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Atom- and Pot-Economical Consecutive Multi-Step Reaction Approach to Polycyclic Aromatic Hydrocarbons (PAHs)

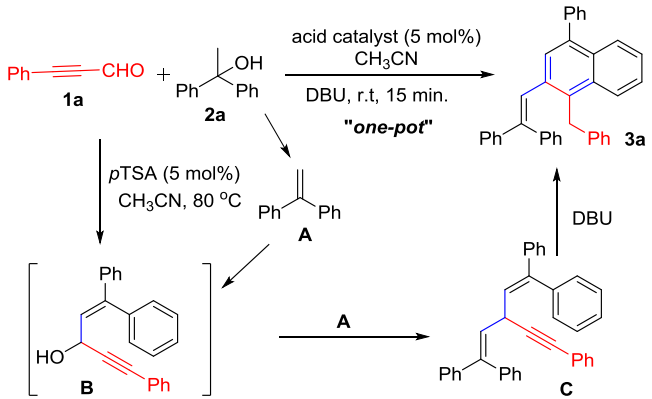
Chada Raji Reddy,* Uredi Dilipkumar and Ravula Shravya
Division of Natural Products Chemistry, CSIR-Indian Institute of Chemical Technology, Hyderabad-500607
E-mail: rajireddy@iict.res.in

Table of Contents

General Experimental:

All reactions were carried out under inert atmosphere with oven-dried glassware. Reagents and solvents were used without further purification, unless otherwise stated. All reactions were magnetically stirred and monitored by thin-layer chromatography carried out on silica plates using UV-light and anisaldehyde for visualization. Column chromatography was performed on silica gel (60–120 and 100-200 mesh) using hexanes and ethyl acetate as eluent. Evaporation of solvents was conducted under reduced pressure at temperatures less than 45 °C. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ solvent on a 300 MHz, 500 MHz and 400 MHz NMR spectrometer. Chemical shifts δ and coupling constants J are given in ppm (parts per million) and Hz (hertz) respectively. Chemical shifts are reported relative to residual solvent as an internal standard for ^{1}H and ^{13}C ($CDCl_3$: δ 7.26 ppm for ^{1}H and 77.0 ppm for ^{13}C). Mass spectra were obtained on Finnigan MAT1020B, micro mass VG 70–70H or LC/MSD trap SL spectrometer operating at 70 eV using direct inlet system.

Table S1: Optimization of reaction conditions[a]



Entry	Dehydration / Addition-Substitution (catalyst-5 mol%, temp, time)	Cycloisomerization (base, temp., time)	Product	Yield (%)[b]
1[c]	$Cu(OTf)_2$, rt, 24 h	----	**C**	19
2	$Cu(OTf)_2$, rt, 24 h	----	**C**	35
3	$BF_3.Et_2O$, rt, 24 h	-----	**C**	27
4	*p*TSA, rt, 24 h	-----	**C**	57
5	*p*TSA, 80 °C, 2 h	-----	**C**	94
6	$Cu(OTf)_2$, 80 °C, 3.5 h	----	**C**	83
7	$ZnCl_2$, 80 °C, 24 h	----	**C**	10
8	$FeCl_3$, 80 °C, 24 h	----	**C**	59
9[d]	-	DBU, rt, 15 min	**3a**	92
10	$Cu(OTf)_2$, 80 °C, 3.5 h	DBU, rt, 15 min	**3a**	72
11	***p*TSA, 80 °C, 2 h**	**DBU, rt, 15 min**	**3a**	**87**

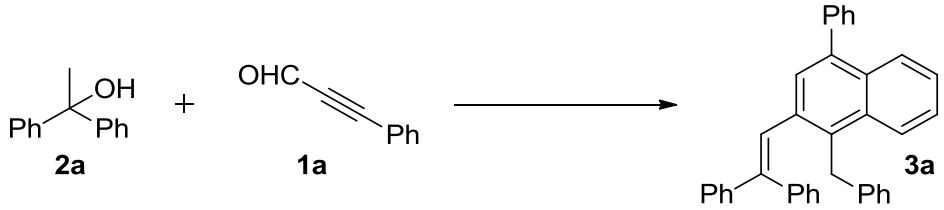
[a]Propargylic aldehyde (1 equiv.) and 1,1-diarylethanol (2 equiv.) in CH_3CN
[b]Isolated yields; [c]One equivalent of **2a** was used; [d]Conversion of **C** to **3a**

The reaction of propargylic aldehyde **1a** and 1,1-diphenylethanol (**2a**) in the presence of various acid catalysts to find the optimal catalyst for the formation of ene-yne through dehydration (to give **A**) followed by nucleophilic addition (to give **B**). Interestingly, it provided a di-alkenyl product **C** in 19% yield at room temperature in the presence of $Cu(OTf)_2$ (entry 1, Table 1). This suggests, the aldehyde underwent nucleophilic addition to **B** followed by immediate nucleophilic substitution with **A** in acidic reaction conditions to give **C**. Then, the reaction was carried out using 2 equivalents of **2a** at room temperature in the presence of different acid catalysts and observed that the reaction was not completed even after 24 h to give **C** (entries 2 to 4, Table 1). We found that when the reaction carried out at 80 °C in presence of *p*TSA in CH_3CN, product **C** could be produced in 94% isolated yield (entry 5, Table 1). Other acid catalysts, $Cu(OTf)_2$, $FeCl_3$ also showed similar effect in providing the product **C**, while $ZnCl_2$ was less effective (entries 6 to 8, Table 1). Based on earlier work on cycloisomerization reactions, the conversion of **C** to naphthalene was tested using DBU and found that the reaction proceeded smoothly to give vinylated naphthalene **3a** in 92% yield (entry 9, Table 1). Further, the reaction conditions were tested for all the four reactions uninterruptedly in one-pot (entries 10 and 11, Table 1). Gratifyingly, the successful formation of naphthalene **3a** was observed in 87% yield.

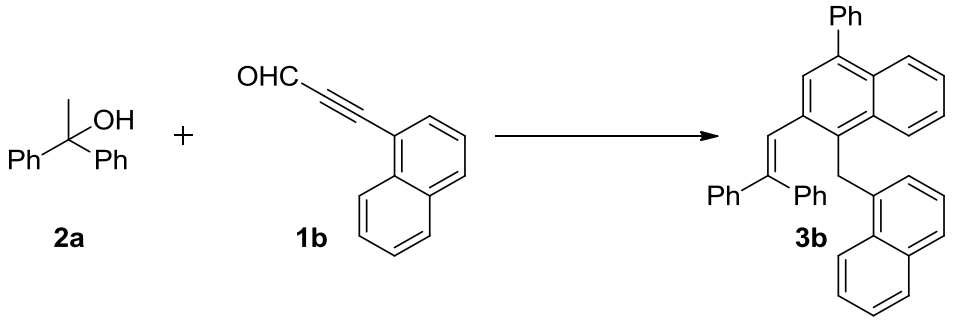
Acetylenic aldehydes (**1a, 1b, 1c, 1e, 1g, 1h),**[1a] **1d,**[1b] **(1f, 1i)**[1c] have been prepared using the literature procedure and the data compared.[1]

1,1-Diarylethan-1-ols (**2a, 2b, 2c, 2e, 2g),**[2a] **2d, 2f,**[2b] have been prepared using the spectral data compared.[2]

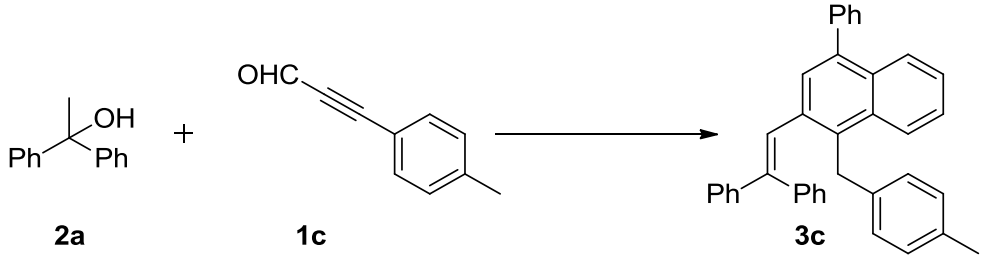
General procedure for the preparation of naphthalenes (3a-3i): To a stirred solution of propargylic aldehyde **1** (1.0 mmol) and 1,1-diphenyl etha-2-ol **2a** (2.0 mmol) in 5 mL of acetonitrile was added *p*TSA (5 mol%) at room temperature. The reaction mixture was stirred at 80 ^{o}C for 1.5-3 h and the reaction mixture was cooled to room temperature. To the reaction mixture DBU (1.0 mmol) was added and stirred for 10-30 min at room temperature. After completion of reaction (monitered by TLC), the mixture was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (EtOAc:hexanes) to afford the corrosponding 2-vinylated naphthalenes.



1-Benzyl-2-(2,2-diphenylvinyl)-4-phenylnaphthalene (3a): 127 mg, 87% yield, white solid; R_f = 0.4 (hexanes) mp 151-153 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.03 (d, J = 8.3 Hz, 1H), 7.82 (d, J = 8.4 Hz, 1H), 7.43–7.38 (m, 1H), 7.37–7.27 (m, 11H), 7.25–7.14 (m, 7H), 7.06 (dd, J = 6.7, 5.3 Hz, 2H), 7.04–7.00 (m, 2H), 6.95 (s, 1H), 4.65 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 144.8, 143.1, 140.5, 140.3, 140.2, 138.0, 134.8, 134.0, 132.9, 132.8, 131.1, 130.0, 128.5, 128.3, 128.2, 128.1, 127.9, 127.6, 127.4, 127.3, 127.2, 126.9, 126.4, 125.9, 125.9, 125.4, 125.0, 34.8; IR (KBr): 3025, 1599, 1492, 1444, 1216, 1074, 1030, 901, 758, 698 cm^{-1}; MS (EI): *m/z* 472 $(M)^{+}$; HRMS (EI): *m/z* calcd for $C_{37}H_{28}$ $(M)^{+}$: 472.2191, found: 472.2187.

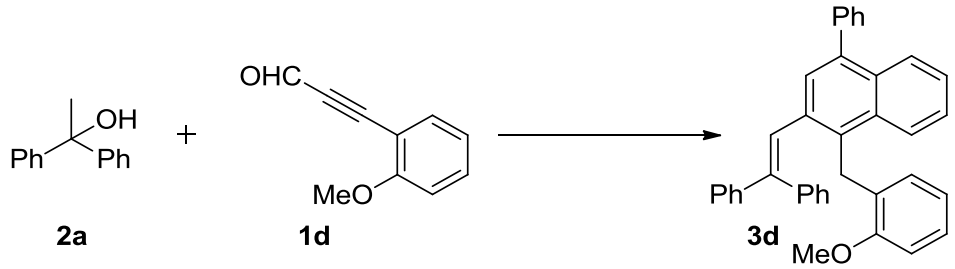


2-(2,2-Diphenylvinyl)-1-(naphthalen-1-ylmethyl)-4-phenylnaphthalene (3b): 120 mg, 83% yield, white solid; R_f = 0.3 (hexanes); mp 137-139 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.37 (d, *J* = 8.3 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.88–7.84 (m, 1H), 7.80 (t, *J* = 8.5 Hz, 1H), 7.72 (d, *J* = 8.2 Hz, 1H), 7.65–7.60 (m, 1H), 7.60–7.54 (m, 1H), 7.51–7.46 (m, 1H), 7.36–7.26 (m, 9H), 7.23–7.20 (m, 4H), 7.19–7.14 (m, 3H), 7.07 (dd, *J* = 7.7, 1.7 Hz, 2H), 7.01 (s, 1H), 6.82 (d, *J* = 6.4 Hz, 1H), 5.05 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 145.1, 142.9, 140.5, 140.4, 138.2, 137.6, 135.6, 135.5, 133.7, 133.4, 133.1, 132.4, 132.0, 131.2, 131.0, 130.1, 128.8, 128.3, 128.1, 128.0, 127.6, 127.3, 127.0, 126.9, 126.7, 126.4, 126.1, 125.9, 125.8, 125.7, 125.5, 125.3, 125.1, 123.3, 31.8; IR (KBr): 3055, 1596, 1522, 1468, 1397, 1029, 791, 757, 669 cm^{-1}; MS (EI): *m/z* 522 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{41}H_{30}$ $(M)^+$: 522.2347, found: 522.2340.



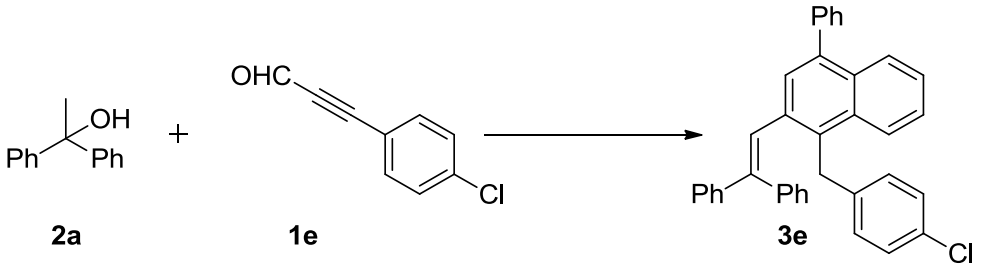
2-(2,2-Diphenylvinyl)-1-(4-methylbenzyl)-4-phenylnaphthalene (3c): 155 mg, 92% yield, white solid; R_f = 0.3 (hexanes) mp 133-135 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.02 (d, *J* = 8.5 Hz, 1H), 7.82 (d, *J* = 8.3 Hz, 1H), 7.39 (t, *J* = 7.6 Hz, 1H), 7.36–7.25 (m, 11H), 7.25–7.18 (m, 2H), 7.11–7.04 (m, 6H), 7.04–6.98 (m, 2H), 6.94 (d, *J* = 1.1 Hz, 1H), 4.61 (s, 2H), 2.29 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.6, 143.1, 140.5, 140.2, 137.9, 137.1, 135.3, 134.7, 134.2, 132.8, 131.0, 130.0, 129.1, 128.2, 128.1, 127.9, 127.6, 127.47, 127.2, 126.8, 126.4, 125.8,

125.3, 125.0, 34.3, 21.0; IR (KBr): 3022, 1595, 1511, 1492, 1443, 1216, 1030, 758, 699 cm^{-1}; MS (EI): *m/z* 486 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{38}H_{30}$ $(M)^+$: 486.2348, found: 486.2343.



2a **1d** **3d**

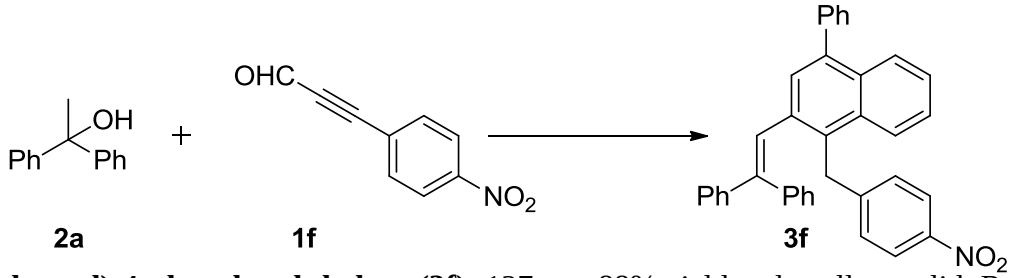
2-(2,2-Diphenylvinyl)-1-(2-methoxybenzyl)-4-phenylnaphthalene (3d): 59 mg, 82% yield, white solid; R_f = 0.3 (hexanes: EtOAc = 95:5); mp 101-103 ^oC; ^1H NMR (400 MHz, $CDCl_3$): δ 7.93 (d, *J* = 8.1 Hz, 1H), 7.82 (dd, *J* = 7.7, 6.4 Hz, 1H), 7.40–7.27 (m, 10H), 7.25–7.14 (m, 5H), 7.10–7.05 (m, 2H), 7.04–7.00 (m, 2H), 6.94 (s, 1H), 6.89 (d, *J* = 8.1 Hz, 1H), 6.80–6.66 (m, 2H), 4.58 (s, 2H), 3.87 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 156.9, 144.5, 143.3, 140.6, 140.4, 137.8, 135.1, 134.2, 133.1, 131.1, 130.9, 130.0, 128.8, 128.5, 128.2, 128.1, 127.9, 127.6, 127.5, 127.2, 126.9, 126.8, 126.3, 125.8, 125.3, 125.1, 120.4, 109.7, 55.2, 28.3; IR (KBr): 2924, 1597, 1502, 1446, 1379, 1073, 1030, 770, 699 cm^{-1}; MS (EI): *m/z* 502 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{38}H_{30}O$ $(M)^+$: 502.2297, found: 502.2291.



2a **1e** **3e**

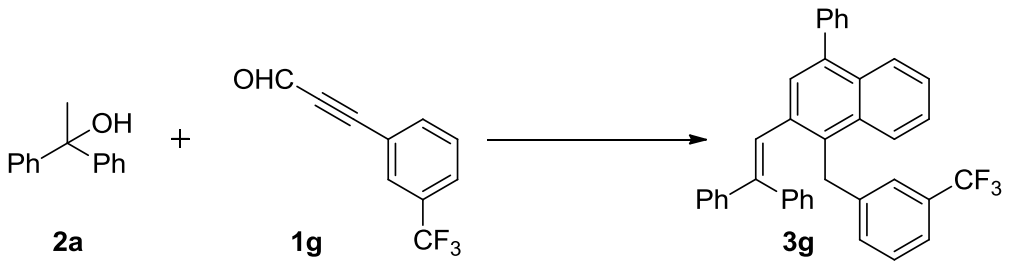
1-(4-Chlorobenzyl)-2-(2,2-diphenylvinyl)-4-phenylnaphthalene (3e): 139 mg, 90% yield, pale yellow solid; R_f = 0.8 (hexanes: EtOAc = 95:5) mp 186-189 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 7.95 (d, *J* = 8.3 Hz, 1H), 7.83 (d, *J* = 8.3 Hz, 1H), 7.45–7.39 (m, 1H), 7.38–7.26 (m, 10H), 7.25–7.19 (m, 5H), 7.13–7.00 (m, 6H), 6.95 (s, 1H), 4.60 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.1, 143.1, 140.4, 140.1, 138.7, 138.3, 134.9, 133.3, 132.7, 131.7, 131.1, 131.0, 130.0, 129.6, 128.6, 128.2, 128.1, 128.0, 128.0, 127.8, 127.3, 127.1, 127.0, 126.6, 126.0,

125.5, 124.7, 34.1; IR (KBr): 3023, 1592, 1488, 1442, 1382, 1180, 1074, 793, 754, 698 cm^{-1}; MS (EI): *m/z* 506 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{37}H_{27}Cl$ $(M)^+$: 506.1801, found: 506.1800.



2a **1f** **3f**

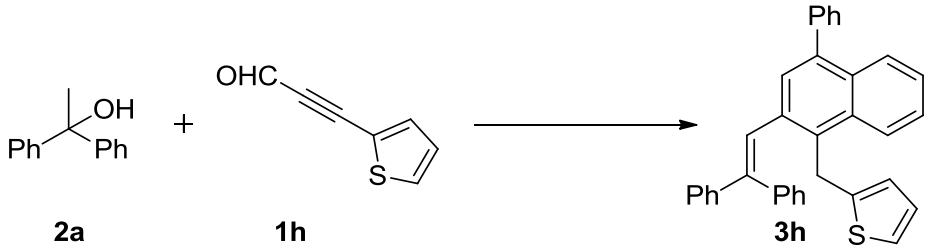
2-(2,2-Diphenylvinyl)-1-(4-nitrobenzyl)-4-phenylnaphthalene (3f): 127 mg, 88% yield, pale yellow solid; R_f = 0.4 (hexanes: EtOAc = 95:5) mp 121-123 ^oC; ^1H NMR (400 MHz, $CDCl_3$): δ 8.11 (d, J = 8.8 Hz, 2H), 7.86 (dd, J = 12.0, 4.6 Hz, 2H), 7.45–7.27 (m, 12H), 7.26–7.19 (m, 3H), 7.15 (s, 1H), 7.07–7.01 (m, 4H), 6.99 (s, 1H), 4.73 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 148.2, 146.4, 145.5, 142.9, 140.1, 139.8, 138.8, 135.1, 132.5, 131.9, 131.1, 130.9, 129.9, 129.0, 128.2, 128.1, 128.0, 127.9, 127.4, 127.0, 126.7, 126.5, 126.2, 125.6, 124.3, 123.7, 34.7.; IR (KBr): 3023, 1596, 1516, 1492, 1343, 1216, 1074, 1015, 754, 699 cm^{-1}; MS (EI): *m/z* 517 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{37}H_{27}NO_2$ $(M)^+$: 517.2041, found: 517.2039.



2a **1g** **3g**

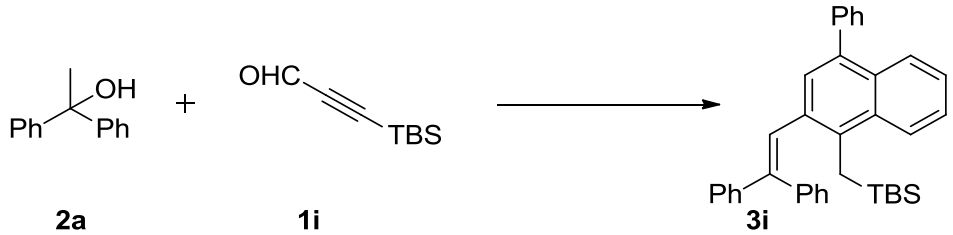
2-(2,2-Diphenylvinyl)-4-phenyl-1-(3-(trifluoromethyl)benzyl)naphthalene (3g): 113 mg, 83% yield, semisolid; R_f = 0.4 (hexanes: EtOAc = 95:5); ^1H NMR (400 MHz, $CDCl_3$): δ 7.97 (d, J = 8.1 Hz, 1H), 7.84 (dt, J = 8.2, 4.0 Hz, 1H), 7.51 (s, 1H), 7.47–7.39 (m, 2H), 7.38–7.25 (m, 12H), 7.25–7.18 (m, 3H), 7.07–7.00 (m, 4H), 6.97 (s, 1H), 4.69 (s, 2H).; ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.3, 143.0, 141.3, 140.3, 140.1,

138.5, 135.0, 132.8, 132.7, 131.6, 131.1, 130.9, 130.1, 130.0, 129.0, 128.3, 128.1, 128.0, 127.8, 127.4, 127.0, 126.9, 126.7, 126.1, 125.5, 125.1, 125.1, 124.6, 122.9, 34.5; IR (KBr): 2925, 1444, 1326, 1162, 1122, 1073, 904, 768, 731, 697 cm^{-1}; MS (EI): *m/z* 540 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{38}H_{27}F_3$ $(M)^+$: 540.2065, found: 540.2061.



2a **1h** **3h**

2-((2-(2,2-Diphenylvinyl)-4-phenylnaphthalen-1-yl)methyl)thiophene (3h): 138 mg, 79% yield, semisolid; R_f = 0.3 (hexanes); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.00 (d, *J* = 8.4 Hz, 1H), 7.74 (dd, *J* = 9.8, 4.5 Hz, 1H), 7.47–7.35 (m, 2H), 7.34–7.11 (m, 12H), 7.05–6.97 (m, 3H), 6.97–6.89 (m, 2H), 6.85 (d, *J* = 6.5 Hz, 1H), 6.80–6.72 (m, 1H), 6.51–6.39 (m, 1H), 4.61 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 145.4, 145.1, 143.0, 140.2, 140.0, 138.6, 132.6, 132.3, 131.1, 131.0, 130.0, 129.6, 128.3, 128.2, 127.9, 127.8, 127.4, 127.0, 126.7, 126.6, 126.1, 125.6, 125.2, 124.3, 29.7; IR (KBr): 2923, 1492, 1444, 1260, 1075, 1027, 795, 768, 731, 698 cm^{-1}; MS (EI): *m/z* 478 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{35}H_{26}S$ $(M)^+$: 478.1755, found: 478.1742.

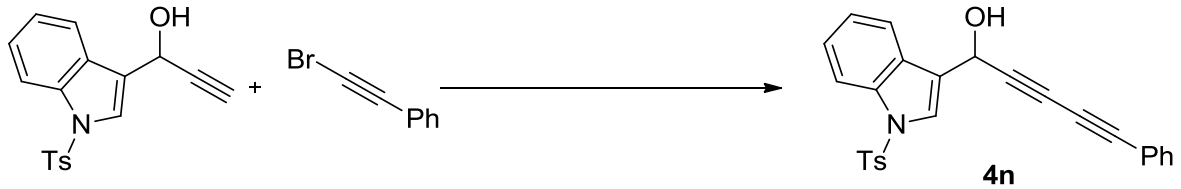


2a **1i** **3i**

***tert*-Butyl((2-(2,2-diphenylvinyl)-4-phenylnaphthalen-1-yl)methyl)dimethylsilane (3i):** 136 mg, 90% yield, white solid; R_f = 0.6 (hexanes: EtOAc = 95:5); mp 190-192 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.14 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.53 (dd, *J* = 8.5, 6.0 Hz,

6H), 7.50–7.35 (m, 6H), 7.24 (s, 1H), 7.17–7.07 (m, 3H), 7.04 (dd, *J* = 6.4, 5.2 Hz, 3H), 2.50 (d, *J* = 13.4 Hz, 1H), 1.76 (t, *J* = 18.6 Hz, 1H), 0.95 (s, 9H), 0.00 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.7, 143.2, 140.9, 140.2, 138.8, 135.3, 133.4, 130.9, 130.1, 129.9, 129.7, 129.3, 128.3, 128.2, 128.2, 127.7, 127.6, 127.1, 127.0, 126.9, 126.2, 125.7, 125.6, 124.3, 26.5, 20.2, 16.9, -5.6, -5.8; IR (KBr): 2951, 1491, 1442, 1249, 1153, 905, 824, 767, 730, 695 cm^{-1}; MS (EI): *m/z* 510 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{37}H_{38}Si$ $(M)^+$: 510.2743, found: 510.2735.

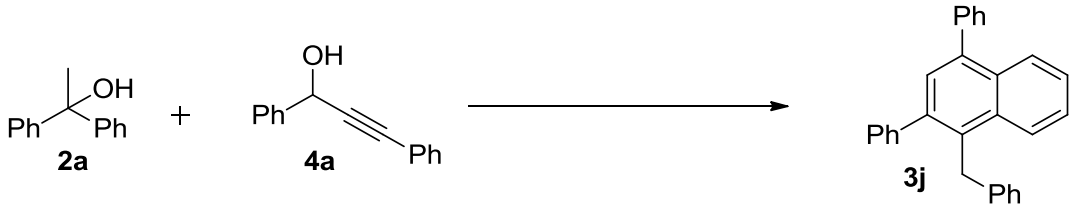
Propargylic alcohols (**4a, 4b, 4c, 4d, 4f, 4g)**[3a] **(4e, 4j, 4l)**[3b] **4h,**[3e] **4i,**[3d] **4k**,[3e] 4**m**[3f] have been prepared using the literature procedure[3] and the spectral data compared.



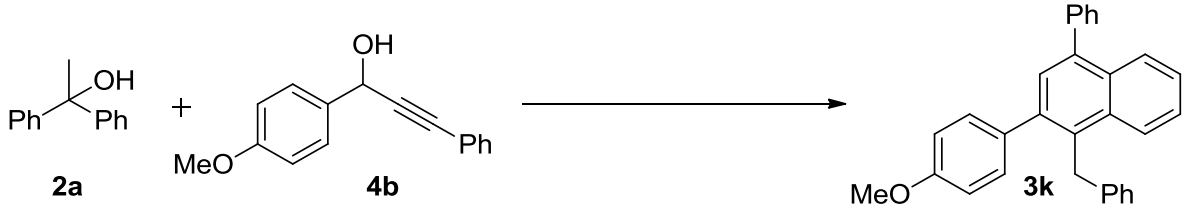
4n

5-Phenyl-1-(1-tosyl-1*H*-indol-3-yl)penta-2,4-diyn-1-ol (4n): To a stirred solution of 1-(1-tosyl-1*H*-indol-3-yl) prop-2-yn-1-ol[4] (1 g, 3.08 mmol) in dry toluene (15 mL were added CuCl (15 mol%, 45 mg), NH_2OH-HCl (30 mol%, 63 mg), *n*-$BuNH_2$ (4.62 mmol, 0.46 mL) and (bromoethynyl)benzene[5] (4.62 mmol, 0.84 g) at 0 ^oC, then the solution was warmed to room temperature and stirred for 2 h. The reaction mixture was quenched with 3 N HCl and extracted with EtOAc. Combined organic extracts were washed with brine, dried over Na_2SO_4, concentrated and purified by flash Column chromatography on silica gel (EtOAc: hexanes) to afford **4n**, 1.11 g, 85% yield, pale yellow solid; R_f = 0.4 (hexanes: EtOAc = 7:3); mp 72-74 ^oC (EtOAc/hexanes); ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.98 (d, *J* = 8.3 Hz, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.77–7.72 (m, 2H), 7.54–7.49 (m, 2H), 7.40–7.36 (m, 1H), 7.36–7.31 (m, 3H), 7.29–7.26 (m, 1H), 7.23 (d, *J* = 8.1 Hz, 2H), 5.80 (s, 1H), 2.34 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 145.1, 135.4, 135.0, 132.5, 129.9, 129.4, 128.4, 128.1, 126.8, 125.1, 124.1, 123.4, 121.4, 121.1, 120.3, 113.6, 80.3, 79.5, 73.0, 70.6, 58.4, 21.5; IR (KBr): 3058, 2234, 1600, 1444, 1368, 1171, 1122, 974, 751, 672 cm^{-1}; MS (ESI): *m/z* 448 $(M+Na)^+$; HRMS (ESI): *m/z* calcd for $C_{26}H_{19}NNaO_3S$ $(M+Na)^+$: 448.0978, found: 448.0990.

General procedure for the preparation of Naphthalenes (3j-3y, 5a): To a stirred solution of propargylic alcohol **1** (1.0 mmol) and 1, 1-diarylethan-1-ol **2** (1.0 mmol) in 5 mL of acetonitrile was added *p*TSA (5 mol%) at room temperature and stirred for 10 to 45 min, after completion of starting material, DBU (1.0 mmol) was added to the reaction mixture and stirred at 80 ^{o}C for 10-60 min. The solvent was evaporated under reduced pressure. The residue was purified by column chromatography on silica gel (EtOAc:hexanes) to afford the corresponding naphthalenes.

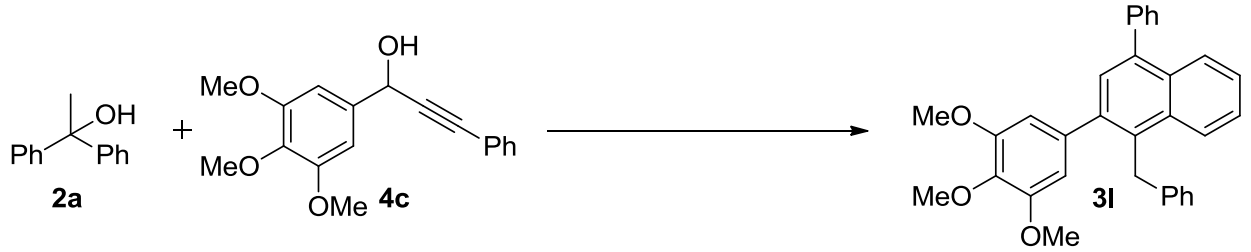


1-Benzyl-2,4-diphenyl naphthalene (3j): 81 mg, 92% yield, white solid; R_f = 0.5 (hexanes) mp 117-119 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.01–7.93 (m, 2H), 7.56 (dt, *J* = 8.0, 1.8 Hz, 2H), 7.53–7.46 (m, 2H), 7.46–7.43 (m, 2H), 7.41 (ddd, *J* = 6.1, 3.2, 1.7 Hz, 2H), 7.39–7.28 (m, 5H), 7.27–7.20 (m, 2H), 7.15 (dd, *J* = 8.5, 6.1 Hz, 1H), 7.12–7.05 (m, 2H), 4.50 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.2, 141.8, 140.7, 140.0, 139.2, 133.1, 131.9, 131.5, 130.3, 129.6, 129.3, 128.4, 128.3, 128.2, 128.1, 127.3, 127.1, 126.7, 126.3, 125.9, 125.7, 125.6, 35.6; IR (KBr): 3023, 1694, 1594, 1498, 1445, 1214, 745, 668 cm^{-1}; MS (EI): *m/z* 370 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{22}$ $(M)^+$: 370.1722, found: 370.1710.

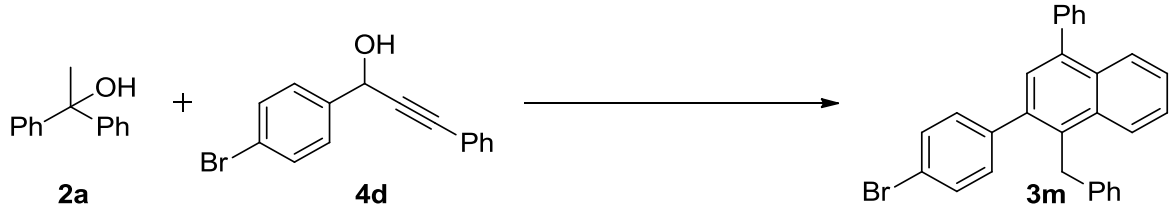


1-Benzyl-2-(4-methoxyphenyl)-4-phenyl naphthalene (3k): 75 mg, 90% yield, white solid; R_f = 0.5 (hexanes) mp 80-83 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.92–7.84 (m, 2H), 7.51–7.45 (m, 2H), 7.42 (dd, *J* = 10.2, 4.7 Hz, 2H), 7.38–7.29 (m, 4H), 7.21 (dd, *J* = 9.1, 2.4 Hz, 2H), 7.18–

7.13 (m, 2H), 7.08 (t, *J* = 7.3 Hz, 1H), 7.02 (d, *J* = 7.3 Hz, 2H), 6.84–6.77 (m, 2H), 4.43 (s, 2H), 3.74 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.8, 141.9, 140.7, 139.6, 139.1, 134.6, 133.1, 131.8, 131.3, 130.4, 130.3, 129.8, 128.4, 128.3, 128.2, 127.3, 126.6, 126.2, 125.9, 125.7, 125.4, 113.6, 55.3, 35.7; IR (KBr): 3027, 2927, 2854, 1512, 1247, 1177, 1035, 773, 731, 700 cm^{-1}; MS (EI): *m/z* 400 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{30}H_{24}O$ $(M)^+$: 400.1827, found: 400.1820.

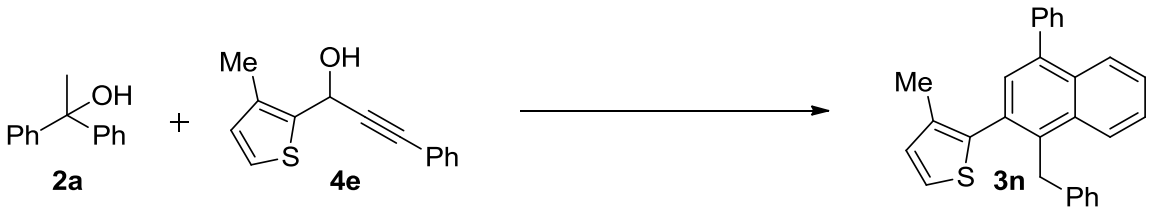


1-Benzyl-4-phenyl-2-(3,4,5-trimethoxy phenyl) naphthalene (3l): 61 mg, 80% yield, light pink solid; R_f = 0.5 (hexanes: EtOAc = 9:1) mp 161-163 ^{o}C ; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.03–7.96 (m, 2H), 7.62–7.55 (m, 2H), 7.55–7.39 (m, 6H), 7.25 (dd, *J* = 9.3, 5.8 Hz, 2H), 7.16 (t, *J* = 7.3 Hz, 1H), 7.11 (d, *J* = 7.4 Hz, 2H), 6.53 (s, 2H), 4.51 (s, 2H), 3.86 (s, 3H), 3.57 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 152.7, 142.0, 140.6, 139.9, 139.2, 137.5, 136.9, 133.4, 131.6, 131.3, 130.2, 129.1, 128.4, 128.3, 128.2, 127.3, 126.6, 126.4, 125.8, 125.7, 125.6, 106.3, 60.9, 55.7, 35.8; IR (KBr): 2922, 1594, 1495, 1446, 1375, 1219, 892, 758, 704 cm^{-1}; MS (EI): *m/z* 460 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{32}H_{28}O_3$ $(M)^+$: 460.2038, found: 460.2030.

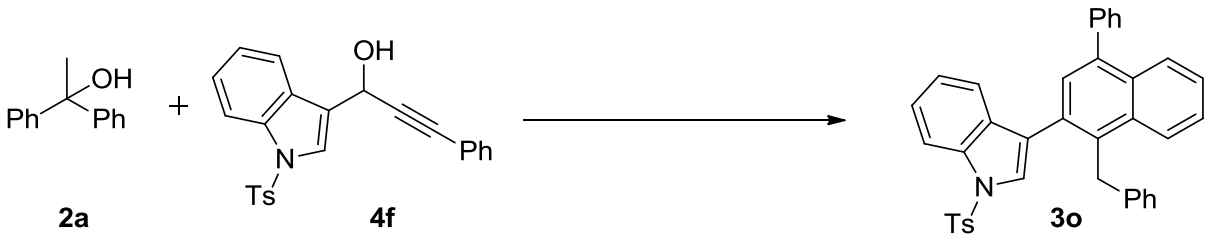


13) 1-Benzyl-2-(4-bromophenyl)-4-phenyl naphthalene (3m): 71 mg, 92% yield, white solid; R_f = 0.5 (hexanes) mp 151-153 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99–7.93 (m, 2H), 7.57–7.53 (m, 2H), 7.52–7.37 (m, 8H), 7.26–7.21 (m, 4H), 7.16 (t, *J* = 7.3 Hz, 1H), 7.06 (d, *J* = 7.1

Hz, 2H), 4.46 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.4, 141.0, 140.4, 139.4, 138.6, 133.0, 131.9, 131.5, 131.2, 131.0, 130.2, 129.0, 128.5, 128.3, 128.1, 127.4, 126.7, 126.4, 125.8, 125.7, 121.4, 35.5; IR (KBr): 3027, 1597, 1489, 1448, 1379, 1072, 1009, 953, 832, 758, 701 cm^{-1}; MS (EI): *m/z* 448 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{21}Br$ $(M)^+$: 448.0826, found: 448.0819.



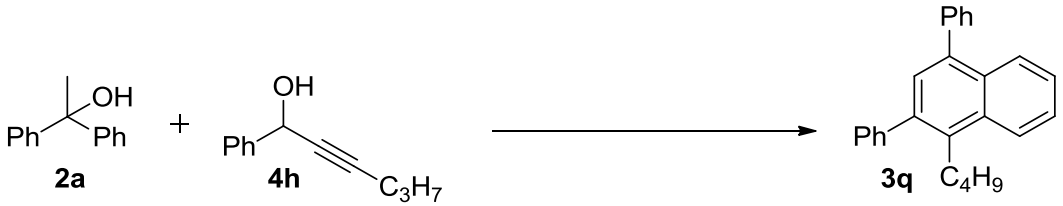
14) 2-(1-Benzyl-4-phenylnaphthalen-2-yl)-3-methyl thiophene (3n): 66 mg, 87% yield, white solid; R_f = 0.5 (hexanes) mp 64-66 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.07–7.93 (m, 2H), 7.53 (t, *J* = 7.7 Hz, 2H), 7.48 (dd, *J* = 14.2, 6.6 Hz, 2H), 7.42 (dd, *J* = 6.3, 2.1 Hz, 4H), 7.23–7.15 (m, 3H), 7.10 (dd, *J* = 14.3, 7.0 Hz, 1H), 7.05 (d, *J* = 7.3 Hz, 2H), 6.88 (d, *J* = 5.1 Hz, 1H), 4.50 (s, 2H), 2.00 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.2, 140.4, 138.9, 137.0, 135.4, 135.0, 132.9, 132.0, 131.9, 130.3, 130.2, 129.4, 128.2, 127.3, 126.7, 126.2, 126.0, 125.9, 125.7, 123.9, 35.5, 14.3; IR (KBr): 2923, 1596, 1494, 1448, 1376, 1032, 936, 893, 763, 704 cm^{-1}; MS (EI): *m/z* 390 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{28}H_{22}S$ $(M)^+$: 390.1442, found: 390.1440.



3-(1-Benzyl-4-phenylnaphthalen-2-yl)-1-tosyl-1*H*-indole (3o): 63 mg, 90% yield, white solid; R_f = 0.5 (hexanes: EtOAc = 20:1) mp 186-188 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.04 (d, *J* = 8.3 Hz, 1H), 7.99 (qd, *J* = 6.1, 3.1 Hz, 2H), 7.59 (d, *J* = 8.3 Hz, 2H), 7.57–7.52 (m, 2H), 7.52–7.40 (m, 7H), 7.39–7.31 (m, 2H), 7.29–7.23 (m, 2H), 7.20 (q, *J* = 7.2 Hz, 2H), 7.10 (d, *J* = 8.2 Hz, 2H), 7.03 (d, *J* = 7.4 Hz, 2H), 4.39 (s, 2H),

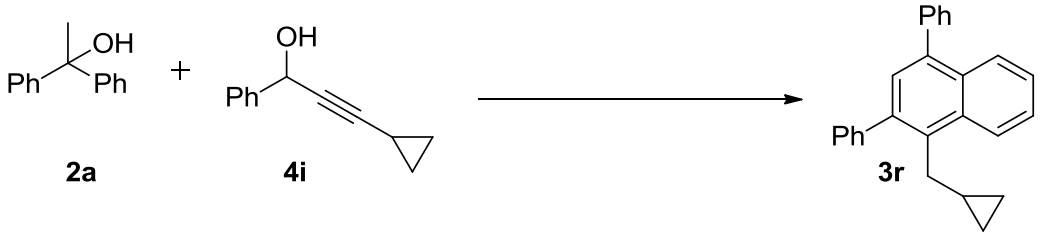
2.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 144.8, 141.3, 140.4, 139.4, 135.0, 134.9, 134.0, 133.2, 131.8, 131.1, 130.2, 130.1, 129.8, 129.3, 128.5, 128.3, 128.0, 127.4, 126.8, 126.7, 126.4, 126.0, 125.9, 125.8, 124.9, 124.3, 123.6, 123.4, 120.5, 113.8, 35.7, 21.6; IR (KBr): 3061, 3027, 2924, 1599, 1446, 1373, 1174, 1128, 977, 752, 684 cm^{-1}; MS (EI): *m/z* 563 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{38}H_{29}NO_2S$ $(M)^+$: 563.1919, found: 563.1913.

(*E*)-1-Benzyl-4-phenyl-2-styrylnaphthalene (3p): 59 mg, 78% yield, colorless liquid; R_f = 0.6 (hexanes); ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.08 (d, *J* = 7.9 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.81 (s, 1H), 7.60 (dd, *J* = 22.5, 5 Hz, 5H), 7.54–7.32 (m, 9H), 7.27–7.14 (m, 5H), 4.71 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 140.9, 140.5, 139.5, 137.5, 133.5, 133.3, 132.7, 131.8, 131.7, 130.2, 128.7, 128.6, 128.3, 128.2, 127.7, 127.3, 126.8, 126.7, 126.6, 126.4, 126.1, 125.5, 125.1, 125.1, 34.1; IR (KBr): 2925, 1729, 1596, 1496, 1450, 1216, 1029, 963, 755, 701 cm^{-1}; MS (EI): *m/z* 396 $(M)^+$; HRMS (ESI): *m/z* calcd for $C_{31}H_{24}$ $(M)^+$: 396.1878, found: 396.1863.

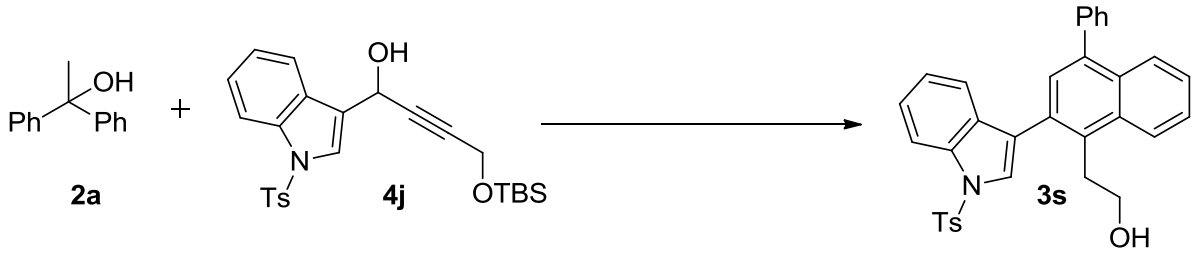


2,4-Diphenyl-1-propyl naphthalene (3q): 81 mg, 88% yield, Colorless liquid; R_f = 0.6 (hexanes); ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.17 (d, *J* = 8.5 Hz, 1H), 7.97 (d, *J* = 8.4 Hz, 1H), 7.56 (ddd, *J* = 8.3, 6.8, 1.2 Hz, 1H), 7.53–7.49 (m, 2H), 7.49–7.34 (m, 7H), 7.32 (s, 1H), 3.13–2.96 (m,

2H), 1.75–1.61 (m, 2H), 1.42–1.30 (m, 2H), 0.85 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.7, 140.7, 138.6, 137.9, 135.6, 132.3, 131.3, 130.2, 129.5, 128.2, 128.0, 127.1, 126.8, 126.8, 126.0, 125.4, 124.9, 33.7, 29.2, 23.1, 13.8; IR (KBr): 3058, 2956, 2925, 2855, 1493, 1219, 1033, 896, 770, 701 cm^{-1}; MS (EI): *m/z* 322 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{25}H_{22}$ $(M)^+$: 322.1722, found: 322.1717.



1-(Cyclopropylmethyl)-2,4-diphenyl naphthalene (3r): 85 mg, 88% yield, white solid; R_f = 0.6 (hexanes) mp 111-113 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.32 (d, *J* = 8.5 Hz, 1H), 7.98 (d, *J* = 8.4 Hz, 1H), 7.61–7.55 (m, 1H), 7.55–7.50 (m, 2H), 7.46 (t, *J* = 7.6 Hz, 3H), 7.44–7.32 (m, 7H), 3.05 (d, *J* = 6.1 Hz, 2H), 1.13–0.93 (m, 1H), 0.43–0.34 (m, 2H), 0.05–-0.02 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.8, 140.7, 138.8, 138.1, 134.9, 132.6, 131.4, 130.2, 129.9, 129.5, 128.2, 127.9, 127.1, 126.8, 126.7, 125.9, 125.4, 125.4, 33.2, 12.1, 5.5; IR (KBr): 3075, 3024, 2868, 1592, 1493, 1218, 1016, 827, 760, 702 cm^{-1}; MS (EI): *m/z* 334 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{26}H_{22}$ $(M)^+$: 334.1722, found: 334.1719.

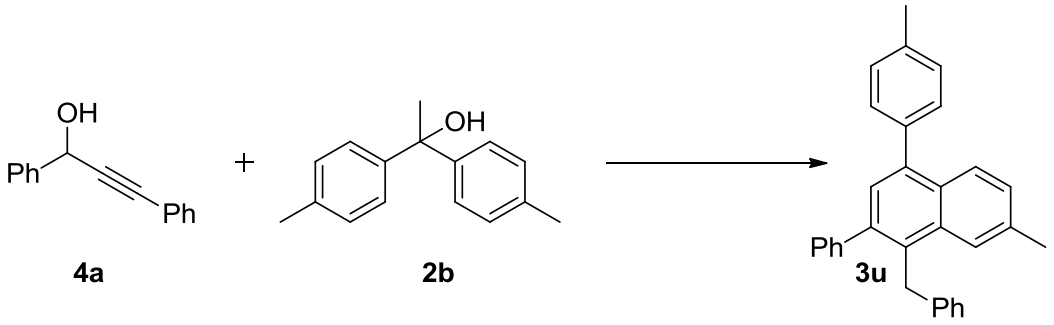


2-(4-Phenyl-2-(1-tosyl-1*H*-indol-3-yl)naphthalen-1-yl)ethan-1-ol (3s): 49 mg, 90% yield, pale yellow solid; R_f = 0.5 (hexanes: EtOAc = 4:1) mp 102-105 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.14 (d, *J* = 8.5 Hz, 1H), 7.99 (d, *J* = 8.3 Hz, 1H), 7.89 (d, *J* = 8.4 Hz, 1H), 7.75 (d, *J* =

8.3 Hz, 2H), 7.65 (s, 1H), 7.49 (dd, *J* = 11.3, 4.0 Hz, 1H), 7.44–7.08 (m, 13H), 3.76 (t, *J* = 7.2 Hz, 2H), 3.26 (t, *J* = 7.2 Hz, 2H), 2.26 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 145.0, 140.3, 139.1, 135.2, 134.9, 132.8, 131.7, 131.1, 130.1, 130.0, 129.7, 129.6, 128.3, 127.4, 126.9, 126.4, 125.9, 125.0, 124.7, 123.7, 123.6, 120.5, 113.8, 63.4, 32.9, 21.6; IR (KBr): 2956, 1598, 1444, 1368, 1169, 1124, 1091, 1012, 948, 748, 690, 659 cm^{-1}; MS (EI): *m/z* 517 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{33}H_{27}NO_3S(M)^+$: 517.1712, found: 517.1709.

2a **4k** **3t**

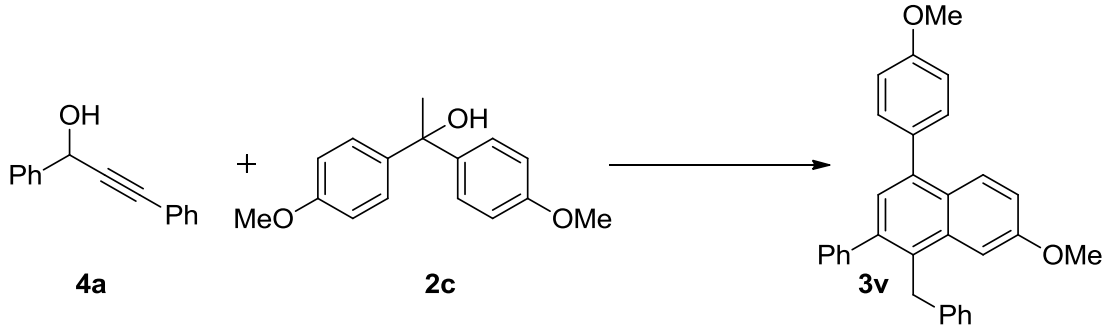
1-Methyl-2,4-diphenyl naphthalene (3t): 57 mg, 80% yield, colorless liquid; R_f = 0.5 (hexanes); ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.36 (d, *J* = 8.4 Hz, 1H), 8.14 (d, *J* = 8.5 Hz, 1H), 7.77 (ddd, *J* = 8.3, 6.8, 1.3 Hz, 1H), 7.73–7.68 (m, 2H), 7.68–7.58 (m, 7H), 7.58–7.52 (m, 2H), 7.46–7.41 (m, 1H), 2.85 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.5, 140.7, 138.6, 138.1, 133.2, 130.9, 130.3, 130.2, 129.9, 129.3, 128.2, 128.1, 127.1, 126.8, 126.6, 126.1, 125.6, 124.8, 16.4; IR (KBr): 3063, 1594, 1498, 1445, 1379, 1167, 1071, 1032, 994, 899, 761, 701 cm^{-1}; MS (EI): *m/z* 294 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{23}H_{18}$ $(M)^+$: 294.1408, found: 294.1400.



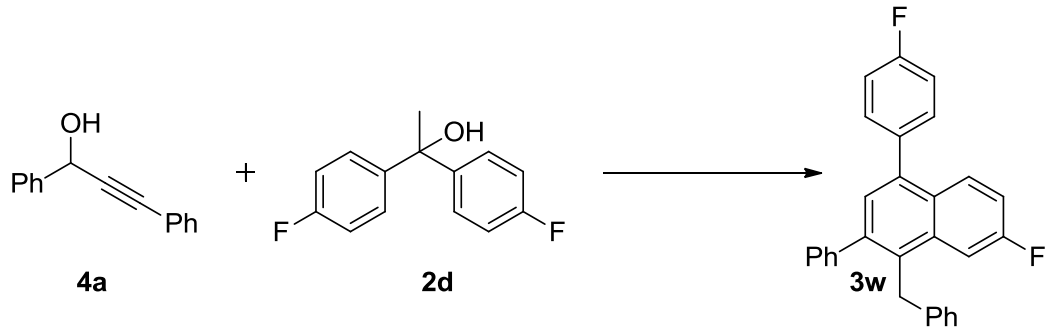
4a **2b** **3u**

1-Benzyl-7-methyl-2-phenyl-4-(*p*-tolyl)naphthalene (3u): 79 mg, 90% yield, white solid; R_f = 0.4 (hexanes), mp 130-132 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.89 (dd, *J* = 8.4, 4.4 Hz, 1H), 7.74 (s, 1H), 7.45 (dd, *J* = 7.6, 3.7 Hz, 3H), 7.32 (ddd, *J* = 12.2, 11.0, 5.0 Hz, 8H), 7.22 (dd, *J* =

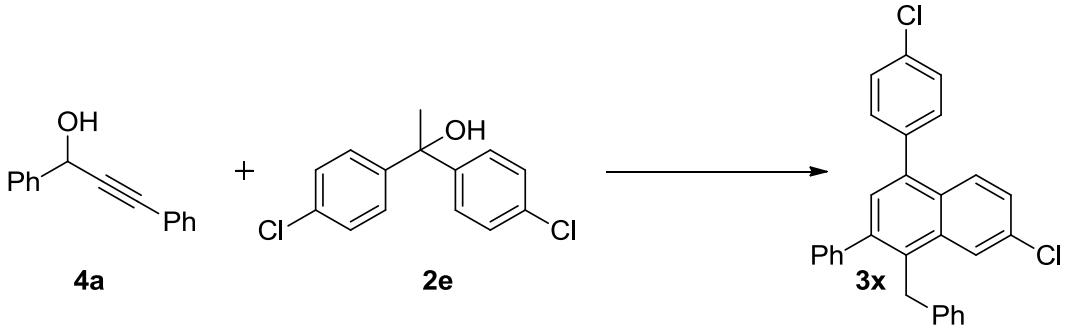
7.8, 2.5 Hz, 2H), 7.17–7.13 (m, 1H), 7.09 (s, 2H), 4.46 (d, *J* = 3.2 Hz, 2H), 2.45 (d, *J* = 2.6 Hz, 3H), 2.41 (d, *J* = 2.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.3, 141.8, 140.0, 138.8, 137.8, 136.8, 135.7, 133.2, 130.9, 130.0, 129.6, 129.3, 128.9, 128.6, 128.3, 128.1, 127.9, 127.6, 126.9, 126.5, 125.5, 124.8, 35.4, 21.2, 21.2; IR (KBr): 3024, 1599, 1493, 1450, 1216, 1029, 824, 755, 700 cm^{-1}; MS (EI): *m/z* 396 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{31}H_{26}$ $(M)^+$: 396.2034, found: 396.2030.



1-Benzyl-7-methoxy-4-(4-methoxyphenyl)-2-phenylnaphthalene (3v): 70 mg, 85% yield, white solid; R_f = 0.2 (hexanes) mp 113-115 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.81 (d, *J* = 9.2 Hz, 1H), 7.41–7.36 (m, 2H), 7.34–7.23 (m, 6H), 7.22 (d, *J* = 5.2 Hz, 1H), 7.14 (d, *J* = 8.1 Hz, 2H), 7.06 (dd, *J* = 11.8, 7.1 Hz, 3H), 7.00–6.91 (m, 3H), 4.36 (s, 2H), 3.81 (s, 3H), 3.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.9, 157.6, 142.5, 141.7, 140.6, 138.6, 134.3, 133.1, 131.2, 130.4, 129.3, 129.0, 128.6, 128.4, 128.3, 128.2, 128.1, 127.3, 127.0, 125.7, 117.6, 113.7, 104.9, 55.4, 55.1, 36.0; IR (KBr): 2926, 1614, 1515, 1452, 1245, 1227, 1177, 1035, 832, 701 cm^{-1}; MS (EI): *m/z* 430 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{31}H_{26}O_2$ $(M)^+$: 430.1932, found: 430.1930.

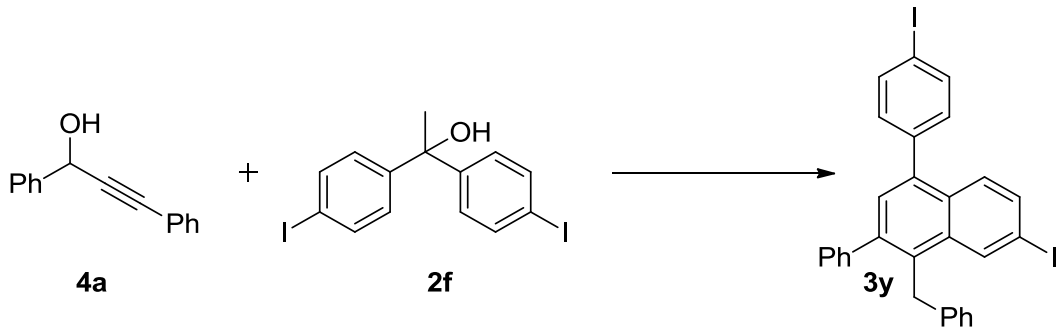


1-Benzyl-7-fluoro-4-(4-fluorophenyl)-2-phenylnaphthalene (3w): 79 mg, 92% yield, white solid; R_f = 0.2 (hexanes) mp 96-98 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89 (dd, J = 9.3, 6.0 Hz, 1H), 7.56 (dd, J = 11.5, 2.5 Hz, 1H), 7.51–7.47 (m, 2H), 7.37–7.33 (m, 6H), 7.26–7.22 (m, 2H), 7.21–7.15 (m, 4H), 7.06 (d, J = 7.1 Hz, 2H), 4.42 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 163.4, 161.9, 161.4, 160.0, 141.7, 141.0, 138.1, 136.3, 134.4, 131.6, 129.2, 128.9, 128.5, 128.2, 128.1, 127.3, 125.9, 115.8, 115.4, 115.2, 109.7, 109.5, 35.7; IR (KBr): 3027, 1623, 1604, 1517, 1450, 1419, 1223, 1203, 1157, 838, 768, 703 cm^{-1}; MS (EI): *m/z* 406 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{20}F_2$ $(M)^+$: 406.1533, found: 406.1522.



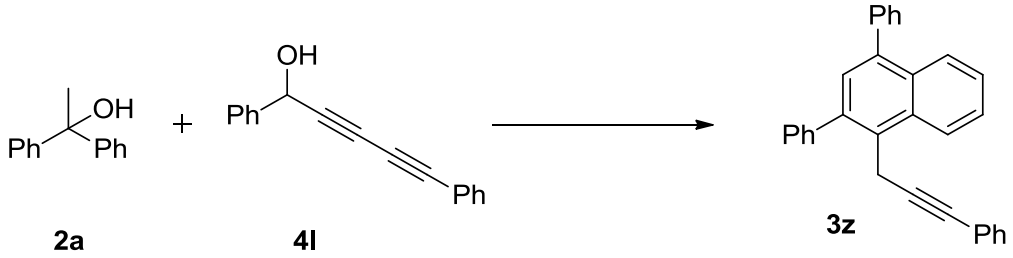
1-Benzyl-7-chloro-4-(4-chlorophenyl)-2-phenylnaphthalene (3x): 78 mg, 95% yield, pale yellow solid; R_f = 0.6 (hexanes: EtOAc = 95:5) mp 161-163 ^{o}C ; ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95 (d, J = 1.9 Hz, 1H), 7.83 (d, J = 9.0 Hz, 1H), 7.46 (d, J = 1.6 Hz, 3H), 7.40 (s, 1H), 7.37–7.30 (m, 6H), 7.24 (dd, J = 9.7, 4.9 Hz, 3H), 7.17 (t, J = 7.3 Hz, 1H), 7.04 (d, J = 7.2 Hz, 2H), 4.43 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.6, 141.1, 141.0, 138.5, 137.8, 134.1, 133.7, 132.6, 131.8, 131.4, 129.8, 129.6, 129.2, 128.7, 128.6, 128.3, 128.2, 128.1, 127.4, 126.6, 126.0, 125.0,

35.5; IR (KBr): 3026, 1603, 1491, 1451, 1426, 1090, 899, 877, 838, 751, 700 cm^{-1}; MS (EI): *m/z* 438 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{20}Cl_2$ $(M)^+$: 438.0942, found: 438.0940.



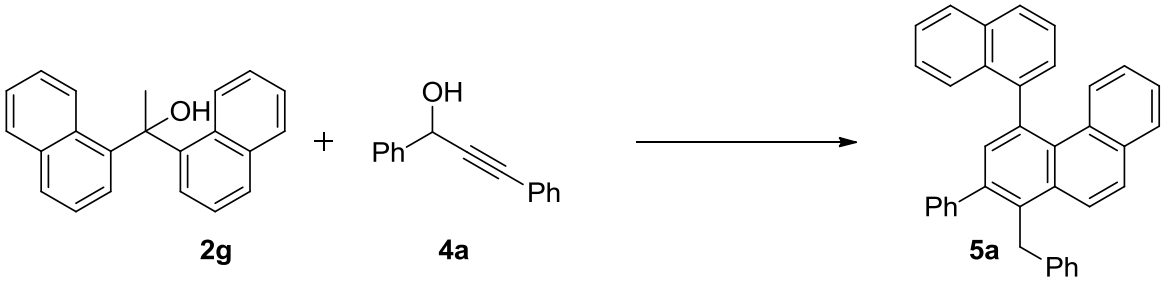
1-Benzyl-7-iodo-4-(4-iodophenyl)-2-phenylnaphthalene (3y): 61 mg, 88% yield, white solid; R_f = 0.8 (petroleum ether : EtOAc = 95:5) mp 115-117 ^oC; ^1H NMR (400 MHz, $CDCl_3$): δ 8.29 (s, 1H), 7.75 (d, *J* = 8.3 Hz, 1H), 7.55 (dd, *J* = 9.1, 5.0 Hz, 2H), 7.33 (s, 1H), 7.26 (dd, *J* = 8.3, 4.3 Hz, 5H), 7.15 (dt, *J* = 14.6, 4.9 Hz, 6H), 6.96 (d, *J* = 7.0 Hz, 2H), 4.35 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.5, 141.0, 140.88 139.5, 137.9, 137.5, 134.9, 134.8, 134.3, 132.0, 131.6, 129.9, 129.2, 128.5, 128.2, 128.2, 128.1, 127.9, 127.3, 125.9, 93.3, 92.9, 35.3; IR (KBr): 3024, 1596, 1491, 1450, 1207, 1005, 923, 853, 826, 756, 700 cm^{-1}; MS (EI): *m/z* 621 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{20}I_2$ $(M)^+$: 621.9654, found: 621.9649.

General procedure for the mono cyclisation (3z, 5b, 5c): To a stirred solution of 1,1 diarylehan-1-ol **2** (1.0 mmol) and bisacetylenic alcohols **4** (1.0 mmol) in 5 mL of acetonitrile was added *p*TSA (5 mol%) at room temperature and stirred for 10 min, after the completion of starting material DBU (1.0 mmol) was added to the reaction mixture at room temperature and was stirred at 80 ^oC for 30 min. After the completion of reaction (monitored by TLC), the reaction mixture was concentrated under reduced pressure. Purified by column chromatography on silica gel (EtOAc: hexanes) to afford corresponding polycyclic aromatic hydrocarbons.



2a **4l** **3z**

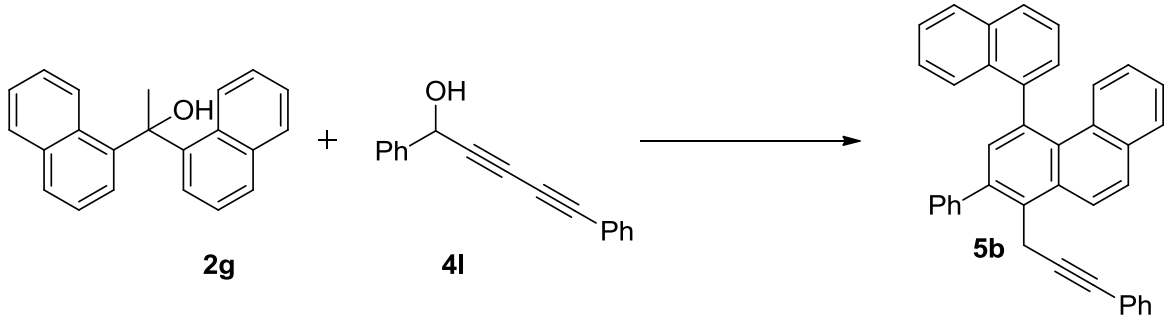
2,4-Diphenyl-1-(3-phenylprop-2-yn-1-yl) naphthalene (3z): 59 mg, 80% yield, light brown solid; R_f = 0.4 (hexanes: EtOAc = 20:1) mp 86-88 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 8.60 (d, J = 8.2 Hz, 1H), 7.93 (d, J = 8.4 Hz, 1H), 7.74–7.69 (m, 2H), 7.60 (ddd, J = 8.3, 6.8, 3.3 Hz, 1H), 7.55–7.34 (m, 11H), 7.32–7.26 (m, 4H), 3.91 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.9, 141.2, 140.3, 140.2, 136.6, 134.4, 130.5, 130.3, 130.0, 129.7, 128.6, 128.5, 128.3, 128.0, 128.0, 127.5, 127.3, 127.2, 126.8, 126.5, 126.2, 118.4, 96.0, 80.3, 26.2; IR (KBr): 2922, 1594, 1496, 1450, 1218, 1071, 1030, 909, 756, 699 cm^{-1}; MS (EI): *m/z* 394 $(M)^+$; HRMS (ESI): *m/z* calcd for $C_{31}H_{22}$ $(M)^+$: 394.1722, found: 394.1713.



2g **4a** **5a**

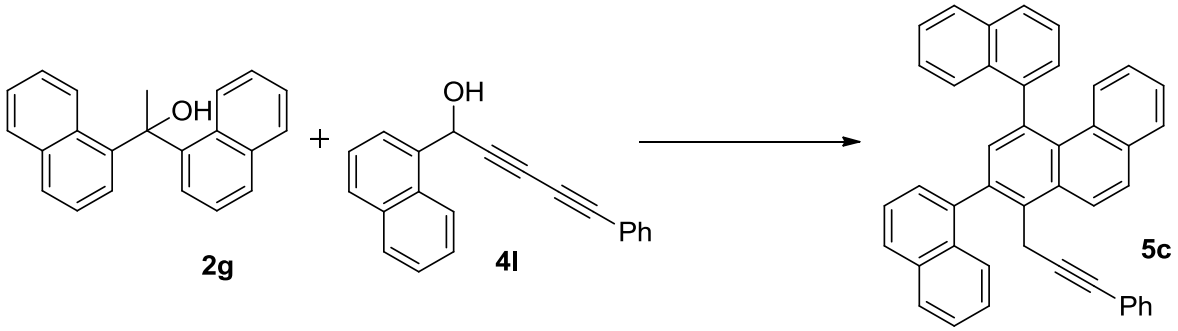
1-Benzyl-4-(naphthalen-1-yl)-2-phenyl anthracene (5a): 90 mg, 87% yield, pale yellow solid; R_f = 0.6 (hexanes) mp 161-163 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 7.93–7.85 (m, 3H), 7.67 (dd, J = 7.9, 1.3 Hz, 1H), 7.63 (d, J = 9.2 Hz, 1H), 7.56–7.46 (m, 5H), 7.39 (ddd, J = 8.1, 6.8, 1.1 Hz, 1H), 7.33–7.28 (m, 2H), 7.27–7.20 (m, 6H), 7.17 (d, J = 1.3 Hz, 1H), 7.12 (t, J = 7.3 Hz, 1H), 7.07 (d, J = 7.1 Hz, 2H), 6.79 (ddd, J = 8.6, 7.0, 1.5 Hz, 1H), 4.55 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 143.1, 141.8, 141.7, 140.7, 136.8, 134.0, 133.6, 132.8, 132.6, 132.0, 130.6,

129.6, 129.4, 128.5, 128.3, 128.2, 128.1, 128.1, 127.7, 127.6, 127.1, 126.8, 126.3, 126.3, 126.1, 126.0, 125.9, 125.8, 125.3, 124.4, 36.3; IR (KBr): 3021, 1591, 1497, 1446, 1394, 1256, 1214, 1024, 745 cm^{-1}; MS (EI): *m/z* 470 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{37}H_{26}$ $(M)^+$: 470.2035, found: 470.2031.



2g **4l** **5b**

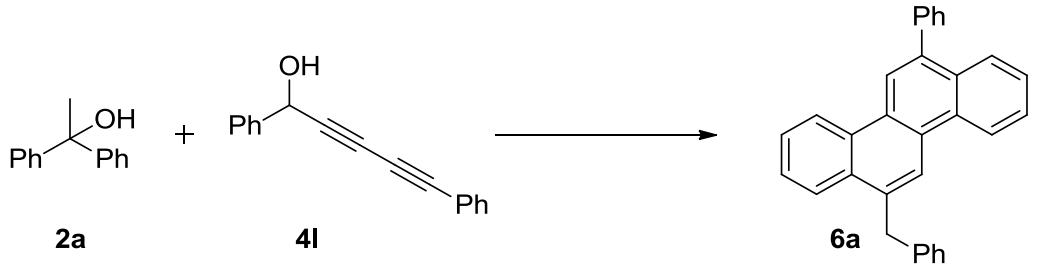
4-(Naphthalen-1-yl)-2-phenyl-1-(3-phenylprop-2-yn-1-yl)phenanthrene (5b): 71 mg, 86% yield, white solid; R_f = 0.6 (hexanes) mp 146-148 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 8.69 (d, *J* = 9.1 Hz, 1H), 7.96 (dd, *J* = 16.0, 8.2 Hz, 2H), 7.87 (d, *J* = 9.1 Hz, 1H), 7.82 (d, *J* = 7.5 Hz, 1H), 7.72 (d, *J* = 6.7 Hz, 2H), 7.59 (dd, *J* = 14.3, 6.2 Hz, 2H), 7.52–7.42 (m, 5H), 7.40–7.32 (m, 5H), 7.31 (d, *J* = 4.4 Hz, 3H), 7.25–7.20 (m, 1H), 6.87 (t, *J* = 7.3 Hz, 1H), 3.95 (s, 2H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.6, 141.9, 140.6, 138.0, 136.5, 134.4, 133.9, 133.0, 132.6, 131.7, 130.2, 129.7, 128.7, 128.7, 128.5, 128.3, 128.1, 128.0, 127.9, 127.8, 127.4, 127.3, 126.5, 126.3, 126.2, 126.1, 126.0, 125.7, 125.5, 119.6, 96.4, 80.7, 26.3; IR (KBr): 2924, 2185, 1596, 1454, 1267, 1083, 1017, 792, 753, 695 cm^{-1}; MS (EI): *m/z* 494 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{39}H_{26}$ $(M)^+$: 494.2035, found: 494.2031.



2g **4l** **5c**

2,4-Di(naphthalen-1-yl)-1-(3-phenylprop-2-yn-1-yl)phenanthrene (5c): 77 mg, 85% yield, white solid; R_f = 0.2 (hexanes) mp 102-104 ^oC; ^1H NMR (400 MHz, $CDCl_3$): δ 8.72–8.57 (m, 1H), 7.99–7.76 (m, 7H), 7.68–7.32 (m, 12H), 7.31–7.18 (m, 2H), 7.16–7.05 (m, 1H), 6.94–6.85 (m, 1H), 6.76 (t, *J* = 7.8 Hz, 2H), 3.67 (d, *J* = 4.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.5, 142.4, 141.2, 141.0, 139.0, 137.7, 137.5, 136.2, 134.0, 133.9, 133.8, 133.6, 133.5, 133.1, 131.9, 131.8, 131.7, 130.3, 128.8, 128.3, 128.2, 128.1, 127.8, 127.5, 127.4, 126.6, 126.5, 126.4, 126.3, 126.1, 126.0, 125.9, 125.6, 125.5, 125.2, 121.8, 96.7, 80.5, 25.9; IR (KBr): 2924, 2188, 1596, 1454, 1390, 1280, 1169, 1007, 800, 779, 754, 697 cm^{-1}; MS (EI): *m/z* 544 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{43}H_{28}$ $(M)^+$: 544.2191, found: 544.2199.

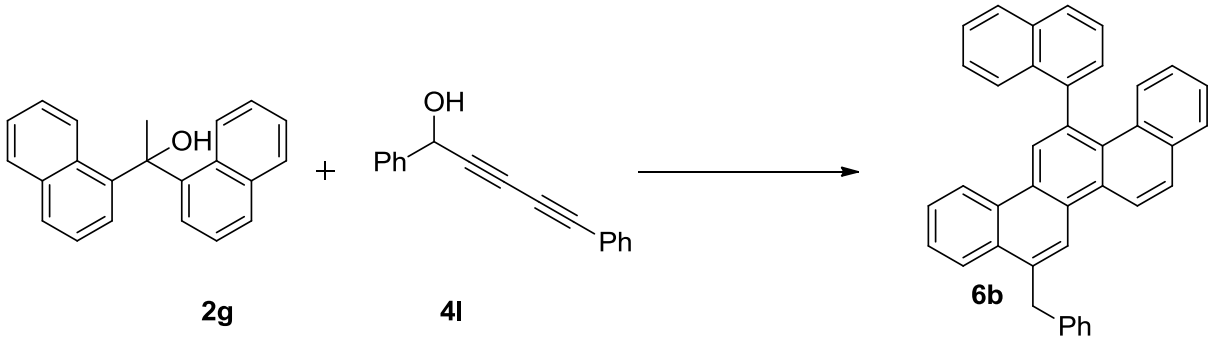
General procedure for the di cyclisation (6a-6d): To a stirred solution of 1,1 diarylehan-1-ol **2** (1.0 mmol) and bisacetylenic alcohol **4** (1.0 mmol) in 5 mL of acetonitrile was added *p*TSA (5 mol%) at room temperature and stirred for 10 min, after the completion of starting material DBU (1.0 mmol) was added to the reaction mixture at room temperature and stirred at 80 ^oC for 12 h. After the completion of reaction (monitored by TLC), the reaction mixture was concentrated under reduced pressure. Purified by column chromatography on silica gel (EtOAc: hexanes) to afford corresponding polycyclic aromatic hydrocarbons.



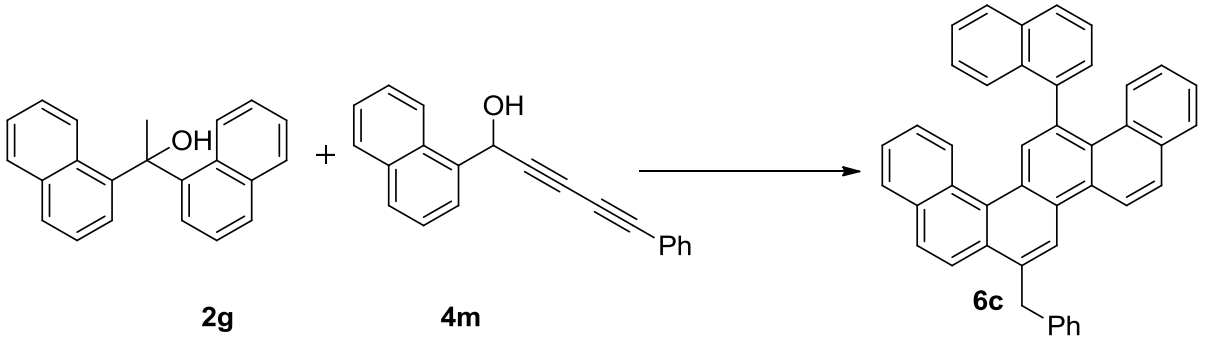
2a **4l** **6a**

6-Benzyl-12-phenyl chrysene (6a): 59 mg, 70% yield, light brown solid; R_f = 0.4 (hexanes: EtOAc = 20:1) mp 196-198 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 8.79 (dd, *J* = 19.4, 8.4 Hz, 2H), 8.63 (d, *J* = 16.2 Hz, 2H), 8.14 (t, *J* = 7.8 Hz, 1H), 8.01 (d, *J* = 8.3 Hz, 1H), 7.71–7.61 (m, 4H), 7.60–7.54 (m, 4H), 7.51 (ddd, *J* = 6.9, 4.0, 2.2 Hz, 2H), 7.46 (d, *J* = 4.3 Hz, 1H), 7.30 (d, *J* = 4.4 Hz, 3H), 4.68 (s, 2H); ^{13}C NMR (100 MHz,

$CDCl_3$): δ 141.3, 138.9, 135.3, 131.0, 130.6, 130.3, 129.2, 128.7, 128.5, 128.4, 128.3, 127.4, 127.3, 127.1, 126.9, 126.6, 126.5, 126.4, 126.3, 126.2, 125.1, 123.7, 123.3, 122.6, 122.2, 40.2; IR (KBr): 3064, 1593, 1492, 1443, 1398, 1267, 1216, 1170, 1030, 882, 756, 701 cm^{-1}; MS (EI): *m/z* 394 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{31}H_{22}$ $(M)^+$: 394.1722, found: 394.1716.

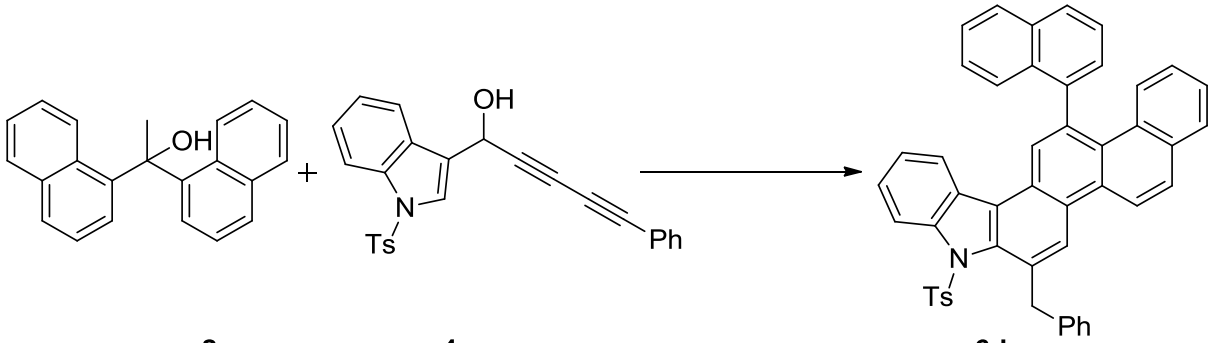


5-Benzyl-13-(naphthalen-1-yl)picene (6b): 66 mg, 73% yield, white solid; R_f = 0.6 (hexanes: EtOAc = 95:5) mp 211-213 ^oC; ^1H NMR (500 MHz, $CDCl_3$); δ 8.77 (d, *J* = 9.3 Hz, 1H), 8.71 (s, 1H), 8.67 (dd, *J* = 13.4, 6.2 Hz, 2H), 8.10–8.04 (m, 1H), 7.99–7.90 (m, 3H), 7.82 (d, *J* = 6.7 Hz, 1H), 7.54 (tdd, *J* = 16.6, 15.1, 7.7 Hz, 6H), 7.43–7.38 (m, 1H), 7.32–7.23 (m, 5H), 7.18–7.11 (m, 2H), 6.83 (ddd, *J* = 8.6, 6.9, 1.5 Hz, 1H), 4.65 (s, 2H).; ^{13}C NMR (125 MHz, $CDCl_3$): δ 143.7, 140.4, 136.4, 135.7, 134.0, 133.0, 132.2, 131.3, 130.7, 130.5, 129.8, 128.7, 128.7, 128.6, 128.3, 128.2, 128.0, 127.8, 127.7, 127.4, 126.9, 126.8, 126.7, 126.6, 126.5, 126.4, 126.3, 126.2, 126.1, 125.9, 125.4, 125.0, 123.8, 123.1, 121.7, 40.4; IR (KBr): 2924, 2854, 1457, 1261, 1180, 1079, 1025, 801, 780, 753, 695cm^{-1}; MS (EI): *m/z* 494 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{39}H_{26}$ $(M)^+$: 494.2035, found: 494.2027.



2g **4m** **6c**

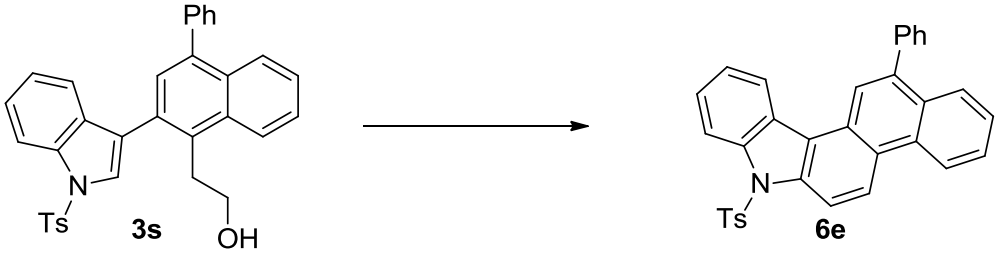
8-Benzyl-16-(naphthalen-1-yl)benzo[*a*]picene (6c): 64 mg, 71% yield, white solid; R_f = 0.2 (hexanes); mp 237-239 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 9.10 (t, *J* = 7.0 Hz, 1H), 8.91 (d, *J* = 8.6 Hz, 1H), 8.82 (d, *J* = 9.3 Hz, 1H), 8.78 (s, 1H), 8.02–7.97 (m, 2H), 7.94–7.83 (m, 5H), 7.79 (d, *J* = 8.9 Hz, 1H), 7.66 (d, *J* = 8.7 Hz, 1H), 7.55–7.41 (m, 5H), 7.35–7.23 (m, 6H), 7.18–7.15 (m, 1H), 6.89 (ddd, *J* = 8.5, 6.9, 1.4 Hz, 1H), 4.68 (d, *J* = 37.1 Hz, 2H).; ^{13}C NMR (125 MHz, $CDCl_3$): δ 143.4, 140.6, 135.3, 134.6, 134.2, 133.1, 133.0, 132.1, 131.9, 130.5, 130.3, 130.2, 130.1, 129.6, 129.5, 128.8, 128.8, 128.7, 128.6, 128.4, 128.2, 128.2, 128.0, 127.8, 127.6, 127.2, 126.2, 126.1, 126.0, 125.9, 125.3, 123.7, 122.6, 121.6, 40.5.; IR (KBr): 2923, 1598, 1498, 1450, 1214, 825, 787, 752, 698 cm^{-1}; MS (EI): *m/z* 544 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{43}H_{28}$ $(M)^+$: 544.2191, found: 544.2187.



2g **4n** **6d**

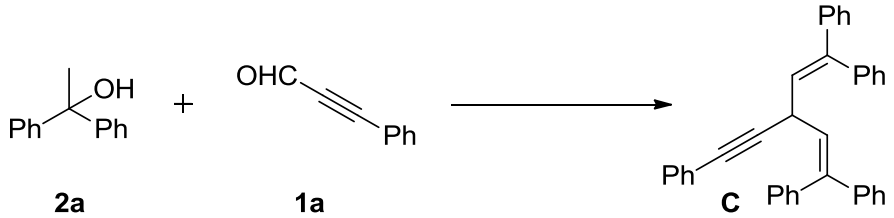
8-Benzyl-15-(naphthalen-1-yl)-9-tosyl-9H-phenanthro[1,2-*c*]carbazole (6d): 89 mg, 78% yield, white color solid; R_f = 0.2 (hexanes), mp 192-195 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): δ 8.66 (d, *J* = 9.3 Hz, 1H), 8.62 (s, 1H), 8.54 (s, 1H), 8.29 (d, *J* = 8.1 Hz, 1H), 8.08–7.91 (m, 4H),

7.86 (d, *J* = 7.9 Hz, 1H), 7.68–7.57 (m, 2H), 7.52 (dd, *J* = 8.6, 2.7 Hz, 2H), 7.49–7.43 (m, 1H), 7.43–7.37 (m, 1H), 7.37–7.26 (m, 6H), 7.22 (dddd, *J* = 9.7, 8.3, 4.7, 0.9 Hz, 2H), 6.98 (d, *J* = 8.4 Hz, 2H), 6.87 (ddd, *J* = 8.5, 6.9, 1.4 Hz, 1H), 6.74 (d, *J* = 8.1 Hz, 2H), 5.07 (q, *J* = 16.3 Hz, 2H), 2.08 (s, 3H).; ^{13}C NMR (75 MHz, $CDCl_3$): *δ* 144.3, 143.3, 142.0, 141.6, 140.01, 137.2, 134.0, 133.9, 133.0, 132.0, 131.6, 130.5, 130.4, 129.9, 129.6, 129.1, 128.7, 128.6, 128.5, 128.3, 128.2, 128.1, 127.9, 127.5, 127.0, 126.9, 126.8, 126.3, 126.1, 125.9, 125.9, 125.8, 125.4, 125.0, 122.3, 121.9, 119.7, 40.6, 29.7, 21.4.; IR (KBr): 2924, 1597, 1489, 1447, 1176, 1092, 809, 754, 698 cm^{-1}; MS (EI): *m/z* 687 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{48}H_{33}NO_2S$ $(M)^+$: 687.2232, found: 687.2230.



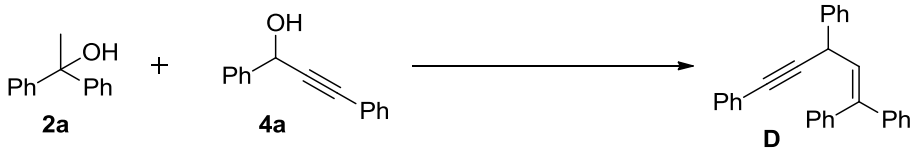
13-Phenyl-7-tosyl-7*H*-naphtho[1,2-*c*]carbazole (6e): To a stirred solution of 2-(4-phenyl-2-(1-tosyl-1*H*-indol-3-yl)naphthalen-1-yl)ethanol **3s** (1.0 mmol) in 5 mL of acetonitrile was added IBX (1.2 mmol) at room temperature and was stirred at 80 ^{o}C for 2 h. After the completion of reaction (monitored by TLC), the reaction mixture was filtered through celite and filtrate was washed with aqueous $NaHCO_3$ (2 x 10 mL), the organic layer was separated dried over Na_2SO_4 and concentrated under reduced pressure to afford 2-(4-phenyl-2-(1-tosyl-1*H*-indol-3-yl)naphthalen-1-yl)acetaldehyde. To the crude aldehyde, was added *p*TSA (5 mol%) at room temperature in 5 mL acetonitrile and stirred for 1 h. The reaction mixture was concentrated under reduced pressure and purified by column chromatography on silica gel (EtOAc: hexanes) to afford the corresponding naphtha carbazole **7e** in 82% yield as pale yellow solid; R_f = 0.6 (hexanes: EtOAc = 9:1) mp 218-221 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$): *δ* 8.87 (dd, *J* = 18.8, 8.8 Hz, 2H), 8.75 (d, *J* = 9.3 Hz, 1H), 8.62 (s, 1H), 8.52 (d, *J* = 8.3 Hz, 1H), 8.45 (d, *J* = 7.9 Hz, 1H), 7.95 (dd, *J* = 8.2, 0.8 Hz, 1H), 7.77–7.68 (m, 3H), 7.63–7.59 (m, 2H), 7.59–7.49 (m, 5H), 7.47–7.42 (m, 1H), 7.06 (t, *J* = 8.0 Hz, 2H), 2.22 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): *δ* 145.0, 141.0, 140.9, 140.8, 140.75, 140.4, 138.6, 138.2, 137.4, 137.3, 134.9, 131.0, 130.1, 129.7, 128.4, 127.6, 127.1,

127.0, 126.8, 126.5, 126.4, 126.2, 124.3, 123.1, 122.9, 122.6, 121.1, 115.4, 114.5, 21.5; IR (KBr): 2923, 1601, 1496, 1444, 1370, 1245, 1219, 1171, 1091, 1046, 748, 668 cm^{-1}; MS (EI): *m/z* 497 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{33}H_{23}NO_2S$ $(M)^+$: 497.1449, found: 497.1443.



2a **1a** **C**

(3-(Phenylethynyl)penta-1,4-diene-1,1,5,5-tetrayl)tetrabenzene (C): 37 mg, 19% yield, white solid; R_f = 0.2 (hexanes), mp 84-86 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 7.46–7.39 (m, 2H), 7.32–7.21 (m, 13H), 7.21–7.12 (m, 6H), 7.04 (ddd, *J* = 7.0, 6.5, 4.8 Hz, 4H), 6.15 (d, *J* = 9.7 Hz, 2H), 4.29 (t, *J* = 9.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.2, 141.8, 138.8, 131.6, 129.6, 128.1, 128.1, 128.0, 127.7, 127.7, 127.4, 127.1, 127.0, 123.6, 90.5, 82.2, 33.0; IR (KBr): 3022, 1597, 1505, 1444, 1380, 1074, 1030, 903, 764, 699 cm^{-1}; MS (EI): *m/z* 472 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{37}H_{28}$ $(M)^+$: 472.2191, found: 472.2187.

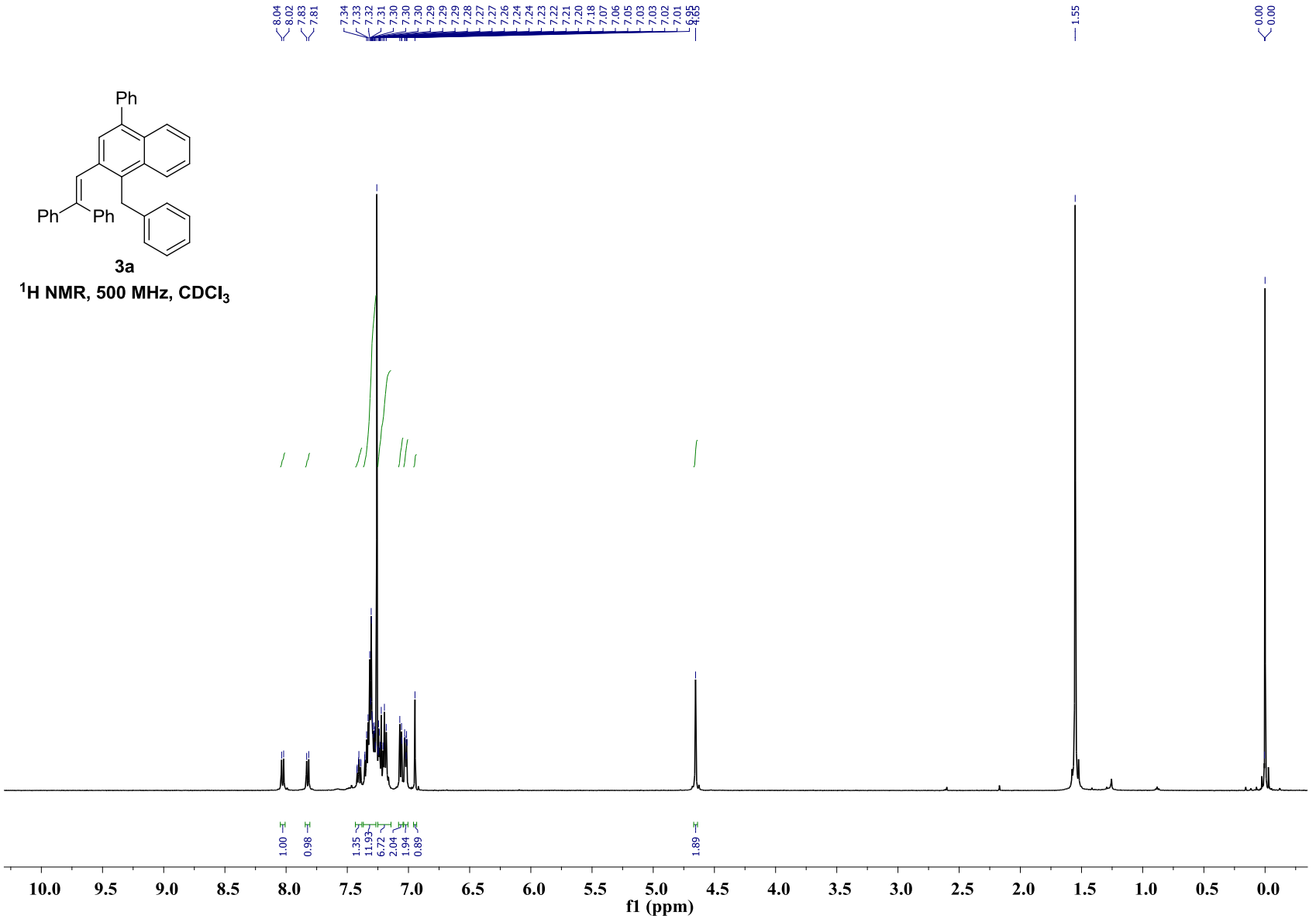


2a **4a** **D**

Pent-1-en-4-yne-1,1,3,5-tetrayltetrabenzene (D): 82 mg, 92% yield, white solid; R_f = 0.2 (hexanes), mp 68-70 ^oC; ^1H NMR (500 MHz, $CDCl_3$): δ 7.51–7.41 (m, 6H), 7.40–7.28 (m, 8H), 7.28–7.23 (m, 6H), 6.22 (d, *J* = 10.1 Hz, 1H), 4.72 (d, *J* = 10.1 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 141.7, 140.6, 139.1, 131.7, 129.9, 128.5, 128.4, 128.2, 128.1, 127.8, 127.5, 127.4, 127.4, 126.8, 123.5, 89.7, 83.9, 37.8; IR (KBr): 3023, 2311, 1758, 1598, 1493, 1445, 1214, 1029, 747 cm^{-1}; MS (EI): *m/z* 370 $(M)^+$; HRMS (EI): *m/z* calcd for $C_{29}H_{22}$ $(M)^+$: 370.1722, found: 370.1710.

References:

1) a) C. R. Reddy, R. R. Valleti, M. D. Reddy, *J. Org. Chem.*, **2013**, *78*, 6495-6502; b) S. Serra, C. Fuganti, *Synett* **2003**, *13*, 2005-2010; c) C. R. Reddy, M. D. Reddy *Org. Biomol. Chem*. **2012**, *10*, 4280-4288.
2) a) F. Gao, X.-J. Deng, Y. Tang, J.-P. Tang, J. Yang, Y.-M. Zhang, *Tetrahedron Lett.* **2014**, *55*, 880–883; b) R. Matsumoto, H. Nishino, *Syn. Comm*, **2015**, *45*, 1807.
3) a) C. R. Reddy, J. Vijaykumar, R. Grée, *Synthesis*, **2013**, *45*, 0830-0836; b) C. R. Reddy, R. R. Valleti, U. Dilipkumar, *Chem. Eur. J.* **2016**, 22, 2501-2506; c) H. Huang, H. Jiang, H. Cao, J. Zhao, D. Shi, *Tetrahedron* **2012**, *68*, 3135-3144; d) C. F. Xu, M. Xu, L. Q. Yang, C. Y. Li, *J. Org. Chem*. **2012**, *77*, 3010-3016; e) H. Yamabe, A. Mizuno, H. Kusama, N. Iwasawa, *J. Am. Chem. Soc*. **2005**, *127*, 3248-3249; f) B. S. Chinta, B. Baire, *RSC Adv.* **2016**, *6*, 54449-54455.
4) Z.-X. Ma, S. He, W. Song, R. P. Hsung, *Org. Lett.* **2012**, *14*, 5736-5739.
5) X. Nie, G. Wang, *J. Org. Chem.* **2006**, *71*, 4734-4741.


Ph
Ph
Ph
3a
1H NMR, 500 MHz, CDCl3
8.04
8.02
7.83
7.81
7.34
7.33
7.32
7.31
7.30
7.30
7.30
7.29
7.29
7.29
7.28
7.27
7.27
7.26
7.24
7.24
7.23
7.22
7.21
7.20
7.18
7.07
7.06
7.05
7.03
7.03
7.02
7.01
6.85
6.85
1.55
0.00
0.00
1.00
0.98
1.35
11.93
6.72
2.04
1.94
0.89
1.89
10.0
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
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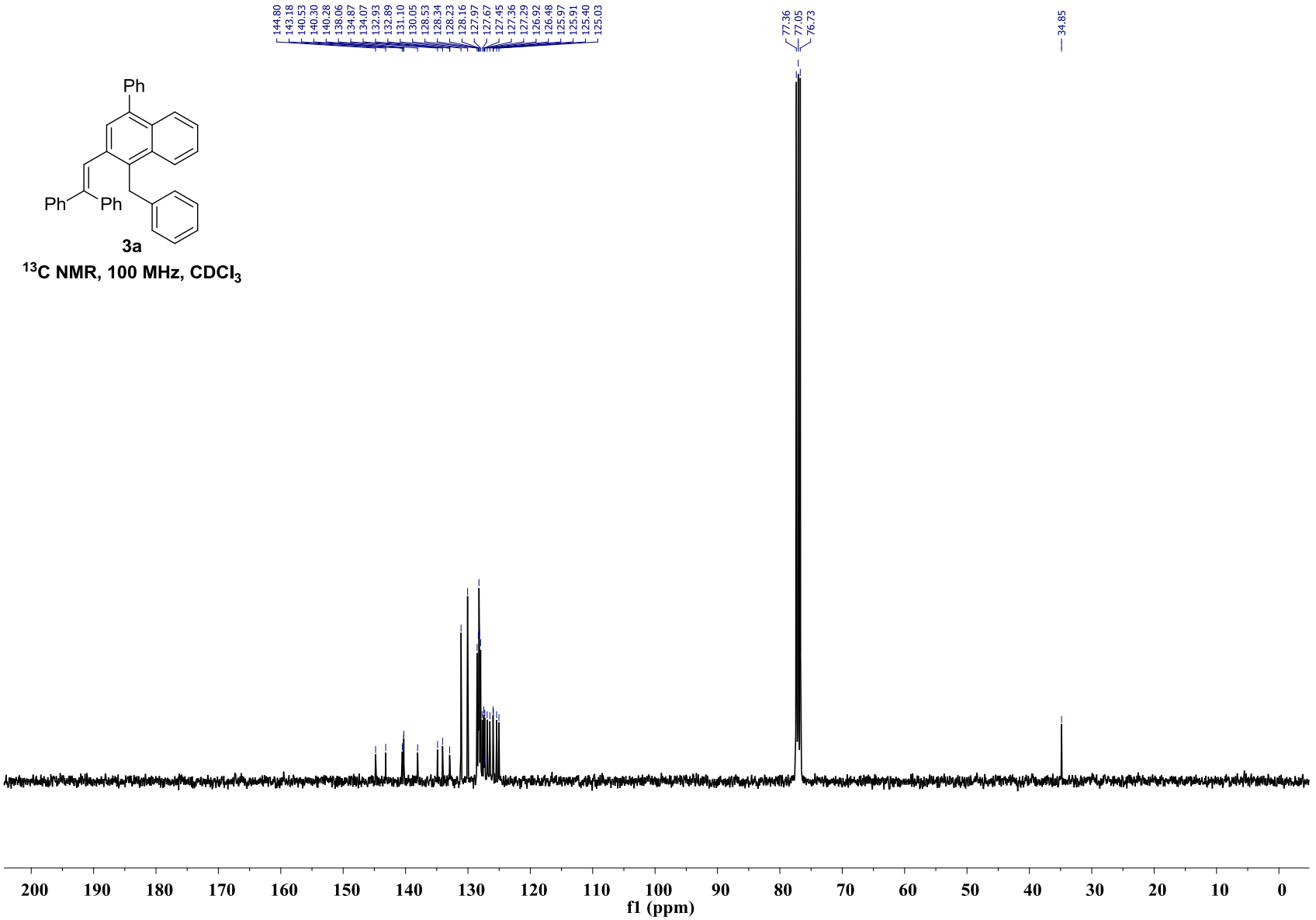
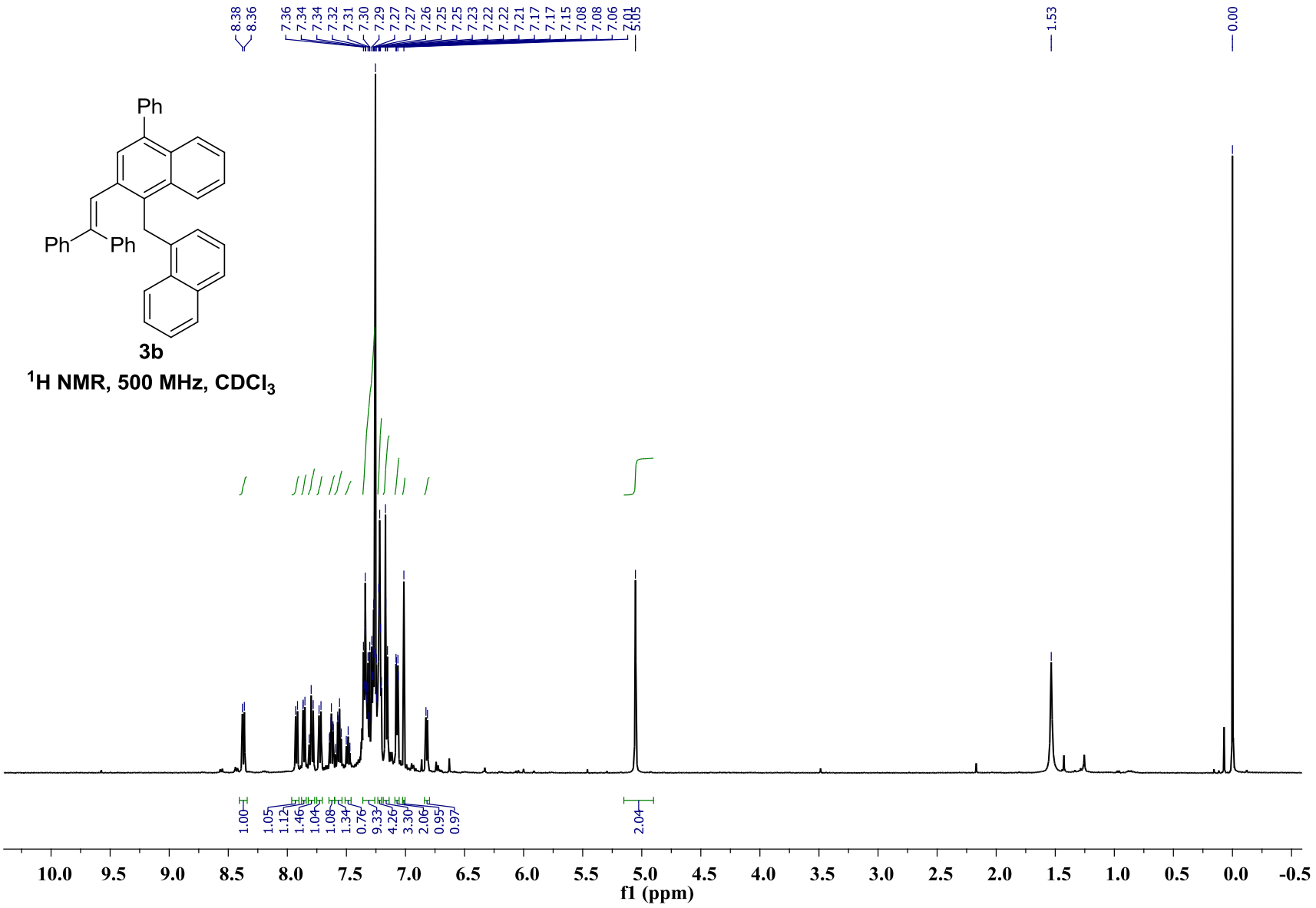
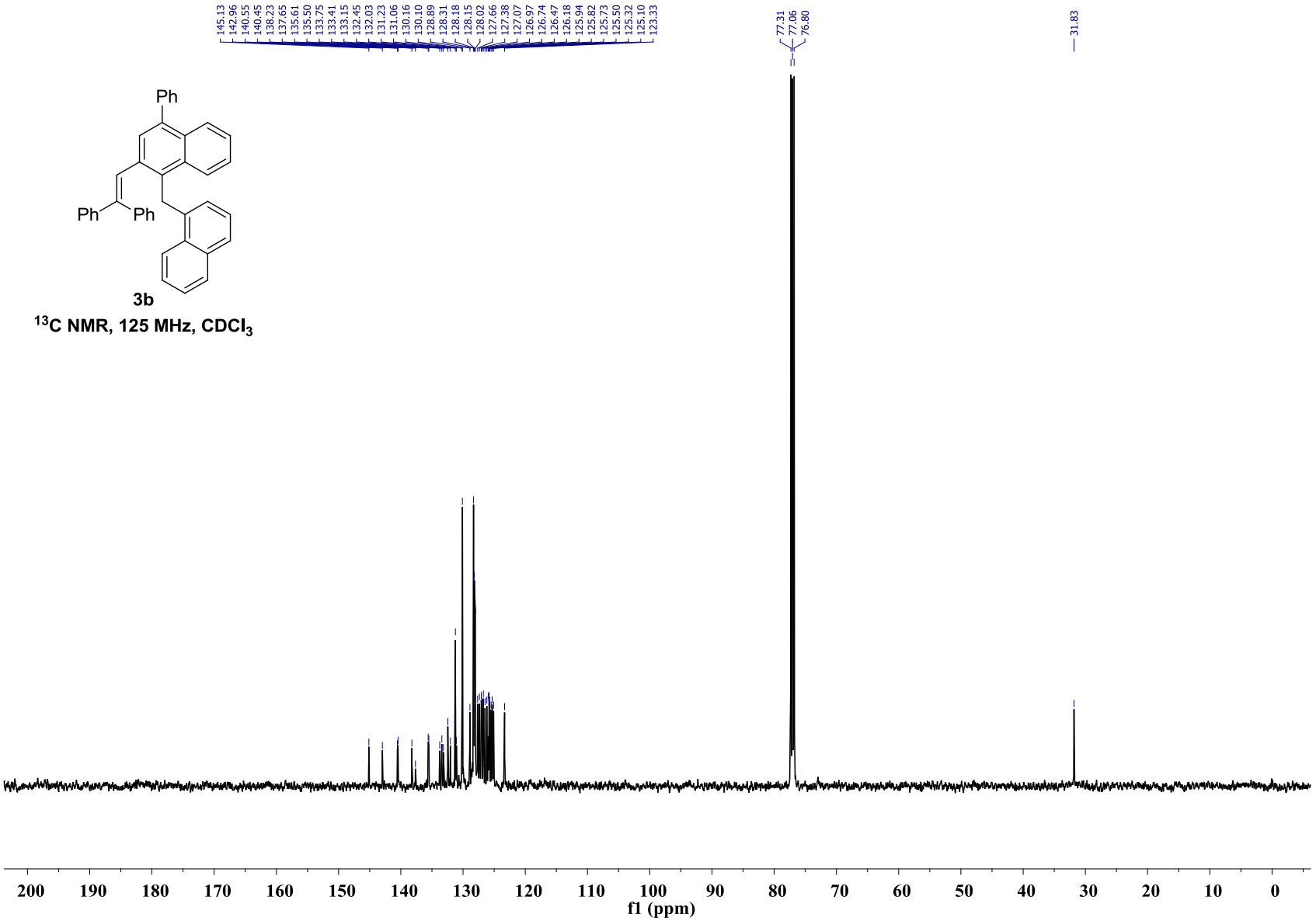
0.5
0.0
f1 (ppm)



3a

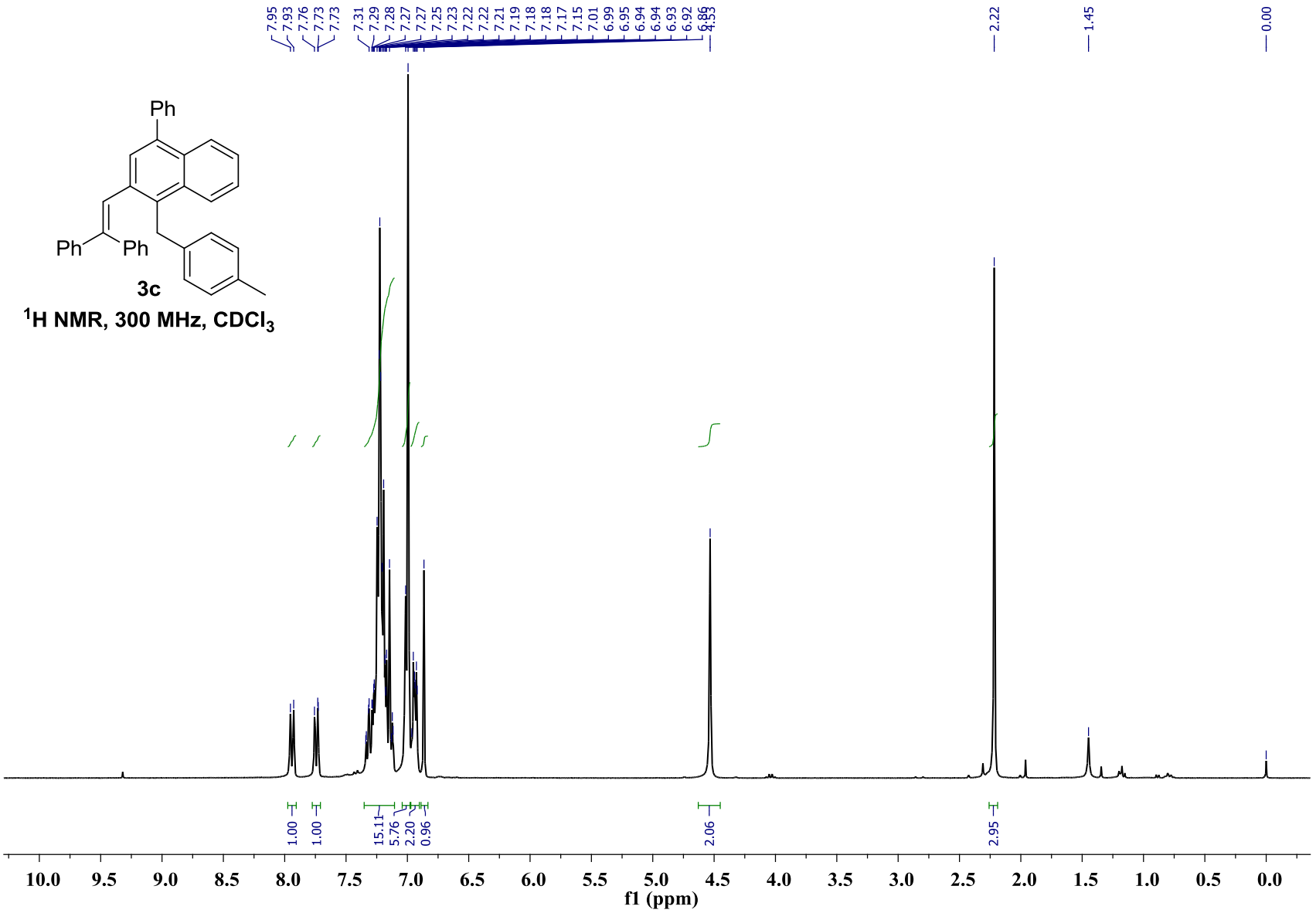
^{13}C NMR, 100 MHz, $CDCl_3$


Ph
Ph
Ph
3b
1H NMR, 500 MHz, CDCl3
8.38
8.36
7.36
7.34
7.34
7.32
7.31
7.30
7.29
7.27
7.27
7.26
7.25
7.25
7.23
7.22
7.22
7.21
7.17
7.17
7.15
7.08
7.08
7.06
7.01
5.05
1.53
0.00
1.00
1.05
1.12
1.46
1.04
1.08
1.34
0.76
9.33
4.26
3.30
2.06
0.95
0.97
2.04
10.0
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
0.0
-0.5
f1 (ppm)



3b

^{13}C NMR, 125 MHz, $CDCl_3$


Ph
Ph
Ph
3c
^{1}H NMR, 300 MHz, CDCl$_3$
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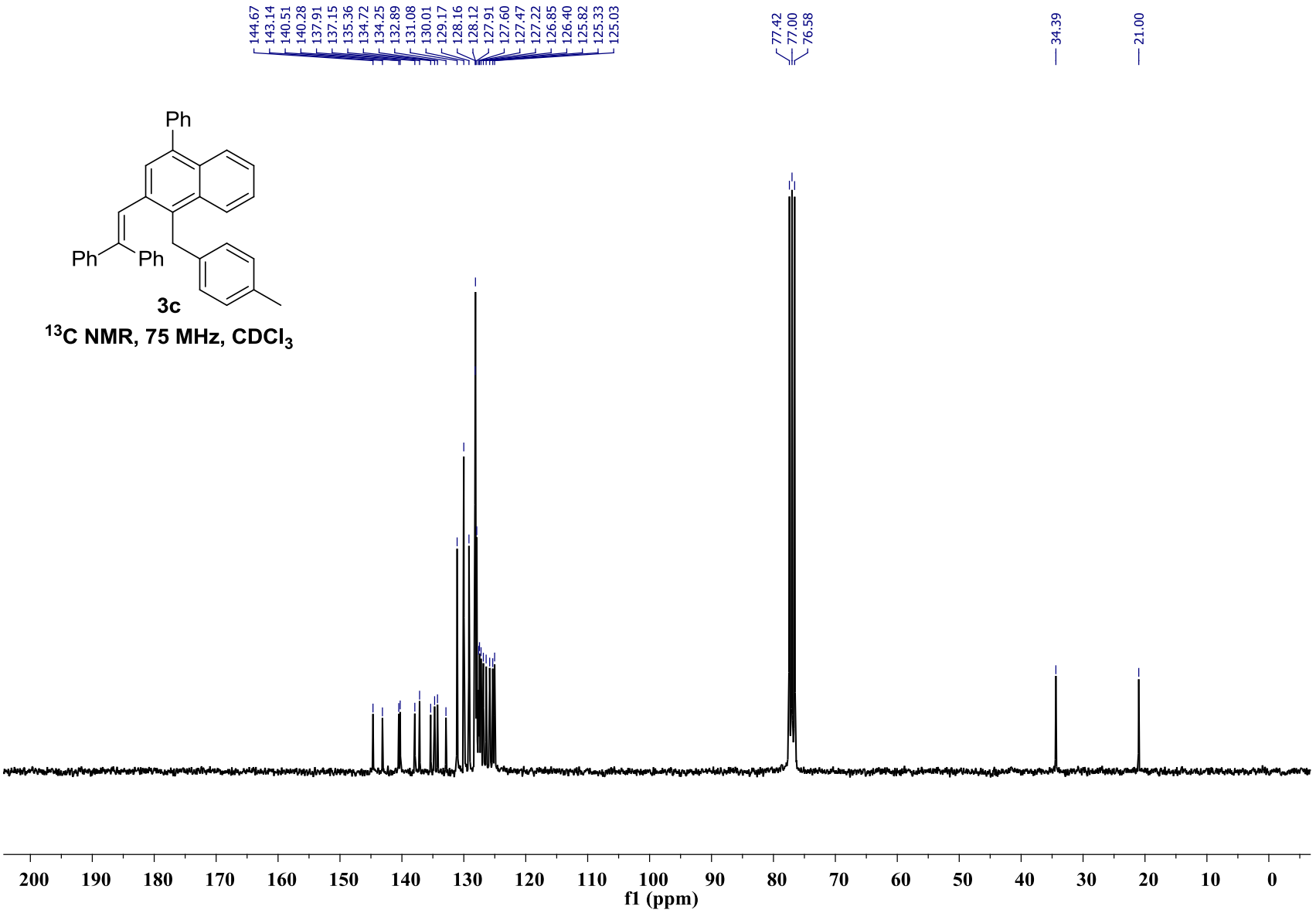
7.93
7.76
7.73
7.73
7.31
7.29
7.28
7.27
7.27
7.25
7.23
7.22
7.22
7.21
7.19
7.18
7.18
7.17
7.15
7.01
6.99
6.95
6.94
6.94
6.93
6.92
6.86
4.53
2.22
1.45
0.00
1.00
1.00
15.11
5.76
2.20
0.96
2.06
2.95
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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143.14
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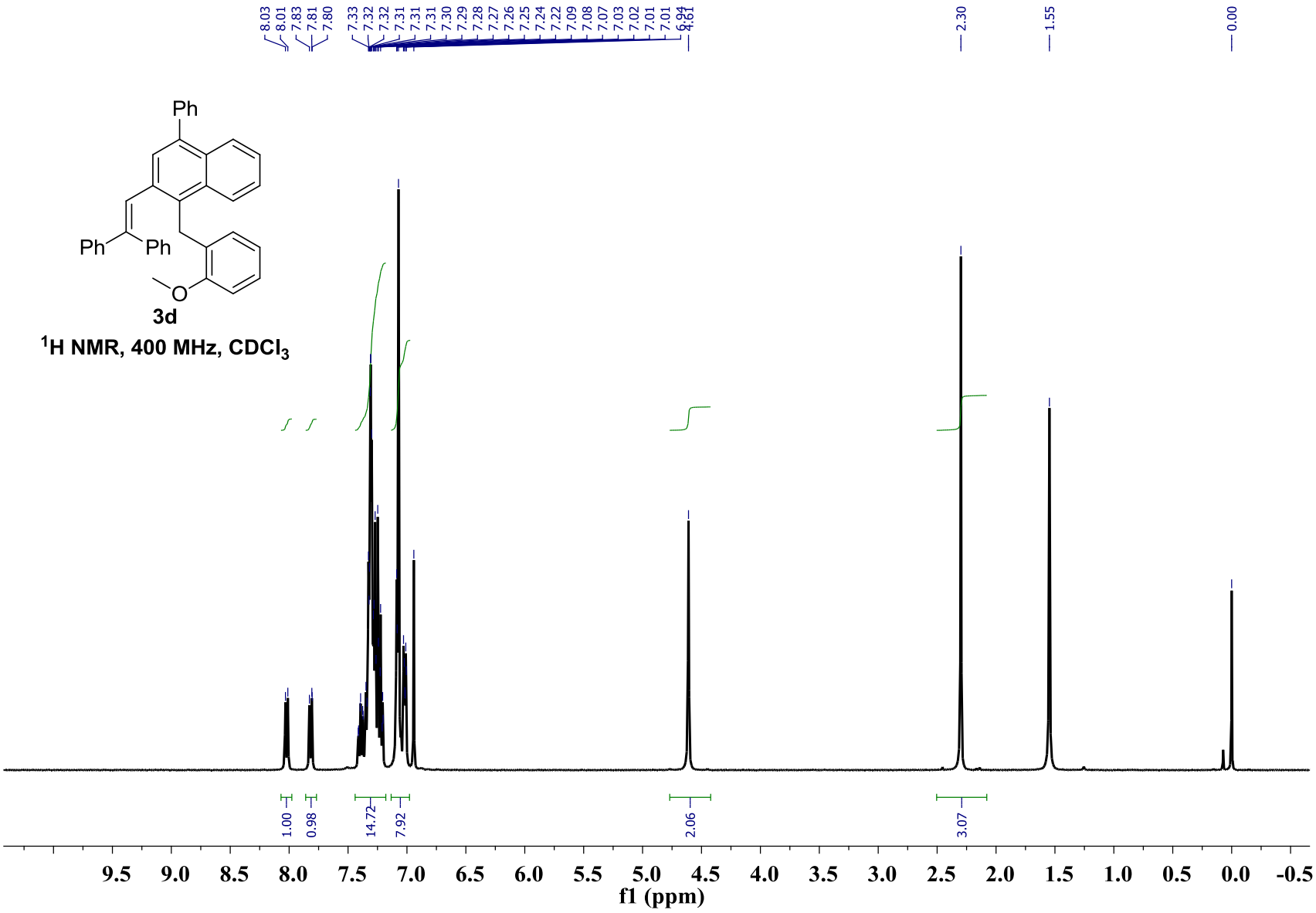
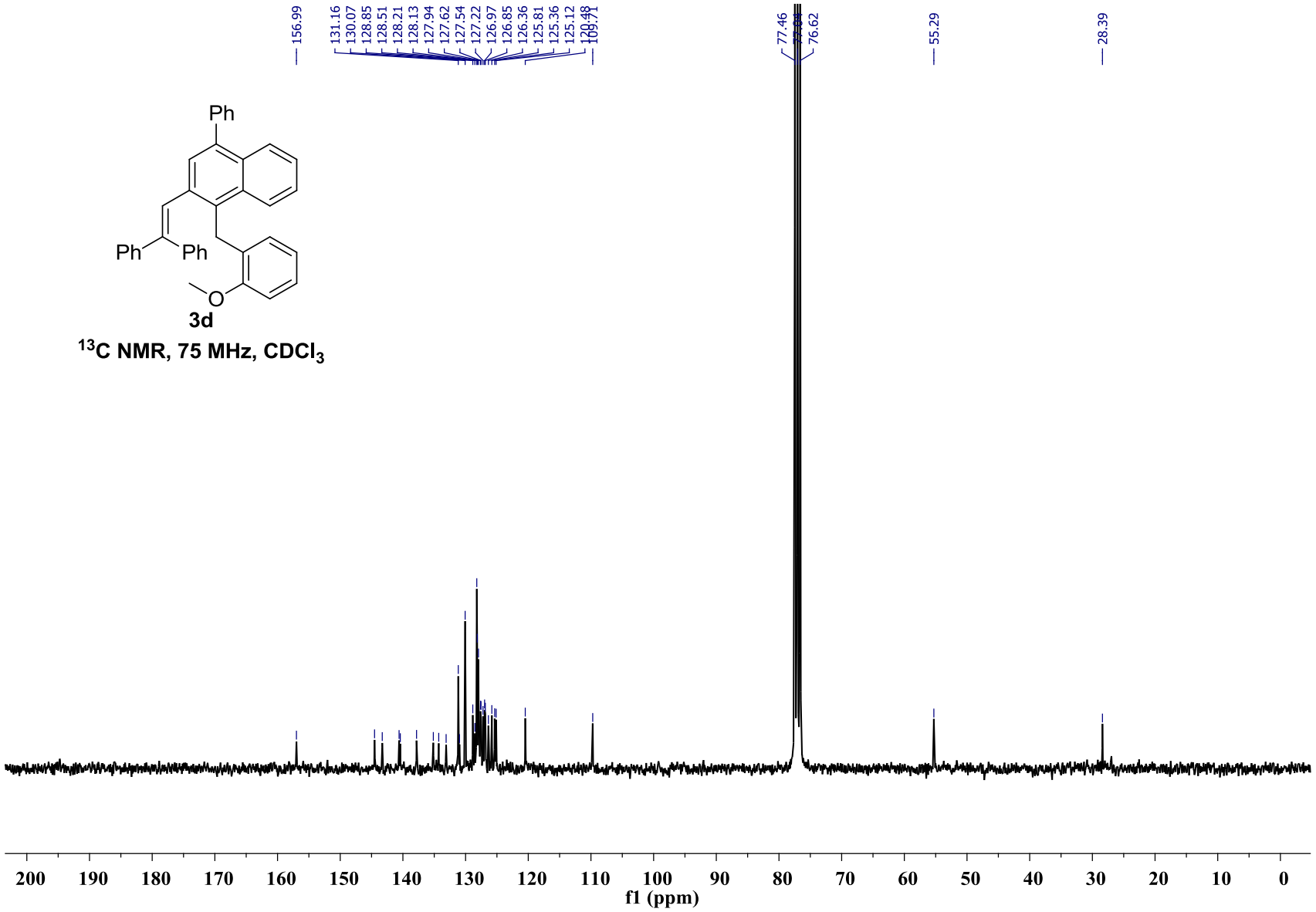
140.28
137.91
137.15
135.36
134.72
134.25
132.89
131.08
130.01
129.17
128.16
128.12
127.91
127.60
127.47
127.22
126.85
126.40
125.82
125.33
125.03
77.42
77.00
76.58
34.39
21.00
Ph
Ph
Ph
3c
13C NMR, 75 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.03
8.01
7.83
7.81
7.80
7.33
7.32
7.32
7.31
7.31
7.31
7.30
7.29
7.28
7.27
7.26
7.25
7.24
7.22
7.09
7.08
7.07
7.03
7.02
7.01
7.01
6.94
6.91
2.30
1.55
0.00
Ph
Ph
Ph
O
3d
1H NMR, 400 MHz, CDCl3
1.00
0.98
14.72
7.92
2.06
3.07
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 0.0 -0.5
f1 (ppm)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130.07
128.85
128.51
128.21
128.13
127.94
127.62
127.54
127.22
126.97
126.85
126.36
125.81
125.36
125.12
77.46
76.62
55.29
28.39
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Ph
Ph
O
3d
^{13}C NMR, 75 MHz, CDCl$_3$
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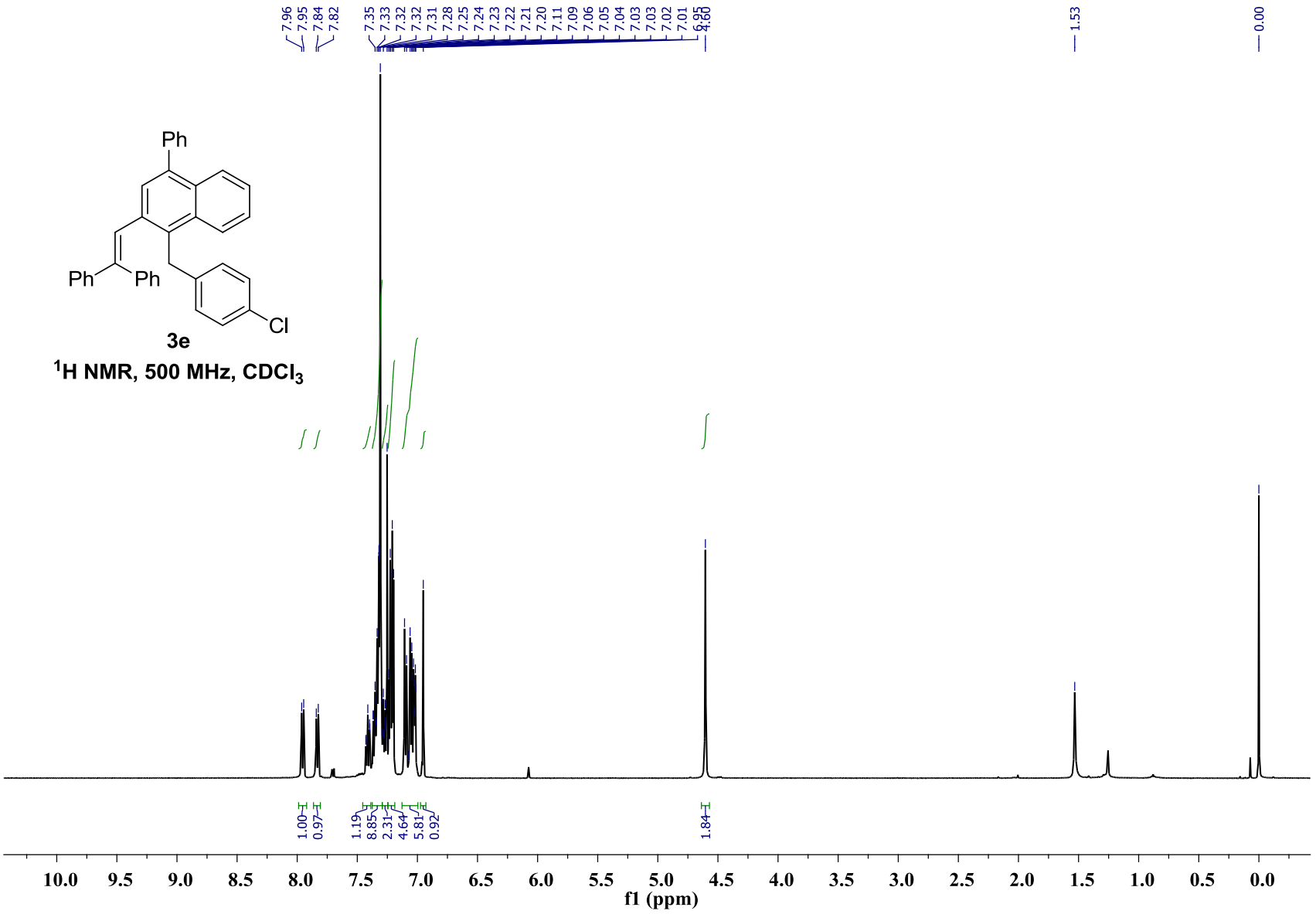
f1 (ppm)


Ph
Ph
Ph
Cl
3e
^{1}H NMR, 500 MHz, CDCl$_3$
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7.95
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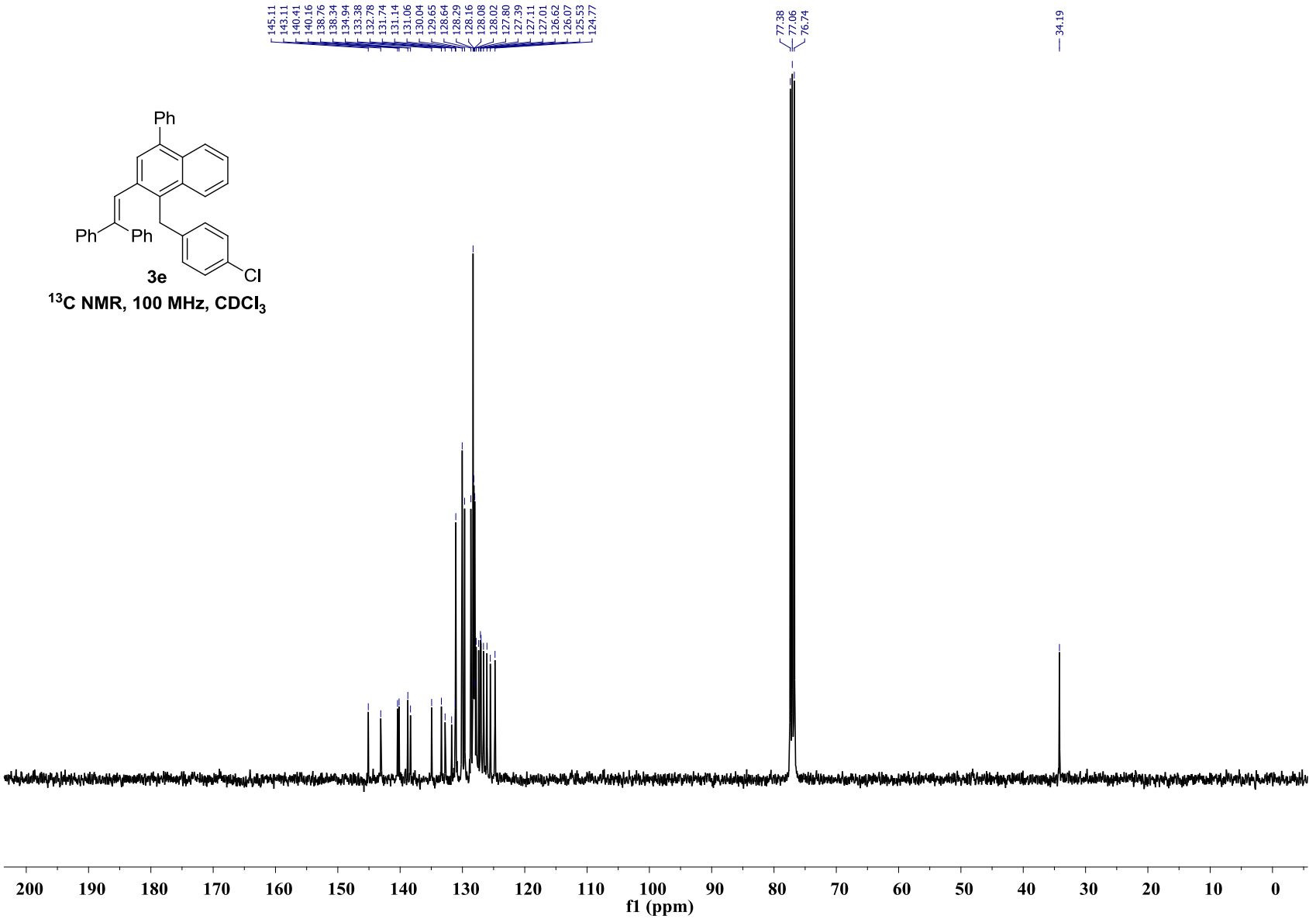
7.33
7.32
7.32
7.31
7.28
7.25
7.24
7.23
7.22
7.21
7.20
7.11
7.09
7.06
7.05
7.04
7.03
7.03
7.02
7.01
6.95
6.80
1.53
0.00
1.00
0.97
1.19
8.85
2.31
4.64
5.81
0.92
1.84
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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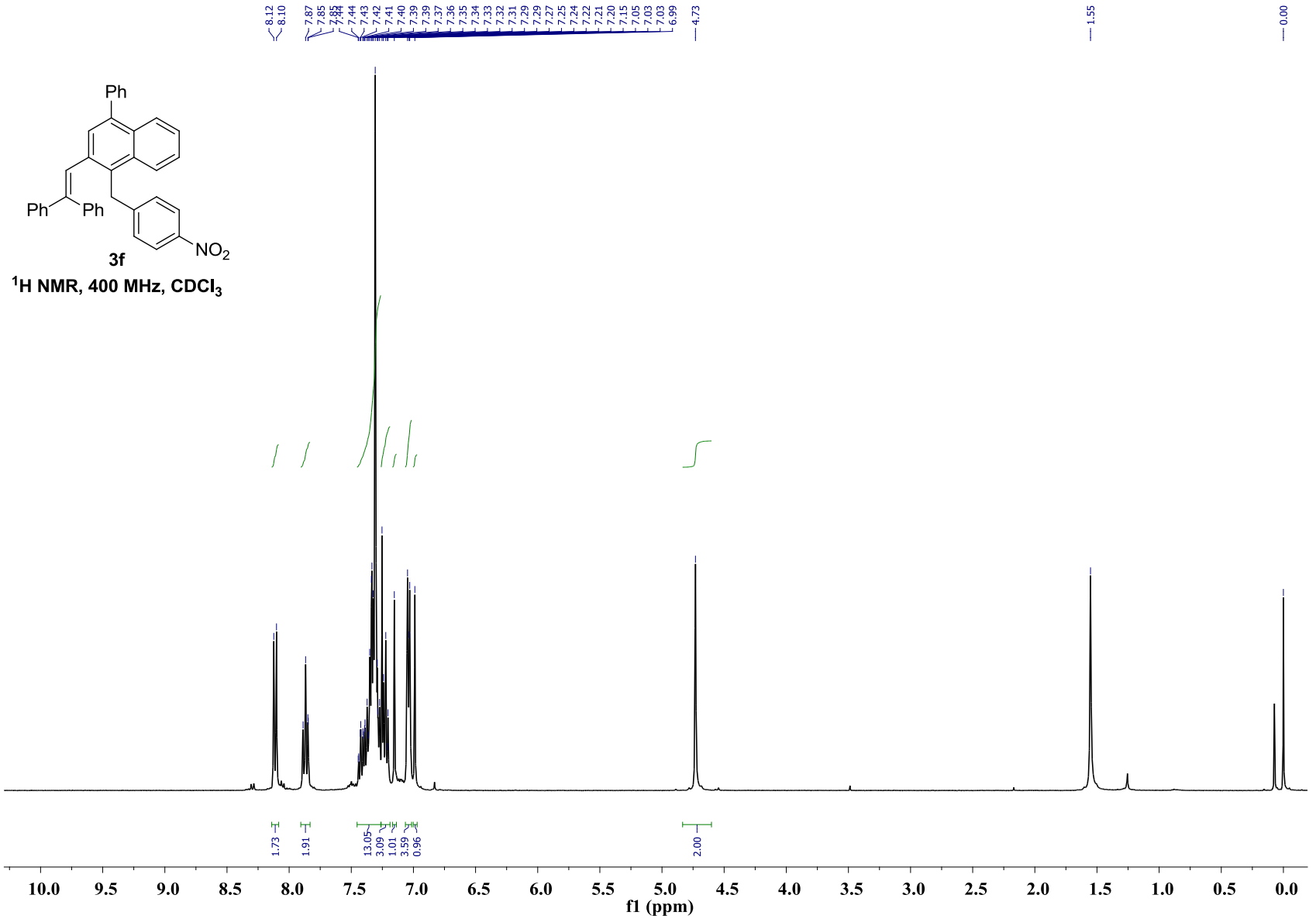
143.11
140.41
140.16
138.76
138.34
134.94
133.38
132.78
131.74
131.14
131.06
130.04
129.65
128.64
128.29
128.16
128.08
128.02
127.80
127.39
127.11
127.01
126.62
126.07
125.53
124.77
77.38
77.06
76.74
34.19
Ph
Ph
Ph
Cl
3e
^{13}C NMR, 100 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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Ph
Ph
NO2
3f
1H NMR, 400 MHz, CDCl3
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7.85
7.44
7.43
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7.39
7.39
7.37
7.36
7.35
7.34
7.33
7.32
7.31
7.29
7.29
7.27
7.25
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7.20
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7.05
7.03
7.03
6.99
4.73
1.55
0.00
1.73
1.91
13.05
3.09
1.01
3.59
0.96
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
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3.5
3.0
2.5
2.0
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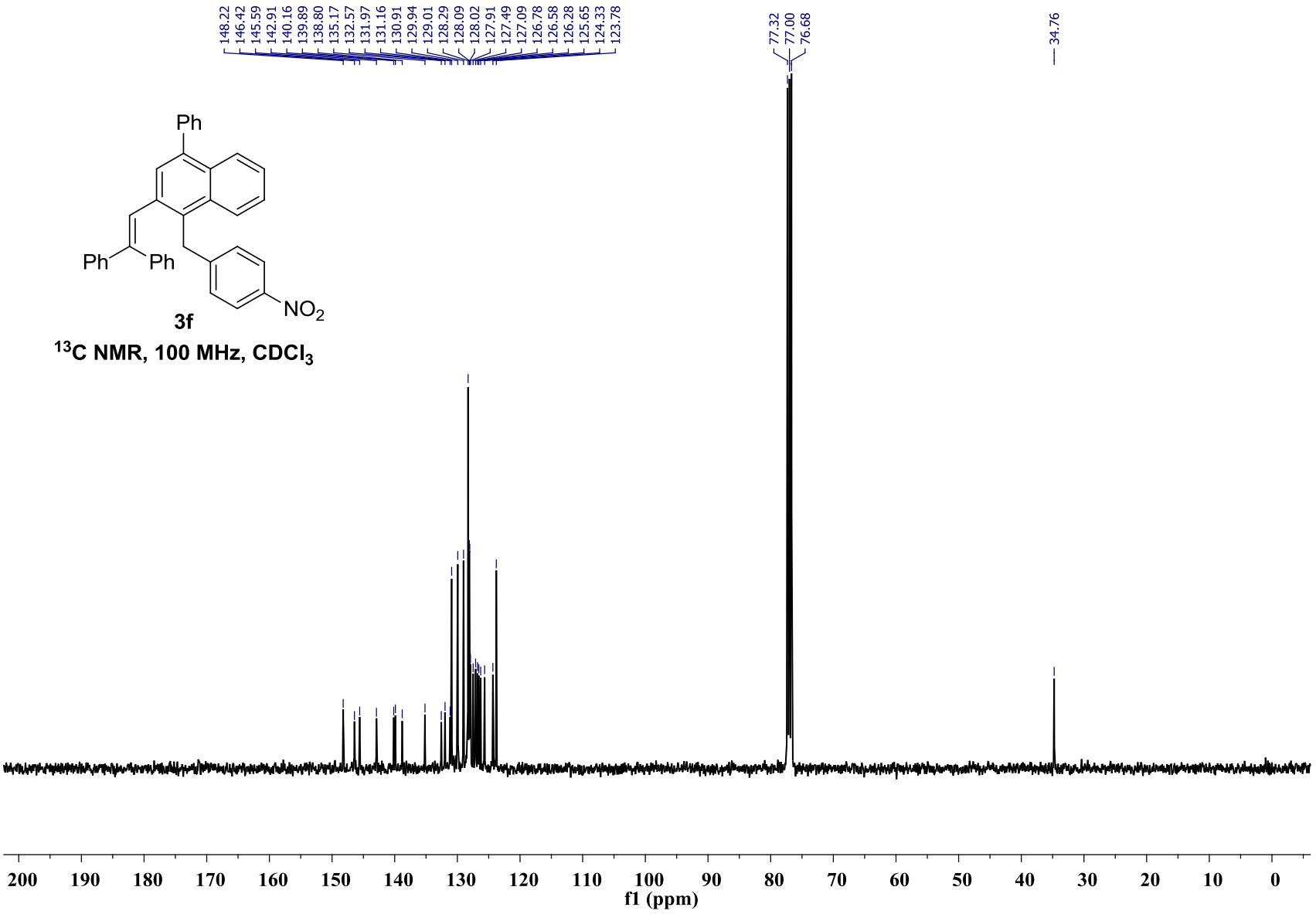
0.0
f1 (ppm)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139.89
138.80
135.17
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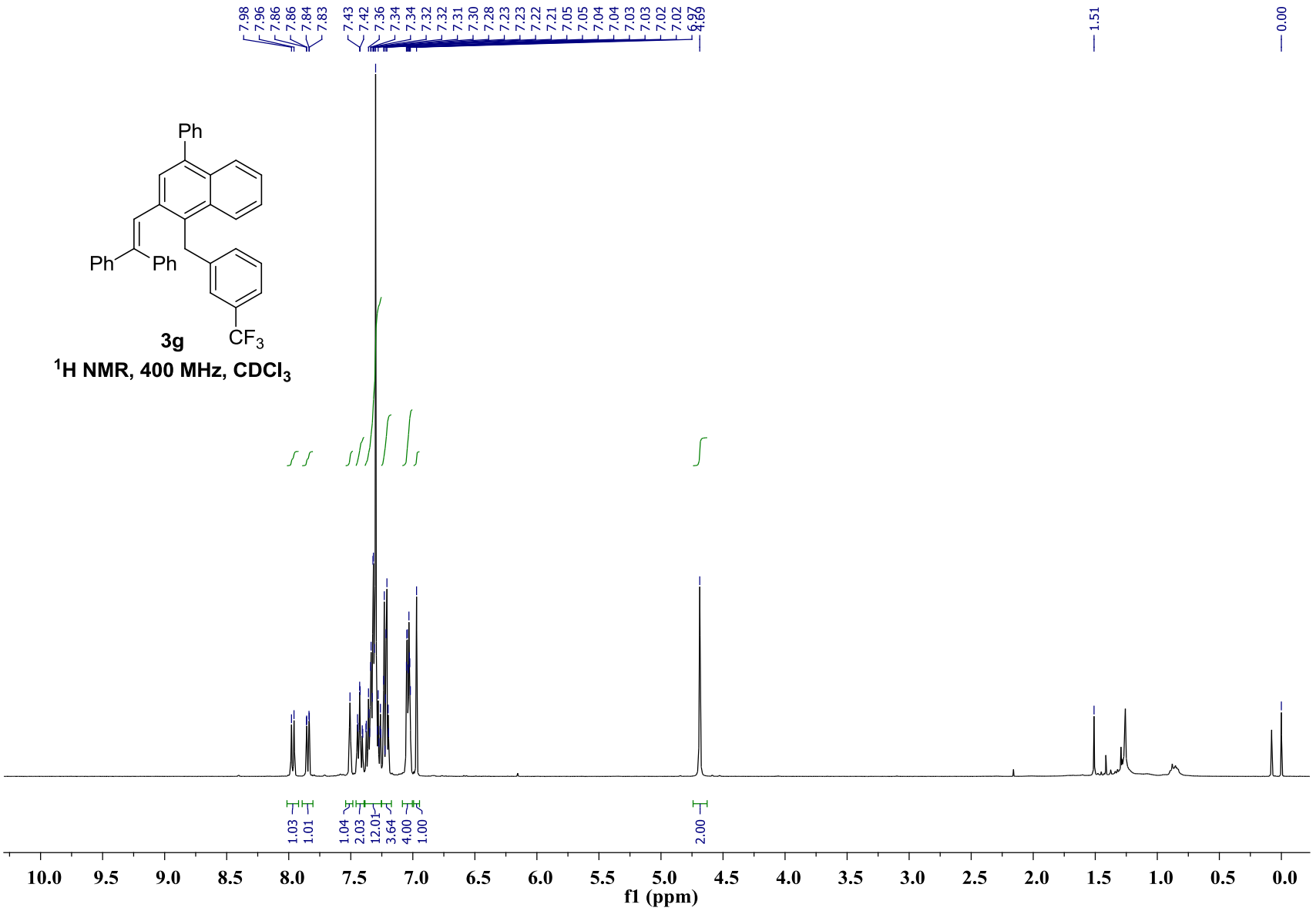
131.16
130.91
129.94
129.01
128.29
128.09
128.02
127.91
127.49
127.09
126.78
126.58
126.28
125.65
124.33
123.78
77.32
77.00
76.68
34.76
Ph
Ph
Ph
NO2
3f
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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Ph
Ph
CF3
3g
1H NMR, 400 MHz, CDCl3
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7.83
7.43
7.42
7.36
7.34
7.34
7.32
7.32
7.31
7.30
7.28
7.23
7.23
7.22
7.21
7.05
7.05
7.04
7.04
7.03
7.03
7.02
7.02
6.97
6.89
1.51
0.00
1.03
1.01
1.04
2.03
12.01
3.64
4.00
1.00
2.00
10.0
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
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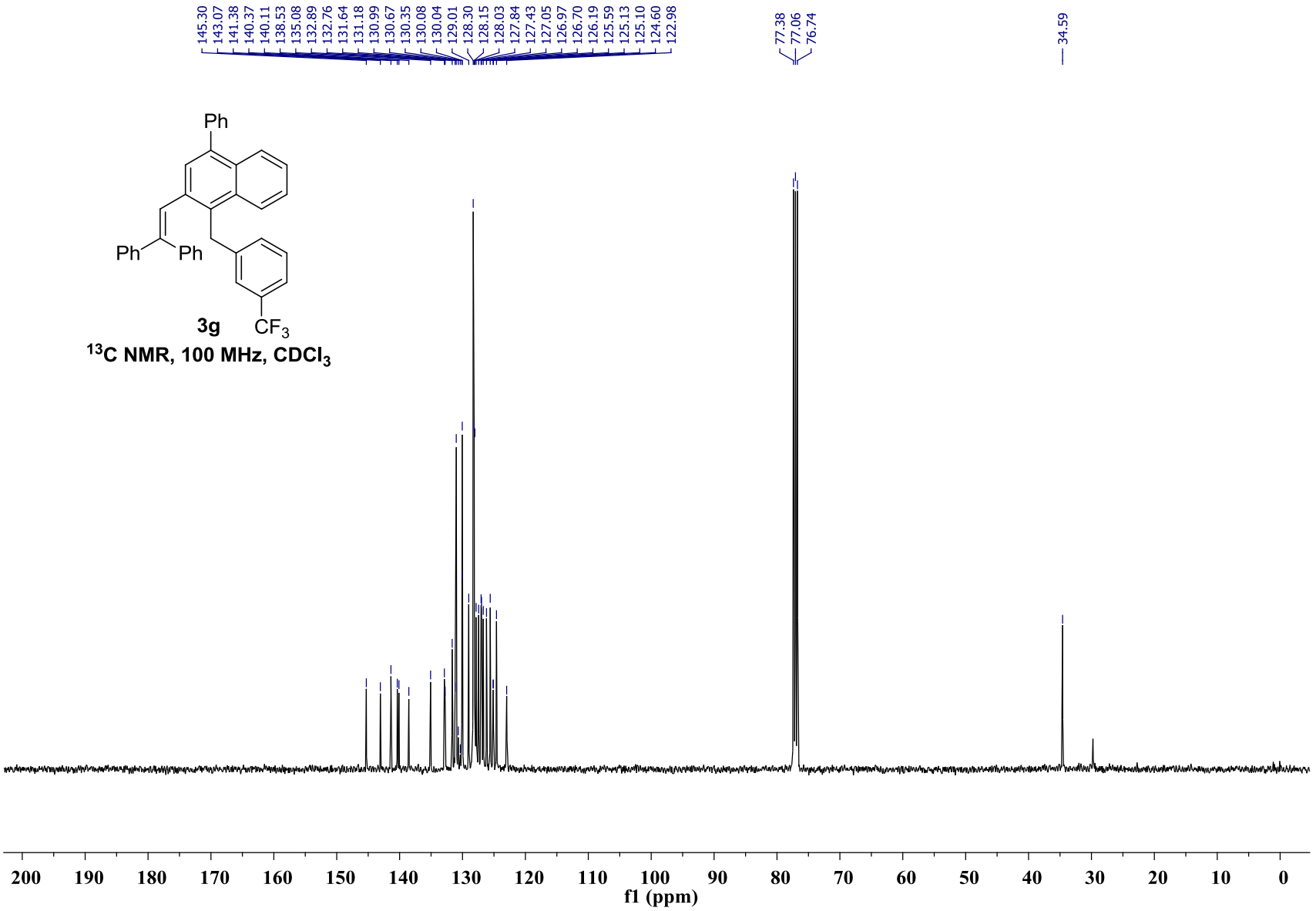
0.0
f1 (ppm)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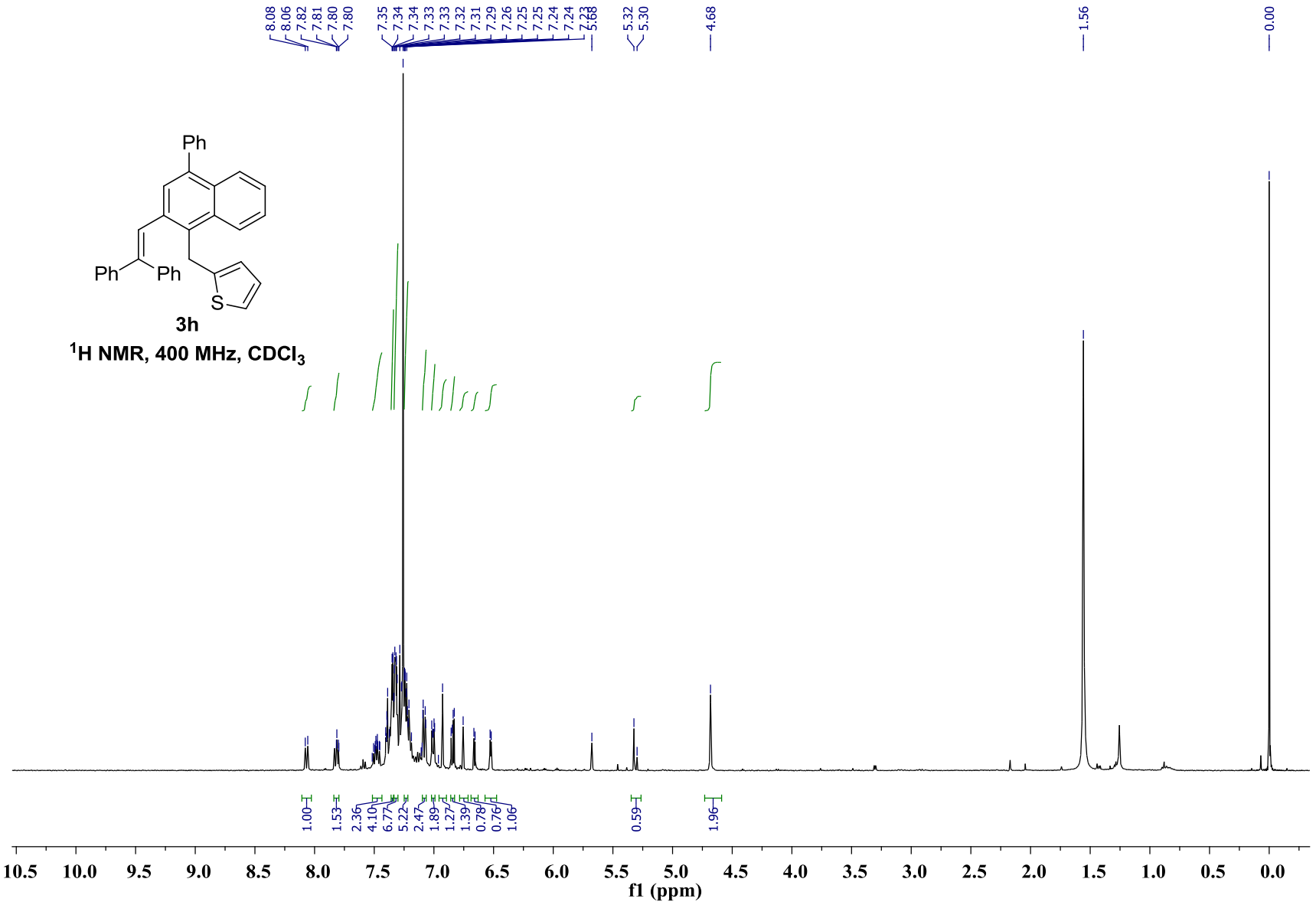
130.67
130.35
130.08
130.04
129.01
128.30
128.15
128.03
127.84
127.43
127.05
126.97
126.70
126.19
125.59
125.13
125.10
124.60
122.98
77.38
77.06
76.74
34.59
Ph
Ph
Ph
CF3
3g
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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Ph
Ph
S
3h
^{1}H NMR, 400 MHz, CDCl$_3$
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8.06
7.82
7.81
7.80
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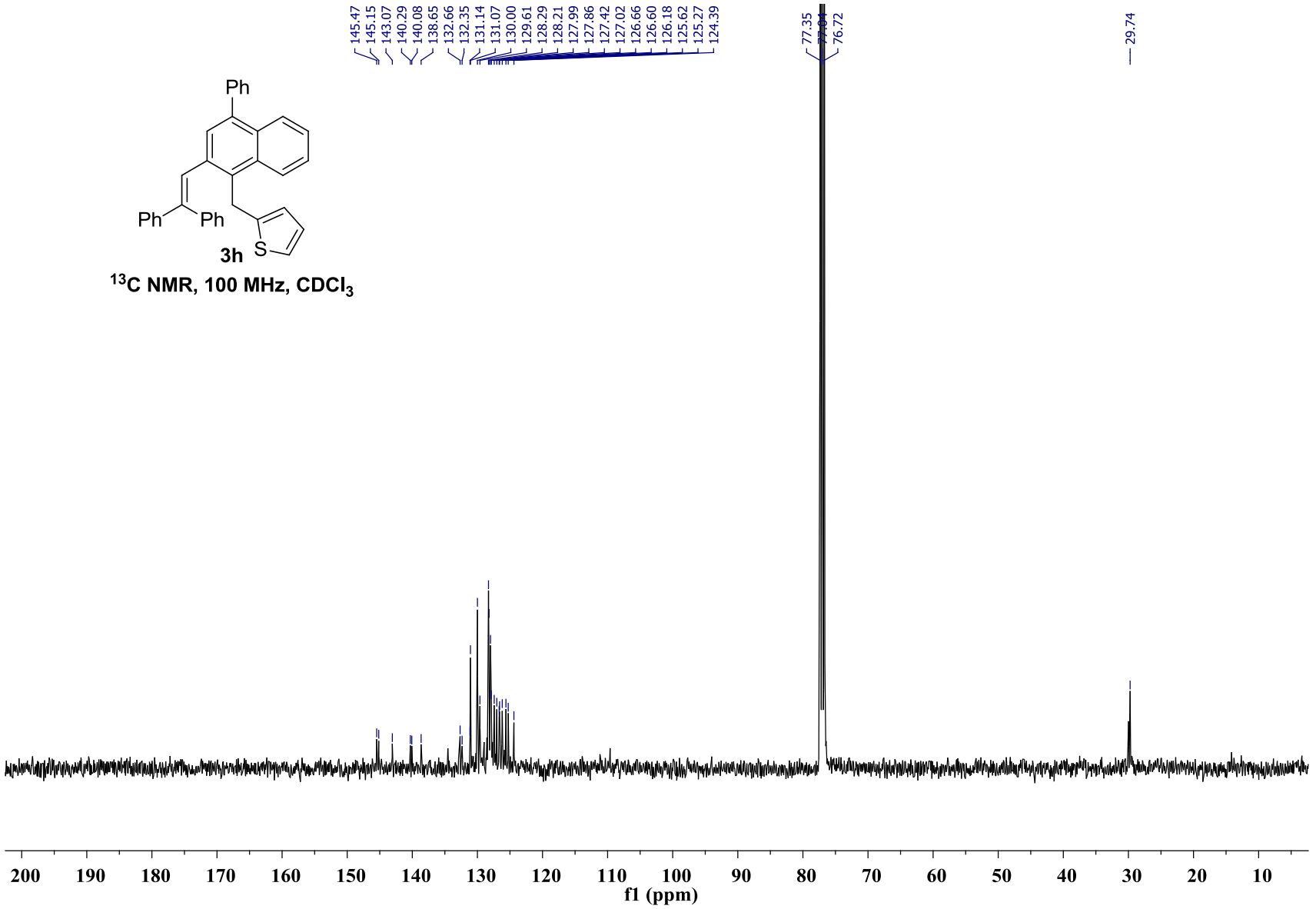
7.35
7.34
7.34
7.33
7.33
7.32
7.31
7.29
7.26
7.25
7.25
7.24
7.24
7.23
5.68
5.32
5.30
4.68
1.56
0.00
1.00
1.53
2.36
4.10
6.77
5.22
2.47
1.89
1.27
1.39
0.78
0.76
1.06
0.59
1.96
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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140.08
138.65
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132.35
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131.07
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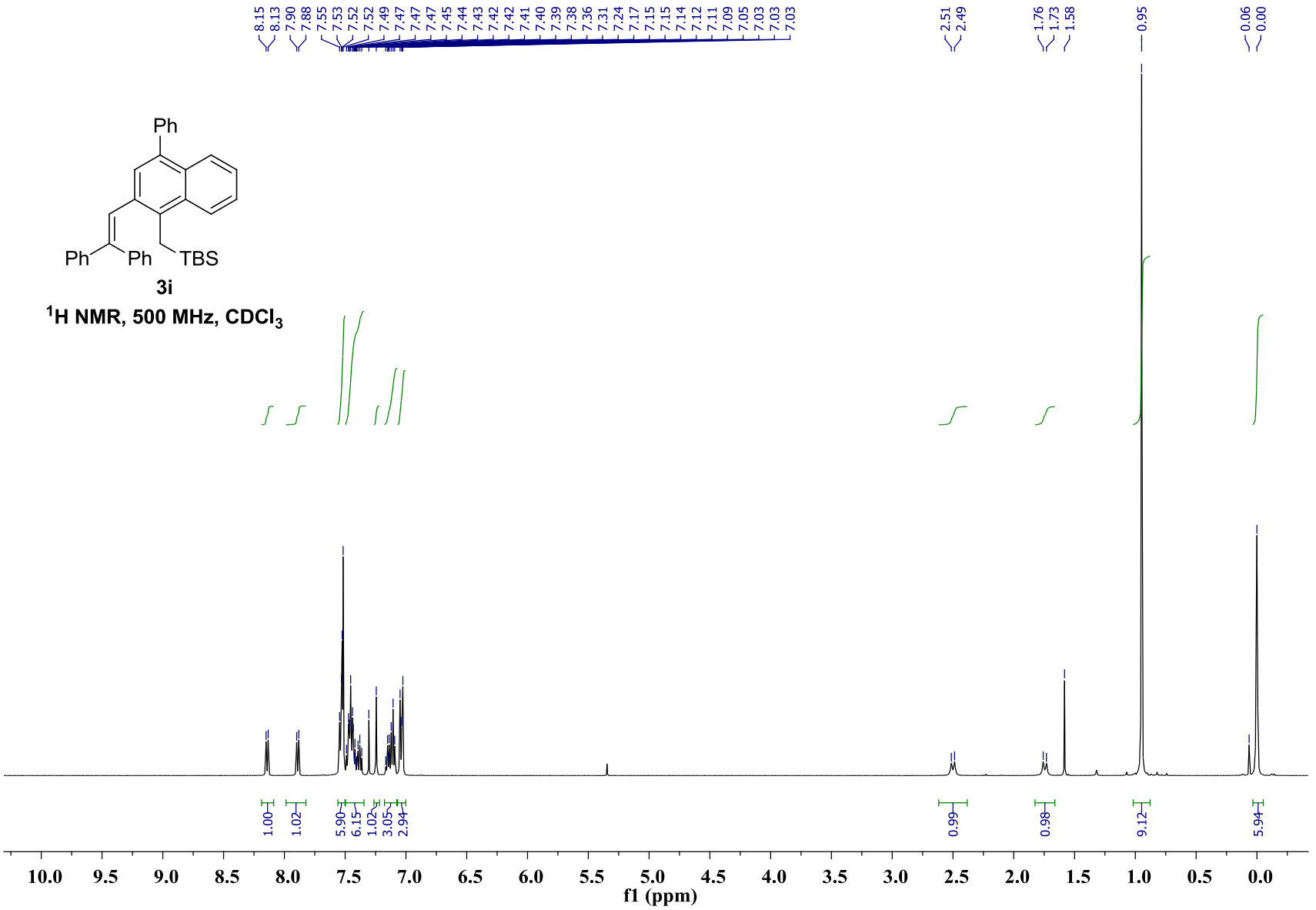
129.61
128.29
128.21
127.99
127.86
127.42
127.02
126.66
126.60
126.18
125.62
125.27
124.39
77.35
77.04
76.72
29.74
Ph
Ph
Ph
S
3h
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)


Ph
Ph
Ph
TBS
3i
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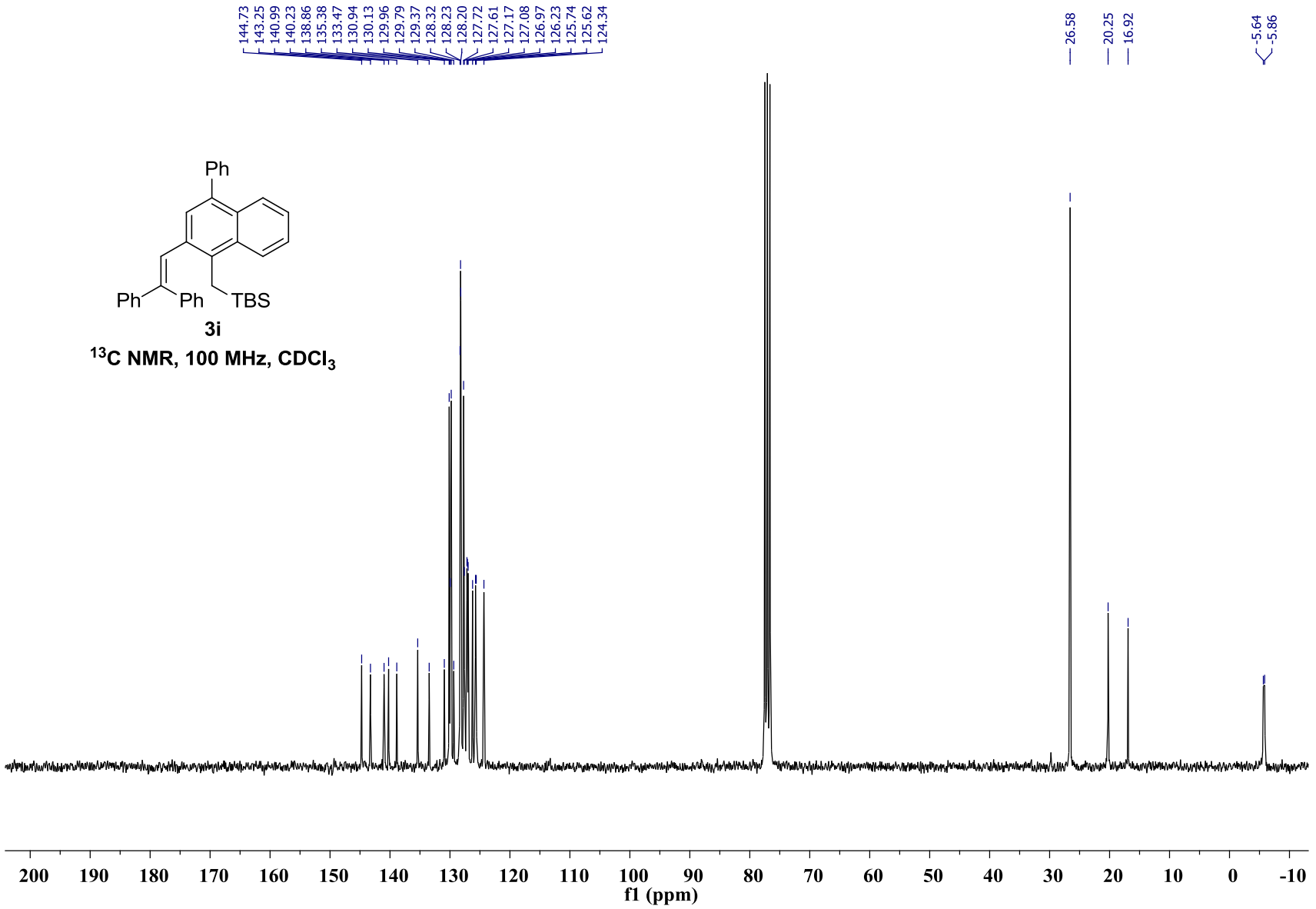
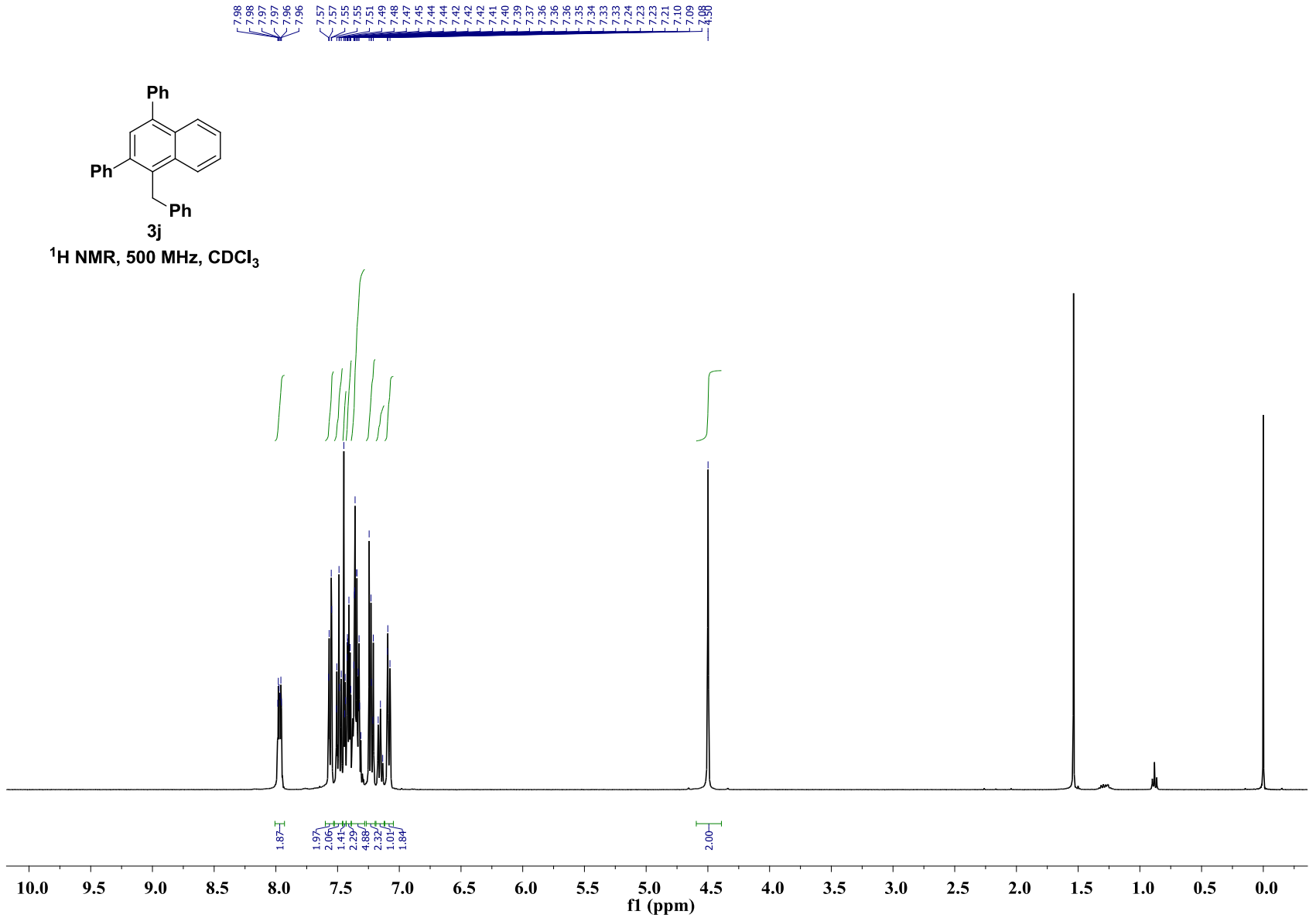
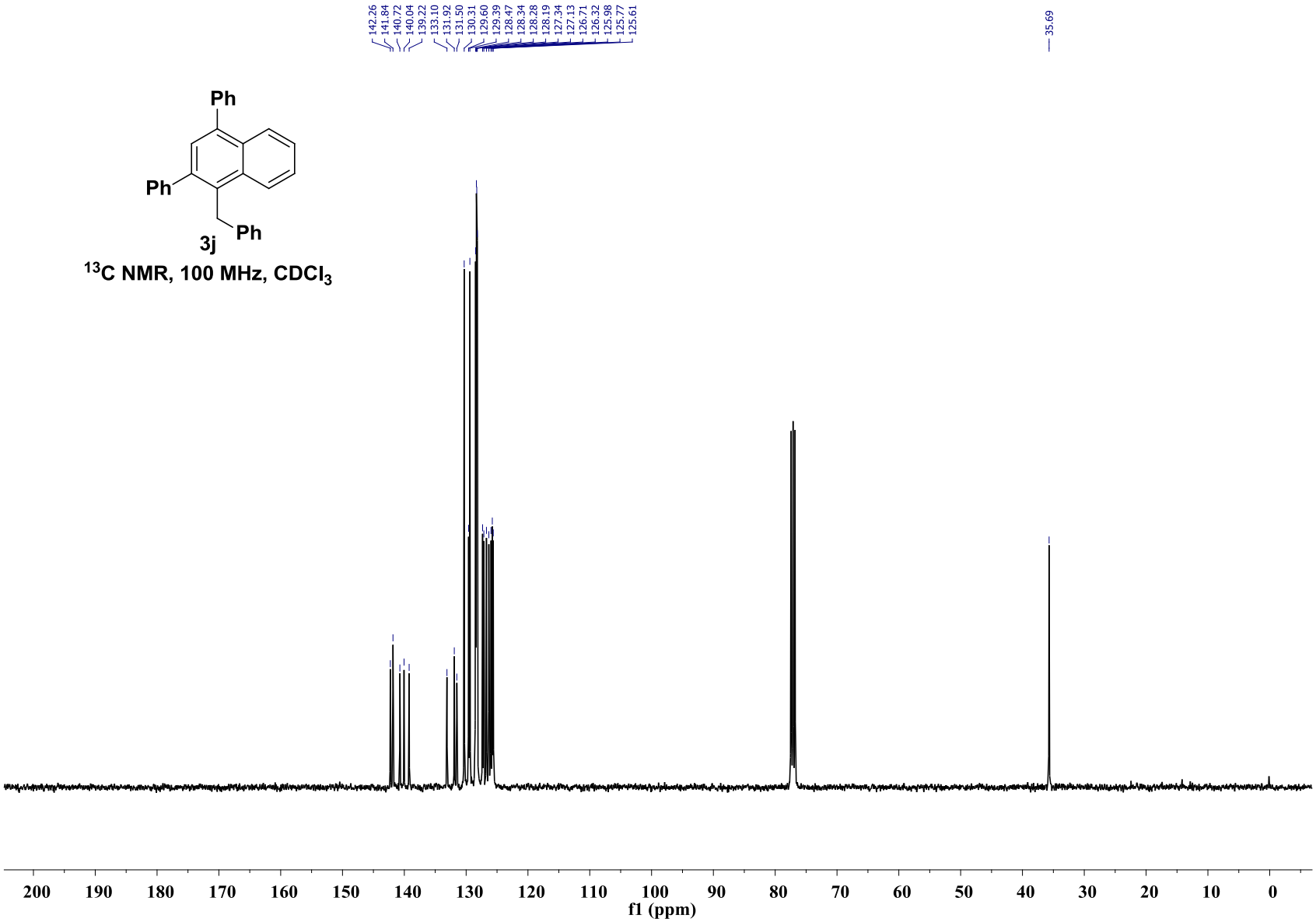
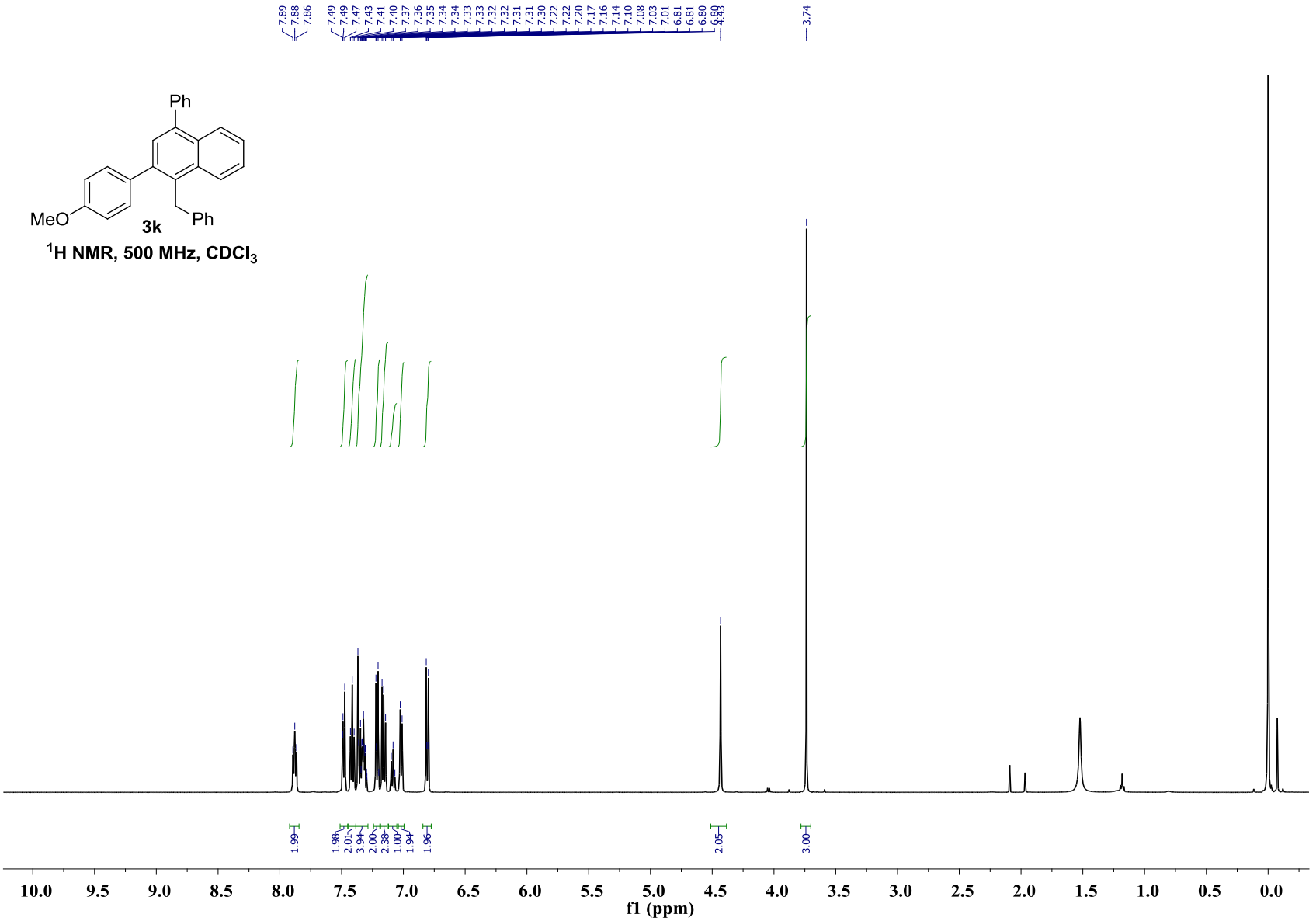
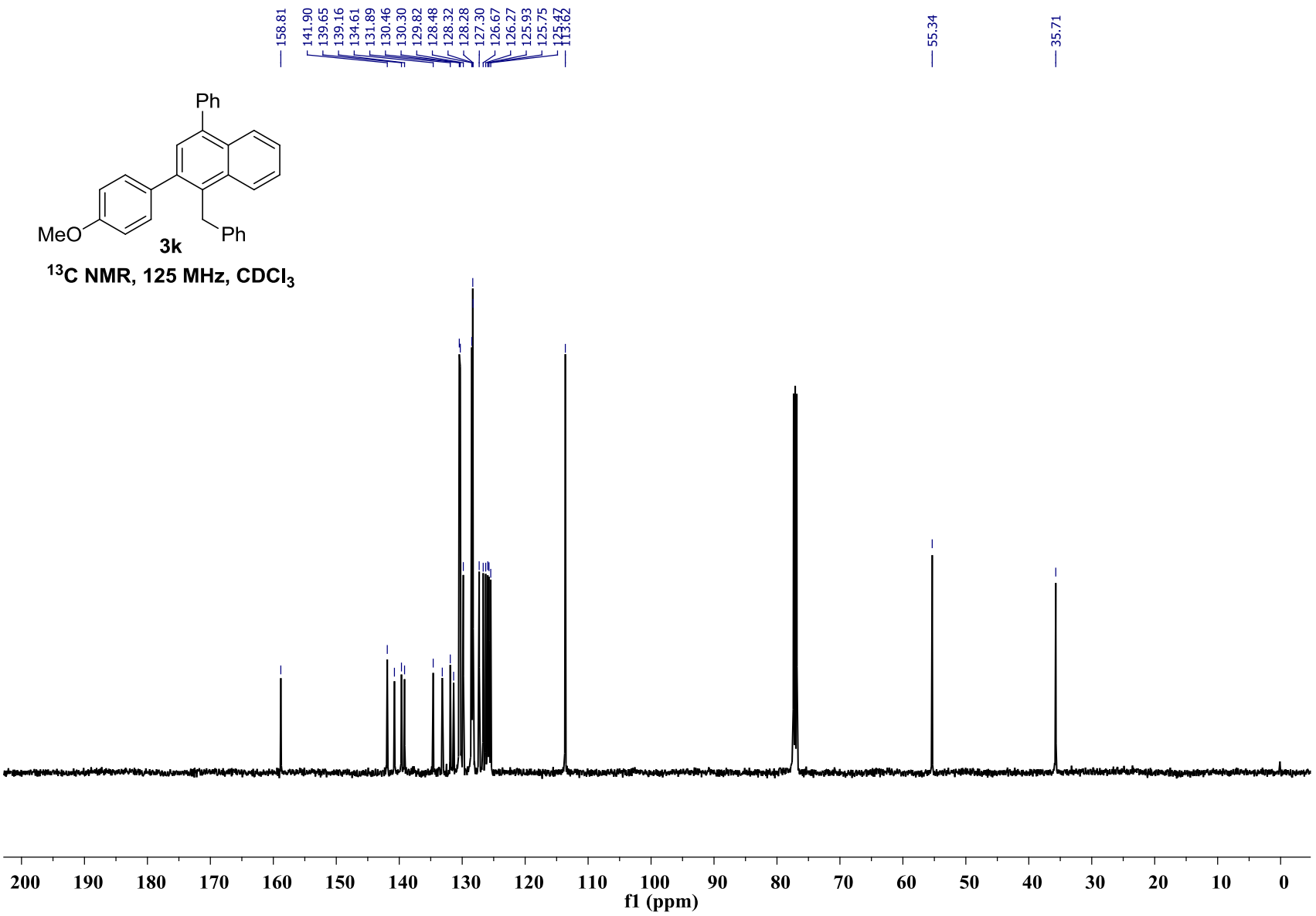
2.51 2.49
1.76 1.73 1.58
0.95
0.06 0.00
1.00 1.02 5.90 6.15 1.02 3.05 2.94
0.99 0.98 9.12 5.94
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

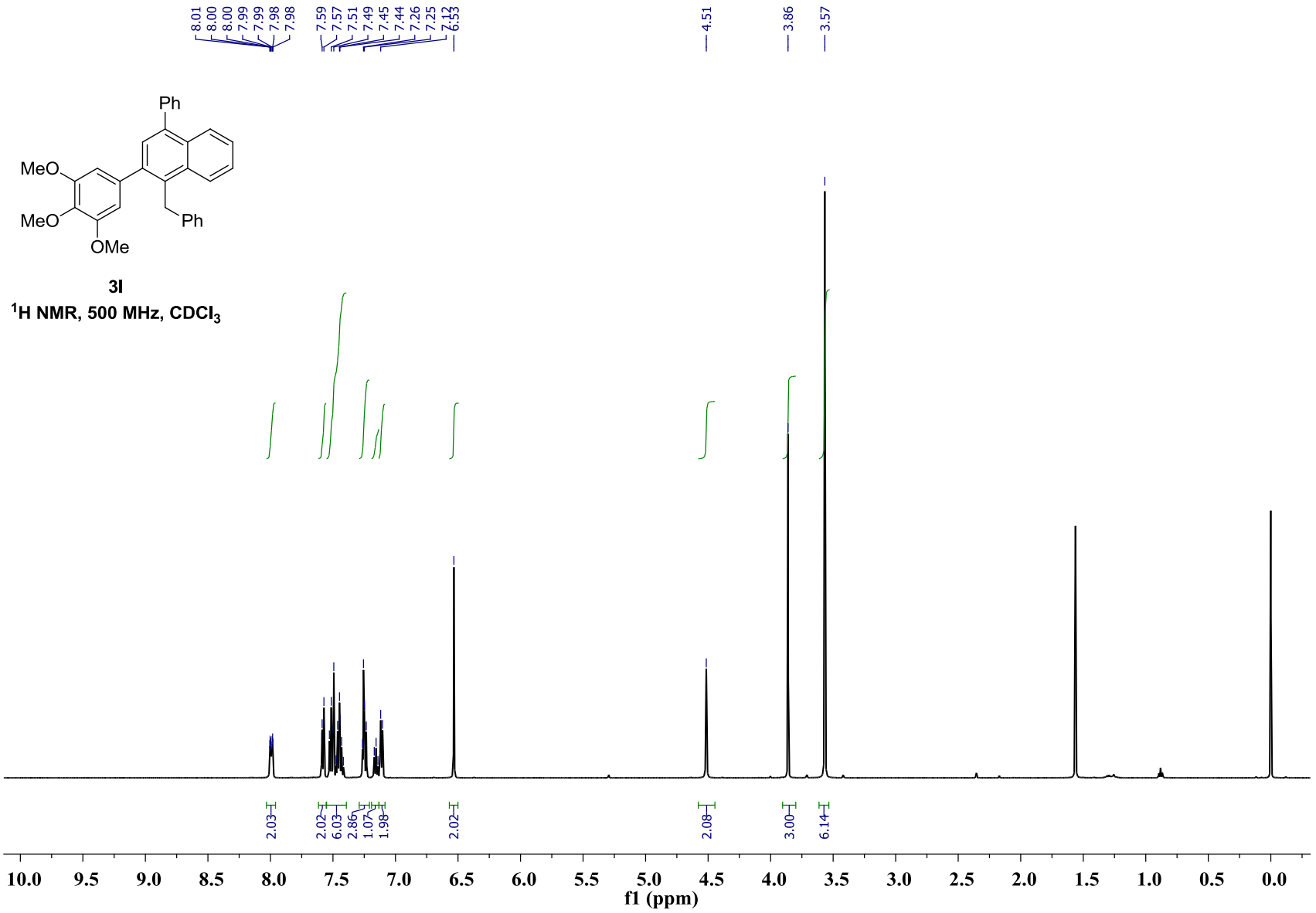

144.73
143.25
140.99
140.23
138.86
135.38
133.47
130.94
130.13
129.96
129.79
129.37
128.32
128.23
128.20
127.72
127.61
127.17
127.08
126.97
126.23
125.74
125.62
124.34
26.58
20.25
16.92
-5.64
-5.86
Ph
Ph
Ph
TBS
3i
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

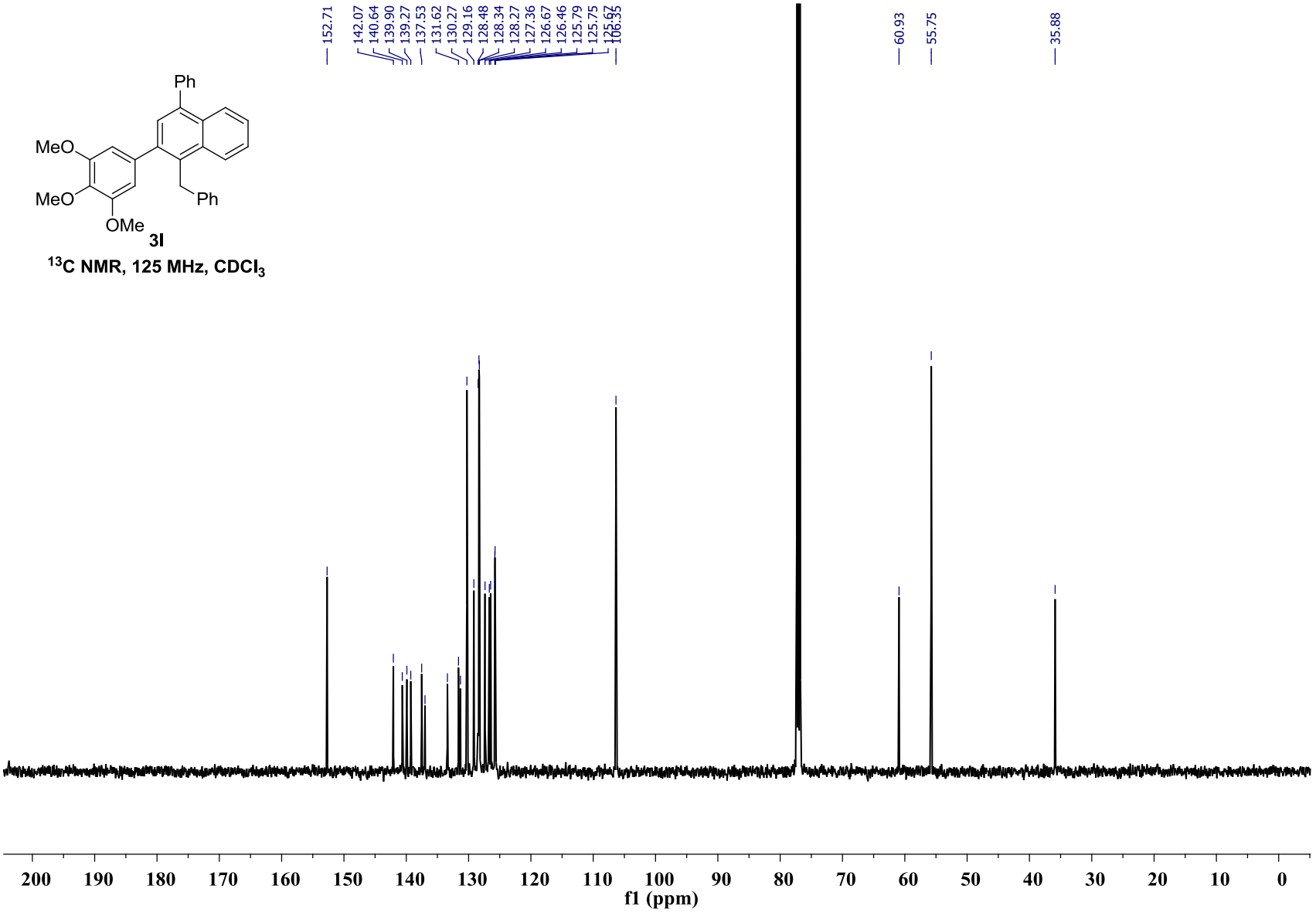

Ph
Ph
Ph
3j
1H NMR, 500 MHz, CDCl3
f1 (ppm)


142.26
141.84
140.72
140.04
139.22
133.10
131.92
131.50
130.31
129.60
129.39
128.47
128.34
128.28
128.19
127.34
127.13
126.71
126.32
125.98
125.77
125.61
35.69
Ph
Ph
Ph
3j
^{13}C NMR, 100 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Ph
MeO
Ph
3k
^{1}H NMR, 500 MHz, CDCl$_3$
7.89
7.88
7.86
7.49
7.49
7.47
7.43
7.41
7.40
7.37
7.36
7.35
7.34
7.34
7.33
7.33
7.32
7.32
7.31
7.31
7.30
7.22
7.22
7.20
7.17
7.16
7.14
7.10
7.08
7.03
7.01
6.81
6.81
6.80
6.80
4.43
3.74
1.99
1.98
2.01
3.94
2.00
2.38
1.00
1.94
1.96
2.05
3.00
10.0
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
0.0
f1 (ppm)

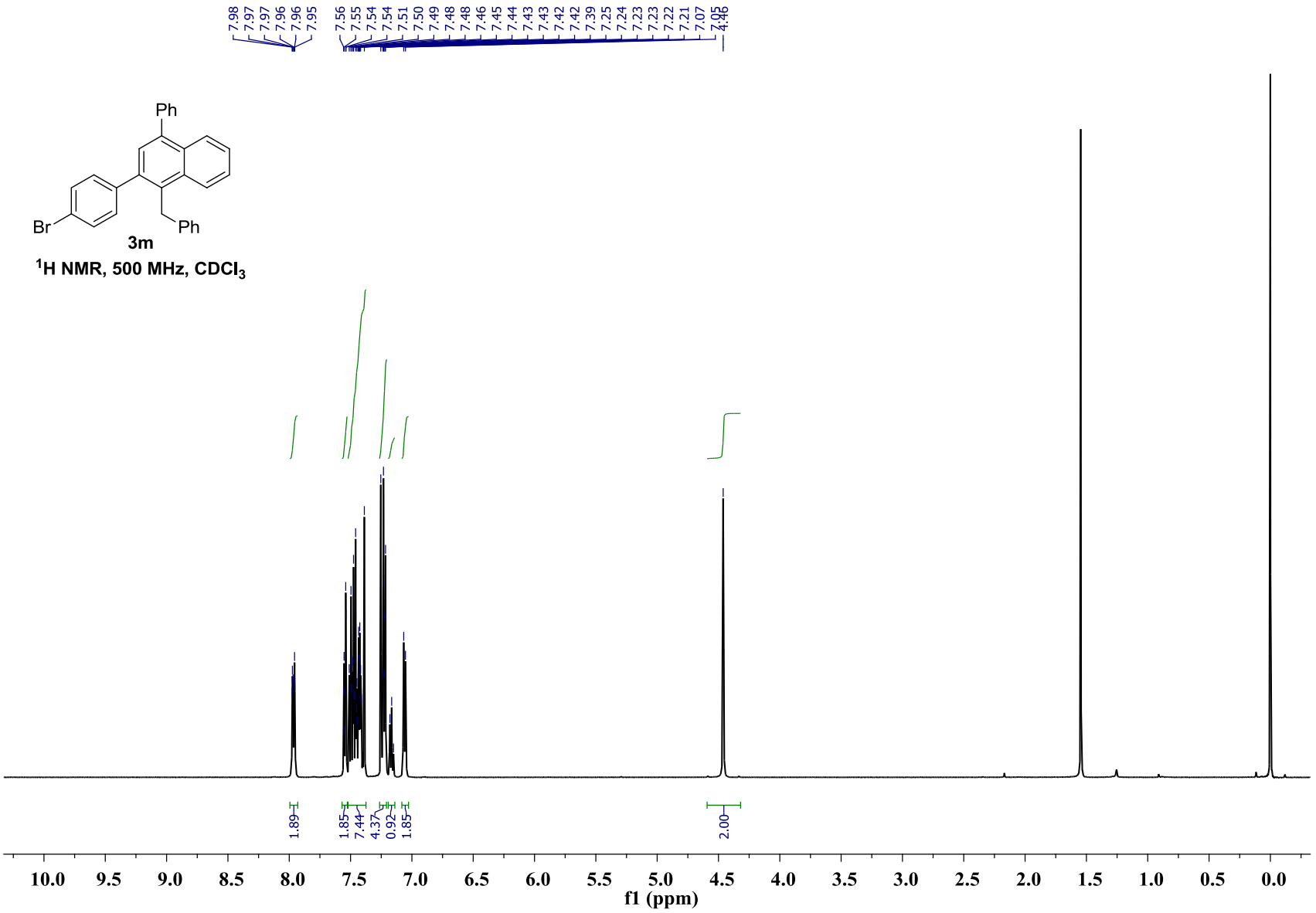

158.81
141.90
139.65
139.16
134.61
131.89
130.46
130.30
129.82
128.48
128.32
128.28
127.30
126.67
126.27
125.93
125.75
55.34
35.71
Ph
MeO
Ph
3k
13C NMR, 125 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

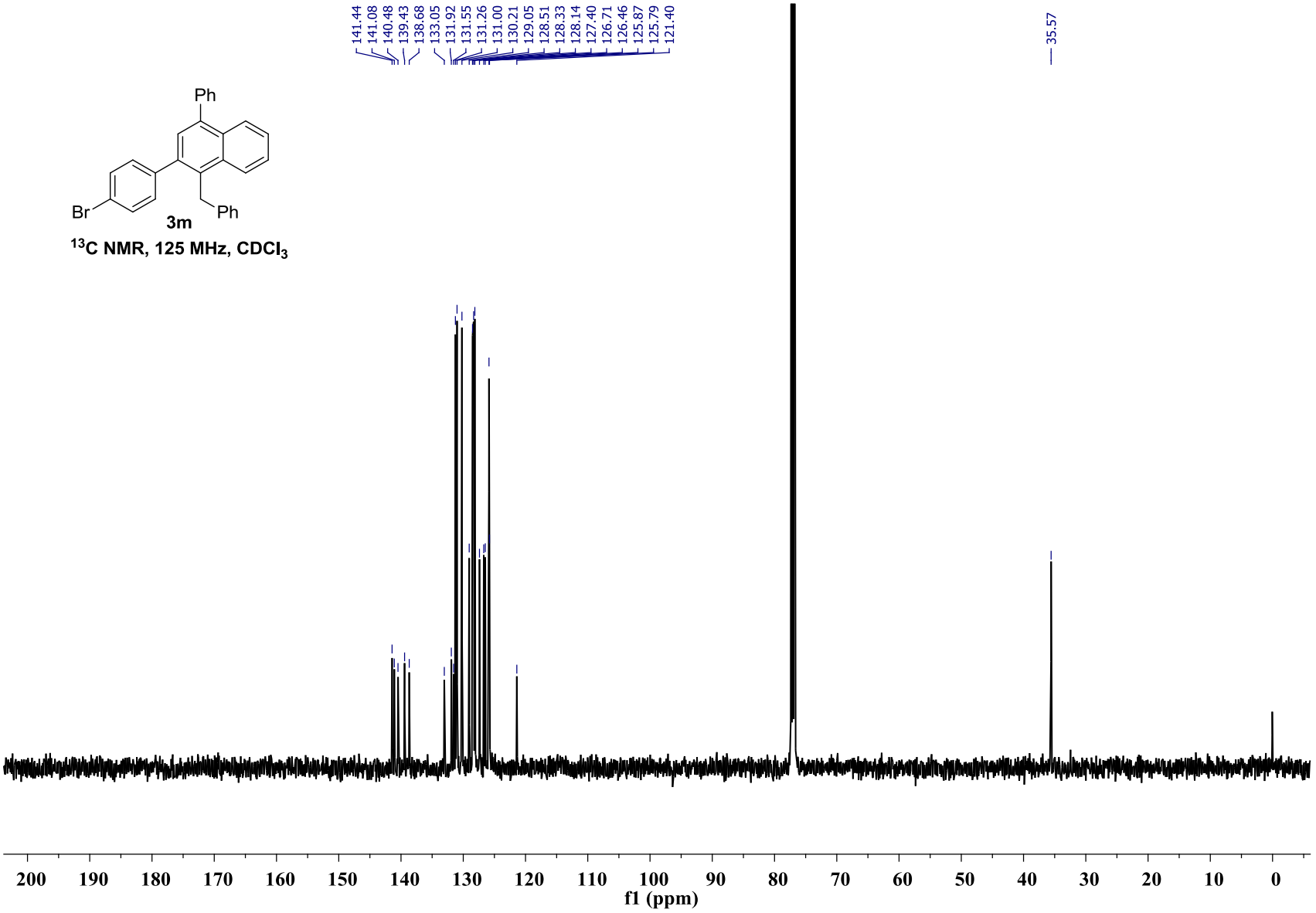

8.01
8.00
8.00
7.99
7.99
7.98
7.98
7.59
7.57
7.51
7.49
7.45
7.44
7.26
7.25
7.12
6.53
4.51
3.86
3.57
Ph
MeO
MeO
OMe
Ph
3l
1H NMR, 500 MHz, CDCl3
2.03
2.02
6.03
2.86
1.07
1.98
2.02
2.08
3.00
6.14
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

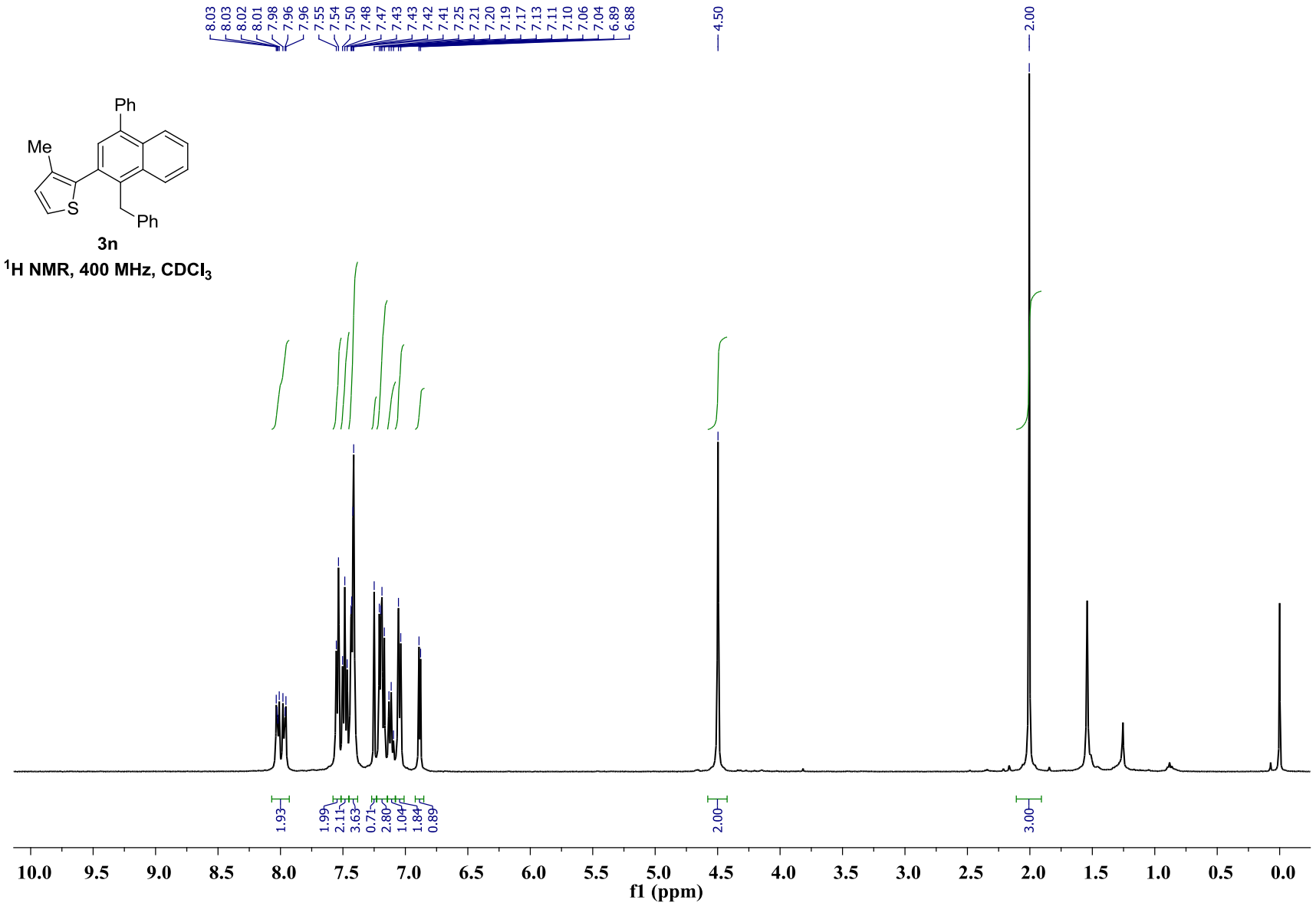


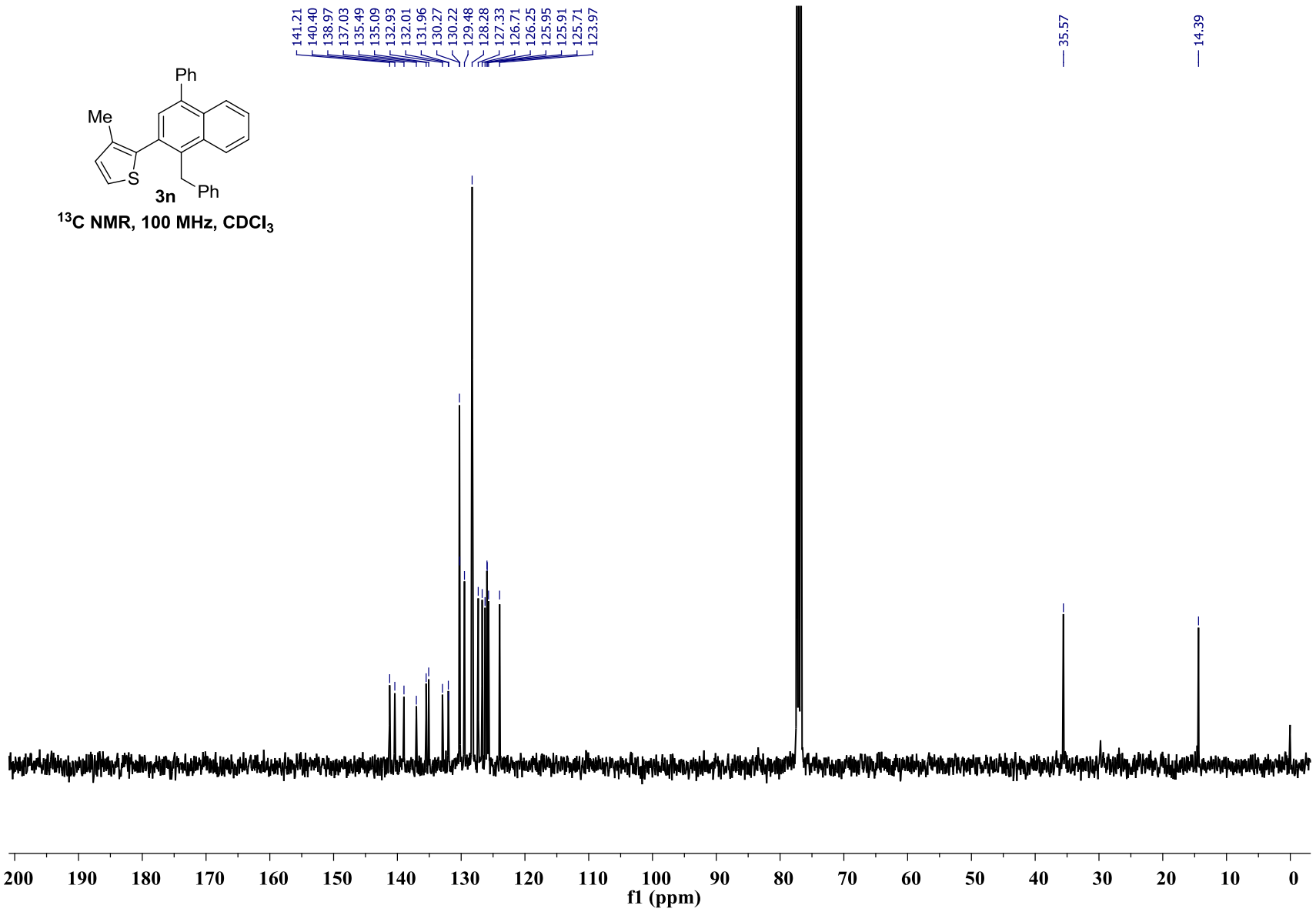
3l

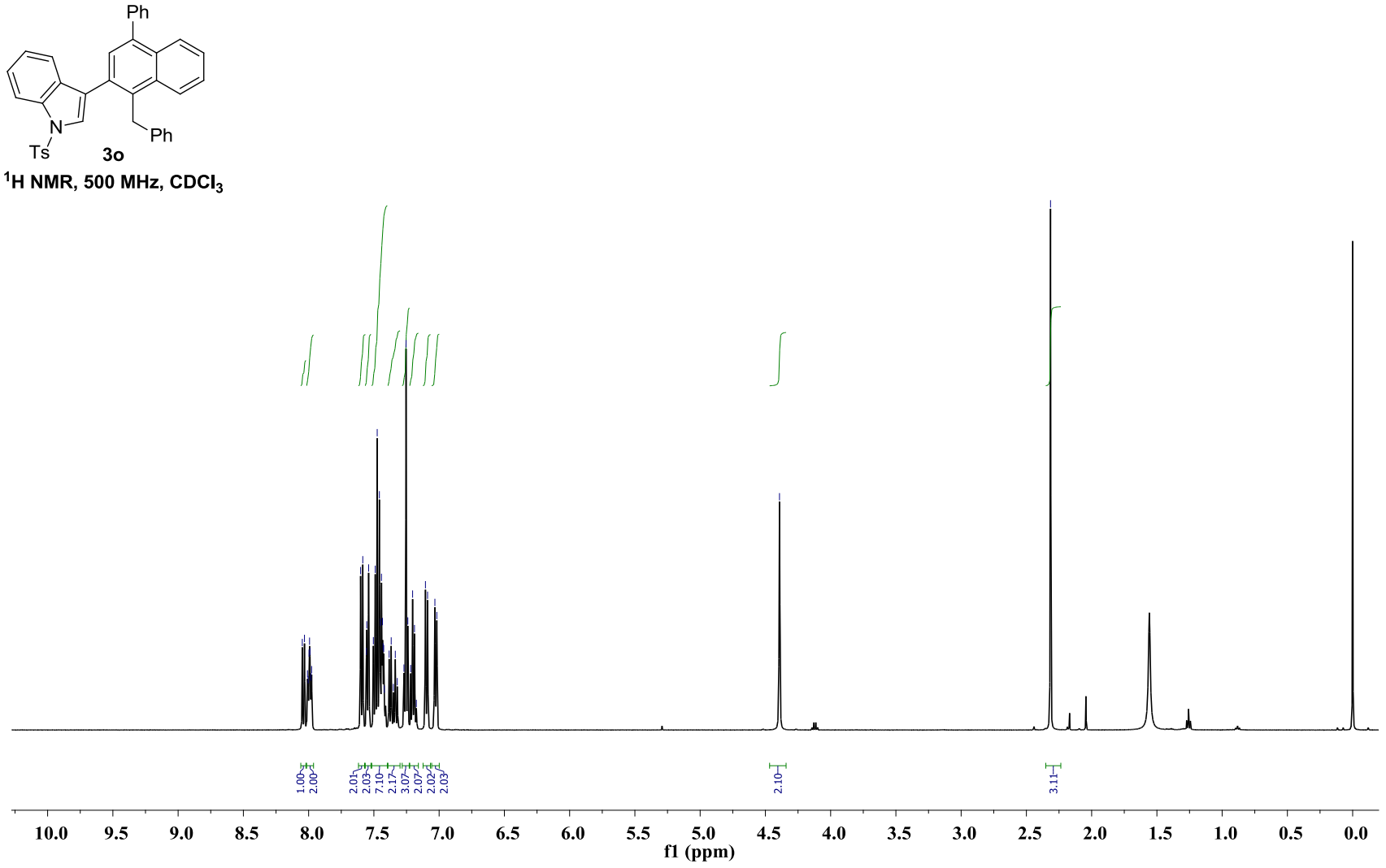
^{13}C NMR, 125 MHz, $CDCl_3$

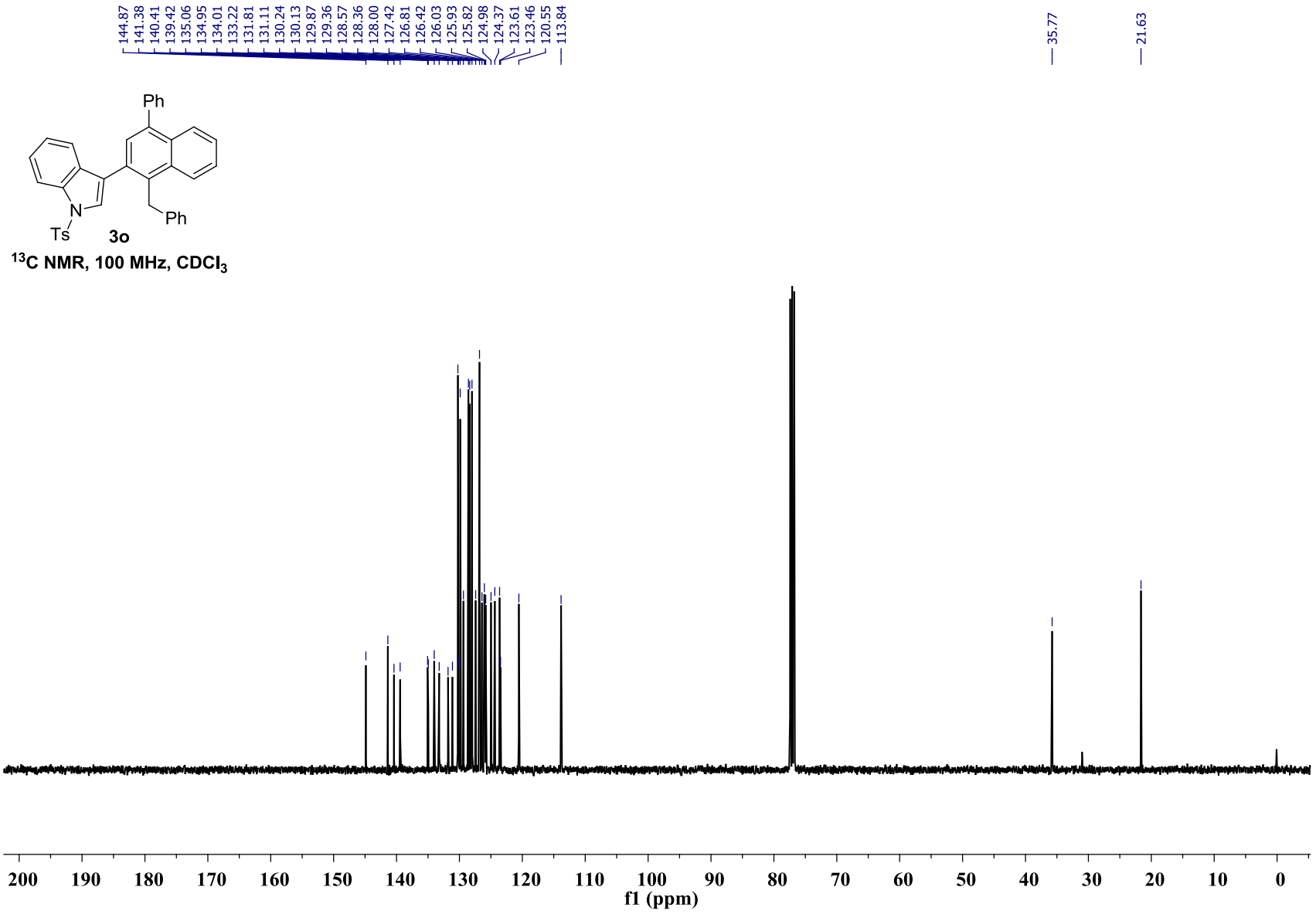

7.98
7.97
7.97
7.96
7.96
7.95
7.56
7.55
7.54
7.54
7.51
7.50
7.49
7.48
7.48
7.46
7.45
7.44
7.43
7.43
7.42
7.42
7.39
7.25
7.24
7.23
7.23
7.22
7.21
7.07
7.05
4.46
Ph
Br
Ph
3m
1H NMR, 500 MHz, CDCl3
1.89
1.85
7.44
4.37
0.92
1.85
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

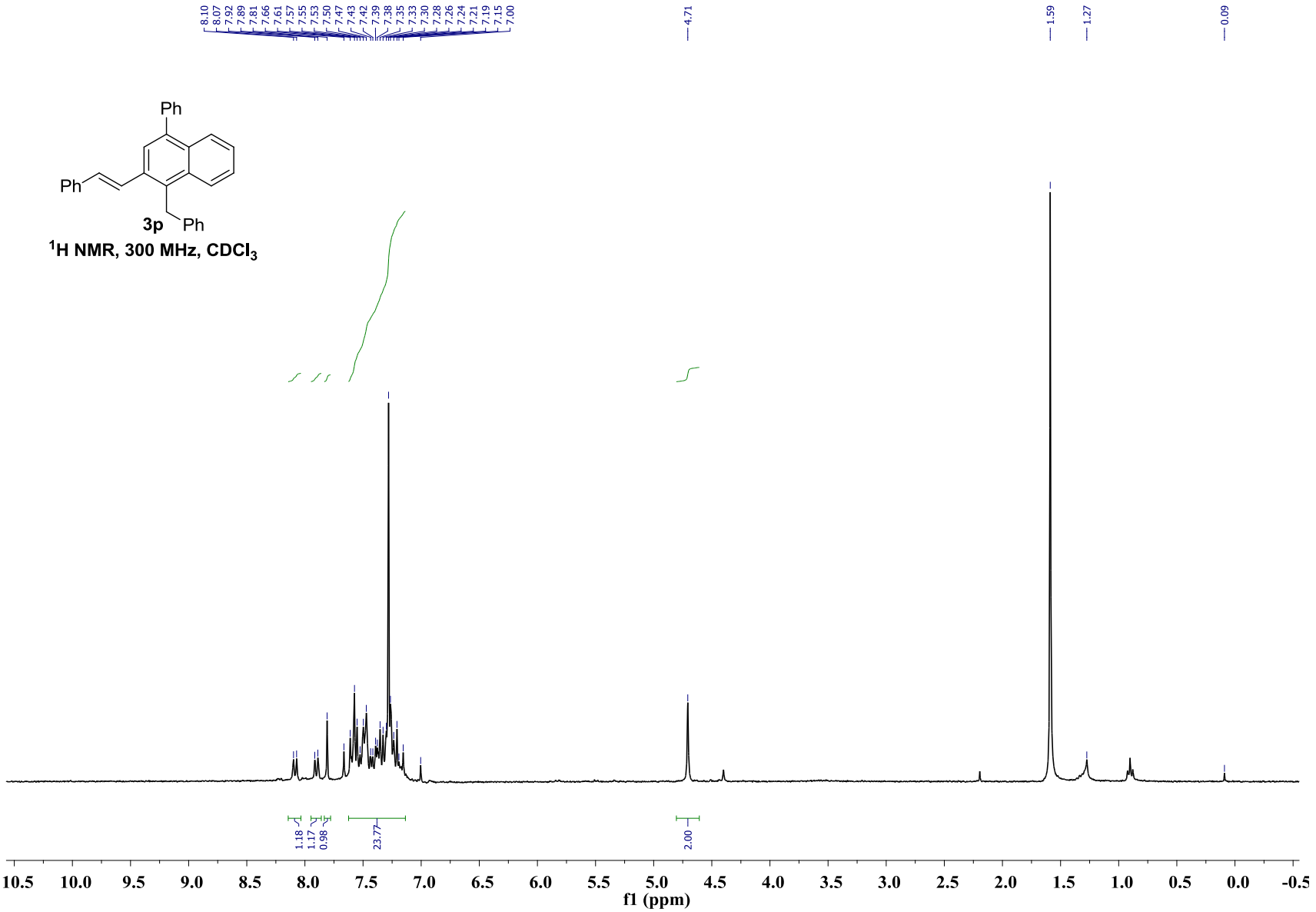

141.44
141.08
140.48
139.43
138.68
133.05
131.92
131.55
131.26
131.00
130.21
129.05
128.51
128.33
128.14
127.40
126.71
126.46
125.87
125.79
121.40
35.57
Ph
Br
Ph
3m
13C NMR, 125 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

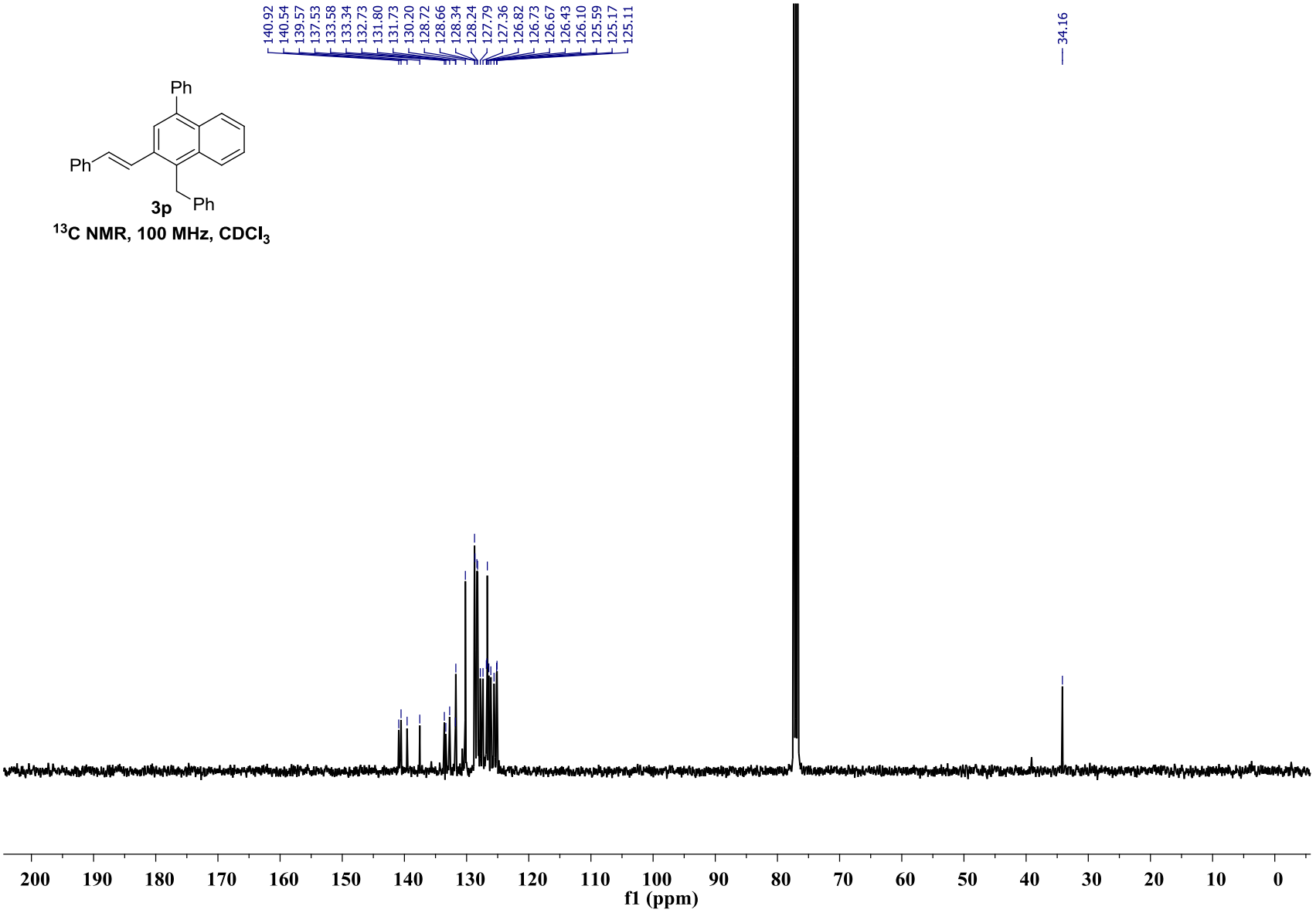

Ph
Me
S
Ph
3n
1H NMR, 400 MHz, CDCl3
8.03
8.03
8.02
8.01
7.98
7.96
7.96
7.55
7.54
7.50
7.48
7.47
7.43
7.43
7.42
7.41
7.25
7.21
7.20
7.19
7.17
7.13
7.11
7.10
7.06
7.04
6.89
6.88
4.50
2.00
1.93
1.99
2.11
3.63
0.71
2.80
1.04
1.84
0.89
2.00
3.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


141.21
140.40
138.97
137.03
135.49
135.09
132.93
132.01
131.96
130.27
130.22
129.48
128.28
127.33
126.71
126.25
125.95
125.91
125.71
123.97
35.57
14.39
Ph
Me
S
Ph
3n
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

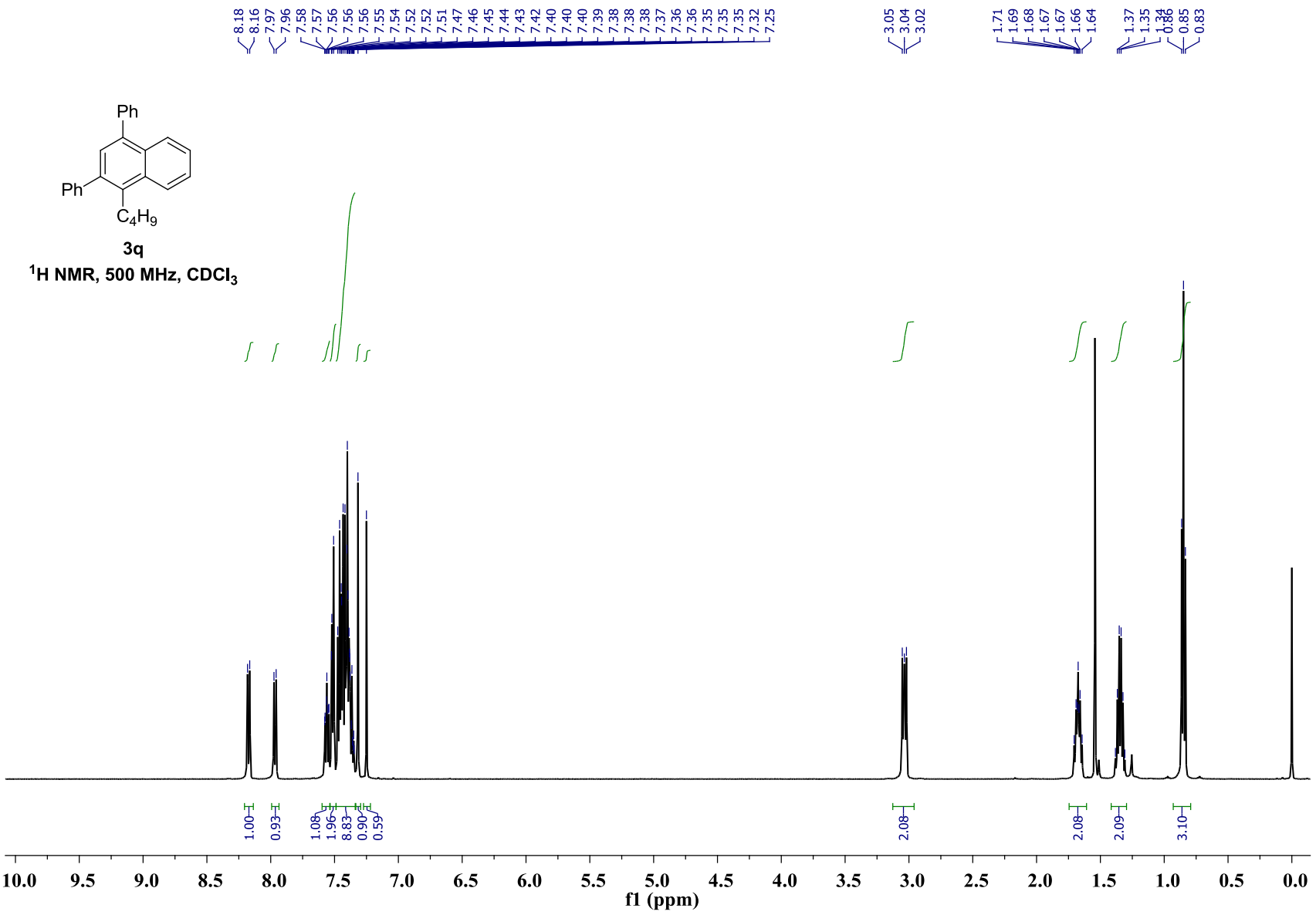

8.05
8.03
8.01
8.00
8.00
7.99
7.99
7.98
7.98
7.60
7.59
7.56
7.55
7.54
7.50
7.49
7.47
7.46
7.45
7.44
7.43
7.43
7.42
7.42
7.38
7.37
7.35
7.34
7.32
7.27
7.25
7.24
7.22
7.20
7.19
7.17
7.10
7.09
7.03
7.02
4.39
2.32
Ph
N
Ts
Ph
3o
1H NMR, 500 MHz, CDCl3
1.00
2.00
2.01
2.03
7.10
2.17
3.07
2.07
2.02
2.03
2.10
3.11
10.0
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
0.0
f1 (ppm)

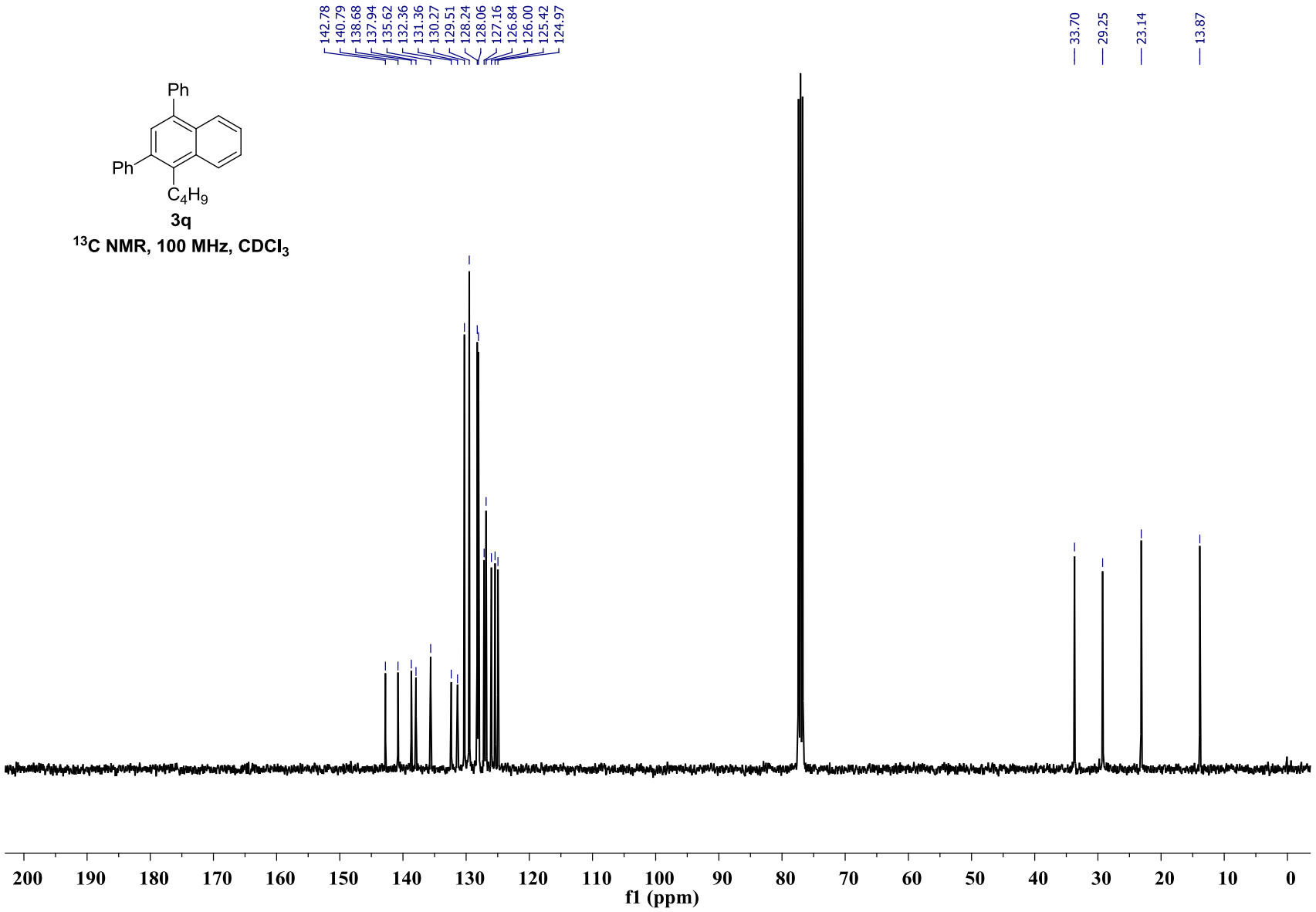

144.87
141.38
140.41
139.42
135.06
134.95
134.01
133.22
131.81
131.11
130.24
130.13
129.87
129.36
128.57
128.36
128.00
127.42
126.81
126.42
126.03
125.93
125.82
124.98
124.37
123.61
123.46
120.55
113.84
35.77
21.63
Ph
N
Ts
Ph
3o
^{13}C NMR, 100 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

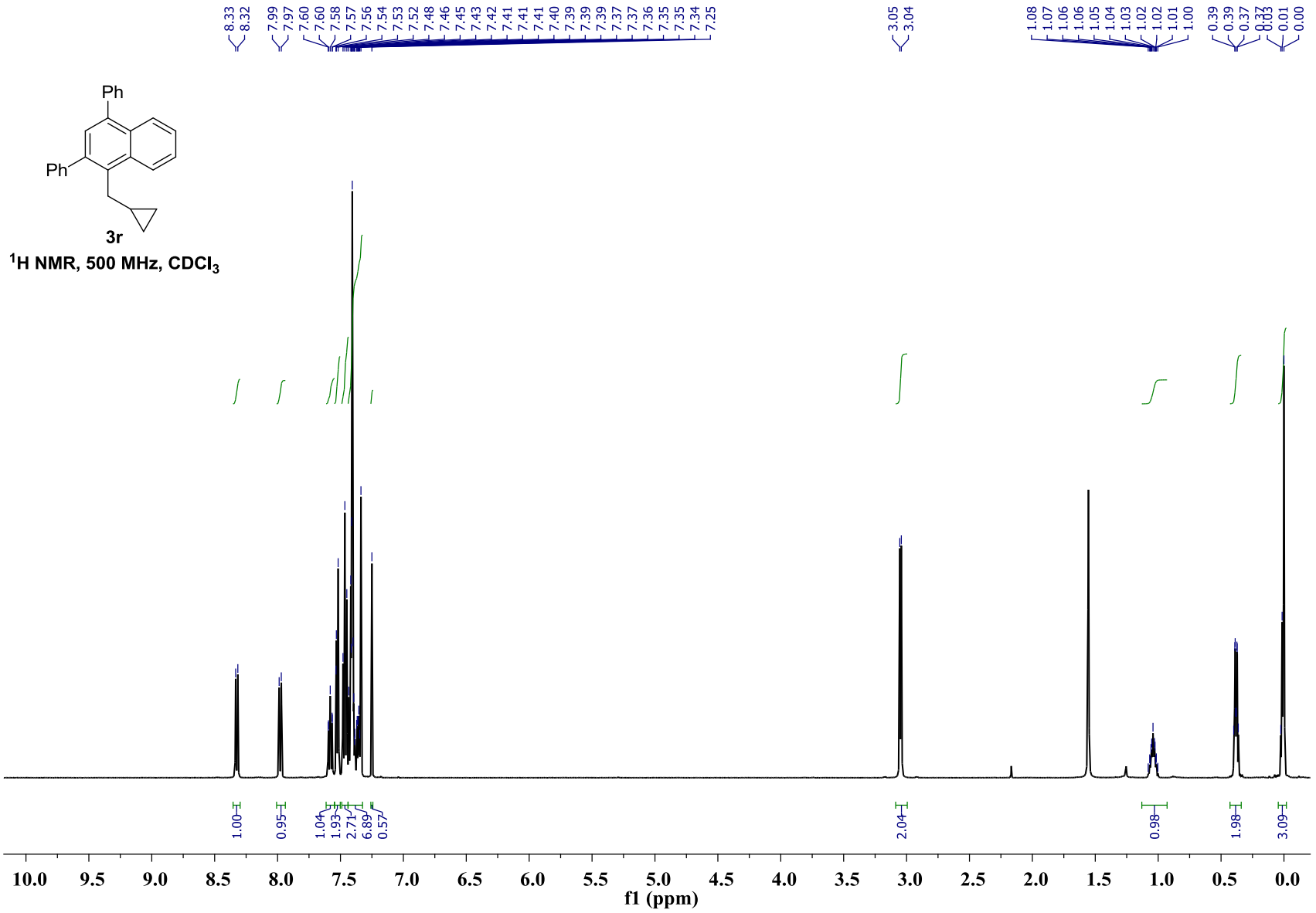

8.10
8.07
7.92
7.89
7.81
7.66
7.61
7.57
7.55
7.53
7.50
7.47
7.43
7.42
7.39
7.38
7.35
7.33
7.30
7.28
7.26
7.24
7.21
7.19
7.15
7.00
4.71
1.59
1.27
0.09
Ph
Ph
3p
Ph
1H NMR, 300 MHz, CDCl3
1.18
1.17
0.98
23.77
2.00
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

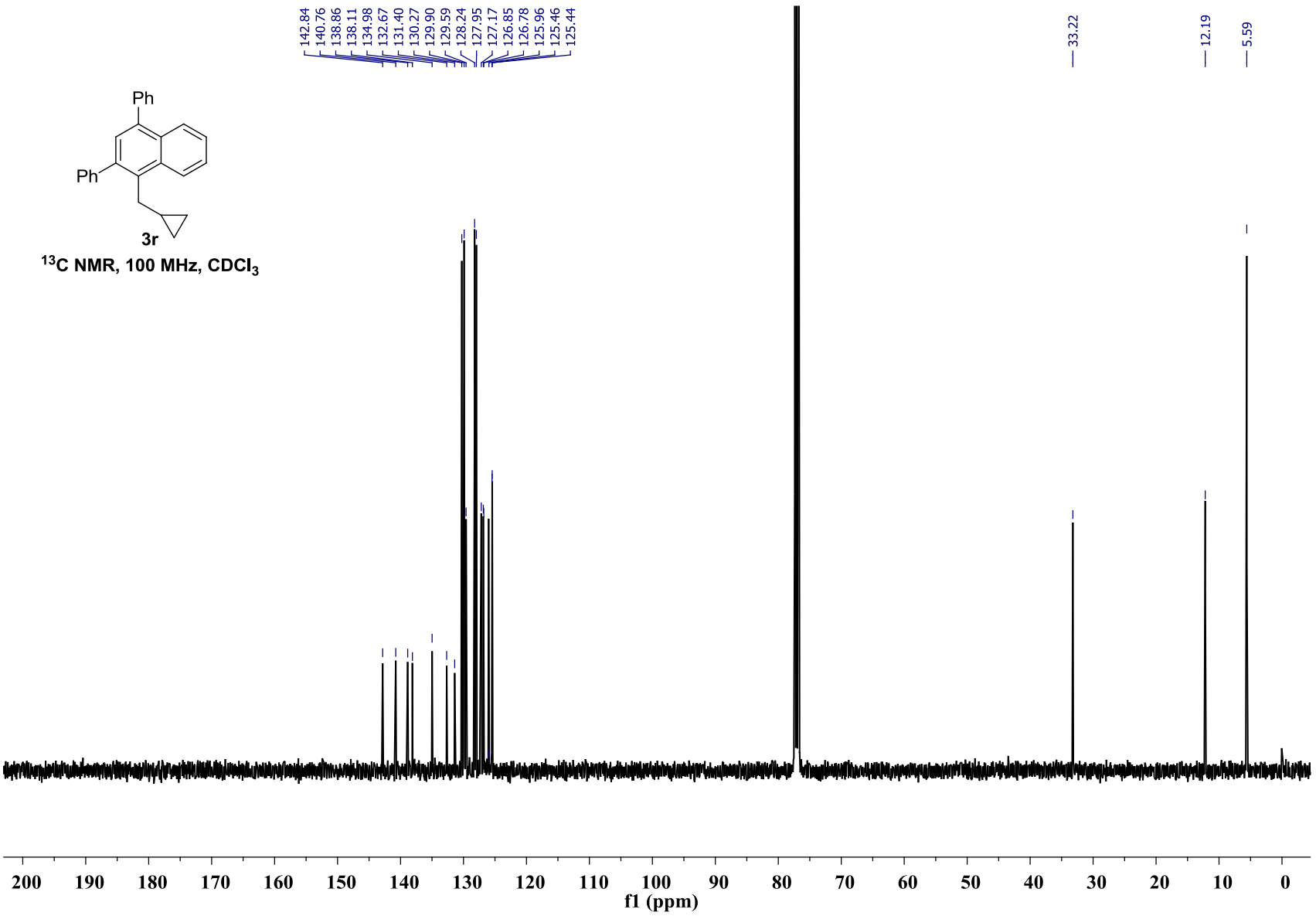


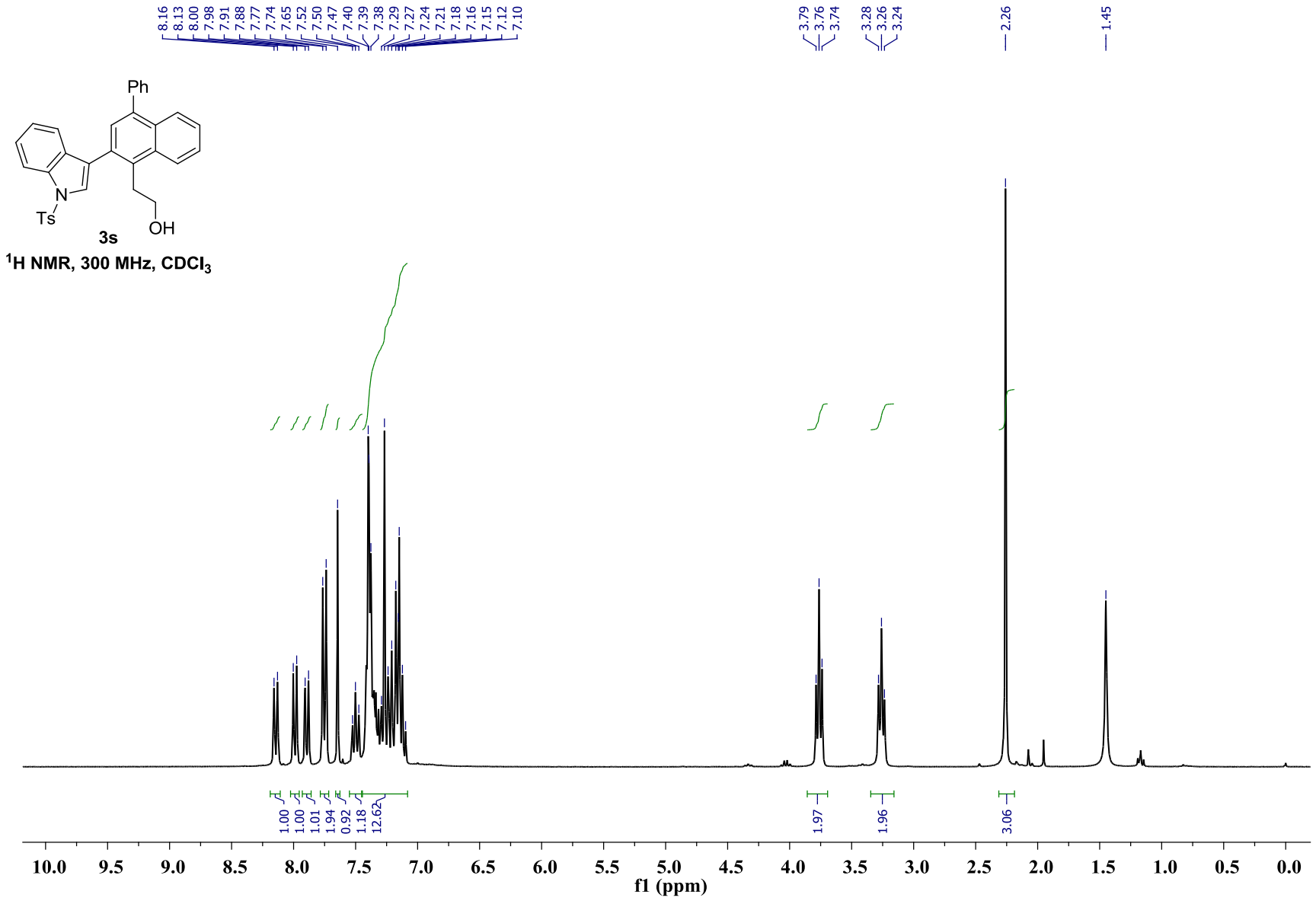
^{13}C NMR, 100 MHz, $CDCl_3$

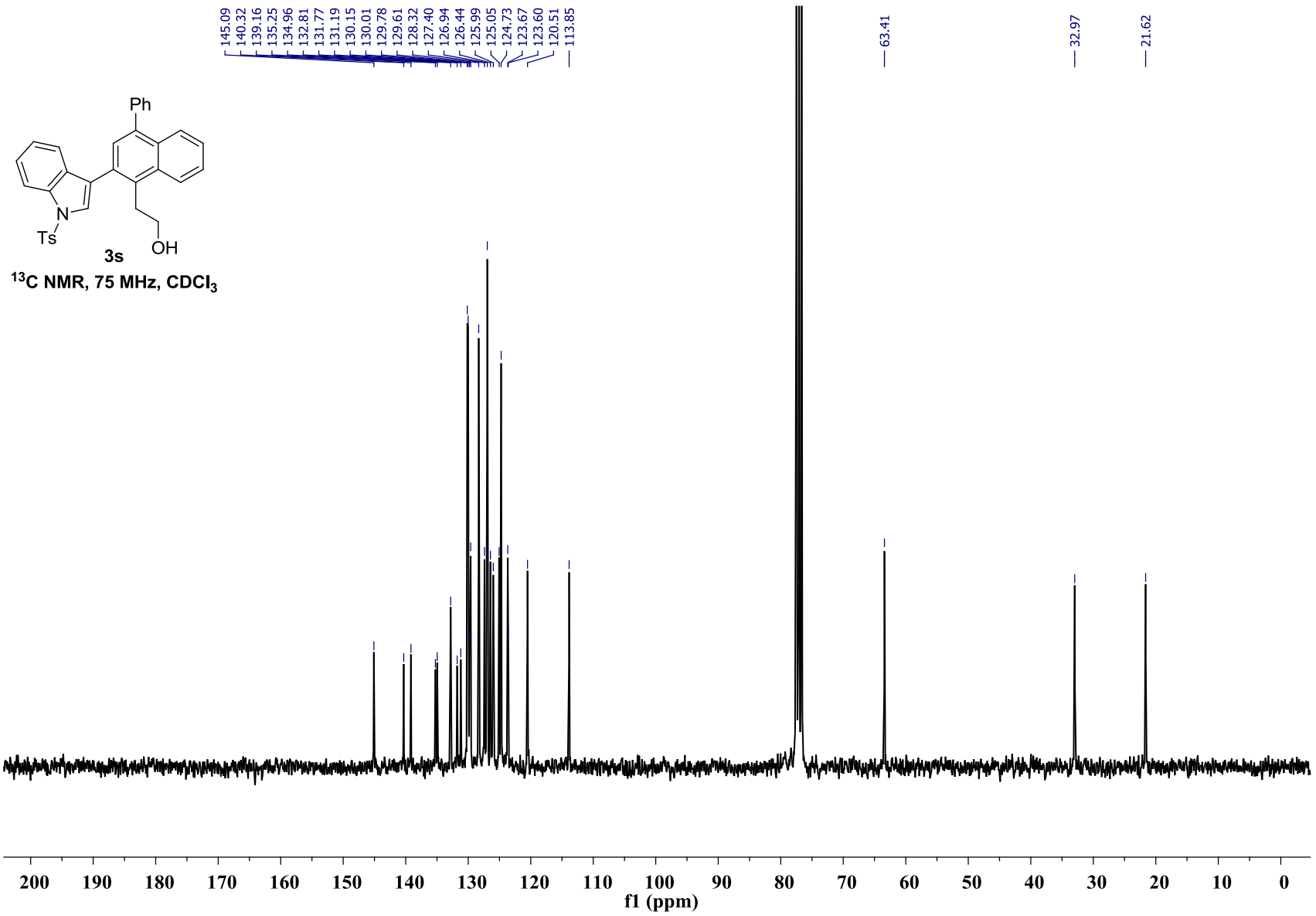

Ph
Ph
C_4H_9
3q
^{1}H NMR, 500 MHz, $CDCl_3$
8.18 8.16 7.97 7.96 7.58 7.57 7.56 7.56 7.56 7.55 7.54 7.52 7.52 7.51 7.47 7.46 7.45 7.44 7.43 7.42 7.40 7.40 7.40 7.39 7.38 7.38 7.38 7.37 7.36 7.36 7.35 7.35 7.35 7.32 7.25
3.05 3.04 3.02
1.71 1.69 1.68 1.67 1.67 1.66 1.64
1.37 1.35 1.34 0.86 0.85 0.83
1.00 0.93 1.08 1.96 8.83 0.90 0.59
2.08
2.08 2.09 3.10
10.0 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 0.0
f1 (ppm)

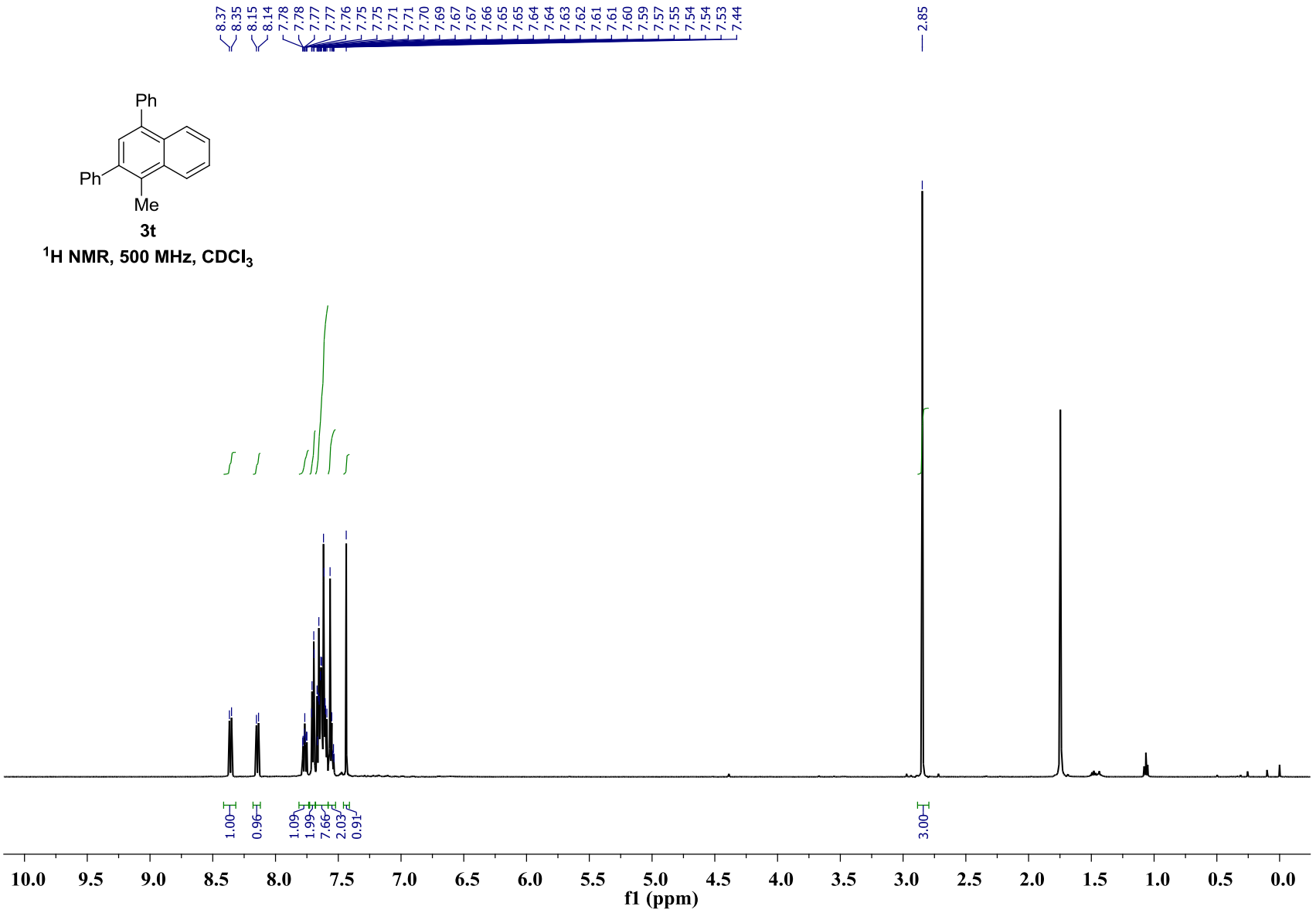

142.78
140.79
138.68
137.94
135.62
132.36
131.36
130.27
129.51
128.24
128.06
127.16
126.84
126.00
125.42
124.97
33.70
29.25
23.14
13.87
Ph
Ph
C4H9
3q
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


Ph
Ph
3r
^{1}H NMR, 500 MHz, CDCl$_3$
8.33 8.32 7.99 7.97 7.60 7.60 7.58 7.57 7.56 7.54 7.53 7.52 7.48 7.46 7.45 7.43 7.42 7.41 7.41 7.41 7.40 7.39 7.39 7.39 7.37 7.37 7.36 7.35 7.35 7.34 7.25
3.05 3.04
1.08 1.07 1.06 1.06 1.05 1.04 1.03 1.02 1.02 1.01 1.00
0.39 0.39 0.37 0.03 0.01 0.00
1.00 0.95 1.04 1.93 2.71 6.89 0.57
2.04
0.98
1.98
3.09
10.0 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 0.0
f1 (ppm)


142.84
140.76
138.86
138.11
134.98
132.67
131.40
130.27
129.90
129.59
128.24
127.95
127.17
126.85
126.78
125.96
125.46
125.44
33.22
12.19
5.59
Ph
Ph
3r
^{13}C NMR, 100 MHz, CDCl$_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

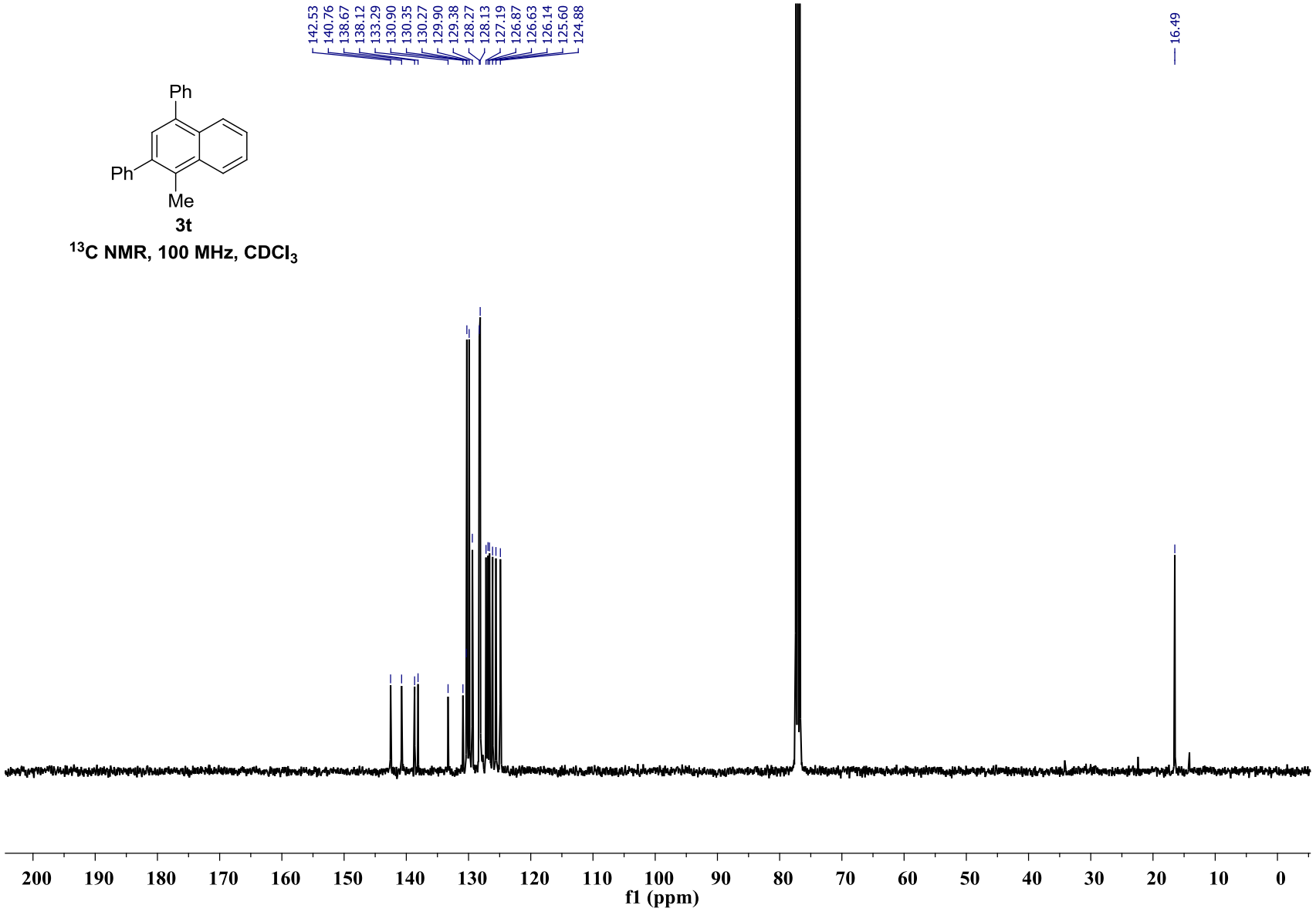

8.16
8.13
8.00
7.98
7.91
7.88
7.77
7.74
7.65
7.52
7.50
7.47
7.40
7.39
7.38
7.29
7.27
7.24
7.21
7.18
7.16
7.15
7.12
7.10
3.79
3.76
3.74
3.28
3.26
3.24
2.26
1.45
Ph
N
Ts
OH
3s
1H NMR, 300 MHz, CDCl3
1.00
1.00
1.01
1.94
0.92
1.18
12.62
1.97
1.96
3.06
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

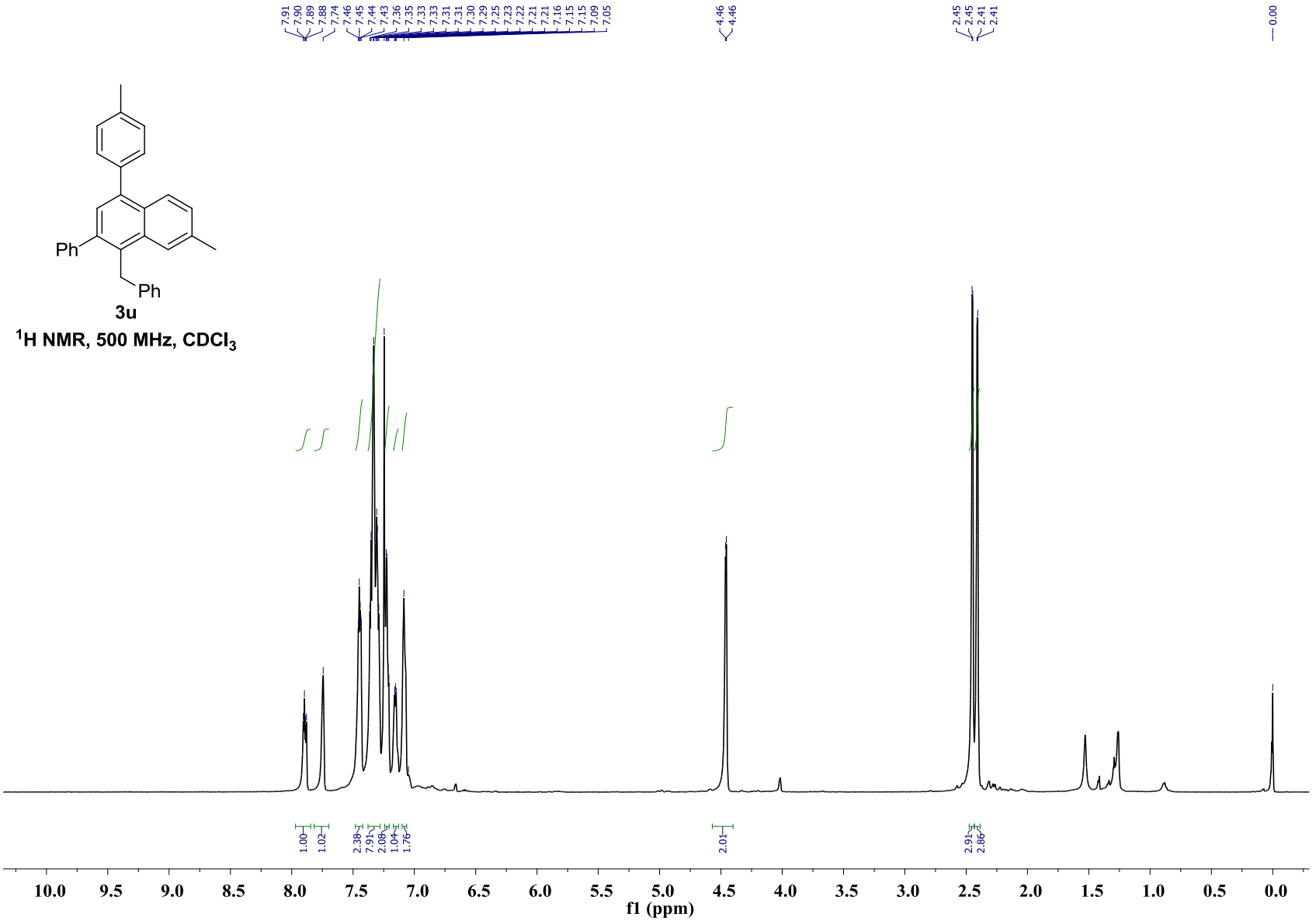

145.09
140.32
139.16
135.25
134.96
132.81
131.77
131.19
130.15
130.01
129.78
129.61
128.32
127.40
126.94
126.44
125.99
125.05
124.73
123.67
123.60
120.51
113.85
63.41
32.97
21.62
Ph
N
Ts
OH
3s
^{13}C NMR, 75 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

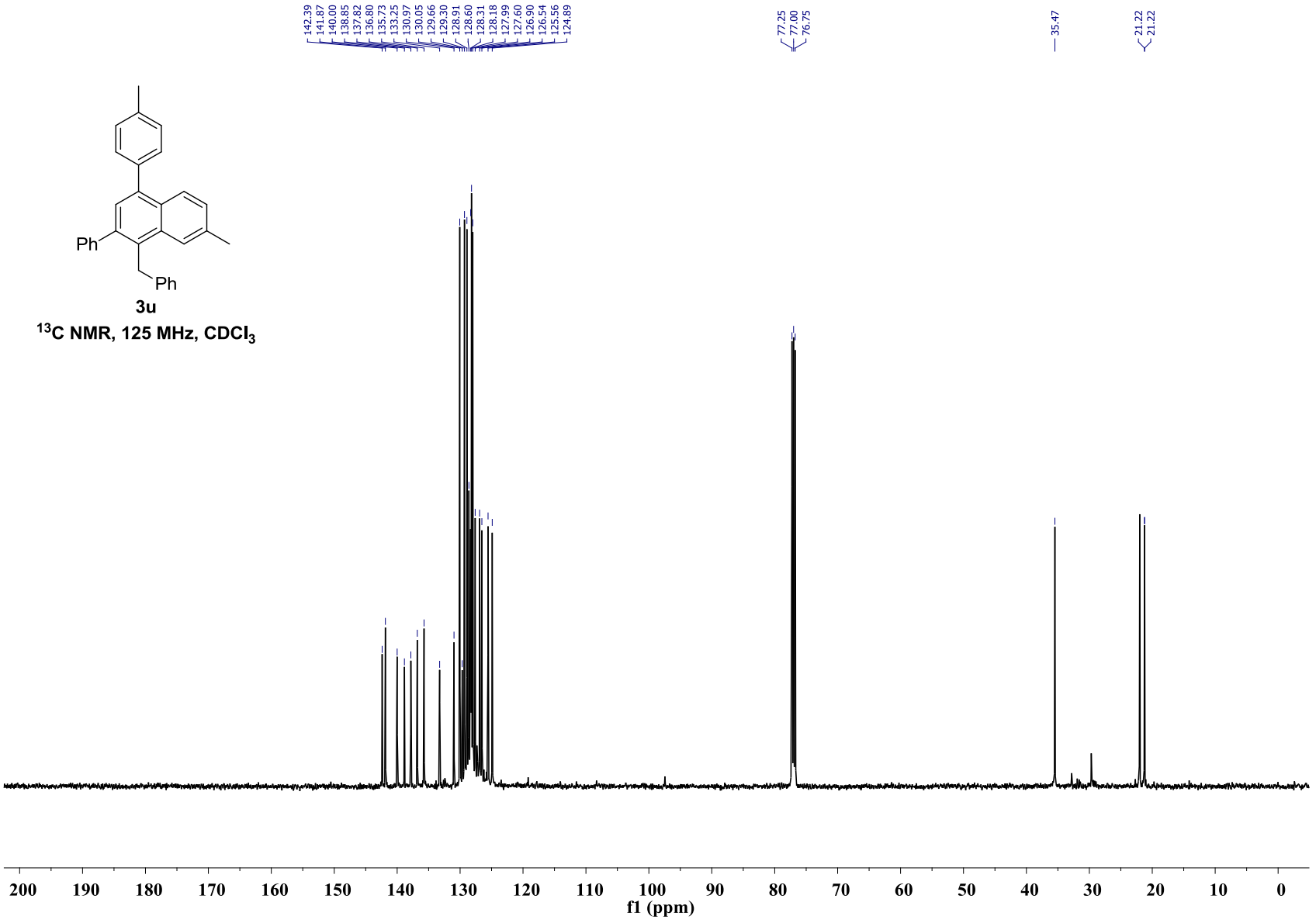


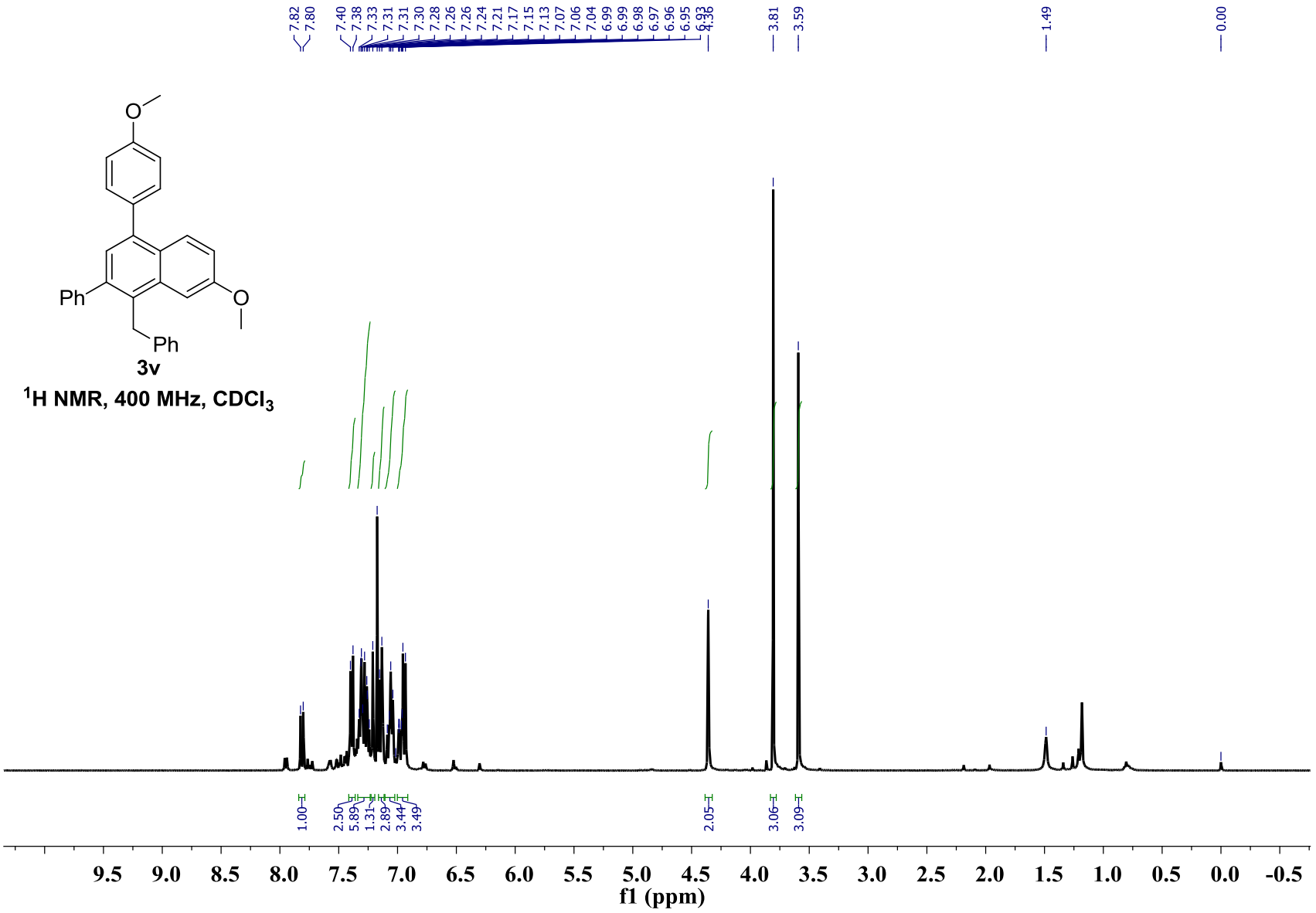
3t

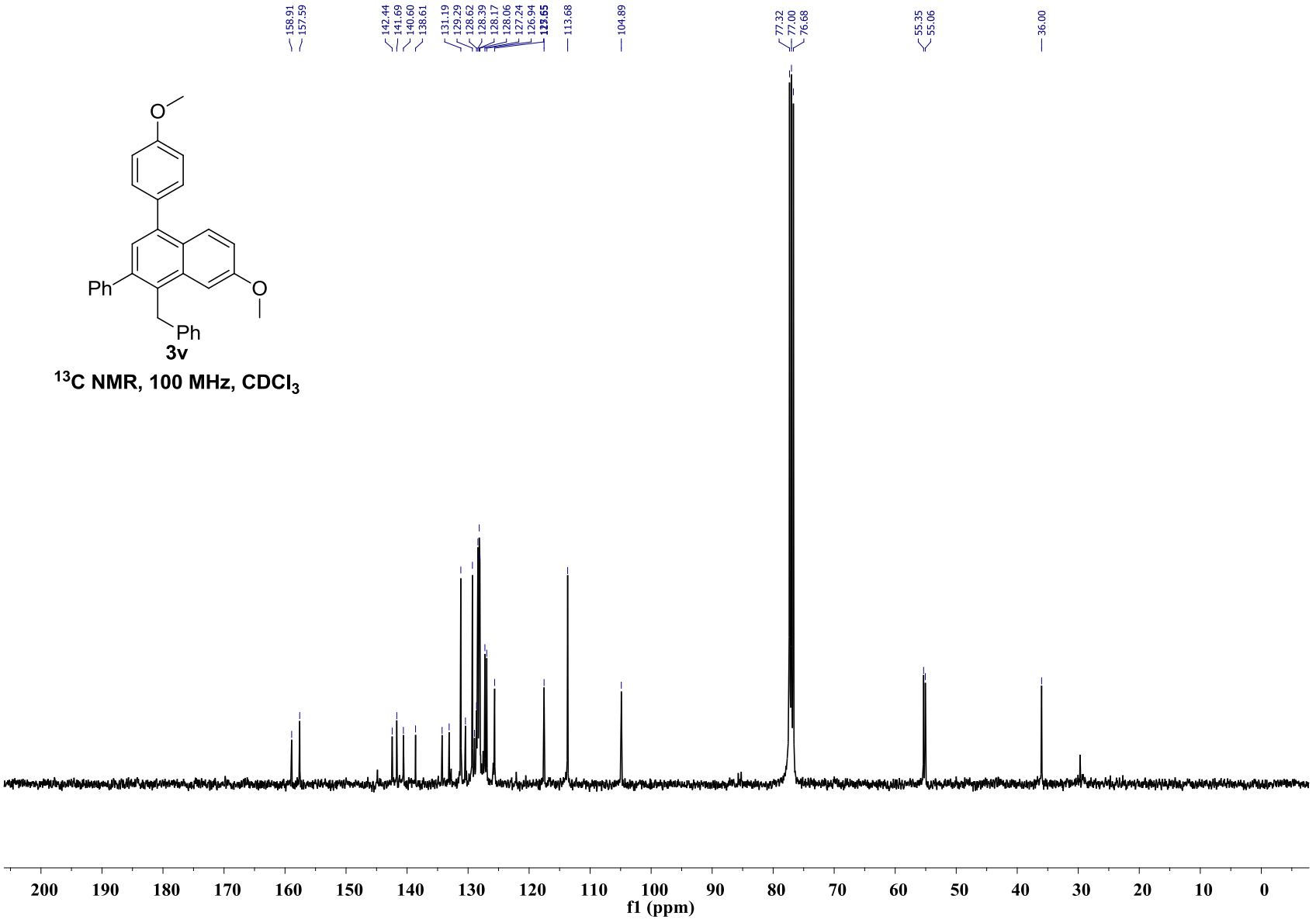
^{1}H NMR, 500 MHz, $CDCl_3$

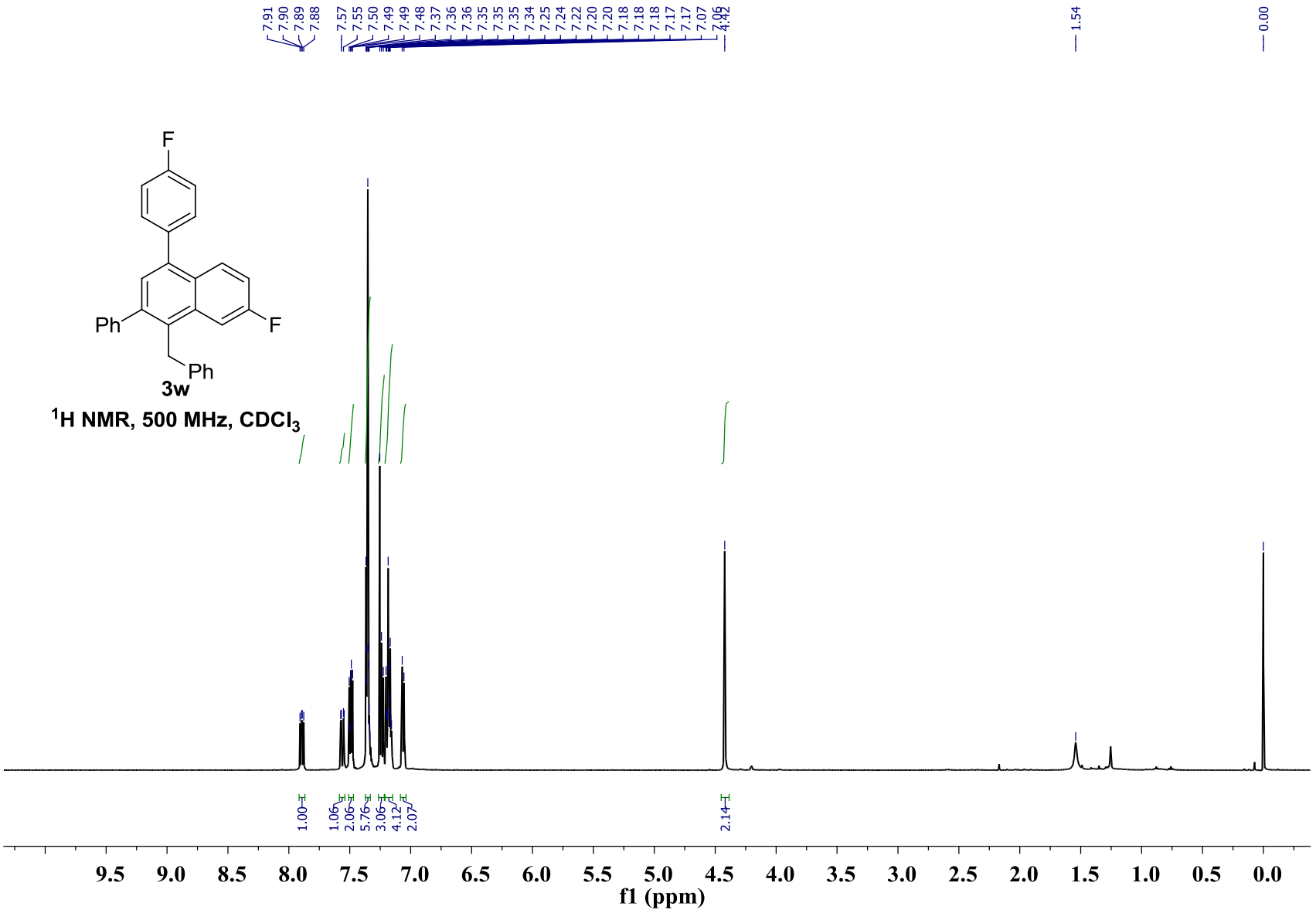

142.53
140.76
138.67
138.12
133.29
130.90
130.35
130.27
129.90
129.38
128.27
128.13
127.19
126.87
126.63
126.14
125.60
124.88
16.49
Ph
Ph
Me
3t
^{13}C NMR, 100 MHz, CDCl$_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

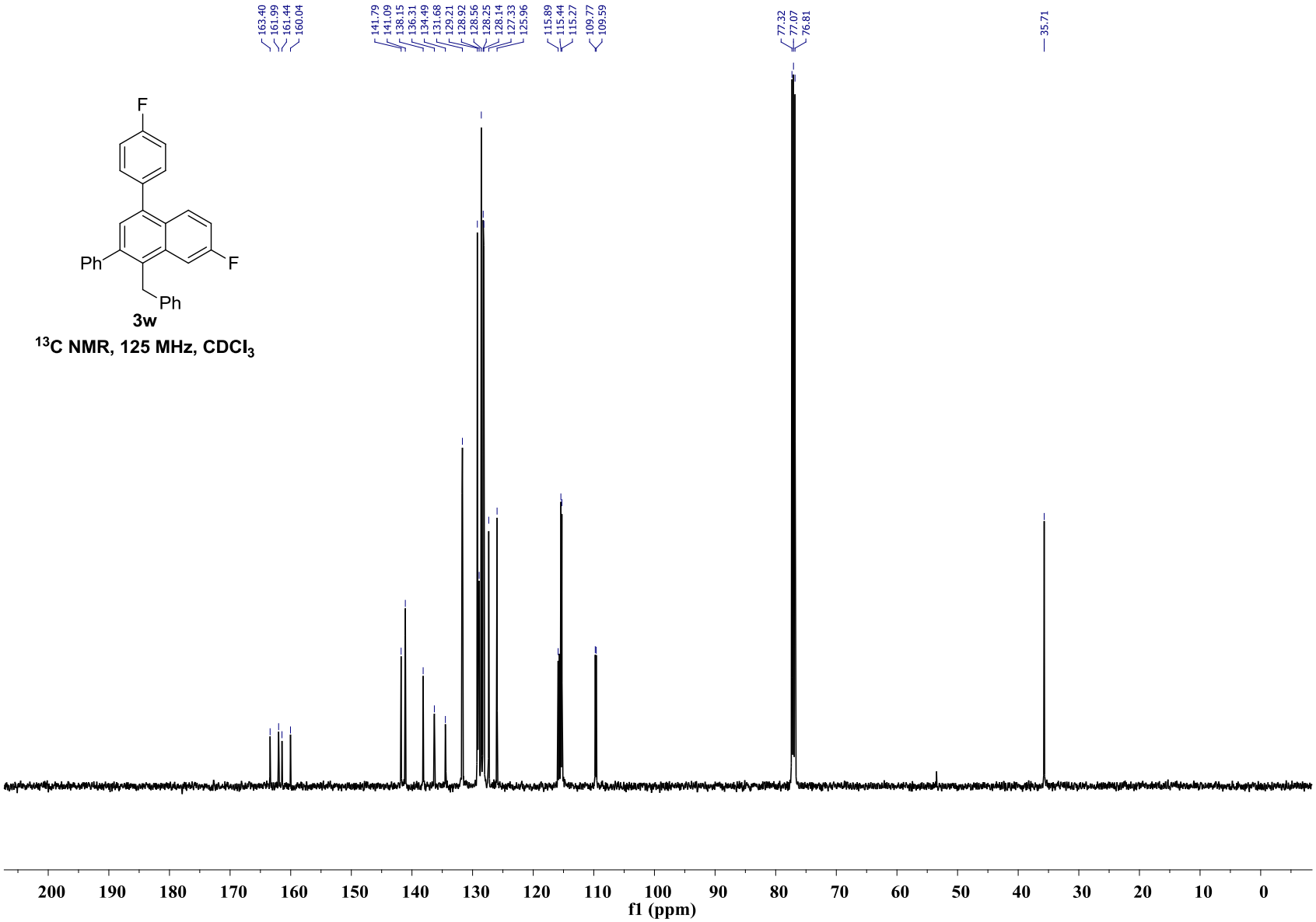

Ph
Ph
3u
1H NMR, 500 MHz, CDCl3
7.91
7.90
7.89
7.88
7.74
7.46
7.45
7.44
7.43
7.36
7.35
7.33
7.33
7.31
7.31
7.30
7.29
7.25
7.23
7.22
7.21
7.21
7.16
7.15
7.15
7.09
7.05
4.46
4.46
2.45
2.45
2.41
2.41
0.00
1.00
1.02
2.38
7.91
2.08
1.04
1.76
2.01
2.91
2.86
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

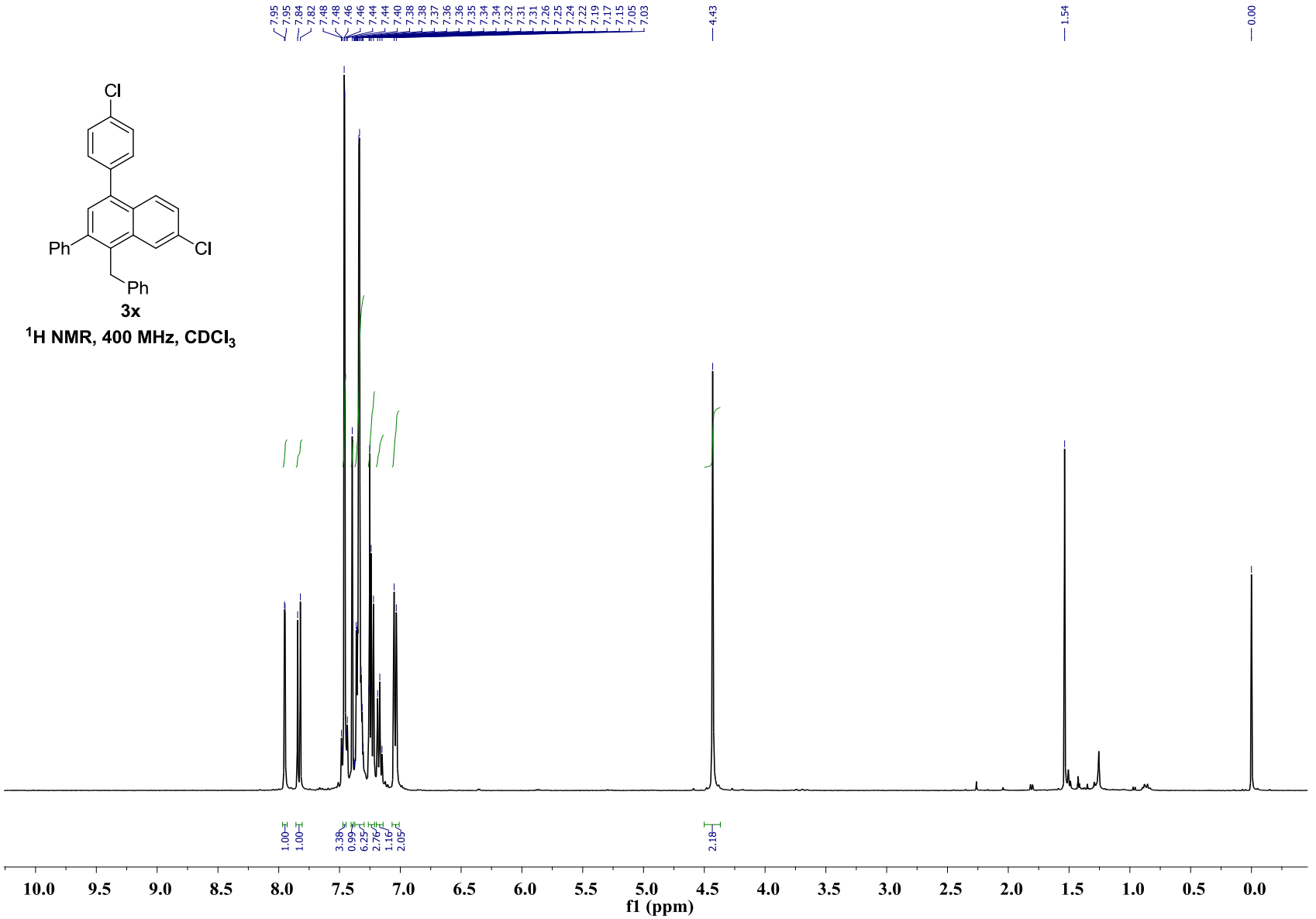

142.39
141.87
140.00
138.85
137.82
136.80
135.73
133.25
130.97
130.05
129.66
129.30
128.91
128.60
128.31
128.18
127.99
127.60
126.90
126.54
125.56
124.89
77.25
77.00
76.75
35.47
21.22
21.22
Ph
Ph
3u
^{13}C NMR, 125 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

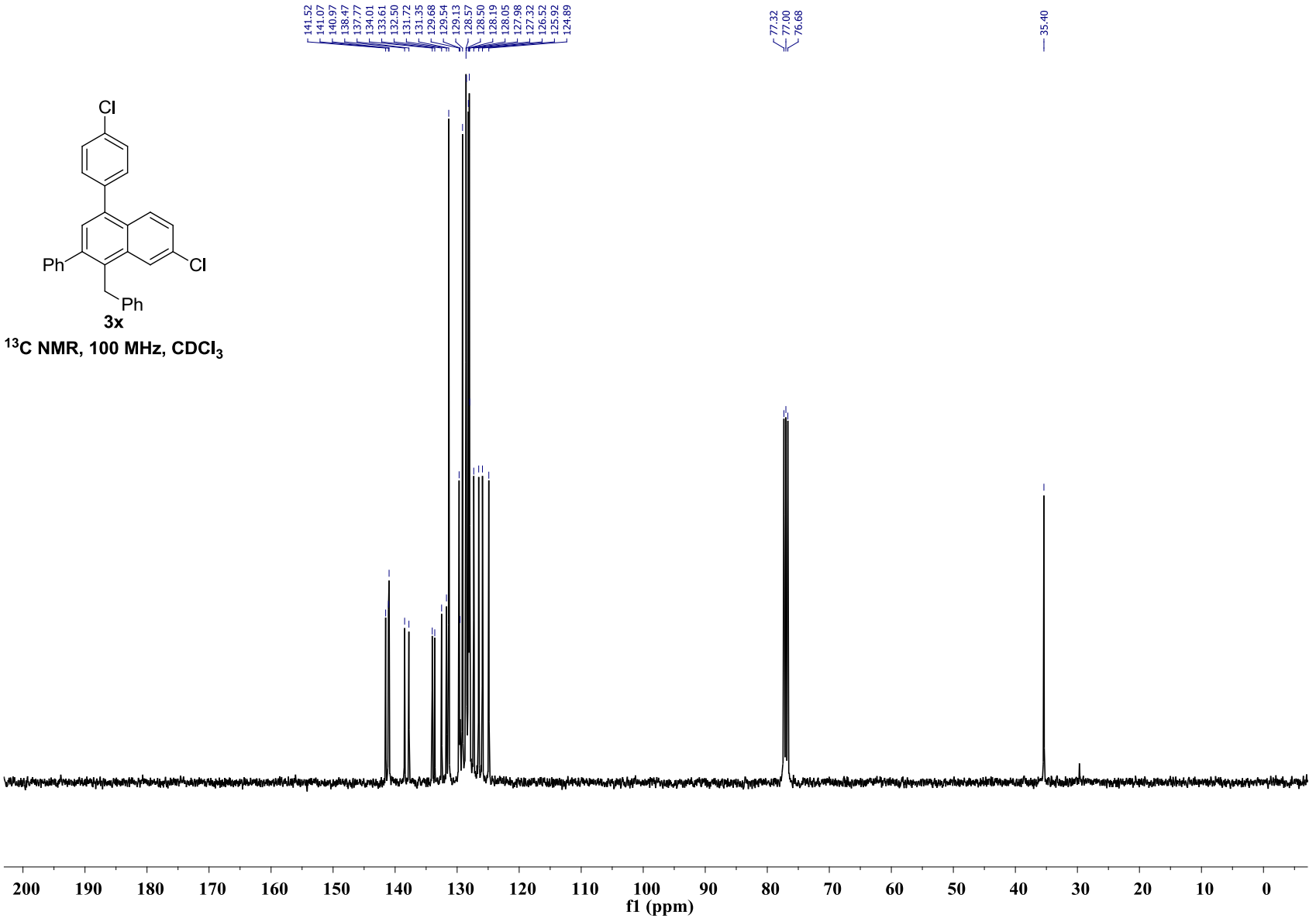

7.82
7.80
7.40
7.38
7.33
7.31
7.31
7.30
7.28
7.26
7.26
7.24
7.21
7.17
7.15
7.13
7.07
7.06
7.04
6.99
6.99
6.98
6.97
6.96
6.95
6.93
4.36
3.81
3.59
1.49
0.00
O
Ph
O
Ph
3v
1H NMR, 400 MHz, CDCl3
1.00
2.50
5.89
1.31
2.89
3.44
3.49
2.05
3.06
3.09
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

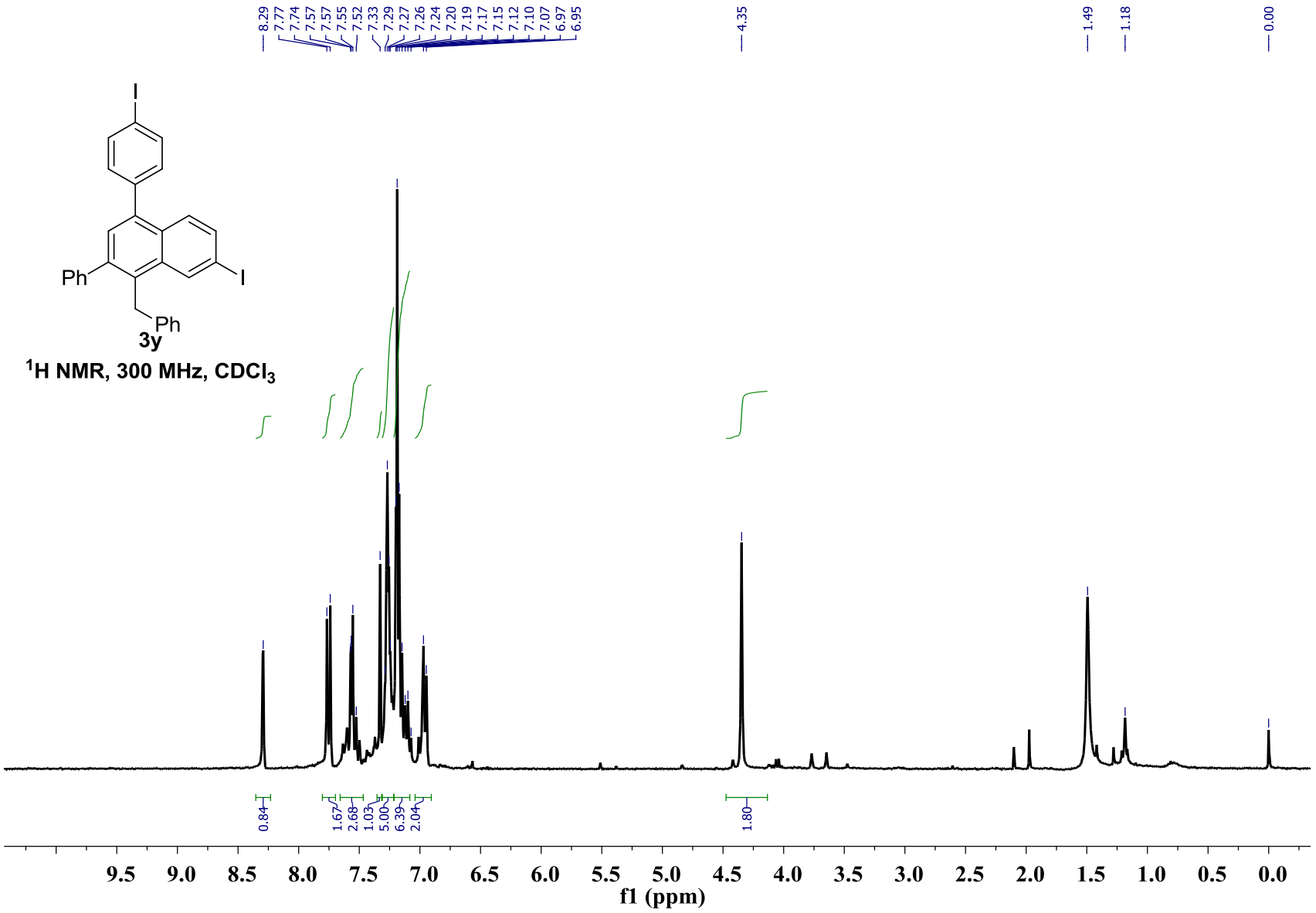

158.91
157.59
142.44
141.69
140.60
138.61
131.19
129.29
128.62
128.39
128.17
128.06
127.24
126.94
113.68
104.89
77.32
77.00
76.68
55.35
55.06
36.00
O
Ph
O
Ph
3v
^{13}C NMR, 100 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.91
7.90
7.89
7.88
7.57
7.55
7.50
7.49
7.49
7.48
7.37
7.36
7.36
7.35
7.35
7.35
7.34
7.25
7.24
7.22
7.20
7.20
7.18
7.18
7.17
7.17
7.07
4.42
1.54
0.00
F
Ph
F
Ph
3w
1H NMR, 500 MHz, CDCl3
1.00
1.06
2.06
5.76
3.06
4.12
2.07
2.14
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 0.0
f1 (ppm)

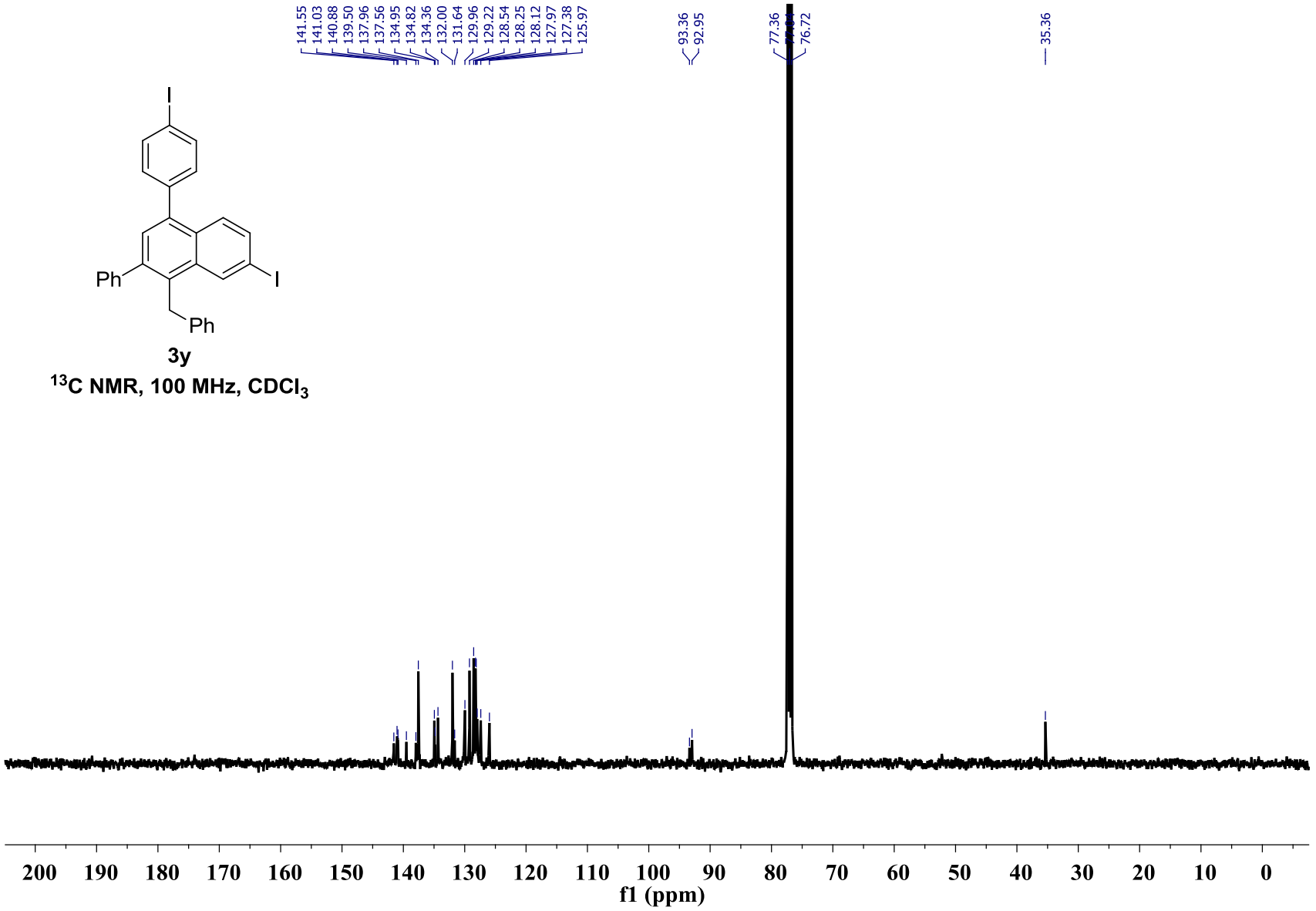

163.40
161.99
161.44
160.04
141.79
141.09
138.15
136.31
134.49
131.68
129.21
128.92
128.56
128.25
128.14
127.33
125.96
115.89
115.44
115.27
109.77
109.59
77.32
77.07
76.81
35.71
F
Ph
F
Ph
3w
^{13}C NMR, 125 MHz, CDCl$_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


Cl
Ph
Cl
Ph
3x
^{1}H NMR, 400 MHz, CDCl$_3$
7.95
7.95
7.84
7.82
7.48
7.48
7.46
7.46
7.44
7.44
7.40
7.38
7.38
7.37
7.36
7.36
7.35
7.34
7.34
7.32
7.31
7.31
7.26
7.25
7.24
7.22
7.19
7.17
7.15
7.05
7.03
4.43
1.54
0.00
1.00
1.00
3.38
0.99
6.25
2.76
1.16
2.05
2.18
10.0
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
0.0
f1 (ppm)


141.52
141.07
140.97
138.47
137.77
134.01
133.61
132.50
131.72
131.35
129.68
129.54
129.13
128.57
128.50
128.19
128.05
127.98
127.32
126.52
125.92
124.89
77.32
77.00
76.68
35.40
Cl
Ph
Cl
Ph
3x
^{13}C NMR, 100 MHz, CDCl$_3$
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

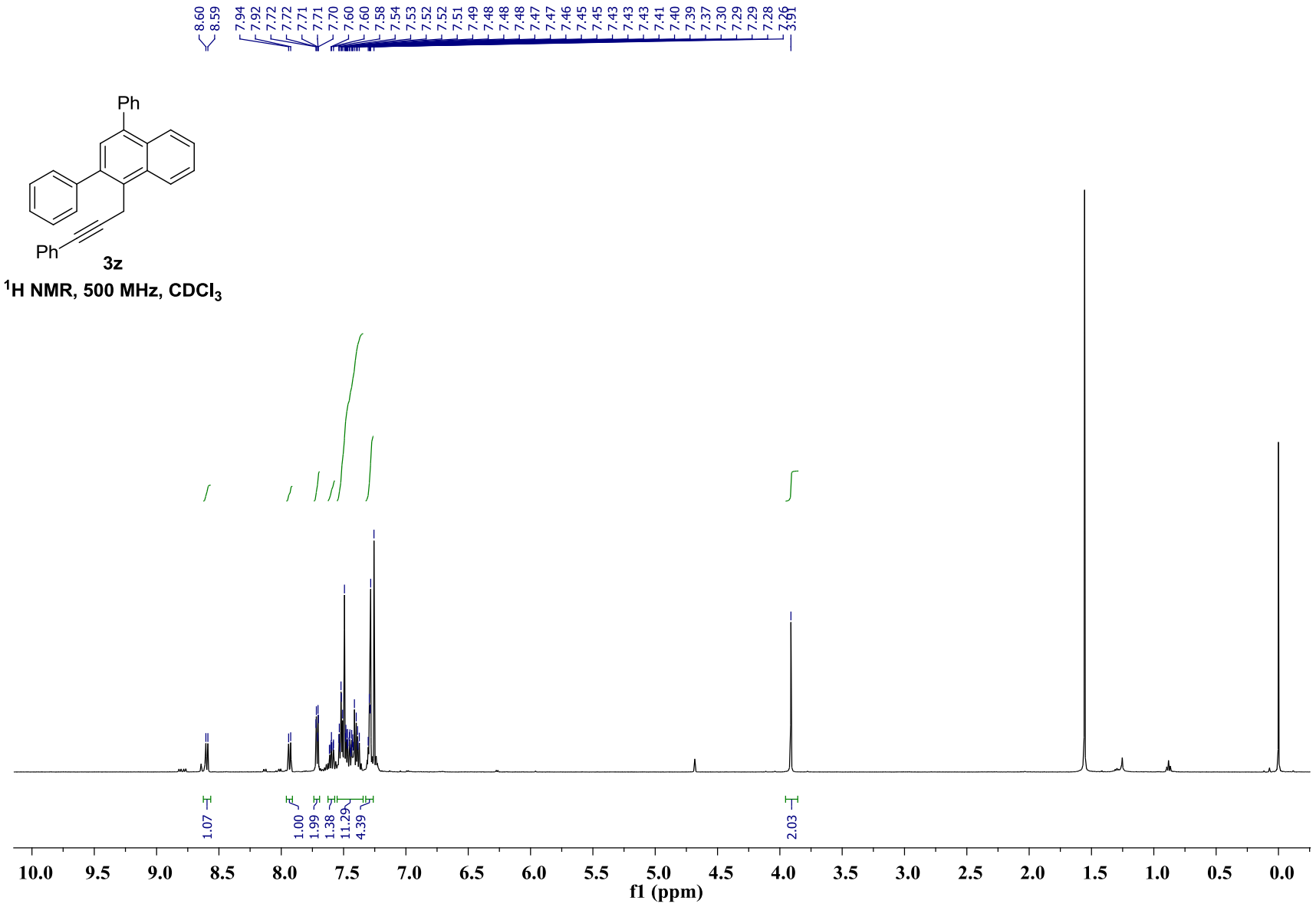


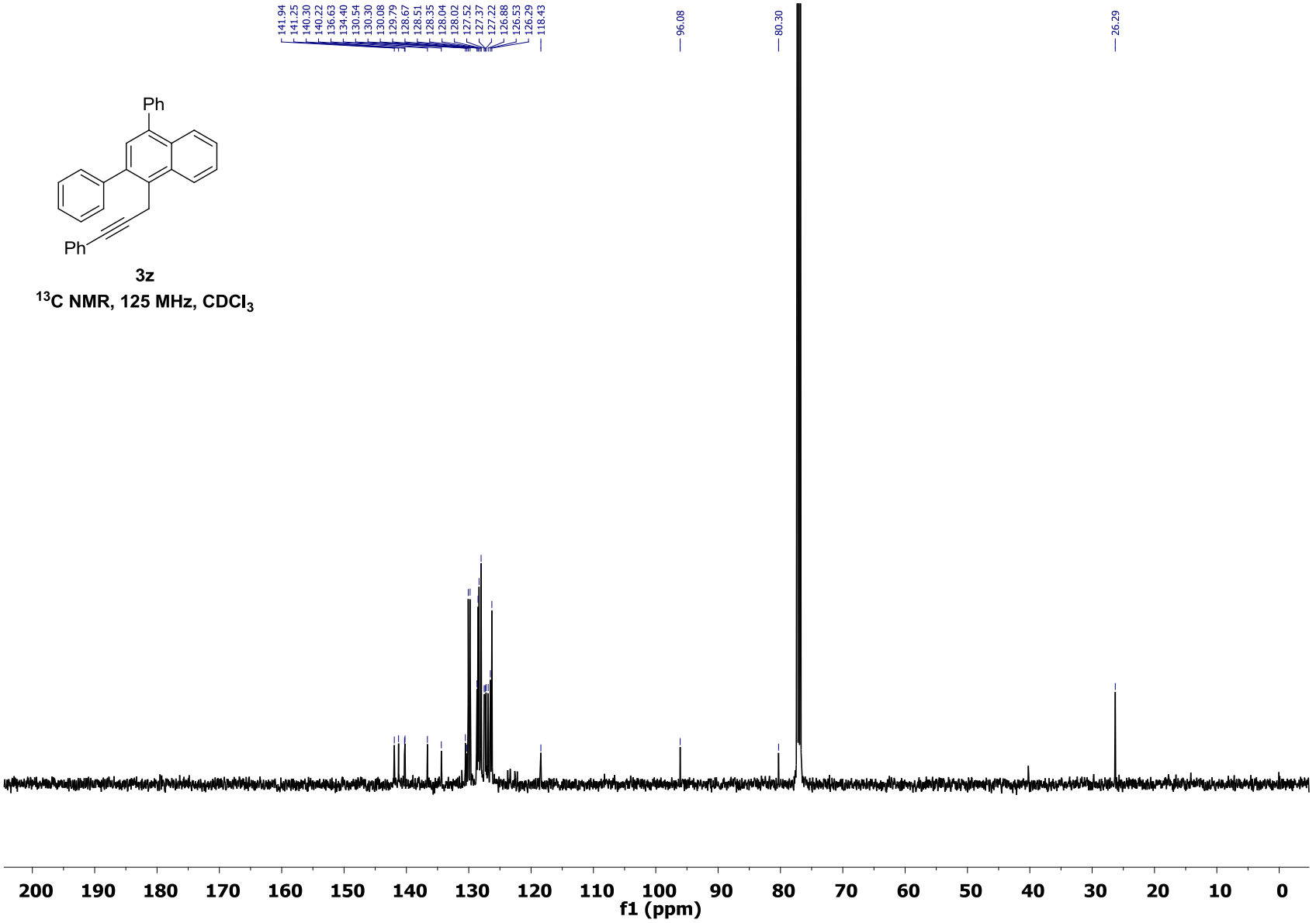
^{1}H NMR, 300 MHz, $CDCl_3$



3y

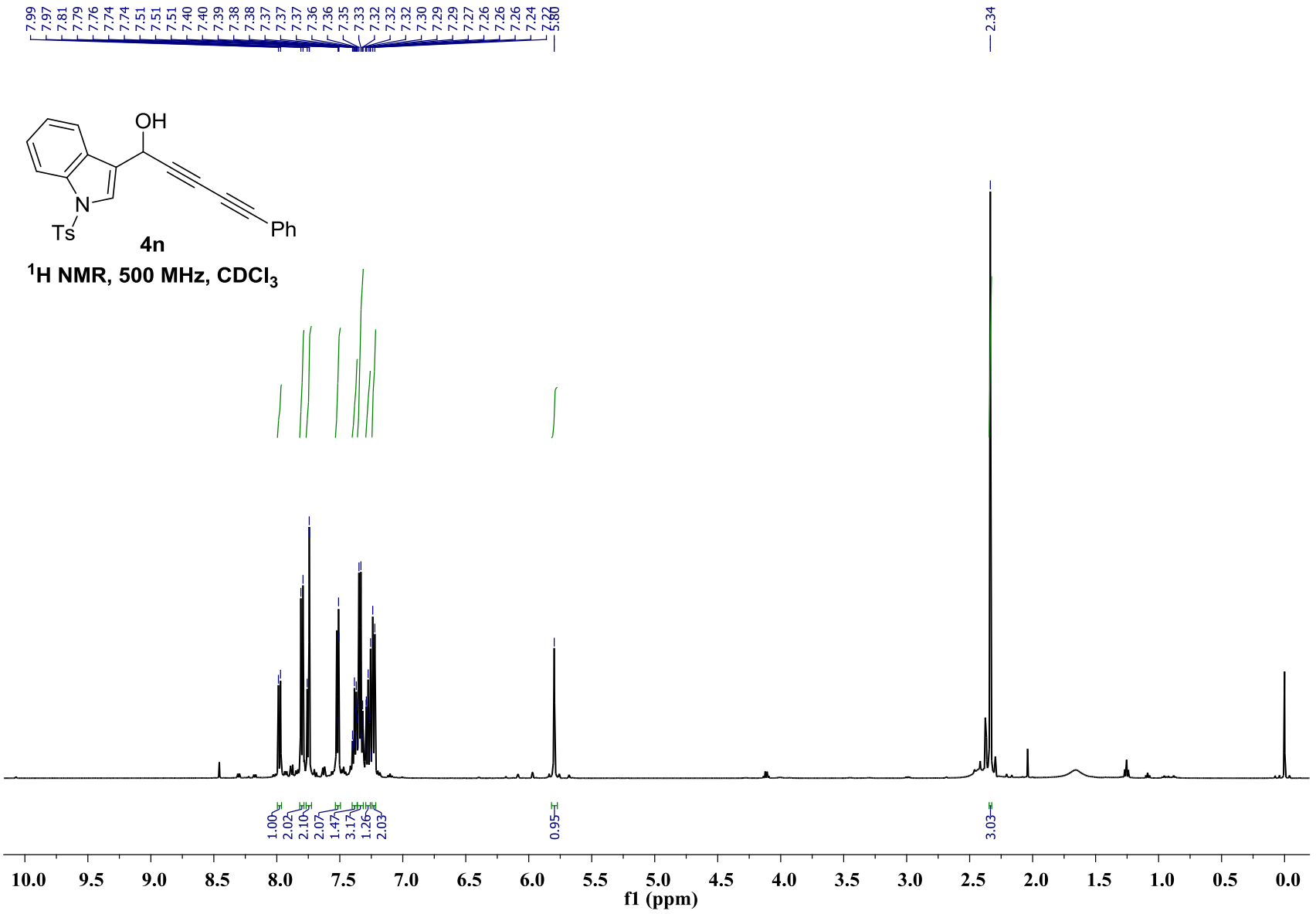
^{13}C NMR, 100 MHz, $CDCl_3$

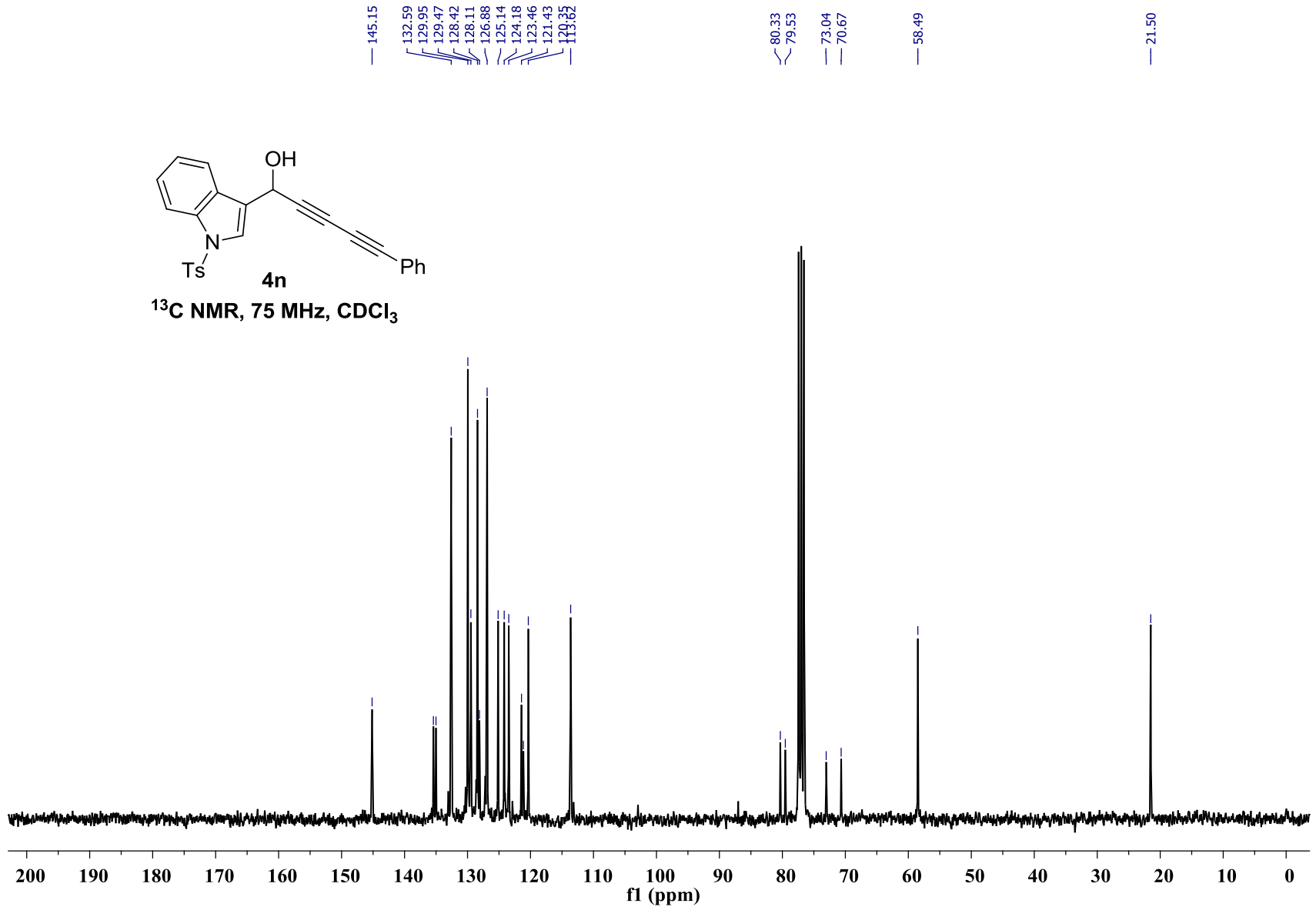

8.60
8.59
7.94
7.92
7.72
7.72
7.71
7.71
7.70
7.60
7.60
7.58
7.54
7.53
7.52
7.52
7.51
7.49
7.48
7.48
7.48
7.47
7.47
7.46
7.45
7.45
7.43
7.43
7.43
7.41
7.40
7.39
7.37
7.30
7.29
7.29
7.28
7.26
3.91
Ph
Ph
3z
1H NMR, 500 MHz, CDCl3
1.07
1.00
1.99
1.38
11.29
4.39
2.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

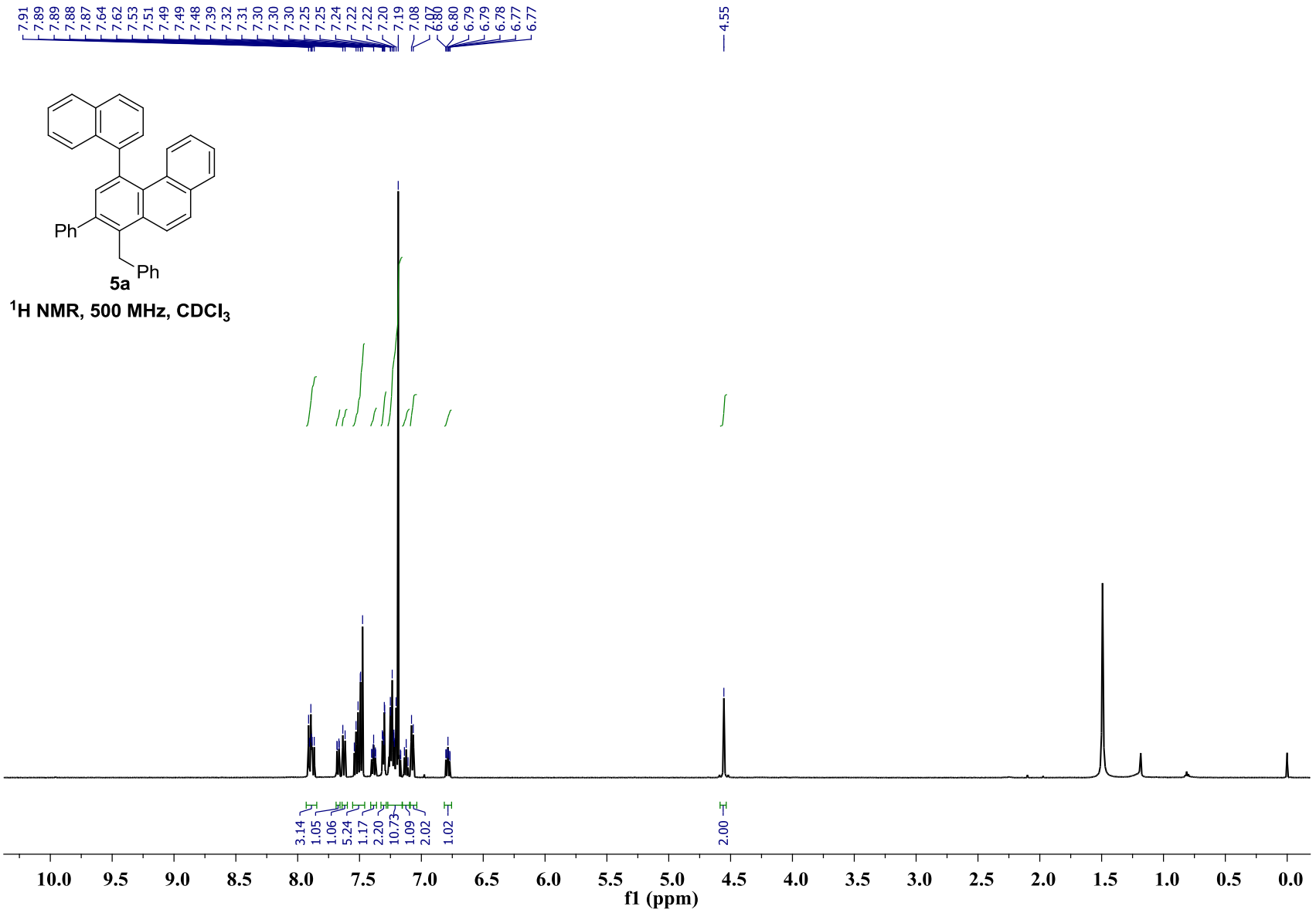


3z

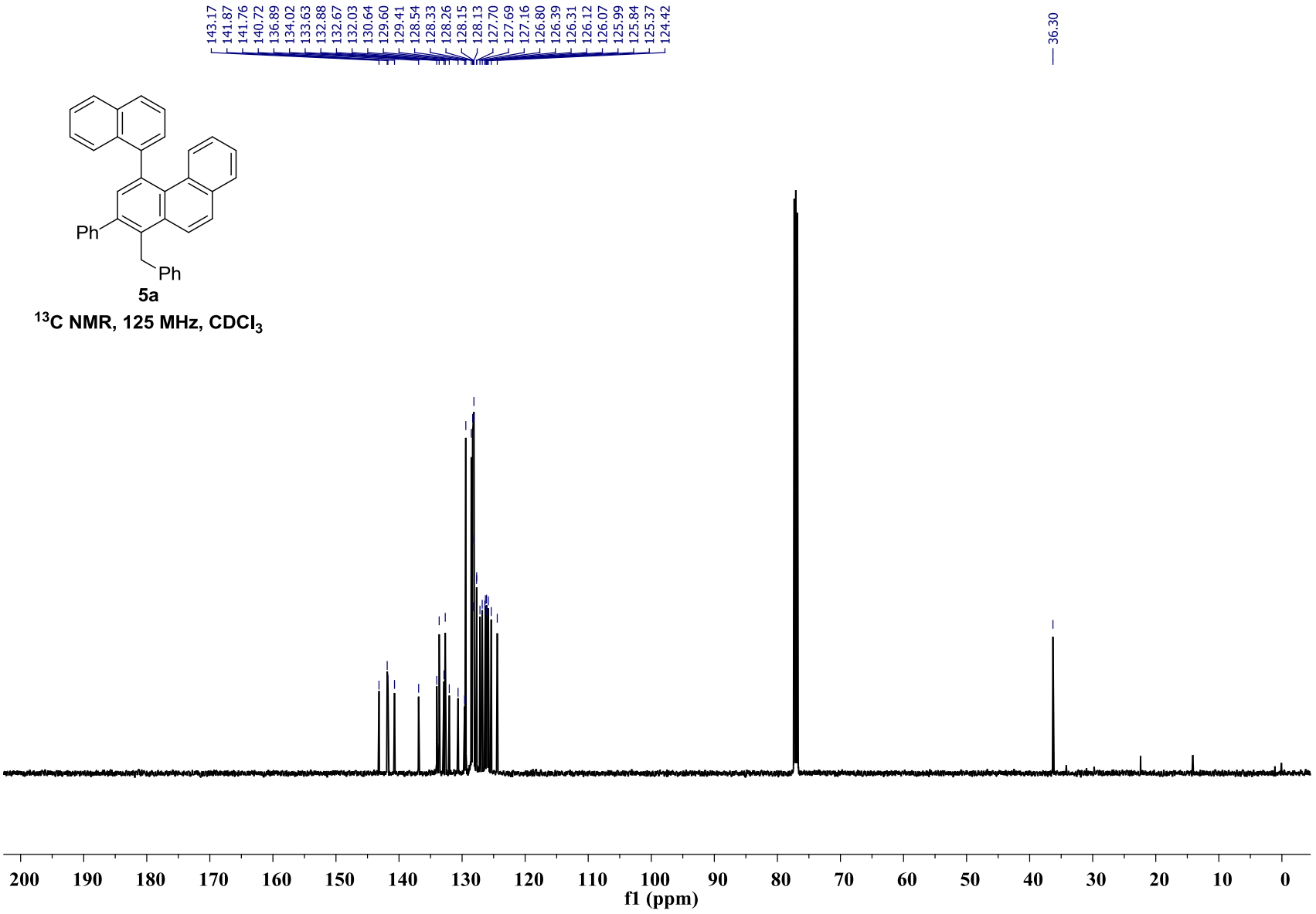
^{13}C NMR, 125 MHz, $CDCl_3$


7.99
7.97
7.81
7.79
7.76
7.74
7.74
7.51
7.51
7.51
7.40
7.40
7.39
7.38
7.38
7.37
7.37
7.37
7.36
7.36
7.35
7.33
7.32
7.32
7.32
7.30
7.29
7.29
7.27
7.26
7.26
7.26
7.24
7.22
5.80
2.34
OH
N
Ts
Ph
4n
1H NMR, 500 MHz, CDCl3
1.00
2.02
2.10
2.07
1.47
3.17
1.26
2.03
0.95
3.03
10.0
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
0.0
f1 (ppm)


145.15
132.59
129.95
129.47
128.42
128.11
126.88
125.14
124.18
123.46
121.43
80.33
79.53
73.04
70.67
58.49
21.50
OH
N
Ts
Ph
4n
13C NMR, 75 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

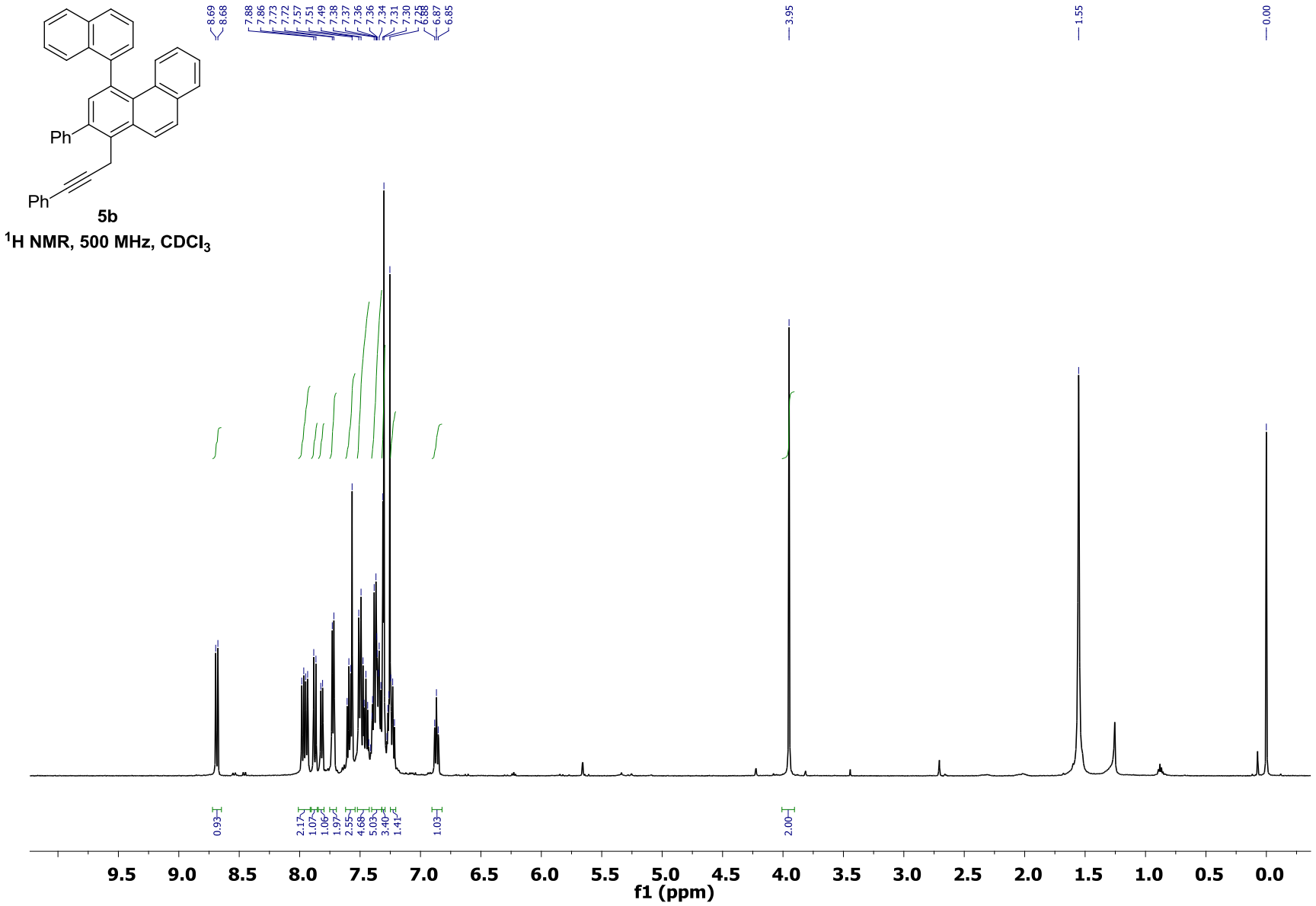


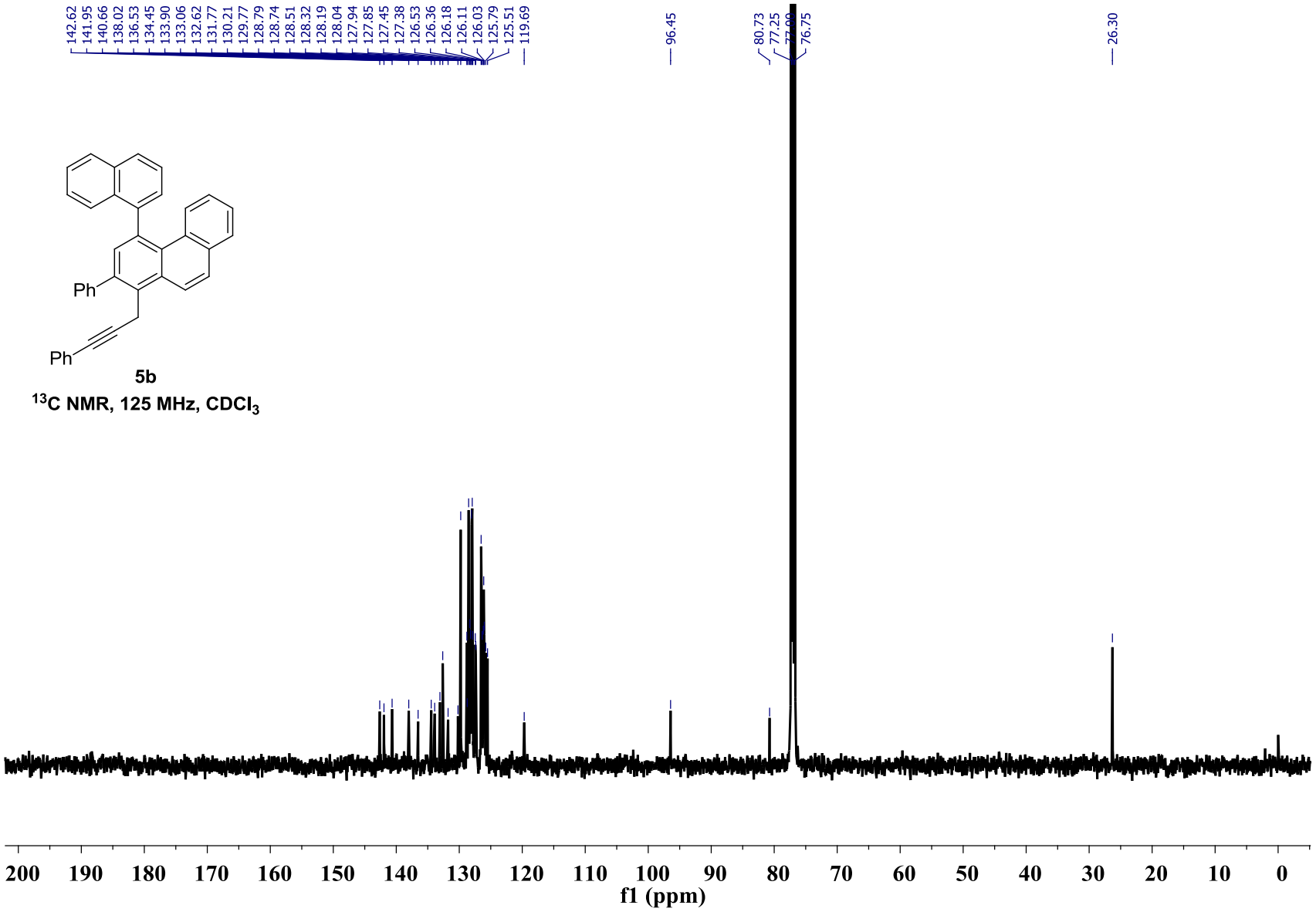
^{1}H NMR, 500 MHz, $CDCl_3$



5a

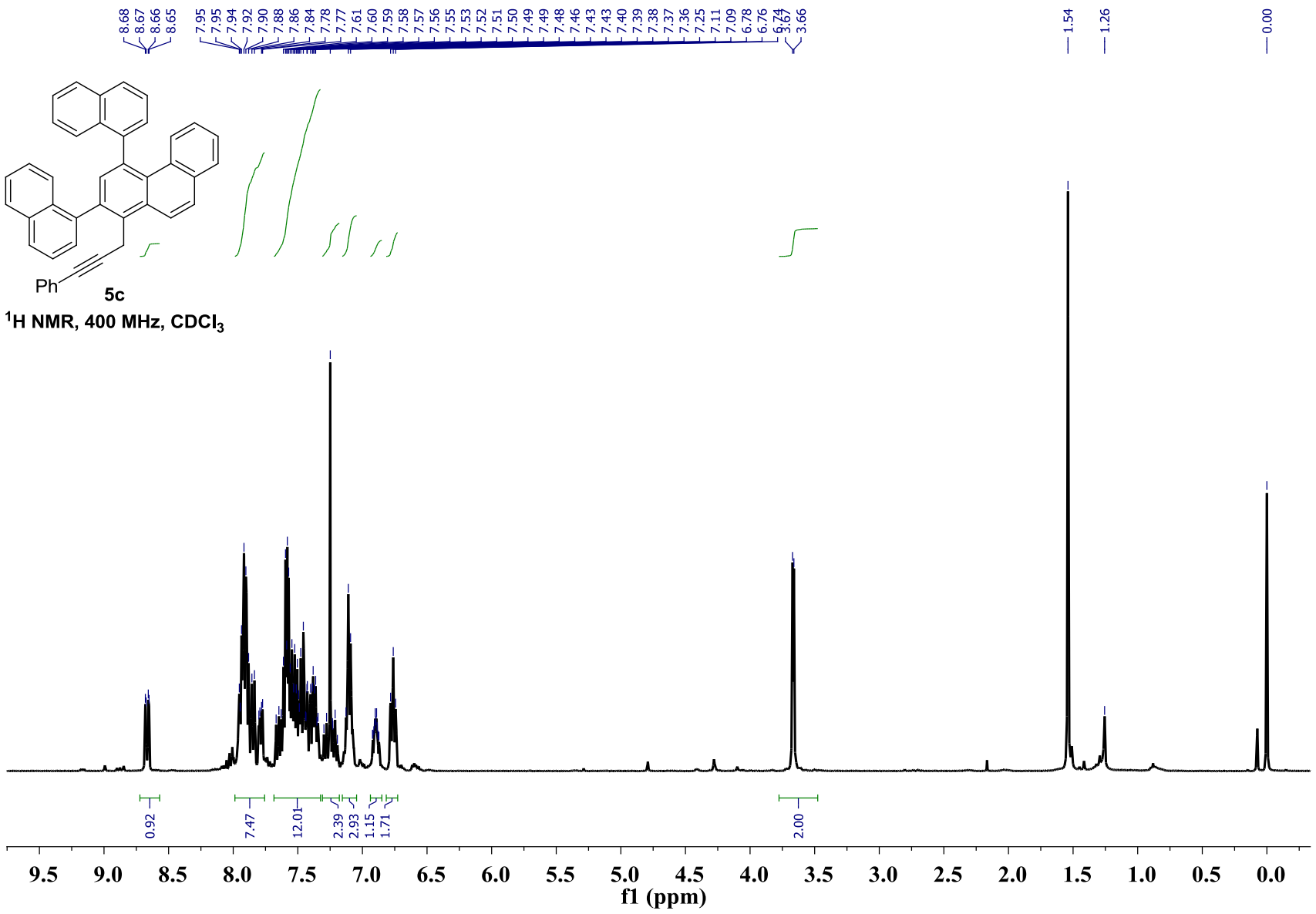
^{13}C NMR, 125 MHz, $CDCl_3$

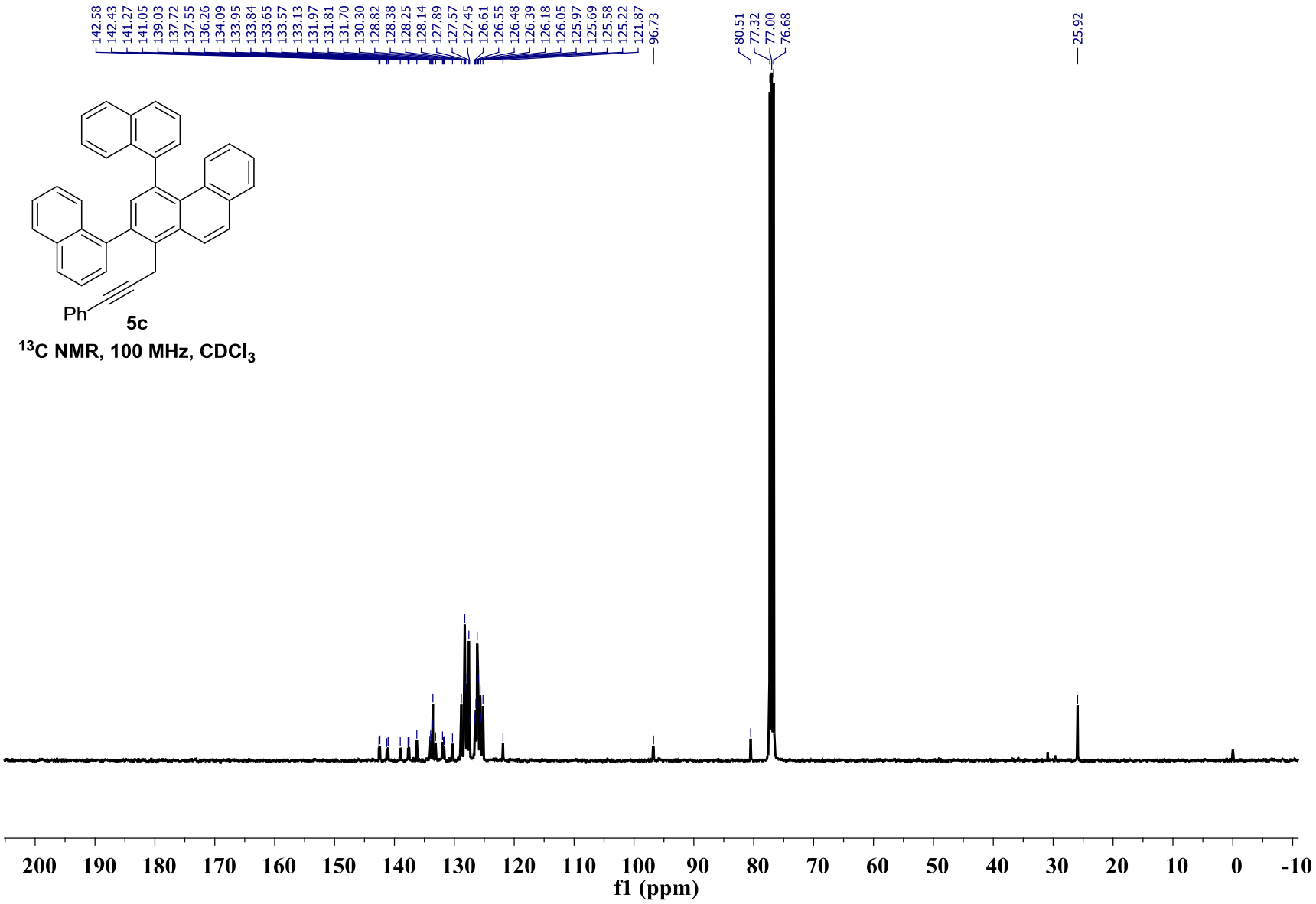

Ph
Ph
5b
^{1}H NMR, 500 MHz, CDCl$_3$
8.69
8.68
7.88
7.86
7.73
7.72
7.57
7.51
7.49
7.38
7.37
7.36
7.36
7.34
7.31
7.30
7.25
6.88
6.87
6.85
3.95
1.55
0.00
0.93
2.17
1.07
1.06
1.97
2.55
4.68
5.03
3.40
1.41
1.03
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

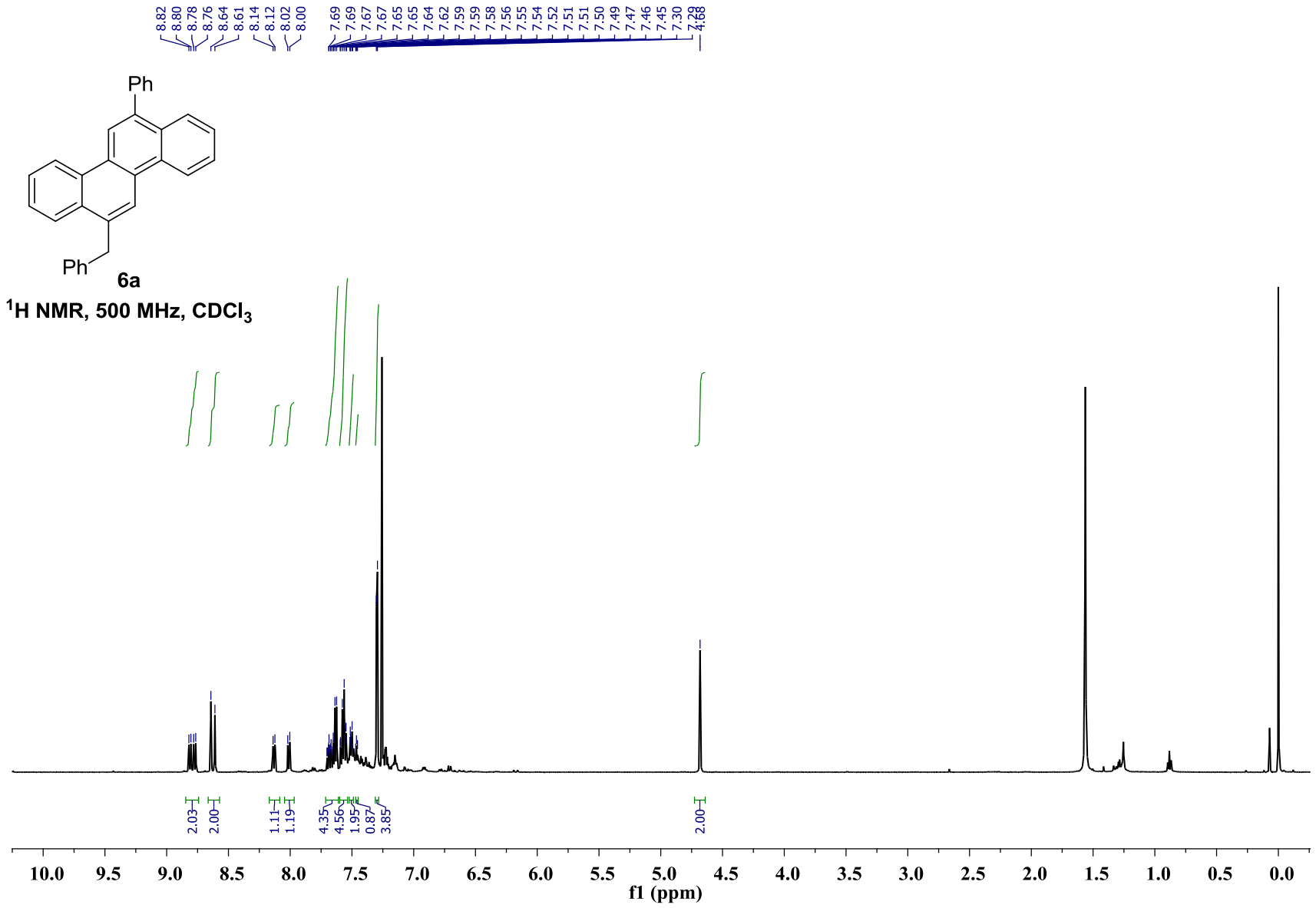


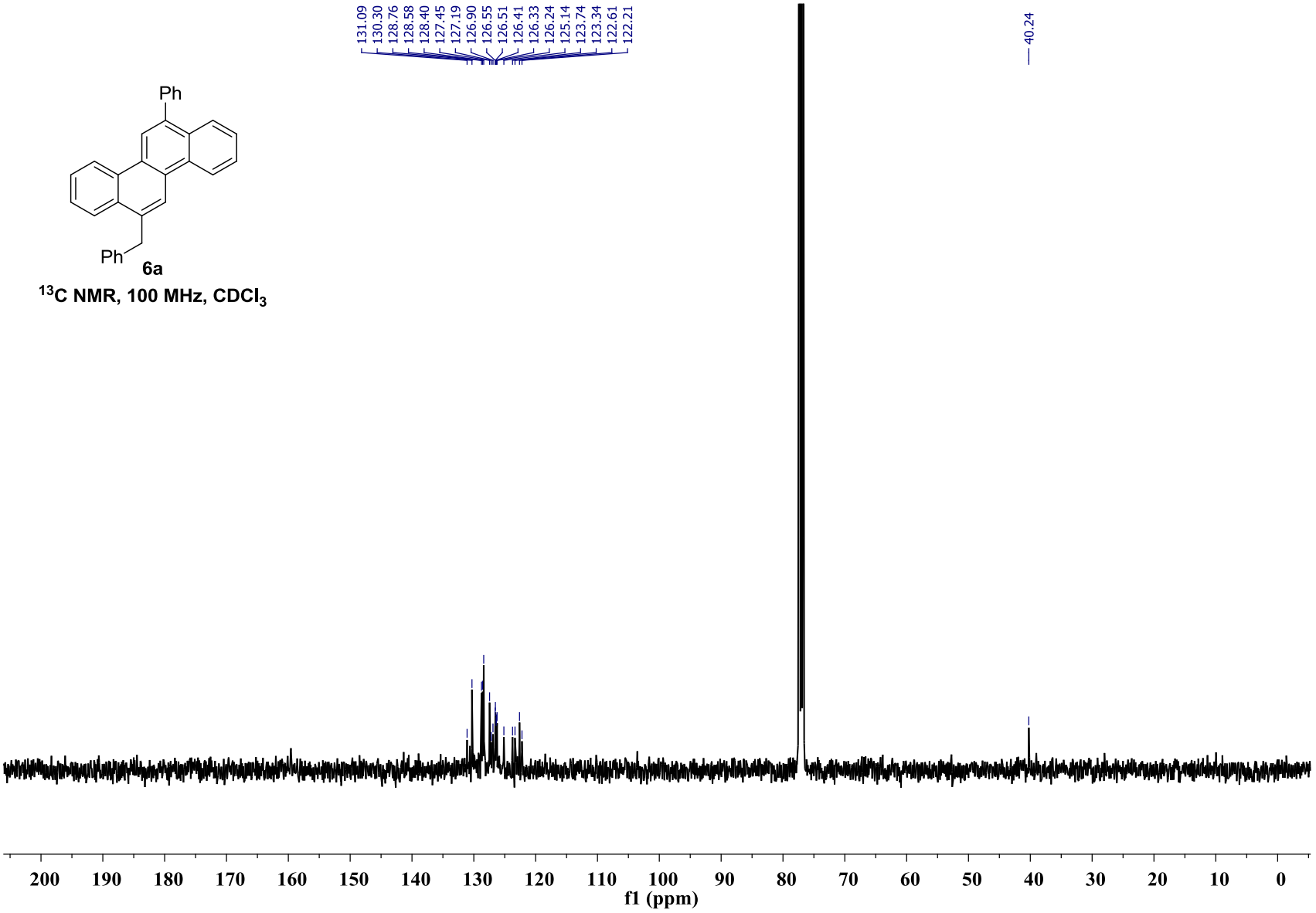
5b

^{13}C NMR, 125 MHz, $CDCl_3$


8.68
8.67
8.66
8.65
7.95
7.95
7.94
7.92
7.90
7.88
7.86
7.84
7.78
7.77
7.61
7.60
7.59
7.58
7.57
7.56
7.55
7.53
7.52
7.51
7.50
7.49
7.49
7.48
7.46
7.43
7.43
7.40
7.39
7.38
7.37
7.36
7.25
7.11
7.09
6.78
6.76
6.74
3.67
3.66
1.54
1.26
0.00
Ph
5c
^{1}H NMR, 400 MHz, CDCl$_3$
0.92
7.47
12.01
2.39
2.93
1.15
1.71
2.00
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
0.0
f1 (ppm)

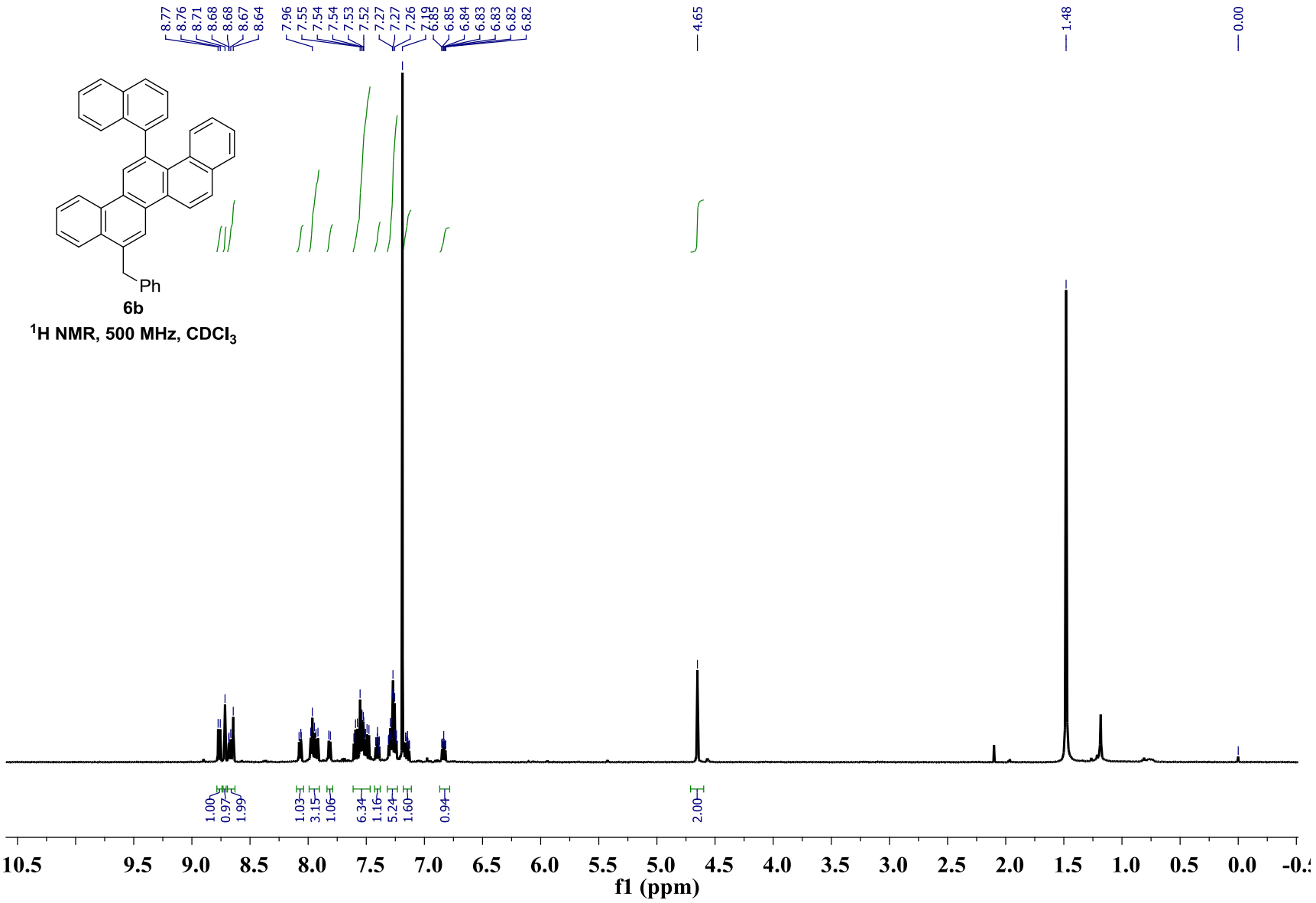

142.58
142.43
141.27
141.05
139.03
137.72
137.55
136.26
134.09
133.95
133.84
133.65
133.57
133.13
131.97
131.81
131.70
130.30
128.82
128.38
128.25
128.14
127.89
127.57
127.45
126.61
126.55
126.48
126.39
126.18
126.05
125.97
125.69
125.58
125.22
121.87
96.73
80.51
77.32
77.00
76.68
25.92
Ph
5c
^{13}C NMR, 100 MHz, CDCl$_3$
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

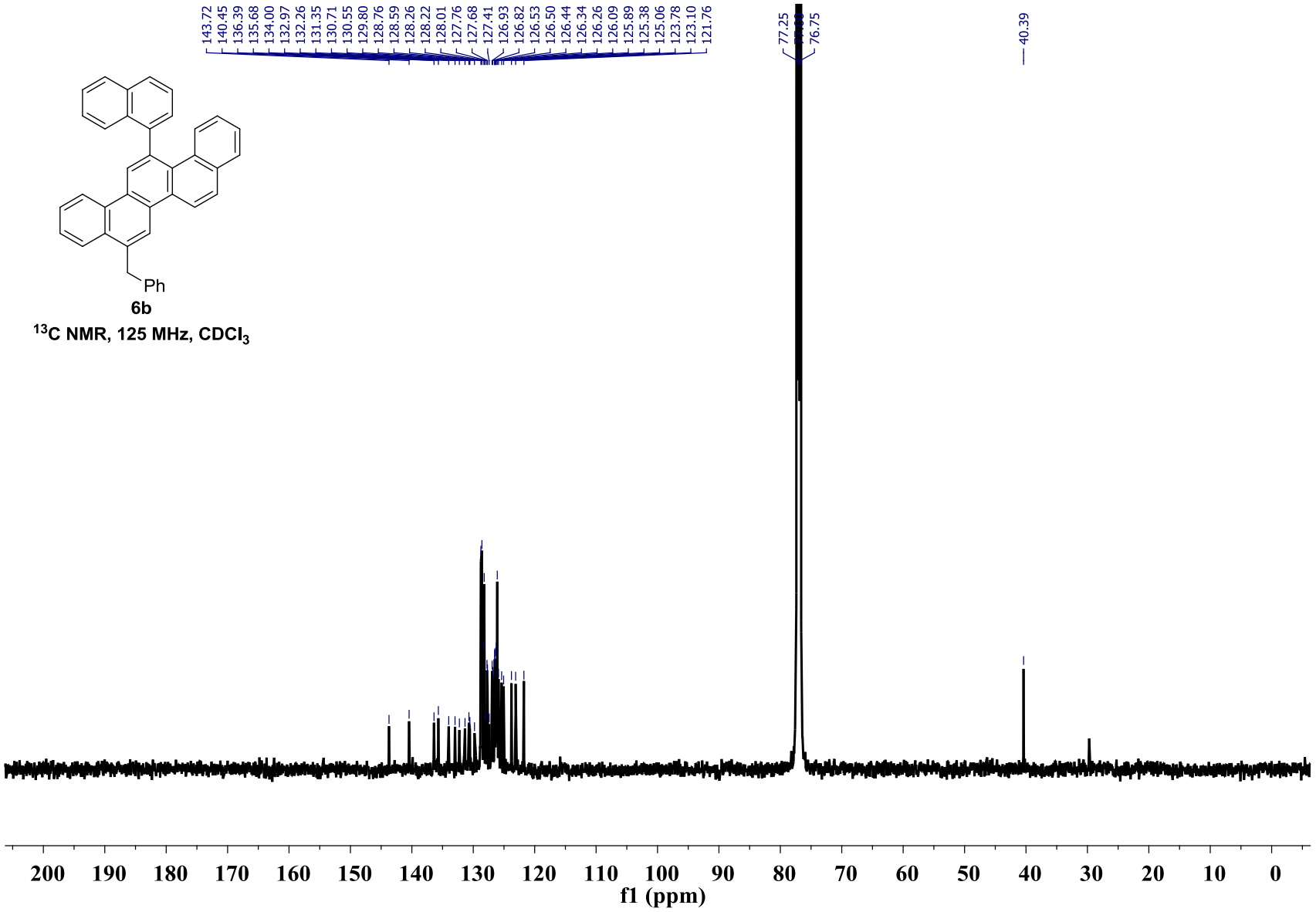

8.82
8.80
8.78
8.76
8.64
8.61
8.14
8.12
8.02
8.00
7.69
7.69
7.67
7.67
7.65
7.65
7.64
7.62
7.59
7.59
7.58
7.56
7.55
7.54
7.52
7.51
7.51
7.50
7.49
7.47
7.46
7.45
7.30
7.29
4.68
Ph
Ph
6a
1H NMR, 500 MHz, CDCl3
2.03
2.00
1.11
1.19
4.35
4.56
1.95
0.87
3.85
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

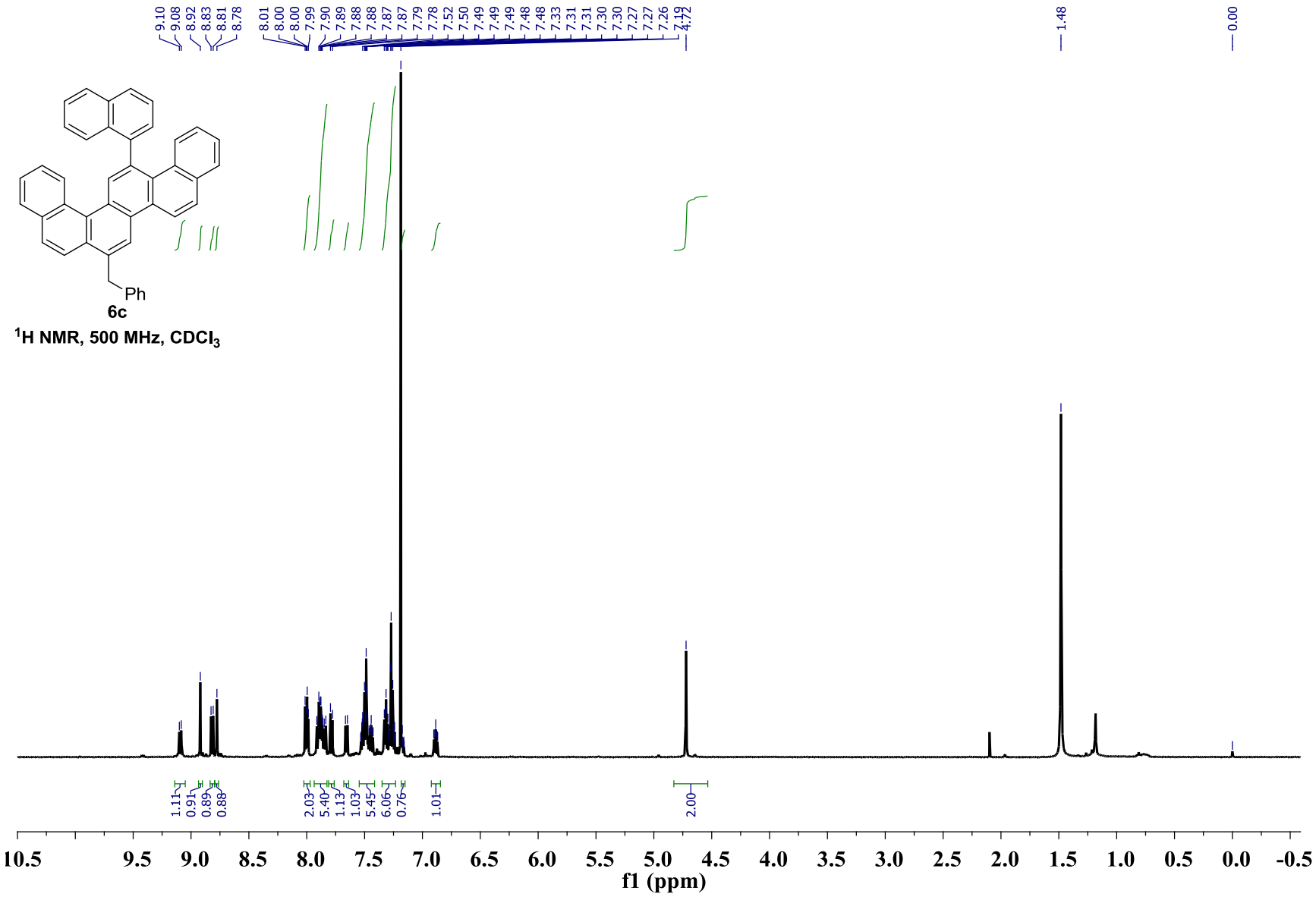


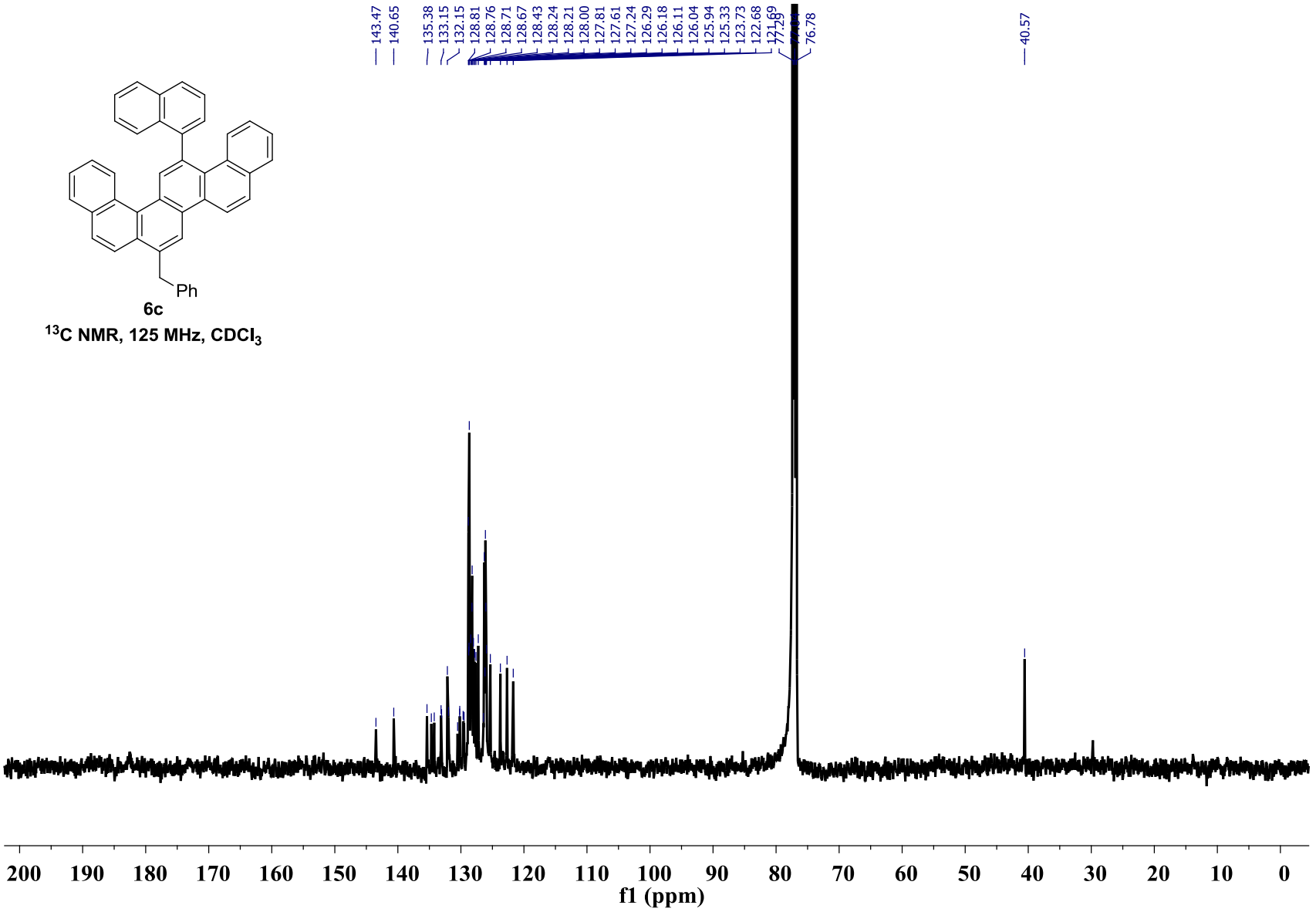
6a

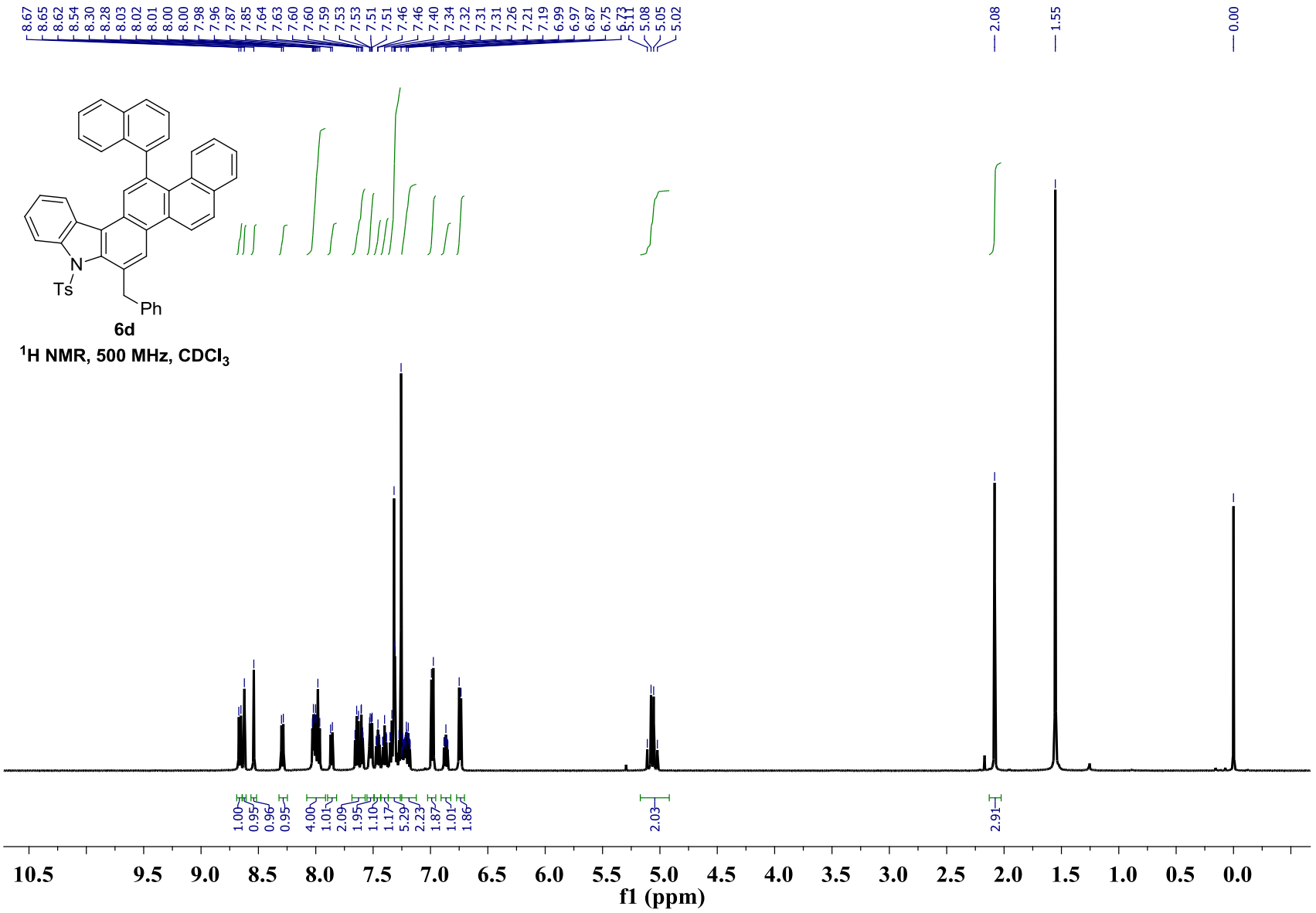
^{13}C NMR, 100 MHz, $CDCl_3$

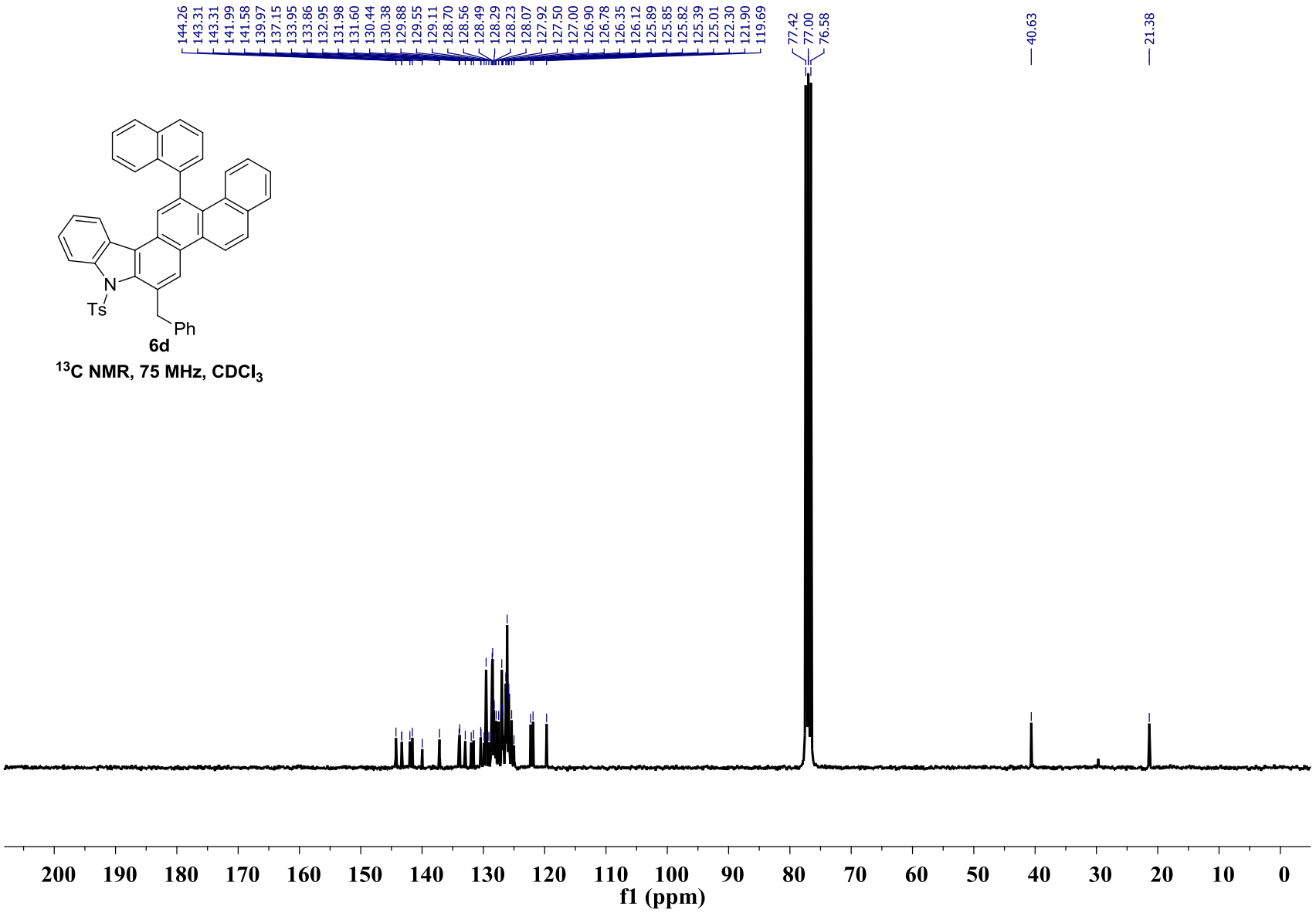

8.77
8.76
8.71
8.68
8.68
8.67
8.64
7.96
7.55
7.54
7.54
7.53
7.52
7.27
7.27
7.26
7.19
6.85
6.84
6.83
6.83
6.82
6.82
4.65
1.48
0.00
Ph
6b
1H NMR, 500 MHz, CDCl3
1.00
0.97
1.99
1.03
3.15
1.06
6.34
1.16
5.24
1.60
0.94
2.00
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


143.72
140.45
136.39
135.68
134.00
132.97
132.26
131.35
130.71
130.55
129.80
128.76
128.59
128.26
128.22
128.01
127.76
127.68
127.41
126.93
126.82
126.53
126.50
126.44
126.34
126.26
126.09
125.89
125.38
125.06
123.78
123.10
121.76
77.25
76.75
40.39
Ph
6b
13C NMR, 125 MHz, CDCl3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


9.10
9.08
8.92
8.83
8.81
8.78
8.01
8.00
8.00
7.99
7.90
7.89
7.88
7.88
7.87
7.87
7.79
7.78
7.52
7.50
7.49
7.49
7.49
7.48
7.48
7.33
7.31
7.31
7.30
7.30
7.27
7.27
7.26
7.19
4.72
1.48
0.00
Ph
6c
1H NMR, 500 MHz, CDCl3
1.11
0.91
0.89
0.88
2.03
5.40
1.13
1.03
5.45
6.06
0.76
1.01
2.00
10.5
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
0.0
-0.5
f1 (ppm)

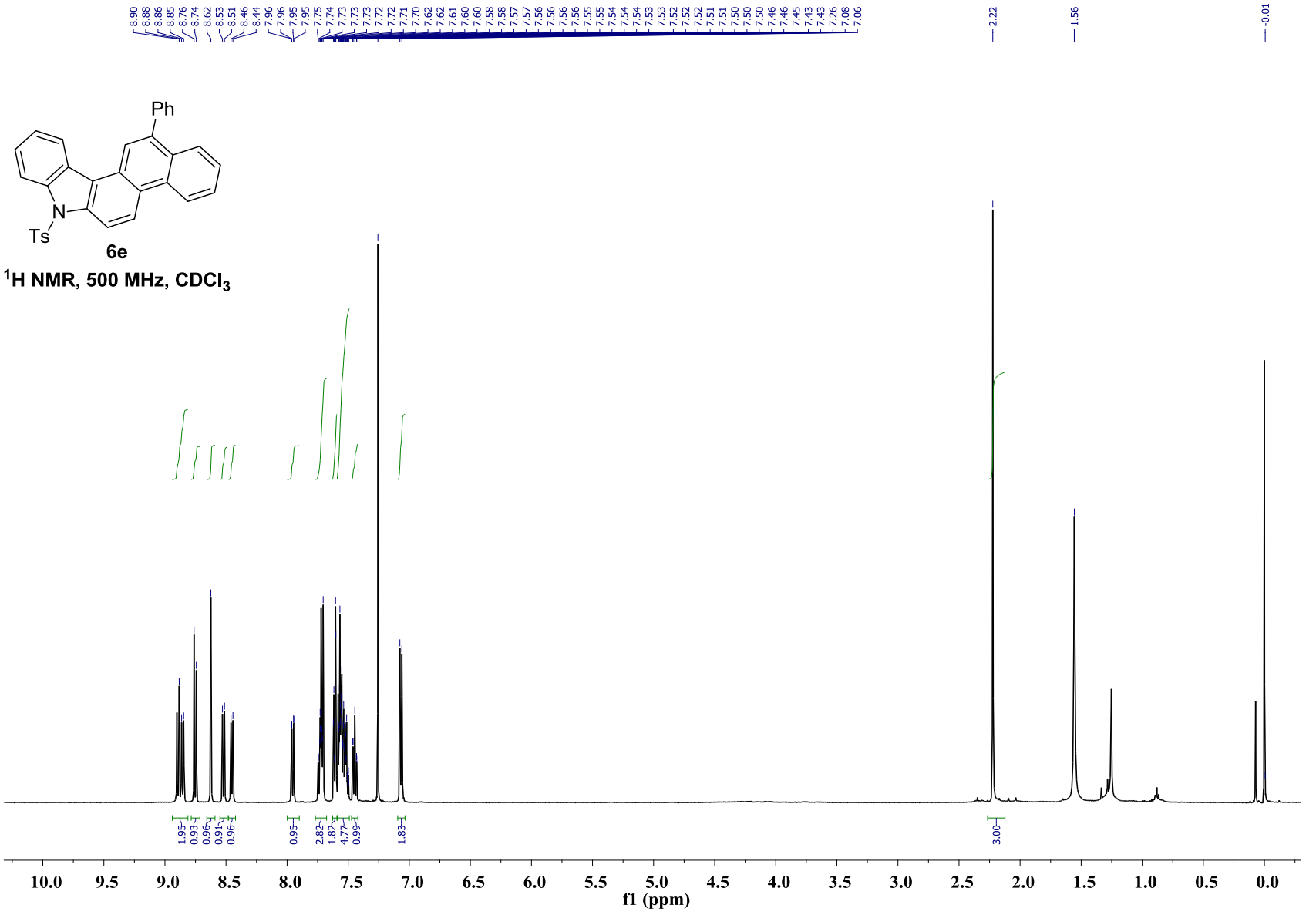

143.47
140.65
135.38
133.15
132.15
128.81
128.76
128.71
128.67
128.43
128.24
128.21
128.00
127.81
127.61
127.24
126.29
126.18
126.11
126.04
125.94
125.33
123.73
122.68
121.69
77.29
76.78
40.57
Ph
6c
13C NMR, 125 MHz, CDCl3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

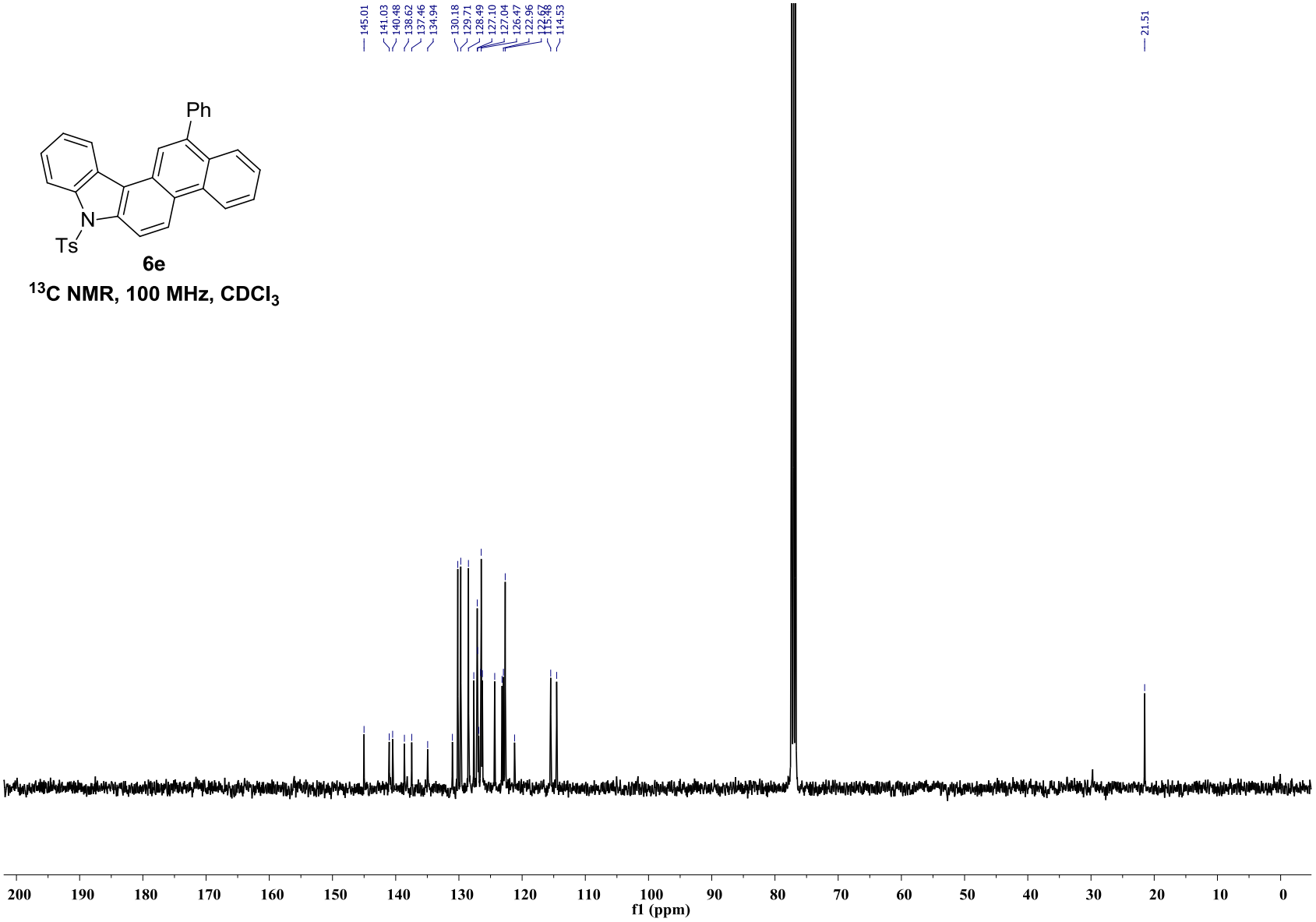

8.67
8.65
8.62
8.54
8.30
8.28
8.03
8.02
8.01
8.00
8.00
8.00
7.98
7.96
7.87
7.85
7.64
7.63
7.60
7.60
7.59
7.53
7.53
7.51
7.51
7.46
7.46
7.40
7.34
7.32
7.31
7.31
7.26
7.21
7.19
6.99
6.97
6.87
6.75
5.11
5.08
5.05
5.02
2.08
1.55
0.00
N
Ts
Ph
6d
1H NMR, 500 MHz, CDCl3
1.00
0.95
0.96
0.95
4.00
1.01
2.09
1.95
1.10
1.17
5.29
2.23
1.87
1.01
1.86
2.03
2.91
10.5
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
0.0
f1 (ppm)



6d

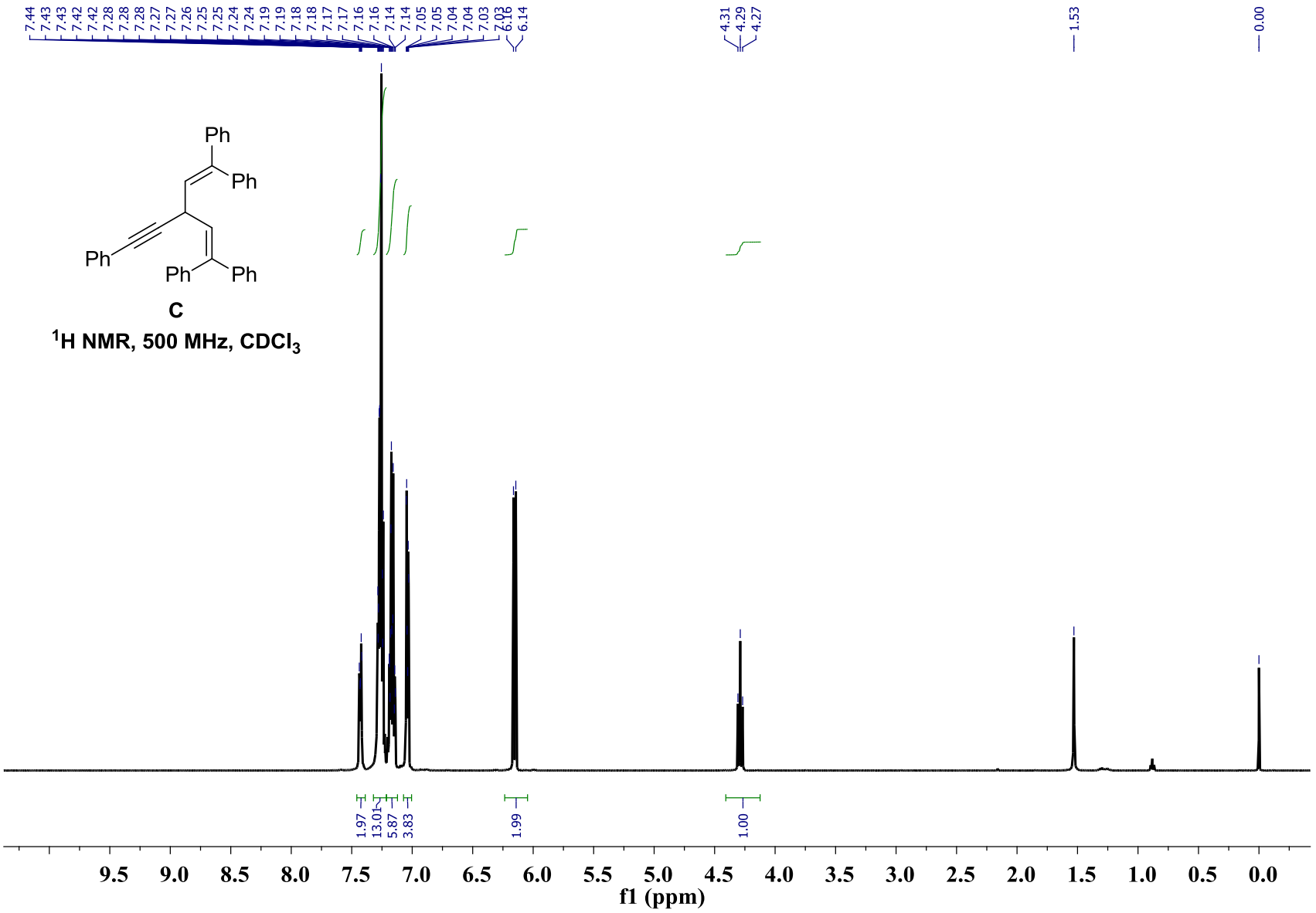
^{13}C NMR, 75 MHz, $CDCl_3$

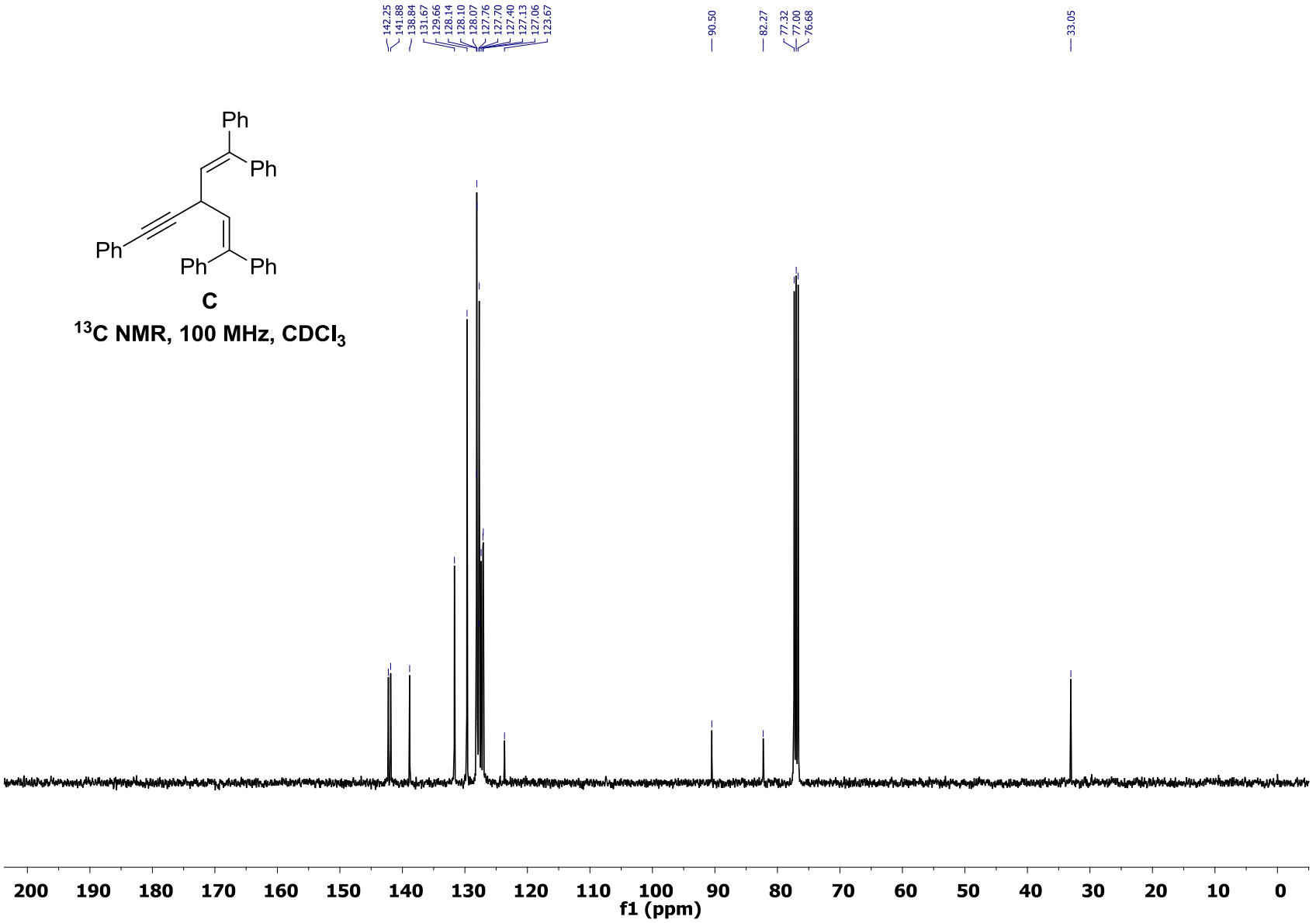

Ph
N
Ts
6e
1H NMR, 500 MHz, CDCl3
f1 (ppm)

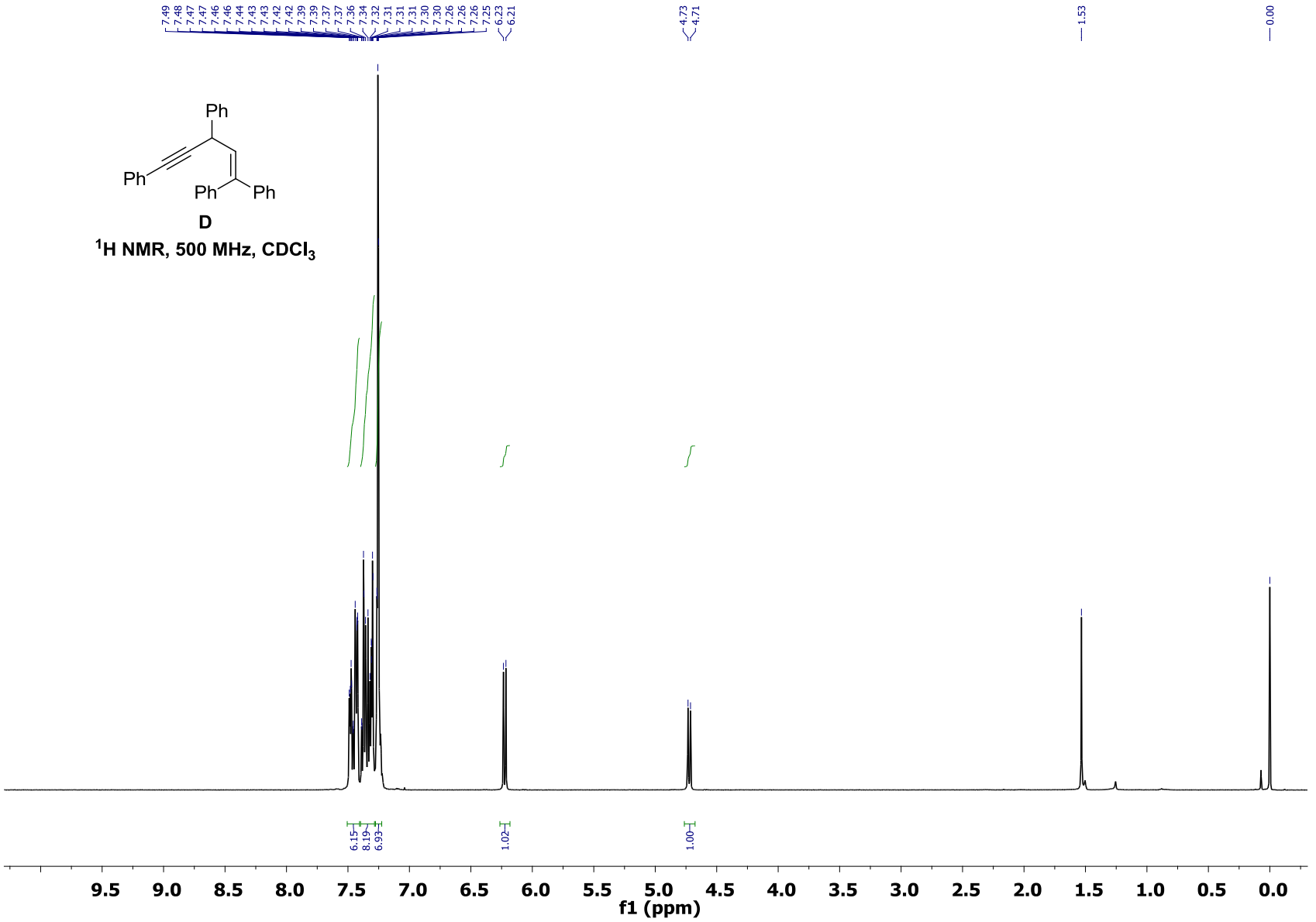


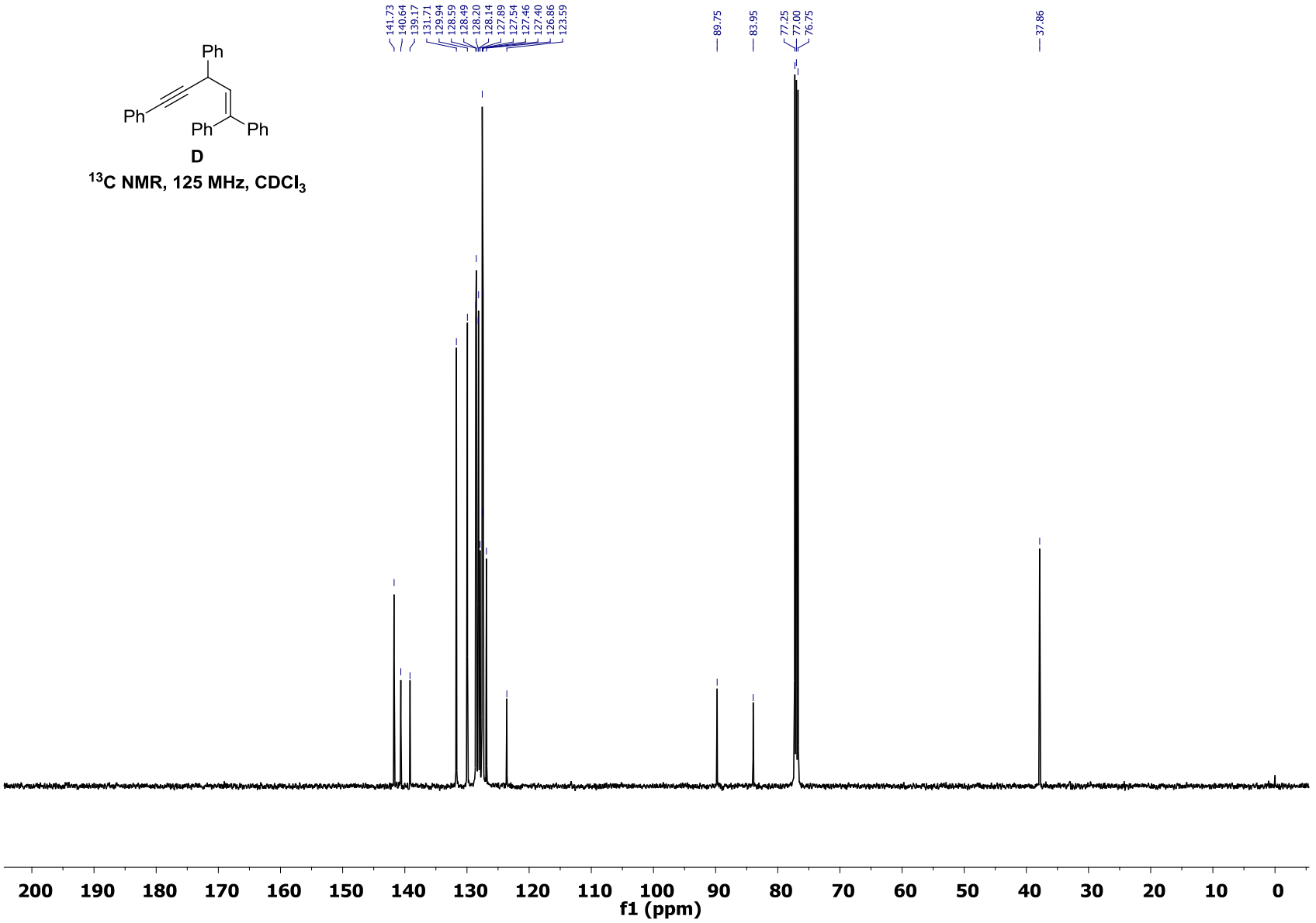
6e

^{13}C NMR, 100 MHz, $CDCl_3$


7.44
7.43
7.43
7.42
7.42
7.28
7.28
7.28
7.27
7.27
7.26
7.25
7.25
7.24
7.24
7.19
7.19
7.18
7.18
7.17
7.17
7.16
7.16
7.14
7.14
7.05
7.05
7.04
7.04
7.03
7.03
6.16
6.14
4.31
4.29
4.27
1.53
0.00
Ph
Ph
Ph
Ph
Ph
C
1H NMR, 500 MHz, CDCl3
1.97
13.01
5.87
3.83
1.99
1.00
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
0.0
f1 (ppm)


142.25
141.88
138.84
131.67
129.66
128.14
128.10
128.07
127.76
127.70
127.40
127.13
127.06
123.67
90.50
82.27
77.32
77.00
76.68
33.05
Ph
Ph
Ph
Ph
Ph
C
13C NMR, 100 MHz, CDCl3
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.49
7.48
7.47
7.47
7.46
7.46
7.44
7.43
7.43
7.42
7.42
7.39
7.39
7.37
7.37
7.36
7.34
7.32
7.31
7.31
7.31
7.30
7.30
7.26
7.26
7.25
6.23
6.21
4.73
4.71
1.53
0.00
Ph
Ph
Ph
Ph
D
1H NMR, 500 MHz, CDCl3
6.15
8.19
6.93
1.02
1.00
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
0.0
f1 (ppm)


Ph
Ph
Ph
Ph
D
^{13}C NMR, 125 MHz, CDCl$_3$
141.73
140.64
139.17
131.71
129.94
128.59
128.49
128.20
128.14
127.89
127.54
127.46
127.40
126.86
123.59
89.75
83.95
77.25
77.00
76.75
37.86
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)