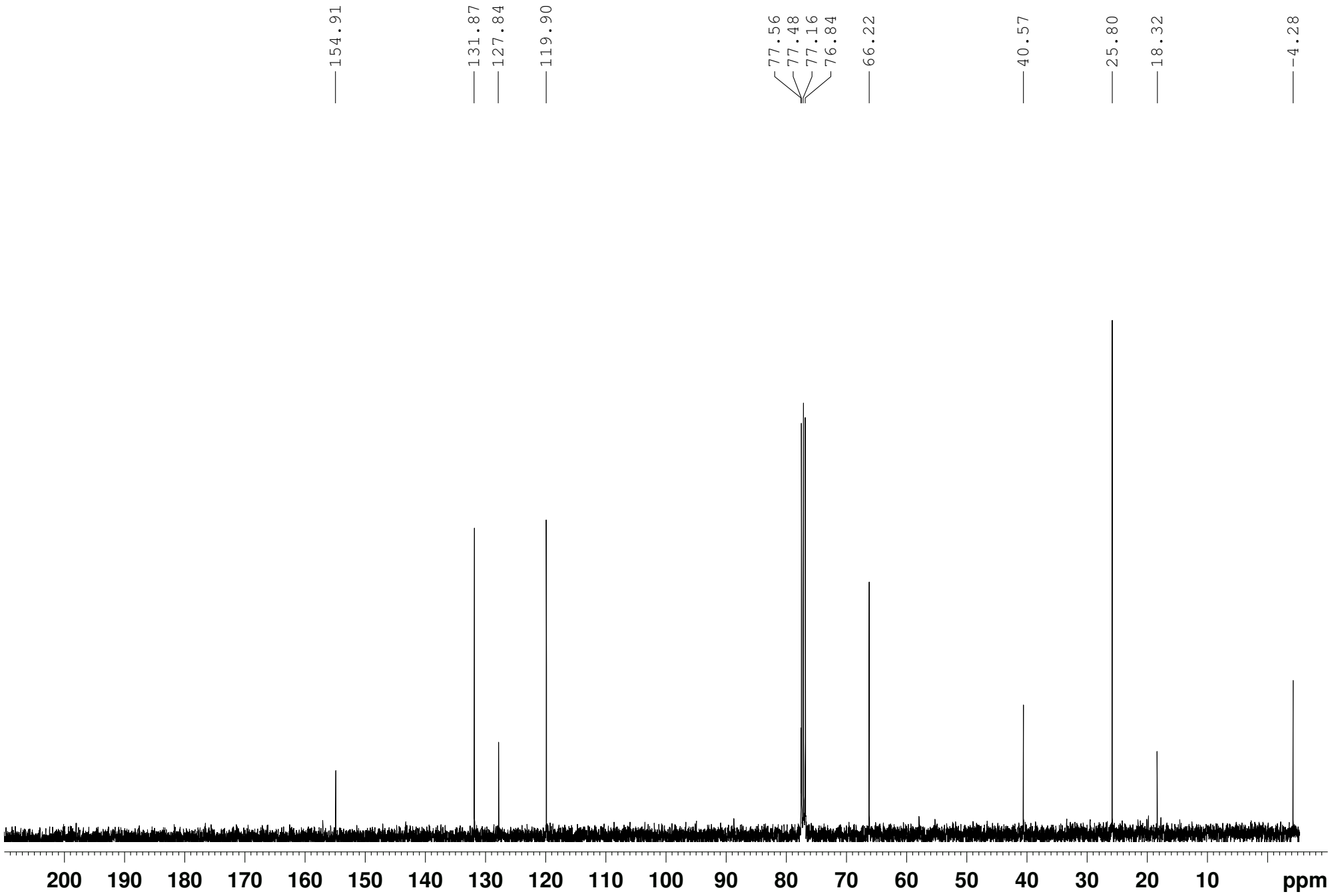
3
2
1
0
ppm
2.01
2.03
4.05
2.00
2.05
9.11
6.02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40.57
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18.32
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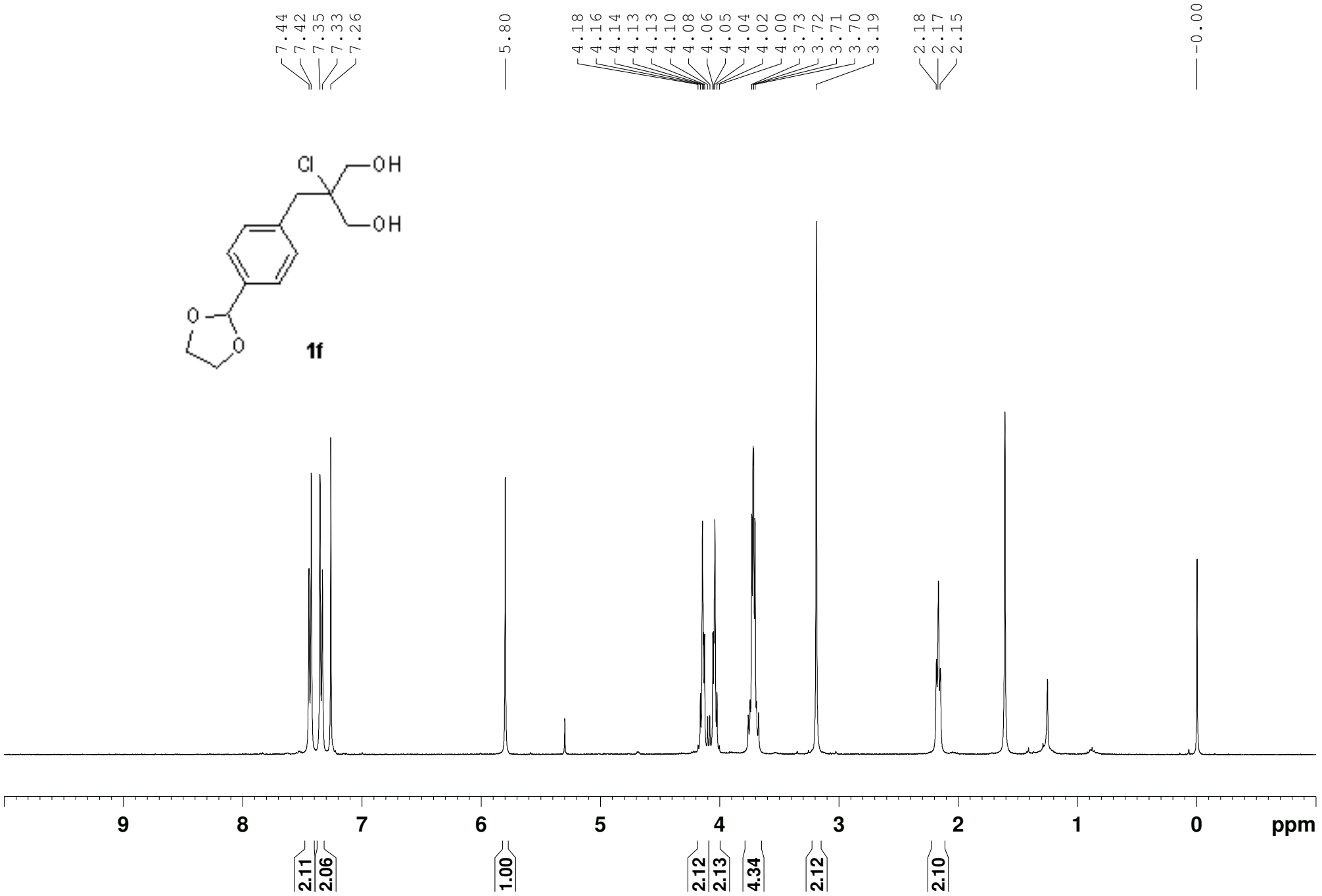
10
ppm


7.44
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4.16
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4.06
4.05
4.04
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2.18
2.17
2.15
0.00
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O
O
1f
9
8
7
6
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4
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1
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2.06
1.00
2.12
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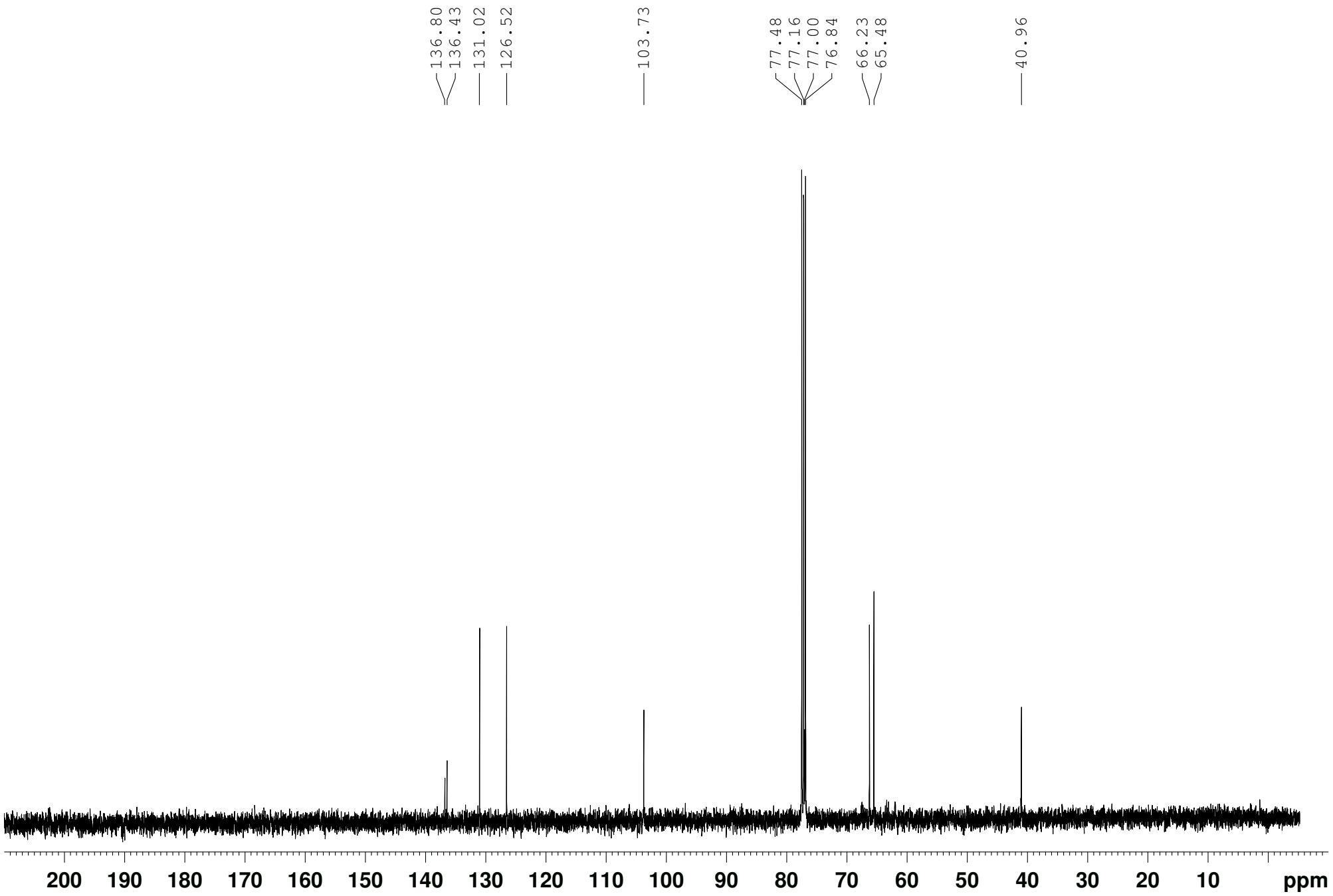
2.12
2.10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131.02
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65.48
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190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
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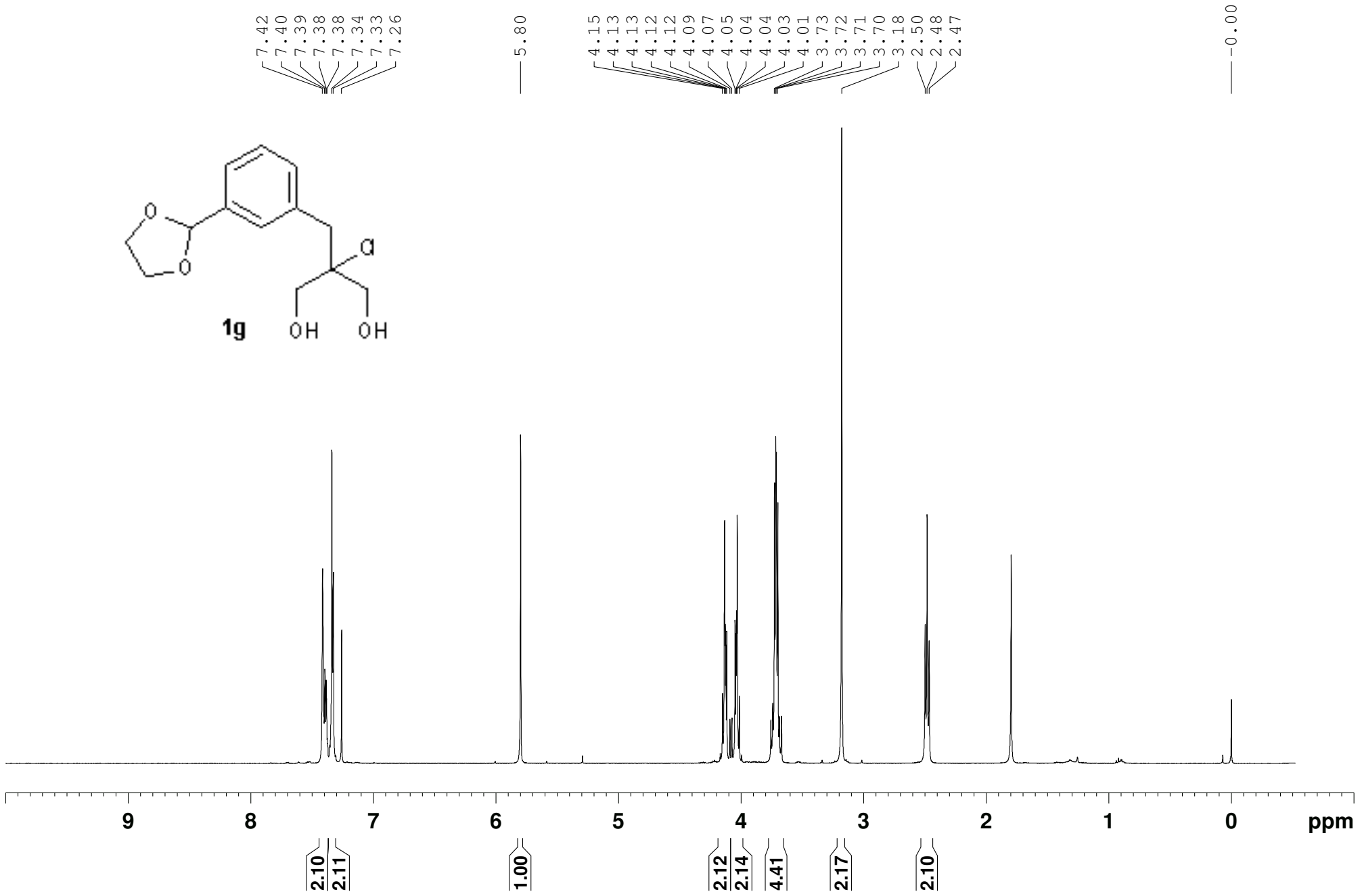
ppm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4.12
4.09
4.07
4.05
4.04
4.04
4.03
4.01
3.73
3.72
3.71
3.70
3.18
2.50
2.48
2.47
0.00
O
O
Cl
OH
OH
1g
9
8
7
6
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2.12
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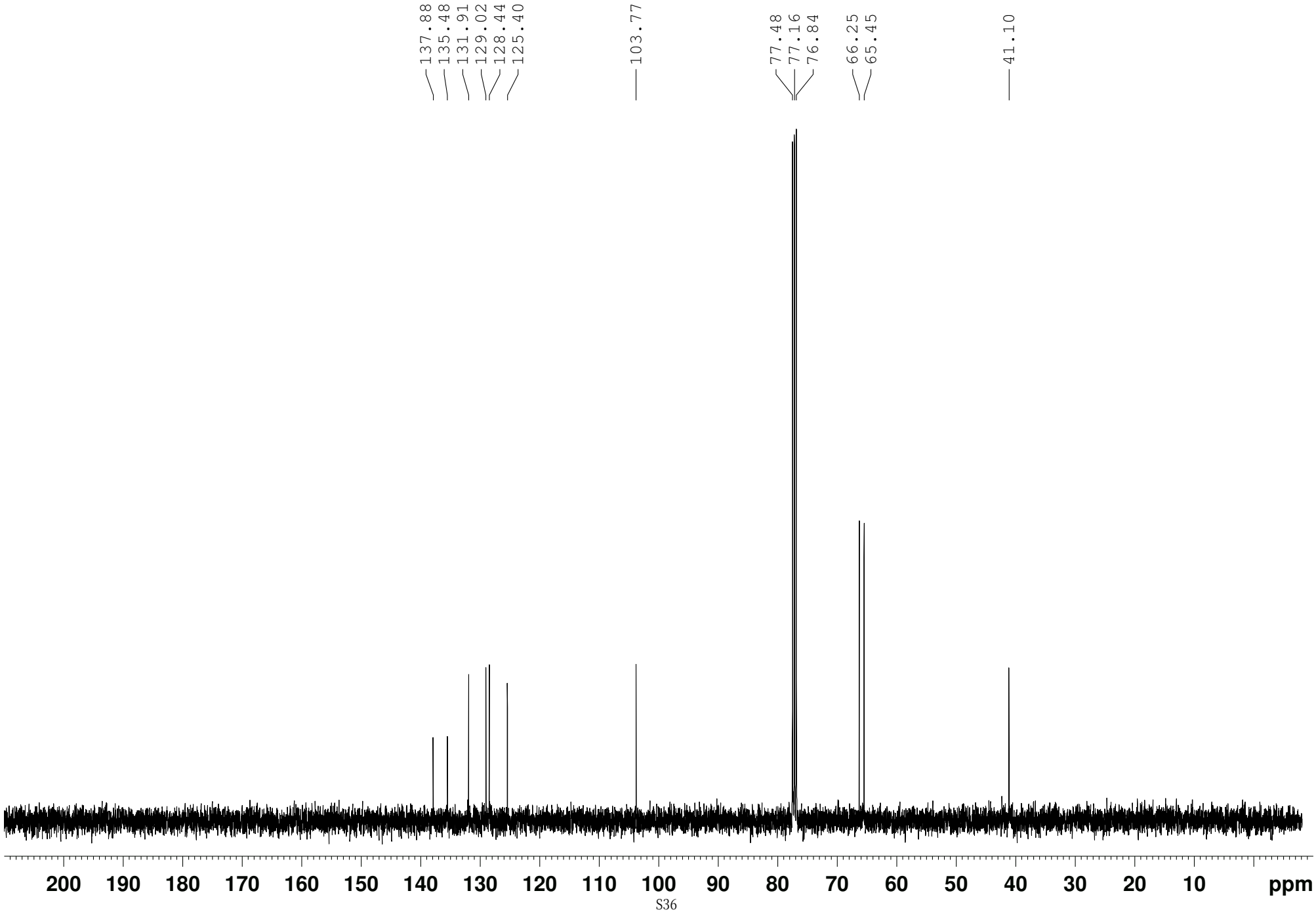
2.10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65.45
41.10
200
190
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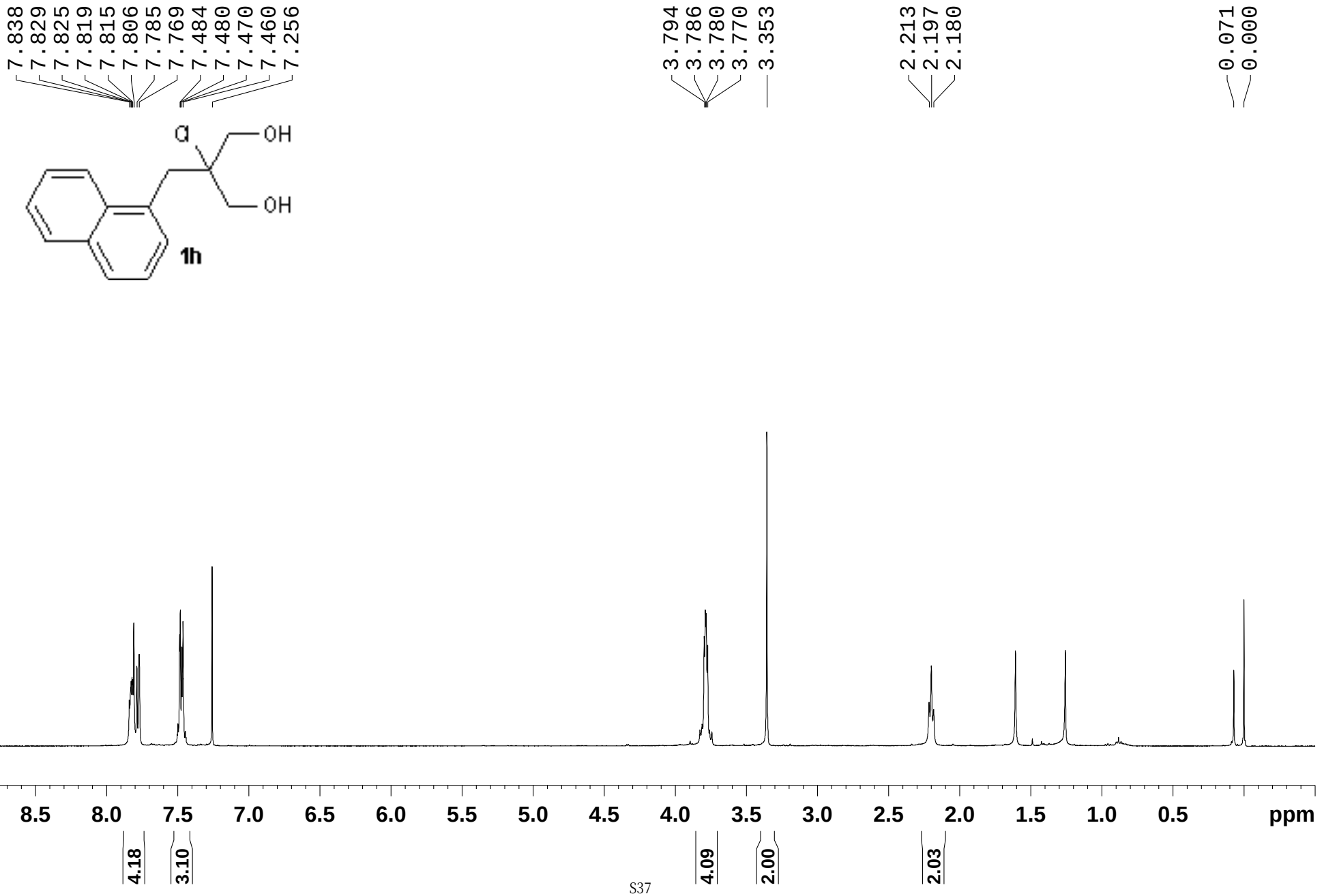
20
10
ppm

lbs-NAP-diol-H



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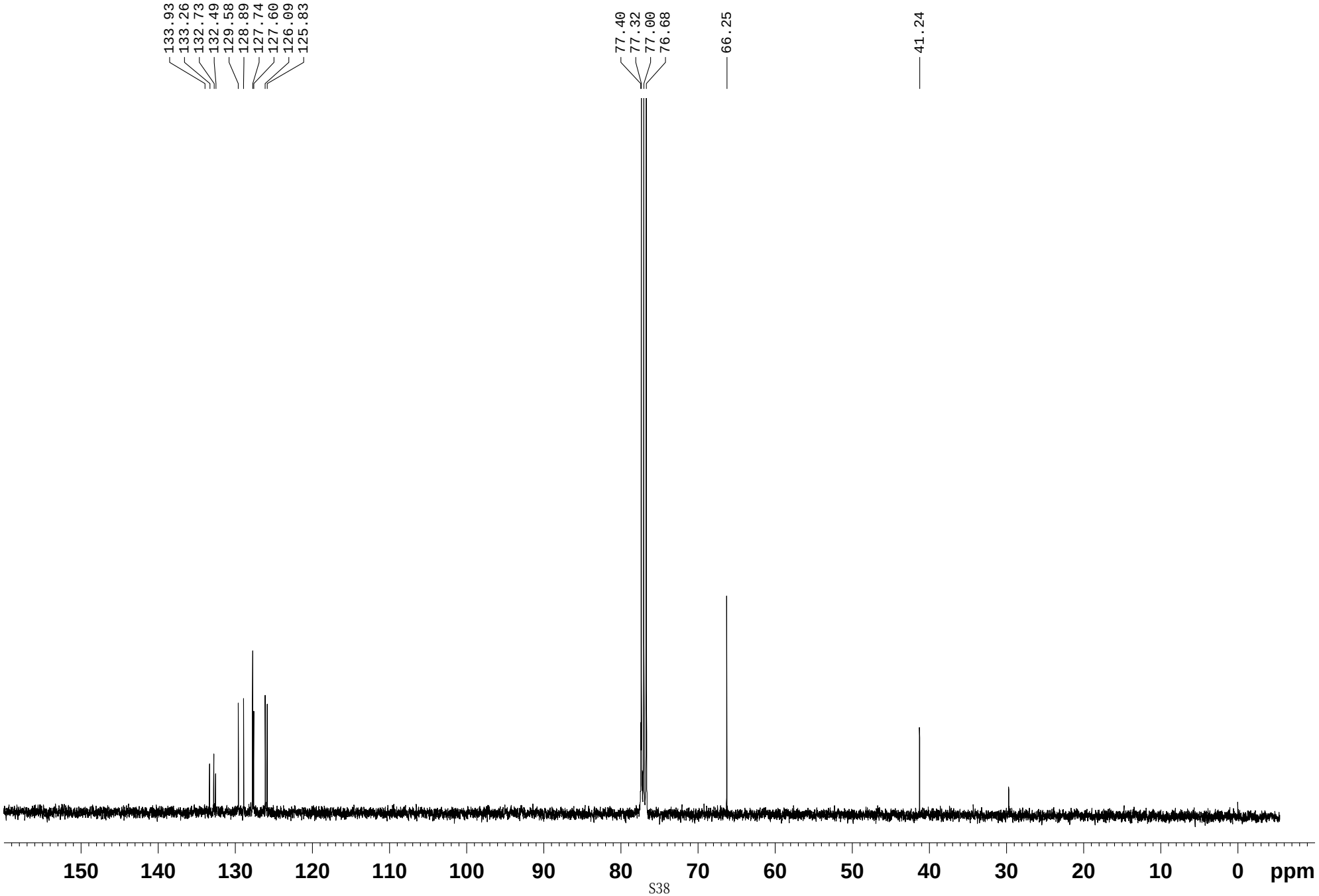

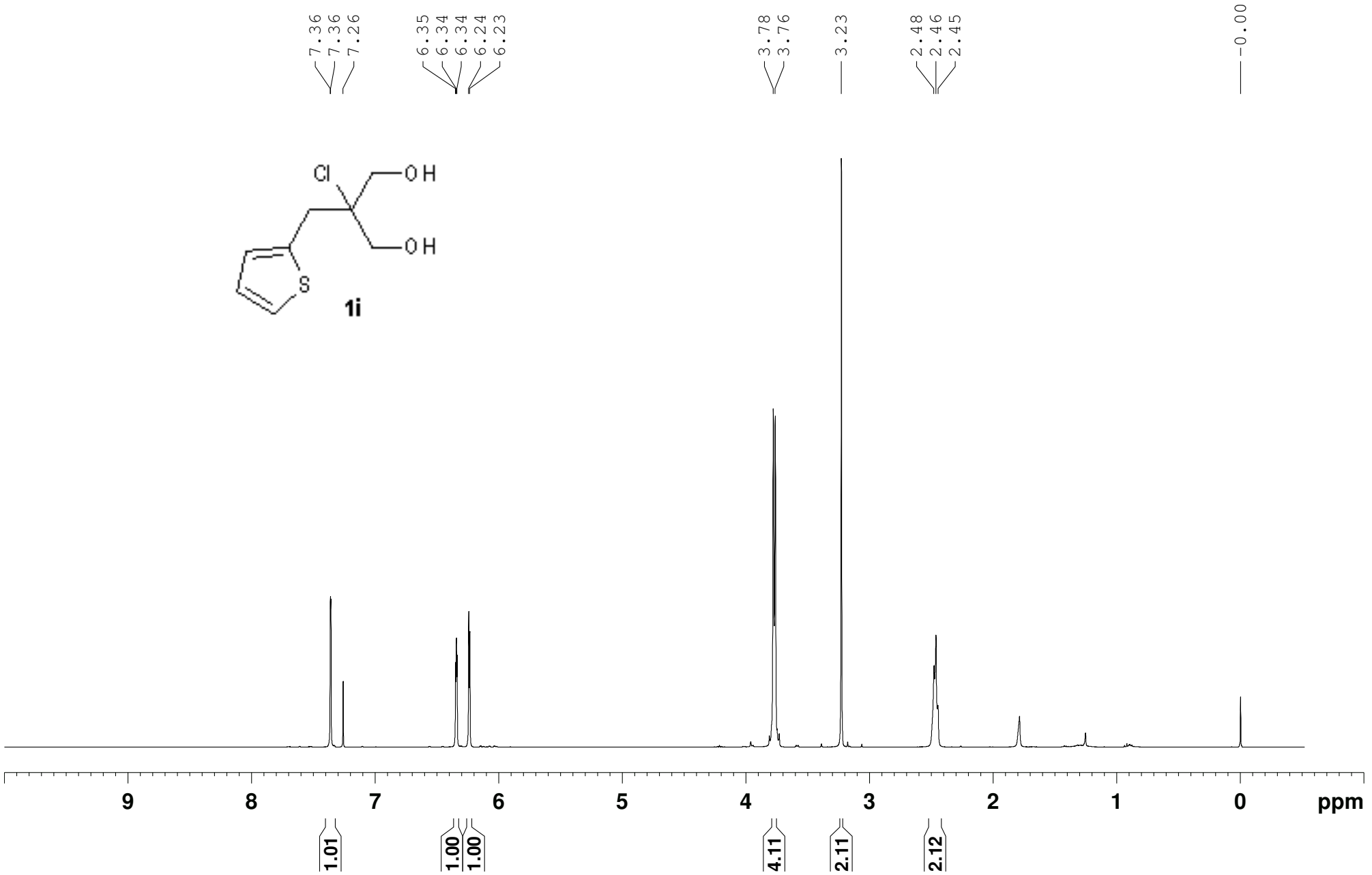
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2.45
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OH
OH
S
1i
9
8
7
6
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1.00
1.00
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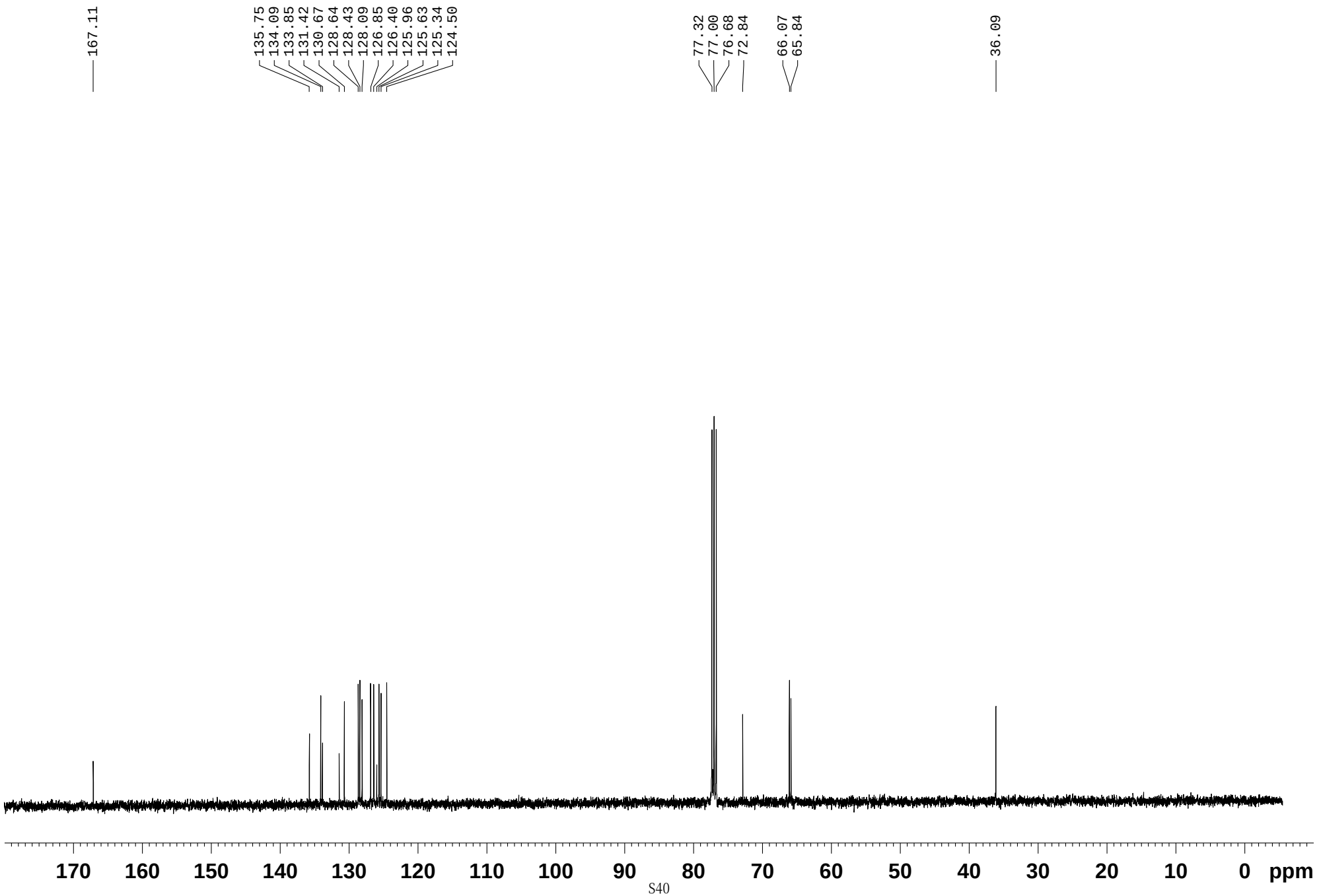
2.11
2.12

2-Cl-thiol-C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77.32
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76.68
72.84
66.07
65.84
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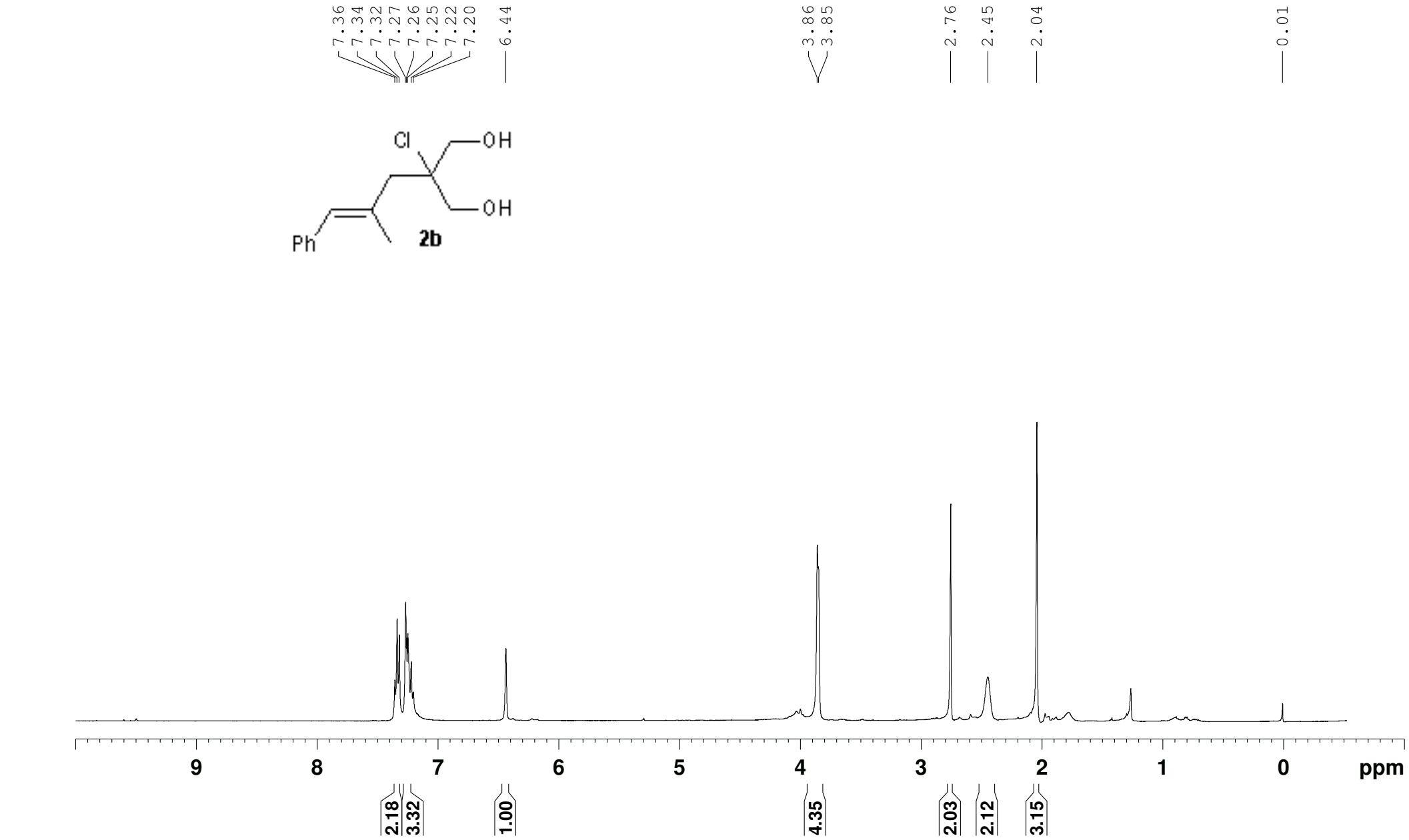
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OH
Ph
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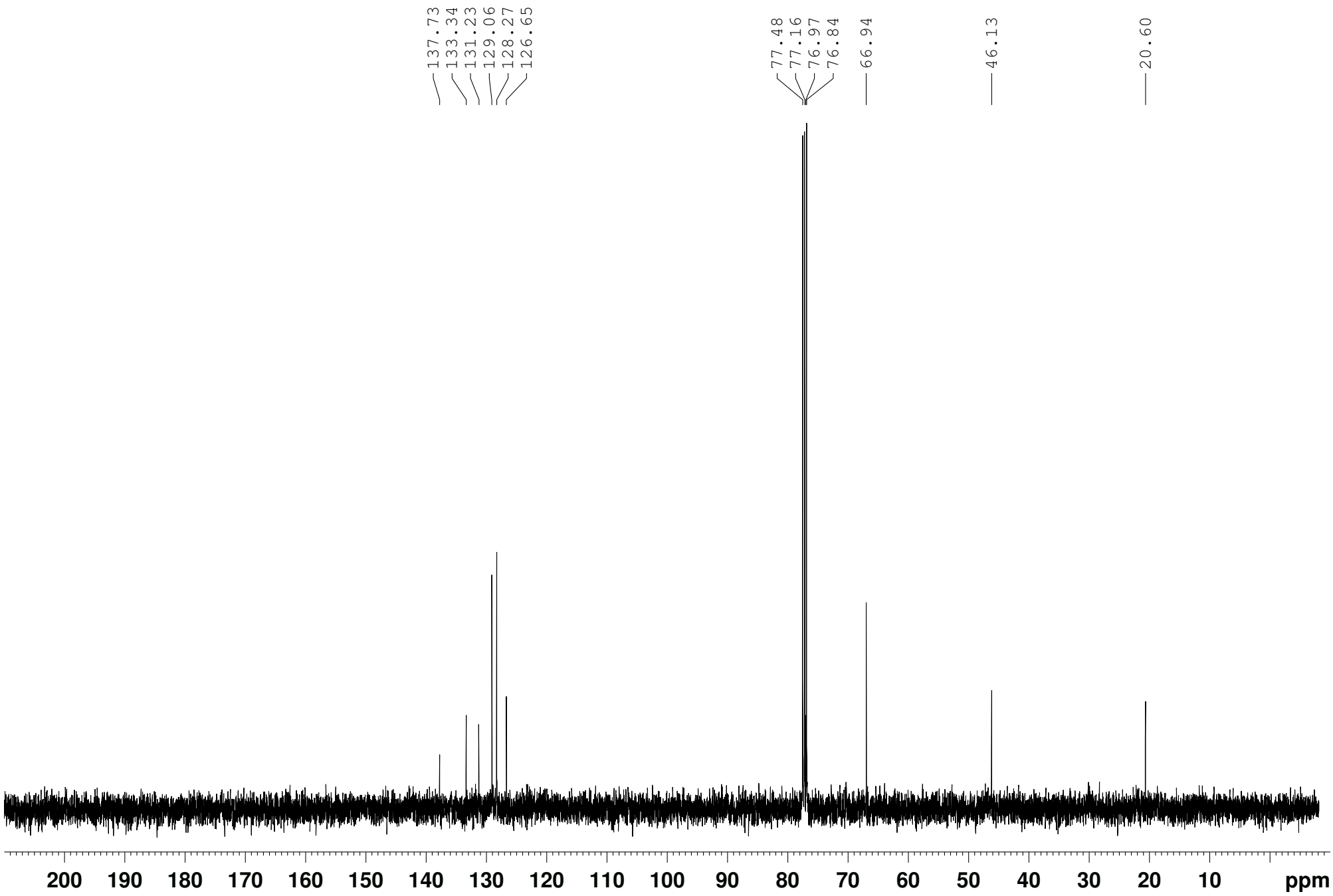
2.12
3.15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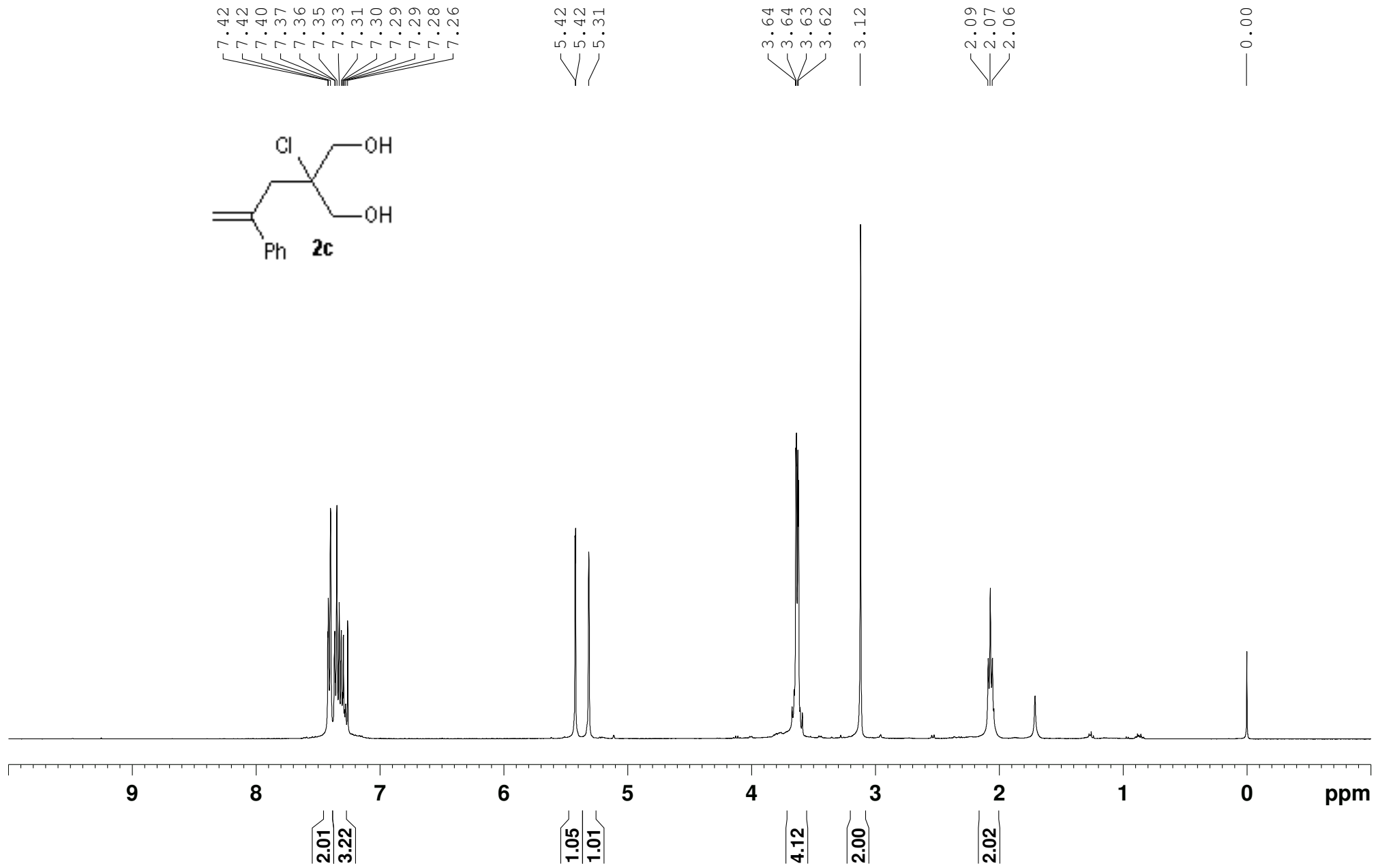
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5.42
5.31
3.64
3.64
3.63
3.62
3.12
2.09
2.07
2.06
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OH
OH
Ph
2c
9
8
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1.01
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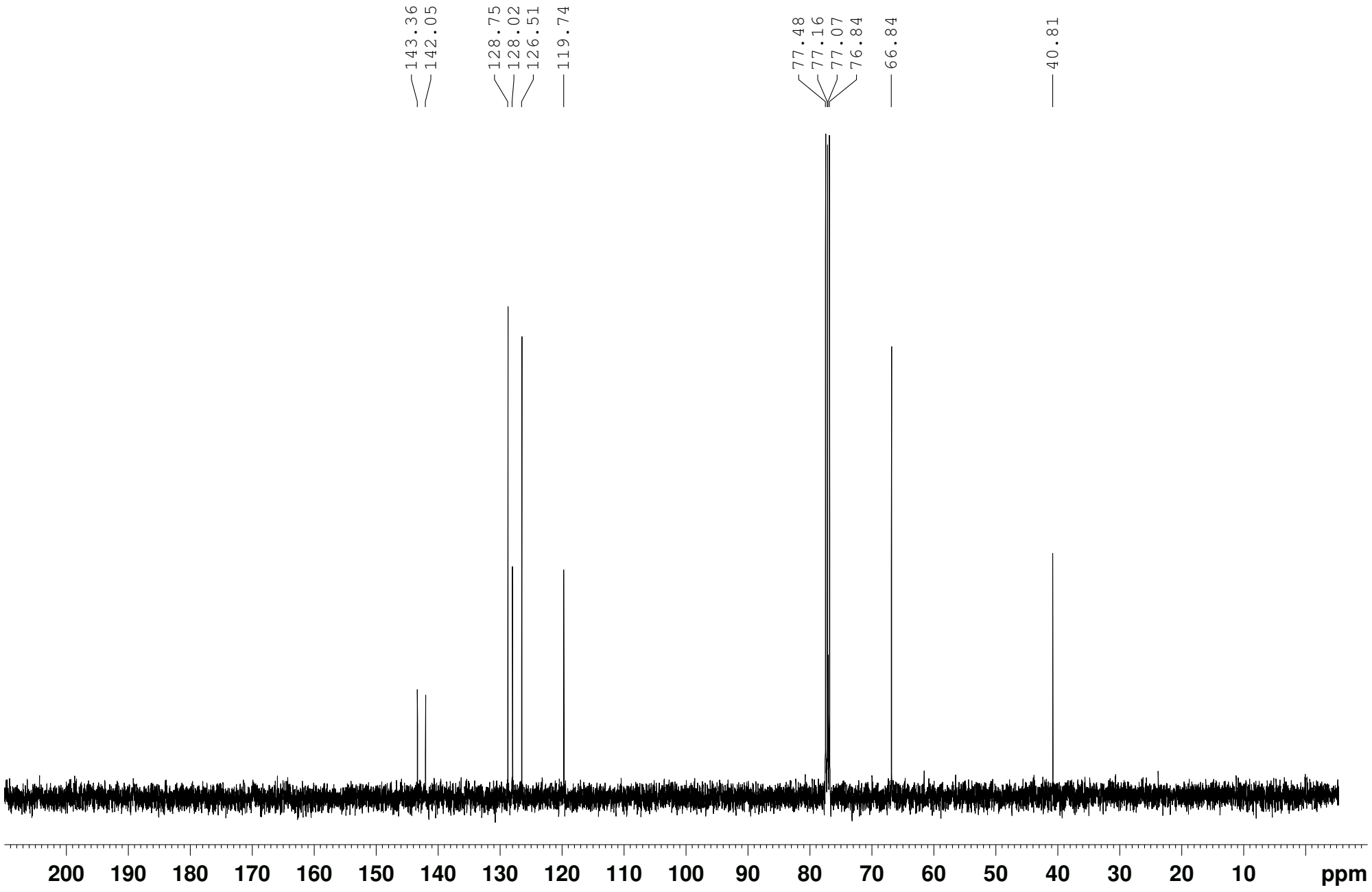
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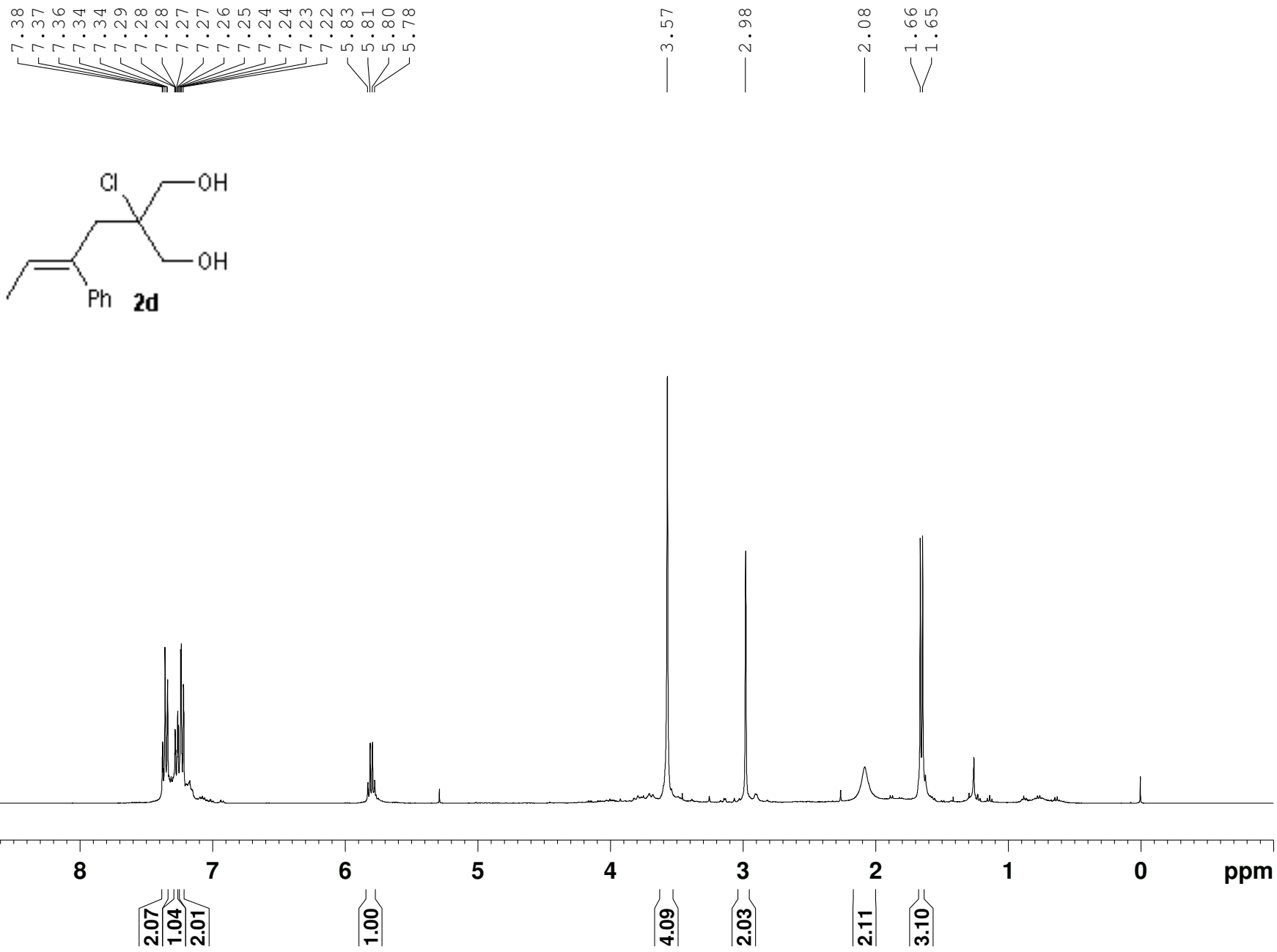
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7.23
7.22
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5.78
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1.65
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OH
OH
Ph
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7
6
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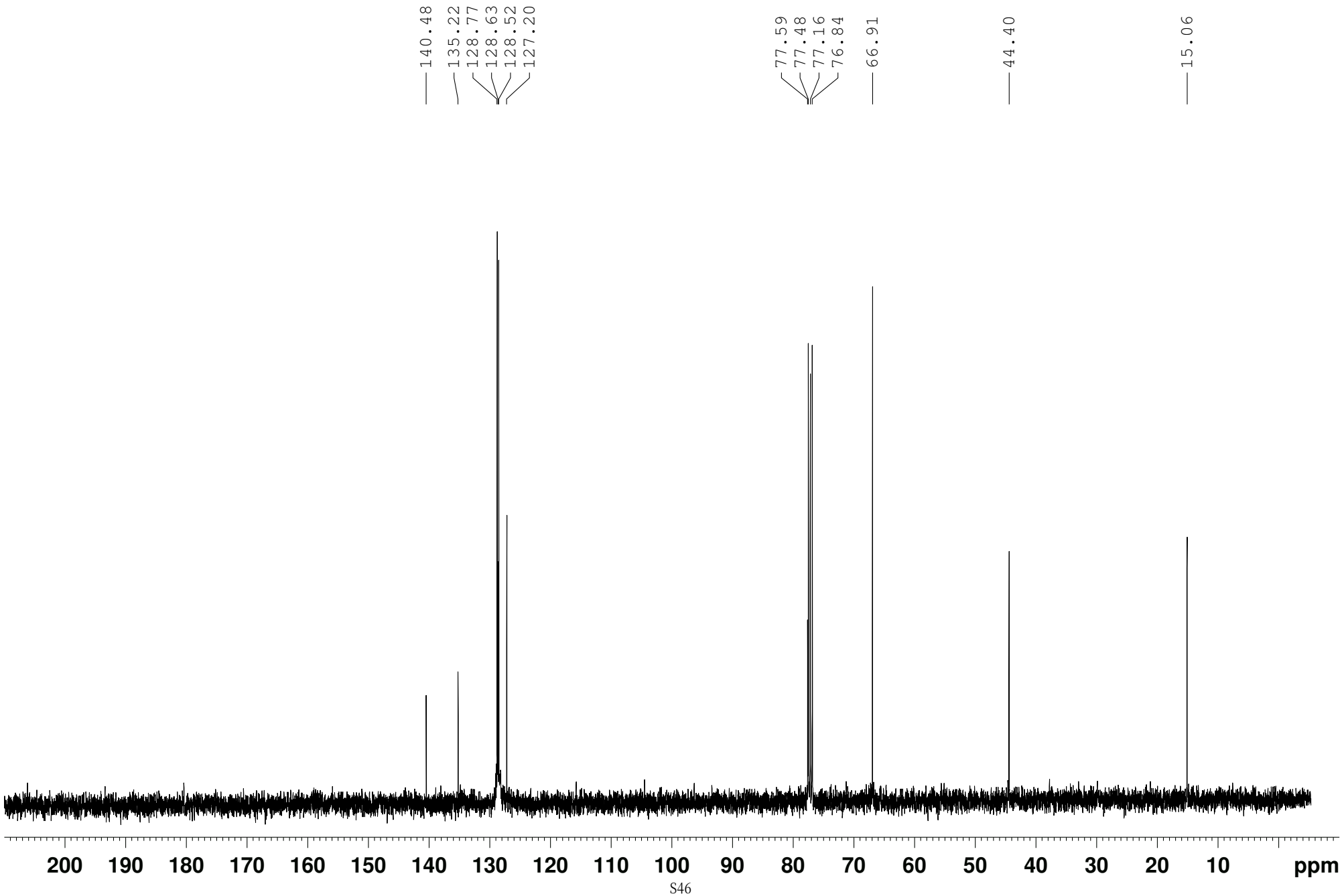
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76.84
66.91
44.40
15.06
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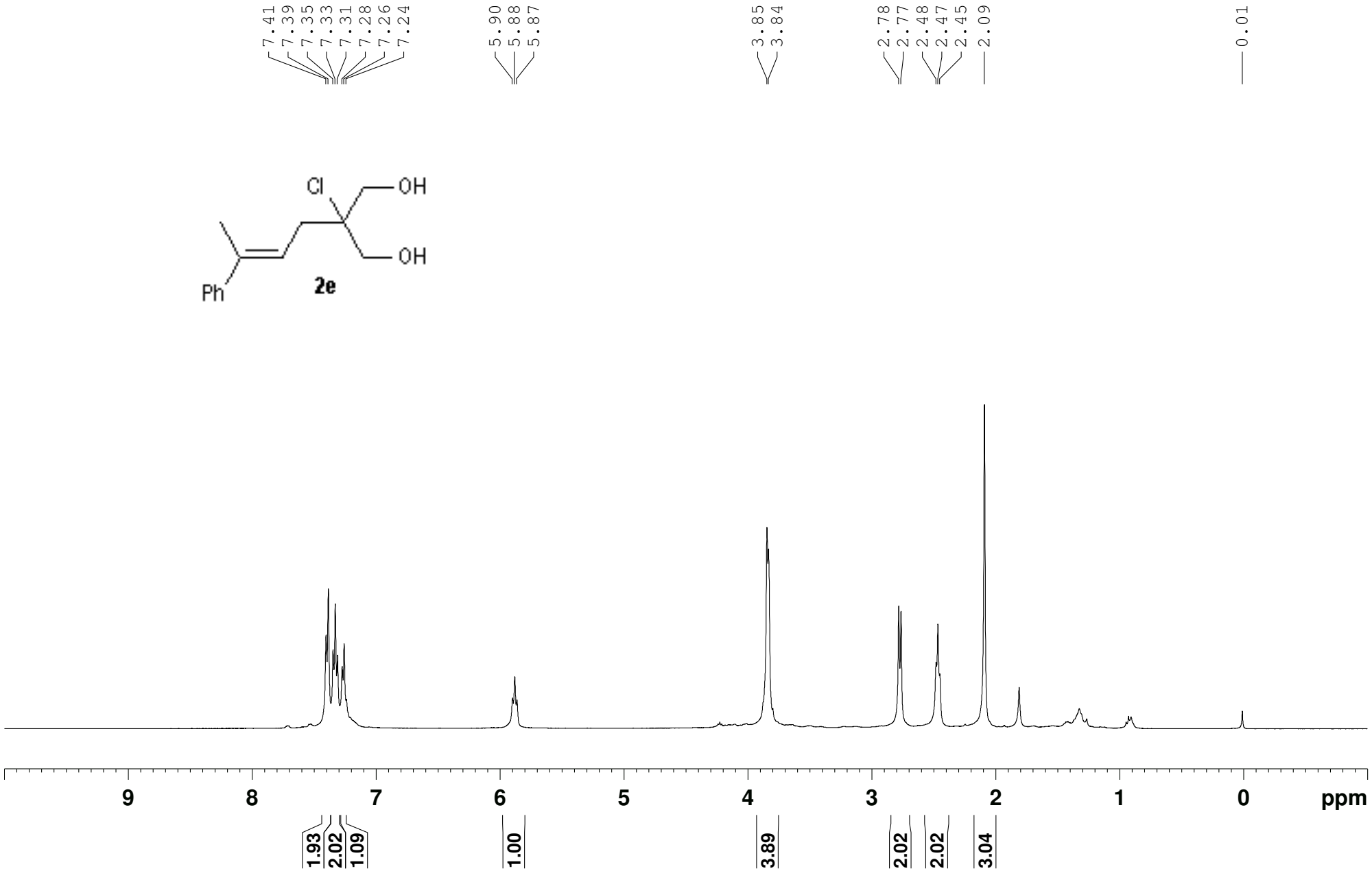
ppm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2.78
2.77
2.48
2.47
2.45
2.09
0.01
Cl
OH
OH
Ph
2e
9
8
7
6
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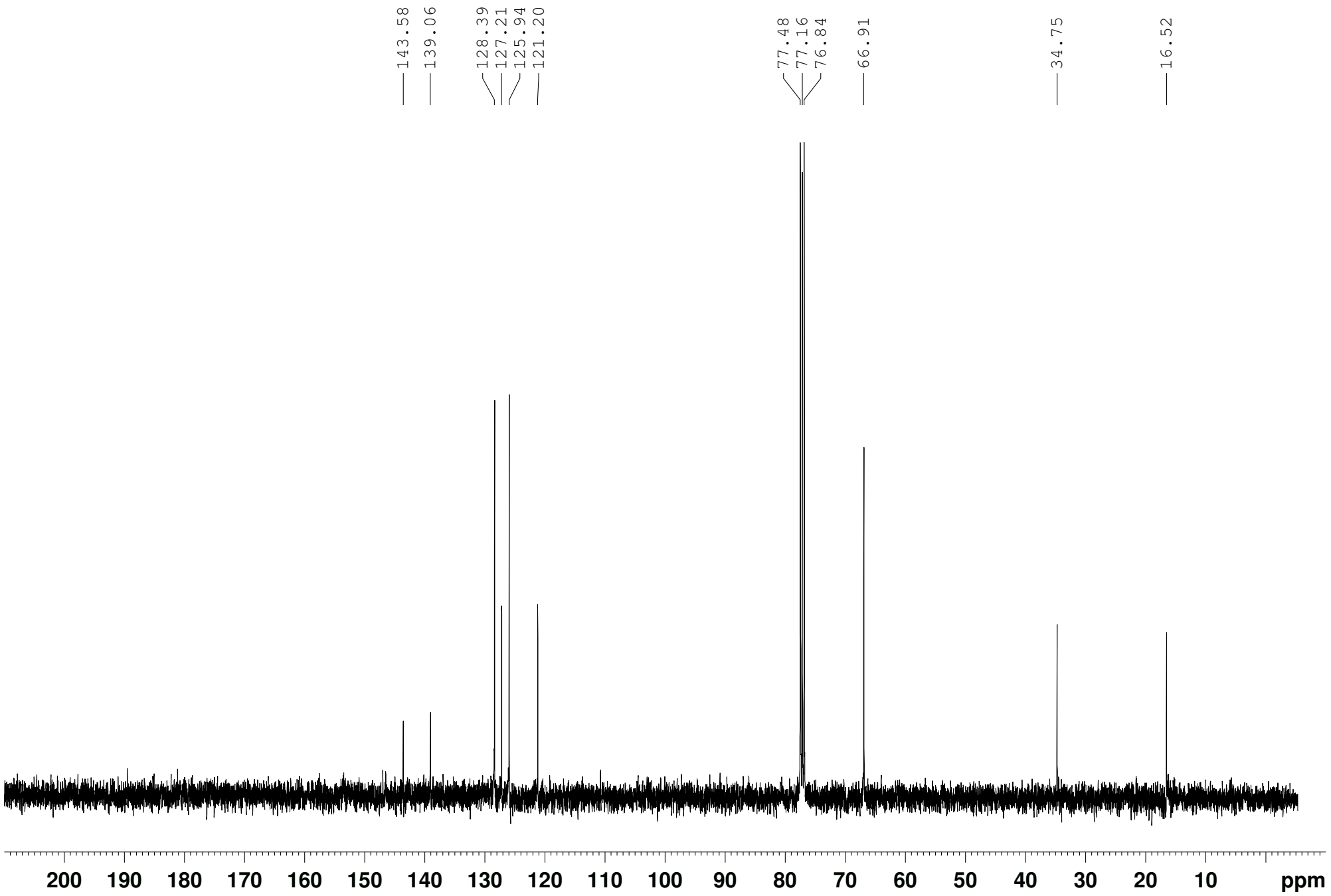
2.02
3.04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16.52
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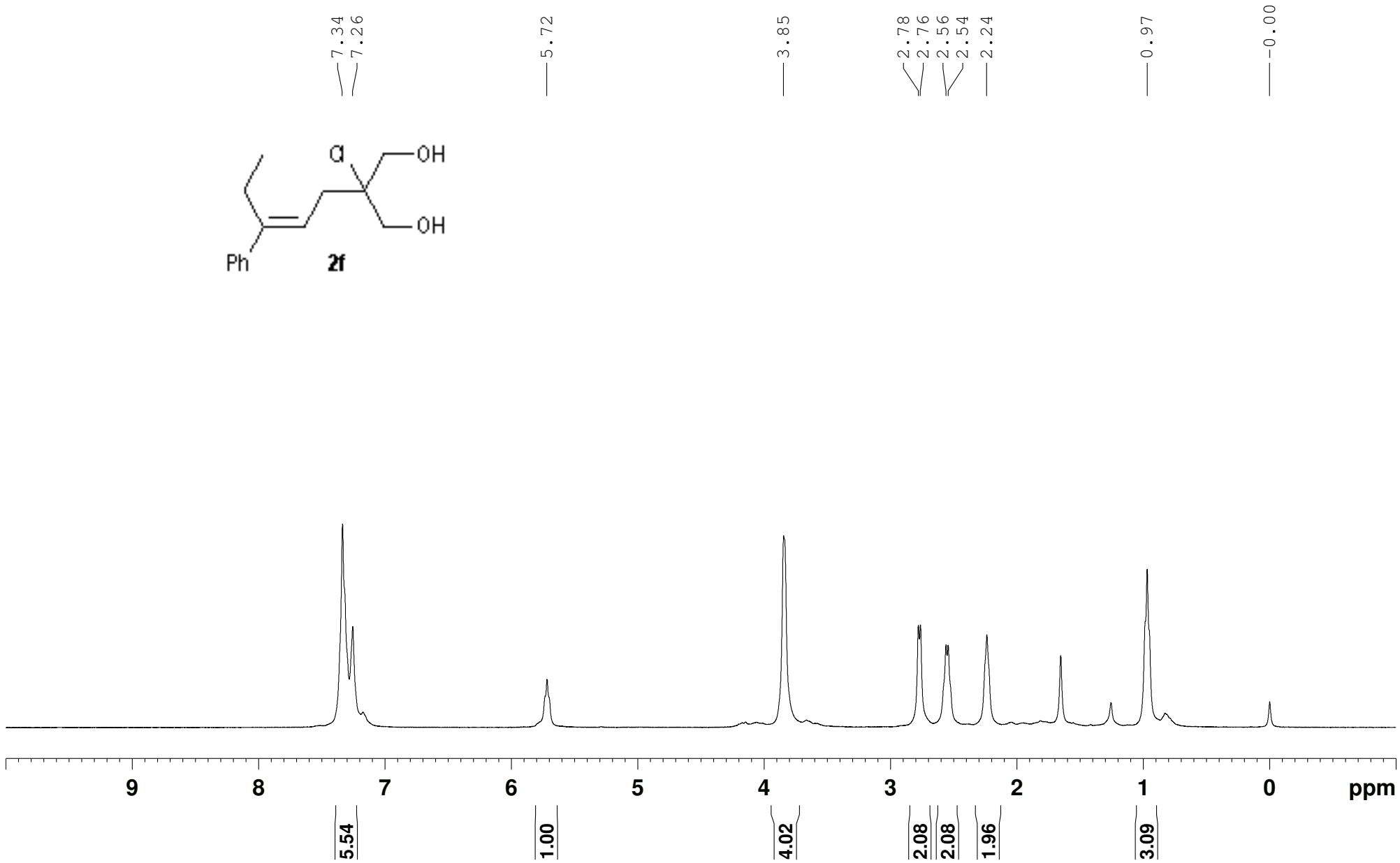
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OH
Ph
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8
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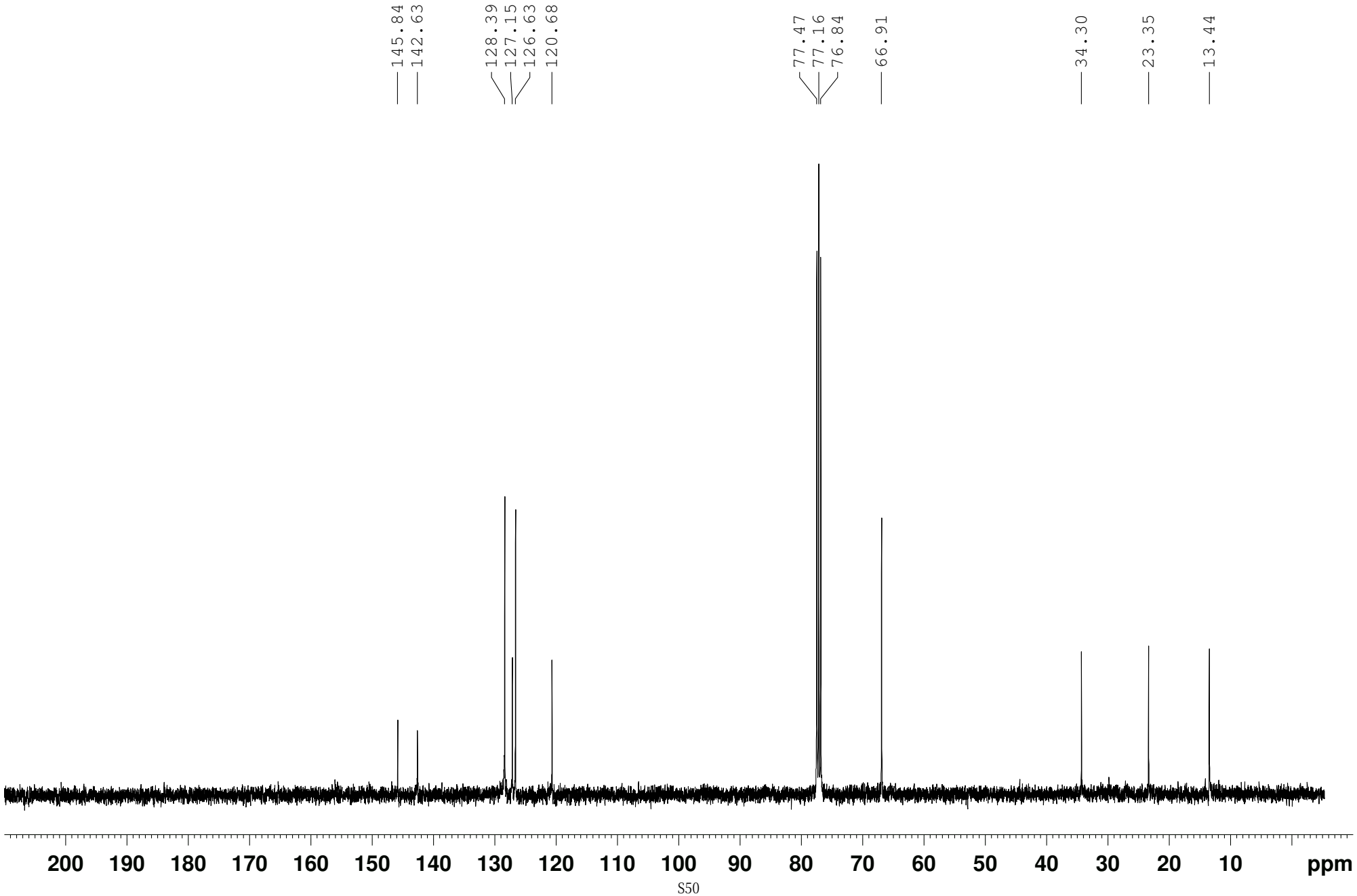
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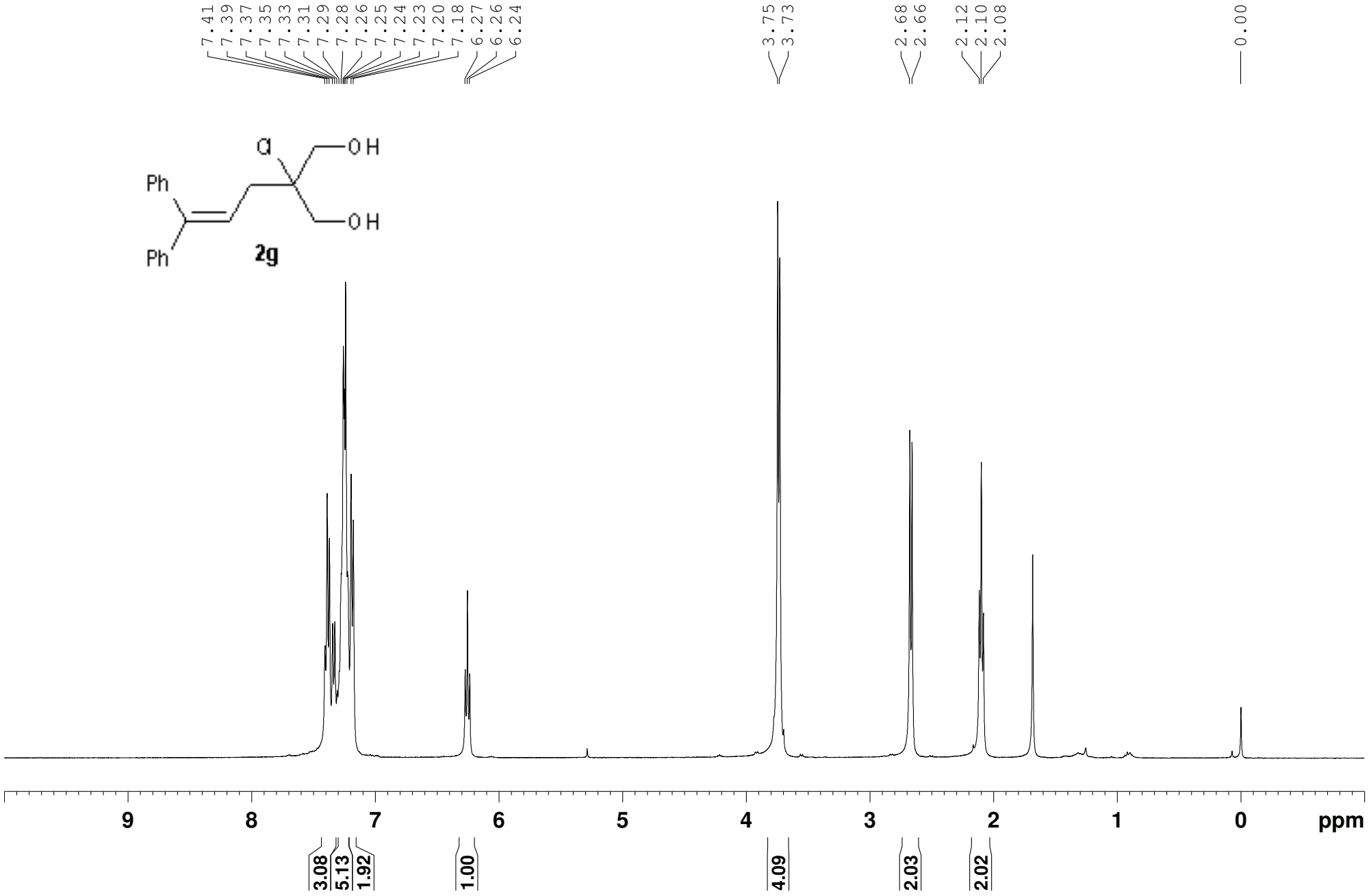
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7.18
6.27
6.26
6.24
3.75
3.73
2.68
2.66
2.12
2.10
2.08
0.00
Cl
OH
OH
Ph
Ph
2g
9
8
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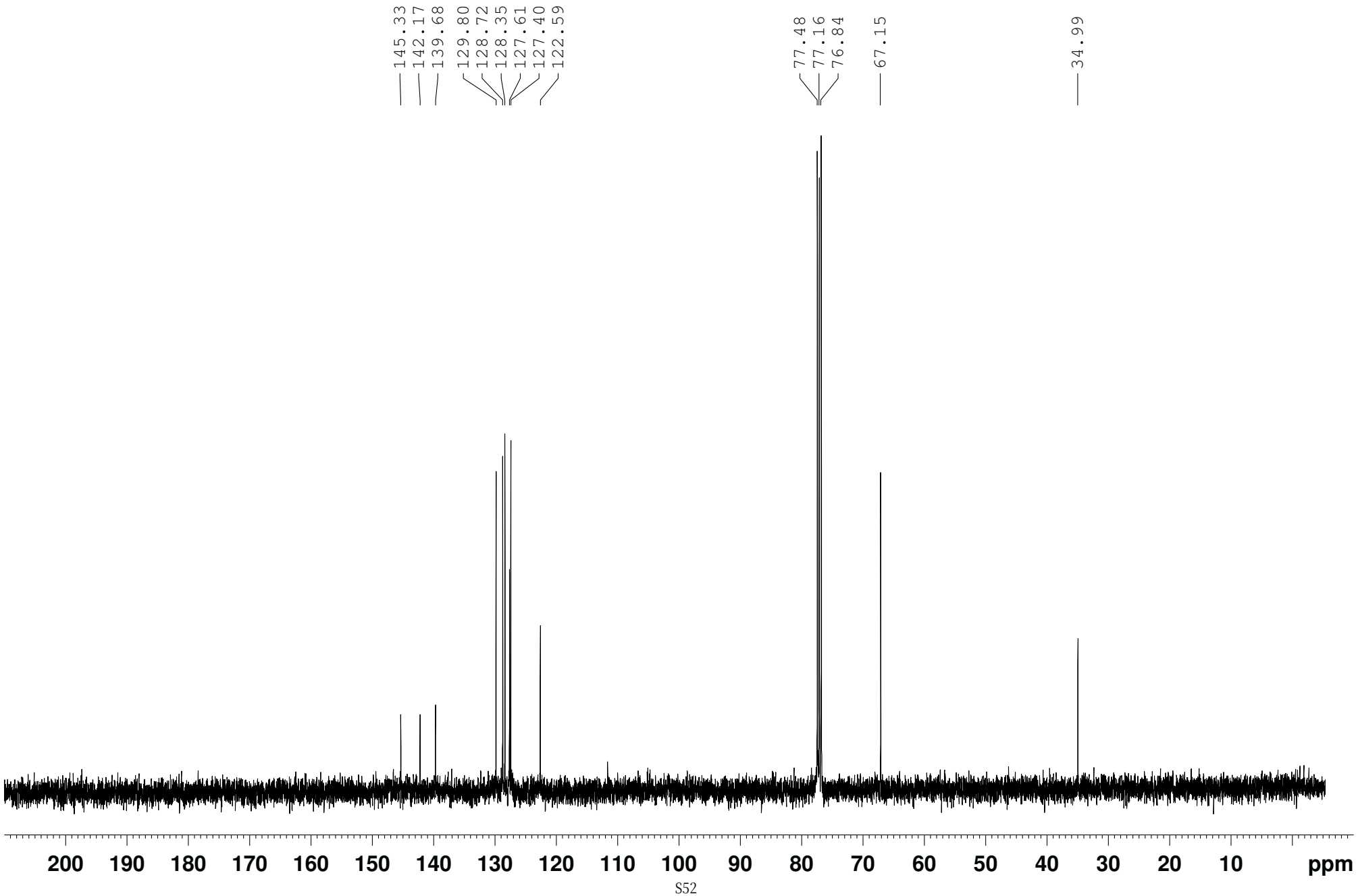
2.02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76.84
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34.99
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70
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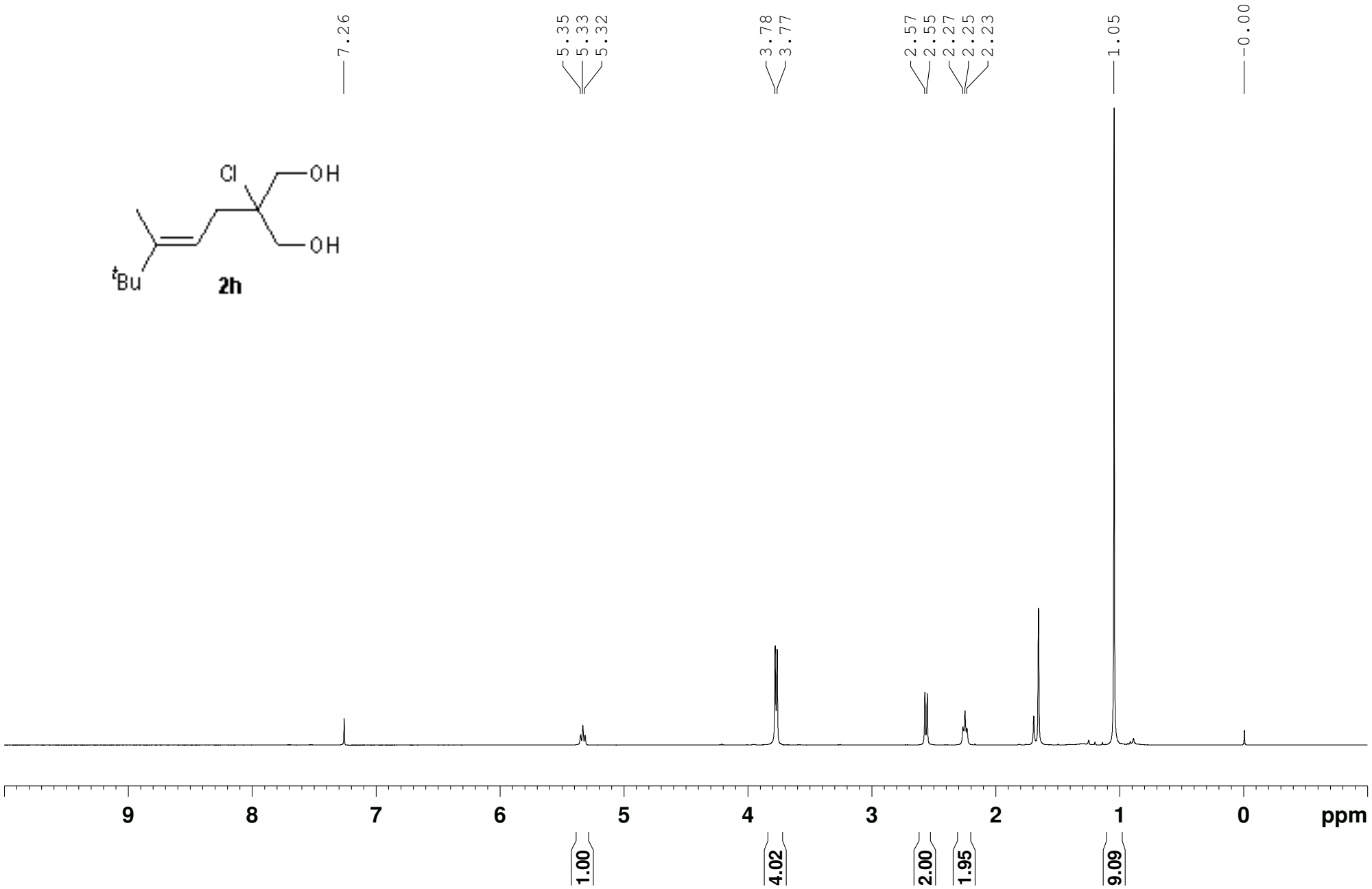
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2.25
2.23
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0.00
Cl
OH
OH
tBu
2h
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4.02
2.00
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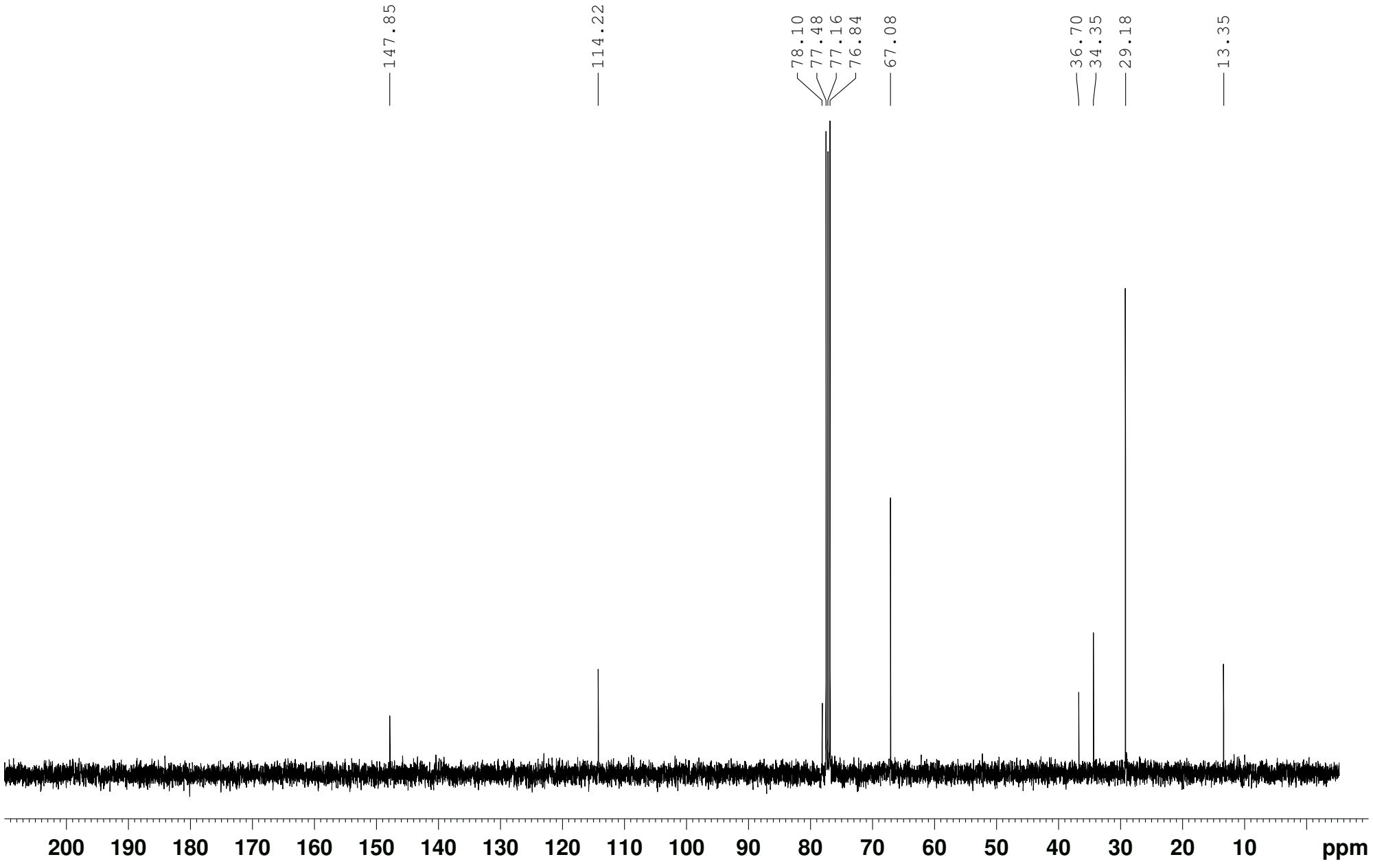
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29.18
13.35
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150
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130
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70
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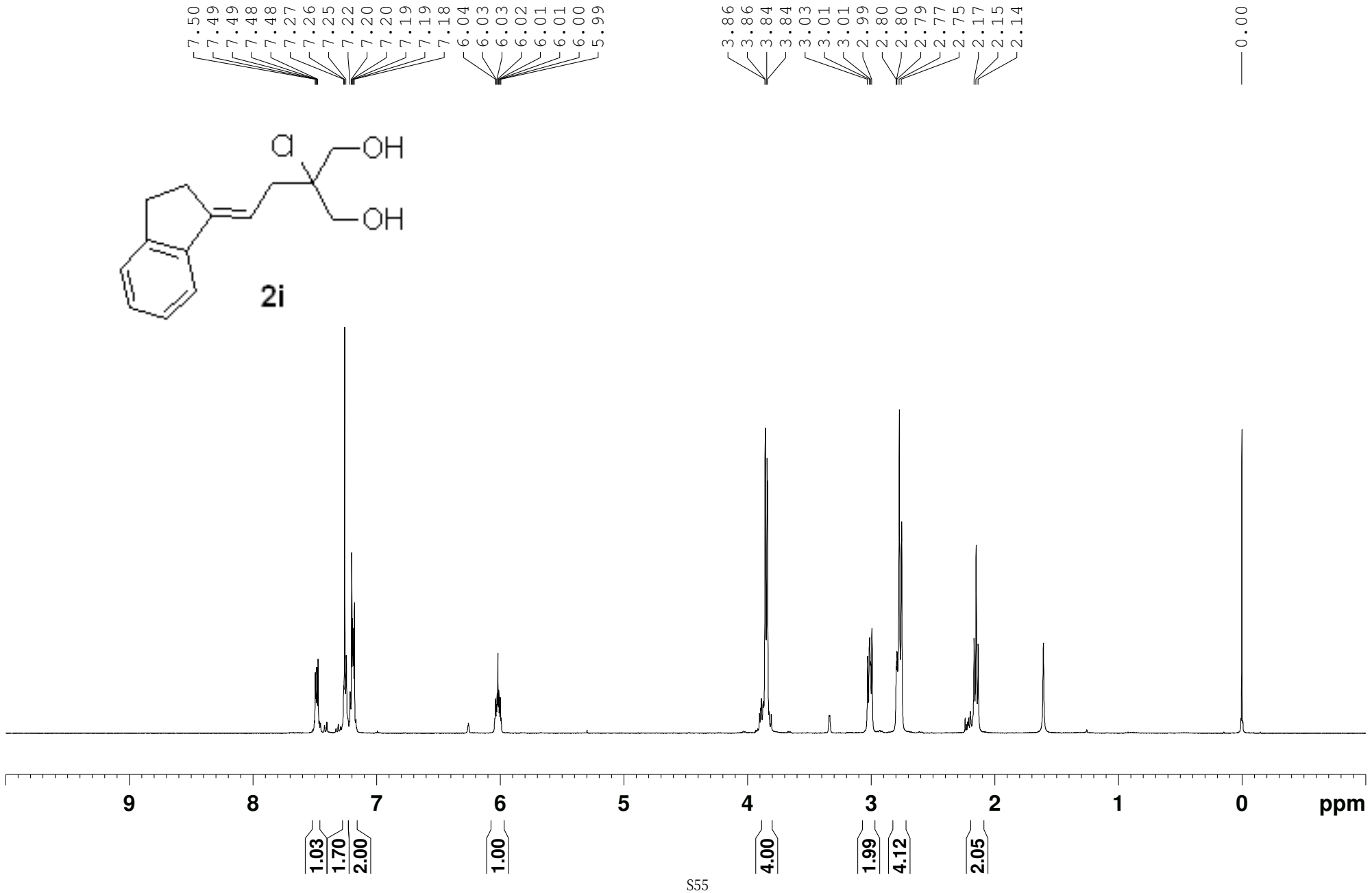
20
10
ppm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7.18
6.04
6.03
6.03
6.02
6.01
6.01
6.00
5.99
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3.86
3.84
3.84
3.03
3.01
3.01
2.99
2.80
2.80
2.79
2.77
2.75
2.17
2.15
2.14
0.00
Cl
OH
OH
2i
9
8
7
6
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ppm
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1.00
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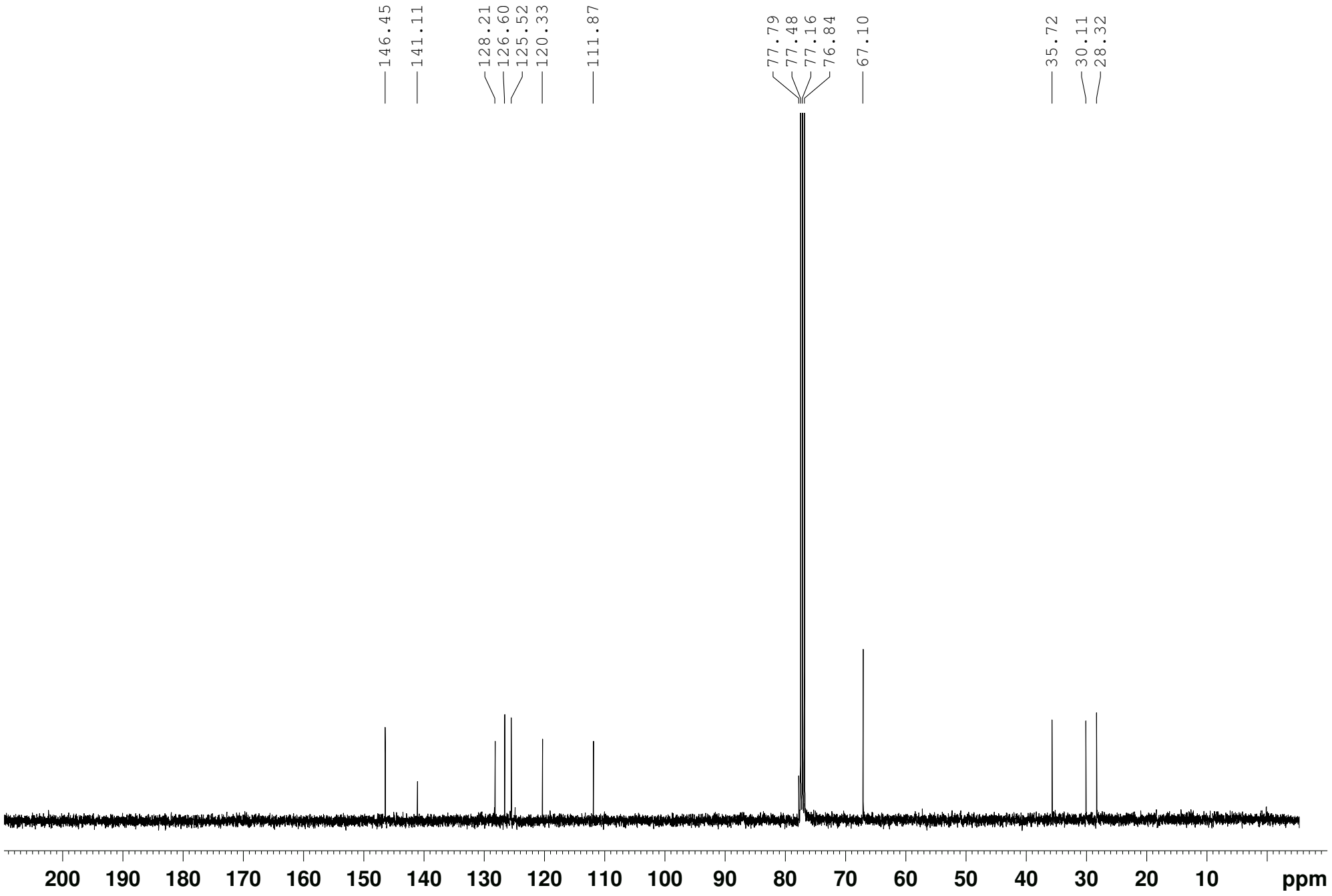
1.99
4.12
2.05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67.10
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30.11
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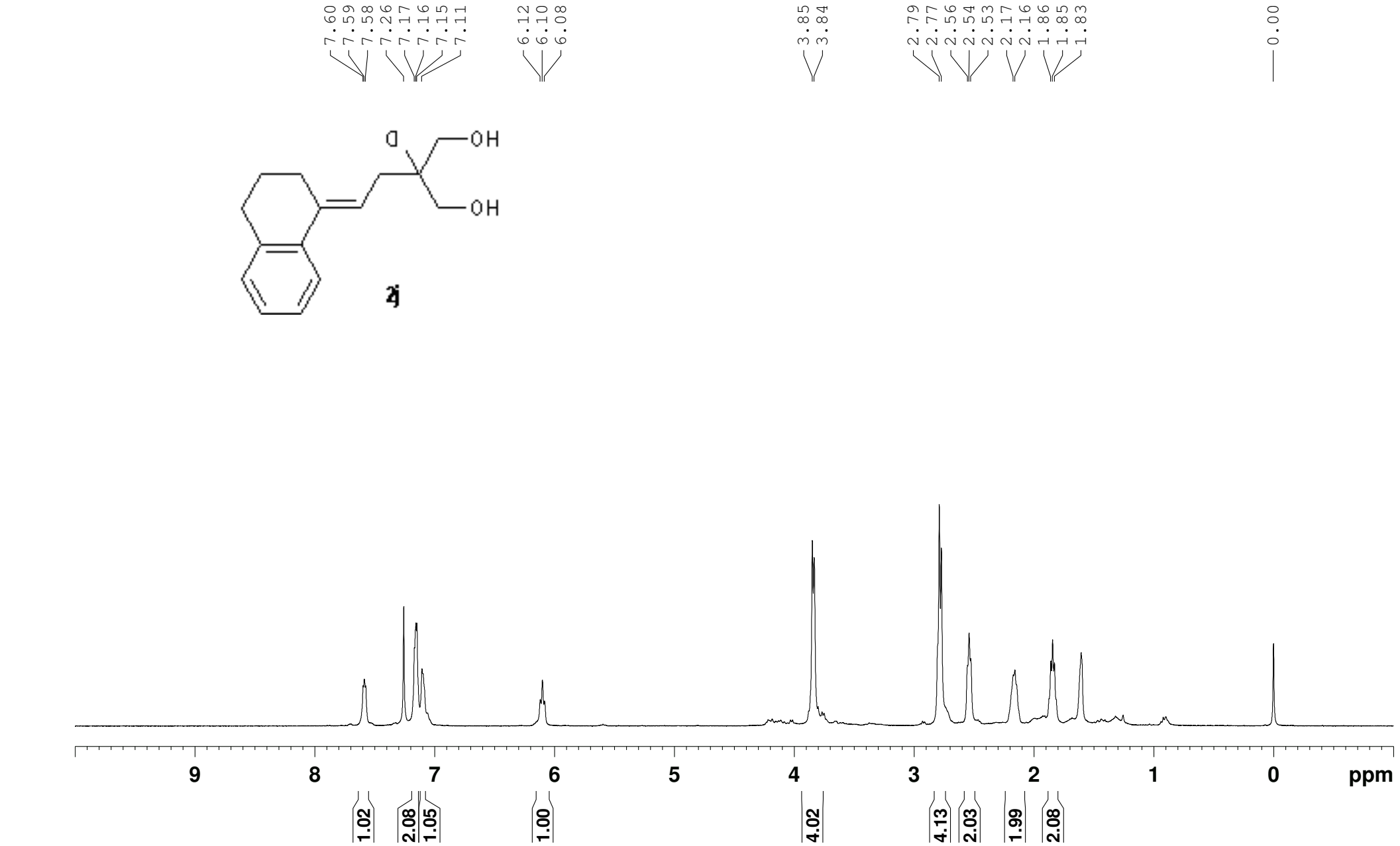
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6.10
6.08
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3.84
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2.77
2.56
2.54
2.53
2.17
2.16
1.86
1.85
1.83
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OH
OH
9
8
7
6
5
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4.02
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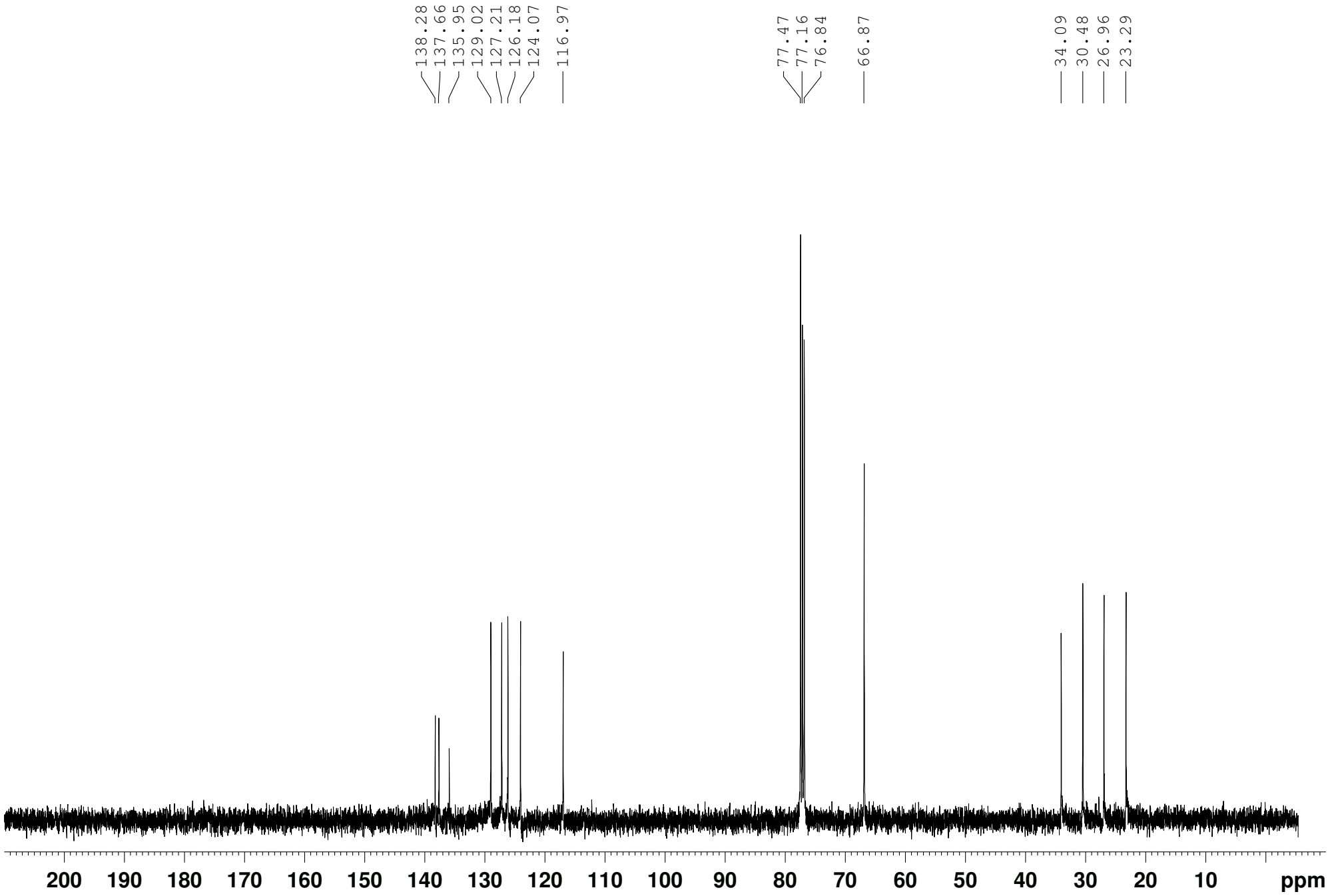
2.08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66.87
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23.29
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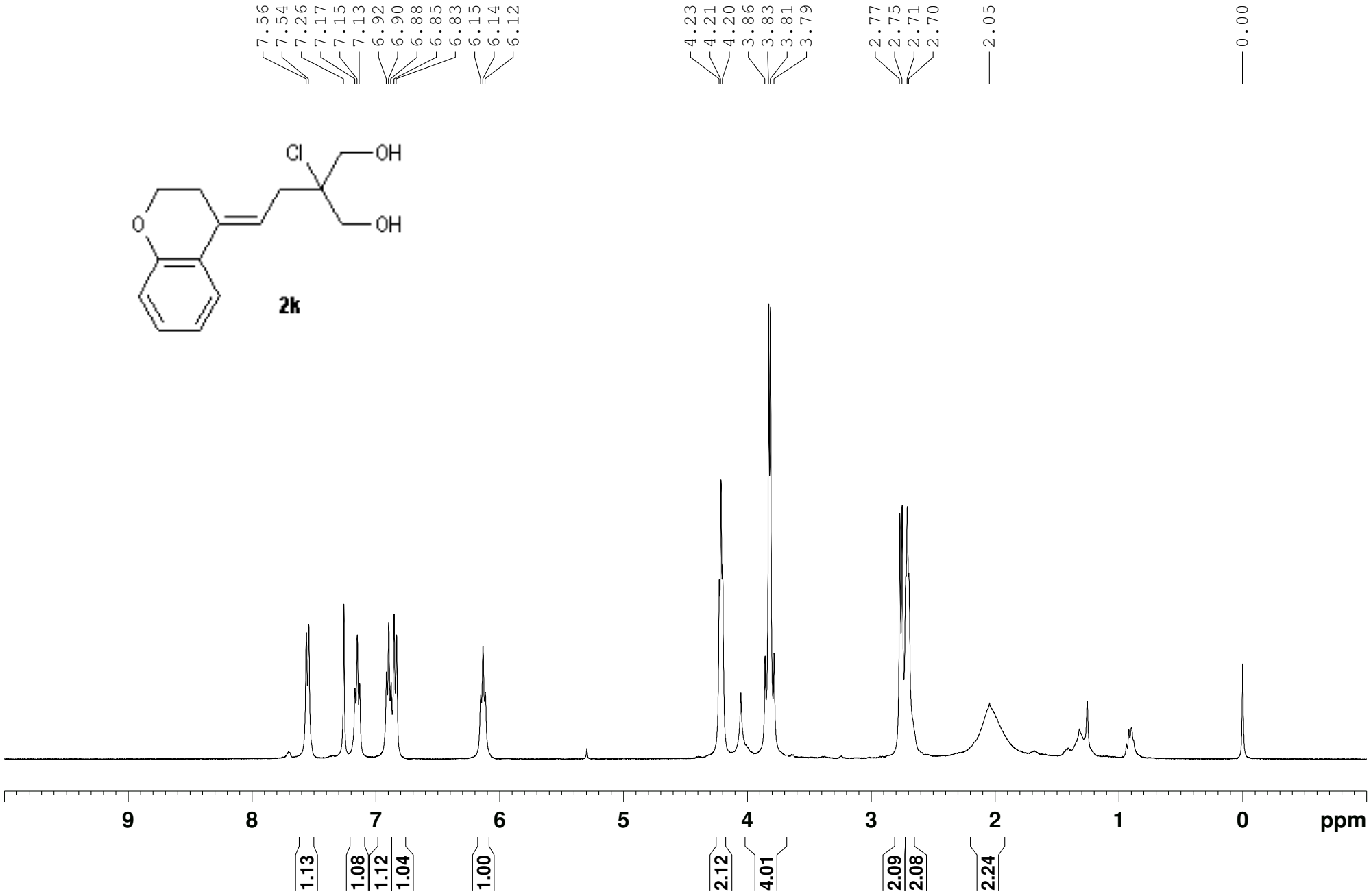
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6.12
4.23
4.21
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3.86
3.83
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2.77
2.75
2.71
2.70
2.05
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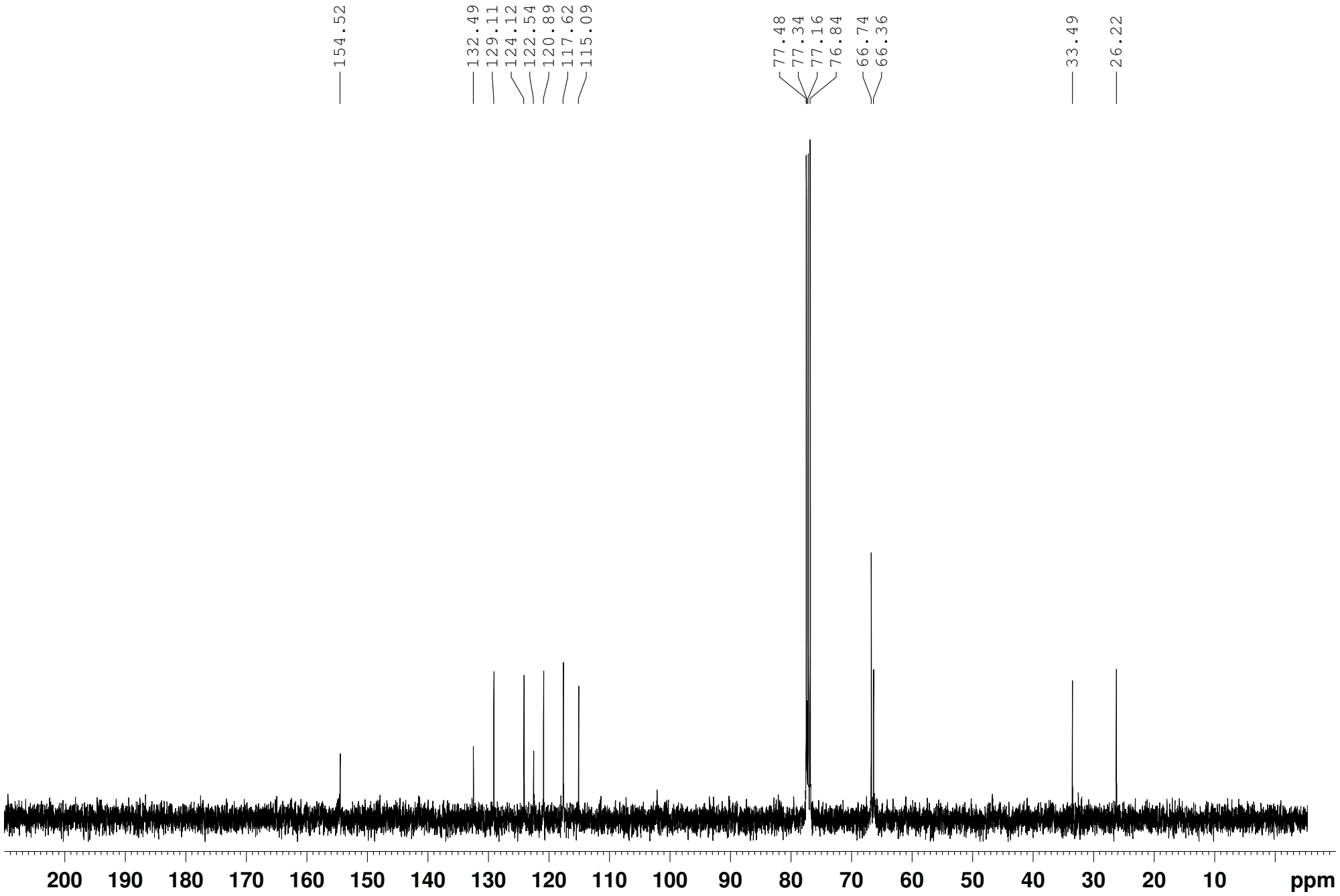
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26.22
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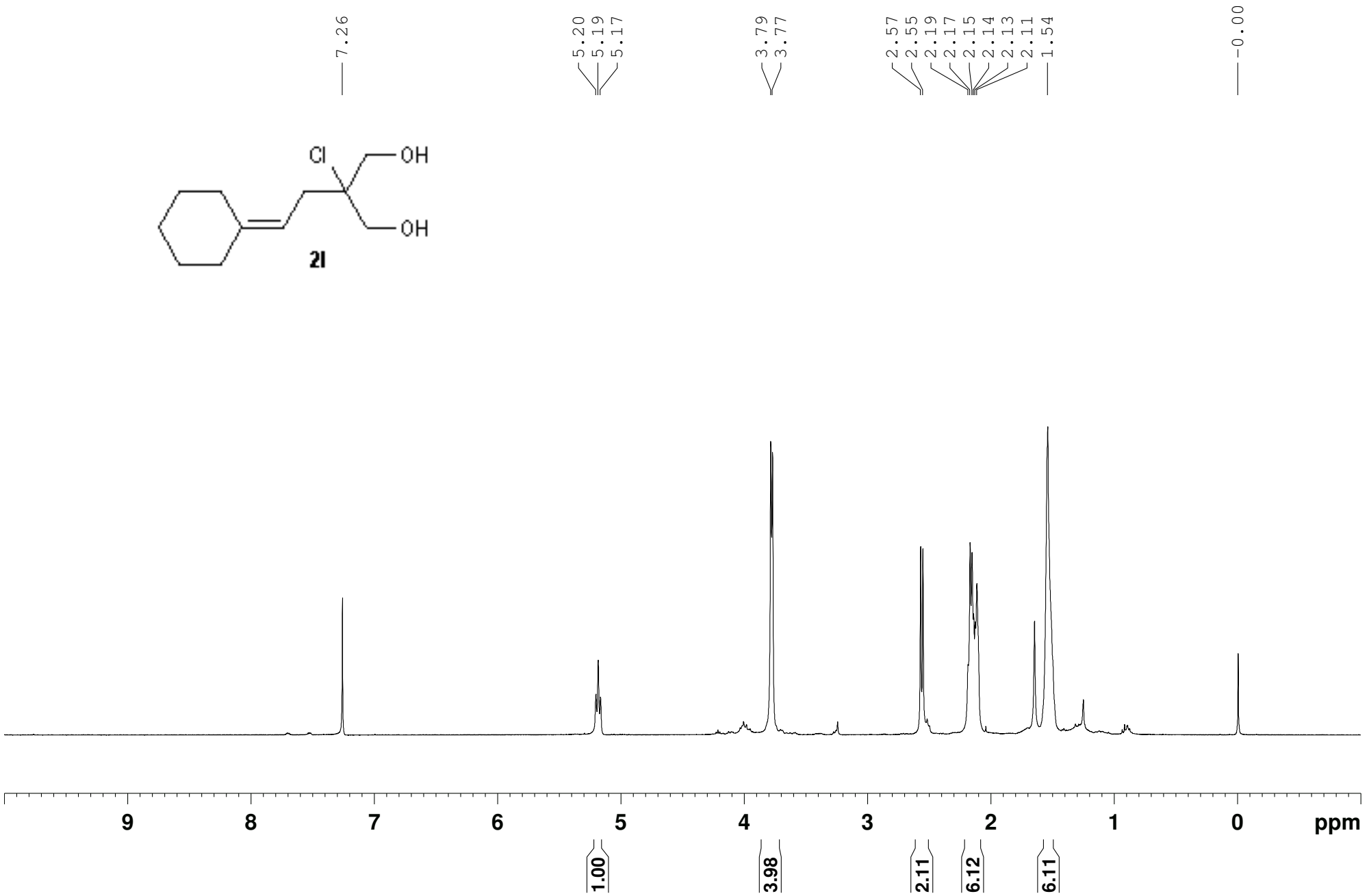
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2.13
2.11
1.54
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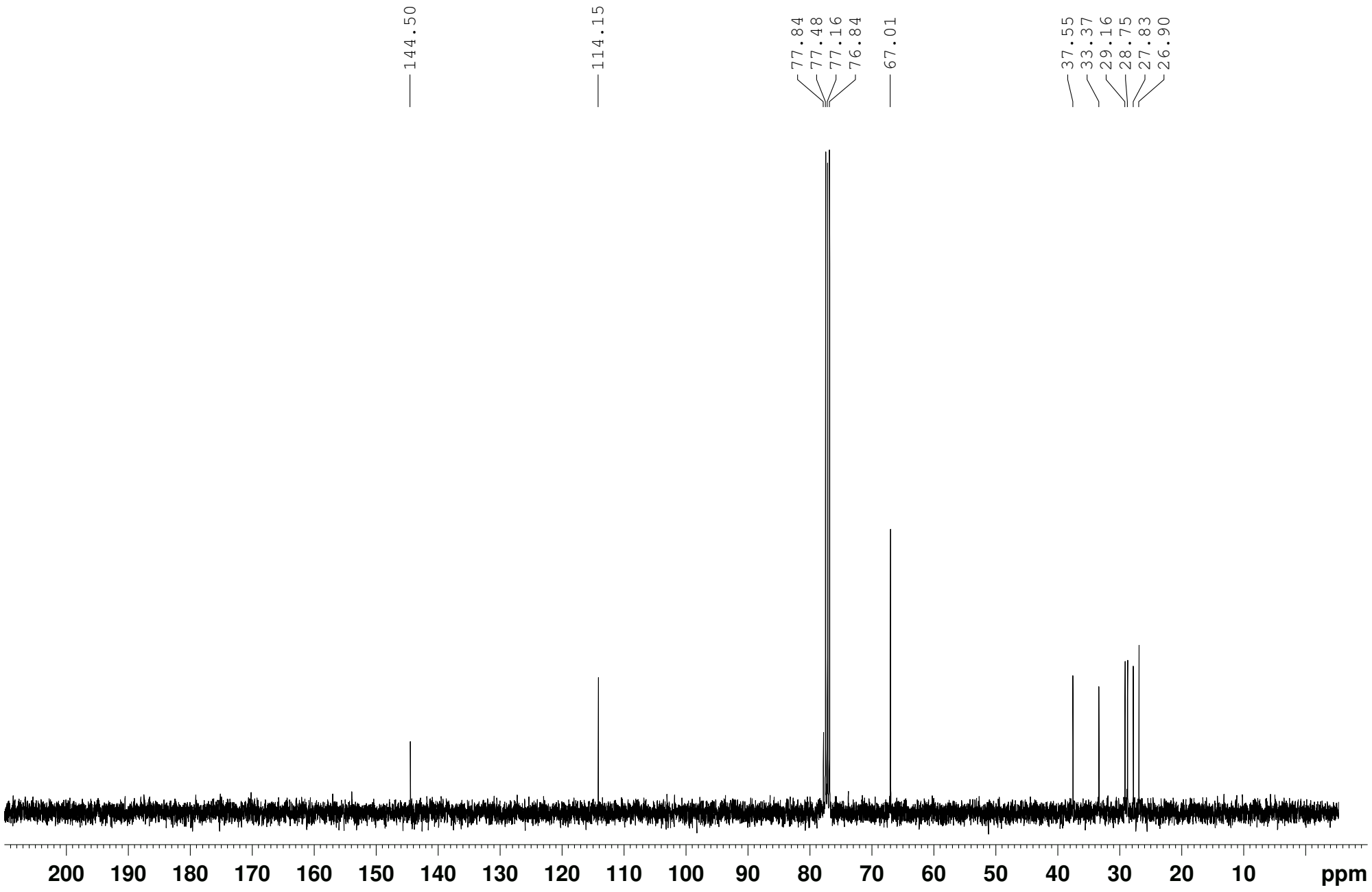
6.11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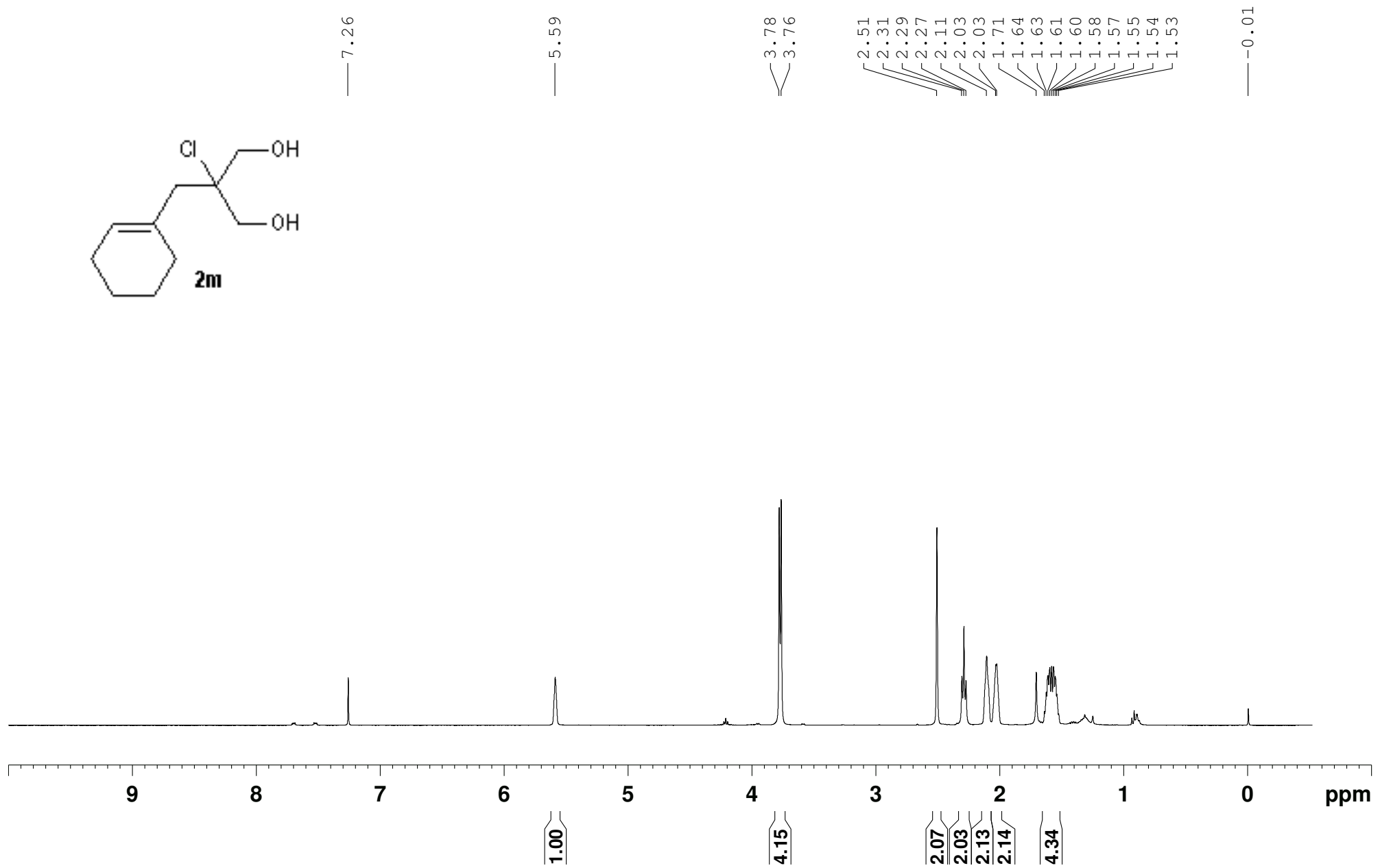
10
ppm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1.63
1.61
1.60
1.58
1.57
1.55
1.54
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0.01
Cl
OH
OH
2m
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8
7
6
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0
ppm
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4.15
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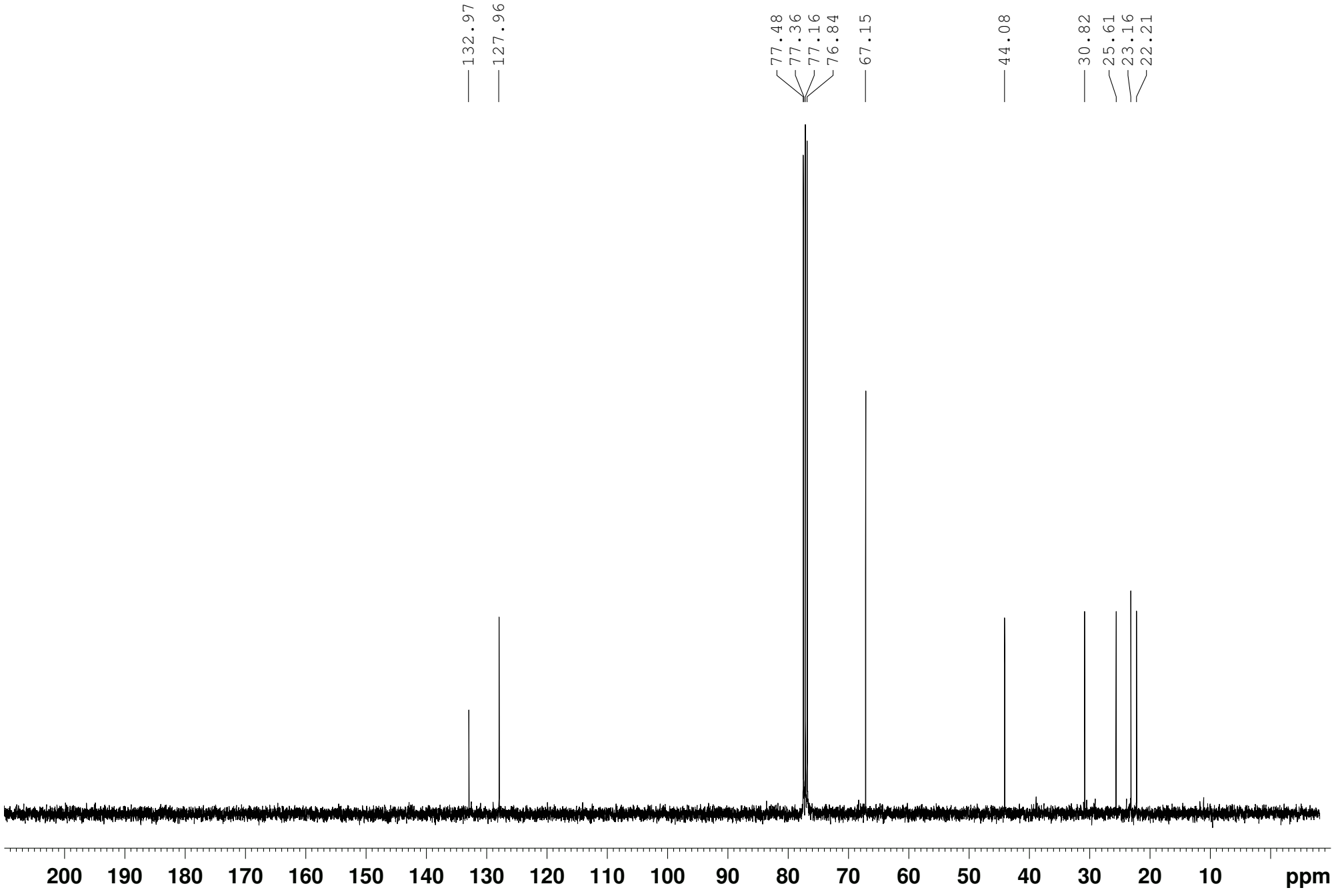
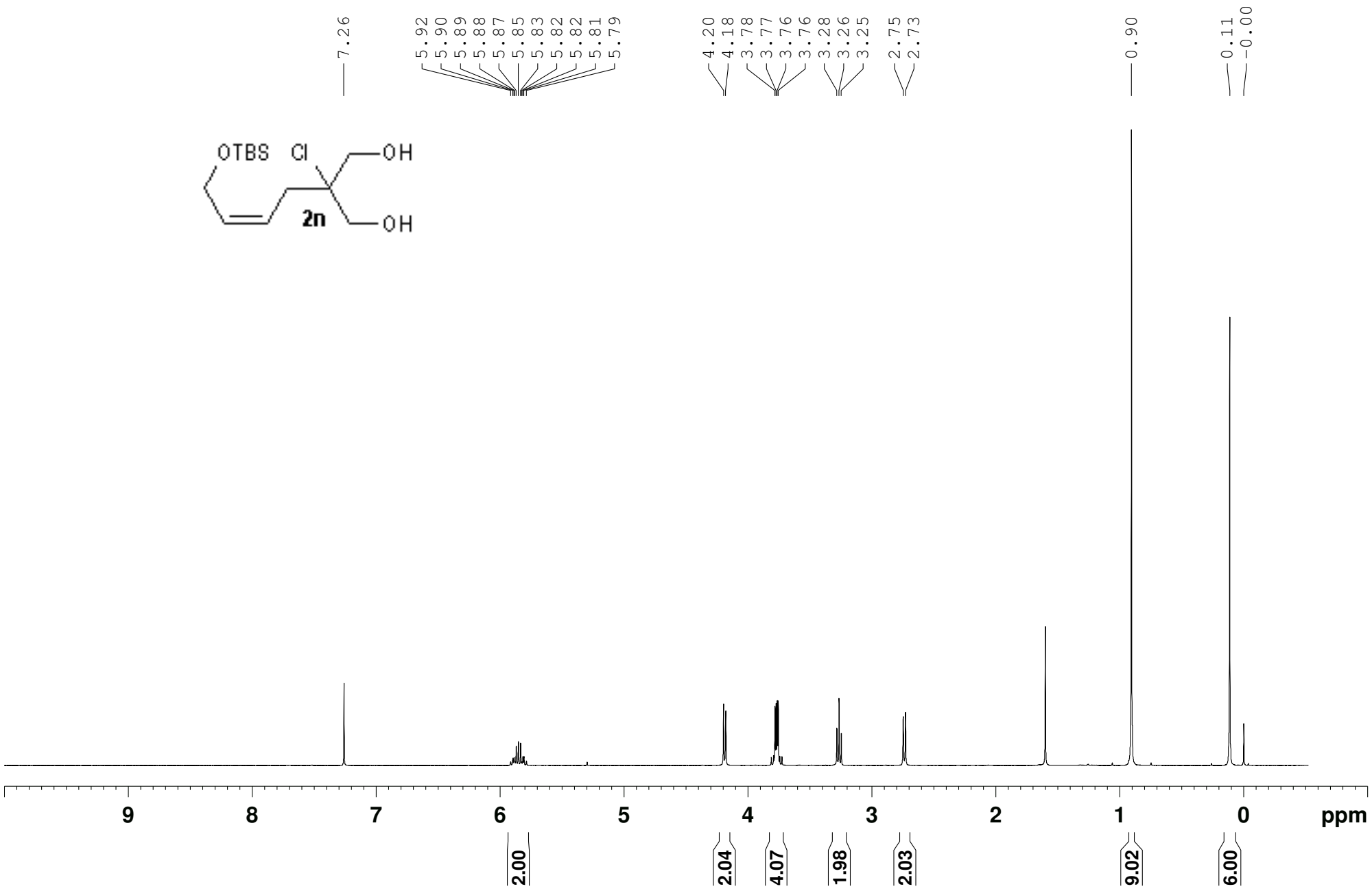
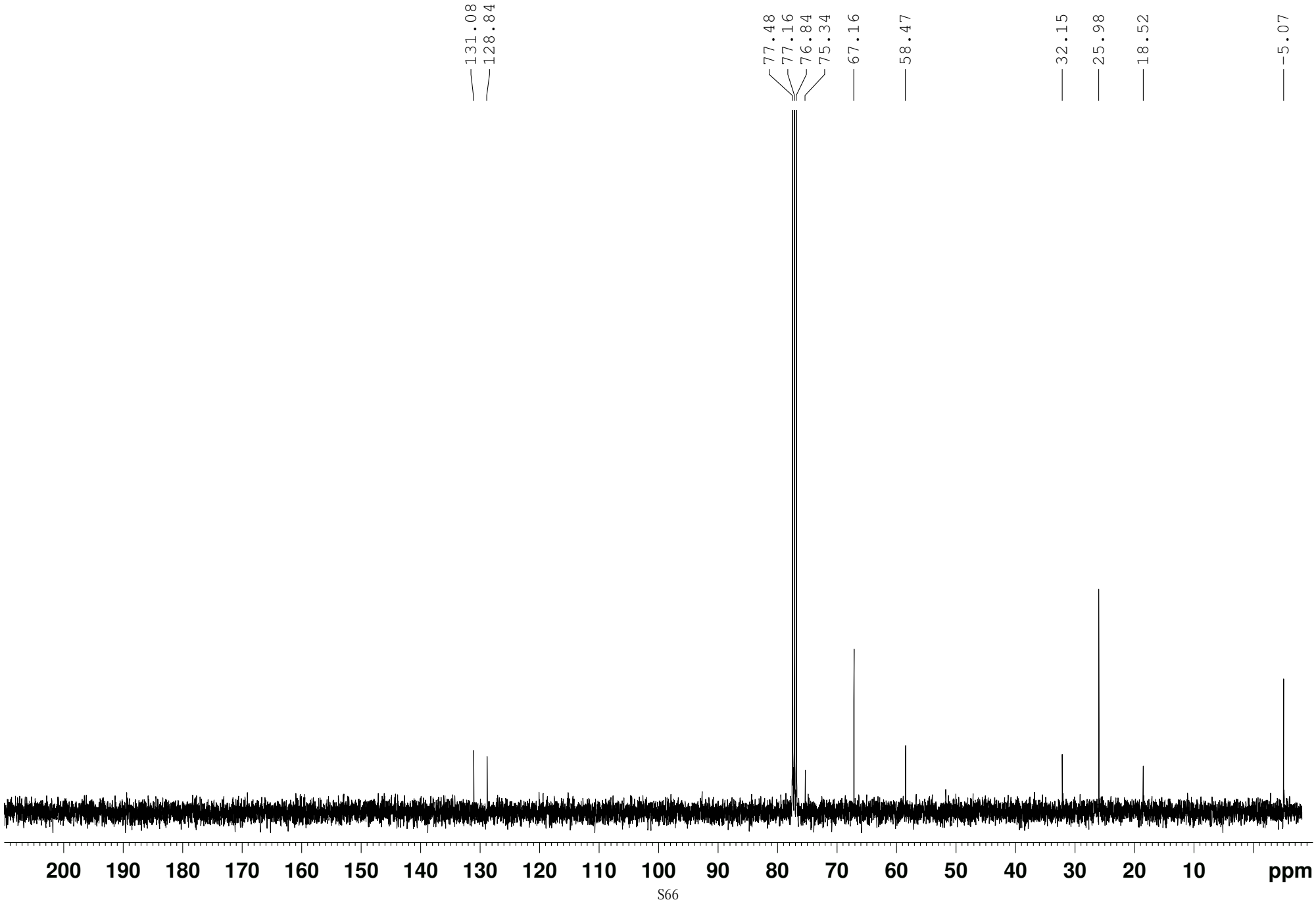
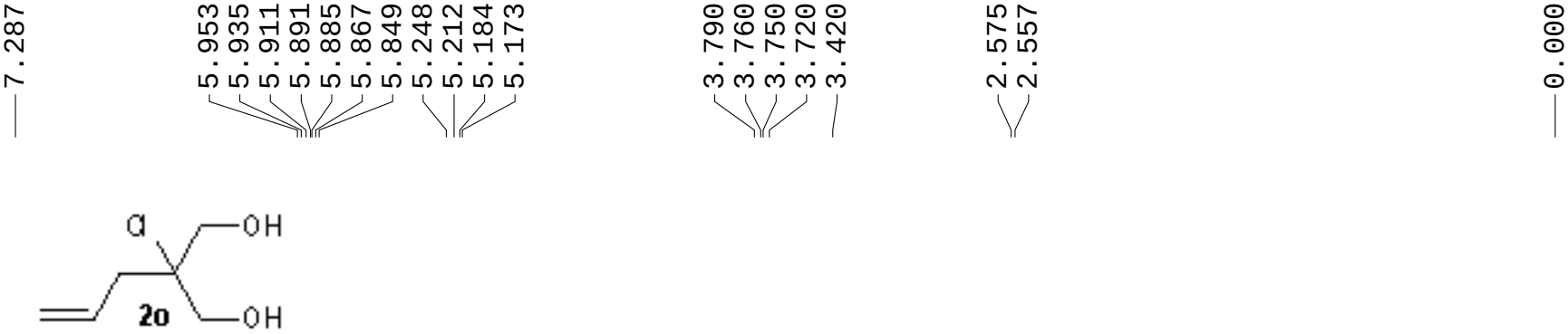
2.03
2.13
2.14
4.34


132.97
127.96
77.48
77.36
77.16
76.84
67.15
44.08
30.82
25.61
23.16
22.21
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

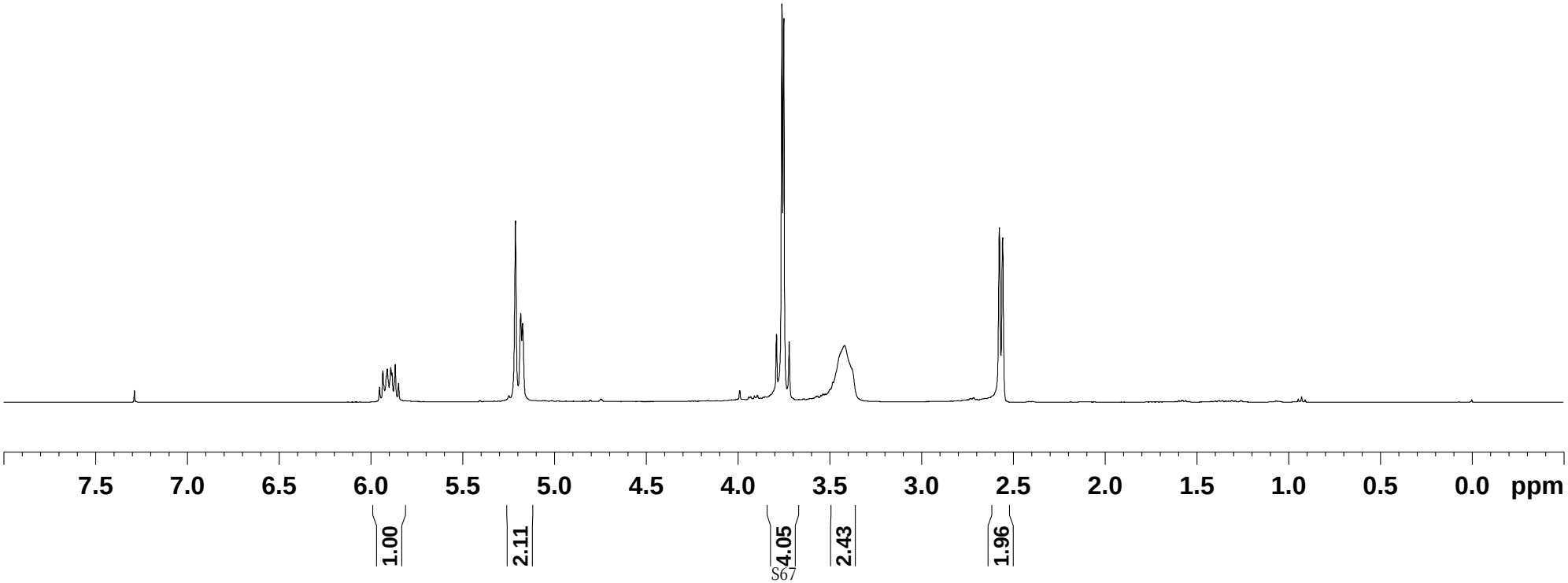

7.26
5.92
5.90
5.89
5.88
5.87
5.85
5.83
5.82
5.82
5.81
5.79
4.20
4.18
3.78
3.77
3.76
3.76
3.28
3.26
3.25
2.75
2.73
0.90
0.11
0.00
OTBS
Cl
OH
OH
2n
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.04
4.07
1.98
2.03
9.02
6.00


131.08
128.84
77.48
77.16
76.84
75.34
67.16
58.47
32.15
25.98
18.52
-5.07
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

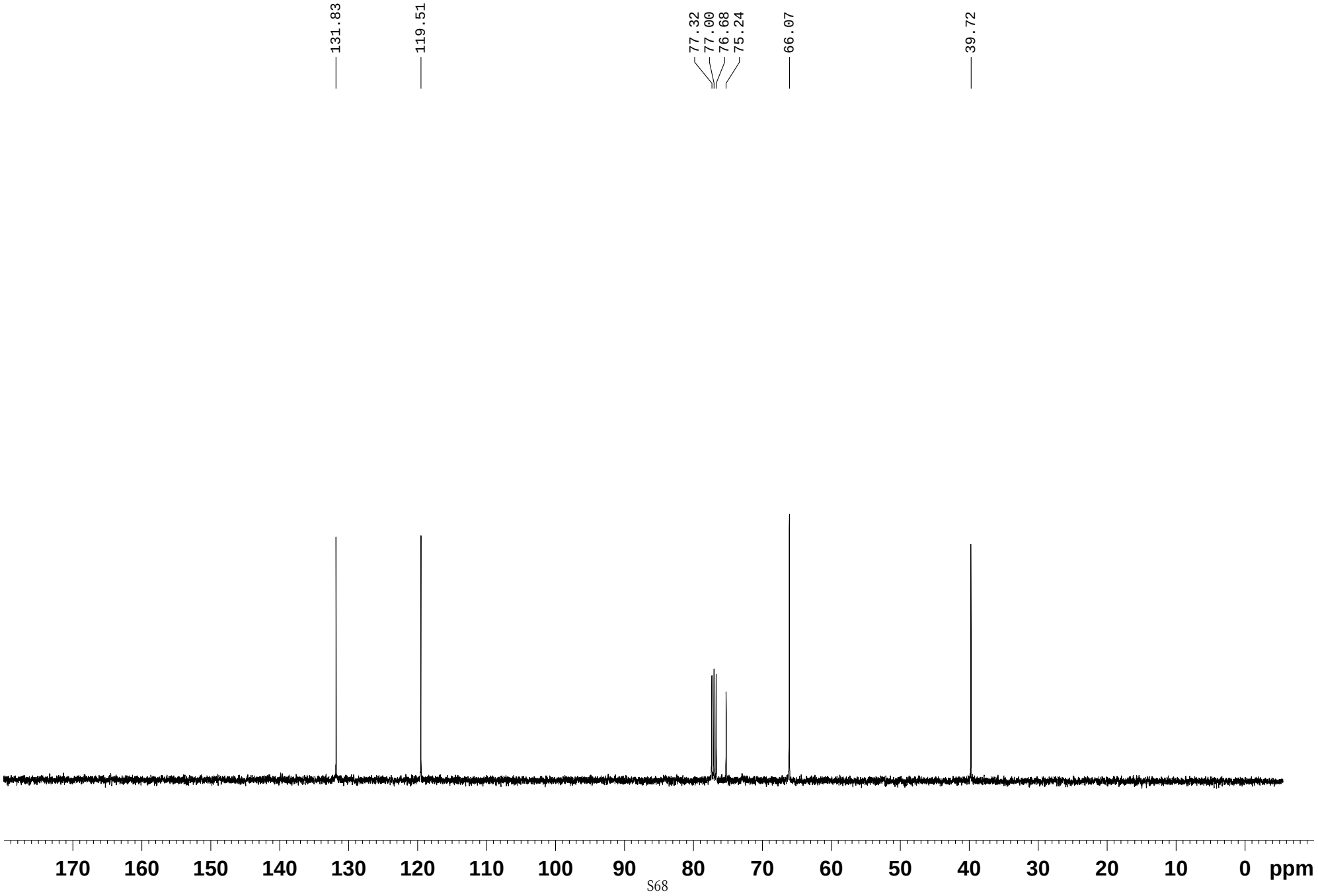
lbs-allyl-diol-H6

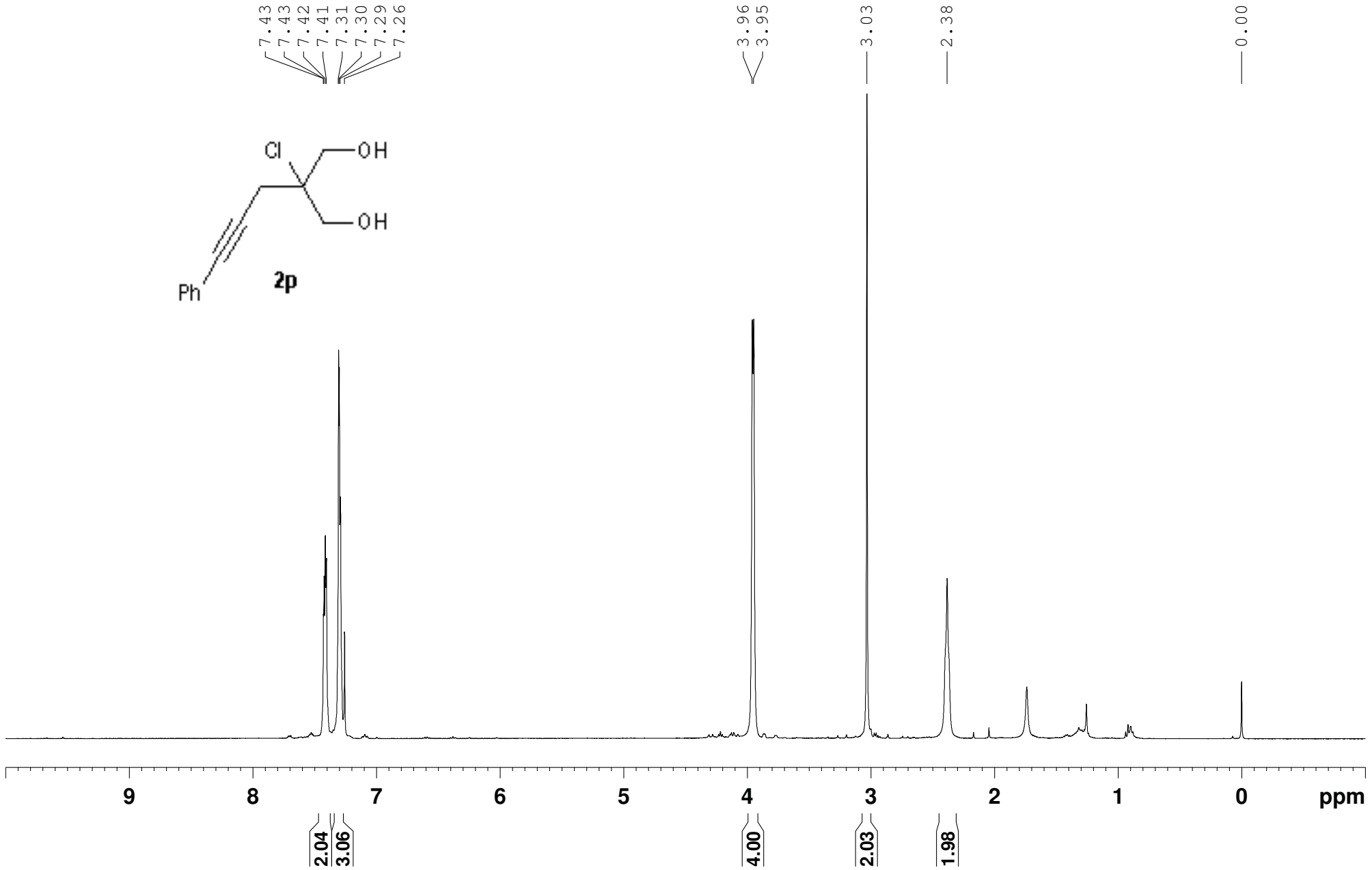


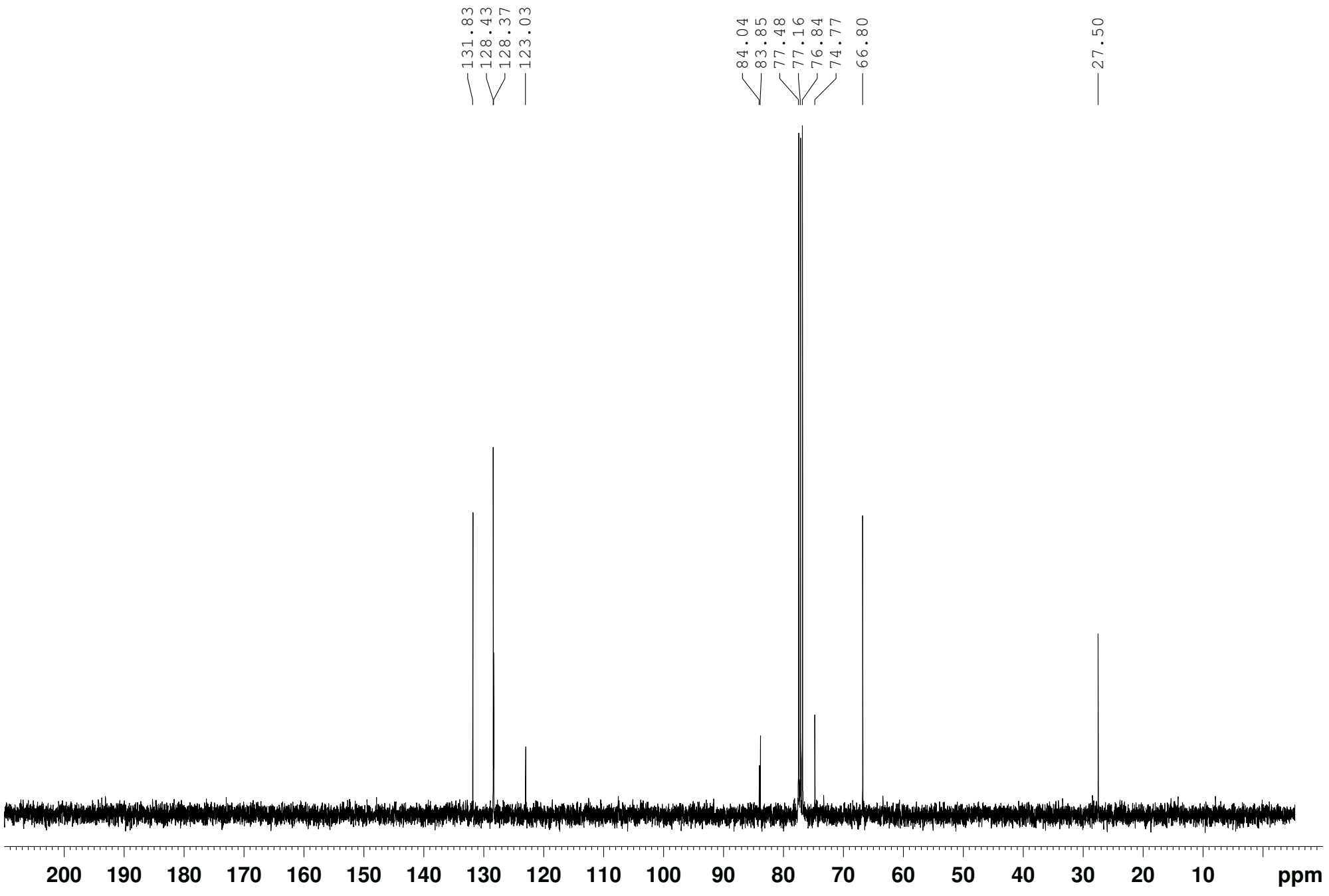
2o



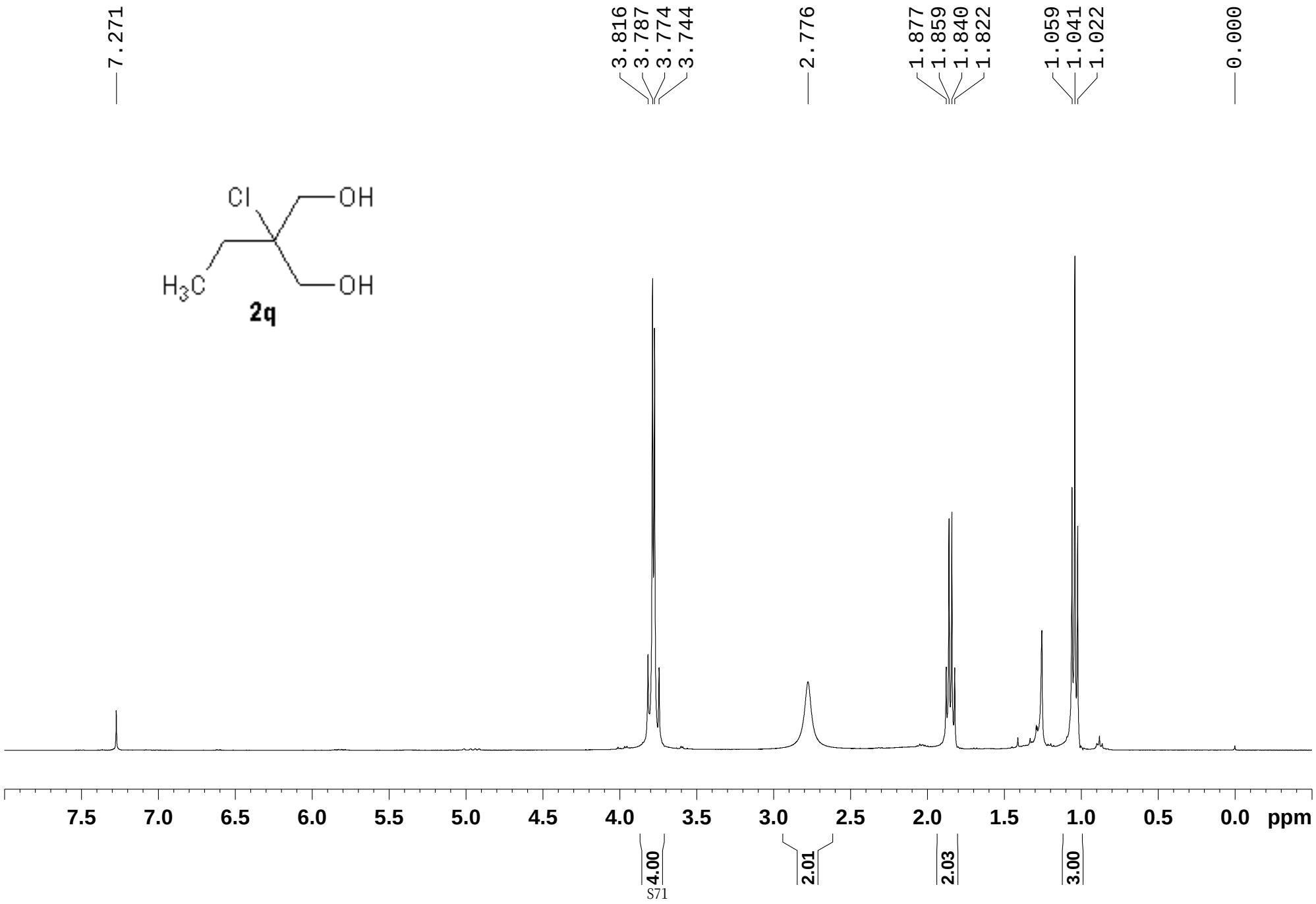
lbs-allyl-diol-C6



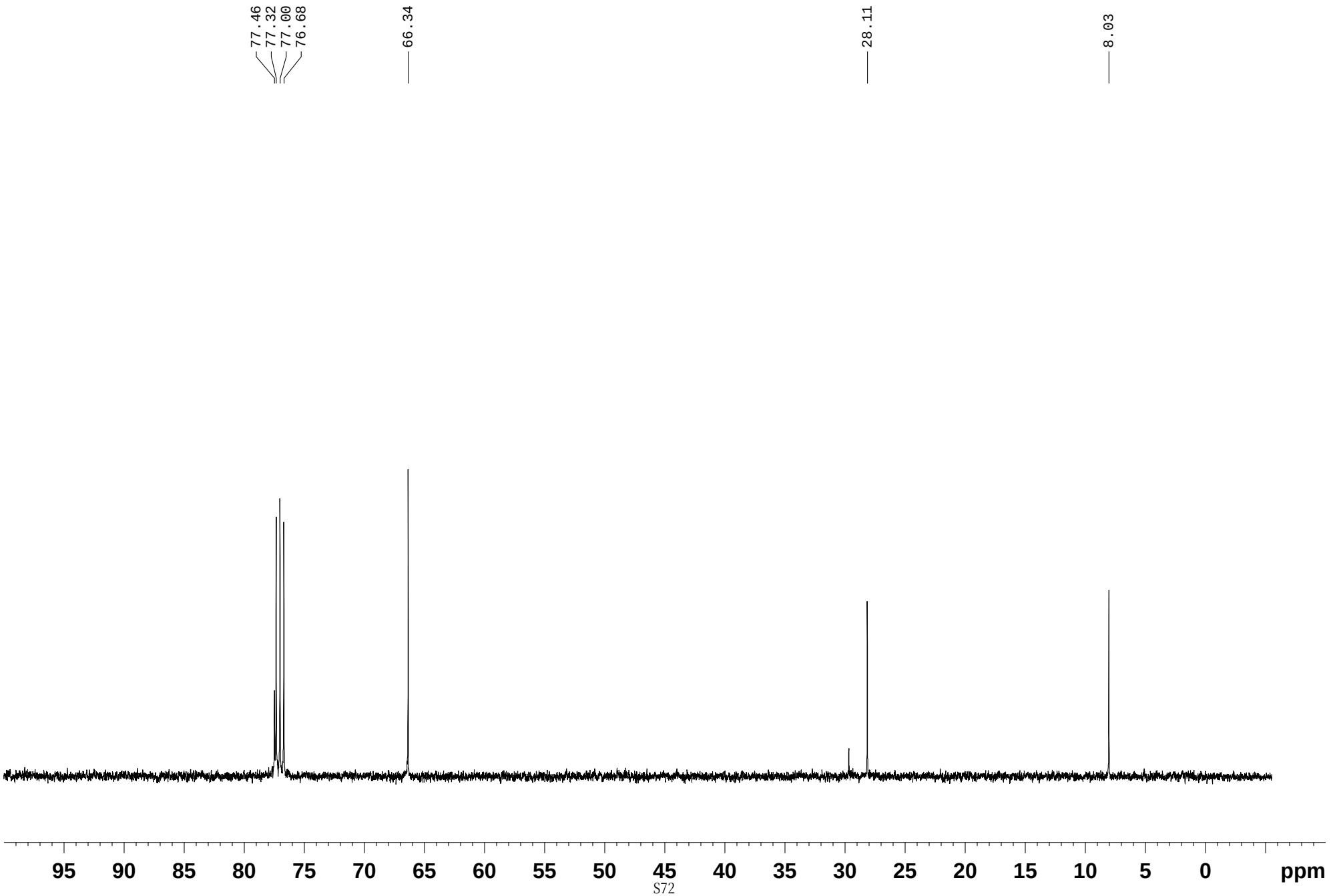

7.43
7.43
7.42
7.41
7.31
7.30
7.29
7.26
3.96
3.95
3.03
2.38
0.00
Cl
OH
OH
Ph
2p
9
8
7
6
5
4
3
2
1
0
ppm
2.04
3.06
4.00
2.03
1.98


131.83
128.43
128.37
123.03
84.04
83.85
77.48
77.16
76.84
74.77
66.80
27.50
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

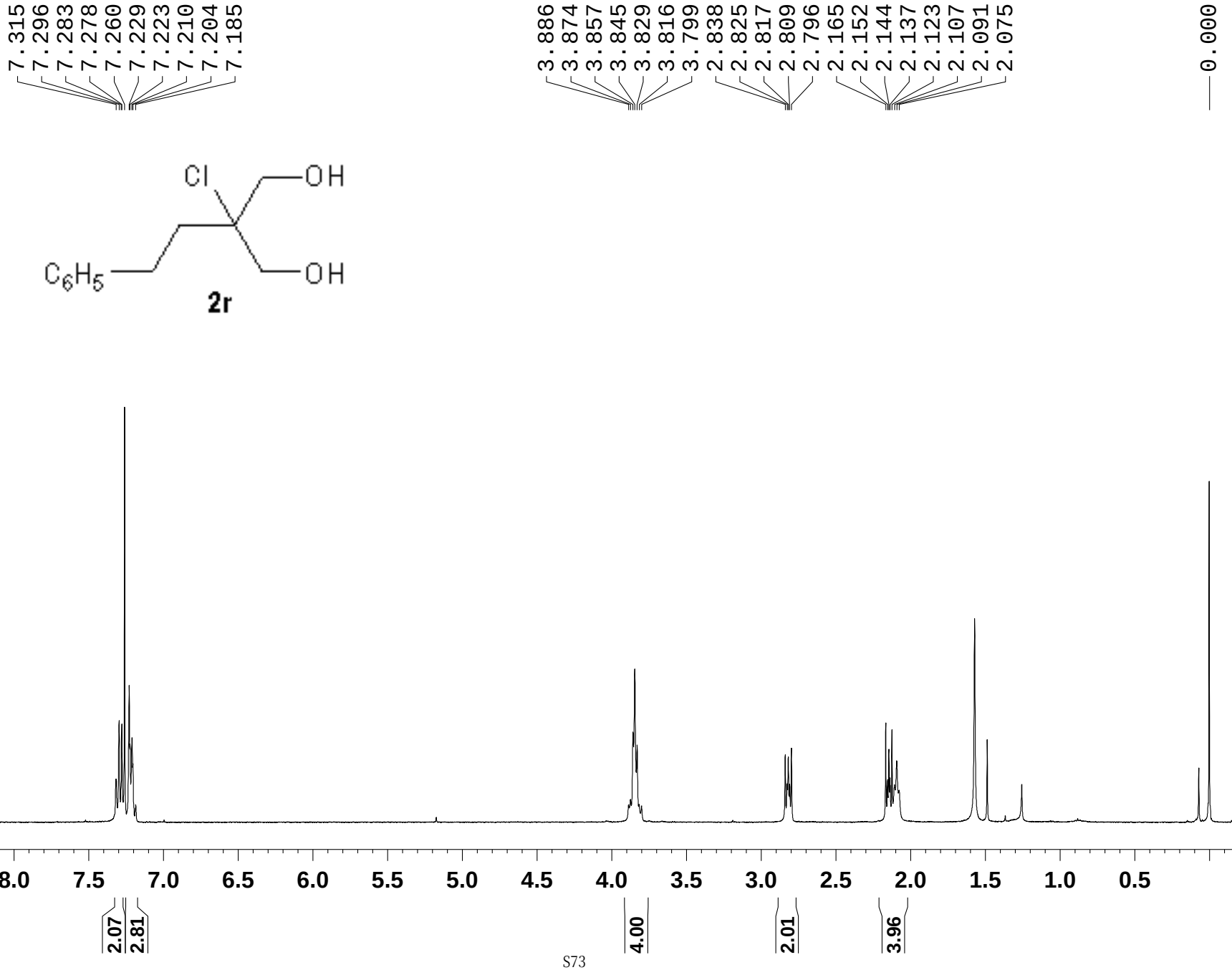
lbs-Et-Diol-H


7.271
3.816
3.787
3.774
3.744
2.776
1.877
1.859
1.840
1.822
1.059
1.041
1.022
0.000
Cl
OH
OH
H3C
2q
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
4.00
2.01
2.03
3.00

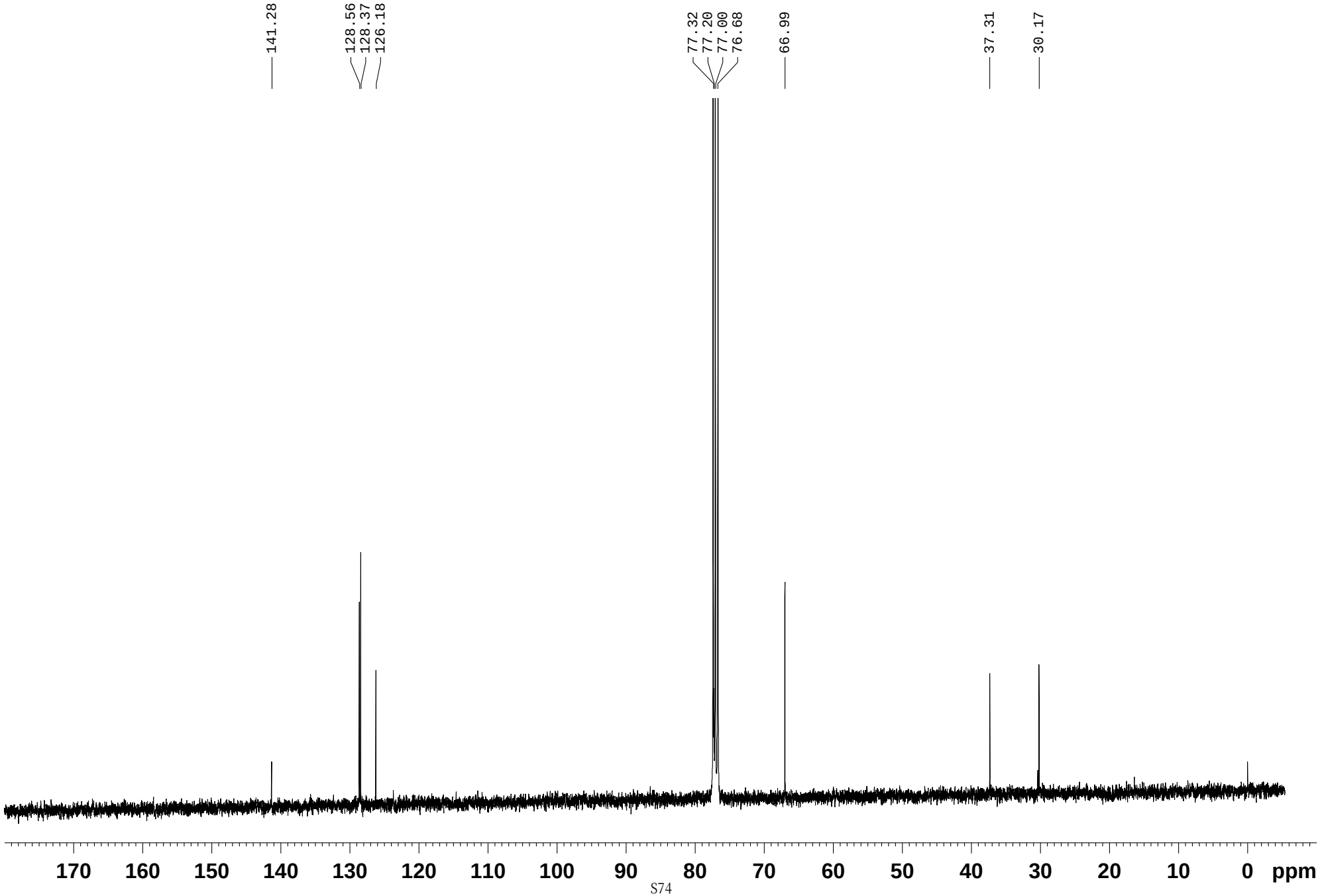
lbs-Et-Diol-C


77.46
77.32
77.00
76.68
66.34
28.11
8.03
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
ppm

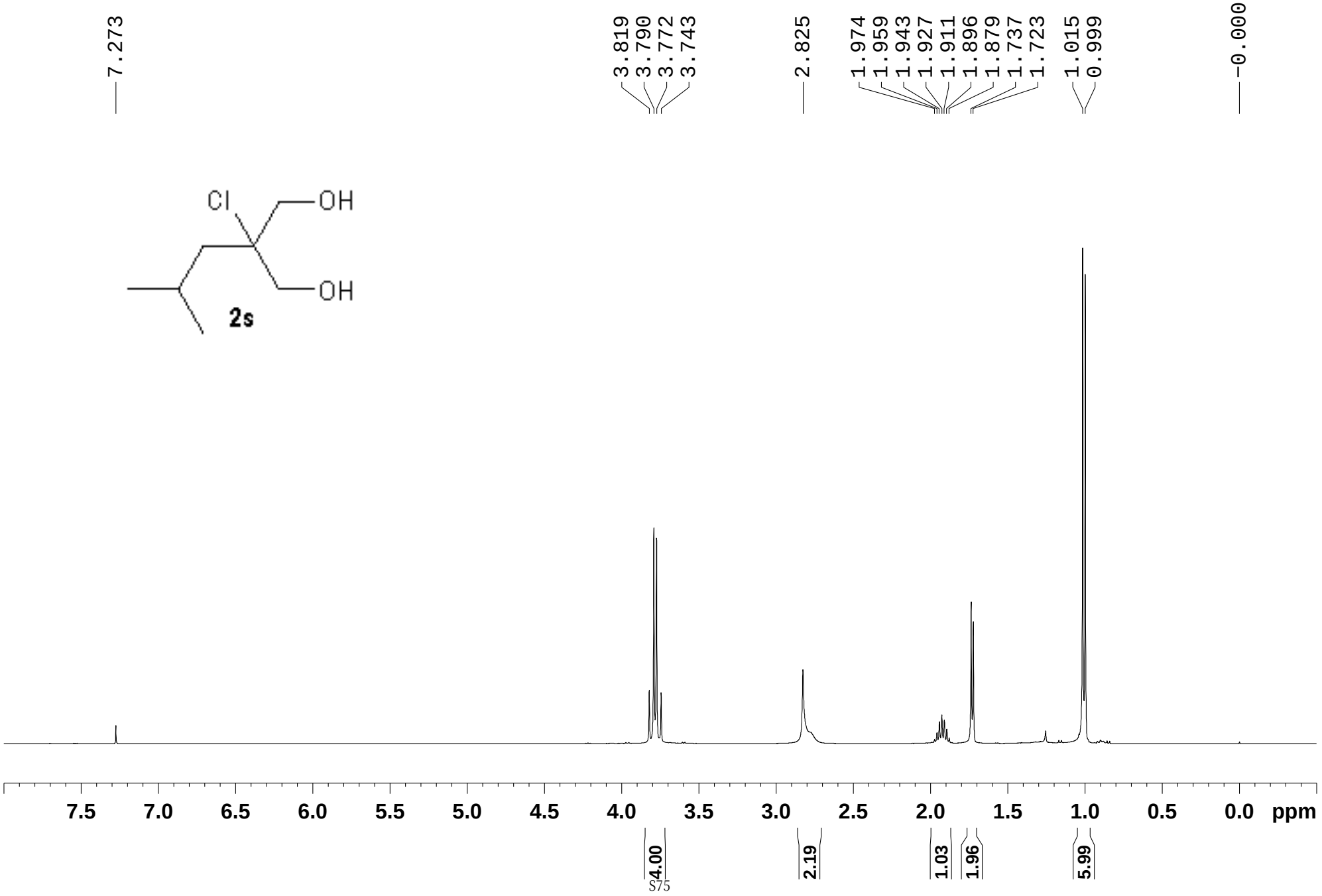
lbs-PhCH2CH2-diol-H



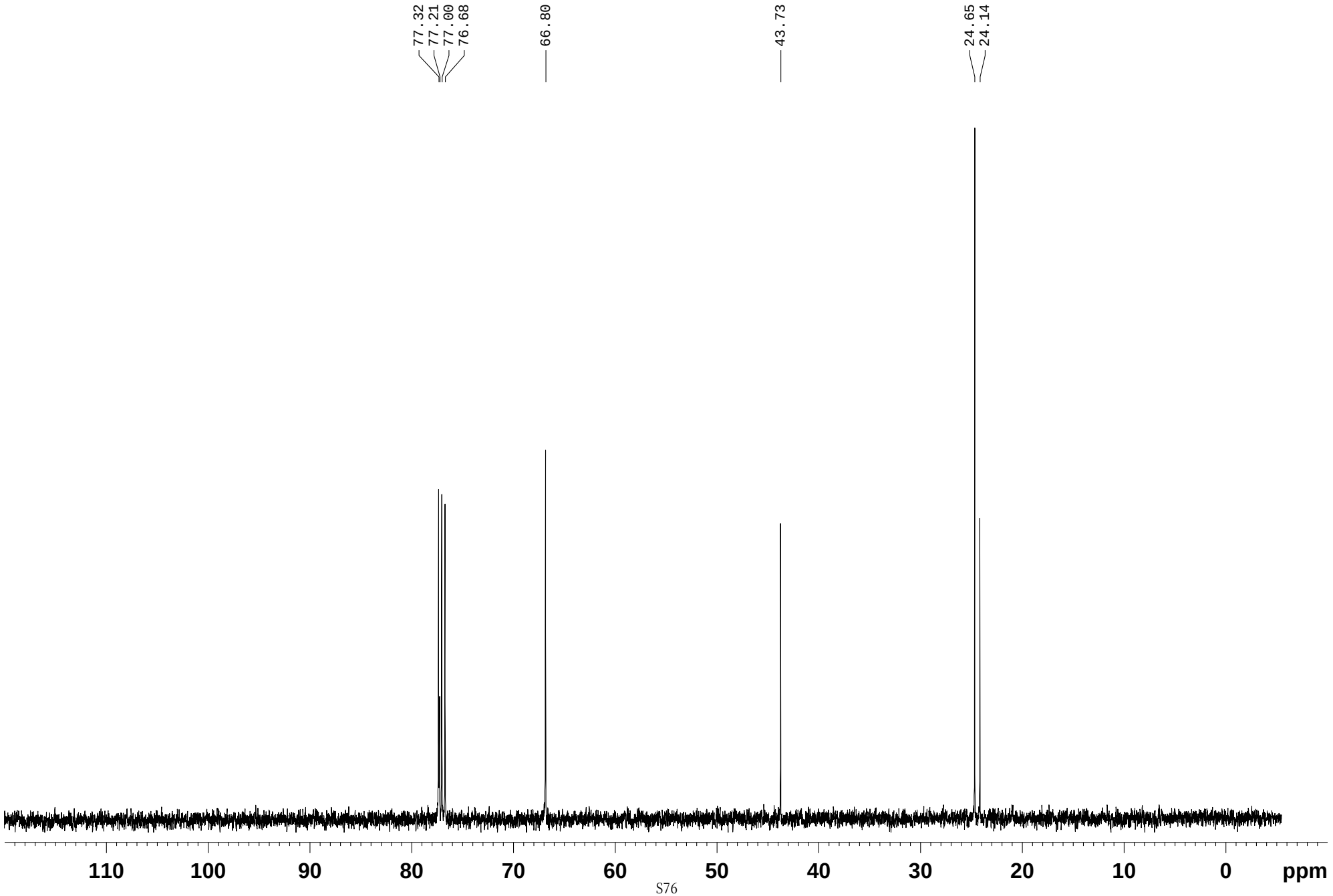
lbs-PhCH2CH2-diol-C



lbs-ipr-diol-H



lbs-ipr-diol-C



lbs-Bn-Cl-H

8.960 8.938 8.266 8.248 8.089 8.068 7.924 7.904 7.669 7.649 7.630 7.585 7.565 7.559 7.548 7.539 7.519 7.359 7.343 7.330 7.310 7.304 7.289 7.277 7.256

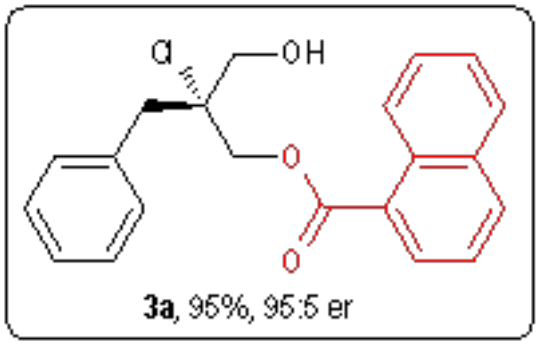
4.664 4.634 4.516 4.487

3.786 3.768

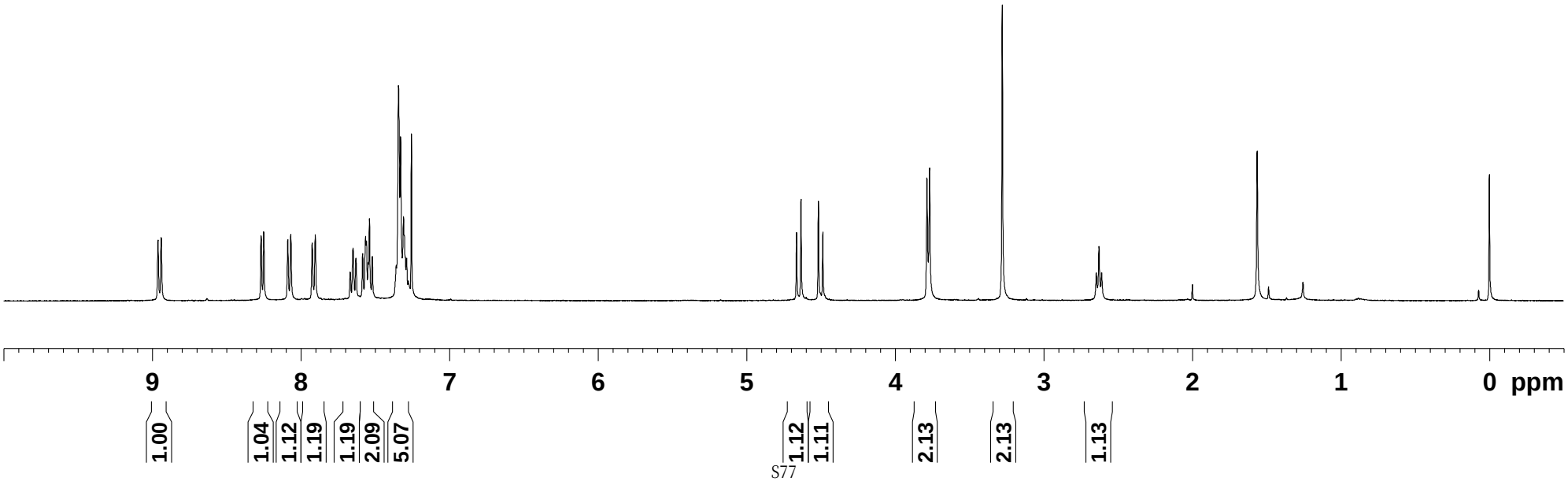
3.279

2.646 2.628 2.610

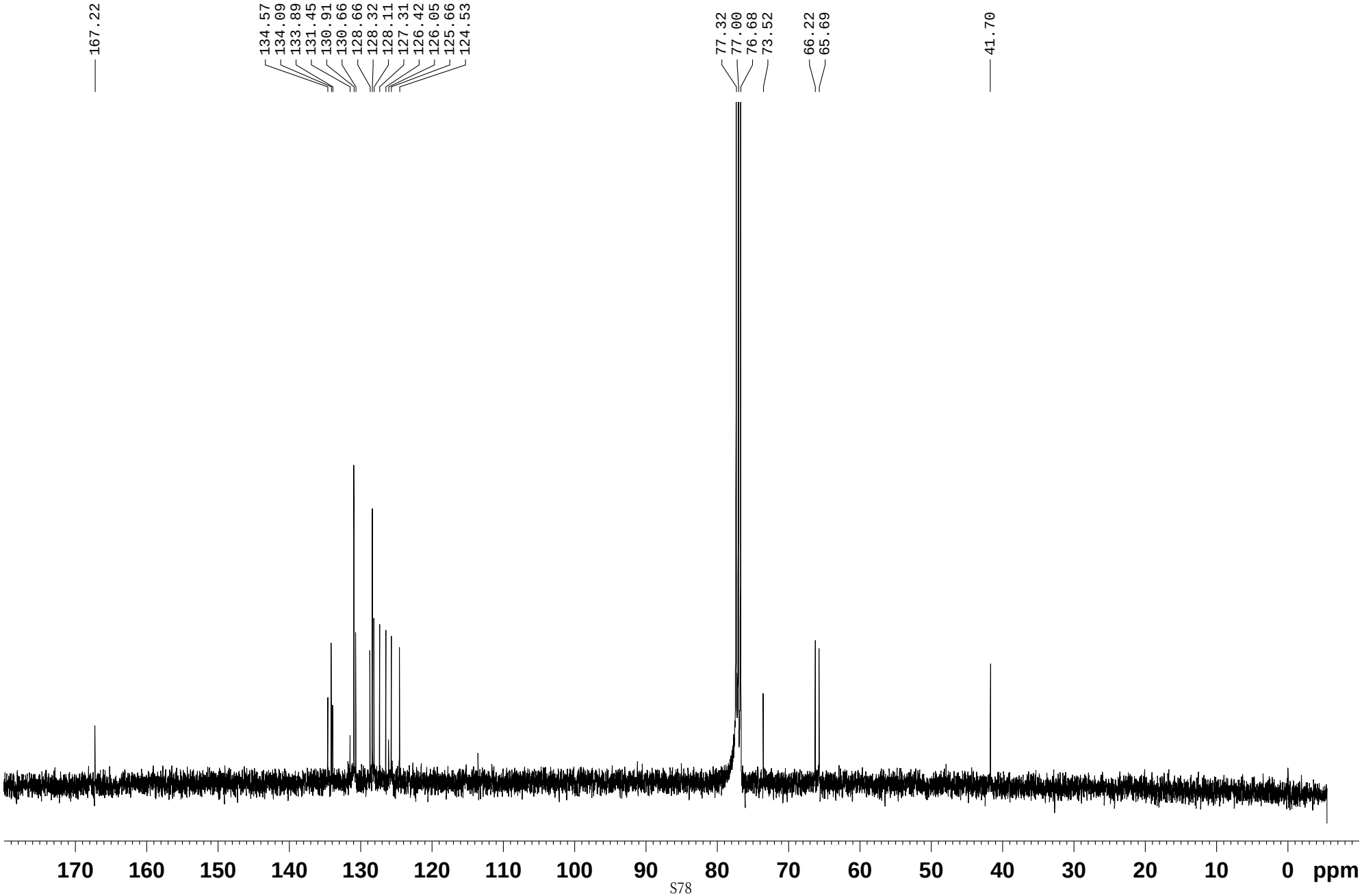
0.000



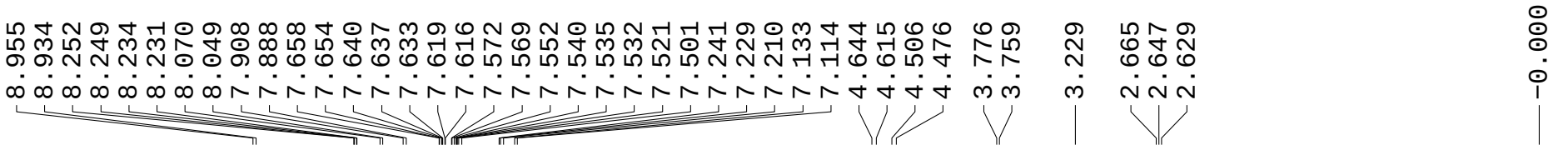
3a, 95%, 95:5 er

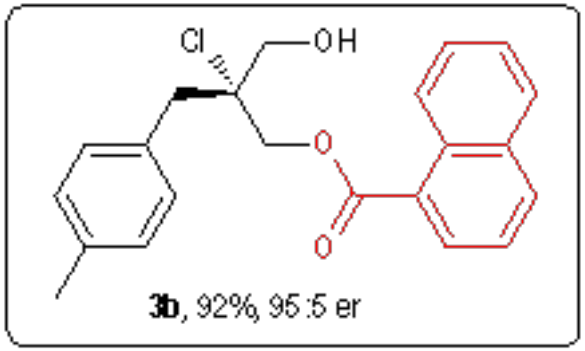


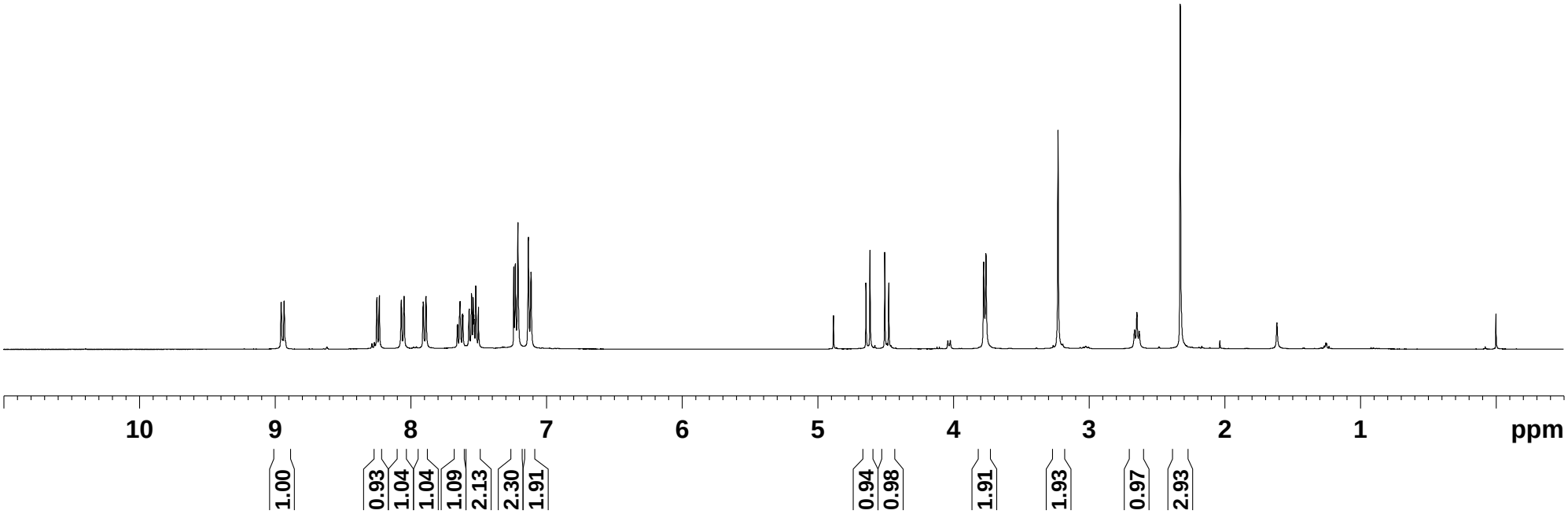
lbs-Bn-Cl-C


167.22
134.57
134.09
133.89
131.45
130.91
130.66
128.66
128.32
128.11
127.31
126.42
126.05
125.66
124.53
77.32
77.00
76.68
73.52
66.22
65.69
41.70
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

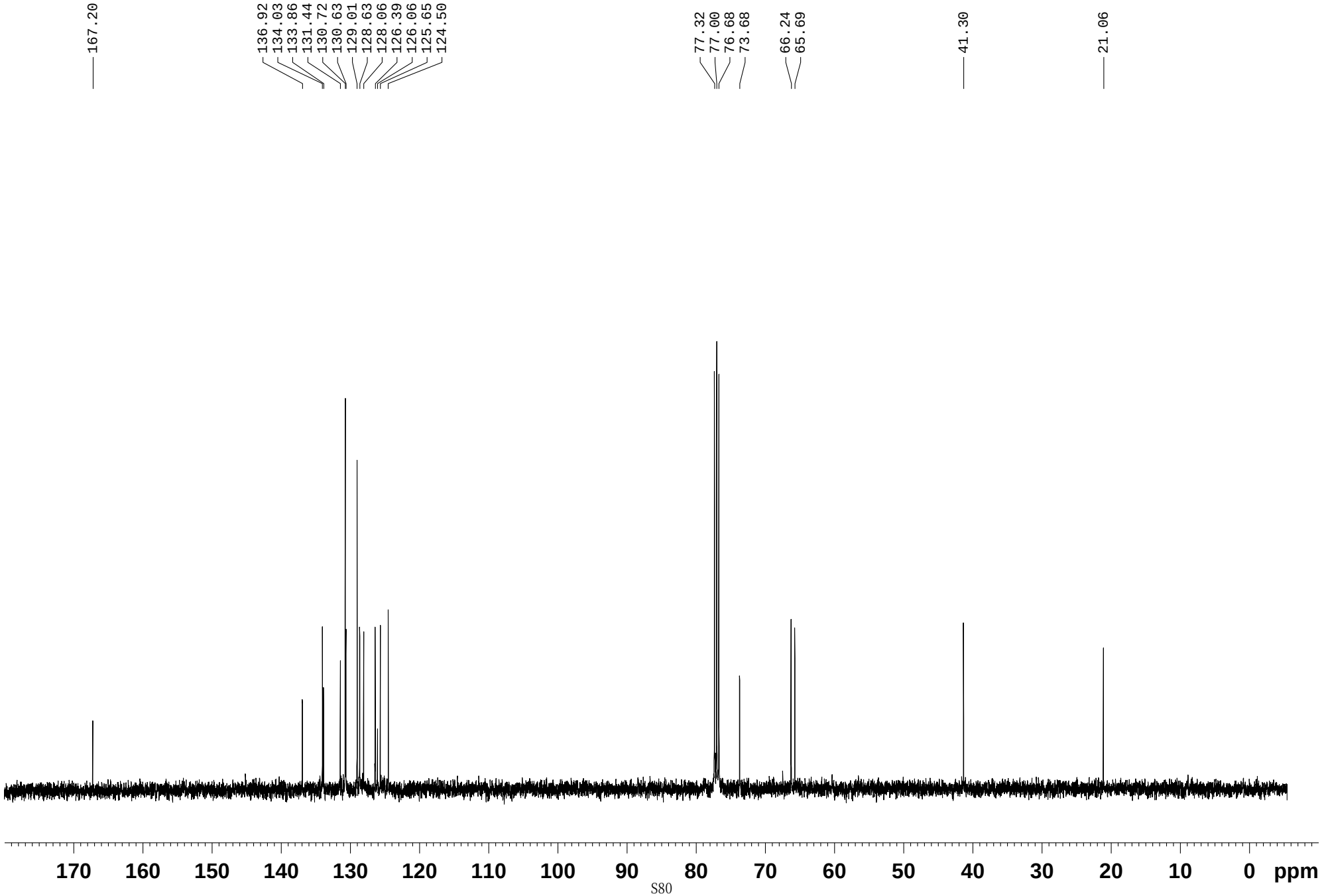
lbs-4-Me-Cl-H


8.955
8.934
8.252
8.249
8.234
8.231
8.070
8.049
7.908
7.888
7.658
7.654
7.640
7.637
7.633
7.619
7.616
7.572
7.569
7.552
7.540
7.535
7.532
7.521
7.501
7.241
7.229
7.210
7.133
7.114
4.644
4.615
4.506
4.476
3.776
3.759
3.229
2.665
2.647
2.629
-0.000


Cl
OH
O
O
3b, 92%, 95:5 er


10
9
8
7
6
5
4
3
2
1
ppm
1.00
0.93
1.04
1.04
1.09
2.13
2.30
1.91
0.94
0.98
1.91
1.93
0.97
2.93

lbs-4-Me-Cl-C

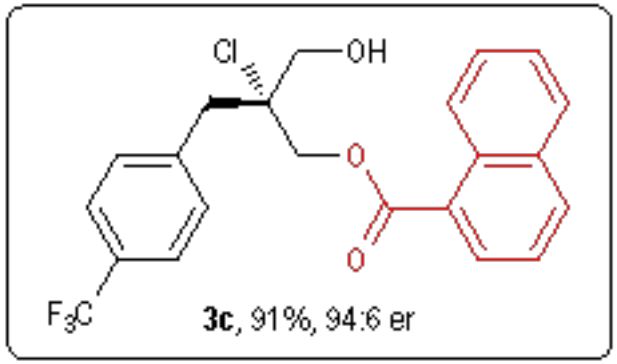

167.20
136.92
134.03
133.86
131.44
130.72
130.63
129.01
128.63
128.06
126.39
126.06
125.65
124.50
77.32
77.00
76.68
73.68
66.24
65.69
41.30
21.06
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

lbs-4-CF3-Cl-H

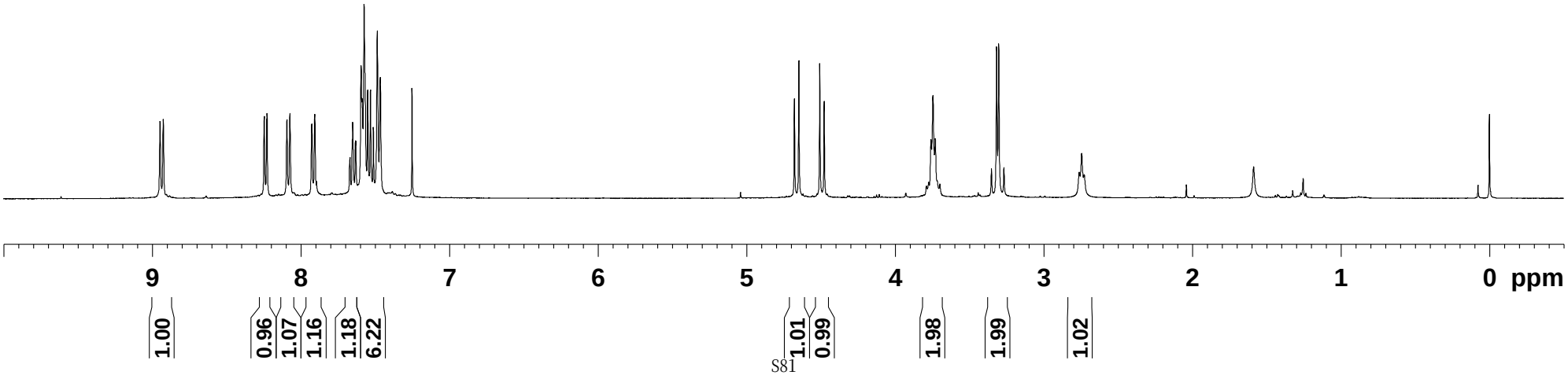
8.924
8.246
8.243
8.227
8.225
8.092
8.072
7.925
7.904
7.672
7.670
7.655
7.652
7.634
7.631
7.595
7.589
7.575
7.551
7.532
7.513
7.486
7.466
7.252

4.678
4.649
4.508
4.478
3.790
3.775
3.759
3.746
3.730
3.699
3.352
3.317
3.303
3.268
2.761
2.744
2.727

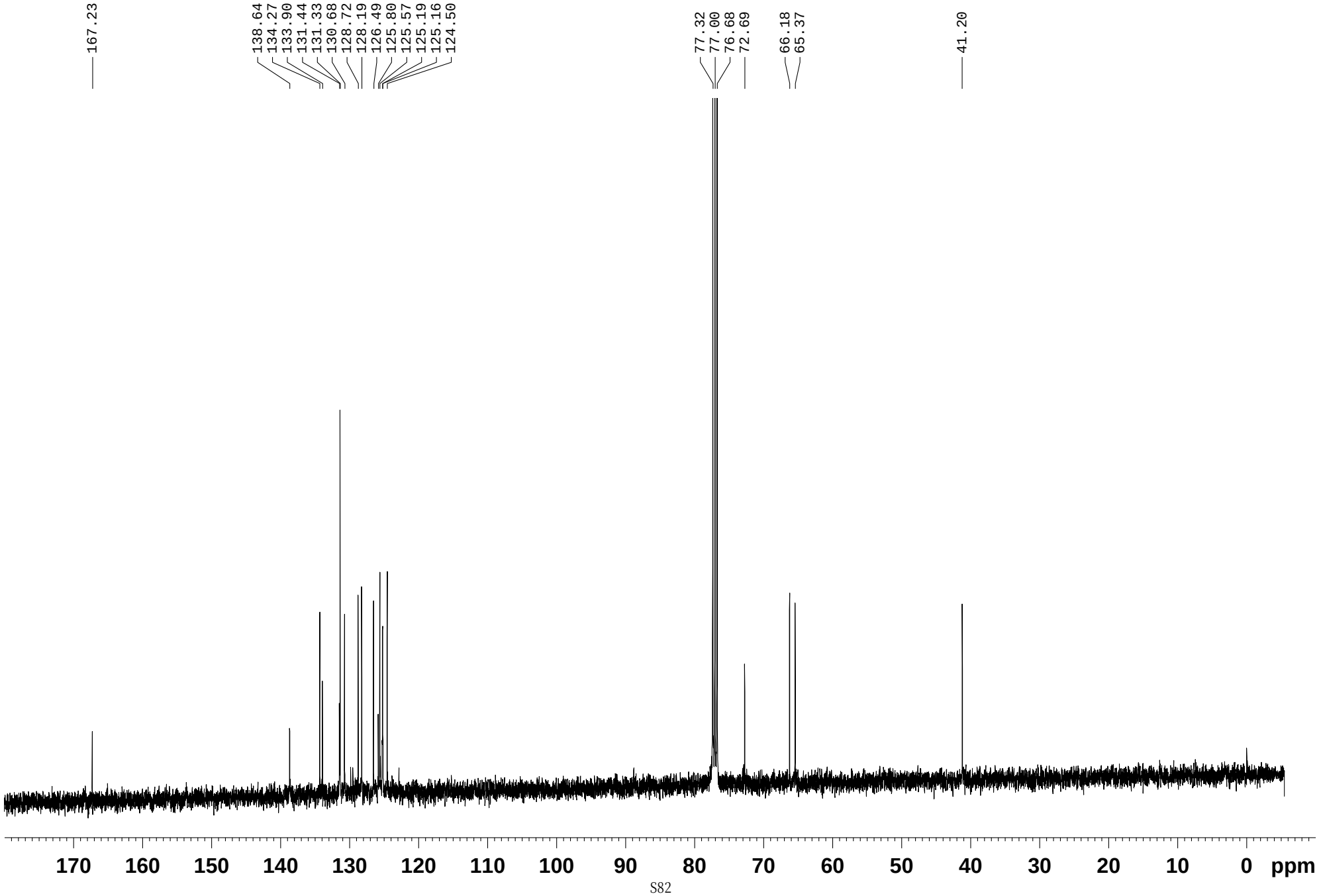
0.000

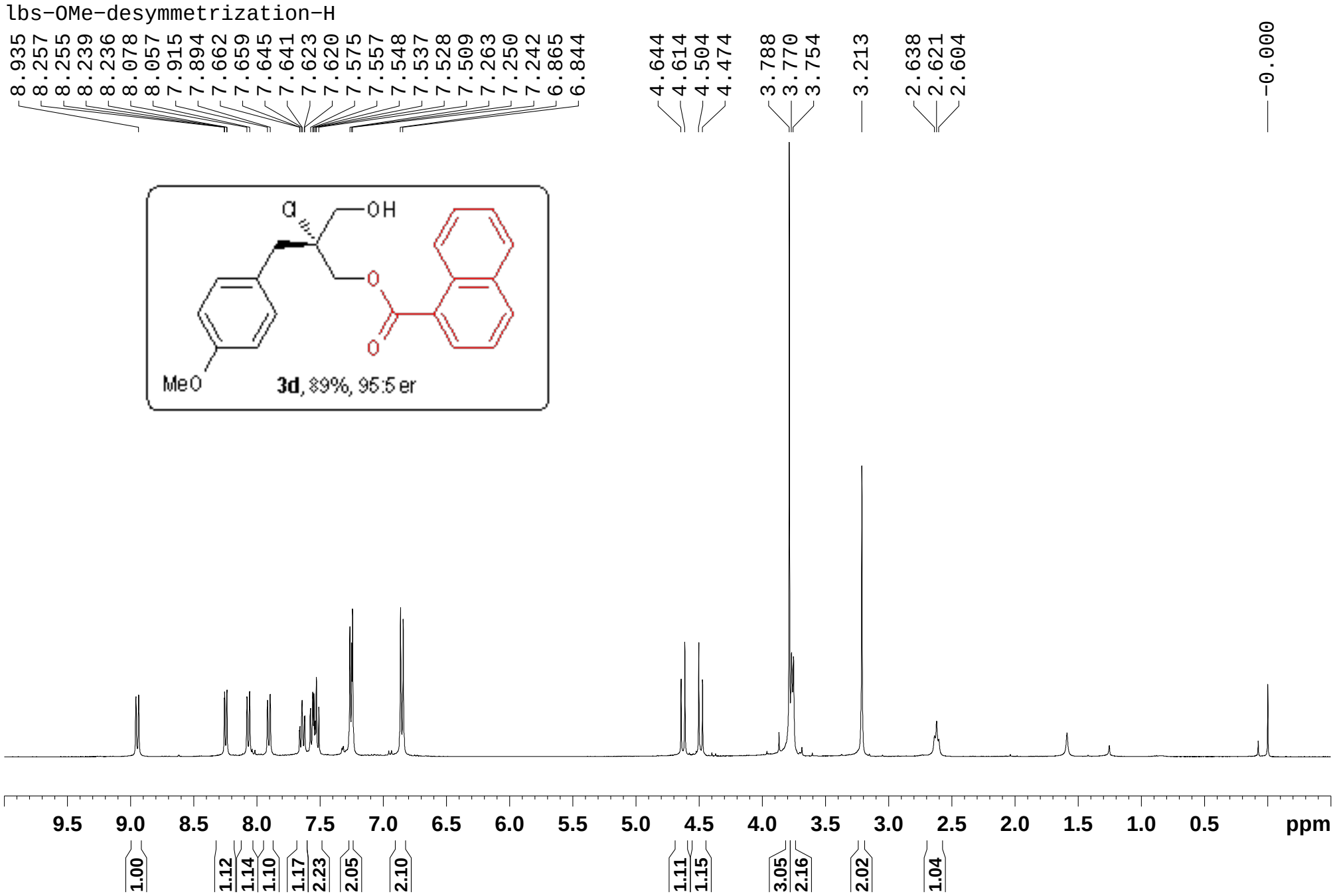


3c, 91%, 94:6 er

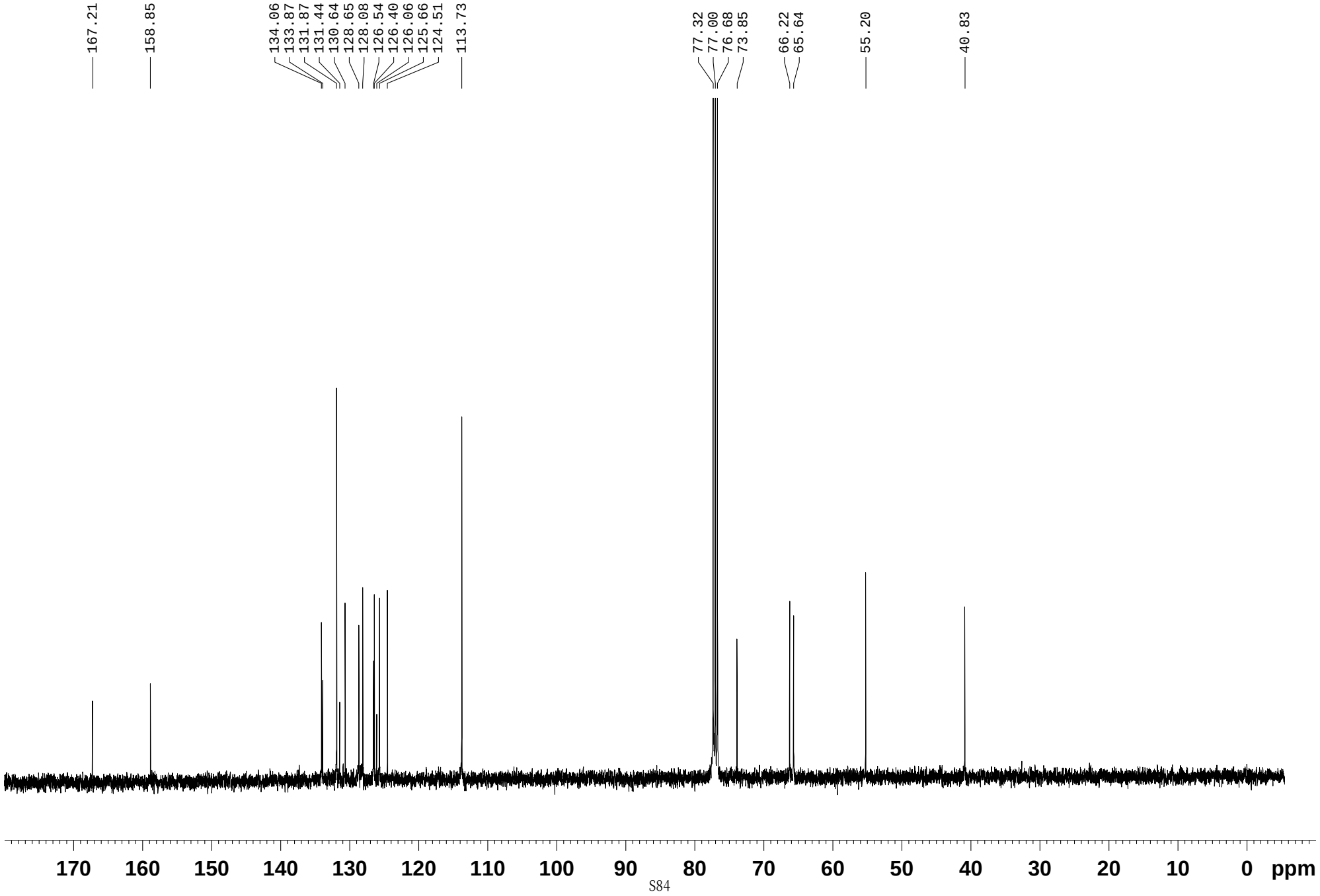


lbs-4-CF3-Cl-C

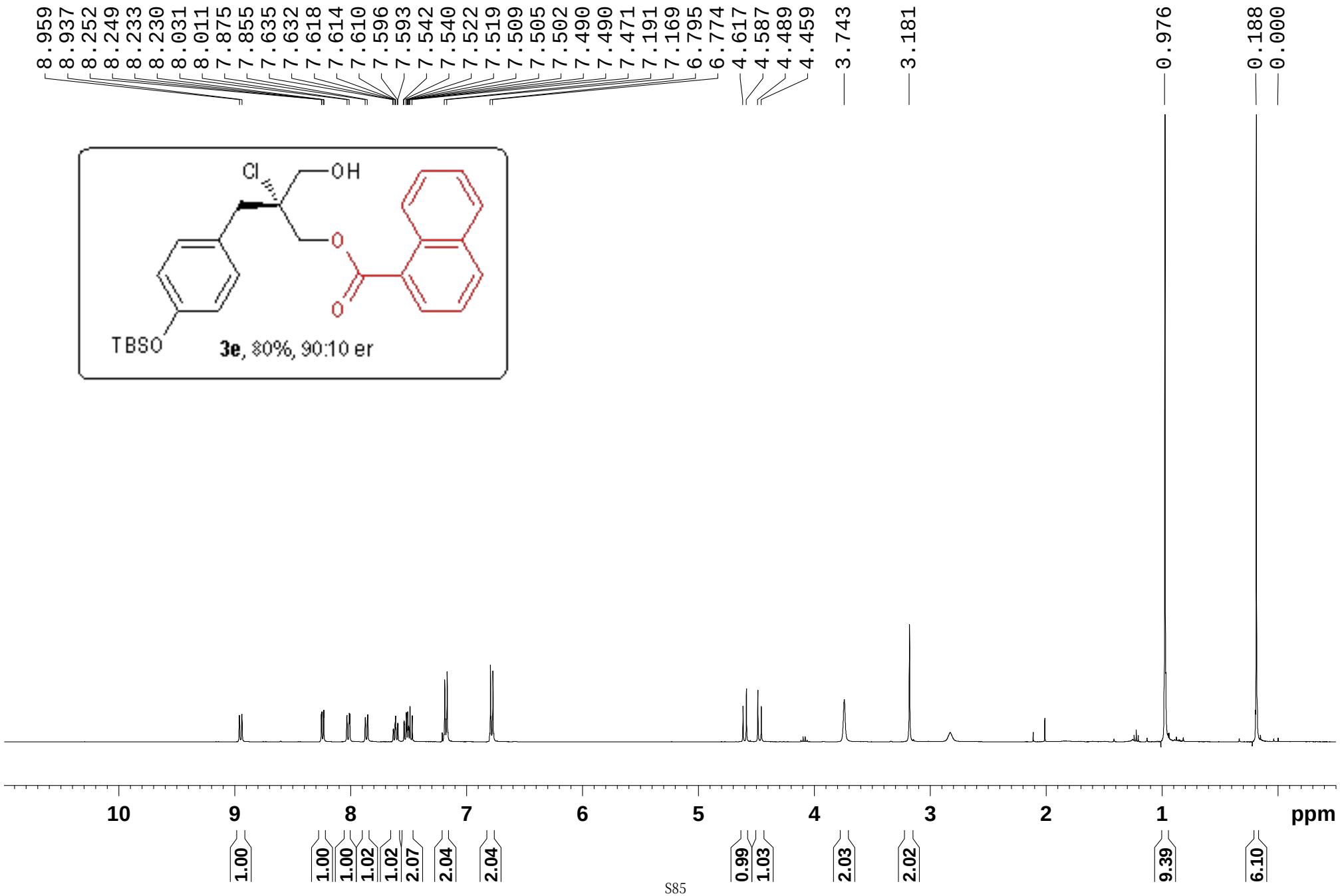

167.23
138.64
134.27
133.90
131.44
131.33
130.68
128.72
128.19
126.49
125.80
125.57
125.19
125.16
124.50
77.32
77.00
76.68
72.69
66.18
65.37
41.20
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


lbs-OMe-desymmetrization-H
8.935
8.257
8.255
8.239
8.236
8.078
8.057
7.915
7.894
7.662
7.659
7.645
7.641
7.623
7.620
7.575
7.557
7.548
7.537
7.528
7.509
7.263
7.250
7.242
6.865
6.844
4.644
4.614
4.504
4.474
3.788
3.770
3.754
3.213
2.638
2.621
2.604
-0.000
Cl
OH
O
O
MeO
3d, 89%, 95:5 er
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.00
1.12
1.14
1.10
1.17
2.23
2.05
2.10
1.11
1.15
3.05
2.16
2.02
1.04

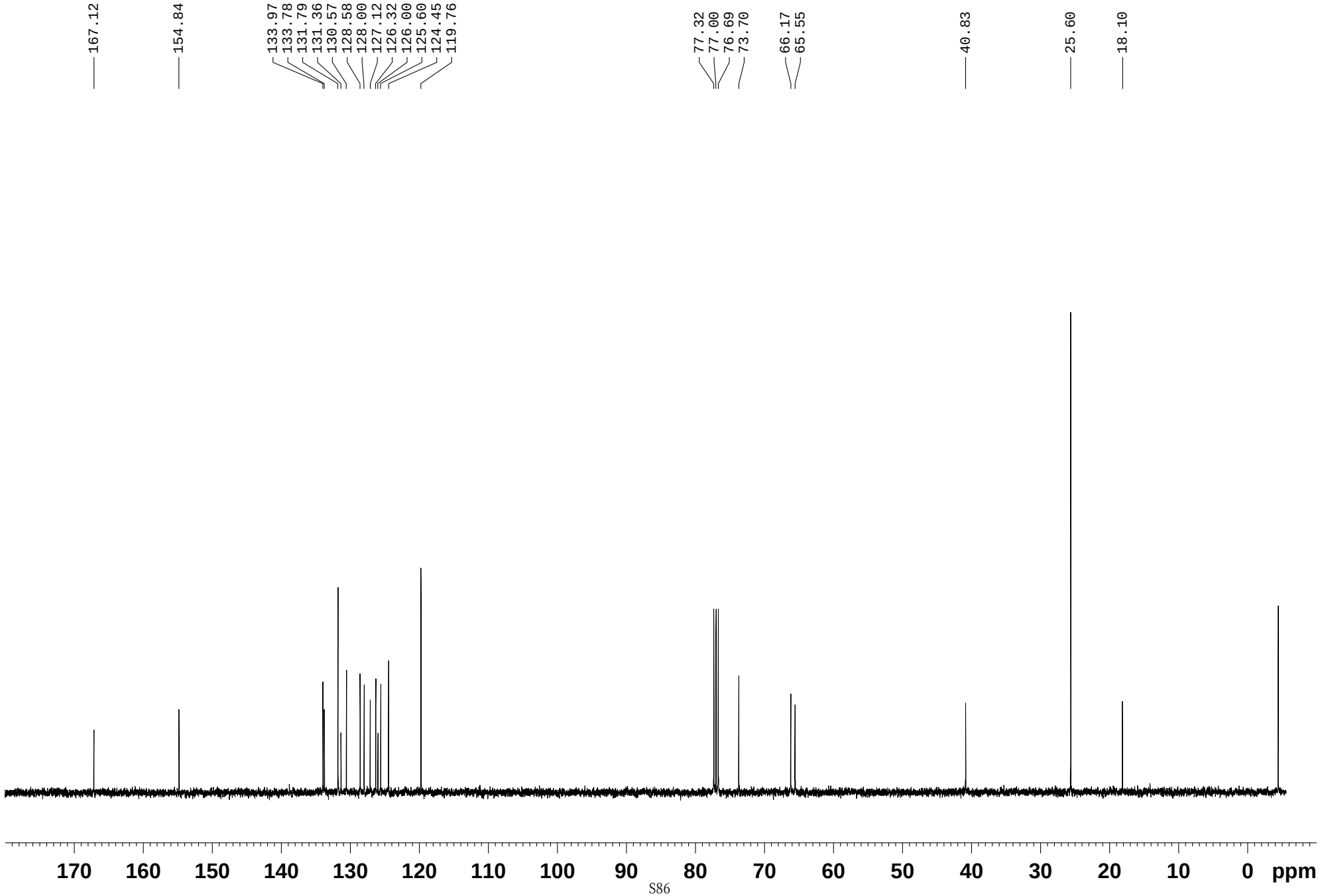
lbs-OMe-desymmetrization-C1



lbs-TBS-Cl-H

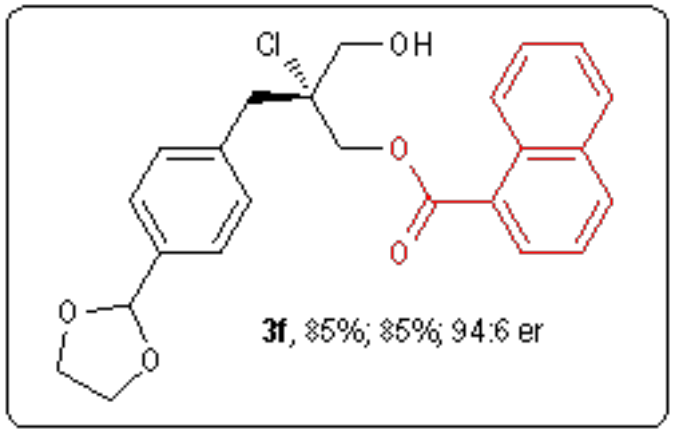

8.959
8.937
8.252
8.249
8.233
8.230
8.031
8.011
7.875
7.855
7.635
7.632
7.618
7.614
7.610
7.596
7.593
7.542
7.540
7.522
7.519
7.509
7.505
7.502
7.490
7.490
7.471
7.191
7.169
6.795
6.774
4.617
4.587
4.489
4.459
3.743
3.181
0.976
0.188
0.000
Cl
OH
O
O
TBSO
3e, 80%, 90:10 er
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.00
1.00
1.02
1.02
2.07
2.04
2.04
0.99
1.03
2.03
2.02
9.39
6.10

lbs-TBS-Cl-C1

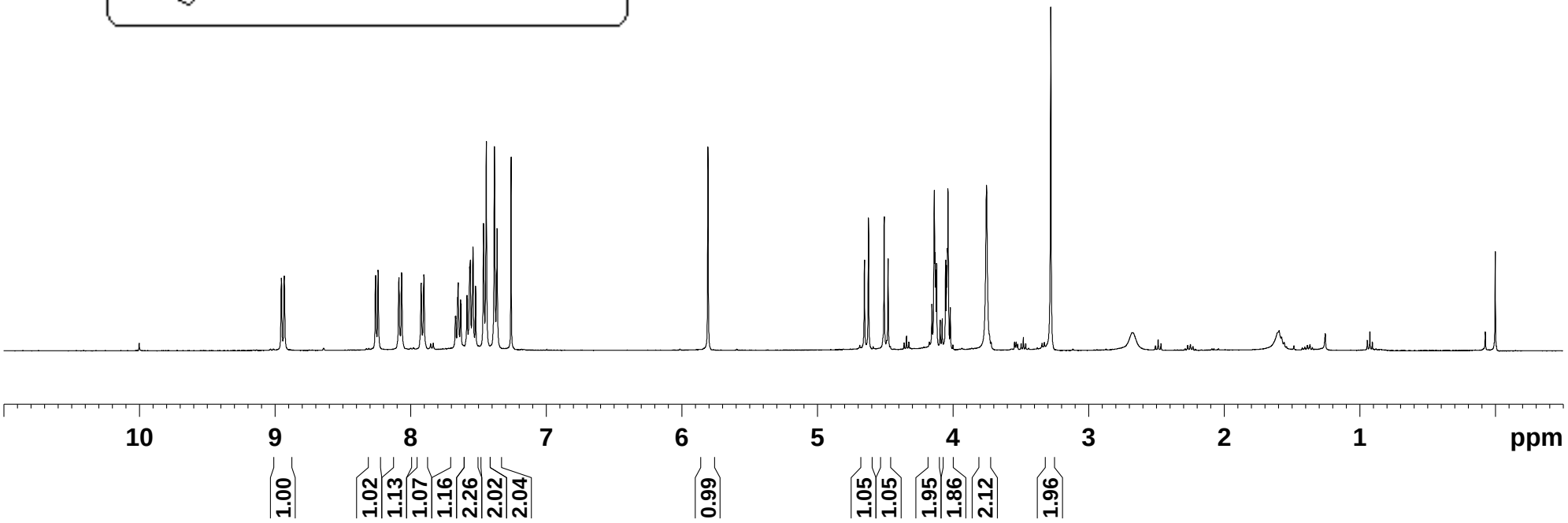

167.12
154.84
133.97
133.78
131.79
131.36
130.57
128.58
128.00
127.12
126.32
126.00
125.60
124.45
119.76
77.32
77.00
76.69
73.70
66.17
65.55
40.83
25.60
18.10
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

lbs-4-protecting-ethyl-ol-H1

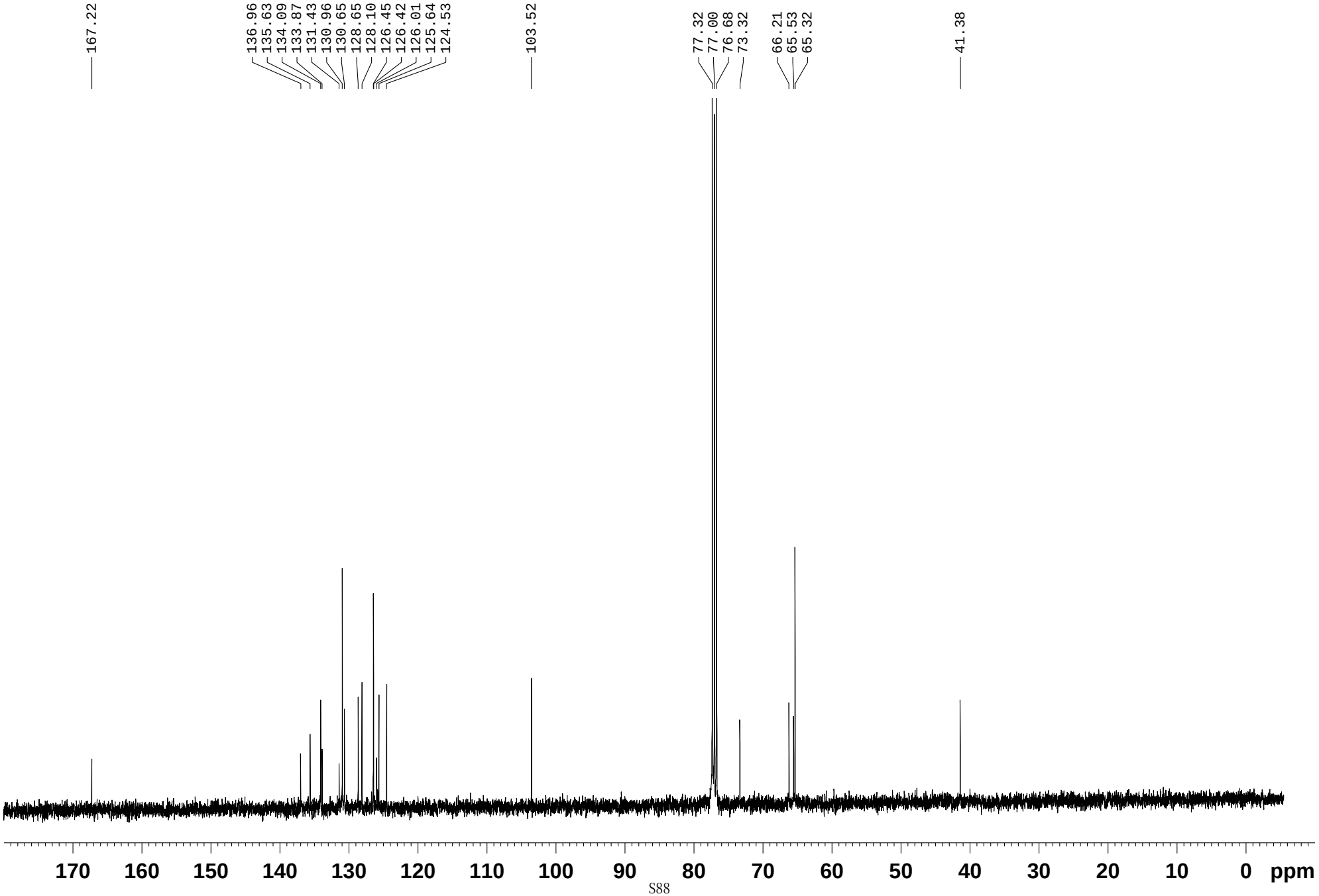
8.950 8.929 8.256 8.254 8.238 8.236 8.084 8.063 7.919 7.899 7.667 7.664 7.650 7.646 7.628 7.625 7.582 7.580 7.561 7.557 7.537 7.518 7.459 7.439 7.379 7.359 7.256 5.804 4.650 4.620 4.505 4.475 4.152 4.135 4.130 4.125 4.117 4.051 4.044 4.039 4.034 4.017 3.750 3.279 0.000



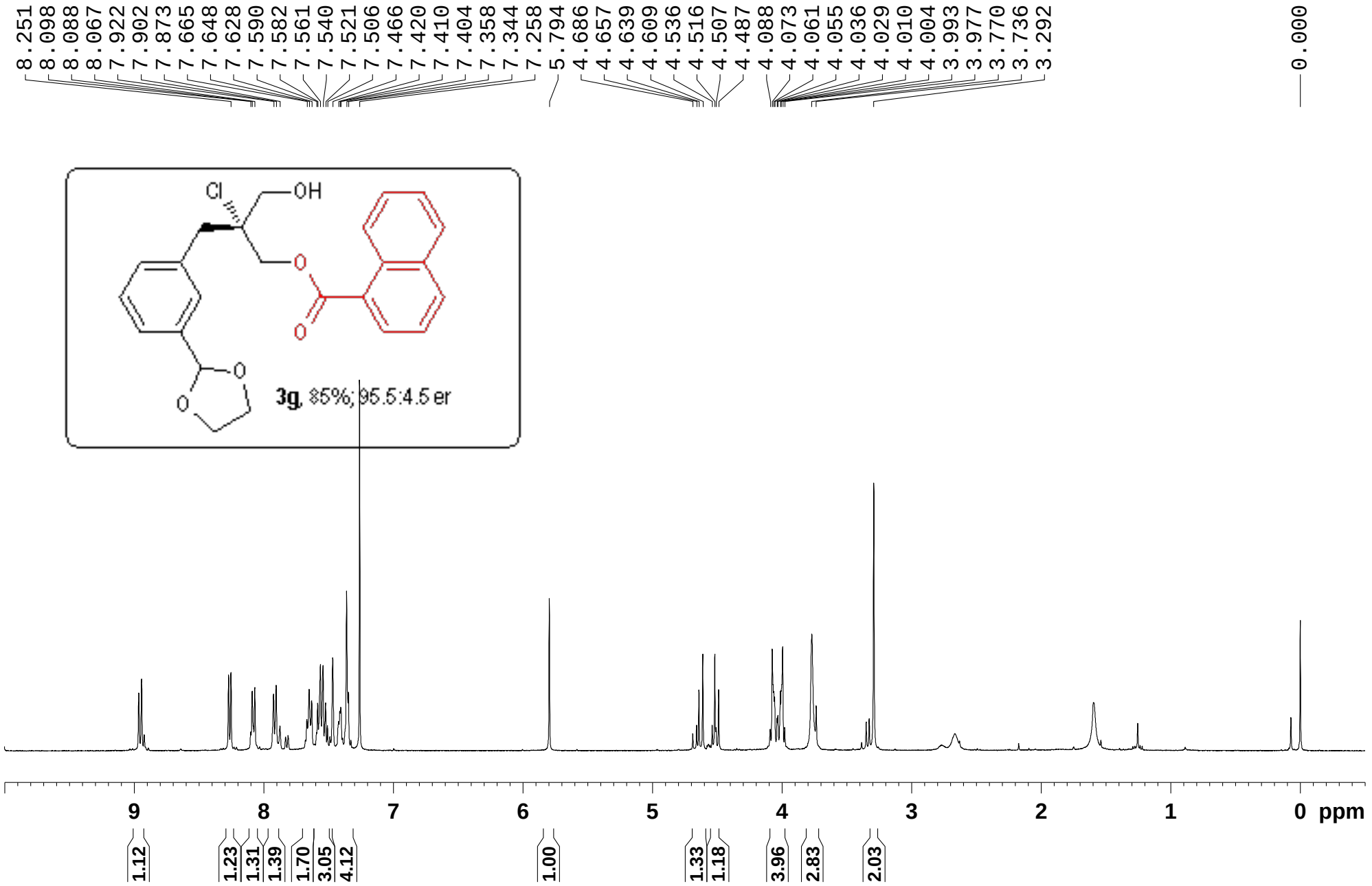
3f, 85%; 85%; 94:6 er



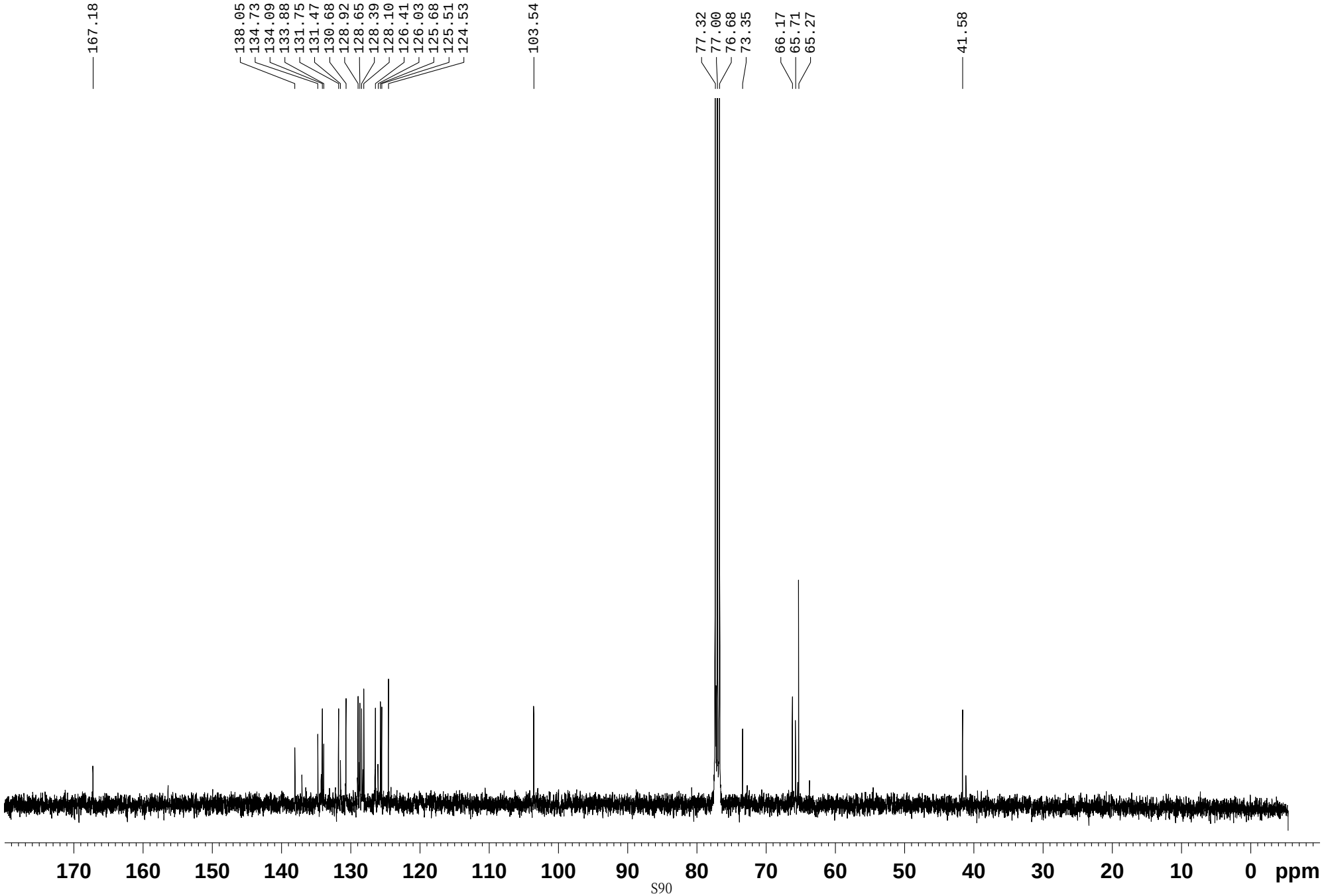
lbs-4-protecting-ethyl-ol-C



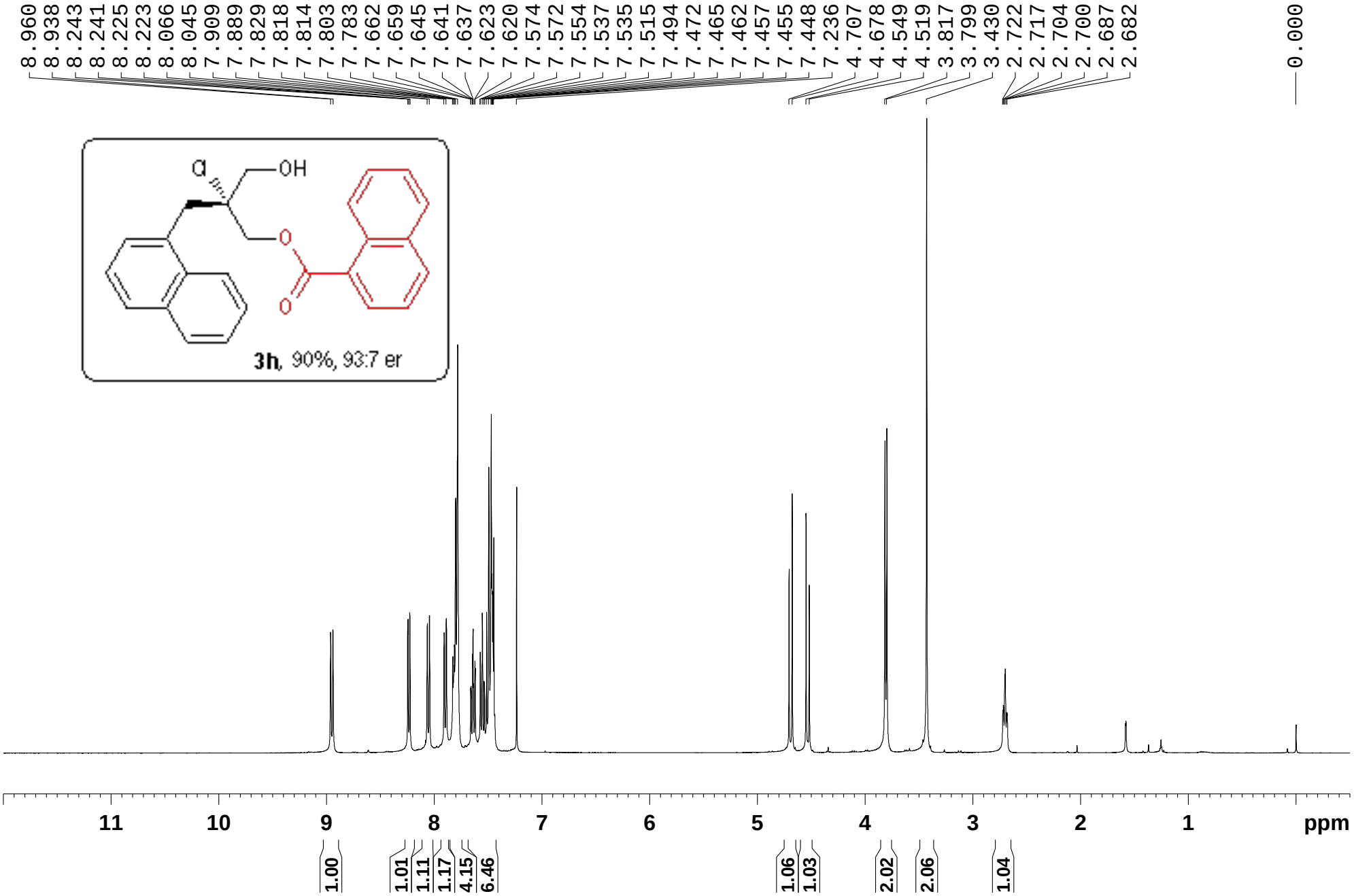
lbs-m-protecting-H



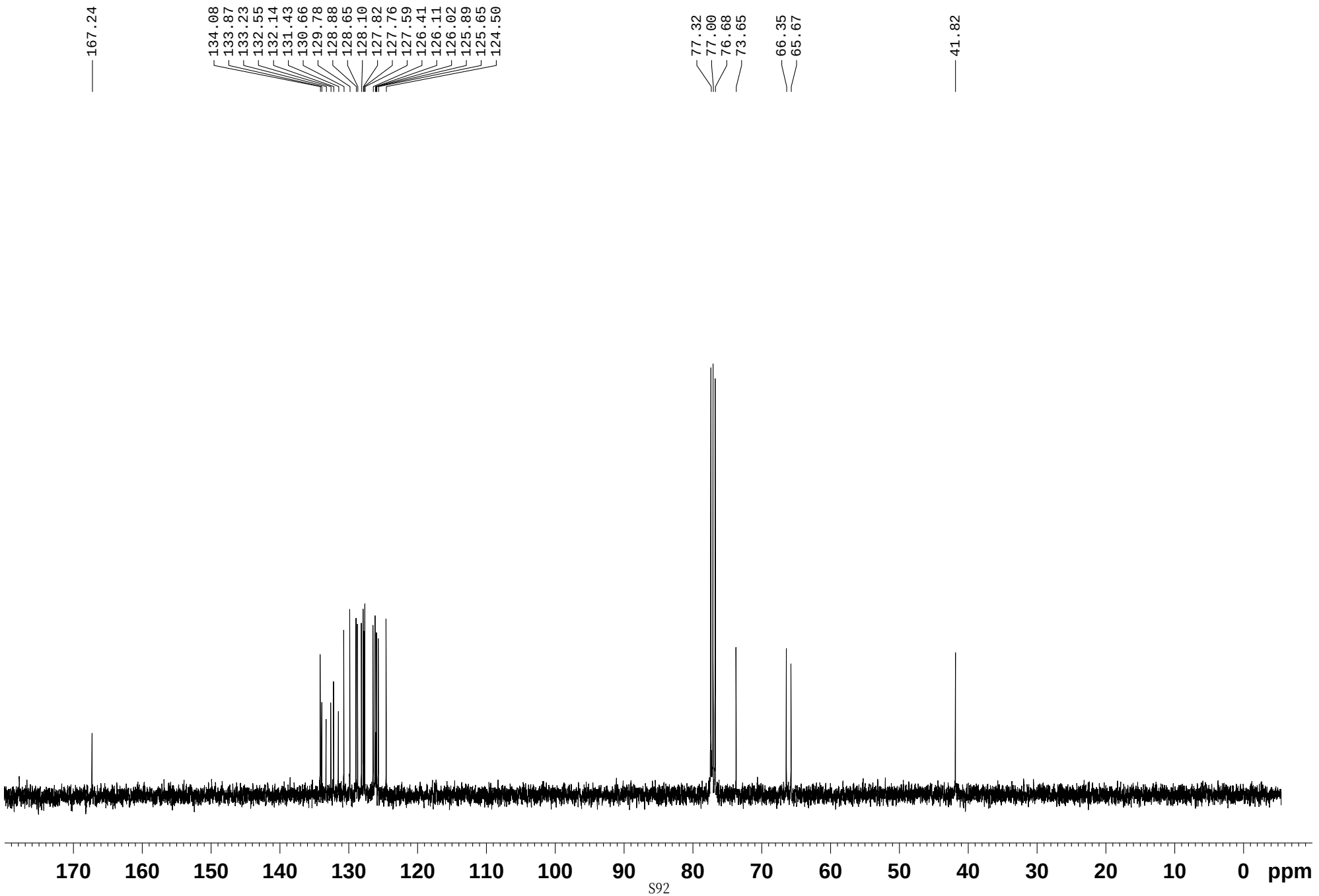
lbs-m-protecting-C



lbs-NAP-Cl-H1


8.960
8.938
8.243
8.241
8.225
8.223
8.066
8.045
7.909
7.889
7.829
7.818
7.814
7.803
7.783
7.662
7.659
7.645
7.641
7.637
7.623
7.620
7.574
7.572
7.554
7.537
7.535
7.515
7.494
7.472
7.465
7.462
7.457
7.455
7.448
7.236
4.707
4.678
4.549
4.519
3.817
3.799
3.430
2.722
2.717
2.704
2.700
2.687
2.682
0.000
Cl
OH
O
O
3h, 90%, 93:7 er
11
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.01
1.11
1.17
4.15
6.46
1.06
1.03
2.02
2.06
1.04

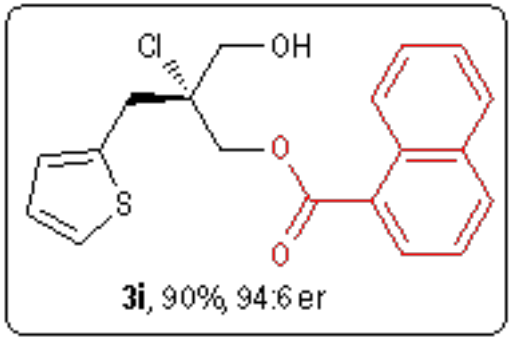
lbs-NAP-Cl-C1


167.24
134.08
133.87
133.23
132.55
132.14
131.43
130.66
129.78
128.88
128.65
128.10
127.82
127.76
127.59
126.41
126.11
126.02
125.89
125.65
124.50
77.32
77.00
76.68
73.65
66.35
65.67
41.82
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

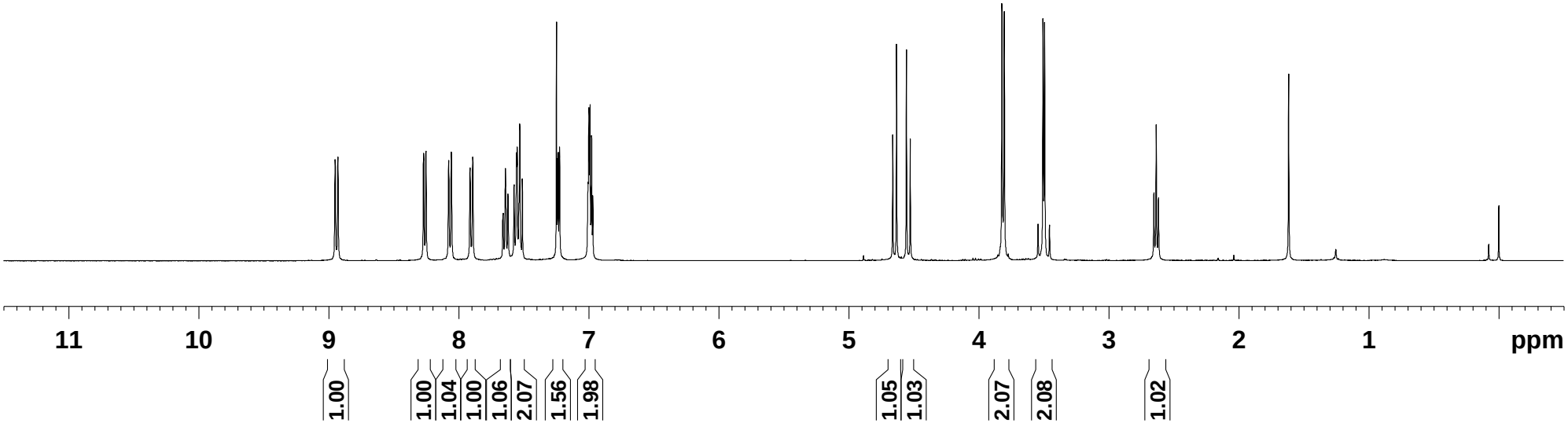
2-Cl-thiol-H

8.952 8.930 8.272 8.270 8.254 8.252 8.078 8.057 7.913 7.893 7.662 7.659 7.644 7.641 7.623 7.620 7.574 7.556 7.550 7.538 7.536 7.531 7.511 7.249 7.239 7.236 7.227 7.224 7.005 6.999 6.990 6.978 6.969 4.662 4.633 4.556 4.527 3.822 3.804 3.544 3.506 3.494 3.456 2.653 2.635 2.617

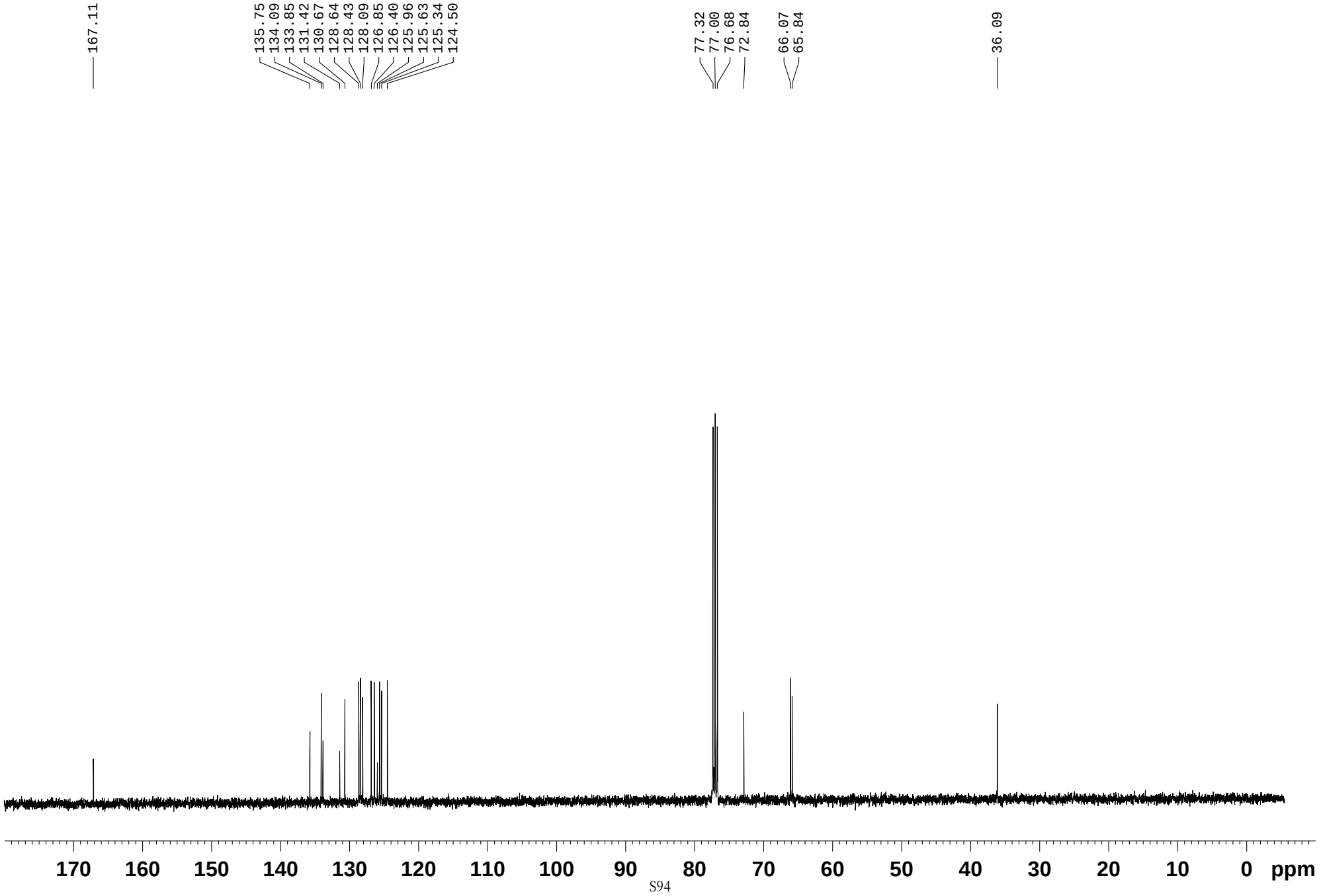
0.000



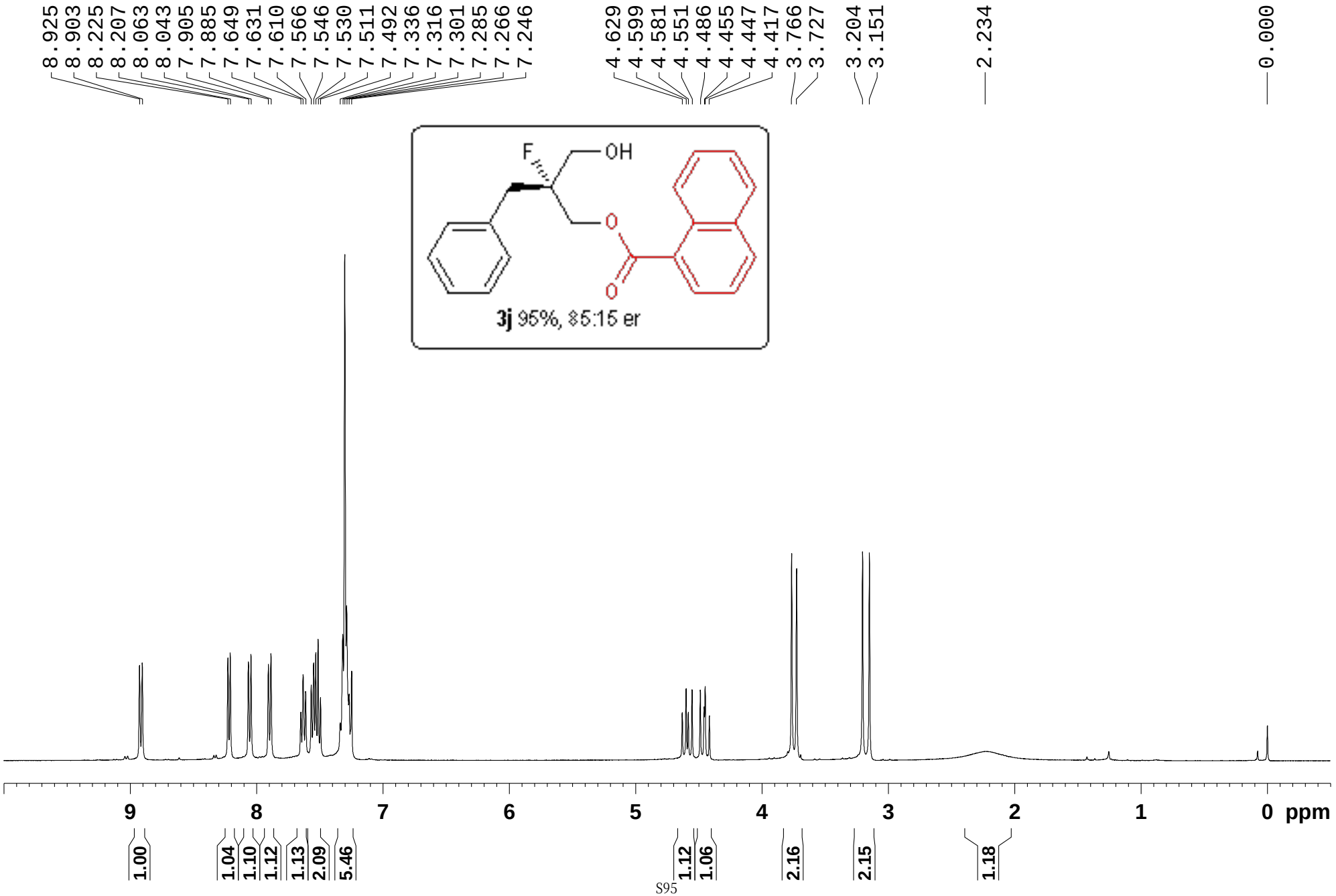
3i, 90%, 94:6 er



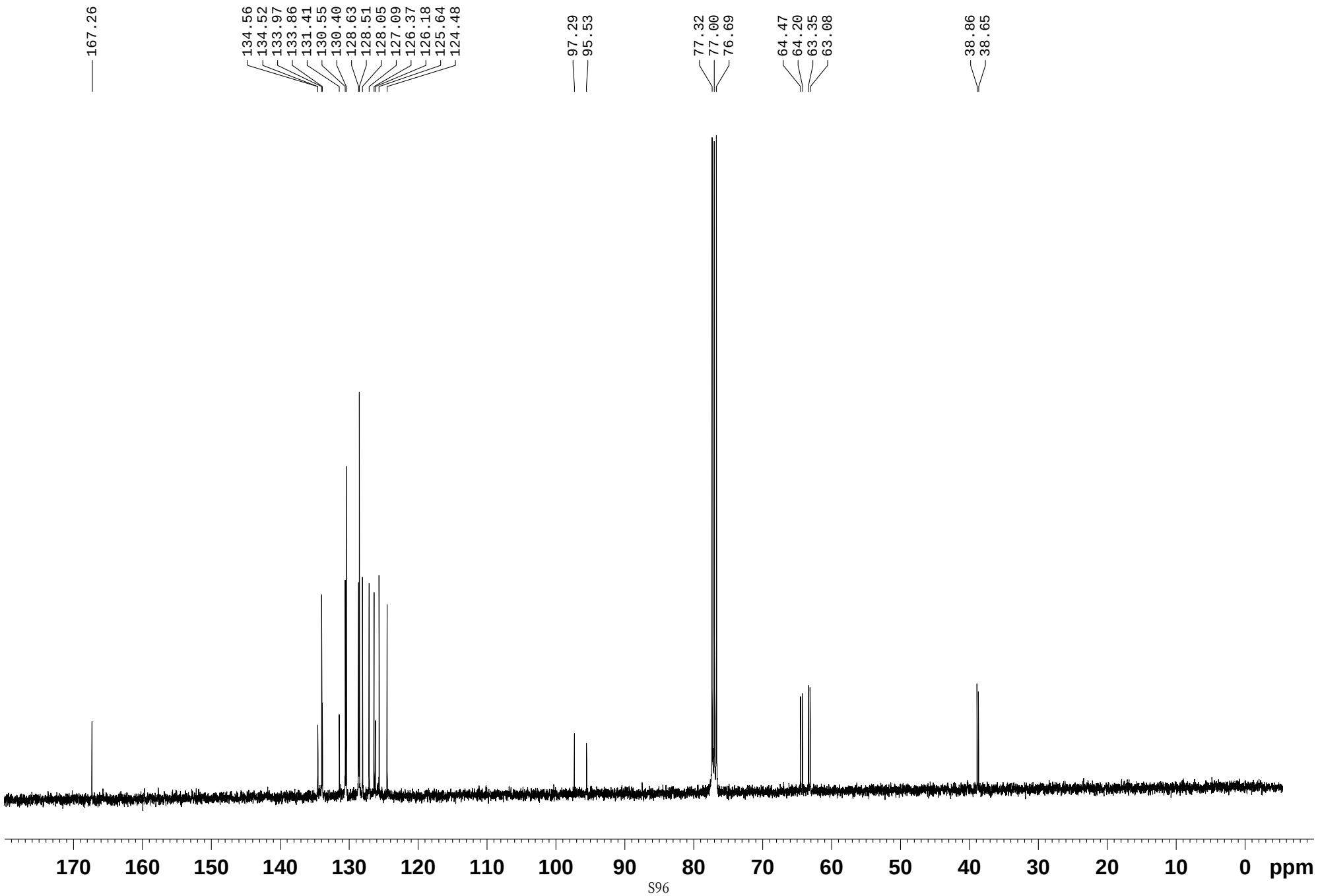
2-Cl-thiol-C


167.11
135.75
134.09
133.85
131.42
130.67
128.64
128.43
128.09
126.85
126.40
125.96
125.63
125.34
124.50
77.32
77.00
76.68
72.84
66.07
65.84
36.09
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

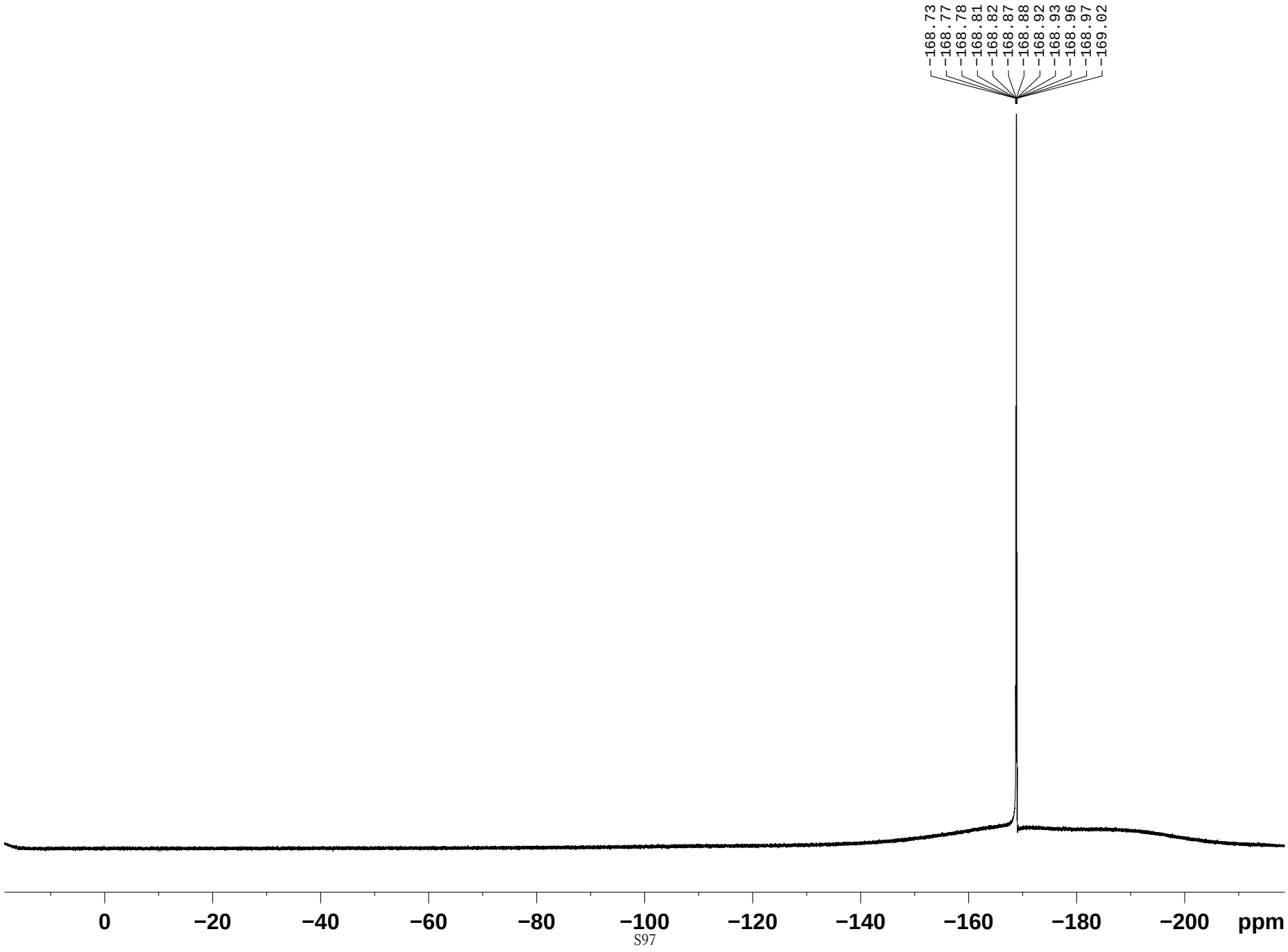
lbs-desymmetrization-F-H



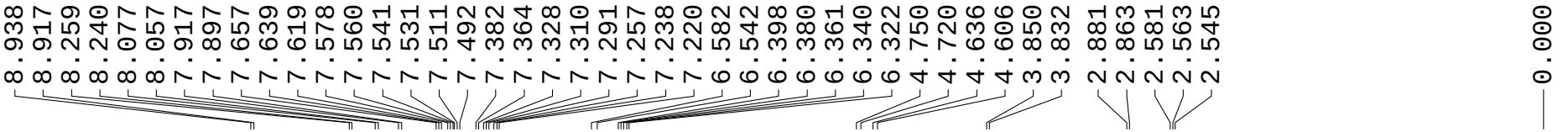
lbs-desymmetrization-F-C1

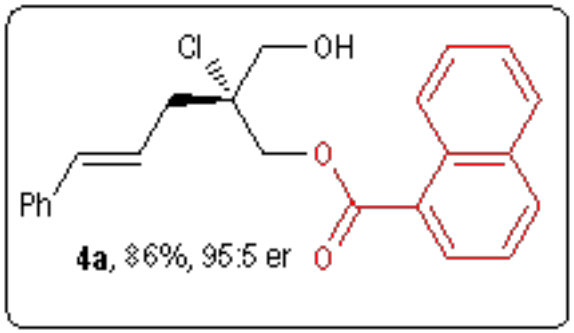


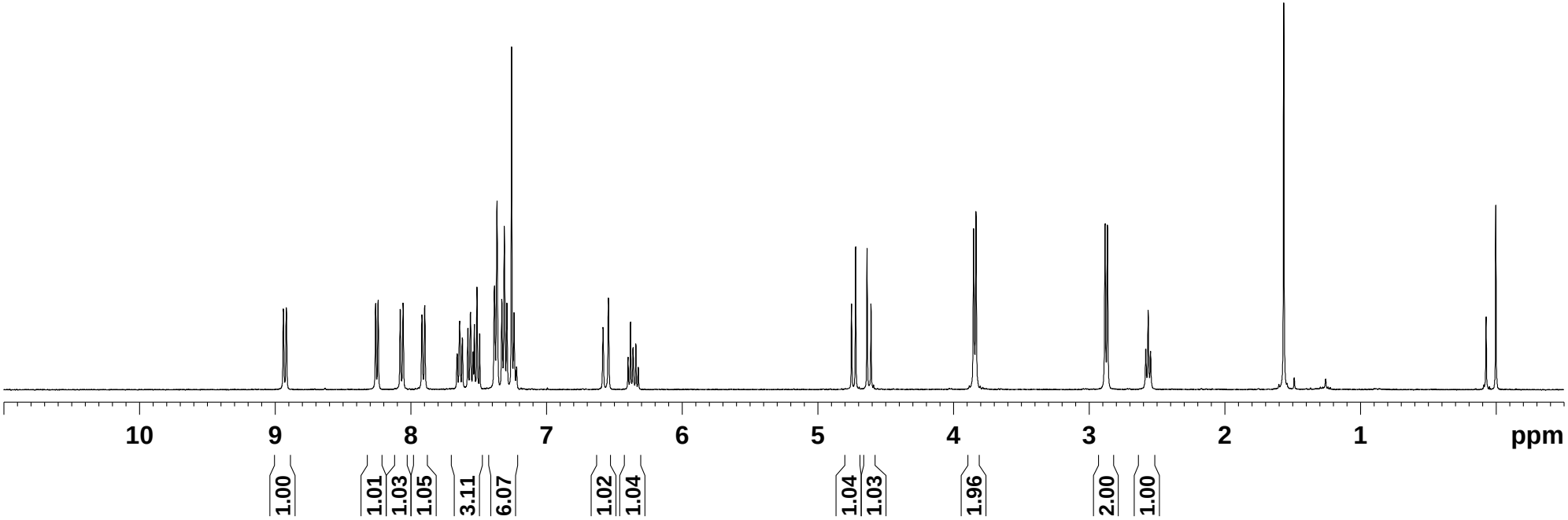
lbs-desymmetrization-F-F



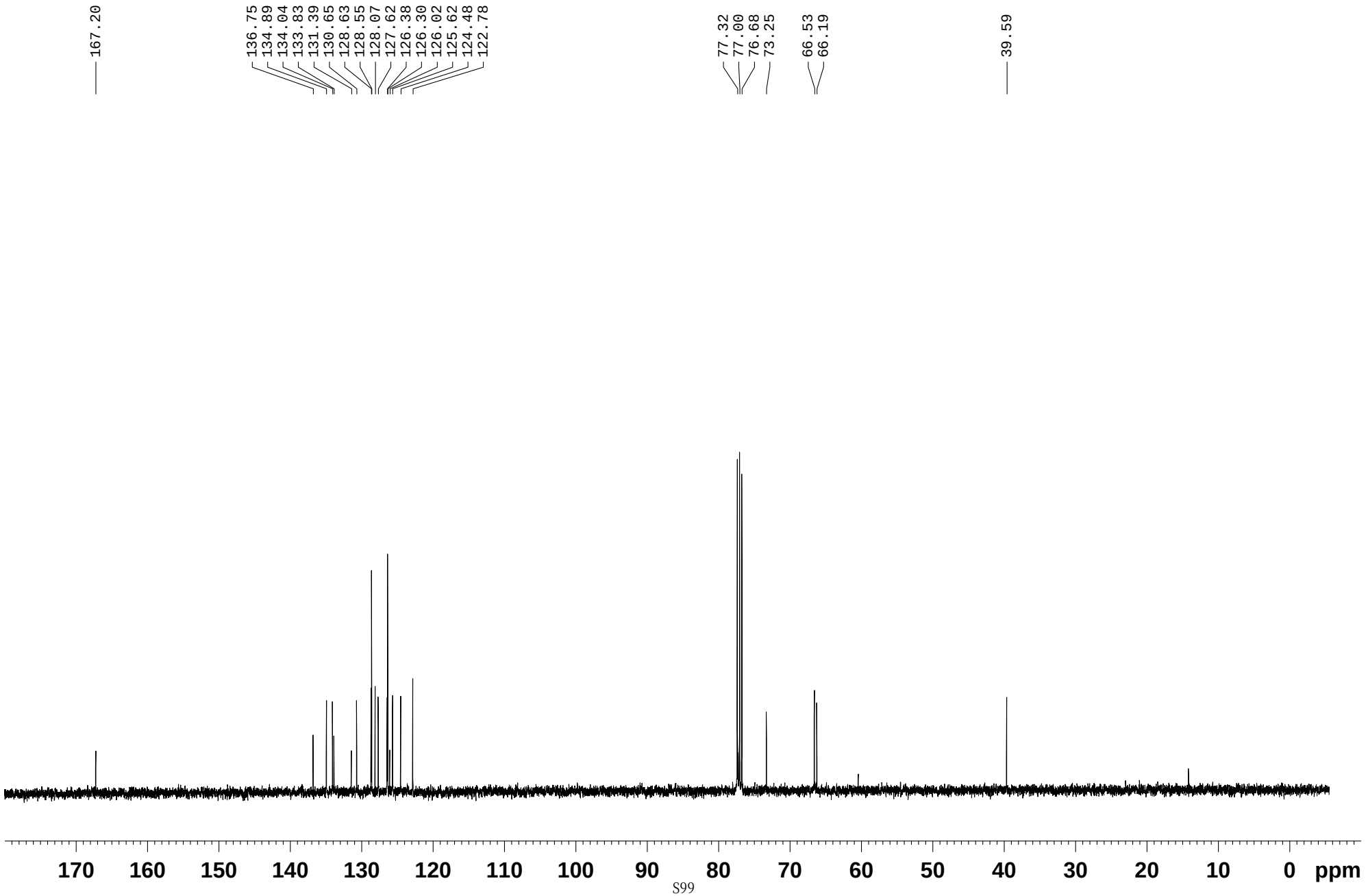
lbs-styrene-CH2-H1





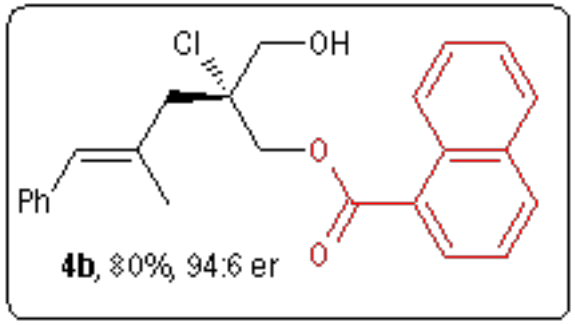


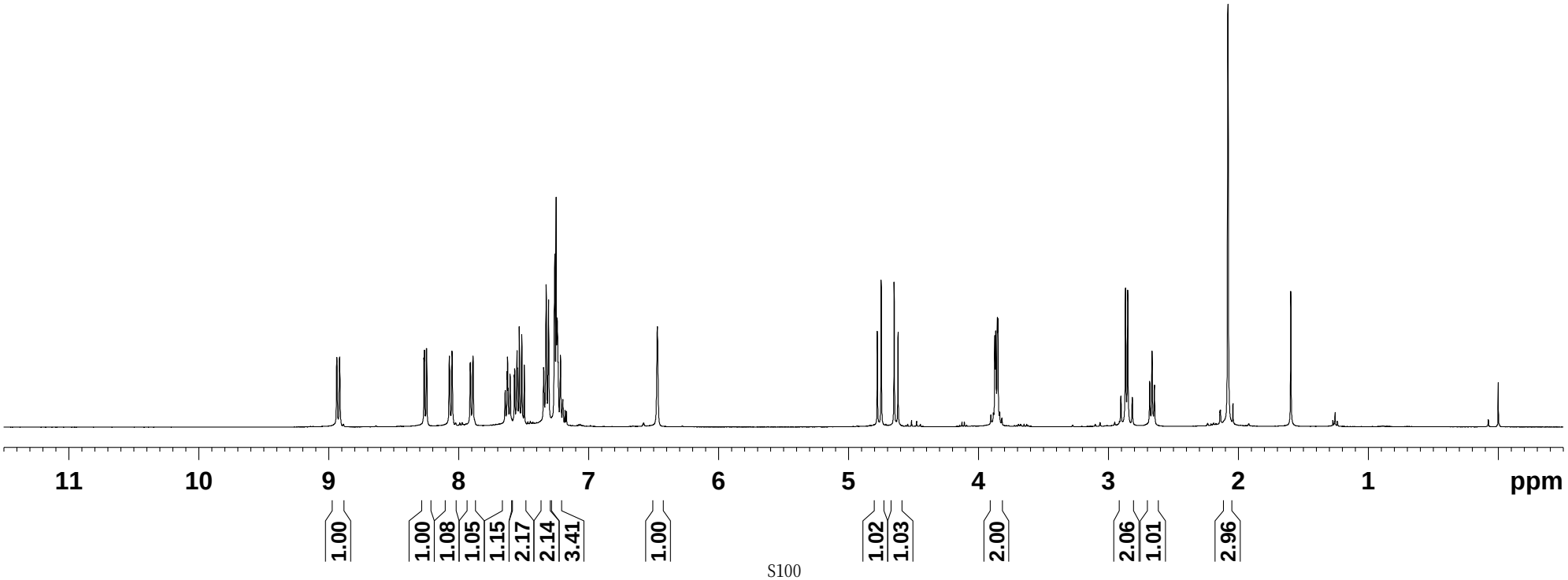
2-Cl-styrene-C



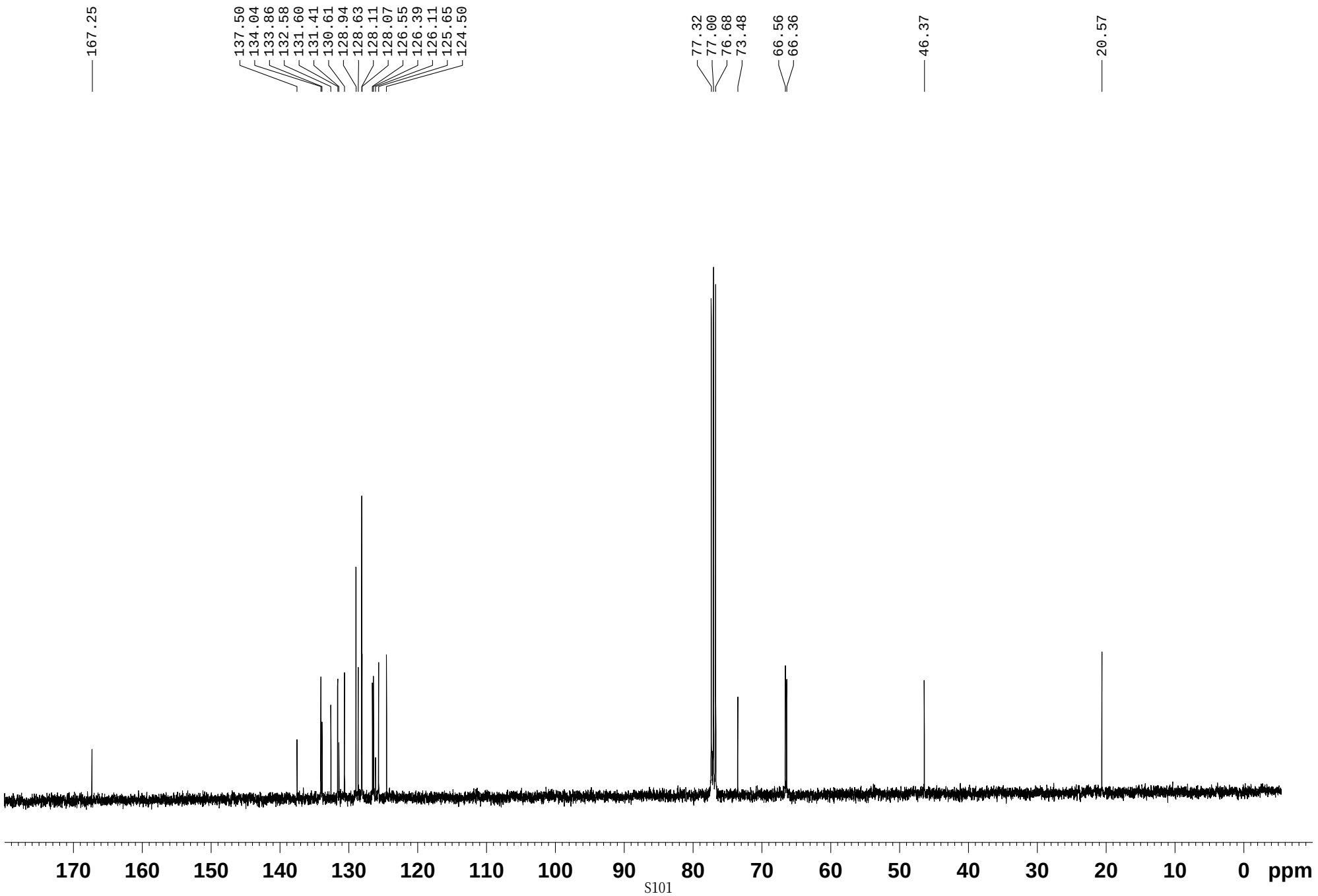
lbs-styrene-a-me-H2

8.934 8.912 8.263 8.261 8.245 8.242 8.068 8.048 8.907 7.887 7.641 7.638 7.624 7.620 7.616 7.602 7.599 7.568 7.565 7.548 7.546 7.531 7.511 7.492 7.342 7.324 7.305 7.257 7.247 7.239 7.232 7.213 6.468 4.775 4.745 4.645 4.616 3.871 3.864 3.851 3.847 2.900 2.865 2.848 2.813 2.679 2.661 2.643 2.078 2.075 0.000





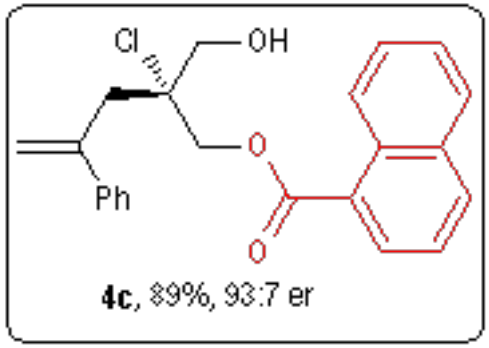
lbs-styrene-a-me-C1



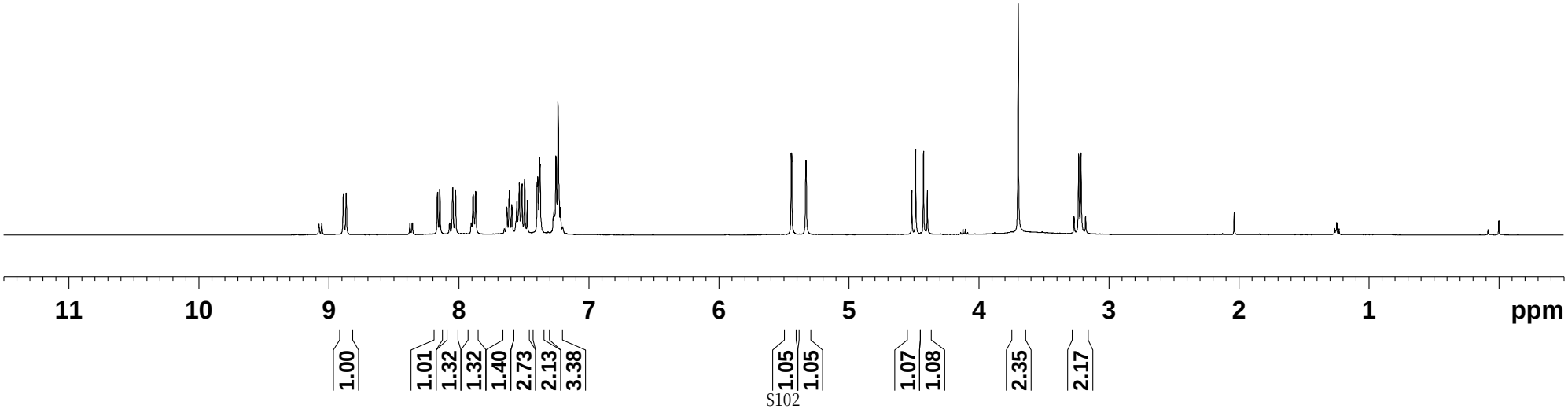
lbs-2-styrene-2′-2-Cl-H

8.885
8.864
8.165
8.163
8.147
8.145
8.047
8.026
7.891
7.871
7.631
7.611
7.593
7.590
7.555
7.553
7.535
7.526
7.513
7.494
7.474
7.397
7.393
7.377
7.374
7.275
7.268
7.263
7.253
7.245
7.237
7.235
7.219
5.442
5.439
5.330
4.515
4.486
4.425
4.396
3.697
3.268
3.232
3.214
3.178

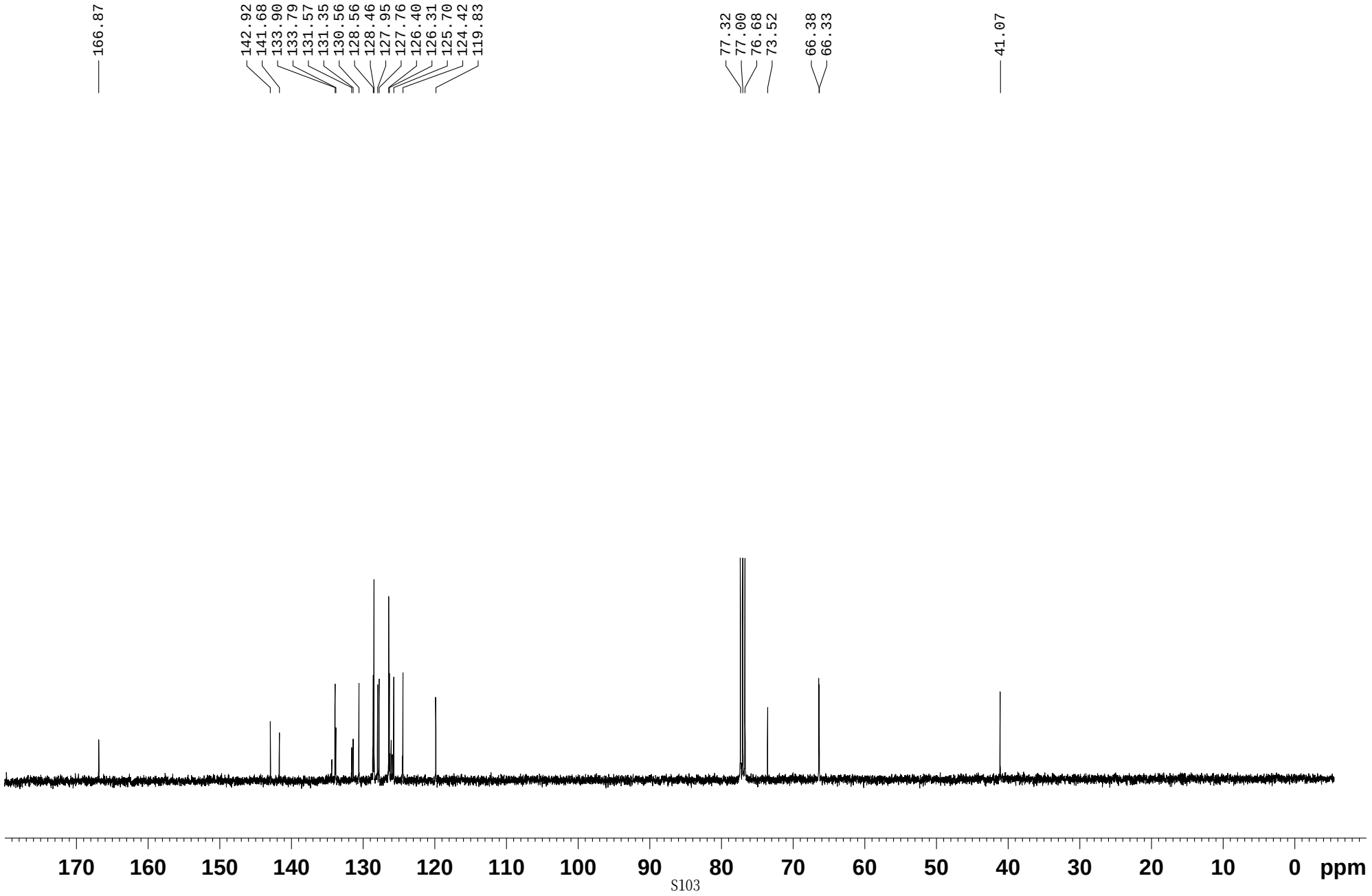
0.000



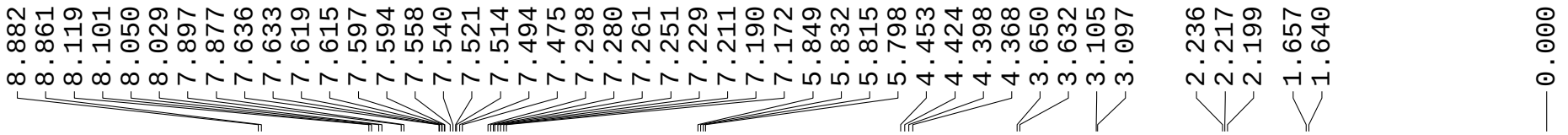
4c, 89%, 93:7 er

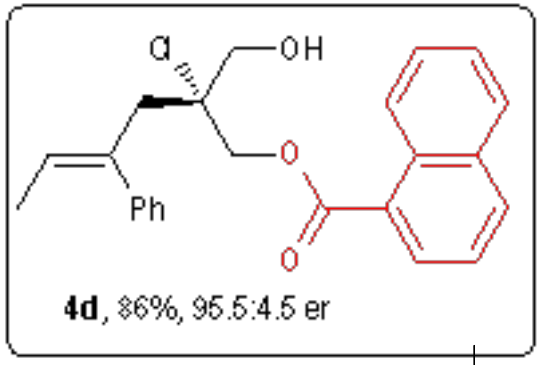


lbs-2-styrene-2'-2-Cl-C

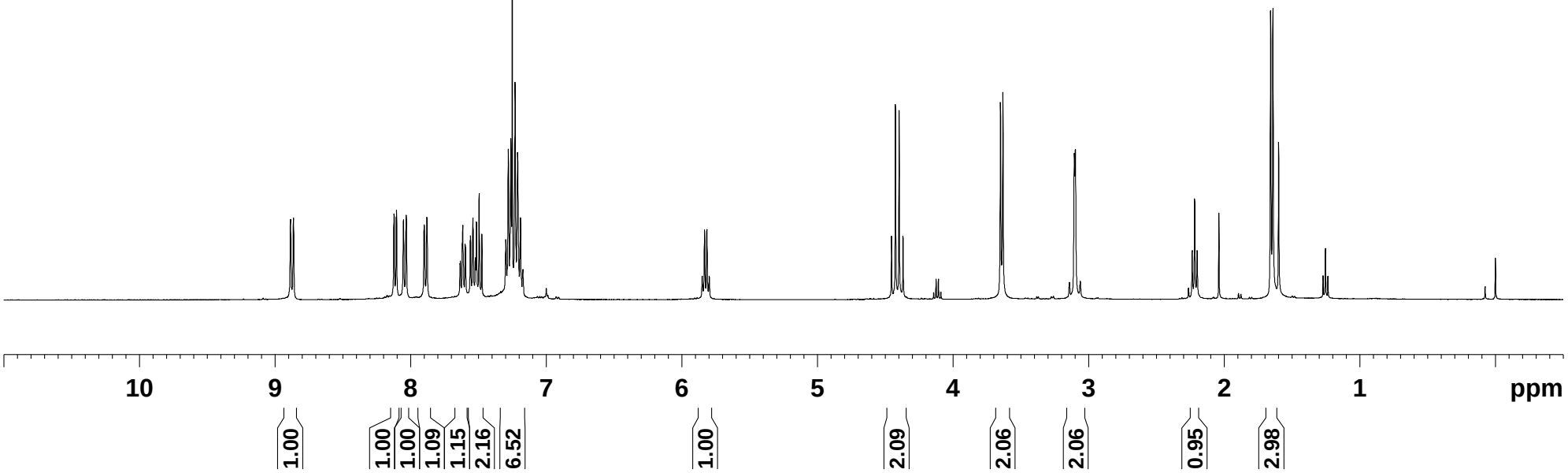


lbs-a-styrene-b'-Me-H1

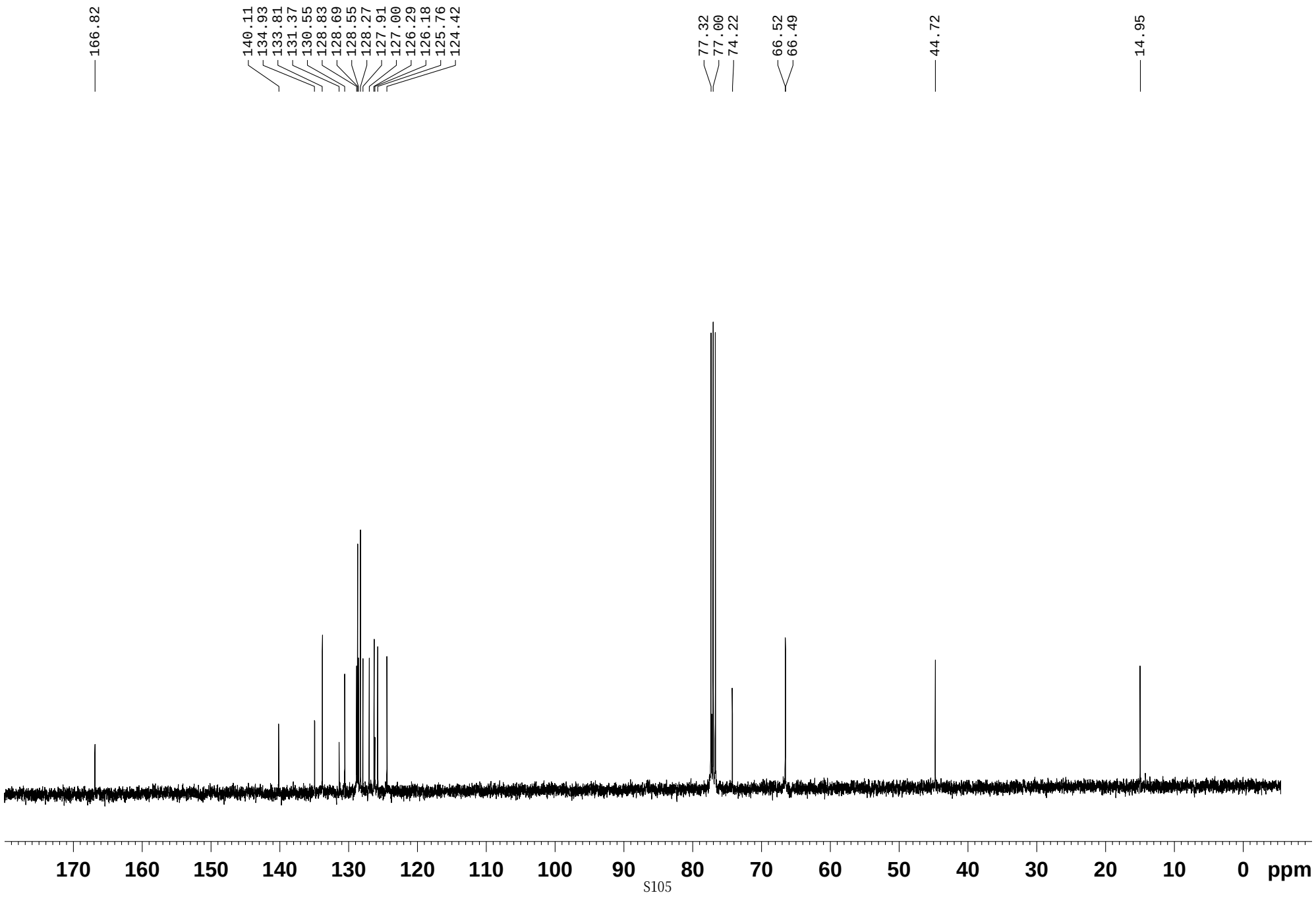




4d, 86%, 95.5:4.5 er

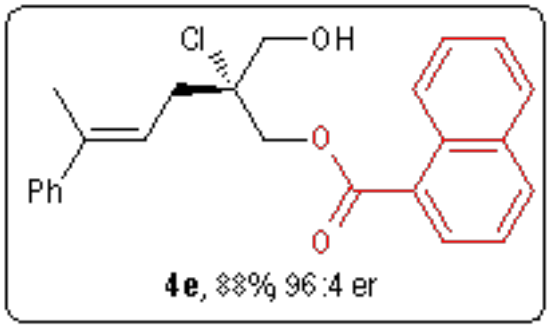


lbs-a-styrene-b'-Me-C1

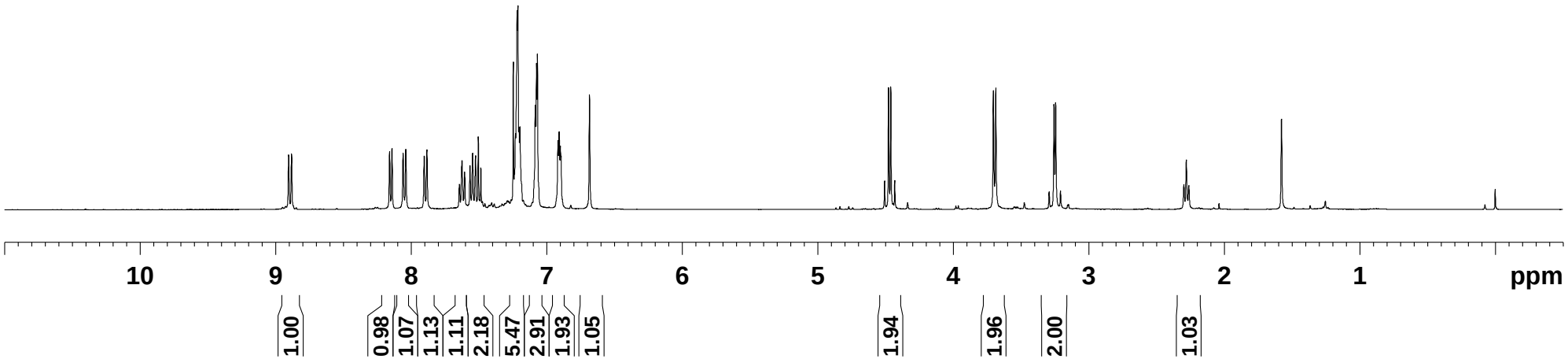


lbs-styrene-5-Ph-6-Ph-H

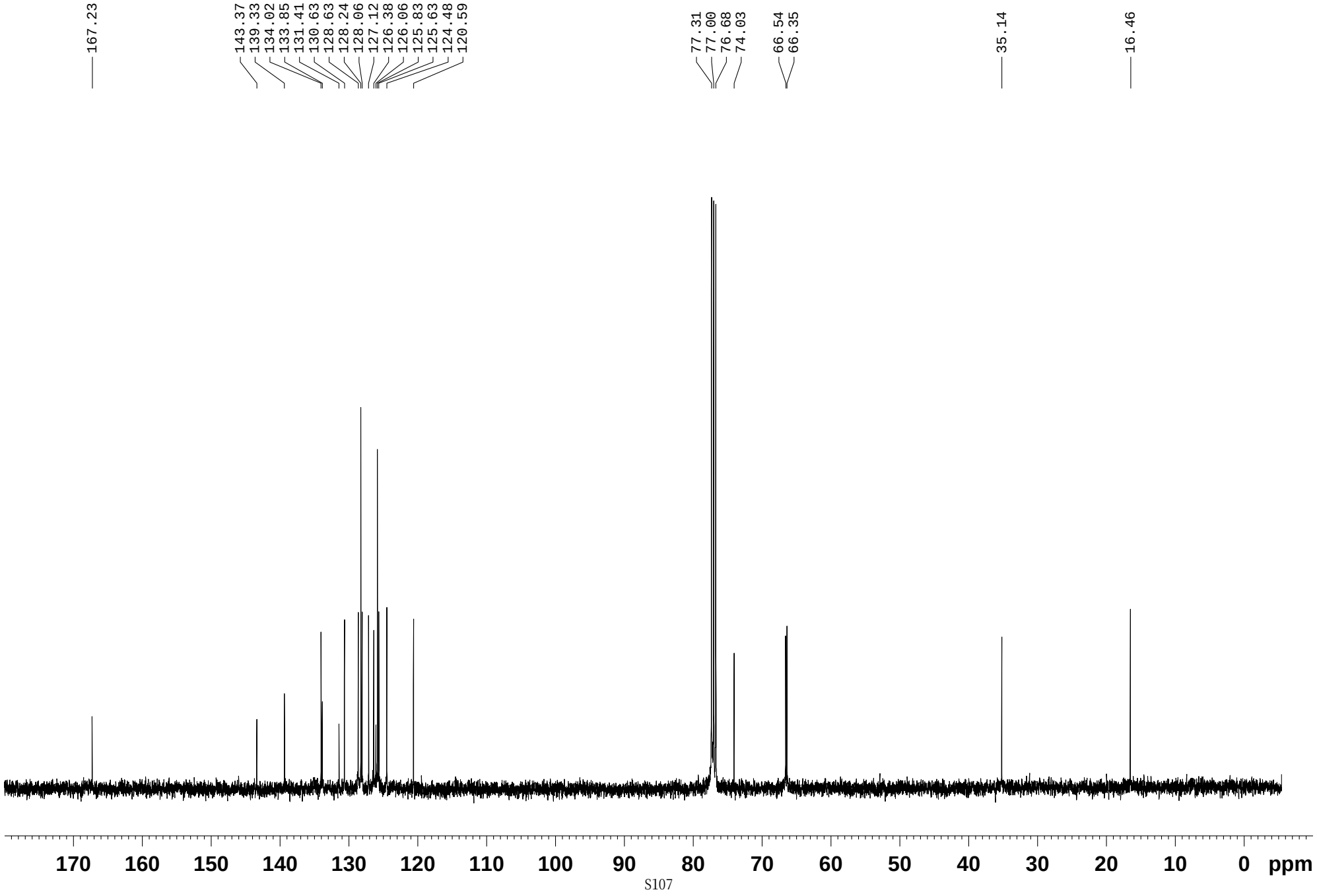
8.905 8.883 8.160 8.142 8.060 8.040 7.904 7.884 7.644 7.625 7.607 7.566 7.547 7.525 7.505 7.486 7.247 7.230 7.218 7.213 7.205 7.197 7.085 7.075 7.069 6.917 6.908 6.899 6.894 6.684 4.507 4.477 4.461 4.431 3.704 3.686 3.292 3.256 3.244 3.208 2.298 2.279 2.261 0.000



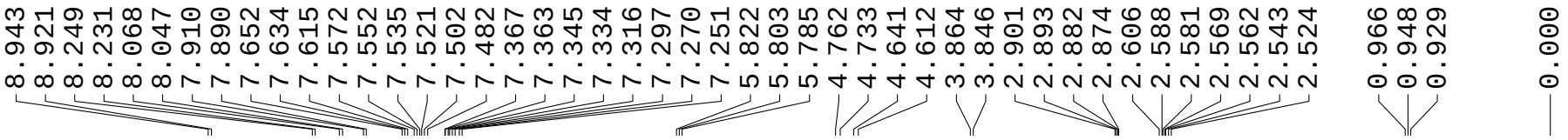
4e, 88%, 96:4 er

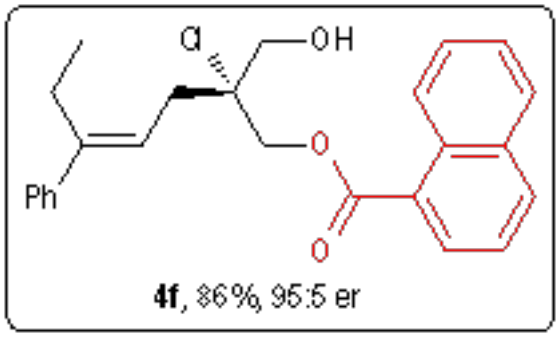


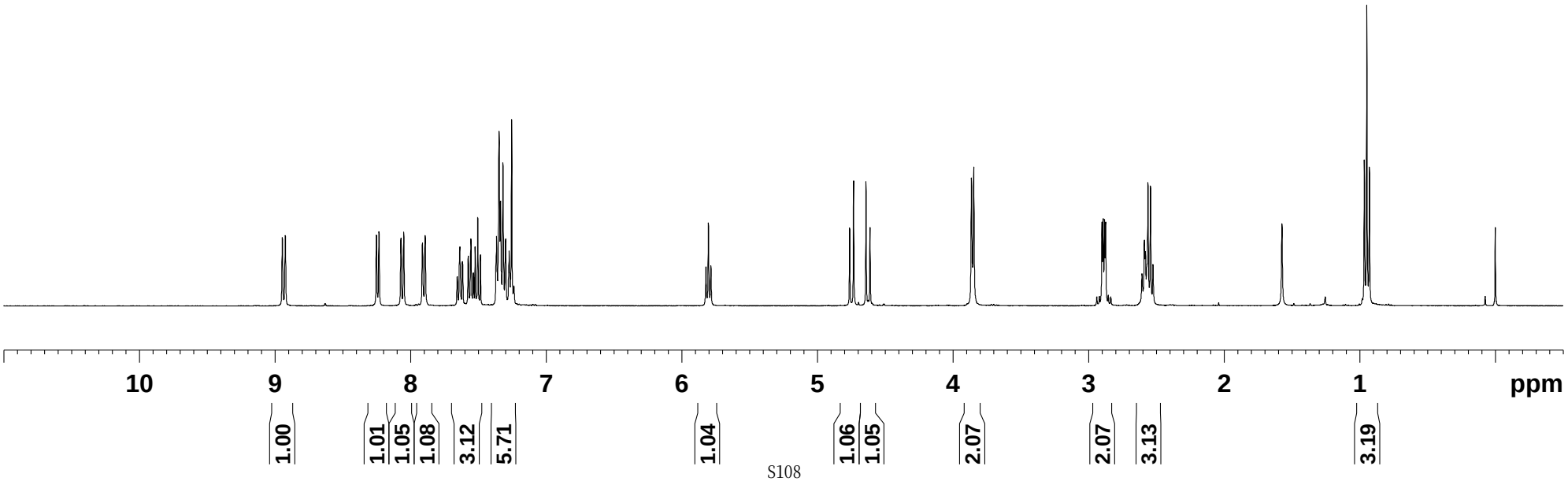
lbs-styrene-5-Me-5-Ph-C



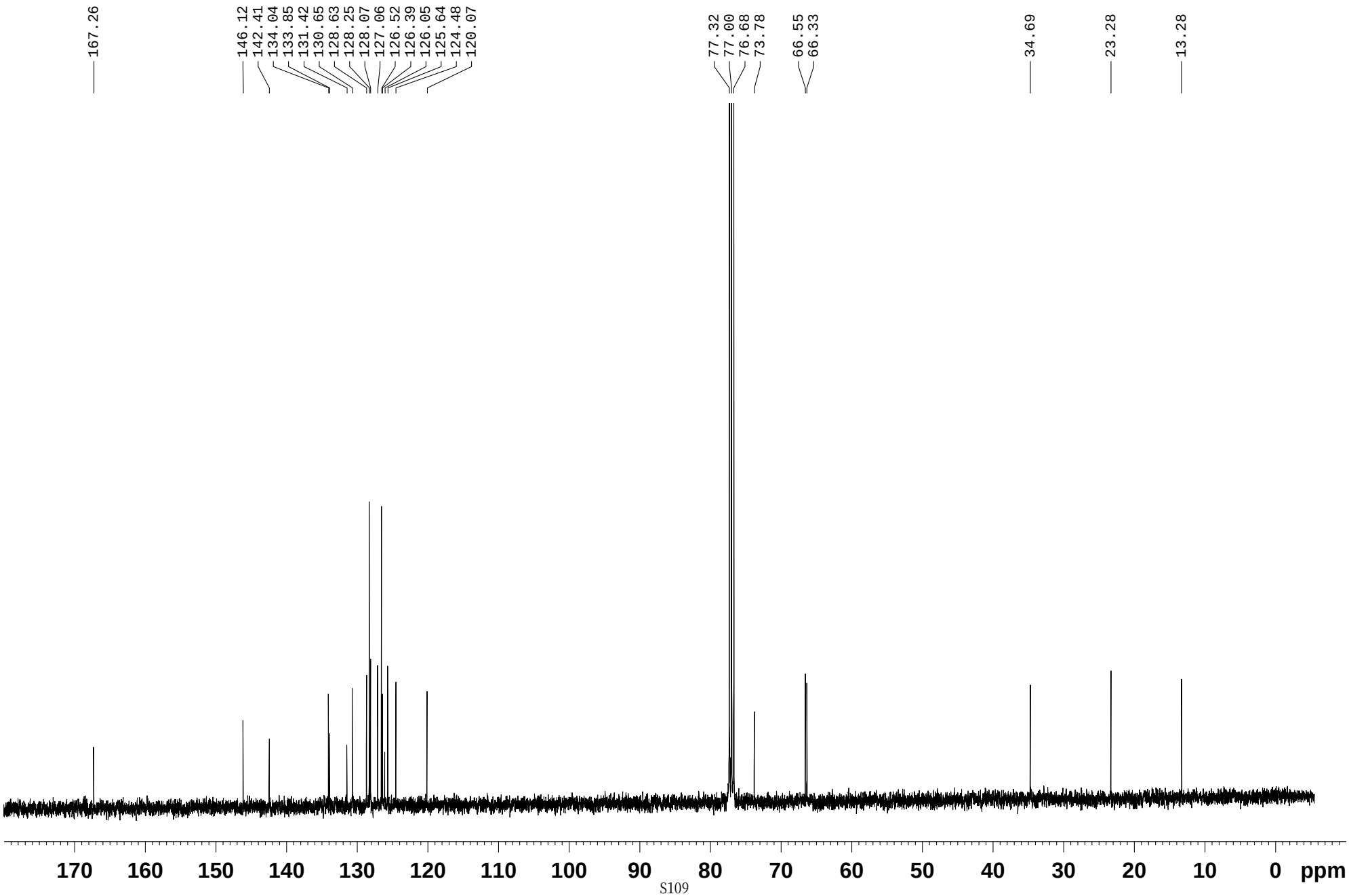
lbs-5-Et-5-Ph-H


8.943
8.921
8.249
8.231
8.068
8.047
7.910
7.890
7.652
7.634
7.615
7.572
7.552
7.535
7.521
7.502
7.482
7.367
7.363
7.345
7.334
7.316
7.297
7.270
7.251
5.822
5.803
5.785
4.762
4.733
4.641
4.612
3.864
3.846
2.901
2.893
2.882
2.874
2.606
2.588
2.581
2.569
2.562
2.543
2.524
0.966
0.948
0.929
0.000

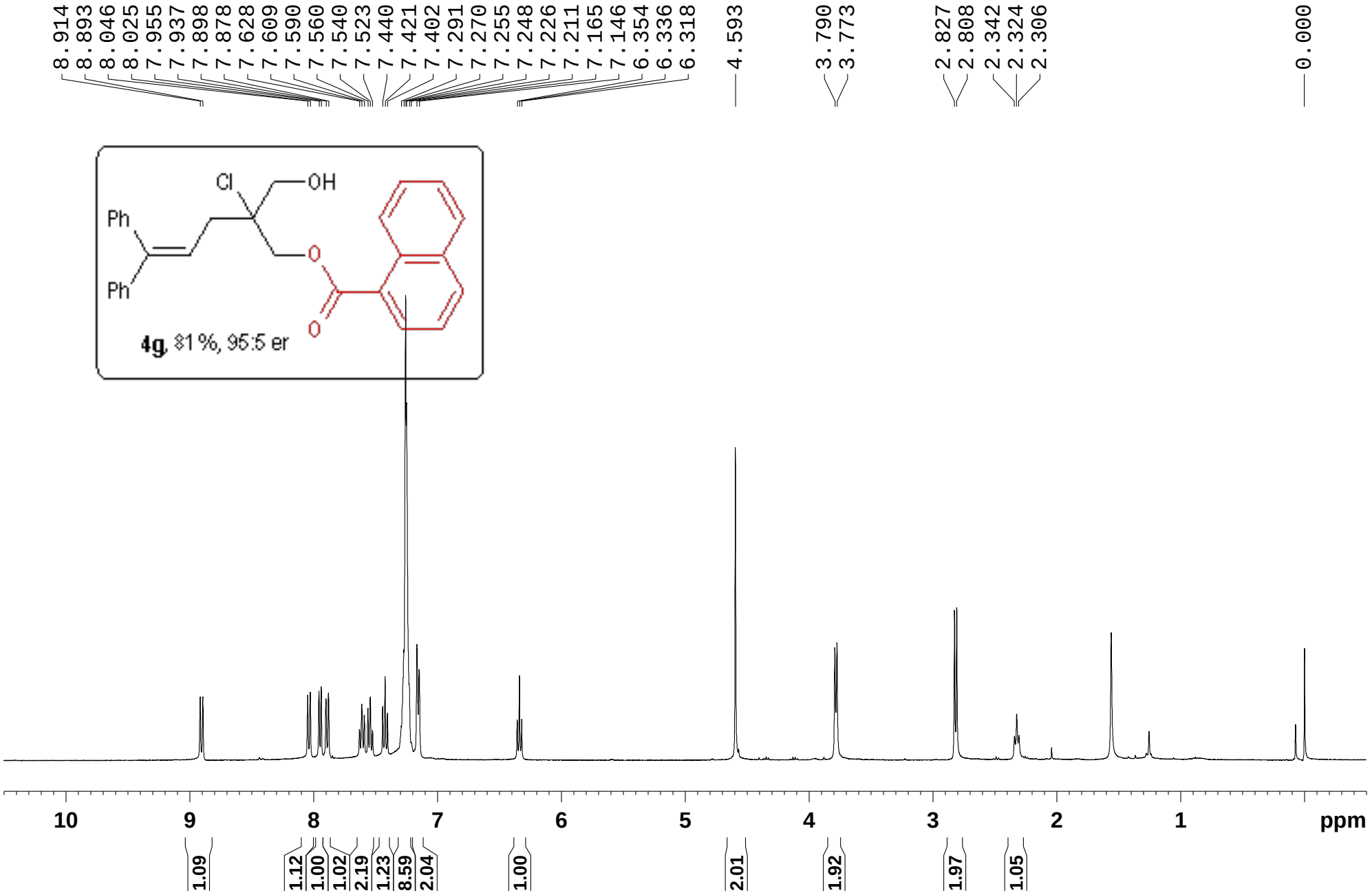

OH
O
O
Ph
4f, 86%, 95:5 er


10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.01
1.05
1.08
3.12
5.71
1.04
1.06
1.05
2.07
2.07
3.13
3.19

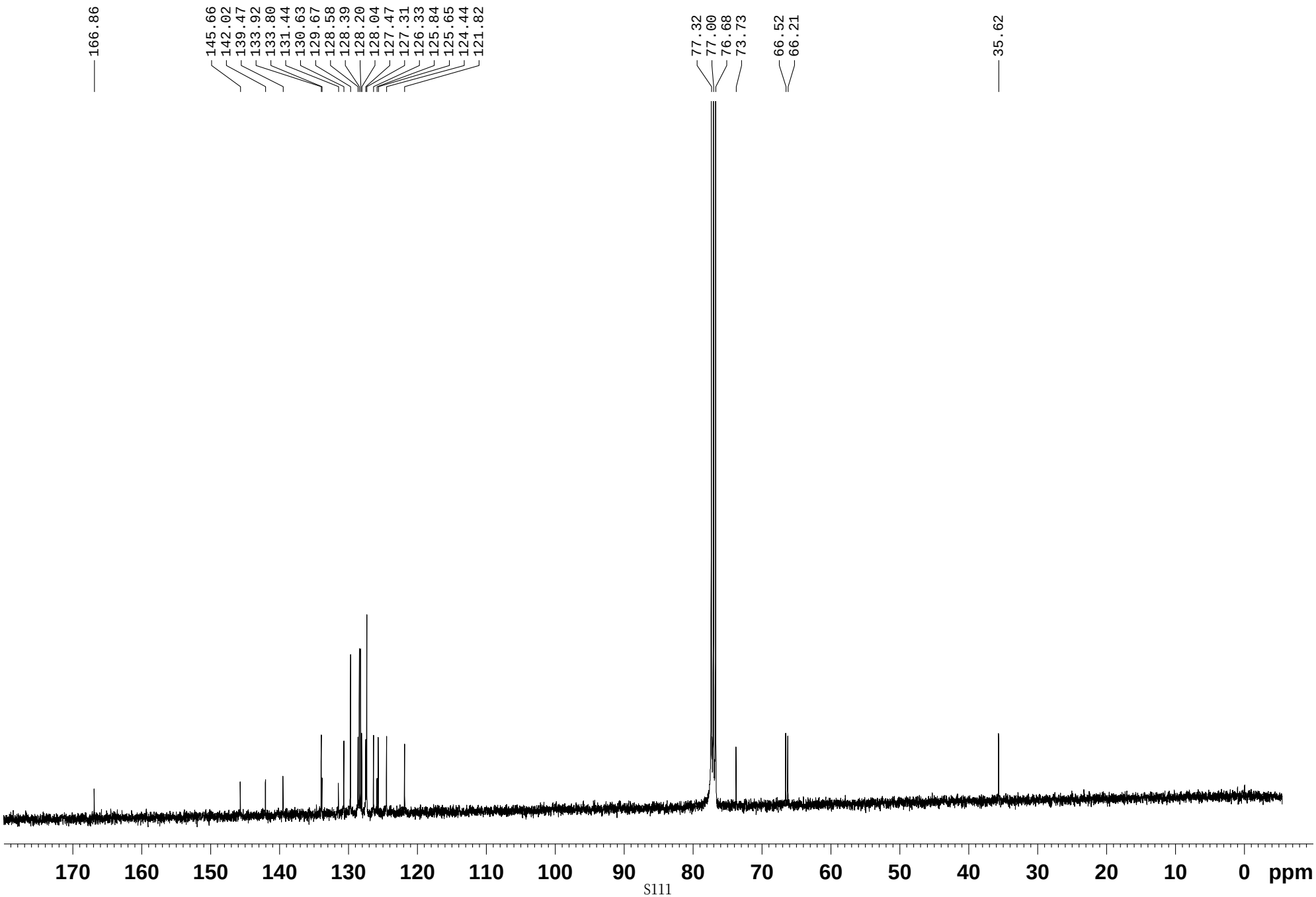
lbs-5-Et-5-Ph-C


167.26
146.12
142.41
134.04
133.85
131.42
130.65
128.63
128.25
128.07
127.06
126.52
126.39
126.05
125.64
124.48
120.07
77.32
77.00
76.68
73.78
66.55
66.33
34.69
23.28
13.28
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

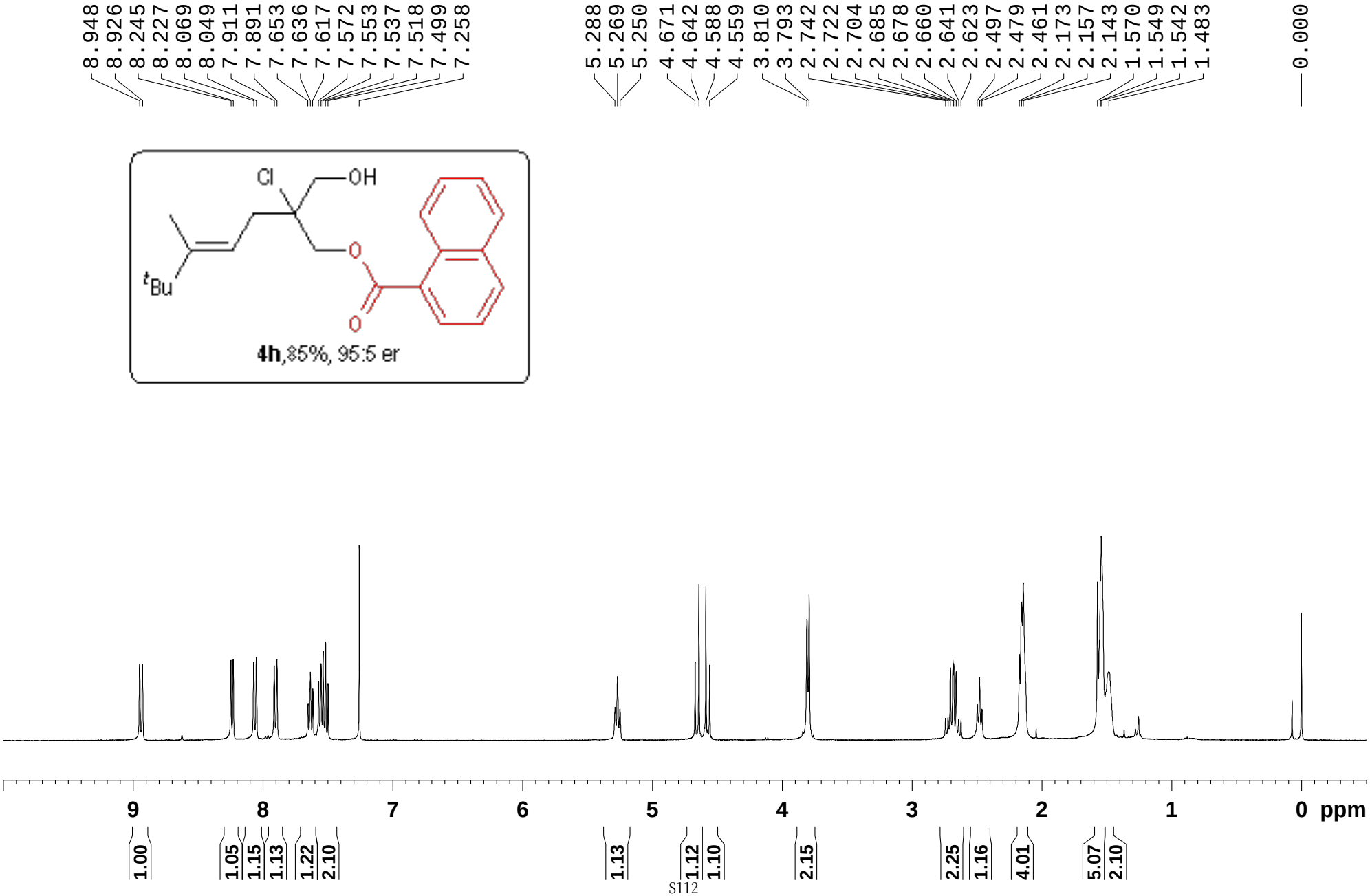
lbs-5-diphenyl-H



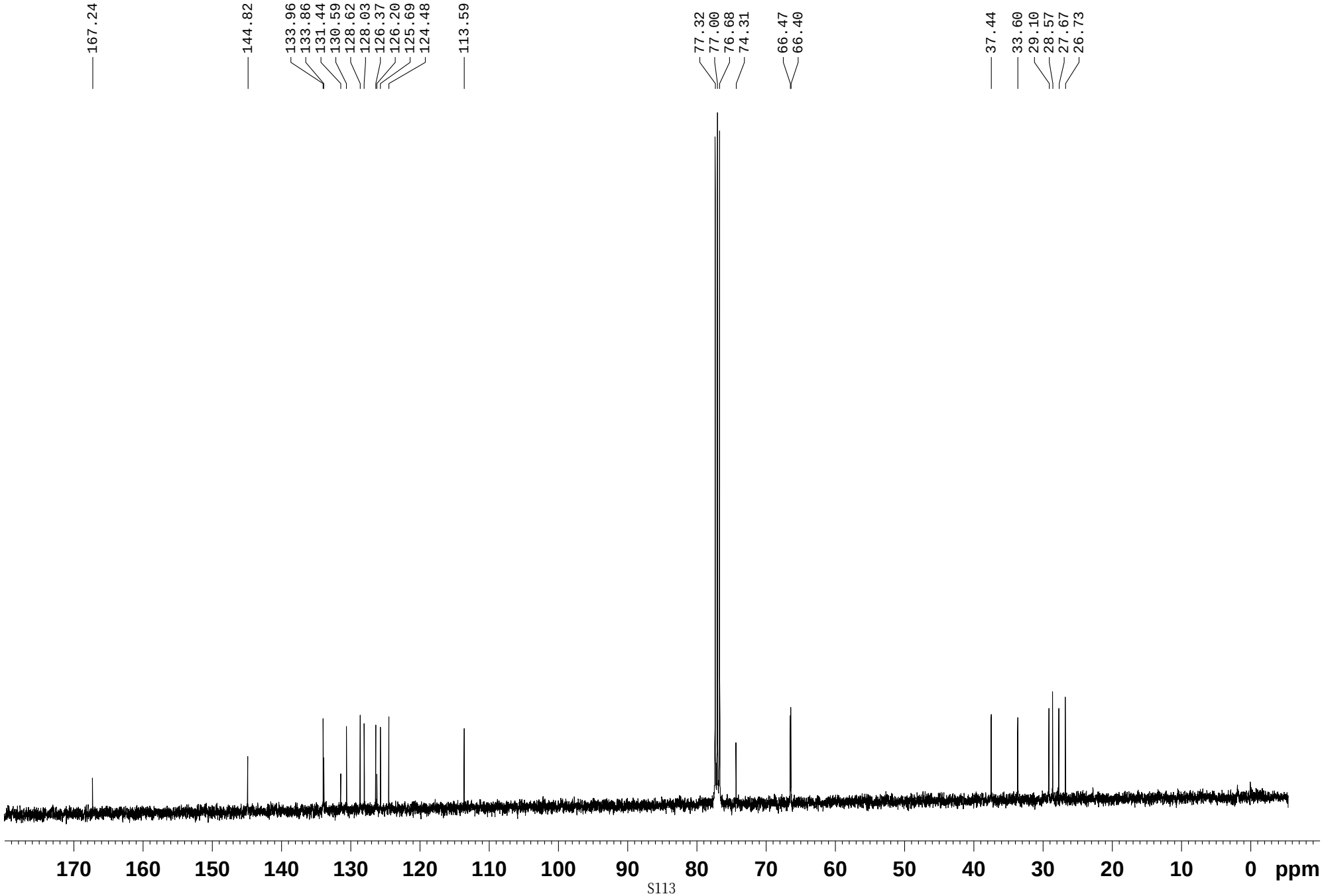
lbs-5-diphenyl-C



lbs-5-tBu-5-Me-H



lbs-5-tBu-5-Me-C



lbs-benzenecyclopentane-H1

8.979
8.957
8.297
8.278
8.108
8.088
7.952
7.931
7.688
7.670
7.650
7.613
7.594
7.576
7.561
7.541
7.525
7.294
7.276
7.253
7.241
7.234
7.223
6.163
6.147
6.129
4.811
4.782
4.696
4.667
3.913
3.896
3.028
3.011
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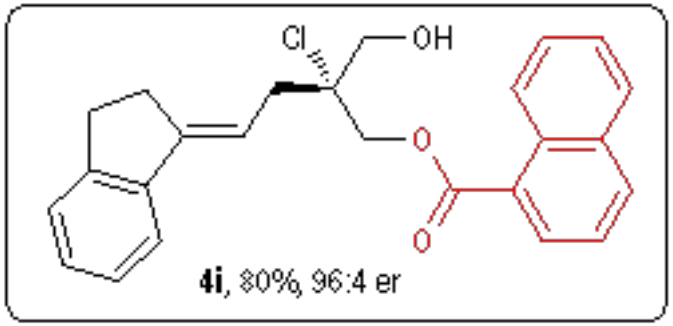
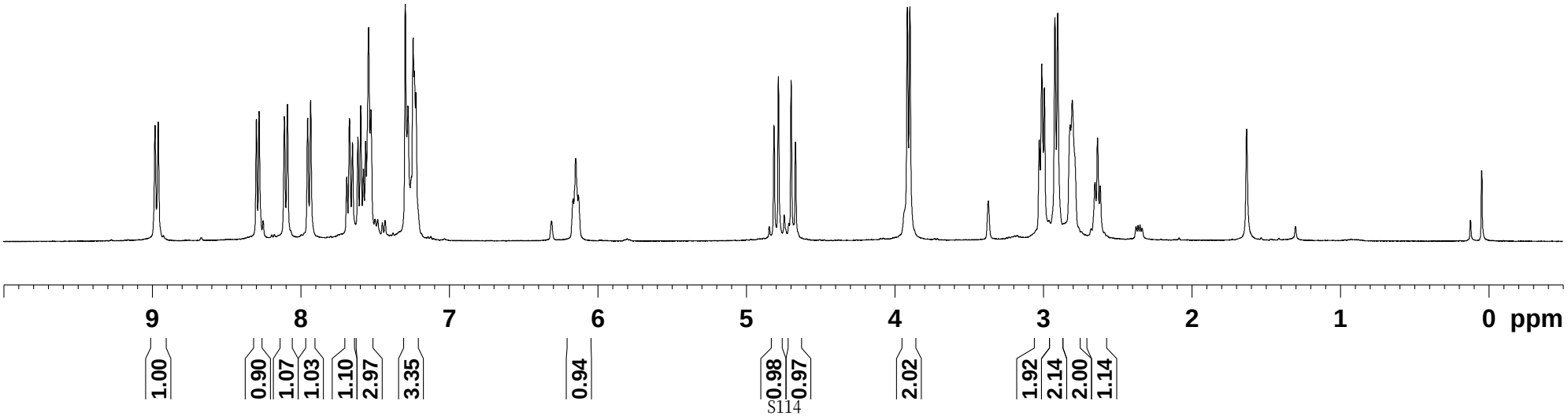
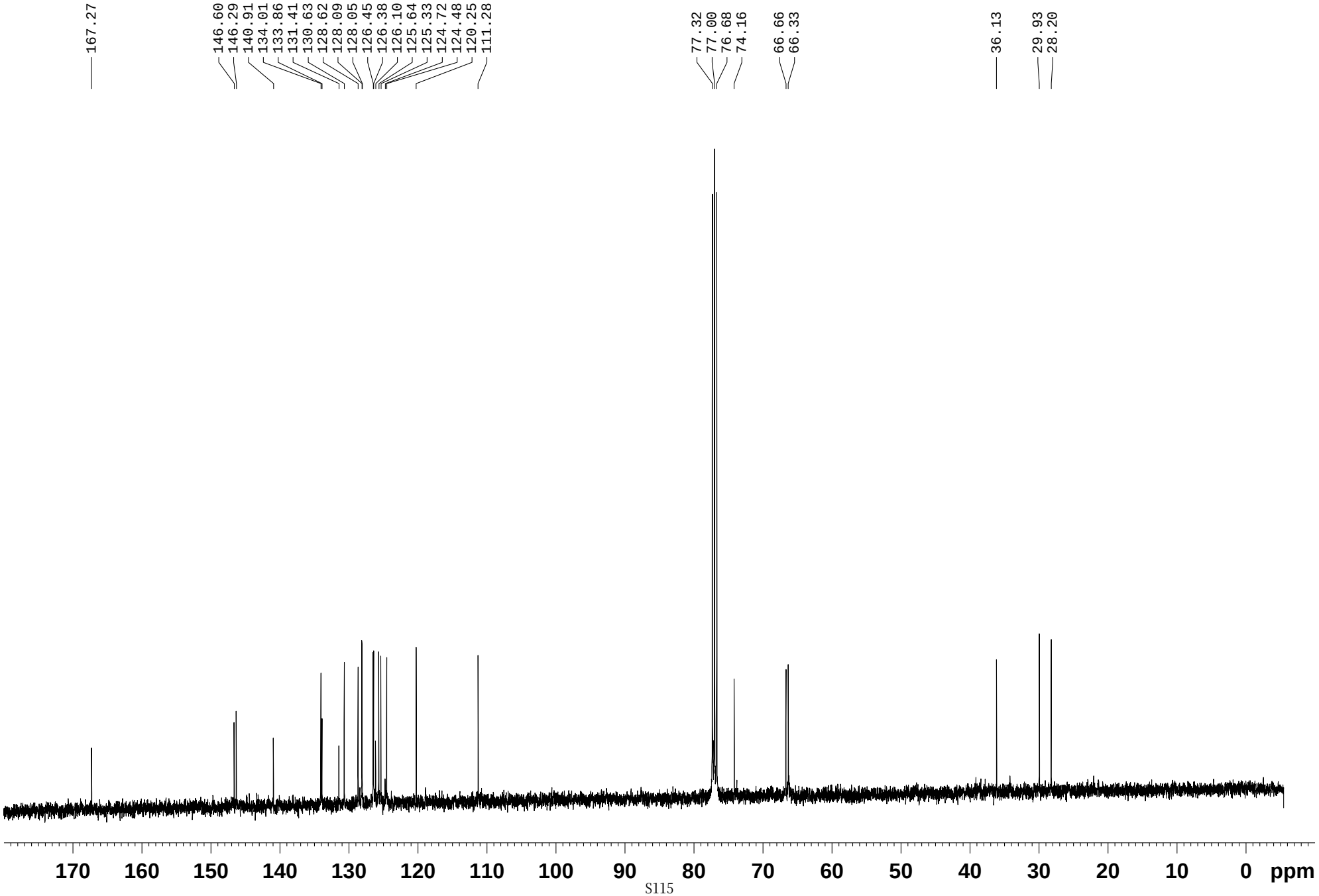
2.962
2.922
2.904
2.820
2.806
2.653
2.635
2.618
0.049



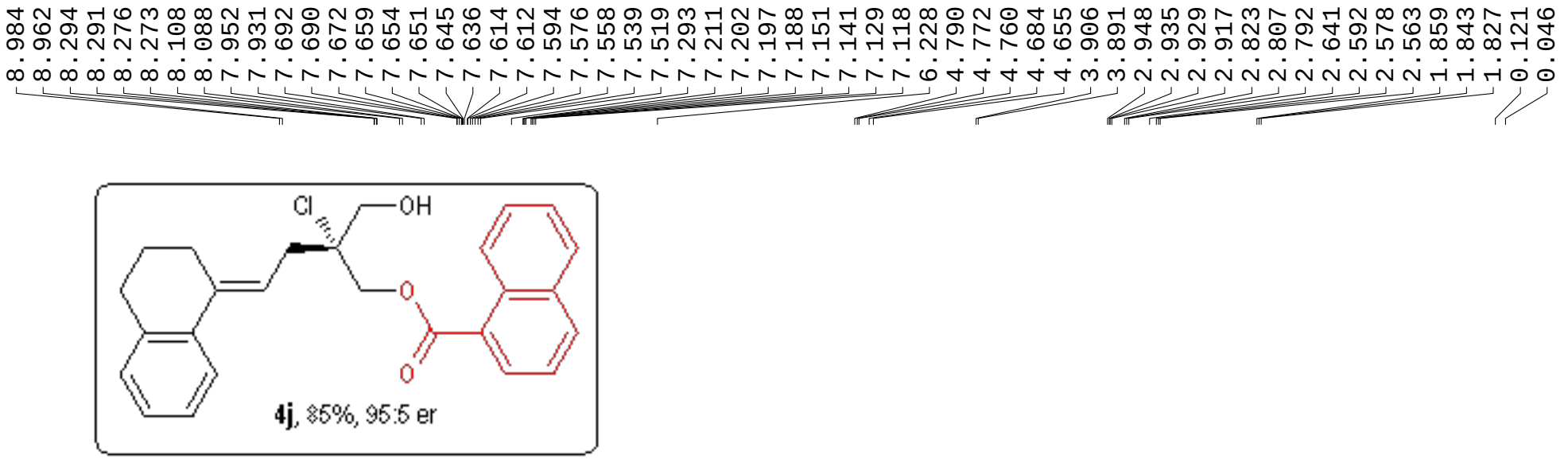
4i, 80%, 96:4 er



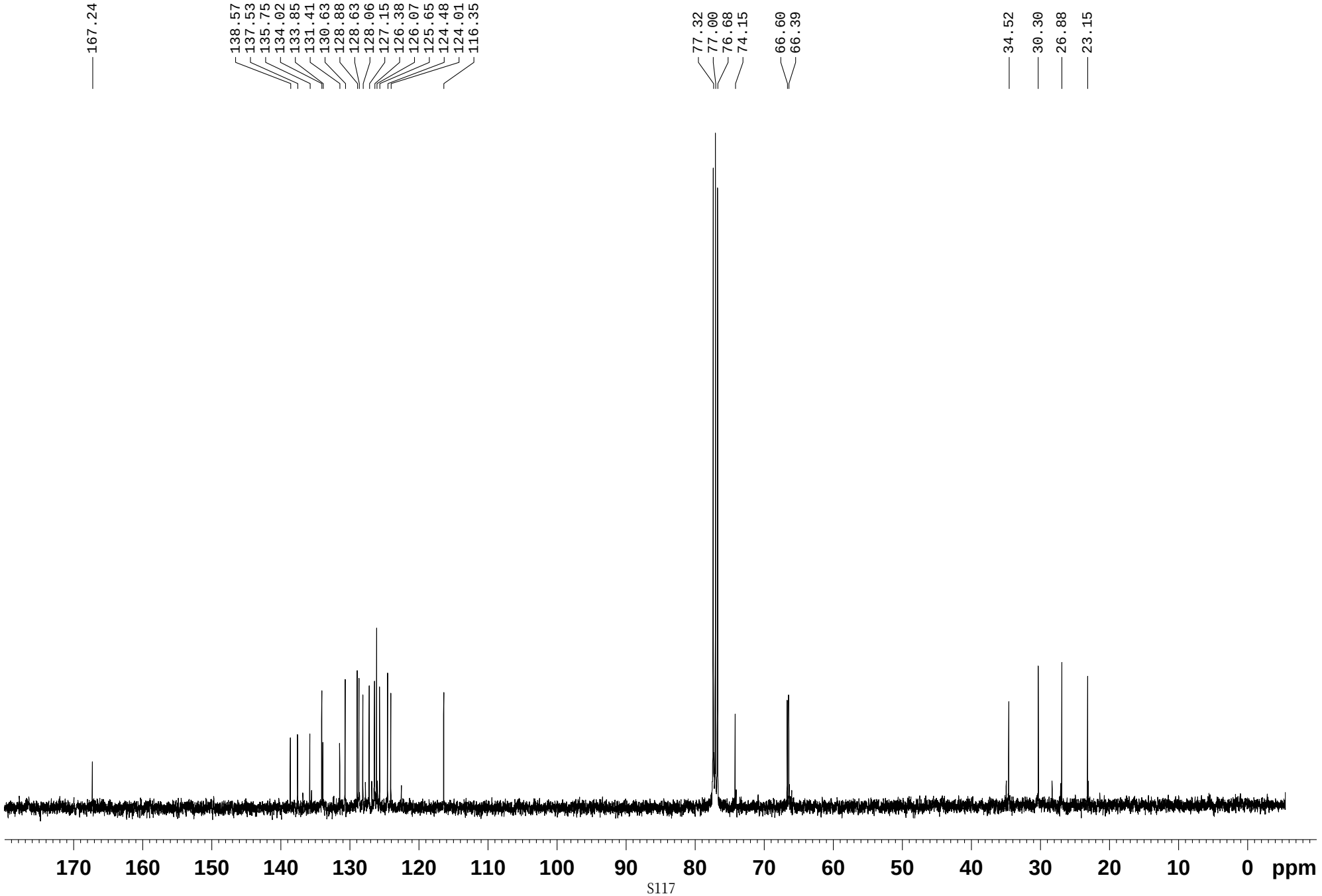
lbs-benzenecyclopentane-C



lbs-benezocyclohexane-H1

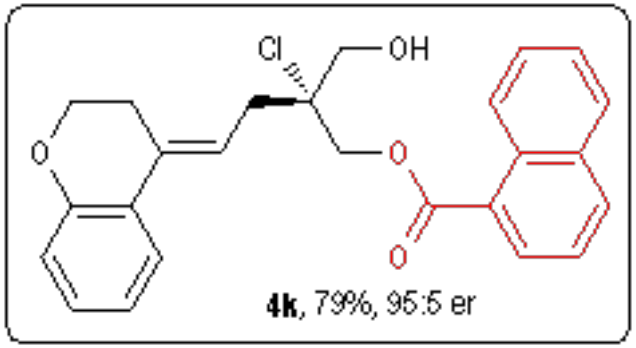


lbs-benezocyclohexane-C

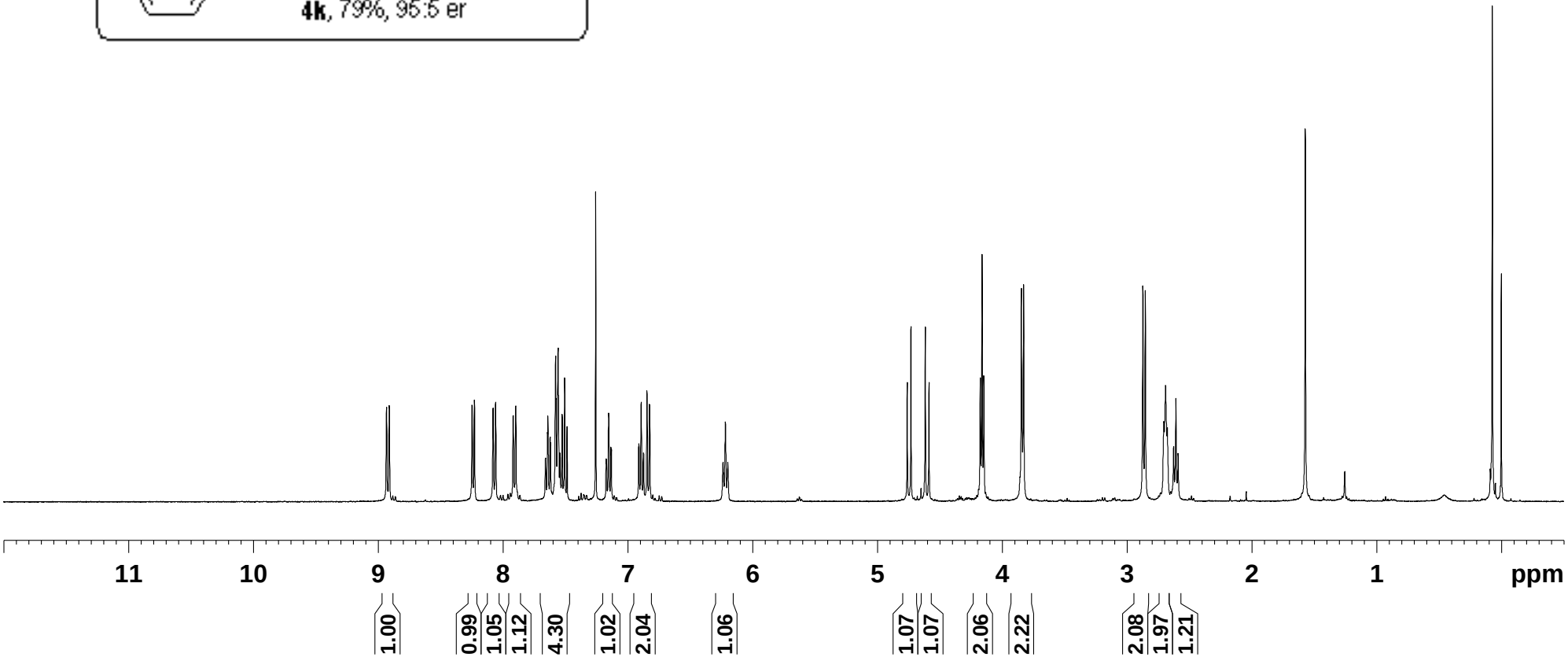


lbs-benzopyran-H4

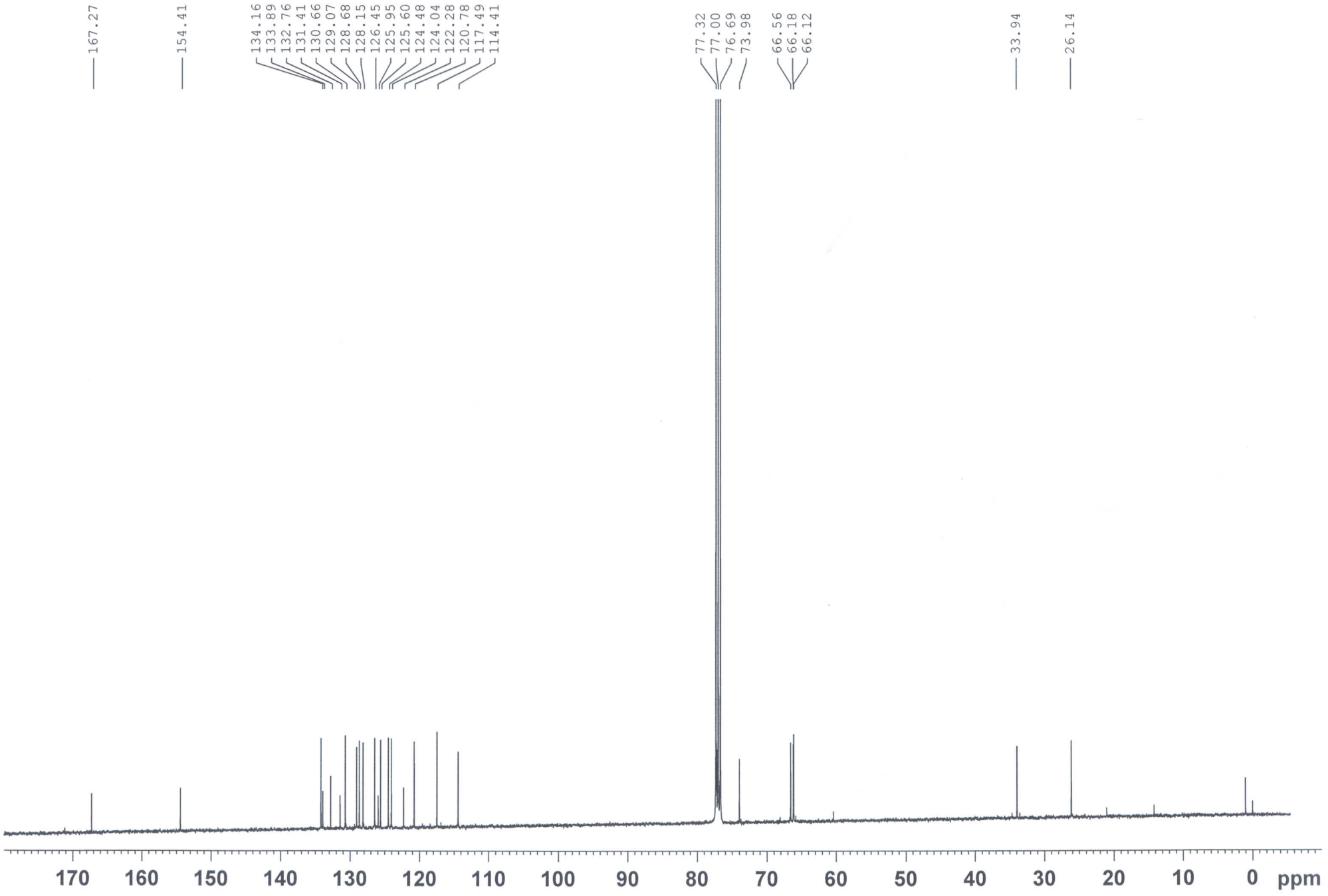
8.933 8.912 8.249 8.247 8.230 8.080 8.059 7.918 7.898 7.661 7.658 7.644 7.641 7.622 7.619 7.579 7.575 7.559 7.544 7.526 7.507 7.487 7.257 7.174 7.170 7.153 7.135 7.132 6.913 6.911 6.893 6.875 6.847 6.826 6.237 6.218 6.199 4.761 4.731 4.616 4.586 4.175 4.161 4.147 3.846 3.828 2.873 2.853 2.704 2.690 2.676 2.626 2.608 2.590 0.072 0.000



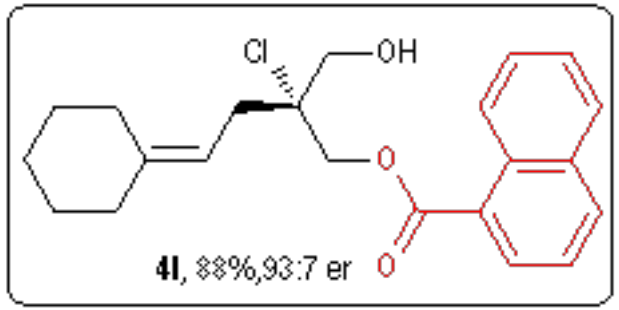
4k, 79%, 95:5 er



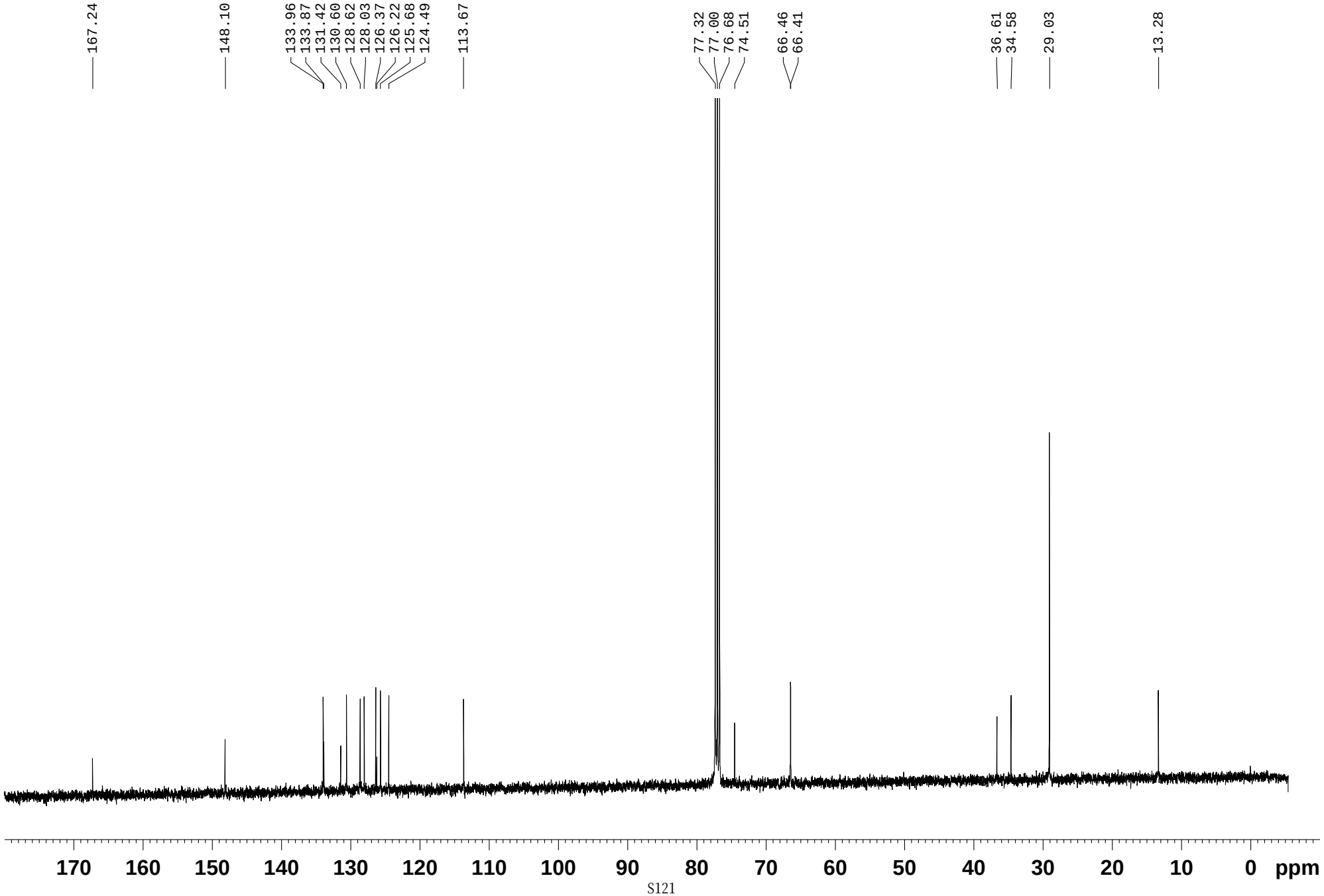
lbs-benzopyran-C3



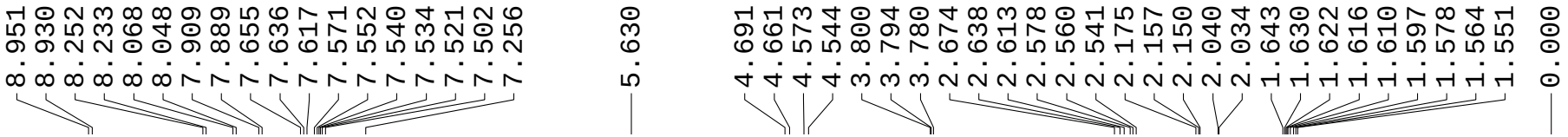
lbs-5-cyclohexane-H

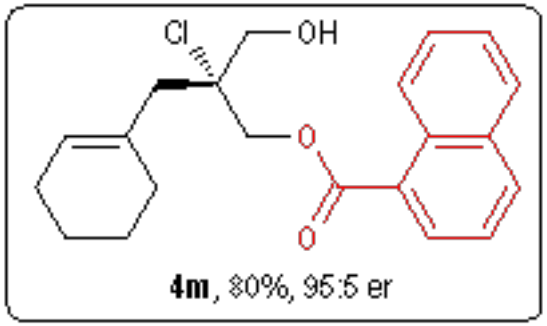


lbs-5-cyclohexane-C

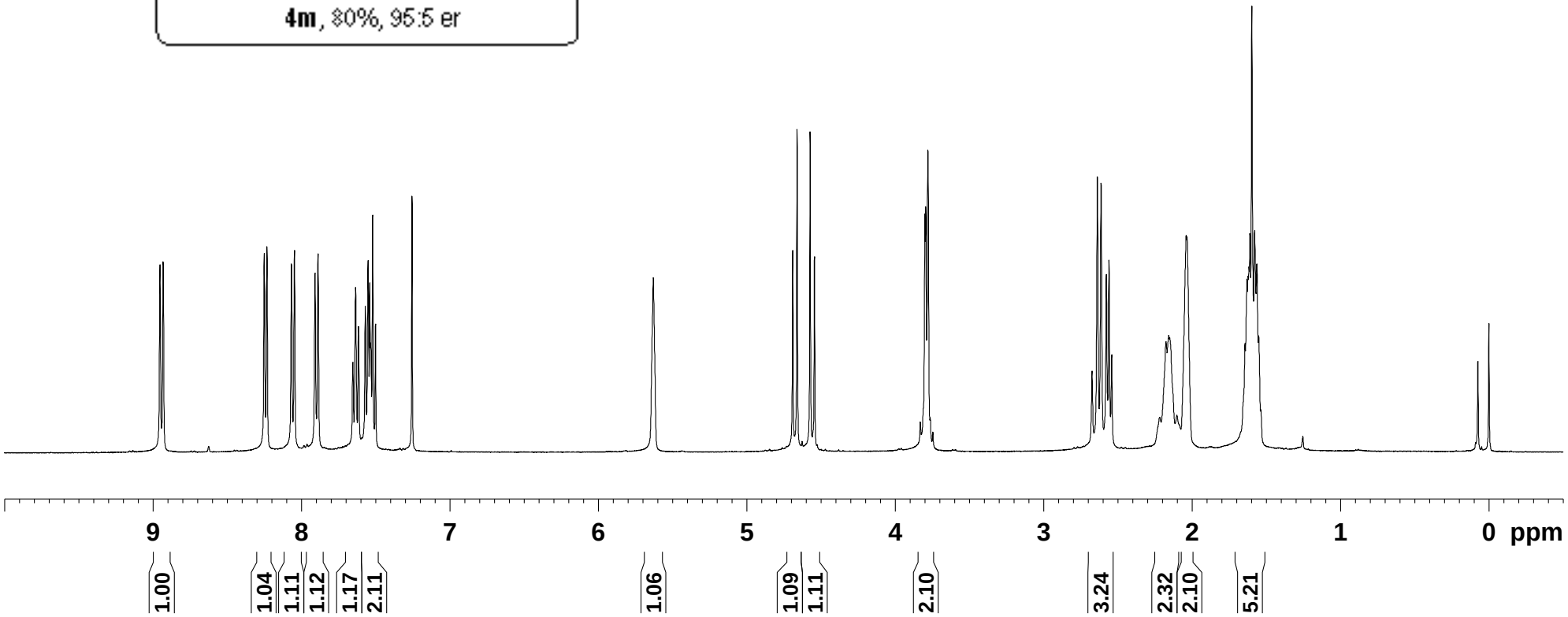


lbs-cyclohexene-H

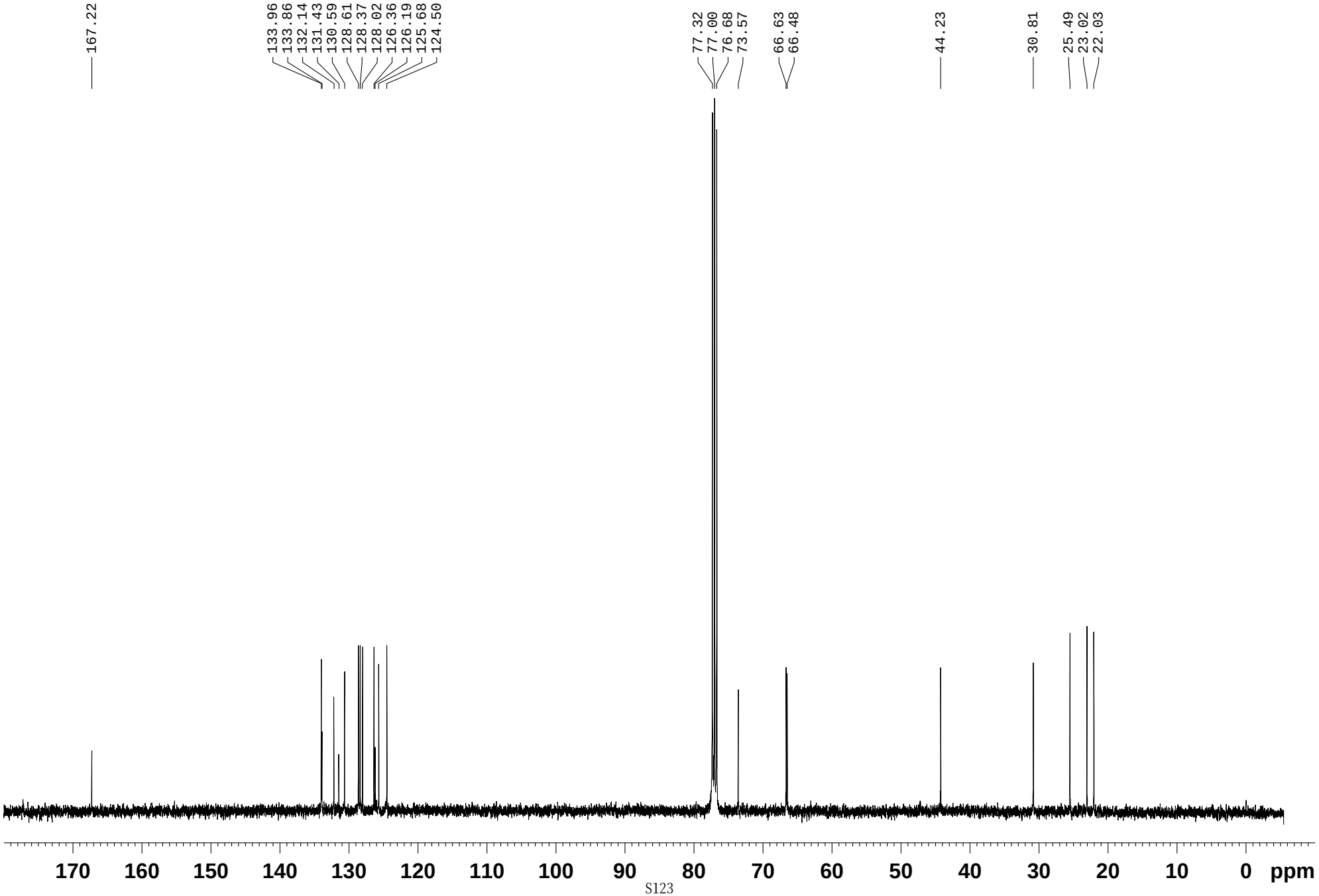




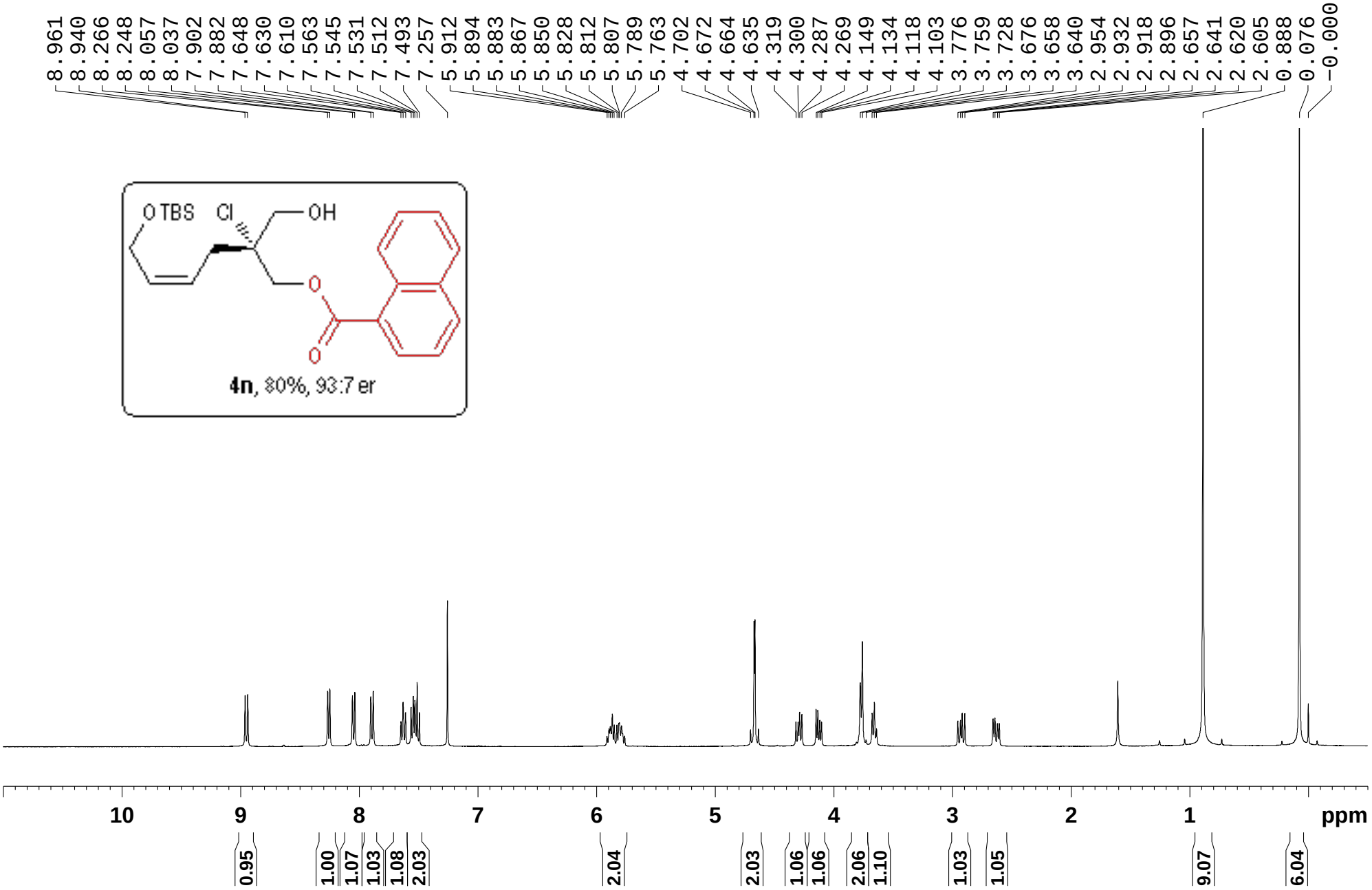
4m, 80%, 95:5 er



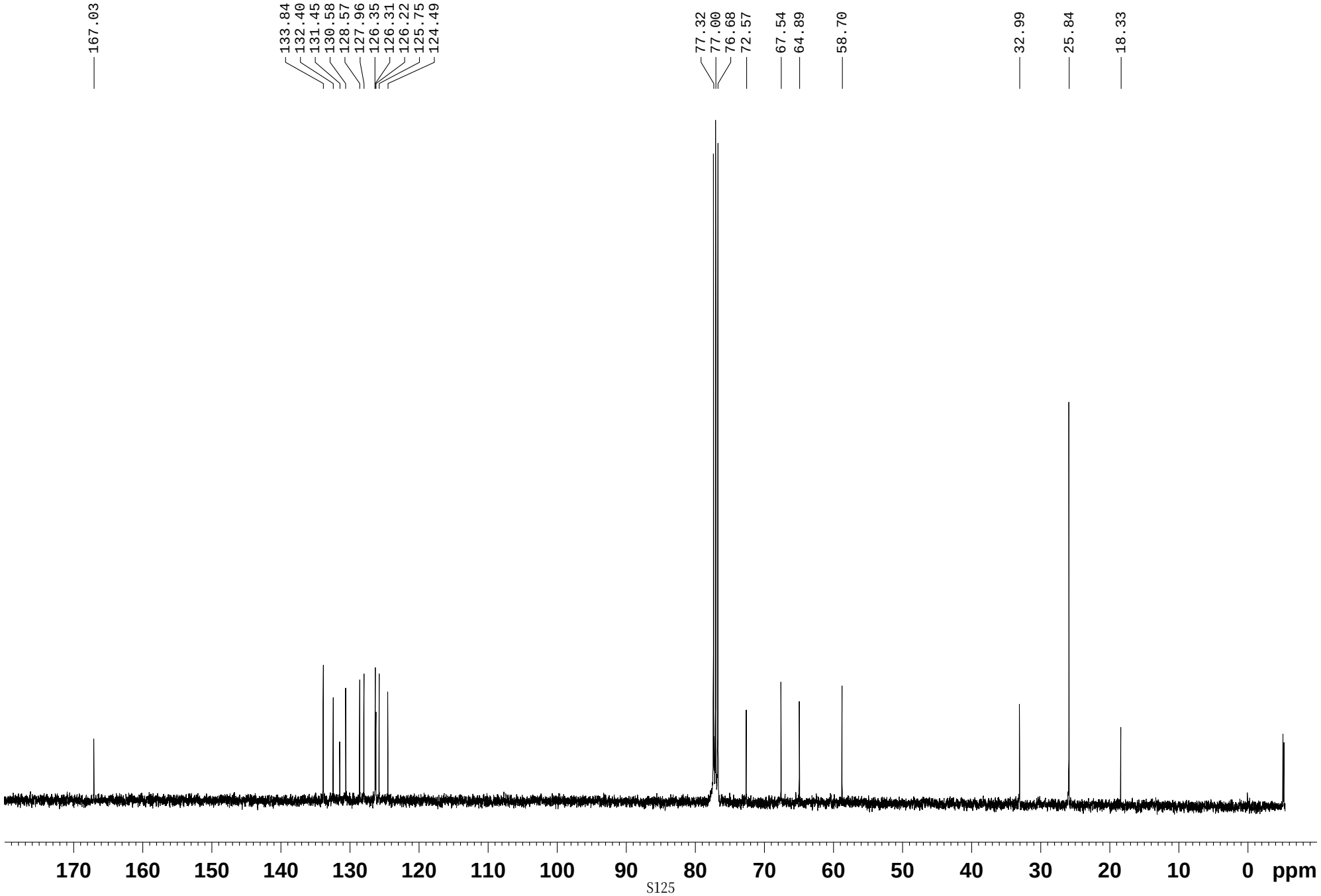
lbs-cyclohexene-C



lbs-cis-olefin-OTBS-H

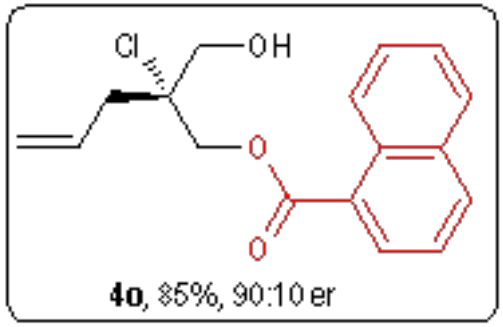


lbs-cis-olefin-OTBS-C

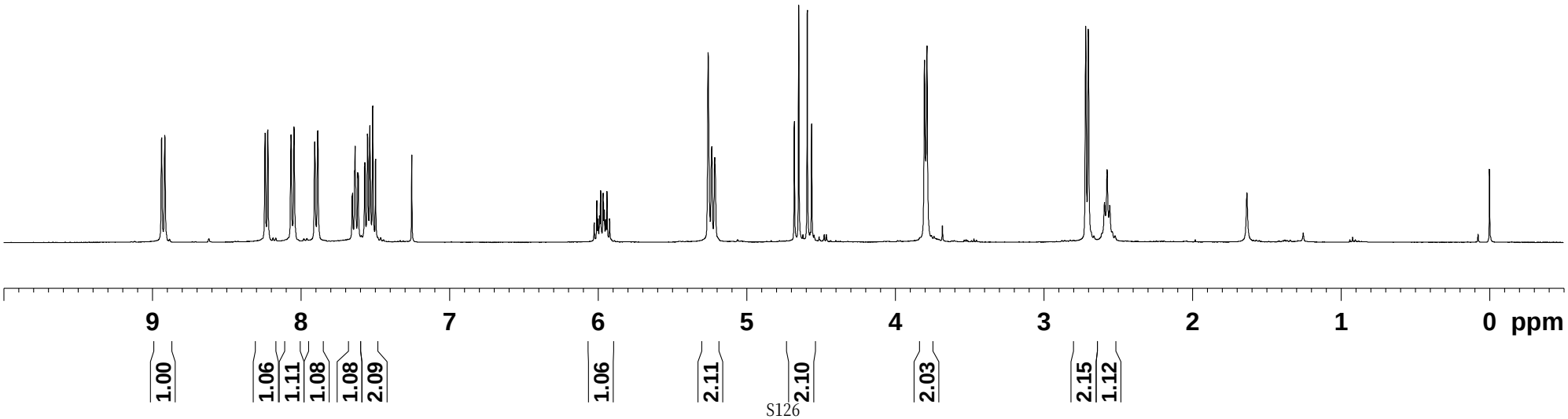


lbs-alyll-Cl-H

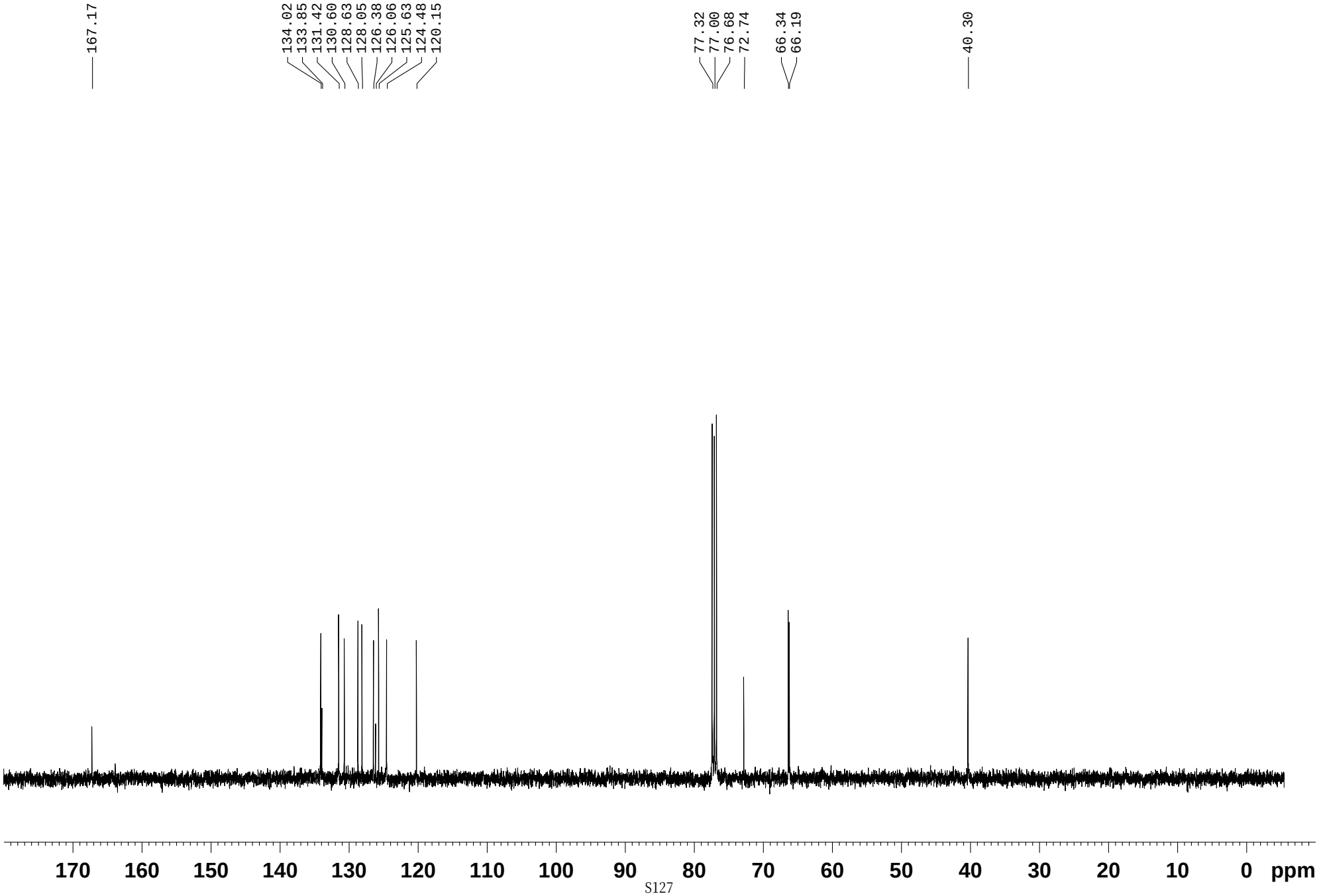
8.238 8.222 8.220 8.065 8.044 7.905 7.884 7.654 7.651 7.636 7.633 7.615 7.612 7.567 7.549 7.534 7.515 7.495 7.252 6.026 6.008 6.000 5.990 5.982 5.967 5.959 5.949 5.941 5.923 5.260 5.234 5.215 5.212 4.679 4.650 4.592 4.563 3.803 3.786 2.718 2.700 2.591 2.574 2.556 0.000



4o, 85%, 90:10 er

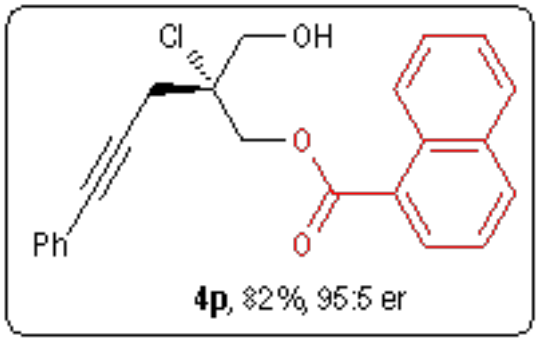


lbs-alyll-Cl-C

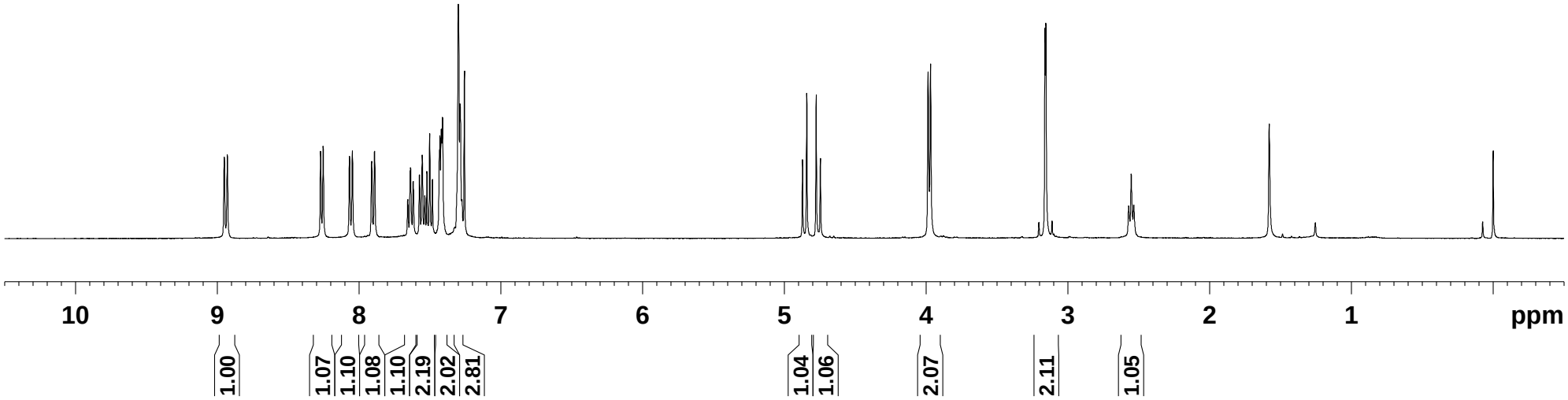


lbs-phenylacetate-Cl-H

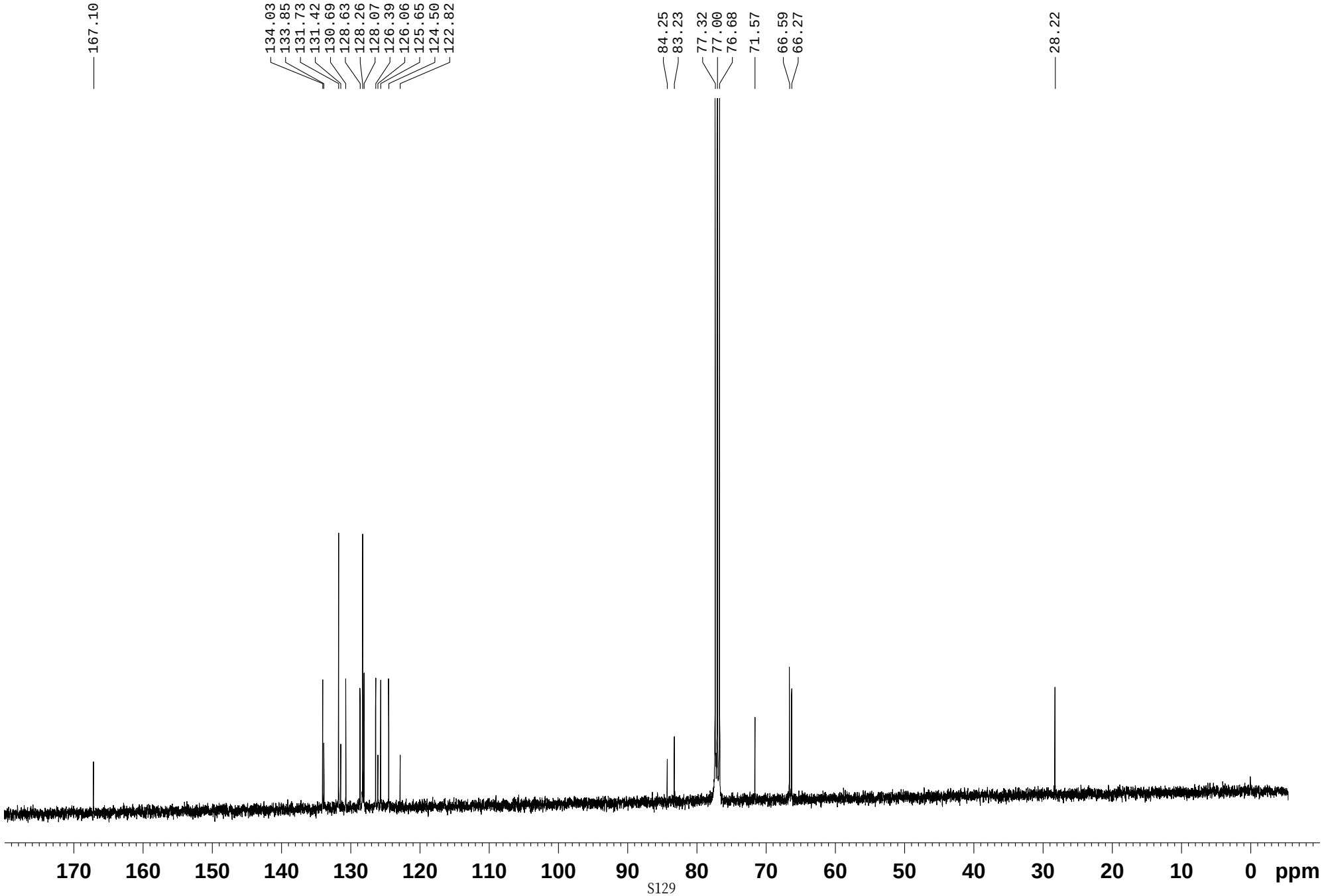
8.948 8.927 8.269 8.251 8.065 8.045 7.909 7.888 7.654 7.635 7.616 7.571 7.552 7.534 7.518 7.499 7.480 7.427 7.417 7.409 7.320 7.298 7.295 7.285 7.272 7.254 4.869 4.839 4.773 4.743 3.983 3.966 3.202 3.158 3.152 3.109 2.571 2.553 2.535 0.000



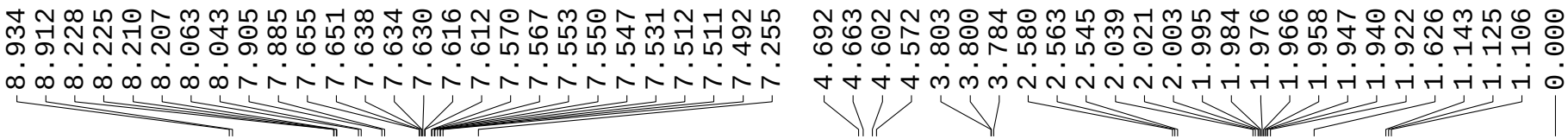
4p, 82%, 95:5 er

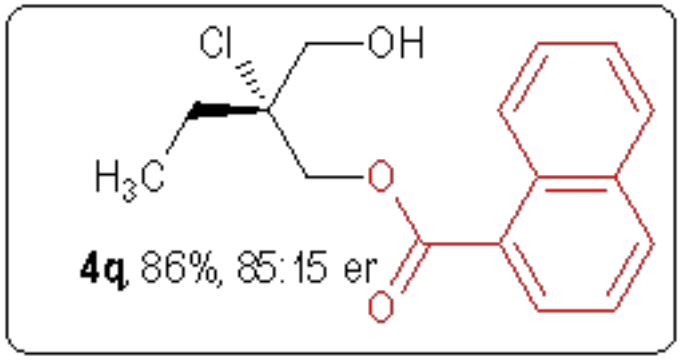


lbs-phenylacetate-Cl-C

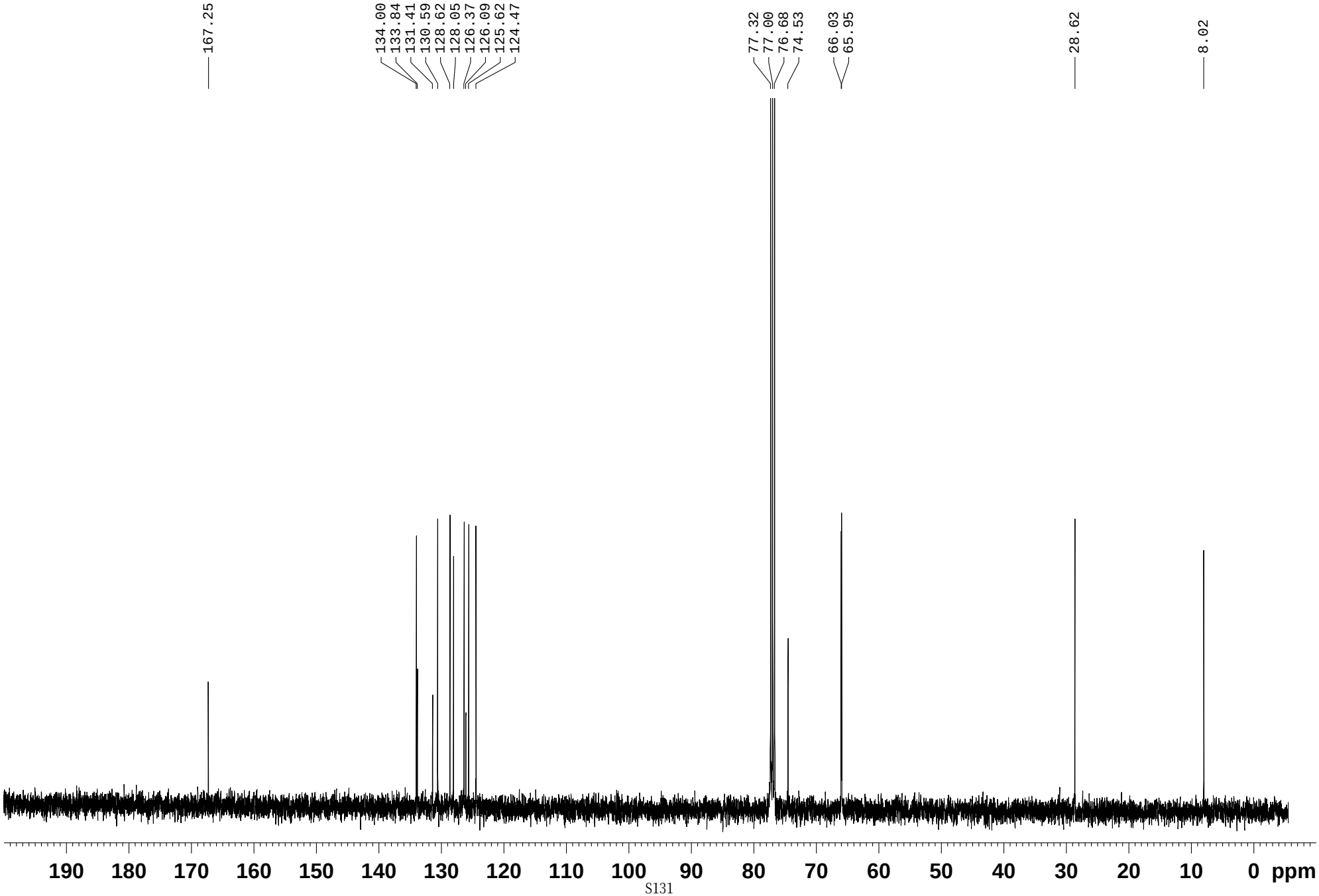


lbs-Et-monoester-H

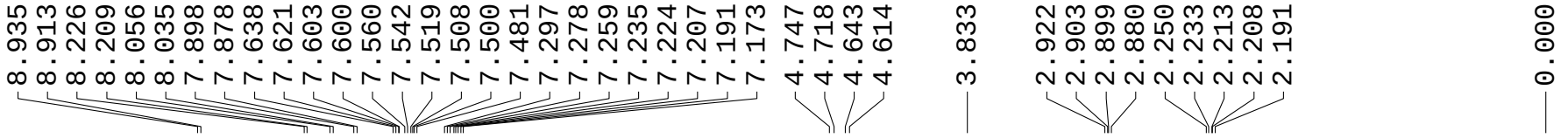


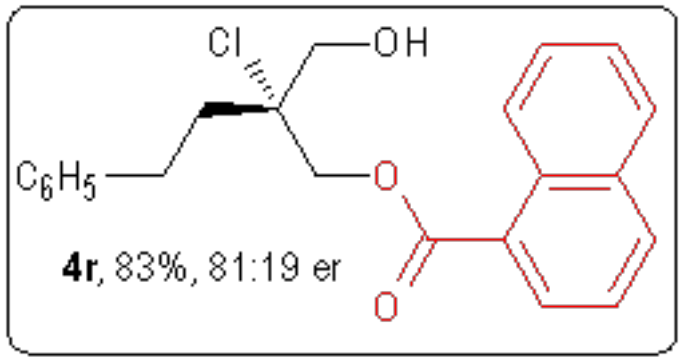


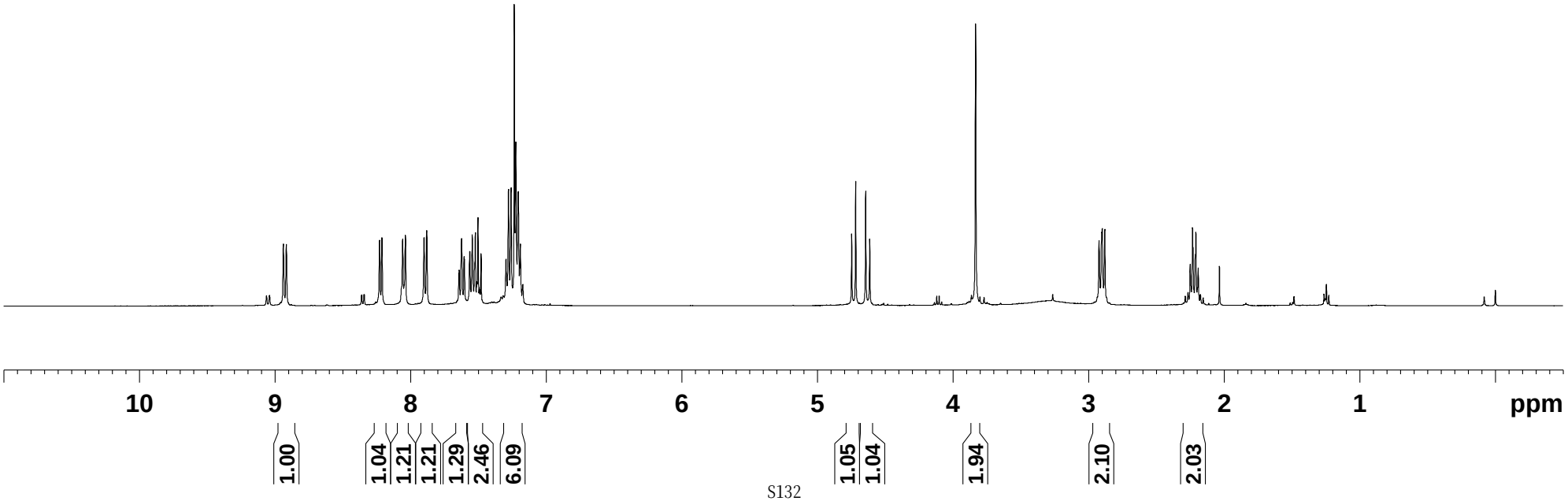
lbs-Et-monoester-C



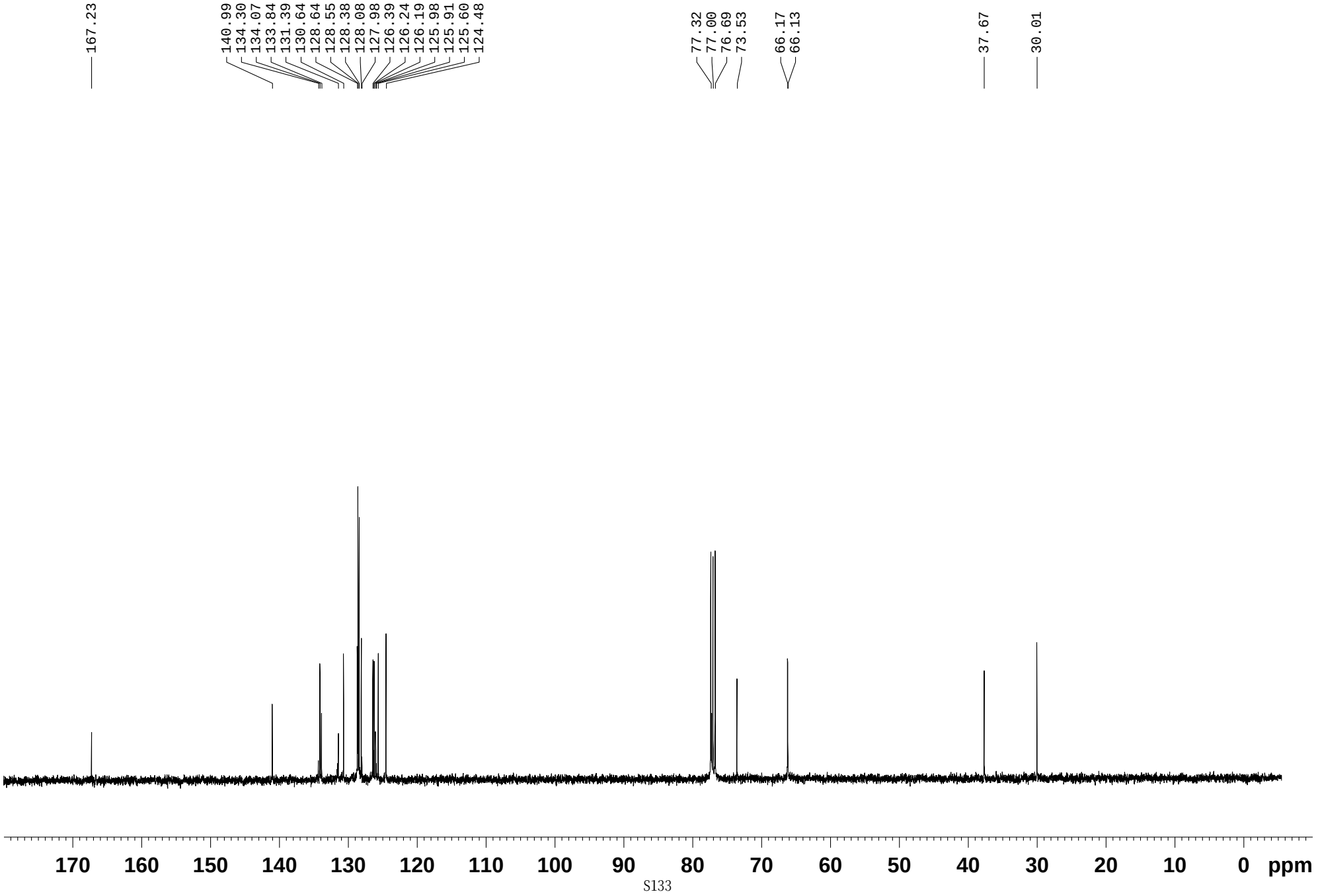
lbs-2-Bn-CH2-2-Cl-H







lbs-2-Bn-CH2-2-Cl-C



lbs-ipr-monoester-H

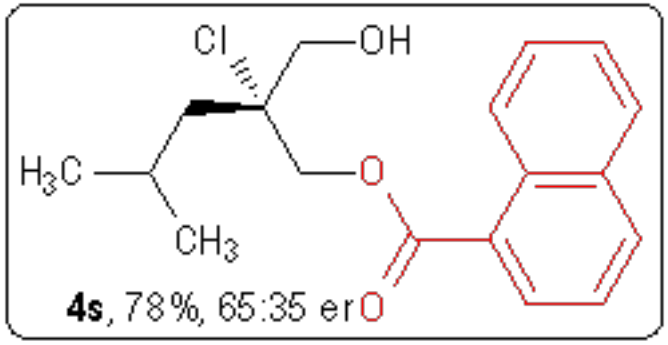
8.227 8.224 8.209 8.206 8.066 8.046 7.907 7.886 7.654 7.651 7.637 7.633 7.629 7.615 7.612 7.571 7.568 7.553 7.551 7.548 7.535 7.531 7.517 7.515 7.497 7.254

4.690 4.660 4.623 4.594

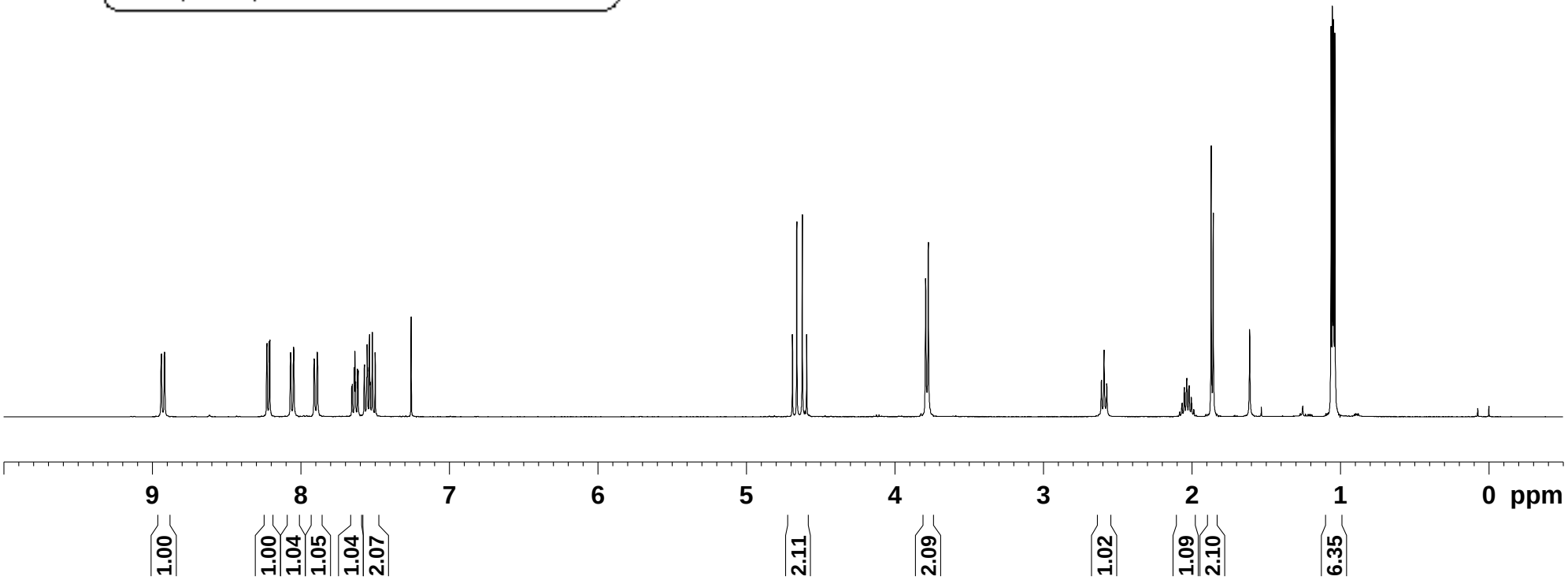
3.793 3.775

2.609 2.591 2.573 2.082 2.066 2.051 2.035 2.020 2.018 2.004 1.987 1.870 1.856 1.063 1.054 1.046 1.037

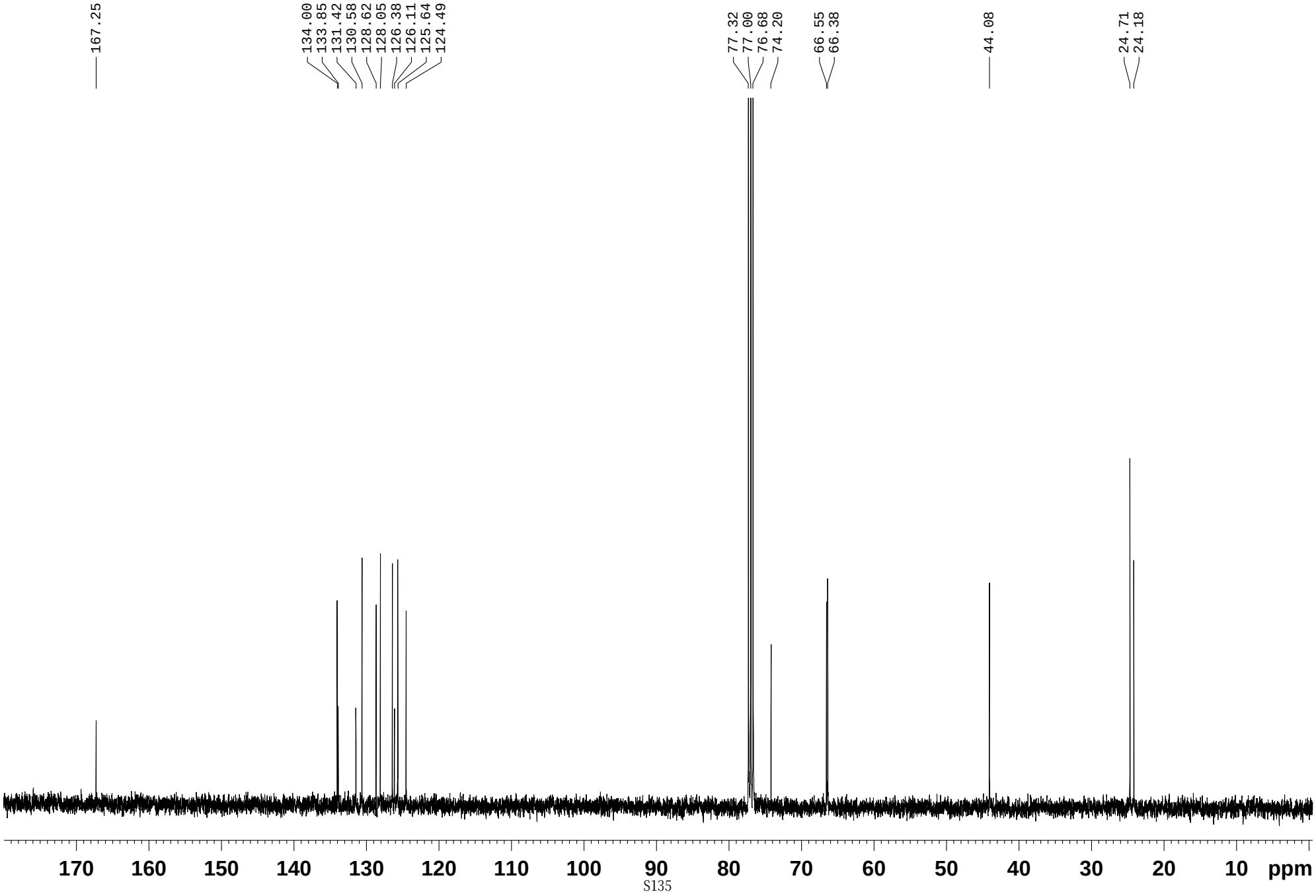
0.000



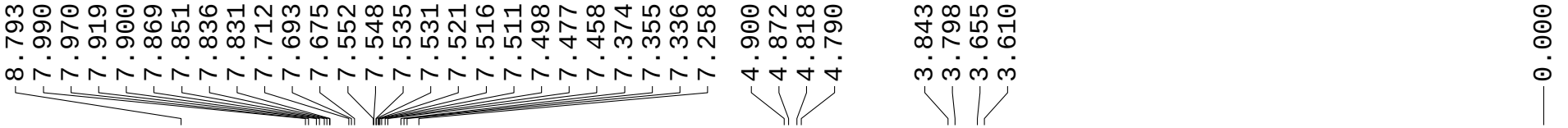
4s, 78%, 65:35 er

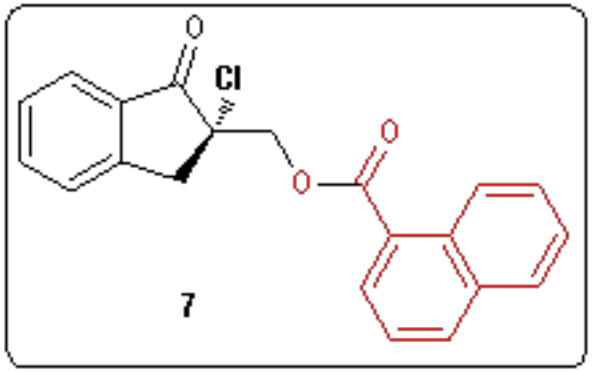


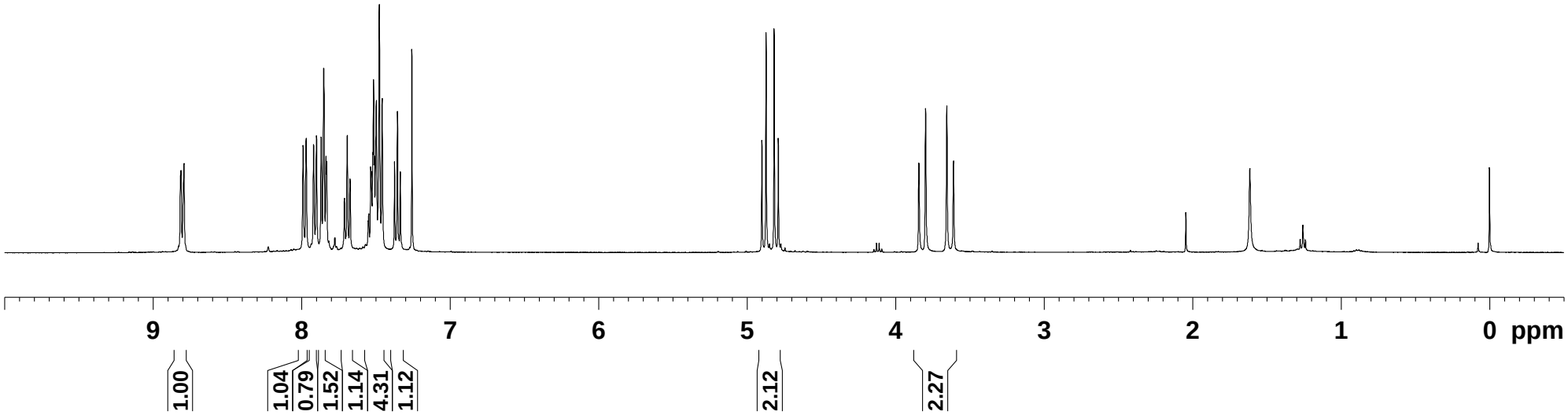
lbs-ipr-monoester-C



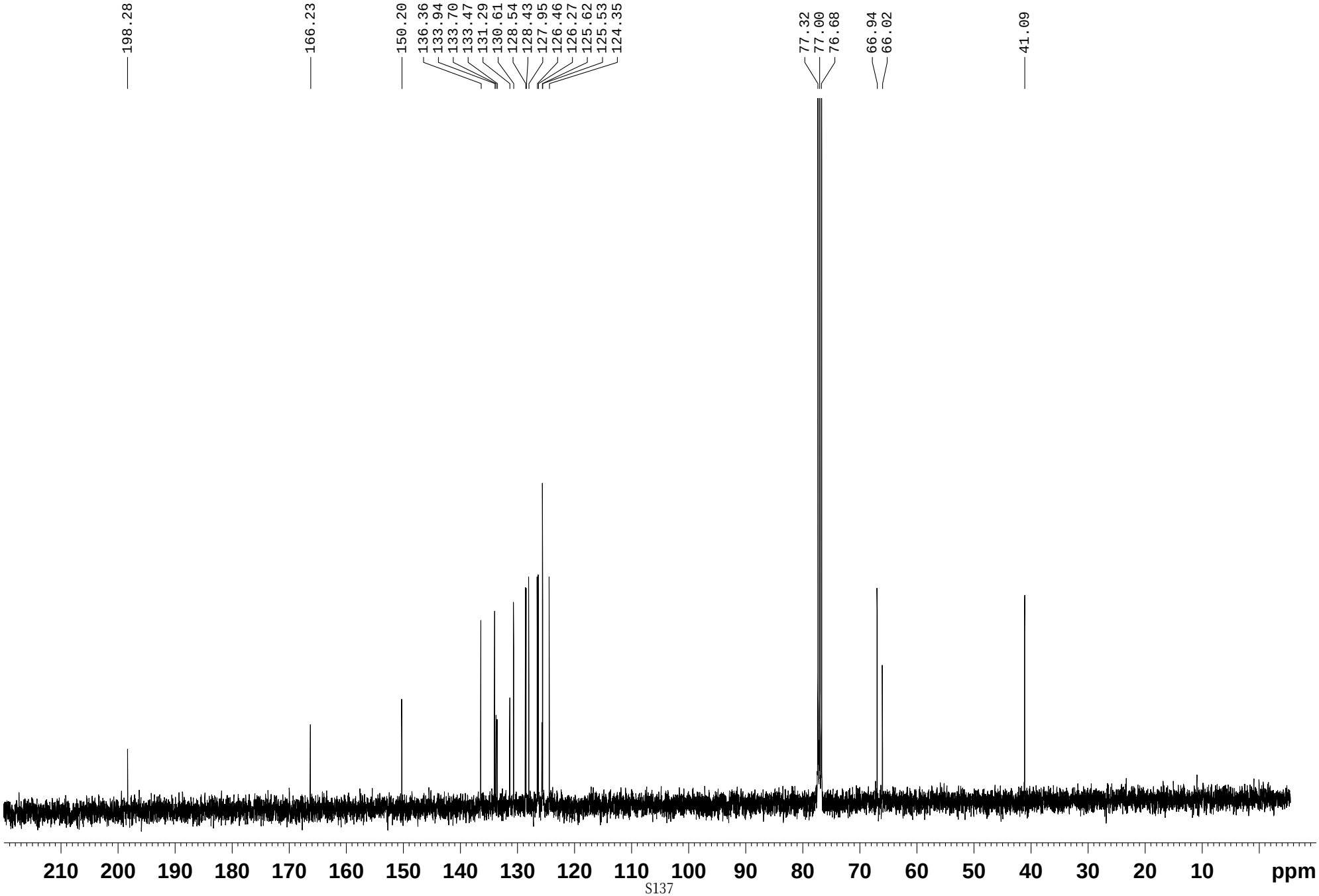
LBS-indanol-ester-H



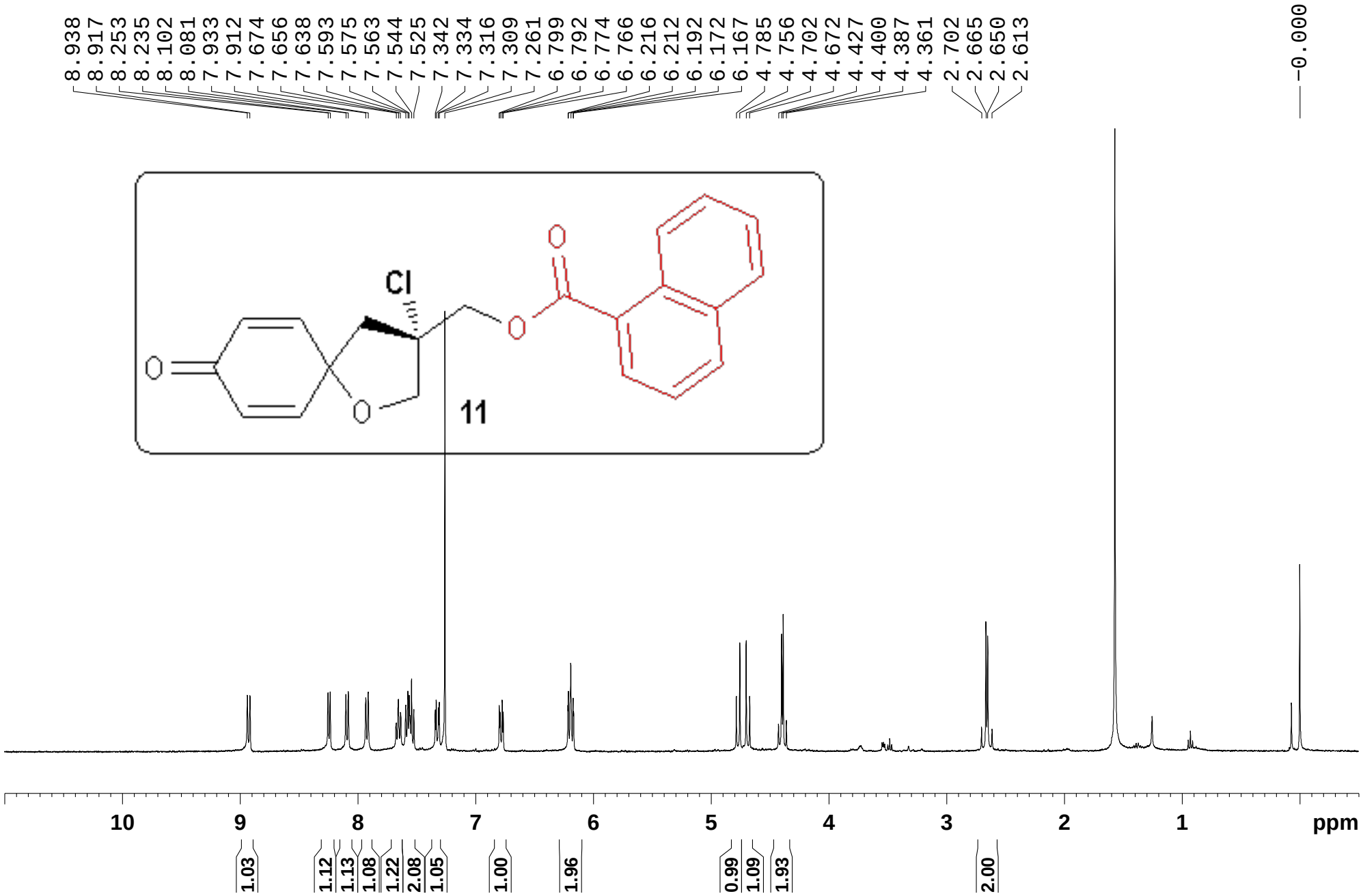




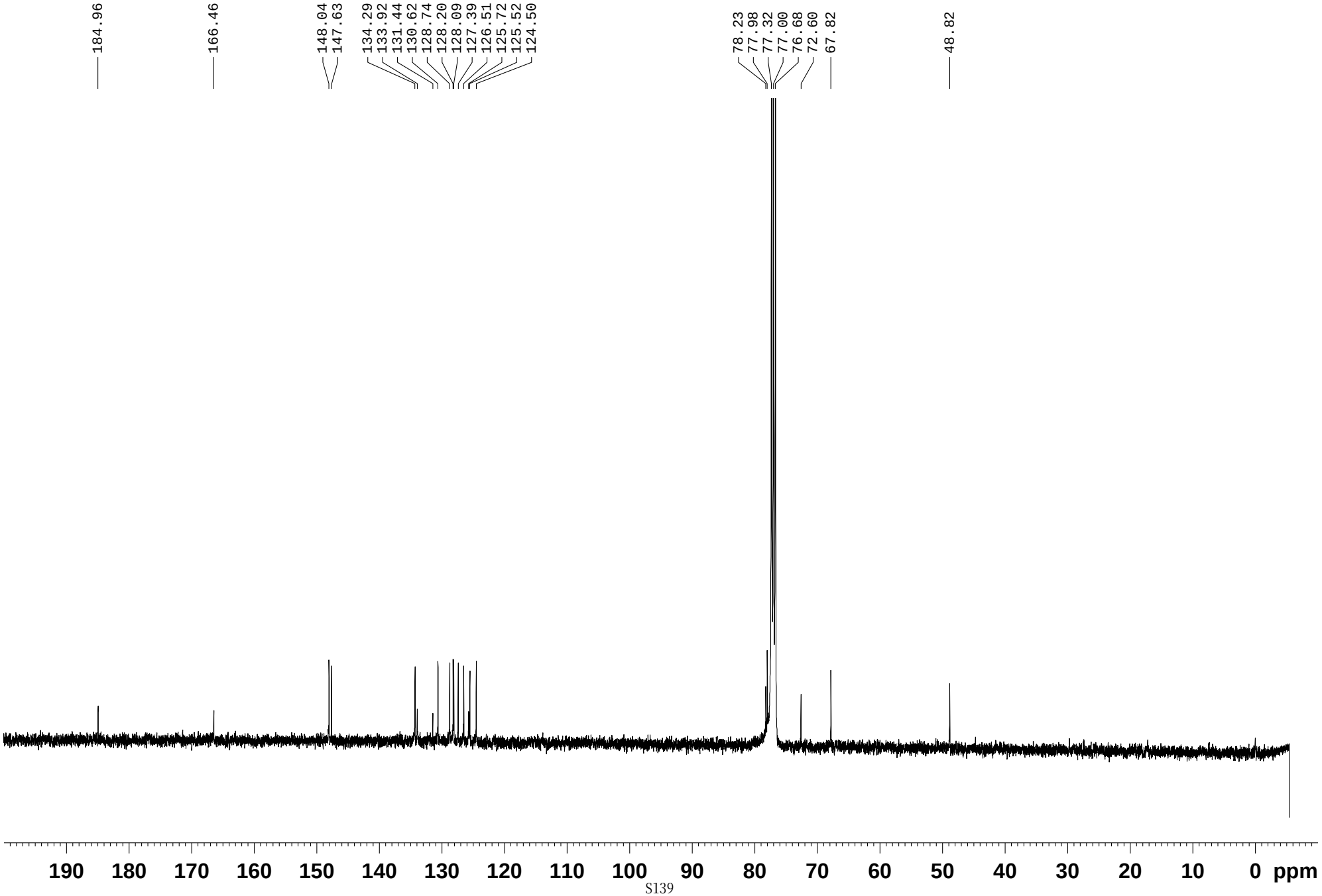
LBS-indanol-ester-C



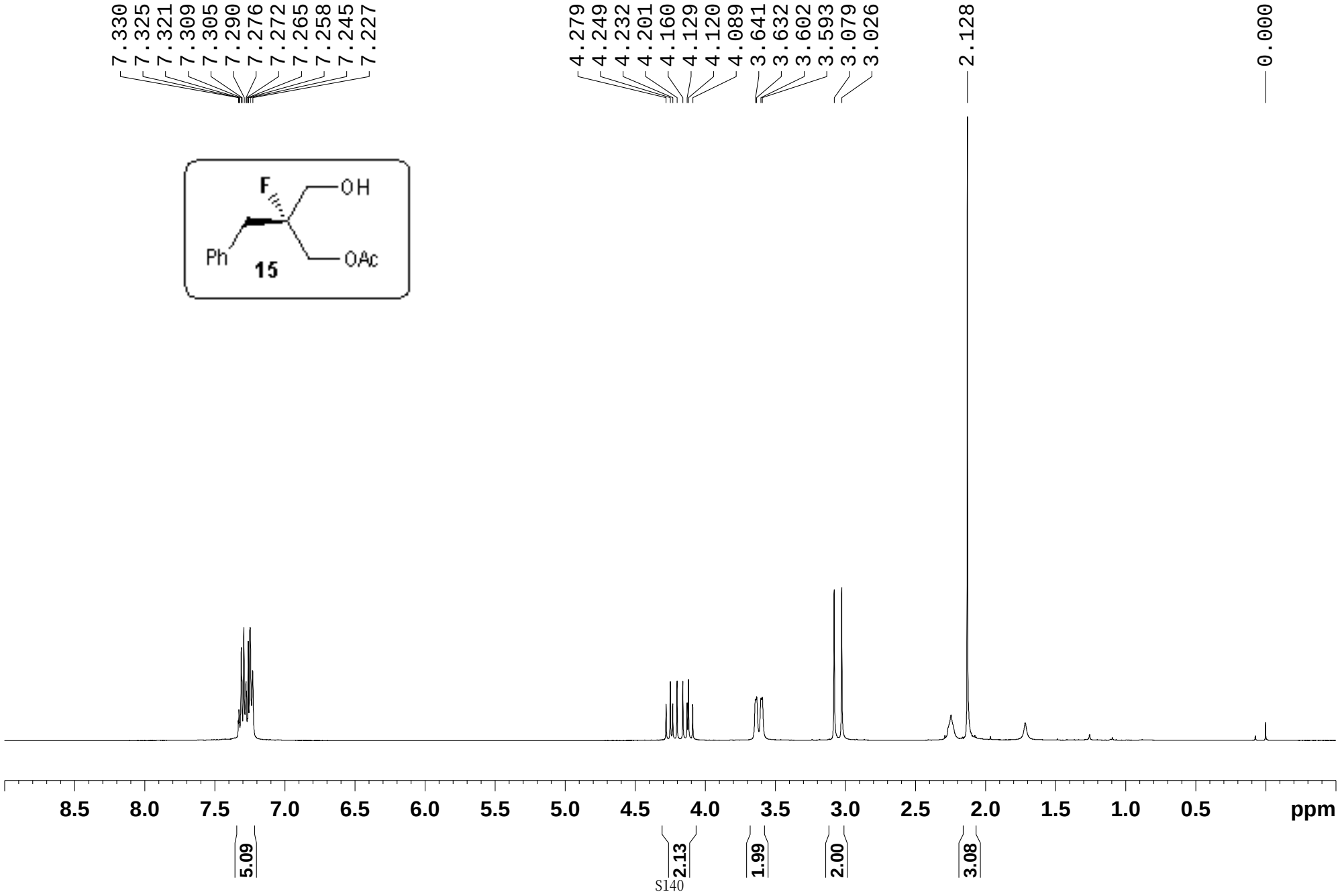
lbs-oxidation-H



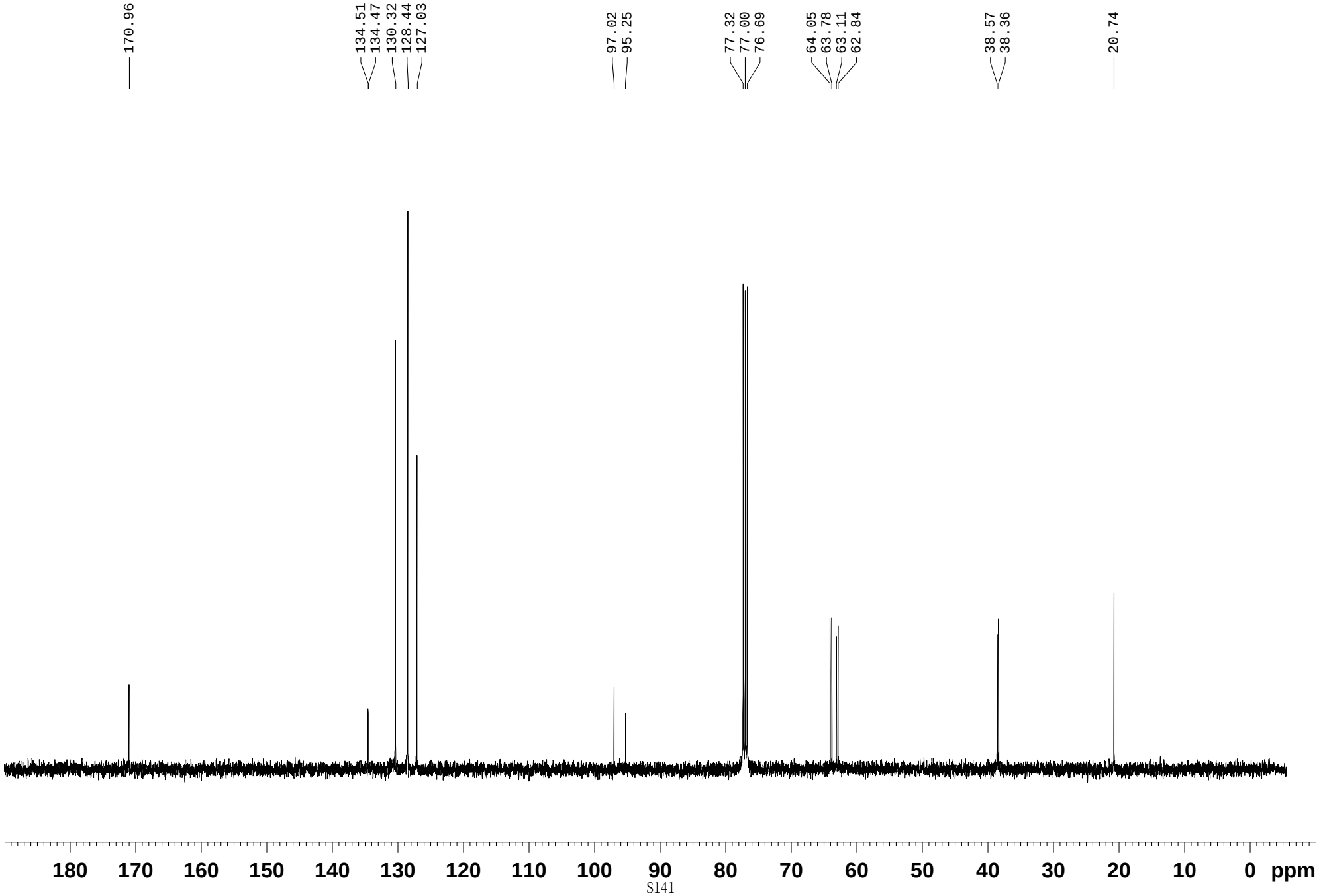
lbs-oxidation-C2



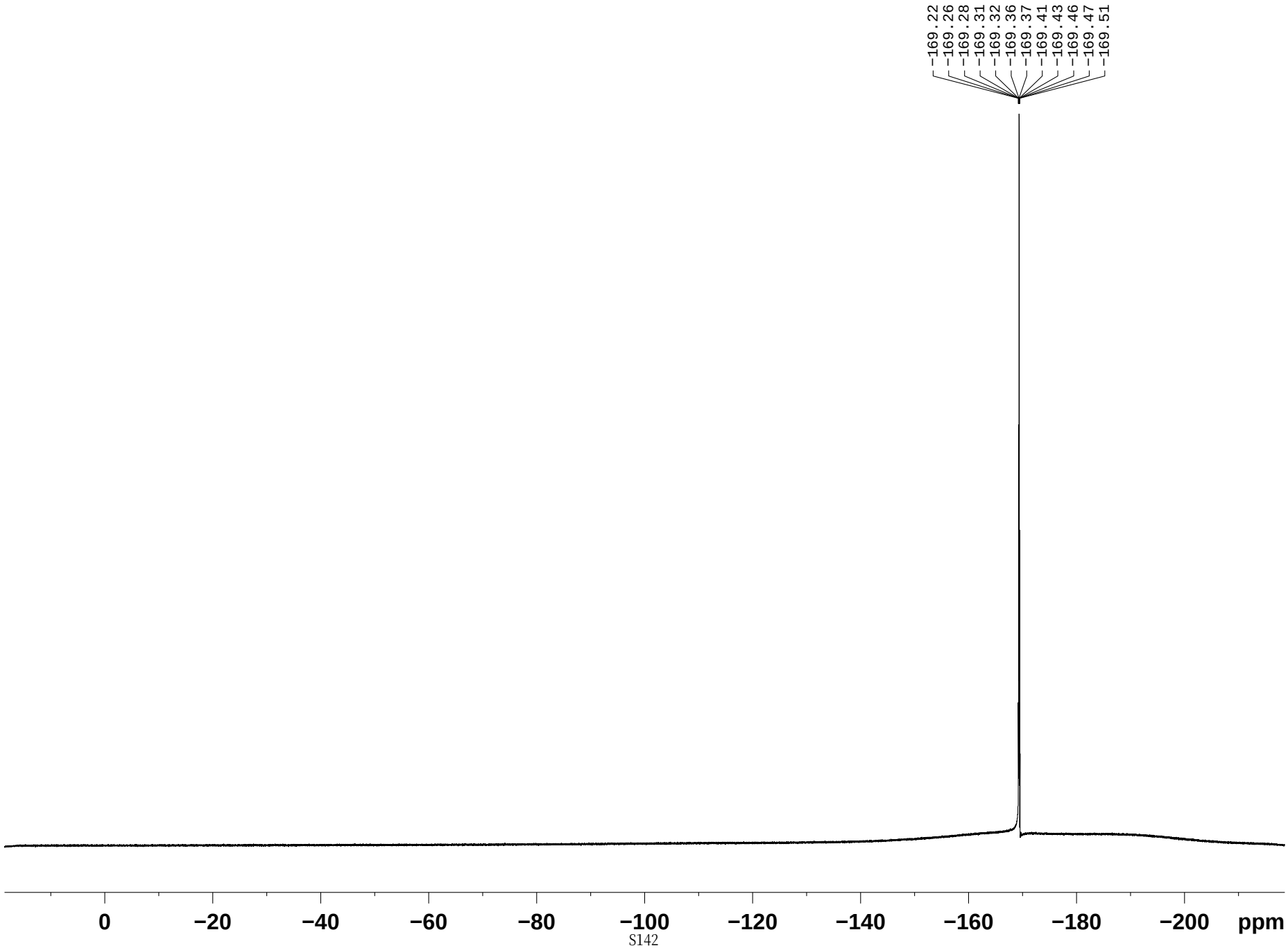
lbs-OAc-H

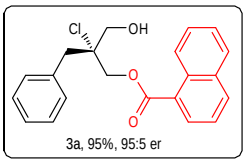

7.330
7.325
7.321
7.309
7.305
7.290
7.276
7.272
7.265
7.258
7.245
7.227
4.279
4.249
4.232
4.201
4.160
4.129
4.120
4.089
3.641
3.632
3.602
3.593
3.079
3.026
2.128
0.000
F
OH
Ph
OAc
15
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
5.09
2.13
1.99
2.00
3.08

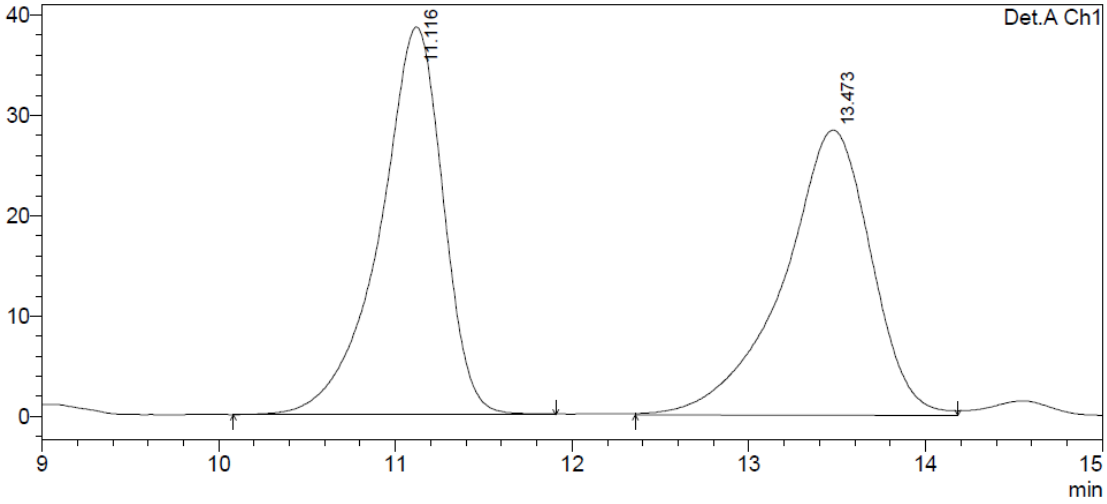
lbs-OAc-C


170.96
134.51
134.47
130.32
128.44
127.03
97.02
95.25
77.32
77.00
76.69
64.05
63.78
63.11
62.84
38.57
38.36
20.74
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

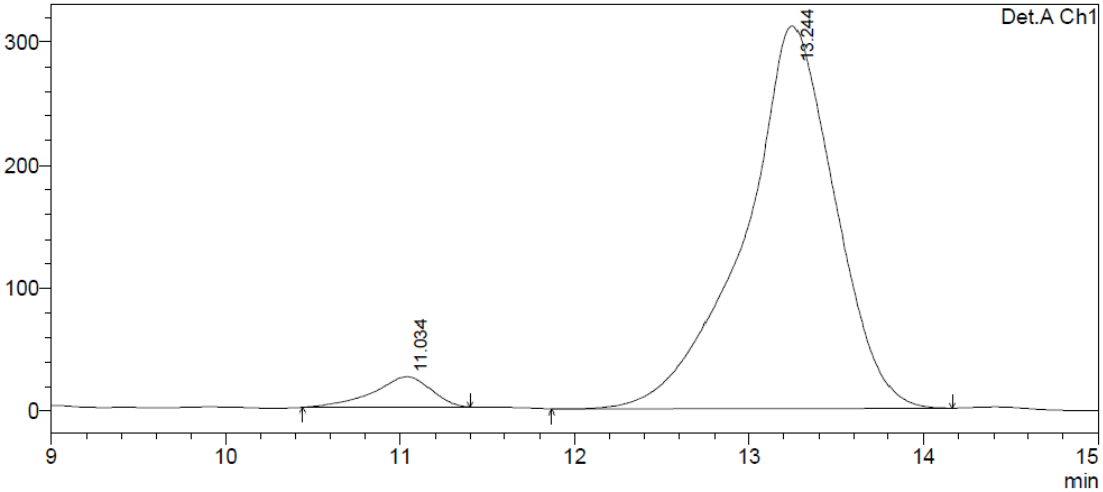
lbs-OAc-F


-169.22
-169.26
-169.28
-169.31
-169.32
-169.36
-169.37
-169.41
-169.43
-169.46
-169.47
-169.51
0
−20
−40
−60
−80
−100
−120
−140
−160
−180
−200
ppm

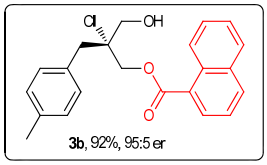




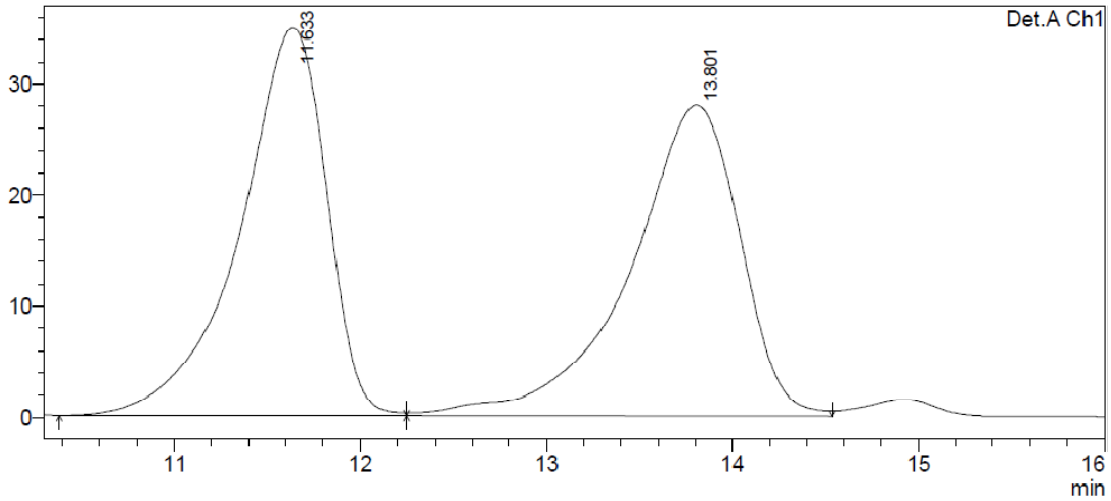
Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.116	965834	38656	49.543	57.642
2	13.473	983655	28406	50.457	42.358
Total		1949489	67062	100.000	100.000



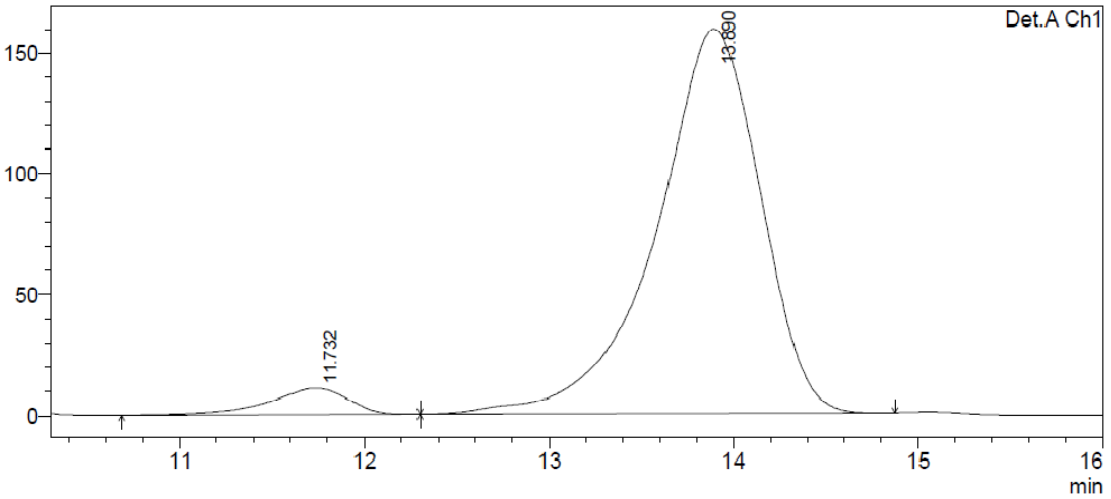
Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.034	574133	24958	4.876	7.434
2	13.244	11199780	310764	95.124	92.566
Total		11773913	335721	100.000	100.000



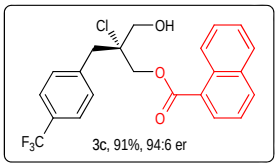
3b, 92%, 95:5 er



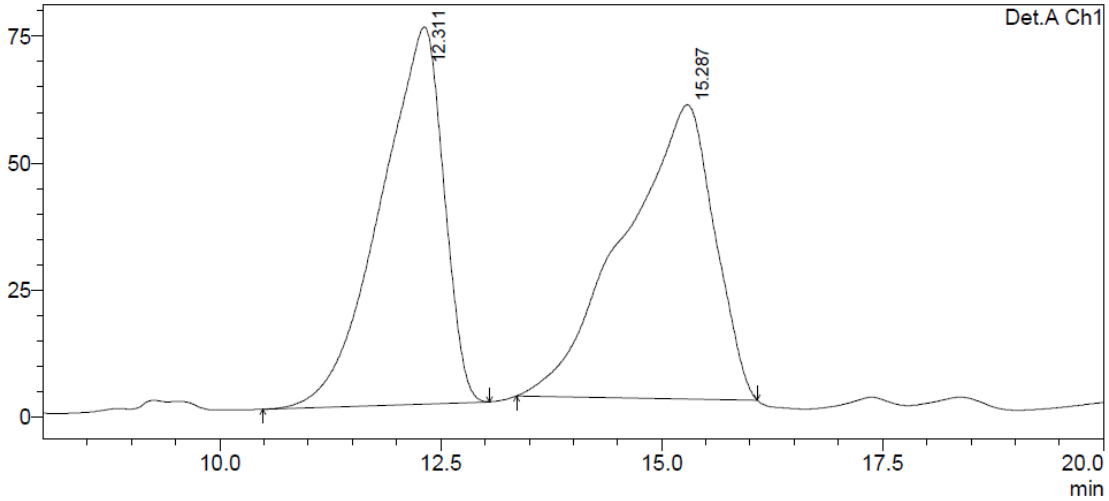
Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.633	1128402	34913	49.377	55.528
2	13.801	1156898	27961	50.623	44.472
Total		2285300	62875	100.000	100.000



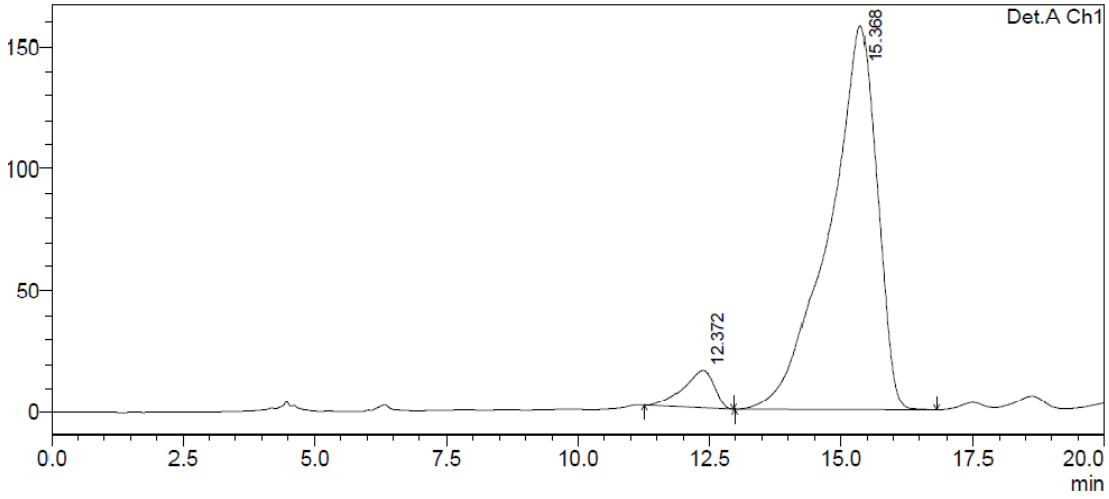
Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.732	325775	10954	4.963	6.442
2	13.890	6238673	159082	95.037	93.558
Total		6564448	170036	100.000	100.000



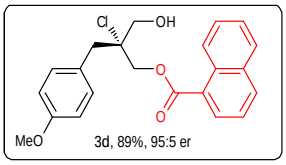
3c, 91%, 94:6 er

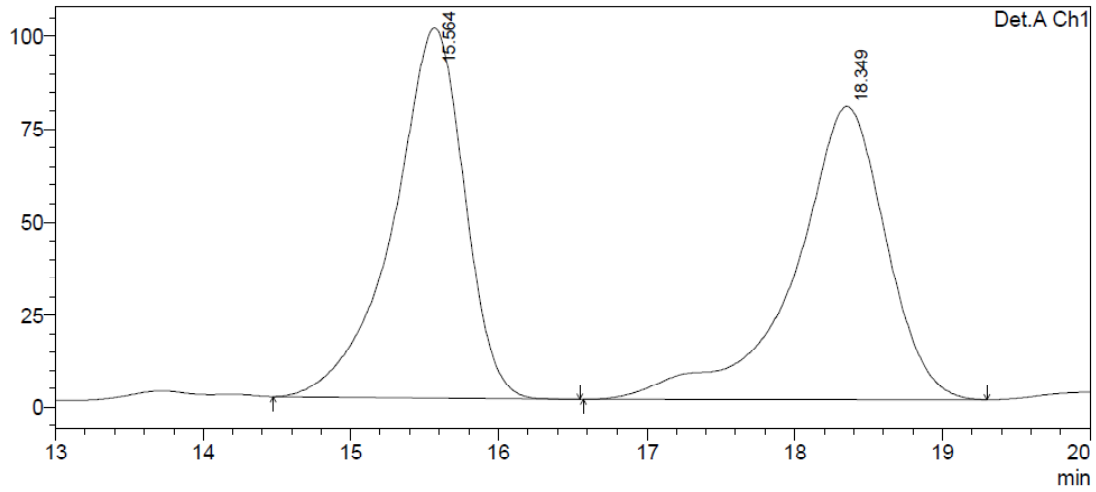


Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.311	3692805	74175	47.348	56.172
2	15.287	4106455	57875	52.652	43.828
Total		7799260	132051	100.000	100.000

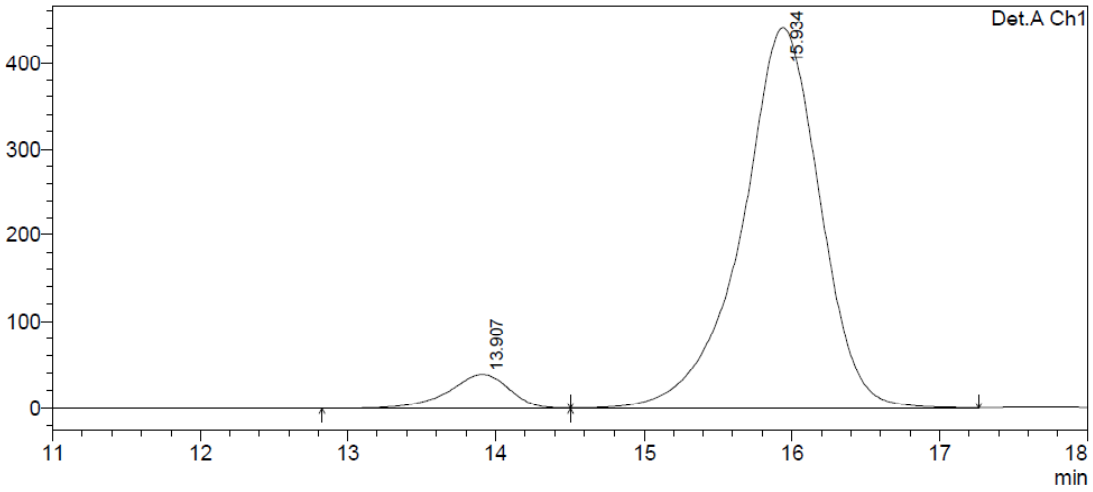


Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.372	650985	15807	6.142	9.127
2	15.368	9948450	157390	93.858	90.873
Total		10599435	173197	100.000	100.000

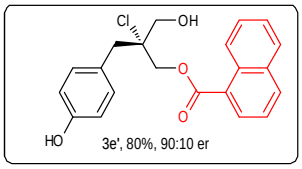




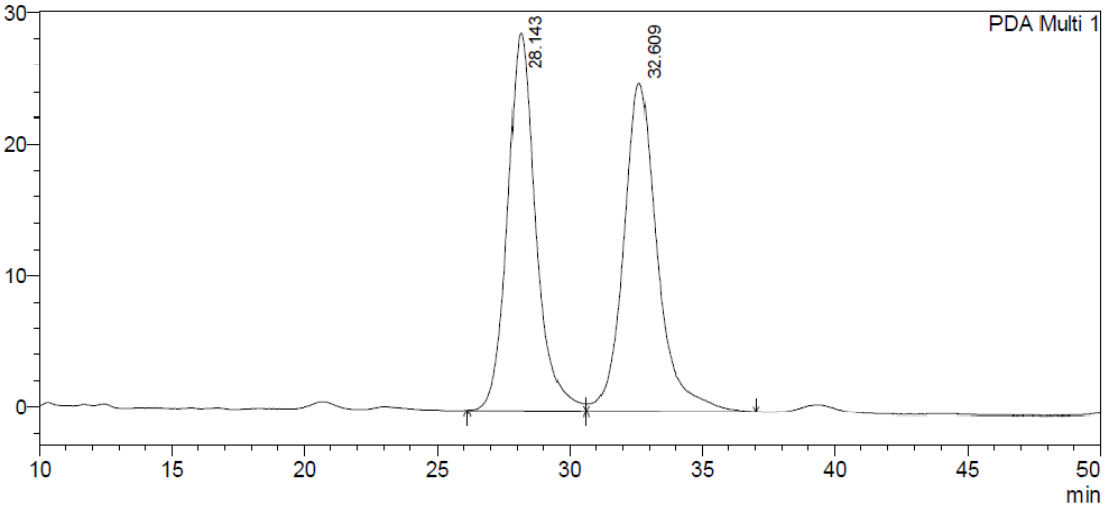
Peak#	Ret. Time	Area	Height	Area %	Height %
1	15.564	3340572	99719	49.196	55.768
2	18.349	3449817	79092	50.804	44.232
Total		6790390	178811	100.000	100.000



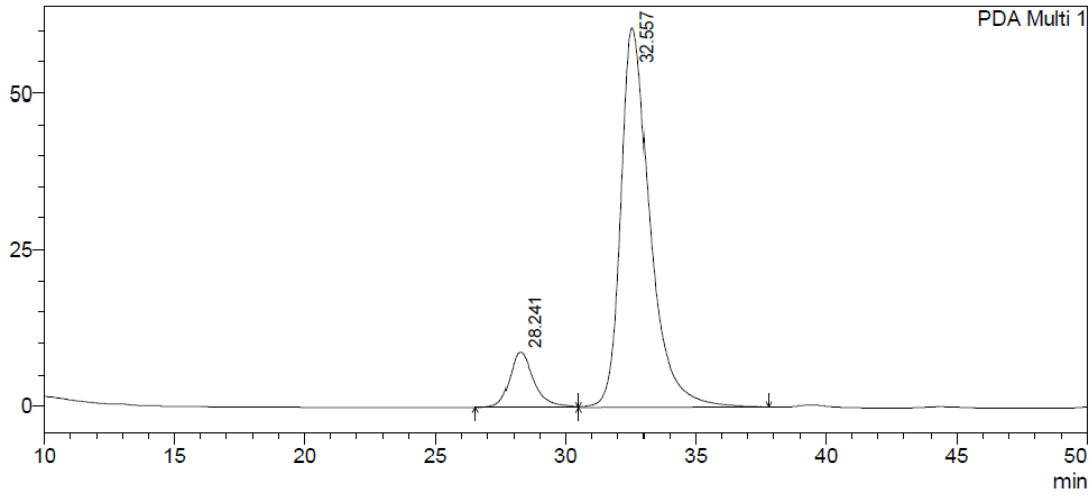
Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.907	788441	32762	4.647	6.920
2	15.934	16179824	440689	95.353	93.080
Total		16968266	473452	100.000	100.000



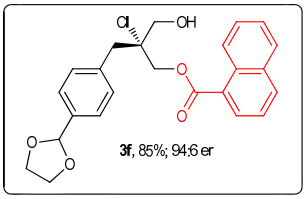
3e', 80%, 90:10 er

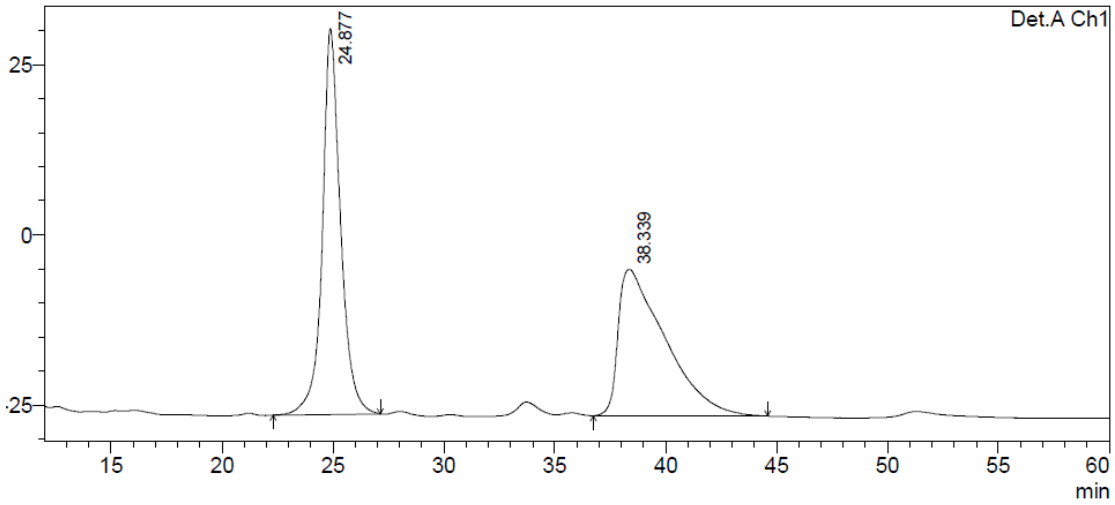


Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.143	2141530	28706	49.121	53.446
2	32.609	2218209	25004	50.879	46.554
Total		4359739	53710	100.000	100.000

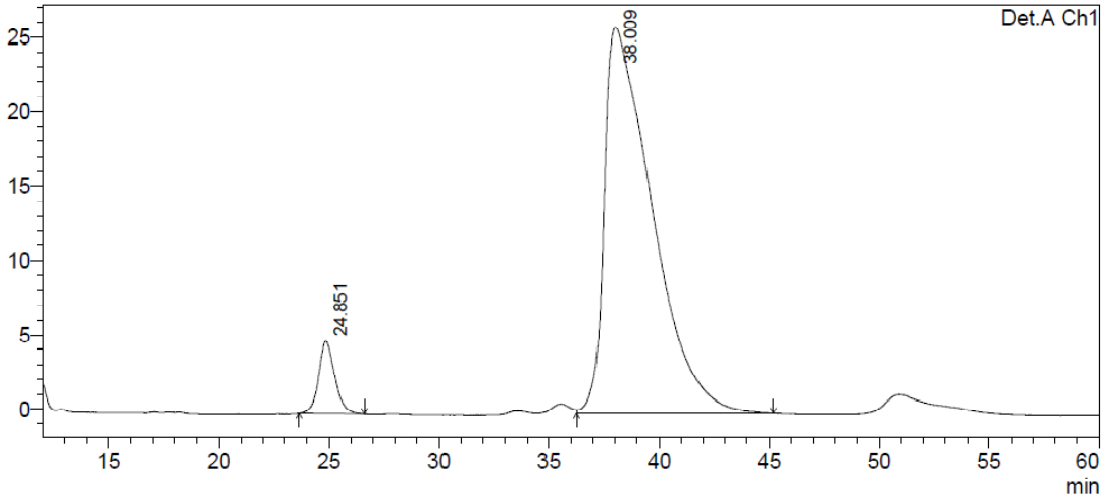


Peak#	Ret. Time	Area	Height	Area %	Height %
1	28.241	489725	8353	9.555	12.118
2	32.557	4635482	60578	90.445	87.882
Total		5125207	68931	100.000	100.000

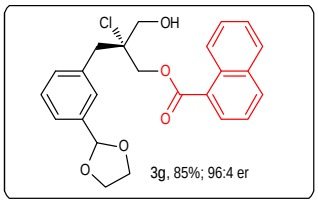


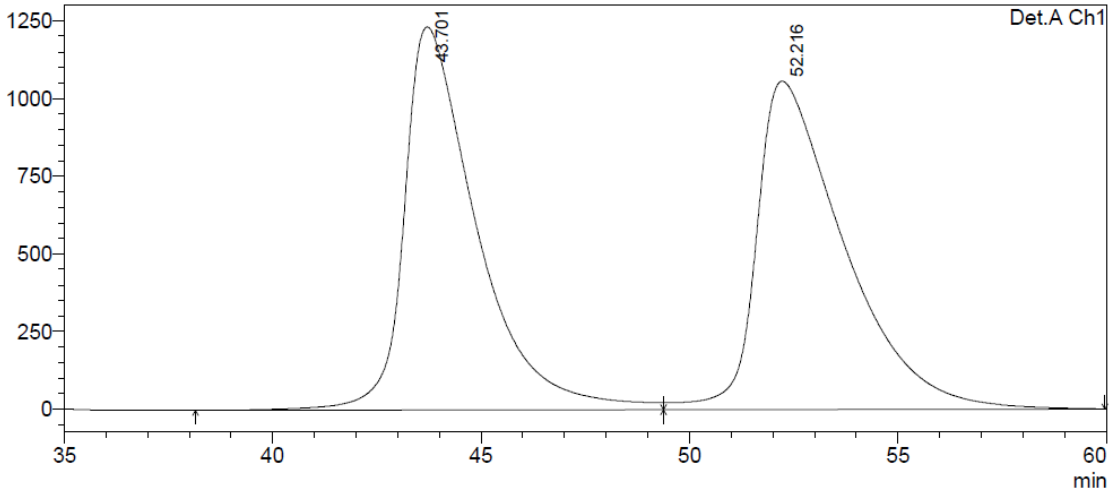


Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.877	3235328	56655	50.523	72.501
2	38.339	3168310	21489	49.477	27.499
Total		6403638	78143	100.000	100.000

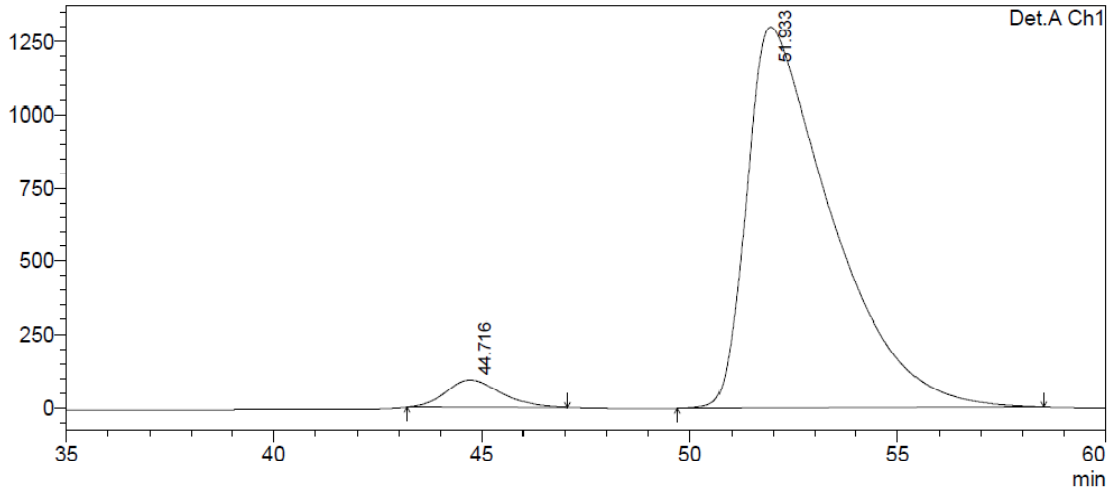


Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.851	249105	4895	5.970	15.865
2	38.009	3923827	25957	94.030	84.135
Total		4172931	30852	100.000	100.000

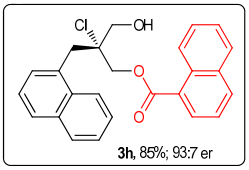


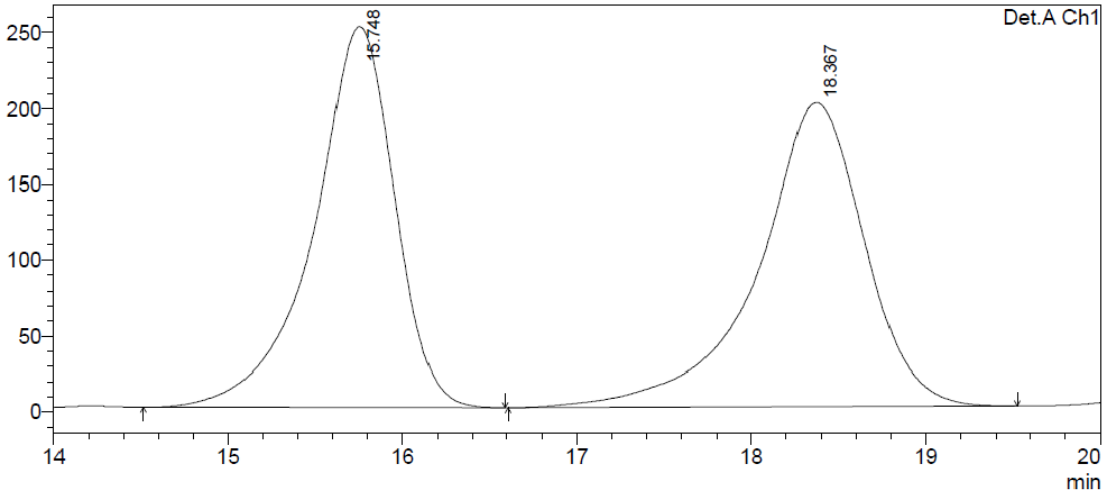


Peak#	Ret. Time	Area	Height	Area %	Height %
1	43.701	150096314	1233562	49.179	53.857
2	52.216	155108183	1056862	50.821	46.143
Total		305204497	2290424	100.000	100.000

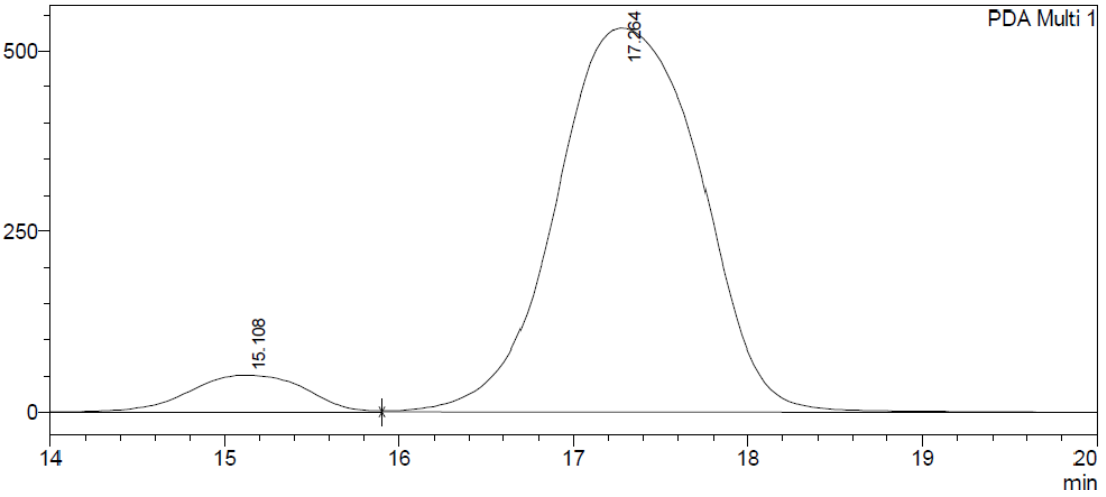


Peak#	Ret. Time	Area	Height	Area %	Height %
1	44.716	8603105	93313	4.452	6.705
2	51.933	184618431	1298427	95.548	93.295
Total		193221536	1391740	100.000	100.000

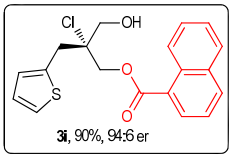




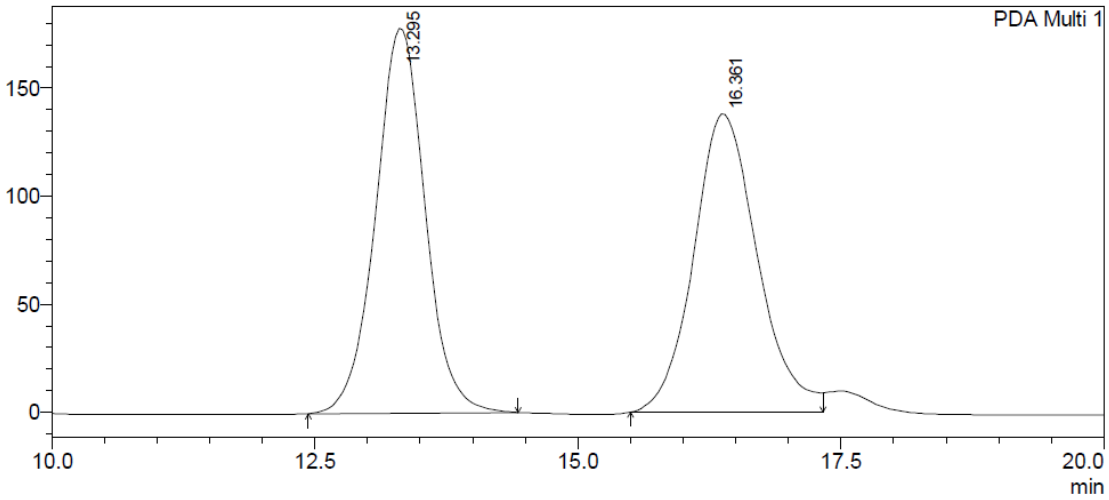
Peak#	Ret. Time	Area	Height	Area %	Height %
1	15.748	8055694	250785	48.598	55.539
2	18.367	8520622	200765	51.402	44.461
Total		16576315	451550	100.000	100.000



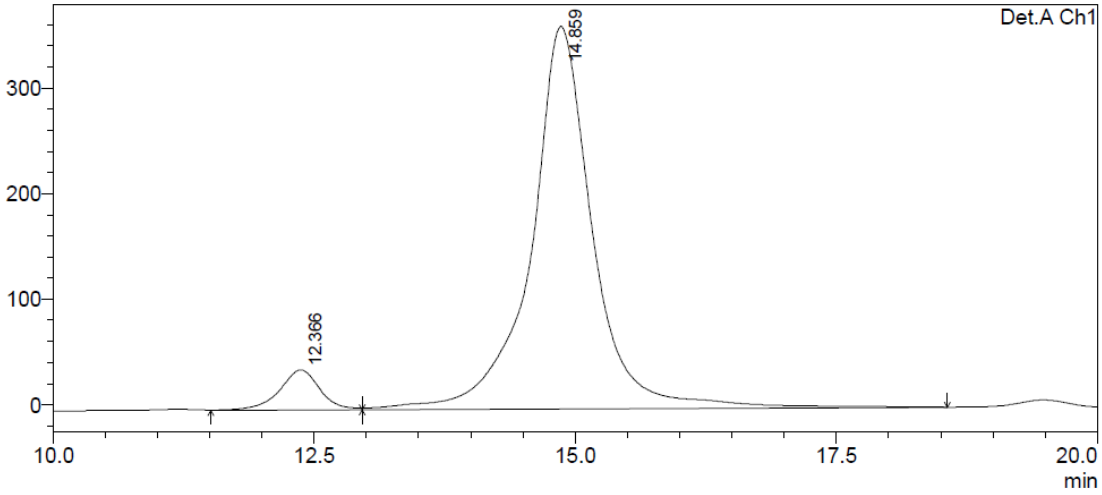
Peak#	Ret. Time	Area	Height	Area %	Height %
1	15.108	2412557	51585	7.296	8.836
2	17.264	30656326	532228	92.704	91.164
Total		33068883	583813	100.000	100.000



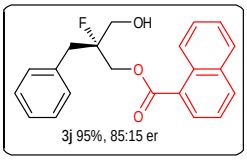
3i, 90%, 94:6 er

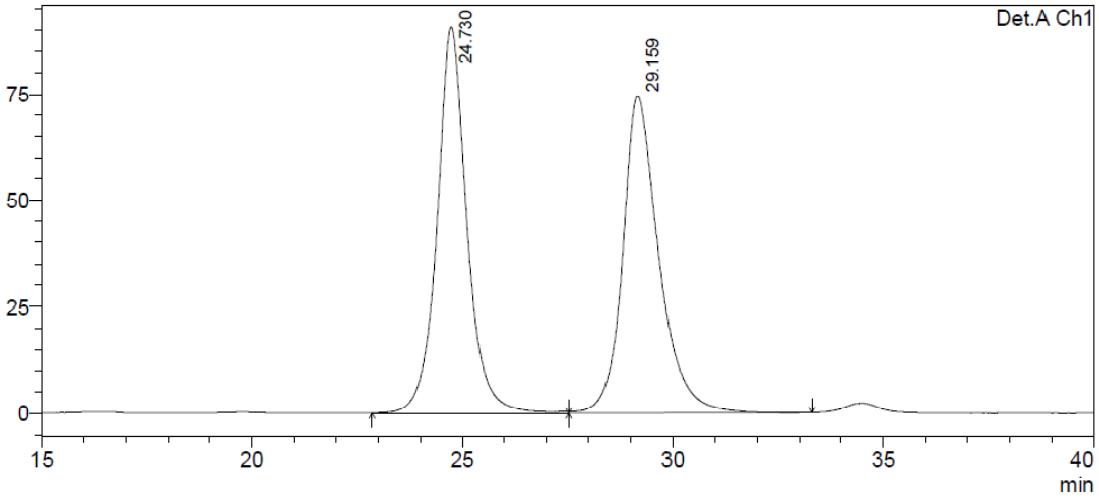


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.295	5833308	178159	50.013	56.327
2	16.361	5830246	138136	49.987	43.673
Total		11663554	316295	100.000	100.000

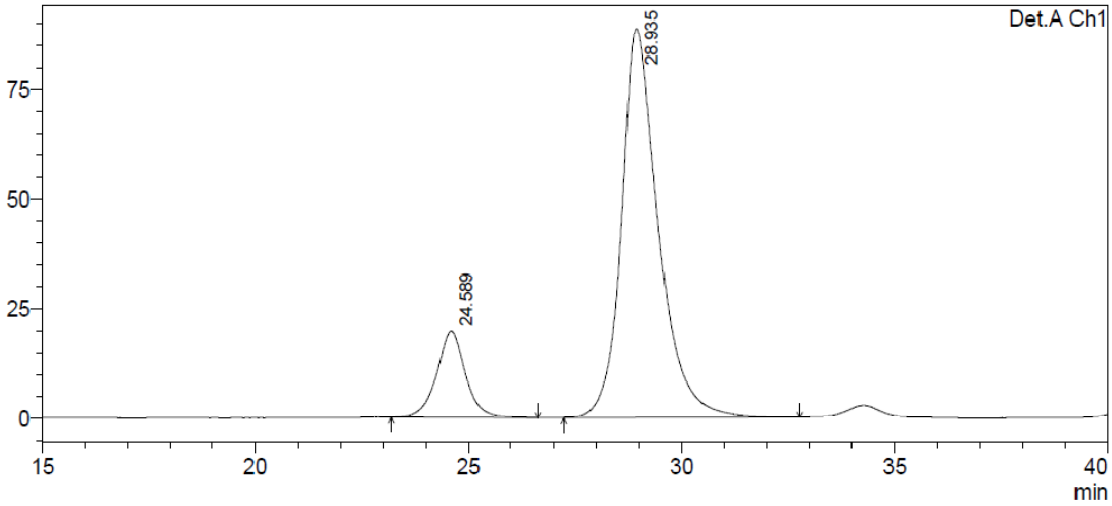


Peak#	Ret. Time	Area	Height	Area %	Height %
1	12.366	1011367	37821	6.352	9.461
2	14.859	14910607	361927	93.648	90.539
Total		15921974	399748	100.000	100.000

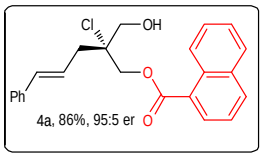




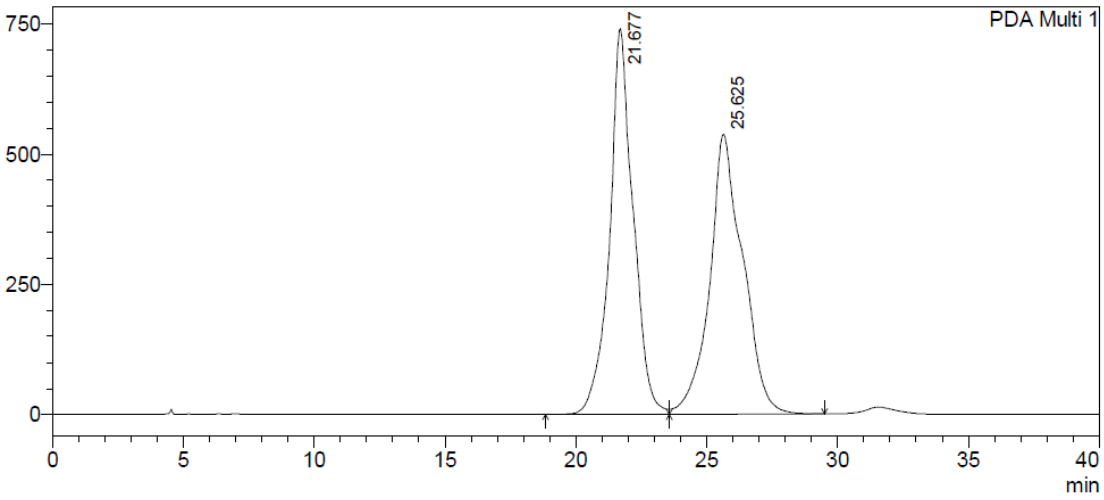
Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.730	4485804	90592	50.132	54.885
2	29.159	4462148	74466	49.868	45.115
Total		8947952	165058	100.000	100.000



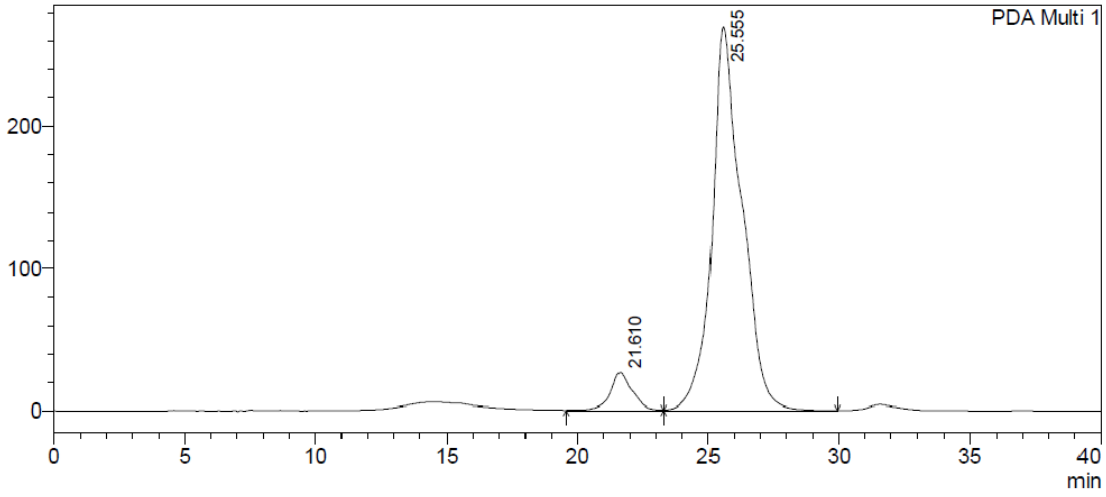
Peak#	Ret. Time	Area	Height	Area %	Height %
1	24.589	931865	19725	14.836	18.199
2	28.935	5349184	88662	85.164	81.801
Total		6281049	108387	100.000	100.000



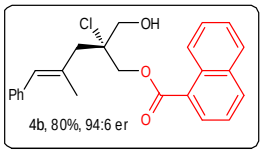
4a, 86%, 95:5 er

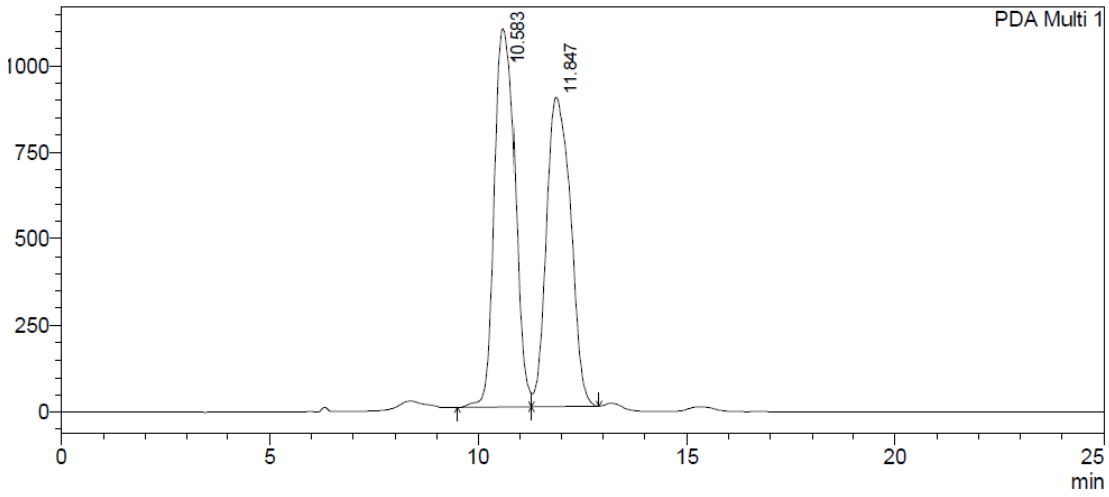


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.677	46469444	740442	49.390	57.932
2	25.625	47617304	537689	50.610	42.068
Total		94086748	1278131	100.000	100.000

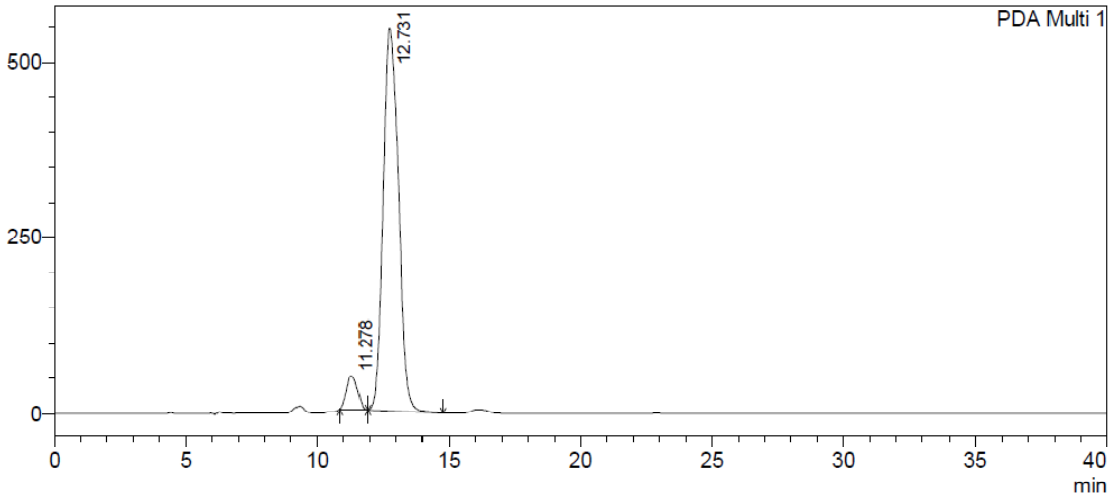


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.610	1136152	24356	5.023	8.279
2	25.555	21482018	269847	94.977	91.721
Total		22618171	294204	100.000	100.000

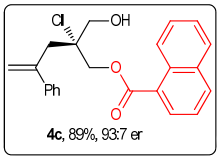


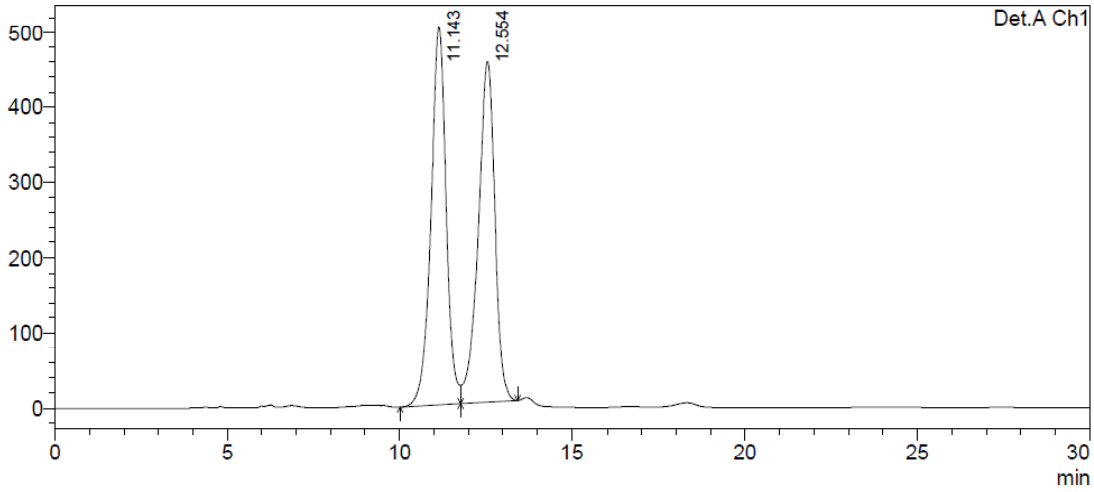


Peak#	Ret. Time	Area	Height	Area %	Height %
1	10.583	37153493	1094179	50.519	55.075
2	11.847	36389383	892514	49.481	44.925
Total		73542876	1986692	100.000	100.000

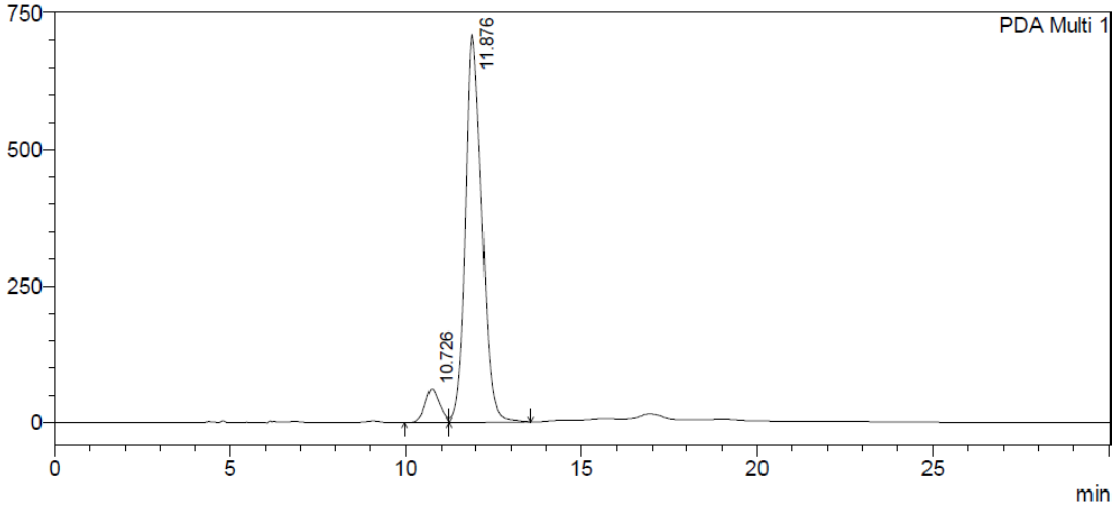


Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.278	1428360	48149	5.989	8.129
2	12.731	22420193	544193	94.011	91.871
Total		23848553	592342	100.000	100.000

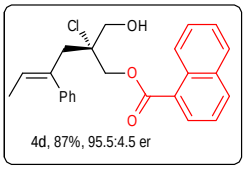


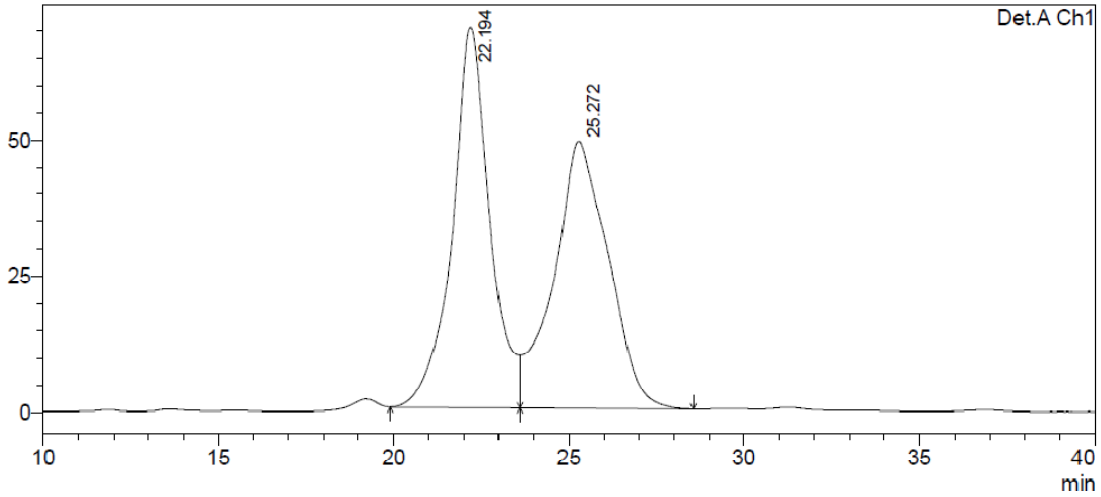


Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.143	15429194	502977	50.295	52.659
2	12.554	15248437	452185	49.705	47.341
Total		30677630	955162	100.000	100.000

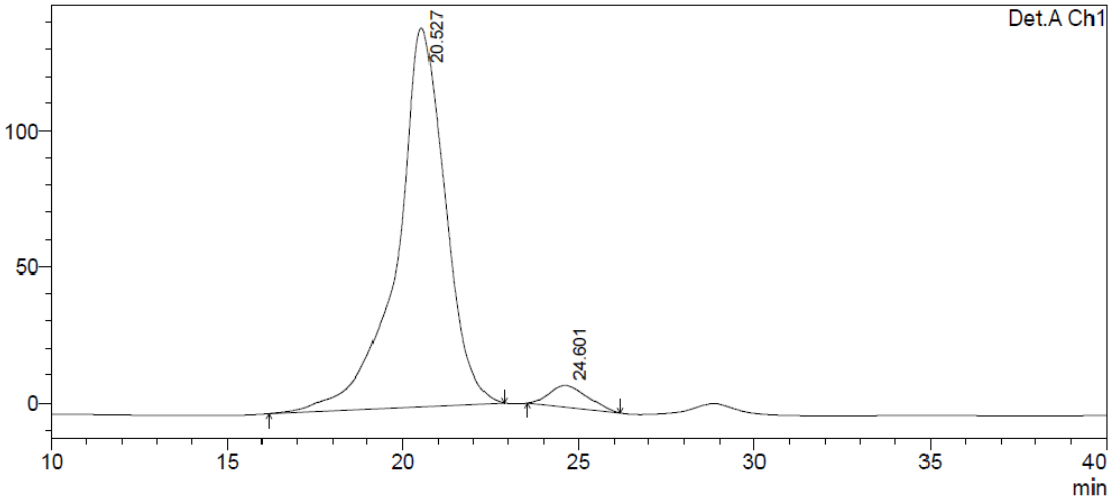


Peak#	Ret. Time	Area	Height	Area %	Height %
1	10.726	1804844	62831	7.219	8.132
2	11.876	23195869	709811	92.781	91.868
Total		25000713	772642	100.000	100.000

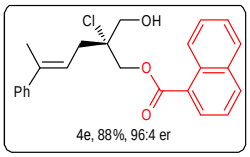


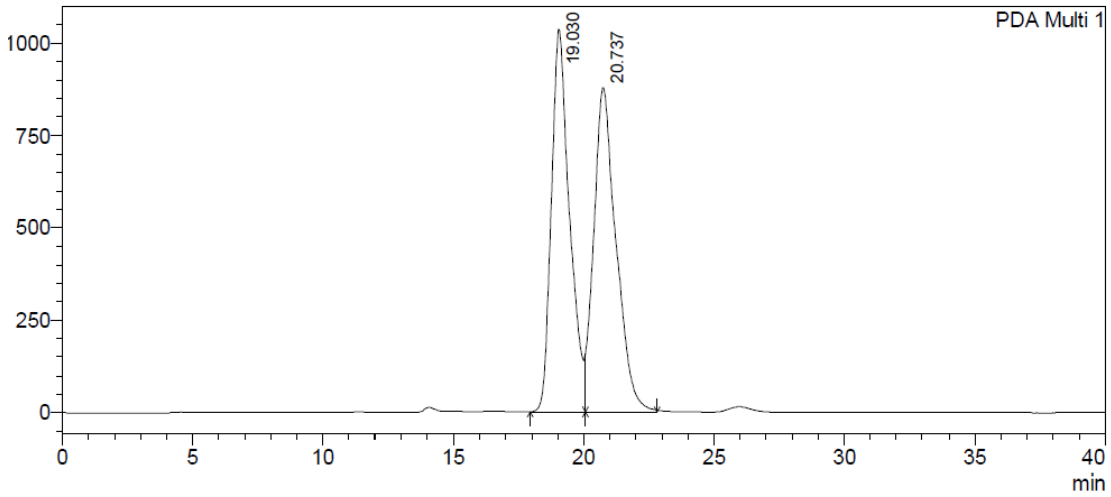


Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.194	5229238	69942	49.591	58.759
2	25.272	5315485	49090	50.409	41.241
Total		10544724	119031	100.000	100.000

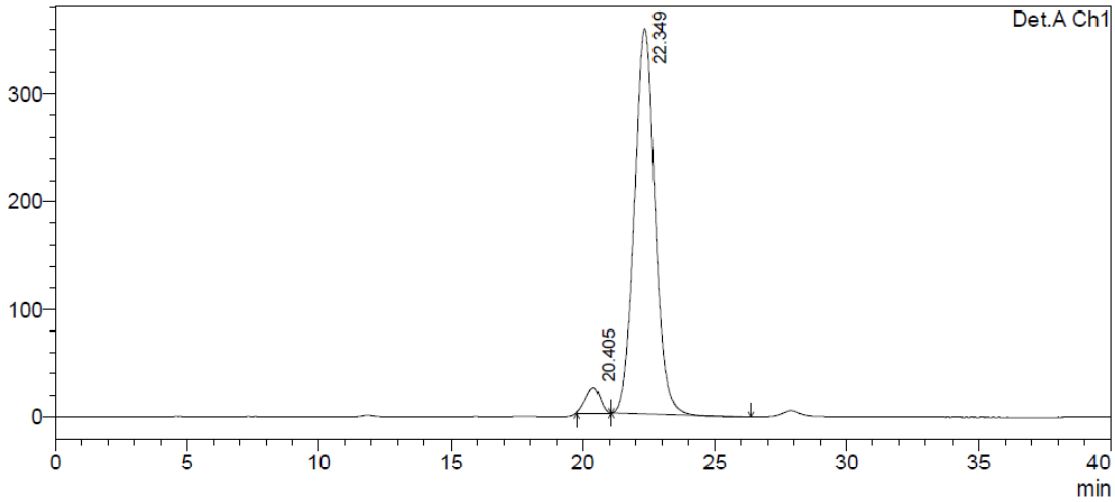


Peak#	Ret. Time	Area	Height	Area %	Height %
1	20.527	13190383	139147	95.527	94.496
2	24.601	617617	8105	4.473	5.504
Total		13807999	147252	100.000	100.000

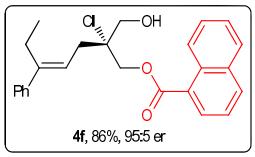


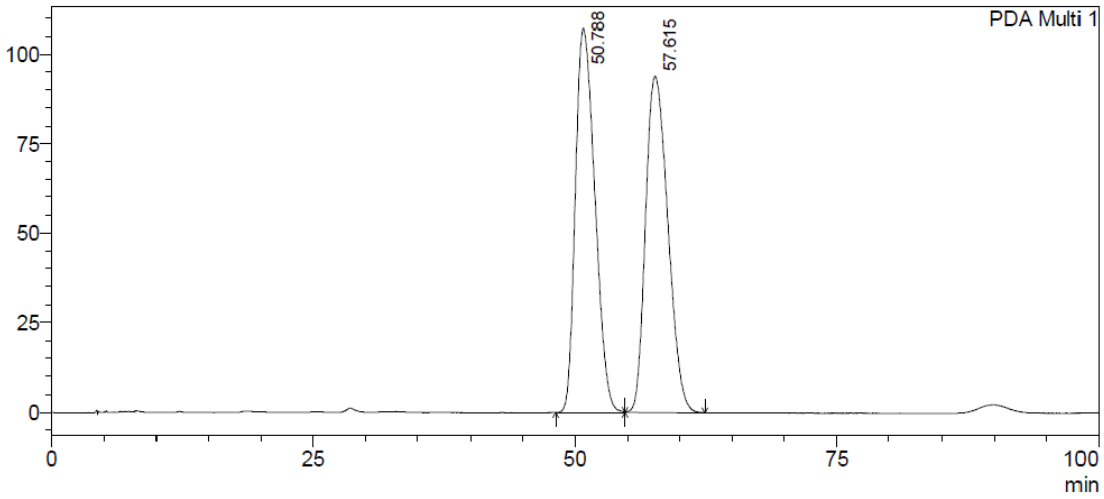


Peak#	Ret. Time	Area	Height	Area %	Height %
1	19.030	51005927	1036004	49.356	54.165
2	20.737	52336100	876684	50.644	45.835
Total		103342026	1912688	100.000	100.000

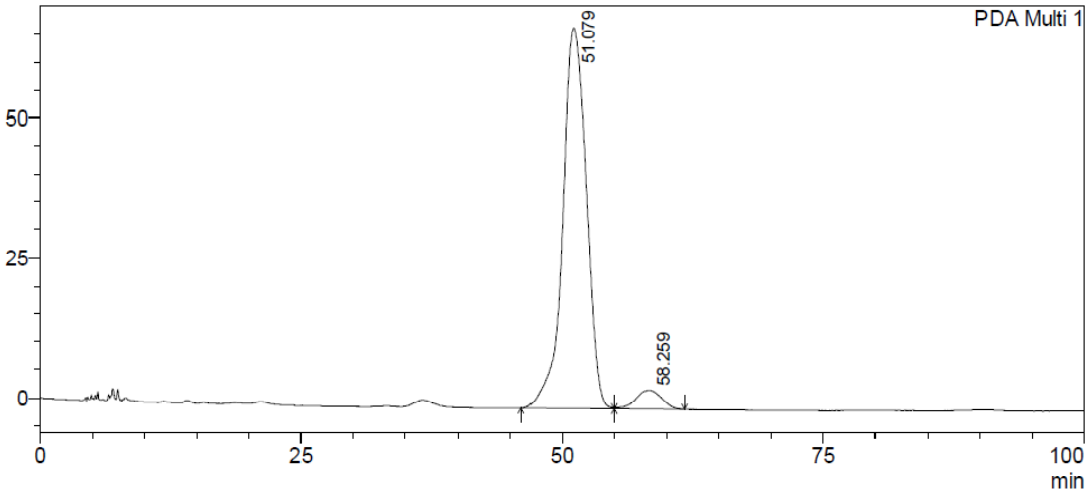


Peak#	Ret. Time	Area	Height	Area %	Height %
1	20.405	824007	22730	4.092	5.974
2	22.349	19311532	357760	95.908	94.026
Total		20135540	380491	100.000	100.000

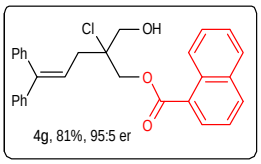


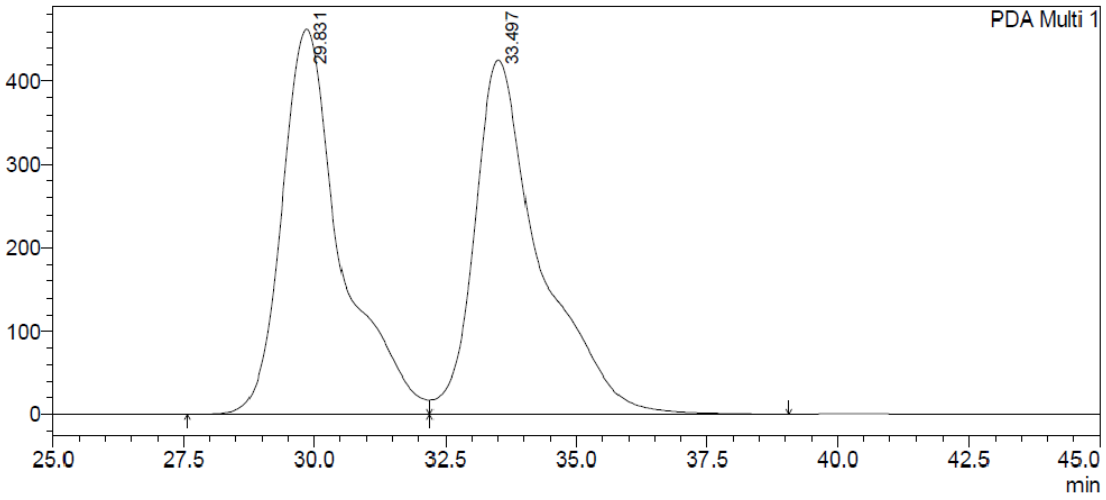


Peak#	Ret. Time	Area	Height	Area %	Height %
1	50.788	14094560	107187	49.920	53.285
2	57.615	14139945	93970	50.080	46.715
Total		28234505	201157	100.000	100.000

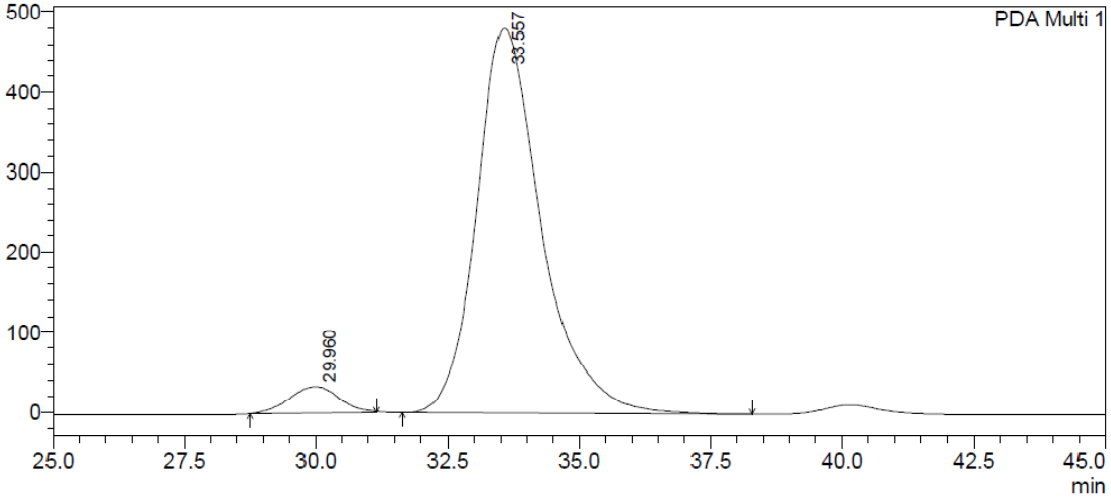


Peak#	Ret. Time	Area	Height	Area %	Height %
1	51.079	10824658	68106	94.976	95.260
2	58.259	572656	3389	5.024	4.740
Total		11397315	71495	100.000	100.000

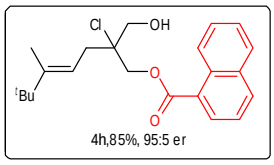


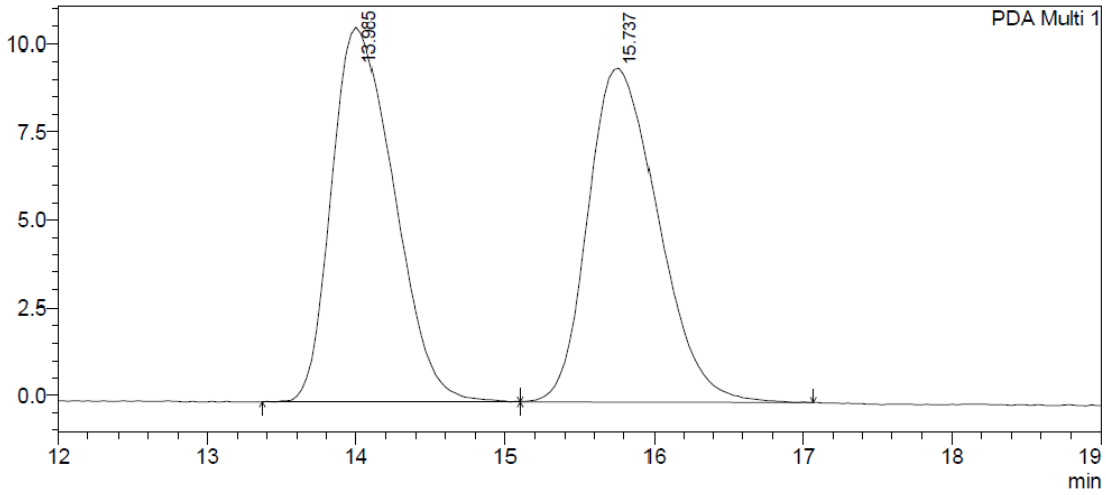


Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.831	36679315	462748	49.644	52.116
2	33.497	37204828	425171	50.356	47.884
Total		73884142	887920	100.000	100.000

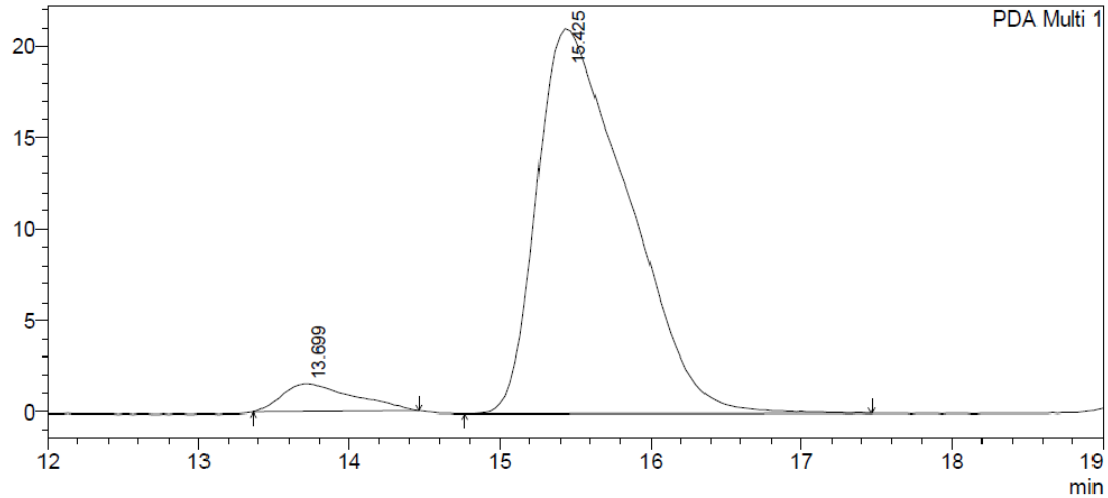


Peak#	Ret. Time	Area	Height	Area %	Height %
1	29.960	2193194	32997	5.047	6.429
2	33.557	41264452	480238	94.953	93.571
Total		43457646	513235	100.000	100.000

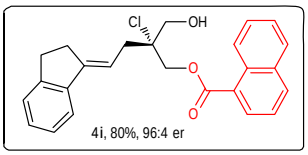


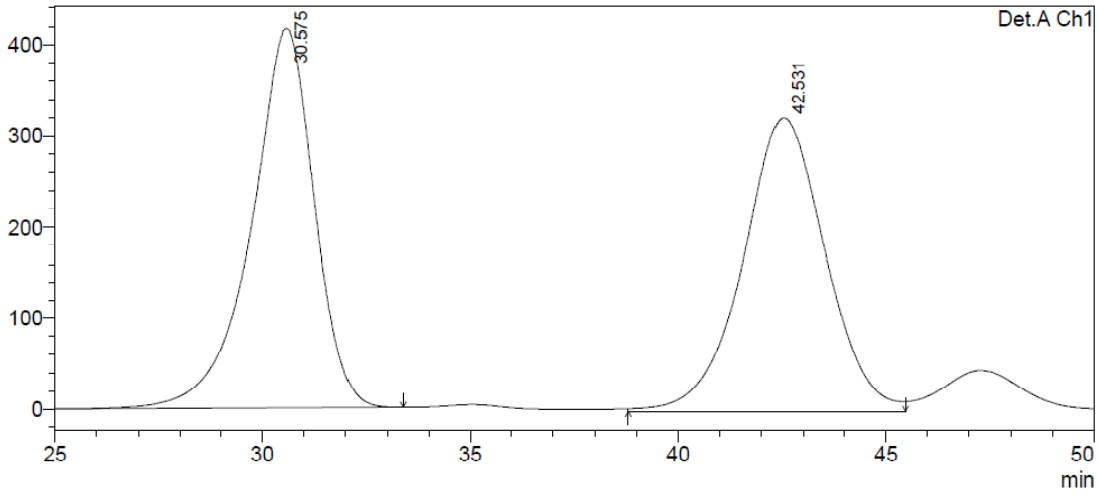


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.985	309490	10646	49.781	52.793
2	15.737	312217	9520	50.219	47.207
Total		621707	20166	100.000	100.000

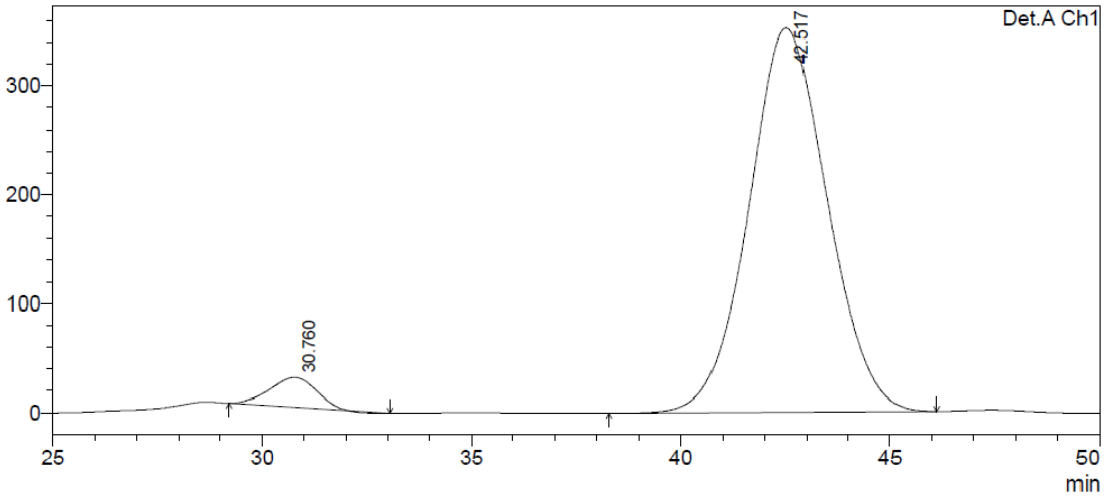


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.699	50300	1528	5.387	6.770
2	15.425	883467	21041	94.613	93.230
Total		933767	22569	100.000	100.000

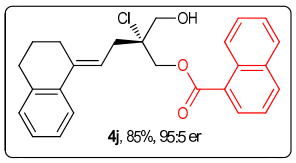


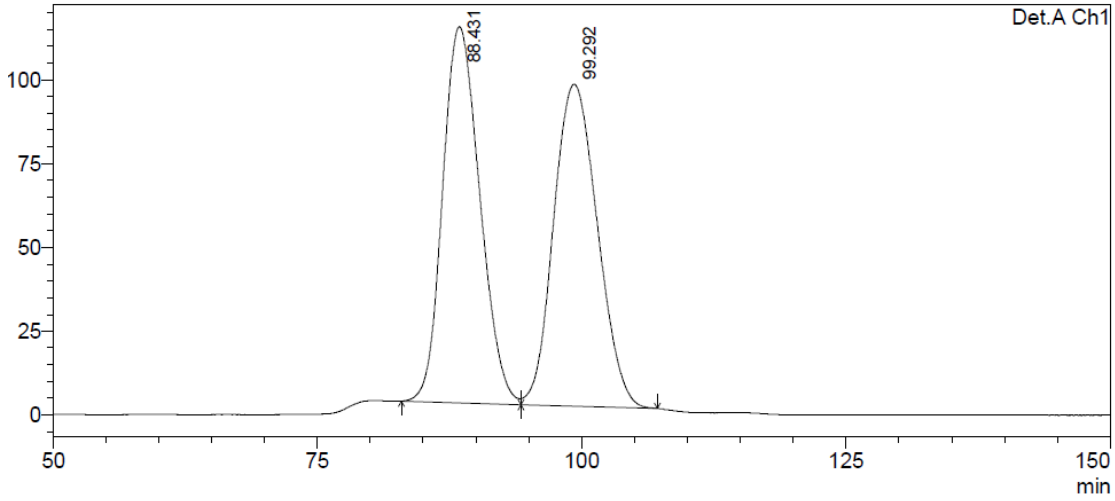


Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.575	43910557	416268	49.971	56.451
2	42.531	43961837	321129	50.029	43.549
Total		87872394	737396	100.000	100.000

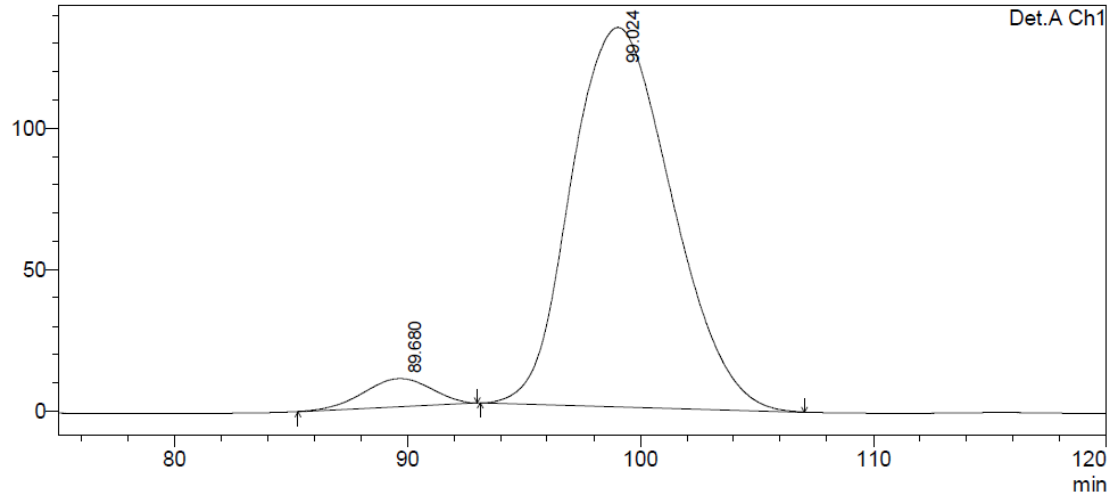


Peak#	Ret. Time	Area	Height	Area %	Height %
1	30.760	2108846	27294	4.381	7.181
2	42.517	46029017	352792	95.619	92.819
Total		48137863	380086	100.000	100.000

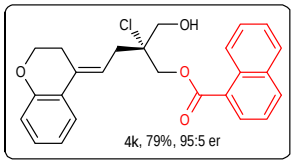


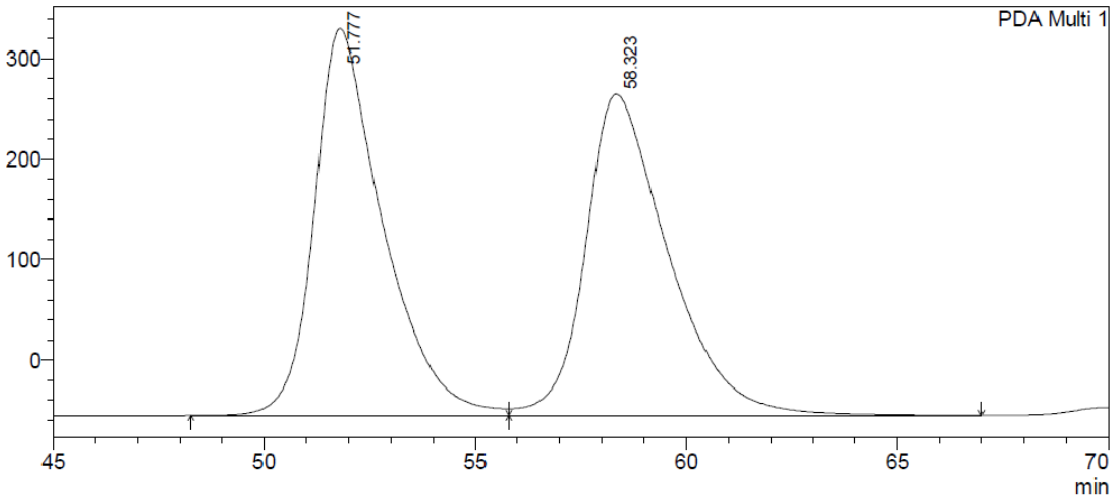


Peak#	Ret. Time	Area	Height	Area %	Height %
1	88.431	27520201	112194	49.837	53.885
2	99.292	27699933	96015	50.163	46.115
Total		55220134	208209	100.000	100.000

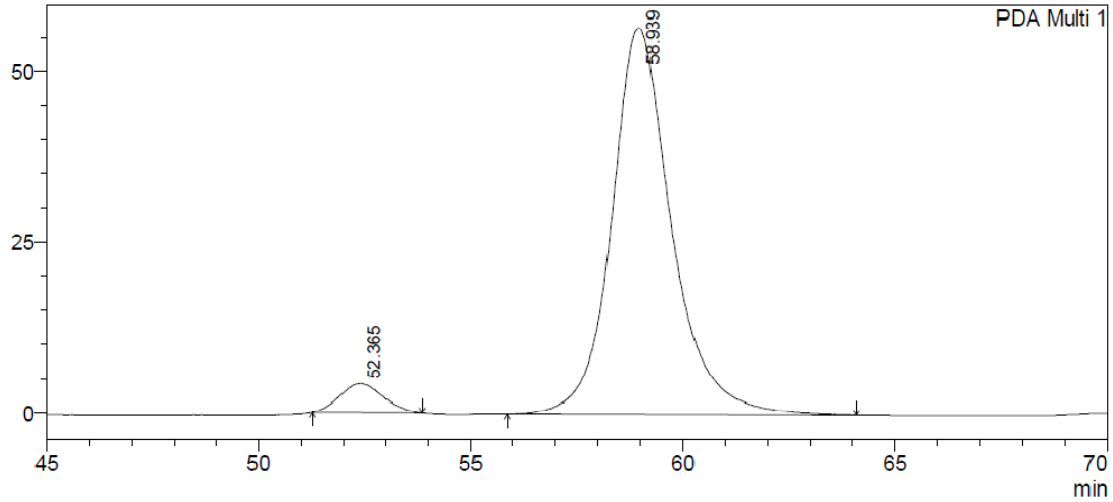


Peak#	Ret. Time	Area	Height	Area %	Height %
1	89.680	2021946	9981	4.776	6.920
2	99.024	40314831	134254	95.224	93.080
Total		42336777	144235	100.000	100.000

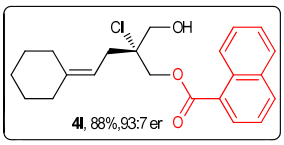


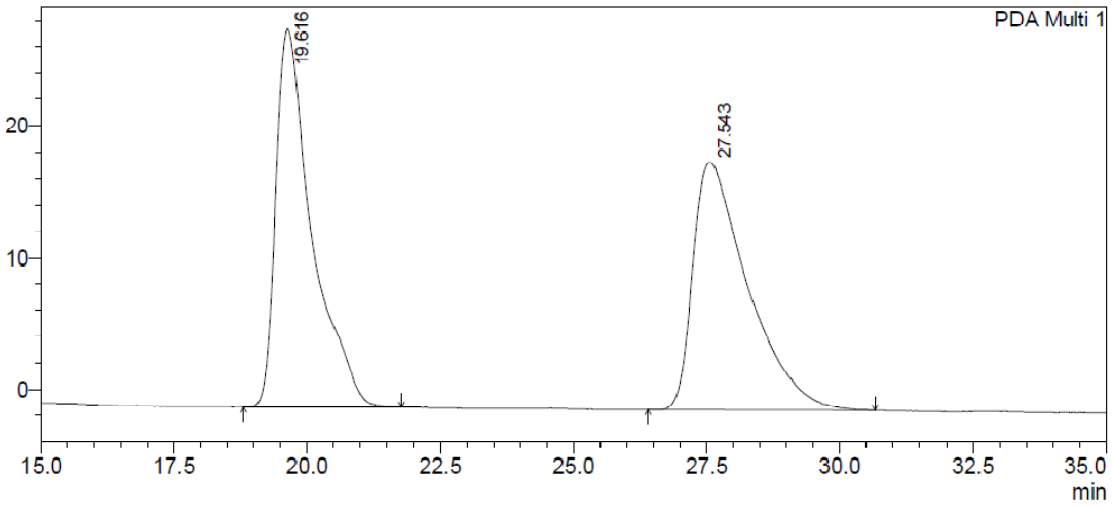


Peak#	Ret. Time	Area	Height	Area %	Height %
1	51.777	43618144	384981	50.010	54.656
2	58.323	43601567	319388	49.990	45.344
Total		87219711	704370	100.000	100.000

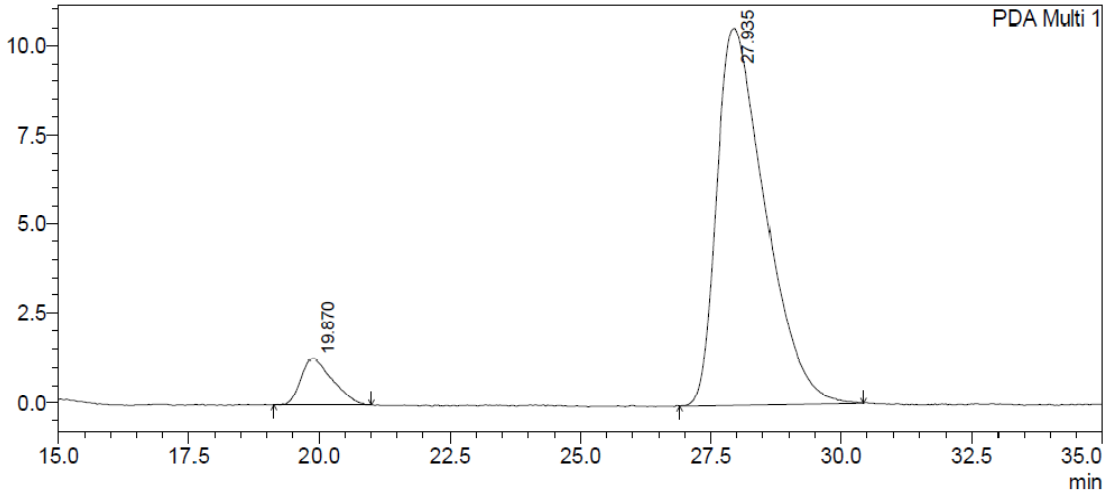


Peak#	Ret. Time	Area	Height	Area %	Height %
1	52.365	292837	4129	5.004	6.799
2	58.939	5559354	56595	94.996	93.201
Total		5852191	60724	100.000	100.000

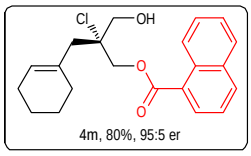


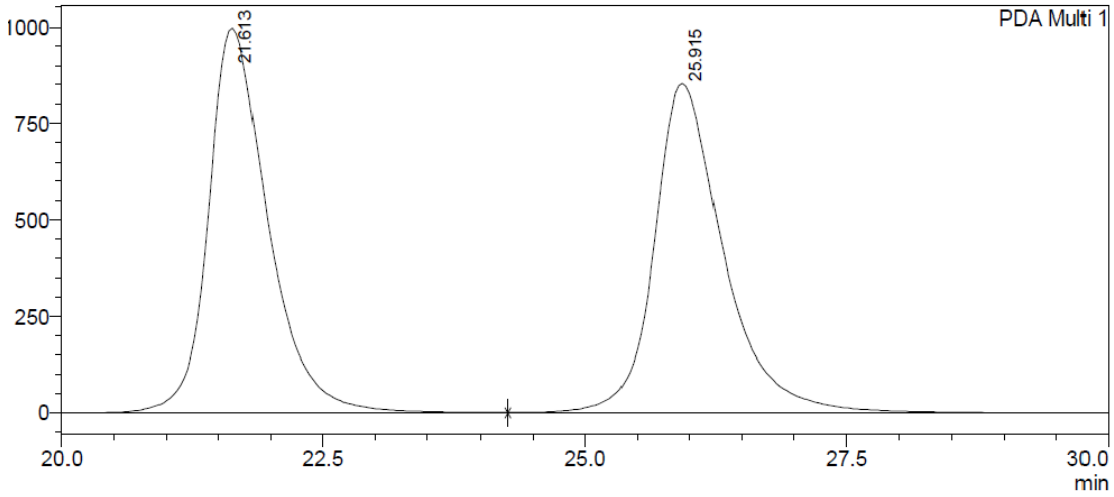


Peak#	Ret. Time	Area	Height	Area %	Height %
1	19.616	1346194	28636	50.019	60.342
2	27.543	1345194	18820	49.981	39.658
Total		2691388	47456	100.000	100.000

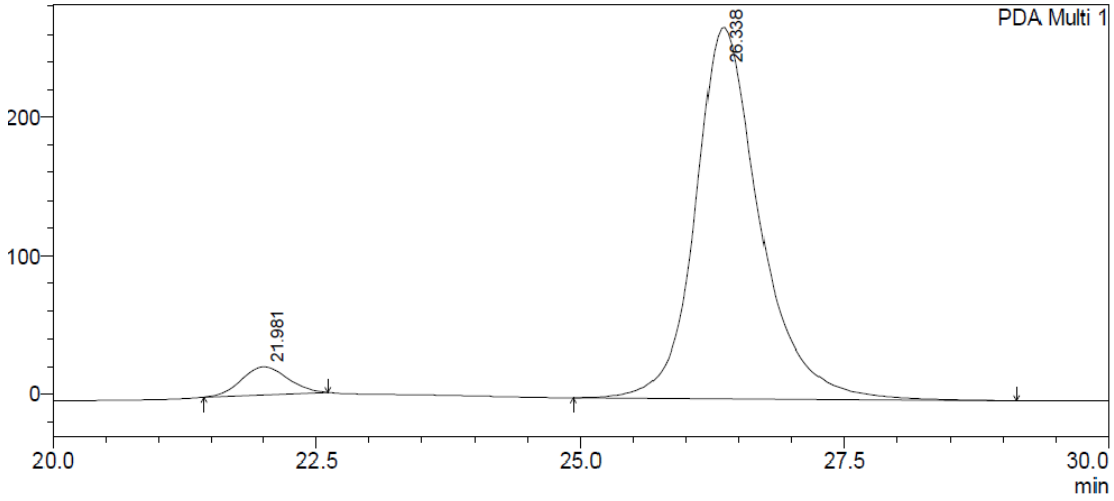


Peak#	Ret. Time	Area	Height	Area %	Height %
1	19.870	54906	1307	7.453	11.008
2	27.935	681806	10563	92.547	88.992
Total		736712	11869	100.000	100.000

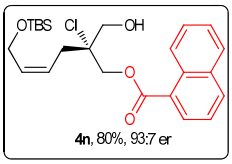




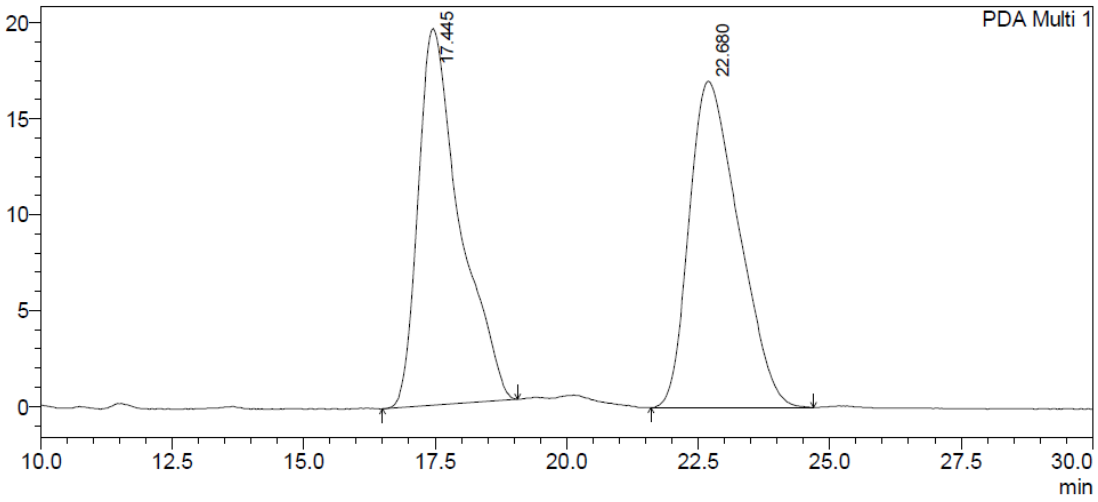
Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.613	39654722	998094	49.934	53.895
2	25.915	39759997	853842	50.066	46.105
Total		79414719	1851936	100.000	100.000



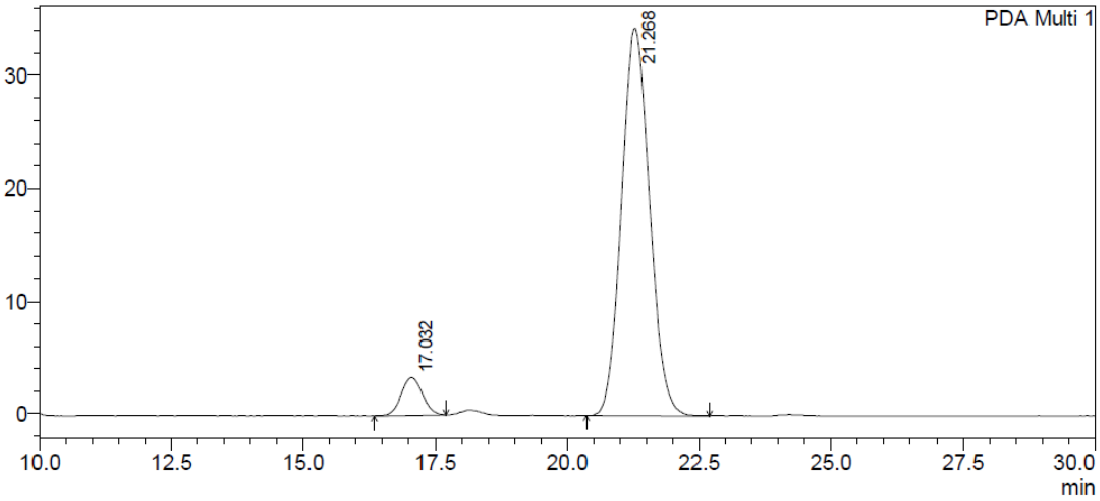
Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.981	630859	20697	5.222	7.151
2	26.338	11449229	268746	94.778	92.849
Total		12080088	289444	100.000	100.000



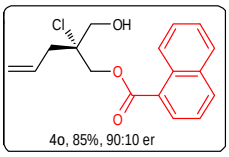
4n, 80%, 93:7 er

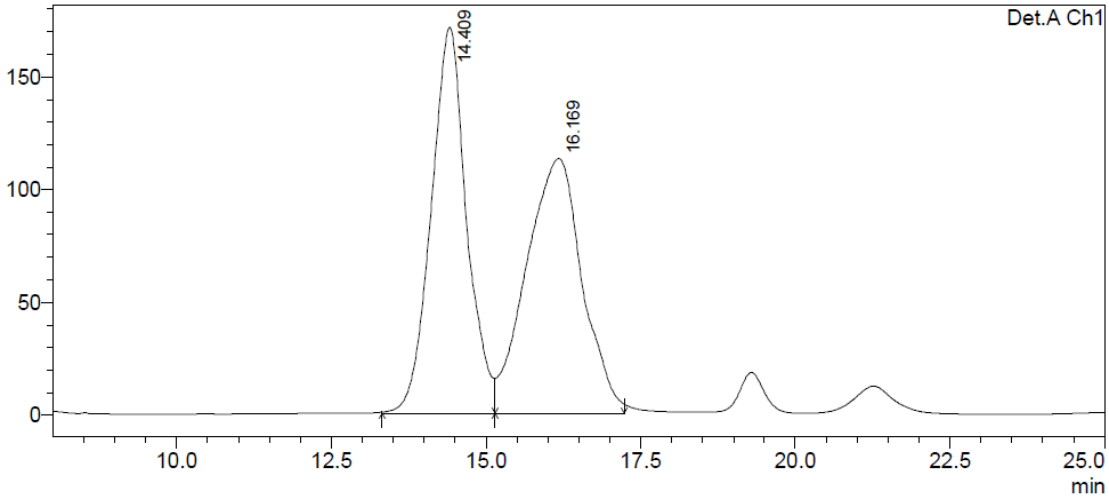


Peak#	Ret. Time	Area	Height	Area %	Height %
1	17.445	1083406	19625	49.303	53.565
2	22.680	1114038	17013	50.697	46.435
Total		2197443	36638	100.000	100.000

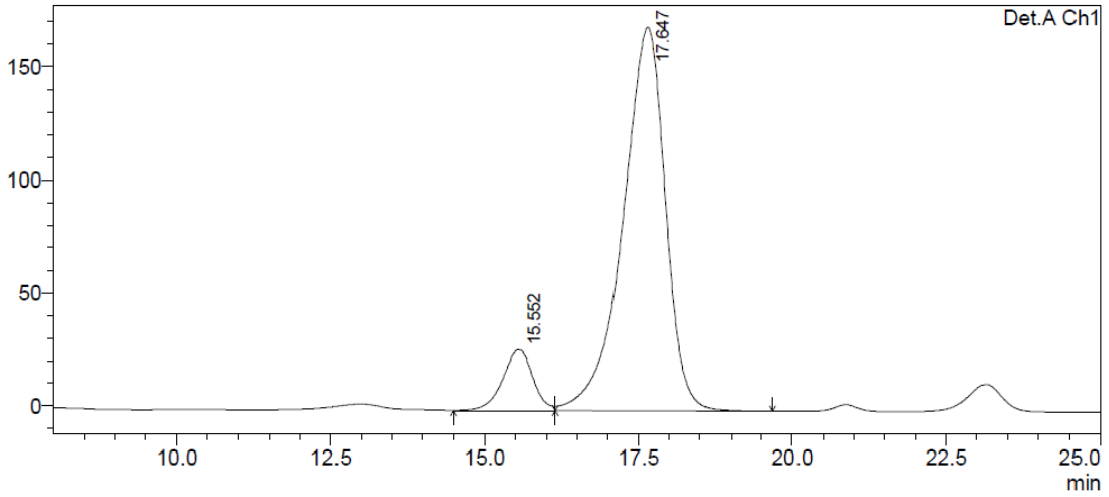


Peak#	Ret. Time	Area	Height	Area %	Height %
1	17.032	94346	3354	6.896	8.893
2	21.268	1273783	34359	93.104	91.107
Total		1368129	37713	100.000	100.000

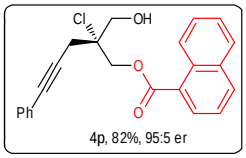




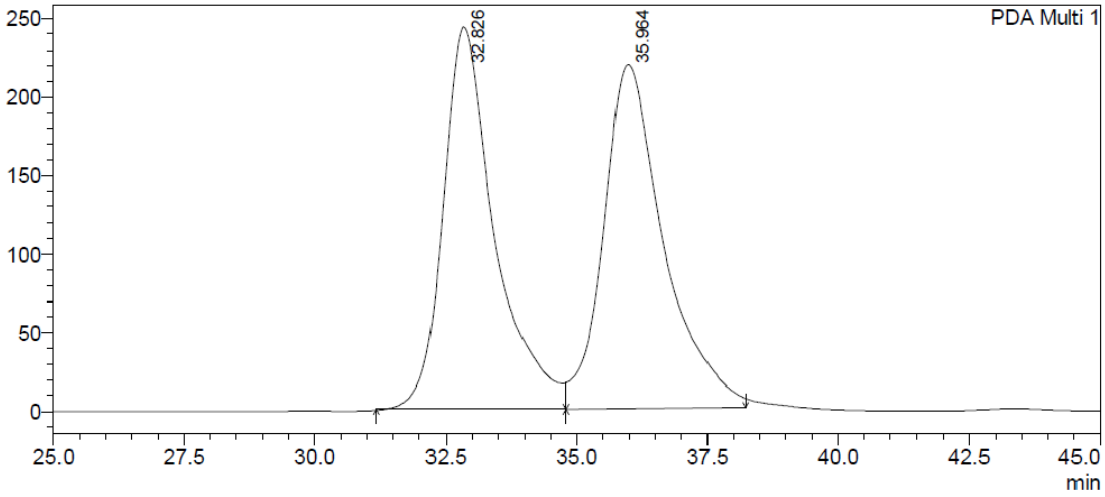
Peak#	Ret. Time	Area	Height	Area %	Height %
1	14.409	6815592	171008	49.104	60.243
2	16.169	7064303	112857	50.896	39.757
Total		13879895	283865	100.000	100.000



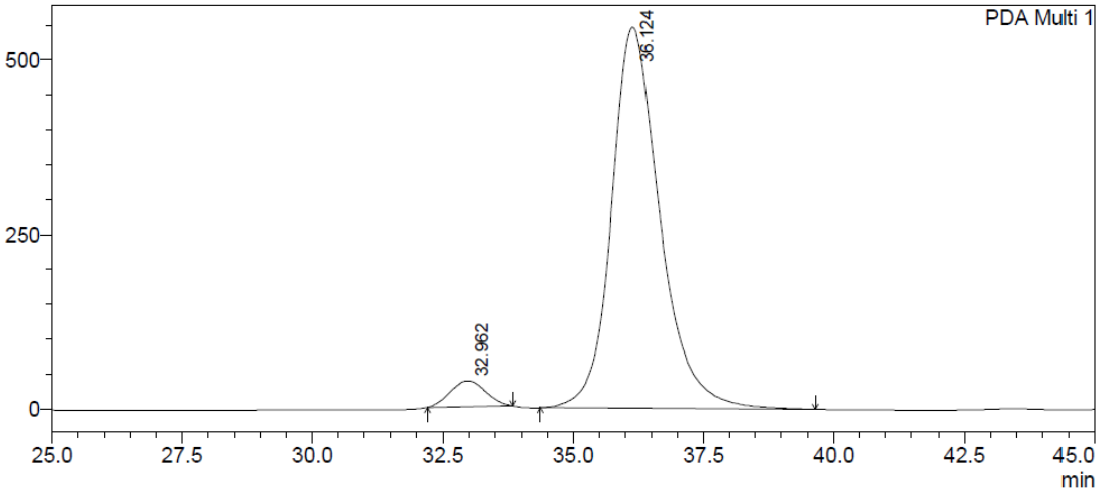
Peak#	Ret. Time	Area	Height	Area %	Height %
1	15.552	898657	26967	9.892	13.712
2	17.647	8186349	169706	90.108	86.288
Total		9085006	196673	100.000	100.000



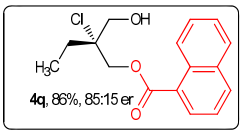
4p, 82%, 95:5 er

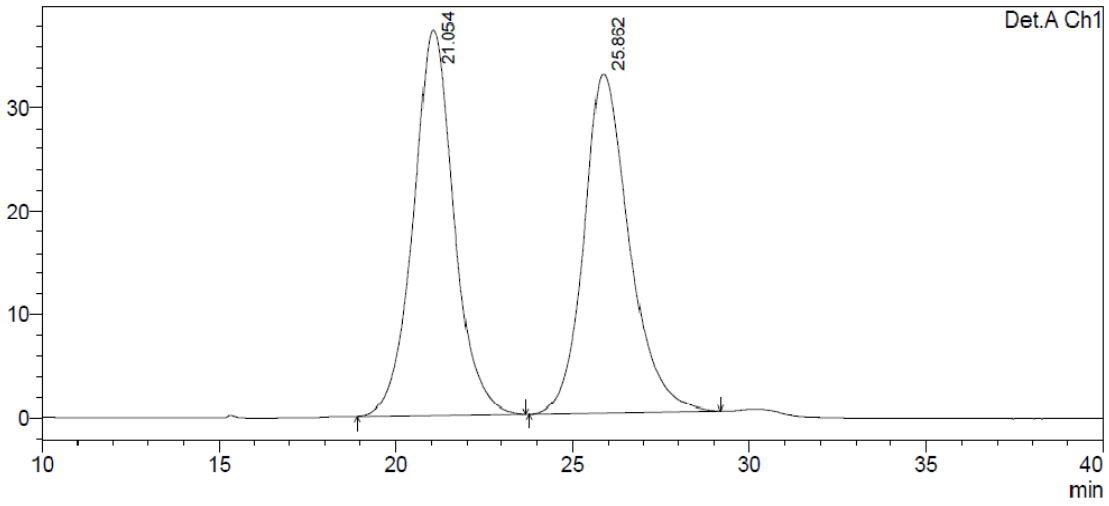


Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.826	16732084	243108	48.999	52.614
2	35.964	17415625	218947	51.001	47.386
Total		34147708	462055	100.000	100.000

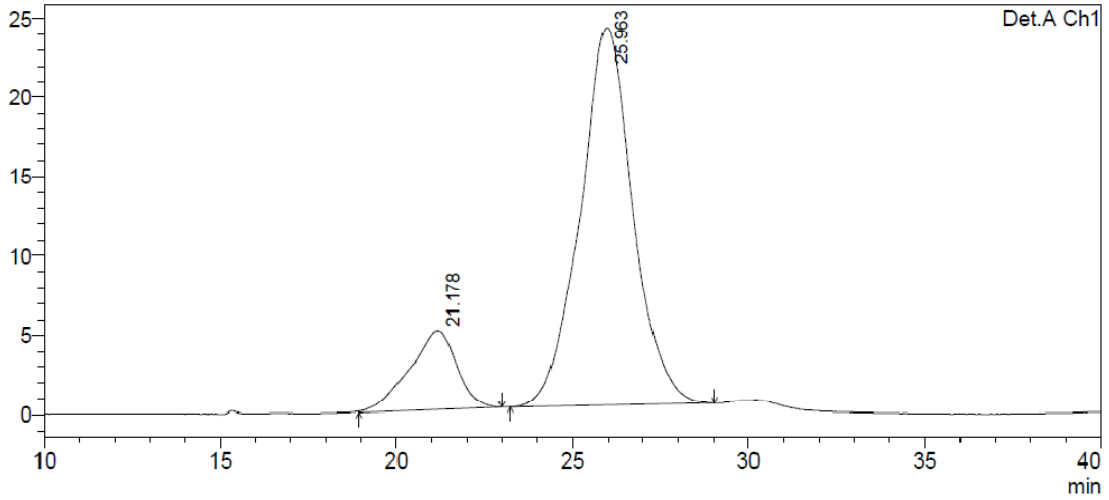


Peak#	Ret. Time	Area	Height	Area %	Height %
1	32.962	1775422	37359	4.796	6.404
2	36.124	35240848	546006	95.204	93.596
Total		37016270	583365	100.000	100.000

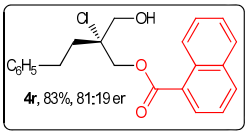


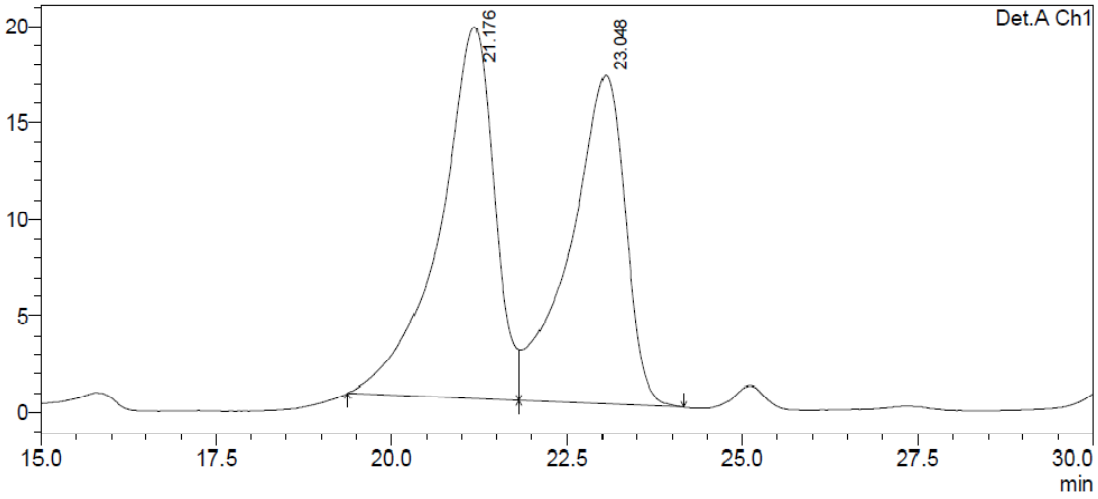


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.054	2985560	37407	50.453	53.321
2	25.862	2931908	32748	49.547	46.679
Total		5917468	70155	100.000	100.000

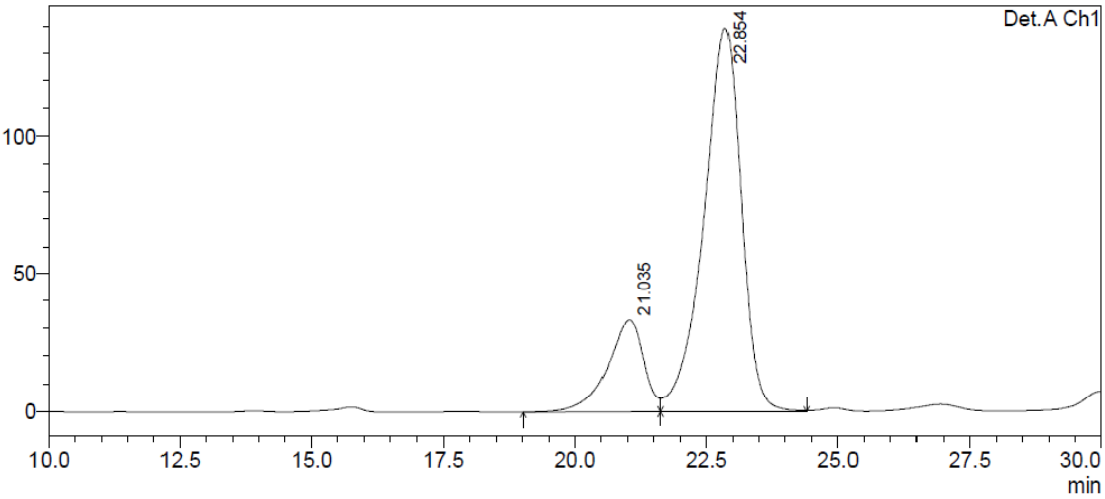


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.178	463976	4935	15.789	17.163
2	25.963	2474705	23817	84.211	82.837
Total		2938681	28752	100.000	100.000

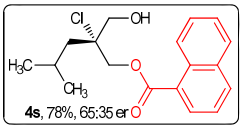


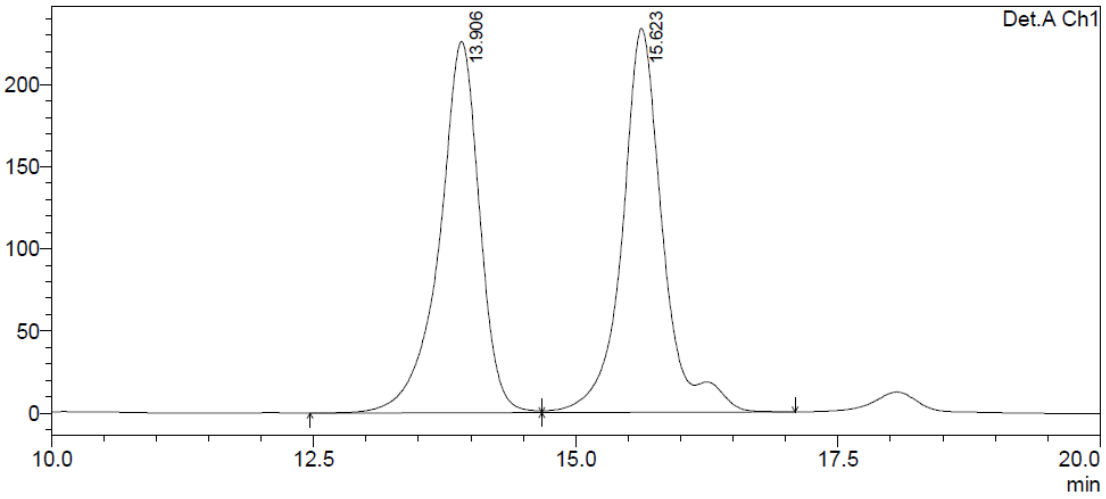


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.176	1034539	19235	52.761	53.108
2	23.048	926280	16983	47.239	46.892
Total		1960819	36218	100.000	100.000

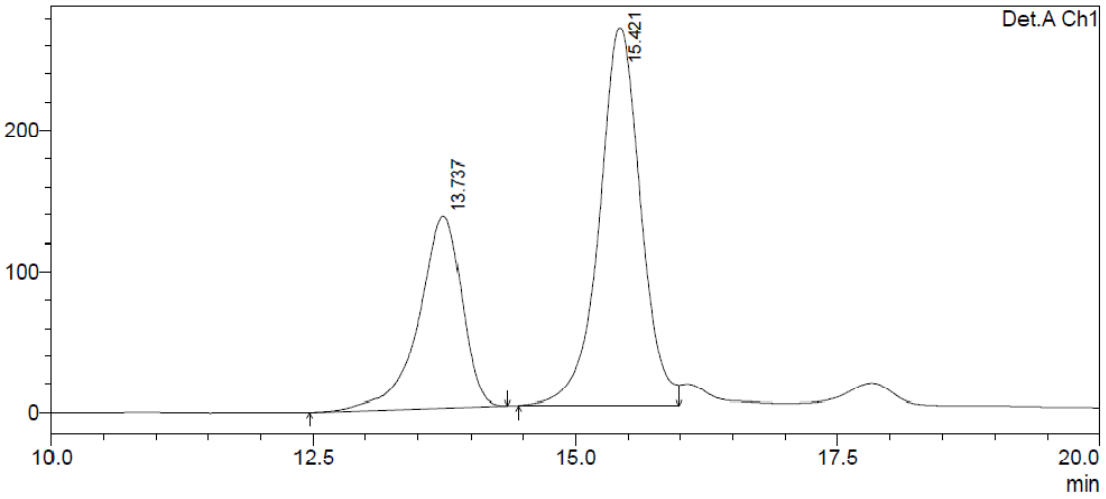


Peak#	Ret. Time	Area	Height	Area %	Height %
1	21.035	1628659	33572	19.142	19.411
2	22.854	6879444	139382	80.858	80.589
Total		8508103	172953	100.000	100.000

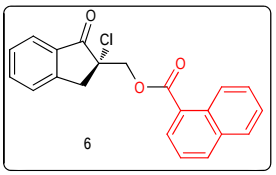


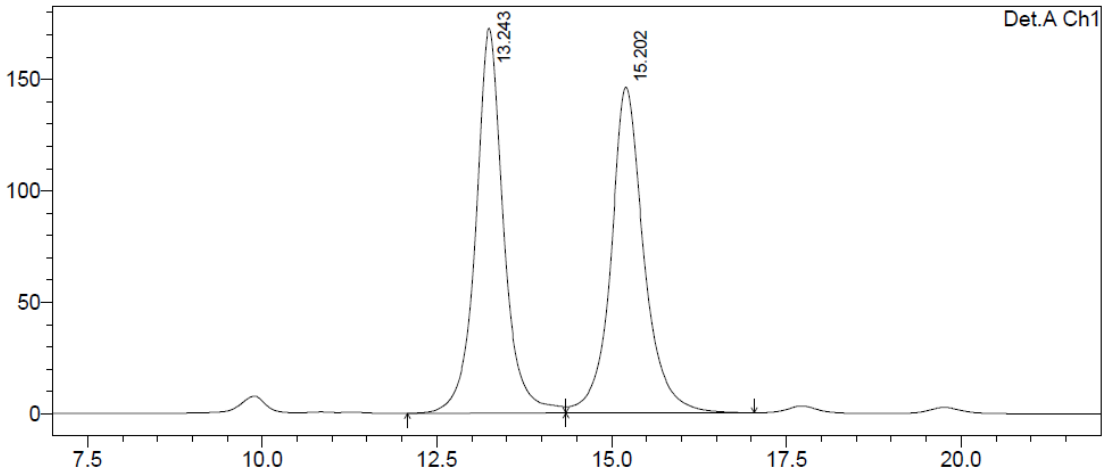


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.906	6059630	226287	49.230	49.176
2	15.623	6249251	233867	50.770	50.824
Total		12308882	460154	100.000	100.000

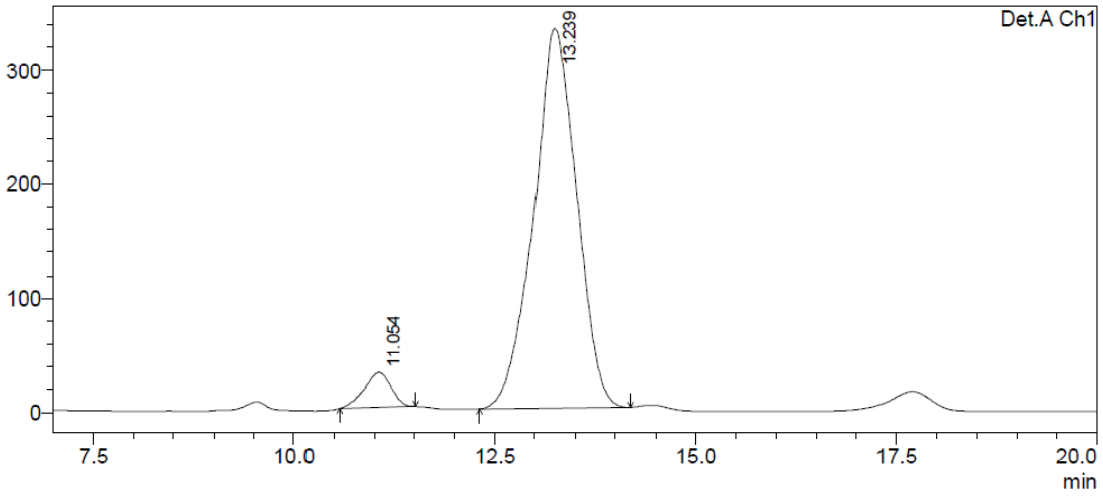


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.737	3909018	135853	34.717	33.596
2	15.421	7350544	268525	65.283	66.404
Total		11259562	404378	100.000	100.000

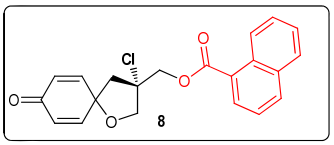


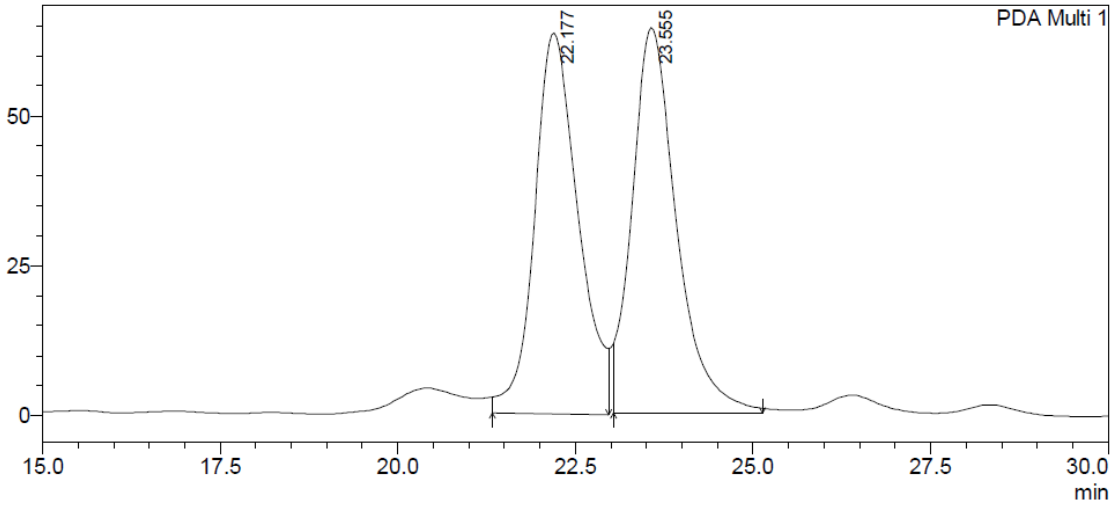


Peak#	Ret. Time	Area	Height	Area %	Height %
1	13.243	4819732	172834	50.018	54.157
2	15.202	4816297	146303	49.982	45.843
Total		9636029	319138	100.000	100.000

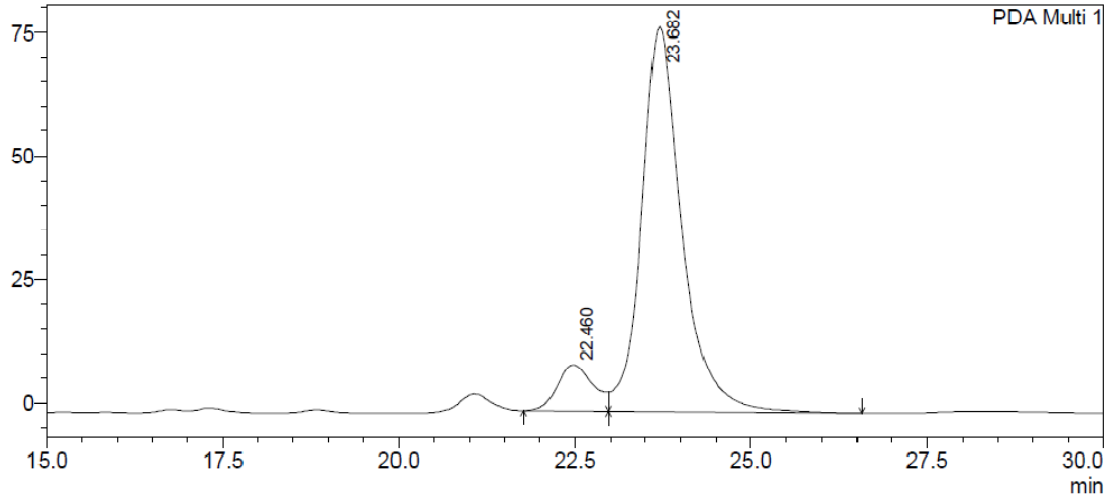


Peak#	Ret. Time	Area	Height	Area %	Height %
1	11.054	720628	30655	5.505	8.434
2	13.239	12370017	332829	94.495	91.566
Total		13090645	363483	100.000	100.000





Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.177	2719334	63570	49.355	49.737
2	23.555	2790460	64244	50.645	50.263
Total		5509794	127814	100.000	100.000



Peak#	Ret. Time	Area	Height	Area %	Height %
1	22.460	334812	9360	9.760	10.729
2	23.682	3095746	77880	90.240	89.271
Total		3430559	87240	100.000	100.000