

**Carbazole Annulation via Cascade Nucleophilic
Addition - Cyclization Involving 2-Silyloxytetraenyl Cation**

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SUPPORTING INFORMATION

1. General Information	S-2
2. Characterization of New Compounds.....	S-3
3. ^1H and ^{13}C NMR Spectra	S-34

GENERAL INFORMATION

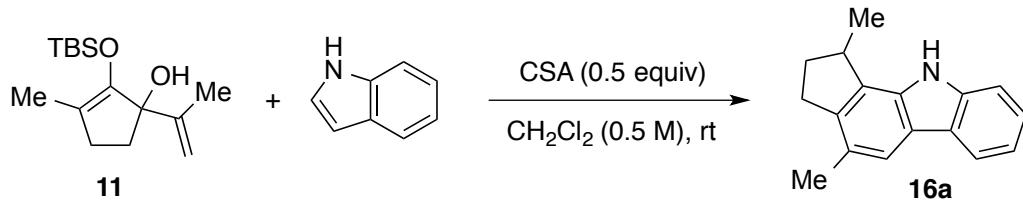
Unless otherwise noted, all materials were used as received from commercial suppliers without further purification. All anhydrous reactions were performed using oven-dried or flame-dried glassware, which was then cooled under vacuum and purged with nitrogen gas. Tetrahydrofuran (THF), dichloromethane (CH_2Cl_2), acetonitrile, toluene, and diethyl ether (Et_2O) were filtered through activated 3Å molecular sieves under nitrogen contained in an M-Braun Solvent Purification System. All reactions were monitored by EMD analytical thin layer chromatography (TLC Silica Gel 60 F₂₅₄, Glass Plates) and analyzed with 254 nm UV light and / or anisaldehyde – sulfuric acid or potassium permanganate treatment. Silica gel for column chromatography was purchased from Dynamic Adsorbents, Inc. or Sigma Aldrich (Flash Silica Gel 32-63u).

Unless otherwise noted, all ^1H and ^{13}C NMR spectra were recorded in CDCl_3 using a Bruker Ascend 400 spectrometer operating at 400 MHz for ^1H and 100 MHz for ^{13}C or Bruker Ascend 500 spectrometer operating at 500 MHz for ^1H and 125 MHz for ^{13}C . Chemical shifts (δ) are reported in ppm relative to residual CHCl_3 as an internal reference (^1H : 7.26 ppm, ^{13}C : 77.23 ppm). Coupling constants (J) are reported in Hertz (Hz). Peak multiplicity is indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), p (pentet), x (septet), h (heptet), b (broad), and m (multiplet). FT-IR spectra were recorded on Bruker Tensor 27 spectrometer and OPUS 6.5 Data Collection Program, and absorption frequencies were reported in reciprocal centimeters (cm^{-1}). High Resolution Mass Spectrometry – Electron Spray Ionization (HRMS-ESI) analyses were performed by the Louisiana State University Mass Spectrometry Facility using an Agilent

6210 Instrument. X-ray structure analyses were performed by the Louisiana State University X-ray Structure Facility using a Bruker APEX-II CCD diffractometer.

CHARACTERIZATION OF NEW COMPOUNDS

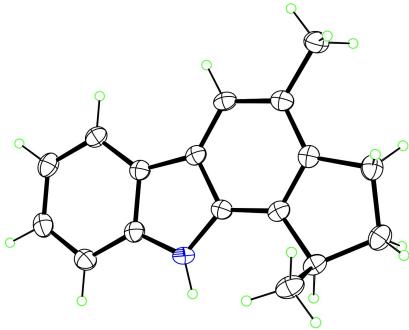
1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (**16a**)



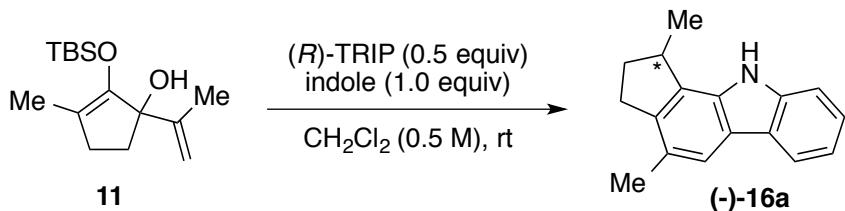
Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL). Indole (22 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes to give compound **16a** in 94% yield (44 mg, 0.175 mmol) as a white solid.

^1H NMR (500 MHz): δ = 8.01 (d, J = 7.8 Hz, 1H), 7.85 (bs, 1H), 7.71 (s, 1H), 7.42 (d, J = 7.9 Hz, 1H), 7.36 (ddd, J = 8.1, 7.0, 1.2 Hz, 1H), 7.21-7.17 (m, 1H), 3.62 (ddd, J = 20.4, 6.9, 6.9 Hz, 1H), 3.09-3.03 (m, 1H), 2.95-2.89 (m, 1H), 2.50-2.44 (m, 1H), 2.42 (s, 3H), 1.87-1.81 (m, 1H), 1.45 (d, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz): δ = 141.18, 139.61, 134.57, 125.37, 124.98, 123.75, 122.57, 119.93, 118.54, 110.52, 38.14, 34.01, 30.67, 20.06, 19.35. IR: $f(\text{cm}^{-1})$ = 3422, 2925, 2859, 1696, 1613, 1490, 1456, 1437, 1377, 1326, 1305, 1245, 1220, 1171, 1140, 1090, 1017, 907, 861, 802, 733, 646, 591, 568, 537, 439. HRMS: $(\text{M} + \text{H})^+ = 236.1434$ calculated for $\text{C}_{17}\text{H}_{18}\text{N}$; 236.1437 experimental.

X-ray structure:

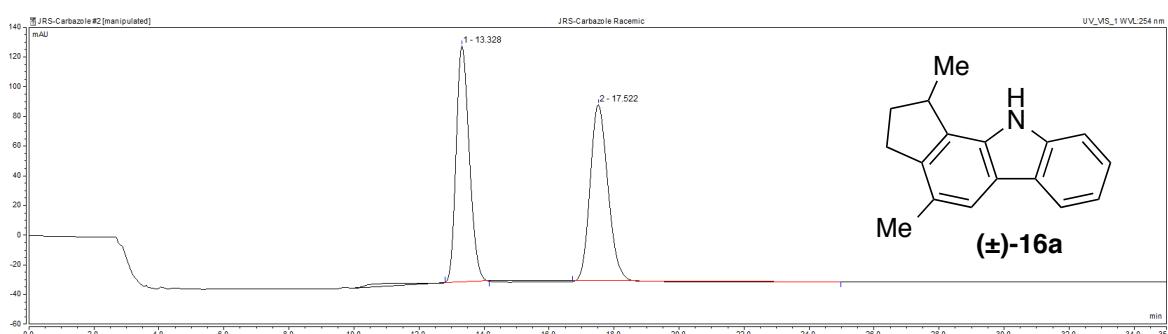
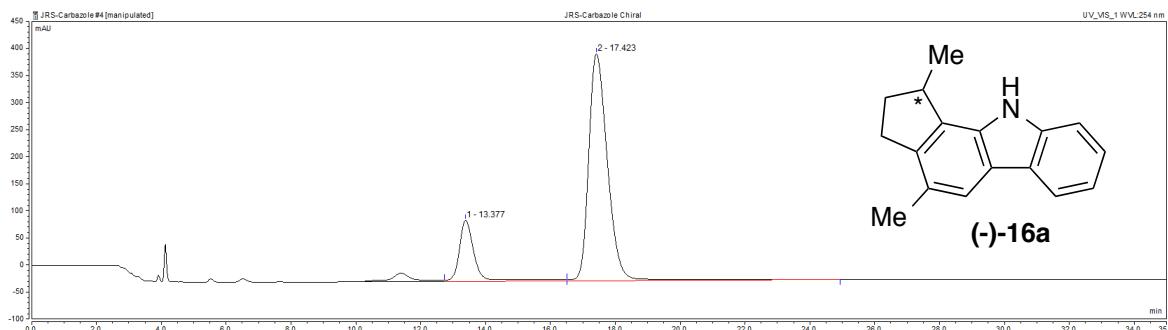


(-)-1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole ((-)-16a)

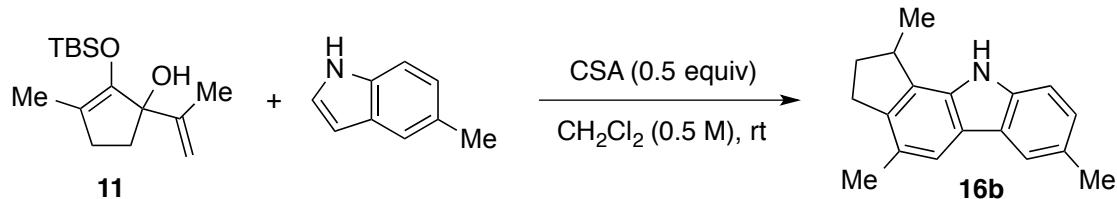


Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL). Indole (22 mg, 0.186 mmol) was then added, followed by (*R*)-TRIP (70 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 72 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes to give compound **(-)-16a** in 72% yield (31 mg, 0.133 mmol, 84:16 er) as a viscous yellow oil. HPLC samples run at a concentration of 1 mg/mL through a Daicel Chiralcel OD-H column using 12% 2-propanol in hexanes at a flow rate of 1 mL/min for 35 minutes.

^1H NMR (500 MHz): δ = 8.02 (d, J = 7.8 Hz, 1H), 7.85 (bs, 1H), 7.71 (s, 1H) 7.43 (d, J = 7.9 Hz, 1H), 7.36 (ddd, J = 8.1, 7.0, 1.2 Hz, 1H), 7.21-7.18 (m, 1H), 3.61 (ddd, J = 20.4, 6.9, 6.9 Hz, 1H), 3.08-3.03 (m, 1H), 2.96-2.90 (m, 1H), 2.48-2.41 (m, 1H), 2.41 (s, 3H), 1.88-1.83 (m, 1H), 1.44 (d, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz): δ = 141.18, 139.60, 134.57, 129.18, 125.38, 124.98, 123.75, 122.57, 119.93, 119.14, 118.55, 110.52, 38.14, 34.01, 30.68, 20.07, 19.36. $[\alpha]_{25}^D = -15.47$ (c = 8.5 in CHCl_3).



1,4,7-trimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (16b)

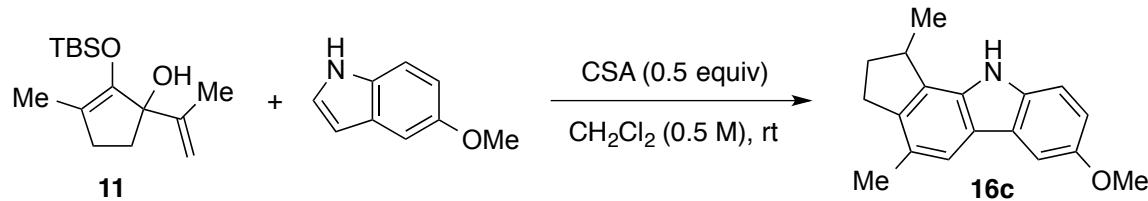


Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH₂Cl₂ (0.37 mL). 5-Methylindole (24 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **16b** in 97% yield (42 mg, 0.180 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 7.81 (s, 1H), 7.75 (bs, 1H), 7.68 (s, 1H), 7.31 (d, *J* = 8.1 Hz, 1H), 7.19 (dd, *J* = 8.3, 1.6 Hz, 1H), 3.61 (ddd, *J* = 20.3, 7.0, 7.0 Hz, 1H), 3.06 (ddd, *J* = 15.3,

9.0, 6.1 Hz, 1H), 2.92 (ddd, J = 15.2, 9.0, 5.8 Hz, 1H), 2.52 (s, 3H), 2.48-2.44 (m, 1H), 2.42 (s, 3H), 1.86-1.82 (m, 1H), 1.45 (d, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz): δ = 140.96, 137.86, 134.92, 129.13, 128.35, 126.27, 125.10, 123.92, 122.47, 119.92, 118.47, 110.17, 38.14, 34.01, 30.66, 21.43, 20.04, 19.35. IR: $f(\text{cm}^{-1})$ = 3423, 2951, 2860, 1677, 1620, 1492, 1447, 1374, 1346, 1295, 1249, 1219, 1186, 1112, 1018, 907, 861, 798, 731, 649, 595, 438. HRMS: $(\text{M} + \text{H})^+$ = 250.1590 calculated for $\text{C}_{18}\text{H}_{20}\text{N}$; 250.1594 experimental.

7-methoxy-1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (16c)

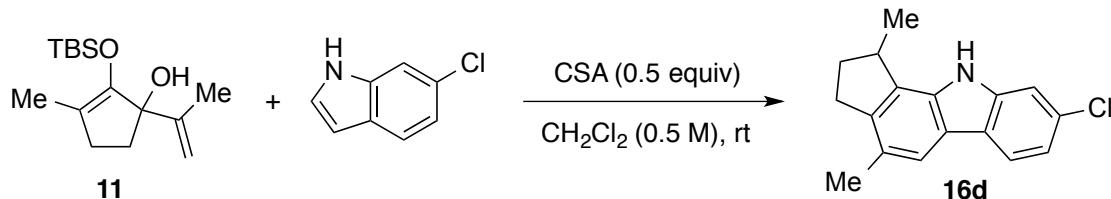


Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL). 5-Methoxyindole (36 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give compound **16c** in 60% yield (35 mg, 0.112 mmol) as a colorless oil.

^1H NMR (500 MHz): δ = 7.71 (bs, 1H), 7.67 (s, 1H), 7.51 (d, J = 2.5 Hz, 1H), 7.31 (d, J = 8.7 Hz, 1H), 7.01 (dd, J = 8.7, 2.5 Hz), 3.93 (s, 3H), 3.60 (ddd, J = 13.9, 13.7, 7.1), 3.06 (ddd, J = 15.3, 8.9, 6.2 Hz, 1H), 2.92 (ddd, J = 15.2, 9.0, 5.8 Hz, 1H), 2.49-2.43 (m, 1H), 2.42 (s, 3H), 1.89-1.81 (m, 1H), 1.44 (d, J = 7.0 Hz). ^{13}C NMR (125 MHz): δ = 153.71, 141.16, 135.46, 134.55, 129.30, 125.03, 124.24, 122.63, 118.43, 114.02, 111.18, 102.98, 56.02, 38.13, 33.98, 30.68, 20.00, 19.34. IR: $f(\text{cm}^{-1})$ = 3424, 2951, 2861, 1698, 1633, 1492, 1459, 1295, 1258, 1213,

1168, 1131, 1107, 1031, 859, 839, 803, 769. HRMS: $(M + H)^+ = 266.1539$ calculated for $C_{18}H_{20}NO$; 288.1530 experimental.

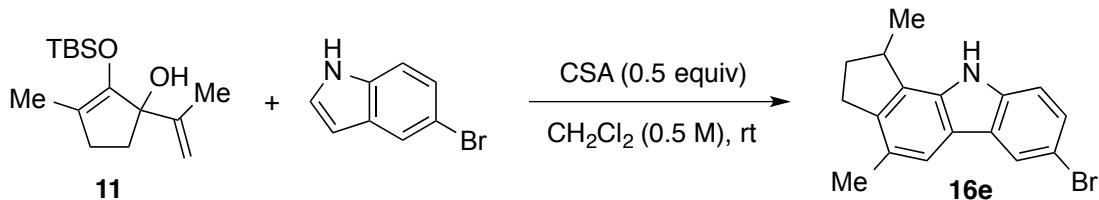
8-chloro-1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (16d)



Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL). 6-Chloroindole (28 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give compound **16d** in 67% yield (34mg, 0.125 mmol) as a colorless oil.

^1H NMR (500 MHz): $\delta = 7.89$ (d, $J = 8.3$ Hz, 1H), 7.86 (bs, 1H), 7.66 (s, 1H), 7.39 (d, $J = 1.9$ Hz, 1H), 7.16 (dd, $J = 8.3, 1.9$ Hz, 1H), 3.64-3.57 (m, 1H), 3.06 (ddd, $J = 15.3, 9.0, 6.2$ Hz, 1H), 2.92 (ddd, $J = 15.9, 8.9, 5.7$ Hz), 2.50-2.44 (m, 1H), 2.42 (s, 3H), 1.90-1.82 (m, 1H), 1.44 (d, $J = 7.0$ Hz, 3H). ^{13}C NMR (125 MHz): $\delta = 141.60, 140.0, 134.76, 130.46, 129.37, 125.95, 122.36, 121.93, 120.63, 119.67, 118.45, 110.60, 38.06, 33.94, 30.66, 20.03, 19.33$. IR: $f(\text{cm}^{-1}) = 3433, 2953, 2862, 1677, 1612, 1482, 1450, 1432, 1373, 1324, 1304, 1277, 1241, 1221, 1146, 1064, 919, 843, 804$. HRMS: $(M + H)^+ = 270.1044$ calculated for $C_{17}H_{17}CN$; 270.1022 experimental.

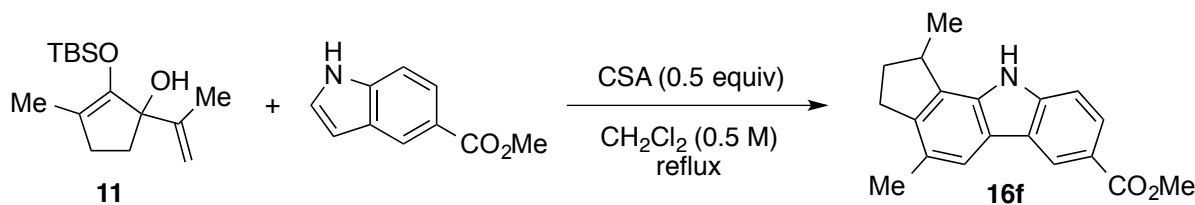
7-bromo-1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (16e)



Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL). 5-Bromoindole (36 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give compound **16e** in 84% yield (49 mg, 0.156 mmol) as a colorless oil.

^1H NMR (500 MHz): δ = 8.11 (d, J = 2.0 Hz, 1H), 7.87 (bs, 1H), 7.65 (s, 1H), 7.43 (dd, J = 8.5, 2.0 Hz, 1H), 7.29 (d, J = 8.6 Hz, 1H), 3.60 (dt, J = 20.4, 6.9 Hz, 1H), 3.06 (ddd, J = 15.5, 9.0, 6.4 Hz, 1H), 2.92 (ddd, J = 15.3, 9.0, 6.0 Hz, 1H), 2.50-2.43 (m, 1H), 2.41 (s, 3H), 1.88-1.81 (m, 1H), 1.44 (d, J = 6.8 Hz, 3H). ^{13}C NMR (125 MHz): δ = 142.11, 138.17, 134.99, 129.36, 127.62, 125.95, 125.59, 122.70, 121.62, 118.66, 111.96, 111.94, 38.12, 33.96, 30.72, 20.04, 19.35. IR: $f(\text{cm}^{-1})$ = 3440, 2953, 2863, 1677, 1628, 1486, 1456, 1375, 1282, 1242, 1223, 1051, 1015, 861. HRMS: $(\text{M} + \text{H})^+ = 314.0539$ calculated for $\text{C}_{17}\text{H}_{17}\text{Br}$; 314.0538 experimental.

methyl 1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole-7-carboxylate (16f)

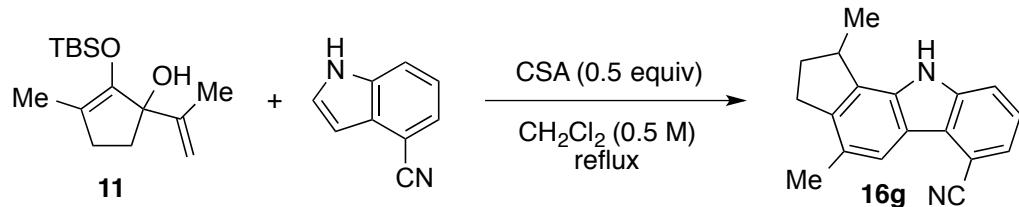


Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.37 mL) in a pressure vessel. Methyl indole-5-carboxylate (33 mg, 0.186 mmol) was then added, followed by camphorsulfonic

acid (40 mg, 0.186 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 7 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **16f** in 99% yield (39.3 mg, 0.134 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.75 (s, 1H), 8.12 (bs, 1H), 8.08 (dd, *J* = 8.5, 1.6 Hz, 1H), 7.56 (s, 1H), 7.41 (d, *J* = 8.5 Hz, 1H), 3.97 (s, 3H), 3.62 (dt, *J* = 20.5, 6.5 Hz, 1H), 3.06 (ddd, *J* = 15.4, 8.9, 6.3 Hz, 1H), 2.93 (ddd, *J* = 15.3, 9.0, 5.6 Hz, 1H), 2.50-2.44 (m, 1H), 2.43 (s, 3H), 1.86 (ddt, *J* = 14.1, 7.8, 4.3 Hz, 1H), 1.45 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 168.00, 142.37, 142.10, 134.95, 129.53, 126.72, 126.41, 123.78, 123.49, 122.52, 122.49, 121.09, 118.86, 110.05, 51.87, 39.10, 33.98, 30.70, 20.11, 19.38. IR: *f*(cm⁻¹) = 3336, 2951, 1692, 1613, 1436, 1350, 1267, 1240, 1221, 1196, 1131, 1089, 759. HRMS: (M + H)⁺ = 294.1489 calculated for C₁₉H₂₀NO₂; 294.1490 experimental.

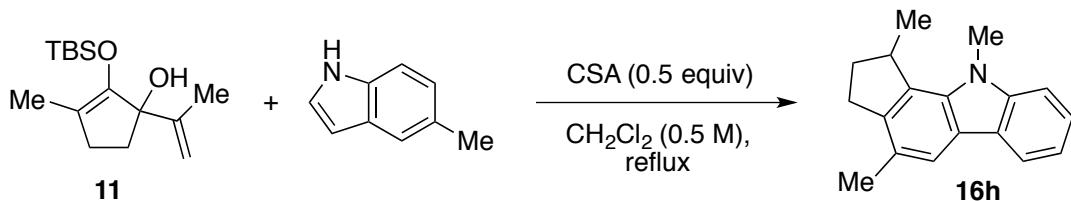
1,4-dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole-6-carbonitrile (**16g**)



Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH₂Cl₂ (0.37 mL) in a pressure vessel. 4-Cyanoindole (26 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (40 mg, 0.186 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 7 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **16f** in 51% yield (25 mg, 0.095 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.22 (s, 1H) 8.10 (bs, 1H), 7.64 (dd, *J* = 8.2, 0.9 Hz, 1H), 7.51 (dd, *J* = 7.5, 1.0 Hz, 1H), 7.39 (t, *J* = 7.8 Hz, 1H), 3.64 (ddd, *J* = 20.7, 7.0, 7.0 Hz, 1H), 3.09 (ddd, *J* = 15.6, 9.0, 6.3 Hz, 1H), 2.95 (ddd, *J* = 16.1, 9.0, 5.7 Hz, 1H), 2.52-2.45 (m, 1H), 2.45 (s, 3H), 1.95-1.86 (m, 1H), 1.45 (d, *J* = 6.9 Hz, 3H). ¹³C NMR (125 MHz): δ = 143.58, 139.31, 135.17, 129.30, 126.85, 124.46, 124.43, 120.35, 119.91, 119.10, 115.01, 103.30, 92.50, 38.14, 33.87, 30.87, 20.06, 19.38. IR: *f*(cm⁻¹) = 3320, 2954, 2927, 2865, 2219, 1702, 1685, 1627, 1498, 1440, 1374, 1320, 1291, 1238, 1162, 1141, 867, 790, 765, 738. HRMS: (M + H)⁺ = 261.1386 calculated for C₁₈H₁₇N₂; 261.1381 experimental.

1,4,10-trimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (16h)

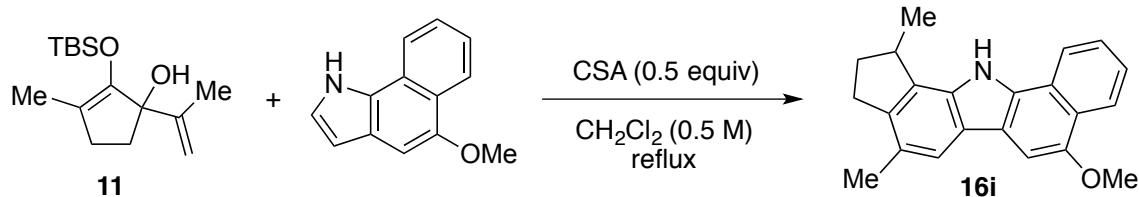


Alcohol **11** (100 mg, 0.372 mmol) was dissolved in CH₂Cl₂ (0.74 mL). 1-Methylindole (46 μL, 0.372 mmol) was then added, followed by camphorsulfonic acid (43 mg, 0.186 mmol). The reaction was allowed to stir at room temperature for 16 hours. The mixture was then directly purified using 100% hexanes → 10% CH₂Cl₂ in hexanes → 20% CH₂Cl₂ in hexanes → 30% CH₂Cl₂ in hexanes to give compound **16h** in 72% yield (67 mg, 0.268 mmol) as a colorless oil.

¹H NMR (500 MHz): d = 8.01 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.73 (s, 1H), 7.41 (ddd, *J* = 8.4, 7.1, 1.3 Hz, 1H), 7.35 (d, *J* = 7.9 Hz, 1H), 7.20 – 7.15 (m, 1H), 4.01 (s, 3H), 3.96 (t, *J* = 7.4 Hz, 1H), 3.05 (ddd, *J* = 16.2, 10.6, 7.9 Hz, 2H), 2.97 – 2.87 (m, 1H), 2.42 (s, 3H), 2.41 – 2.34 (m, 1H), 2.03 – 1.93 (m, 1H), 1.32 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 141.32, 141.29,

136.00, 129.68, 124.81, 123.29, 122.36, 119.64, 119.62, 118.78, 118.49, 108.29, 37.95, 33.63, 30.92, 29.36, 21.91, 19.45. IR: ν (cm⁻¹) = 3286, 2918, 2851, 1599, 1462, 1354, 1316, 1259, 1091, 1014, 794, 732. HRMS: (M + H)⁺ = 250.1590 calculated for C₁₈H₂₀N; 250.1585 experimental.

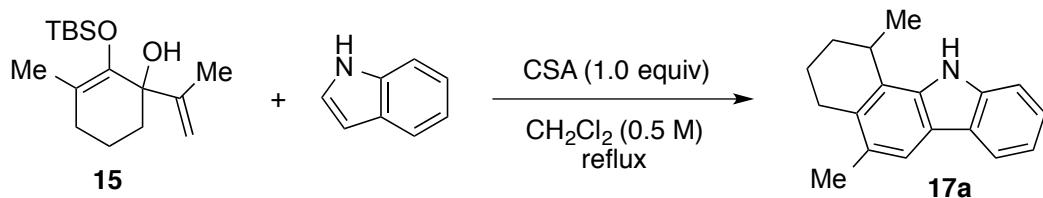
7-methoxy-1,4-dimethyl-1,2,3,12-tetrahydrobenzo[a]cyclopenta[i]carbazole (16i)



Alcohol **11** (50 mg, 0.186 mmol) was dissolved in CH₂Cl₂ (0.37 mL) in a pressure vessel. 5-Methoxybenz[g]indole (36 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.093 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 8 days. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **16h** in 48% yield (25 mg, 0.079 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.40 (d, *J* = 8.4 Hz, 1H), 8.34 (bs, 1H), 8.10 (d, *J* = 8.2 Hz, 1H), 7.71 (s, 1H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.52 (t, *J* = 7.9 Hz, 1H), 7.43 (s, 1H), 4.12 (s, 3H), 3.74-3.67 (m, 1H), 3.12-3.06 (m, 1H), 2.99-2.92 (m, 1H), 2.54-2.48 (m, 1H), 2.46 (s, 3H), 1.92-1.85 (m, 1H), 1.52 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 149.96, 140.03, 133.94, 129.69, 126.04, 125.61, 124.92, 124.28, 123.85, 123.51, 121.86, 120.16, 118.07, 117.84, 97.18, 55.95, 38.24, 34.03, 30.67, 20.21, 19.48. IR: ν (cm⁻¹) = 3461, 2951, 2862, 1689, 1628, 1598, 1525, 1470, 1447, 1377, 1336, 1273, 1248, 1211, 1158, 1117, 1094, 1037, 987, 945, 908, 857, 831. HRMS: (M + H)⁺ = 316.1696 calculated for C₂₂H₂₂NO; 316.1692 experimental.

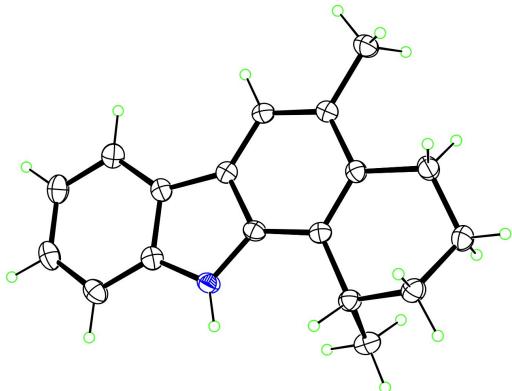
1,5-dimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (17a)



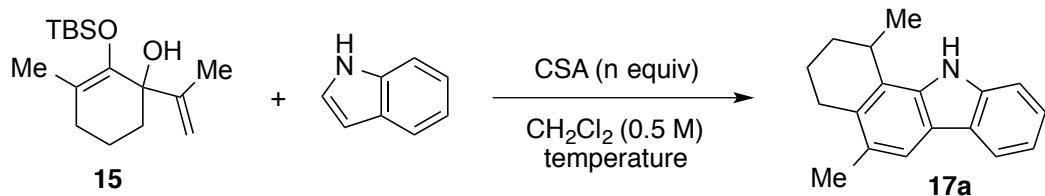
Alcohol **15** (50 mg, 0.186 mmol) was dissolved in CH_2Cl_2 (0.35 mL) in a pressure vessel. Indole (21 mg, 0.186 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.186 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 18 hours. The mixture was then directly purified using 100% hexanes → 10% Et_2O in hexanes → 20% Et_2O in hexanes → 30% Et_2O in hexanes to give compound **17a** in 71% yield (32 mg, 0.126 mmol) as a white solid.

^1H NMR (500 MHz): δ = 8.02 (d, J = 7.8 Hz, 1H), 7.74 (bs, 1H), 7.44 (d, J = 8.1 Hz, 1H), 7.37 (ddt, J = 8.2, 7.1, 1.3 Hz, 1H), 7.23-7.19 (m, 1H), 3.34-3.28 (m, 1H), 2.91-2.86 (m, 1H), 2.71-2.64 (m, 1H), 2.40 (s, 3H), 2.07-1.94 (m, 3H), 1.87-1.83 (m, 1H), 1.44 (d, J = 7.2 Hz, 3H). ^{13}C NMR (125 MHz): δ = 139.30, 136.90, 132.74, 128.03, 124.84, 124.25, 123.80, 120.42, 119.87, 119.09, 118.41, 110.45, 29.48, 28.56, 27.37, 20.57, 20.14, 18.11. IR: $f(\text{cm}^{-1})$ = 3430, 2960, 2927, 2862, 1610, 1491, 1457, 1434, 1421, 1377, 1336, 1296, 1247, 1226, 1187, 1146, 1016, 907, 865, 841, 774, 734. HRMS: $(\text{M} + \text{H})^+ = 250.1590$ calculated for $\text{C}_{18}\text{H}_{20}\text{N}$; 250.1601 experimental.

X-ray structure:



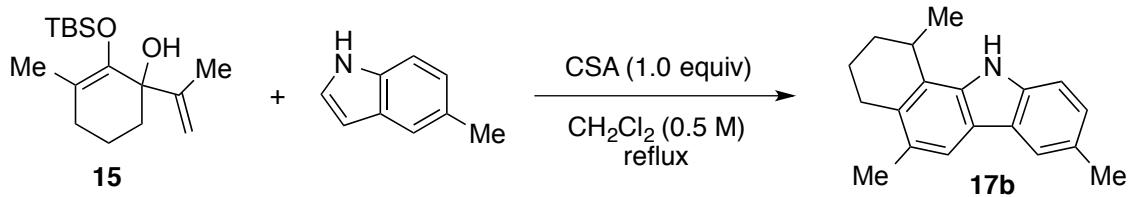
Reaction Optimization:



entry	equiv of CSA	time (h)	temp (°C)	yield [a]
1	0.5	63	rt	48
2	0.5	63	40	36
3	1.0	25	rt	39
4	1.0	22	40	71

[a] Isolated yields after flash column chromatography

1,5,8-trimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (17b)



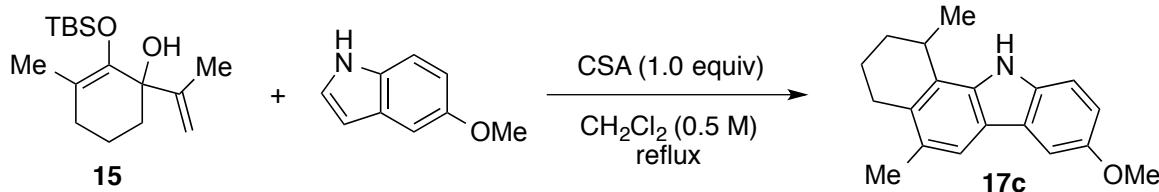
Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH_2Cl_2 (0.35 mL) in a pressure vessel.

5-Methylindole (23 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg,

0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 18 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **17b** in 62% yield (30 mg, 0.111 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 7.80 (s, 1H), 7.77 (bs, 1H), 7.69 (s, 1H), 7.32 (d, *J* = 8.2 Hz, 1H), 7.18 (dd, *J* = 8.2, 1.6 Hz, 1H), 3.33-3.25 (m, 1H), 2.90-2.84 (m, 1H), 2.70-2.61 (m, 1H), 2.52 (s, 3H), 2.38 (s, 3H), 2.03-1.91 (m, 3H), 1.86-1.81 (m, 1H), 1.43 (d, *J* = 7.1 Hz, 3H). ¹³C NMR (125 MHz): δ = 137.55, 137.25, 132.53, 128.30, 127.76, 126.16, 124.21, 123.98, 120.31, 119.86, 118.36, 110.09, 29.50, 28.56, 27.37, 21.44, 20.53, 20.14, 18.12. IR *f*(cm⁻¹) = 3433, 2960, 2929, 2863, 1616, 1493, 1446, 1377, 1295, 1254, 1226, 1190, 1038, 908, 862, 799, 734, 597, 584, 439. HRMS (M + H)⁺ = 264.1747 calculated for C₁₉H₂₂N; 264.1752 experimental.

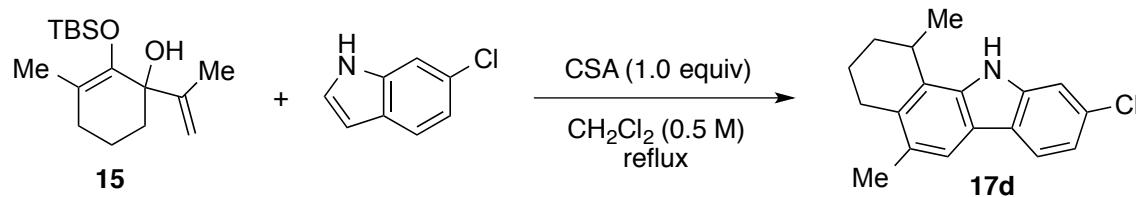
8-methoxy-1,5-dimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (**17c**)



Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH₂Cl₂ (0.35 mL) in a pressure vessel. 5-Methoxyindole (26 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 18 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **17c** in 76% yield (38 mg, 0.135 mmol) as colorless oil.

¹H NMR (500 MHz): δ = 7.72 (bs, 1H), 7.67 (s, 1H), 7.48 (d, *J* = 2.5 Hz, 1H), 7.33 (d, *J* = 8.7 Hz, 1H), 7.00 (dd, *J* = 8.2, 2.6 Hz, 1H), 3.92 (s, 3H), 3.31-3.25 (m, 1H), 2.89-2.84 (m, 1H), 2.68-2.61 (m, 1H), 2.37 (s, 3H), 2.03-1.91 (m, 4H), 1.55 (s, 3H). ¹³C NMR (125 MHz): δ = 153.71, 137.79, 134.26, 132.76, 127.70, 124.40, 124.28, 120.49, 118.31, 113.94, 111.11, 102.92, 56.05, 29.49, 28.55, 27.38, 20.50, 20.13, 18.10. IR: *f*(cm⁻¹) = 3427, 2928, 2864, 2829, 1709, 1629, 1483, 1460, 1292, 1264, 1213, 1188, 1173, 1137, 1107, 1030, 859, 838, 802, 770, 737, 610, 438. HRMS: (M + H)⁺ = 280.1696 calculated for C₁₉H₂₂NO; 280.1704 experimental.

9-chloro-1,5-dimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (17d)

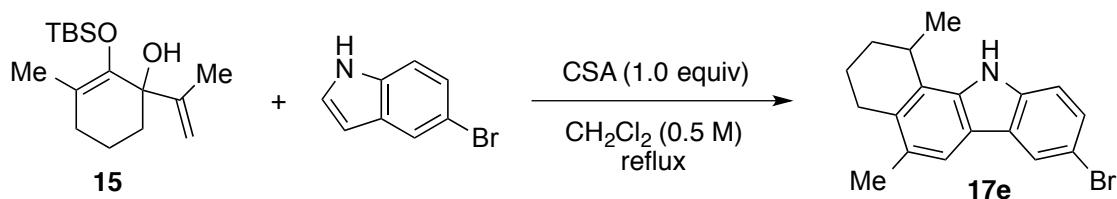


Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH₂Cl₂ (0.35 mL) in a pressure vessel. 6-Chloroindole (27 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 18 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **17d** in 88% yield (44 mg, 0.156 mmol) as a colorless oil.

¹H NMR (400 MHz): δ = 7.89 (s, 1H), 7.87 (s, 1H), 7.67 (s, 1H), 7.41 (s, 1H), 7.16 (d, *J* = 8.3 Hz, 1H), 3.28 (ddd, *J* = 16.4, 8.0, 7.9 Hz, 1H), 2.90-2.84 (m, 1H), 2.69-2.60 (m, 1H), 2.38 (s, 3H), 2.03-1.91 (m, 3H), 1.83-1.81 (m, 1H), 1.42 (d, *J* = 7.1 Hz, 3H). ¹³C NMR (100 MHz): δ = 139.74, 137.13, 133.20, 130.40, 128.67, 124.46, 120.62, 119.67, 118.30, 110.56, 29.38, 28.50,

27.35, 20.58, 20.13, 18.02. IR: ν (cm⁻¹) = 3437, 2959, 2929, 2862, 1610, 1454, 1427, 1287, 1243, 1065, 924, 805. HRMS: (M + H)⁺ = 284.1201 calculated for C₁₈H₁₉ClN; 284.1200 experimental.

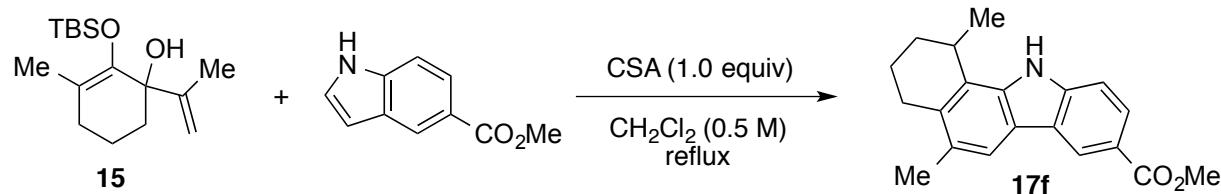
8-bromo-1,5-dimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (17e)



Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH₂Cl₂ (0.35 mL) in a pressure vessel. 5-Bromoindole (35 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 18 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **17e** in 90% yield (53 mg, 0.160 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.10 (d, *J* = 1.8 Hz, 1H), 7.88 (bs, 1H), 7.66 (s, 1H), 7.43 (dd, *J* = 8.5, 1.9 Hz, 1H), 7.30 (d, *J* = 8.6 Hz, 1H), 3.31-3.25 (m, 1H), 2.90-2.84 (m, 1H), 2.65 (ddd, *J* = 17.1, 10.7, 6.5 Hz, 1H), 2.37 (s, 3H), 1.99-1.91 (m, 3H), 1.42 (d, *J* = 7.1 Hz, 3H). ¹³C NMR (125 MHz): δ = 137.85, 137.33, 133.68, 128.61, 127.48, 125.62, 124.45, 122.62, 119.48, 118.44, 111.91, 111.87, 29.38, 28.52, 27.38, 20.55, 20.13, 18.00. IR: ν (cm⁻¹) = 3442, 2961, 2930, 2864, 1490, 1459, 1418, 1284, 1244, 861. HRMS: (M + H)⁺ = 328.0695 calculated for C₁₈H₁₉NBr; 328.0695 experimental.

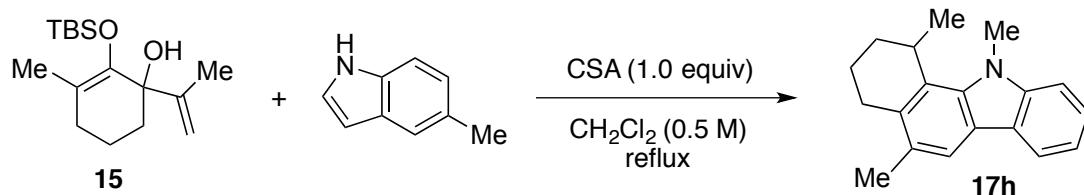
methyl 1,5-dimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole-8-carboxylate (17f)



Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH_2Cl_2 (0.35 mL) in a pressure vessel. Methyl indole 5-carboxylate (31 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 20 hours. The mixture was then directly purified using 100% hexanes → 10% Et_2O in hexanes → 20% Et_2O in hexanes → 30% Et_2O in hexanes to give compound **17f** in 29% yield (16 mg, 0.051 mmol) as a colorless oil.

^1H NMR (500 MHz): δ = 8.74 (s, 1H), 8.13 (bs, 1H), 8.08 (dd, J = 8.5, 1.6 Hz, 1H), 7.77 (s, 1H), 7.44 (d, J = 8.5 Hz, 1H), 3.97 (s, 3H), 3.32-3.29 (m, 1H), 2.90-2.85 (m, 1H), 2.67-2.62 (m, 1H), 2.39 (s, 3H), 1.99-1.94 (m, 3H), 1.86-1.82 (m, 1H), 1.43 (dd, J = 7.2 Hz, 3H). ^{13}C NMR (125 MHz): δ = 168.01, 142.05, 137.33, 133.67, 129.11, 126.59, 124.60, 123.55, 122.47, 121.07, 120.41, 118.65, 110.00, 51.87, 29.37, 28.51, 27.37, 20.69, 20.17, 18.00. IR: $f(\text{cm}^{-1})$ = 3351, 2926, 2856, 1693, 1609, 1584, 1494, 1435, 1393, 1323, 1302, 1261, 1225, 1197, 1163, 1113, 1089, 1016, 985, 907, 865, 803, 770, 730, 683, 648, 596, 496, 440. HRMS: $(\text{M} + \text{H})^+$ = 308.1645 calculated for $\text{C}_{20}\text{H}_{22}\text{NO}_2$; 308.1644 experimental.

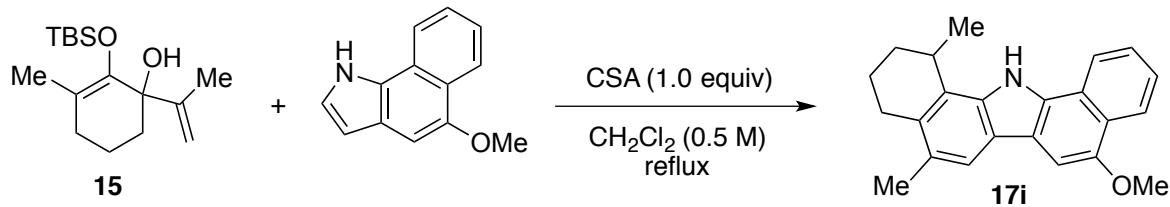
1,5,11-trimethyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (17h)



Alcohol **15** (100 mg, 0.354 mmol) was dissolved in CH₂Cl₂ (0.71 mL) in a pressure vessel. 1-Methylindole (44 μ L, 0.354 mmol) was then added, followed by camphorsulfonic acid (82 mg, 0.354 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 17 hours. The mixture was then directly purified using 100% hexanes → 10% CH₂Cl₂ in hexanes → 20% CH₂Cl₂ in hexanes → 30% CH₂Cl₂ in hexanes to give compound **17b** in 62% yield (58 mg, 0.219 mmol) as a colorless oil.

¹H NMR (500 MHz): d = 7.99 (dd, *J* = 7.7, 1.0 Hz, 1H), 7.74 (s, 1H), 7.45 – 7.38 (m, 1H), 7.37 (d, *J* = 8.2 Hz, 1H), 7.18 (ddd, *J* = 8.0, 6.9, 1.2 Hz, 1H), 4.08 (s, 3H), 3.94 – 3.87 (m, 1H), 2.96 – 2.87 (m, 1H), 2.75 – 2.63 (m, 1H), 2.37 (s, 3H), 2.06 – 2.00 (m, 2H), 1.93 – 1.87 (m, 1H), 1.87 – 1.79 (m, 1H), 1.38 (d, *J* = 7.3 Hz, 3H). ¹³C NMR (125 MHz): d = 142.32, 137.82, 133.14, 128.01, 126.28, 124.83, 123.13, 121.59, 119.30, 118.66, 118.58, 108.68, 32.74, 29.66, 27.92, 27.89, 23.02, 20.42, 17.88. IR *f*(cm⁻¹) = 3336, 2920, 2851, 1600, 1444, 1408, 1324, 1245, 1090, 1018, 798, 731, 681. HRMS (M + H)⁺ = 264.1747 calculated for C₁₉H₂₂N; 264.1747 experimental.

8-methoxy-1,5-dimethyl-2,3,4,13-tetrahydro-1H-dibenzo[a,i]carbazole (**17i**)

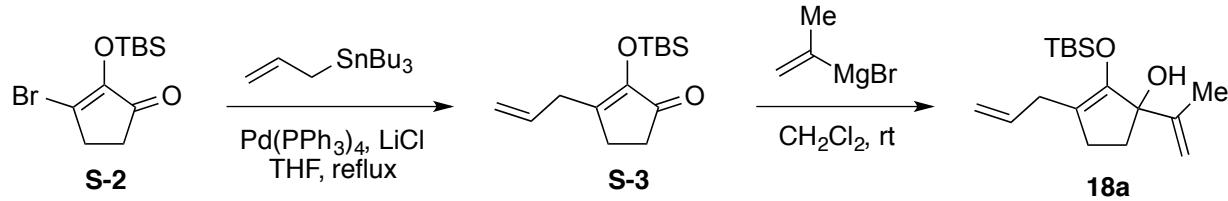


Alcohol **15** (50 mg, 0.177 mmol) was dissolved in CH₂Cl₂ (0.35 mL) in a pressure vessel. 5-Methoxy benz[g]indole (34 mg, 0.177 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.177 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for eight days. The mixture was then directly purified using 100% hexanes → 2% Et₂O in

hexanes → 5% Et₂O in hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes to give compound **17h** in 43% yield (28 mg, 0.085 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.40 (d, *J* = 8.4 Hz, 1H), 8.33 (bs, 1H), 8.12 (d, *J* = 8.2 Hz, 1H), 7.73 (s, 1H), 7.62 (d, *J* = 7.3 Hz, 1H), 7.53-7.50 (m, 1H), 7.42 (s, 1H), 4.12 (s, 3H), 3.47-3.42 (m, 1H), 2.92-2.88 (m, 1H), 2.73-2.66 (m, 1H), 2.42 (s, 3H), 2.06-1.96 (m, 3H), 1.90-1.86 (m, 1H), 1.51 (d, *J* = 7.2 Hz, 3H). ¹³C NMR (125 MHz): δ = 149.73, 136.18, 131.58, 129.16, 128.23, 126.00, 124.84, 124.72, 124.21, 123.50, 121.81, 121.63, 120.14, 118.08, 117.76, 97.11, 55.93, 29.52, 28.61, 27.34, 20.77, 20.26, 18.18. IR: *f*(cm⁻¹) = 3463, 2930, 2863, 2830, 1626, 1597, 1525, 1471, 1446, 1431, 1378, 1290, 1271, 1246, 1209, 1189, 1157, 1125, 1111, 1096, 1032, 985, 858, 830, 758, 737, 701, 431. HRMS: (M + H)⁺ = 330.1852 calculated for C₂₃H₂₄NO; 330.1589 experimental.

2-((tert-butyldimethylsilyl)oxy)-3-(5-methylfuran-2-yl)-1-(prop-1-en-2-yl)cyclopent-2-en-1-ol (18a)



In a pressure vessel, ketone **S-2** (300 mg, 1.03 mmol), allyltributyltin (350 μL, 1.13 mmol), and lithium chloride (218 mg, 5.15 mmol) was dissolved in THF (7 mL). The reaction mixture was then bubbled with a gentle stream of nitrogen gas for thirty minutes, and then Pd(PPh₃)₄ (119 mg, 0.103 mmol) was added. The reaction was then brought to reflux in a sand bath at 70 °C. After stirring for 18 hours, the reaction was then diluted with DI water (20 mL) and extracted with ethyl acetate (3 x 15 mL). The combined organic layers were dried over

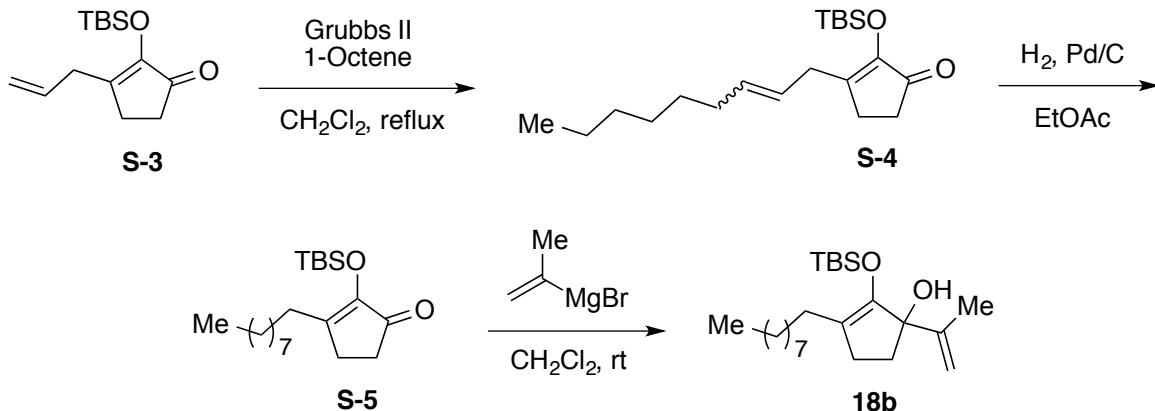
sodium sulfate and concentrated under vacuum. The residual material was then purified with flash column chromatography using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes give ketone **S-3** in 79% yield (206 mg, 0.816 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 5.79 (ddt, *J* = 16.8, 9.9, 6.7 Hz, 1H), 5.15-5.09 (m, 2H), 3.13 (d, *J* = 6.9 Hz, 2H), 2.42-2.40 (m, 2H), 2.34-2.30 (m, 2H), 0.095 (s, 9H), 0.20 (s, 6H). ¹³C NMR (125 MHz): δ = 203.11, 151.97, 149.24, 133.20, 117.28, 33.24, 32.18, 25.72, 24.54, 18.33, -4.06. IR: *f*(cm⁻¹) = 2955, 2928, 2857, 1713, 1639, 1366, 1251, 1112, 856, 841, 785. HRMS: (M + H)⁺ = 253.1618 calculated for C₁₄H₂₅O₂Si; 253.1620 experimental.

Ketone **S-3** (88 mg, 0.349 mmol) was dissolved in dichloromethane (5 mL). Isopropenylmagnesium bromide (2.09 mL, 0.5 M solution in THF) was then slowly added. After one hour, the reaction was quenched with DI H₂O (15 mL). The aqueous layer was extracted with ethyl acetate (3 x 15 mL), and the combined organic layers were dried over sodium sulfate and concentrated under vacuum. The crude material was then purified with flash column chromatography (buffered with 2% TEA) using 100% hexanes → 5% Et₂O in hexanes → 10% Et₂O in hexanes to give product **18a** in 50% yield (51 mg, 0.173 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 5.74 (ddt, *J* = 16.8, 10.1, 6.6 Hz, 1H), 5.06-4.99 (m, 3H), 4.84 (ddd, *J* = 3.1, 1.6, 1.6 Hz, 1H), 2.87-2.78 (m, 2H), 2.28-2.24 (m, 1H), 2.14-2.09 (m, 2H), 1.87-1.83 (m, 1H), 1.72 (s, 3H), 0.92 (s, 9H), 0.15 (s, 3H), 0.14 (s, 3H). ¹³C NMR (125 MHz): δ = 148.42, 147.93, 135.42, 117.54, 115.54, 109.54, 85.57, 35.85, 31.52, 27.65, 25.80, 18.89, 18.38, -3.54, -3.83. IR: *f*(cm⁻¹) = 3469, 2954, 2929, 2857, 1680, 1640, 1472, 1361, 1336, 1250, 1184, 1064, 993, 958, 899, 838, 781, 678, 630, 577. HRMS (M – H₂O)⁺ = 277.1982 calculated for C₁₇H₂₉OSi; 277.1997 experimental.

2-((tert-butyldimethylsilyl)oxy)-3-nonyl-1-(prop-1-en-2-yl)cyclopent-2-en-1-ol (18b)



Ketone **S-3** (200 mg, 0.792 mmol) was dissolved in CH_2Cl_2 (20 mL). 1-Octene (445 μL , 3.96 mmol) was then added, followed by Grubbs second-generation catalyst (20 mg, 0.024 mmol). The reaction was heated to reflux and allowed to stir for 2 days. The reaction was concentrated *in vacuo* and purified directly using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes to give product **S-4** as an inseparable mixture of olefin isomers (E/Z : 5.7:1) in 47% yield (124 mg, 0.370 mmol) as a colorless oil.

^1H NMR (500 MHz): δ = 5.52 (dtt, J = 15.0, 6.7, 1.7 Hz, 1H), 5.37 (dtt, J = 15.0, 6.8, 1.5 Hz, 1H), 3.12 (d, J = 7.5 Hz, 0.4 H), 3.05 (d, J = 6.7 Hz, 1.7 H), 2.80 – 2.78 (m, 1.3 H), 2.49 – 2.47 (m, 1.3 H), 2.38 (m, 2H), 2.30 (m, 2H), 2.08 (q, J = 7.1 Hz, 0.4 H), 2.00 (q, J = 6.6 Hz, 1.7 H), 1.39 – 1.21 (m, 9H), 0.97 (s, 5H), 0.94 (s, 8H), 0.90 – 0.83 (m, 4H), 0.22 (s, 3.6H), 0.18 (s, 6H). ^{13}C NMR (125 MHz): δ = 203.00, 198.24, 153.10, 151.78, 148.87, 135.73, 133.67, 132.92, 124.30, 123.70, 33.95, 32.45, 32.14, 32.12, 32.06, 31.70, 31.66, 29.82, 29.45, 29.30, 28.93, 28.76, 27.82, 27.31, 26.87, 26.79, 25.73, 25.55, 24.55, 24.45, 22.58, 18.32, 18.29, 17.50, 14.01, 13.98, 13.53, -4.07. IR: $f(\text{cm}^{-1})$ = 2927, 2856, 1712, 1638, 1463, 1408, 1363, 1324, 1249, 1152, 1107, 1072, 967, 838, 783, 682, 572, 487. HRMS: $(\text{M} + \text{H})^+ = 337.2557$ calculated for $\text{C}_{20}\text{H}_{37}\text{O}_2\text{Si}$; 337.2559 experimental.

Ketone **S-4** (85 mg, 0.253 mmol) and activated palladium on carbon (8.0 mg, 0.076 mmol) were dissolved in ethyl acetate (1.3 mL). Hydrogen gas was bubbled through reaction for 6 hours. The crude reaction mixture was filtered over Celite pad, concentrated *in vacuo*, and purified directly using 100% hexanes → 2.5% Et₂O in hexanes to give product **S-5** in 48% yield (41 mg, 0.121 mmol) as a colorless oil.

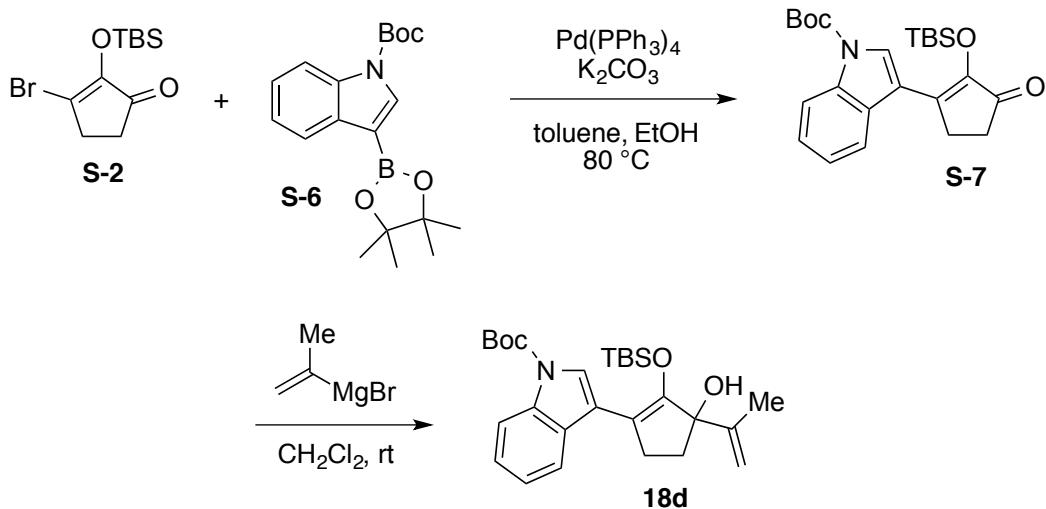
¹H NMR (400 MHz): δ = 2.44 – 2.22 (m, 6H), 1.49 (t, *J* = 7.4 Hz, 2H), 1.33 – 1.22 (m, 13H), 0.95 (s, 9H), 0.88 (t, *J* = 6.6 Hz, 3H), 0.19 (s, 6H). ¹³C NMR (100 MHz): δ = 203.10, 155.40, 149.16, 32.14, 31.85, 29.65, 29.47, 29.38, 29.25, 28.71, 26.98, 25.75, 24.73, 22.65, 18.34, 14.07, -4.05. IR: *f*(cm⁻¹) = 2926, 2854, 1710, 1639, 1462, 1409, 1374, 1248, 1113, 858, 839, 783, 684, 572, 492. HRMS: (M + H)⁺ = 339.2714 calculated for C₂₀H₃₉O₂Si; 339.2720 experimental.

Ketone **S-5** (41 mg, 0.121 mmol) was dissolved in CH₂Cl₂ (0.60 mL). Isopropenylmagnesium bromide (1.1 mL, 0.55 mmol, 0.5 M solution in THF) was then slowly added. After two hours, the reaction was quenched with DI H₂O (10 mL), and the aqueous layer was extracted with ethyl acetate (3 x 15 mL). The combined organic layers were then dried over sodium sulfate and concentrated under vacuum. The residual crude material was then purified with flash column chromatography (buffered with 2% TEA) using 100% hexanes to give product **18b** in 67% yield (31 mg, 0.081 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 5.03 – 5.01 (d, *J*=1.4, 1H), 4.83 (t, *J* = 1.6 Hz, 1H), 2.15-2.08 (m, 3H), 1.99- (dt, *J* = 14.2, 7.4 Hz, 1H), 1.89 – 1.80 (m, 1H), 1.71 (s, 3H), 1.35-1.24 (m, Hz, 21 H), 0.96 (s, 3H), 0.93 (s, 9H), 0.88 (t, *J* = 6.8 Hz, 5H), 0.14 (d, *J* = 3.0 Hz, 6H). ¹³C NMR (125 MHz): δ = 148.18, 147.38, 120.33, 109.42, 85.64, 35.91, 31.89, 30.32, 29.69, 29.58, 29.51, 29.31, 27.65, 27.56, 26.92, 25.87, 22.68, 18.94, 18.43, 14.10, -3.51, -3.80. IR: *f*(cm⁻¹) = 3478,

2925, 2854, 1681, 1462, 1360, 1250, 1070, 897, 859, 837, 780, 677. HRMS: $(M + Na)^+ =$ 403.3003 calculated for $C_{23}H_{44}NaO_2Si$; 403.2989 experimental.

tert-butyl 3-((tert-butyldimethylsilyl)oxy)-3-hydroxy-3-(prop-1-en-2-yl)cyclopent-1-en-1-yl)-1H-indole-1-carboxylate (18d)



In a pressure vessel, ketone **S-2** (153 mg, 0.525 mmol) was dissolved in toluene/ethanol (12 : 4 mL). Potassium carbonate (218 mg, 1.58 mmol) and boronic ester **S-6** (361 mg, 1.05 mmol) was then added, followed by $Pd(PPh_3)_4$ (30 mg, 0.026 mmol). The reaction was then warmed to $80^\circ C$ for 18 hours. The reaction was then diluted with DI water (20 mL) and extracted with ethyl acetate (3 x 15 mL). The combined organic layers were dried over sodium sulfate and concentrated under vacuum. The crude material was purified with flash column chromatography (buffered with 2% TEA) using 100% hexanes \rightarrow 2% Et_2O in hexanes \rightarrow 5% Et_2O in hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give product **S-7** in 73 % yield (163 mg, 0.381 mmol) as colorless oil.

¹H NMR (500 MHz): δ = 8.20 (d, J = 1.2 Hz, 1H), 7.93 (dd, J = 8.8, 1.2 Hz, 1H), 7.61 (d, J = 3.5 Hz, 1H), 6.59 (d, J = 3.7 Hz, 1H), 2.94-2.92 (m, 2H), 2.51-2.49 (m, 2H), 1.68 (s, 9H), 1.00 (s, 9H), 0.27 (s, 6H). ¹³C NMR (125 MHz): δ = 203.05, 149.53, 148.55, 145.62, 135.54, 130.43, 129.15, 126.61, 123.73, 120.35, 114.80, 107.53, 83.97, 31.46, 28.16, 25.92, 24.00, 18.61, -3.56. IR: $f(\text{cm}^{-1})$ = 2930, 2857, 1735, 1699, 1605, 1471, 1438, 1359, 1336, 1285, 1256, 1158, 1132, 1084, 1058, 1041, 1022, 873, 841, 785, 766, 727, 688, 595, 528, 510, 422. HRMS: (M + H)⁺ = 428.2252 calculated for C₂₄H₃₄NO₄Si; 428.2259 experimental.

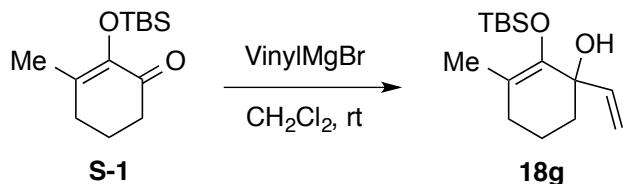
Ketone **S-2** (163 mg, 0.381 mmol) was dissolved in dichloromethane (5 mL). Isopropenylmagnesium bromide (0.833 mL, 0.5 M solution in THF) was then slowly added. After 30 minutes, the reaction was quenched with DI water (20 mL). The aqueous layer was extracted with ethyl acetate (2 x 20 mL). The combined organic layers were dried over sodium sulfate and concentrated under vacuum. The residual crude materials were then purified with flash column chromatography (buffered with 2% TEA) using 100% hexanes → 2% Et₂O in hexanes → 5% Et₂O in hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give product **18d** in 38 % yield (68 mg, 0.145 mmol).

¹H NMR (500 MHz): δ = 8.06 (d, J = 7.4 Hz, 1H), 7.69 (d, J = 1.0 Hz, 1H), 7.56 (d, J = 2.9 Hz, 1H), 7.46 (dd, J = 8.6, 1.2 Hz, 1H), 6.52 (d, J = 3.7 Hz, 1H), 5.10 (s, 1H), 4.91 (t, J = 1.6 Hz, 1H), 2.86 (ddd, J = 15.5, 8.9, 3.7 Hz, 1H), 2.48 (ddd, J = 14.2, 8.5, 5.5 Hz, 1H), 2.24 (ddd, J = 13.2, 8.5, 3.7 Hz, 1H), 1.99 (ddd, J = 13.9, 8.9, 5.5 Hz, 1H), 1.85 (s, 3H), 1.67 (s, 9H), 0.91 (s, 9H), 0.04 (s, 3H), -0.14 (s, 3H). ¹³C NMR (125 MHz): δ = 149.74, 149.25, 147.88, 133.82, 131.11, 130.28, 126.04, 124.11, 120.08, 118.70, 114.51, 109.95, 107.27, 86.31, 83.54, 35.96, 28.95, 28.20, 26.06, 19.04, 18.51, -3.26, -3.54. IR: $f(\text{cm}^{-1})$ = 3522, 3154, 2954, 2930, 2856, 1965, 1734, 1686, 1639, 1574, 1540, 1471, 1438, 1368, 1337, 1282, 1250, 1195, 1157, 1135,

1100, 1083, 1041, 1022, 960, 939, 903, 839, 781, 766, 726, 680, 648, 592, 543, 523, 486, 436.

HRMS: $(M - H_2O)^+ = 452.2615$ calculated for $C_{27}H_{38}NO_3Si$; 452.2619 experimental.

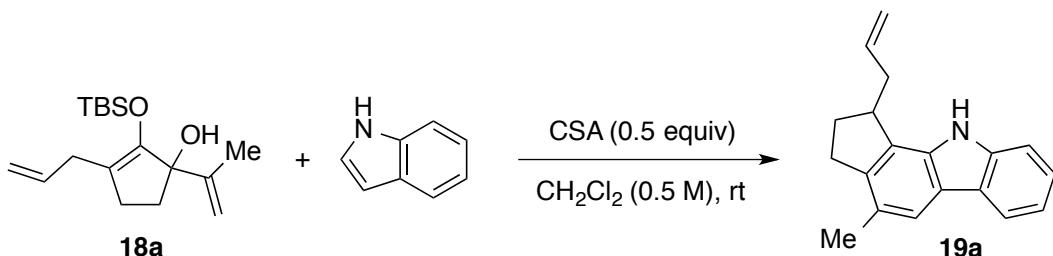
2-((tert-butyldimethylsilyl)oxy)-3-methyl-1-vinylcyclohex-2-en-1-ol (18g)



Ketone **S-1** (500 mg, 2.08 mmol) was dissolved in dichloromethane (10 mL). Vinylmagnesium bromide (3.12 mL, 3.12 mmol, 1 M solution in THF) was then added dropwise. After five minutes, the reaction was quenched with water (20 mL). The aqueous layer was extracted twice with ethyl acetate (3×20 mL), and the combined organic layers were dried over sodium sulfate and concentrated under vacuum. The crude material was then purified with flash column chromatography (buffered with 1% TEA) using 100% hexanes \rightarrow 2% Et_2O in hexanes \rightarrow 5% Et_2O in hexanes to give product **18g** in 56% yield (315 mg, 1.17 mmol) as a yellow oil.

1H NMR (400 MHz): $\delta = 5.96$ (dd, $J = 21.8, 13.4$ Hz, 1H), 5.24 (dd, $J = 21.7, 1.5$ Hz, 1H), 5.13 (dd, $J = 13.4, 1.5$ Hz, 1H), 2.15 (s, 1H), 2.11-1.90 (m, 3H), 1.64-1.57 (m, 4H), 0.94 (s, 9H), 0.16 (s, 3H), 0.12 (s, 3H). ^{13}C NMR (100 MHz): $\delta = 144.18, 143.45, 114.65, 113.58, 73.74, 38.17, 31.27, 26.27, 26.03, 18.70, 17.40, -3.25, -3.31$. IR: $f(cm^{-1}) = 3475, 2930, 2857, 2833, 1671, 1628, 1472, 1462, 1441, 1407, 1388, 1360, 1332, 1311, 1251, 1195, 1171, 1140, 1121, 1087, 1038, 1005, 991, 950, 921, 866, 828, 777, 672, 592, 559, 531, 510, 443, 419$. HRMS: $(M + H)^+ = 291.1751$ calculated for $C_{15}H_{28}NaO_2Si$; 291.1753 experimental.

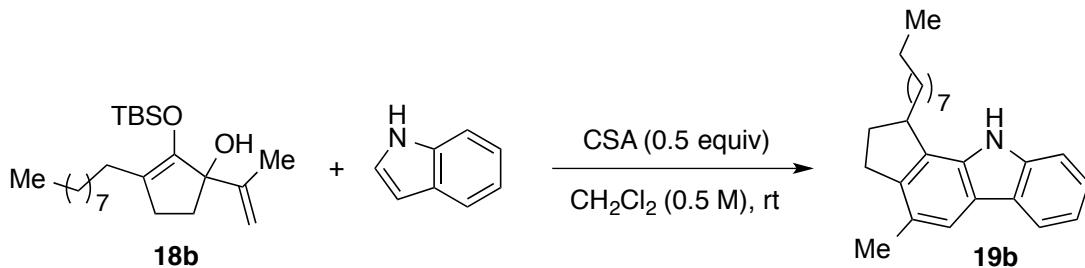
1-allyl-4-methyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19a)



Alcohol **18a** (51 mg, 0.1173 mmol) was dissolved in dichloromethane (0.350 mL). Indole (20 mg, 0.173 mmol) was then added, followed by camphorsulfonic acid (20 mg, 0.087 mmol). The reaction was allowed to stir at room temperature for 5 hours. The mixture was then directly purified using 100% hexanes \rightarrow 5% Et_2O in hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes to give compound **19a** in 51% yield as (25 mg, 0.096 mmol) a colorless oil.

^1H NMR (500 MHz): δ = 8.02 (d, J = 7.8 Hz, 1H), 7.96 (bs, 1H), 7.72 (s, 1H), 7.42 (dt, J = 8.1, 0.9 Hz, 1H), 7.36 (ddd, J = 8.2, 7.0, 1.2 Hz, 1H), 7.20 (ddd, J = 8.0, 7.1, 1.2 Hz, 1H), 5.99 (dddd, J = 13.8, 10.1, 6.9, 6.9 Hz, 1H), 5.22 (dq, J = 17.1, 1.6 Hz, 1H), 5.15 (dt, J = 10.4, 1.1 Hz, 1H), 3.64 (ddd, J = 13.0, 8.0, 5.0 Hz, 1H), 3.01 (ddd, J = 16.0, 7.8, 7.8 Hz, 1H), 2.94 (ddd, J = 16.0, 8.9, 4.7 Hz, 1H), 2.66-2.60 (m, 1H), 2.47-2.43 (m, 1H), 2.44 (s, 3H), 2.42-2.34 (m, 1H), 2.02 (ddd, J = 12.9, 12.9, 4.6 Hz, 1H). ^{13}C NMR (125 MHz): δ = 141.66, 139.54, 137.78, 134.69, 127.48, 125.32, 124.99, 123.71, 122.55, 119.92, 119.12, 118.76, 116.61, 110.53, 43.65, 38.90, 31.35, 30.59, 19.39. IR: $f(\text{cm}^{-1})$ = 3418, 2928, 2856, 1703, 1636, 1614, 1491, 1458, 1438, 1329, 1304, 1247, 1222, 913, 842, 744, 439. HRMS: $(\text{M} + \text{H})^+$ = 262.1590 calculated for $\text{C}_{19}\text{H}_{20}\text{N}$; 262.1593 experimental.

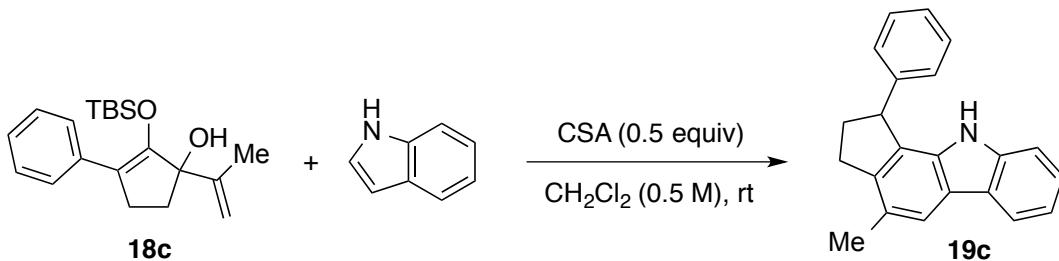
4-methyl-1-nonyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19b)



Alcohol **18b** (31 mg, 0.081 mmol) was dissolved in CH_2Cl_2 (0.20 mL). Indole (9.5 mg, 0.081 mmol) was then added, followed by camphorsulfonic acid (9.4 mg, 0.041 mmol). The reaction was allowed to stir at room temperature for 96 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes to give compound **19b** in 74% yield (20.8 mg, 0.060 mmol) as a colorless oil.

^1H NMR (500 MHz): δ = 8.01 (d, J = 7.7 Hz, 1H), 7.82 (s, 1H), 7.70 (s, 1H), 7.42 (d, J = 8.0 Hz, 1H), 7.36 (t, J = 7.4 Hz, 1H), 7.19 (t, J = 7.4 Hz, 1H), 3.51 (tt, J = 8.7, 4.5 Hz, 1H), 3.04 (dt, J = 15.9, 7.7 Hz, 1H), 2.91 (ddd, J = 13.8, 8.9, 4.8 Hz, 1H), 2.42 (s, 3H), 2.37 (m, 1H), 1.95 (dddd, J = 23.5, 13.0, 8.5, 4.5 Hz, 2H), 1.66 – 1.54 (m, 3H), 1.35–1.20 (sm, 20H), 0.88 (t, J = 6.7 Hz, 5H). ^{13}C NMR (125 MHz): δ = 141.43, 139.56, 134.71, 128.35, 125.35, 124.94, 123.78, 122.51, 119.91, 119.11, 118.52, 110.51, 43.86, 34.73, 31.89, 31.18, 30.77, 30.05, 29.71, 29.64, 29.33, 27.92, 22.68, 19.40, 14.11. IR: $f(\text{cm}^{-1})$ = 3424, 2921, 2851, 1708, 1613, 1490, 1458, 1438, 1377, 1303, 1259, 1089, 1015, 863, 798, 734. HRMS: $(\text{M} + \text{H})^+$ = 348.2686 calculated for $\text{C}_{17}\text{H}_{18}\text{N}$; 348.2696 experimental.

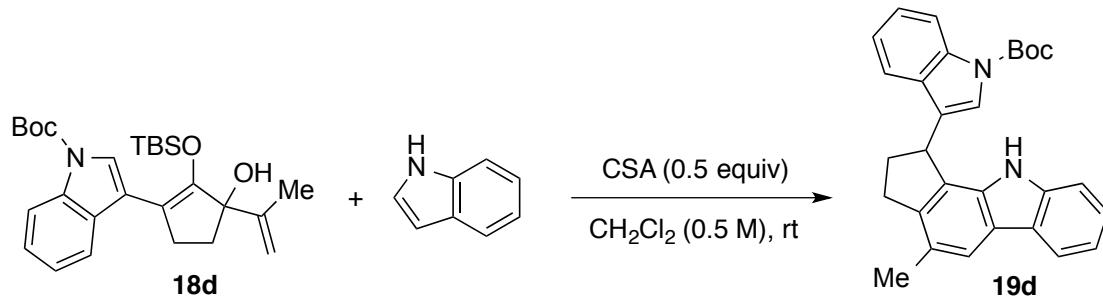
1-methyl-4-phenyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19c)



Alcohol **18c** (50 mg, 0.151 mmol) was dissolved in dichloromethane (0.300 mL). Indole (18 mg, 0.151 mmol) was then added, followed by camphorsulfonic acid (18 mg, 0.08 mmol). The reaction was allowed to stir at room temperature for 24 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **19c** in 63% yield (29 mg, 0.096 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.05 (d, *J* = 7.8 Hz, 1H), 7.97 (bs, 1H), 7.93 (s, 1H), 7.55 (dd, *J* = 8.2, 1.2 Hz, 1H), 7.45 (t, *J* = 2.7 Hz, 1H), 7.42-7.38 (m, 1H), 7.36-7.33 (m, 2H), 7.24-7.21 (m, 1H), 3.70-3.63 (m, 1H), 3.20 (ddd, *J* = 15.5, 8.9, 6.3 Hz, 1H), 3.04 (ddd, *J* = 15.6, 8.5, 5.9 Hz, 1H), 2.46-2.39 (m, 1H), 1.88-1.81 (m, 1H), 1.51 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 142.35, 140.85, 139.83, 135.49, 130.87, 129.88, 128.97, 128.15, 126.28, 125.43, 123.69, 122.93, 120.12, 119.49, 118.91, 110.66, 38.09, 34.70, 31.89, 19.72. IR: *f*(cm⁻¹) = 3424, 3389, 3377, 3057, 3038, 2953, 2928, 2889, 2867, 1694, 1670, 1612, 1576, 1490, 1471, 1451, 1436, 1375, 1353, 1326, 1306, 1284, 1244, 1117, 1100, 1074, 1031, 1016, 931, 878, 864, 839, 767, 739, 701, 585, 491, 439. HRMS: (M + H)⁺ = 298.1590 calculated for C₂₂H₂₀N; 298.1584 experimental.

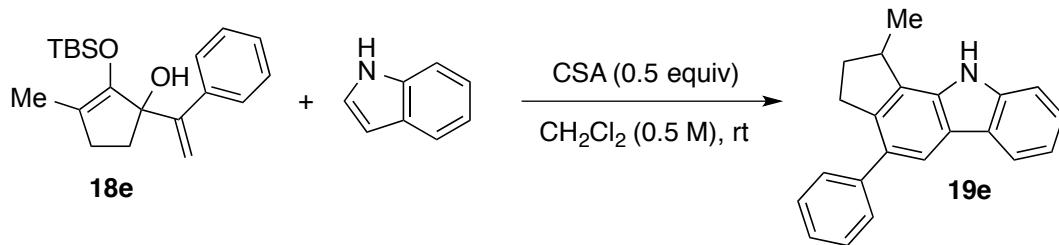
tert-butyl 3-(4-methyl-1,2,3,10-tetrahydrocyclopenta[a]carbazol-1-yl)-1H-indole-1-carboxylate (19d)



Alcohol **18d** (68 mg, 0.145 mmol) was dissolved in dichloromethane (0.290 mL). Indole (17 mg, 0.145 mmol) was then added, followed by camphorsulfonic acid (15 mg, 0.072 mmol). The reaction was allowed to stir at room temperature for 19 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give compound **19d** in 43% yield (27 mg, 0.063 mmol) as a white solid.

^1H NMR (500 MHz): δ = 8.09 (d, J = 8.5 Hz, 1H), 7.99 (d, J = 7.4 Hz, 1H), 7.78 (s, 1H), 7.61 (d, J = 3.8 Hz, 1H), 7.47 (d, J = 1.8 Hz, 1H), 7.27-7.23 (m, 2H), 7.15-7.12 (m, 3H), 6.49 (d, J = 3.8 Hz, 1H), 4.76 (t, J = 8.5 Hz, 1H), 3.20 (ddd, J = 15.8, 9.0, 3.1 Hz, 1H), 3.04 (dt, J = 16.5, 8.4 Hz, 1H), 2.84-2.78 (m, 1H), 2.50 (s, 3H), 2.22-2.14 (m, 1H), 1.67 (s, 9H). ^{13}C NMR (125 MHz): δ = 149.75, 142.12, 139.44, 138.86, 134.91, 131.09, 126.96, 126.36, 125.21, 124.84, 124.30, 123.42, 122.66, 119.90, 119.84, 119.06, 118.97, 115.57, 110.65, 107.25, 83.74, 50.50, 37.53, 31.58, 28.19, 19.4. IR: $f(\text{cm}^{-1})$ = 3454, 3411, 2975, 2931, 2858, 1731, 1631, 1613, 1579, 1536, 1491, 1468, 1458, 1440, 1372, 1347, 1332, 1305, 1247, 1218, 1161, 1130, 1083, 1040, 1024, 852, 820, 766, 734, 632, 574, 487, 439, 421. HRMS: $(\text{M} + \text{H})^+$ = 437.2224 calculated for $\text{C}_{29}\text{H}_{29}\text{N}_2\text{O}_2$; 437.2221 experimental.

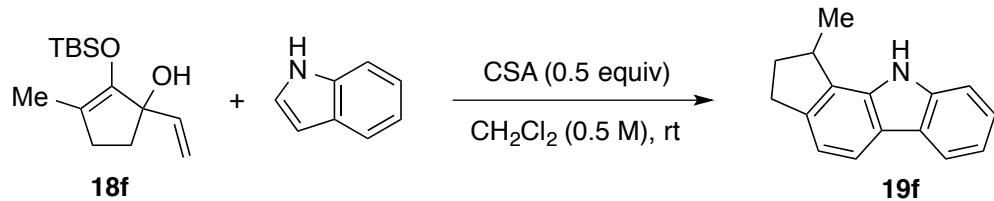
4-methyl-1-phenyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19e)



Alcohol **18e** (55 mg, 0.166 mmol) was dissolved in dichloromethane (0.330 mL). Indole (19 mg, 0.166 mmol) was then added, followed by camphorsulfonic acid (19 mg, 0.083 mmol). The reaction was allowed to stir at room temperature for 19 hours. The mixture was then directly purified using 100% hexanes \rightarrow 10% Et_2O in hexanes \rightarrow 20% Et_2O in hexanes \rightarrow 30% Et_2O in hexanes to give compound **19e** in 92% yield (46 mg, 0.153 mmol) as a yellow solid.

^1H NMR (500 MHz): δ = 8.00 (d, J = 7.8 Hz, 1H), 7.78 (s, 1H), 7.37-7.27 (m, 6H), 7.20-7.14 (m, 2 H), 7.12 (bs, 1H), 4.67 (t, J = 8.4 Hz, 1H), 3.18 (ddd, J = 15.8, 9.0, 3.3 Hz, 1H), 3.03 (dt, J = 16.5, 8.5 Hz, 1H), 2.82-2.75 (m, 1H), 2.49 (s, 3H), 2.20-2.13 (m, 1H). ^{13}C NMR (125 MHz): δ = 144.45, 142.13, 139.45, 134.81, 128.92, 127.89, 126.79, 126.55, 125.21, 124.91, 123.42, 119.87, 119.03, 110.58, 50.53, 37.04, 31.55, 19.40. IR $f(\text{cm}^{-1})$ = 3456, 3025, 2928, 2855, 1701, 1632, 1612, 1490, 1456, 1439, 1372, 1326, 1306, 1245, 1218, 1141, 1077, 1016, 908, 841, 792, 761, 745, 732, 701, 651, 613, 574, 554, 518, 495, 438. HRMS: $(\text{M} + \text{H})^+$ = 298.1590 calculated for $\text{C}_{22}\text{H}_{20}\text{N}$; 298.1581 experimental.

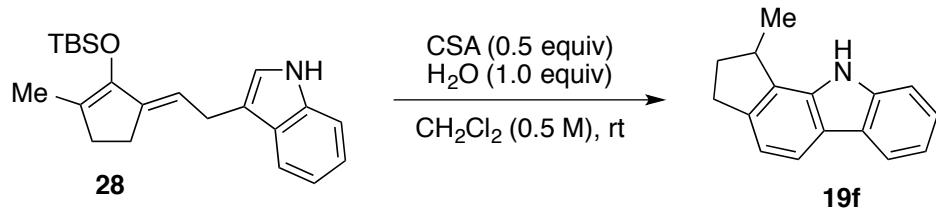
1-Methyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19f)



Alcohol **18f** (100 mg, 0.393 mmol) was dissolved in CH₂Cl₂ (0.80 mL). Indole (46 mg, 0.393 mmol) was then added, followed by camphorsulfonic acid (46 mg, 0.197 mmol). The reaction was allowed to stir at room temperature for 4 days. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes to give compound **19f** in 70% yield (61 mg, 0.276 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.04 (d, *J* = 7.7 Hz, 1H), 7.93 (s, 1H), 7.89 (d, *J* = 7.9 Hz, 1H), 7.44 (d, *J* = 8.1 Hz, 1H), 7.38 (ddd, *J* = 8.2, 7.1, 1.2 Hz, 1H), 7.22 (ddd, *J* = 8.0, 7.1, 1.1 Hz, 1H), 7.13 (d, *J* = 7.9 Hz, 1H), 3.61 (x, *J* = 13.8, 6.9 Hz, 1H), 3.17 (ddd, *J* = 15.7, 8.5, 6.3 Hz, 1H), 3.02 (ddd, *J* = 15.3, 8.7, 6.0 Hz, 1H), 2.46 (dddd, *J* = 12.5, 8.7, 8.0, 6.2 Hz, 1H), 1.85 (ddt, *J* = 12.4, 8.5, 5.7 Hz, 1H), 1.46 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 142.03, 139.48, 136.15, 129.59, 125.16, 123.87, 122.21, 120.00, 119.37, 118.50, 116.30, 110.56, 37.90, 34.52, 31.92, 19.88. IR: *f*(cm⁻¹) = 3422, 3057, 2952, 2923, 2848, 1687, 1610, 1493, 1458, 1421, 1323, 1303, 1259, 1223, 1015, 907, 803, 734, 553. HRMS: (M + H)⁺ = 222.1277 calculated for C₁₆H₁₆N; 222.1277 experimental.

1-Methyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (**19f**) from **28**

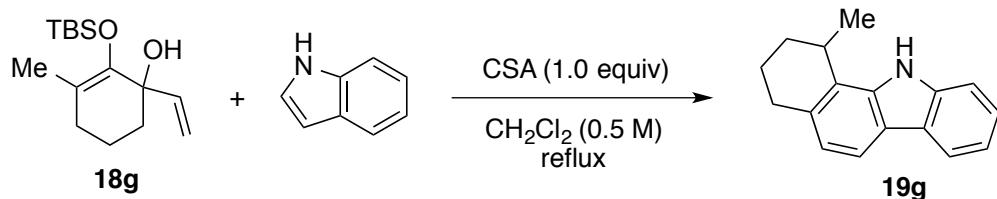


Silyldienol ether **28** (45 mg, 0.126 mmol) was dissolved in CH₂Cl₂ (0.25 mL). DI H₂O (3 μL, 0.126 mmol) was then added, followed by camphorsulfonic acid (15 mg, 0.063 mmol). The reaction was allowed to stir at room temperature for 4 days. The mixture was then directly

purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes to give compound **19f** in 88% yield (26 mg, 0.110 mmol) as a colorless oil.

¹H NMR (500 MHz): δ = 8.05 (d, *J* = 7.7 Hz, 1H), 7.94 (s, 1H), 7.90 (d, *J* = 7.9 Hz, 1H), 7.45 (d, *J* = 8.1 Hz, 1H), 7.38 (ddd, *J* = 8.2, 7.1, 1.2 Hz, 1H), 7.21 (ddd, *J* = 8.0, 7.1, 1.1 Hz, 1H), 7.13 (d, *J* = 7.9 Hz, 1H), 3.63 (x, *J* = 13.8, 6.9 Hz, 1H), 3.18 (ddd, *J* = 15.7, 8.5, 6.3 Hz, 1H), 3.02 (ddd, *J* = 15.3, 8.7, 6.0 Hz, 1H), 2.46 (dddd, *J* = 12.5, 8.7, 8.0, 6.2 Hz, 1H), 1.86 (ddt, *J* = 12.4, 8.5, 5.7 Hz, 1H), 1.45 (d, *J* = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 142.03, 139.48, 136.15, 129.59, 125.16, 123.86, 122.20, 120.00, 119.37, 118.50, 116.29, 110.55, 37.90, 34.52, 31.92, 19.88.

1-Methyl-2,3,4,11-tetrahydro-1H-benzo[a]carbazole (**19g**)

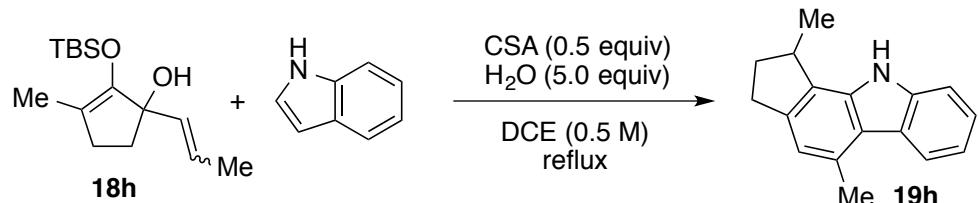


Alcohol **18g** (50 mg, 0.212 mmol) was dissolved in CH₂Cl₂ (0.35 mL). Indole (25 mg, 0.212 mmol) was then added, followed by camphorsulfonic acid (41 mg, 0.212 mmol). The reaction was warmed in a sand bath at 40 °C and allowed to stir for 20 hours. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes → 30% Et₂O in hexanes to give compound **19g** in 62% yield (31 mg, 0.132 mmol) as colorless oil.

¹H NMR (500 MHz) δ = 8.02 (d, *J* = 7.8 Hz, 1H), 7.94 (bs, 1H), 7.82 (d, *J* = 7.8 Hz, 1H), 7.45 (d, *J* = 8.1 Hz, 1H), 7.37 (ddd, *J* = 8.2, 7.1, 1.2 Hz, 1H), 7.23-7.19 (m, 1H), 6.98 (d, *J* = 8.0 Hz, 1H), 3.32-3.27 (m, 1H), 3.00-2.89 (m, 2H), 2.06-1.95 (m, 2H), 1.88-1.83 (m, 2H), 1.43 (d, *J* = 7.2 Hz, 3H). ¹³C NMR (125 MHz) δ = 139.20, 138.26, 134.05, 124.96, 124.25, 123.89, 121.18,

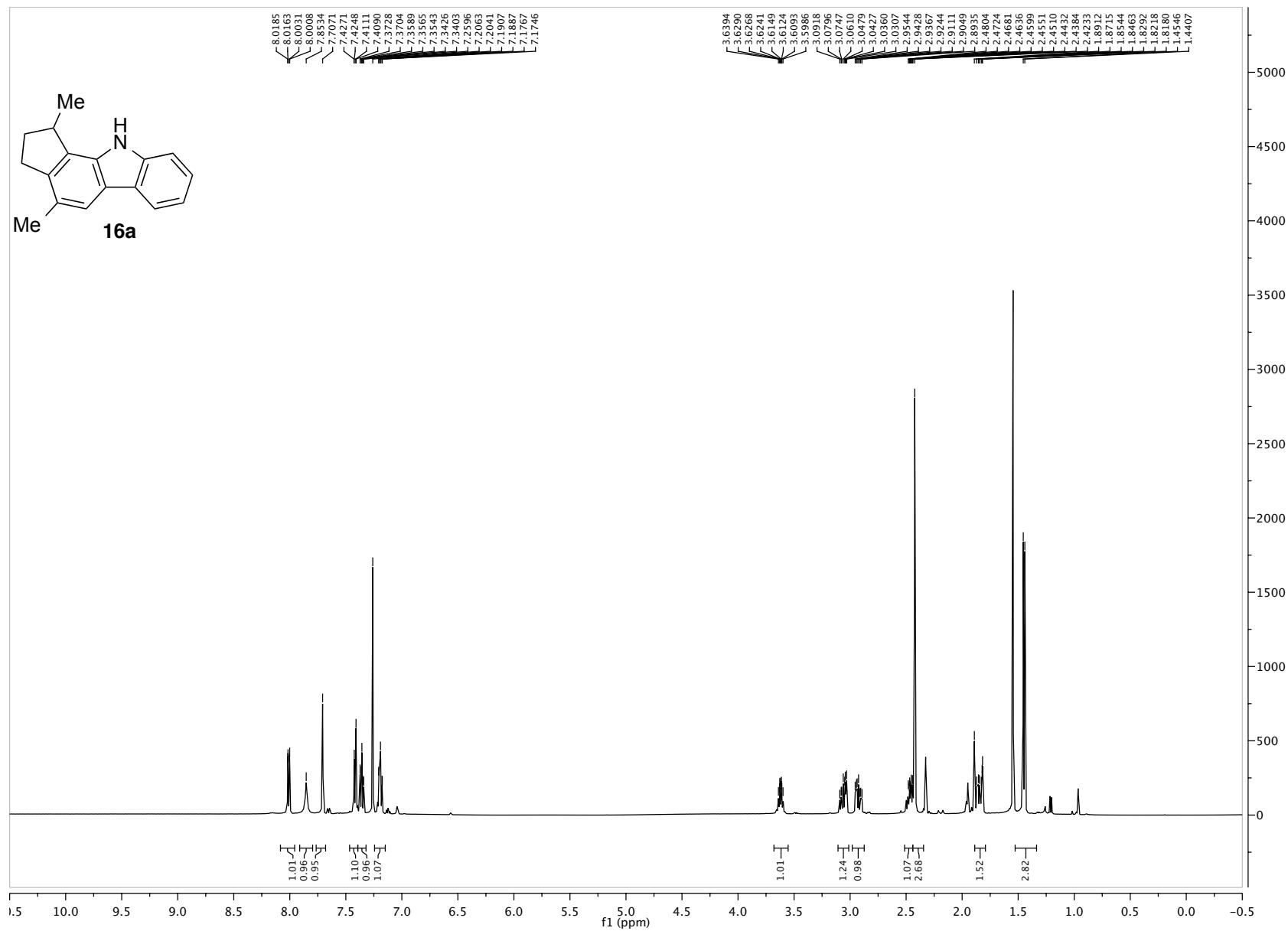
120.83, 119.91, 119.30, 117.58, 110.50, 30.29, 29.91, 28.30, 20.69, 18.46. IR ν (cm⁻¹) = 3430, 2929, 1608, 1459, 1423, 1329, 1305, 1237, 772, 739. HRMS (M + H)⁺ = 236.1434 calculated for C₁₇H₁₇N; 236.1430 experimental.

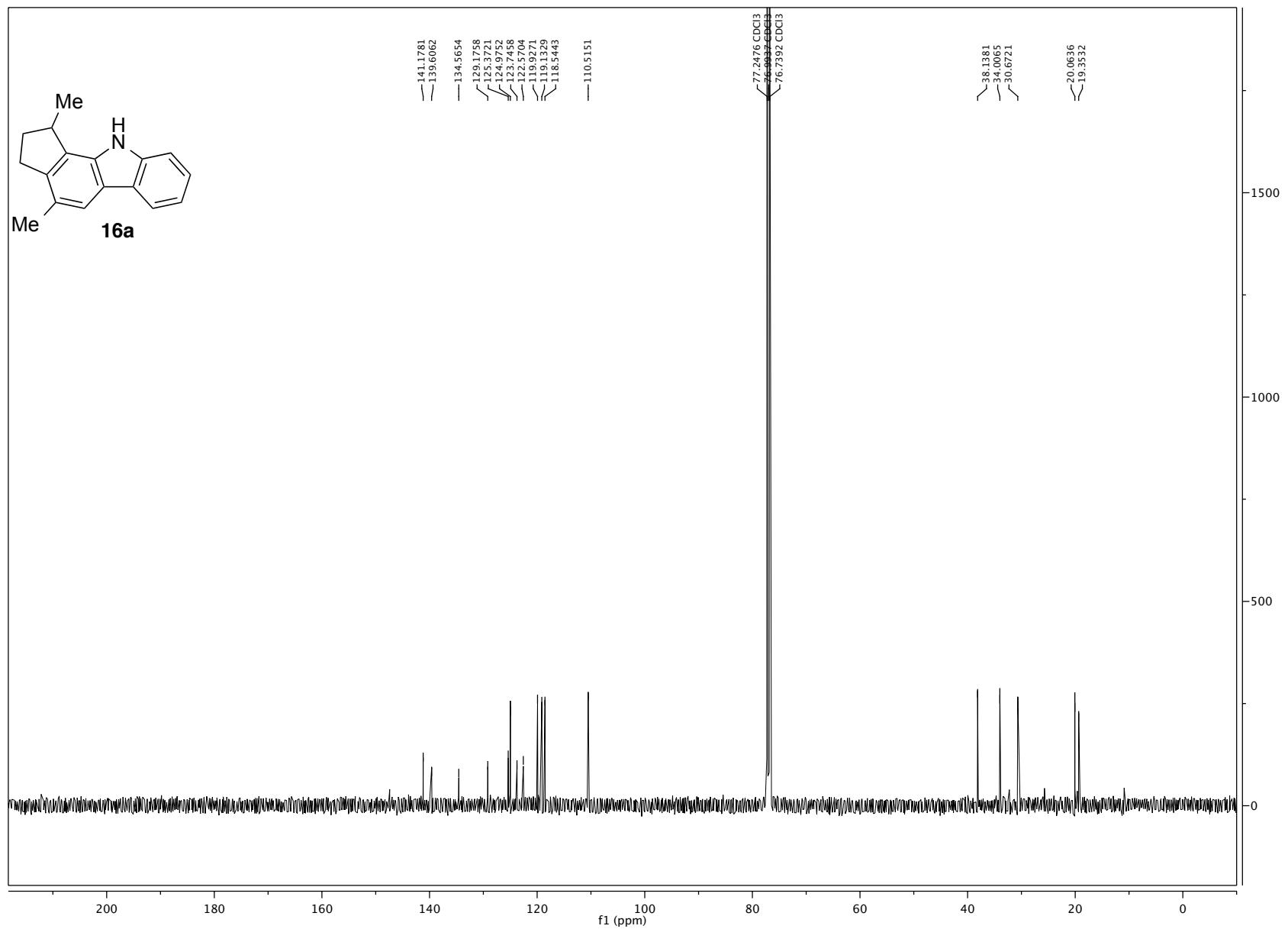
1,5-Dimethyl-1,2,3,10-tetrahydrocyclopenta[a]carbazole (19f)

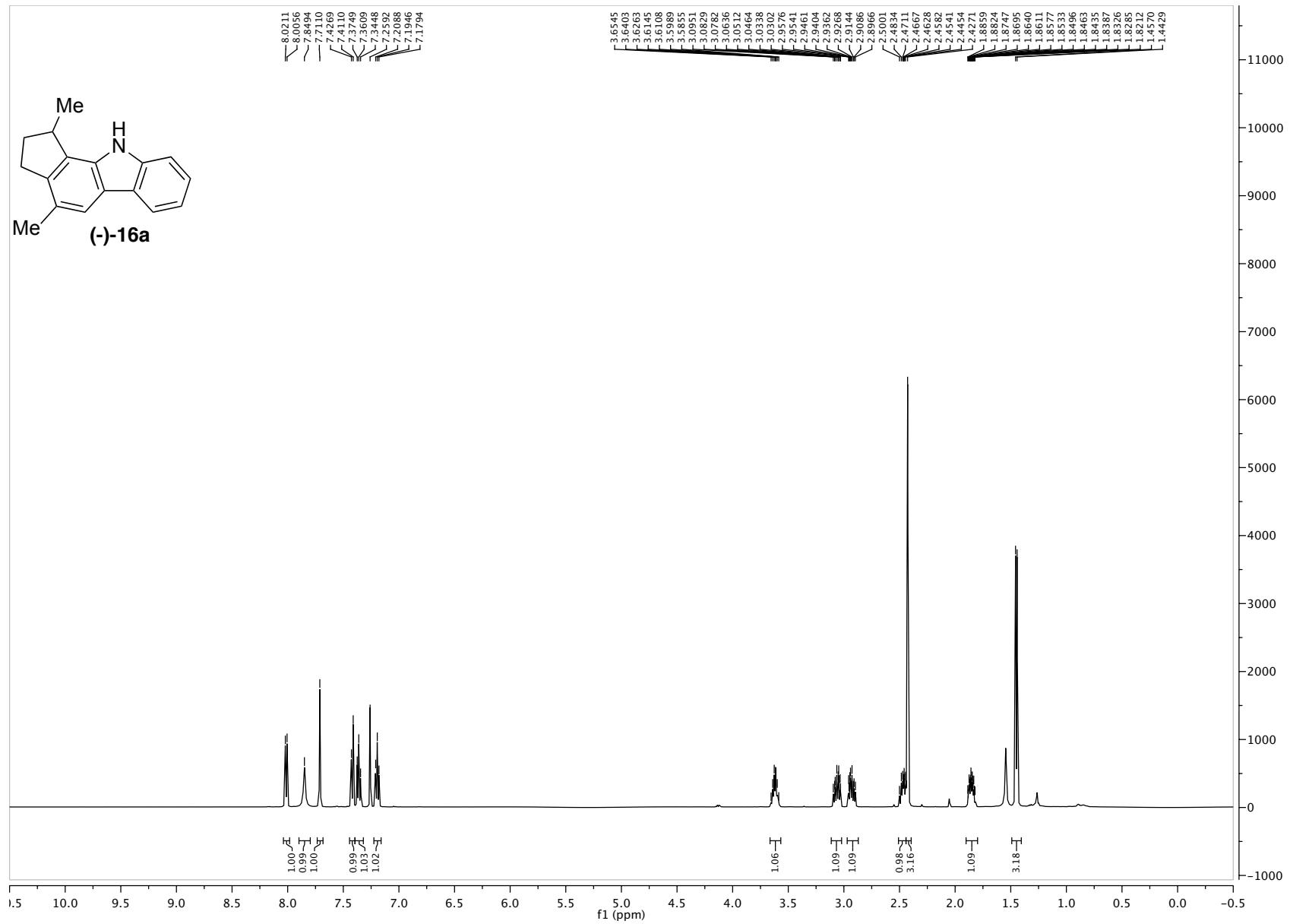


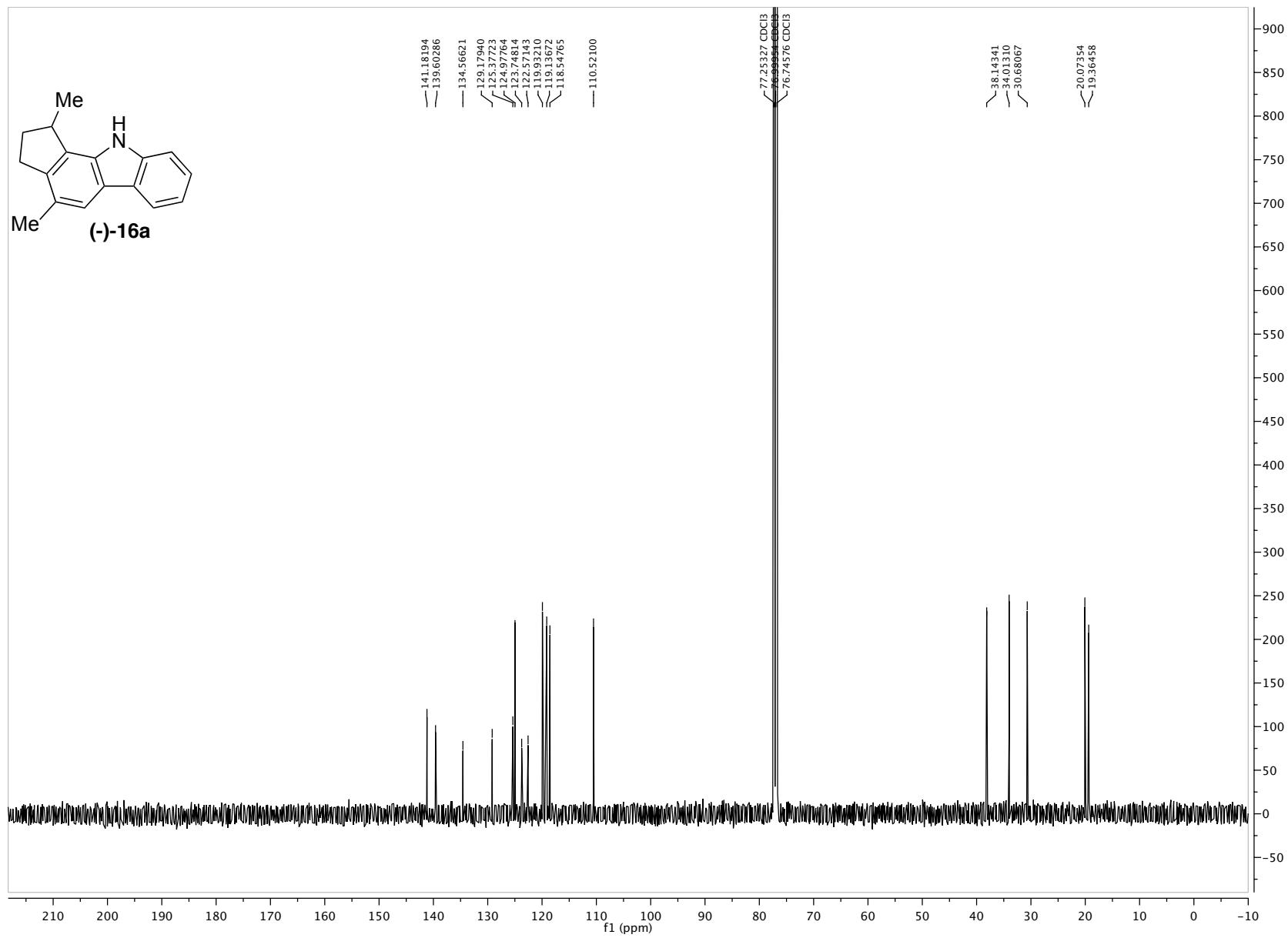
Alcohol **18h** (50 mg, 0.186 mmol) was dissolved in 1,2-dichloroethane (0.37 mL). Indole (22 mg, 0.186 mmol) and water (17 μ L, 0.94 mmol) was then added, followed by camphorsulfonic acid (44 mg, 0.186 mmol). The reaction was warmed in a sand bath at 70 °C and allowed to stir for 4 days. The mixture was then directly purified using 100% hexanes → 10% Et₂O in hexanes → 20% Et₂O in hexanes to give compound **19h** in 25% yield (11 mg, 0.047 mmol) as a colorless oil.

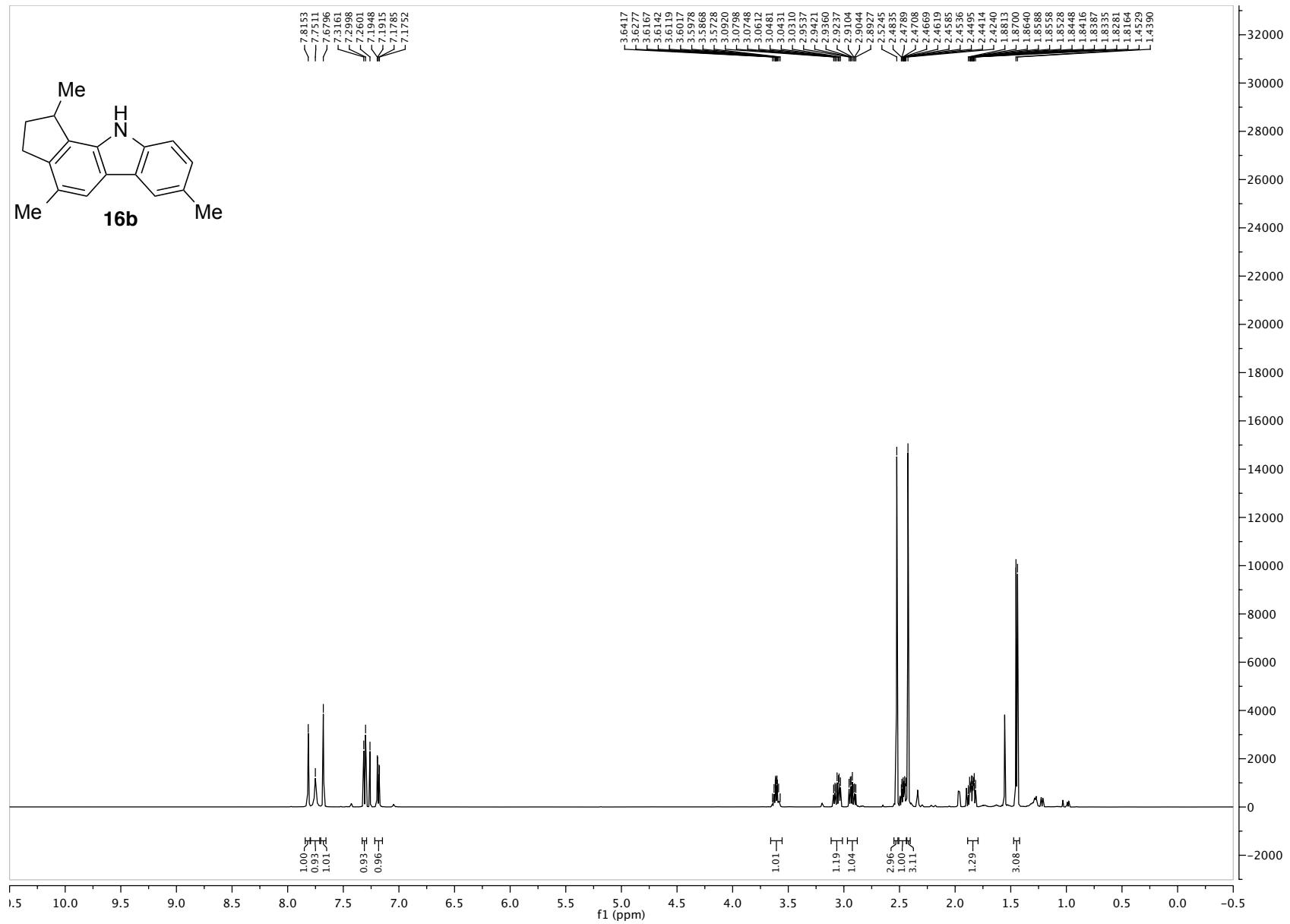
¹H NMR (500 MHz): δ = 8.15 (d, J = 7.9 Hz, 1H), 7.97 (bs, 1H), 7.46 (d, J = 7.9 Hz, 1H), 7.39 (t, J = 7.6 Hz, 1H), 7.23 (d, J = 7.4 Hz, 1H), 6.93 (s, 1H), 3.59 (x, J = 6.6 Hz, 1H), 3.14 (ddd, J = 15.7, 8.5, 6.3 Hz, 1H), 2.99 (ddd, J = 14.8, 8.5, 5.6 Hz, 1H), 2.45 (dtd, J = 12.4, 8.4, 6.3 Hz, 1H), 1.84 (ddt, J = 12.3, 8.4, 5.5 Hz, 1H), 1.44 (d, J = 7.0 Hz, 3H). ¹³C NMR (125 MHz): δ = 141.98, 139.50, 136.00, 131.70, 127.07, 124.55, 124.46, 122.15, 120.62, 119.30, 117.76, 110.33, 37.70, 34.61, 31.81, 20.84, 20.06. IR: ν (cm⁻¹) = 3423, 2954, 2923, 2851, 1455, 1259, 1082, 1018, 797, 734. HRMS: (M + H)⁺ = 236.1434 calculated for C₁₇H₁₈N; 236.1438 experimental.

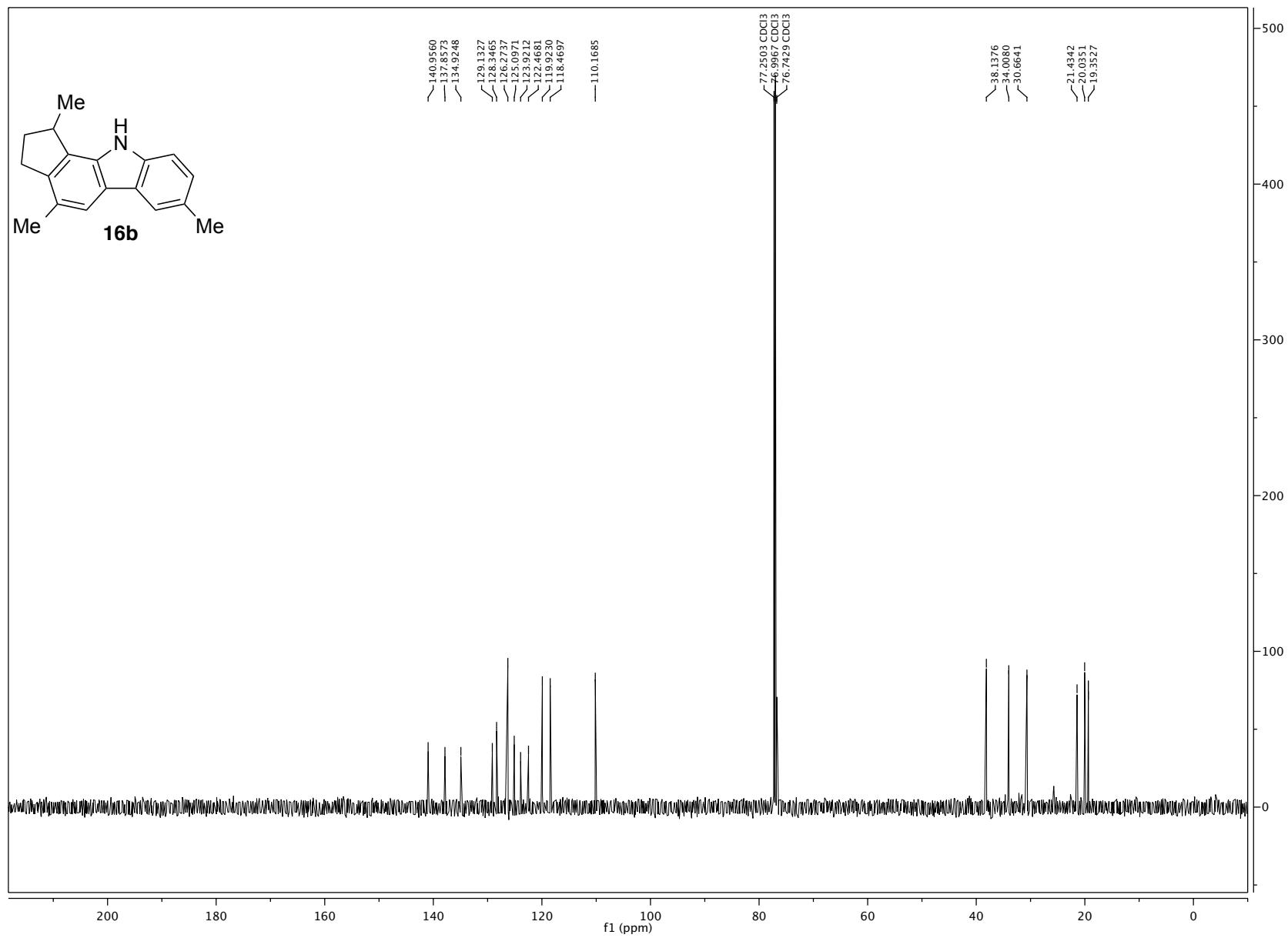


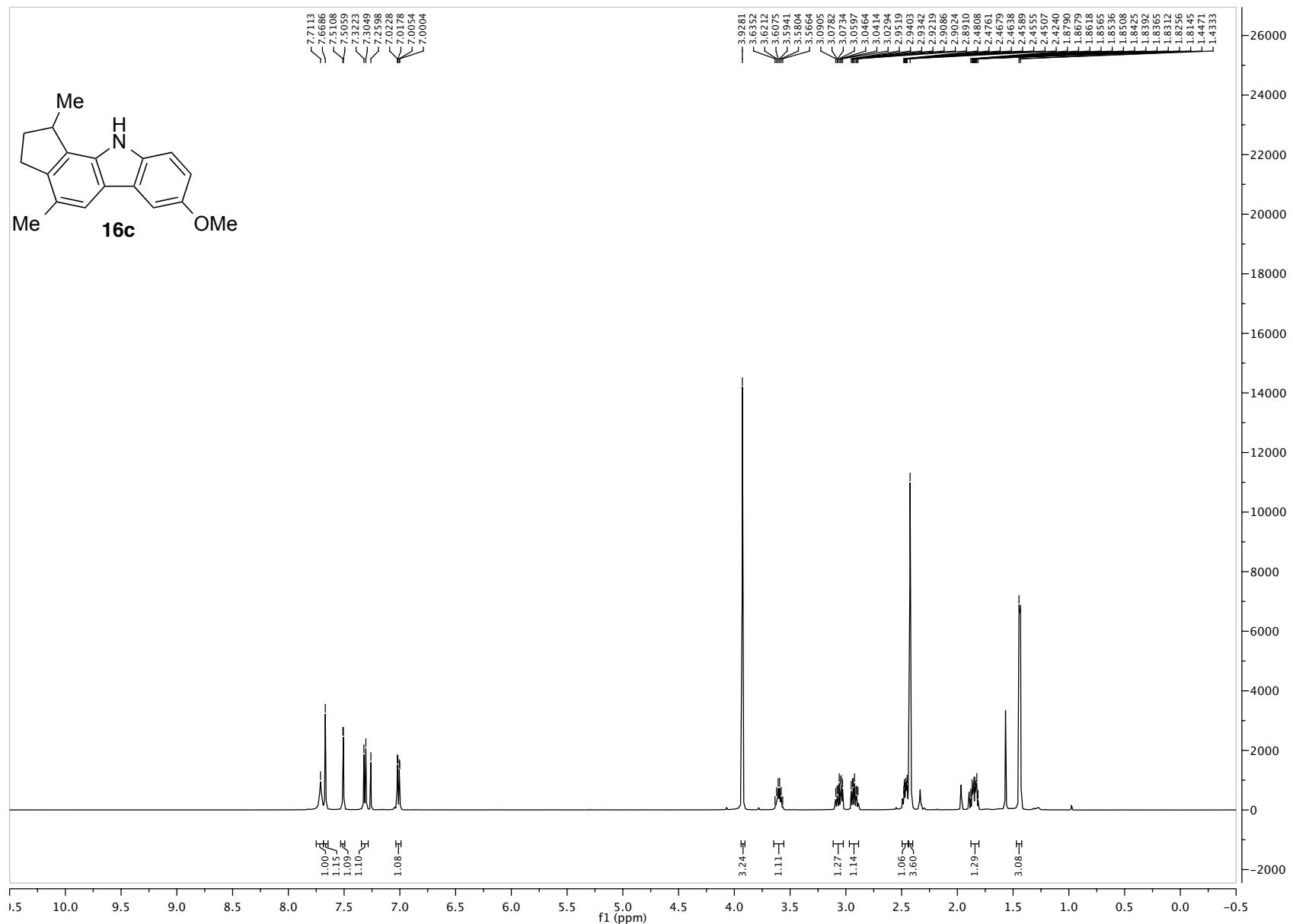


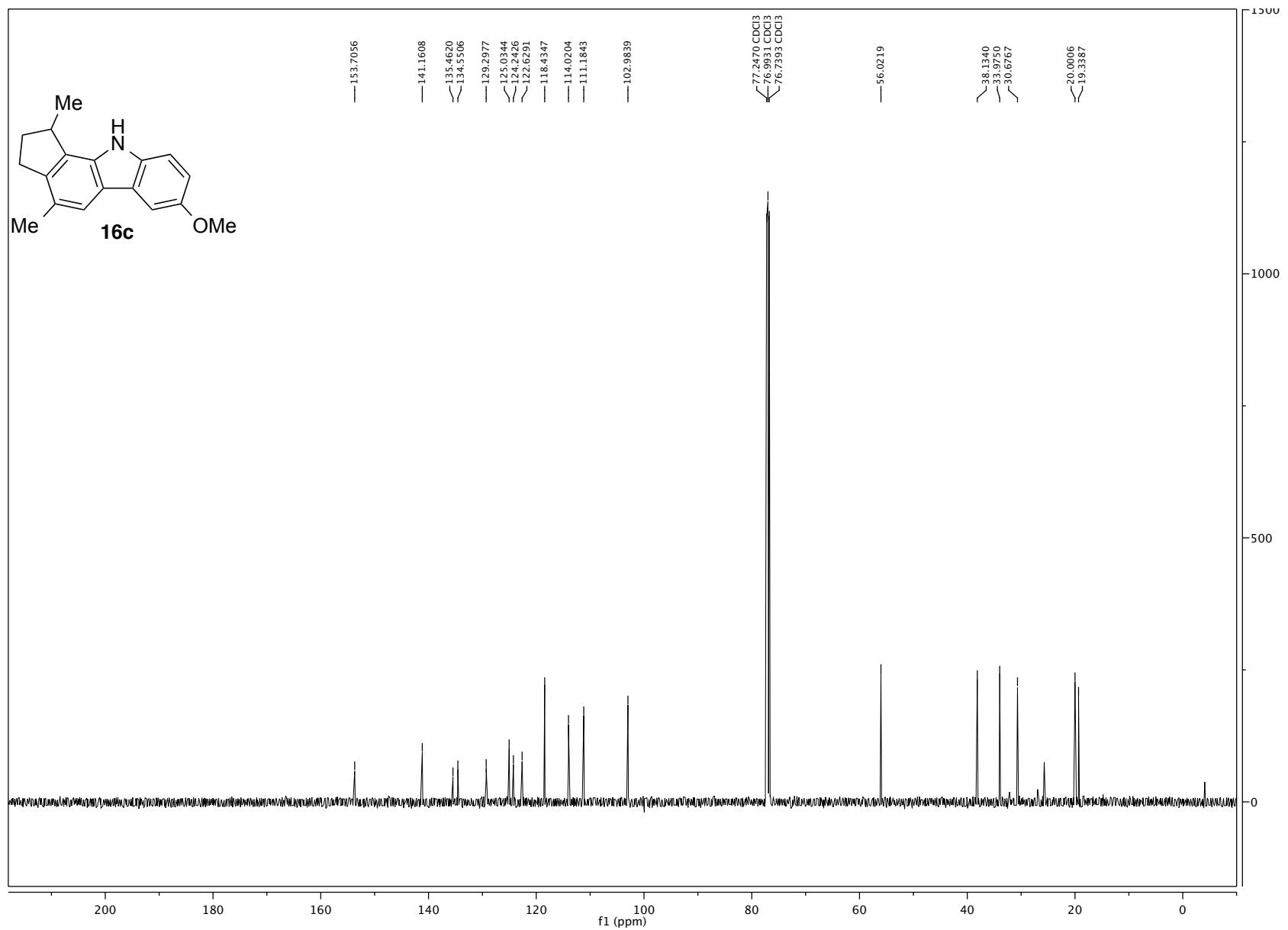


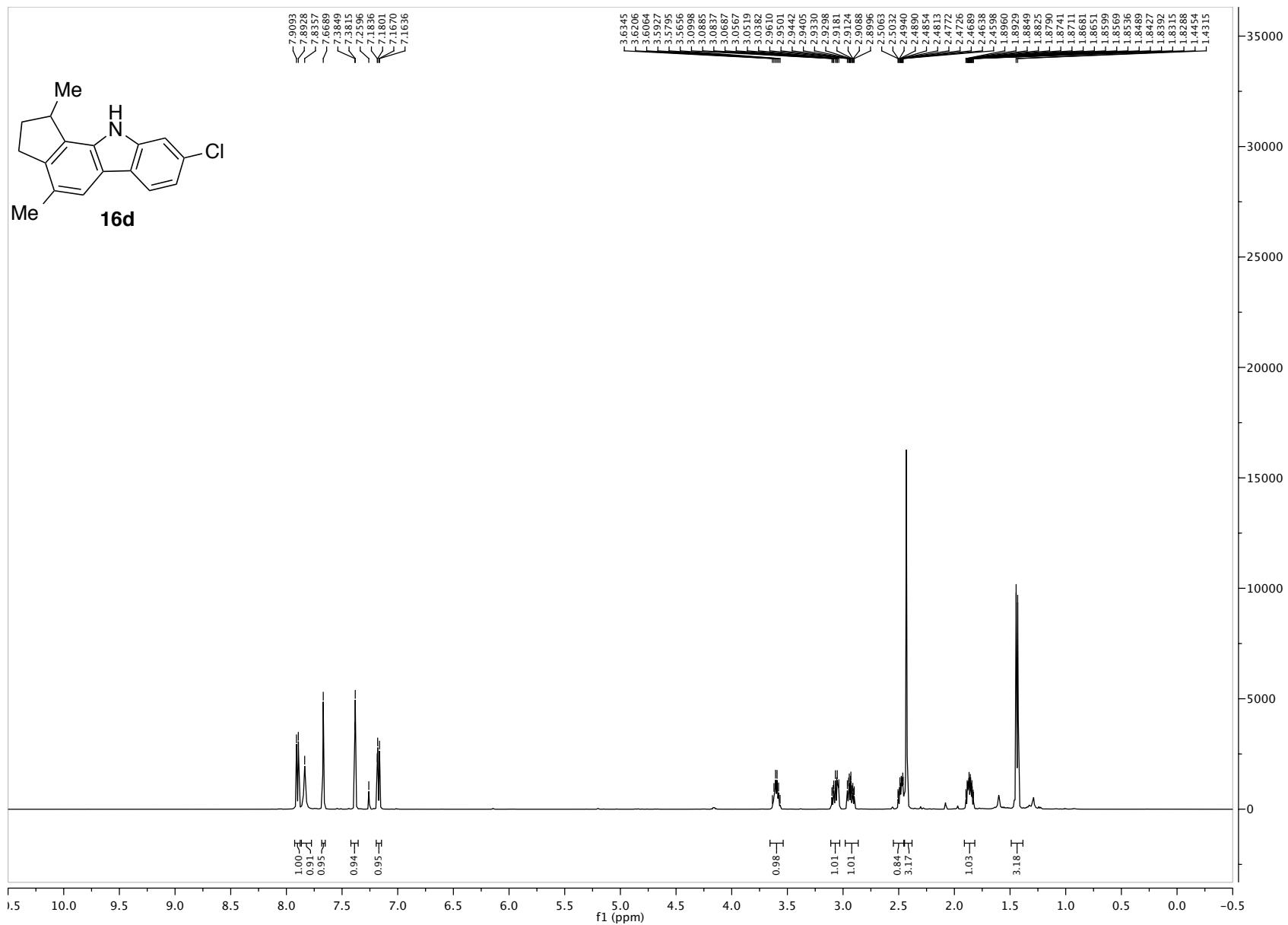


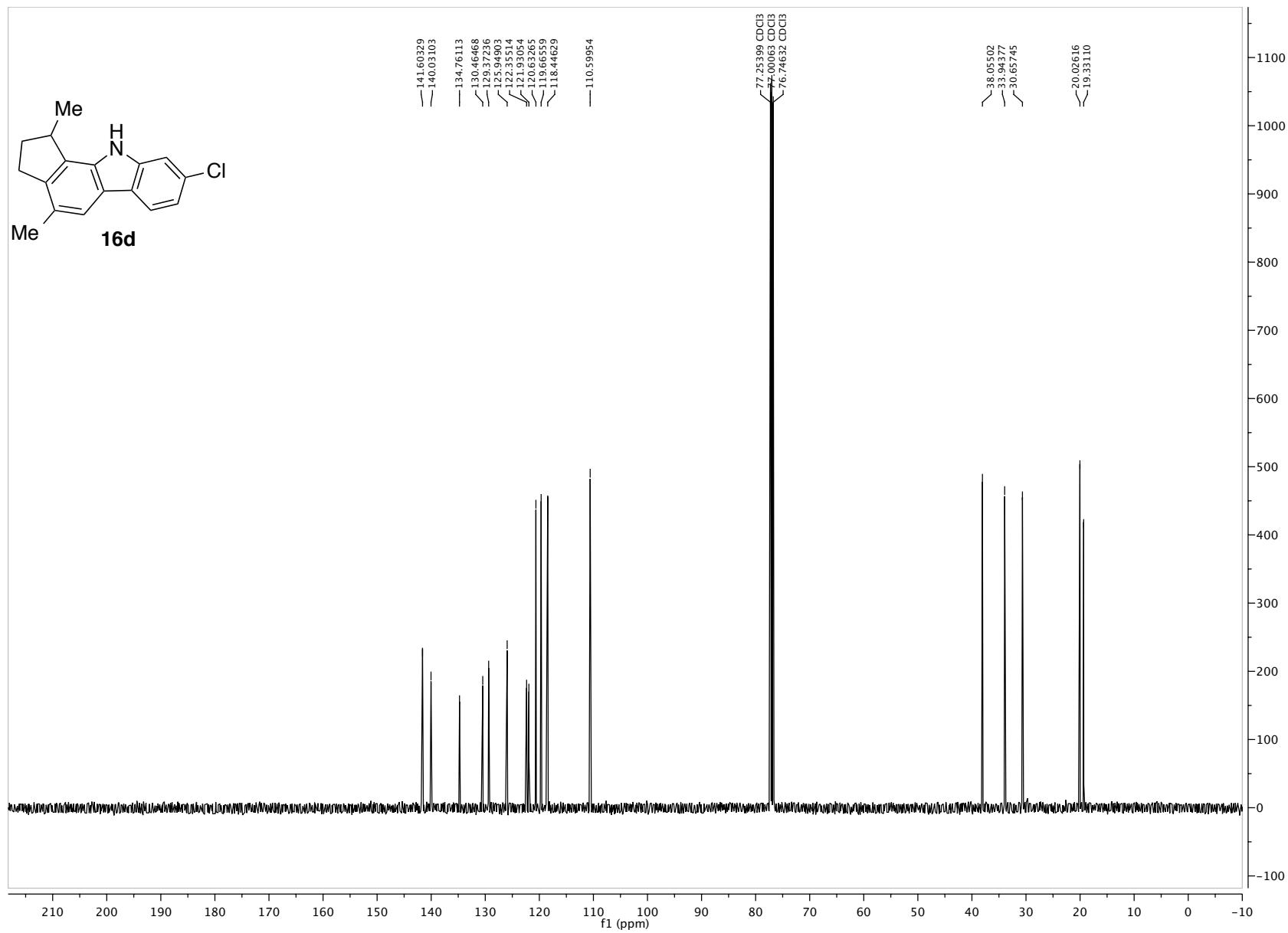


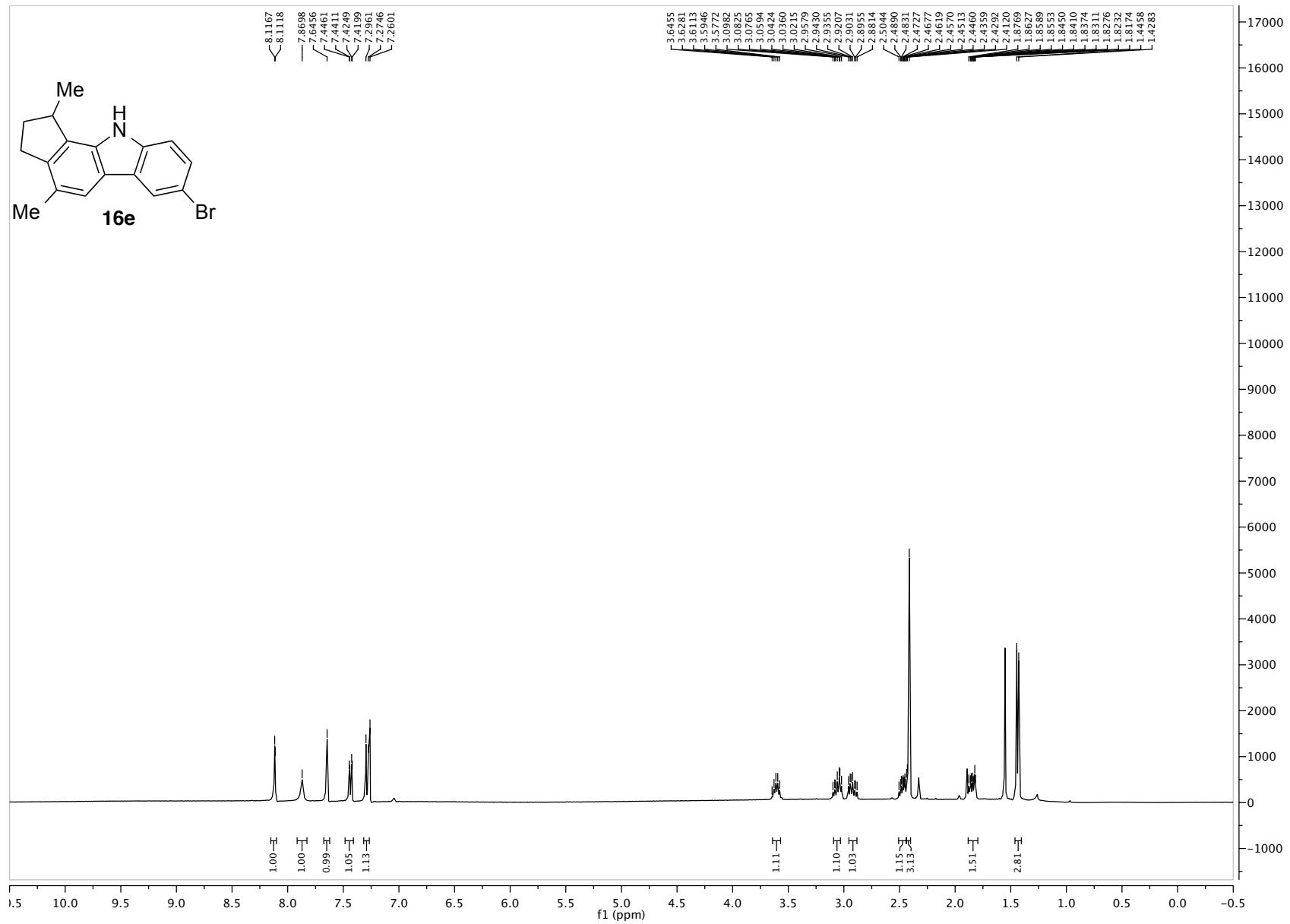


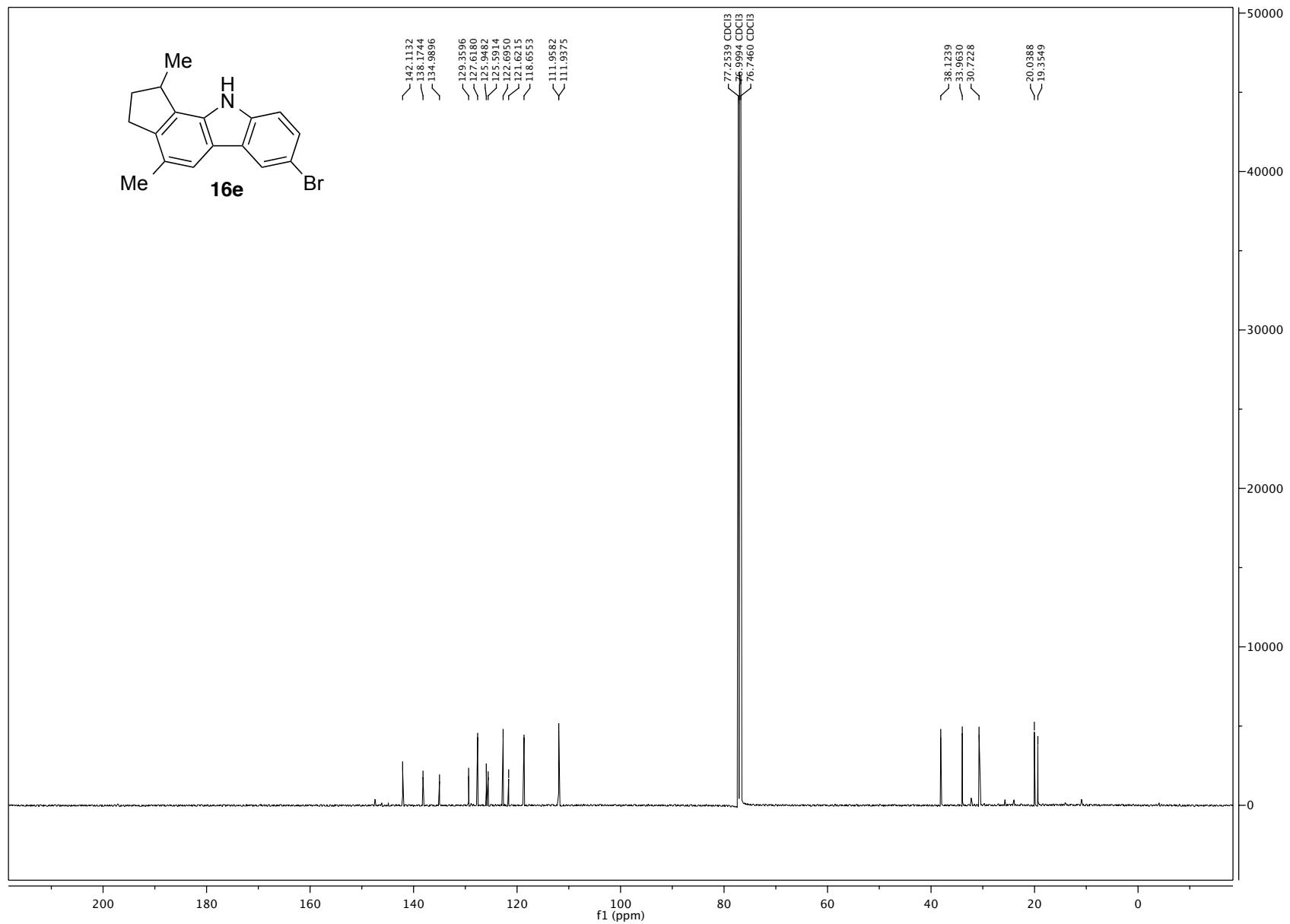


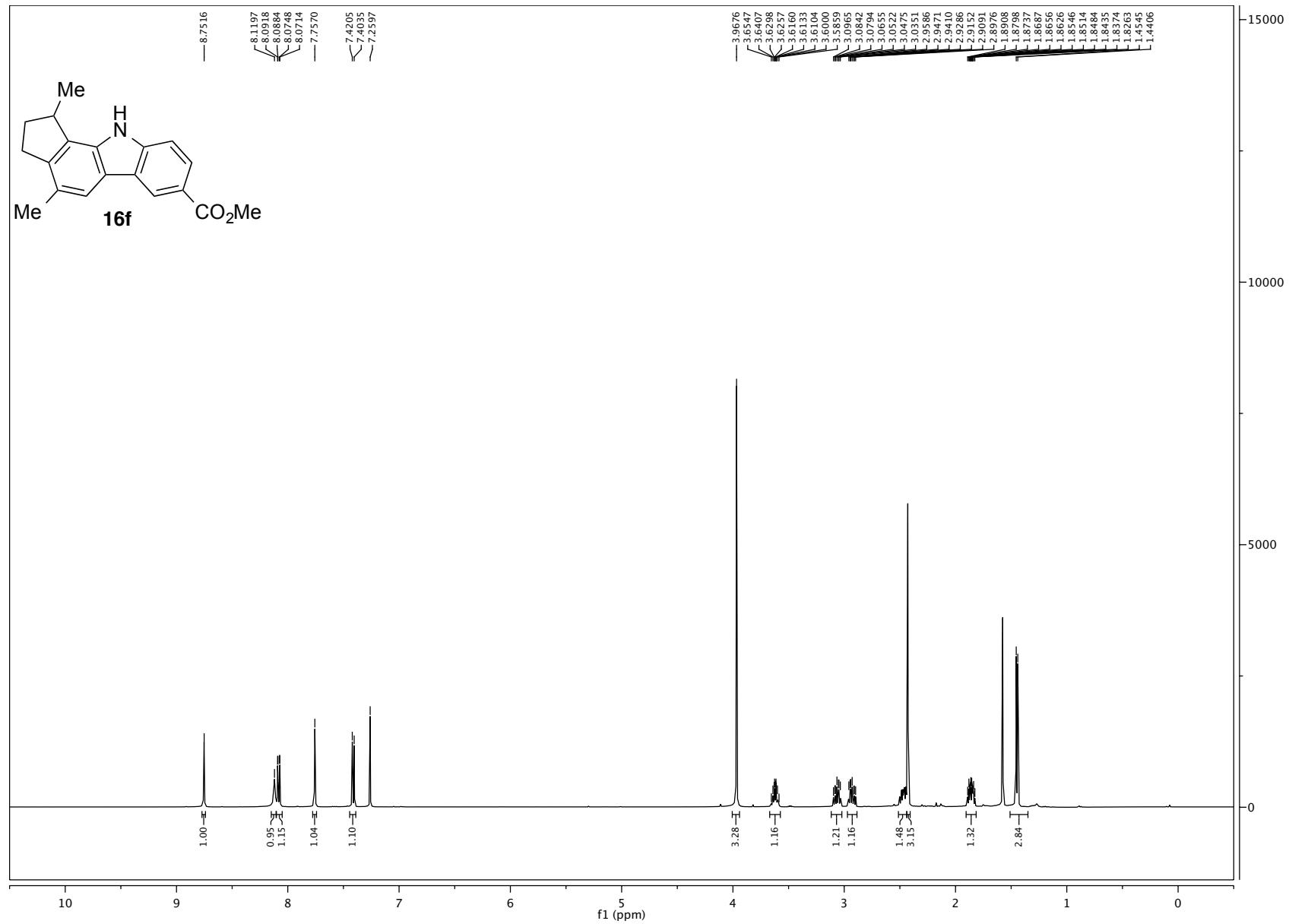


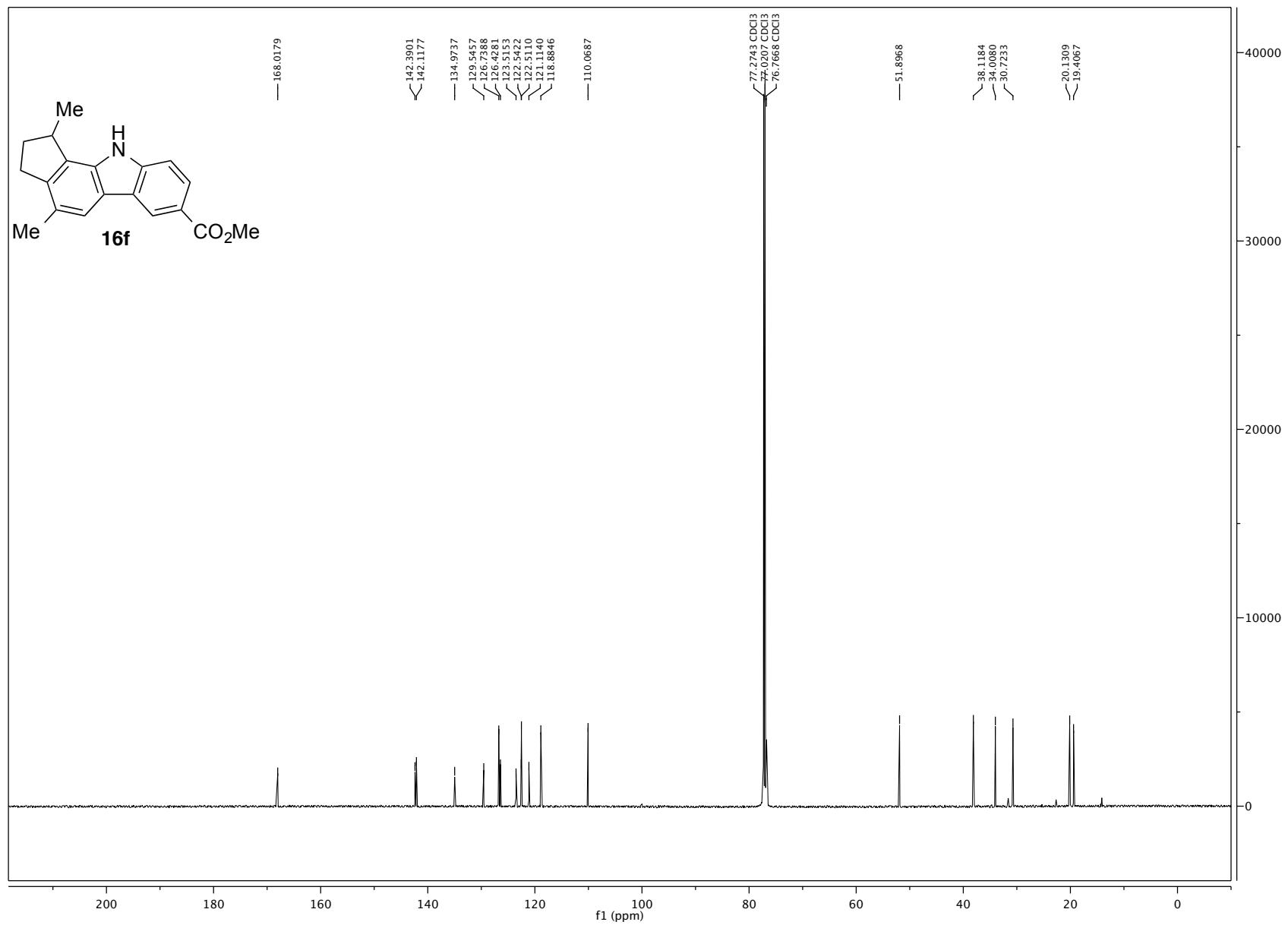


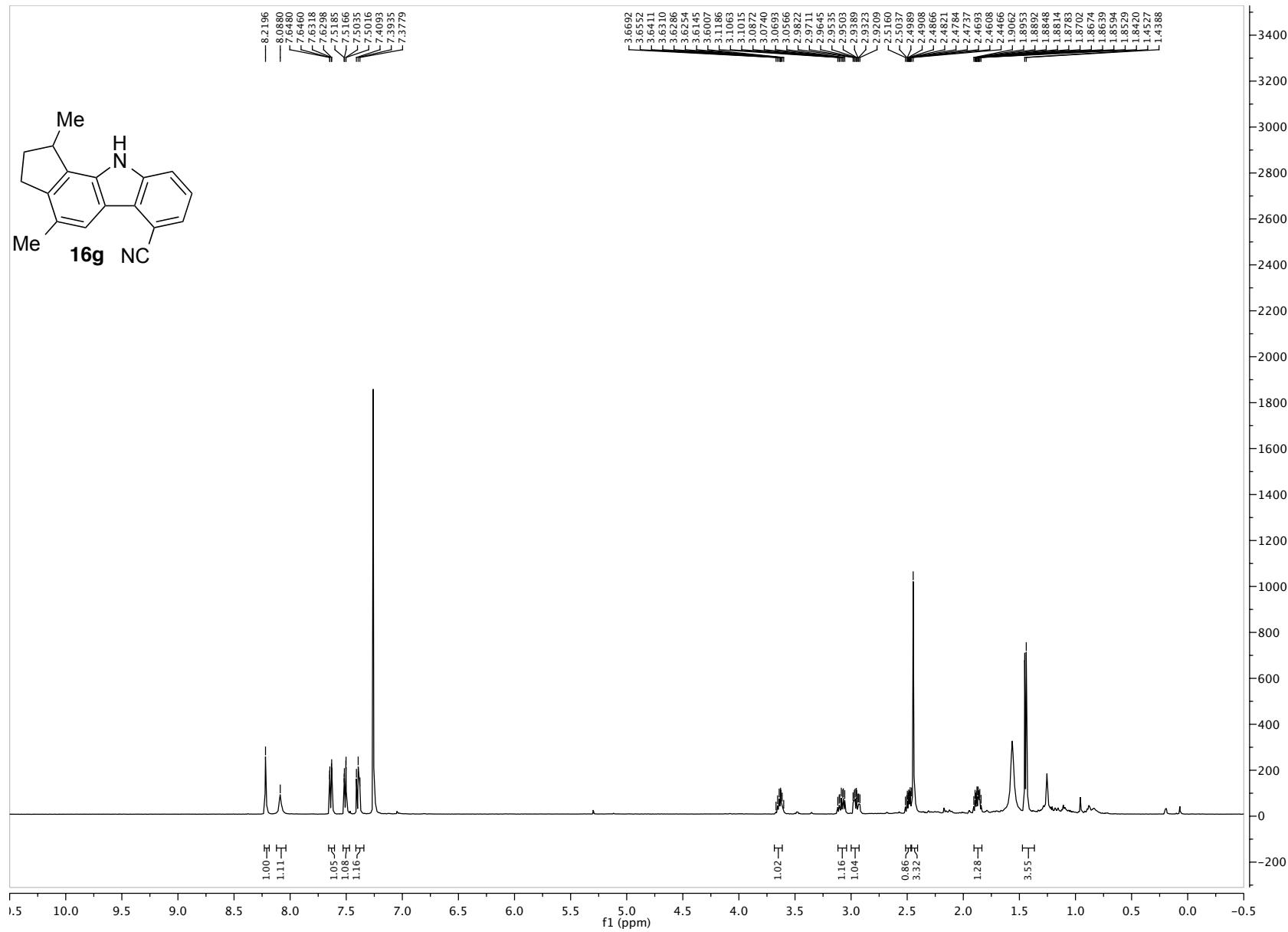


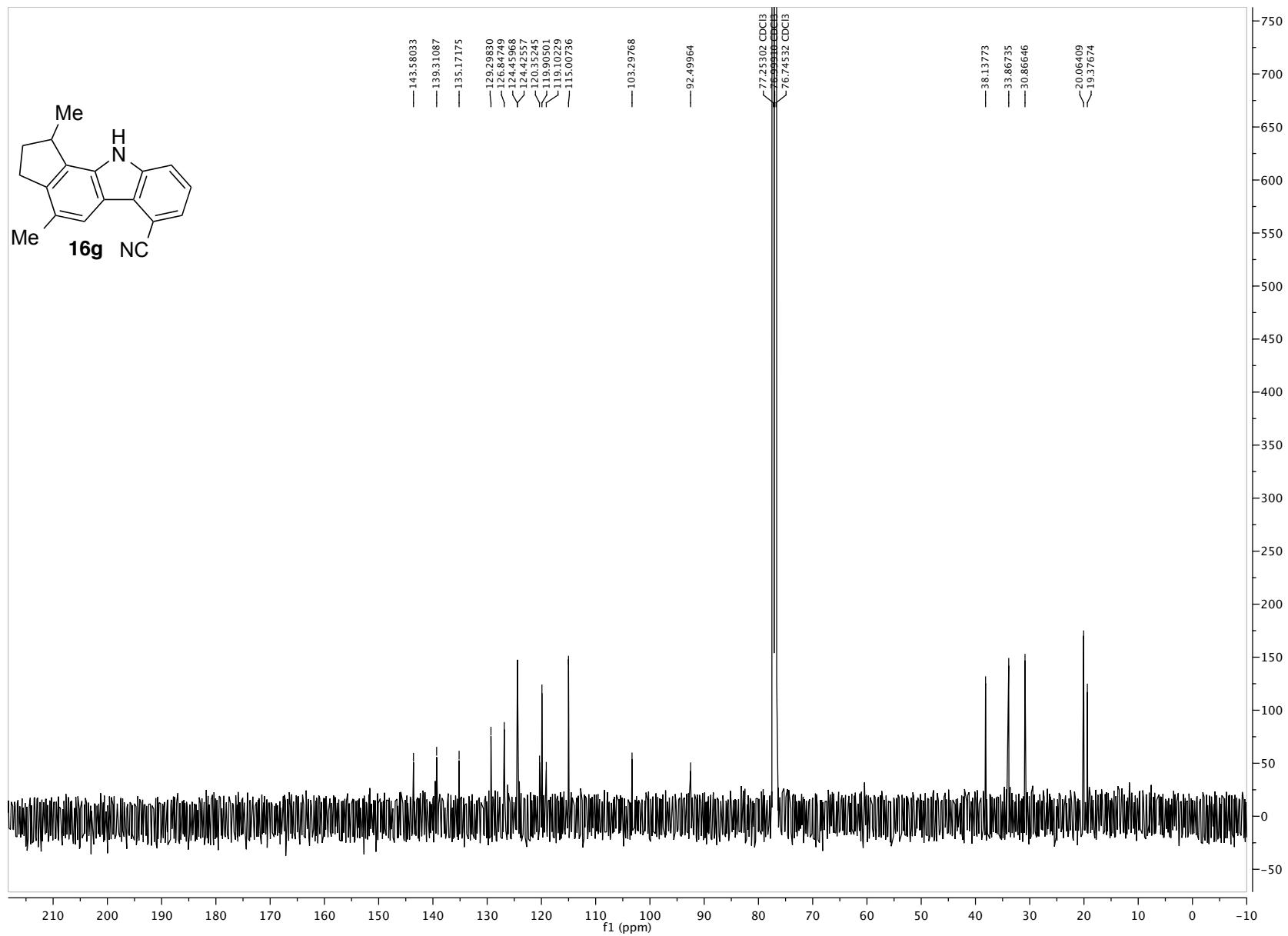


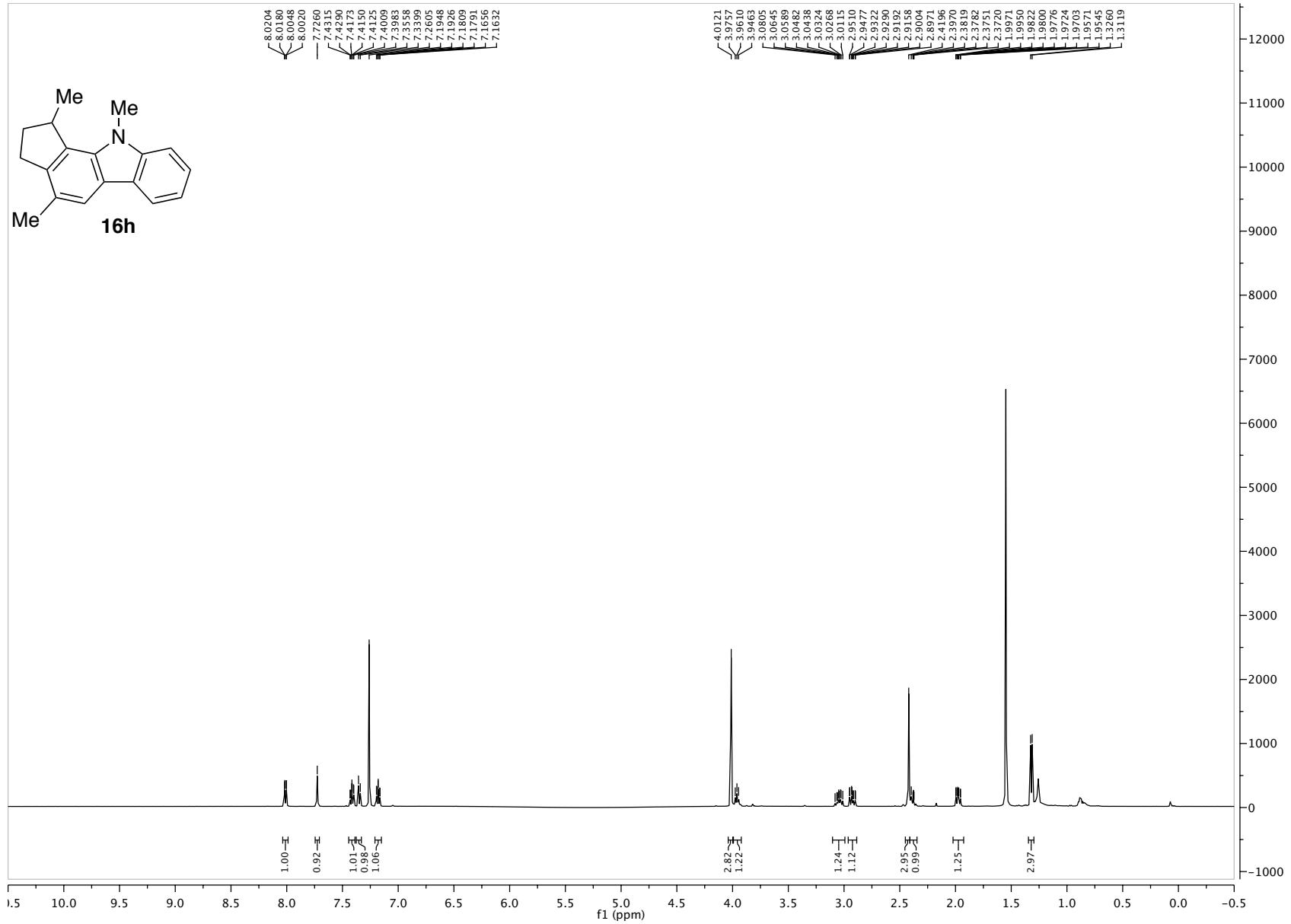


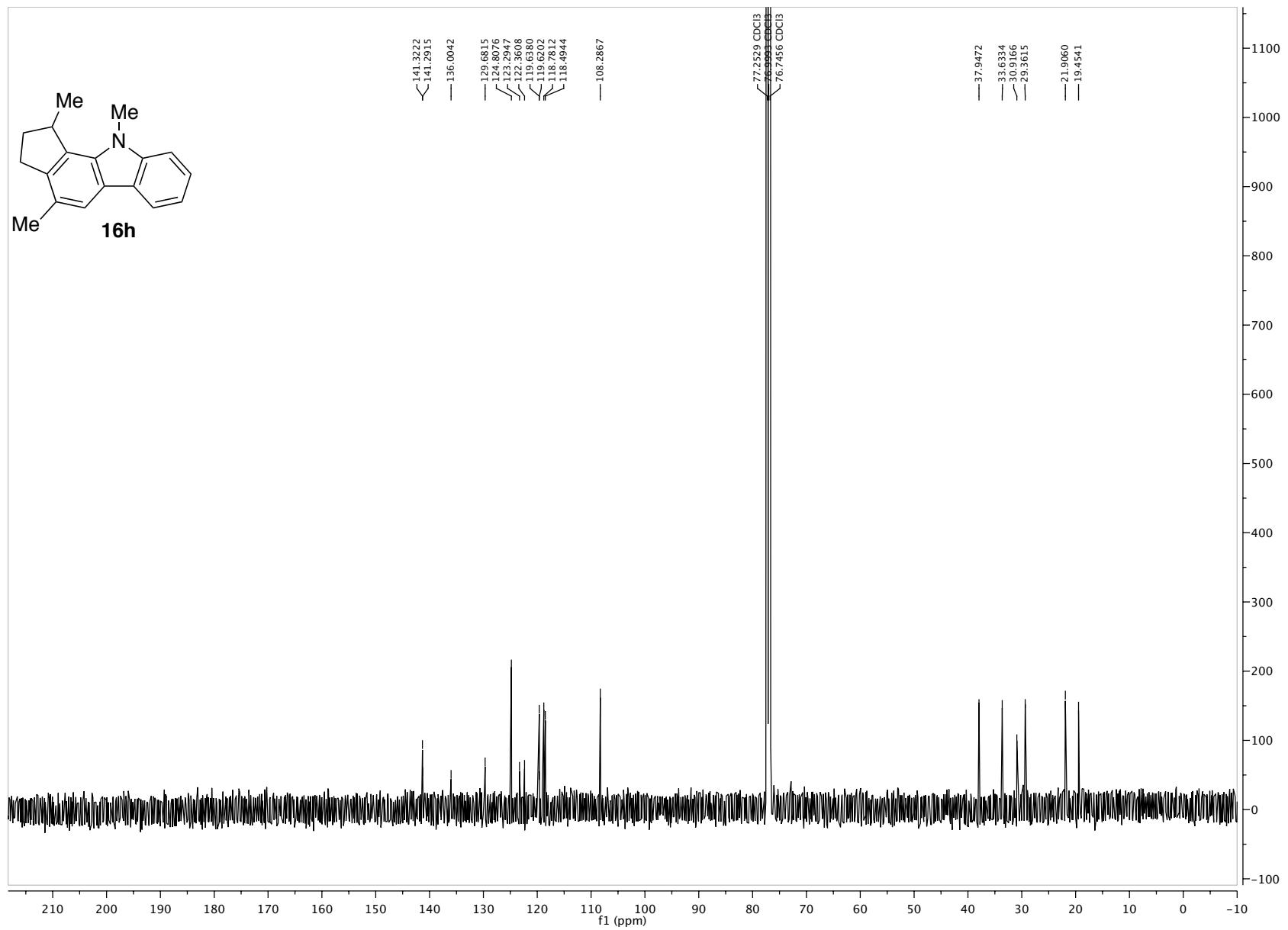


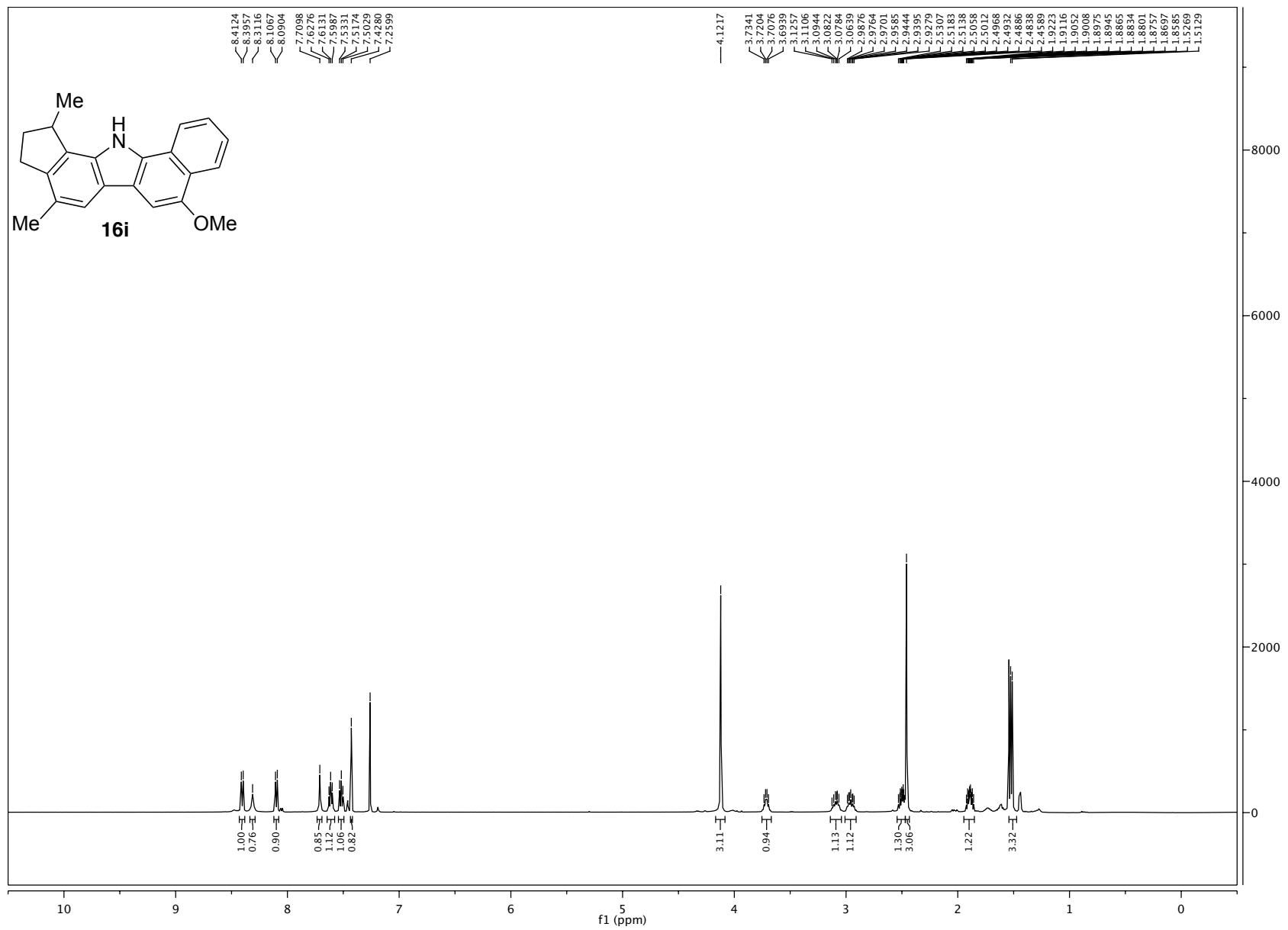


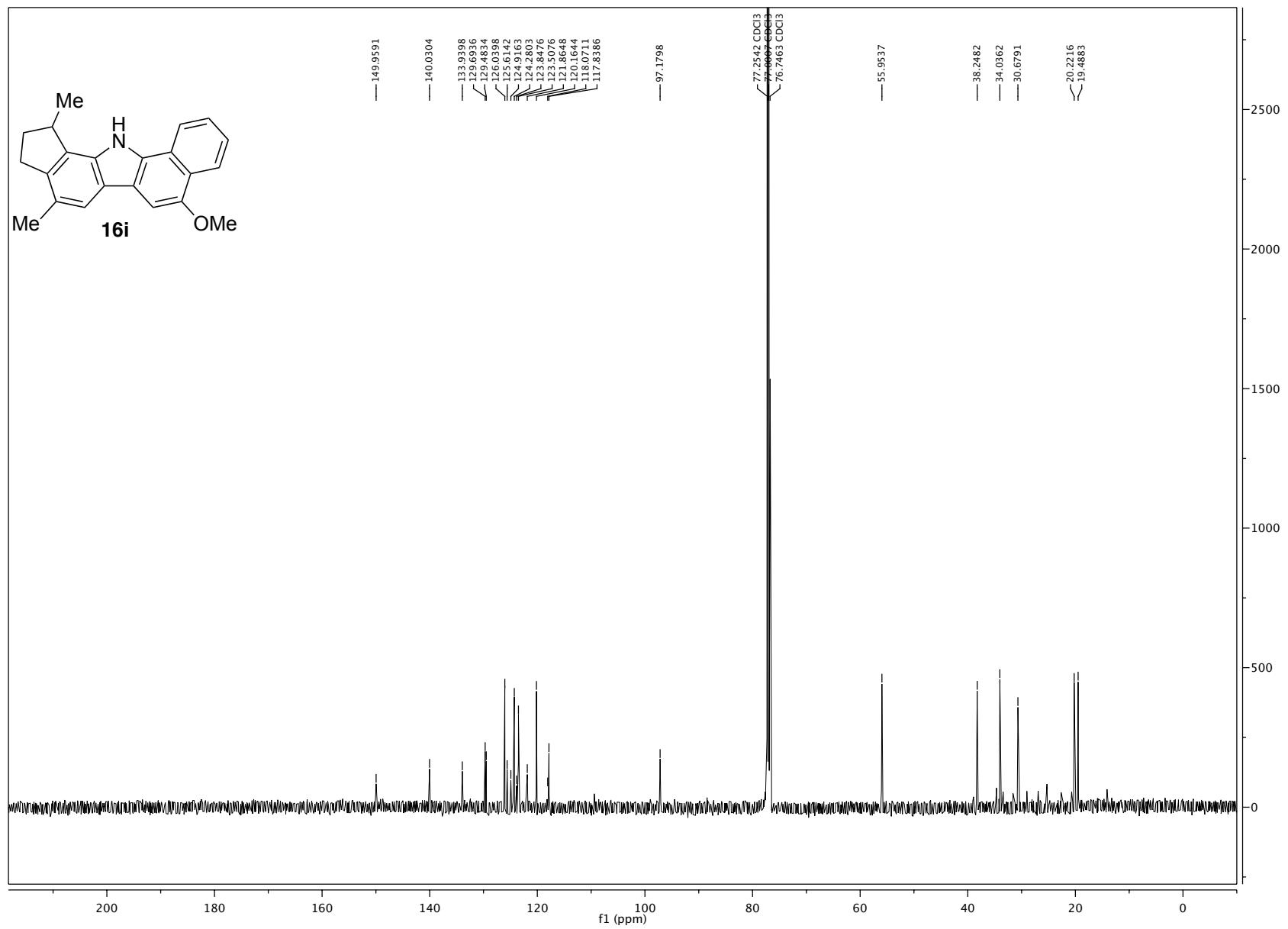


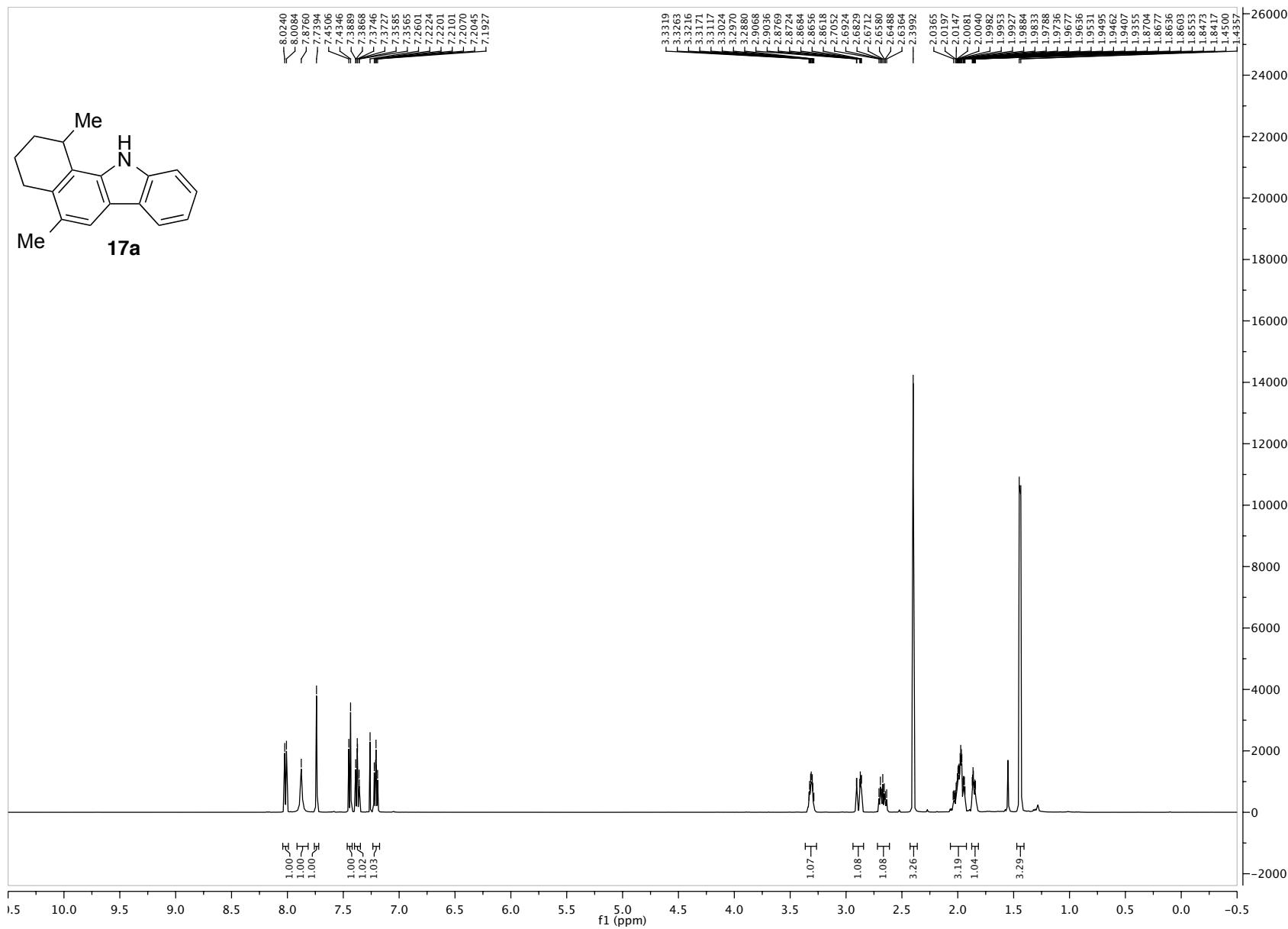


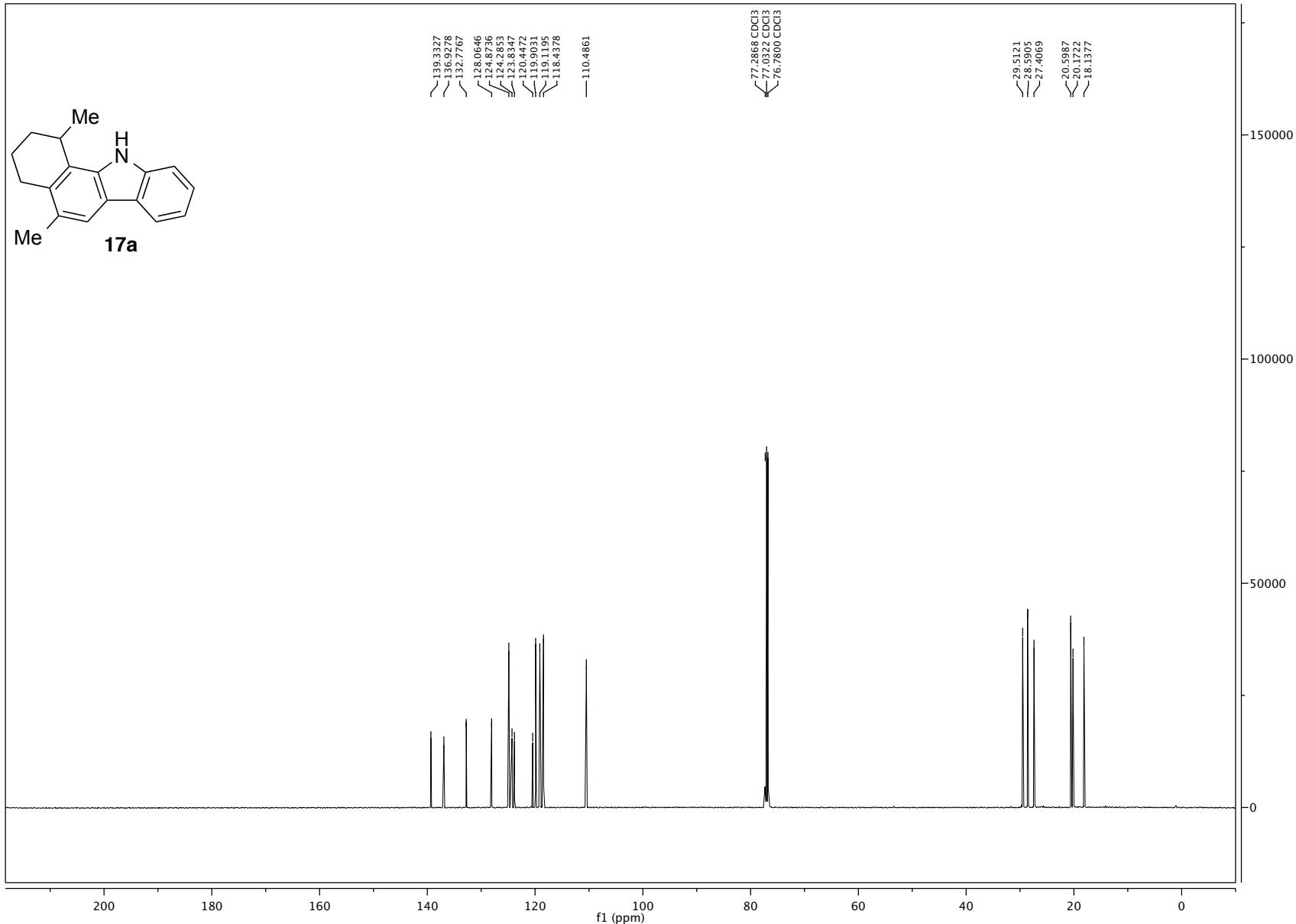


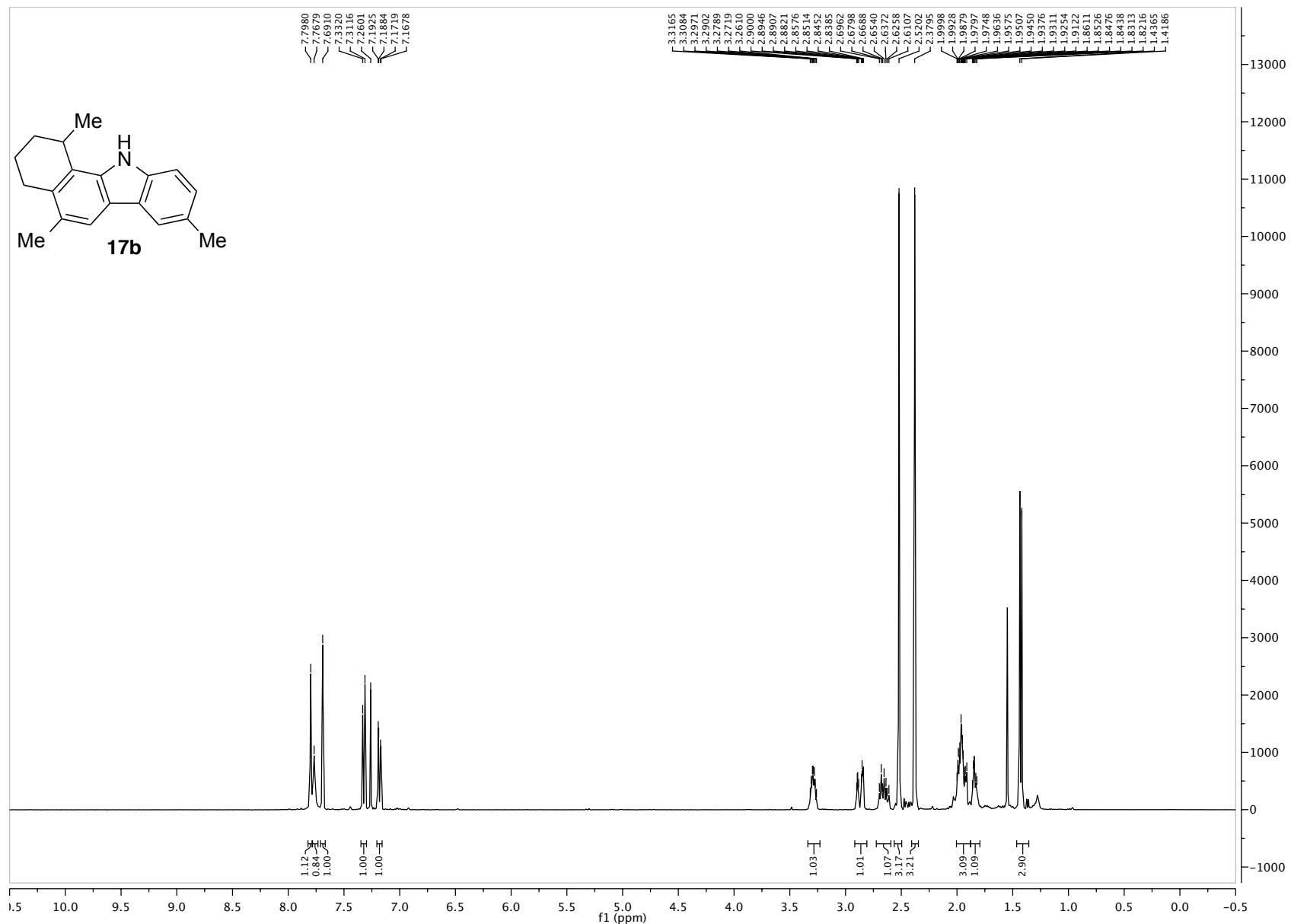


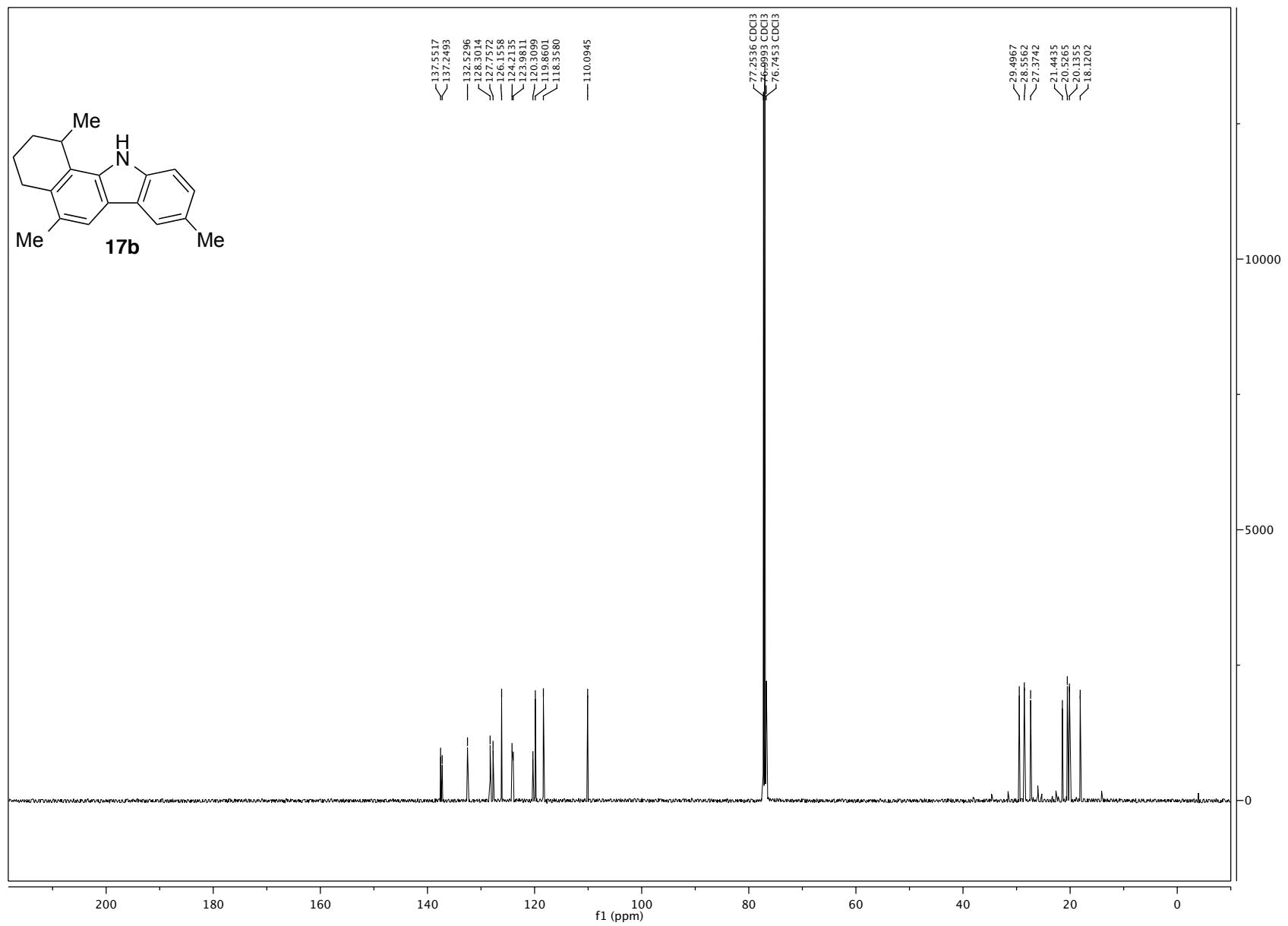


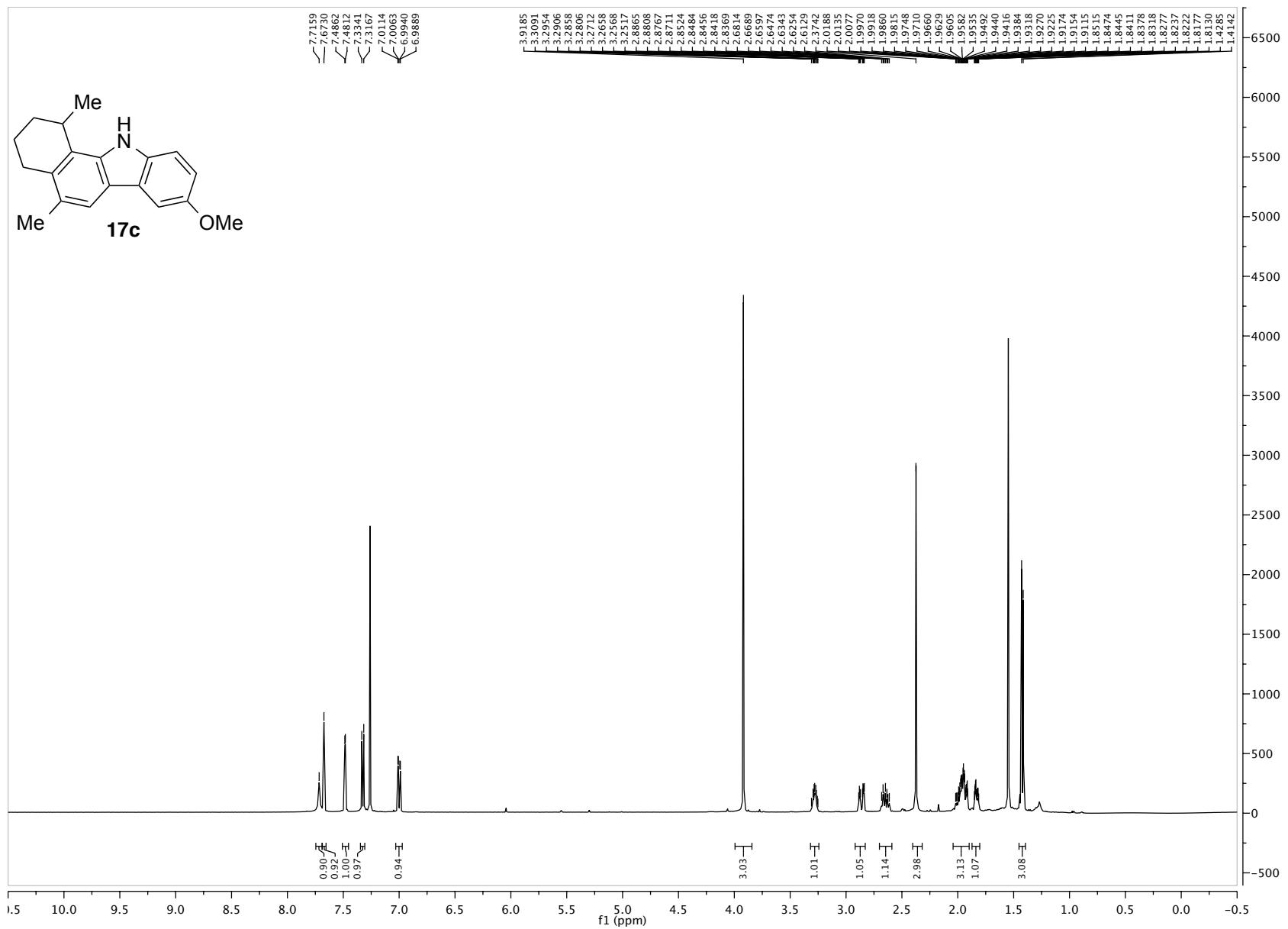


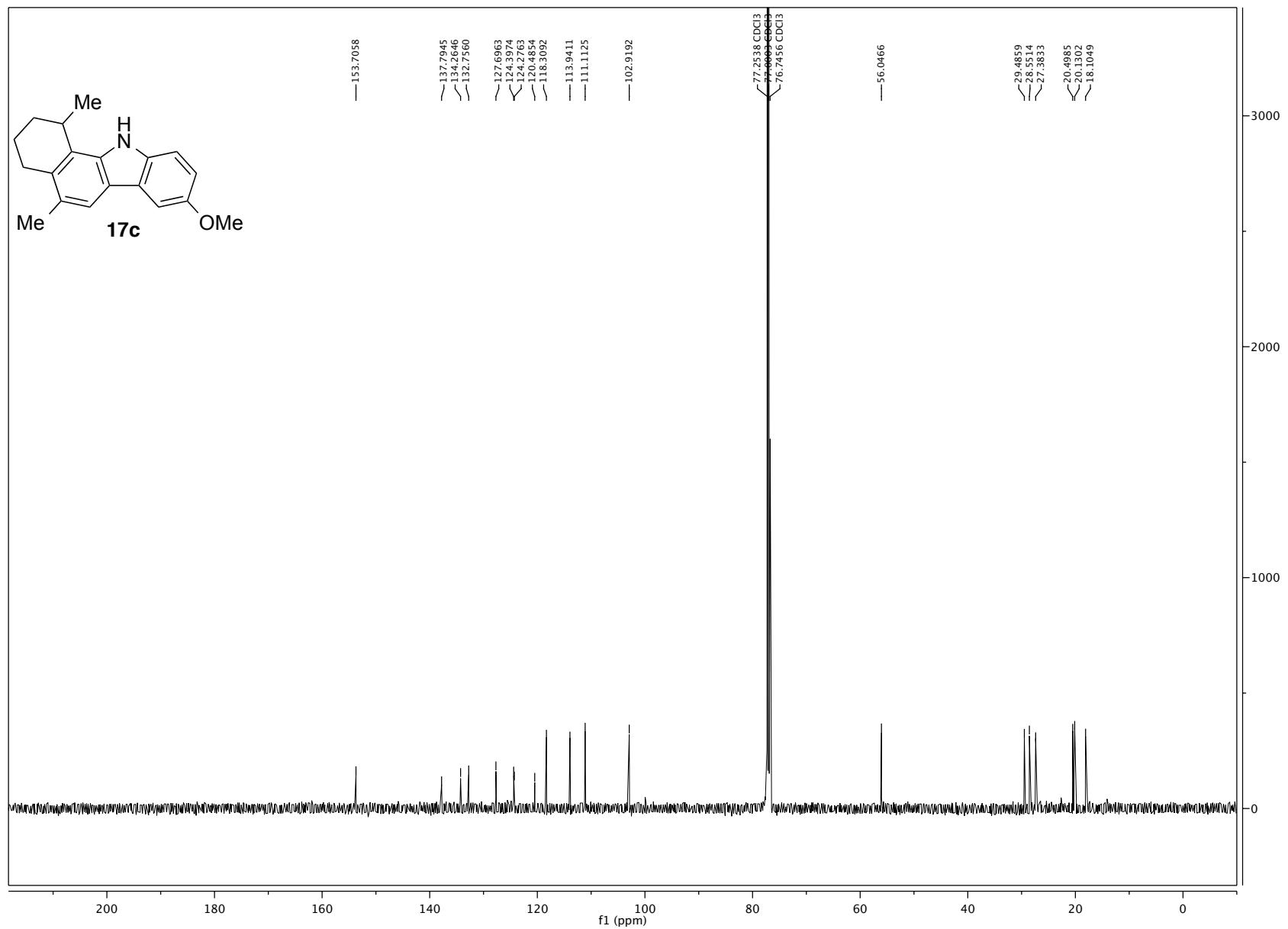


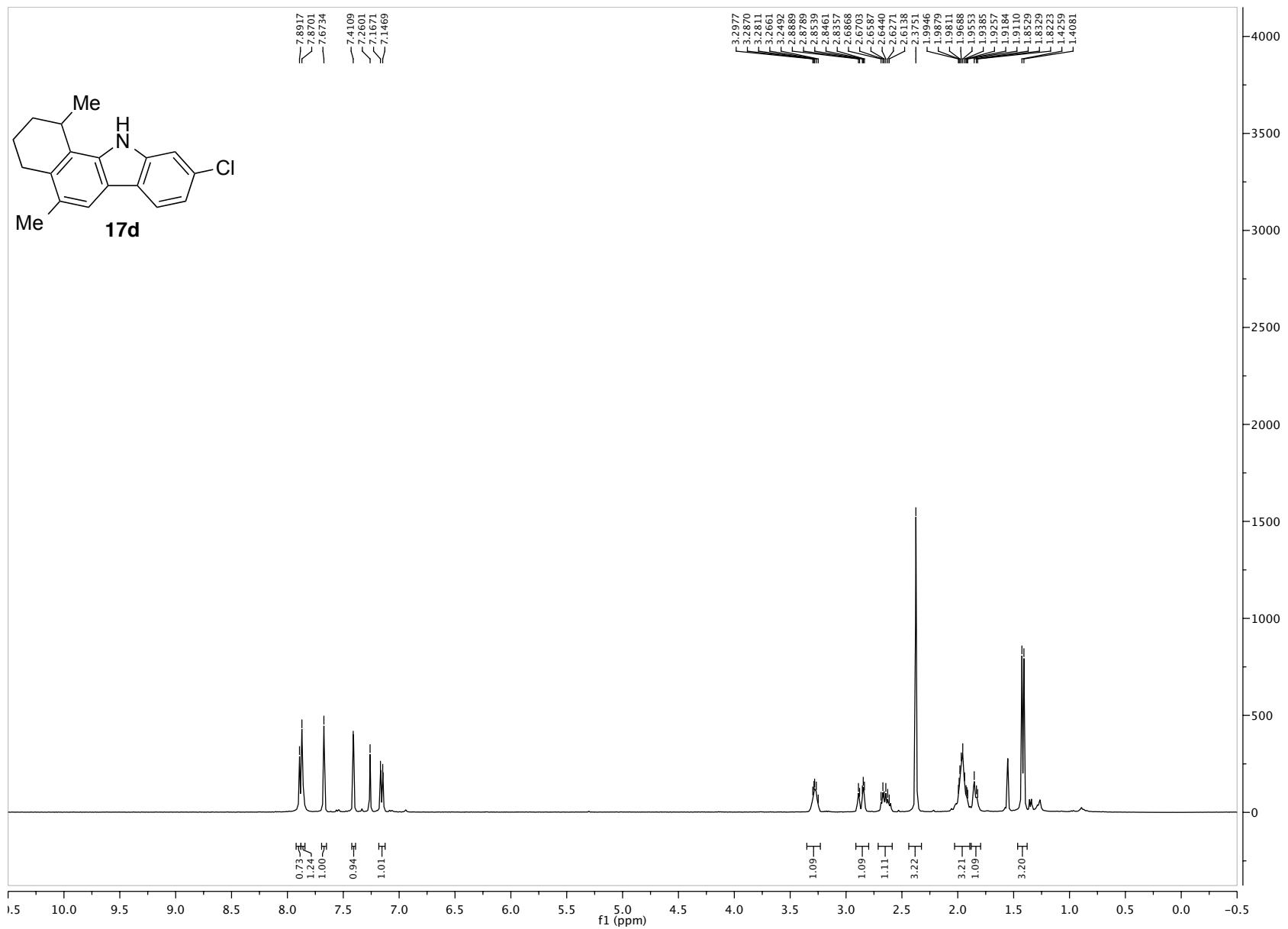


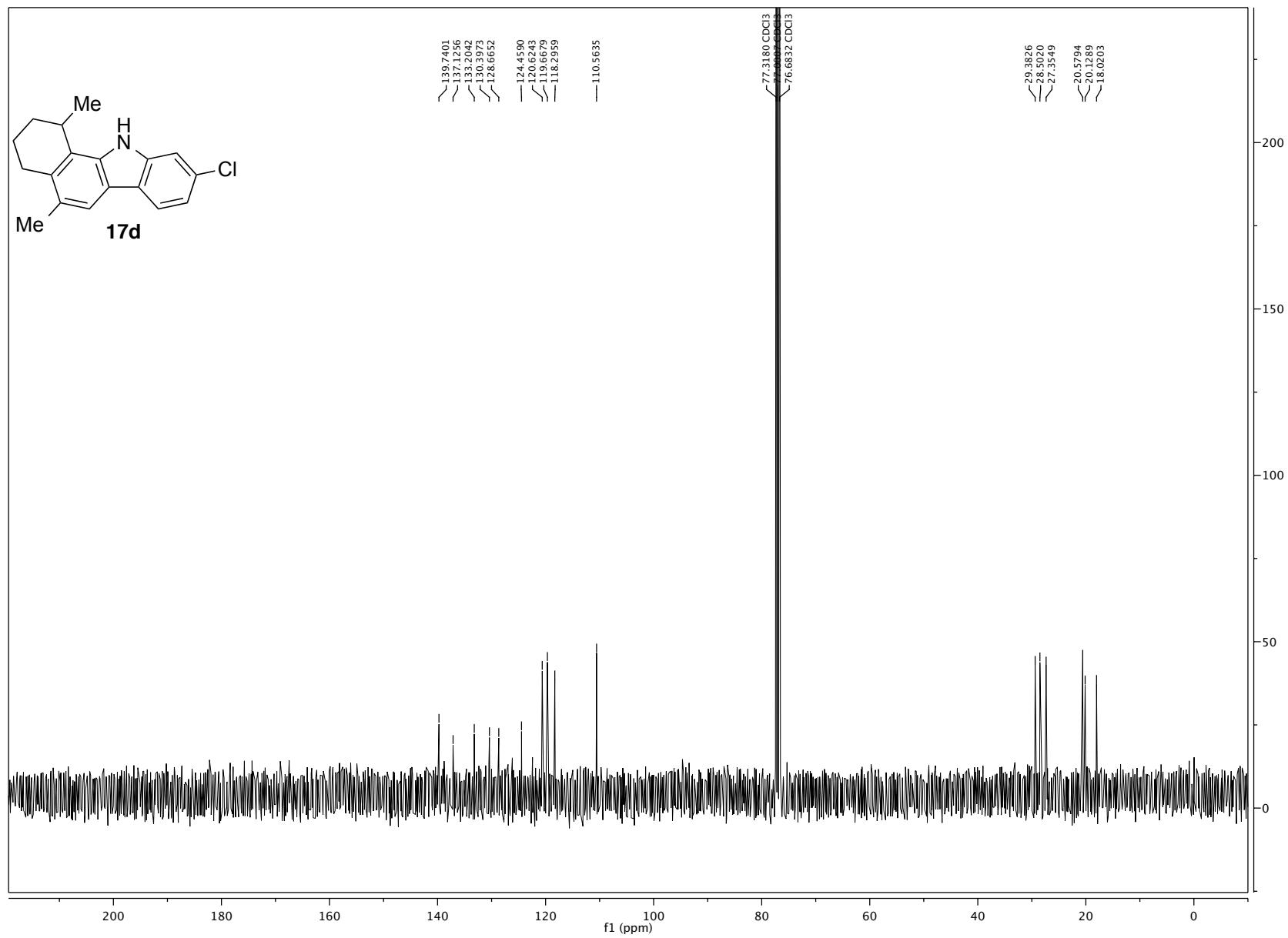


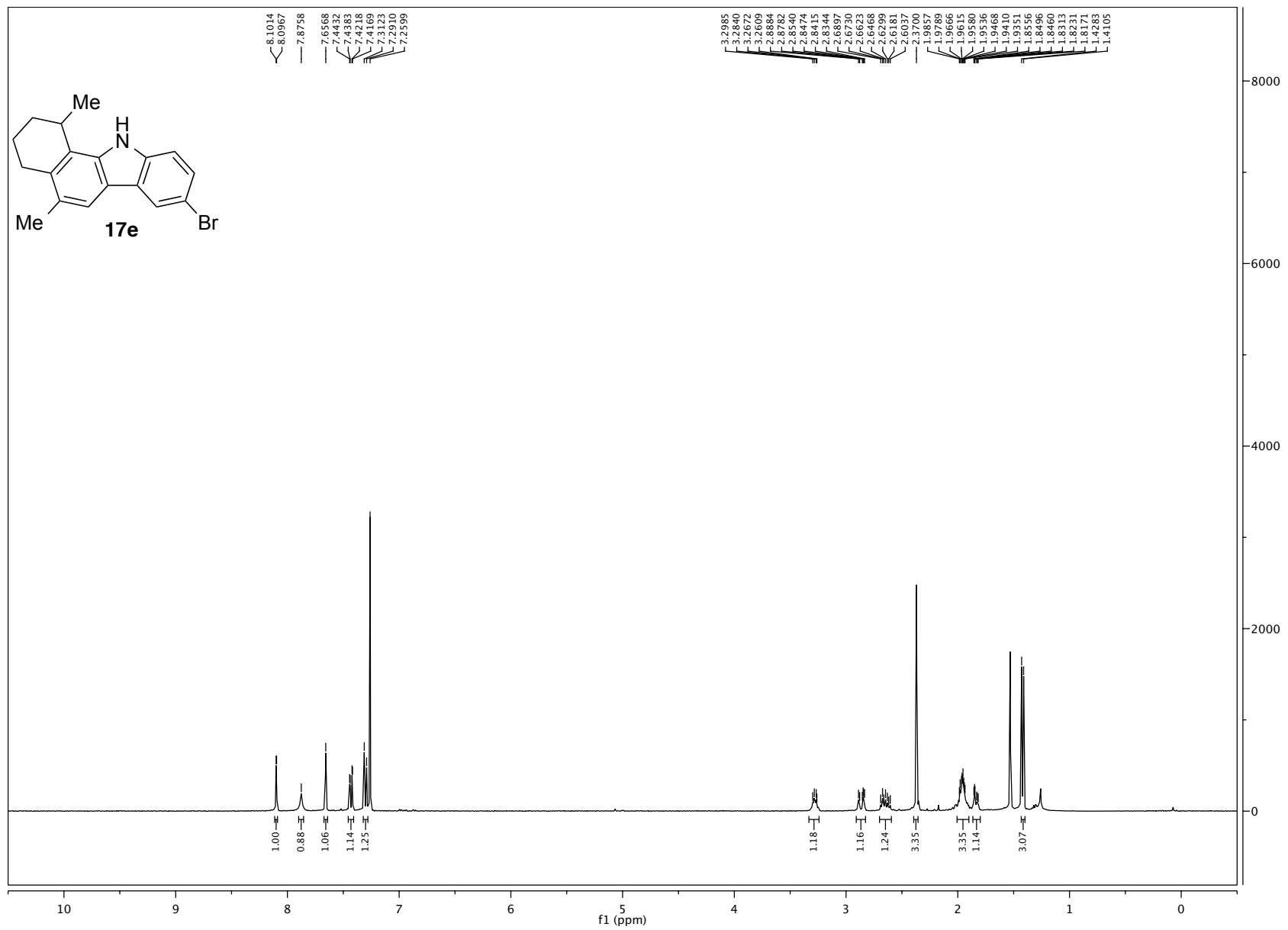


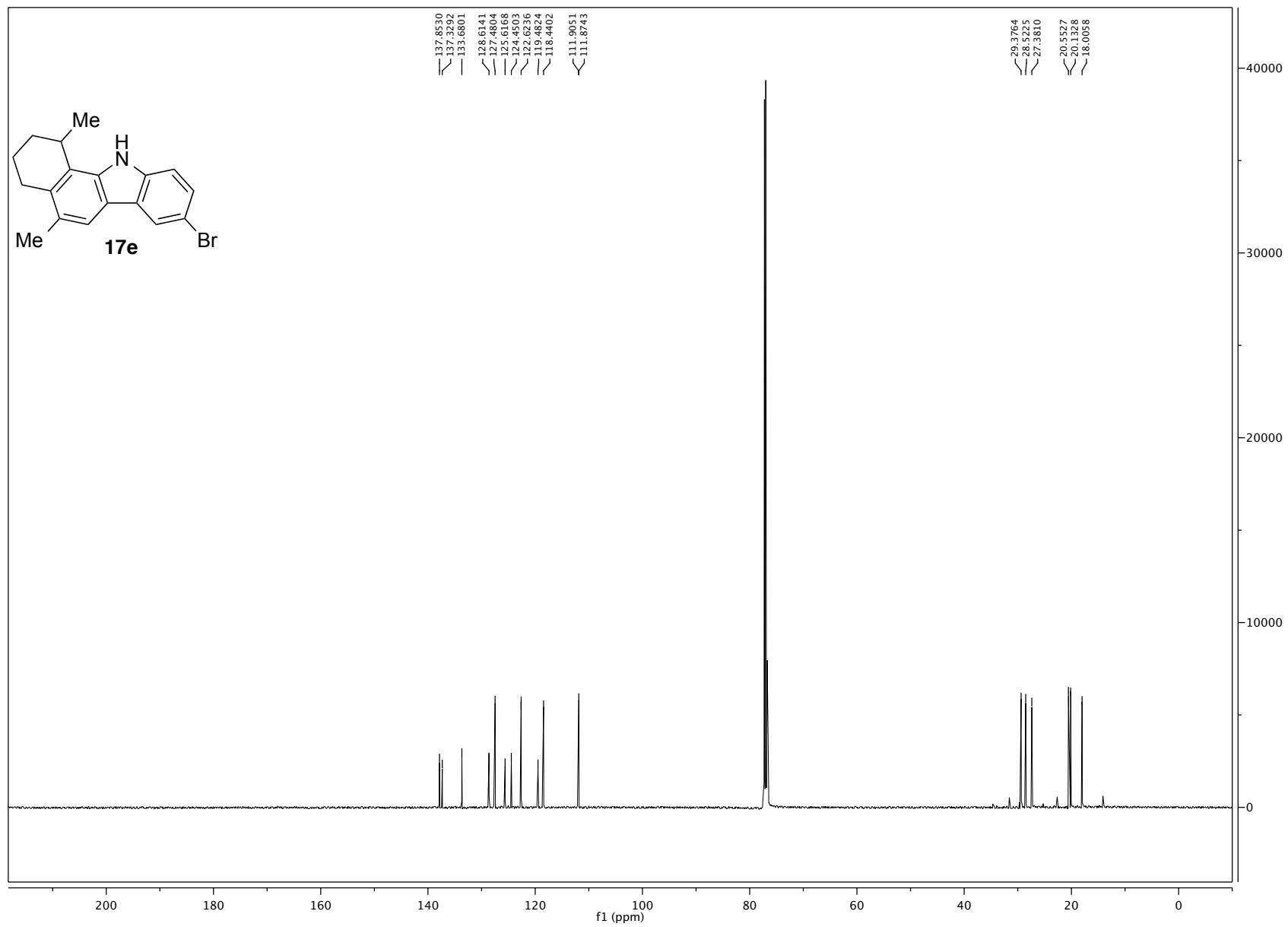


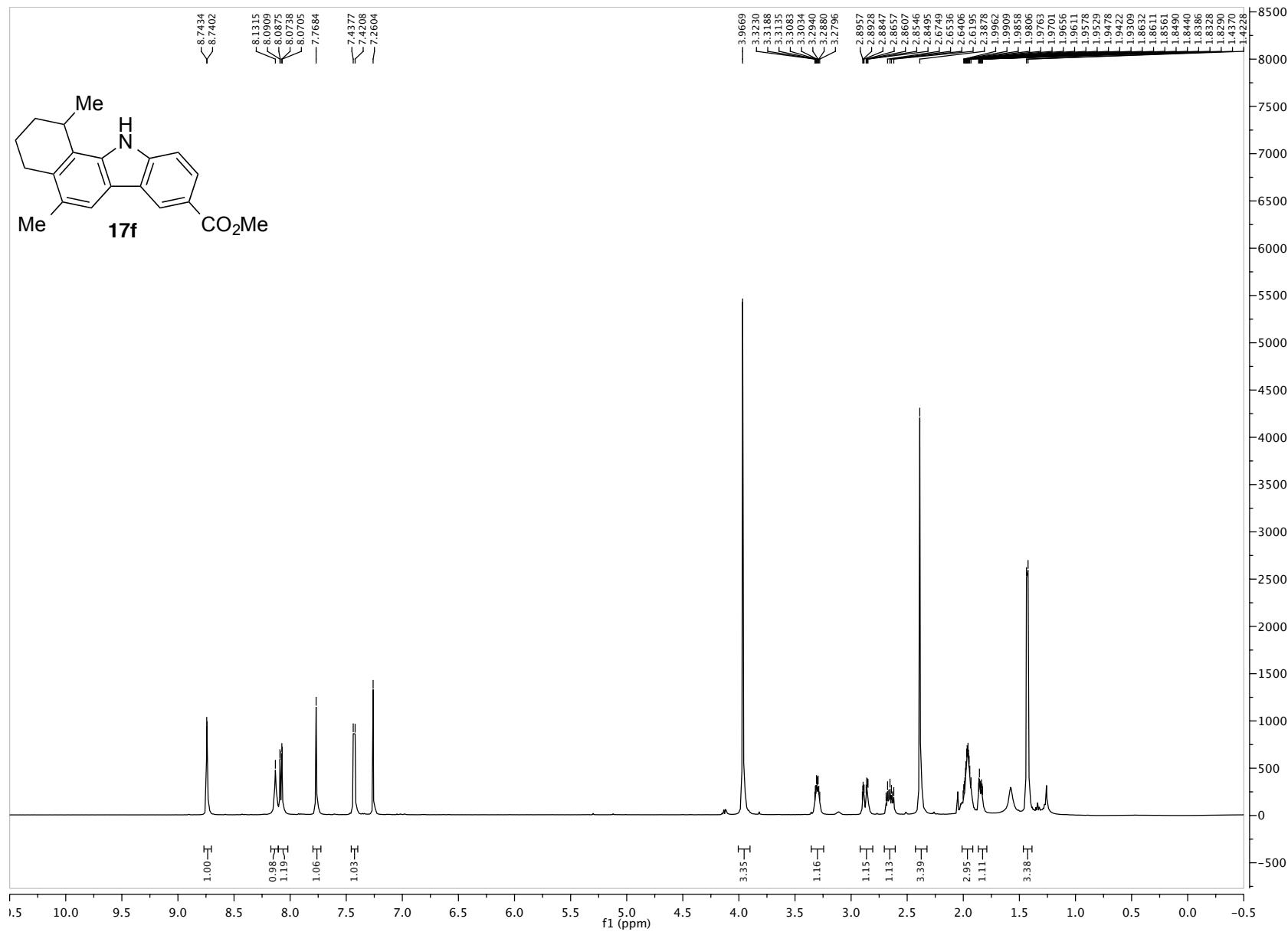


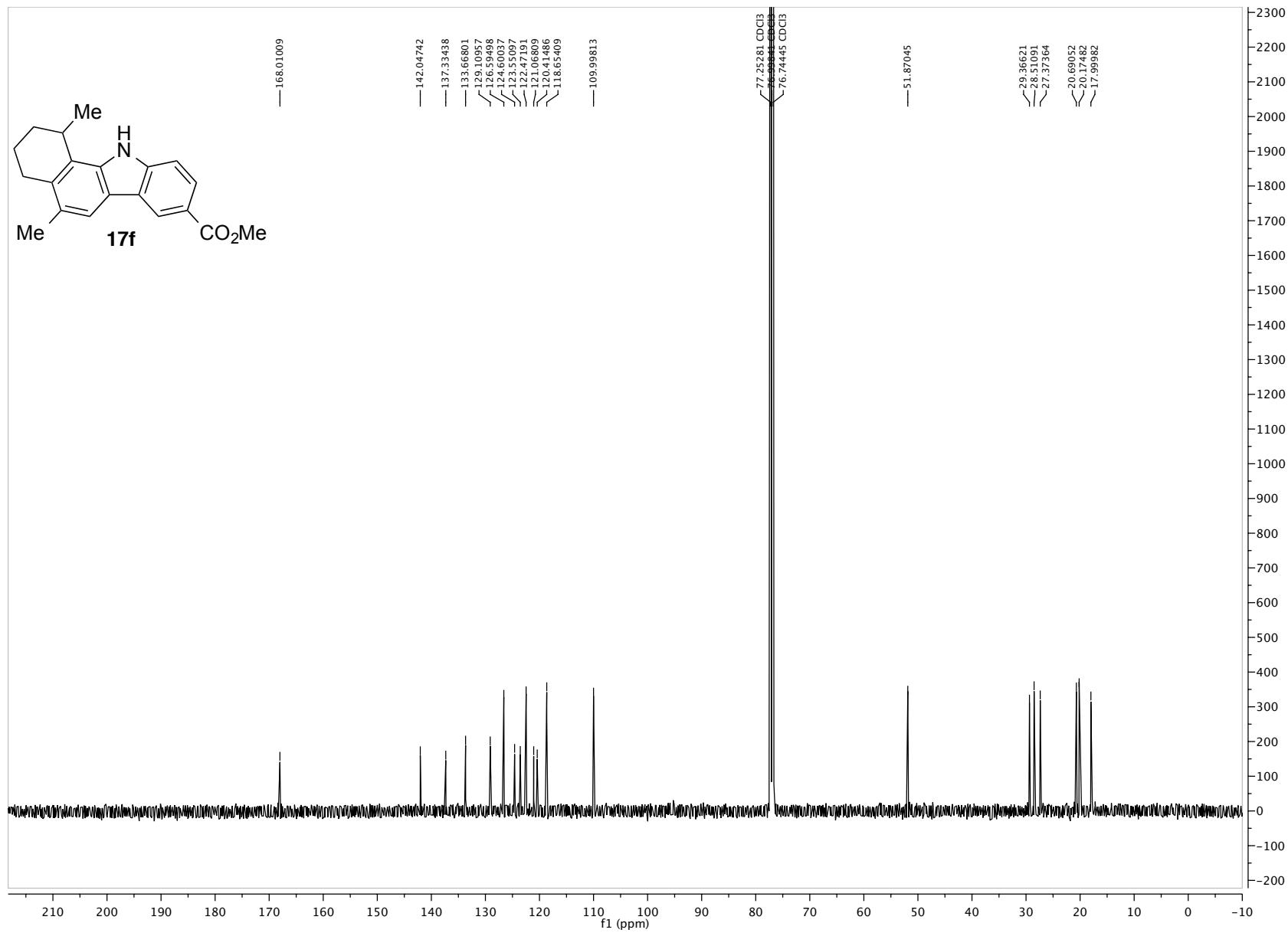


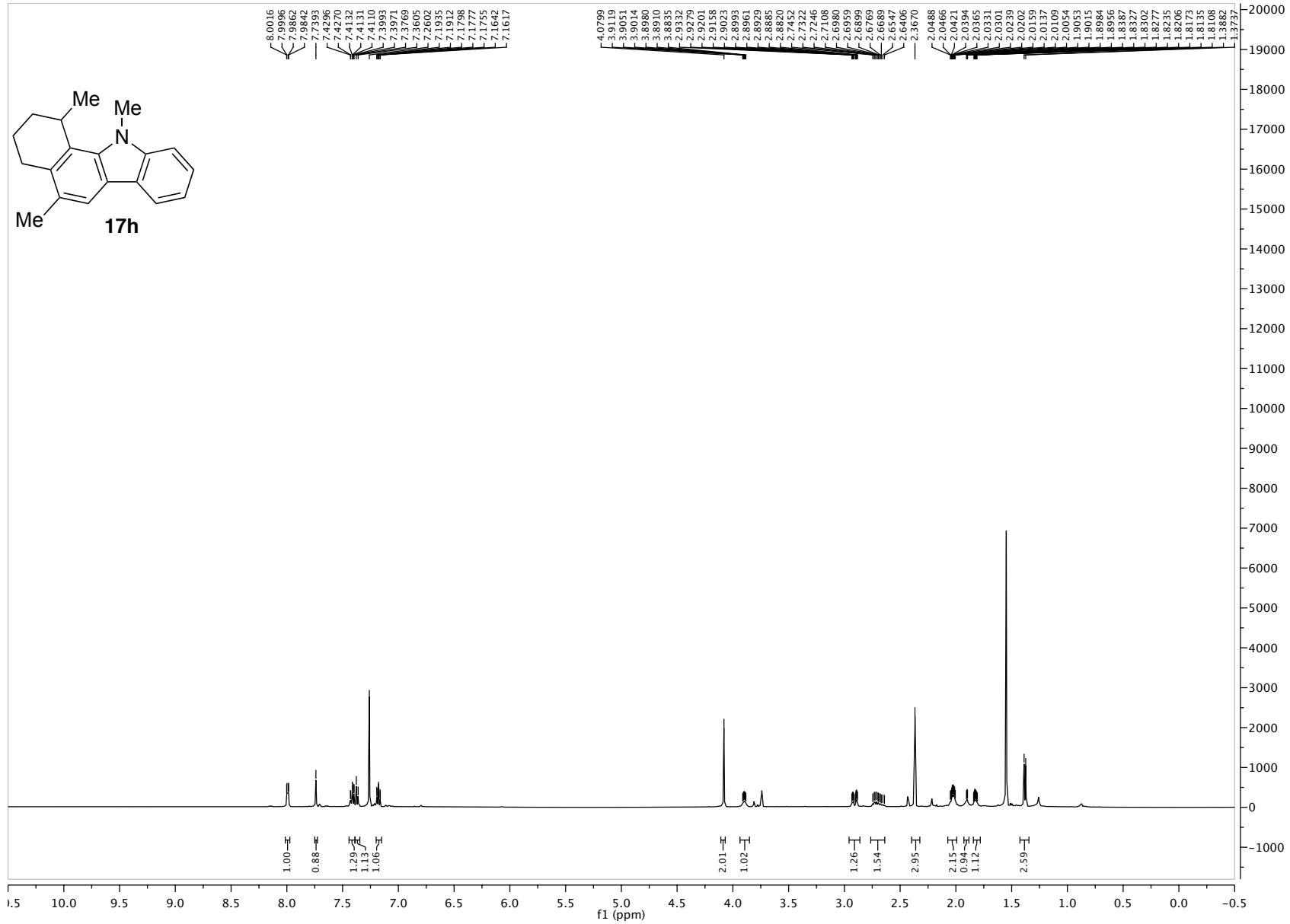


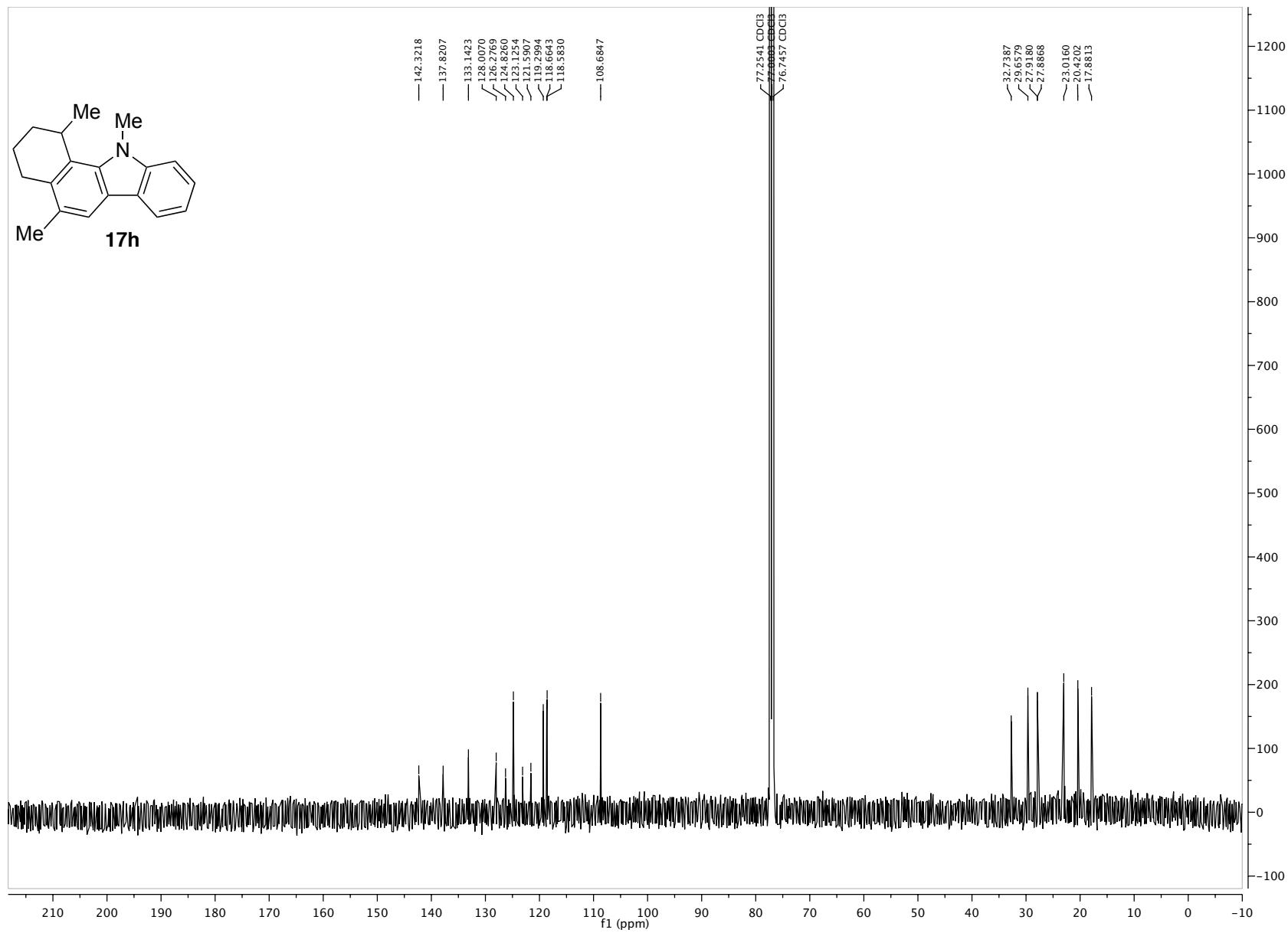


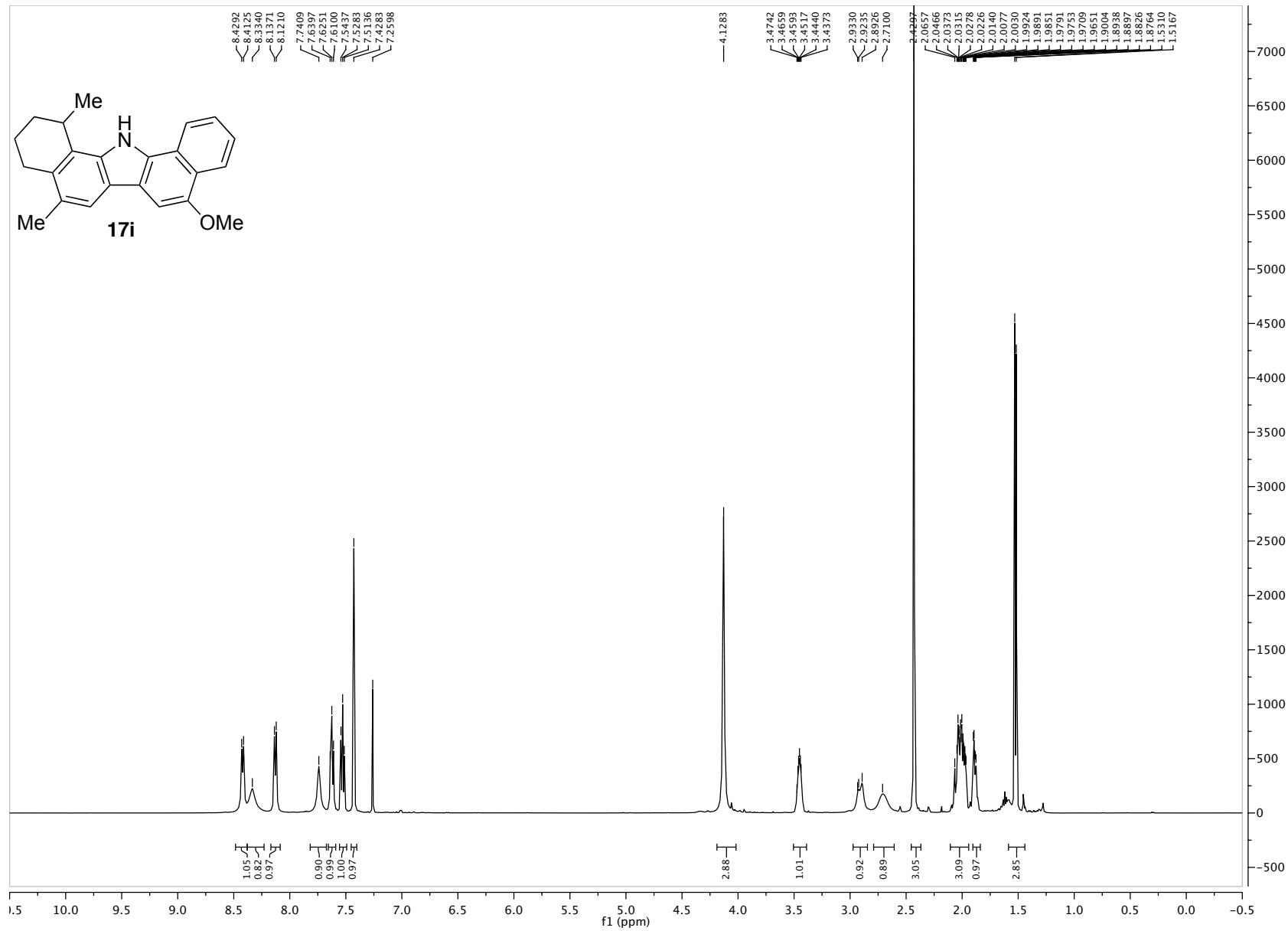


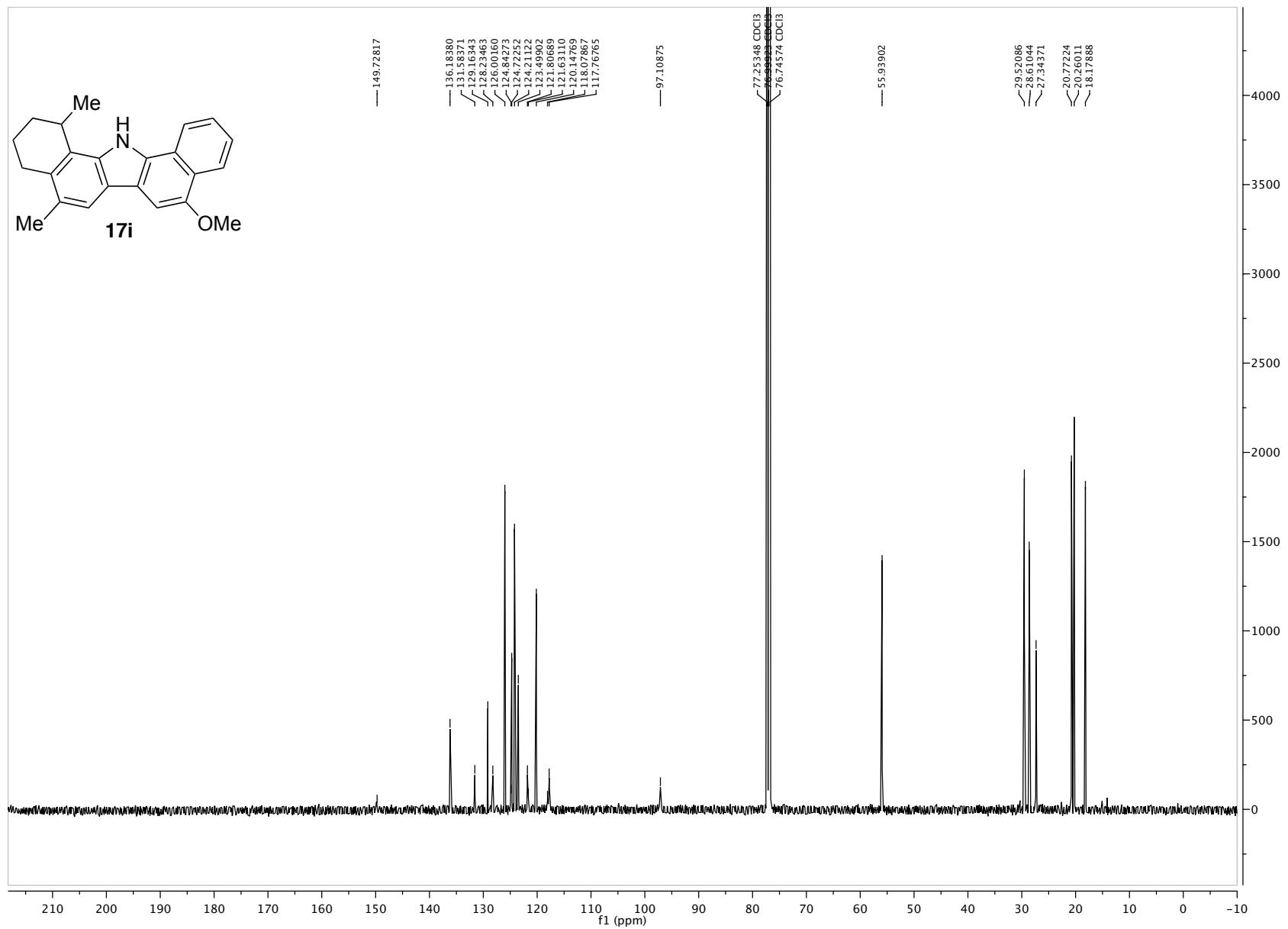


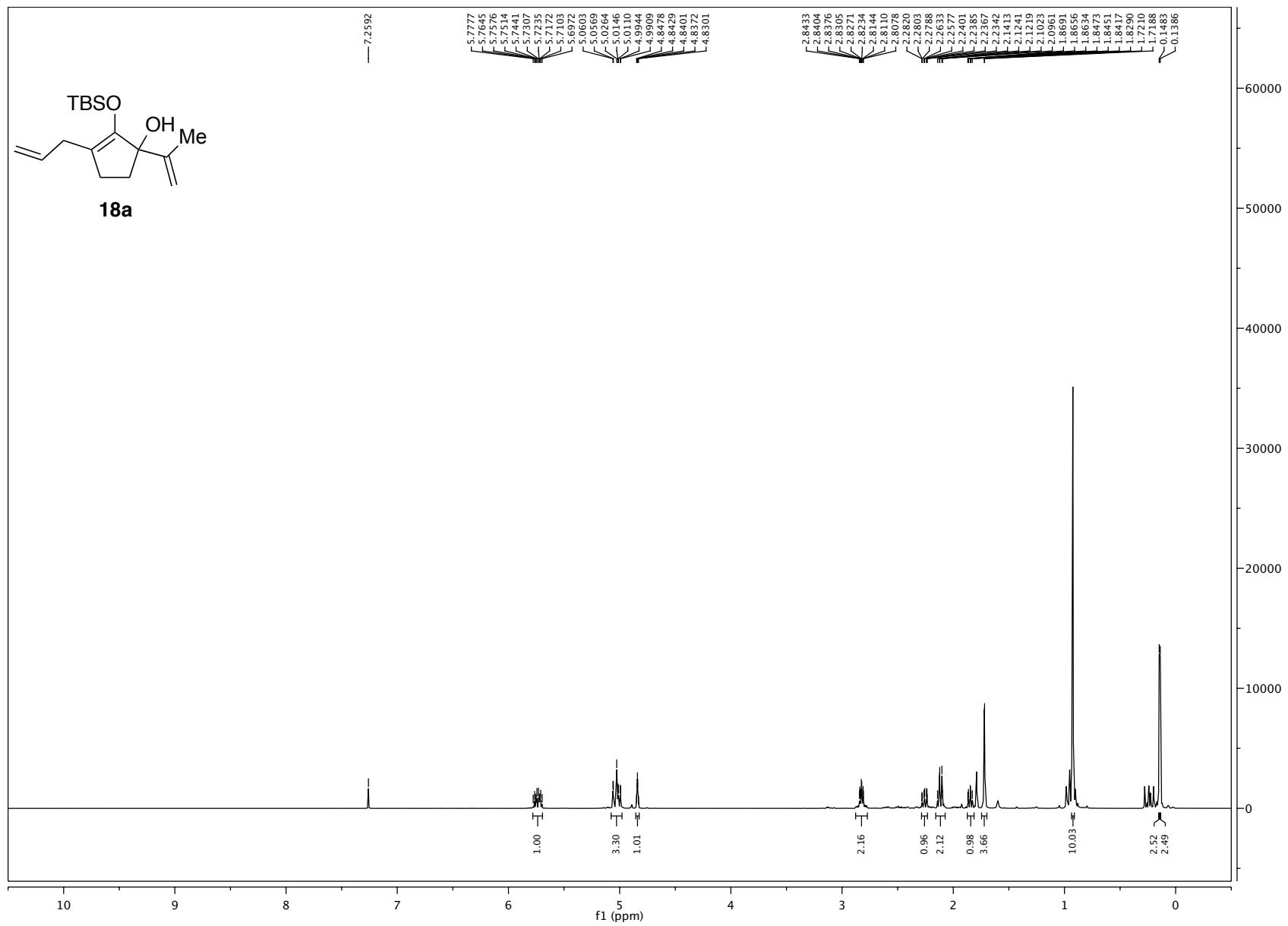


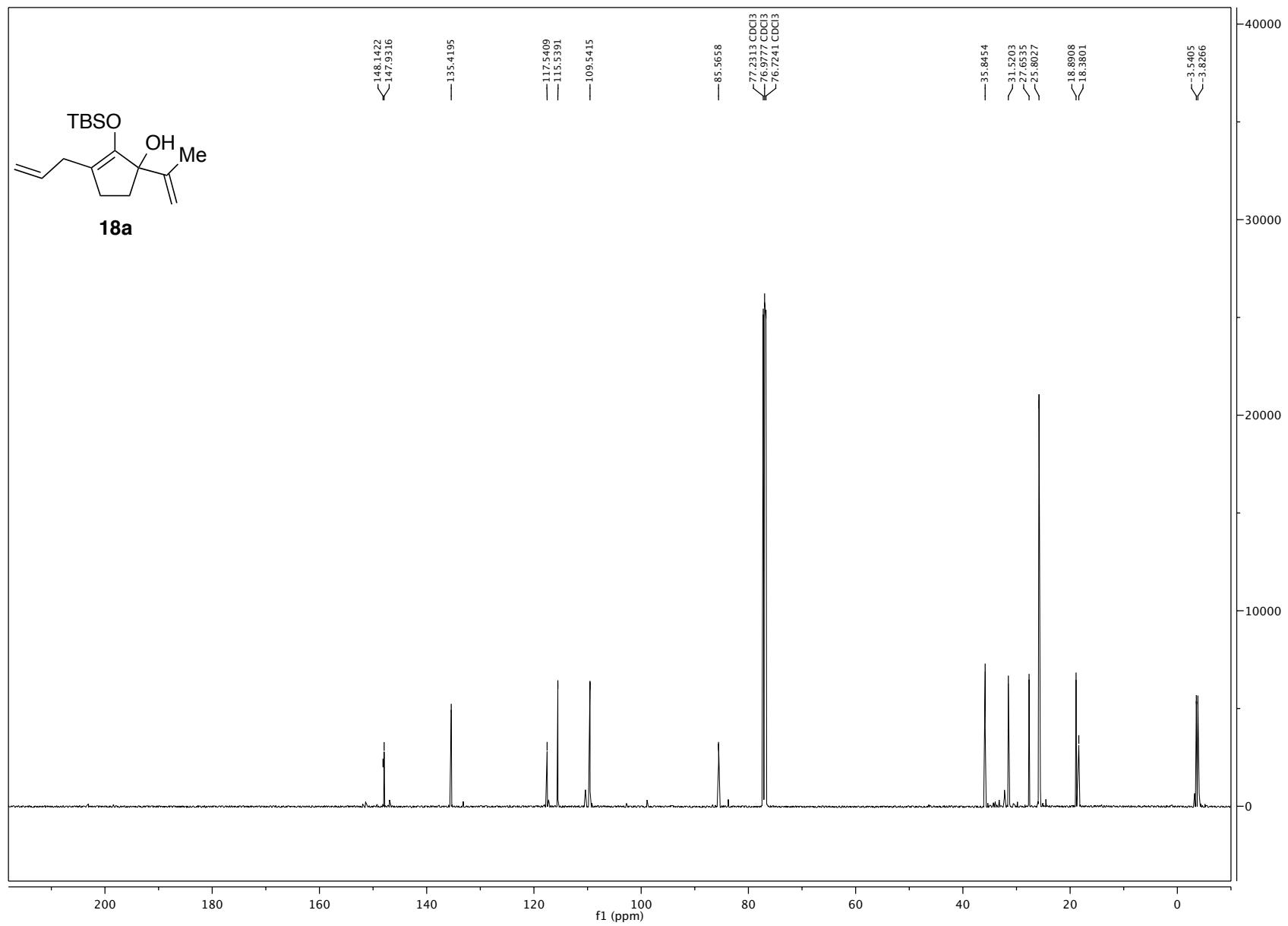


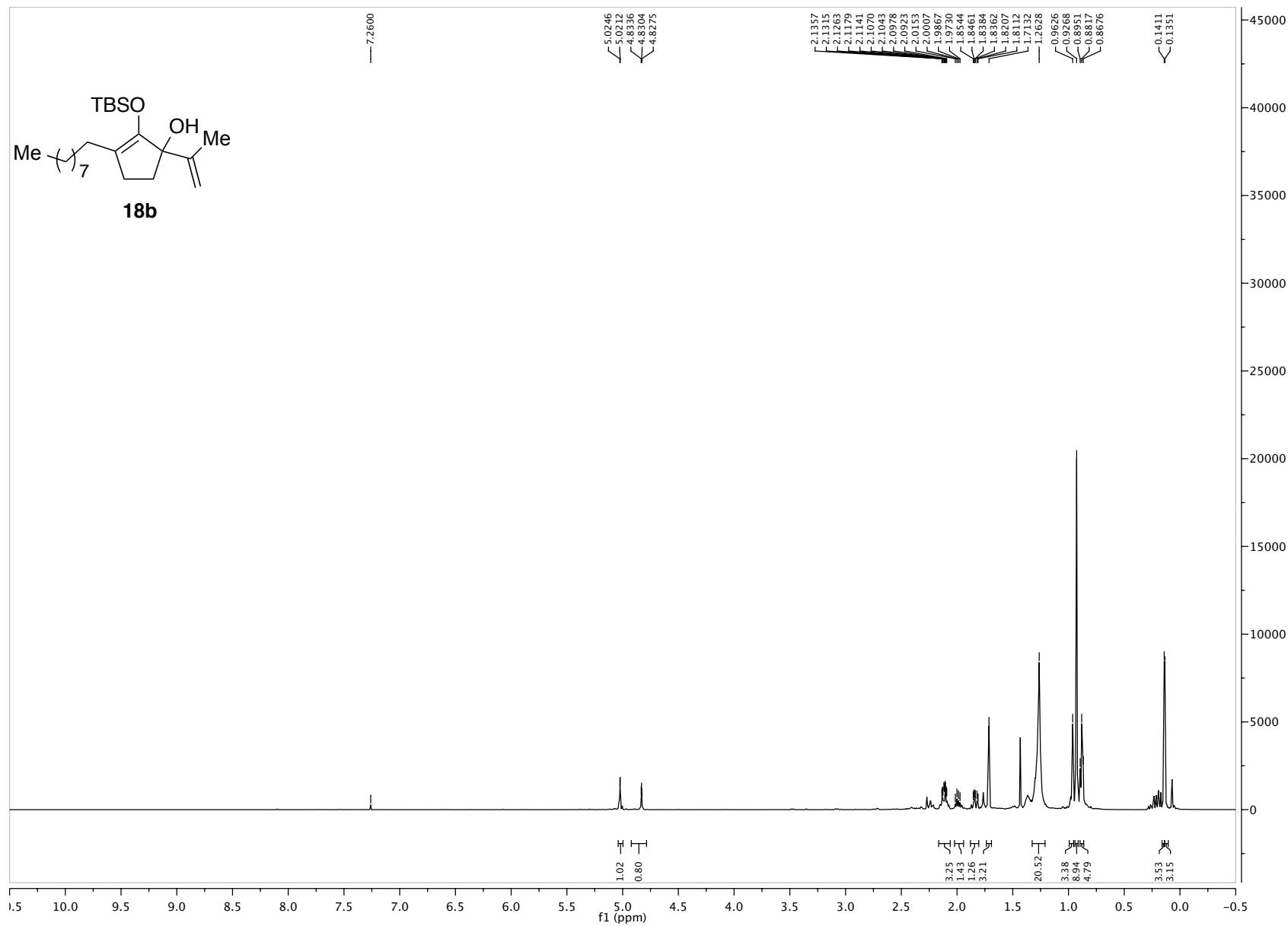


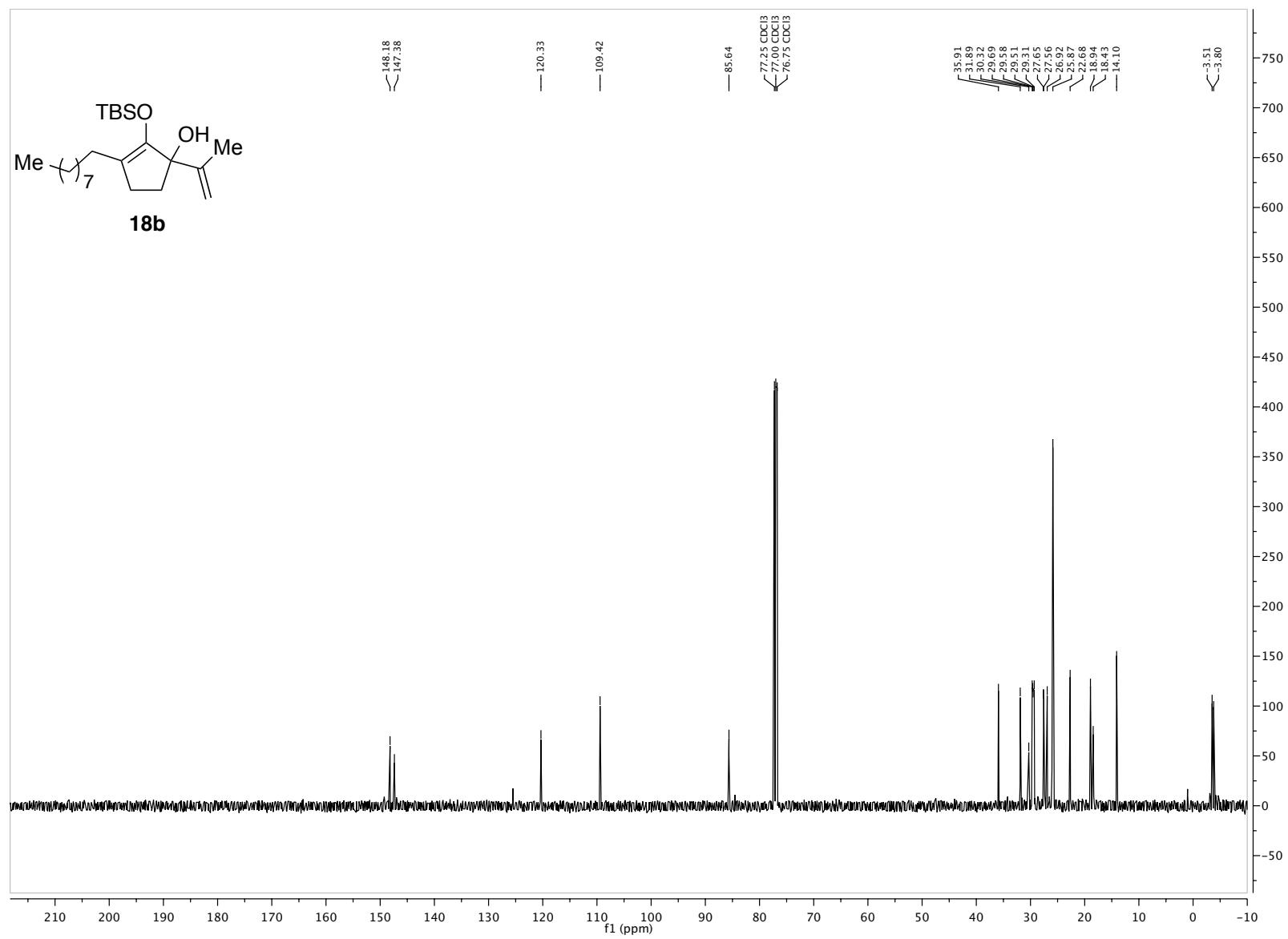


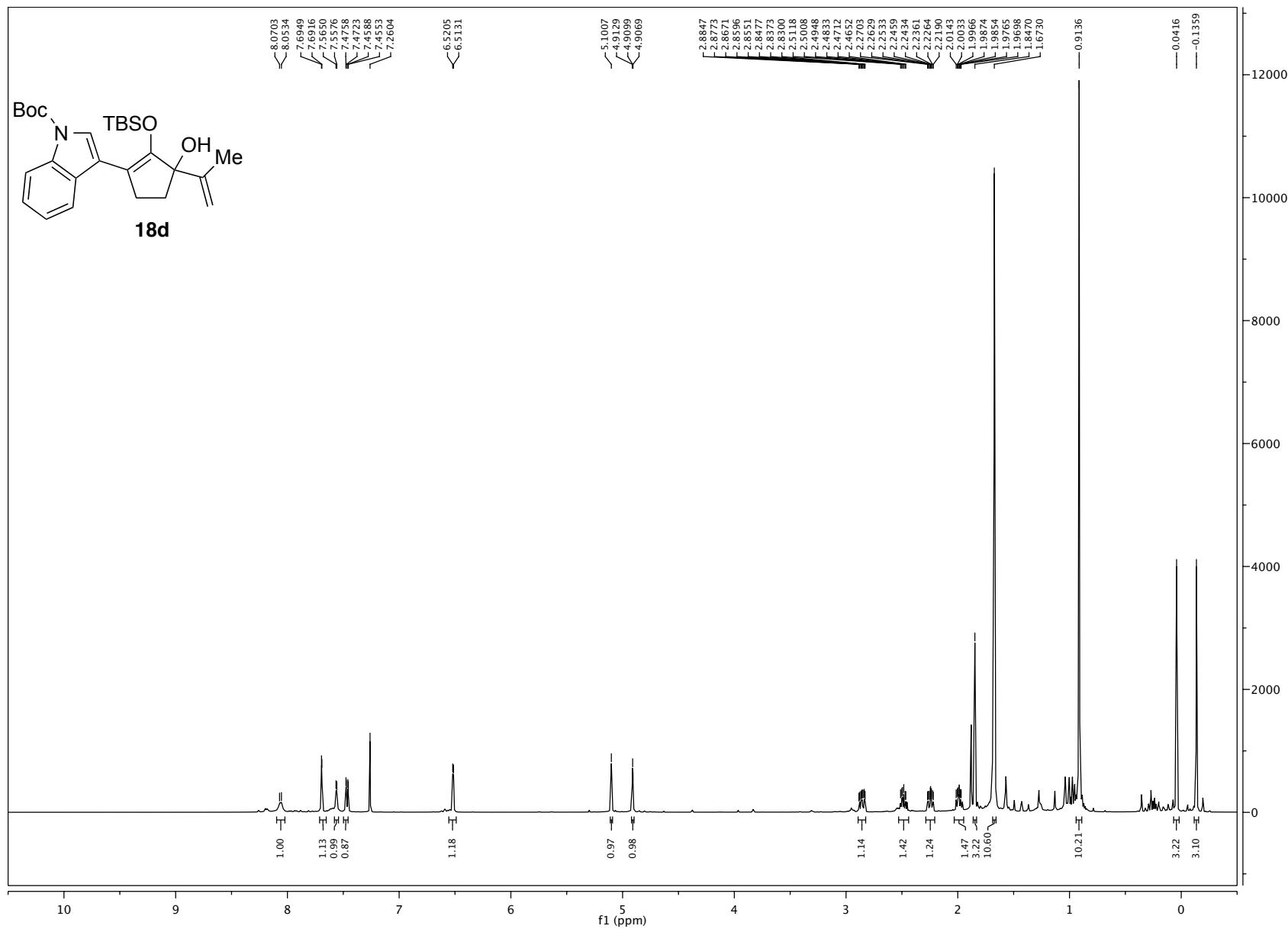


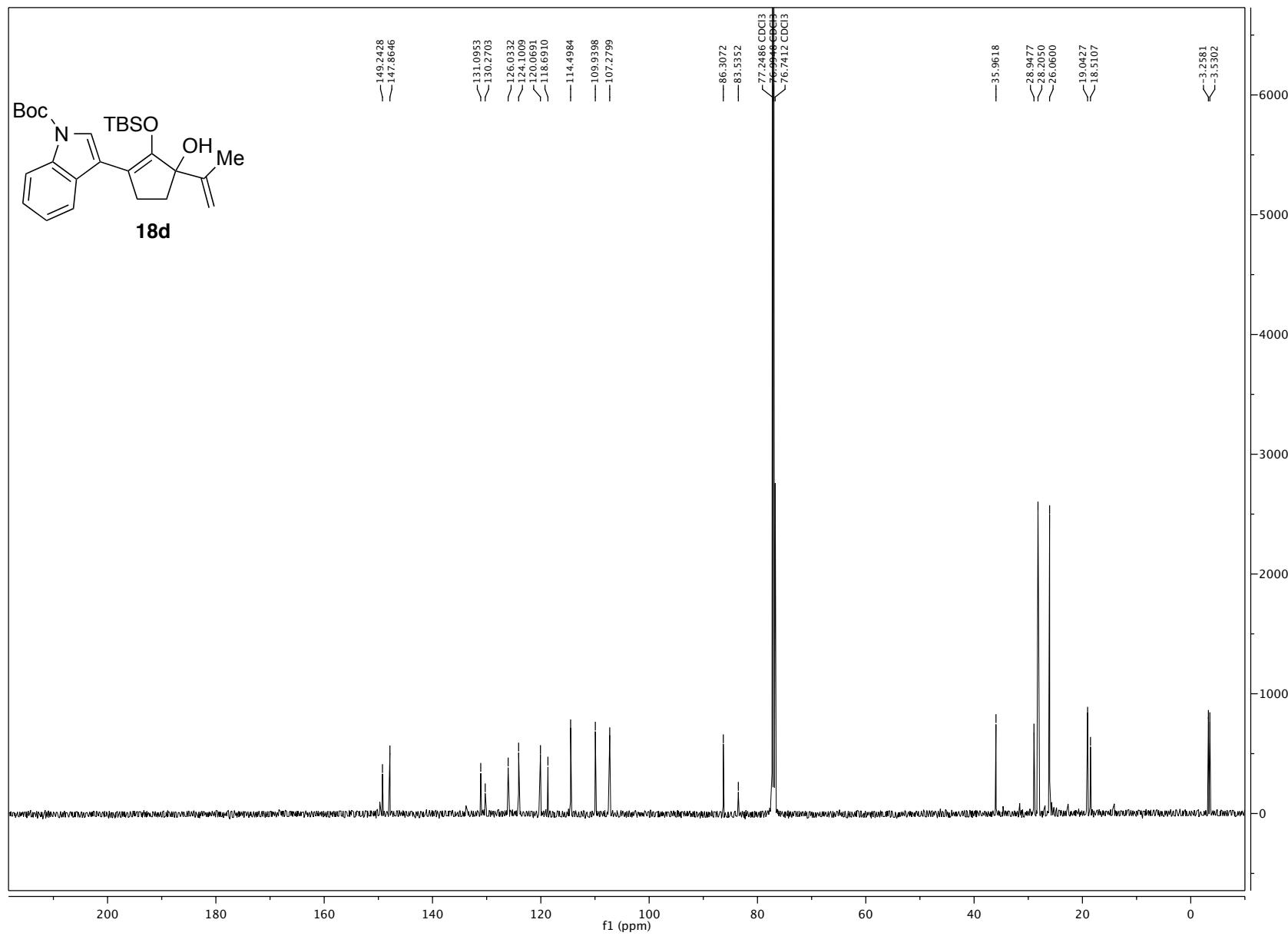


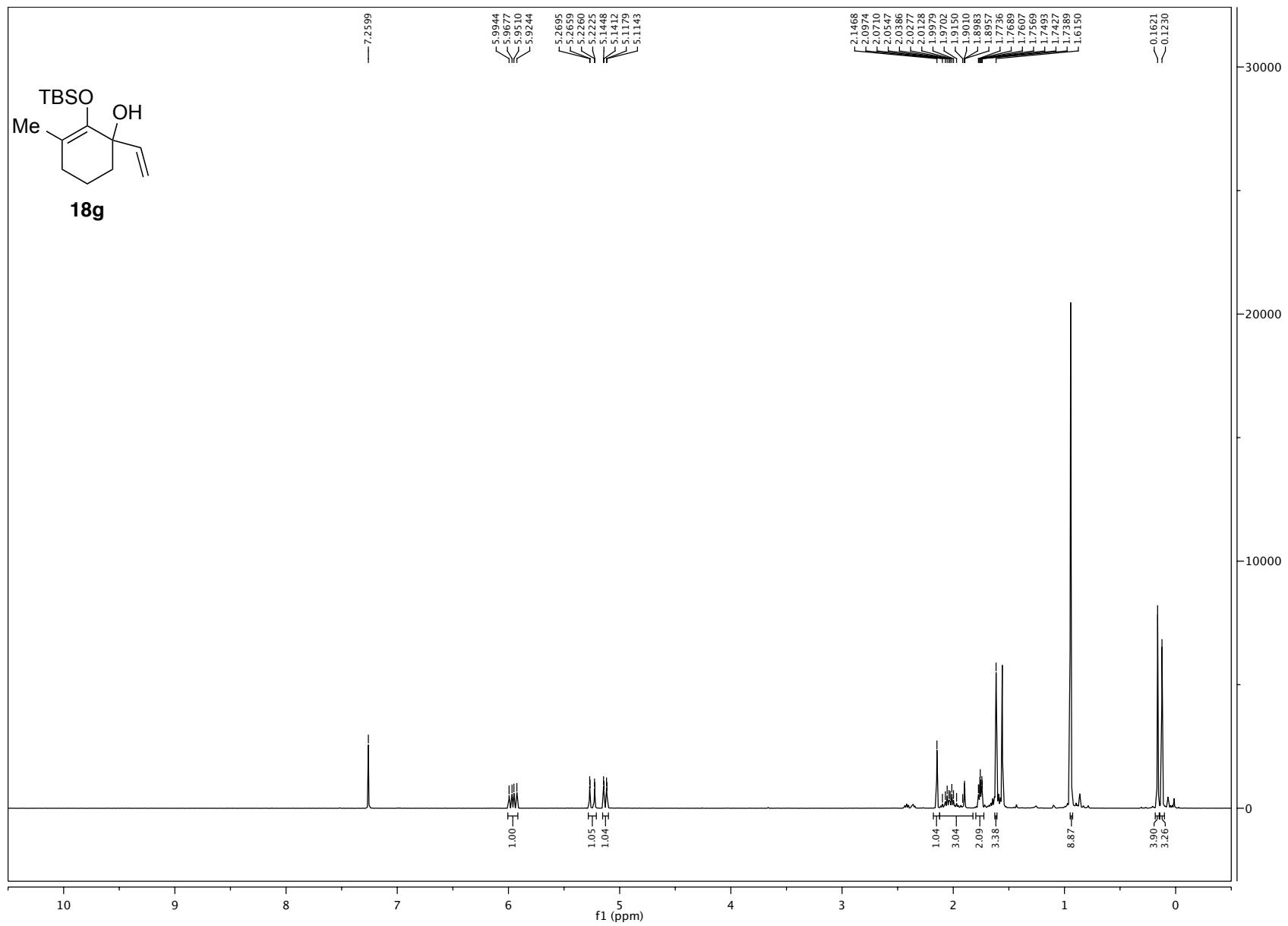


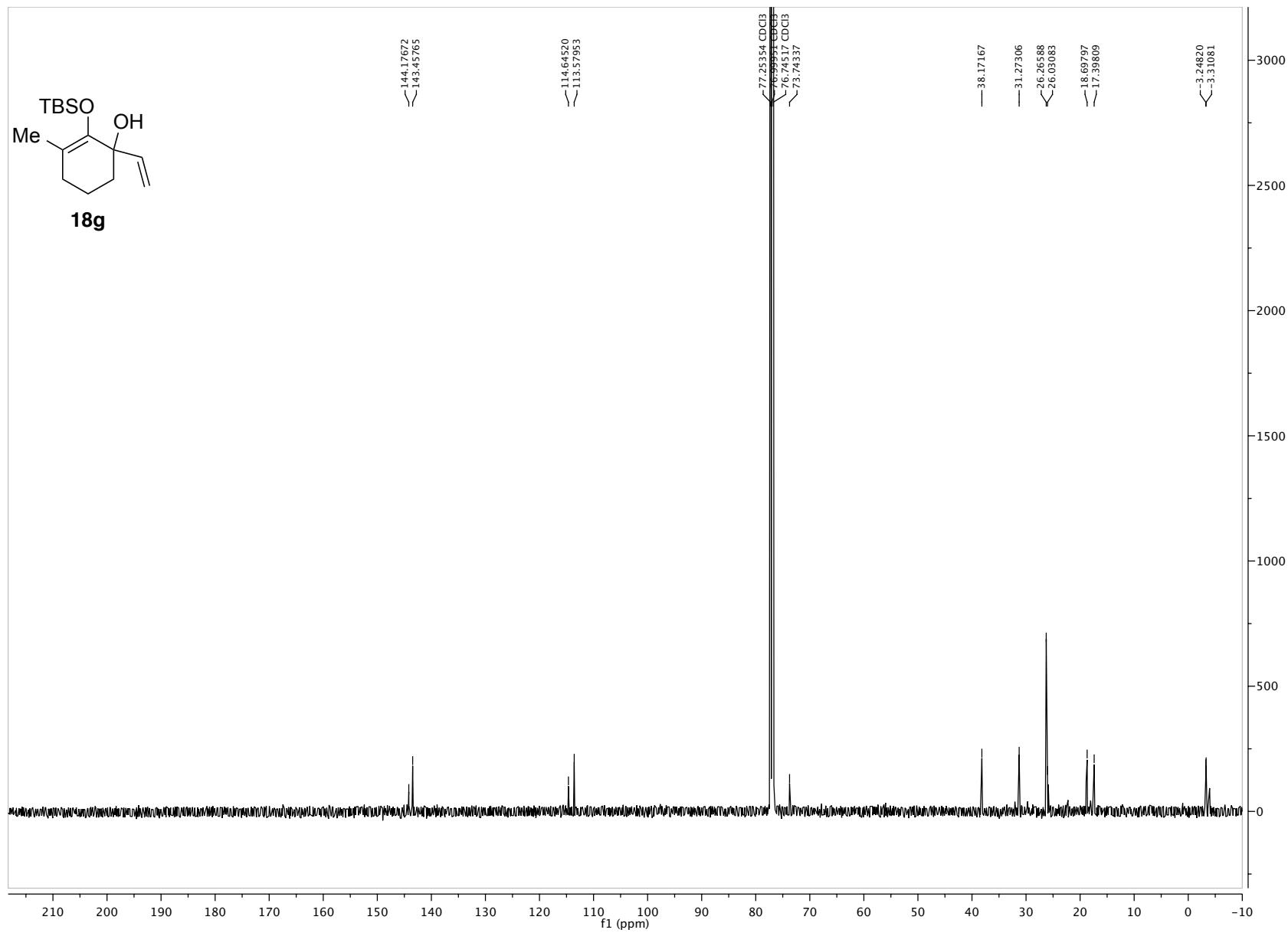


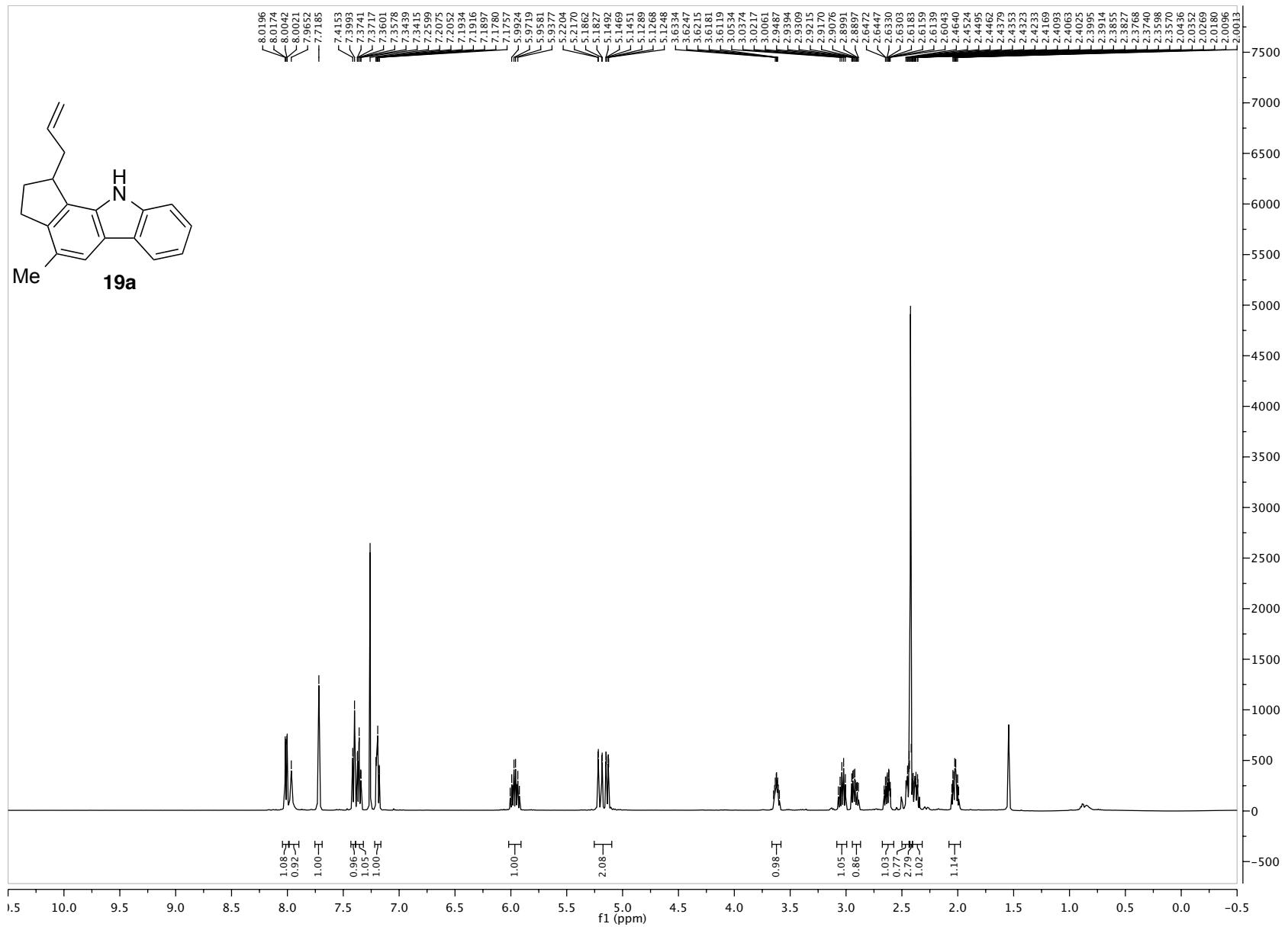


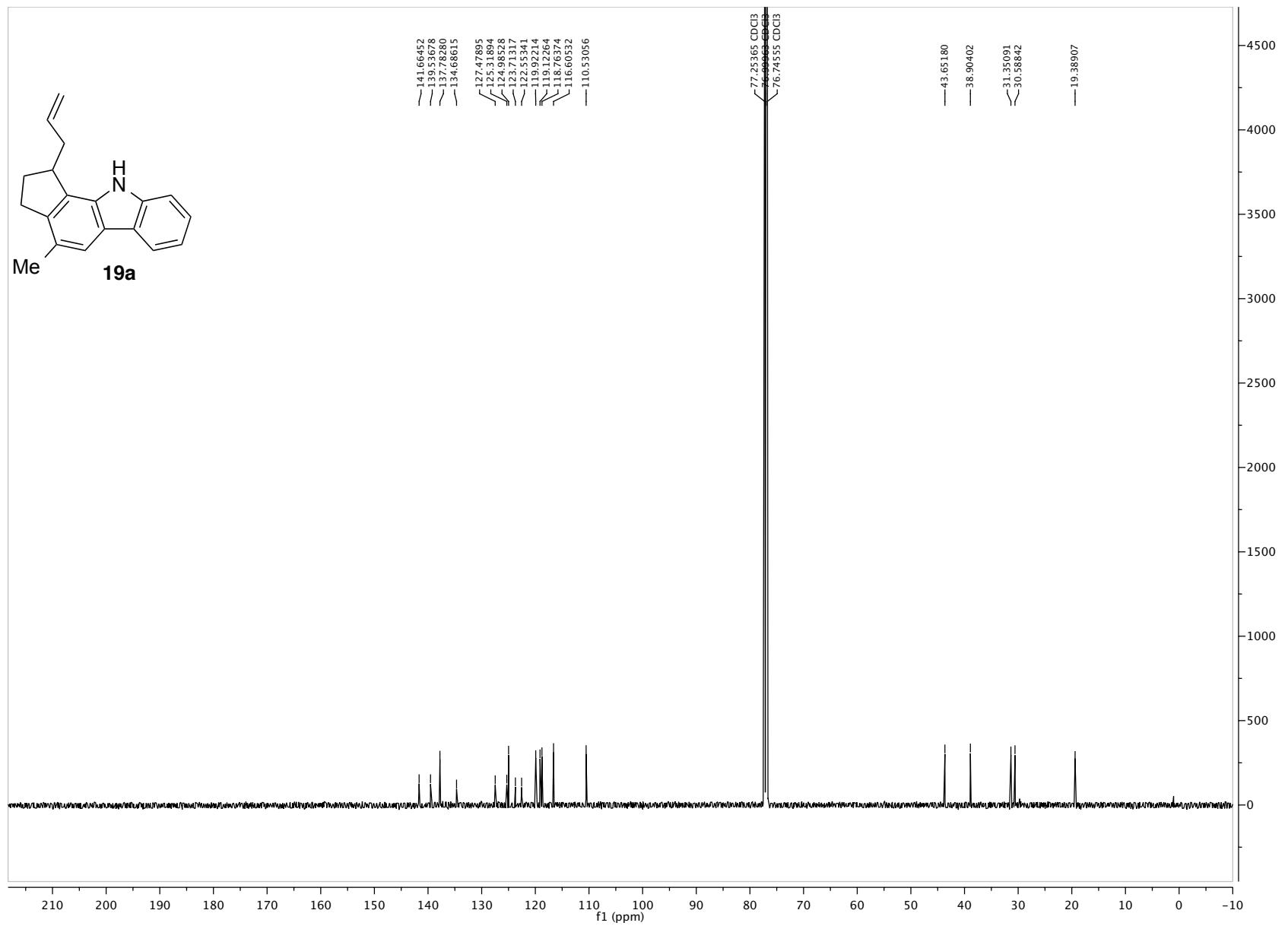


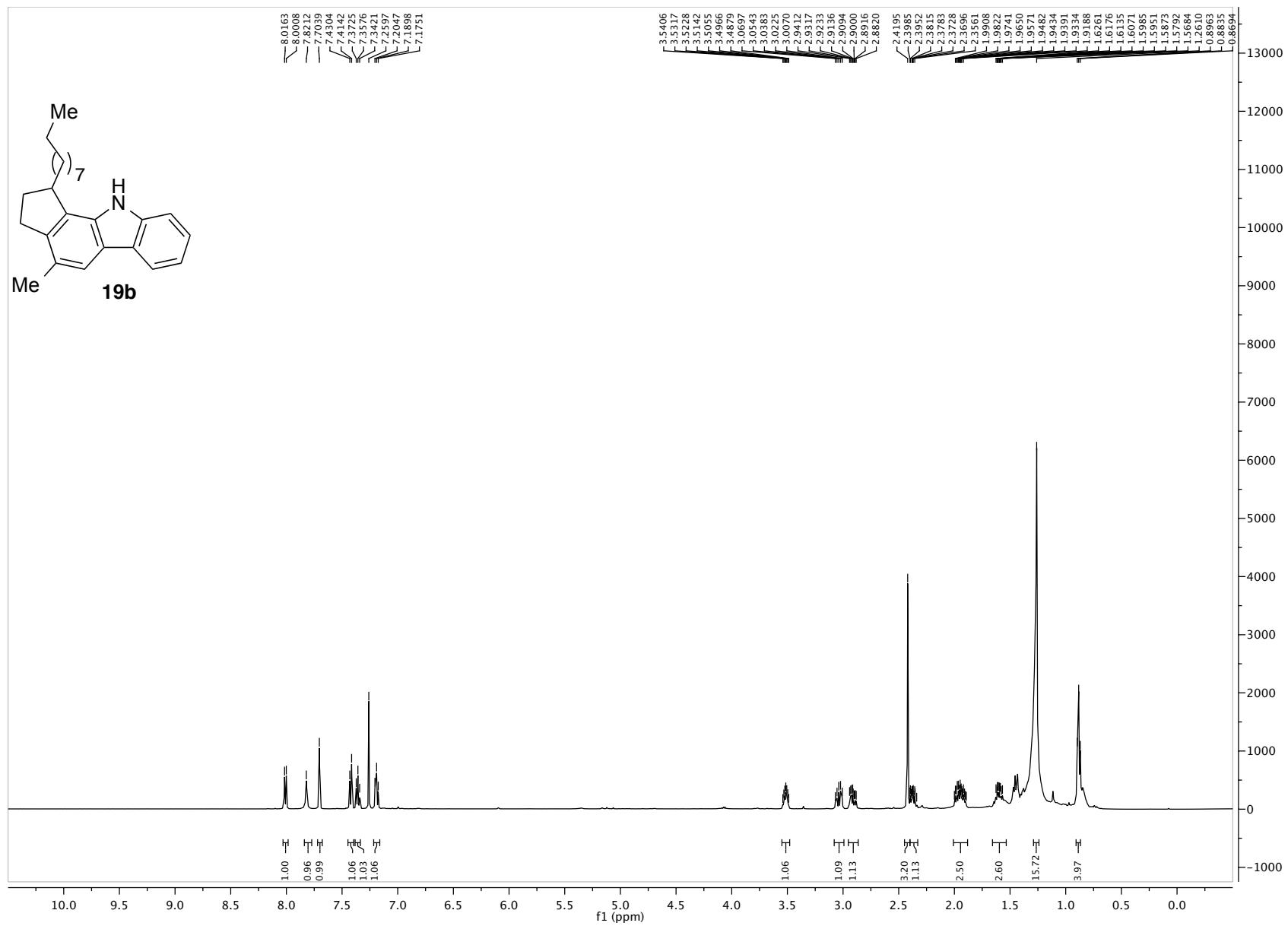


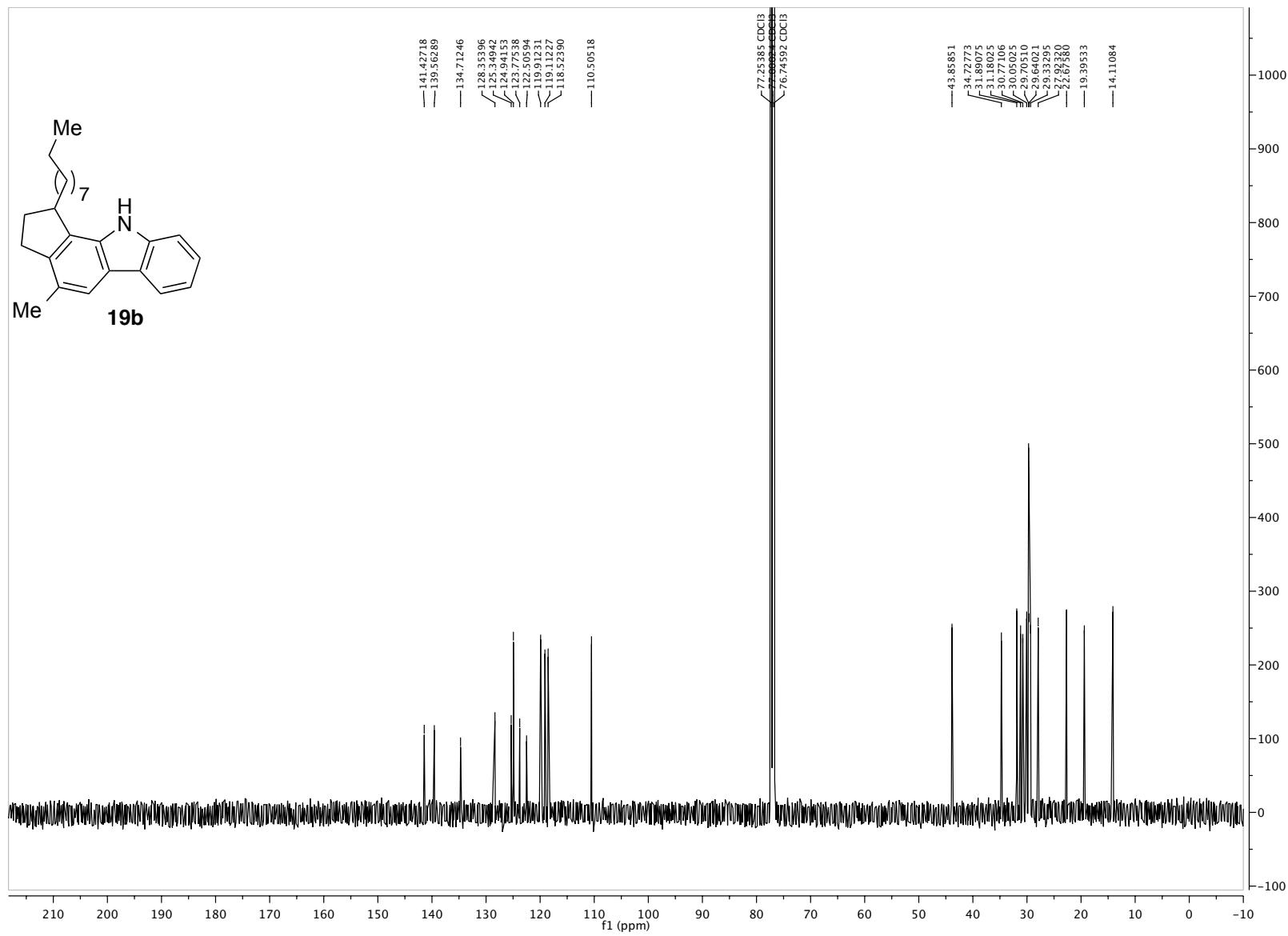


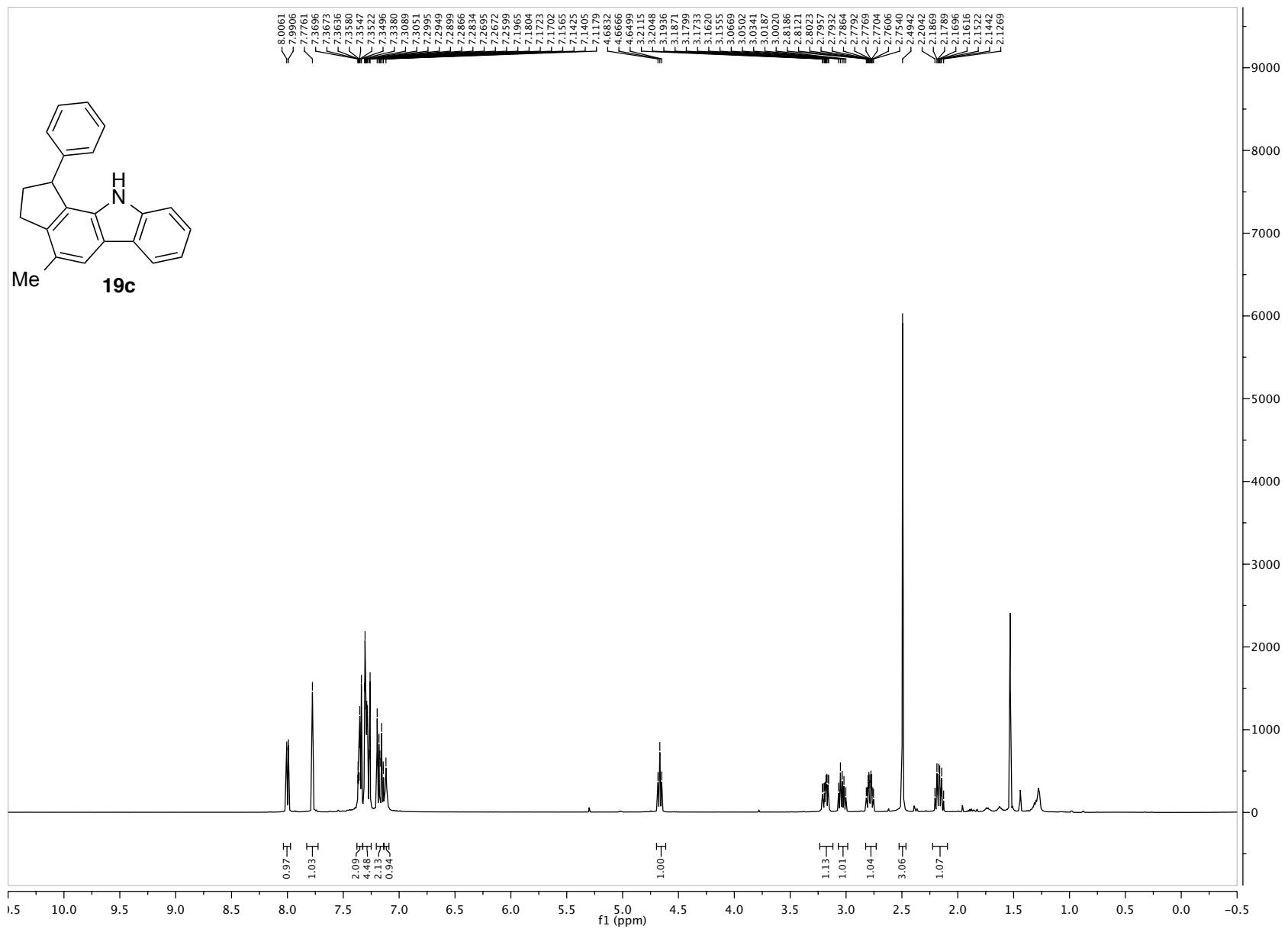


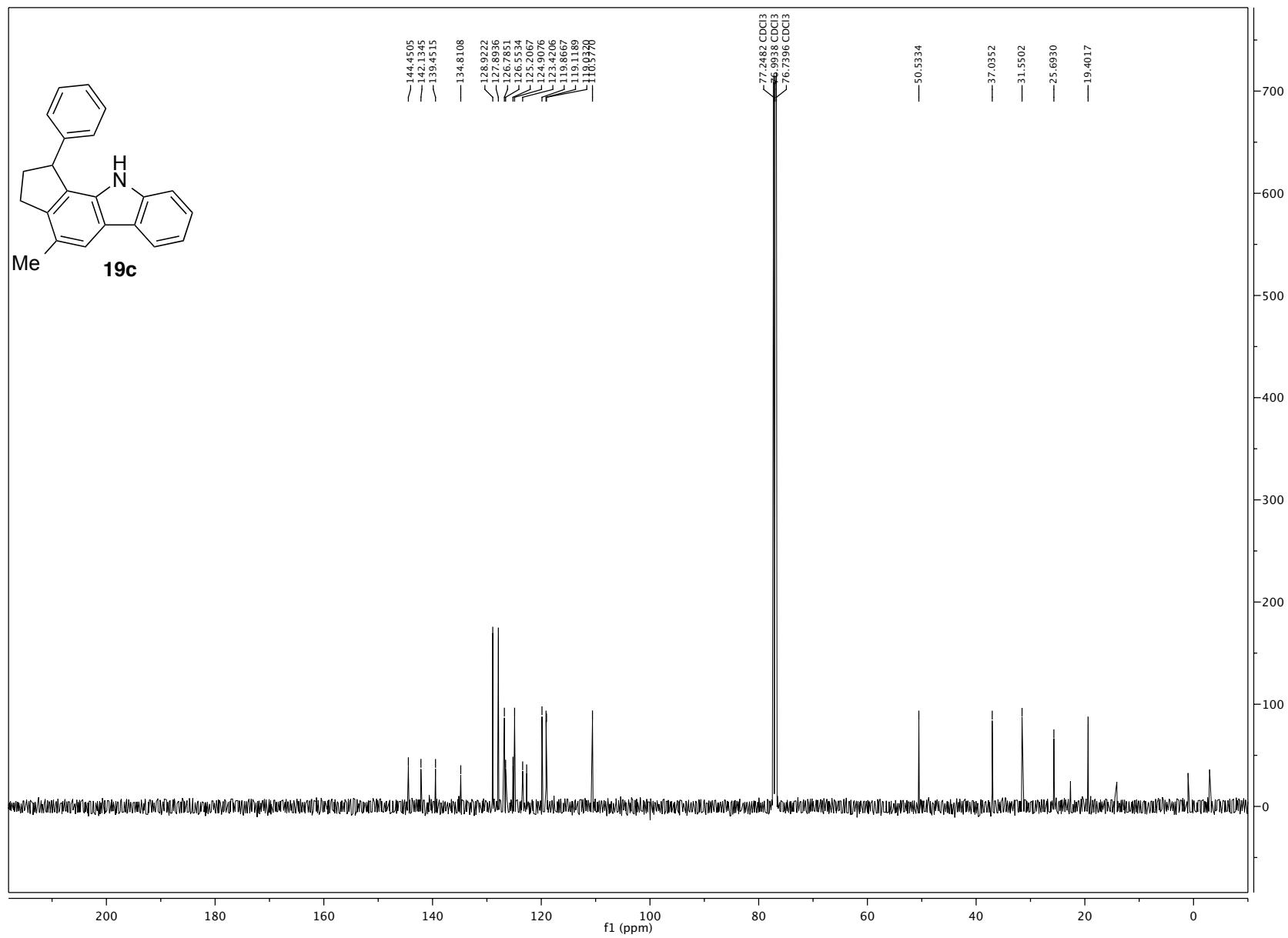


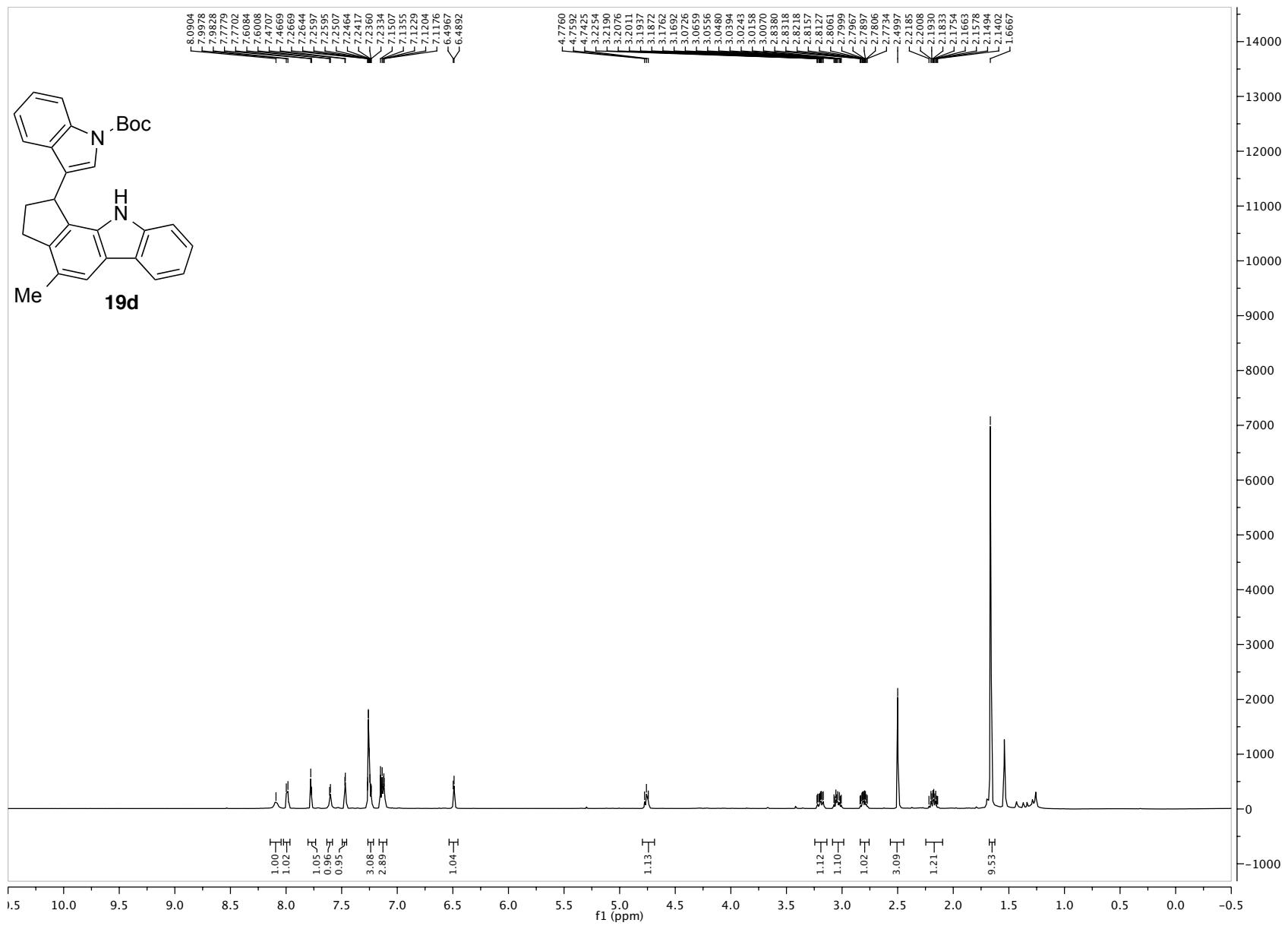


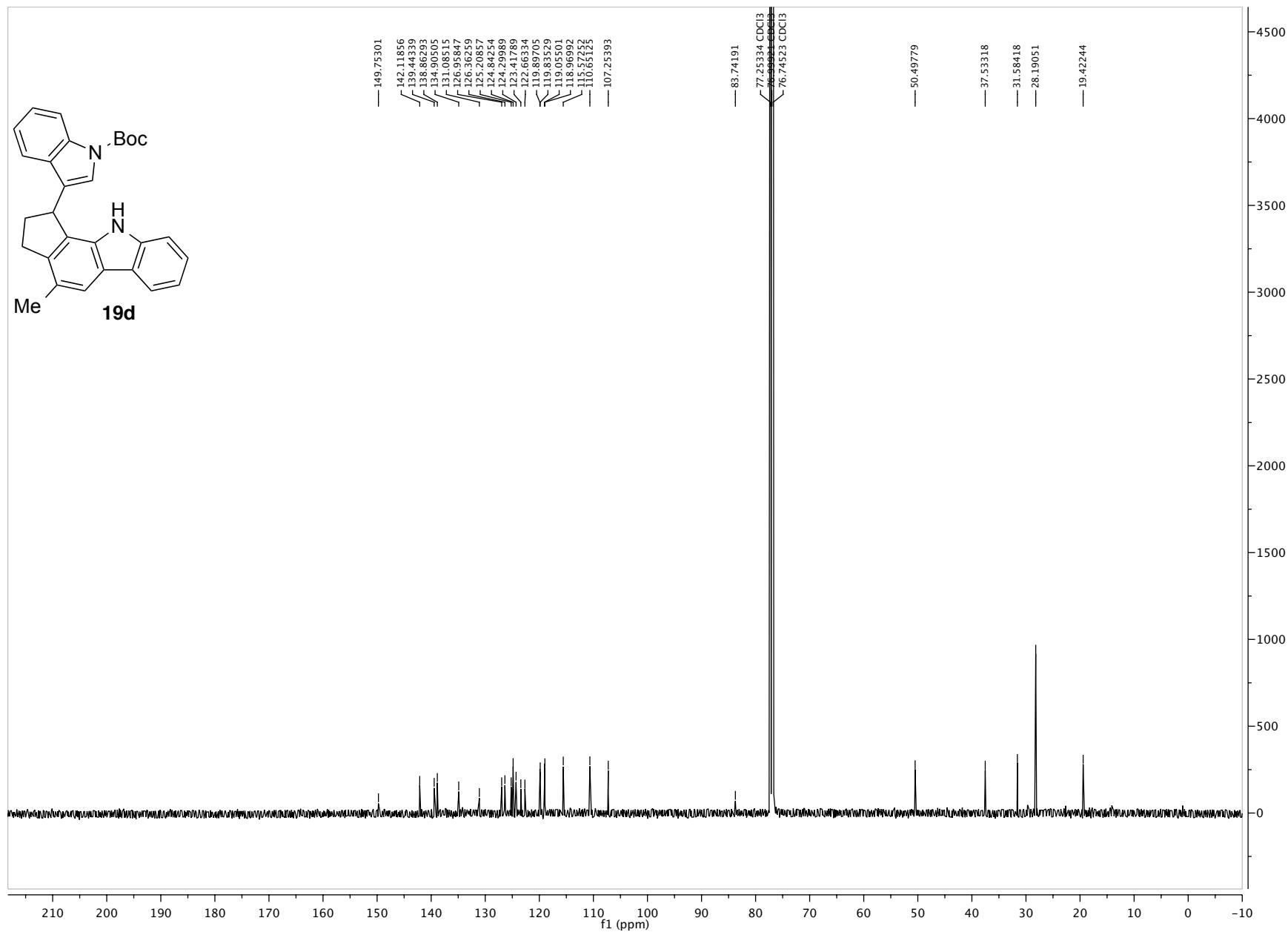


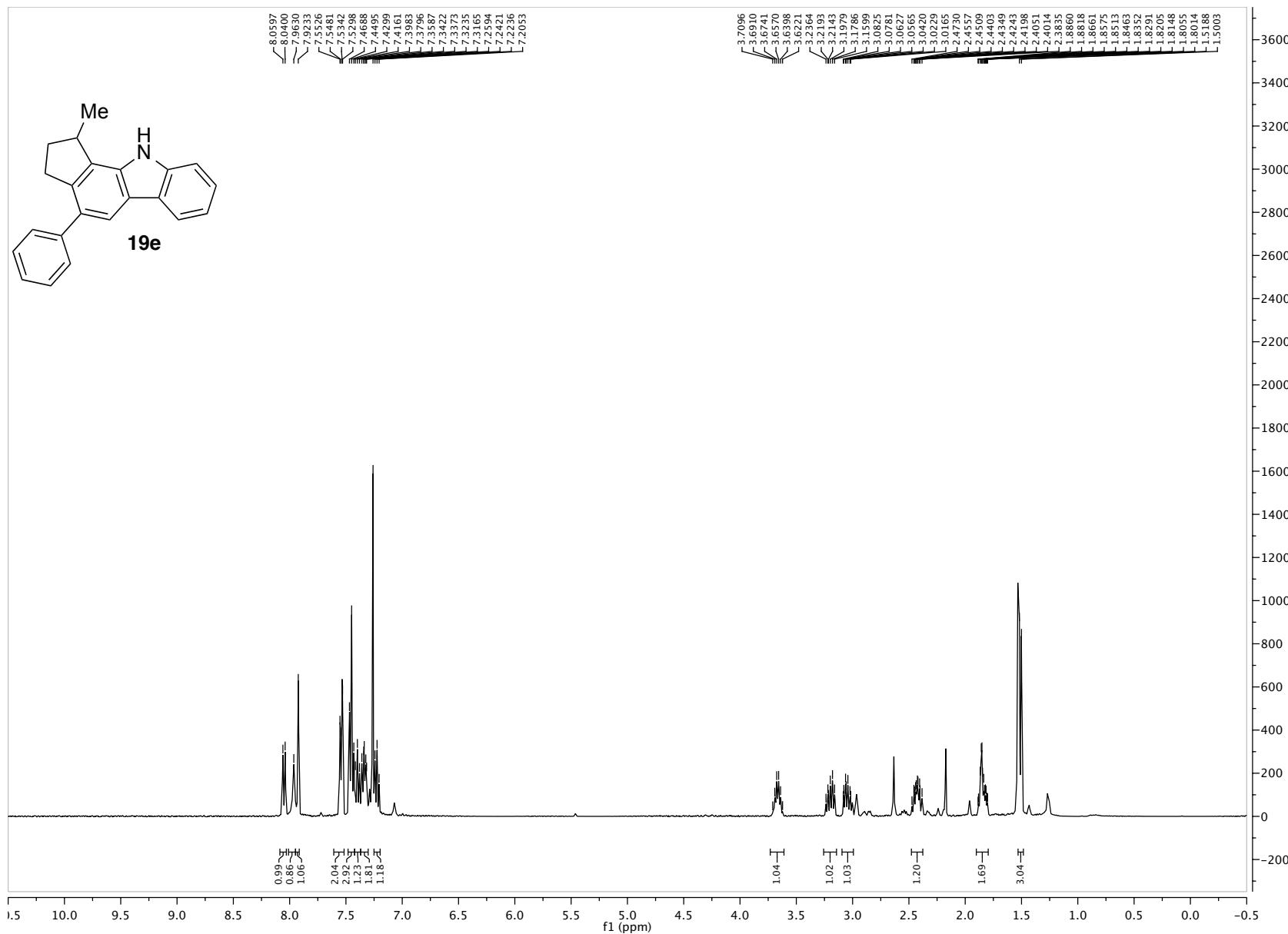


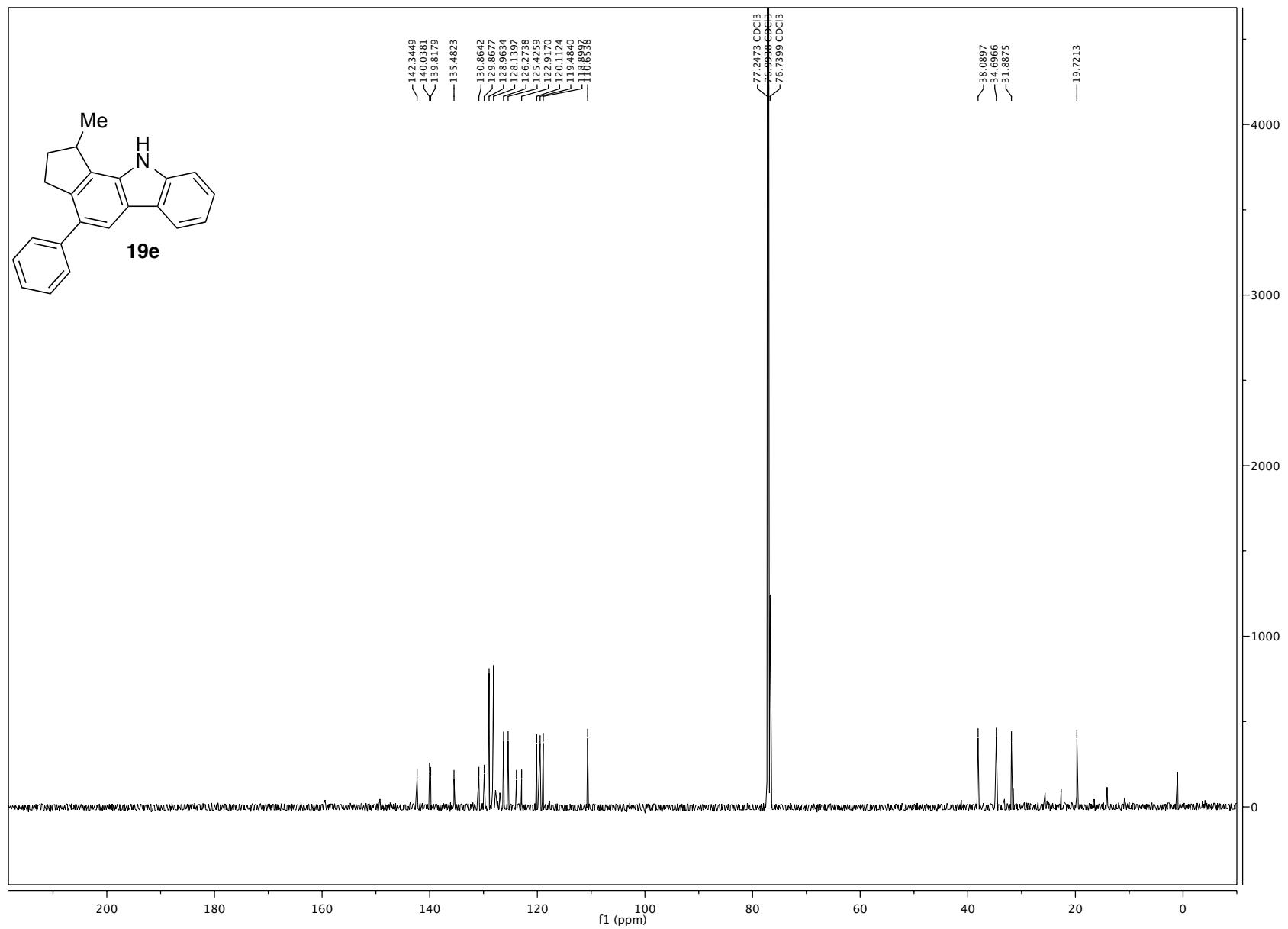


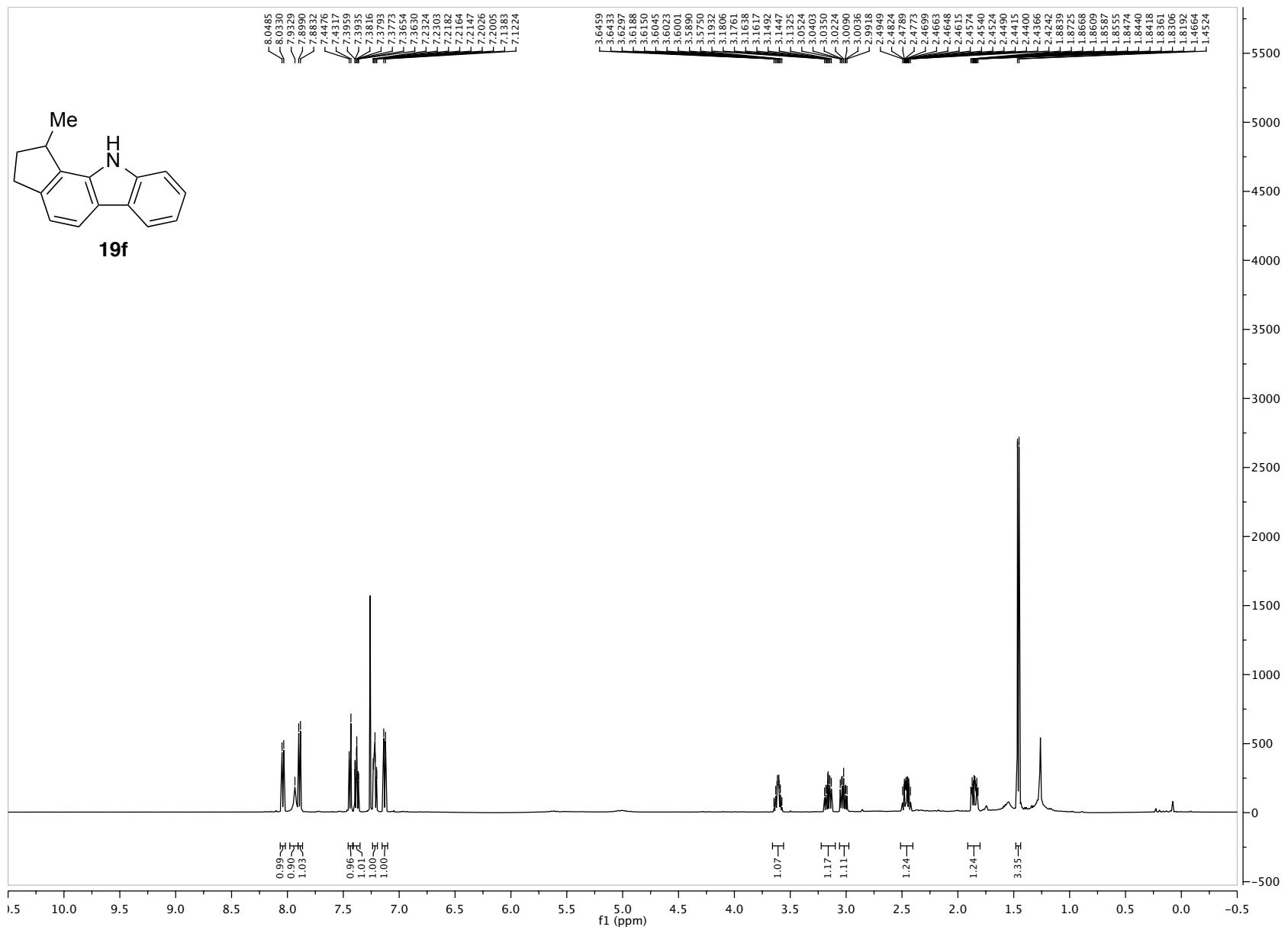


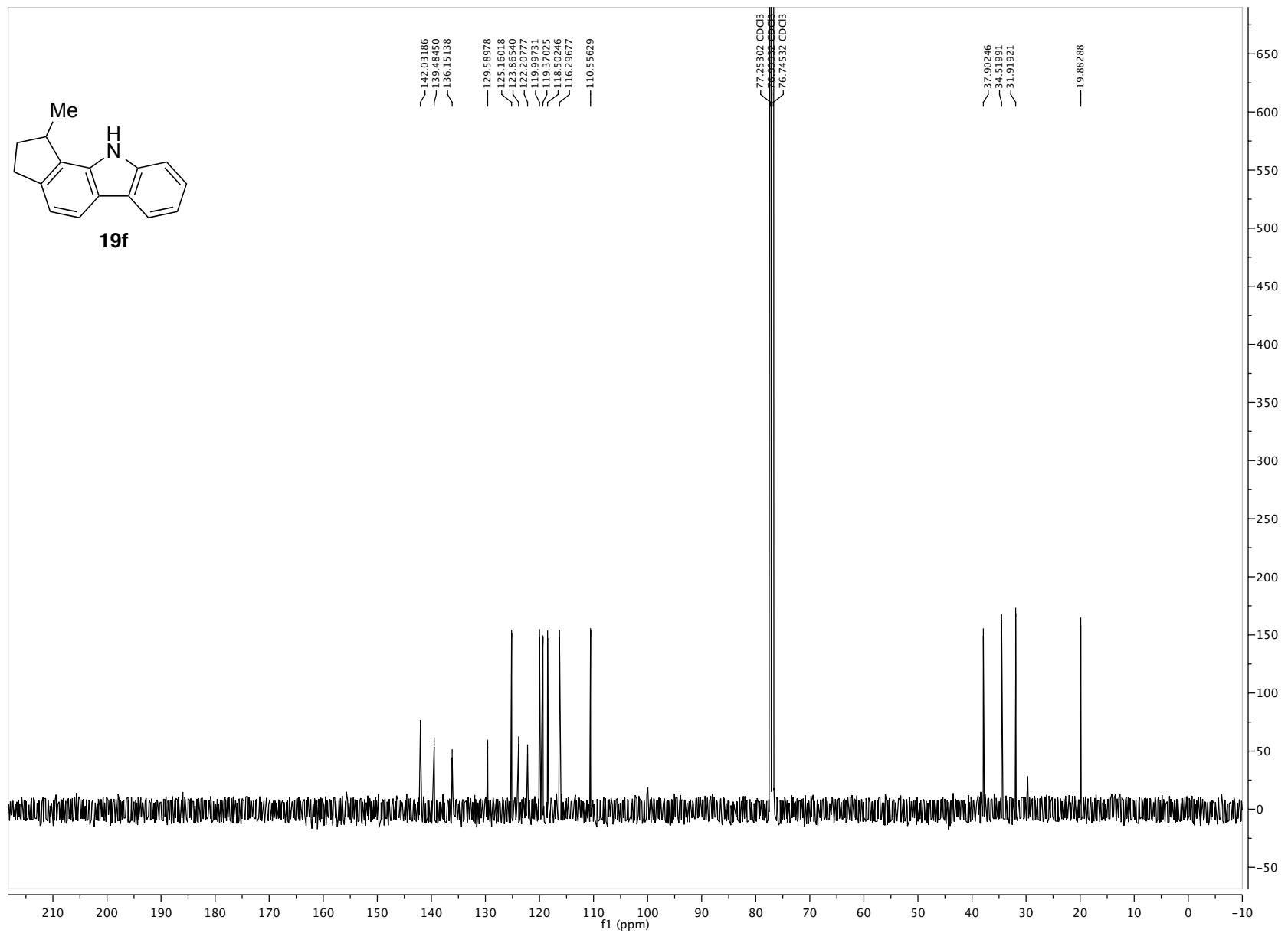


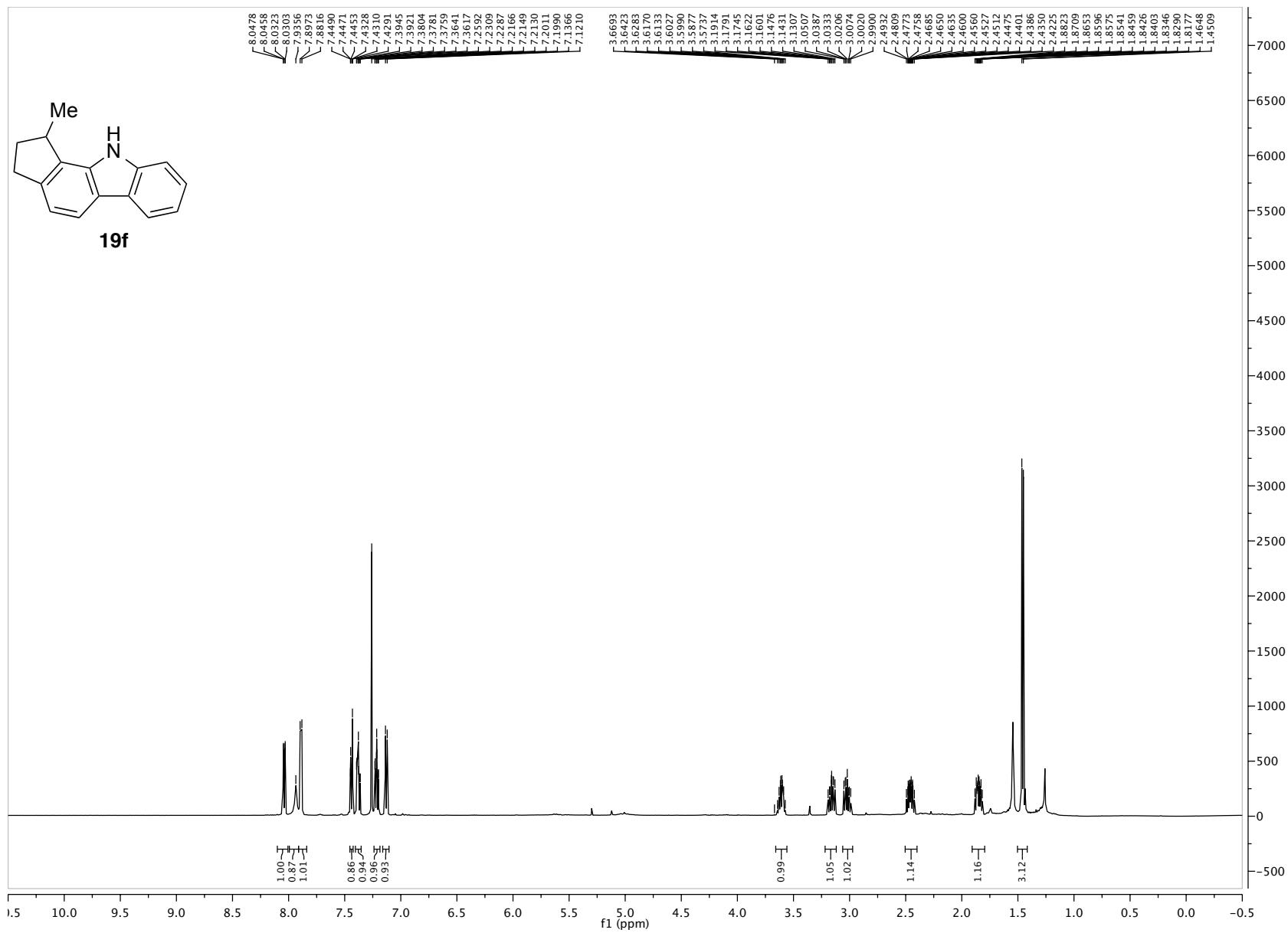


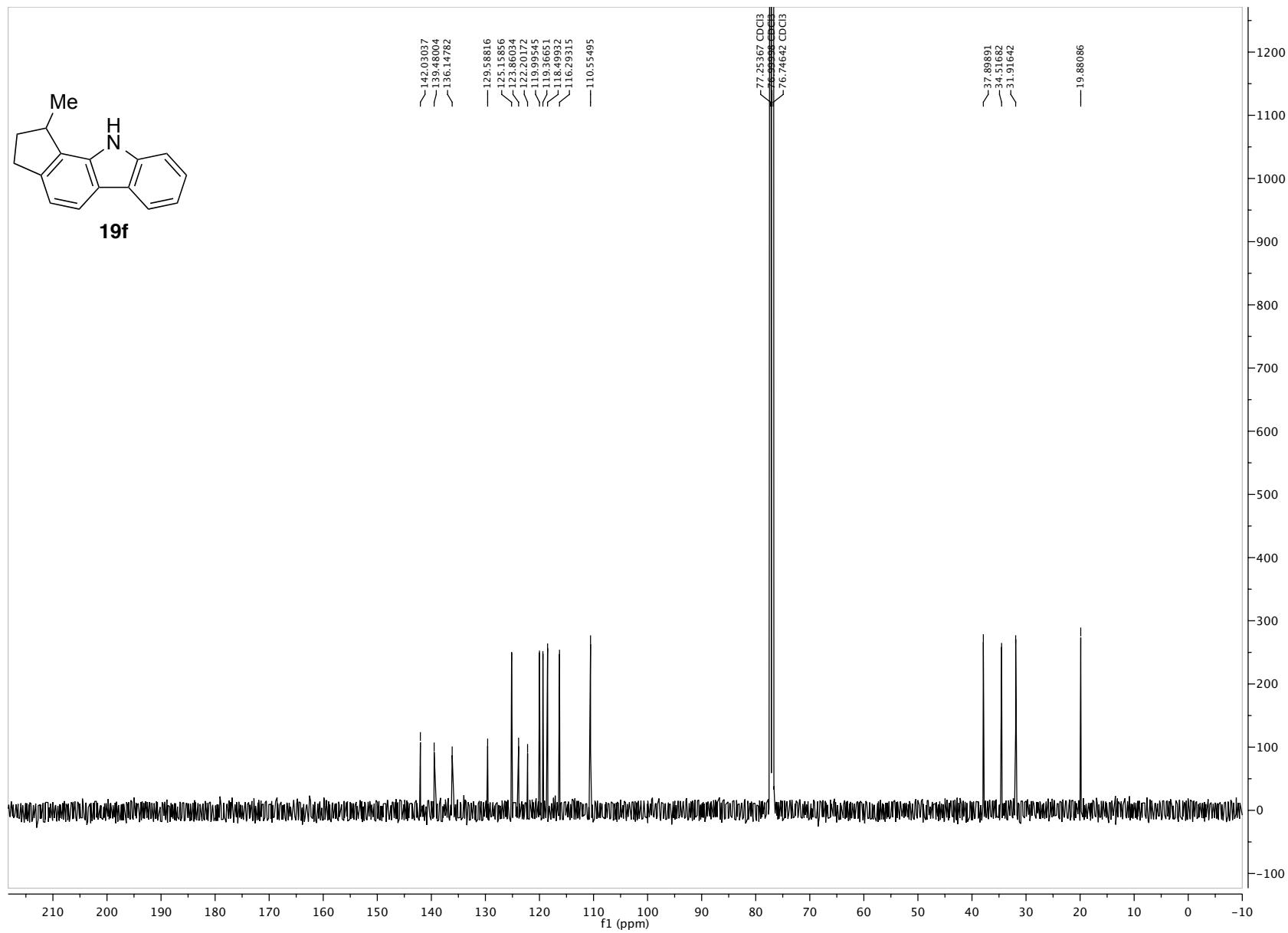


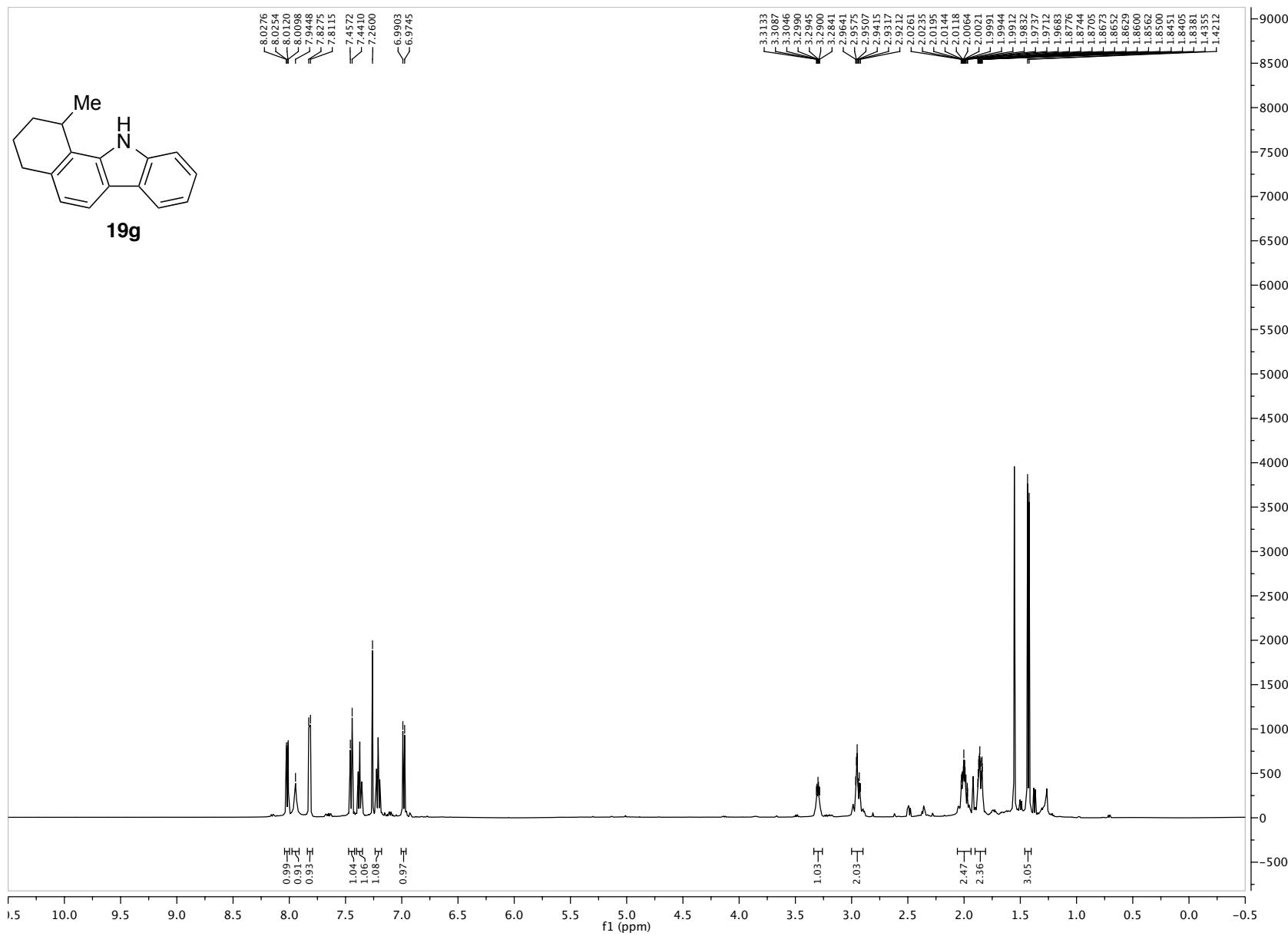


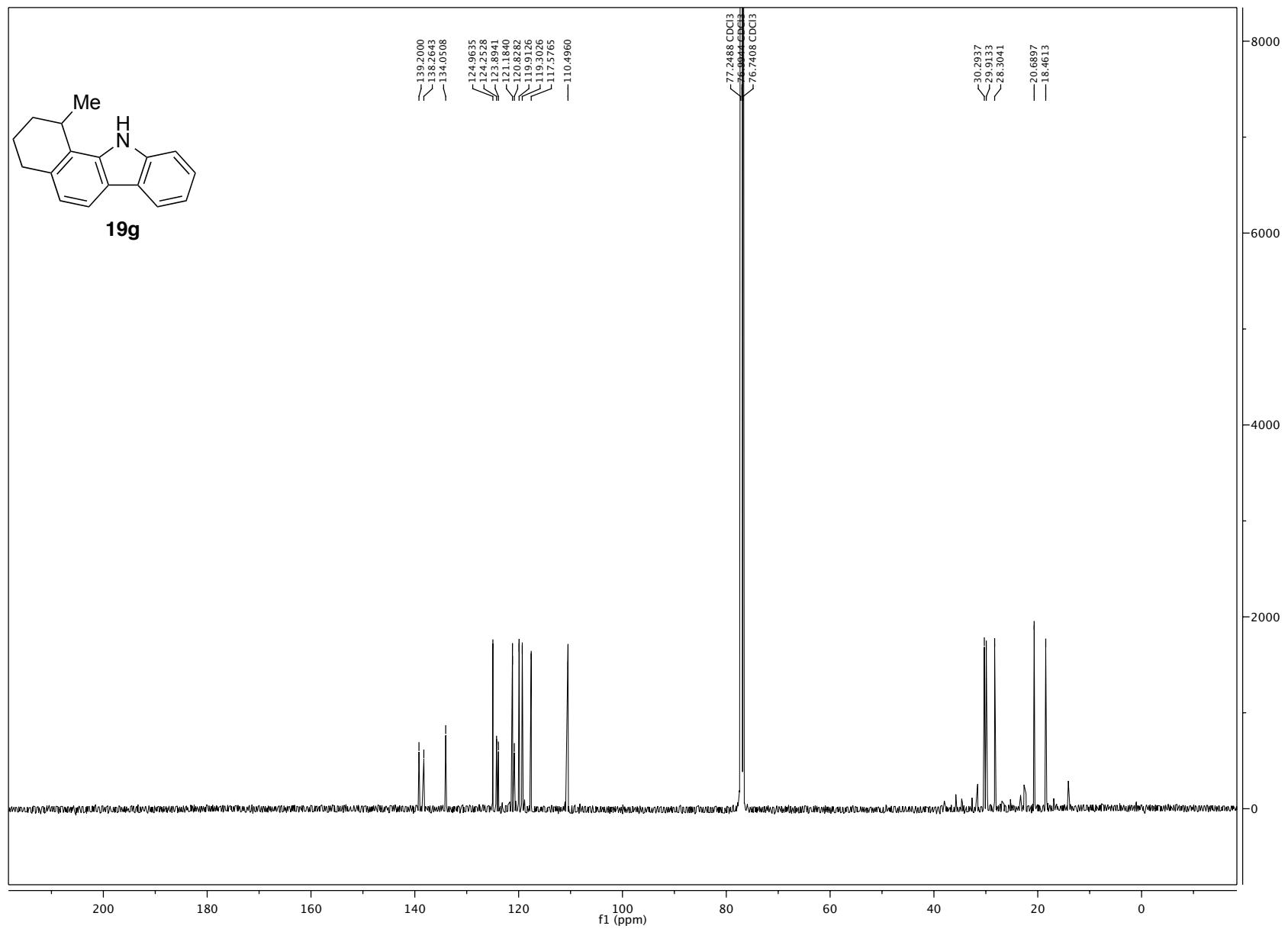


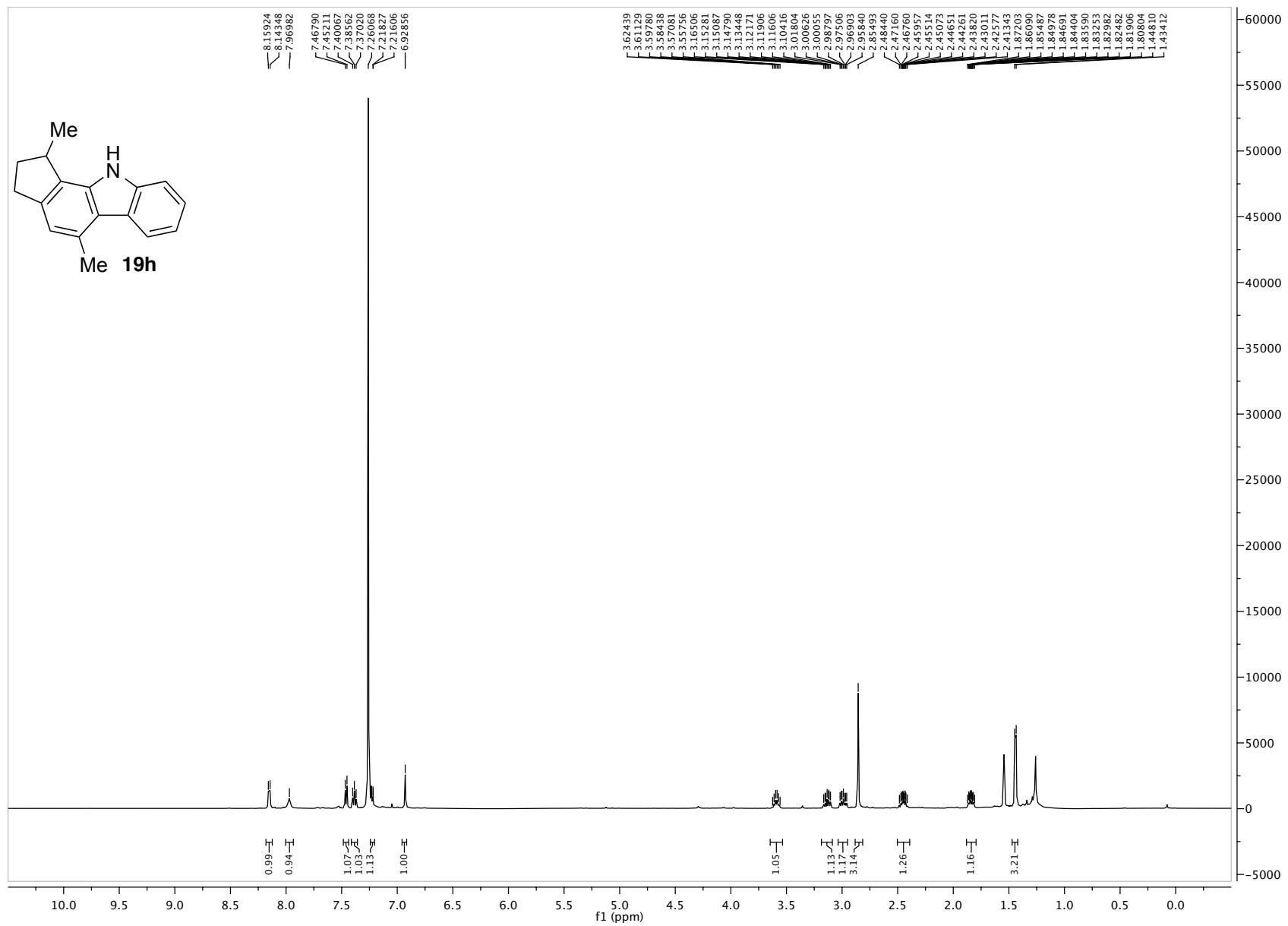


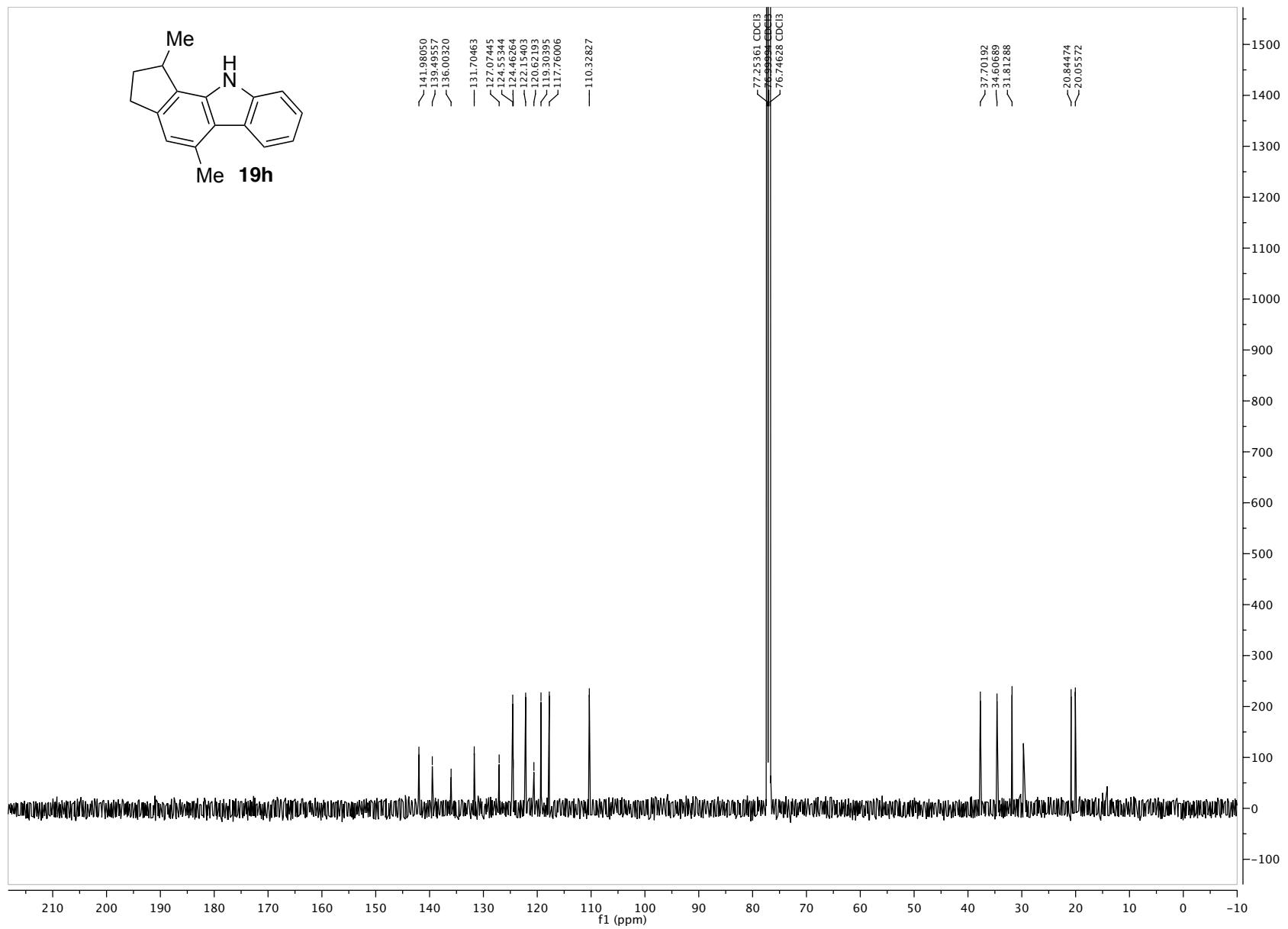


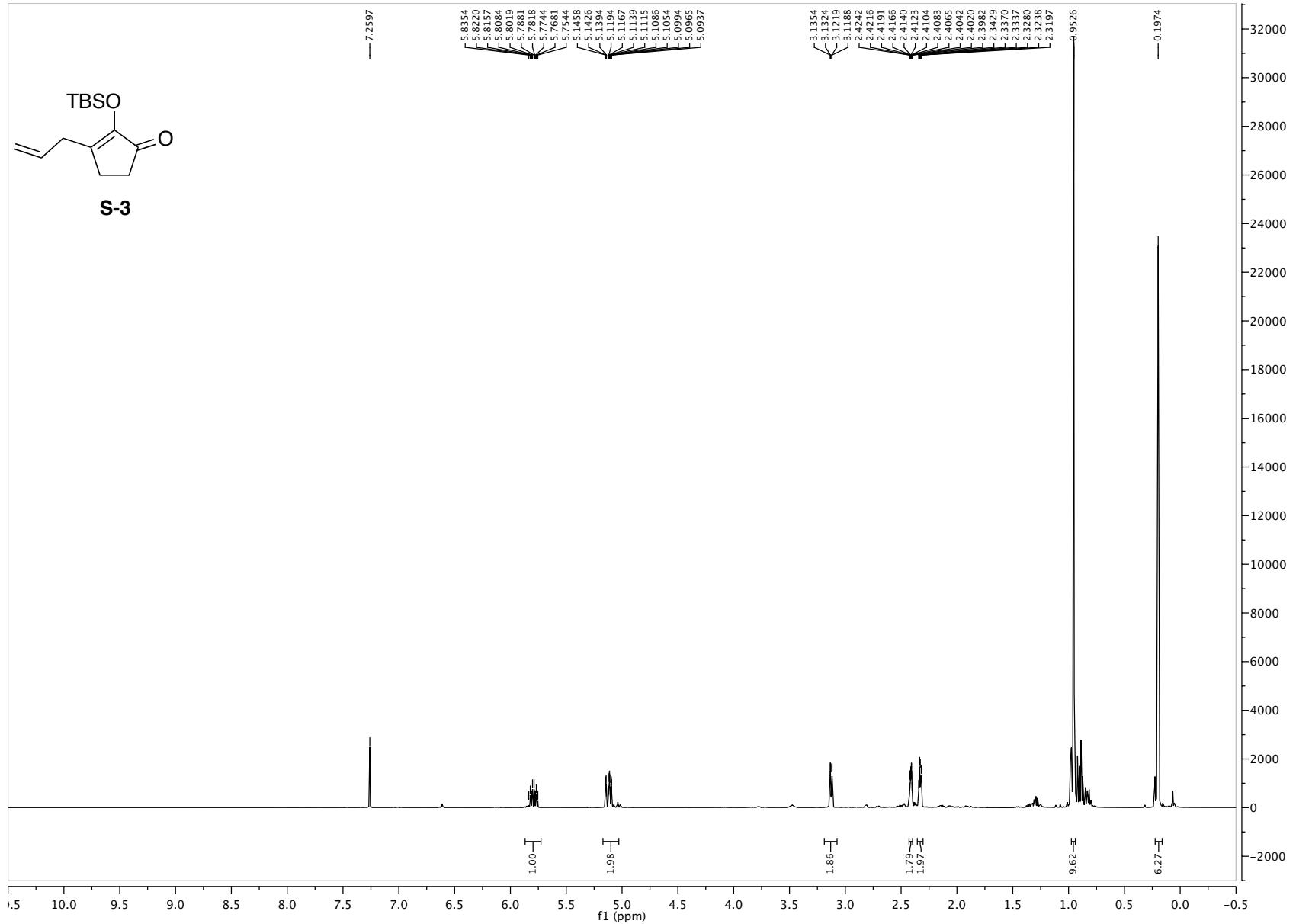




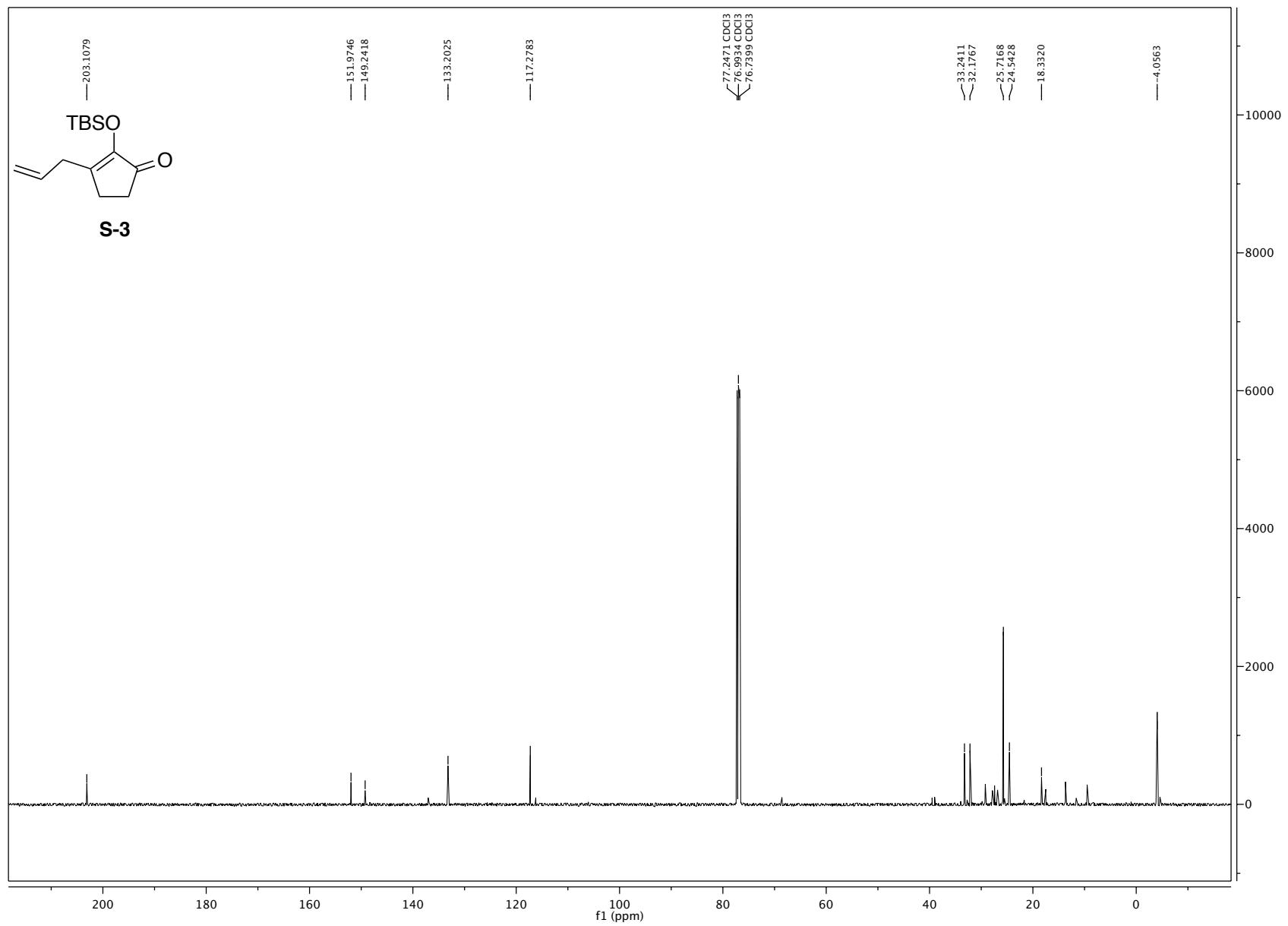




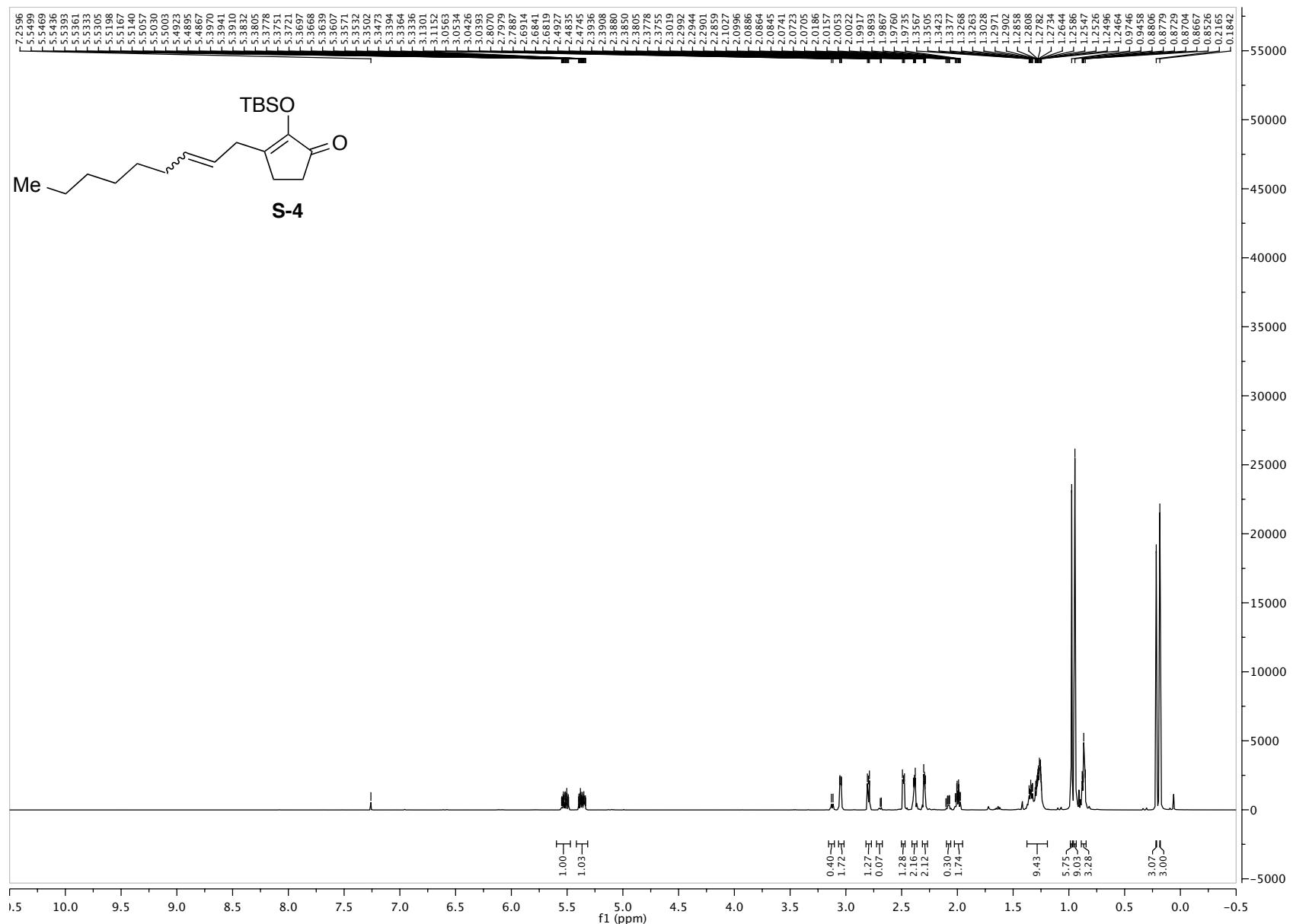




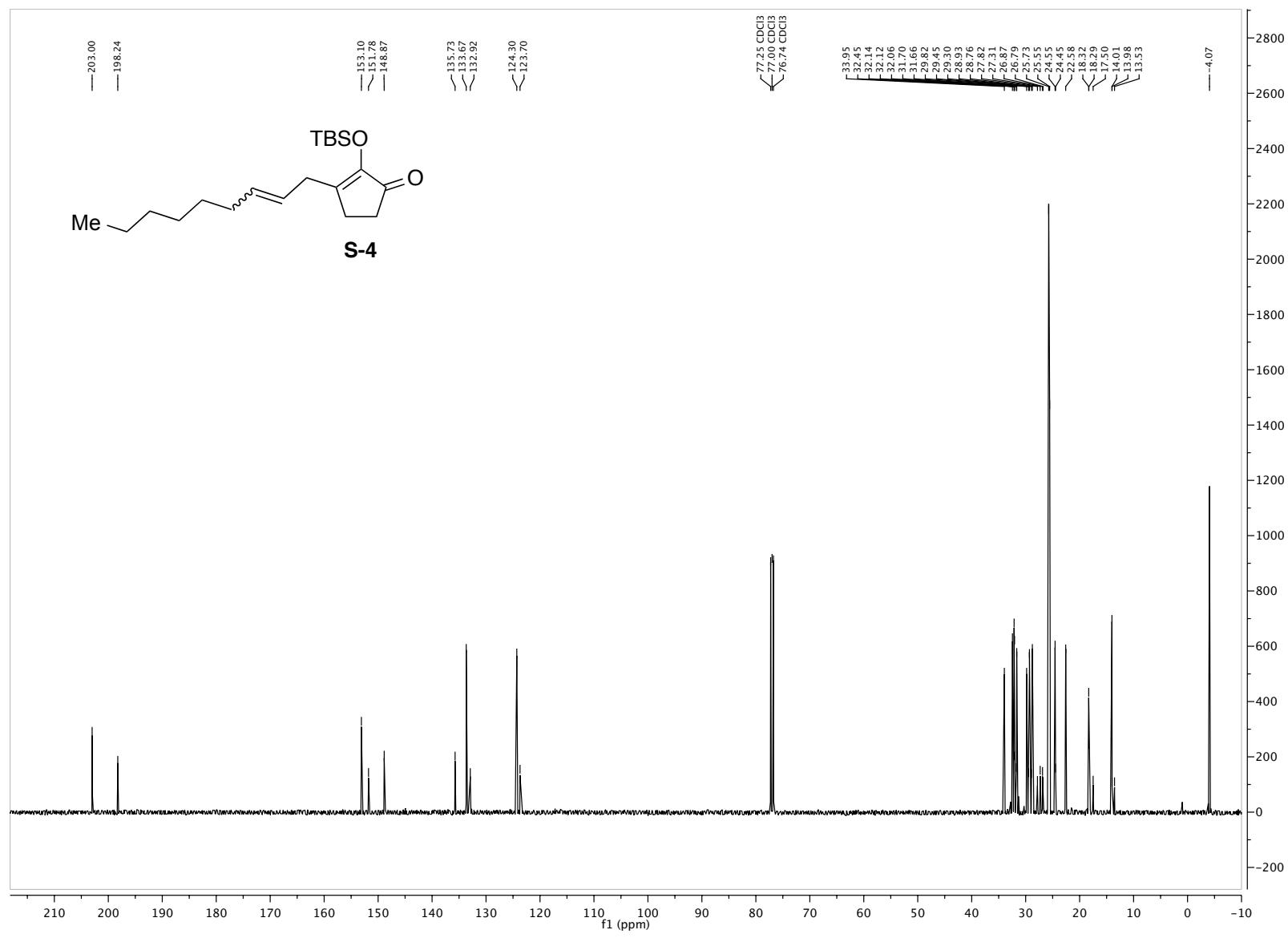
S-96



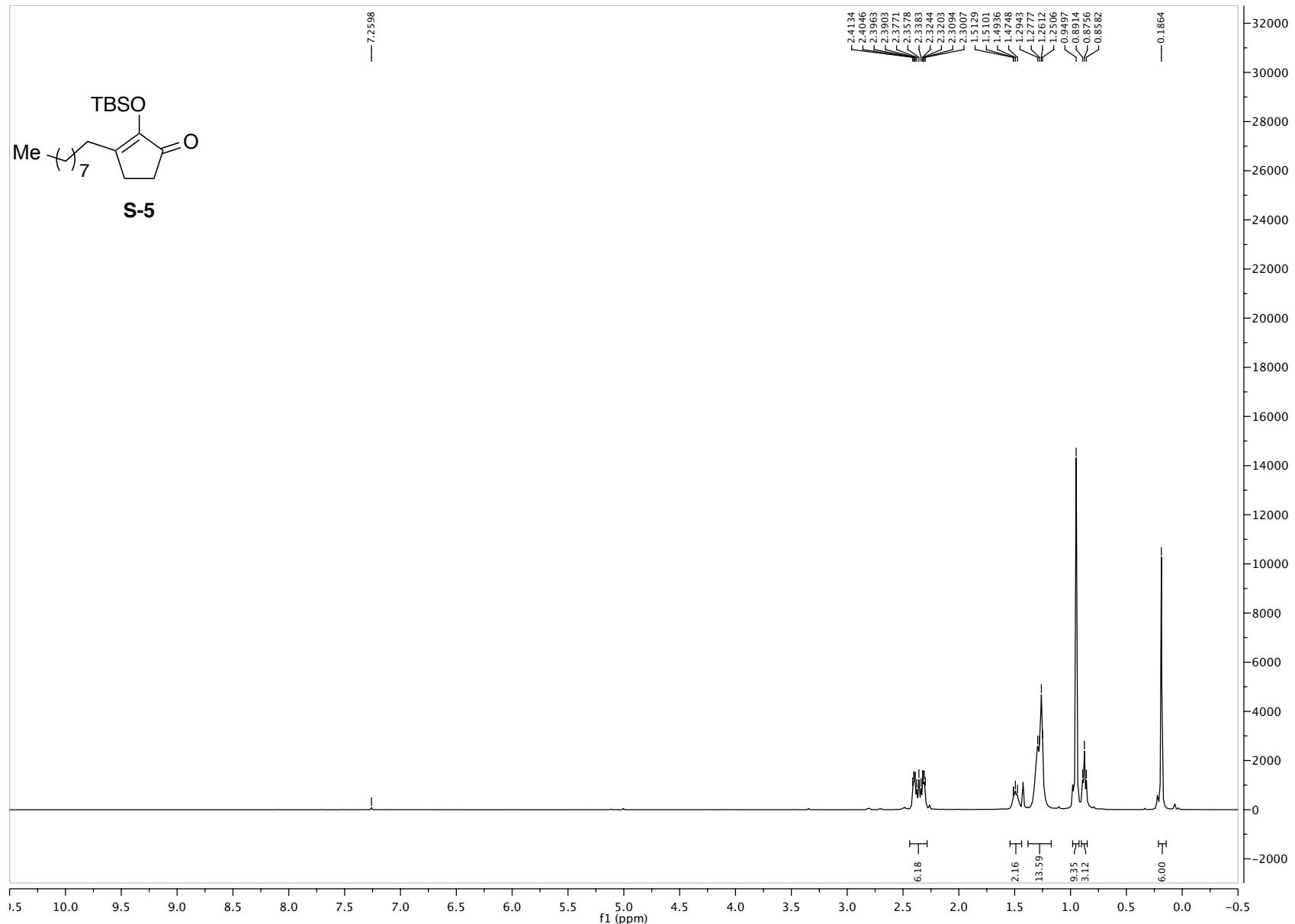
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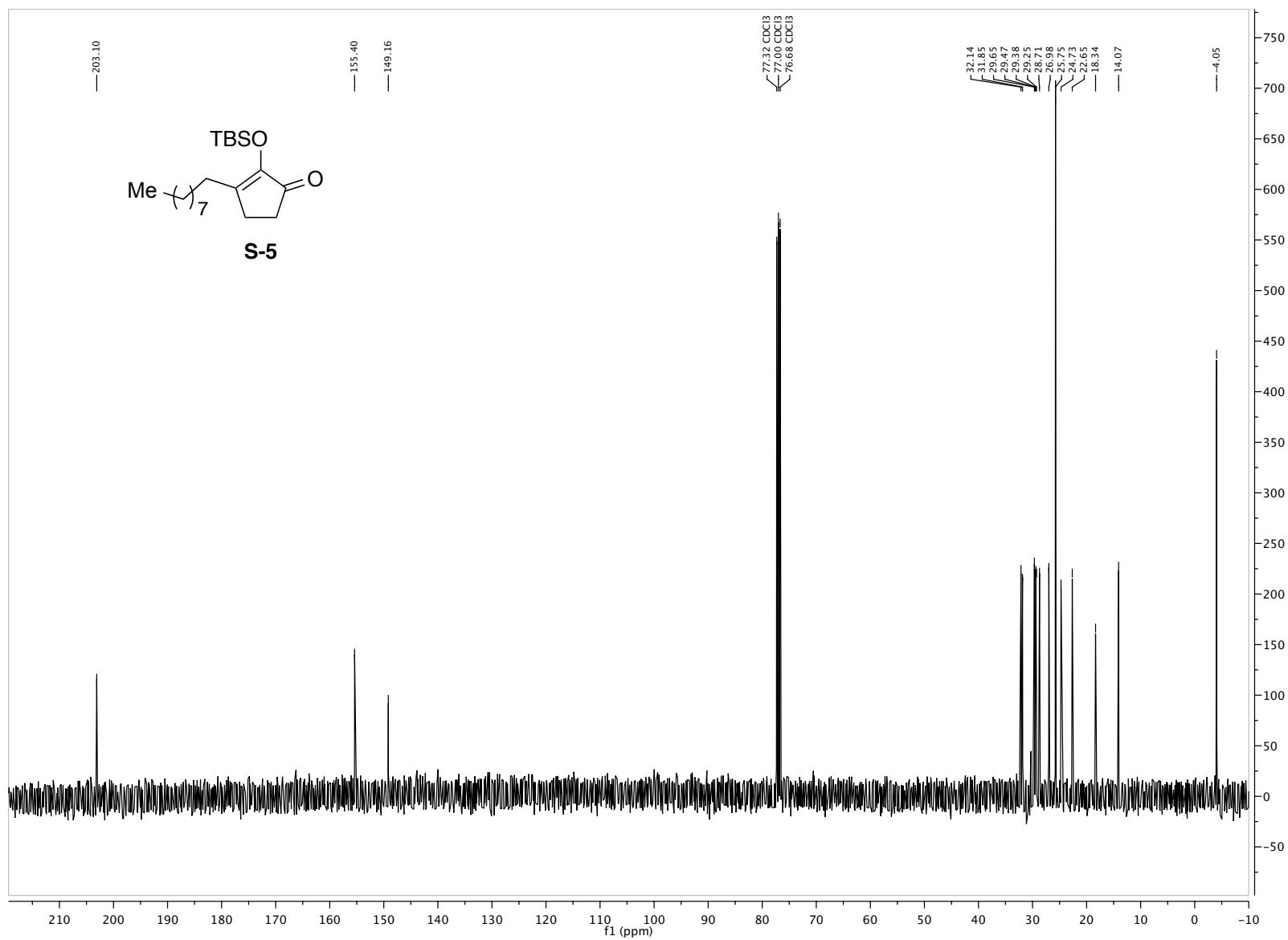
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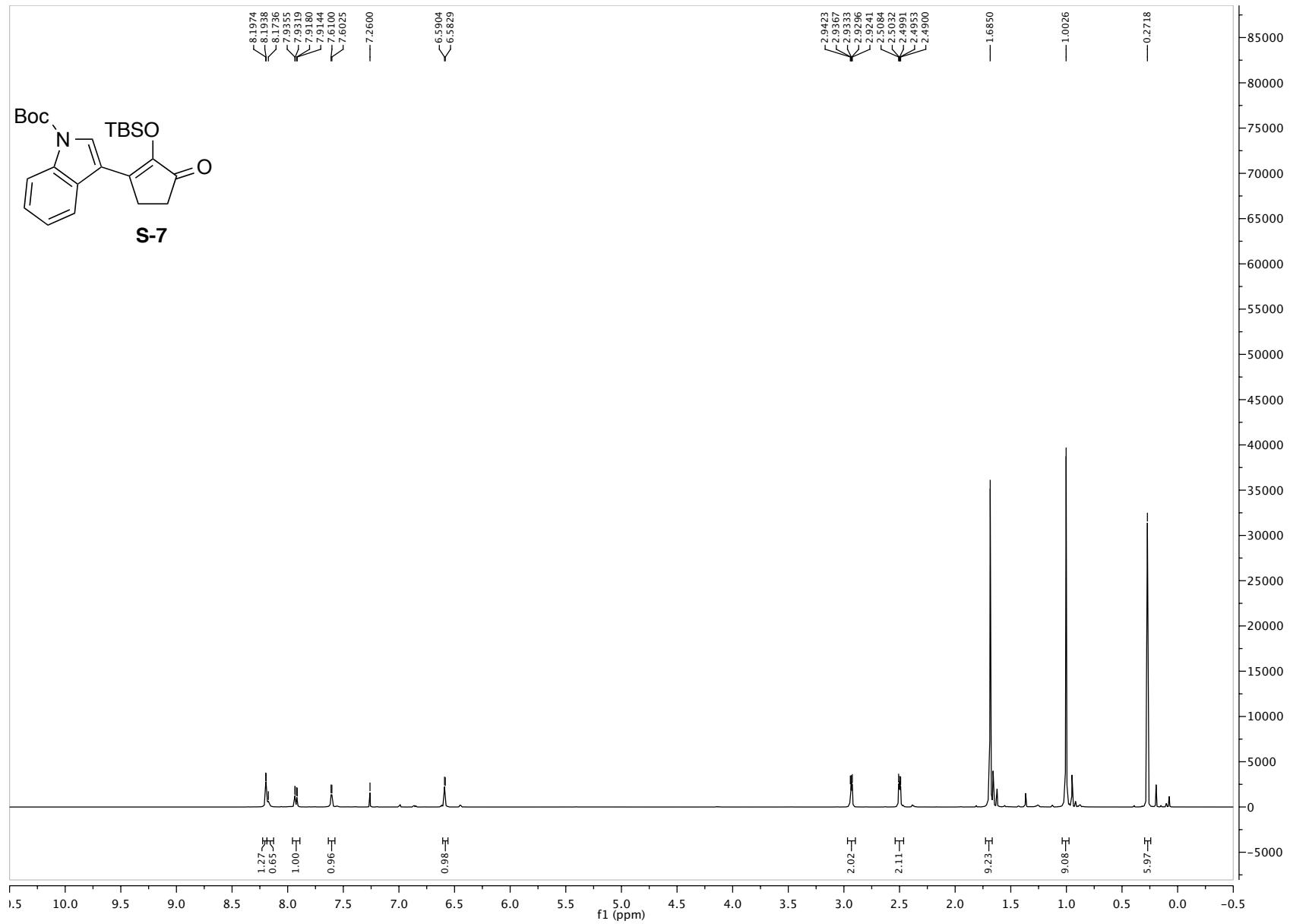
S-99



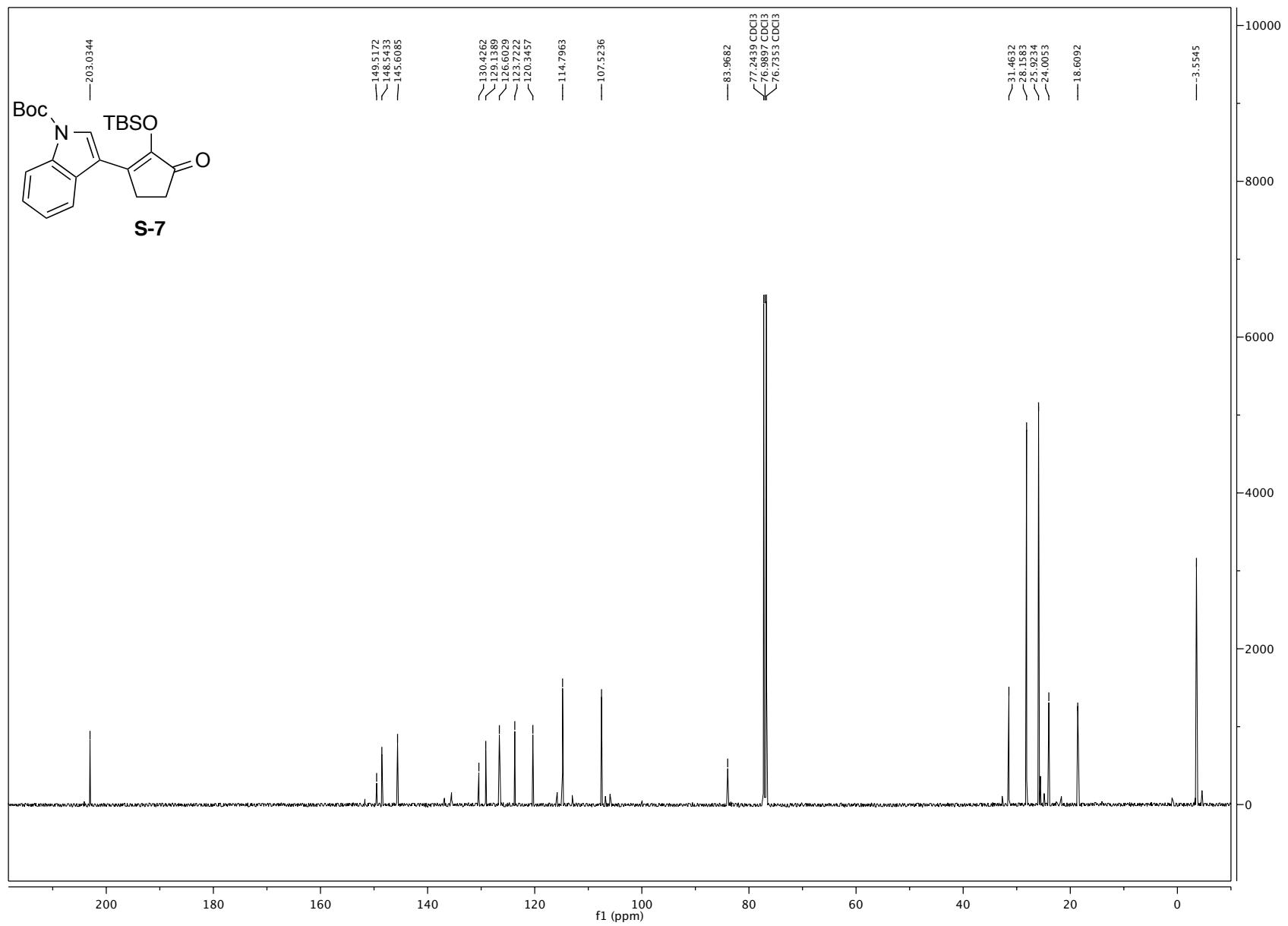
S-100



S-101



S-102



S-103