Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supporting Information

Brønsted Acid Catalyzed Direct C6 Functionalization of 2,3-Disubstituted Indoles for Construction of Cyano-Substituted All-Carbon Quaternary Centers

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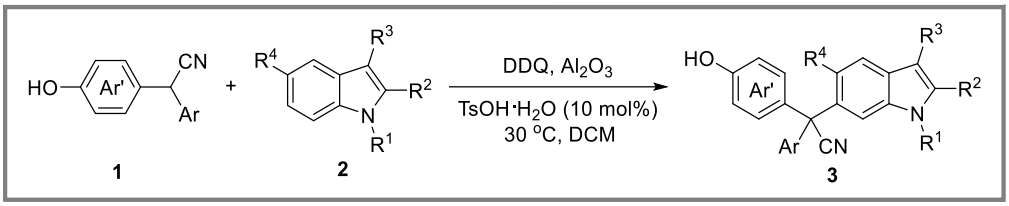
1. General and Materials

General: All reactions were carried out under an atmosphere of nitrogen using the standard Schlenk techniques, unless otherwise noted. Solvents were treated prior to use according to the standard methods. Proton (^{1}H NMR) nuclear magnetic resonance spectra were recorded at 400 MHz. Carbon (^{13}C NMR) nuclear magnetic resonance spectra were recorded at 100 MHz. Fluorine (^{19}F NMR) nuclear magnetic resonance spectra were recorded at 376 MHz. The chemical shifts are given in parts per million (ppm) on the delta (δ) scale. The solvent peak was used as a reference value, for ^{1}H NMR: $CDCl_3$ = 7.26 ppm, $(CD_3)_2CO$ = 2.05 ppm; for ^{13}C NMR: $CDCl_3$ = 77.23 ppm, $(CD_3)_2CO$ = 29.84 and 206.26 ppm. The heat source for all heating reactions is the oil bath. High-resolution mass spectrometry (HRMS (ESI-TOF) m/z) was measured on an electro-spray ionization (ESI) apparatus using time-of-flight (TOF) mass spectrometry. Enantiomeric excess was determined by HPLC analysis using chiral column described below in detail. Optical rotations were measured by polarimeter. Flash column chromatography was performed on silica gel (200-300 mesh). All reactions were monitored by TLC analysis.

Materials: The 2,2-diarylacetonitrile **1a-v**[1] and indoles **2b-m**[2] were prepared according to the known methods, all of which are the known compounds. Commercially available reagents and solvents were used throughout without further purification.

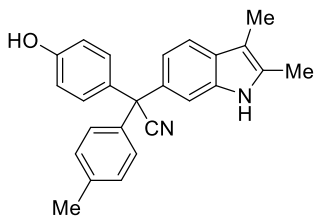
2. General Procedure for Indole C6 Functionalization



To a solution of 2,2-diarylacetonitrile **1** (0.24 mmol, 1.2 equiv) in dichlorometahne (2.0 mL) was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (0.22 mmol, 1.1 equiv) and aluminum oxide (base, 80.0 mg) at room temperature. The reaction mixture was stirred at 30 °C for 2-5 h, followed by addition of indole derivatives **2** (0.20 mmol, 1.0 equiv) and *p*-toluenesulfonic acid monohydrate (3.8 mg, 0.02 mmol). The reaction mixture continued to stir at 30 °C for 15 min-24 hours (TLC monitoring). Then, the crude mixture was directly purified by flash chromatography on silica gel using hexanes/ethyl acetate as eluent to afford the desirable indole C6 functionalization products **3**.

2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3aa):

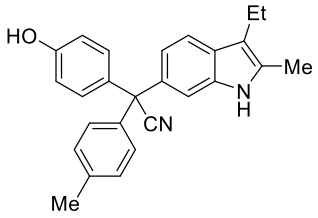
The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 70.1 mg, 96% yield, white foamy solid, mp 240-241 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.66 (brs, 1H), 8.47 (s, 1H), 7.25 (d, *J* = 8.3 Hz, 1H), 7.05-7.03 (m, 2H), 6.97-6.95 (m, 2H), 6.90-6.87 (m, 2H), 6.84 (d, *J* = 1.4 Hz, 1H), 6.76 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.73-6.69 (m, 2H), 2.19 (s, 3H), 2.17 (s, 3H), 2.03 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 157.9, 139.9, 138.4, 136.1, 133.9, 133.5, 133.1, 130.8, 129.9, 129.8, 129.4, 125.1, 120.1, 118.4, 116.1, 111.5, 106.8, 57.4, 20.9, 11.4, 8.5. HRMS Calculated for



$C_{25}H_{23}N_2O$ $[M+H]^+$ 367.1805, found: 367.1807.

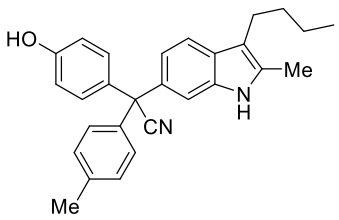
2-(3-Ethyl-2-methyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3ab):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 3.5 hours. 56.9 mg, 72% yield, white solid, mp 265-267 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.82 (brs, 1H), 8.61 (s, 1H), 7.47 (d, *J* = 8.3 Hz, 1H), 7.22-7.20 (m, 2H), 7.13-7.11 (m, 2H), 7.06-7.03 (m, 2H), 6.99 (d, *J* = 1.4 Hz, 1H), 6.90 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.90-6.85 (m, 2H), 2.70 (q, *J* = 7.5 Hz, 2H), 2.36 (s, 3H), 2.34 (s, 3H), 1.19 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 157.9, 139.8, 138.3, 136.2, 133.8, 133.1, 133.0, 130.7, 129.9, 129.4, 128.8, 125.0, 120.1, 118.5, 116.0, 113.8, 111.6, 57.4, 20.9, 17.8, 15.9, 11.4. HRMS Calculated for $C_{26}H_{26}N_2O$ $[M+H]^+$ 381.1961, found: 381.1963.



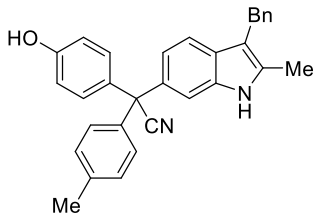
2-(3-Butyl-2-methyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3ac):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 5 hours. 49.7 mg, 61% yield, yellow solid, mp 172-173 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (s, 1H), 7.46-7.44 (m, 1H), 7.15- 7.09 (m, 4H), 7.09-7.04 (m, 2H), 6.96-6.94 (m, 2H), 6.76-6.74 (m, 2H), 5.75 (brs, 1H), 2.66 (t, *J* = 7.4 Hz, 2H), 2.35 (s, 3H), 2.32 (s, 3H), 1.63-1.55 (m, 2H), 1.42-1.33 (m, 2H), 0.93 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 138.4, 137.8, 134.9, 133.2, 133.1, 132.3, 130.4, 129.3, 128.8, 128.4, 124.6, 120.1, 118.3, 115.5, 112.6, 111.0, 56.8, 33.1, 23.9, 22.8, 21.1, 14.2, 11.8. HRMS Calculated for $C_{26}H_{29}N_2O$ $[M+H]^+$ 409.2274, found: 409.2270.



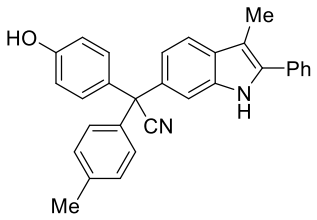
2-(3-Benzyl-2-methyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3ad):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 82.1 mg, 93% yield, white foamy solid, mp 136-137 °C, new compound, R_f = 0.35 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (s, 1H), 7.34 (d, *J* = 8.4 Hz, 1H), 7.26-7.21 (m, 4H), 7.18-7.15 (m, 1H), 7.14-7.08 (m, 4H), 7.04-7.01(m, 2H), 6.96 (d, *J* = 1.4 Hz, 1H), 6.90 (dd, *J* = 8.3, 1.7 Hz, 1H), 6.74-6.71(m, 2H), 5.99 (brs, 1H), 4.04 (s, 2H), 2.35 (s, 3H), 2.31 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 141.5, 138.24, 137.8, 135.0, 133.3, 133.3, 133.0, 130.3, 129.3, 128.8, 128.4, 128.4, 125.9, 124.6, 120.4, 118.4, 115.5, 111.0, 110.7, 56.7, 30.2, 21.1, 11.8.. HRMS Calculated for $C_{31}H_{27}N_2O$ $[M+H]^+$ 443.2118, found: 443.2118.



2-(4-Hydroxyphenyl)-2-(3-methyl-2-phenyl-1*H*-indol-6-yl)-2-(*p*-tolyl)acetonitrile (3ae):

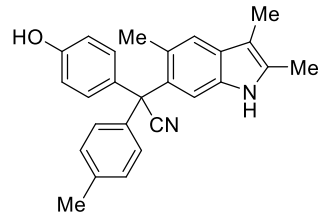
The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 78.7 mg, 92% yield, white foamy solid, mp 145-146 °C, new compound, R_f = 0.30 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (s, 1H), 7.57-7.53 (m, 3H),



7.47 (t, *J* = 7.6 Hz, 2H), 7.36 (t, *J* = 7.3 Hz, 1H), 7.23-7.13 (m, 4H), 7.10-7.07 (m, 4H), 6.81-6.79 (m, 2H), 6.05 (s, 1H), 2.46 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 138.1, 137.9, 135.5, 134.7, 133.0, 132.9, 130.3, 129.5, 129.4, 128.9, 128.8, 127.8, 127.6, 124.5, 120.7, 119.2, 115.6, 111.5, 108.6, 56.8, 21.1, 9.7. HRMS Calculated for $C_{30}H_{25}N_2O$ $[M+H]^+$ 429.1961, found: 429.1965.

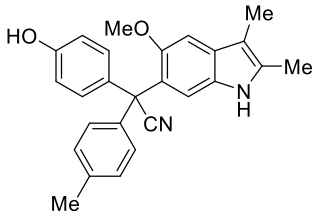
2-(4-Hydroxyphenyl)-2-(*p*-tolyl)-2-(2,3,5-trimethyl-1*H*-indol-6-yl)acetonitrile (3af):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 67.9 mg, 89% yield, white foamy solid, mp 172-173 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.67 (brs, 1H), 8.66 (s, 1H), 7.28 (s, 1H), 7.23-7.21 (m, 2H), 7.12-7.10 (m, 2H), 7.06-7.01 (m, 2H), 6.90-6.87 (m, 2H), 6.43 (s, 1H), 2.36 (s, 3H), 2.31 (s, 3H), 2.28 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 157.9, 139.3, 138.3, 134.7, 133.4, 132.6, 132.4, 130.7, 130.2, 130.1, 129.3, 127.5, 124.2, 121.7, 116.2, 116.1, 112.9, 106.1, 56.4, 22.0, 21.0, 11.4, 8.5. HRMS Calculated for $C_{26}H_{25}N_2O$ $[M+H]^+$ 381.1961, found: 381.1963.



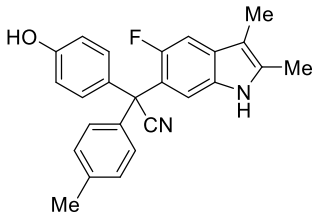
2-(4-Hydroxyphenyl)-2-(5-methoxy-2,3-dimethyl-1*H*-indol-6-yl)-2-(*p*-tolyl)acetonitrile (3ag):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 15 minutes. 74.9 mg, 95% yield, white foamy solid, mp 181-182 °C, new compound, R_f = 0.25 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (brs, 1H), 7.11-7.06 (m, 4H), 7.00-6.98 (m, 3H), 6.74 (d, *J* = 8.7 Hz, 2H), 6.28 (s, 2H), 3.72 (s, 3H), 2.34 (s, 3H), 2.26 (s, 3H), 2.20 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 152.0, 138.1, 137.4, 132.9, 132.6, 130.0, 129.8, 129.3, 129.2, 128.4, 124.0, 123.9, 115.5, 112.2, 106.9, 101.5, 56.8, 53.6, 21.1, 11.7, 8.6. HRMS Calculated for $C_{26}H_{25}N_2O_2$ $[M+H]^+$ 397.1911, found: 397.1914.

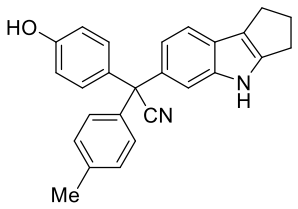


2-(5-Fluoro-2,3-dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3ah):

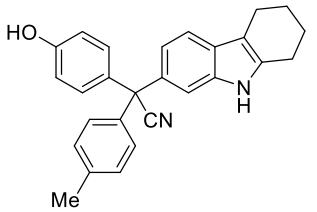
The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 6 hours. 53.4 mg, 70% yield, white foamy solid, mp 276-277 °C, new compound, R_f = 0.25 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.90 (s, 1H), 8.70 (s, 1H), 7.24-7.22 (m, 2H), 7.19-7.13 (m, 3H), 7.08-7.06 (d, *J* = 8.7 Hz, 2H), 6.90-6.88 (m, 2H), 6.48 (d, *J* = 6.6 Hz, 1H), 2.35 (s, 3H), 2.34 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 158.1, 155.9 (d, $^1J_{F\text{-}C}$ = 237.0 Hz), 138.5, 135.4, 132.2, 131.6, 130.6 (d, $^3J_{F\text{-}C}$ = 9.0 Hz), 130.4, 130.1, 128.9, 123.4, 121.9 (d, $^2J_{F\text{-}C}$ = 15.0 Hz), 116.2, 116.2 (d, $^3J_{F\text{-}C}$ = 9.0 Hz), 112.6 (d, $^4J_{F\text{-}C}$ = 3.0 Hz), 107.2 (d, $^4J_{F\text{-}C}$ = 4.0 Hz), 104.5 (d, $^2J_{F\text{-}C}$ = 24.0 Hz), 53.6, 21.0, 11.5, 8.5. ^{19}F NMR (376 MHz, Acetone-d_6) δ -120.81. HRMS Calculated for $C_{25}H_{22}FN_2O$ $[M+H]^+$ 385.1711, found: 385.1709.



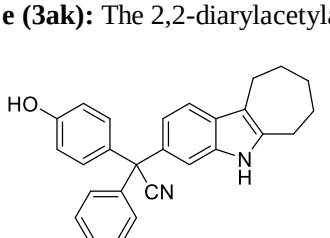
2-(4-Hydroxyphenyl)-2-(1,2,3,4-tetrahydrocyclopenta[*b*]indol-6-yl)-2-(*p*-tolyl)acetonitrile (3ai): The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 20 minutes. 68.0 mg, 90% yield, yellow oily liquid, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (brs, 1H), 7.38 (d, *J* = 8.3 Hz, 1H), 7.14-7.10 (m, 3H), 7.07-7.05 (m, 3H), 6.94 (dd, *J* = 8.3, 1.7 Hz, 1H), 6.76 (d, *J* = 8.6 Hz, 2H), 5.61 (brs, 1H), 2.85-2.8 (m, 4H), 2.56-2.49 (m, 2H), 2.35 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.5, 145.5, 140.7, 138.4, 137.8, 133.3, 132.9, 130.4, 129.3, 128.8, 124.58, 124.2, 120.7, 119.7, 118.5, 115.5, 112.1, 56.8, 28.8, 26.0, 24.5, 21.1. HRMS Calculated for $C_{26}H_{23}N_2O$ $[M+H]^+$ 379.1805, found: 379.1805.



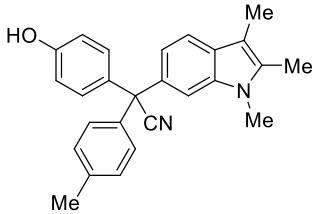
2-(4-Hydroxyphenyl)-2-(2,3,4,9-tetrahydro-1*H*-carbazol-7-yl)-2-(*p*-tolyl)acetonitrile (3aj): The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 20 minutes. 72.6 mg, 93% yield, white foamy solid, mp 143-144 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (s, 1H), 7.41 (d, *J* = 8.3 Hz, 1H), 7.14-7.09 (m, 4H), 7.06-7.04 (m, 2H), 7.01 (d, *J* = 1.1 Hz, 1H), 6.95 (dd, *J* = 8.3, 1.6 Hz, 1H), 6.78-6.71 (m, 2H), 5.76 (brs, 1H), 2.69 (s, 4H), 2.35 (s, 3H), 1.91-1.82 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 138.4, 137.8, 135.8, 135.4, 133.5, 133.4, 130.4, 129.3, 128.9, 127.4, 124.6, 120.3, 117.9, 115.4, 111.2, 110.3, 56.8, 23.4, 23.3, 23.2, 21.1, 21.0. HRMS Calculated for $C_{27}H_{25}N_2O$ $[M+H]^+$ 393.1961, found: 393.1963.



2-(5,6,7,8,9,10-Hexahydrocyclohepta[*b*]indol-3-yl)-2-(4-hydroxyphenyl)-2-(*p*-tolyl)acetonitrile (3ak): The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 20 minutes. 75.6 mg, 93% yield, white foamy solid, mp 147-148 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 10.63 (brs, 1H), 9.42 (s, 1H), 8.21 (d, *J* = 8.4 Hz, 1H), 8.00-7.98 (m, 2H), 7.92-7.90 (m, 2H), 7.84-7.82 (m, 2H), 7.77 (s, 1H), 7.70 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.66-7.64 (m, 2H), 3.66-3.55 (m, 4H), 3.12 (s, 3H), 2.67-2.61 (m, 2H), 2.54-2.51 (m, 4H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 157.9, 140.3, 139.9, 138.3, 135.1, 133.6, 133.1, 130.8, 129.9, 129.6, 129.4, 125.1, 120.2, 118.2, 116.0, 113.7, 111.7, 57.4, 32.7, 29.8, 29.6, 28.3, 25.3, 21.0. HRMS Calculated for $C_{28}H_{27}N_2O$ $[M+H]^+$ 407.2118, found: 407.2116.



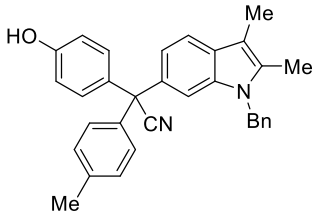
2-(4-Hydroxyphenyl)-2-(*p*-tolyl)-2-(1,2,3-trimethyl-1*H*-indol-6-yl)acetonitrile (3al): The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 20 minutes. 69.5 mg, 91% yield, yellow foamy solid, mp 111-112 °C, new compound, R_f = 0.45 (hexanes/ ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 (d, *J* = 8.3 Hz, 1H), 7.21-7.17 (m, 5H), 7.14-7.12 (m, 2H), 6.93 (dd, *J* = 8.3, 1.6 Hz, 1H), 6.85-6.82 (d, *J* = 8.7 Hz, 2H), 6.23 (s, 1H), 3.57 (s, 3H), 2.40 (s,



3H), 2.37 (s, 3H), 2.30 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 138.4, 137.8, 136.2, 134.4, 133.1, 132.8, 130.3, 129.3, 128.8, 128.0, 124.7, 119.7, 118.0, 115.5, 109.0, 106.3, 57.0, 29.6, 21.1, 10.3, 8.9. HRMS Calculated for $C_{26}H_{25}N_2O$ $[M+H]^+$ 381.1961, found: 381.1964.

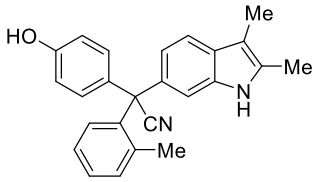
2-(1-benzyl-2,3-dimethyl-1H-indol-6-yl)-2-(4-hydroxyphenyl)-2-(p-tolyl)acetonitrile (3am):

The 2,2-diarylacetylacetone **1a** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hours. 79.1 mg, 87% yield, yellow foamy solid, mp 101-102 °C, new compound, R_f = 0.50 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 8.2 Hz, 1H), 7.25-7.20 (m, 3H), 7.09-7.05 (m, 4H), 7.02-6.97 (m, 4H), 6.91-6.89 (m, 2H), 6.77-6.72 (m, 2H), 5.67 (brs, 1H), 5.15 (s, 2H), 2.36 (s, 3H), 2.32 (s, 3H), 2.29 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 138.3, 137.7, 137.7, 136.0, 134.1, 133.1, 132.9, 130.2, 129.2, 128.8, 128.7, 128.3, 127.3, 126.4, 124.5, 120.0, 118.1, 115.4, 109.8, 107.2, 56.8, 46.8, 21.1, 10.5, 8.9. HRMS Calculated for $C_{32}H_{28}N_2O$ $[M+H]^+$ 457.2274, found: 457.2273.



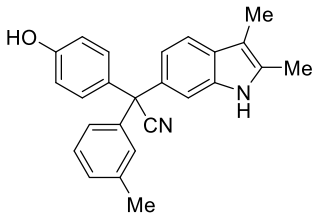
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*o*-tolyl)acetonitrile (3ba):

The 2,2-diarylacetylacetone **1** was oxidized for 4 hours, then indole C6 functionalization was conducted for 7 hours. 53.6 mg, 73% yield, white solid, mp 234-235 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.85 (s, 1H), 8.69 (s, 1H), 7.44 (d, *J* = 8.3 Hz, 1H), 7.30-7.25 (m, 2H), 7.13-7.05 (m, 1H), 7.03-7.01 (m, 3H), 6.92-6.88 (m, 3H), 6.56 (d, *J* = 7.9 Hz, 1H), 2.35 (s, 3H), 2.25 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 158.0, 140.7, 138.5, 136.4, 133.6, 133.2, 132.9, 132.3, 130.7, 130.4, 129.9, 129.1, 126.6, 124.1, 119.9, 118.5, 116.2, 111.3, 106.9, 56.6, 21.7, 11.4, 8.5. HRMS Calculated for $C_{25}H_{23}N_2O$ $[M+H]^+$ 367.1805, found: 367.1808.



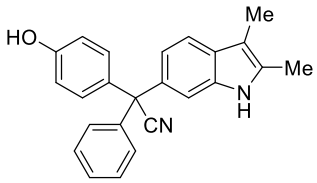
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(*m*-tolyl)acetonitrile (3ca):

The 2,2-diarylacetylacetone **1** was oxidized for 4 hours, then indole C6 functionalization was conducted for 30 minutes. 69.5 mg, 95% yield, white foamy solid, mp 222-223 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (s, 1H), 7.43-7.41 (m, 1H), 7.21-7.16 (m, 1H), 7.13-7.12 (m, 2H), 7.09-7.03 (m, 2H), 6.99-6.93 (m, 3H), 6.80-6.73 (m, 2H), 5.99 (brs, 1H), 2.32 (s, 3H), 2.30 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 141.2, 138.4, 134.8, 133.1, 132.9, 132.5, 130.3, 129.5, 129.0, 128.8, 128.4, 126.1, 124.6, 120.2, 118.1, 115.5, 110.9, 107.1, 57.0, 21.6, 11.6, 8.5. HRMS Calculated for $C_{25}H_{23}N_2O$ $[M+H]^+$ 367.1805, found: 367.1806.



2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-phenylacetonitrile (3da):

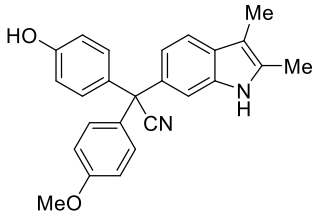
The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 66.5 mg, 94% yield, white foamy solid, mp 106-107 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (s, 1H), 7.42 (d, *J* = 8.8 Hz,



1H), 7.32-7.30 (m, 3H), 7.24-7.22 (m, 2H), 7.06-7.03 (m, 2H), 6.98-6.96 (m, 2H), 6.77-6.75 (m, 2H), 5.87 (brs, 1H), 2.31 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 141.2, 134.8, 133.0, 132.8, 132.6, 130.3, 129.0, 128.9, 128.6, 128.0, 124.5, 120.1, 118.1, 115.5, 110.9, 107.1, 57.1, 11.6, 8.5. HRMS Calculated for $C_{24}H_{21}N_2O$ $[M+H]^+$ 353.1648, found: 353.1645.

2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(4-methoxyphenyl)acetonitrile (3ea):

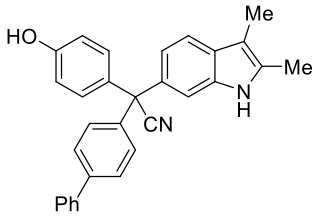
The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1.5 hours. 71.9 mg, 94% yield, white foamy solid, mp 138-139 ºC, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1).



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.41 (d, *J* = 8.8 Hz, 1H), 7.14-7.10 (m, 2H), 7.05-7.04 (m, 2H), 6.97-6.95 (m, 2H), 6.85-6.81 (m, 2H), 6.77-6.73 (m, 2H), 5.88 (brs, 1H), 3.80 (s, 3H), 2.31 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.0, 155.6, 134.8, 133.3, 133.2, 133.0, 132.5, 130.2, 130.1, 128.9, 124.7, 120.0, 118.0, 115.5, 113.9, 110.8, 107.0, 56.4, 55.4, 11.6, 8.5. HRMS Calculated for $C_{25}H_{23}N_2O_2$ $[M+H]^+$ 383.1754, found: 383.1851.

2-([1,1'-Biphenyl]-4-yl)-2-(2,3-dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)acetonitrile (3fa):

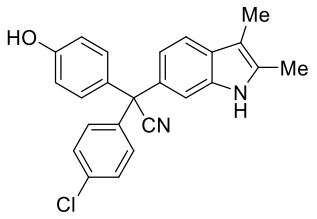
The 2,2-diarylacetylacetone **1** was oxidized for 4.5 hours, then indole C6 functionalization was conducted for 17 hours. 69.9 mg, 82% yield, yellow foamy solid, mp 148-149 ºC, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1).



^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.60-7.53(m, 4H), 7.46-7.43 (m, 3H), 7.38-7.35 (m, 1H), 7.32-7.29 (m, 2H), 7.11-7.09 (m, 2H), 7.02-7.00 (m, 2H), 6.80-7.78 (m, 2H), 5.91 (brs, 1H), 2.32 (s, 3H), 2.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 140.8, 140.3, 140.3, 134.9, 133.1, 133.0, 132.5, 130.4, 129.4, 129.1, 129.0, 127.7, 127.3, 127.2, 124.5, 120.2, 118.2, 115.6, 110.9, 107.2, 56.9, 11.7, 8.5. HRMS Calculated for $C_{30}H_{25}N_2O$ $[M+H]^+$ 429.1961, found: 429.1959.

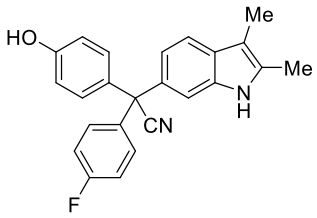
2-(4-Chlorophenyl)-2-(2,3-dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)acetonitrile (3ga):

The 2,2-diarylacetylacetone **1** was oxidized for 2 hours, then indole C6 functionalization was conducted for 1 hour. 70.3 mg, 91% yield, white foamy solid, mp 219-220 ºC, new compound, R_f = 0.30 (hexanes/ethyl acetate 3/1).

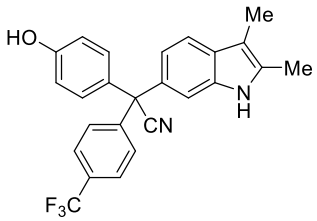


^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (s, 1H), 7.42 (d, *J* = 8.3 Hz, 1H), 7.31-7.27 (m, 2H), 7.19-7.15 (m, 2H), 7.06-7.04 (m, 2H), 6.99 (s, 1H), 6.92 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.79-6.76 (m, 2H), 5.43 (brs, 1H), 2.34 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 139.9, 134.9, 134.1, 132.7, 132.4, 132.4, 130.3, 130.2, 129.2, 128.8, 124.2, 119.9, 118.3, 115.7, 110.8, 107.2, 56.6, 11.6, 8.5. HRMS Calculated for $C_{24}H_{20}ClN_2O$ $[M+H]^+$ 387.1259 (^{35}Cl), 389.1239 (^{37}Cl), found: 387.1262 (^{35}Cl), 389.1248 (^{37}Cl).

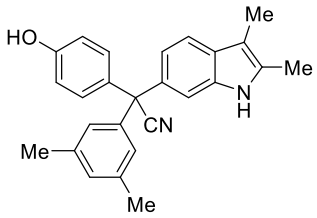
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-fluorophenyl)-2-(4-hydroxyphenyl)acetonitrile (3ha): The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 45 minutes. 70.8 mg, 96% yield, yellow foamy solid, mp 140-141 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.85 (brs, 1H), 8.70 (s, 1H), 7.43 (d, *J* = 8.3 Hz, 1H), 7.29-7.24 (m, 2H), 7.20-7.14 (m, 2H), 7.07-7.03 (m, 2H), 7.01 (d, *J* = 1.3 Hz, 1H), 6.92-6.87 (m, 3H), 2.35 (s, 3H), 2.19 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 162.9 (d, $^1J_{F-C}$ = 245.0 Hz), 158.1, 138.9 (d, $^4J_{F-C}$ = 3.0 Hz), 136.2, 133.7, 133.5, 132.8, 131.5 (d, $^3J_{F-C}$ = 9.0 Hz), 130.7, 129.9, 124.8, 120.0, 118.6, 116.2, 116.1 (d, $^2J_{F-C}$ = 22.0 Hz), 111.5, 106.9, 57.1, 11.4, 8.4. ^{19}F NMR (376 MHz, Acetone-d_6) δ -115.89. HRMS Calculated for $C_{24}H_{20}FN_2O$ $[M+H]^+$ 371.1554, found: 371.1557.



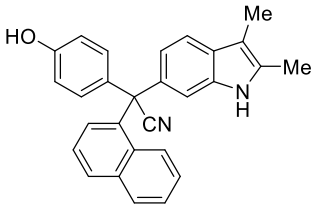
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(4-(trifluoromethyl)phenyl)acetonitrile (3ia): The 2,2-diarylacetylacetone **1** was oxidized for 2.5 hours, then indole C6 functionalization was conducted for 20 minutes. 75.9 mg, 90% yield, yellow foamy solid, mp 253-254 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.89 (brs, 1H), 8.71 (s, 1H), 7.79 (d, *J* = 8.3 Hz, 2H), 7.49 (d, *J* = 8.2 Hz, 2H), 7.44 (d, *J* = 8.3 Hz, 1H), 7.08-7.05 (m, 2H), 7.00 (s, 1H), 6.92- 6.88 (m, 3H), 2.36 (s, 3H), 2.20 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 158.3, 147.3, 136.2, 133.9, 132.8, 132.1, 130.8, 130.3, 130.3 (q, $^2J_{F-C}$ = 32.0 Hz), 130.1 (q, $^3J_{F-C}$ = 8.0 Hz), 130.1, 125.4 (q, $^1J_{F-C}$ = 202.0 Hz), 120.0, 118.7, 116.4, 111.6, 107.0, 57.7, 11.4, 8.4. ^{19}F NMR (376 MHz, Acetone-d_6) δ -63.03. HRMS Calculated for $C_{25}H_{20}F_3N_2O$ $[M+H]^+$ 421.1522, found: 421.1521.



2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(3,5-dimethylphenyl)-2-(4-hydroxyphenyl)acetonitrile (3ja): The 2,2-diarylacetylacetone **1** was oxidized for 2 hours, then indole C6 functionalization was conducted for 15 minutes. 72.1 mg, 95% yield, white foamy solid, mp 133-134 °C, new compound, R_f = 0.35 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.82 (brs, 1H), 8.60 (s, 1H), 7.40 (d, *J* = 8.3 Hz, 1H), 7.05-7.01 (m, 2H), 7.00 (s, 1H), 6.99 (d, *J* = 1.7 Hz, 1H), 6.90 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.86-6.84 (m, 4H), 2.35 (s, 3H), 2.25 (s, 6H), 2.19 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 157.9, 142.7, 138.8, 136.1, 133.9, 133.5, 133.1, 130.8, 130.1, 129.8, 127.3, 125.1, 120.2, 118.3, 116.0, 111.6, 106.8, 57.6, 21.4, 11.4, 8.5. HRMS Calculated for $C_{26}H_{25}N_2O$ $[M+H]^+$ 381.1961, found: 381.1965.



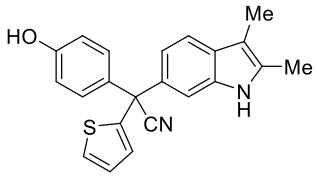
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(naphthalen-1-yl)acetonitrile (3ka): The 2,2-diarylacetylacetone **1** was oxidized for 2 h, then C6 functionalization was conducted for 1 hour. 73.2 mg, 91% yield, yellow foamy solid, mp 168-169 °C, new compound, R_f = 0.45



(hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (dd, *J* = 15.4, 8.3 Hz, 2H), 7.65 (d, *J* = 7.9 Hz, 1H), 7.57-7.55 (m, 2H), 7.50-7.39 (m, 4H), 7.07 (d, *J* = 8.7 Hz, 2H), 7.01-6.98 (m, 2H), 6.76-6.73 (m, 2H), 5.62 (brs, 1H), 2.28 (s, 3H), 2.19 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 138.6, 134.8, 132.9, 132.7, 132.7, 132.6, 132.5, 130.4, 129.0, 128.4, 128.4, 127.9, 127.6, 126.9, 126.7, 126.7, 124.5, 120.2, 118.1, 115.6, 111.0, 107.1, 57.2, 11.5, 8.5. HRMS Calculated for $C_{28}H_{23}N_2O$ $[M+H]^+$ 403.1805, found: 403.1803.

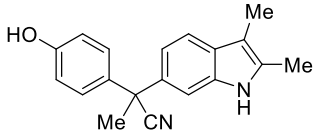
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)-2-(thiophen-2-yl)acetonitrile (3la):

The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 2 hours. 64.7 mg, 90% yield, yellow foamy solid, mp 139-140 °C, new compound, R_f = 0.30 (hexanes/ethyl acetate 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (s, 1H), 7.43 (d, *J* = 8.3 Hz, 1H), 7.29 (dd, *J* = 4.7, 1.6 Hz, 1H), 7.18-7.16 (m, 2H), 7.13 (s, 1H), 7.04 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.99-6.96 (m, 2H), 6.78-6.75 (m, 2H), 5.41 (brs, 1H), 2.34 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 145.5, 134.8, 133.4, 133.4, 132.7, 129.6, 129.3, 128.4, 126.9, 126.8, 123.3, 119.4, 118.1, 115.5, 110.1, 107.2, 53.3, 11.7, 8.5. HRMS Calculated for $C_{22}H_{19}N_2OS$ $[M+H]^+$ 359.1213, found: 359.1212.



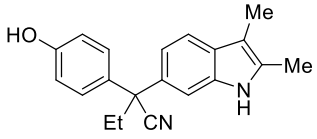
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl)propanenitrile (3ma):

The 2,2-diarylacetylacetone **1** was oxidized for 2 hours, then indole C6 functionalization was conducted for 1 hour. 33.2 mg, 57% yield, yellow oily liquid, new compound, R_f = 0.50 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (brs, 1H), 7.42 (d, *J* = 8.3 Hz, 1H), 7.27 (d, *J* = 7.5 Hz, 1H), 7.23-7.19 (m, 2H), 7.01 (dd, *J* = 8.3, 1.7 Hz, 1H), 6.78-6.75 (m, 2H), 5.24 (brs, 1H), 2.34 (s, 3H), 2.20 (s, 3H), 2.09 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 135.0, 134.2, 132.2, 128.9, 128.2, 124.6, 118.3, 117.8, 115.7, 108.6, 107.2, 45.7, 28.8, 11.7, 8.5. HRMS Calculated for $C_{19}H_{19}N_2O$ $[M+H]^+$ 291.1492, found: 291.1490.



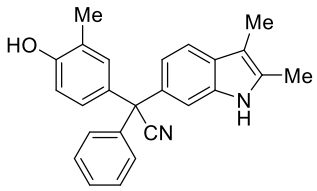
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxyphenyl) (3na):

The 2,2-diarylacetylacetone **1** was oxidized for 4 hours, then indole C6 functionalization was conducted for 24 hours. 35.5 mg, 58% yield, yellow oily liquid, new compound, R_f = 0.20 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (s, 1H), 7.42 (d, *J* = 8.3 Hz, 1H), 7.28 (d, *J* = 1.4 Hz, 1H), 7.22-7.18 (m, 2H), 7.00 (dd, *J* = 8.3, 1.7 Hz, 1H), 6.78-6.74 (m, 2H), 6.15 (brs, 1H), 2.41 (q, *J* = 7.2 Hz, 2H), 2.32 (s, 3H), 2.20 (s, 3H), 1.03 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 135.1, 133.1, 132.8, 132.2, 128.8, 128.5, 123.5, 118.3, 117.9, 115.7, 109.2, 107.0, 52.1, 33.2, 11.6, 10.3, 8.5. HRMS Calculated for $C_{20}H_{21}N_2O$ $[M+H]^+$ 305.1648, found: 305.1650.



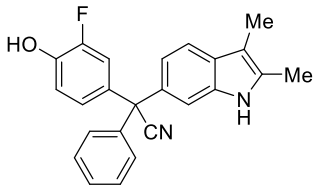
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(4-hydroxy-3-methylphenyl)-2-phenylacetonitrile (3oa):

The 2,2-diarylacetylacetone **1** was oxidized for 2 hours, then indole C6 functionalization was conducted for 20 minutes. 65.3 mg, 89% yield, white foamy solid, mp 130-131 °C, new compound, R_f = 0.45 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.85 (brs, 1H), 8.55 (s, 1H), 7.44-7.37 (m, 4H), 7.28-7.25 (m, 2H), 7.03-7.01 m, 2H), 6.92 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.86-6.80 (m, 2H), 2.36 (s, 3H), 2.21 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 156.0, 142.9, 136.2, 133.8, 133.6, 132.9, 131.9, 129.9, 129.5, 129.3, 128.6, 128.1, 125.3, 125.1, 120.2, 118.4, 115.3, 111.6, 106.8, 57.8, 16.4, 11.4, 8.5. HRMS Calculated for $C_{25}H_{23}N_2O$ $[M+H]^+$ 367.1805, found: 367.1803.



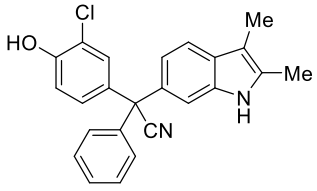
2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-(3-fluoro-4-hydroxyphenyl)-2-phenylacetonitrile (3pa):

The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 50 minutes. 70.2 mg, 95% yield, white foamy solid, mp 133-134 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (s, 1H), 7.43 (d, *J* = 8.3 Hz, 1H), 7.36-7.31 (m, 3H), 7.26-7.22 (m, 2H), 7.02 (d, *J* = 1.6 Hz, 1H), 6.97-6.91 (m, 4H), 5.53 (brs, 1H), 2.34 (s, 3H), 2.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.8 (d, $^1J_{F\text{-}C}$ = 238.0 Hz), 143.5 (d, $^{12}J_{F\text{-}C}$ = 14.0 Hz), 140.8, 134.9, 133.8 (d, $^3J_{F\text{-}C}$ = 5.0 Hz), 132.7, 132.5, 129.2, 128.8, 128.7, 128.2, 125.4 (d, $^3J_{F\text{-}C}$ = 3.0 Hz), 124.0, 120.0, 118.2, 117.4 (d, $^4J_{F\text{-}C}$ = 2.0 Hz), 116.8, 116.6, 110.8, 107.2, 57.0 (d, $^4J_{F\text{-}C}$ = 1.0 Hz), 11.6, 8.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -139.04. HRMS Calculated for $C_{24}H_{19}FN_2O$ $[M+H]^+$ 371.1554, found: 371.1552.



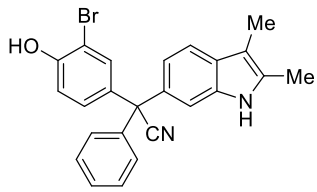
2-(3-Chloro-4-hydroxyphenyl)-2-(2,3-dimethyl-1*H*-indol-6-yl)-2-phenylacetonitrile (3qa):

The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 50 minutes. 71.5 mg, 92% yield, white foamy solid, mp 126-127 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, Acetone-d_6) δ 9.87 (brs, 1H), 9.15 (s, 1H), 7.45-7.37 (m, 4H), 7.28-7.26 (m, 2H), 7.12 (s, 1H), 7.08-7.03 (m, 2H), 7.02 (s, 1H), 6.91 (d, *J* = 8.3 Hz, 1H), 2.35 (s, 3H), 2.20 (s, 3H). ^{13}C NMR (100 MHz, Acetone-d_6) δ 153.6, 142.0, 136.1, 134.6, 133.8, 132.9, 130.9, 130.0, 129.5, 129.4, 129.4, 128.9, 124.5, 121.2, 119.9, 118.6, 117.6, 111.5, 106.9, 57.5, 11.4, 8.4. HRMS Calculated for $C_{24}H_{20}Cl\ N_2O$ $[M+H]^+$ 387.1259 (^{35}Cl), 389.1239 (^{37}Cl), found: 387.1260 (^{35}Cl), 389.1234 (^{37}Cl).



2-(3-Bromo-4-hydroxyphenyl)-2-(2,3-dimethyl-1*H*-indol-6-yl)-2-phenylacetonitrile (3ra):

The 2,2-diarylacetylacetone **1** was oxidized for 3 hours, then indole C6 functionalization was conducted for 1 hour. 81.5 mg, 95% yield, white foamy solid, mp 115-116 °C, new compound, R_f = 0.40 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (s, 1H), 7.44 (d, *J* = 8.3 Hz, 1H), 7.36-7.33 (m, 4H), 7.25-7.22 (m, 2H),



7.08 (dd, *J* = 8.6, 2.3 Hz, 1H), 7.02 (d, *J* = 1.4 Hz, 1H), 6.98-6.93 (m, 2H), 5.69 (brs, 1H), 2.35 (s, 3H), 2.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.2, 140.8, 134.9, 134.8, 132.6, 132.5, 132.4, 129.9, 129.2, 128.9, 128.8, 128.2, 123.9, 120.0, 118.3, 116.0, 110.8, 110.5, 107.3, 56.8, 11.7, 8.5. HRMS Calculated for $C_{24}H_{20}N_2O$ $[M+H]^+$ 431.0754 (^{79}Br), 433.0736 (^{81}Br), found: 431.0755 (^{79}Br), 431.0736 (^{81}Br).

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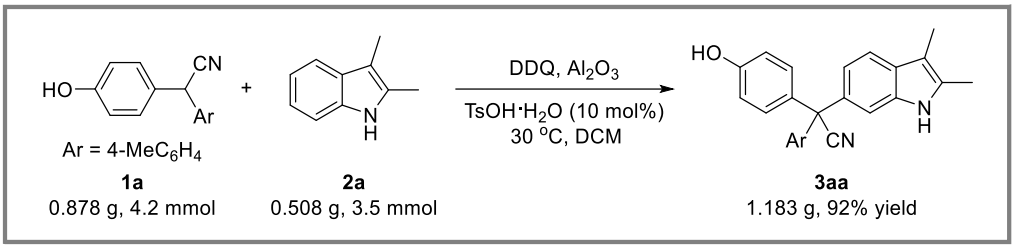
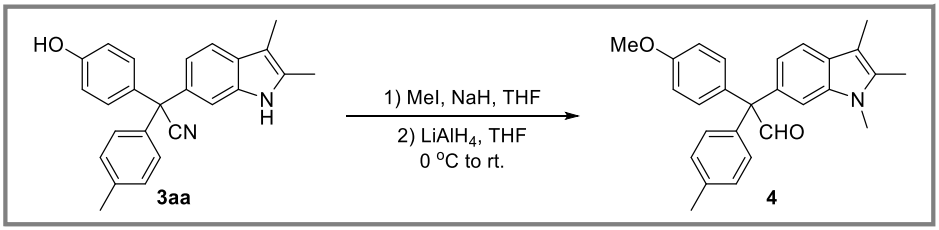
3. Experiment at Gram Scale and Synthetic Transformations

3.1 Experiment at Gram Scale



To a solution of 2,2-diarylacetonitrile **1a** (0.878 g, 4.2 mmol) in dichloromethane (20 mL) was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (0.885 g, 3.9 mmol) and aluminum oxide (base, 1.200 g) at room temperature. The reaction was stirred at 30 °C for 3 hours, followed by 2,3-dimethylindole **2a** (0.508 g, 3.5 mmol) and *p*-toluenesulfonic acid monohydrate (0.067 g, 0.35 mmol). The reaction continued to stir at 30 °C for 1 hour (TLC monitoring). Then, the volatiles were removed under reduced pressure, and the residue was purified by column chromatography on silca gel using hexanes/dichloromethane (10:1 to 3:1) as eluent to afford the desirable products **3aa**.

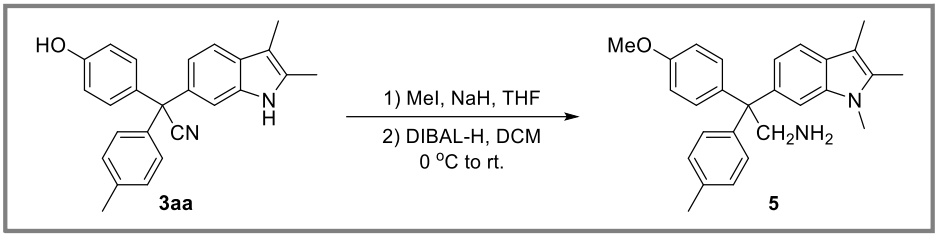
3.2 Synthetic Transformations[3]



To a solution of **3aa** (36.6 mg, 0.10 mmol) in THF (5.0 mL) was added NaH (60% in mineral oil, 12.0 mg, 0.30 mmol) under nitrogen and the reaction mixture was stirred at 0 °C for 30 min. Then MeI (15 uL, 0.3 mmol) was added. The reaction was allowed to warm to room temperature. Once reaction was determined to be complete via thin layer chromatographic analysis, the reaction was quenched with saturated aqueous ammonium chloride at 0 °C. The aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent. Then to a solution of the product in dichloromethane (2.0 mL) was added lithium aluminum hydride (7.6 mg, 0.20 mmol) at 0 °C and degassed with nitrogen. The reaction mixture was stirred 16 hours at the room temperature. The mixture was quenched with water at 0 °C. The aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried

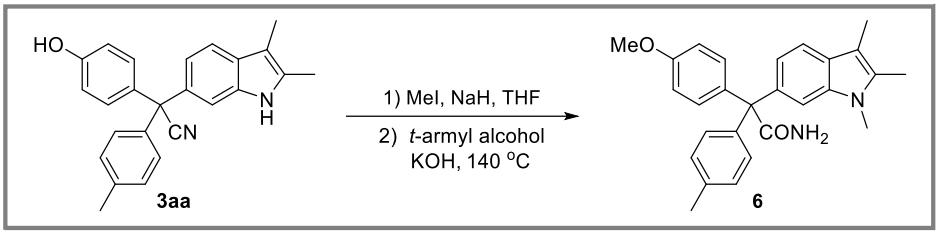
over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent to afford the product **4**.

2-(4-Methoxyphenyl)-2-(*p*-tolyl)-2-(1,2,3-trimethyl-1*H*-indol-6-yl)acetaldehyde (4):
31.5 mg, 79% yield, colorless viscous liquid, new compound, R_f = 0.80 (hexanes/ethyl acetate 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.1 Hz, 1H), 7.11-7.04 (m, 6H), 6.95 (s, 1H), 6.88 (dd, *J* = 8.1, 1.3 Hz, 1H), 6.85-6.81 (m, 2H), 5.63 (s, 1H), 3.80 (s, 3H), 3.55 (s, 3H), 2.34 (s, 3H), 2.33 (s, 3H), 2.25 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.9, 142.4, 137.5, 137.2, 136.7, 135.5, 132.7, 130.5, 129.5, 129.0, 126.9, 120.8, 117.7, 113.6, 109.3, 106.1, 56.1, 55.4, 29.6, 21.2, 10.3, 9.0. HRMS Calculated for $C_{27}H_{28}NO_2$ $[M+H]^+$ 398.2115, found: 398.2116.



To a solution of **3aa** (36.6 mg, 0.10 mmol) in THF (5.0 mL) was added NaH (60% in mineral oil, 12.0 mg, 0.30 mmol) under nitrogen and the reaction mixture was stirred at 0 °C for 30 min. Then MeI (15 uL, 0.3 mmol) was added. The reaction was allowed to warm to room temperature. Once reaction was determined to be complete via thin layer chromatographic analysis, the reaction was quenched with saturated aqueous ammonium chloride at 0 °C. The aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent. Then to a solution of the product in dichloromethane (2.0 mL) was added diisobutylaluminum hydride (1.0 M in toluene, 0.30 mmol) at 0 °C and degassed with nitrogen. The reaction mixture was stirred at the room temperature overnight. The mixture was quenched with saturated aqueous ammonium chloride at 0 °C. The aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent to afford **5**.

2-(4-Methoxyphenyl)-2-(*p*-tolyl)-2-(1,2,3-trimethyl-1*H*-indol-6-yl)ethan-1-amine (5):
27.5 mg, 69% yield, colorless viscous liquid, new compound, R_f = 0.40 (hexanes/ethyl acetate 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, *J* = 8.3 Hz, 1H), 7.20- 7.16 (m, 2H), 7.14-7.08 (m, 4H), 7.05 (d, *J* = 1.3 Hz, 1H), 6.87 (dd, *J* = 8.3, 1.6 Hz, 1H), 6.84-6.81 (m, 2H), 4.66 (d, *J* = 4.4 Hz, 2H), 3.80 (s, 3H), 3.53 (s, 3H), 2.34 (s, 6H), 2.25 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.9, 143.5, 138.5, 137.5, 136.4, 135.8, 133.2, 130.6, 129.3, 128.8, 126.8, 120.5, 117.6, 113.3, 109.7, 106.0, 71.0, 58.2, 55.2, 29.5, 21.0, 10.2, 8.8. HRMS Calculated for $C_{27}H_{30}N_2O$ $[M+H]^+$ 399.2431, found: 399.2465.



To a solution of **3aa** (36.6 mg, 0.10 mmol) in THF (5.0 mL) was added NaH (60% in mineral oil, 12.0 mg, 0.30 mmol) under nitrogen and the reaction mixture was stirred at 0 °C for 30 min. Then MeI (15 uL, 0.3 mmol) was added. The reaction was allowed to warm to room temperature. Once reaction was determined to be complete via thin layer chromatographic analysis, the reaction was quenched with saturated aqueous ammonium chloride at 0 °C. The aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent. Then to a solution of the product in *t*-armyl alcohol (2.0 mL) was added potassium hydroxide (56.1 mg, 0.50 mmol) and the mixture was heated to 140 °C for 48 hours. After cooling to room temperature, the mixture was passed through a pad of celite. Then the filtrate was removed under vacuum and the residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (3:1) as eluent to afford the product **6**.

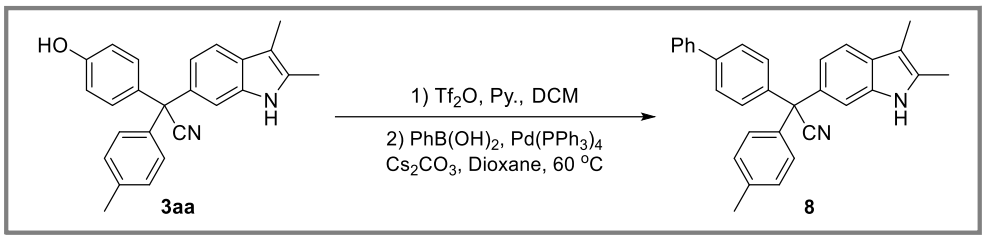
2-(4-Methoxyphenyl)-2-(*p*-tolyl)-2-(1,2,3-trimethyl-1*H*-indol-6-yl)acetamide (6):
35.0 mg, 85% yield, colorless viscous liquid, new compound, R_f = 0.20 (hexanes/ethyl acetate 3/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.3 Hz, 1H), 7.24-7.19 (m, 4H), 7.17 (d, *J* = 1.1 Hz, 1H), 7.06 (d, *J* = 8.1 Hz, 2H), 6.89 (dd, *J* = 8.3, 1.5 Hz, 1H), 6.80-6.78 (m, 2H), 6.16 (s, 1H), 5.90 (s, 1H), 3.77 (s, 3H), 3.50 (s, 3H), 2.31 (s, 6H), 2.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.2, 158.2, 141.4, 136.5, 136.3, 136.1, 133.6, 131.7, 130.4, 128.5, 127.0, 122.0, 117.2, 113.0, 110.4, 106.1, 66.9, 55.2, 29.5, 21.0, 10.2, 8.8. HRMS Calculated for $C_{27}H_{28}N_2O_2$ $[M+H]^+$ 413.2224, found: 413.2229.

To a solution of **3aa** (36.6 mg, 0.10 mmol) in dichloromethane (2.0 mL) were added pyridine (16 uL, 0.20 mmol) and a solution of trifluoromethanesulfonic anhydride (20 uL, 0.12 mmol) in dichloromethane (2.0 mL) sequentially. The reaction mixture was stirred for 5 hours. Then water (10 mL) was added. The layers were separated, and the aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent. Then a mixture of the product, 10% Pd/C (10.6 mg, 0.01 mmol, 10 wt %), ammonium acetate (15.4 mg, 0.20 mmol), and

magnesium (12.0 mg, 0.50 mmol) in methanol (3.0 mL) was stirred at room temperature under hydrogen balloon for 12 h. Then the crude product was directly purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent to afford the desirable product **7**.

2-(2,3-Dimethyl-1*H*-indol-6-yl)-2-phenyl-2-(*p*-tolyl)acetonitrile (7):

27.9 mg, 80% yield, colorless viscous liquid, new compound, R_f = 0.45 (hexanes/ethyl acetate 10/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (s, 1H), 7.42 (d, *J* = 8.3 Hz, 1H), 7.34-7.30 (m, 3H), 7.26-7.23 (m, 2H), 7.15-7.11 (m, 4H), 7.00 (d, *J* = 1.3 Hz, 1H), 6.97 (dd, *J* = 8.3, 1.7 Hz, 1H), 2.36 (s, 3H), 2.33 (s, 3H), 2.21 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.4, 138.3, 137.9, 134.9, 133.2, 132.3, 129.3, 129.0, 128.9, 128.6, 128.0, 124.4, 120.3, 118.1, 110.9, 107.3, 57.4, 21.1, 11.7, 8.5. HRMS Calculated for $C_{25}H_{22}N_2$ $[M+H]^+$ 351.1856, found: 351.1859.



To a solution of **3aa** (36.6 mg, 0.10 mmol) in dichloromethane (2.0 mL) were added pyridine (16 uL, 0.20 mmol) and a solution of trifluoromethanesulfonic anhydride (20 uL, 0.12 mmol) in dichloromethane (2.0 mL) sequentially. The reaction mixture was stirred for 5 hours. Then water (10 mL) was added. The layers were separated, and the aqueous layer was extracted with ethyl acetate (10 mL×3). The combined organic layers were washed with brine (10 mL), dried over anhydrous sodium sulfate, filtered, and concentrated. The residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent. Then to a solution of the product, phenylboronic acid (18.3 mg, 0.15 mmol), cesium carbonate (97.7 mg, 0.30 mmol) in dioxane (2.0 mL) was added tetrakis(triphenylphosphine)palladium (17.3 mg, 0.015 mmol) and degassed with nitrogen. The reaction mixture was stirred at 60 °C for 48 hours and then filtered through a short pad of celite, which was washed three times with dichloromethane. The filtrate was concentrated and the residue was purified by flash chromatography on silica gel using hexanes/ethyl acetate (10:1) as eluent to afford **8**.

2-([1,1'-Biphenyl]-4-yl)-2-(2,3-dimethyl-1*H*-indol-6-yl)-2-(*p*-tolyl)acetonitrile (8):

39.0 mg, 91% yield, colorless viscous liquid, new compound, R_f = 0.60 (hexanes/ethyl acetate 5/1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (brs, 1H), 7.61-7.55 (m, 4H), 7.47-7.43 (m, 3H), 7.38 (d, *J* = 7.3 Hz, 1H), 7.35-7.32 (m, 2H), 7.20-7.14 (m, 4H), 7.07 (d, *J* = 1.3 Hz, 1H), 7.03 (dd, *J* = 8.3, 1.7 Hz, 1H), 2.38 (s, 3H), 2.35 (s, 3H), 2.23 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.8, 140.4, 140.4, 138.2, 137.9, 134.9, 133.2, 132.4, 129.5, 129.4, 129.1, 129.0, 128.9, 127.7, 127.2, 127.2, 124.3, 120.3, 118.2, 110.9, 107.3, 57.2, 21.2, 11.7, 8.6. HRMS Calculated for $C_{31}H_{26}N_2$ $[M+H]^+$ 427.2169, found: 427.2176.

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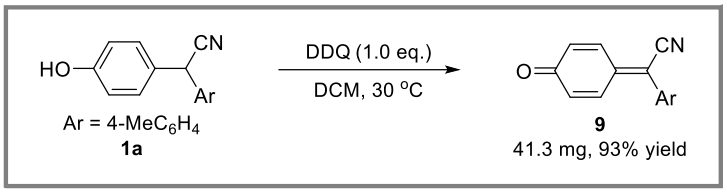
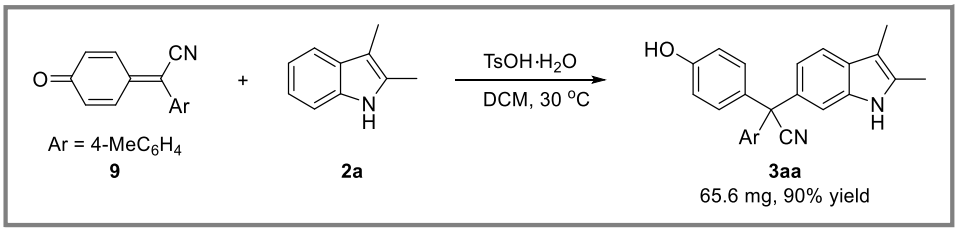
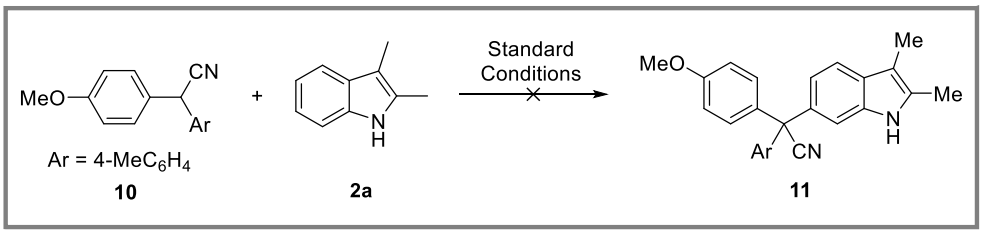
4. Control Experiments



To a solution of **1a** (44.6 mg, 0.20 mmol, 1.0 equiv) in dichloromethane (2.0 mL) was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (45.4 mg, 0.20 mmol, 1.0 equiv) and it was stirred at rt for 1 hour. Then it was purified directly by silica gel chromatography using hexanes/ethyl acetate (10:1) as eluent to afford **9**. 41.3 mg, 93% yield, known compound[4]. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (dd, *J* = 10.0, 2.6 Hz, 1H), 7.50 (dd, *J* = 10.1, 2.6 Hz, 1H), 7.43 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 6.60 (dd, *J* = 10.0, 1.8 Hz, 1H), 6.48 (dd, *J* = 10.1, 1.8 Hz, 1H), 2.45 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 186.6, 142.3, 139.1, 137.1, 134.7, 131.2, 130.6, 130.1, 129.3, 124.3, 117.2, 21.6.

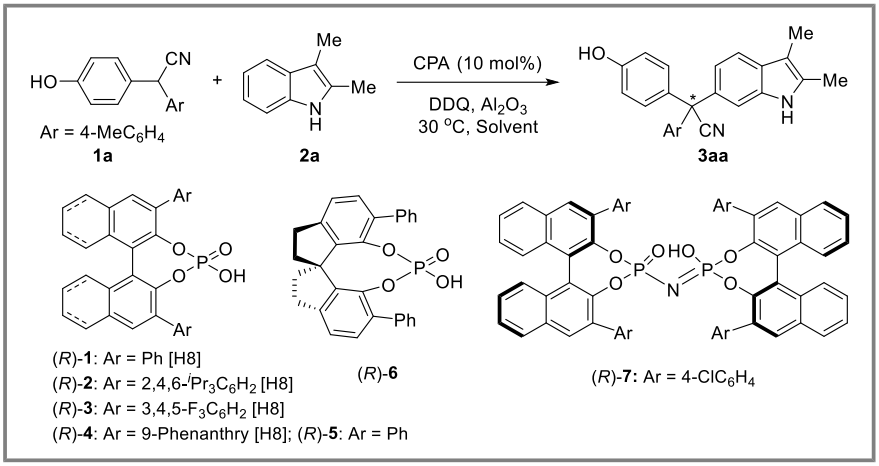


To a solution of **4** (44.2 mg, 0.20 mmol) in dichloromethane (2.0 mL) was added 2,3-dimethylindole **2a** (29.0 mg, 0.20 mmol) and *p*-toluenesulfonic acid monohydrate (3.9 mg, 0.02 mmol). The reaction mixture was stirred for 1 hour at 30 °C. Then it was purified directly by silica gel chromatography using hexanes/ethyl acetate (10:1 to 3:1) as eluent to afford **3aa** (65.6 mg, 90% yield).



To a solution of 2,2-diarylacetonitrile **10** (56.9 mg, 0.24 mmol) in dichloromethane (2.0 mL) was added 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (49.9 mg, 0.22 mmol) and aluminum oxide (base, 80.0 mg) at room temperature. The reaction was stirred at 30 °C for 3 hours, followed by 2,3-dimethylindole **2a** (29.0 mg, 0.20 mmol) and *p*-toluenesulfonic acid monohydrate (3.8 mg, 0.02 mmol). The reaction continued to stir at 30 °C for 1 hour (TLC monitoring). The reaction didn't produce the target product **11**.

5. Preliminary Investigation on the Catalytic Asymmetric Version



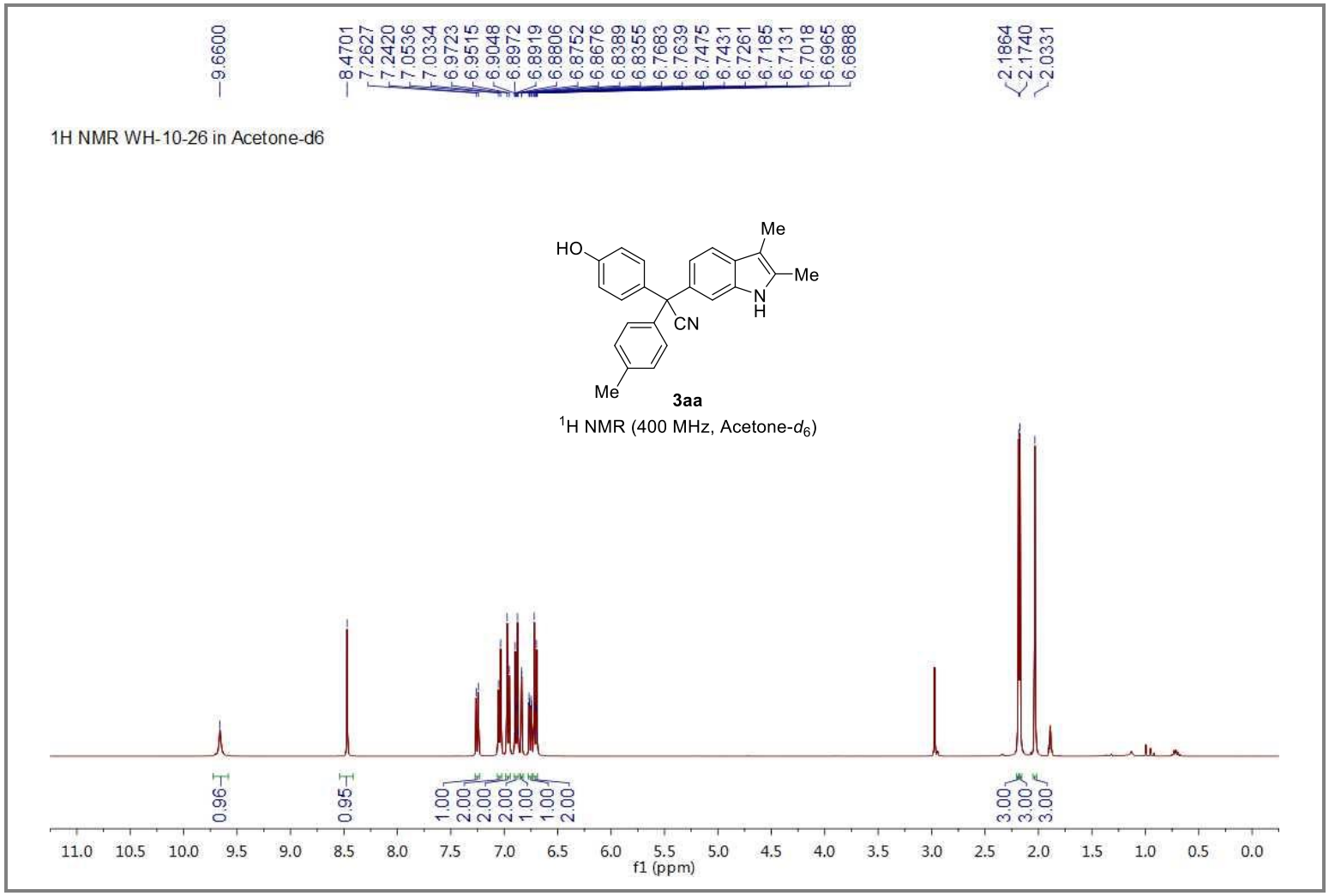
Entry [a]	CPA	Solvent	Yield [b](%)	ee [c](%)
1	(*R*)-**1**	DCM	84	18
2	(*R*)-**2**	DCM	62	6
3	(*R*)-**3**	DCM	94	33
4	(*R*)-**4**	DCM	90	13
5	(*R*)-**5**	DCM	88	16
6	(*R*)-**6**	DCM	73	13
7	(*R*)-**7**	DCM	91	1
8	(*R*)-**3**	THF	27	3
9	(*R*)-**3**	MeCN	70	6
10	(*R*)-**3**	Toluene	93	25

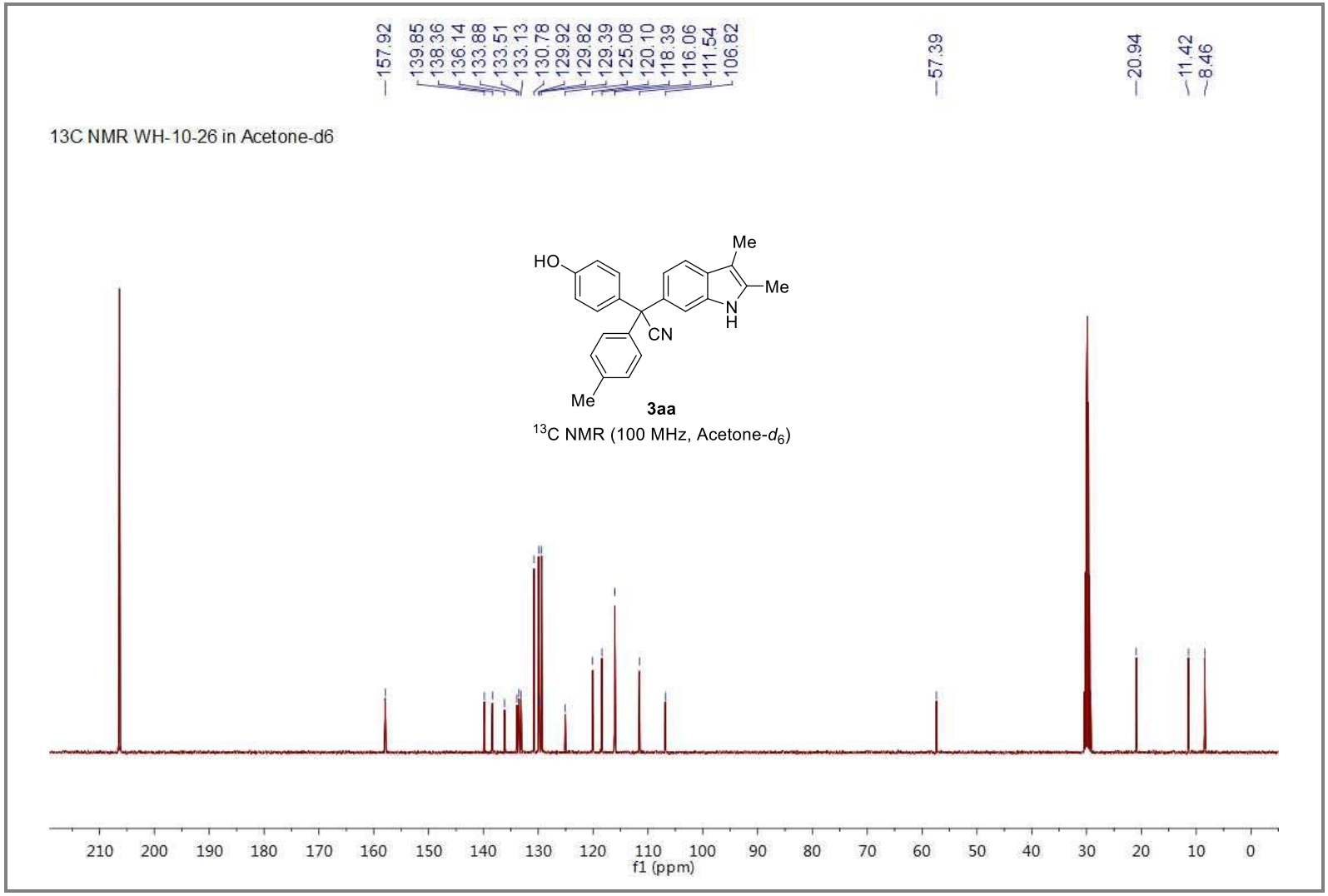
Reaction Conditions: [a] **1a** (0.24 mmol), Al_2O_3 (basic, 80.0 mg), DDQ (0.22 mmol), DCM (2.0 mL), 30 °C, 3 hours. Then **2a** (0.20 mmol), CPA (10 mol%), 2 hours. [b] Yield of isolated product. [c] Determined by HPLC (Entry 3, Chiracel OD-H, 254 nm, 30 °C, *n*-Hexane/*i*-PrOH = 80/20, flow = 0.8 mL/min, retention time 7.6 min (major) and 11.3 min, 33% ee).

6. References

1. (a) X. Liu, C. Zhao, R. Zhu and L. Liu, Construction of Vicinal Quaternary Carbon Stereocenters Through Diastereo- and Enantioselective Oxidative 1,6-Conjugate Addition, *Angew. Chem. Int. Ed*., 2021, **60**, 18499-18503; (b) Y. Mao, Z. Wang, G. Wang, R. Zhao, L. Kan, X. Pan and L. Liu, Redox Deracemization of Tertiary Stereocenters Adjacent to an Electron-Withdrawing Group, *ACS Catal*., 2020, **10**, 7785-7791.
2. L. Wang, J. Zhou, T.-M. Ding, Z.-Q. Yan, S.-H. Hou, G.-D. Zhu and S.-Y. Zhang, Asymmetric *N*-Hydroxyalkylation of Indoles with Ethyl Glyoxalates Catalyzed by a Chiral Phosphoric Acid: Highly Enantioselective Synthesis of Chiral *N*,*O*-Aminal Indole Derivatives, *Org. Lett*., 2019, **21**, 2795-2799.
3. (a) X. Pan, Z. Wang, L. Kan, Y. Mao, Y. Zhua and L. Liu, Cross-dehydrogenative Coupling Enables Enantioselective Access to CF_3-substituted Allcarbon Quaternary Stereocenters, *Chem. Sci*., 2020, **11**, 2414-2419; (b) Z. Wang, Y. Zhu, X. Pan, G. Wang and L. Liu, Synthesis of Chiral Triarylmethanes Bearing All-Carbon Quaternary Stereocenters: Catalytic Asymmetric Oxidative Cross-Coupling of 2,2-Diarylacetonitriles and (Hetero)arenes, *Angew. Chem. Int. Ed*., 2020, **59**, 3053-3057.
4. Y. Zhu, H. Wang, G. Wang, Z. Wang, Z. Liu and L. Liu, Enantioselective Construction of Single and Vicinal All-Carbon Quaternary Stereocenters through Ion-Pair-Catalyzed 1,6-Conjugate Addition, *Org. Lett*., 2021, **23**, 7248-7253.

7. Copy of NMR and HPLC Spectra

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139.85
138.36
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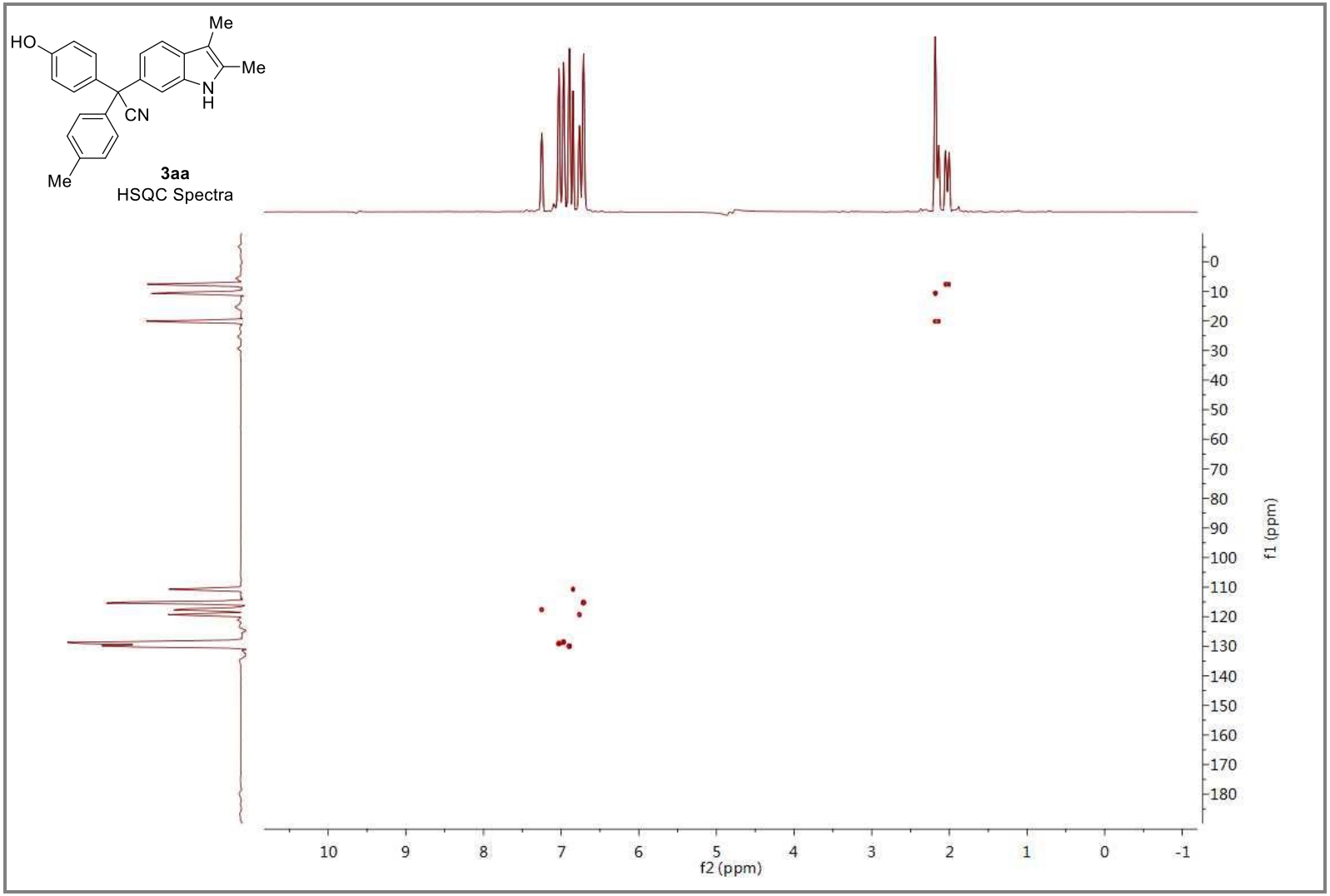
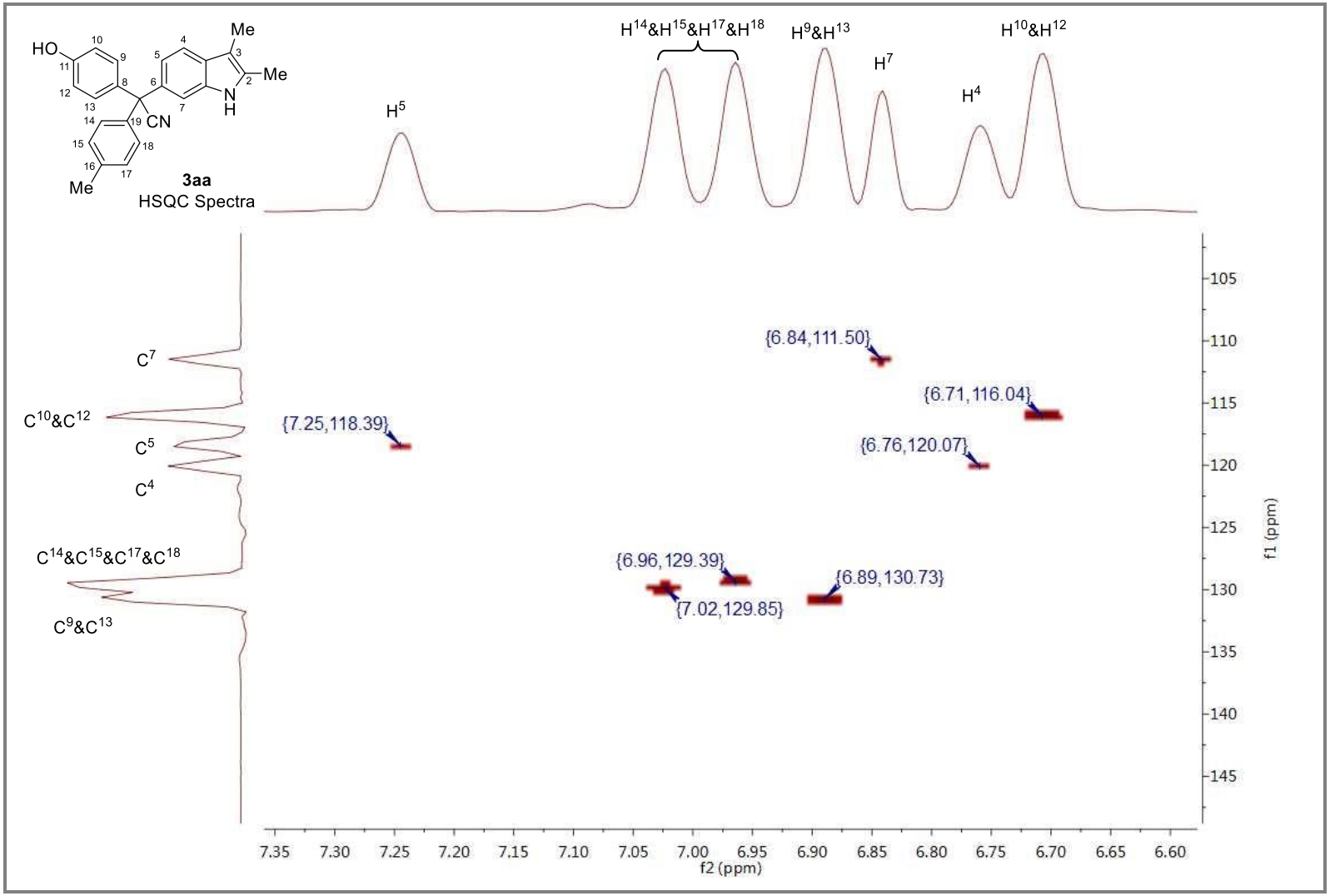
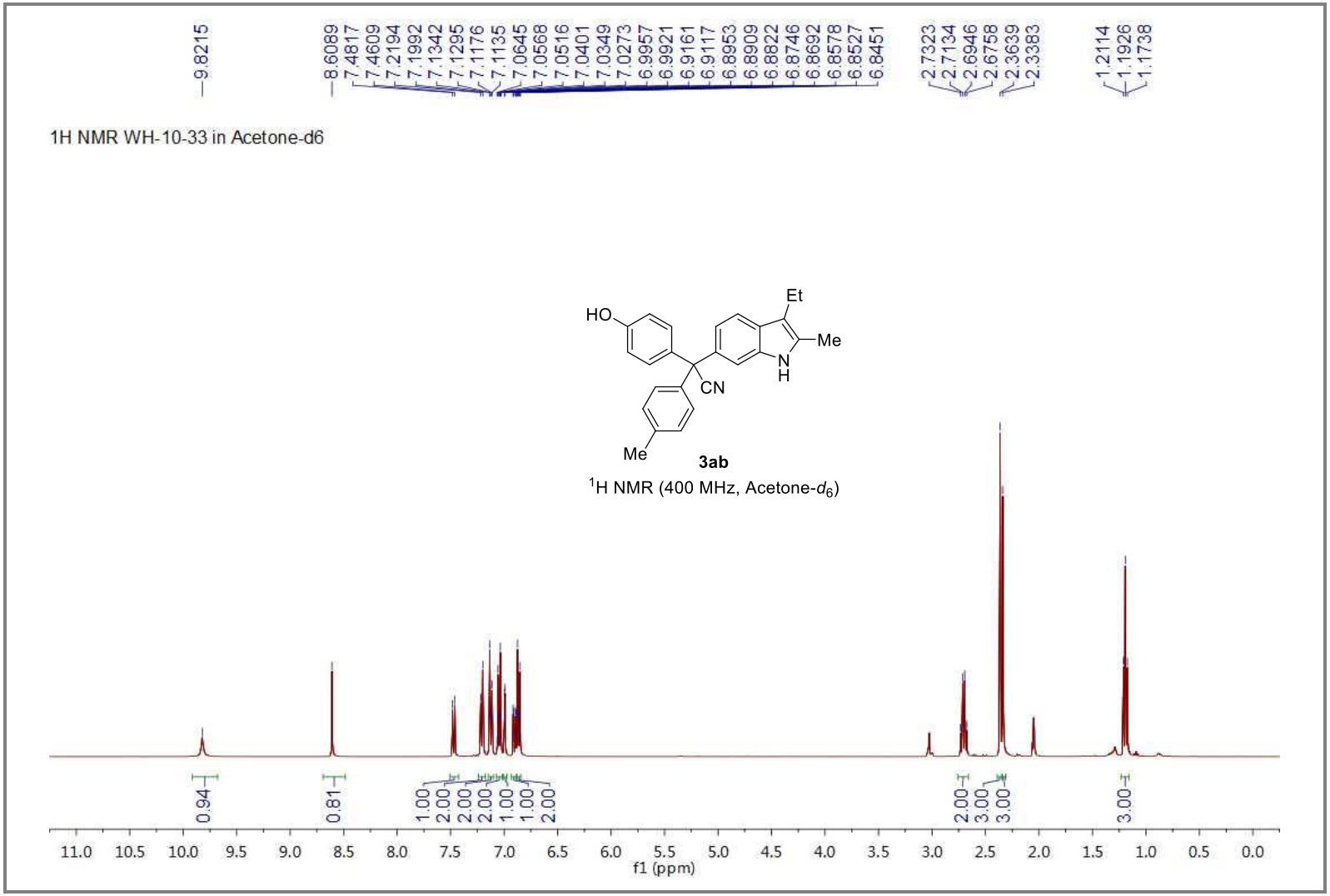
133.88
133.51
133.13
130.78
129.92
129.82
129.39
125.08
120.10
118.39
116.06
111.54
106.82
57.39
20.94
11.42
8.46
13C NMR WH-10-26 in Acetone-d6
HO
Me
Me
N
H
CN
Me
3aa
13C NMR (100 MHz, Acetone-d6)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


HO
Me
Me
N
H
CN
Me
3aa
HSQC Spectra
f2 (ppm)
f1 (ppm)


HO
Me
Me
Me
CN
N
H
3aa
HSQC Spectra
H5
H14&H15&H17&H18
H9&H13
H7
H4
H10&H12
C7
C10&C12
C5
C4
C14&C15&C17&C18
C9&C13
{6.84,111.50}
{6.71,116.04}
{7.25,118.39}
{6.76,120.07}
{6.96,129.39}
{6.89,130.73}
{7.02,129.85}
f2 (ppm)
f1 (ppm)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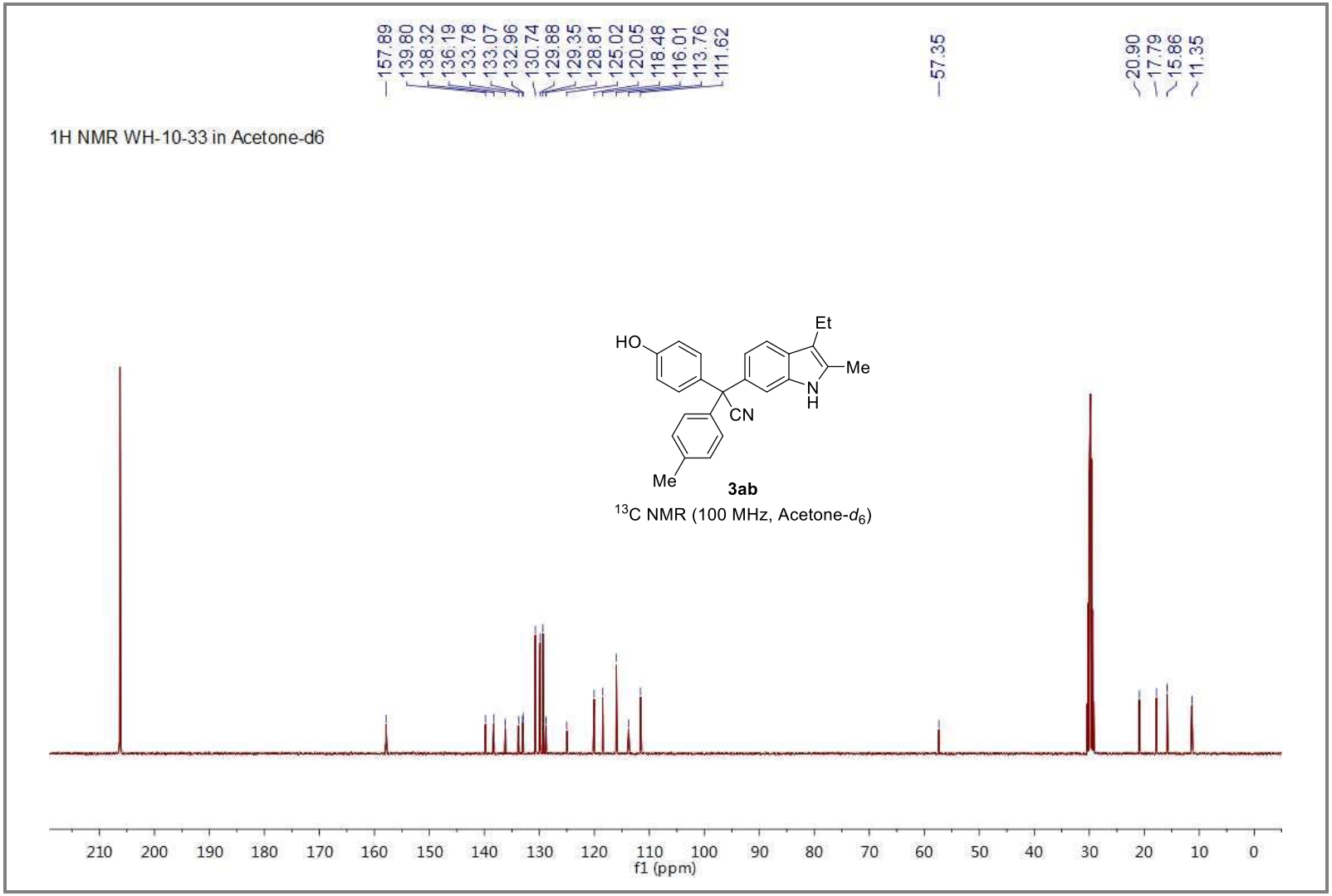
8.6089
7.4817
7.4609
7.2194
7.1992
7.1342
7.1295
7.1176
7.1135
7.0645
7.0568
7.0516
7.0401
7.0349
7.0273
6.9957
6.9921
6.9161
6.9117
6.8953
6.8909
6.8822
6.8746
6.8692
6.8578
6.8527
6.8451
2.7323
2.7134
2.6946
2.6758
2.3639
2.3383
1.2114
1.1926
1.1738
1H NMR WH-10-33 in Acetone-d6
HO
Et
Me
N
H
CN
Me
3ab
1H NMR (400 MHz, Acetone-d6)
0.94
0.81
1.00
2.00
2.00
2.00
1.00
1.00
2.00
2.00
3.00
3.00
3.00
11.0
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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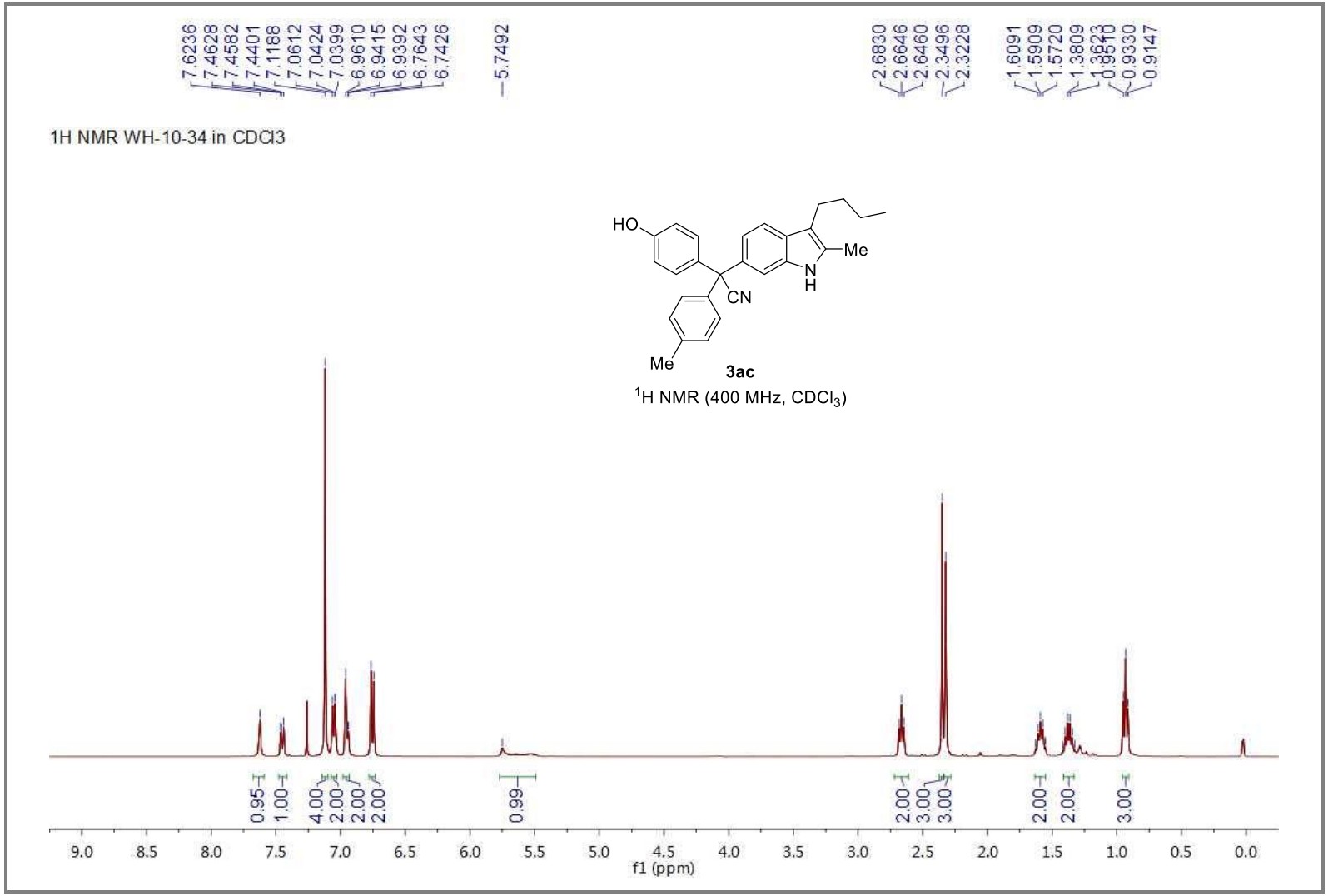
138.32
136.19
133.78
133.07
132.96
130.74
129.88
129.35
128.81
125.02
120.05
118.48
116.01
113.76
111.62
57.35
20.90
17.79
15.86
11.35
1H NMR WH-10-33 in Acetone-d6
HO
Et
Me
N
H
CN
Me
3ab
13C NMR (100 MHz, Acetone-d6)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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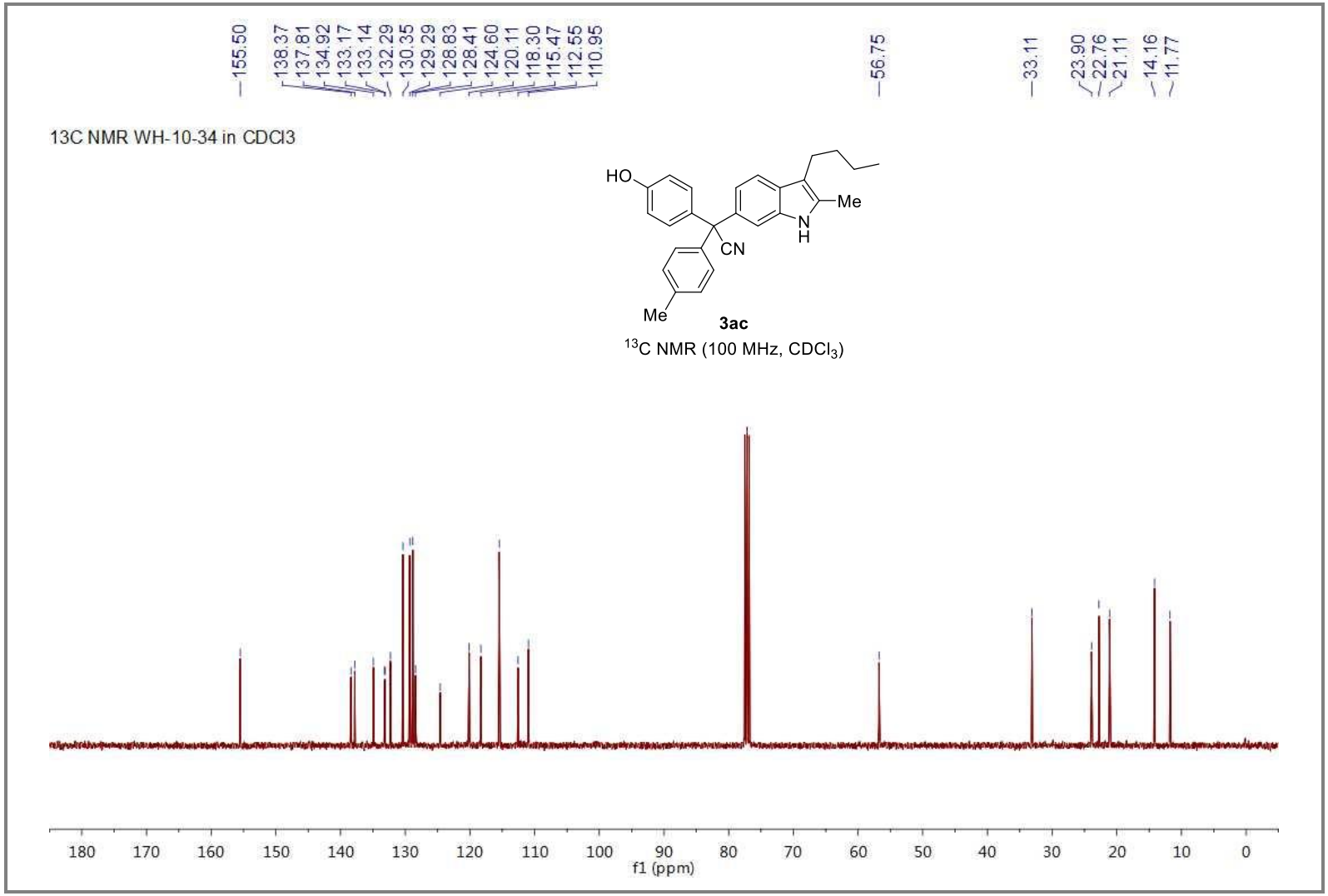
7.4401
7.1188
7.0612
7.0424
7.0399
6.9610
6.9415
6.9392
6.7643
6.7426
5.7492
2.6830
2.6646
2.6460
2.3496
2.3228
1.6091
1.5909
1.5720
1.3809
0.9510
0.9330
0.9147
1H NMR WH-10-34 in CDCl3
HO
Me
N
H
CN
Me
3ac
1H NMR (400 MHz, CDCl3)
0.95
1.00
4.00
2.00
2.00
2.00
0.99
2.00
3.00
3.00
2.00
2.00
3.00
9.0
8.5
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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138.37
137.81
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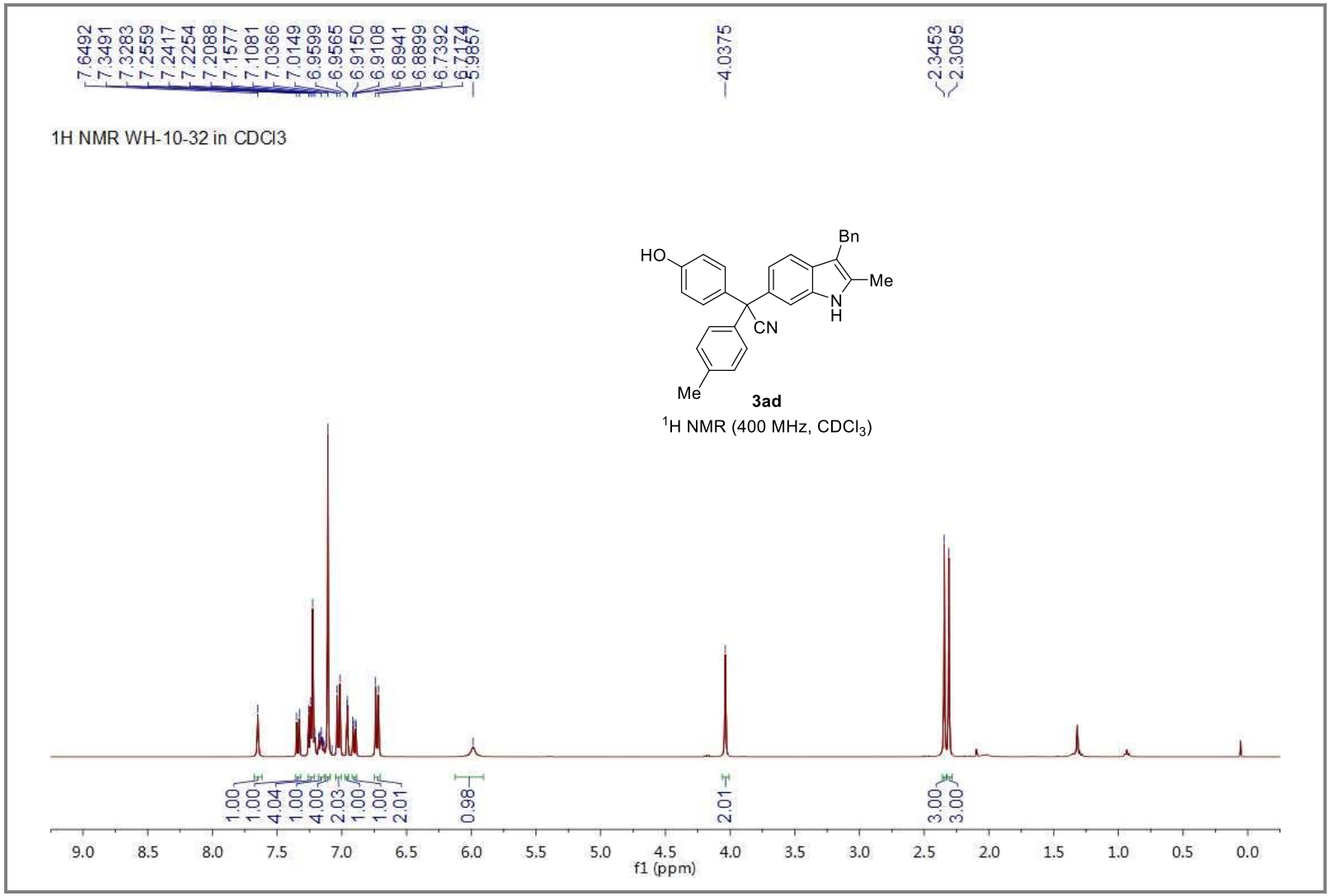
133.17
133.14
132.29
130.35
129.29
128.83
128.41
124.60
120.11
118.30
115.47
112.55
110.95
56.75
33.11
23.90
22.76
21.11
14.16
11.77
13C NMR WH-10-34 in CDCl3
HO
Me
N
H
CN
Me
3ac
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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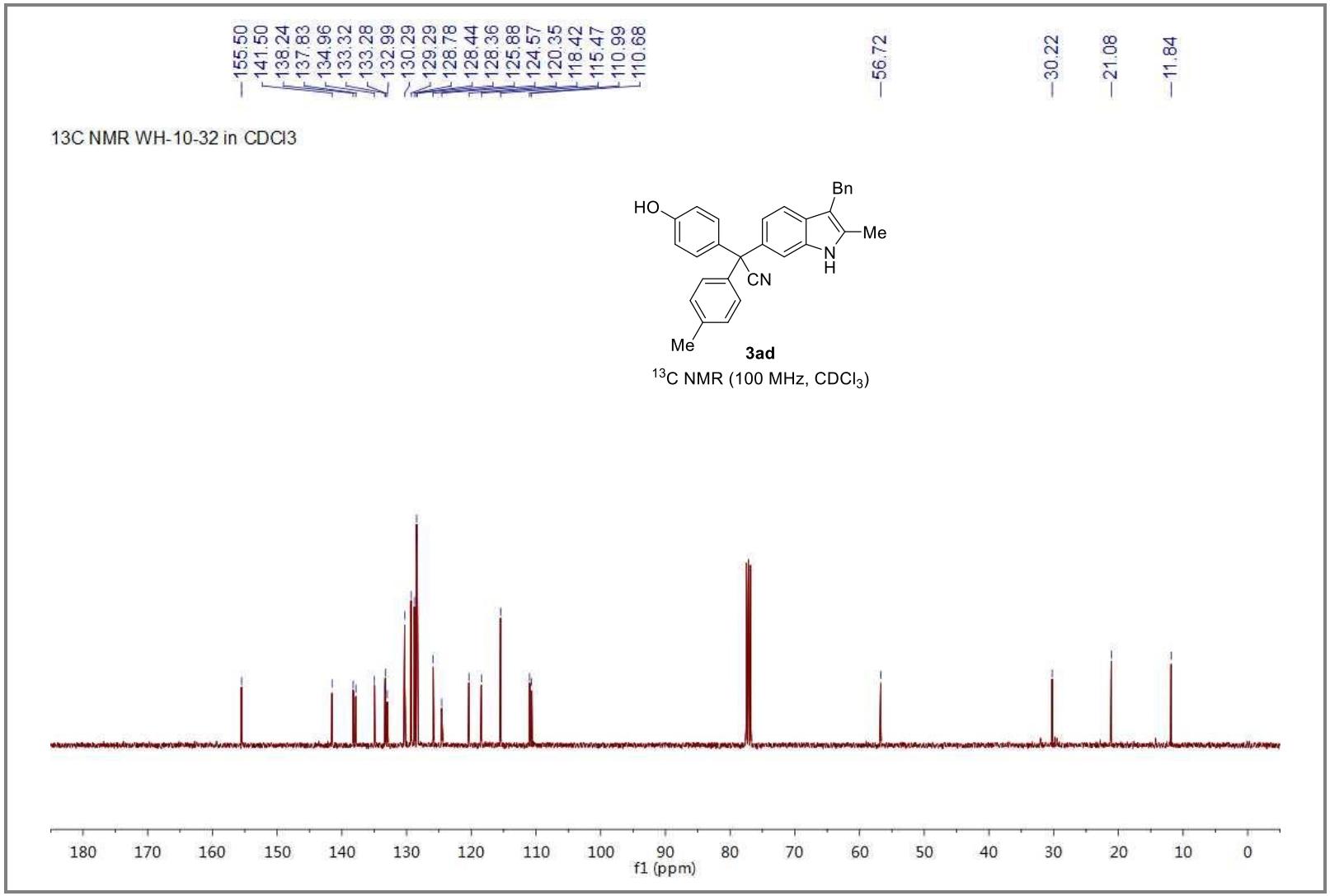
7.3283
7.2559
7.2417
7.2254
7.2088
7.1577
7.1081
7.0366
7.0149
6.9599
6.9565
6.9150
6.9108
6.8941
6.8899
6.7392
6.7174
5.9857
4.0375
2.3453
2.3095
1H NMR WH-10-32 in CDCl3
HO
Bn
Me
N
H
CN
Me
3ad
1H NMR (400 MHz, CDCl3)
1.00
1.00
4.04
1.00
4.00
2.03
1.00
1.00
2.01
0.98
2.01
3.00
3.00
9.0
8.5
8.0
7.5
7.0
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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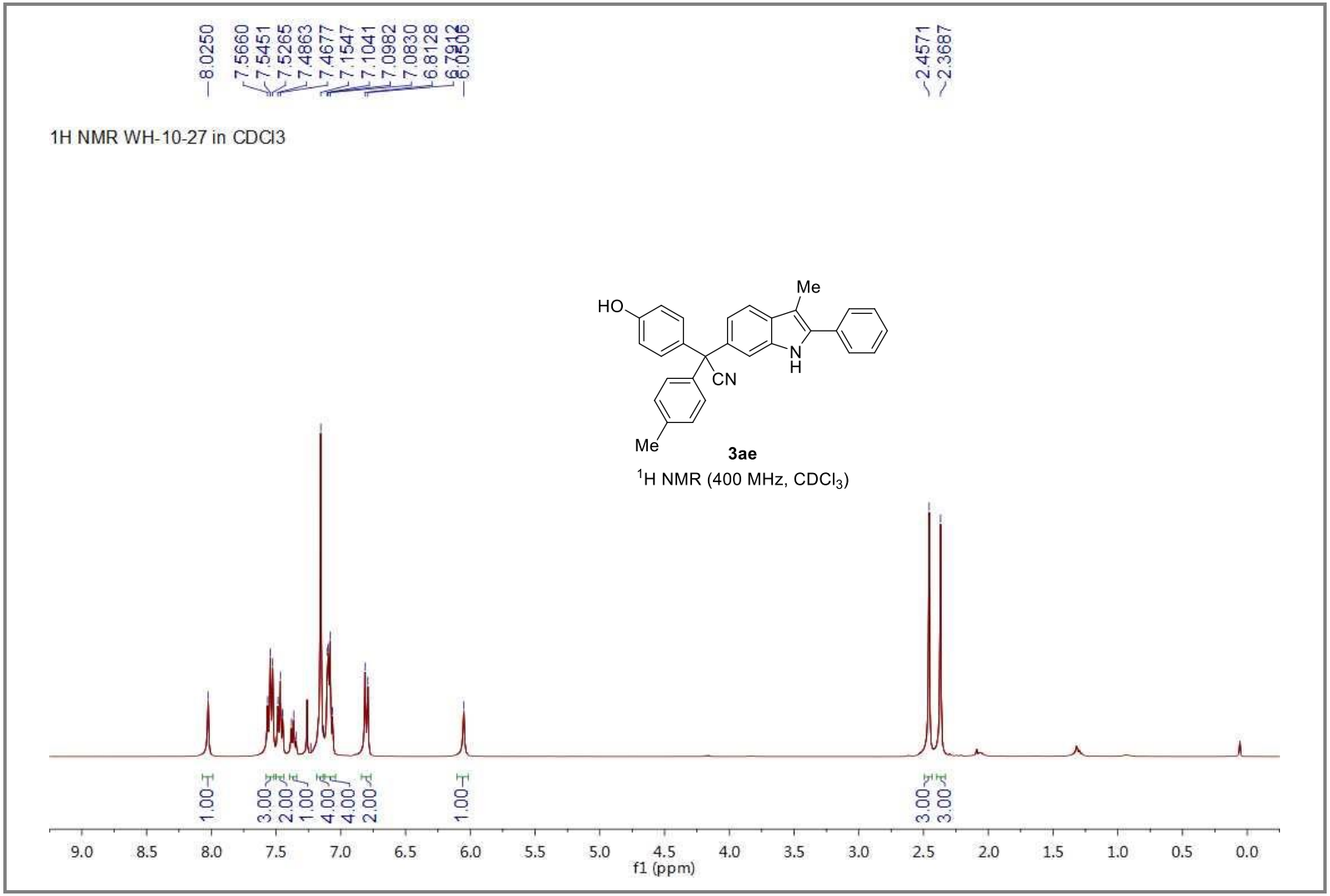
141.50
138.24
137.83
134.96
133.32
133.28
132.99
130.29
129.29
128.78
128.44
128.36
125.88
124.57
120.35
118.42
115.47
110.99
110.68
56.72
30.22
21.08
11.84
13C NMR WH-10-32 in CDCl3
HO
Bn
Me
N
H
CN
Me
3ad
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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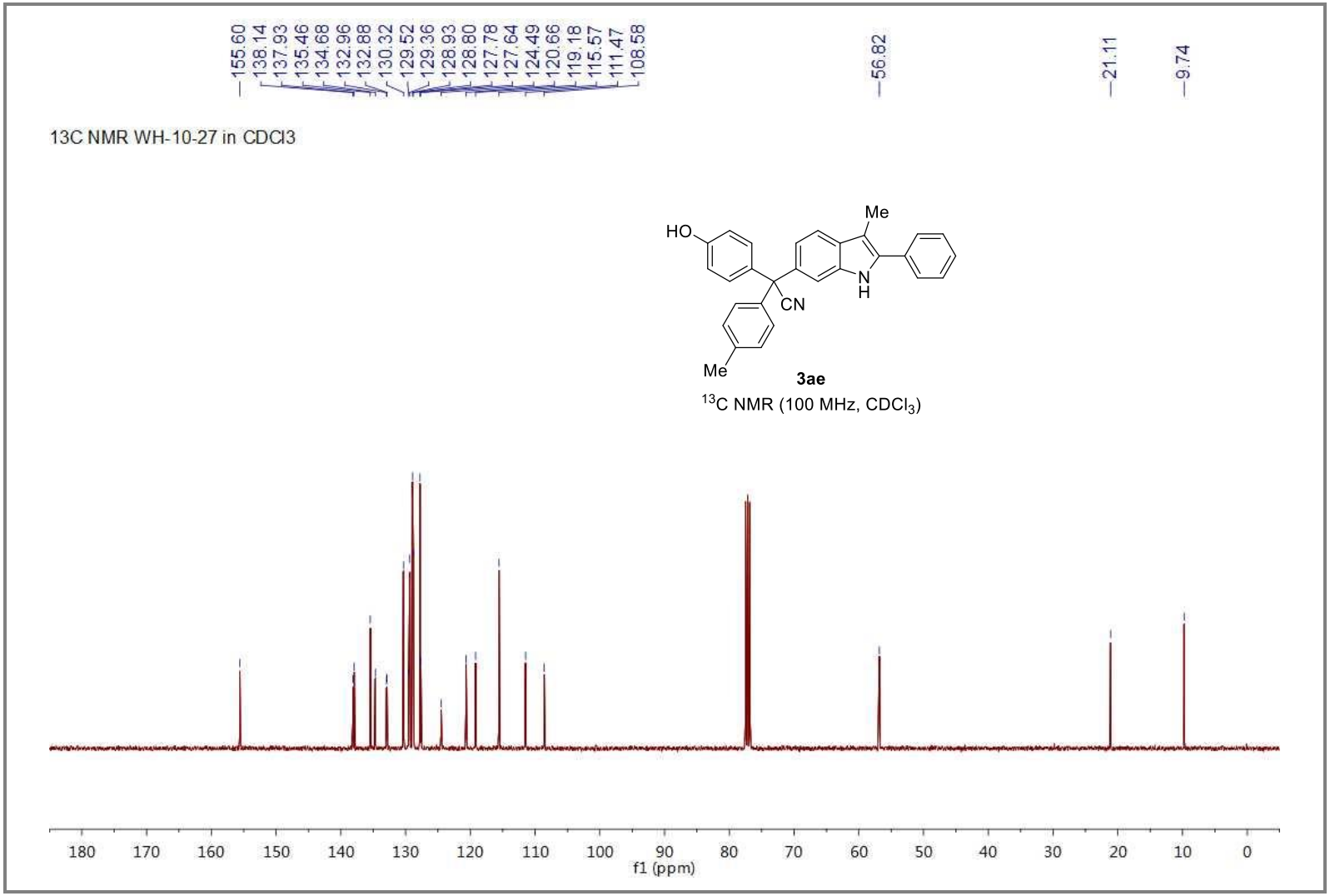
7.5451
7.5265
7.4863
7.4677
7.1547
7.1041
7.0982
7.0830
6.8128
6.7912
6.0506
2.4571
2.3687
1H NMR WH-10-27 in CDCl3
HO
Me
N
H
CN
Me
3ae
1H NMR (400 MHz, CDCl3)
1.00
3.00
2.00
1.00
4.00
4.00
2.00
1.00
3.00
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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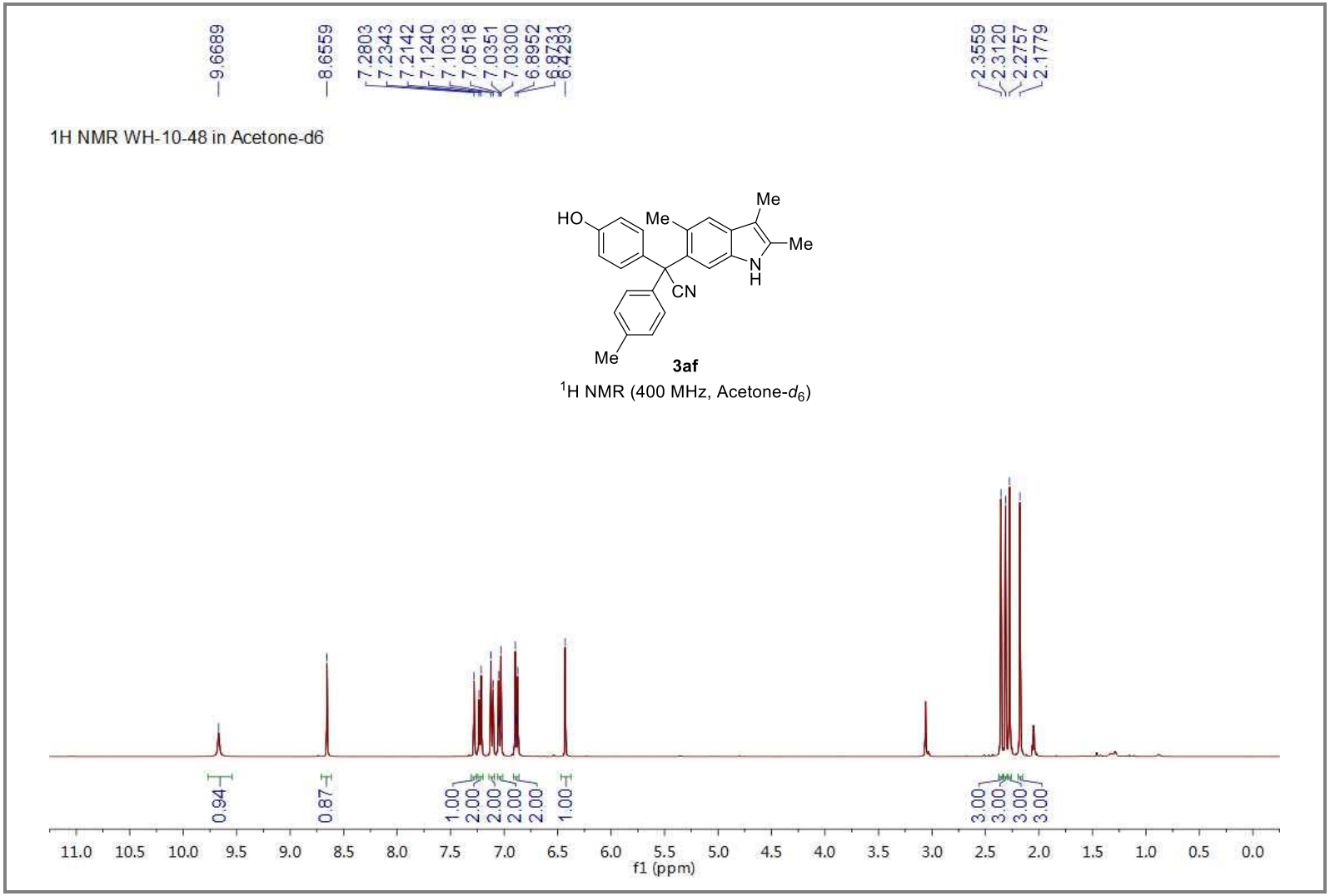
135.46
134.68
132.96
132.88
130.32
129.52
129.36
128.93
128.80
127.78
127.64
124.49
120.66
119.18
115.57
111.47
108.58
56.82
21.11
9.74
13C NMR WH-10-27 in CDCl3
HO
Me
N
H
CN
Me
3ae
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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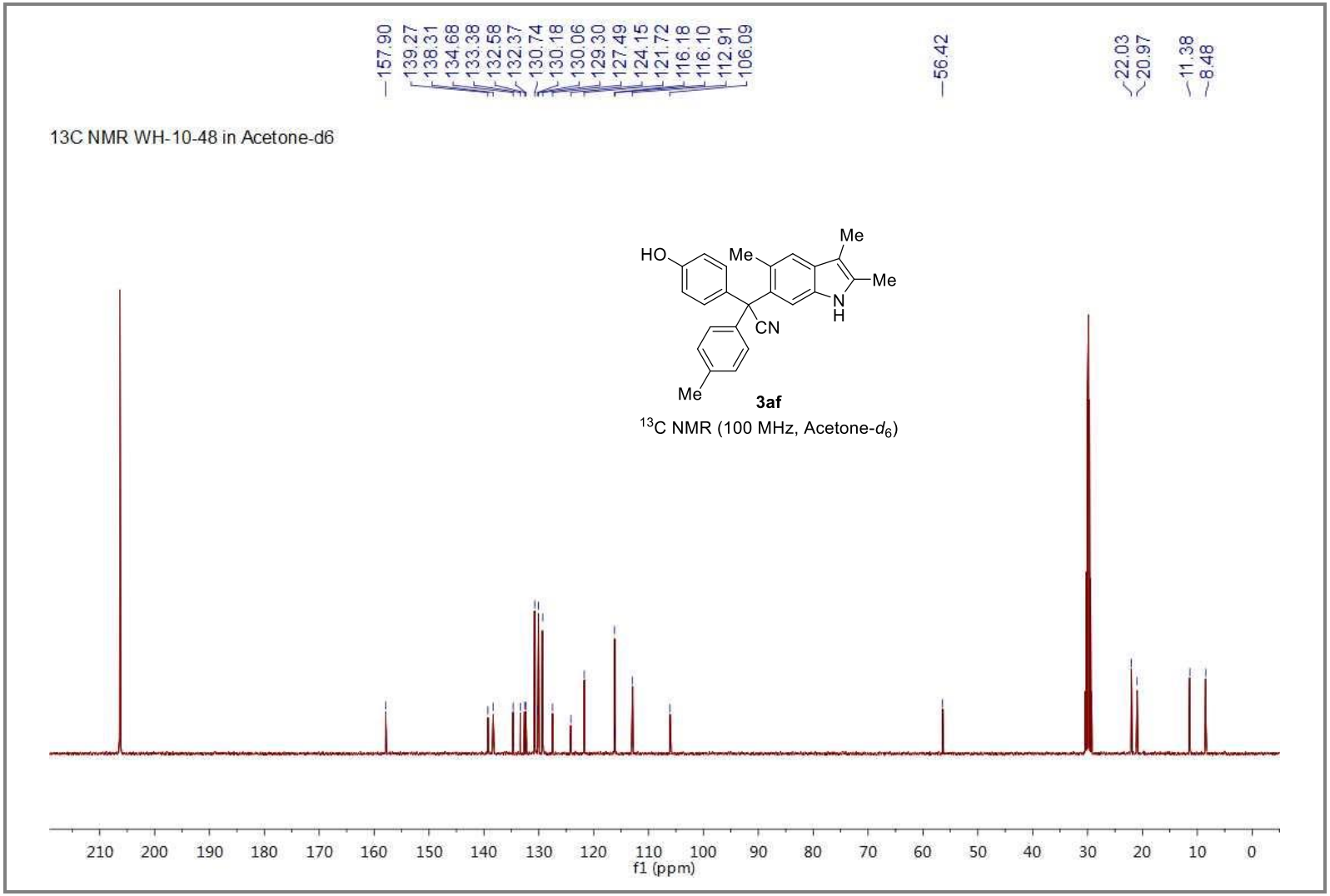
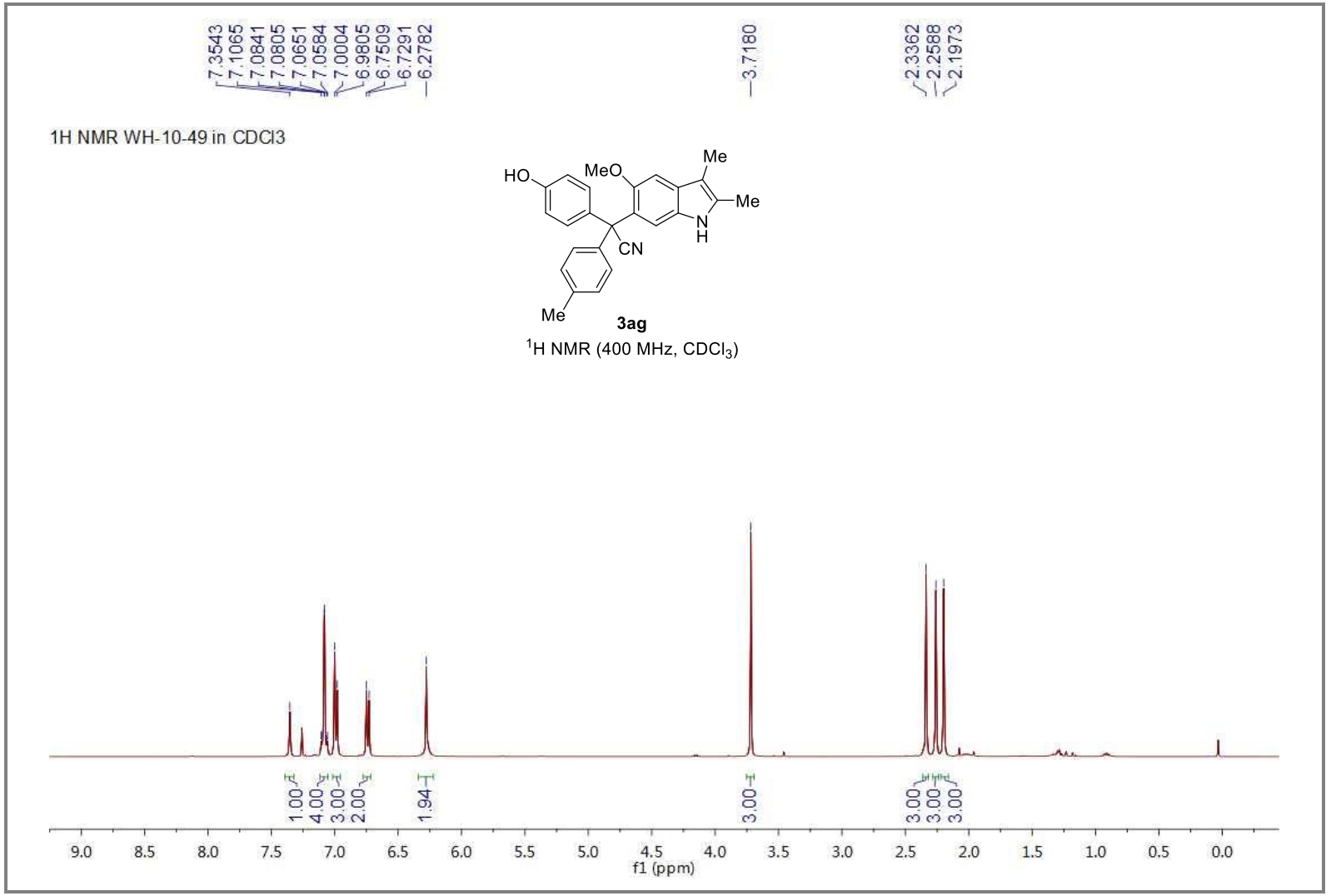
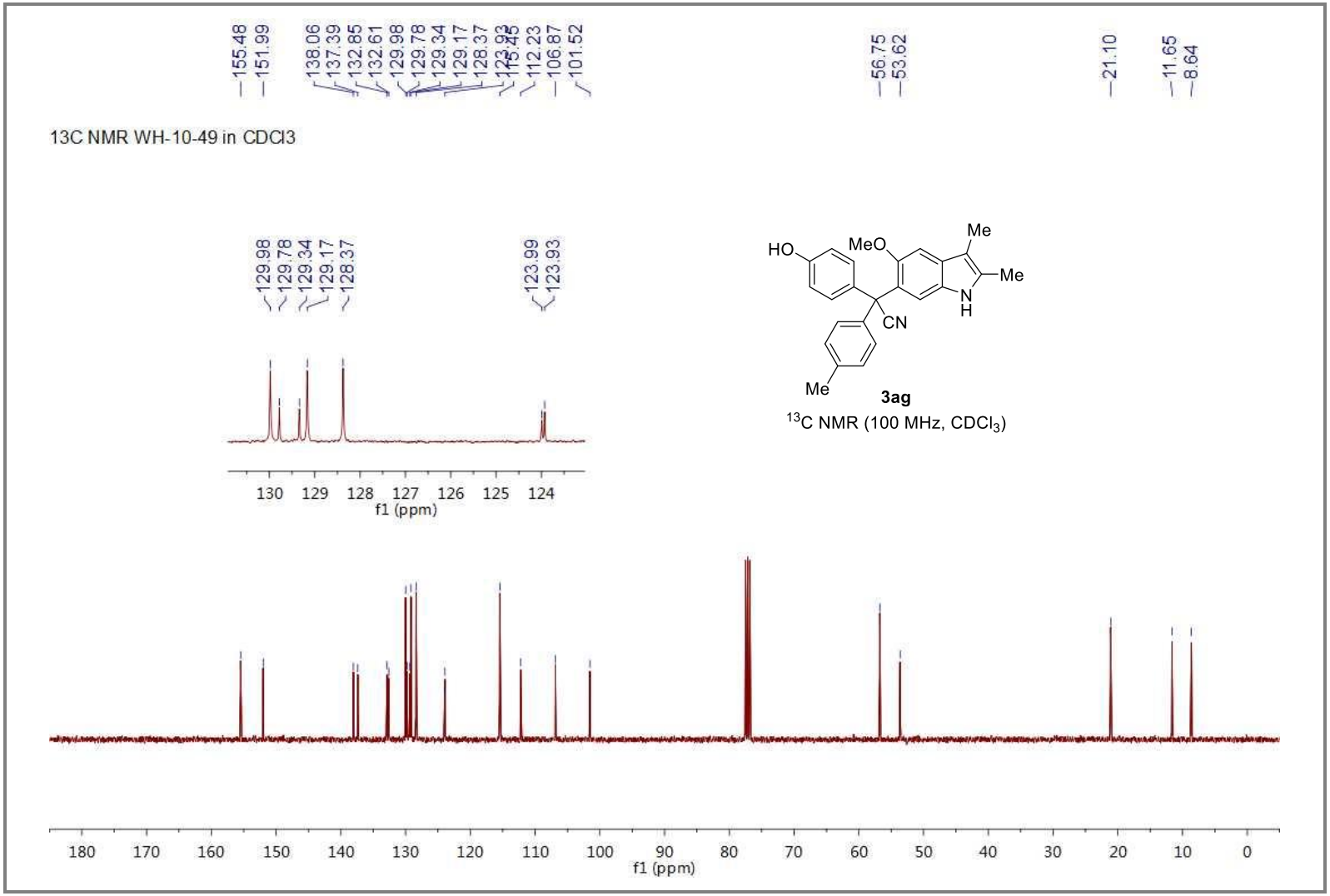
7.2142
7.1240
7.1033
7.0518
7.0351
7.0300
6.8952
6.8731
6.8283
2.3559
2.3120
2.2757
2.1779
1H NMR WH-10-48 in Acetone-d6
HO
Me
Me
Me
N
H
CN
Me
3af
1H NMR (400 MHz, Acetone-d6)
0.94
0.87
1.00
2.00
2.00
2.00
2.00
1.00
3.00
3.00
3.00
3.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

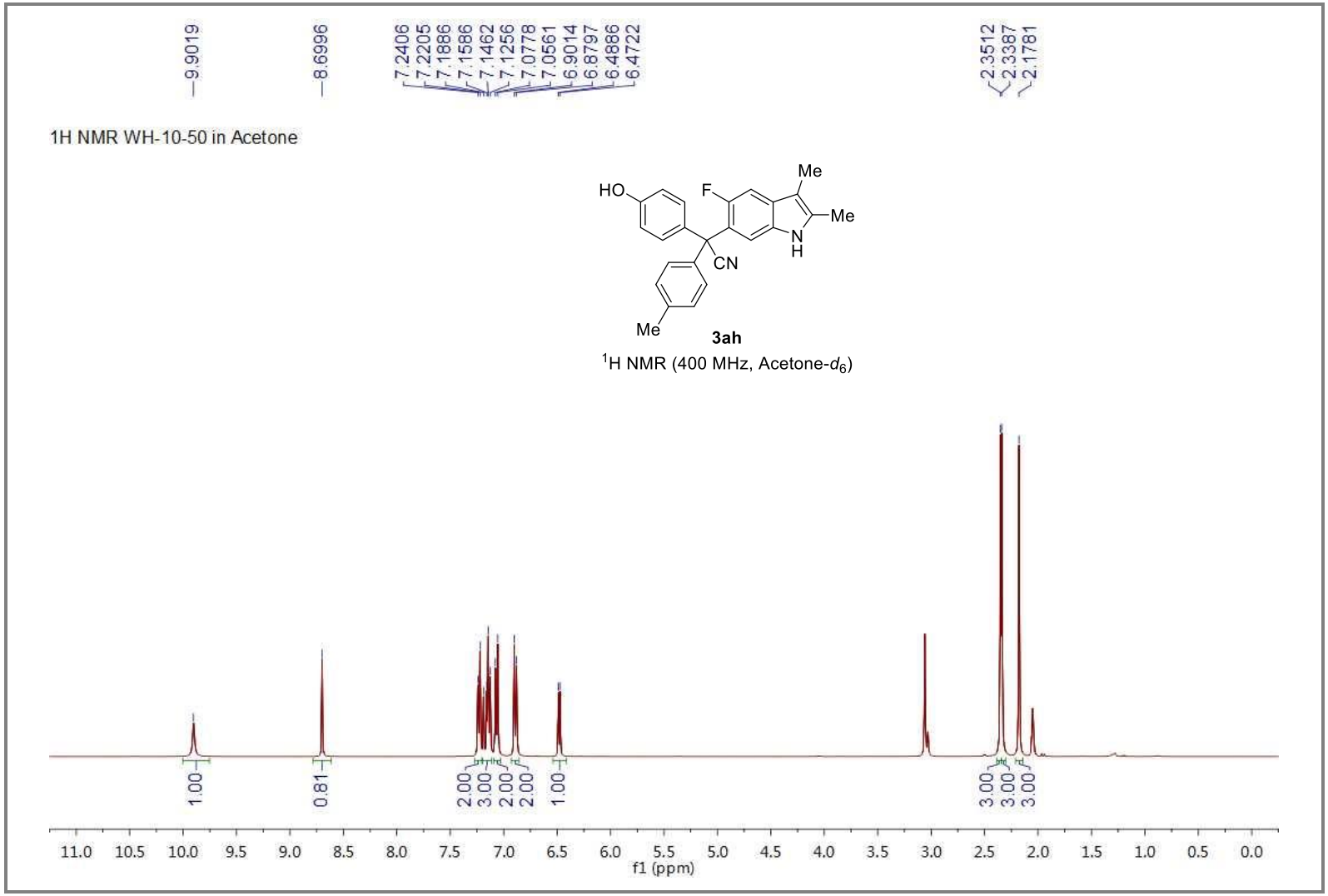

157.90
139.27
138.31
134.68
133.38
132.58
132.37
130.74
130.18
130.06
129.30
127.49
124.15
121.72
116.18
116.10
112.91
106.09
56.42
22.03
20.97
11.38
8.48
13C NMR WH-10-48 in Acetone-d6
HO
Me
Me
Me
N
H
CN
Me
3af
13C NMR (100 MHz, Acetone-d6)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



3ag

^{1}H NMR (400 MHz, $CDCl_3$)


155.48
151.99
138.06
137.39
132.85
132.61
129.98
129.78
129.34
129.17
128.37
123.99
123.93
115.45
112.23
106.87
101.52
56.75
53.62
21.10
11.65
8.64
13C NMR WH-10-49 in CDCl3
129.98
129.78
129.34
129.17
128.37
123.99
123.93
130 129 128 127 126 125 124
f1 (ppm)
HO
MeO
Me
Me
N
H
CN
Me
3ag
13C NMR (100 MHz, CDCl3)
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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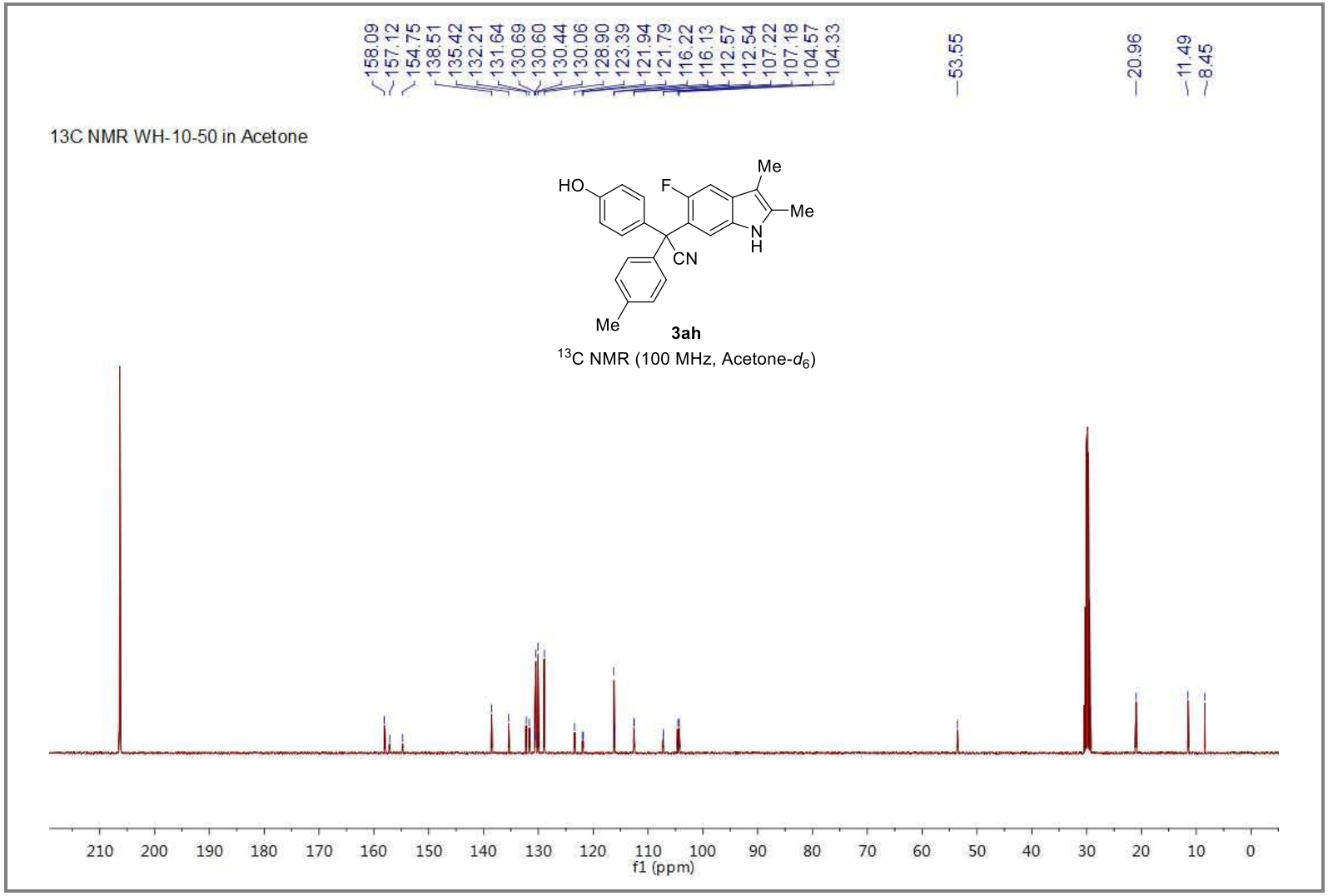
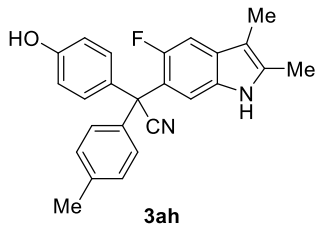
7.2205
7.1886
7.1586
7.1462
7.1256
7.0778
7.0561
6.9014
6.8797
6.4886
6.4722
2.3512
2.3387
2.1781
1H NMR WH-10-50 in Acetone
HO
F
Me
Me
N
H
CN
Me
3ah
1H NMR (400 MHz, Acetone-d6)
1.00
0.81
2.00
3.00
2.00
2.00
1.00
3.00
3.00
3.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

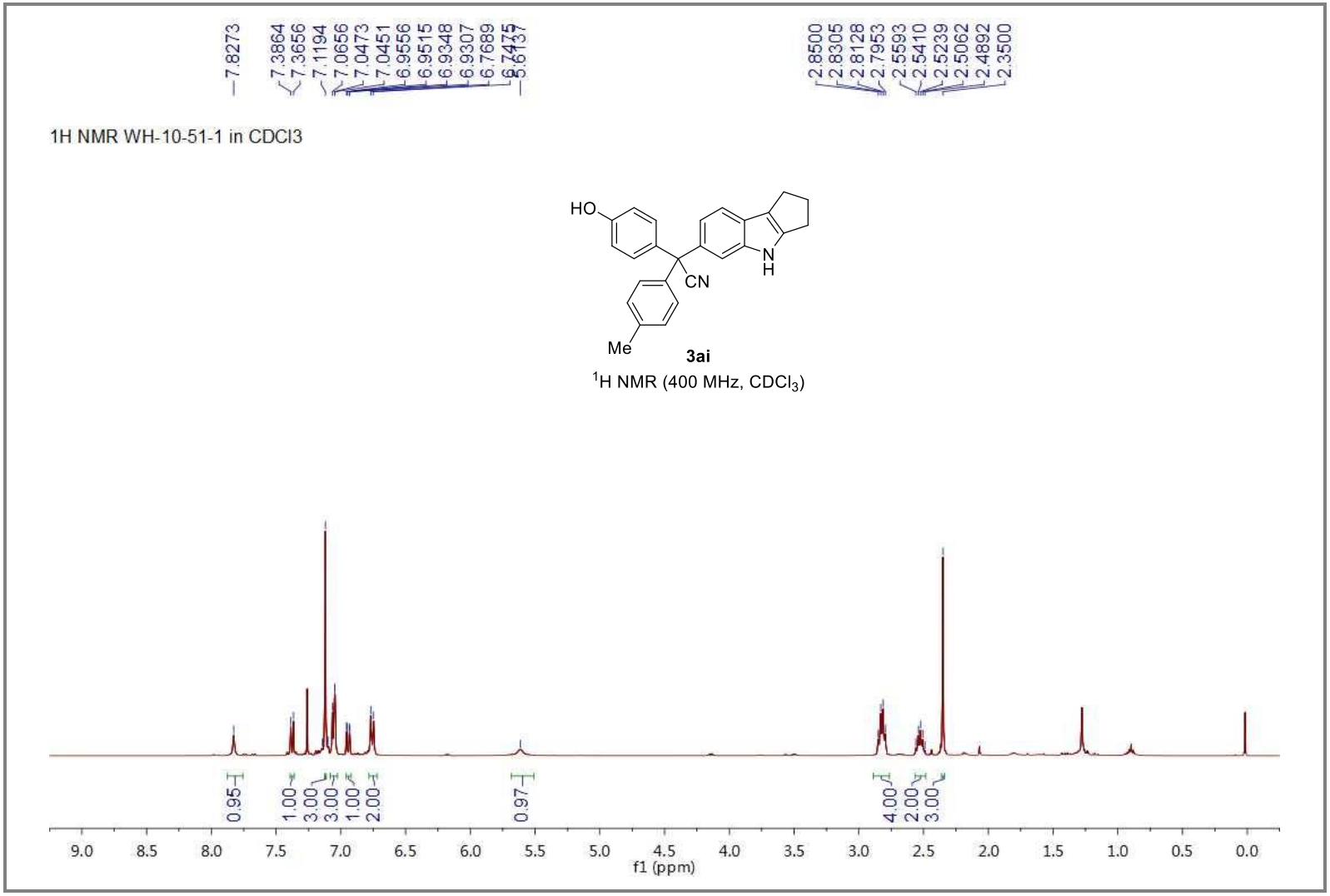

158.09
157.12
154.75
138.51
135.42
132.21
131.64
130.69
130.60
130.44
130.06
128.90
123.39
121.94
121.79
116.22
116.13
112.57
112.54
107.22
107.18
104.57
104.33
53.55
20.96
11.49
8.45
13C NMR WH-10-50 in Acetone
HO
F
Me
Me
N
H
CN
Me
3ah
13C NMR (100 MHz, Acetone-d6)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

19F NMR WH-10-50 in Acetone



3ah

^{19}F NMR (376 MHz, Acetone-d_6)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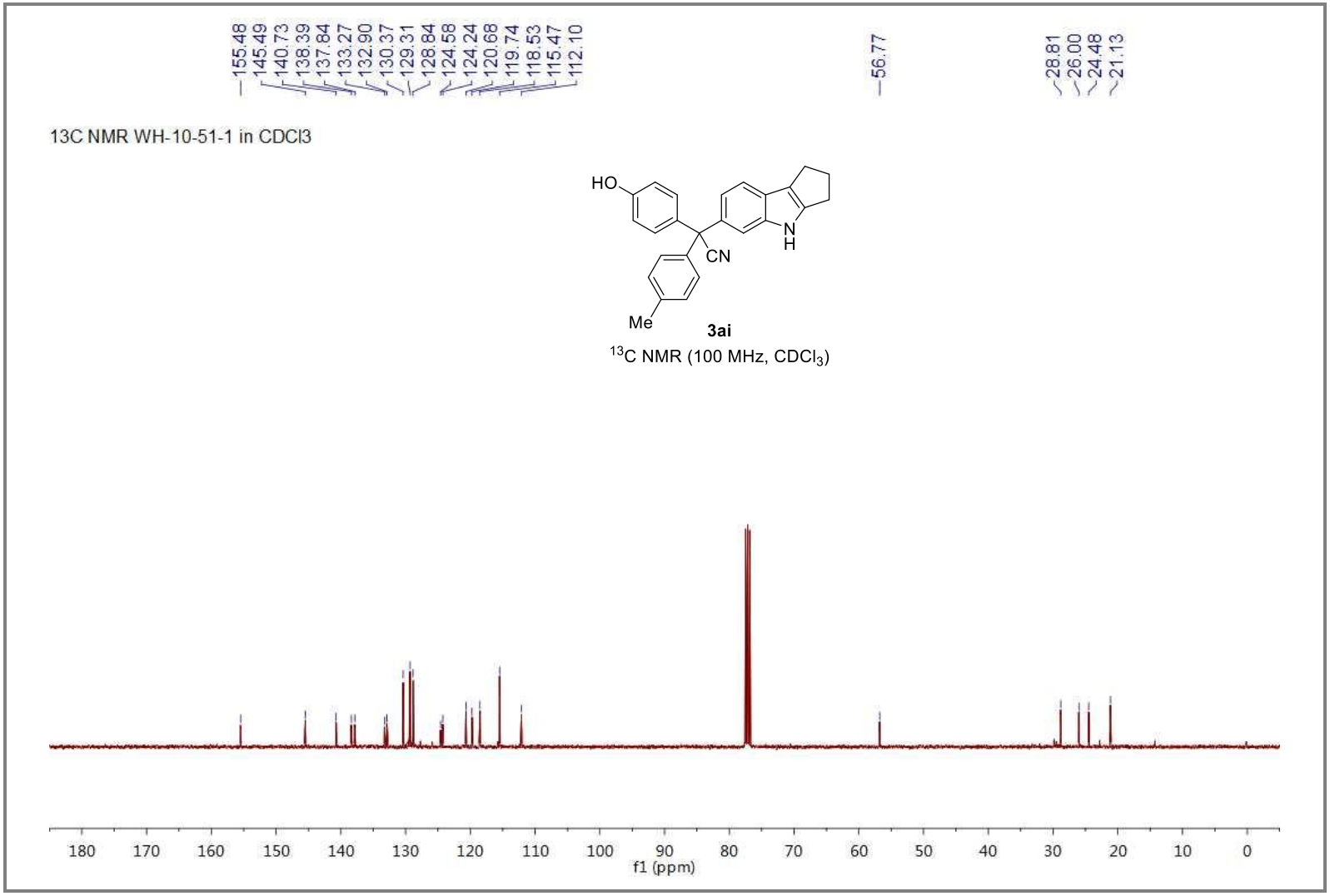
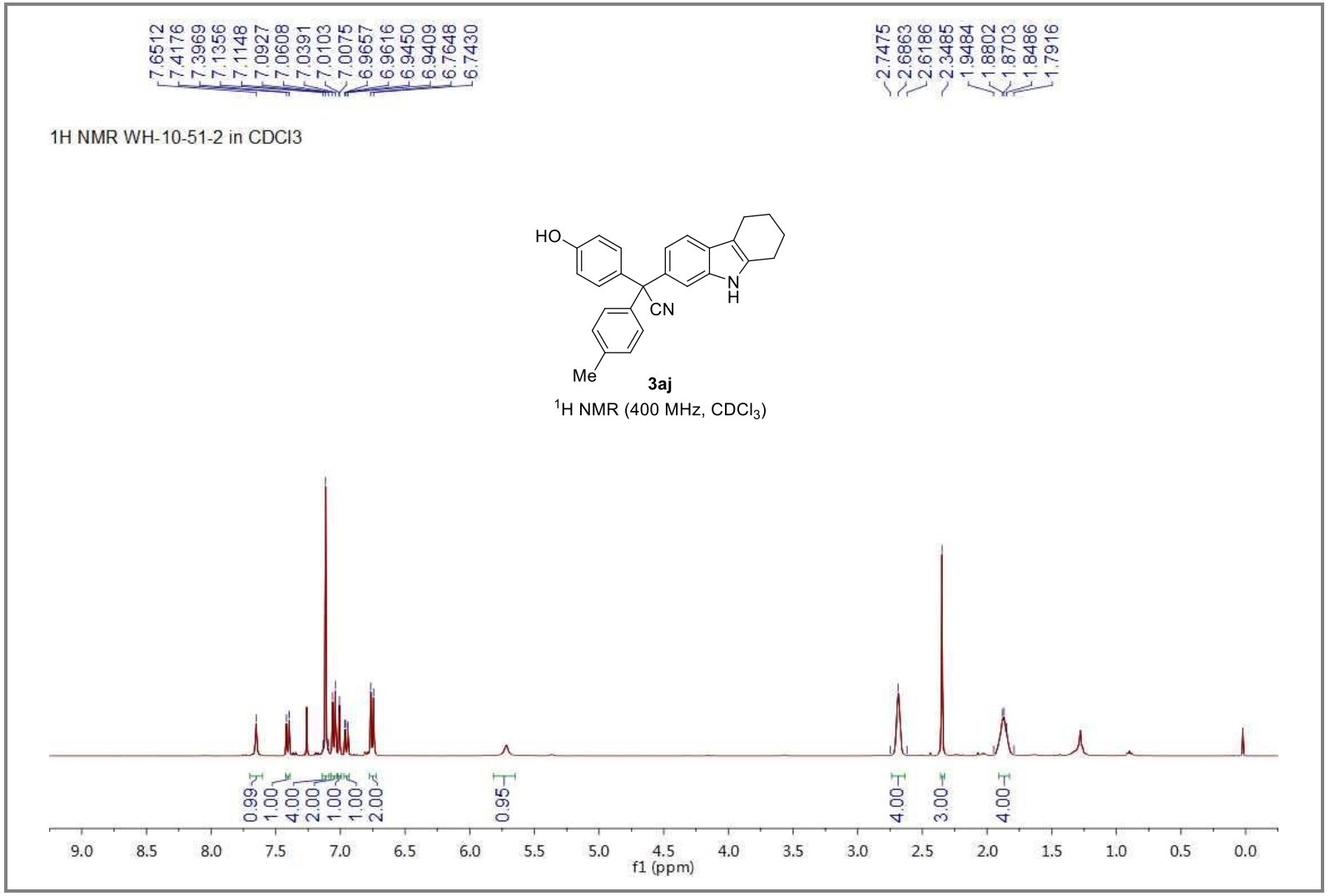
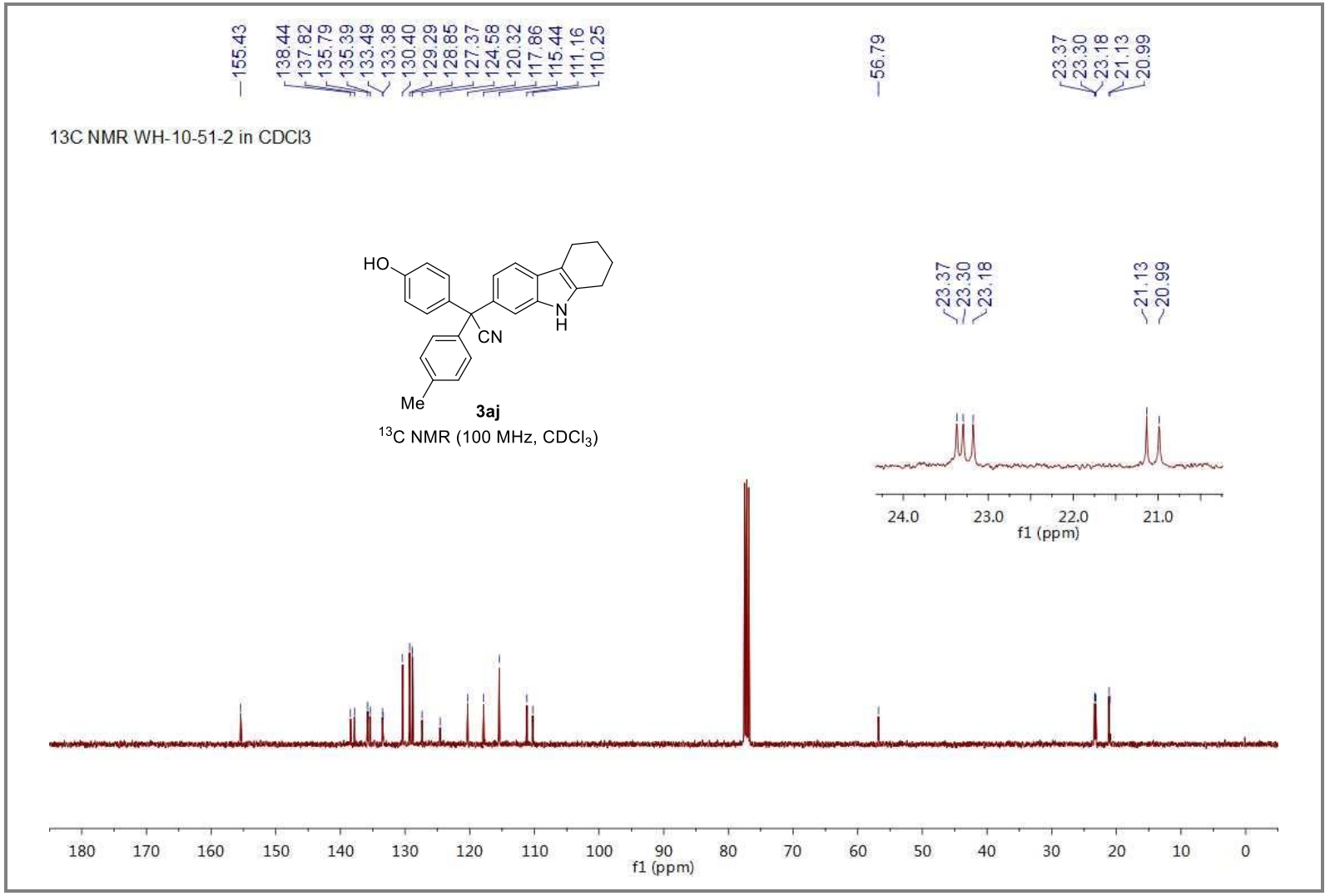
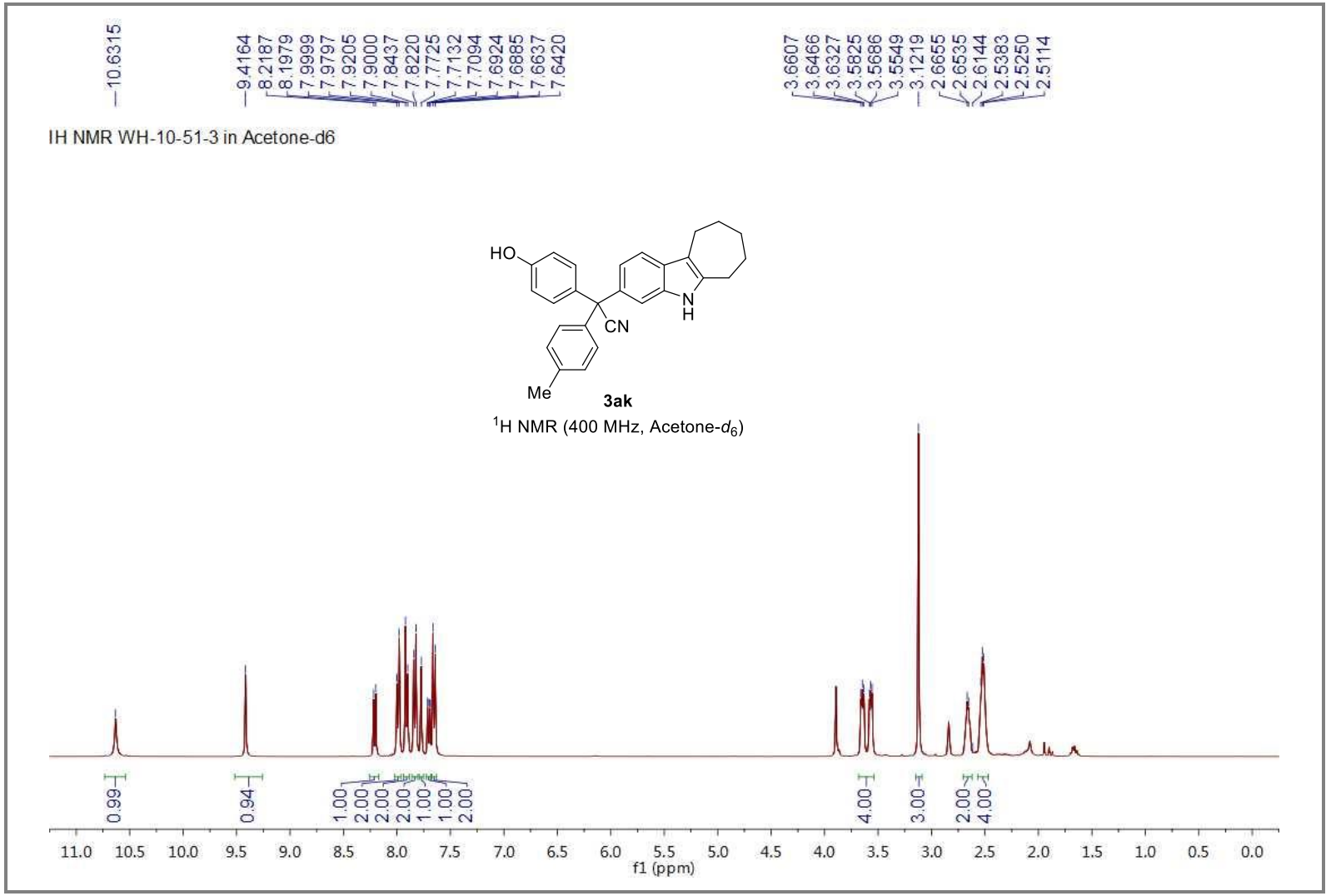
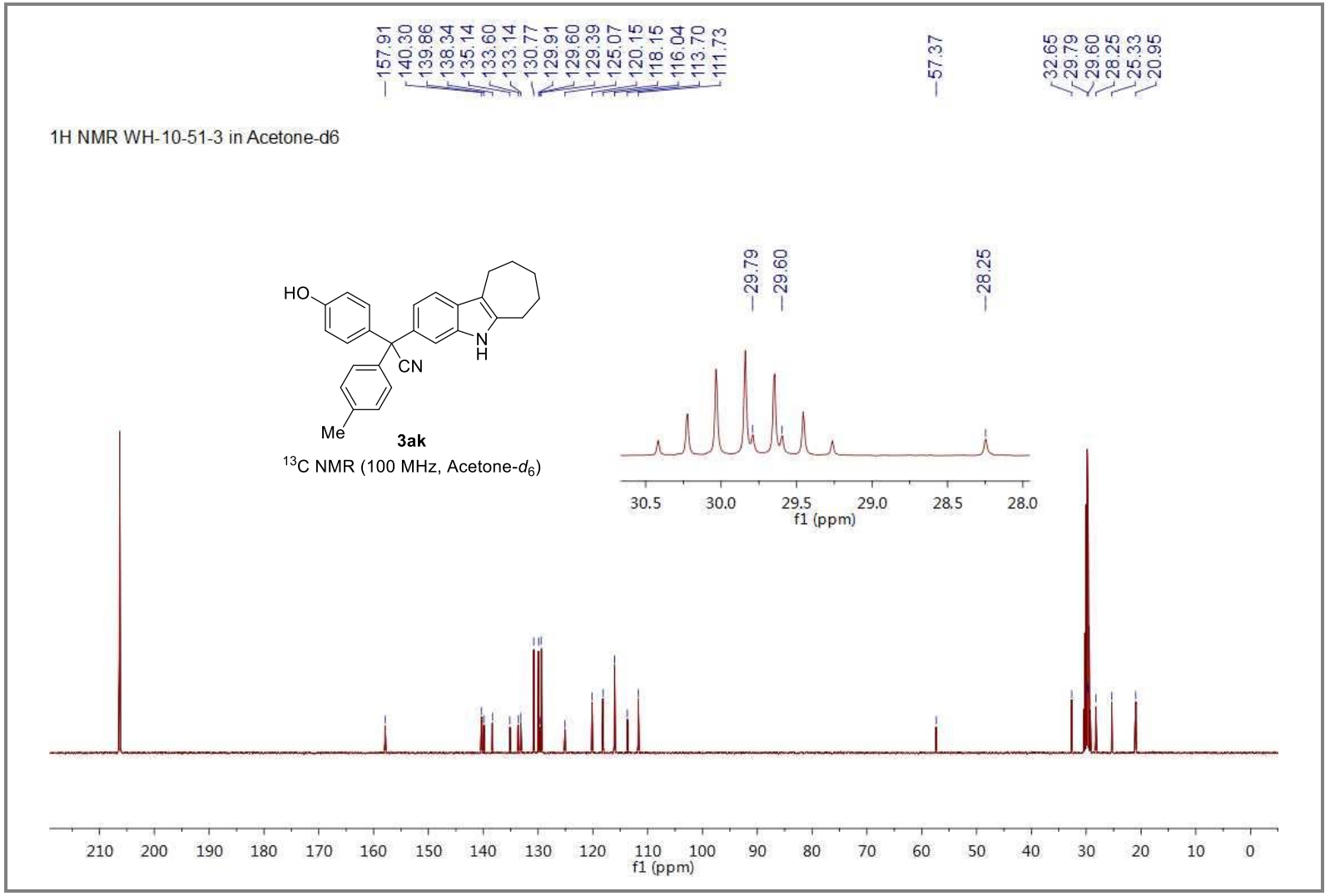
7.3864
7.3656
7.1194
7.0656
7.0473
7.0451
6.9556
6.9515
6.9348
6.9307
6.7689
6.7475
6.6137
2.8500
2.8305
2.8128
2.7953
2.5593
2.5410
2.5239
2.5062
2.4892
2.3500
1H NMR WH-10-51-1 in CDCl3
HO
N
H
CN
Me
3ai
^{1}H NMR (400 MHz, $CDCl_3$)
0.95
1.00
3.00
3.00
1.00
2.00
0.97
4.00
2.00
3.00
9.0
8.5
8.0
7.5
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)

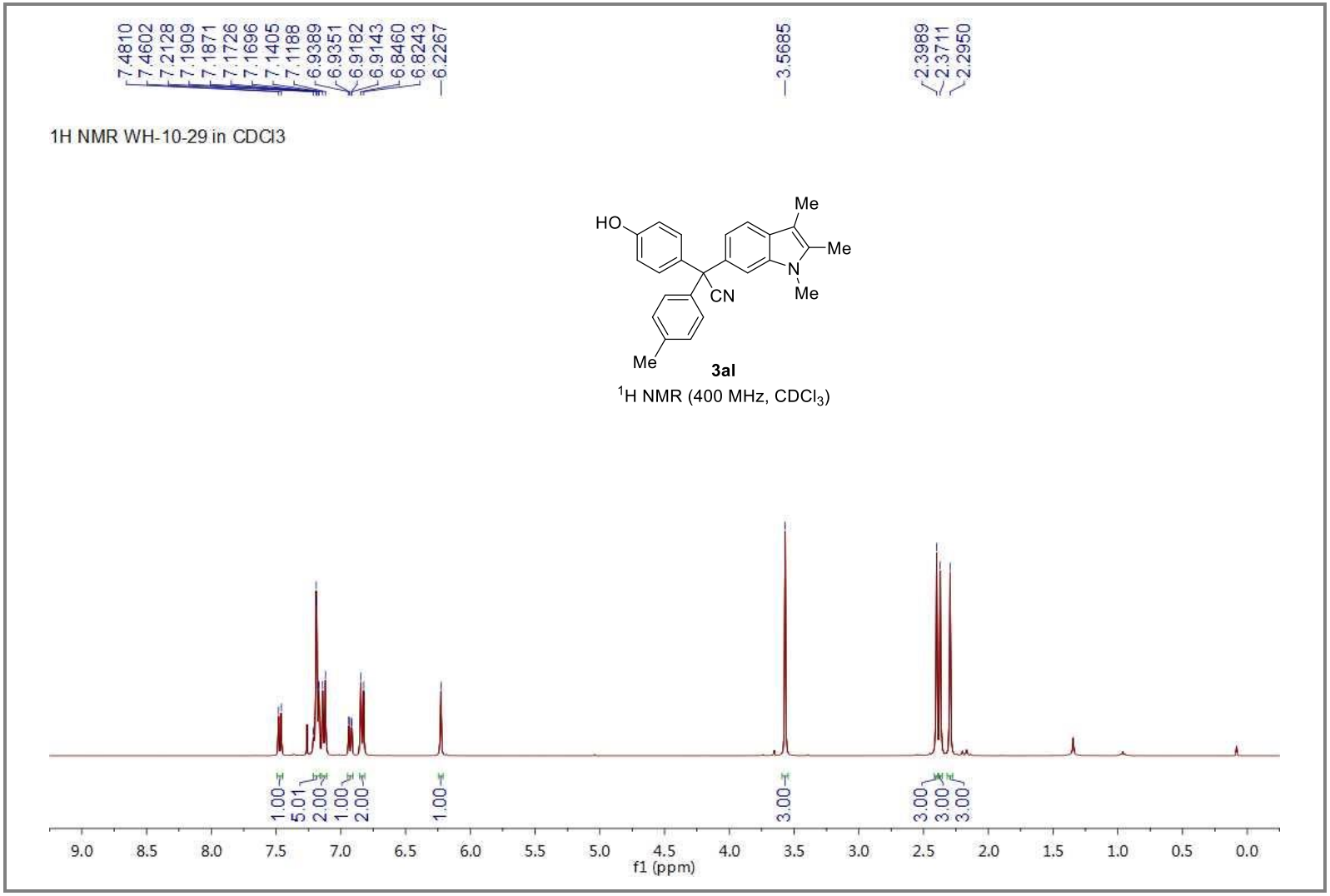

155.48
145.49
140.73
138.39
137.84
133.27
132.90
130.37
129.31
128.84
124.58
124.24
120.68
119.74
118.53
115.47
112.10
56.77
28.81
26.00
24.48
21.13
13C NMR WH-10-51-1 in CDCl3
HO
N
H
CN
Me
3ai
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

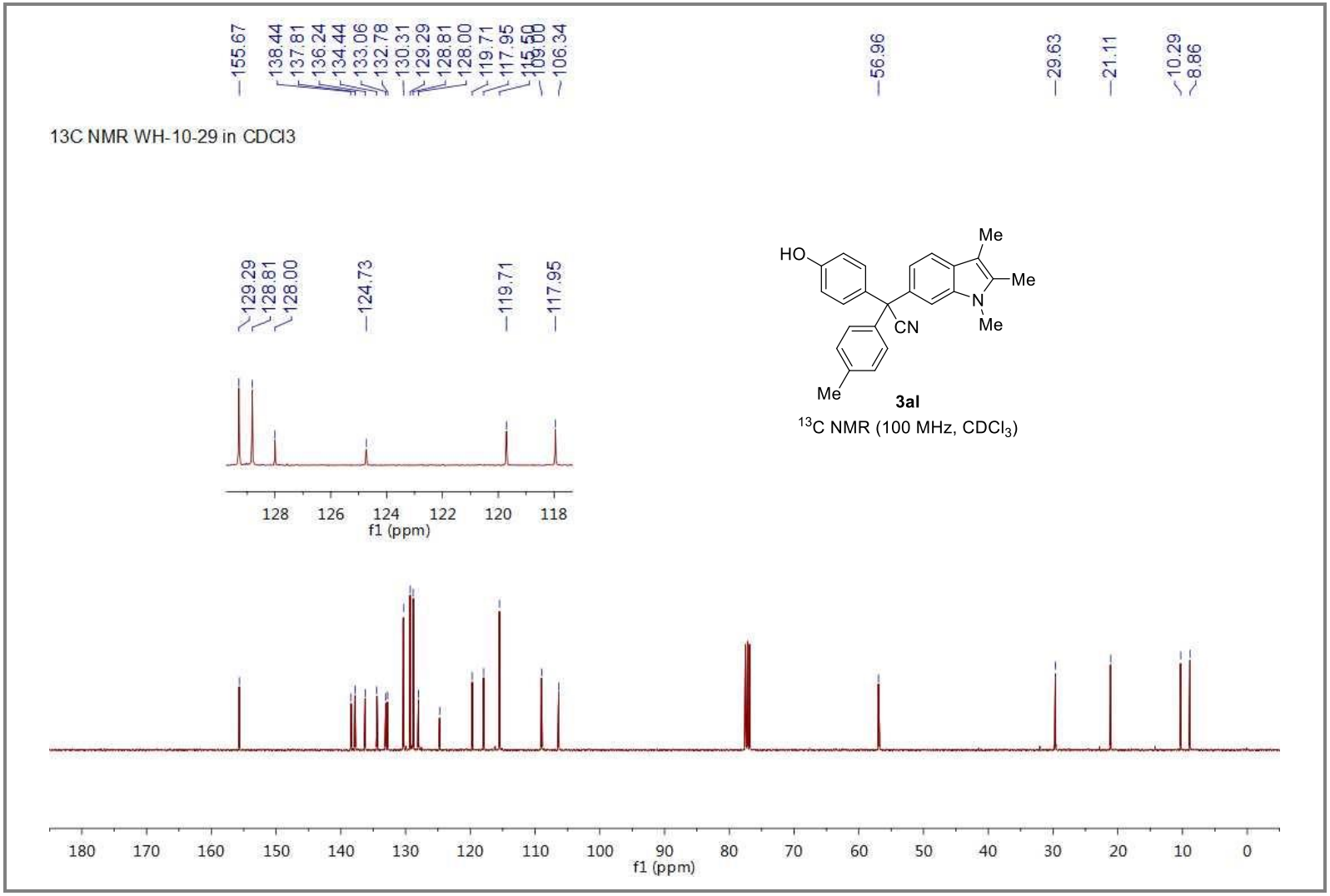

7.6512
7.4176
7.3969
7.1356
7.1148
7.0927
7.0608
7.0391
7.0103
7.0075
6.9657
6.9616
6.9450
6.9409
6.7648
6.7430
2.7475
2.6863
2.6186
2.3485
1.9484
1.8802
1.8703
1.8486
1.7916
1H NMR WH-10-51-2 in CDCl3
HO
N
H
CN
Me
3aj
1H NMR (400 MHz, CDCl3)
0.99
1.00
4.00
2.00
1.00
1.00
2.00
0.95
4.00
3.00
4.00
9.0
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)

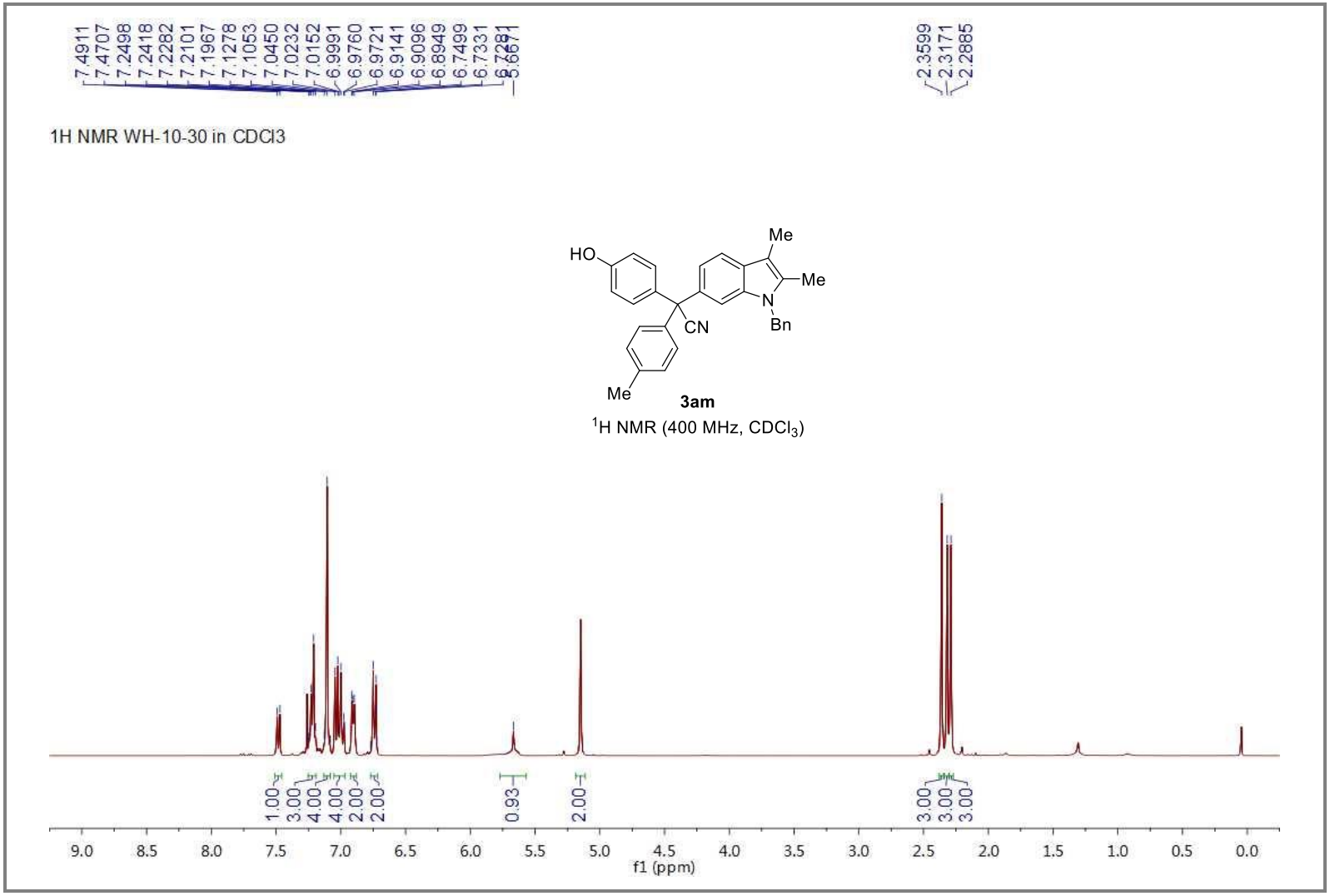

155.43
138.44
137.82
135.79
135.39
133.49
133.38
130.40
129.29
128.85
127.37
124.58
120.32
117.86
115.44
111.16
110.25
56.79
23.37
23.30
23.18
21.13
20.99
13C NMR WH-10-51-2 in CDCl3
HO
N
H
CN
Me
3aj
13C NMR (100 MHz, CDCl3)
f1 (ppm)
f1 (ppm)

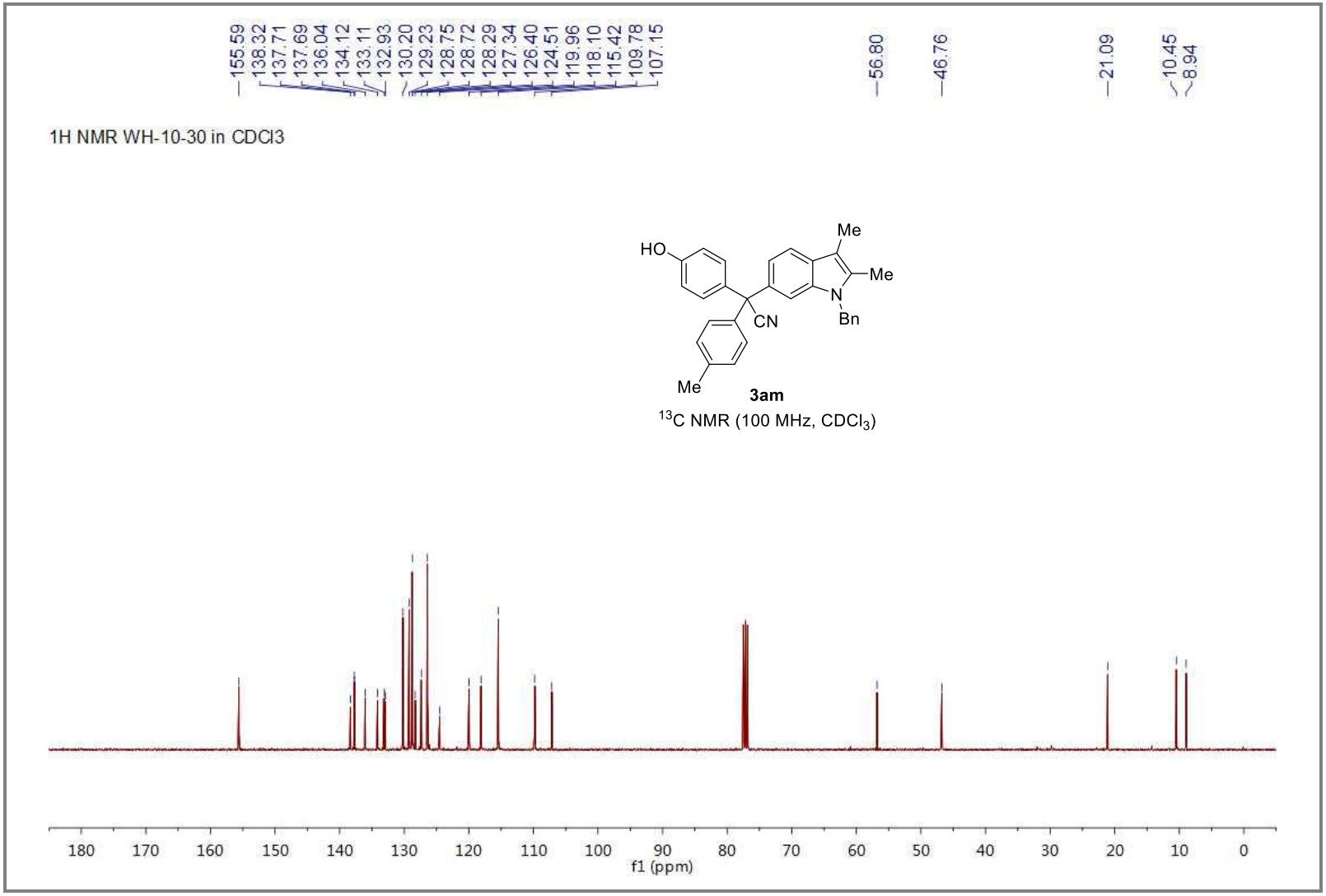

10.6315
9.4164
8.2187
8.1979
7.9999
7.9797
7.9205
7.9000
7.8437
7.8220
7.7725
7.7132
7.7094
7.6924
7.6885
7.6637
7.6420
3.6607
3.6466
3.6327
3.5825
3.5686
3.5549
3.1219
2.6655
2.6535
2.6144
2.5383
2.5250
2.5114
IH NMR WH-10-51-3 in Acetone-d6
HO
N
H
CN
Me
3ak
1H NMR (400 MHz, Acetone-d6)
0.99
0.94
1.00
2.00
2.00
2.00
1.00
1.00
2.00
4.00
3.00
2.00
4.00
11.0
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)

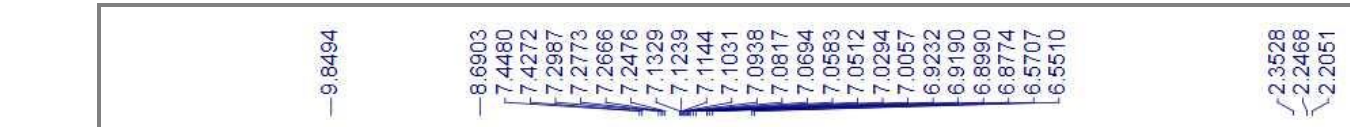

157.91
140.30
139.86
138.34
135.14
133.60
133.14
130.77
129.91
129.60
129.39
125.07
120.15
118.15
116.04
113.70
111.73
57.37
32.65
29.79
29.60
28.25
25.33
20.95
1H NMR WH-10-51-3 in Acetone-d6
HO
N
H
CN
Me
3ak
13C NMR (100 MHz, Acetone-d6)
29.79
29.60
28.25
30.5
30.0
29.5
29.0
28.5
28.0
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.4810
7.4602
7.2128
7.1909
7.1871
7.1726
7.1696
7.1405
7.1188
6.9389
6.9351
6.9182
6.9143
6.8460
6.8243
6.2267
3.5685
2.3989
2.3711
2.2950
1H NMR WH-10-29 in CDCl3
HO
Me
Me
N
Me
CN
Me
3al
1H NMR (400 MHz, CDCl3)
1.00
5.01
2.00
1.00
2.00
1.00
3.00
3.00
3.00
3.00
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)

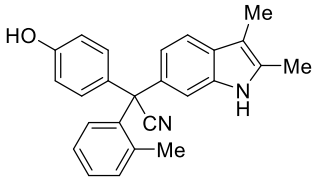

155.67
138.44
137.81
136.24
134.44
133.06
132.78
130.31
129.29
128.81
128.00
119.71
117.95
115.50
109.00
106.34
56.96
29.63
21.11
10.29
8.86
13C NMR WH-10-29 in CDCl3
129.29
128.81
128.00
124.73
119.71
117.95
128
126
124
122
120
118
f1 (ppm)
HO
Me
Me
N
Me
CN
Me
3al
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.4911
7.4707
7.2498
7.2418
7.2282
7.2101
7.1967
7.1278
7.1053
7.0450
7.0232
7.0152
6.9991
6.9760
6.9721
6.9141
6.9096
6.8949
6.7499
6.7331
2.3599
2.3171
2.2885
1H NMR WH-10-30 in CDCl3
HO
Me
Me
N
Bn
CN
Me
3am
1H NMR (400 MHz, CDCl3)
1.00
3.00
4.00
4.00
2.00
2.00
0.93
2.00
3.00
3.00
3.00
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)


155.59
138.32
137.71
137.69
136.04
134.12
133.11
132.93
130.20
129.23
128.75
128.72
128.29
127.34
126.40
124.51
119.96
118.10
115.42
109.78
107.15
56.80
46.76
21.09
10.45
8.94
1H NMR WH-10-30 in CDCl3
HO
Me
Me
N
Bn
CN
Me
3am
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

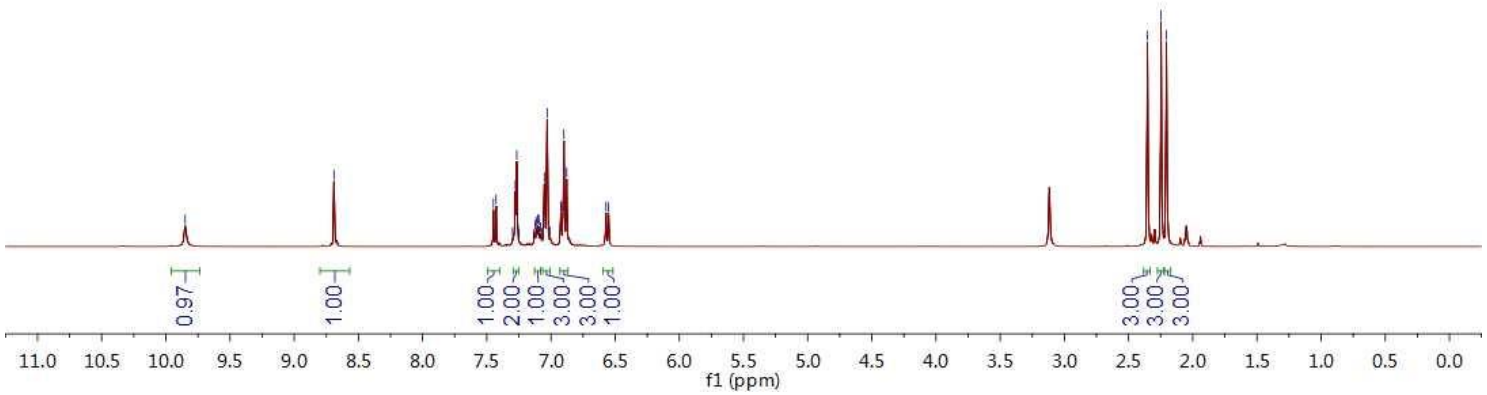


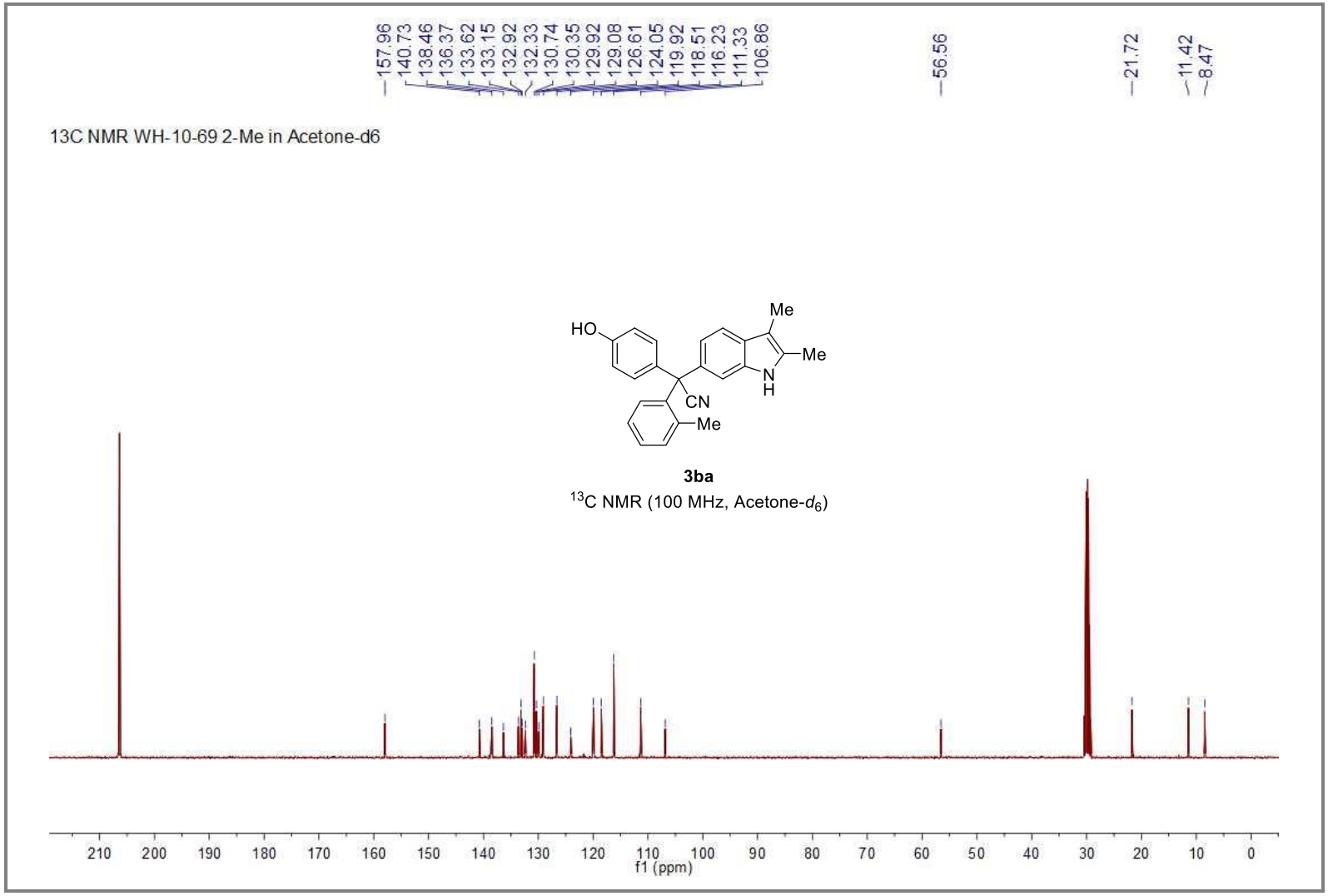
1H NMR WH-10-69 2-Me in Acetone-d6

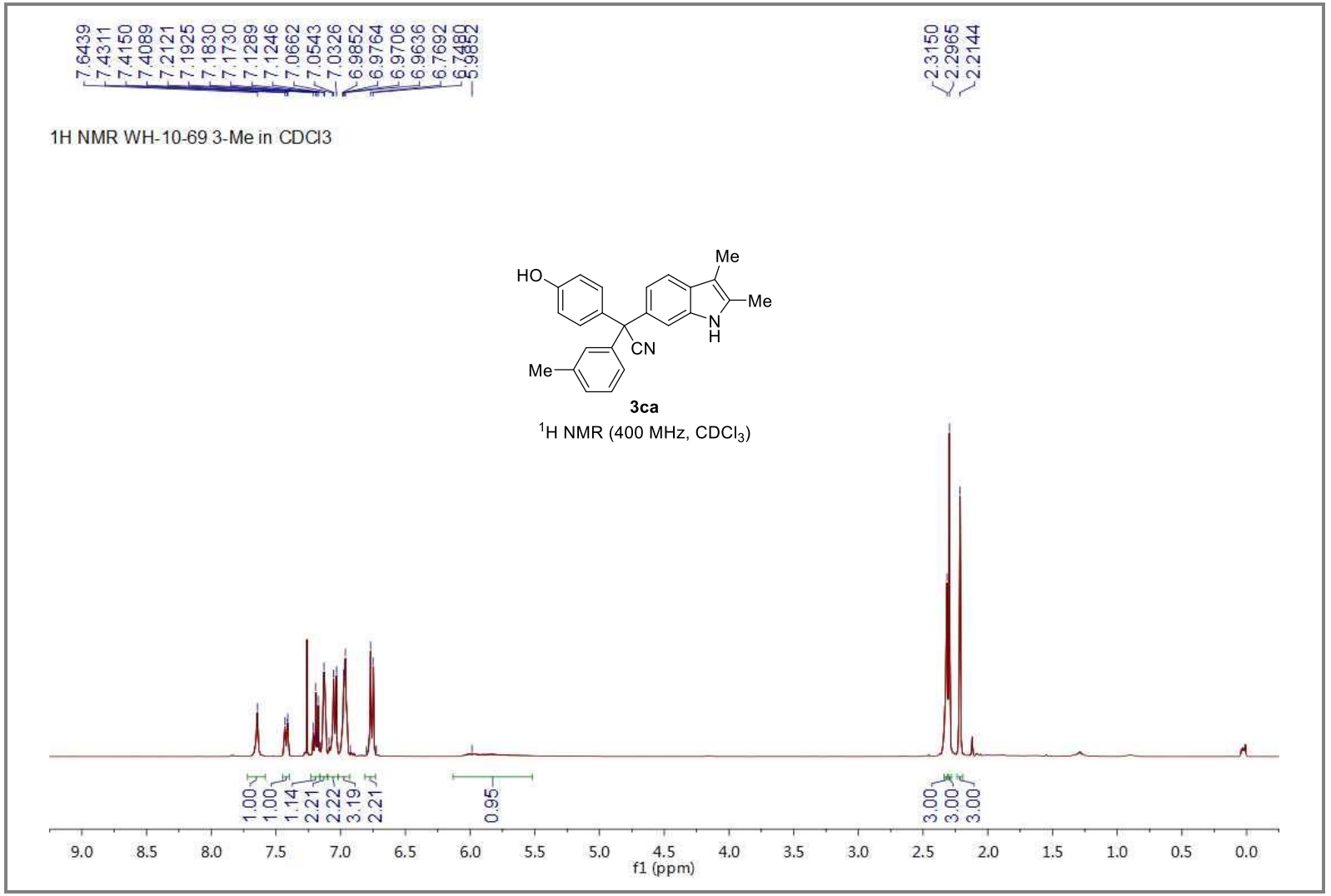


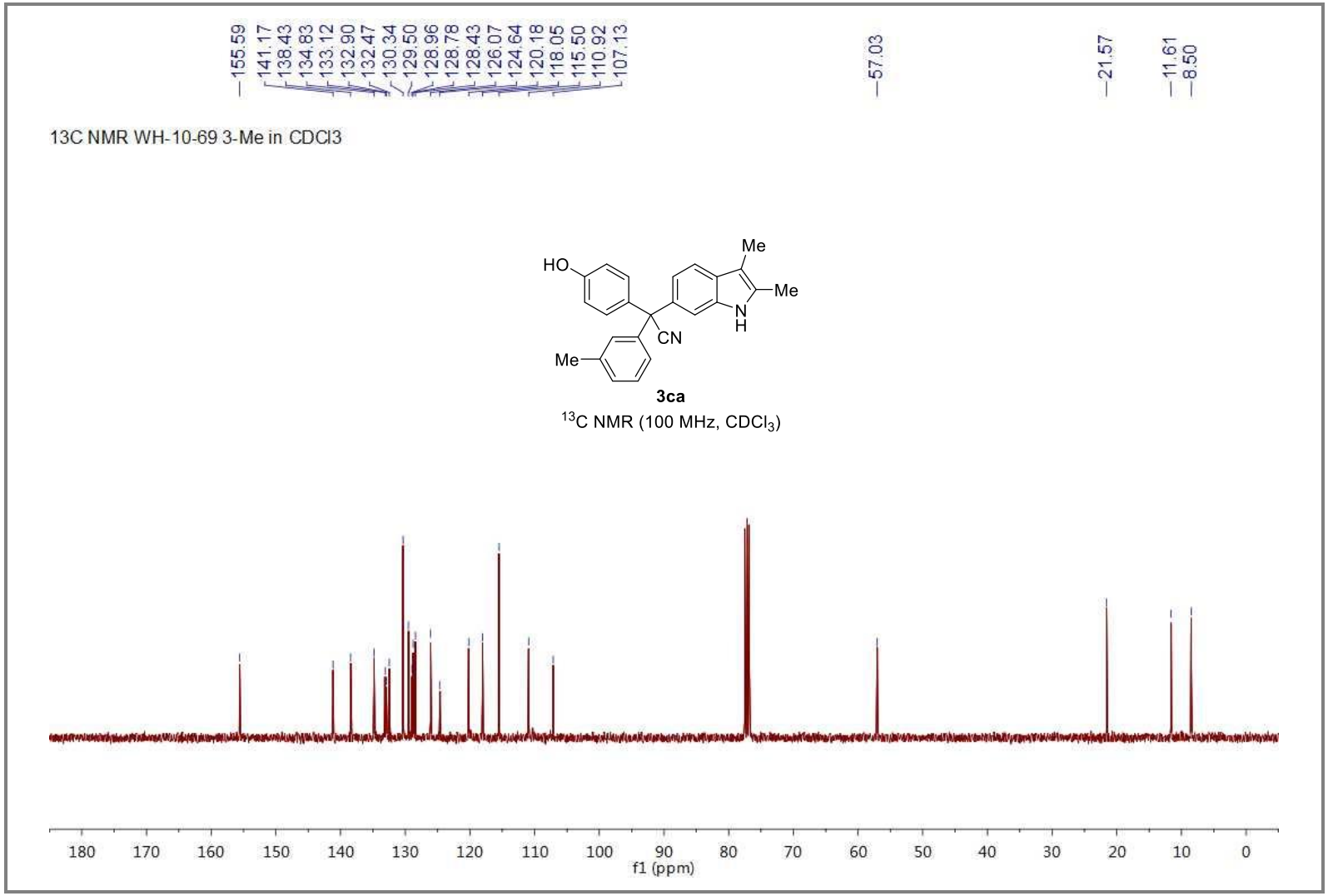
3ba

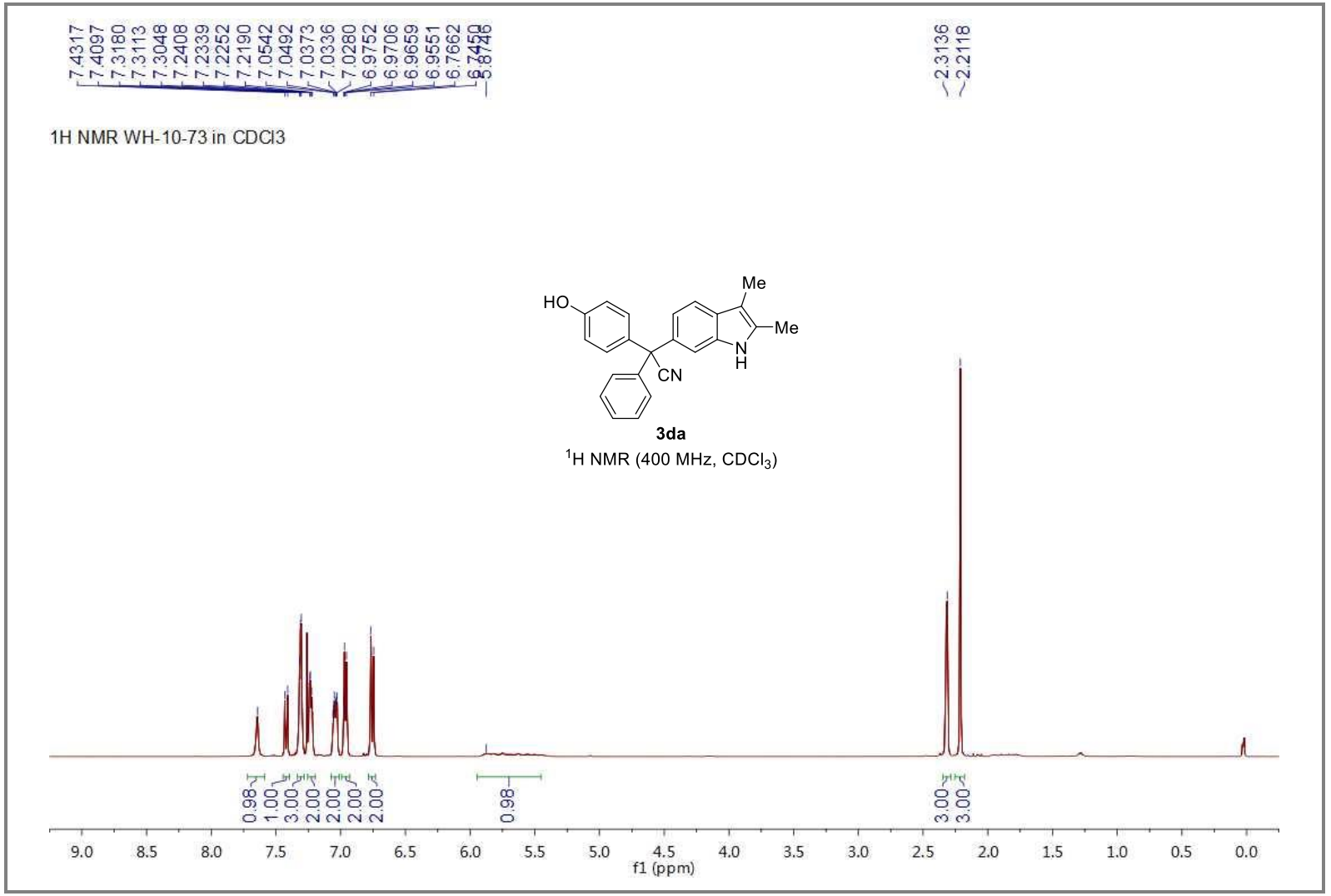
^{1}H NMR (400 MHz, Acetone-d_6)

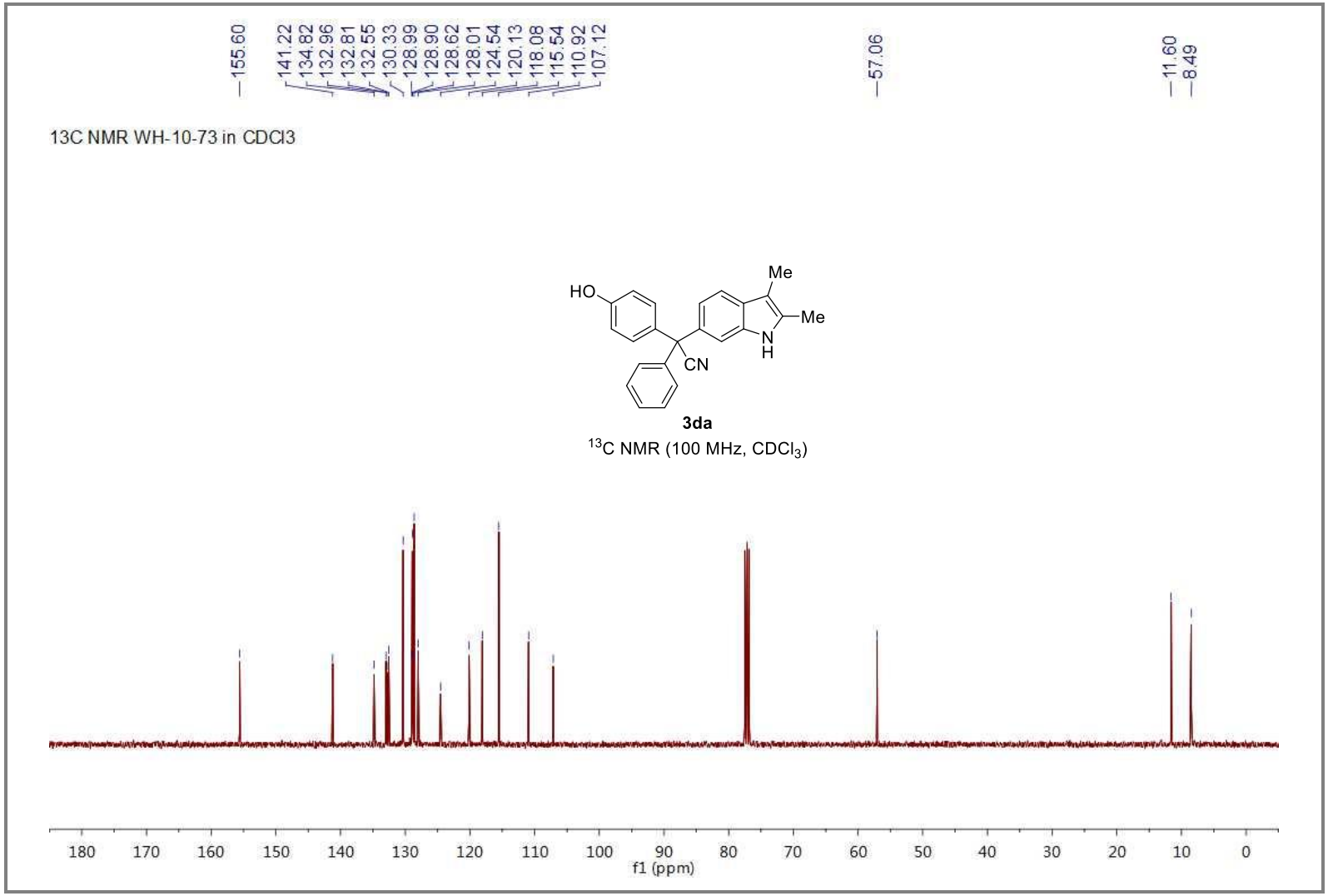


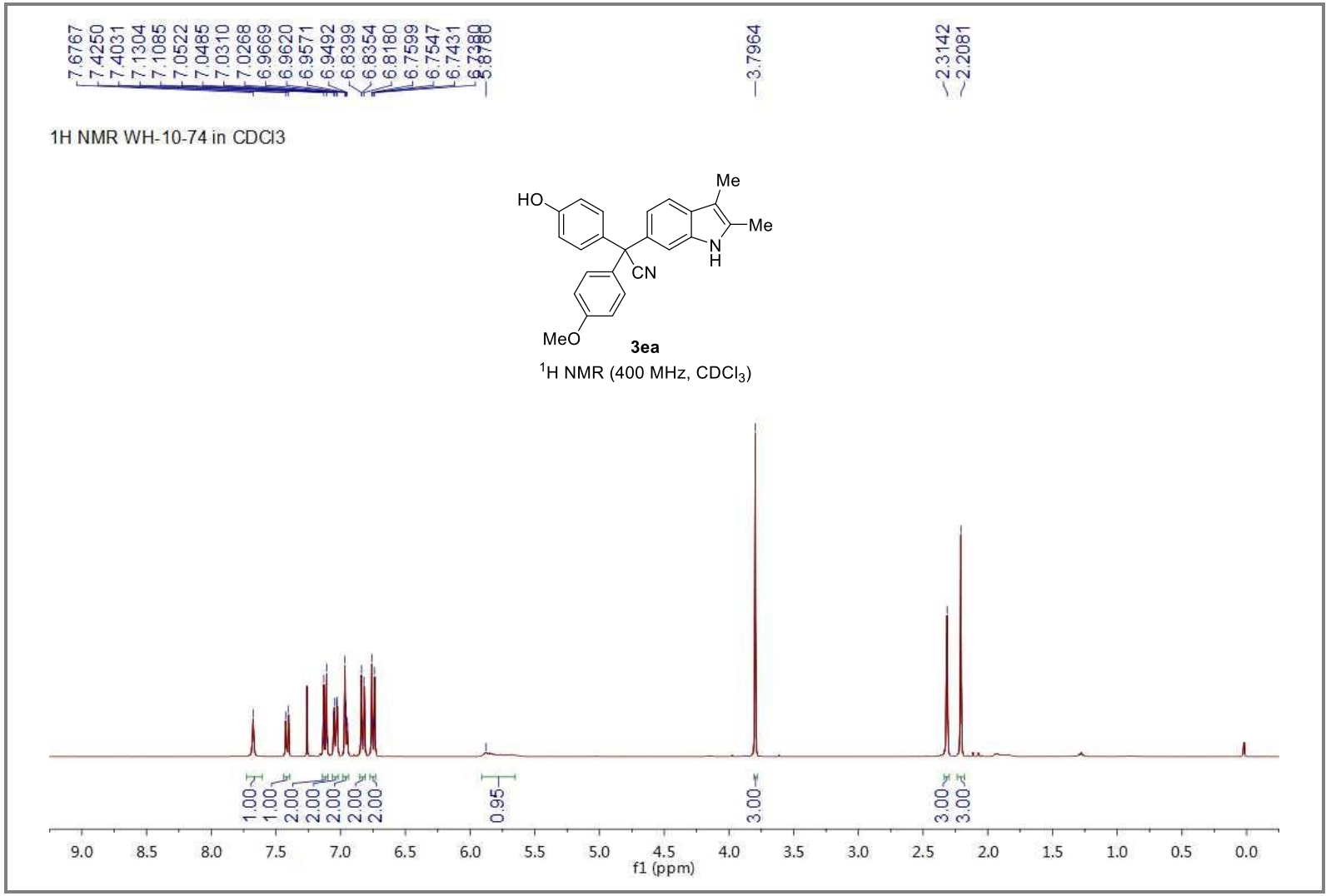

157.96
140.73
138.46
136.37
133.62
133.15
132.92
132.33
130.74
130.35
129.92
129.08
126.61
124.05
119.92
118.51
116.23
111.33
106.86
56.56
21.72
11.42
8.47
13C NMR WH-10-69 2-Me in Acetone-d6
HO
Me
Me
N
H
CN
Me
3ba
13C NMR (100 MHz, Acetone-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

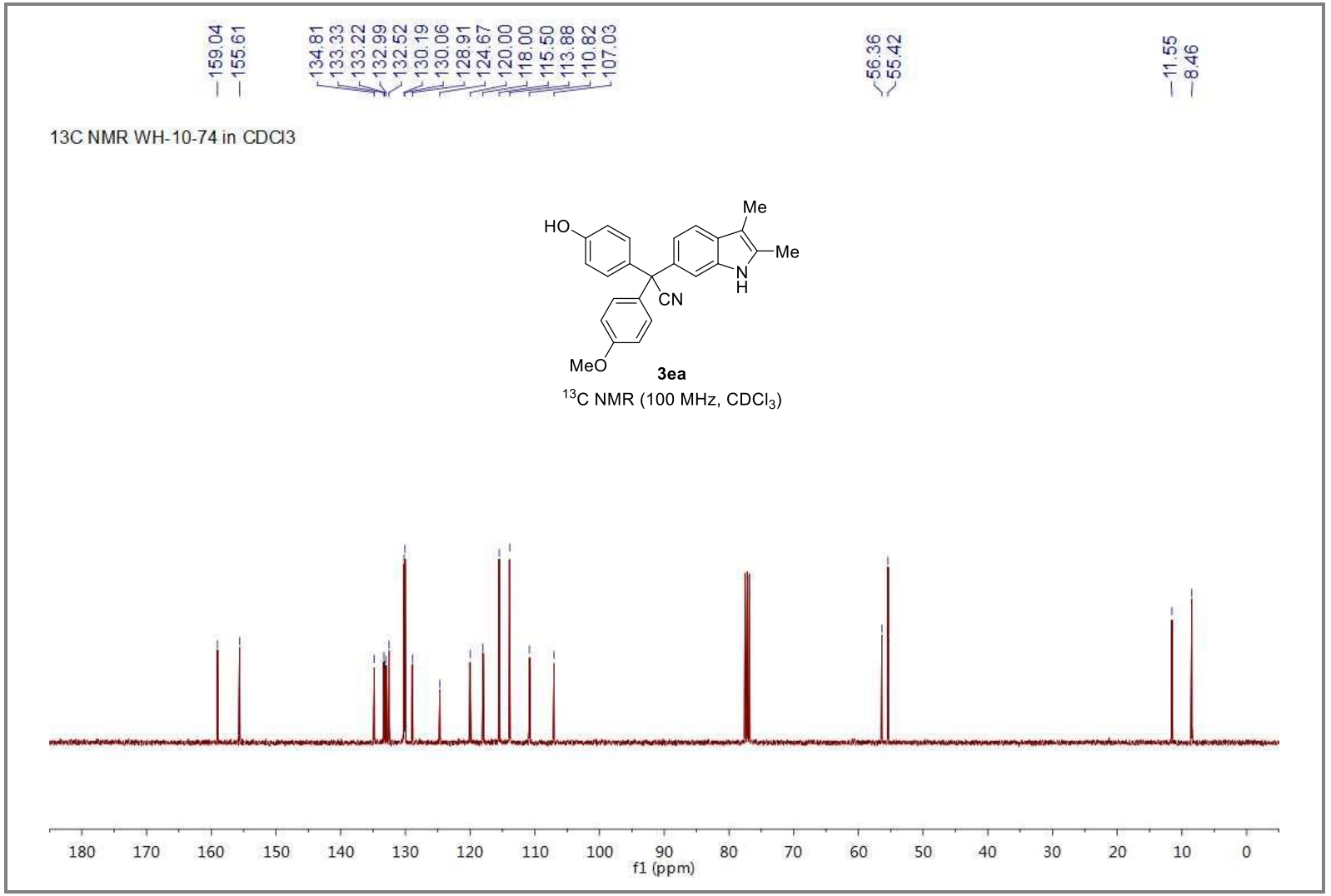

7.6439
7.4311
7.4150
7.4089
7.2121
7.1925
7.1830
7.1730
7.1289
7.1246
7.0662
7.0543
7.0326
6.9852
6.9764
6.9706
6.9636
6.7692
6.7480
6.9852
2.3150
2.2965
2.2144
1H NMR WH-10-69 3-Me in CDCl3
HO
Me
Me
N
H
CN
Me
3ca
1H NMR (400 MHz, CDCl3)
1.00
1.00
1.14
2.21
2.22
3.19
2.21
0.95
3.00
3.00
3.00
9.0
8.5
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)


155.59
141.17
138.43
134.83
133.12
132.90
132.47
130.34
129.50
128.96
128.78
128.43
126.07
124.64
120.18
118.05
115.50
110.92
107.13
57.03
21.57
11.61
8.50
13C NMR WH-10-69 3-Me in CDCl3
HO
Me
Me
N
H
CN
Me
3ca
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

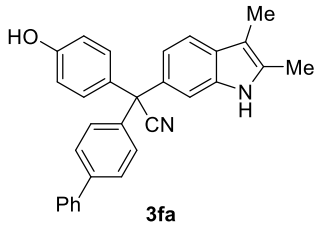

7.4317
7.4097
7.3180
7.3113
7.3048
7.2408
7.2339
7.2252
7.2190
7.0542
7.0492
7.0373
7.0336
7.0280
6.9752
6.9706
6.9659
6.9551
6.7662
2.3136
2.2118
1H NMR WH-10-73 in CDCl3
HO
Me
Me
N
H
CN
3da
1H NMR (400 MHz, CDCl3)
0.98
1.00
3.00
2.00
2.00
2.00
2.00
0.98
3.00
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


155.60
141.22
134.82
132.96
132.81
132.55
130.33
128.99
128.90
128.62
128.01
124.54
120.13
118.08
115.54
110.92
107.12
57.06
11.60
8.49
13C NMR WH-10-73 in CDCl3
HO
Me
Me
N
H
CN
3da
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.6767
7.4250
7.4031
7.1304
7.1085
7.0522
7.0485
7.0310
7.0268
6.9669
6.9620
6.9571
6.9492
6.8399
6.8354
6.8180
6.7599
6.7547
6.7431
3.7964
2.3142
2.2081
1H NMR WH-10-74 in CDCl3
HO
Me
Me
N
H
CN
MeO
3ea
1H NMR (400 MHz, CDCl3)
1.00
1.00
2.00
2.00
2.00
2.00
2.00
0.95
3.00
3.00
3.00
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)

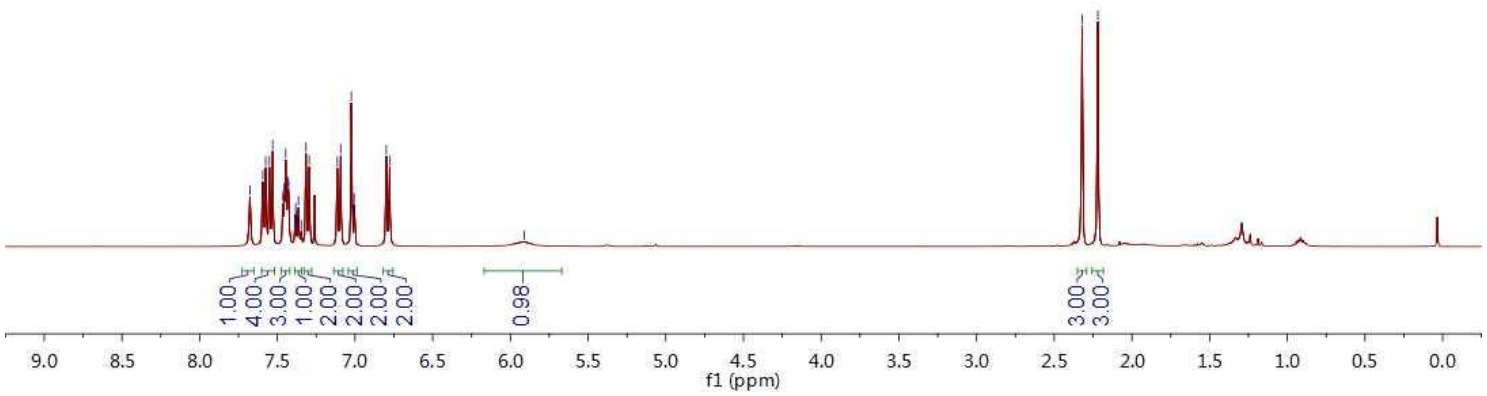

159.04
155.61
134.81
133.33
133.22
132.99
132.52
130.19
130.06
128.91
124.67
120.00
118.00
115.50
113.88
110.82
107.03
56.36
55.42
11.55
8.46
13C NMR WH-10-74 in CDCl3
HO
Me
Me
N
H
CN
MeO
3ea
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

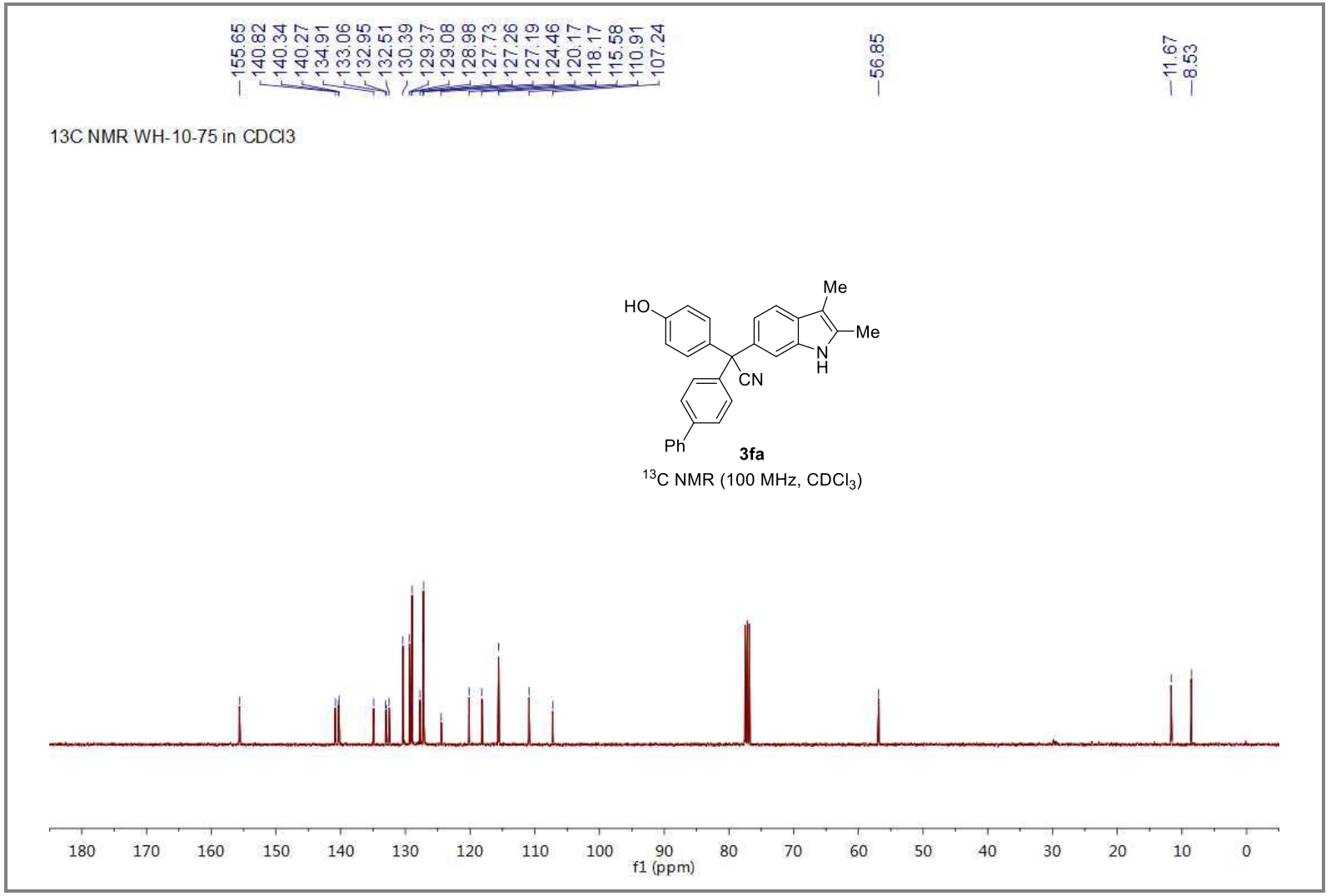
1H NMR WH-10-75 in CDCl3

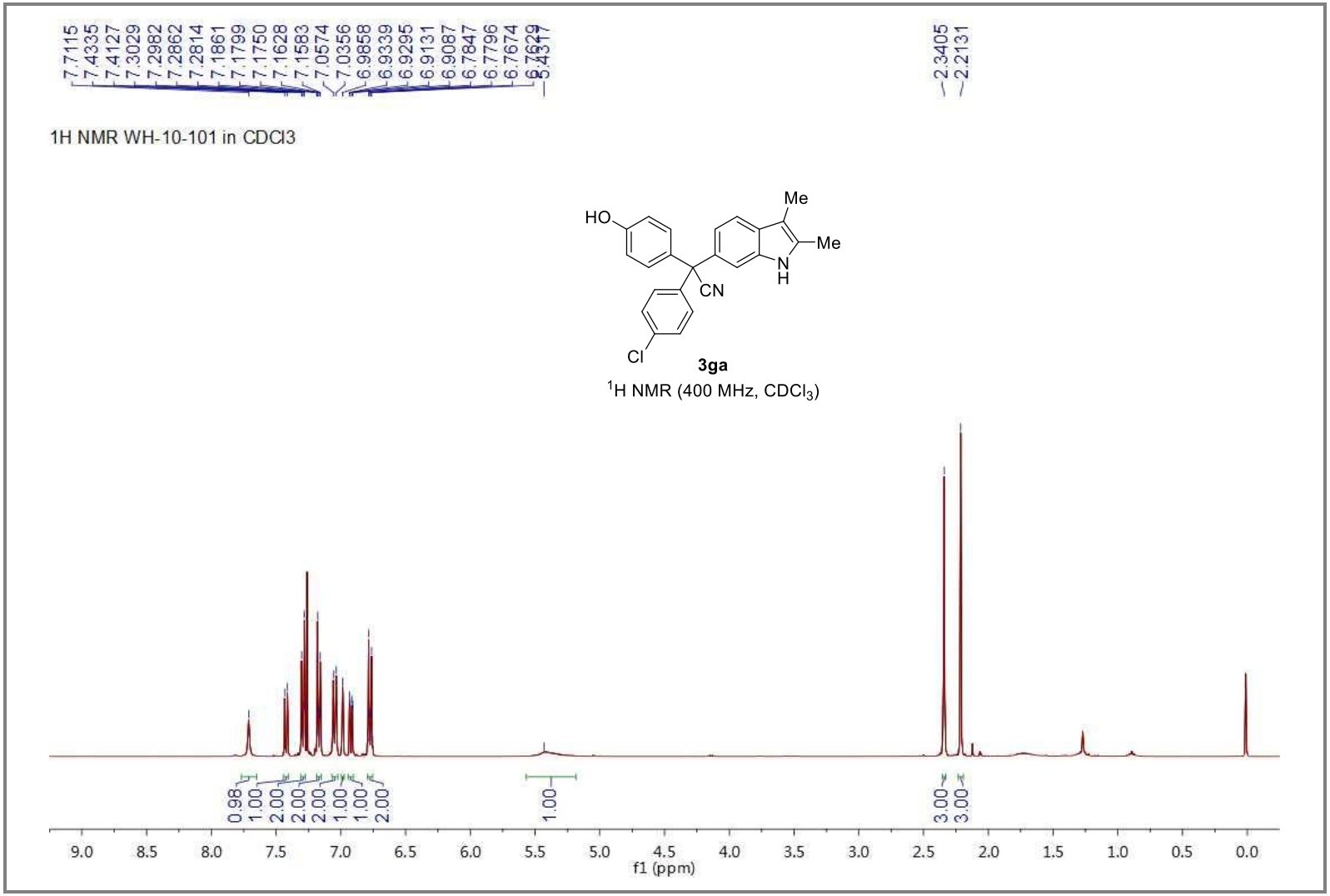


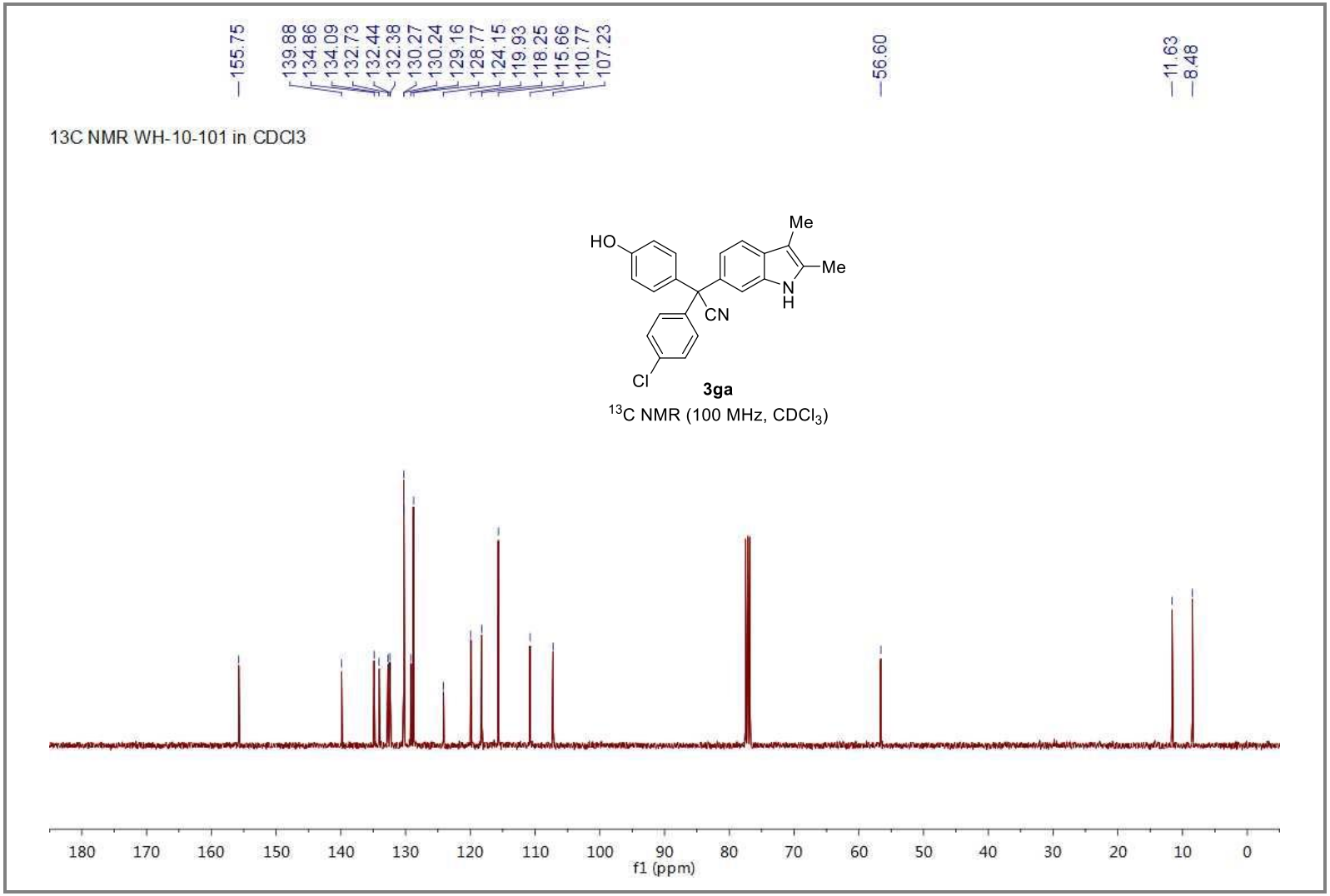
3fa

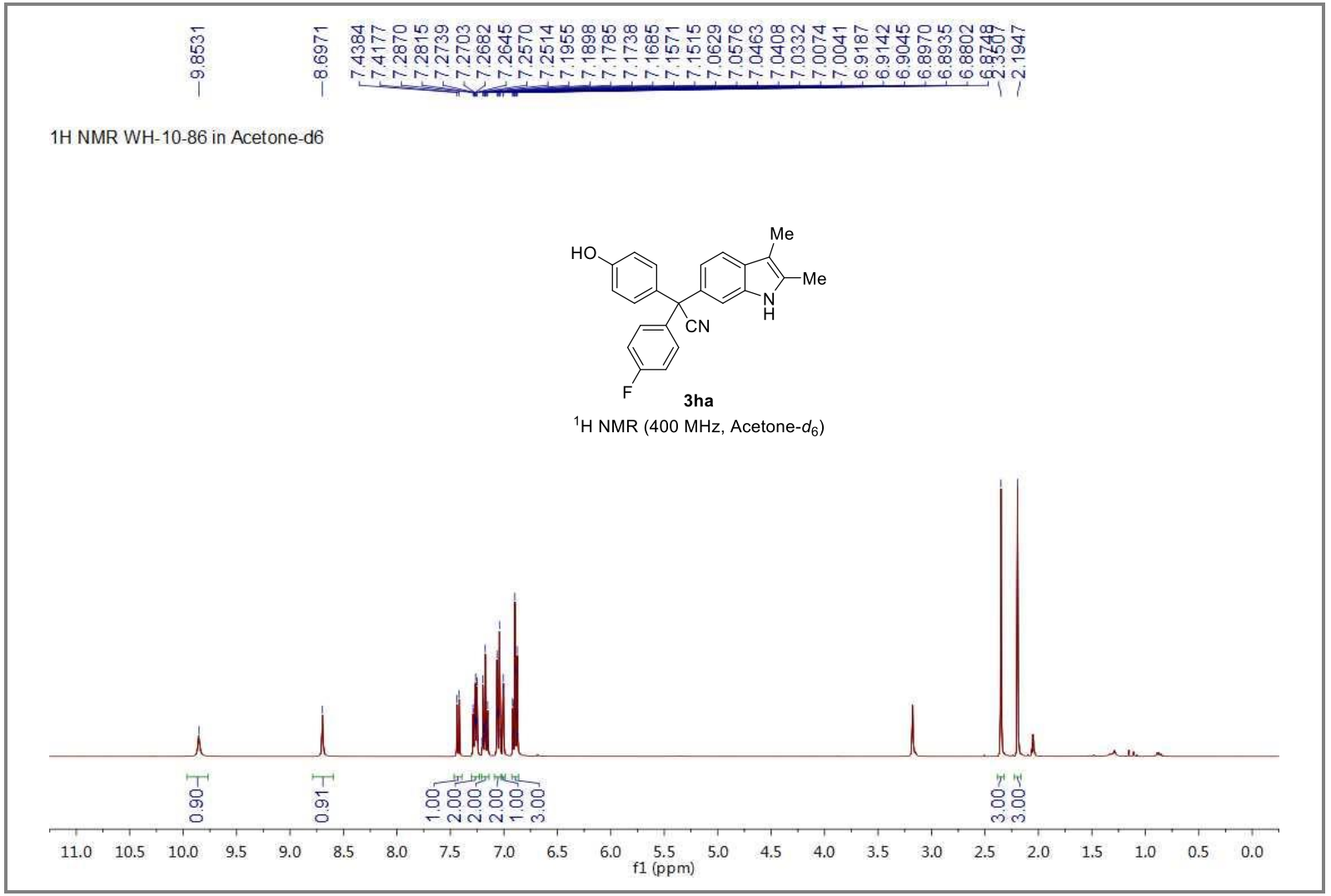
^{1}H NMR (400 MHz, $CDCl_3$)

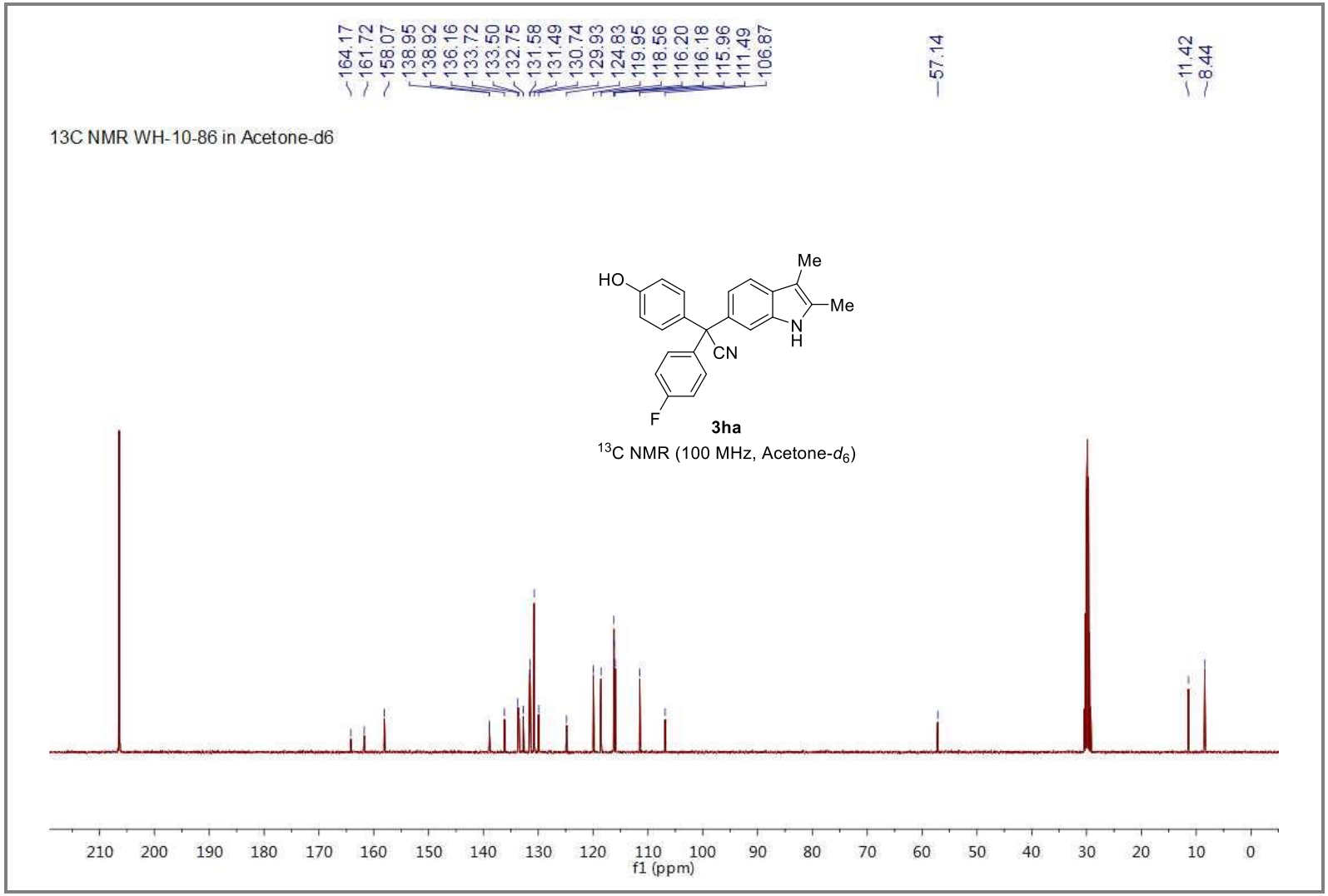



155.65
140.82
140.34
140.27
134.91
133.06
132.95
132.51
130.39
129.37
129.08
128.98
127.73
127.26
127.19
124.46
120.17
118.17
115.58
110.91
107.24
56.85
11.67
8.53
13C NMR WH-10-75 in CDCl3
HO
Me
Me
N
H
CN
Ph
3fa
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

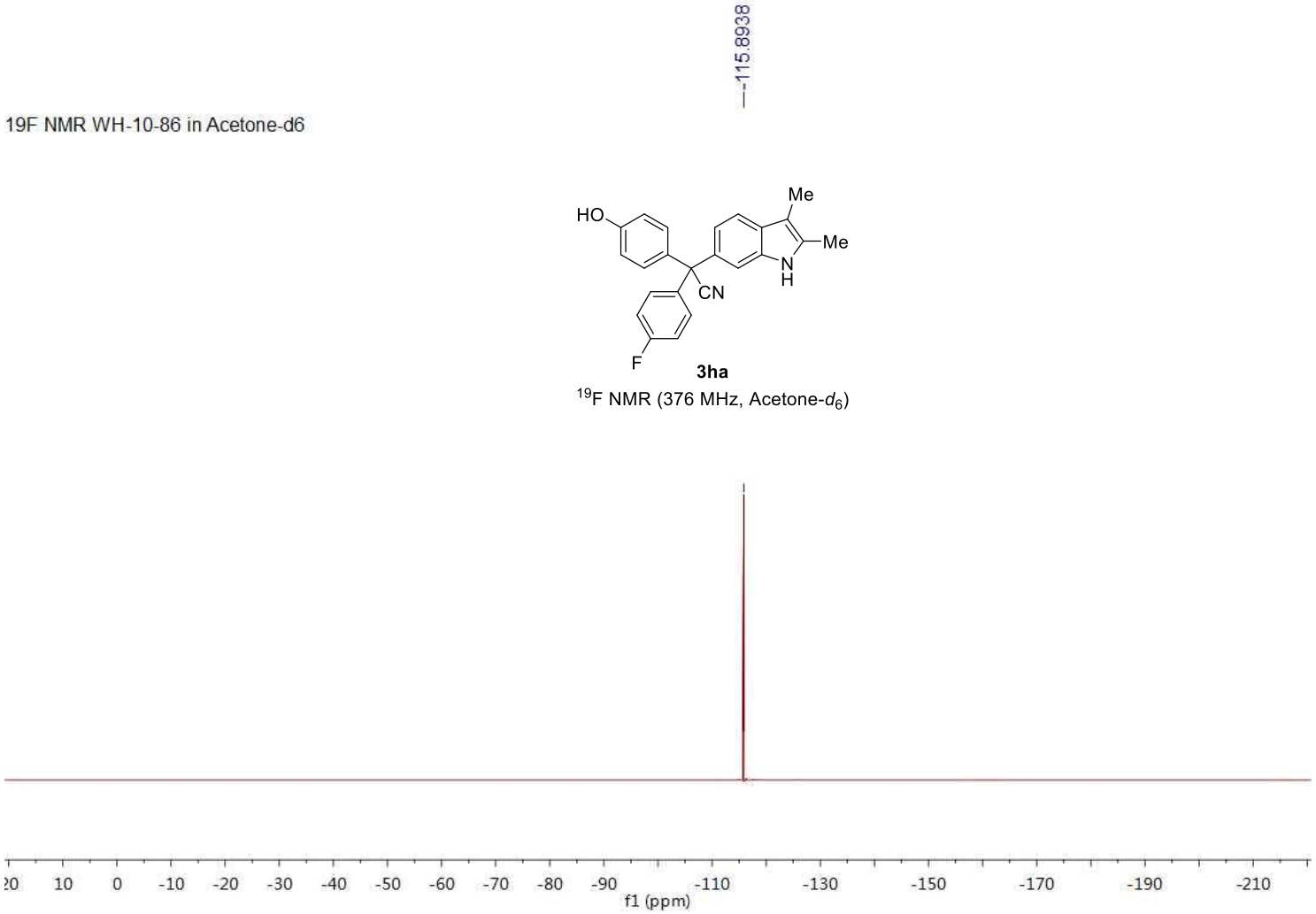

7.7115
7.4335
7.4127
7.3029
7.2982
7.2862
7.2814
7.1861
7.1799
7.1750
7.1628
7.1583
7.0574
7.0356
6.9858
6.9339
6.9295
6.9131
6.9087
6.7847
6.7796
6.7674
2.3405
2.2131
1H NMR WH-10-101 in CDCl3
HO
Me
Me
N
H
CN
Cl
3ga
1H NMR (400 MHz, CDCl3)
0.98
1.00
2.00
2.00
2.00
1.00
1.00
2.00
1.00
3.00
3.00
9.0
8.5
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)


155.75
139.88
134.86
134.09
132.73
132.44
132.38
130.27
130.24
129.16
128.77
124.15
119.93
118.25
115.66
110.77
107.23
56.60
11.63
8.48
13C NMR WH-10-101 in CDCl3
HO
Me
Me
N
H
CN
Cl
3ga
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


9.8531
8.6971
7.4384
7.4177
7.2870
7.2815
7.2739
7.2703
7.2682
7.2645
7.2570
7.2514
7.1955
7.1898
7.1785
7.1738
7.1685
7.1571
7.1515
7.0629
7.0576
7.0463
7.0408
7.0332
7.0074
7.0041
6.9187
6.9142
6.9045
6.8970
6.8935
6.8802
6.8748
2.3507
2.1947
1H NMR WH-10-86 in Acetone-d6
HO
Me
Me
N
H
CN
F
3ha
1H NMR (400 MHz, Acetone-d6)
0.90
0.91
1.00
2.00
2.00
2.00
1.00
3.00
3.00
3.00
11.0
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)

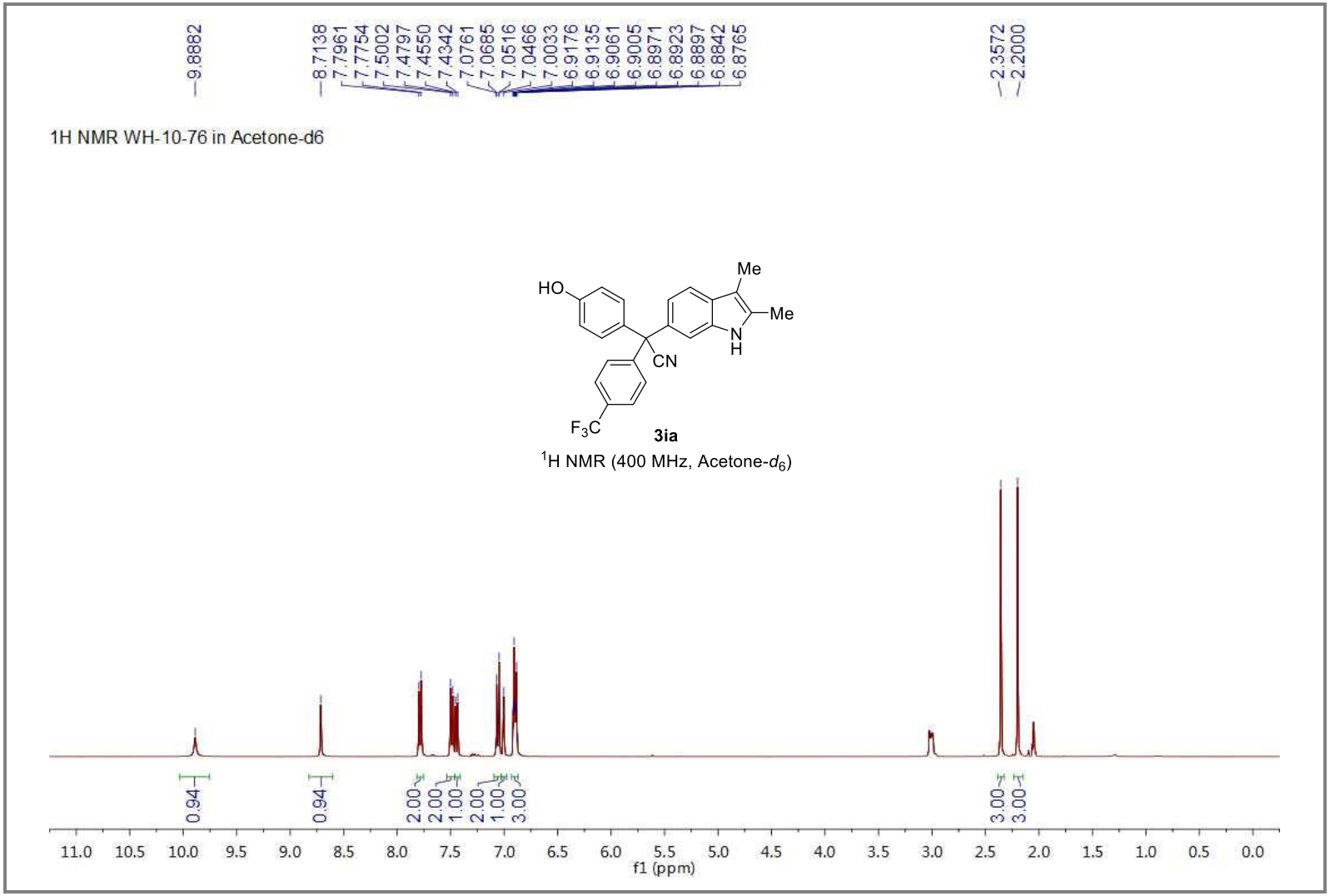

164.17
161.72
158.07
138.95
138.92
136.16
133.72
133.50
132.75
131.58
131.49
130.74
129.93
124.83
119.95
118.56
116.20
116.18
115.96
111.49
106.87
57.14
11.42
8.44
13C NMR WH-10-86 in Acetone-d6
HO
Me
Me
N
H
CN
F
3ha
13C NMR (100 MHz, Acetone-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

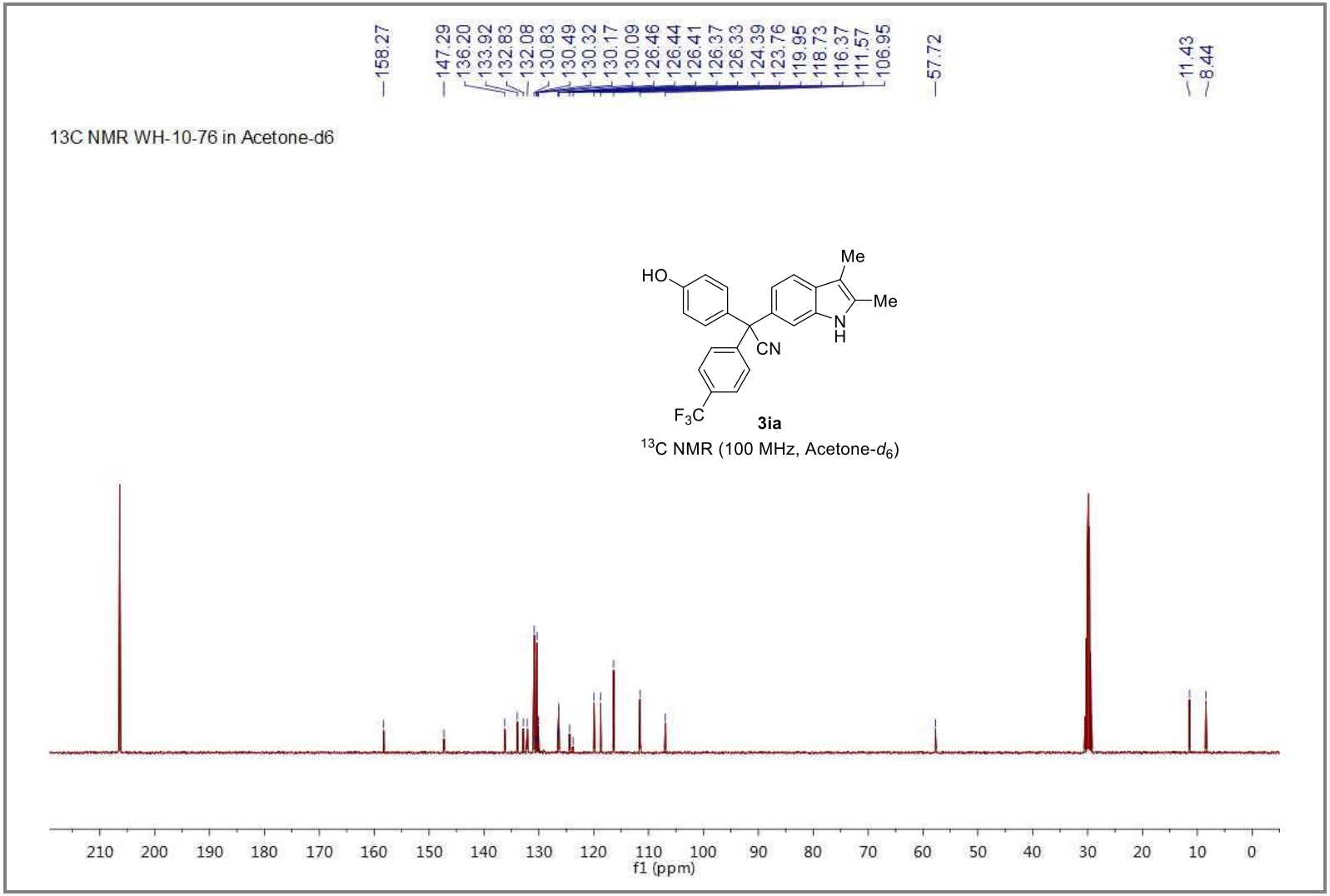
19F NMR WH-10-86 in Acetone-d6

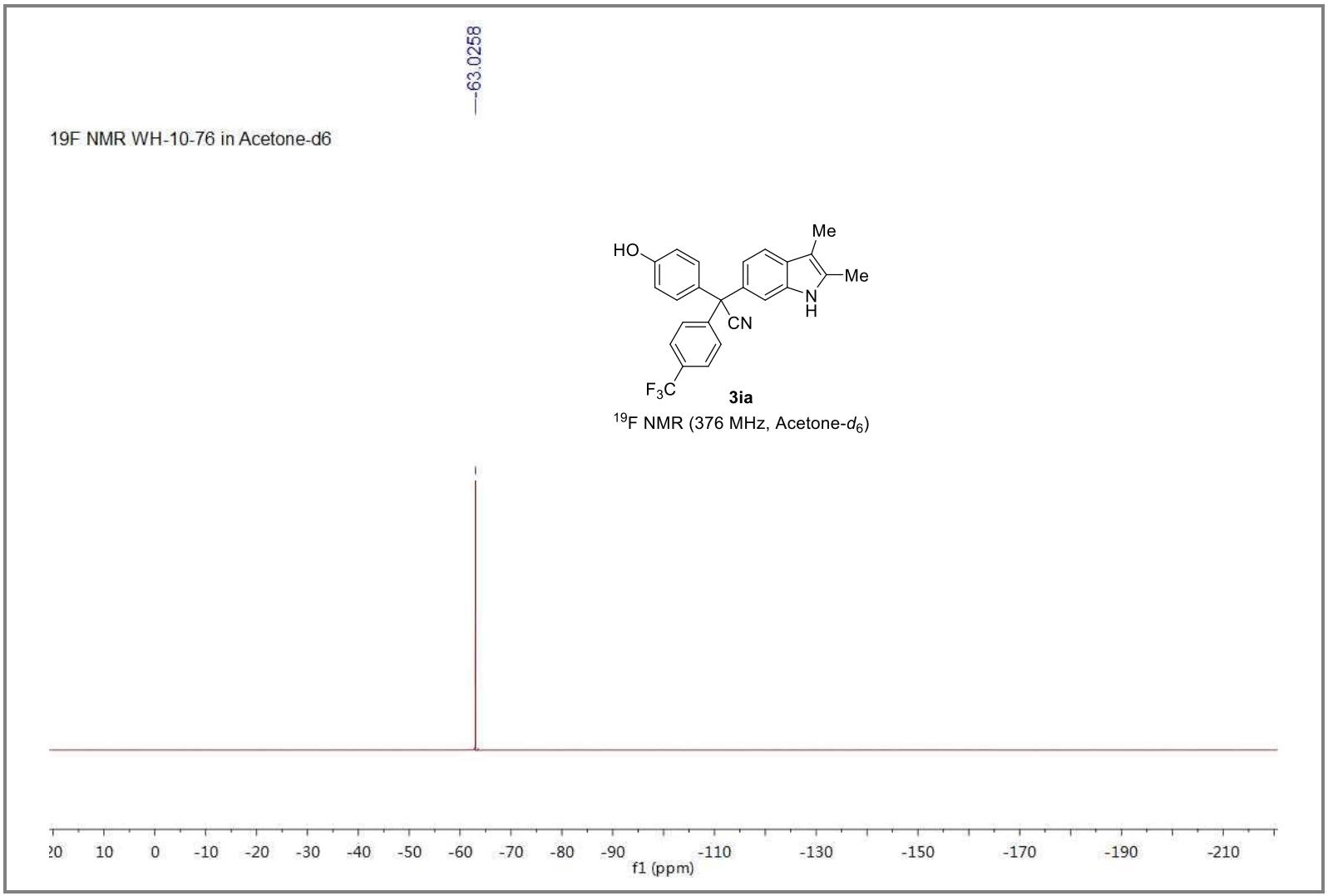


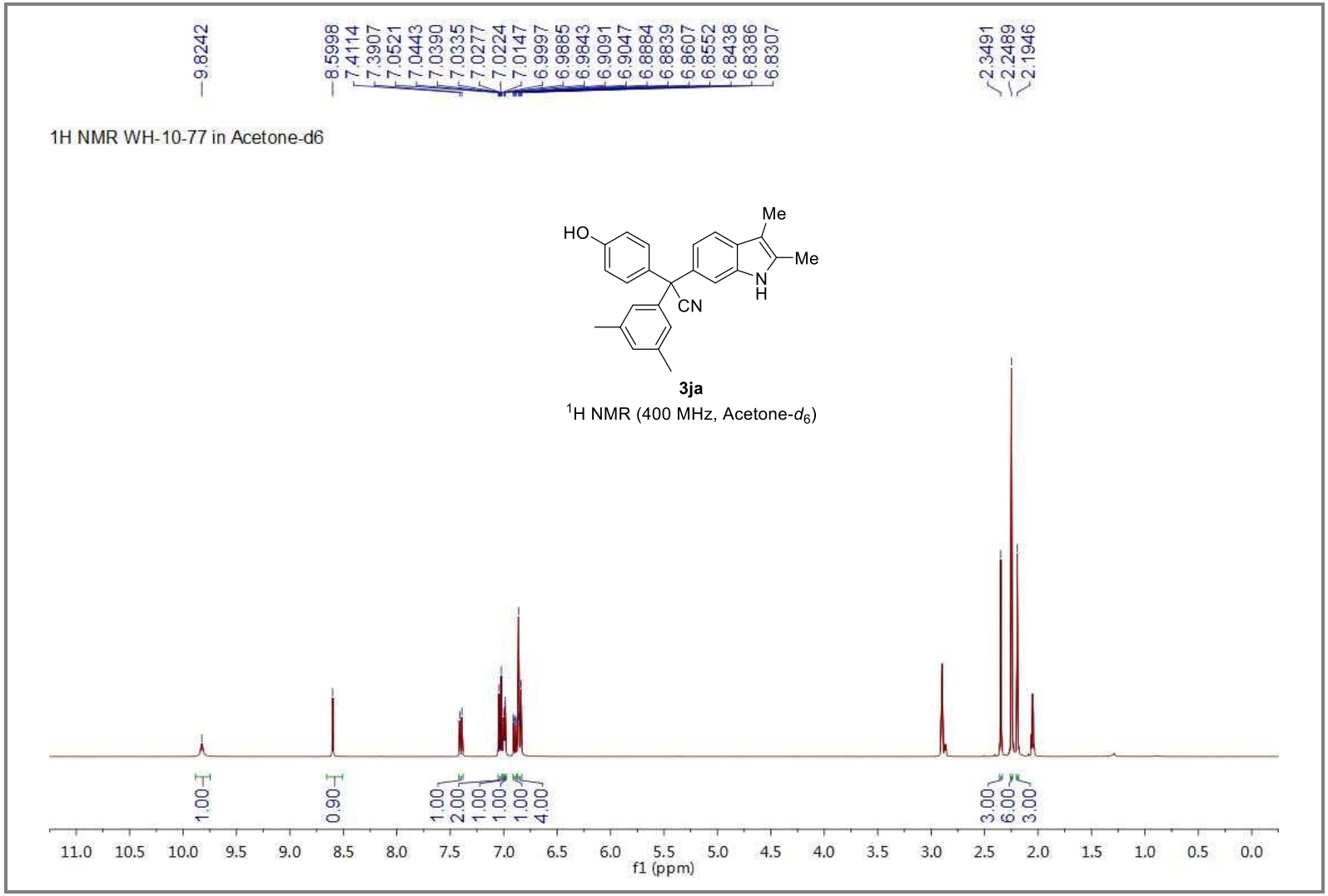
3ha

^{19}F NMR (376 MHz, Acetone-d_6)


9.8882
8.7138
7.7961
7.7754
7.5002
7.4797
7.4550
7.4342
7.0761
7.0685
7.0516
7.0466
7.0033
6.9176
6.9135
6.9061
6.9005
6.8971
6.8923
6.8897
6.8842
6.8765
2.3572
2.2000
1H NMR WH-10-76 in Acetone-d6
HO
Me
Me
N
H
CN
F3C
3ia
1H NMR (400 MHz, Acetone-d6)
0.94
0.94
2.00
2.00
1.00
2.00
1.00
3.00
3.00
3.00
11.0 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)

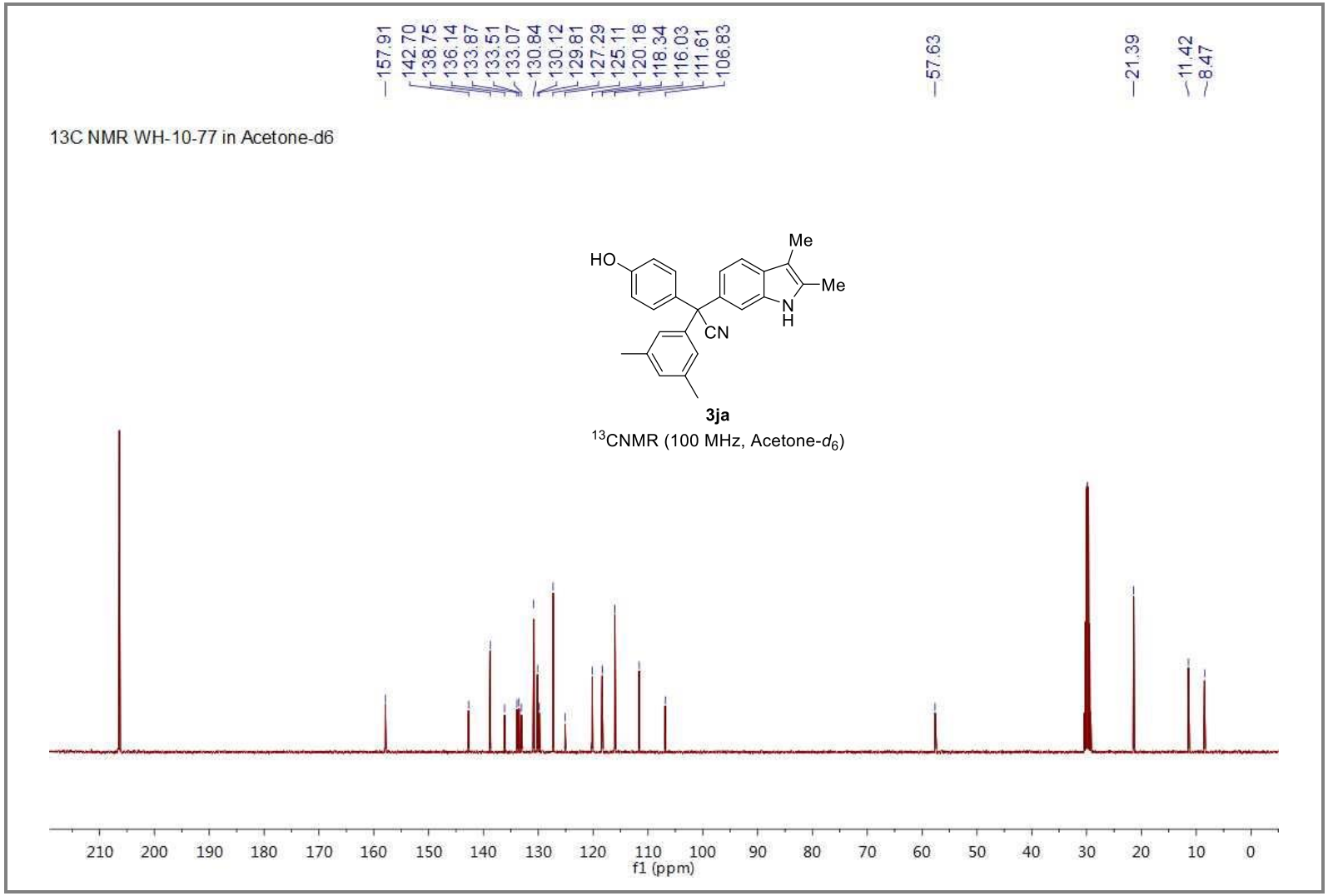

158.27
147.29
136.20
133.92
132.83
132.08
130.83
130.49
130.32
130.17
130.09
126.46
126.44
126.41
126.37
126.33
124.39
123.76
119.95
118.73
116.37
111.57
106.95
57.72
11.43
8.44
13C NMR WH-10-76 in Acetone-d6
HO
Me
Me
N
H
CN
F3C
3ia
13C NMR (100 MHz, Acetone-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-63.0258
19F NMR WH-10-76 in Acetone-d6
HO
Me
Me
N
H
CN
F3C
3ia
19F NMR (376 MHz, Acetone-d6)
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-110
-130
-150
-170
-190
-210
f1 (ppm)

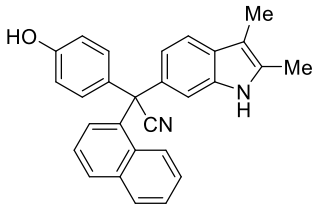


3ja

^{1}H NMR (400 MHz, Acetone-d_6)

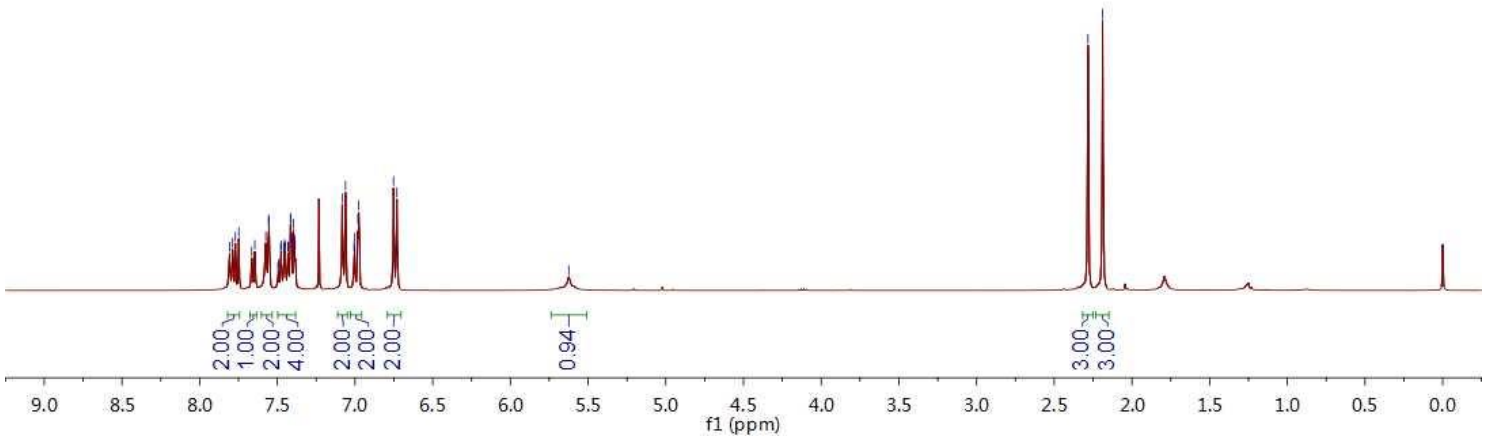

157.91
142.70
138.75
136.14
133.87
133.51
133.07
130.84
130.12
129.81
127.29
125.11
120.18
118.34
116.03
111.61
106.83
57.63
21.39
11.42
8.47
13C NMR WH-10-77 in Acetone-d6
HO
Me
Me
N
H
CN
3ja
13CNMR (100 MHz, Acetone-d6)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

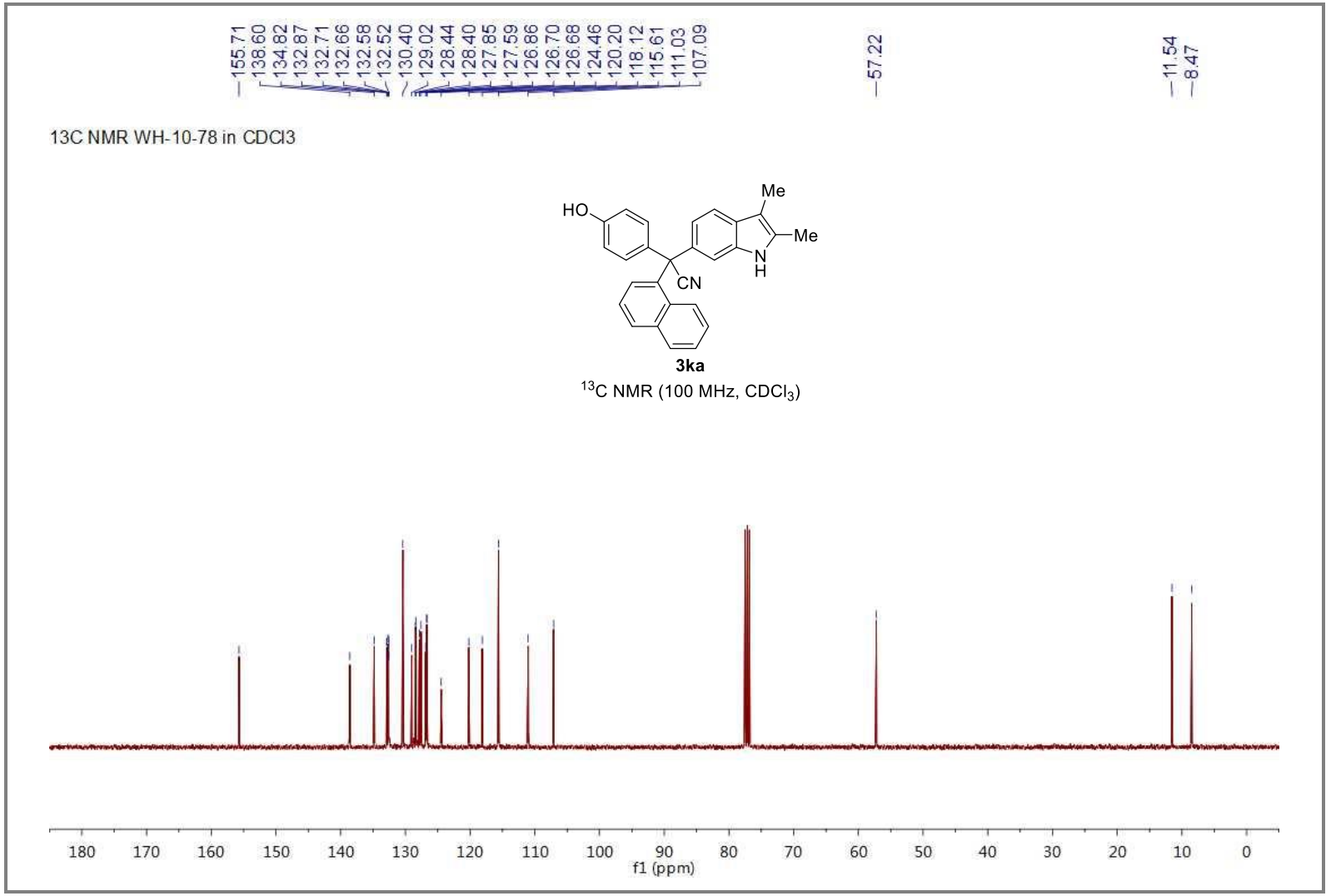
1H NMR WH-10-78 in CDCl3

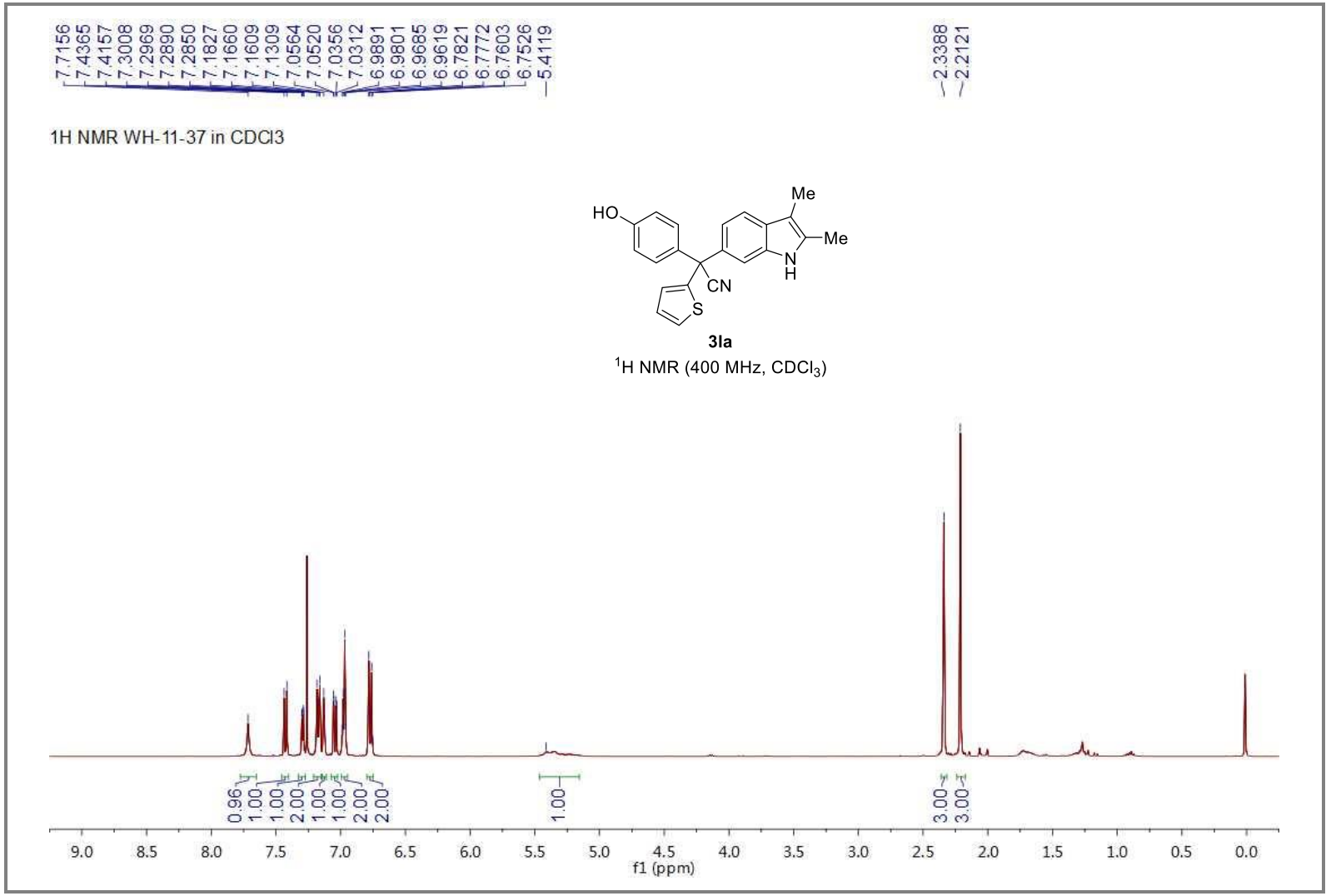


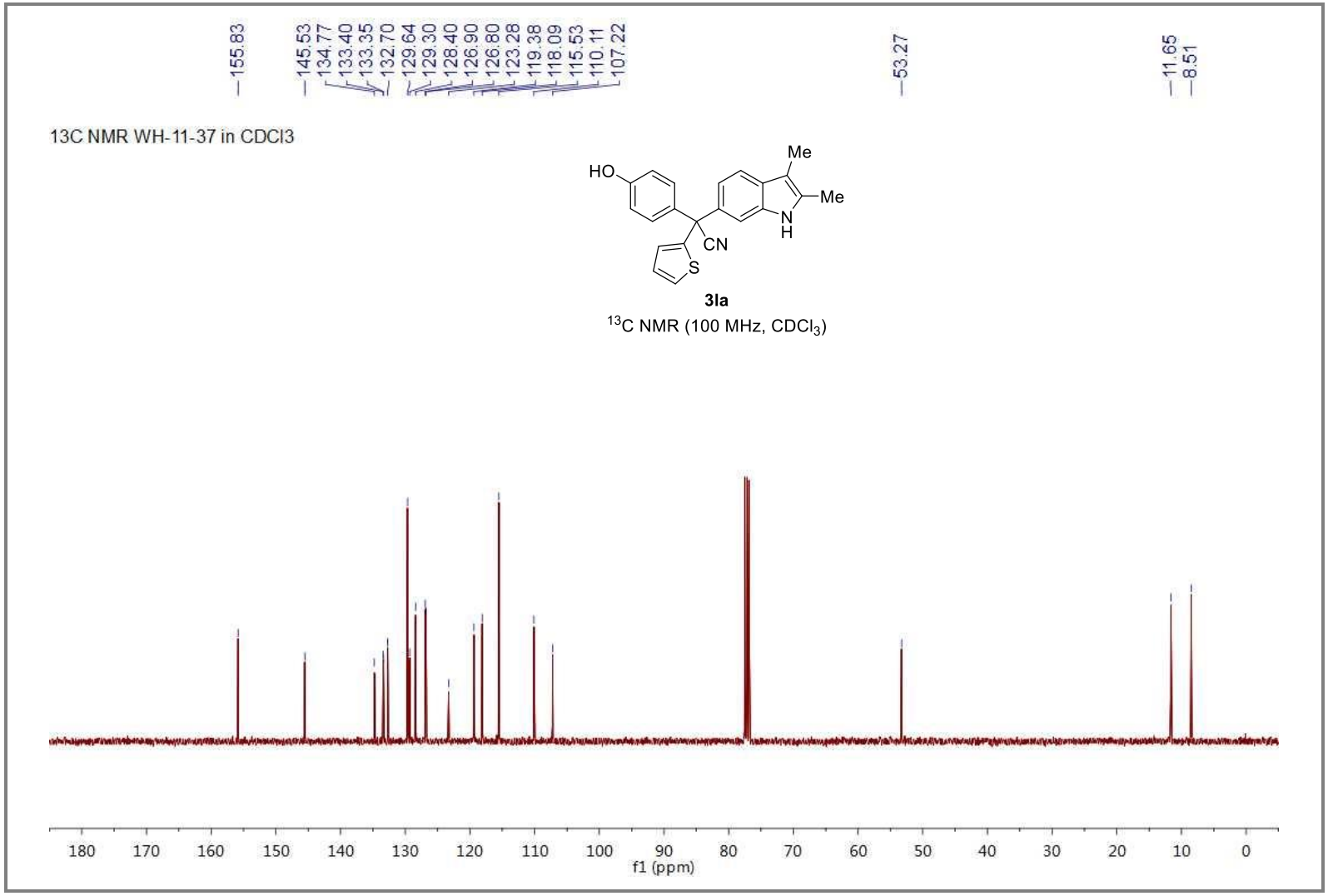
3ka

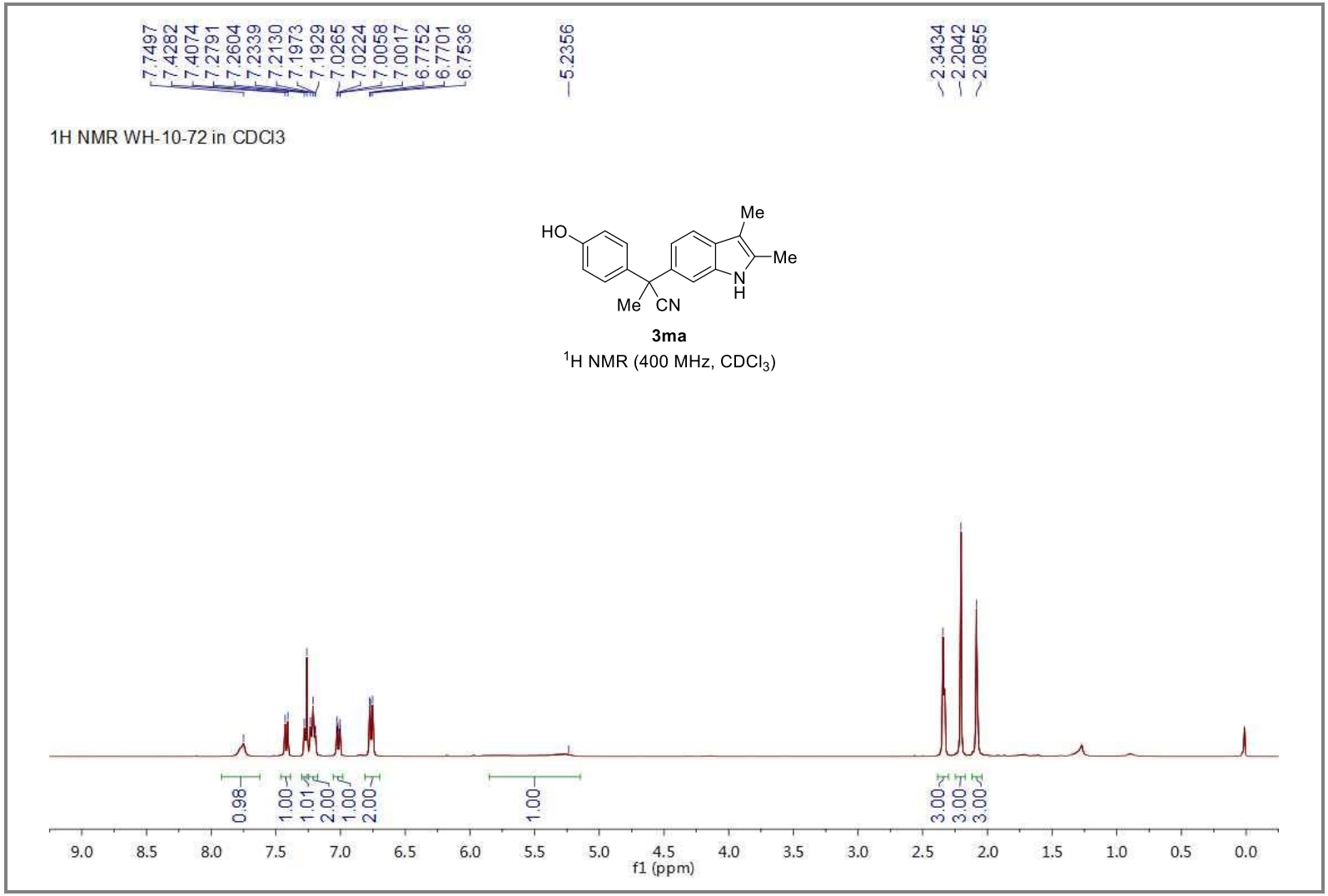
^{1}H NMR (400 MHz, $CDCl_3$)




155.71
138.60
134.82
132.87
132.71
132.66
132.58
132.52
130.40
129.02
128.44
128.40
127.85
127.59
126.86
126.70
126.68
124.46
120.20
118.12
115.61
111.03
107.09
57.22
11.54
8.47
13C NMR WH-10-78 in CDCl3
HO
Me
Me
N
H
CN
3ka
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

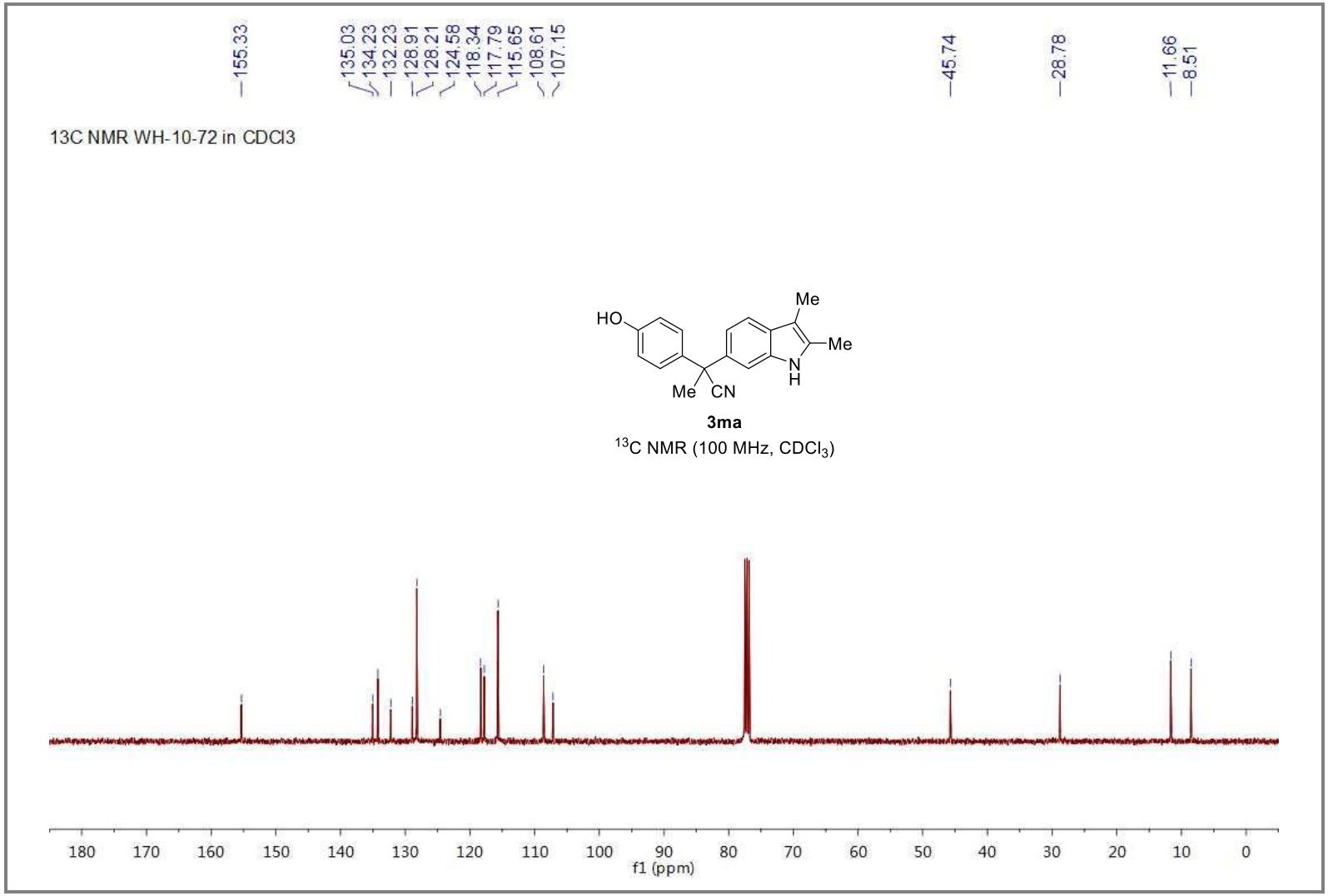

7.7156
7.4365
7.4157
7.3008
7.2969
7.2890
7.2850
7.1827
7.1660
7.1609
7.1309
7.0564
7.0520
7.0356
7.0312
6.9891
6.9801
6.9685
6.9619
6.7821
6.7772
6.7603
6.7526
5.4119
2.3388
2.2121
1H NMR WH-11-37 in CDCl3
HO
Me
Me
N
H
CN
S
3la
1H NMR (400 MHz, CDCl3)
0.96
1.00
1.00
2.00
1.00
1.00
2.00
2.00
1.00
3.00
3.00
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)

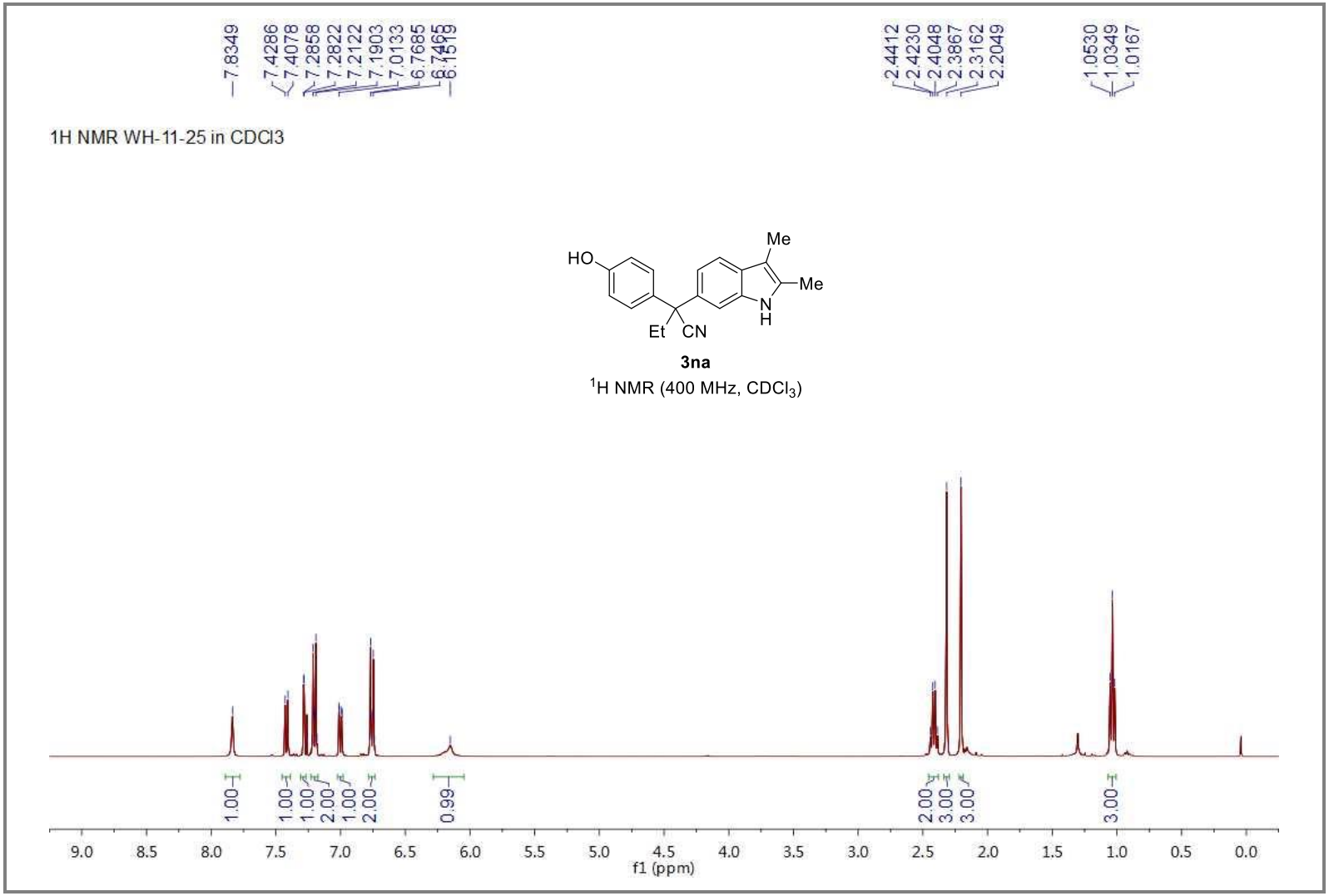

155.83
145.53
134.77
133.40
133.35
132.70
129.64
129.30
128.40
126.90
126.80
123.28
119.38
118.09
115.53
110.11
107.22
53.27
11.65
8.51
13C NMR WH-11-37 in CDCl3
HO
Me
Me
N
H
CN
S
3la
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

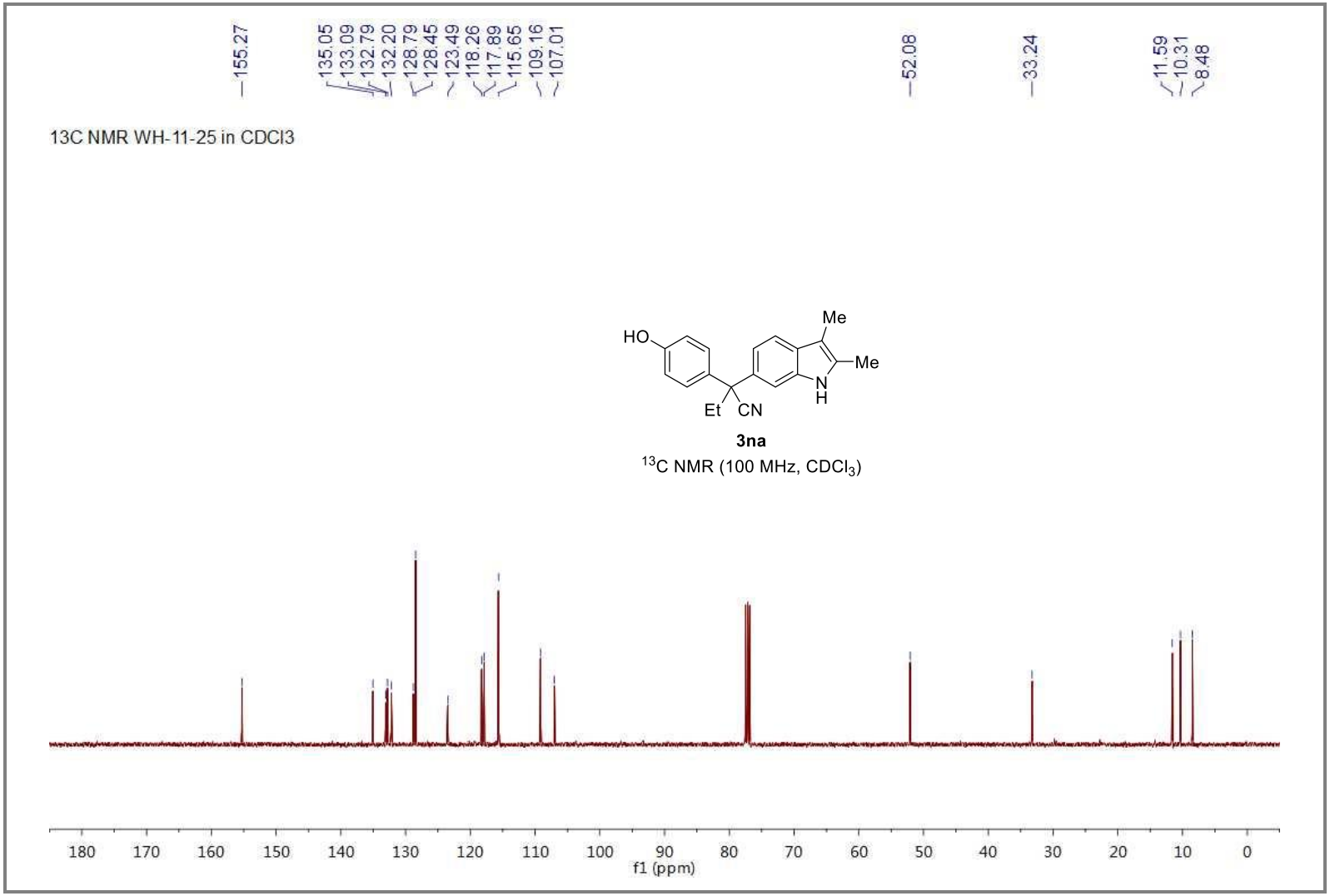


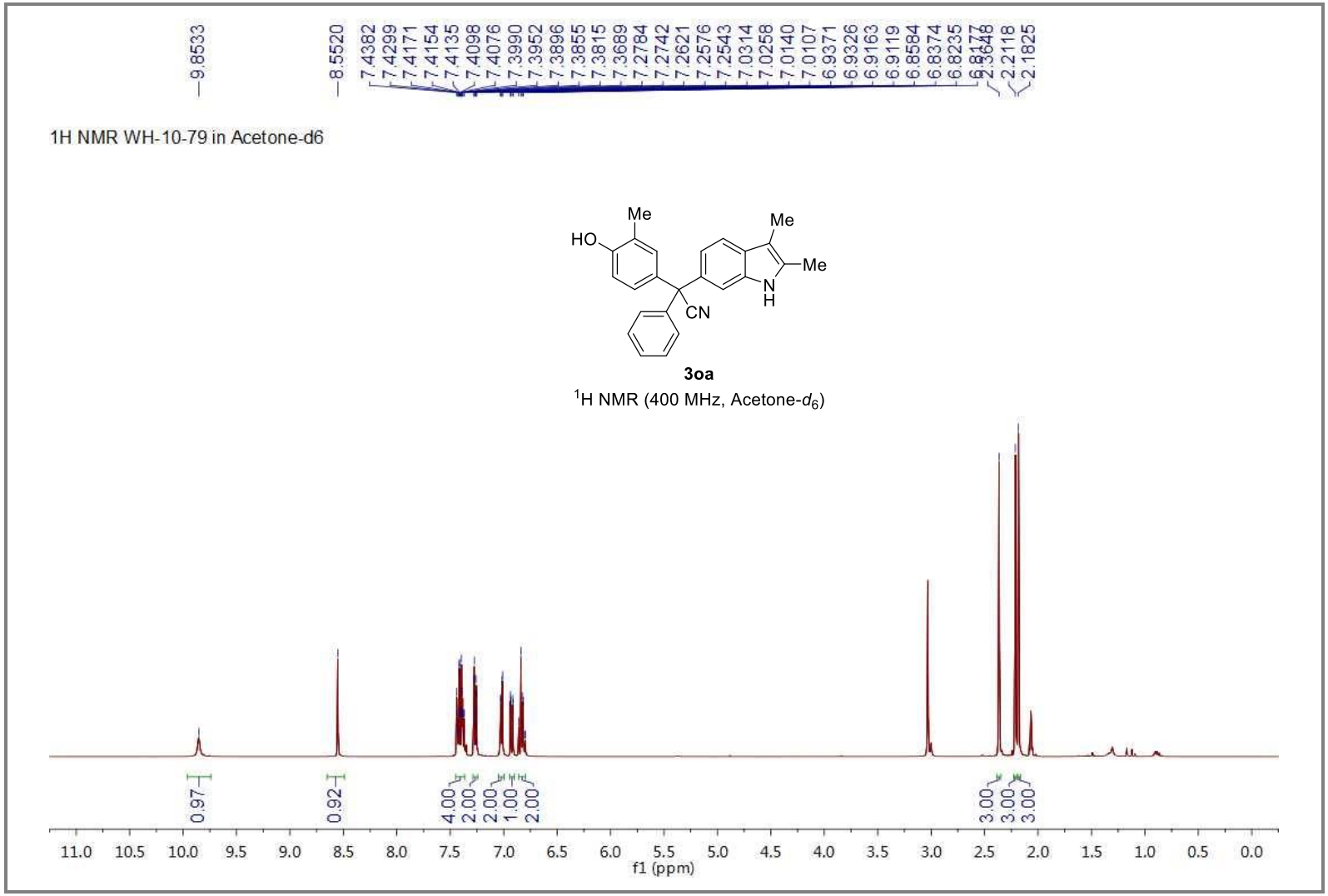
3ma

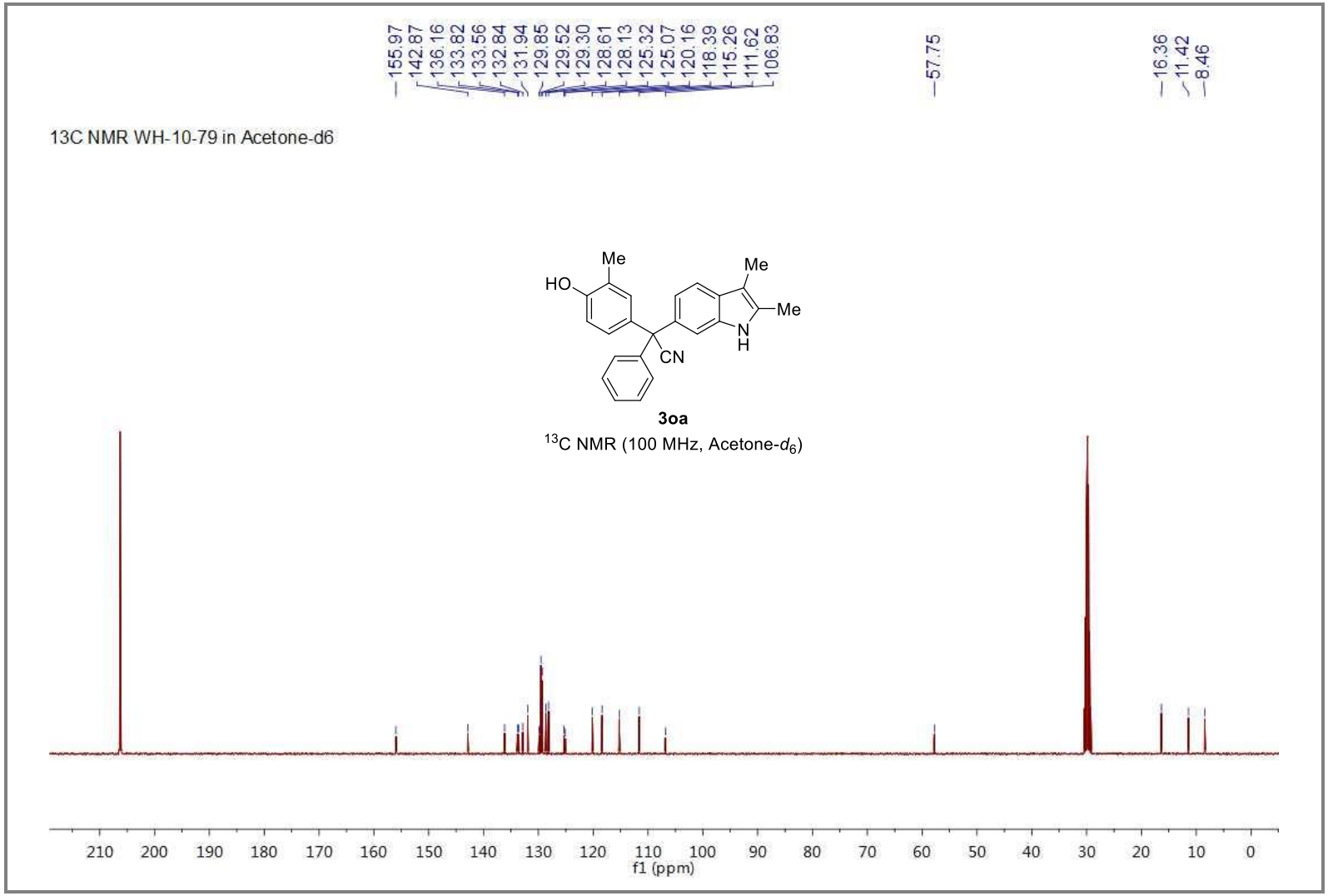
^{1}H NMR (400 MHz, $CDCl_3$)

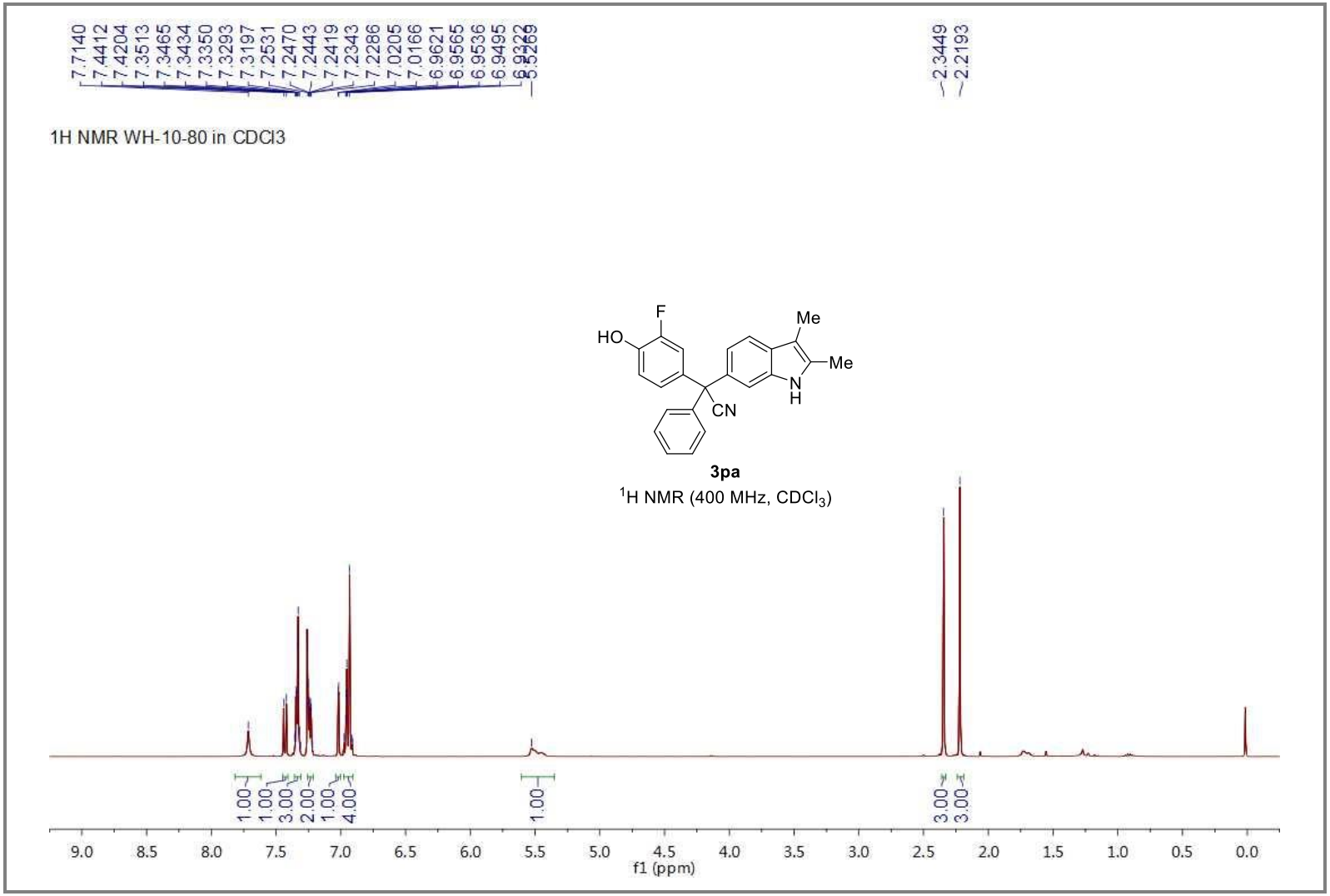

155.33
135.03
134.23
132.23
128.91
128.21
124.58
118.34
117.79
115.65
108.61
107.15
45.74
28.78
11.66
8.51
13C NMR WH-10-72 in CDCl3
HO
Me
Me
N
H
Me
CN
3ma
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

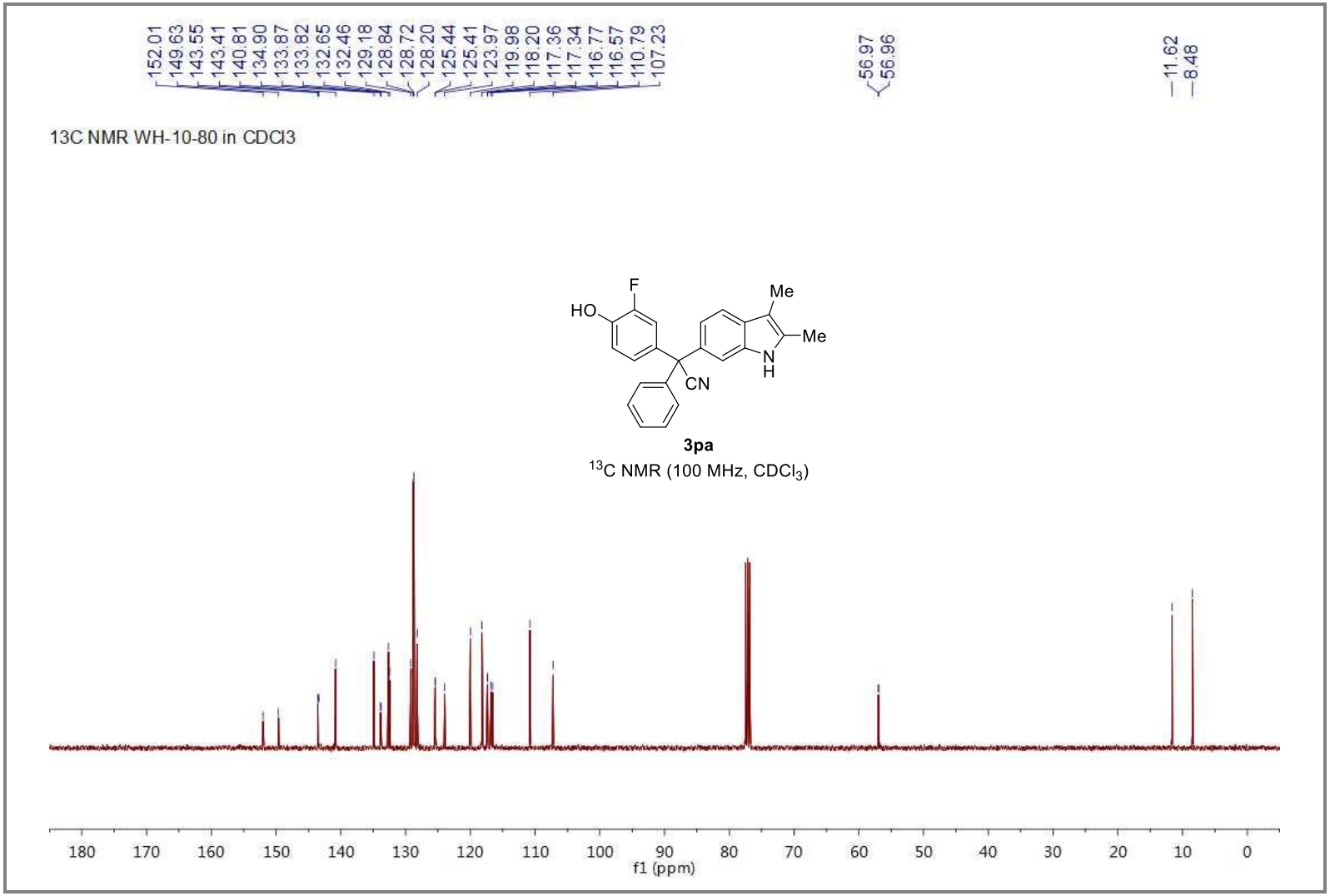

7.8349
7.4286
7.4078
7.2858
7.2822
7.2122
7.1903
7.0133
6.7685
6.7465
6.1519
2.4412
2.4230
2.4048
2.3867
2.3162
2.2049
1.0530
1.0349
1.0167
1H NMR WH-11-25 in CDCl3
HO
Me
Me
N
H
Et
CN
3na
1H NMR (400 MHz, CDCl3)
1.00
1.00
1.00
2.00
1.00
2.00
0.99
2.00
3.00
3.00
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


155.27
135.05
133.09
132.79
132.20
128.79
128.45
123.49
118.26
117.89
115.65
109.16
107.01
52.08
33.24
11.59
10.31
8.48
13C NMR WH-11-25 in CDCl3
HO
Me
Me
N
H
Et
CN
3na
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

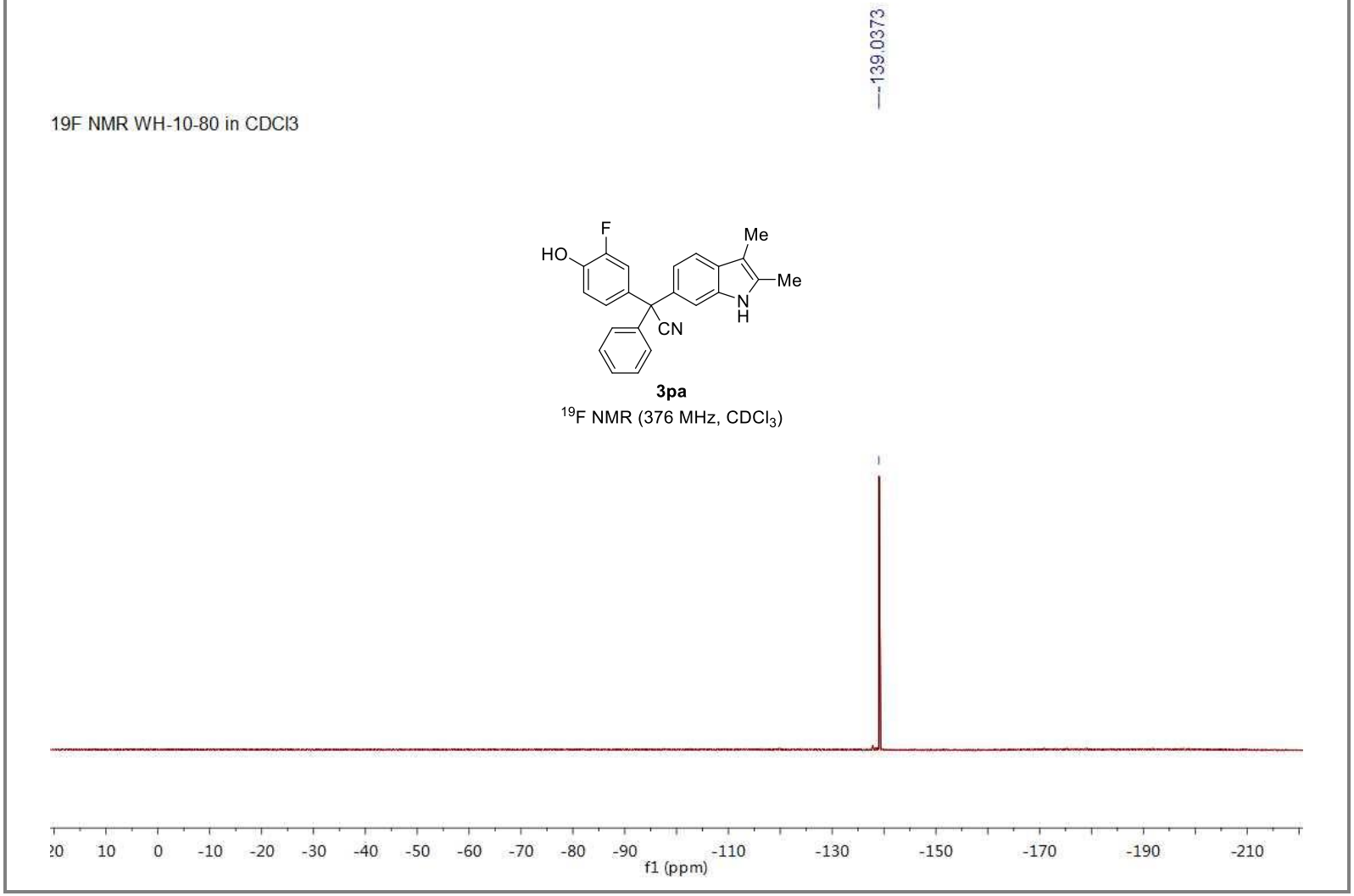

9.8533
8.5520
7.4382
7.4299
7.4171
7.4154
7.4135
7.4098
7.4076
7.3990
7.3952
7.3896
7.3855
7.3815
7.3689
7.2784
7.2742
7.2621
7.2576
7.2543
7.0314
7.0258
7.0140
7.0107
6.9371
6.9326
6.9163
6.9119
6.8584
6.8374
6.8235
2.3648
2.2118
2.1825
1H NMR WH-10-79 in Acetone-d6
HO
Me
Me
Me
N
H
CN
3oa
1H NMR (400 MHz, Acetone-d6)
0.97
0.92
4.00
2.00
2.00
1.00
2.00
3.00
3.00
3.00
11.0
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)


155.97
142.87
136.16
133.82
133.56
132.84
131.94
129.85
129.52
129.30
128.61
128.13
125.32
125.07
120.16
118.39
115.26
111.62
106.83
57.75
16.36
11.42
8.46
13C NMR WH-10-79 in Acetone-d6
Me
HO
Me
Me
N
H
CN
3oa
13C NMR (100 MHz, Acetone-d6)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.7140
7.4412
7.4204
7.3513
7.3465
7.3434
7.3350
7.3293
7.3197
7.2531
7.2470
7.2443
7.2419
7.2343
7.2286
7.0205
7.0166
6.9621
6.9565
6.9536
6.9495
2.3449
2.2193
1H NMR WH-10-80 in CDCl3
F
HO
Me
Me
N
H
CN
3pa
1H NMR (400 MHz, CDCl3)
1.00
1.00
3.00
2.00
1.00
4.00
1.00
3.00
3.00
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)

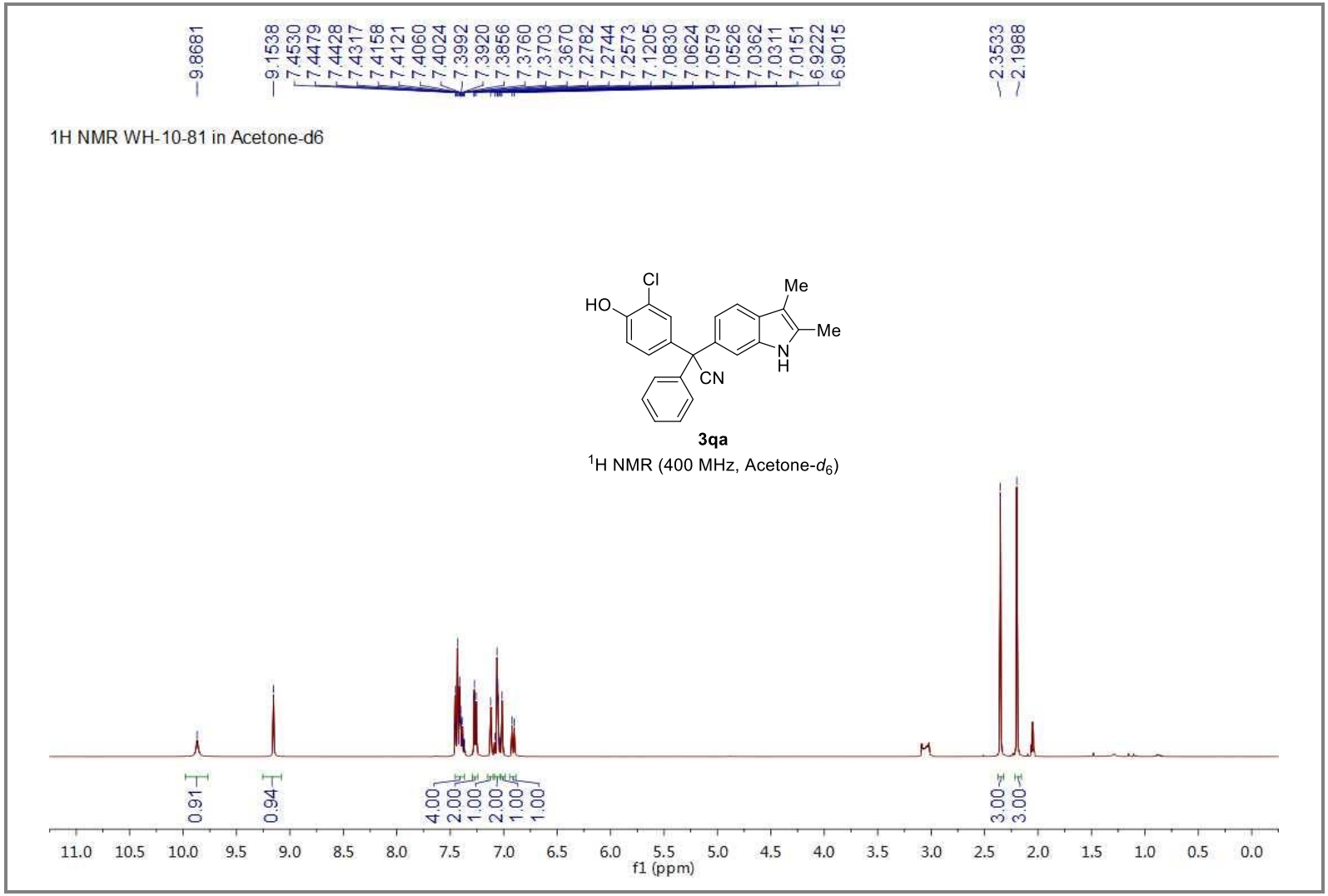

152.01
149.63
143.55
143.41
140.81
134.90
133.87
133.82
132.65
132.46
129.18
128.84
128.72
128.20
125.44
125.41
123.97
119.98
118.20
117.36
117.34
116.77
116.57
110.79
107.23
56.97
56.96
11.62
8.48
13C NMR WH-10-80 in CDCl3
F
HO
Me
Me
N
H
CN
3pa
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

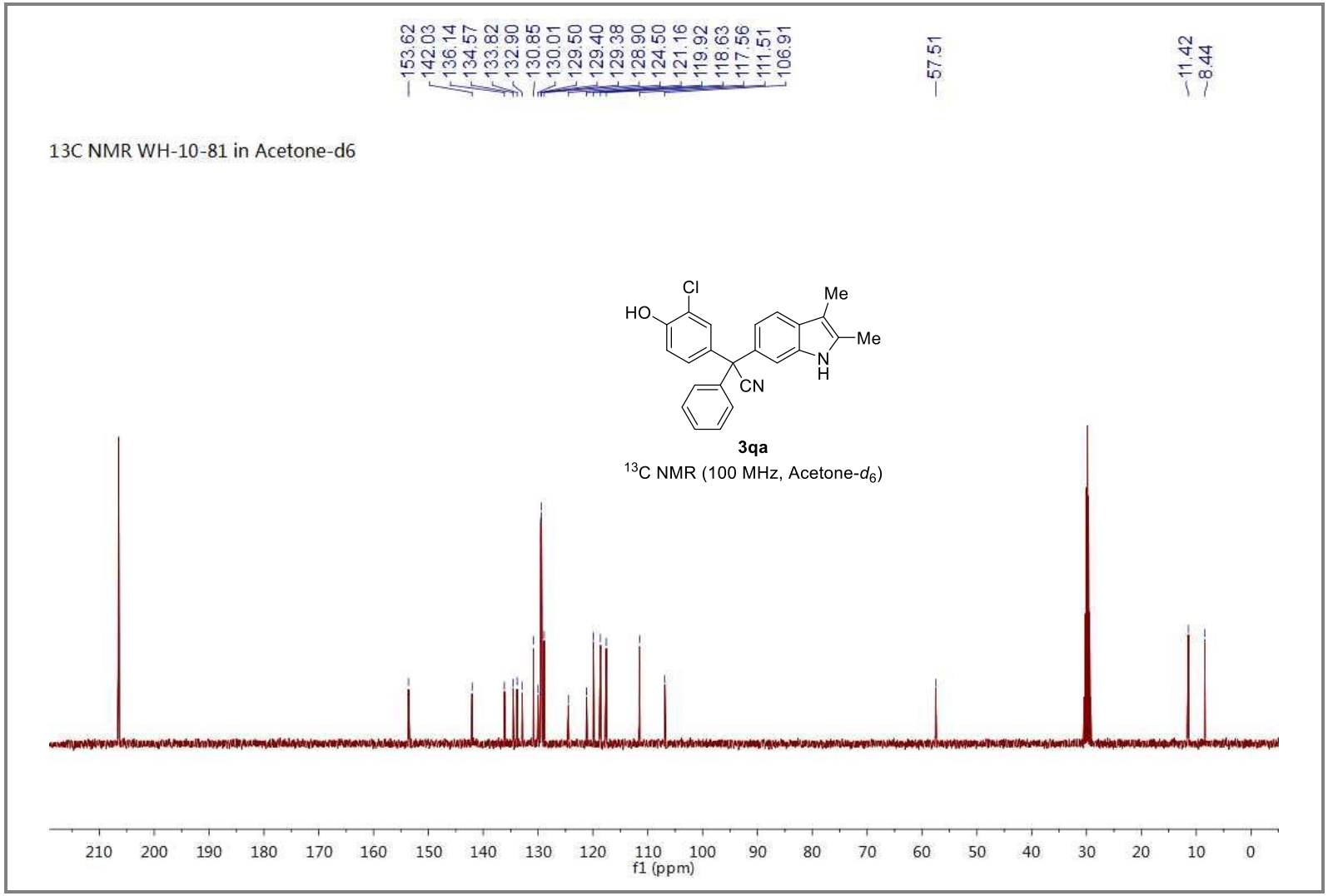
19F NMR WH-10-80 in CDCl3



3pa

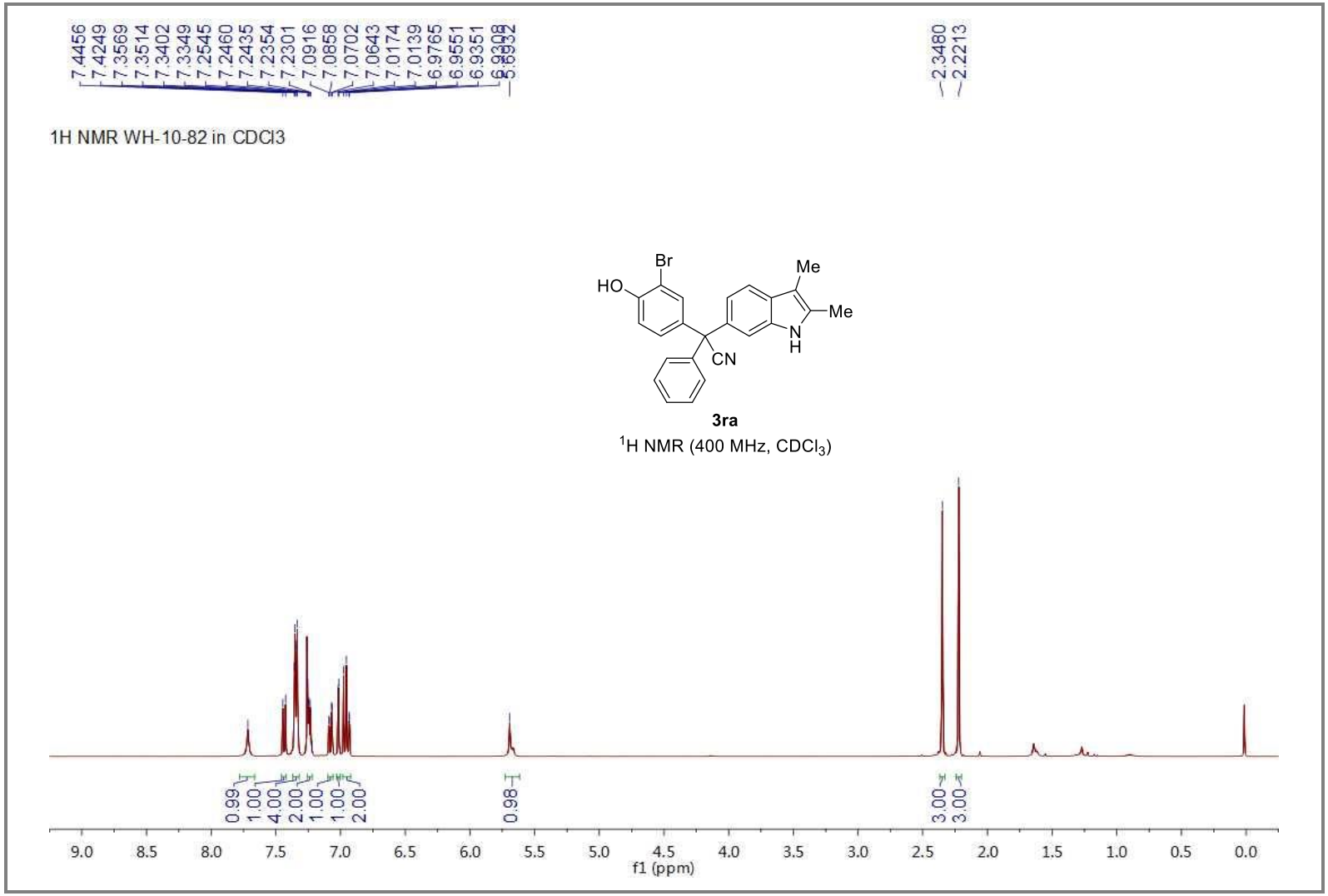
^{19}F NMR (376 MHz, $CDCl_3$)

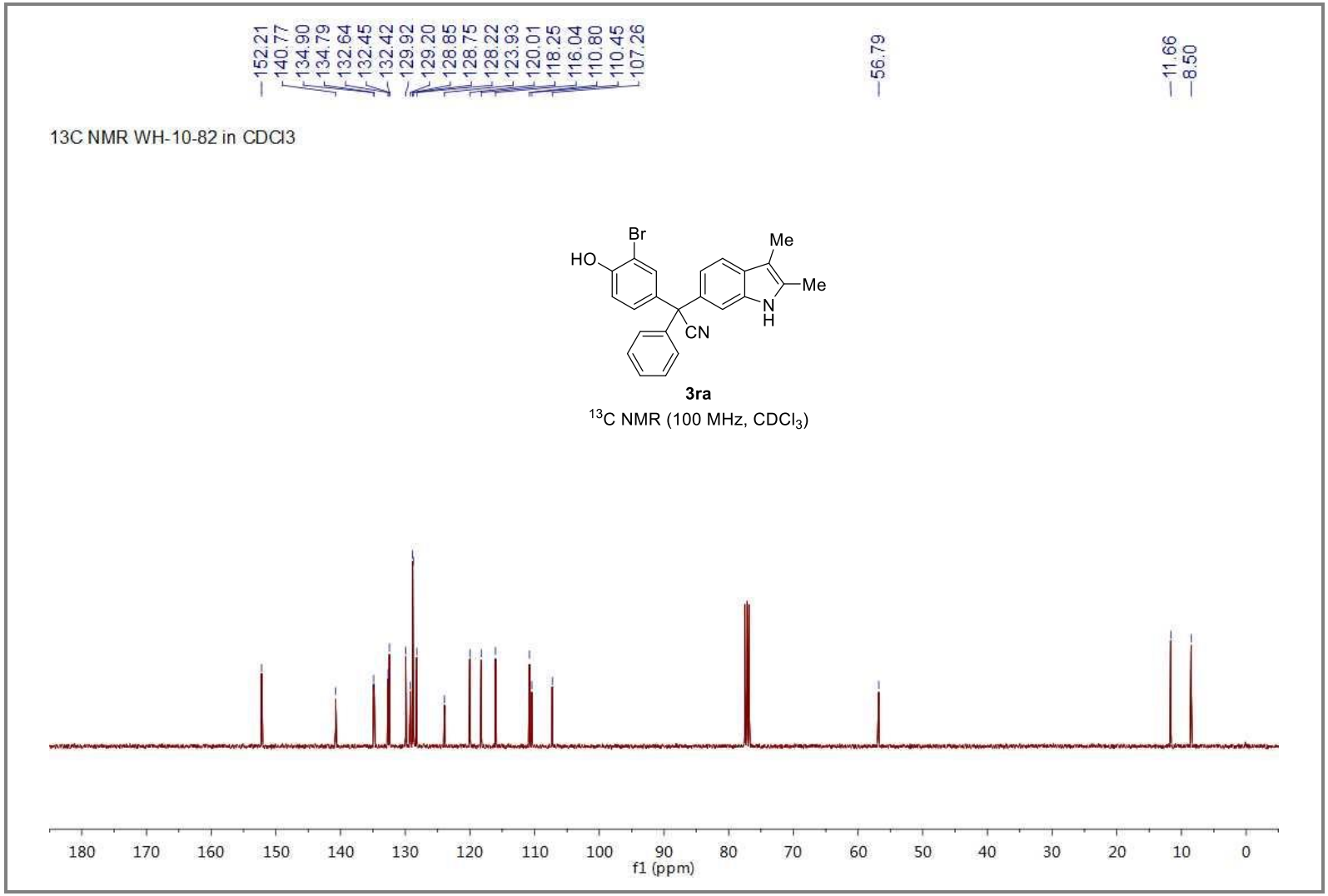

9.8681
9.1538
7.4530
7.4479
7.4428
7.4317
7.4158
7.4121
7.4060
7.4024
7.3992
7.3920
7.3856
7.3760
7.3703
7.3670
7.2782
7.2744
7.2573
7.1205
7.0830
7.0624
7.0579
7.0526
7.0362
7.0311
7.0151
6.9222
6.9015
2.3533
2.1988
1H NMR WH-10-81 in Acetone-d6
Cl
HO
Me
Me
N
H
CN
3qa
1H NMR (400 MHz, Acetone-d6)
0.91
0.94
4.00
2.00
1.00
2.00
1.00
1.00
3.00
3.00
11.0 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)

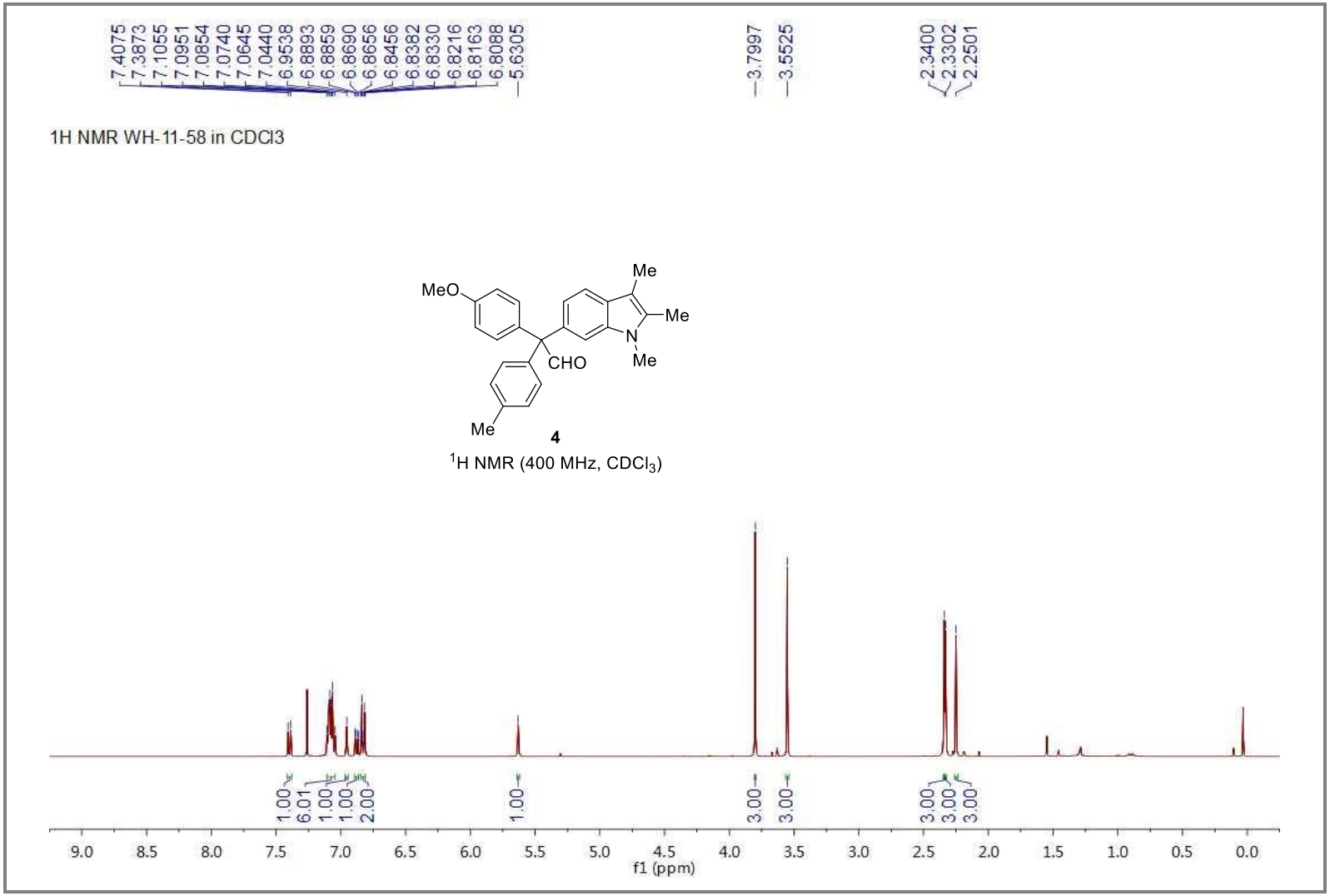


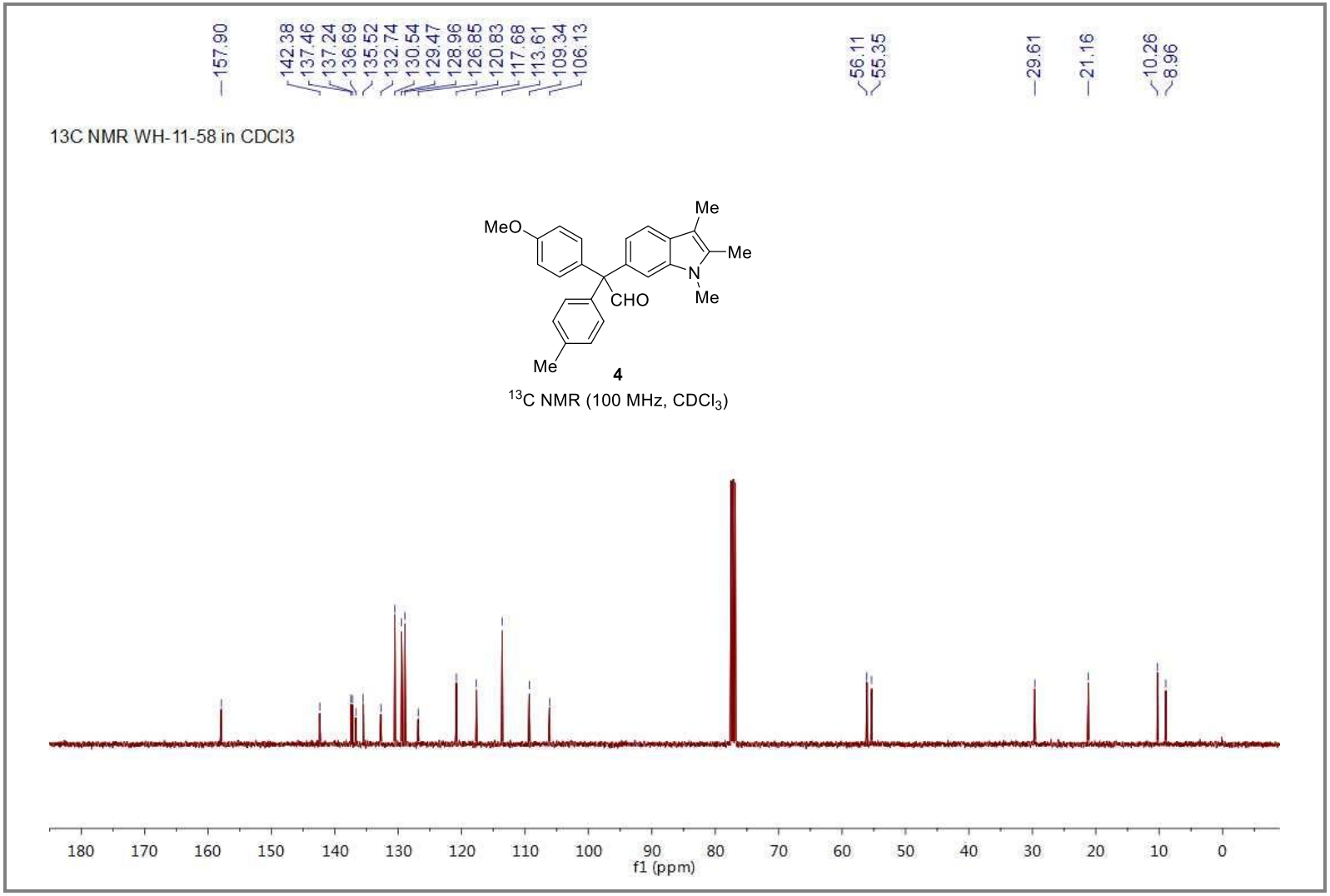
3qa

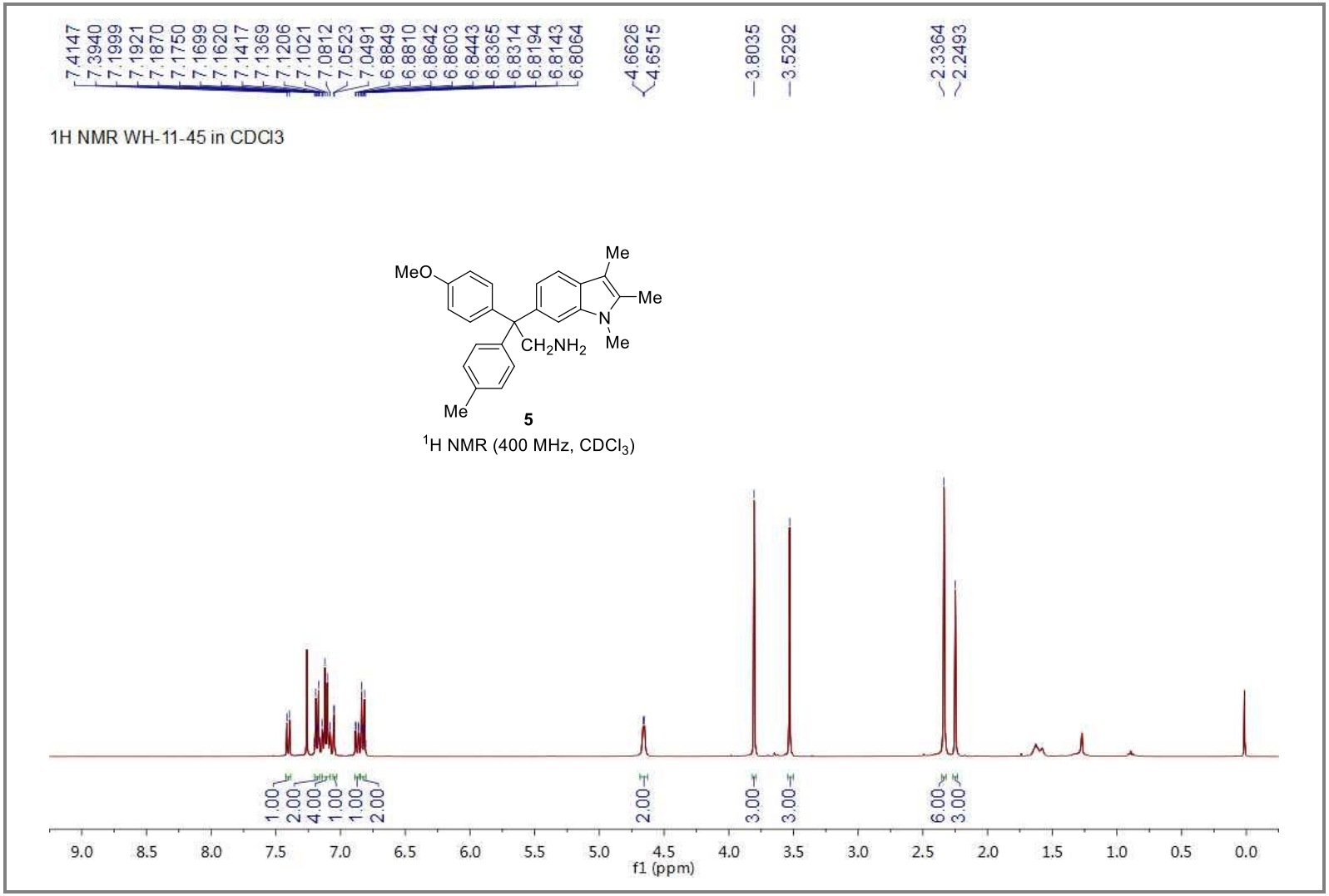
^{13}C NMR (100 MHz, Acetone-d_6)

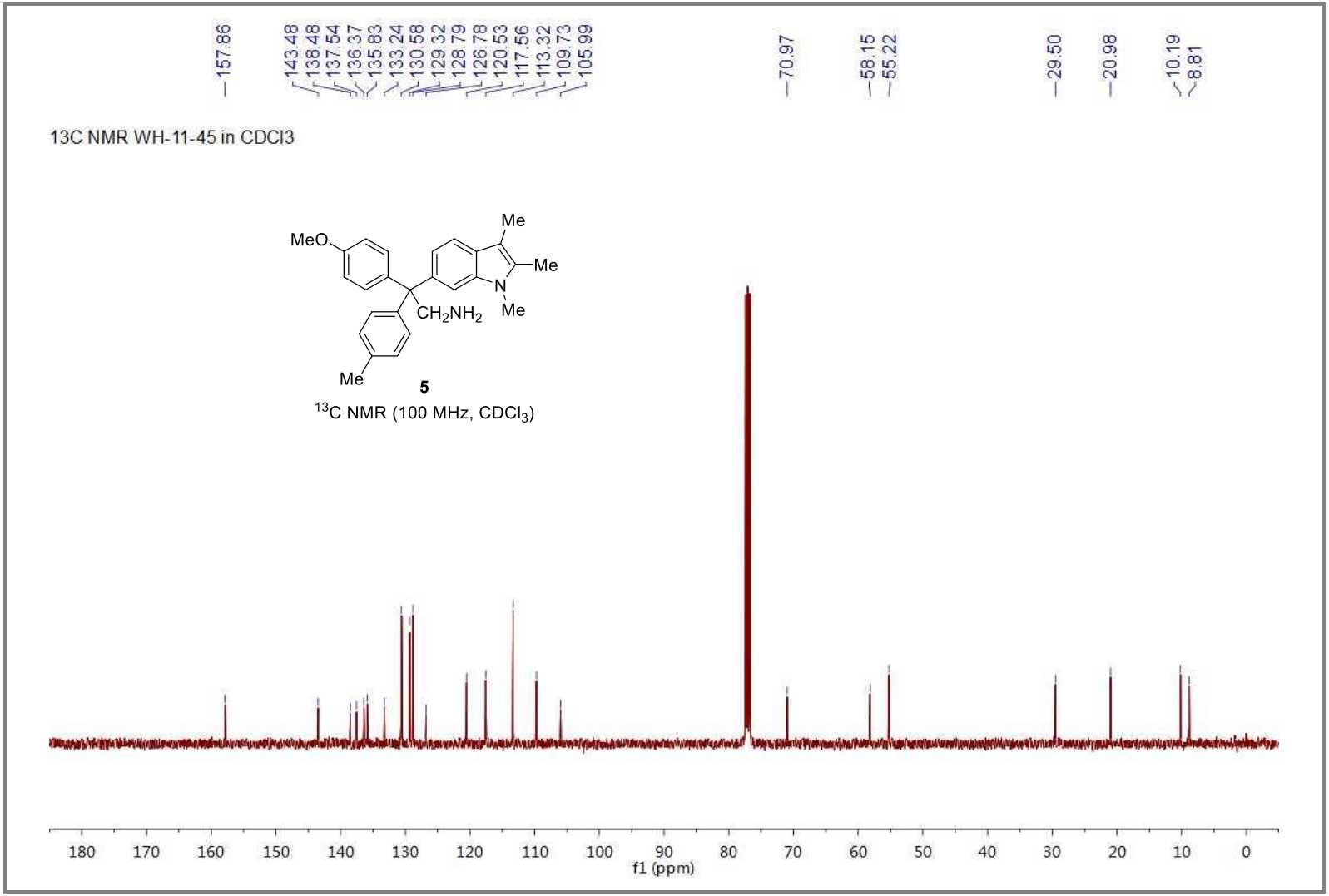

7.4456
7.4249
7.3569
7.3514
7.3402
7.3349
7.2545
7.2460
7.2435
7.2354
7.2301
7.0916
7.0858
7.0702
7.0643
7.0174
7.0139
6.9765
6.9551
6.9351
2.3480
2.2213
1H NMR WH-10-82 in CDCl3
Br
HO
Me
Me
N
H
CN
3ra
1H NMR (400 MHz, CDCl3)
0.99
1.00
4.00
2.00
1.00
1.00
2.00
0.98
3.00
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
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)

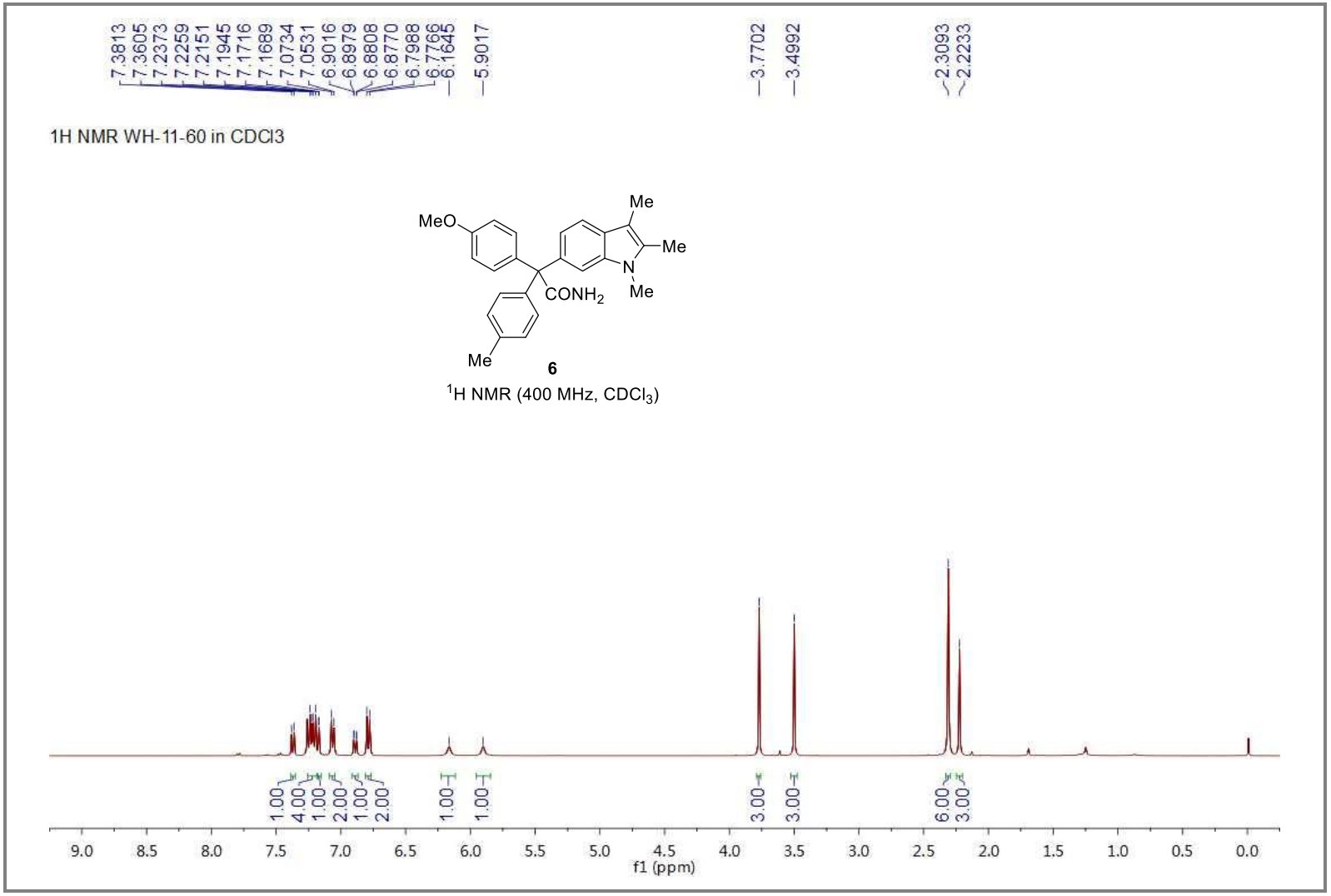

152.21
140.77
134.90
134.79
132.64
132.45
132.42
129.92
129.20
128.85
128.75
128.22
123.93
120.01
118.25
116.04
110.80
110.45
107.26
56.79
11.66
8.50
13C NMR WH-10-82 in CDCl3
Br
HO
Me
Me
N
H
CN
3ra
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

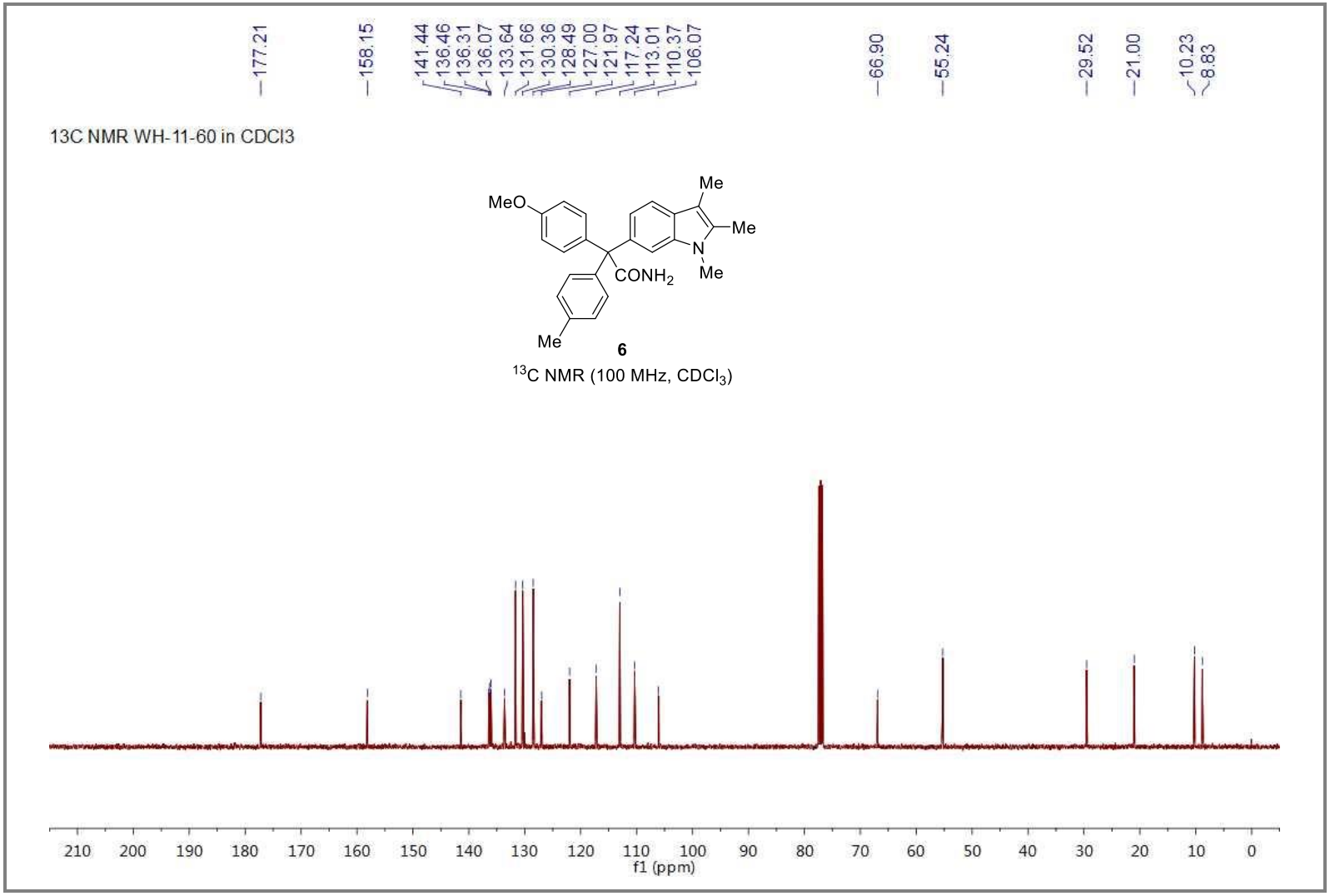

7.4075
7.3873
7.1055
7.0951
7.0854
7.0740
7.0645
7.0440
6.9538
6.8893
6.8859
6.8690
6.8656
6.8456
6.8382
6.8330
6.8216
6.8163
6.8088
5.6305
3.7997
3.5525
2.3400
2.3302
2.2501
1H NMR WH-11-58 in CDCl3
MeO
Me
Me
N
Me
CHO
Me
4
1H NMR (400 MHz, CDCl3)
1.00
6.01
1.00
1.00
2.00
1.00
3.00
3.00
3.00
3.00
3.00
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)

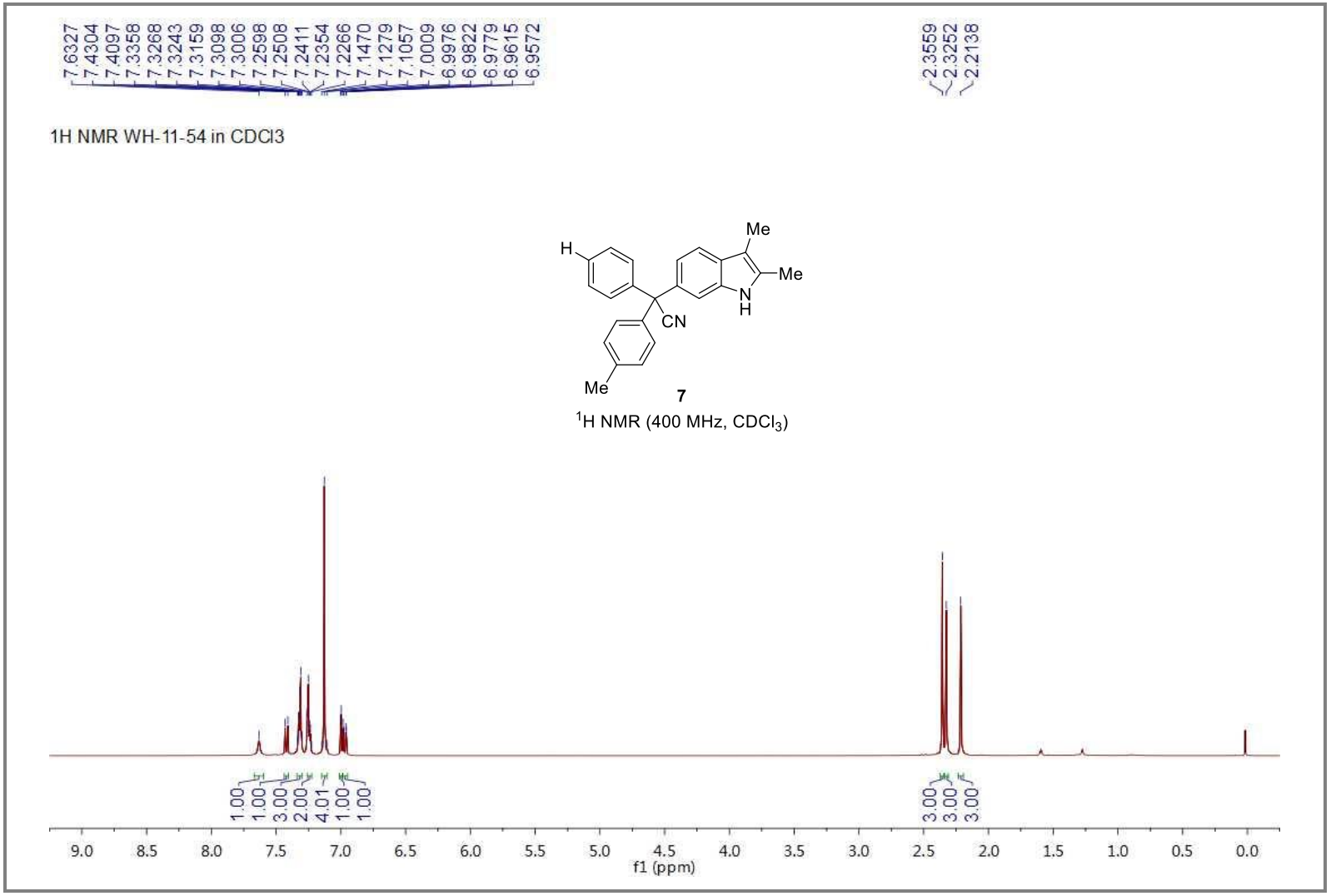

157.90
142.38
137.46
137.24
136.69
135.52
132.74
130.54
129.47
128.96
126.85
120.83
117.68
113.61
109.34
106.13
56.11
55.35
29.61
21.16
10.26
8.96
13C NMR WH-11-58 in CDCl3
MeO
Me
Me
N
Me
CHO
Me
4
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

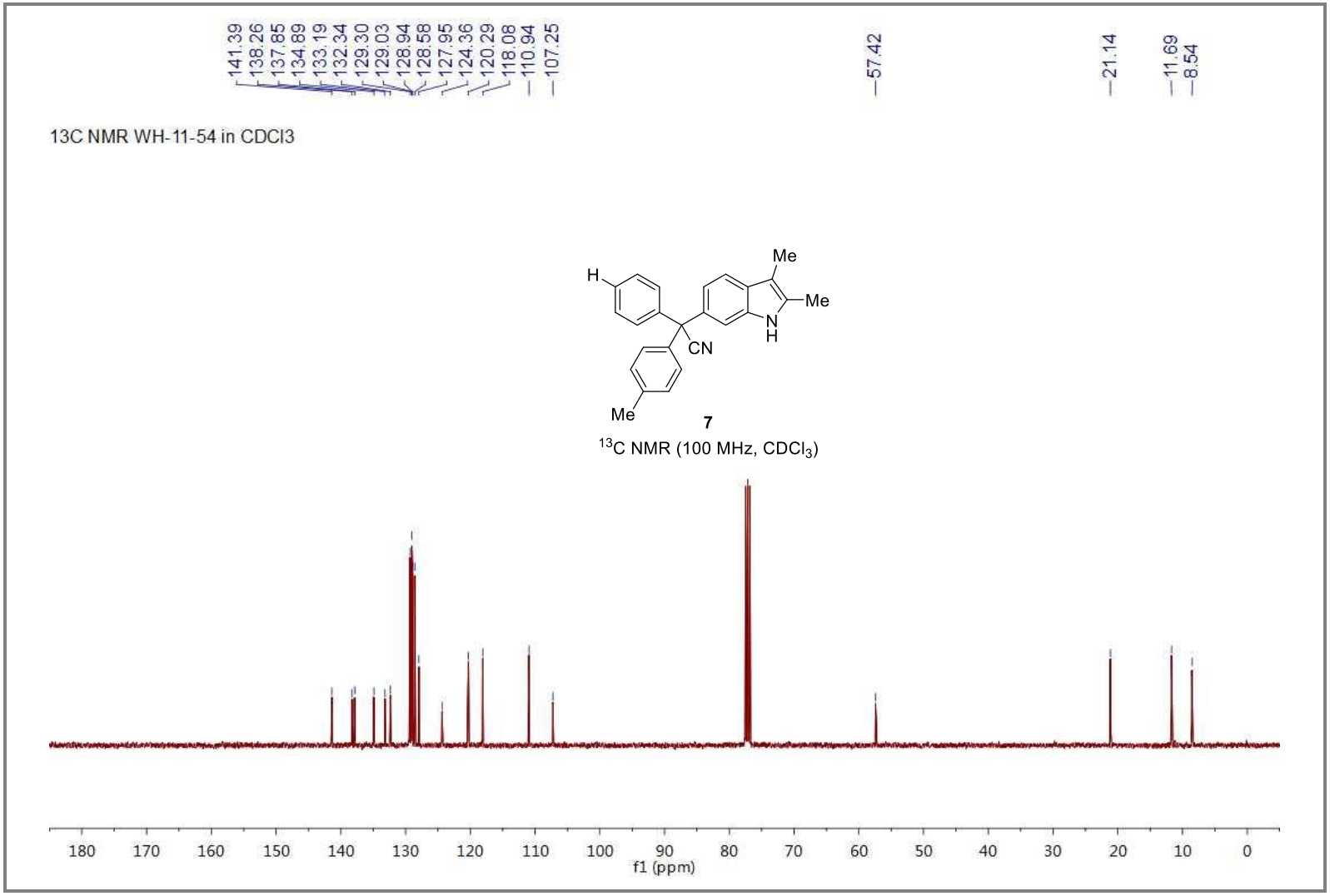

7.4147
7.3940
7.1999
7.1921
7.1870
7.1750
7.1699
7.1620
7.1417
7.1369
7.1206
7.1021
7.0812
7.0523
7.0491
6.8849
6.8810
6.8642
6.8603
6.8443
6.8365
6.8314
6.8194
6.8143
6.8064
4.6626
4.6515
3.8035
3.5292
2.3364
2.2493
1H NMR WH-11-45 in CDCl3
MeO
Me
Me
N
Me
CH2NH2
Me
5
1H NMR (400 MHz, CDCl3)
1.00
2.00
4.00
1.00
1.00
2.00
2.00
3.00
3.00
6.00
3.00
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)


157.86
143.48
138.48
137.54
136.37
135.83
133.24
130.58
129.32
128.79
126.78
120.53
117.56
113.32
109.73
105.99
70.97
58.15
55.22
29.50
20.98
10.19
8.81
13C NMR WH-11-45 in CDCl3
MeO
Me
Me
N
Me
CH2NH2
Me
5
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

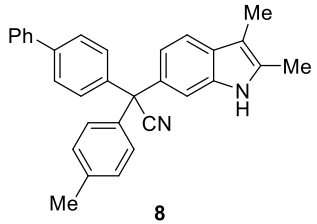

7.3813
7.3605
7.2373
7.2259
7.2151
7.1945
7.1716
7.1689
7.0734
7.0531
6.9016
6.8979
6.8808
6.8770
6.7988
6.7766
6.1645
5.9017
3.7702
3.4992
2.3093
2.2233
1H NMR WH-11-60 in CDCl3
MeO
Me
Me
N
Me
CONH2
Me
6
1H NMR (400 MHz, CDCl3)
1.00
4.00
1.00
2.00
1.00
2.00
1.00
1.00
3.00
3.00
6.00
3.00
9.0
8.5
8.0
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)


177.21
158.15
141.44
136.46
136.31
136.07
133.64
131.66
130.36
128.49
127.00
121.97
117.24
113.01
110.37
106.07
66.90
55.24
29.52
21.00
10.23
8.83
13C NMR WH-11-60 in CDCl3
MeO
Me
Me
N
Me
CONH2
Me
6
13C NMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.6327
7.4304
7.4097
7.3358
7.3268
7.3243
7.3159
7.3098
7.3006
7.2598
7.2508
7.2411
7.2354
7.2266
7.1470
7.1279
7.1057
7.0009
6.9976
6.9822
6.9779
6.9615
6.9572
2.3559
2.3252
2.2138
1H NMR WH-11-54 in CDCl3
H
Me
Me
N
H
CN
Me
7
1H NMR (400 MHz, CDCl3)
1.00
1.00
3.00
2.00
4.01
1.00
1.00
3.00
3.00
3.00
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)

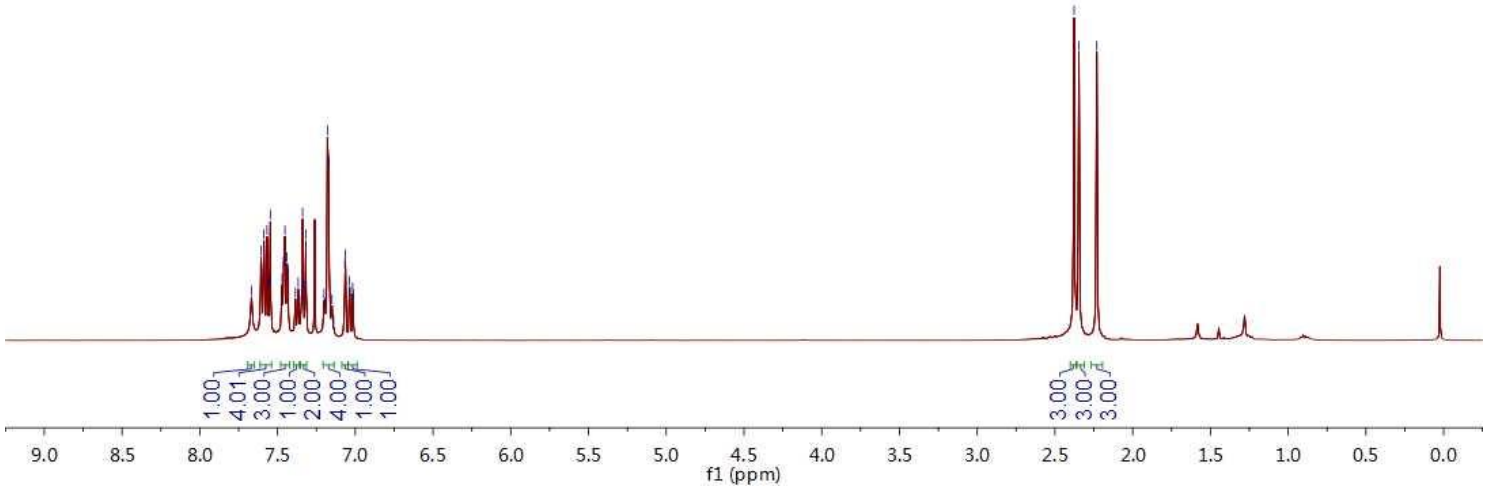

141.39
138.26
137.85
134.89
133.19
132.34
129.30
129.03
128.94
128.58
127.95
124.36
120.29
118.08
110.94
107.25
57.42
21.14
11.69
8.54
13C NMR WH-11-54 in CDCl3
H
Me
Me
N
H
CN
Me
7
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

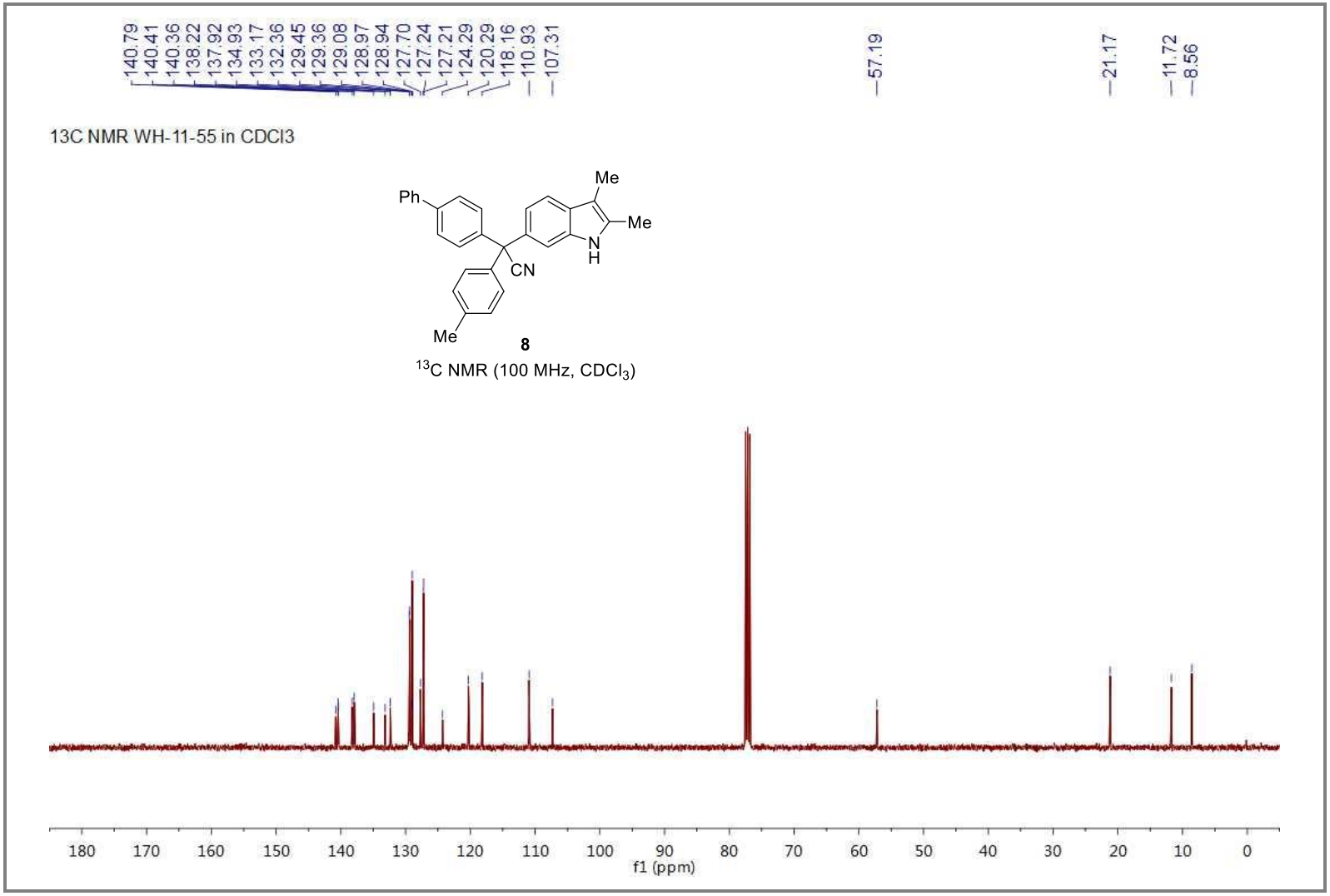
1H NMR WH-11-55 in CDCl3

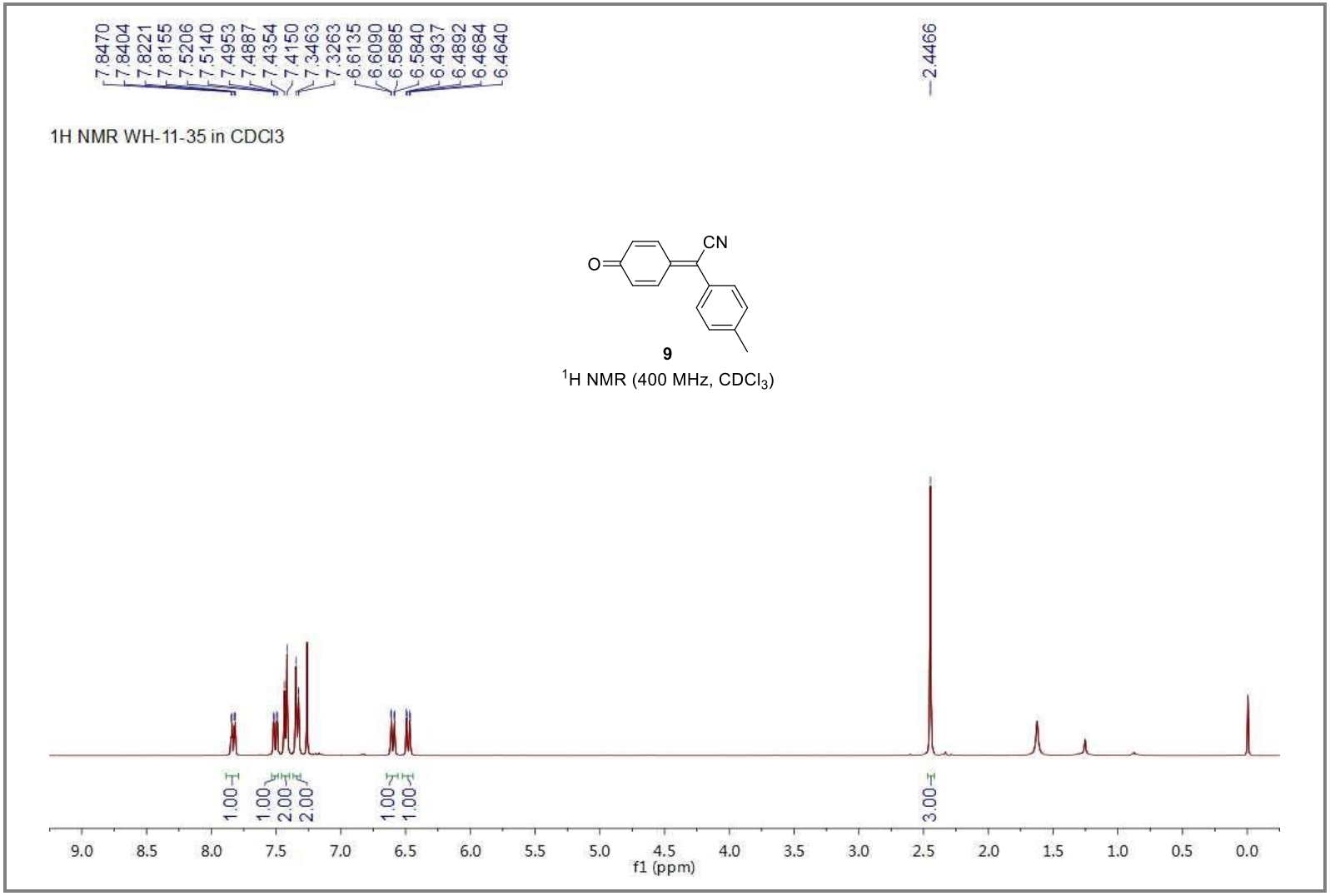


8

^{1}H NMR (400 MHz, $CDCl_3$)

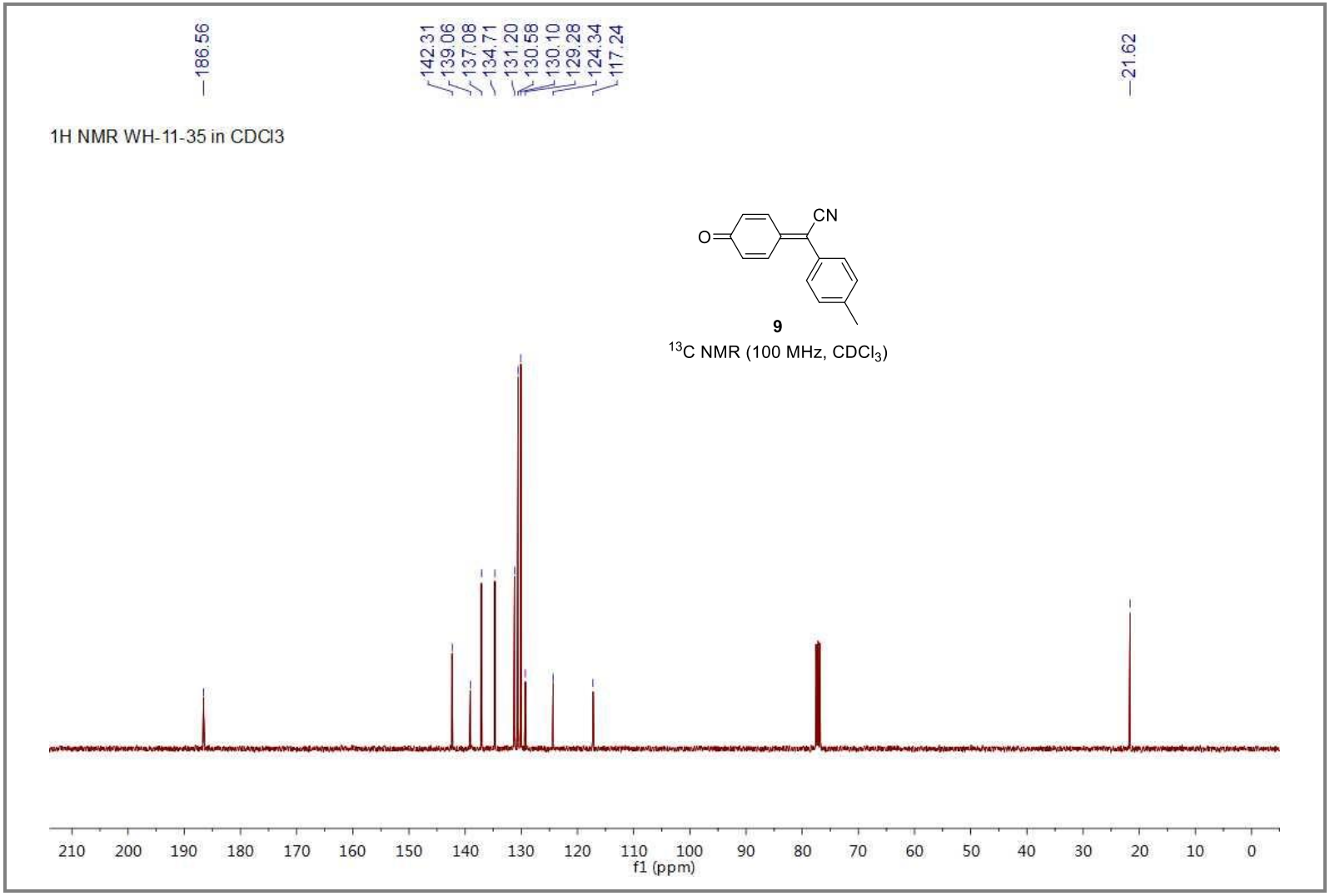



140.79
140.41
140.36
138.22
137.92
134.93
133.17
132.36
129.45
129.36
129.08
128.97
128.94
127.70
127.24
127.21
124.29
120.29
118.16
110.93
107.31
57.19
21.17
11.72
8.56
13C NMR WH-11-55 in CDCl3
Ph
Me
Me
N
H
CN
Me
8
13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



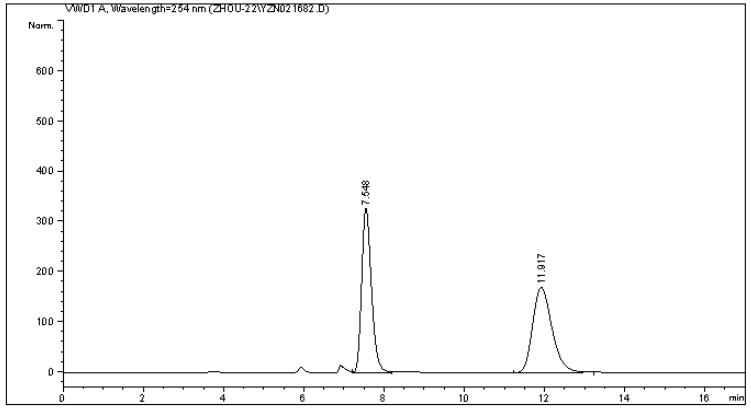
9

^{1}H NMR (400 MHz, $CDCl_3$)


186.56
142.31
139.06
137.08
134.71
131.20
130.58
130.10
129.28
124.34
117.24
21.62
1H NMR WH-11-35 in CDCl3
CN
O
9
13C NMR (100 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Data File C:\CHEM32\1\DATA\ZHOU-22\YZN021682.D
Sample Name: WH-11-61 (+/-)

Acq. Operator :
Acq. Instrument : Instrument 1 Location : -
Injection Date : 9/20/2022 7:38:36 AM
Acq. Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed : 9/20/2022 7:37:57 AM
(modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed : 9/21/2022 7:47:18 AM
(modified after loading)
Sample Info : OD-H, Hexane/i-PrOH = 80/20, 0.8 mL/min, 30 oC, 254 nm

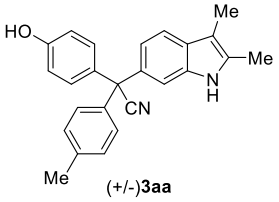


Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.548	VV	0.2607	5577.19141	328.46286	49.6531
2	11.917	BB	0.5136	5655.12109	169.86157	50.3469
Totals :				1.12323e4	498.32443	

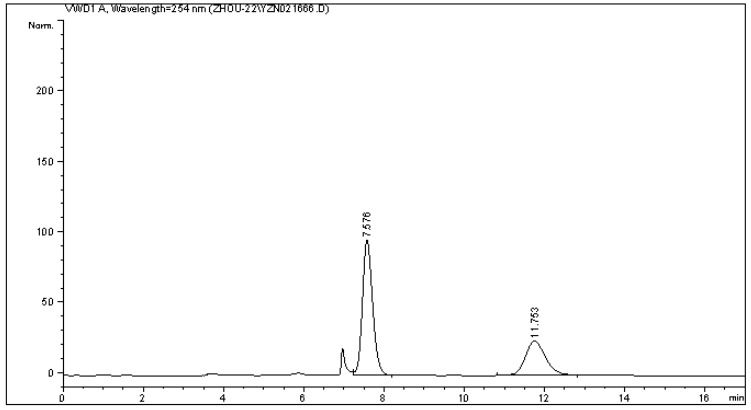


(+/-)**3aa**

*** End of Report ***

Data File C:\CHEM32\1\DATA\ZHOU-22\YZN021666.D
Sample Name: WH-11-56-2

Acq. Operator :
Acq. Instrument : Instrument 1 Location : -
Injection Date : 9/1/2022 3:15:05 AM
Acq. Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed : 9/1/2022 3:14:42 AM
(modified after loading)
Analysis Method : C:\CHEM32\1\METHODS\DEF_LC.M
Last changed : 9/21/2022 7:43:50 AM
(modified after loading)
Sample Info : OD-H, Hexane/i-PrOH = 80/20, 0.8 mL/min, 30 oC, 254 nm

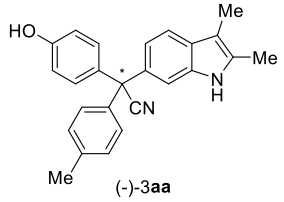


Area Percent Report

Sorted By : Signal
Multiplier: : 1.0000
Dilution: : 1.0000
Use Multiplier & Dilution Factor with ISTDs

Signal 1: VWD1 A, Wavelength=254 nm

Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	7.576	VB	0.2719	1695.19385	95.82535	66.5801
2	11.753	BB	0.5393	850.90210	24.22729	33.4199
Totals :				2546.09595	120.05263	



(-)-3**aa**

*** End of Report ***