Supporting Information

Direct Synthesis of 2-Substituted Benzonitriles via Alkylcyanation of Arynes with *N,N*-Disubstituted Aminomalononitriles

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Contents

1. General Information

All reactions under standard conditions were carried out under argon atmosphere and monitored by thin-layer chromatography (TLC) on gel F254 plates. All products were purified through silica gel chromatography (200~300 mesh). Column chromatography was carried out with light petroleum ether (bp. 60~90 °C), ethyl acetate and dichloromethane as eluent. ^{1}H and ^{13}C spectra were recorded in $CDCl_3$ on 400 MHz instruments. Chemical shifts (δ) are reported in ppm, and coupling constants (J) are in hertz (Hz). High-resolution mass spectral analysis (HRMS) data were measured on the Apex II by means of the ESI technique. Melting point was measured with SGW-X4B instrument.

All the chemicals were used as obtained from vendors. The substrates 2-(Trimethylsil yl)phenyl trifluoromethanesulfonate (**2a**), 4-Methyl-2-(trimethylsilyl)phenyl Trifluoromethanes ulfonate (**2b**), 2-Methyl-6-(trimethylsilyl)phenyl Trifluoromethanesulfonate (**2c**), 4-Methoxy-2-(trimethylsilyl)phenyl Trifluoromethanesulfonate (**2d**), 4,5-Dimethoxy-2-(trimethylsilyl)phenyl T rifluoromethanesulfonate (**2e**) and 3-(Trimethylsilyl)-2-naphthyl Trifluoromethanesulfonate (**2 f**) are commercially available.

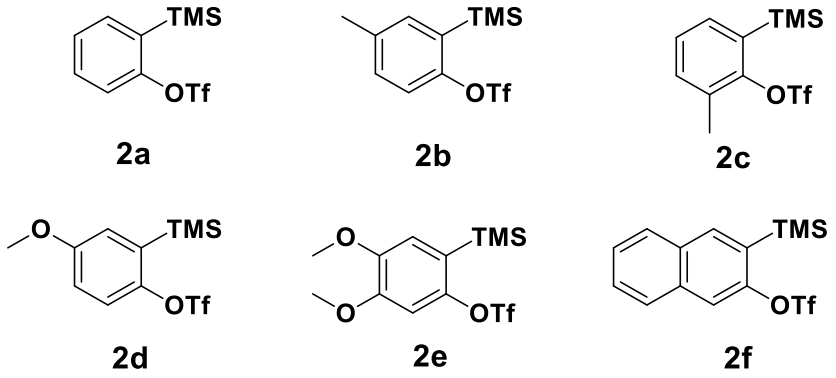
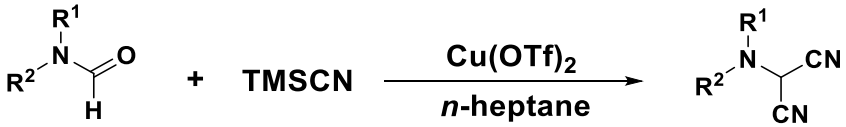


Figure 1. Commercially purchased aryne precursors 2a-2f

2. General experimental procedure

2.1 General procedure for the synthesis of *N,N*-disubstituted aminomalononitriles 1a-1w

Substrates **1** were prepared according to the procedure reported in literature.[1]



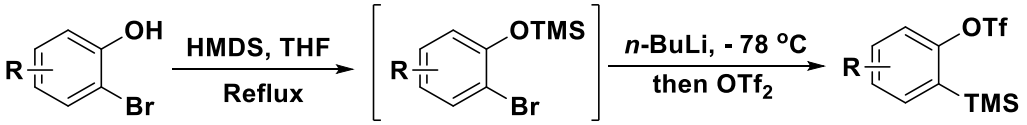
General Procedure A: using the preparation of 2-(methyl(phenyl)amino)malononitrile from *N*-methyl-*N*-phenylformamide as an example

To a stirred solution of *N*-methyl-*N*-phenylformamide (2.0 g, 14.80 mmol) in *n*-heptane (20.0 mL) were successively added Copper(II) trifluoromethanesulfonate (535 mg, 1.48 mmol) and Trimethylsilyl Cyanide (4.07 ml, 32.56 mmol) at 80 °C under argon atmosphere. The reaction mixture was continued stirring for 8 h. Upon completion of the reaction (monitored by TLC), the reaction mixture was quenched by slow addition of water. The aqueous layer was extracted three

times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography on silica gel (petroleum ether : EtOAc = 30:1 to 20:1) to afford 2-(methyl(phenyl)amino)malononitrile as a white solid (0.76 g, 30%).

2.2 General procedure for the synthesis of aryne precursors 2g and 2h

Substrates **2g** and **2h** were prepared according to the procedure reported in literature.[2]



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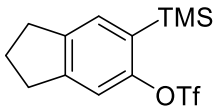
General Procedure B: using the preparation of 6-(trimethylsilyl)benzo[d][1,3]dioxol-5-yl trifluoromethanesulfonate from sesamol as an example

To a cooled (0 °C) solution of sesamol (5.0 g, 36.2 mmol) in AcOH (11 mL) was added a solution of bromine (1.5 mL, 29.0 mmol) in AcOH (6.3 mL) dropwise over 15 minutes. The mixture was then rapidly poured onto ice. The resulting green solid was collected by filtration, washed copiously with water and extracted with ethyl acetate (3×35 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure to afford the crude product as a dull green solid (3.99 g, 51 %), which was used without further purification.

A mixture of the obtained crude product and HMDS (2.9 mL, 13.9 mmol) in THF (38 mL) was refluxed for 4 h. The solvent was evaporated under reduced pressure, and the residue was subjected to high vacuum to remove excess NH_3 and unreacted HMDS. The resulted crude product was used without further purification.

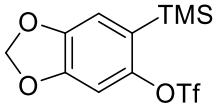
To a solution of the obtained crude product in THF (41 mL) was added *n*-BuLi (6.1 mL, 2.5 M, in THF, 15.3 mmol) dropwise at -78 °C. After stirring for 30 min, Tf_2O (2.8 mL, 16.7mmol) was then added dropwise to the mixture. The mixture was then stirred for 30 min under the same temperature. Then the mixture was warmed to room temperature and stirred for 20 minutes. After that, $NaHCO_3$ (cold sat. aqueous solution) and H_2O were sequentially added to the mixture. The aqueous layer was extracted with ethyl acetate (3×30 mL), the combined organic layers were dried over Na_2SO_4, filtrated and concentrated in vacuo. The crude material was purified by flash column chromatography on silica gel to afford the title compound **2h** as yellow oil, 4.35 g, 91% yield. (Rf = 0.25, eluent: petroleum ether).



2g

6-(trimethylsilyl)-2,3-dihydro-1H-inden-5-yl trifluoromethanesulfonate (2g):

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (s, 1H), 7.21 (s, 1H), 2.93-2.87 (m, 4H), 2.14-2.06 (m, 2H), 0.37 (s, 9H). The ^{1}H NMR of **2g** is consistent with the reported spectra.[2]

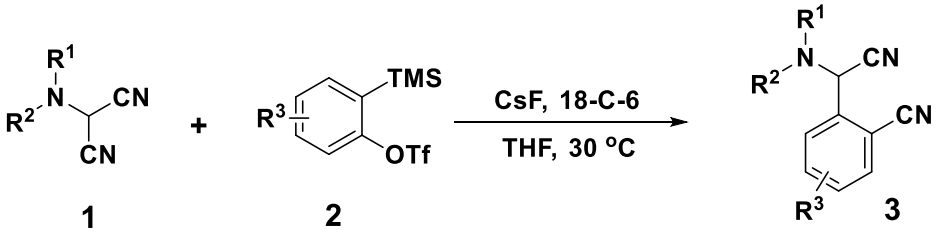


2h

6-(trimethylsilyl) benzo[d] [1,3] dioxol-5-yl trifluoromethanesulfonate (2h):

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.89 (s, 1H), 6.86 (s, 1H), 6.02 (s, 2H), 0.35 (s, 9H). The ^{1}H NMR of **2h** is consistent with the reported spectra.[2]

2.3 General experimental procedure C for products 3a-3ad.

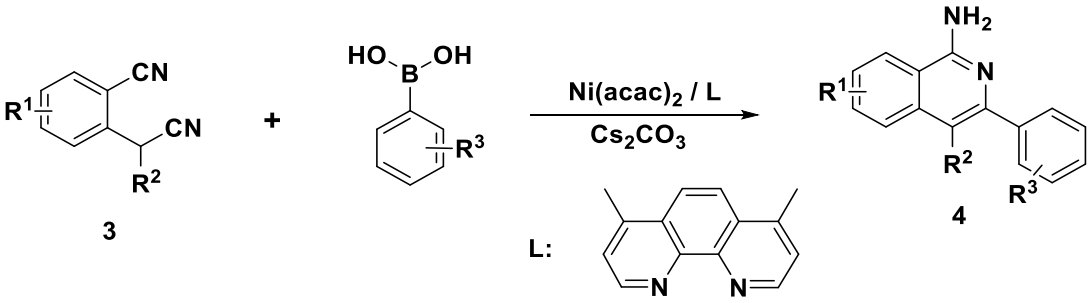


1 2 3

Using the preparation of ethyl 1-aminoisoquinoline-3-carboxylate from 2-formylbenzonitrile and 2-isocyanoacetate as an example

To a reaction tube were added 2-(methyl(phenyl)amino)malononitrile **1b** (100 mg, 0.58 mmol) in THF (2.0 mL), 2-(Trimethylsilyl)phenyl trifluoromethanesulfonate **2a** (213 μL, 1.5 equiv), CsF (177 mg, 2.0 equiv) and 18-C-6 (309 mg, 2.0 equiv) under argon atmosphere. The mixture was stirred at 30 °C for 2 h. After completion of reaction as indicated by TLC, the mixture was concentrated *in vacuo*, and the residue was purified by flash column chromatograph (petroleum ether : EtOAc = 30:1 to 10:1) to give the desired product **3b**.

2.4 General experimental procedure D for products 4a and 4b.[3]

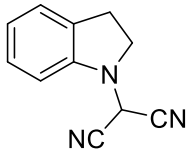


Using the preparation of N^4-methyl-N^4, 3-diphenylisoquinoline-1, 4-diamine from 2-(cyano(methyl(phenyl)amino)methyl)benzonitrile as an example

The aryl boronic acid (1.0 mmol), $Ni(acac)_2$ (0.025 mmol), ligand (0.025 mmol), and Cs_2CO_3 (0.1 mmol) were added sequentially to a solution of the substituted 2-(cyanomethyl)benzonitrile (0.5 mmol) in toluene (2 mL). The reaction mixture was stirred at 110 °C for 6 h. After cooling, the mixture was diluted with EtOAc (20 mL) and H_2O (15 mL). After separation, the aqueous phase was washed with EtOAc (20 mL). The combined organic phase was washed with brine and then dried over anhydrous Na_2SO_4. The solvent was removed under reduced pressure, and the residue was purified under column chromatography to afford the desired product.

3. Characterization of substrates and products.

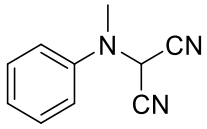
3.1 Characterization of substrates 1a-1t.



1a

2-(indolin-1-yl)malononitrile (1a):

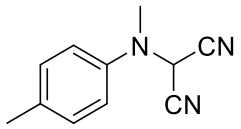
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.19 (m, 2H), 6.98 (t, *J* = 7.6 Hz, 1H), 6.70 (d, *J* = 8.0 Hz, 1H), 5.42 (s, 1H), 3.57 (t, *J* = 8.0 Hz, 2H), 3.10 (t, *J* = 8.0 Hz, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.91, 130.70, 127.64, 125.45, 122.30, 109.86, 108.88, 52.00, 41.28, 28.11. The ^{1}H NMR and ^{13}C NMR of **1a** are consistent with the reported spectra.[1]



1b

2-(methyl(phenyl)amino)malononitrile (1b):

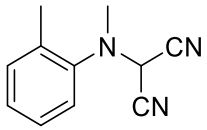
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (dd, *J* = 8.8, 7.6 Hz, 2H), 7.13 (t, *J* = 7.2 Hz, 1H), 7.05 (d, *J* = 8.0 Hz, 2H), 5.43 (s, 1H), 3.09 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.28, 129.78, 123.98, 118.59, 110.27, 46.75, 37.34. The ^{1}H NMR and ^{13}C NMR of **1b** are consistent with the reported spectra.[1]



1c

2-(methyl(*p*-tolyl)amino)malononitrile (1c):

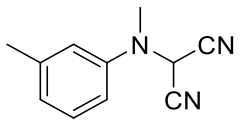
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18 (d, *J* = 8.4 Hz, 2H), 6.97 (d, *J* = 8.4 Hz, 2H), 5.35 (s, 1H), 3.04 (s, 3H), 2.34 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.01, 134.04, 130.25, 119.16, 110.33, 47.31, 37.58, 20.55; **HRMS** (ESI) calcd for $C_{11}H_{11}N_3$ $[M-H]^-$: 184.0880, found 184.0886.



1d

2-(methyl(*o*-tolyl)amino)malononitrile (1d):

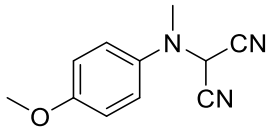
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.15 (m, 3H), 7.13-7.09 (m, 1H), 4.82 (s, 1H) , 2.87 (s, 3H) , 2.27 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.66, 133.37, 131.29, 126.85, 126.43, 121.40, 110.34, 47.27, 37.92, 17.08; **HRMS** (ESI) calcd for $C_{11}H_{11}N_3$ $[M-H]^-$: 184.0880, found 184.0886.



1e

2-(methyl(*m*-tolyl)amino)malononitrile (1e):

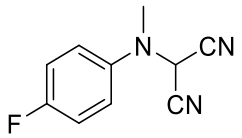
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (t, *J* = 8.0 Hz, 1H), 6.90 (d, *J* = 7.2 Hz, 1H), 6.80-6.77 (m, 2H), 5.39 (s, 1H), 3.01 (s, 3H) , 2.33 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.12, 139.61, 129.38, 124.47, 118.98, 115.26, 110.35, 46.55, 37.05, 21.37; **HRMS** (ESI) calcd for $C_{11}H_{11}N_3$ $[M-H]^-$: 184.0880, found 184.0887.



1f

2-((4-methoxyphenyl)(methyl)amino)malononitrile (1f):

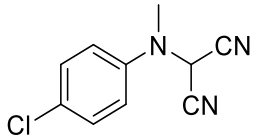
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (d, *J* = 8.8 Hz, 2H), 6.90 (d, *J* = 9.2 Hz, 2H), 5.21 (s, 1H), 3.79 (s, 3H), 2.98 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.94, 139.85, 122.07, 114.78, 110.38, 55.39, 48.30, 38.29; **HRMS** (ESI) calcd for $C_{11}H_{11}N_3O$ $[M-H]^-$: 200.0829, found 200.0839.



1g

2-((4-fluorophenyl)(methyl)amino)malononitrile (1g):

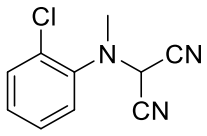
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (s, 2H), 7.06 (d, *J* = 1.6 Hz, 2H), 5.31 (s, 1H), 3.02 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.49 (d, *J* = 243.3 Hz), 142.54 (d, *J* = 2.2 Hz), 121.58 (d, *J* = 8.1 Hz), 116.37 (d, *J* = 22.7 Hz), 110.19, 47.68, 38.00; **HRMS** (ESI) calcd for $C_{10}H_8FN_3$ $[M-H]^-$: 188.0629, found 188.0639.



1h

2-((4-chlorophenyl)(methyl)amino)malononitrile (1h):

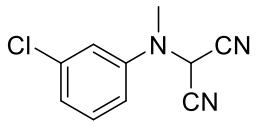
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 8.8 Hz, 2H), 6.98 (d, *J* = 9.2 Hz, 2H), 5.38 (s, 1H), 3.05 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.74, 129.74, 129.36, 120.03, 110.03, 46.71, 37.54; **HRMS** (ESI) calcd for $C_{10}H_8{}^{35}ClN_3$ $[M-H]^-$: 204.0334, found 204.0341; **HRMS** (ESI) calcd for $C_{10}H_8{}^{37}ClN_3$ $[M-H]^-$: 206.0305, found 206.0314.



1i

2-((2-chlorophenyl)(methyl)amino)malononitrile (1i):

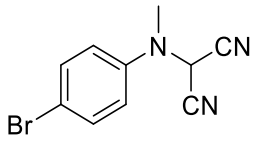
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.32 (td, *J* = 8.4, 1.2 Hz, 1H), 7.27 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.20-7.16 (m, 1H), 5.35 (s, 1H) , 3.04 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 143.24, 130.82, 129.00, 128.10, 127.18, 122.85, 109.99, 46.65, 37.09; **HRMS** (ESI) calcd for $C_{10}H_8{}^{35}ClN_3$ [M-H]$^-$: 204.0334, found 204.0326; **HRMS** (ESI) calcd for $C_{10}H_8{}^{37}ClN_3$ [M-H]$^-$: 206.0305, found 206.0314.



1j

2-((3-chlorophenyl)(methyl)amino)malononitrile (1j):

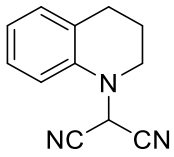
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (t, *J* = 8.0 Hz, 1H), 7.10-7.08 (m, 1H), 7.00 (t, *J* = 2.0 Hz, 1H), 6.90 (dd, *J* = 8.4, 2.8 Hz, 1H), 5.44 (s, 1H), 3.09 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.27, 135.59, 130.79, 123.85, 118.53, 116.10, 109.94, 46.19, 37.17; **HRMS** (ESI) calcd for $C_{10}H_8{}^{35}ClN_3$ [M-H]$^-$: 204.0334, found 204.0335; **HRMS** (ESI) calcd for $C_{10}H_8{}^{37}ClN_3$ [M-H]$^-$: 206.0305, found 206.0311.



1k

2-((4-bromophenyl)(methyl)amino)malononitrile (1k):

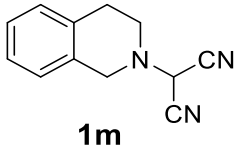
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 8.8 Hz, 2H), 6.92 (d, *J* = 8.8 Hz, 2H), 5.37 (s, 1H), 3.06 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.28, 132.74, 120.30, 116.95, 109.98, 46.53, 37.51; **HRMS** (ESI) calcd for $C_{10}H_8{}^{79}BrN_3$ [M-H]$^-$: 247.9829, found 247.9840; **HRMS** (ESI) calcd for $C_{10}H_8{}^{81}BrN_3$ [M-H]$^-$: 249.9809, found 249.9820.



1l

2-(3, 4-dihydroquinolin-1(*2H*)-yl)malononitrile (1l):

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23-7.18 (m, 1H), 7.13 (dd, *J* = 7.6, 1.2 Hz, 1H), 6.94 (t, *J* = 7.2 Hz, 1H), 6.73 (d, *J* = 8.4 Hz, 1H), 5.67 (s, 1H), 3.44 (t, *J* = 6.0 Hz, 2H), 2.83 (t, *J* = 6.4 Hz, 2H), 2.14-2.08 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.45, 130.03, 127.27, 126.43, 121.27, 112.47, 110.48, 47.50, 42.94, 26.83, 21.70; **HRMS** (ESI) calcd for $C_{12}H_{11}N_3$ [M-H]$^-$: 196.0880, found 196.0876.

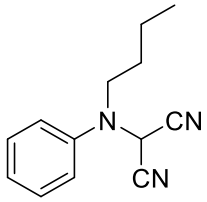


1m

2-(3,4-dihydroisoquinolin-2(*1H*)-yl)malononitrile (1m):

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22-7.14 (m, 3H), 7.09-7.07 (m, 1H), 4.85 (s, 1H), 3.93 (s, 2H), 3.04-2.98 (m, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 132.35, 131.49, 128.71, 126.99, 126.45, 126.26, 109.67,

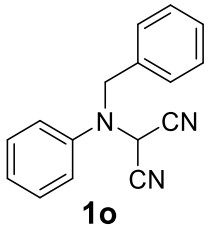
52.19, 48.15, 48.10, 28.69. The ^{1}H NMR and ^{13}C NMR of **1m** are consistent with the reported spectra.[1]



1n

2-(butyl(phenyl)amino)malononitrile (1n):

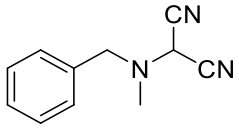
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (dd, *J* = 8.4, 7.6 Hz, 2H), 7.19 (t, *J* = 7.2 Hz, 1H), 7.15 (dd, *J* = 8.0, 1.2 Hz, 2H), 5.29 (s, 1H), 3.37 (t, *J* = 7.2 Hz, 2H), 1.61-1.54 (m, 2H), 1.46-1.36 (m, 2H), 0.95 (t, *J* = 7.2 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.73, 129.63, 124.75, 121.05, 110.89, 50.76, 46.48, 29.09, 19.79, 13.52; **HRMS** (ESI) calcd for $C_{13}H_{15}N_3$ $[M-H]^-$: 212.1193, found 212.1202.



1o

2-(benzyl(phenyl)amino)malononitrile (1o)

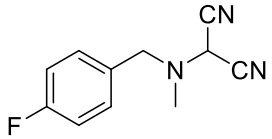
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.36 (m, 2H), 7.35-7.32 (m, 4H), 7.31-7.29 (m, 1H), 7.21 (dd, *J* = 8.8, 1.2 Hz, 2H), 7.15 (t, *J* = 7.2 Hz, 1H), 5.13 (s, 1H), 4.43 (s, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.32, 134.98, 129.63, 128.97, 128.47, 128.26, 125.23, 121.39, 110.55, 56.39, 44.40; **HRMS** (ESI) calcd for $C_{16}H_{13}N_3$ $[M-H]^-$: 246.1037, found 246.1041.



1p

2-(benzyl(methyl)amino)malononitrile (1p)

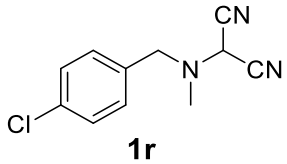
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43-7.35 (m, 5H), 4.62 (s, 1H), 3.70 (s, 2H), 2.56 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 134.80, 128.77, 128.36, 109.84, 58.71, 46.09, 39.24. The ^{1}H NMR and ^{13}C NMR of **1p** are consistent with the reported spectra.[1]



1q

2-((4-fluorobenzyl)(methyl)amino)malononitrile (1q)

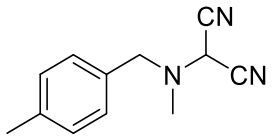
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (dd, *J* = 8.4, 5.2 Hz, 2H), 7.07 (t, *J* = 8.4 Hz, 2H), 4.63 (s, 1H), 3.66 (s, 2H), 2.53 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.51 (d, *J* = 245.8 Hz), 130.70 (d, *J* = 2.5 Hz), 130.54 (d, *J* = 8.1 Hz), 115.68 (d, *J* = 21.3 Hz), 109.82, 57.94, 46.23, 39.13; **HRMS** (ESI) calcd for $C_{11}H_{10}FN_3$ $[M-H]^-$: 202.0786, found 202.0789.



1r

2-((4-chlorobenzyl)(methyl)amino)malononitrile (1r)

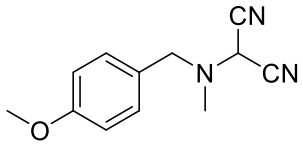
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 4.61 (s, 1H), 3.66 (s, 2H), 2.52 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 134.36, 133.39, 130.19, 129.09, 109.73, 58.12, 46.33, 39.37; **HRMS** (ESI) calcd for $C_{11}H_{10}{}^{35}ClN_3$ $[M-H]^-$: 218.0490, found 218.0498; **HRMS** (ESI) calcd for $C_{11}H_{10}{}^{37}ClN_3$ $[M-H]^-$: 220.0461, found 220.0470.



1s

2-(methyl(4-methylbenzyl)amino)malononitrile (1s)

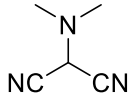
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (dd, *J* = 12.4, 8.4 Hz, 4H), 4.56 (s, 1H), 3.60 (s, 2H), 2.51 (s, 3H), 2.34 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 138.26, 131.70, 129.49, 128.79, 109.88, 58.54, 45.88, 39.26, 20.93; **HRMS** (ESI) calcd for $C_{12}H_{13}N_3$ $[M-H]^-$: 198.1037, found 198.1032.



1t

2-((4-methoxybenzyl)(methyl)amino)malononitrile (1t)

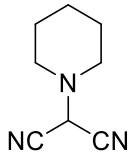
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, *J* = 8.8 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 2H), 4.59 (s, 1H), 3.79 (s, 3H), 3.60 (s, 2H), 2.53 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.68, 130.19, 126.65, 114.23, 109.92, 58.27, 55.14, 45.73, 39.30; **HRMS** (ESI) calcd for $C_{12}H_{13}N_3O$ $[M-H]^-$: 214.0986, found 214.0987.



1u

2-(dimethylamino)malononitrile (1u)

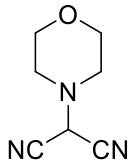
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.67 (s, 1H), 2.38 (s, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 109.76, 48.74, 41.51; **HRMS** (ESI) calcd for $C_5H_7N_3$ $[M+H]^+$: 110.0713, found 110.0715.



1v

2-(piperidin-1-yl)malononitrile (1v)

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.64 (s, 1H), 2.61 (t, *J* = 5.2 Hz, 4H), 1.69-1.63 (m, 4H), 1.50-1.44 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 109.90, 51.06, 48.79, 25.03, 22.78. The ^{1}H NMR and ^{13}C NMR of **1v** are consistent with the reported spectra.[1]

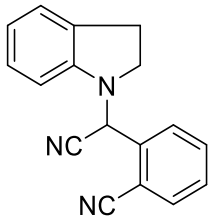


1w

2-morpholinomalononitrile (1w)

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.65 (s, 1H), 3.79 (t, *J* = 4.8 Hz, 4H), 2.72 (t, *J* = 4.4 Hz, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 109.36, 65.91, 49.89, 48.24. The ^{1}H NMR and ^{13}C NMR of **1w** are consistent with the reported spectra.[1]

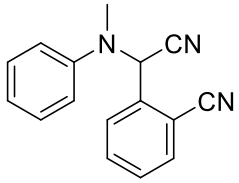
3.2 Characterization of products 3a-3y.



3a

2-(cyano(indolin-1-yl)methyl)benzonitrile (3a):

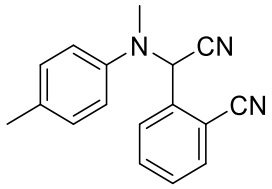
3a was obtained through the general procedure C in 75% yield as a white solid. **IR** (neat) 2928, 2226, 1618, 1485, 1251, 757 cm^{-1}; **mp** 195-197 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 1H), 7.79 (d, *J* = 7.6 Hz, 1H), 7.73 (t, *J* = 7.6 Hz, 1H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.17 (t, *J* = 7.2 Hz, 2H), 6.87 (t, *J* = 7.2 Hz, 1H), 6.78 (d, *J* = 8.0 Hz, 1H), 5.97 (s, 1H), 3.44-3.37 (m, 1H), 3.17-3.12 (m, 1H), 3.09-3.02 (m, 1H), 3.00-2.91 (m, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.29, 136.49, 134.18, 133.05, 130.40, 129.85, 128.54, 127.56, 125.01, 121.06, 116.26, 114.37, 112.71, 108.86, 53.50, 50.40, 28.03; **HRMS** (ESI) calcd for $C_{17}H_{13}N_3$ $[M+H]^+$: 260.1182, found 260.1190.



3b

2-(cyano(methyl(phenyl)amino)methyl)benzonitrile (3b):

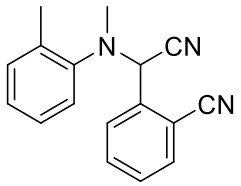
3b was obtained through the general procedure C in 68% yield as a white solid. **IR** (neat) 2924, 2225, 1619, 1496, 1262, 766 cm^{-1}; **mp** 167-169 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85-7.80 (m, 2H), 7.73-7.69 (m, 1H), 7.56 (t, *J* = 8.0 Hz, 1H), 7.36 (t, *J* = 8.8 Hz, 2H), 7.25 (d, *J* = 8.0 Hz, 2H), 7.07 (t, *J* = 7.6 Hz, 1H), 5.93 (s, 1H), 2.70 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.72, 136.68, 134.48, 132.95, 129.84, 129.41, 129.35, 123.04, 119.05, 116.70, 114.54, 112.51, 59.31, 35.16; **HRMS** (ESI) calcd for $C_{16}H_{13}N_3$ $[M+H]^+$: 248.1182, found 248.1185.



3c

2-(cyano(methyl(*p*-tolyl)amino)methyl)benzonitrile (3c):

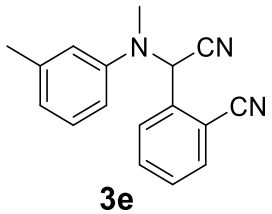
3c was obtained through the general procedure C in 61 % yield as a white solid. **IR** (neat) 2922, 2227, 1686, 1487, 1255, 773 cm^{-1}; **mp** 116-117 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.83-7.80 (m, 2H), 7.72-7.68 (m, 1H), 7.58-7.54 (m, 1H), 7.17 (s, 4H), 5.85 (s, 1H), 2.67 (s, 3H), 2.32 (s, 3H); **^{13}C NMR** (100MHz, $CDCl_3$) δ 146.50, 136.83, 134.41, 132.94, 132.89, 129.94, 129.77, 129.36, 119.65, 116.77, 114.58, 112.62, 59.98, 35.51, 20.64; **HRMS** (ESI) calcd for $C_{17}H_{15}N_3$ $[M+H]^+$: 262.1339, found 262.1342.



3d

2-(cyano(methyl(*o*-tolyl)amino)methyl)benzonitrile (3d):

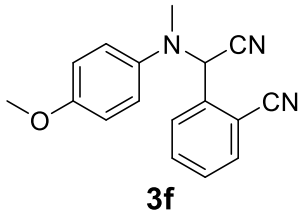
3d was obtained through the general procedure C in 72% yield as a white solid. **IR** (neat) 2925, 2223, 1619, 1494, 1255, 763 cm^{-1}; **mp** 94-96 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.6 Hz, 1H), 7.65-7.57 (m, 2H), 7.53-7.46 (m, 2H), 7.21 (t, *J* = 6.8 Hz, 1H), 7.14-7.06 (m, 2H), 5.55 (s, 1H), 2.75 (s, 3H), 2.15 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.43, 136.97, 134.94, 133.68, 132.63, 131.26, 129.48, 129.11, 126.70, 125.88, 122.30, 116.45, 116.24, 113.00, 58.78, 39.99, 17.63; **HRMS** (ESI) calcd for $C_{17}H_{15}N_3$ $[M+H]^+$: 262.1339, found 262.1343.



3e

2-(cyano(methyl(*m*-tolyl)amino)methyl)benzonitrile (3e):

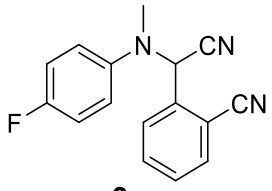
3e was obtained through the general procedure C in 62% yield as a white solid. **IR** (neat) 2920, 2224, 1603, 1494, 1280, 771 cm^{-1}; **mp** 89-91 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85-7.79 (m, 2H), 7.70 (t, *J* = 7.6 Hz, 1H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.26-7.22 (m, 1H), 7.05 (d, *J* = 6.4 Hz, 2H), 6.88 (d, *J* = 7.6 Hz, 1H), 5.93 (s, 1H), 2.67 (s, 3H), 2.36 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.74, 139.17, 136.75, 134.46, 132.90, 129.78, 129.32, 129.17, 123.83, 119.61, 116.68, 116.02, 114.58, 112.49, 59.23, 35.11, 21.64; **HRMS** (ESI) calcd for $C_{17}H_{15}N_3$ $[M+H]^+$: 262.1339, found 262.1342.



3f

2-(cyano((4-methoxyphenyl)(methyl)amino)methyl)benzonitrile (3f):

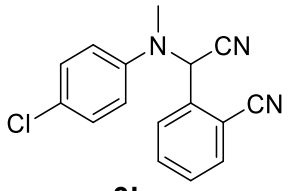
3f was obtained through the general procedure C in 63% yield as a white solid. **IR** (neat) 2923, 2227, 1511, 1459, 1248, 763 cm^{-1}; **mp** 89-90 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.82 (d, *J* = 7.6 Hz, 1H), 7.76 (d, *J* = 7.6 Hz, 1H), 7.68 (t, *J* = 7.6 Hz, 1H), 7.56 (t, *J* = 7.6 Hz, 1H), 7.26 (d, *J* = 8.8 Hz, 2H), 6.89 (d, *J* = 8.8 Hz, 2H), 5.69 (s, 1H), 3.79 (s, 3H), 2.65 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 156.41, 142.47, 136.83, 134.32, 132.87, 129.77, 129.43, 122.59, 116.92, 114.66, 114.53, 112.77, 61.27, 55.43, 36.43; **HRMS** (ESI) calcd for $C_{17}H_{15}N_3O$ $[M+H]^+$: 278.1288, found 278.1293.



3g

2-(cyano((4-fluorophenyl)(methyl)amino)methyl)benzonitrile (3g):

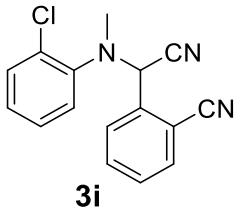
3g was obtained through the general procedure C in 61% yield as a white solid. **IR** (neat) 2924, 2227, 1509, 1488, 1232, 763 cm^{-1}; **mp** 92-93 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84-7.79 (m, 2H), 7.71 (t, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 7.6 Hz, 1H), 7.29-7.26 (m, 2H), 7.05 (t, *J* = 8.8 Hz, 2H), 5.76 (s, 1H), 2.66 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.30 (d, *J* = 241.9 Hz), 145.15 (d, *J* = 2.4 Hz), 136.47, 134.42, 132.99, 129.95, 129.41, 122.16 (d, *J* = 8.2 Hz), 116.84, 116.07 (d, *J* = 22.5 Hz), 114.37, 112.62, 60.66, 35.98; **HRMS** (ESI) calcd for $C_{16}H_{12}FN_3$ $[M+H]^+$: 266.1088, found 266.1093.



3h

2-(((4-chlorophenyl)(methyl)amino)(cyano)methyl)benzonitrile (3h):

3h was obtained through the general procedure C in 55% yield as a white solid. **IR** (neat) 2920, 2228, 1647, 1496, 1265, 763 cm^{-1}; **mp** 108-109 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.82 (t, *J* = 7.2 Hz, 2H), 7.72 (t, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.31 (d, *J* = 8.8 Hz, 2H), 7.18 (d, *J* = 8.8 Hz, 2H), 5.87 (s, 1H), 2.67 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.28, 136.33, 134.49, 133.05, 130.00, 129.40, 129.34, 128.31, 120.45, 116.67, 114.29, 112.47, 59.26, 35.33; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{35}ClN_3$ $[M+H]^+$: 282.0793, found 282.0802; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{37}ClN_3$ $[M+H]^+$: 284.0763, found 284.0771.

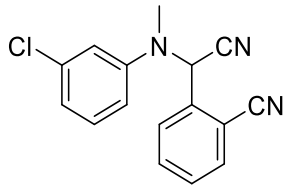


3i

2-(((2-chlorophenyl)(methyl)amino)(cyano)methyl)benzonitrile (3i):

3i was obtained through the general procedure C in 71% yield as a white solid. **IR** (neat) 2921, 2228, 1648, 1481, 1267, 760 cm^{-1}; **mp** 79-80 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.76-7.73 (m, 2H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.45-7.37 (m, 2H), 7.29 (t, *J* = 7.6 Hz, 1H), 7.12 (t, *J* = 7.6 Hz,

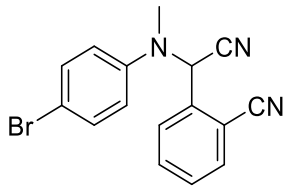
1H), 5.73 (s, 1H), 2.83 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.75, 136.09, 134.04, 132.72, 130.93, 130.82, 129.70, 129.03, 127.72, 126.58, 123.68, 116.29, 115.79, 113.03, 58.19, 38.46; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{35}ClN_3$ $[M+H]^+$: 282.0793, found 282.0799; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{37}ClN_3$ $[M+H]^+$: 284.0763, found 284.0768.



3j

2-(((3-chlorophenyl)(methyl)amino)(cyano)methyl)benzonitrile (3j):

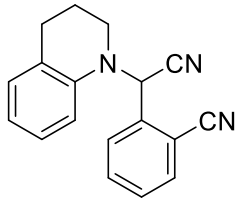
3j was obtained through the general procedure C in 56% yield as a white solid. **IR** (neat) 2921, 2228, 1594, 1488, 1277, 764 cm^{-1}; **mp** 97-99 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87-7.80 (m, 2H), 7.73 (t, *J* = 7.6 Hz, 1H), 7.58 (t, *J* = 7.6 Hz, 1H), 7.28 (t, *J* = 8.0 Hz, 1H), 7.16-7.12 (m, 2H), 7.04-7.02 (m, 1H), 5.94 (s, 1H), 2.70 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 149.70, 136.26, 135.12, 134.56, 133.09, 130.41, 130.04, 129.32, 122.68, 118.50, 116.54, 116.51, 114.30, 112.41, 58.39, 35.01; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{35}ClN_3$ $[M+H]^+$: 282.0793, found 282.0801; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{37}ClN_3$ $[M+H]^+$: 284.0763, found 284.0768.



3k

2-(((4-bromophenyl)(methyl)amino)(cyano)methyl)benzonitrile (3k):

3k was obtained through the general procedure C in 60% yield as a white solid. **IR** (neat) 2924, 2227, 1618, 1493, 1265, 763 cm^{-1}; **mp** 90-91 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.82 (t, *J* = 8.8 Hz, 2H), 7.72 (t, *J* = 7.6 Hz, 1H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.45 (d, *J* = 8.8 Hz, 2H), 7.11 (d, *J* = 8.8 Hz, 2H), 5.88 (s, 1H), 2.67 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.70, 136.29, 134.49, 133.05, 132.31, 130.00, 129.31, 120.59, 116.63, 115.73, 114.26, 112.42, 58.94, 35.22; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{79}BrN_3$ $[M+H]^+$: 326.0287, found 326.0298; **HRMS** (ESI) calcd for $C_{16}H_{12}{}^{81}BrN_3$ $[M+H]^+$: 328.0267, found 328.0276.

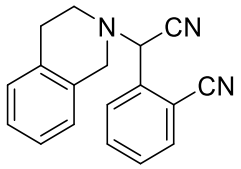


3l

2-(cyano(3,4-dihydroquinolin-1(*2H*)-yl)methyl)benzonitrile (3l):

3l was obtained through the general procedure C in 55% yield as a white solid. **IR** (neat) 2925, 2231, 1599, 1494, 1277, 764 cm^{-1}; **mp** 177-179 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.0 Hz, 1H), 7.78 (d, *J* = 7.6 Hz, 1H), 7.73 (t, *J* = 7.6 Hz, 1H), 7.55 (t, *J* = 7.2 Hz, 1H), 7.15 (t, *J* = 7.2 Hz, 1H), 7.07 (d, *J* = 7.2 Hz, 1H), 6.98 (d, *J* = 8.4 Hz, 1H), 6.84 (t, *J* = 7.2 Hz, 1H), 6.14 (s, 1H), 3.20-3.14 (m, 1H),

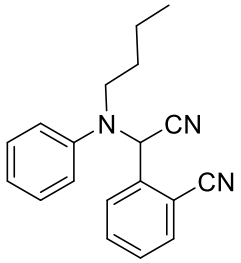
2.95-2.81 (m, 2H), 2.78-2.71 (m, 1H), 2.06-1.89 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 142.96, 137.03, 134.61, 132.98, 129.74, 129.63, 129.22, 127.14, 126.29, 120.22, 116.36, 115.21, 113.28, 112.19, 54.96, 45.78, 27.45, 21.98; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1348.



3m

2-(cyano(3,4-dihydroisoquinolin-2(*1H*)-yl)methyl)benzonitrile (3m):

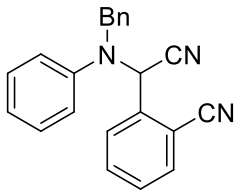
3m was obtained through the general procedure C in 80% yield as a white solid. **IR** (neat) 2922, 2227, 1618, 1449, 1267, 756 cm^{-1}; **mp** 110-112 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 7.6 Hz, 1H), 7.77-7.69 (m, 2H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.16-7.09 (m, 3H), 6.97 (d, *J* = 8.0 Hz, 1H), 5.29 (s, 1H), 3.91 (d, *J* = 14.4 Hz, 1H), 3.63 (d, *J* = 14.4 Hz, 1H), 3.11-3.00 (m, 2H), 2.92-2.81 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.78, 134.09, 133.51, 132.88, 132.61, 129.62, 128.71, 128.65, 126.44, 126.38, 125.79, 116.46, 113.88, 113.35, 60.77, 51.34, 48.09, 29.02; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1348.



3n

2-((butyl(phenyl)amino)(cyano)methyl)benzonitrile (3n):

3n was obtained through the general procedure C in 65% yield as a white solid. **IR** (neat) 2931, 2227, 1598, 1498, 1263, 763 cm^{-1}; **mp** 65-66 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 7.6 Hz, 1H), 7.71 (d, *J* = 7.6 Hz, 1H), 7.63 (t, *J* = 7.6 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.32 (t, *J* = 8.4 Hz, 2H), 7.24 (d, *J* = 7.6 Hz, 2H), 7.10 (t, *J* = 7.2 Hz, 1H), 5.70 (s, 1H), 3.30-3.23 (m, 1H), 2.99-2.91 (m, 1H), 1.47-1.31 (m, 2H), 1.28-1.11 (m, 2H), 0.73 (t, *J* = 7.6 Hz, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 146.58, 137.19, 134.31, 132.77, 129.63, 129.51, 129.27, 124.33, 122.56, 116.88, 115.62, 112.80, 59.62, 49.14, 29.23, 19.91, 13.54; **HRMS** (ESI) calcd for $C_{19}H_{19}N_3$ $[M+H]^+$: 290.1652, found 290.1659.

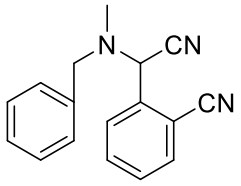


3o

2-((benzyl(phenyl)amino)(cyano)methyl)benzonitrile (3o):

3o was obtained through the general procedure C in 62% yield as a white solid. **IR** (neat) 2921, 2225, 1598, 1497, 1210, 764 cm^{-1}; **mp** 117-118 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.70 (t, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.6 Hz, 1H), 7.41 (t, *J* = 7.2 Hz, 1H), 7.25-7.22 (m, 6H), 7.18 (t, *J* = 7.2 Hz, 2H), 7.11 (t, *J* = 7.2 Hz, 1H), 7.04-6.99 (m, 1H), 5.86 (s, 1H), 4.44 (d, *J* = 14.8 Hz, 1H), 4.23 (d, *J* = 14.8 Hz, 1H);

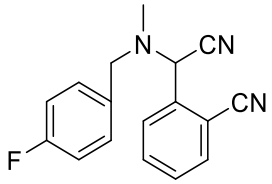
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.75, 136.60, 136.45, 134.25, 132.77, 129.67, 129.62, 129.15, 128.27, 127.93, 127.17, 124.10, 121.91, 116.91, 115.19, 112.65, 58.98, 53.82; **HRMS** (ESI) calcd for $C_{22}H_{17}N_3$ $[M+H]^+$: 324.1495, found 324.1504.



3p

2-((benzyl(methyl)amino)(cyano)methyl)benzonitrile (3p):

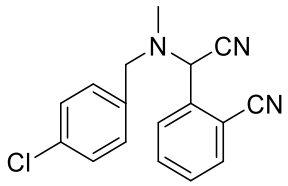
3p was obtained through the general procedure C in 65% yield as a white solid. **IR** (neat) 2921, 2228, 1601, 1454, 1267, 737 cm^{-1}; **mp** 82-84 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.0 Hz, 2H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.40 (d, *J* = 6.8 Hz, 2H), 7.32 (t, *J* = 7.2 Hz, 2H), 7.27 (t, *J* = 6.8 Hz, 1H), 5.23 (s, 1H), 3.75 (d, *J* = 12.8 Hz, 1H), 3.66 (d, *J* = 12.8 Hz, 1H), 2.17 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.12, 136.59, 134.20, 132.51, 129.41, 128.98, 128.82, 128.33, 127.57, 116.76, 113.66, 112.89, 60.44, 59.14, 37.30; **HRMS** (ESI) calcd for $C_{17}H_{15}N_3$ $[M+H]^+$: 262.1339, found 262.1342.



3q

2-(cyano((4-fluorobenzyl)(methyl)amino)methyl)benzonitrile (3q):

3q was obtained through the general procedure C in 70% yield as a yellow oil; **IR** (neat) 2924, 2228, 1603, 1510, 1223, 764 cm^{-1}; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.4 Hz, 2H), 7.66 (t, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.37 (t, *J* = 8.4 Hz, 2H), 7.00 (t, *J* = 8.4 Hz, 2H), 5.22 (s, 1H), 3.74 (d, *J* = 12.8 Hz, 1H), 3.63 (d, *J* = 12.8 Hz, 1H), 2.13 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.27 (d, *J* = 244.4 Hz), 137.11, 134.28, 132.62, 132.38 (d, *J* = 2.9 Hz), 130.69 (d, *J* = 8.2 Hz), 129.53, 128.90, 116.83, 115.24 (d, *J* = 21.2 Hz), 113.60, 112.93, 60.42, 58.65, 37.11; **HRMS** (ESI) calcd for $C_{17}H_{14}FN_3$ $[M+H]^+$: 280.1245, found 280.1251.

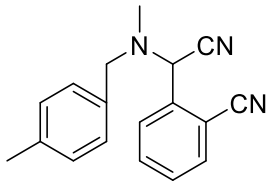


3r

2-(((4-chlorobenzyl)(methyl)amino)(cyano)methyl)benzonitrile (3r):

3r was obtained through the general procedure C in 70% yield as a yellow solid. **IR** (neat) 2923, 2228, 1619, 1492, 1321, 764 cm^{-1}; **mp** 101-103 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.80-7.77 (m, 2H), 7.66 (t, *J* = 7.6 Hz, 1H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.36-7.27 (m, 4H), 5.23 (s, 1H), 3.74 (d, *J* = 12.8 Hz, 1H), 3.62 (d, *J* = 12.8 Hz, 1H), 2.14 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.02, 135.19, 134.28, 133.40, 132.63, 130.36, 129.56, 128.88, 128.55, 116.82, 113.56, 112.92, 60.51, 58.61 37.23; **HRMS** (ESI) calcd for $C_{17}H_{14}{}^{35}ClN_3$ $[M+H]^+$: 296.0949, found 296.0959; **HRMS** (ESI) calcd for $C_{17}H_{14}{}^{37}ClN_3$

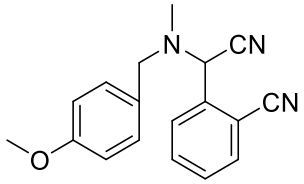
[M+H]$^+$: 298.0920, found 298.0925.



3s

2-(cyano(methyl(4-methylbenzyl)amino)methyl)benzonitrile (3s):

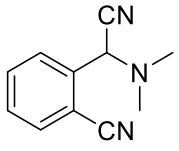
3s was obtained through the general procedure C in 71% yield as a yellow solid. **IR** (neat) 2923, 2228, 1600, 1450, 1267, 765 cm^{-1}; **mp** 112-113 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 7.6 Hz, 2H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 1H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.14 (d, *J* = 8.0 Hz, 2H), 5.22 (s, 1H), 3.72 (d, *J* = 12.8 Hz, 1H), 3.65 (d, *J* = 12.8 Hz, 1H), 2.33(s, 3H), 2.16 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.33, 137.32, 134.27, 133.56, 132.52, 129.41, 129.08, 129.07, 128.93, 116.79, 113.73, 113.04, 60.42, 59.05, 37.30, 21.03; **HRMS** (ESI) calcd for $C_{18}H_{17}N_3$ [M+H]$^+$: 276.1495, found 276.1502.



3t

2-(cyano((4-methoxybenzyl)(methyl)amino)methyl)benzonitrile (3t):

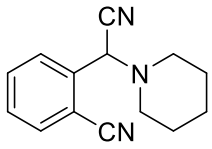
3t was obtained through the general procedure C in 72% yield as a yellow solid. **IR** (neat) 2924, 2227, 1611, 1450, 1246, 763 cm^{-1}; **mp** 91-93 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 7.33 (d, *J* = 8.8 Hz, 2H), 6.86 (d, *J* = 8.8 Hz, 2H), 5.21 (s, 1H), 3.78 (s, 3H), 3.70 (d, *J* = 12.8 Hz, 1H), 3.62 (d, *J* = 12.8 Hz, 1H), 2.13 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.15, 137.33, 134.30, 132.56, 130.37, 129.42, 128.93, 128.65, 116.86, 113.78, 113.73, 112.96, 60.31, 58.89, 55.16, 37.09; **HRMS** (ESI) calcd for $C_{18}H_{17}N_3O$ [M+H]$^+$: 292.1444, found 292.1453.



3u

2-(cyano(dimethylamino)methyl)benzonitrile (3u):

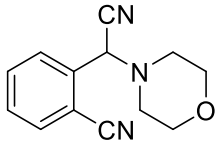
3u was obtained through the general procedure C in 28% yield as a yellow oil. **IR** (neat) 2953, 2228, 1605, 1487, 1223, 764 cm^{-1}; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 7.6 Hz, 1H), 7.71 (d, *J* = 8.0 Hz, 1H), 7.65 (t, *J* = 7.6 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 5.06 (s, 1H), 2.33 (s, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.31, 133.93, 132.56, 129.44, 128.51, 116.53, 113.52, 113.09, 61.38, 41.49; **HRMS** (ESI) calcd for $C_{11}H_{11}N_3$ [M+H]$^+$: 186.1026, found 186.1023.



3v

2-(cyano(dimethylamino)methyl)benzonitrile (3v):

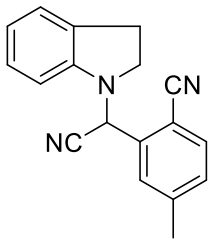
3v was obtained through the general procedure C in 45% yield as a yellow solid. **IR** (neat) 2938, 2228, 1628, 1451, 1278, 766 cm^{-1}; **mp** 65-67 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.6 Hz, 1H), 7.69 (d, *J* = 8.0 Hz, 1H), 7.62 (t, *J* = 7.6 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 1H), 5.00 (s, 1H), 2.60-2.57 (m, 2H), 2.46-2.40 (m, 2H), 1.65-1.57 (m, 2H), 1.55-1.40 (m, 4H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 137.27, 133.96, 132.26, 129.17, 128.52, 116.47, 113.88, 113.02, 61.34, 50.59, 25.30, 23.61; **HRMS** (ESI) calcd for $C_{14}H_{15}N_3$ $[M+H]^+$: 226.1339, found 226.1335.



3w

2-(cyano(morpholino)methyl)benzonitrile (3w):

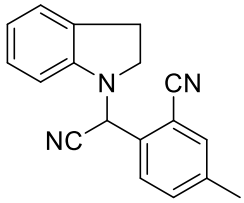
3w was obtained through the general procedure C in 64% yield as yellow solid. **IR** (neat) 2914, 2228, 1487, 1454, 1250, 766cm^{-1}; **mp** 80-82 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 7.6 Hz, 1H), 7.69 (d, *J* = 7.6 Hz, 1H), 7.63 (t, *J* = 8.0 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 1H), 5.03 (s, 1H), 3.71-3.66 (m, 2H), 3.64-3.59 (m, 2H), 2.67-2.62 (m, 2H), 2.49-2.45 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 136.13, 133.99, 132.45, 129.50, 128.60, 116.35, 113.44, 112.97, 66.10, 60.62, 49.47; **HRMS** (ESI) calcd for $C_{13}H_{13}N_3O$ $[M+H]^+$: 228.1131, found 228.1128.



3x

2-(cyano(indolin-1-yl)methyl)-4-methylbenzonitrile (3x):

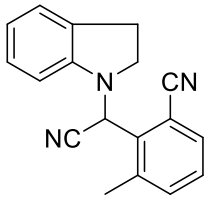
3x and **3x'** was obtained through the general procedure C in 72% yield (3x:3x' = 1:1.7) as a white solid. **IR** (neat) 2925, 2227, 1608, 1485, 1266, 739 cm^{-1}; **mp** (3x) 161-163 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.69 (s, 1H), 7.67 (d, *J* = 7.6 Hz, 1H), 7.35 (d, *J* = 7.6 Hz, 1H), 7.18-7.14 (m, 2H), 6.86 (t, *J* = 7.2 Hz, 1H), 6.77 (d, *J* = 7.6 Hz, 1H), 5.93 (s, 1H), 3.43-3.36 (m, 1H), 3.18-3.12 (m, 1H), 3.09-3.02 (m, 1H), 3.00-2.91 (m, 1H), 2.52 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.38, 144.42, 136.38, 134.06, 130.42, 129.35, 129.30, 127.56, 125.08, 121.01, 116.57, 114.55, 109.69, 108.89, 53.56, 50.39, 28.09, 22.02; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1335.



3x'

2-(cyano(indolin-1-yl)methyl)-5-methylbenzonitrile (3x'):

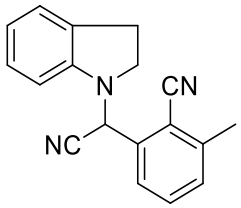
3x and **3x'** was obtained through the general procedure C in 72% yield (3u:3u' = 1:1.7) as a white solid. **IR** (neat) 2923, 2229, 1607, 1485, 1251, 747 cm^{-1}; **mp** (3x') 126-128 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 1H), 7.59 (s, 1H), 7.51 (d, *J* = 7.6 Hz, 1H), 7.17-7.13(m, 2H), 6.86 (t, *J* = 7.2 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 5.92 (s, 1H), 3.42-3.35 (m, 1H), 3.17-3.11 (m, 1H), 3.08-3.01 (m, 1H), 2.99-2.90 (m, 1H), 2.45 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.38, 140.40, 134.61, 133.72, 133.59, 130.45, 128.52, 127.58, 125.01, 120.99, 116.45, 114.58, 112.54, 108.89, 53.22, 50.29, 28.07, 20.89; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1335.



3y

2-(cyano(indolin-1-yl)methyl)-3-methylbenzonitrile (3y):

3y and **3y'** was obtained through the general procedure C in 78% yield (3y:3y' = 1:2.1) as a white solid. **IR** (neat) 2921, 2226, 1606, 1485, 1251, 749 cm^{-1}; **mp** (3y) 189-191 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 7.6 Hz, 1H), 7.53 (d, *J* = 6.8 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 1H), 7.17-7.10 (m, 2H), 6.86 (t, *J* = 7.6 Hz, 1H), 6.64 (d, *J* = 7.6 Hz, 1H), 5.80 (s, 1H), 3.51-3.41 (m, 2H), 3.07-2.94 (m, 2H), 2.66 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 149.08, 139.23, 136.30, 133.89, 132.52, 130.56, 129.78, 127.61, 124.99, 120.78, 117.04, 115.25, 113.48, 108.33, 51.98, 51.04, 28.21, 19.97; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1347.

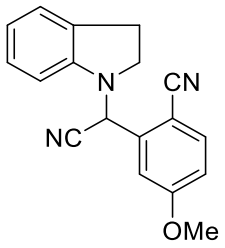


3y'

2-(cyano(indolin-1-yl)methyl)-6-methylbenzonitrile (3y'):

3y and **3y'** was obtained through the general procedure C in 78% yield (3y:3y' = 1:2.1) as a white solid. **IR** (neat) 2920, 2221, 1602, 1484, 1247, 755 cm^{-1}; **mp** (3y') 117-119 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.6 Hz, 1H), 7.59 (t, *J* = 7.6 Hz, 1H), 7.42 (t, *J* = 8.0 Hz, 1H), 7.18-7.14 (m, 2H), 6.86 (t, *J* = 7.2 Hz, 1H), 6.80 (d, *J* = 7.6 Hz, 1H), 5.95 (s, 1H), 3.44-3.37 (m, 1H), 3.17-3.12 (m, 1H), 3.08-3.01 (m, 1H), 2.99-2.91 (m, 1H), 2.61 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.42, 144.18, 136.69, 132.40, 131.10, 130.42, 127.56, 125.86, 124.96, 120.97, 115.41, 114.58, 112.95, 108.93,

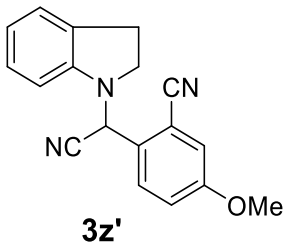
53.70, 50.43, 28.04, 20.79; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3$ $[M+H]^+$: 274.1339, found 274.1347.



3z

2-(cyano(indolin-1-yl)methyl)-4-methoxybenzonitrile (3z):

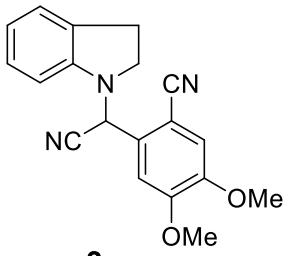
3z and **3z'** was obtained through the general procedure C in 70% yield (3z:3z' = 1:2.0) as a white solid. **IR** (neat) 2929, 2229, 1606, 1486, 1257, 751 cm^{-1}; **mp** (3z) 168-169 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.71 (d, *J* = 8.8 Hz, 1H), 7.39 (d, *J* = 2.4 Hz, 1H), 7.18-7.14 (m, 2H), 7.00 (d, *J* = 8.4 Hz, 1H), 6.86 (t, *J* = 7.6 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 5.92 (s, 1H), 3.93 (s, 3H), 3.43-3.36 (m, 1H), 3.21-3.16 (m, 1H), 3.09-2.92 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.91, 148.31, 138.50, 135.94, 130.39, 127.56, 124.99, 121.00, 116.66, 115.32, 114.39, 114.32, 108.86, 103.93, 55.89, 53.54, 50.42, 28.05; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3O$ $[M+H]^+$: 290.1288, found 290.1299.



3z'

2-(cyano(indolin-1-yl)methyl)-5-methoxybenzonitrile (3z'):

3z and **3z'** was obtained through the general procedure C in 70% yield (3z:3z' = 1:2.0) as a white solid. **IR** (neat) 2932, 2372, 1727, 1460, 1286, 745 cm^{-1}; **mp** (3z') 134-136 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.4 Hz, 1H), 7.26 (d, *J* = 2.8 Hz, 1H), 7.20-7.13 (m, 3H), 6.85 (t, *J* = 7.6 Hz, 1H), 6.76 (d, *J* = 8.4 Hz, 1H), 5.90 (s, 1H), 3.86 (s, 3H), 3.40-3.33 (m, 1H), 3.16-3.11 (m, 1H), 3.07-2.89 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 160.03, 148.36, 130.43, 129.92, 128.18, 127.51, 124.95, 120.89, 119.43, 118.39, 116.14, 114.66, 113.56, 108.83, 55.80, 52.80, 50.25, 27.99; **HRMS** (ESI) calcd for $C_{18}H_{15}N_3O$ $[M+H]^+$: 290.1288, found 290.1299.

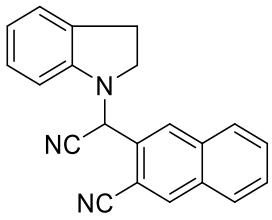


3aa

2-(cyano(indolin-1-yl)methyl)-4,5-dimethoxybenzonitrile (3aa):

3aa was obtained through the general procedure C in 64% yield as a yellow solid. **IR** (neat) 2937, 2223, 1601, 1460, 1224, 744 cm^{-1}; **mp** 183-185 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.27 (s, 1H), 7.17-7.13 (m, 3H), 6.85 (t, *J* = 7.2 Hz, 1H), 6.76 (d, *J* = 8.0 Hz, 1H), 5.91 (s, 1H), 4.00 (s, 3H), 3.91 (s, 3H), 3.41-3.34 (m, 1H), 3.21-3.16 (m, 1H), 3.08-2.91 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 152.50, 149.39, 148.30, 130.38, 130.32, 127.49, 124.92, 120.87, 116.58, 115.45, 114.76, 111.09, 108.78, 103.91,

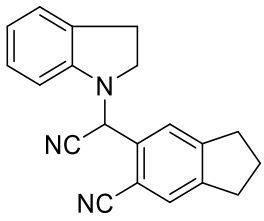
56.38, 56.31, 53.15, 50.36, 27.99; **HRMS** (ESI) calcd for $C_{19}H_{17}N_3O_2$ $[M+H]^+$: 320.1394, found 320.1404.



3ab

3-(cyano(indolin-1-yl)methyl)-2-naphthonitrile (3ab):

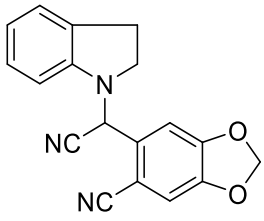
3ab was obtained through the general procedure C in 71% yield as a white solid. **IR** (neat) 2918, 2222, 1599, 1485, 1255, 754 cm^{-1}; **mp** 241-242 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.34 (d, *J* = 12.0 Hz, 2H), 8.01 (d, *J* = 8.0 Hz, 1H), 7.95 (d, *J* = 8.0 Hz, 1H), 7.78-7.69 (m, 2H), 7.19-7.15 (m, 2H), 6.89-6.83 (m, 2H), 6.08 (s, 1H), 3.48-3.41 (m, 1H), 3.16-3.11 (m, 1H), 3.08-3.02 (m, 1H) , 3.00-2.91 (m, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.41, 136.66, 133.93, 132.14, 130.57, 130.47, 130.13, 128.81, 128.52, 128.43, 128.29, 127.62, 125.06, 121.10, 116.78, 114.65, 109.30, 109.03, 53.77, 50.36, 28.05; **HRMS** (ESI) calcd for $C_{21}H_{15}N_3$ $[M+H]^+$: 310.1339, found 310.1349.



3ac

6-(cyano(indolin-1-yl)methyl)-2,3-dihydro-1H-indene-5-carbonitrile (3ac):

3ac was obtained through the general procedure C in 76% yield as a yellow solid. **IR** (neat) 2930, 2228, 1605, 1485, 1250, 754 cm^{-1}; **mp** 156-158 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.74 (s, 1H), 7.59 (s, 1H), 7.18-7.14 (m, 2H), 6.87-6.81 (m, 2H), 5.97 (s, 1H), 3.43-3.36 (m, 1H), 3.20-3.14 (m, 1H), 3.08-2.90 (m, 6H) , 2.21-2.14 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.62, 148.36, 146.28, 134.34, 130.26, 129.59, 127.36, 124.76, 124.56, 120.65, 116.90, 114.68, 109.93, 108.69, 53.20, 50.12, 33.10, 32.17, 27.86, 24.94; **HRMS** (ESI) calcd for $C_{20}H_{17}N_3$ $[M+H]^+$: 300.1495, found 300.1491.



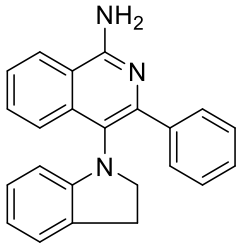
3ad

6-(cyano(indolin-1-yl)methyl)benzo[d][1,3]dioxole-5-carbonitrile (3ad):

3ad was obtained through the general procedure C in 70% yield as a yellow solid. **IR** (neat) 2909, 2218, 1618, 1487, 1252, 758 cm^{-1}; **mp** 169-171 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.32 (s, 1H), 7.18-7.12 (m, 3H), 6.86 (t, *J* = 7.2 Hz, 1H), 6.78 (d, *J* = 8.4 Hz, 1H), 6.13 (s, 2H), 5.90 (s, 1H), 3.42-3.35 (m, 1H), 3.25-3.19 (m, 1H), 3.09-2.91 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 151.66, 148.39, 148.25, 132.67, 130.29, 127.49, 124.92, 120.90, 116.29, 114.53, 112.68, 109.19, 108.77, 105.30, 103.06,

53.10, 50.31, 27.98; **HRMS** (ESI) calcd for $C_{18}H_{13}N_3O_2$ [M+H]$^+$: 304.1081, found 304.1077.

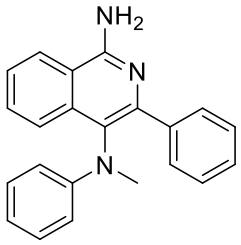
3.3 Characterization of products 4a and 4b



4a

4-(indolin-1-yl)-3-phenylisoquinolin-1-amine (4a):

4a was obtained through the general procedure D in 61% yield as a yellow solid. **IR** (neat) 2925, 1721, 1605, 1434, 1273, 743 cm^{-1}; **mp** 191-192 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.4 Hz, 1H), 7.70-7.63 (m, 3H), 7.57-7.48 (m, 2H), 7.36-7.29 (m, 3H), 7.13 (d, *J* = 7.2 Hz, 1H), 6.95 (t, *J* = 8.0 Hz, 1H), 6.63 (t, *J* = 7.2 Hz, 1H), 6.05 (d, *J* = 7.6 Hz, 1H), 5.29 (s, 2H), 3.70-3.63 (m, 1H), 3.46-3.40 (m, 1H), 3.21-3.13 (m, 1H), 3.03-2.94 (m, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.45, 152.32, 150.47, 139.58, 136.11, 130.25, 128.64, 128.36, 128.08, 127.82, 127.58, 126.00, 124.60, 124.17, 123.37, 122.48, 118.33, 116.37, 106.18, 52.10, 28.67; **HRMS** (ESI) calcd for $C_{23}H_{19}N_3$ [M+H]$^+$: 338.1652, found 338.1645.

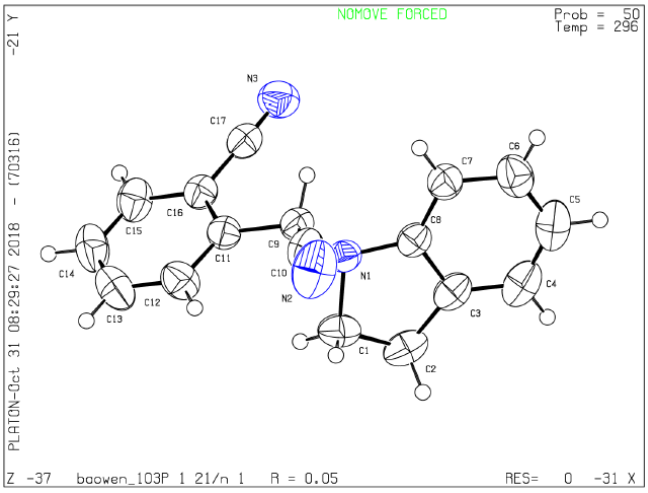


4b

***N*^{4}-methyl-*N*^{4}, 3-diphenylisoquinoline-1, 4-diamine (4b):**

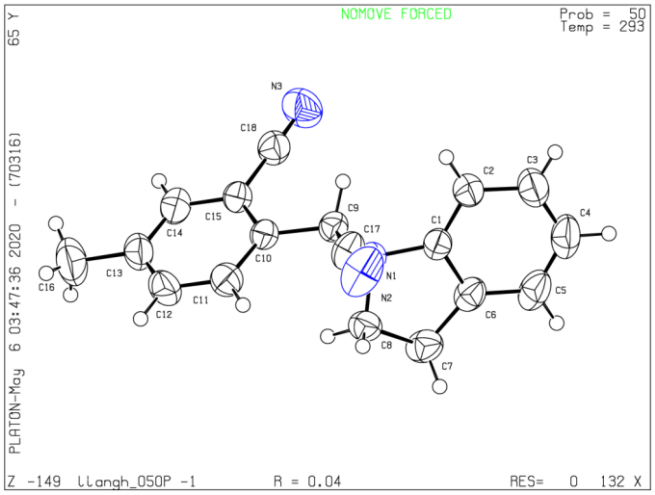
4b was obtained through the general procedure D in 63% yield as a yellow solid. **IR** (neat) 2928, 1720 1599, 1435, 1265, 739 cm^{-1}; **mp** 178-180 °C; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.0 Hz, 1H), 7.60-7.47 (m, 5H), 7.34-7.29 (m, 3H), 7.18 (t, *J* = 8.0 Hz, 2H), 6.71 (t, *J* = 7.2 Hz, 1H), 6.55 (d, *J* = 8.0 Hz, 2H), 5.40 (s, 2H), 3.01 (s, 3H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 154.43, 149.78, 149.18, 139.30, 136.47, 130.67, 129.19, 128.37, 128.10, 127.88, 127.45, 126.14, 124.26, 123.22, 118.33, 116.35, 112.12, 38.72; **HRMS** (ESI) calcd for $C_{22}H_{19}N_3$ [M+H]$^+$: 326.1652, found 326.1646.

4. X-Ray ellipsoid plots of products




```
Bond precision:  C-C = 0.0032 A          Wavelength=0.71073

Cell:            a=8.4918(5)     b=10.0409(5)        c=16.7446(7)
                 alpha=90        beta=100.191(5)     gamma=90
Temperature:     296 K

                 Calculated                  Reported
Volume           1405.21(13)                 1405.22(12)
Space group      P 21/n                      P 1 21/n 1
Hall group       : -P 2yn                    -P 2yn
Moiety formula   C17 H13 N3                  C17 H13 N3
Sum formula      C17 H13 N3                  C17 H13 N3
Mr               259.30                      259.30
Dx,g cm-3        1.226                       1.226
Z                4                           4
Mu (mm-1)        0.075                       0.075
F000             544.0                       544.0
F000'            544.18
h,k,lmax         10,12,20                    10,12,20
Nref             2778                        2772
Tmin,Tmax        0.987,0.991                 0.767,1.000
Tmin'            0.987

Correction method= # Reported T Limits: Tmin=0.767 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.998          Theta(max)= 26.020

R(reflections)= 0.0543( 1855)     wR2(reflections)= 0.1426( 2772)

S = 1.085                 Npar= 181
```

Figure S1. The single crystal analysis for 3a (CCDC number: 1876354)



Bond precision: C-C = 0.0020 A Wavelength=1.54184

Cell: a=8.0685(11) b=8.5074(8) c=10.8878(13)
alpha=93.111(9) beta=96.047(10) gamma=91.869(9)
Temperature: 293 K

	Calculated	Reported
Volume	741.55(15)	741.55(15)
Space group	P -1	P -1
Hall group	-P 1	-P 1
Moiety formula	C18 H15 N3	C18 H15 N3
Sum formula	C18 H15 N3	C18 H15 N3
Mr	273.33	273.33
Dx,g cm-3	1.224	1.224
Z	2	2
Mu (mm-1)	0.579	0.579
F000	288.0	288.0
F000'	288.78	
h,k,lmax	9,10,12	9,10,12
Nref	2616	2598
Tmin,Tmax	0.926,0.960	0.541,1.000
Tmin'	0.922	

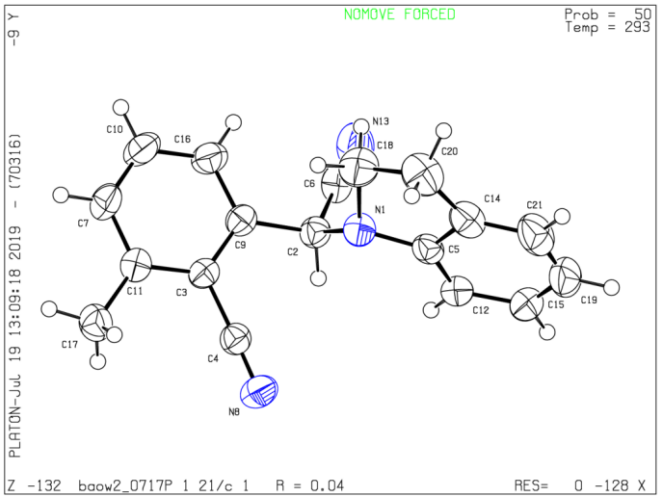
Correction method= # Reported T Limits: Tmin=0.541 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.993 Theta(max)= 66.583

R(reflections)= 0.0410(2232) wR2(reflections)= 0.1220(2598)

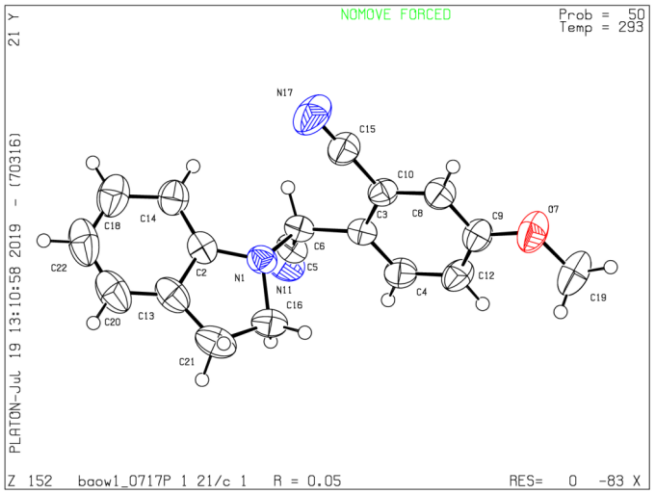
S = 1.064 Npar= 192

Figure S2. The single crystal analysis for 3x' (CCDC number: 2002471)




```
Bond precision:  C-C = 0.0020 A          Wavelength=1.54184

Cell:            a=8.2710(2)     b=9.9844(2)          c=18.3806(4)
                 alpha=90        beta=102.740(2)      gamma=90
Temperature:     293 K

                 Calculated                Reported
Volume           1480.52(6)                1480.52(6)
Space group      P 21/c                    P 1 21/c 1
Hall group       -P 2ybc                   -P 2ybc
Moiety formula   C18 H15 N3                C18 H15 N3
Sum formula      C18 H15 N3                C18 H15 N3
Mr               273.33                    273.33
Dx,g cm-3        1.226                     1.226
Z                4                         4
Mu (mm-1)        0.580                     0.580
F000             576.0                     576.0
F000'            577.55
h,k,lmax         9,11,21                   9,11,21
Nref             2609                      2566
Tmin,Tmax        0.901,0.933               0.249,1.000
Tmin'            0.896

Correction method= # Reported T Limits: Tmin=0.249 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.984          Theta(max)= 66.587

R(reflections)= 0.0433( 2341)     wR2(reflections)= 0.1215( 2566)

S = 1.059                 Npar= 191
```

Figure S3. The single crystal analysis for 3y' (CCDC number: 1941766)




```
Bond precision:  C-C = 0.0025 A          Wavelength=1.54184

Cell:            a=9.2780(4)     b=23.2807(7)         c=7.4089(3)
                 alpha=90        beta=102.520(4)      gamma=90
Temperature:     293 K

                 Calculated                Reported
Volume           1562.26(11)               1562.25(10)
Space group      P 21/c                    P 1 21/c 1
Hall group       -P 2ybc                   -P 2ybc
Moiety formula   C18 H15 N3 O              C18 H15 N3 O
Sum formula      C18 H15 N3 O              C18 H15 N3 O
Mr               289.33                    289.33
Dx,g cm-3        1.230                     1.230
Z                4                         4
Mu (mm-1)        0.628                     0.628
F000             608.0                     608.0
F000'            609.75
h,k,lmax         11,27,8                   11,27,8
Nref             2764                      2690
Tmin,Tmax        0.900,0.927               0.595,1.000
Tmin'            0.893

Correction method= # Reported T Limits: Tmin=0.595 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 0.973          Theta(max)= 66.592

R(reflections)= 0.0454( 2277)     wR2(reflections)= 0.1337( 2690)

S = 1.049                 Npar= 200
```

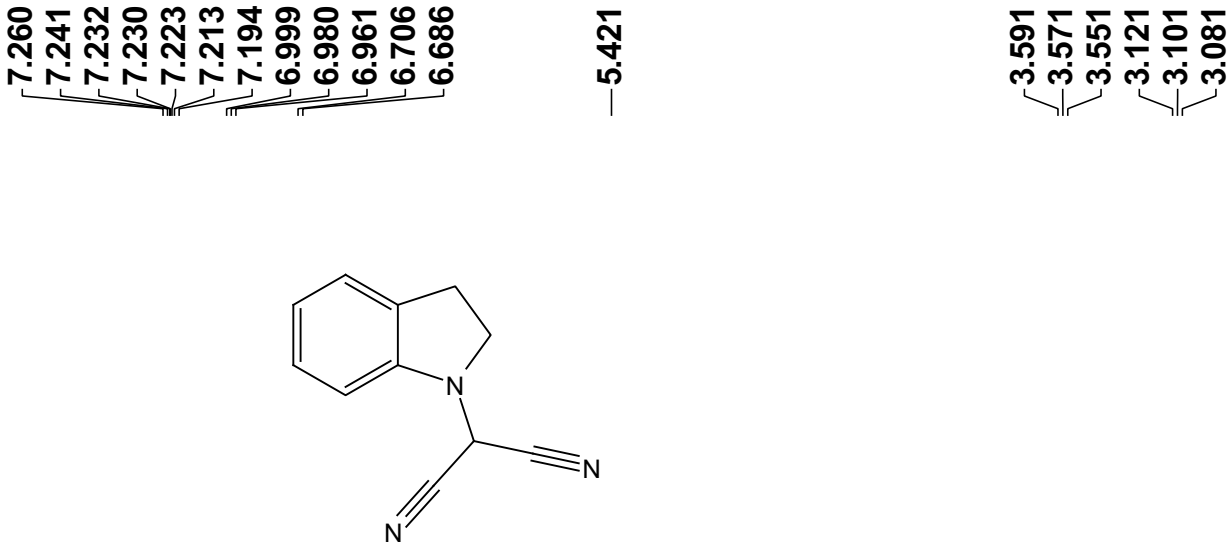
Figure S4. The single crystal analysis for 3z' (CCDC number: 1941767)

5. References

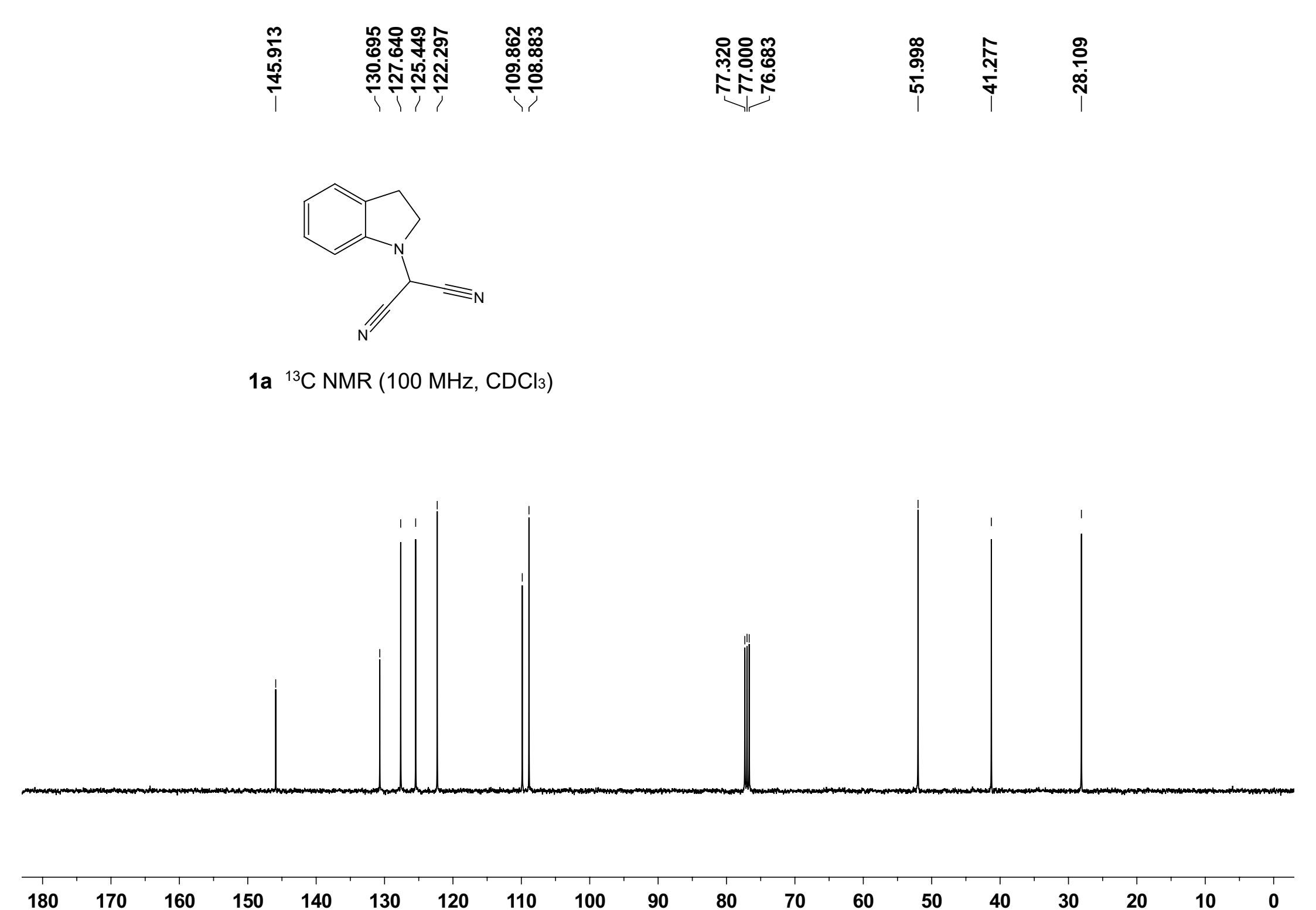
(1) X.-Q. Mou, L. Xu, S.-H. Wang and C. Yang, *Tetrahedron Lett.*, 2015, 56, 2820-2822.

(2) H. Jiang, Y. Zhang, W. Xiong, J. Cen, L. Wang, R. Cheng, C. Qi and W. Wu, *Org. Lett.*, 2019, 21, 345-349.

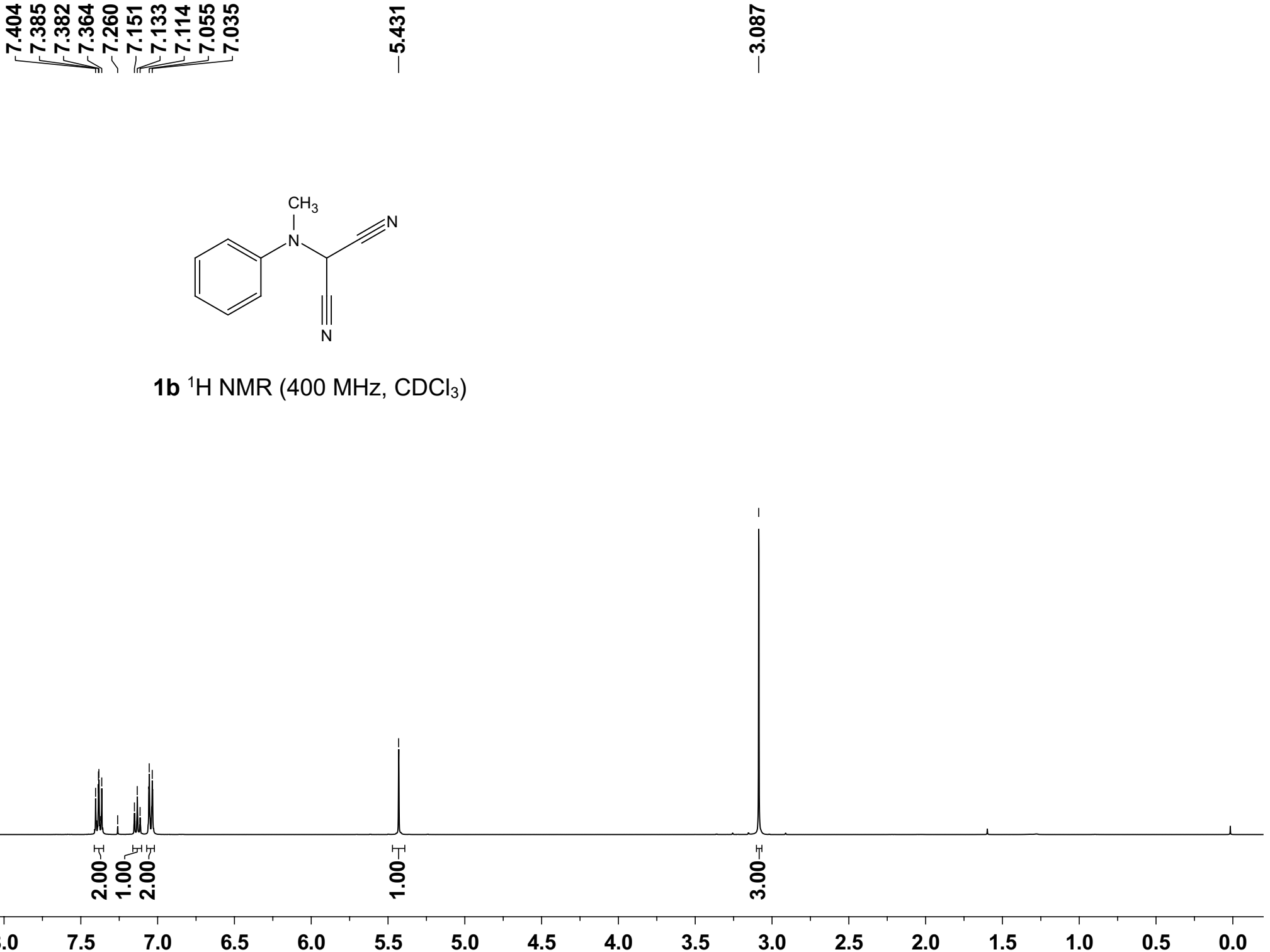
(3) X. Yang, H. Yu, Y. Xu and L. Shao, *J. Org. Chem.*, 2018, 83, 9682-9695.



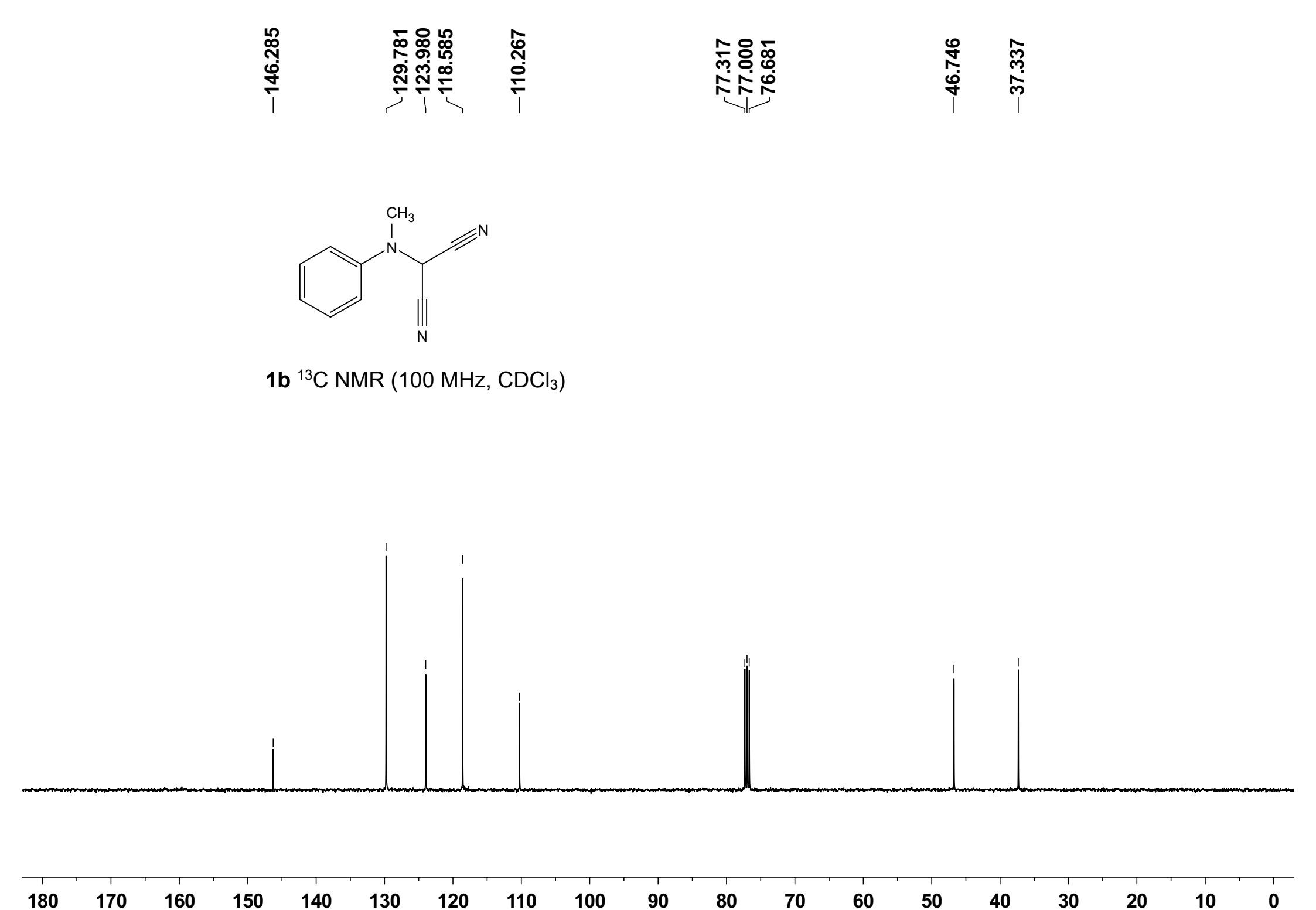
1a ^{1}H NMR (400 MHz, $CDCl_3$)



1a ^{13}C NMR (100 MHz, $CDCl_3$)



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



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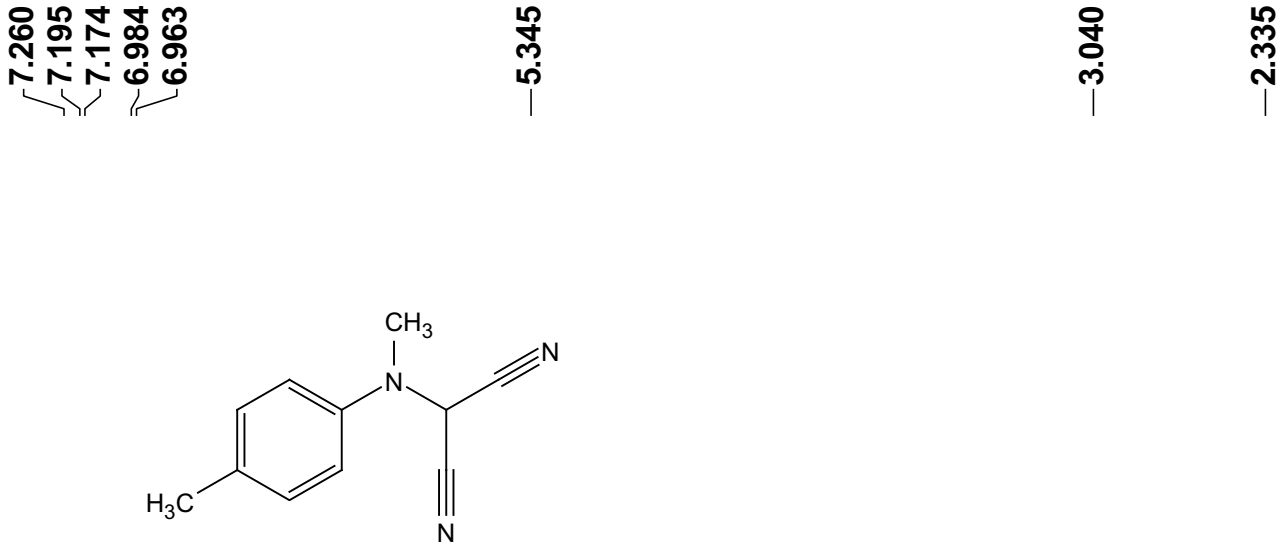

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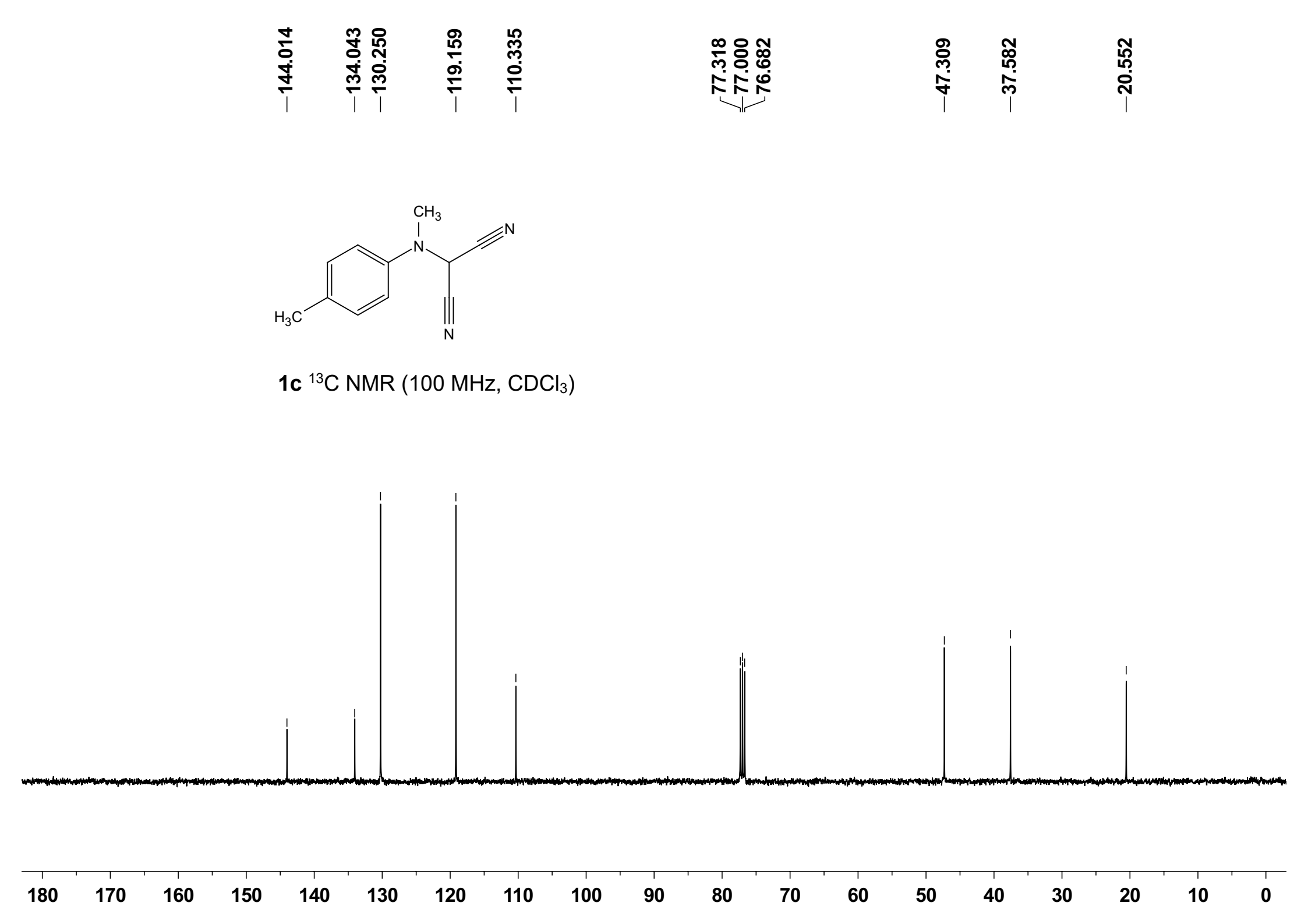

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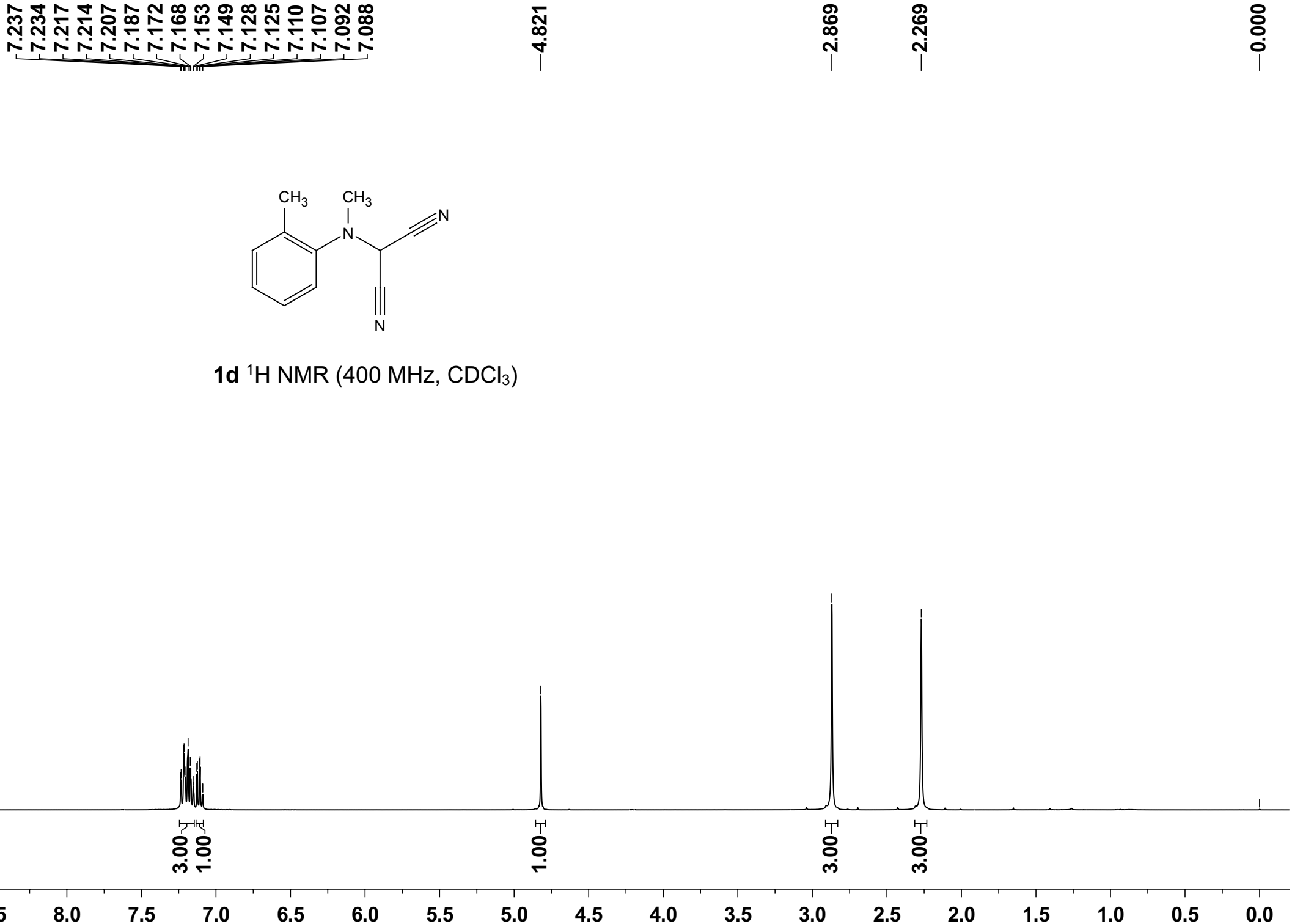

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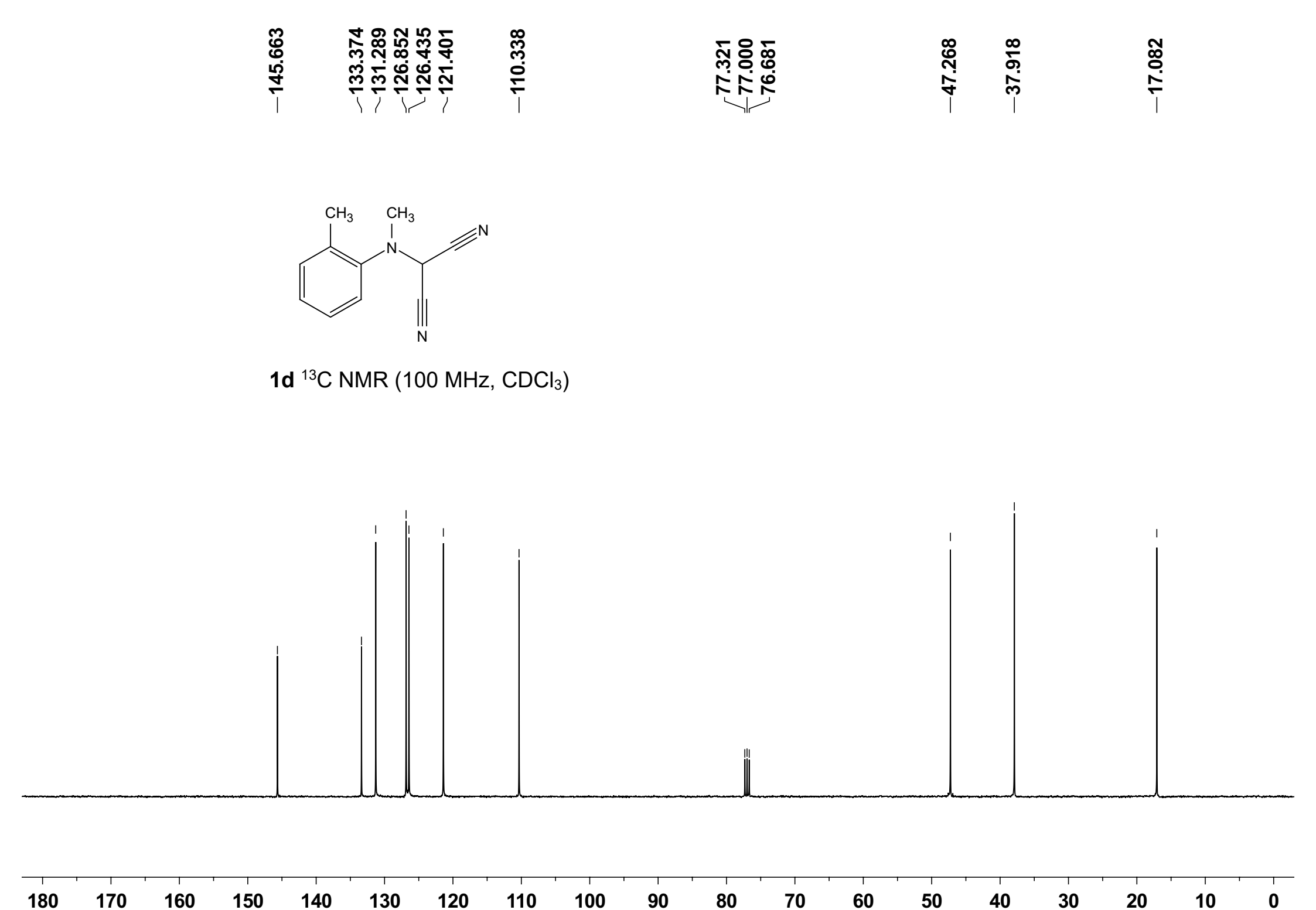
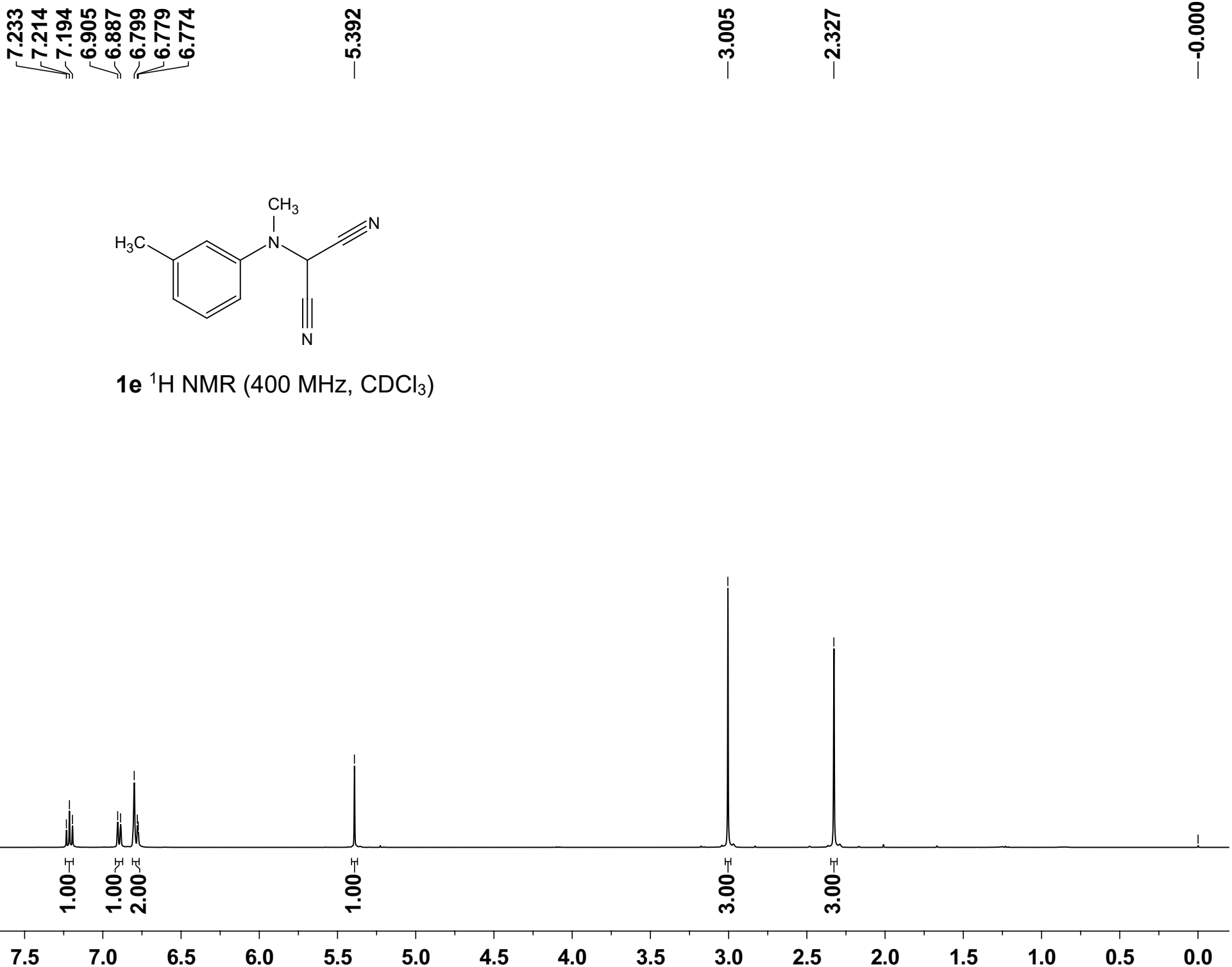


1d ^{13}C NMR (100 MHz, $CDCl_3$)



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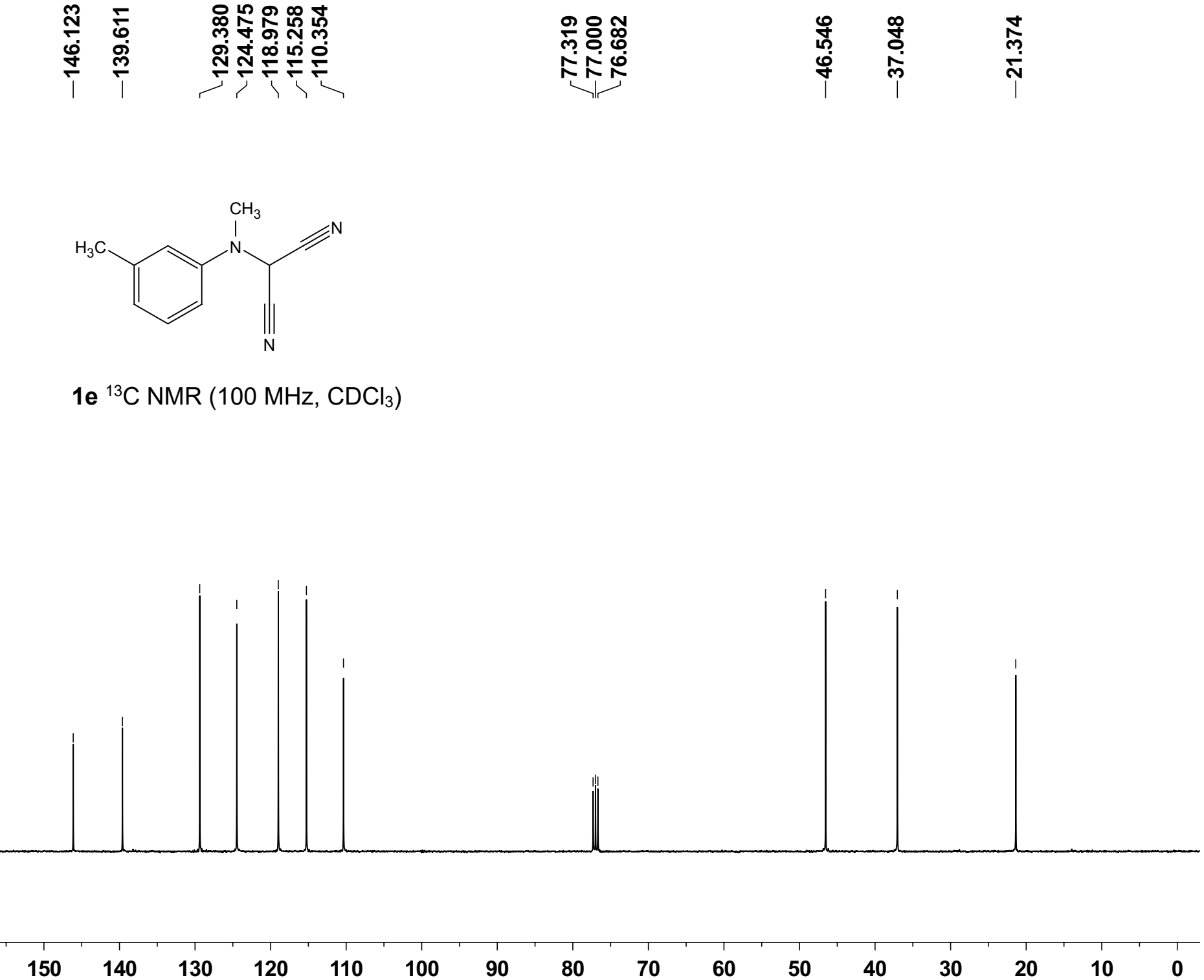

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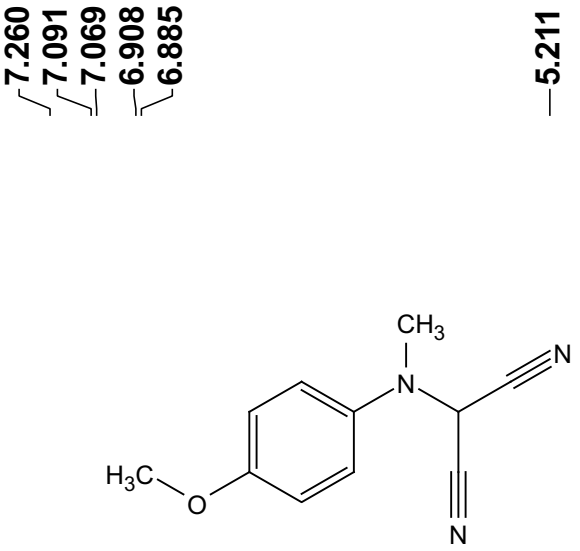

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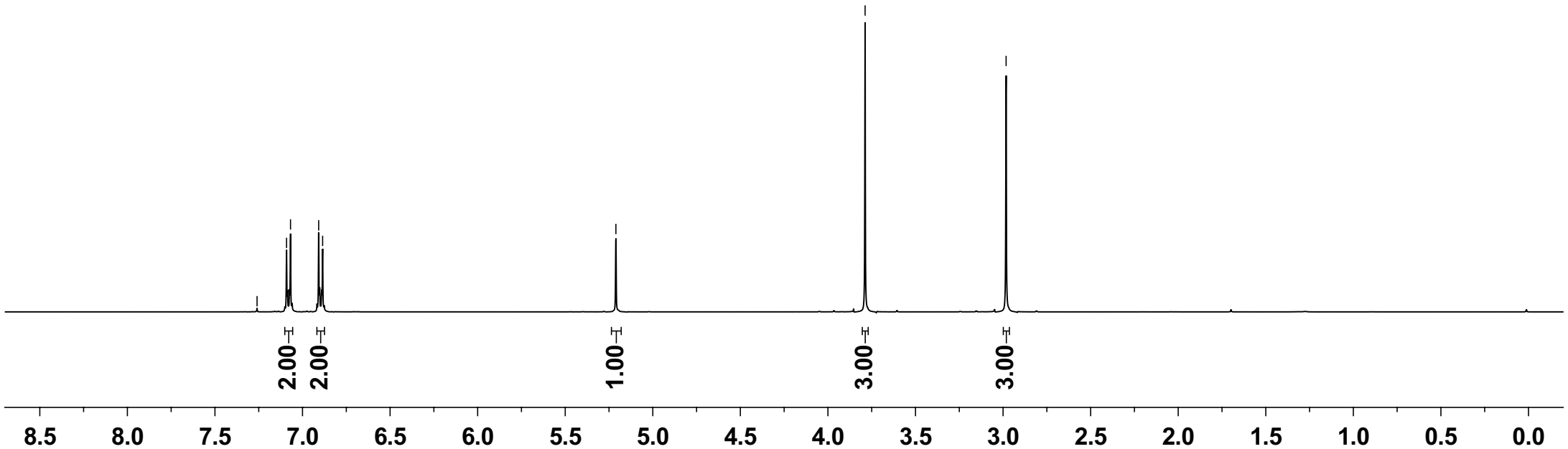

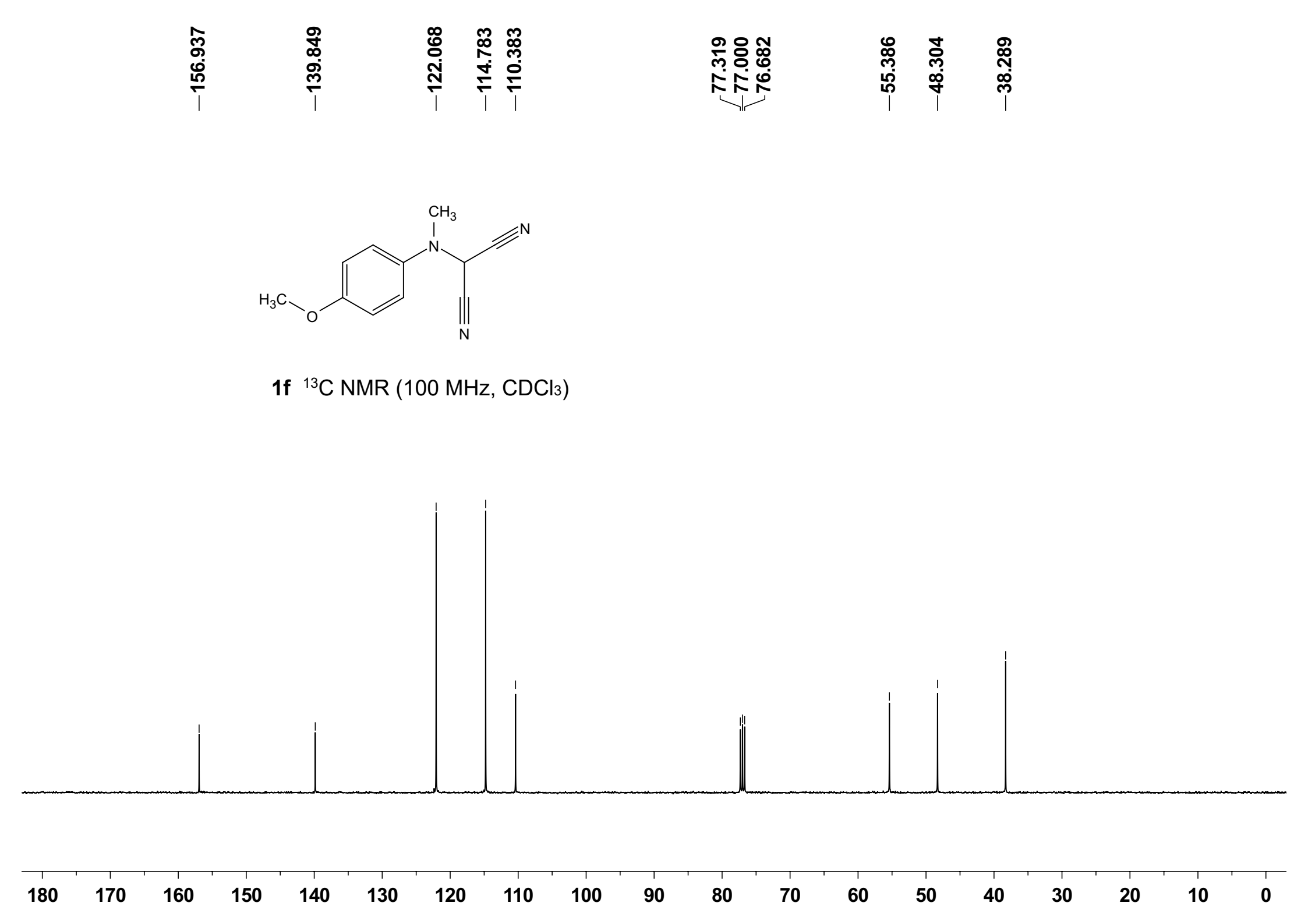

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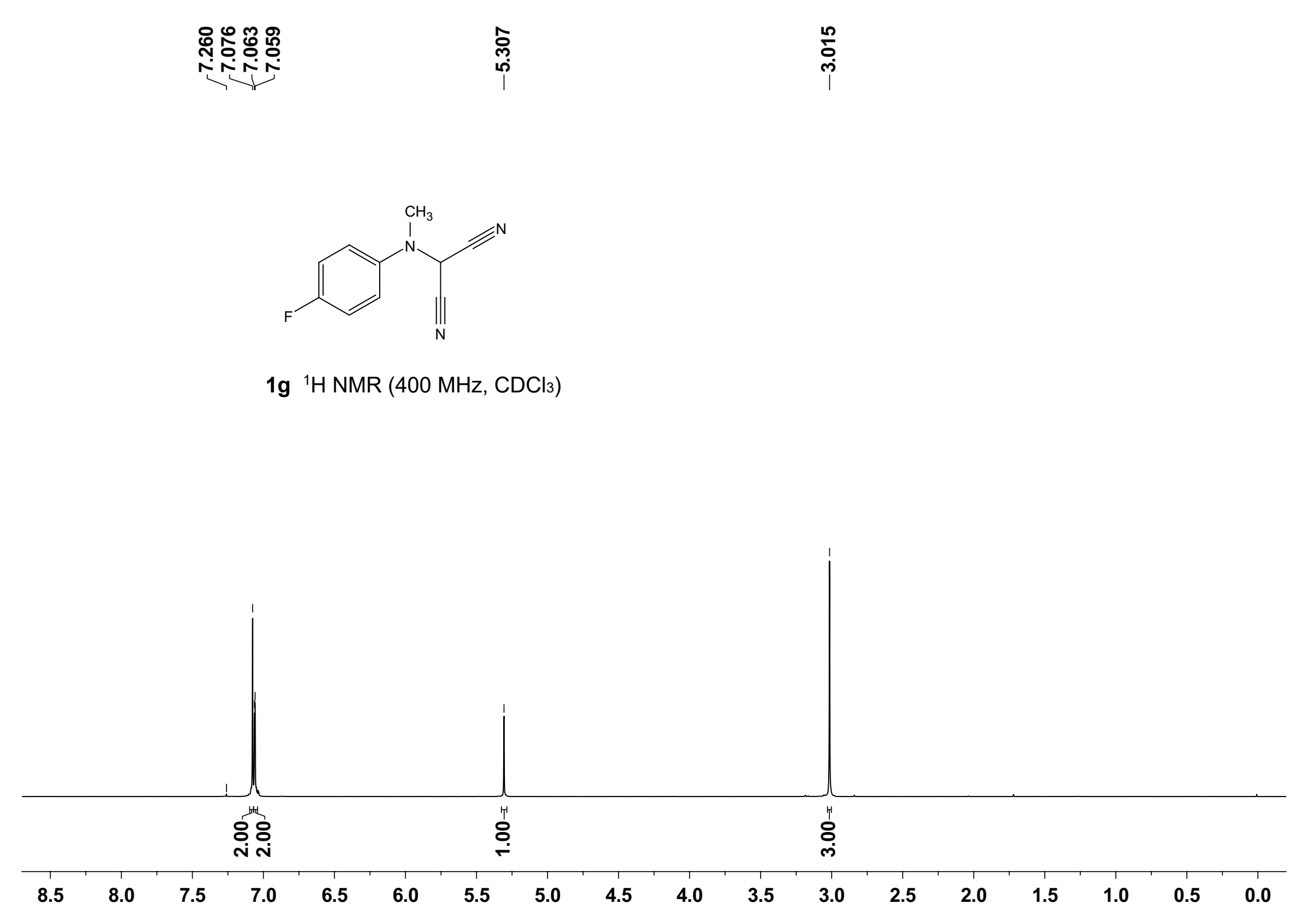

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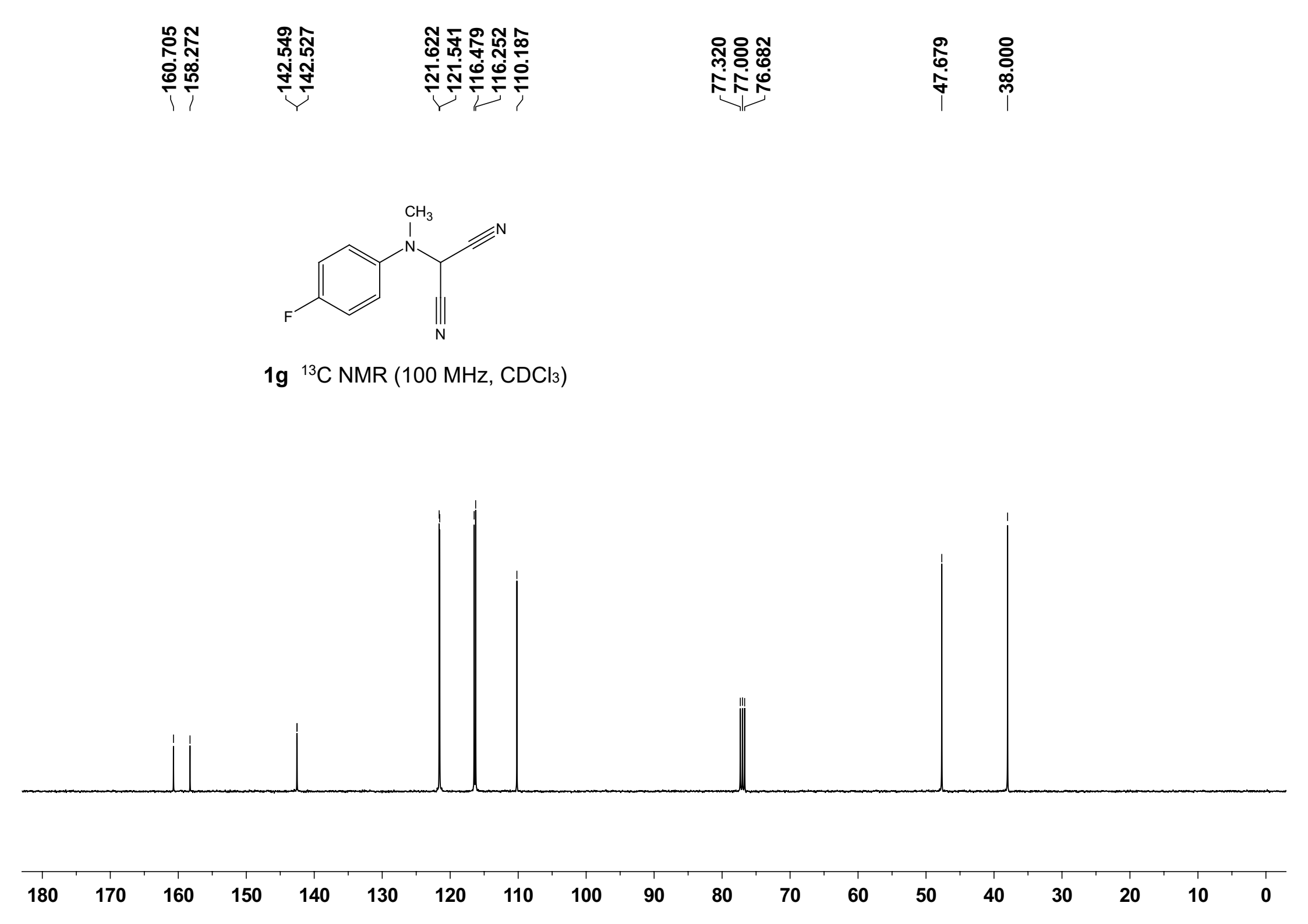
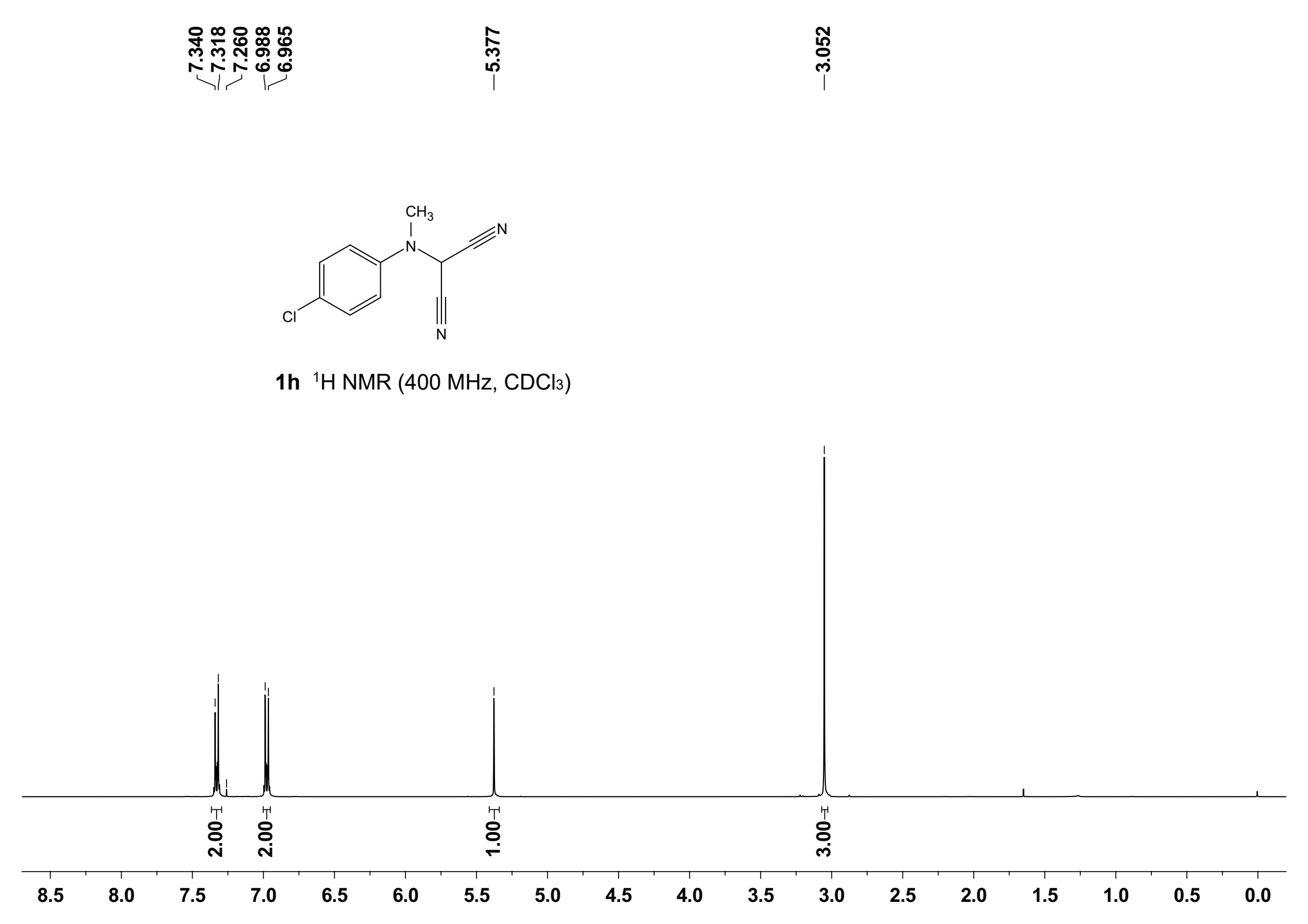
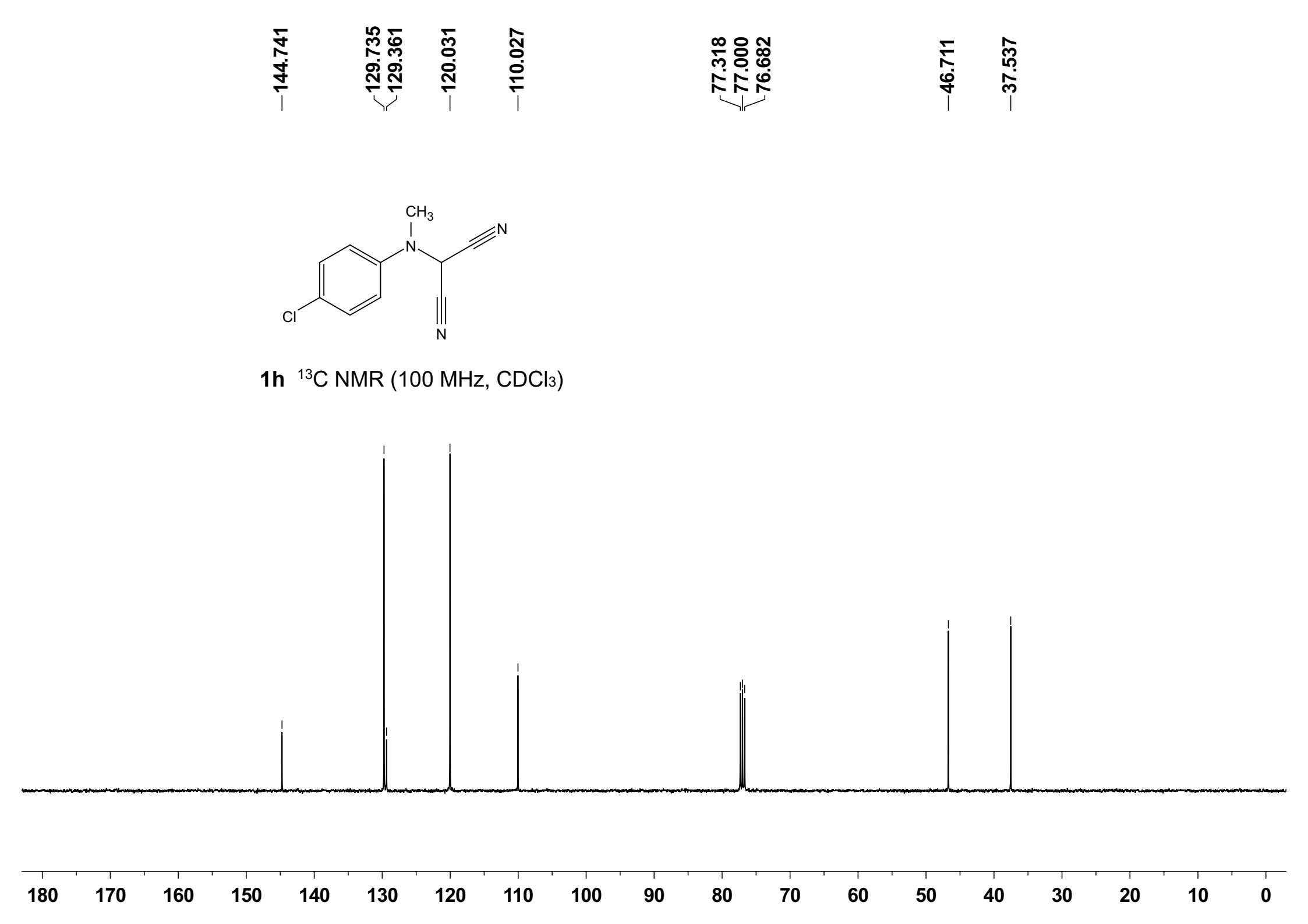


1g ^{13}C NMR (100 MHz, $CDCl_3$)



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



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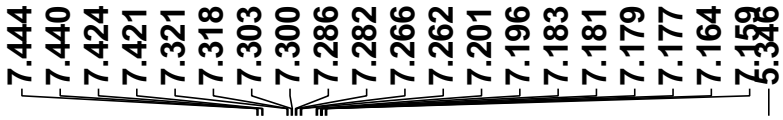
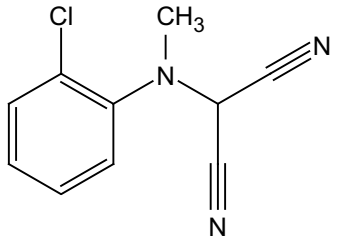
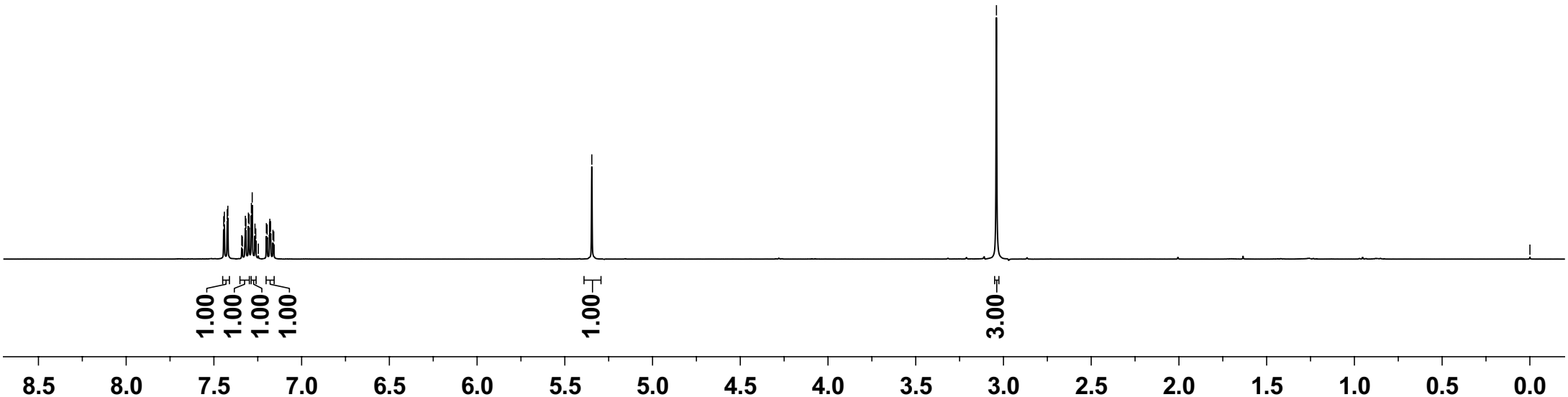
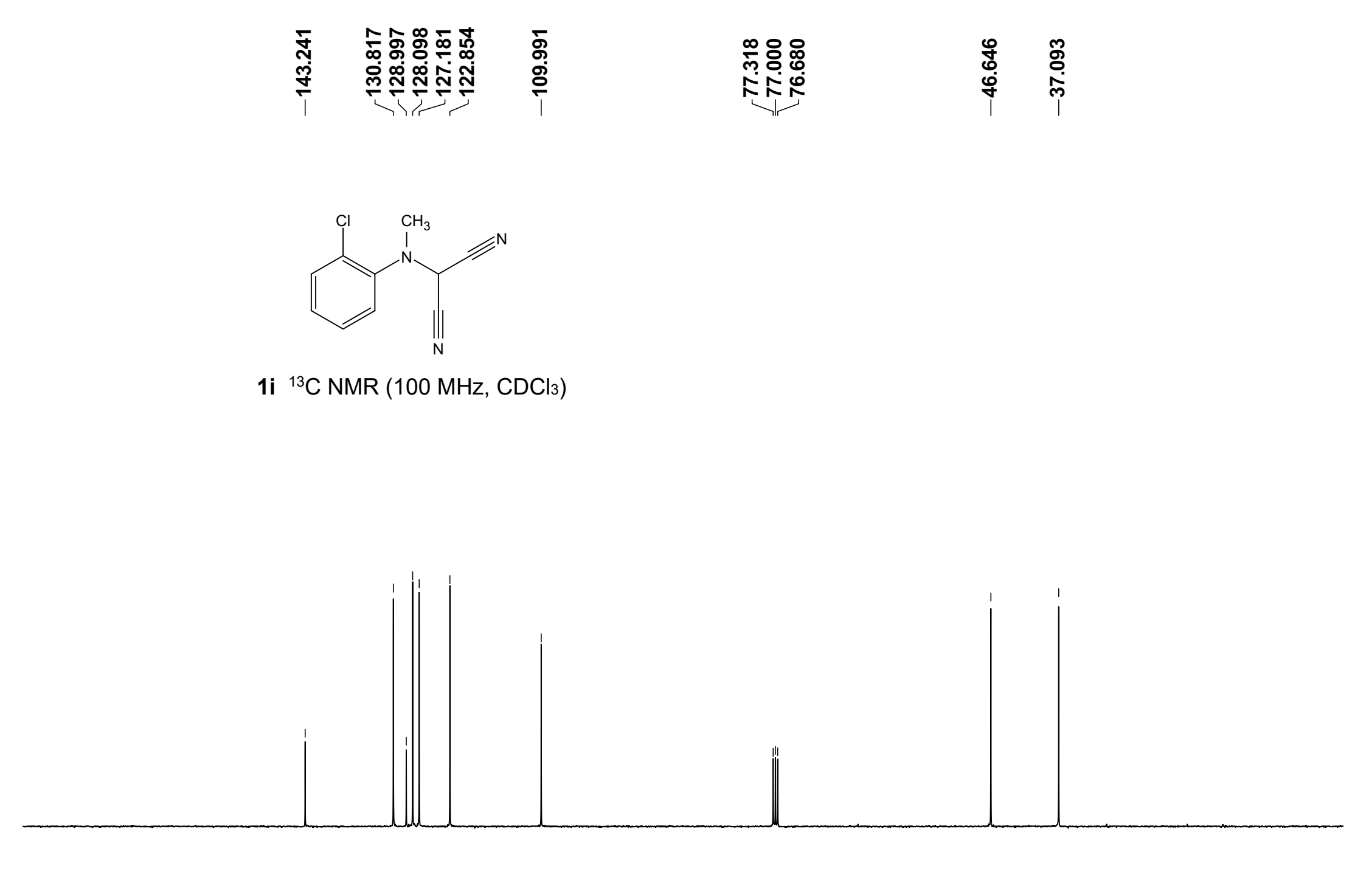


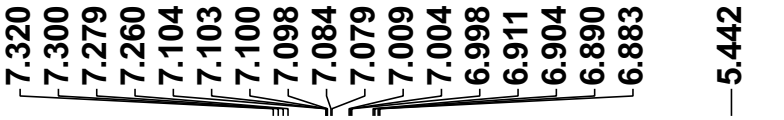


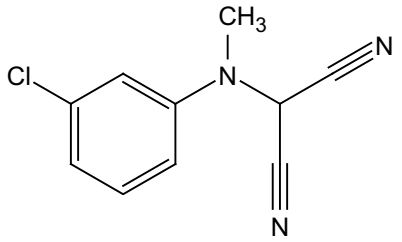
1i ^{1}H NMR (400 MHz, $CDCl_3$)





1i ^{13}C NMR (100 MHz, $CDCl_3$)





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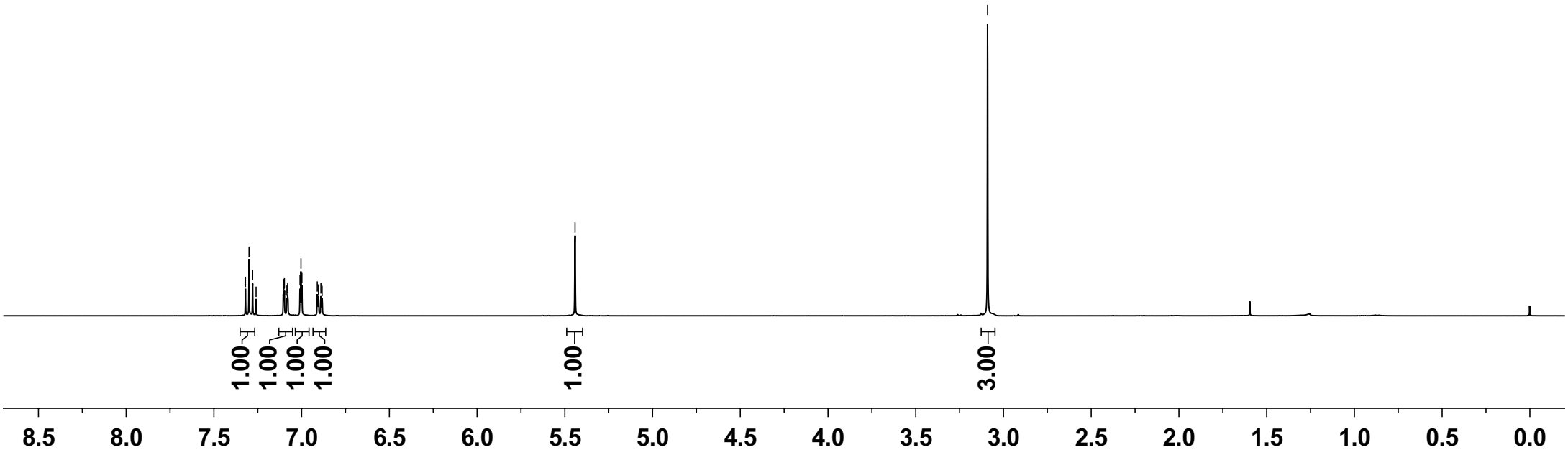

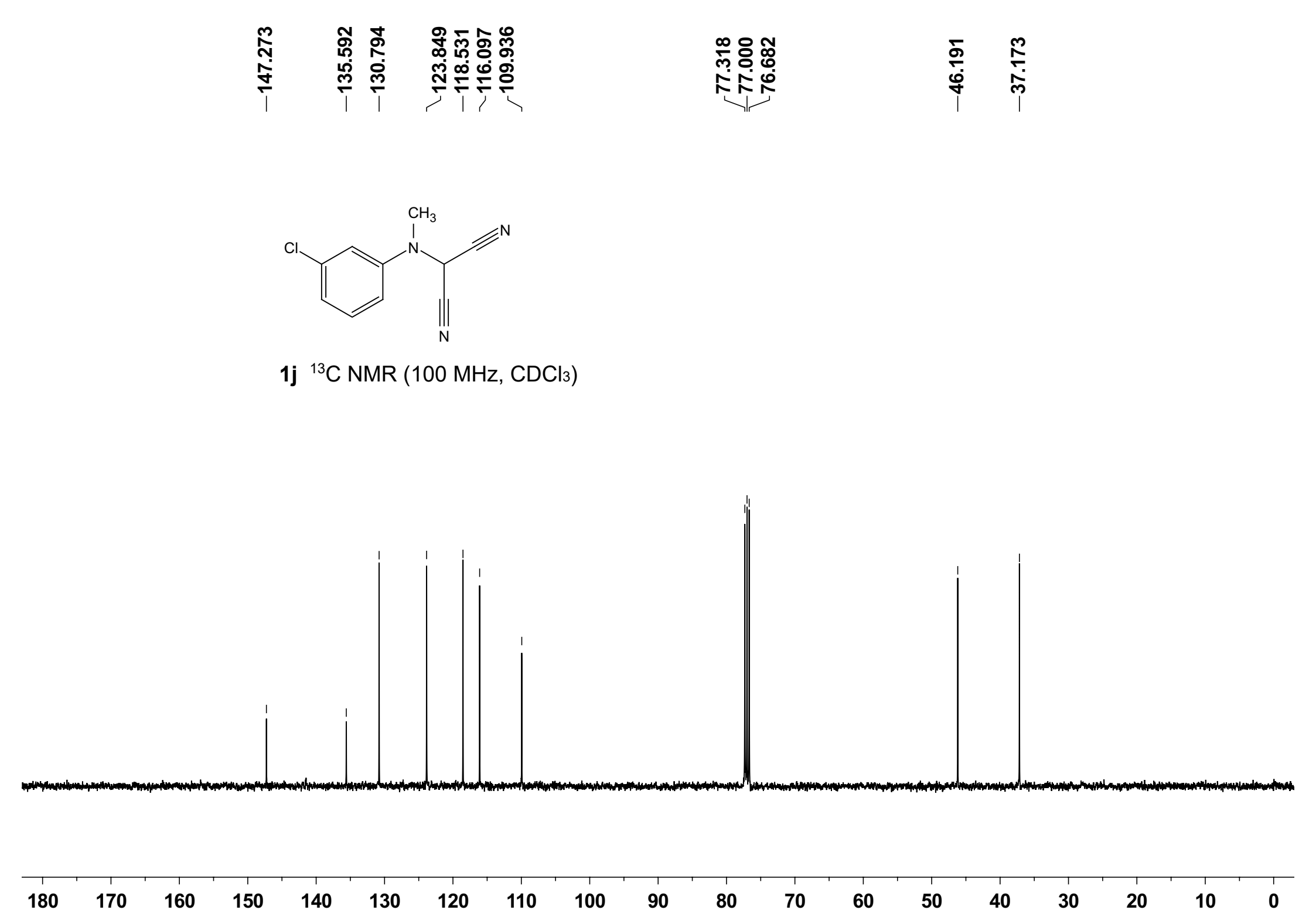

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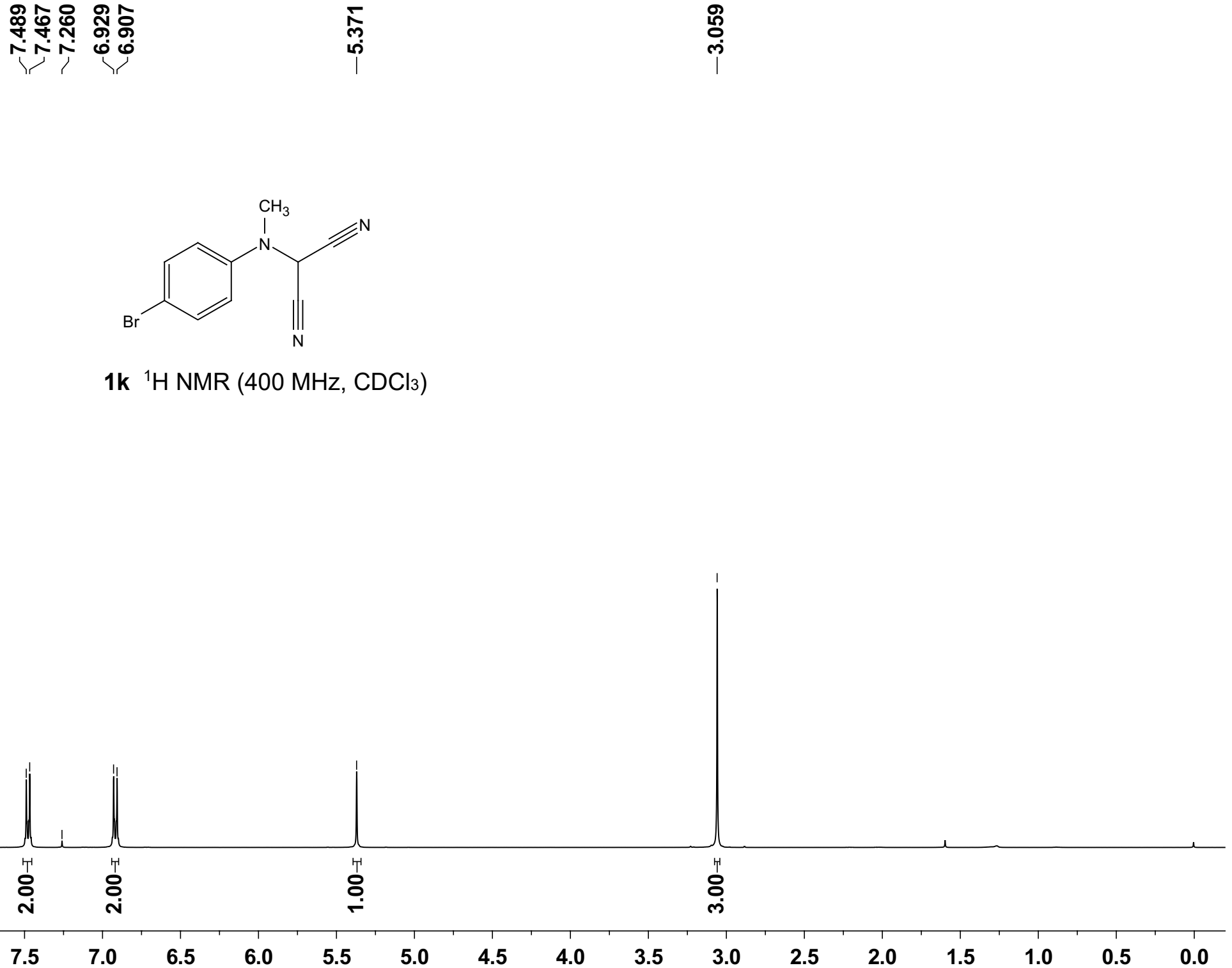

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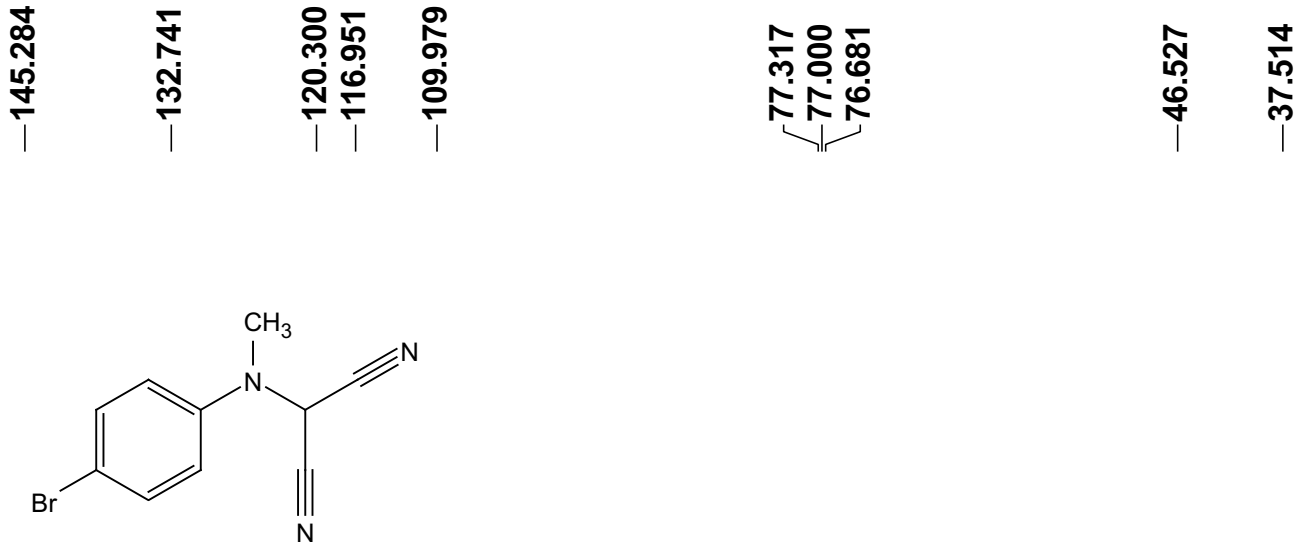
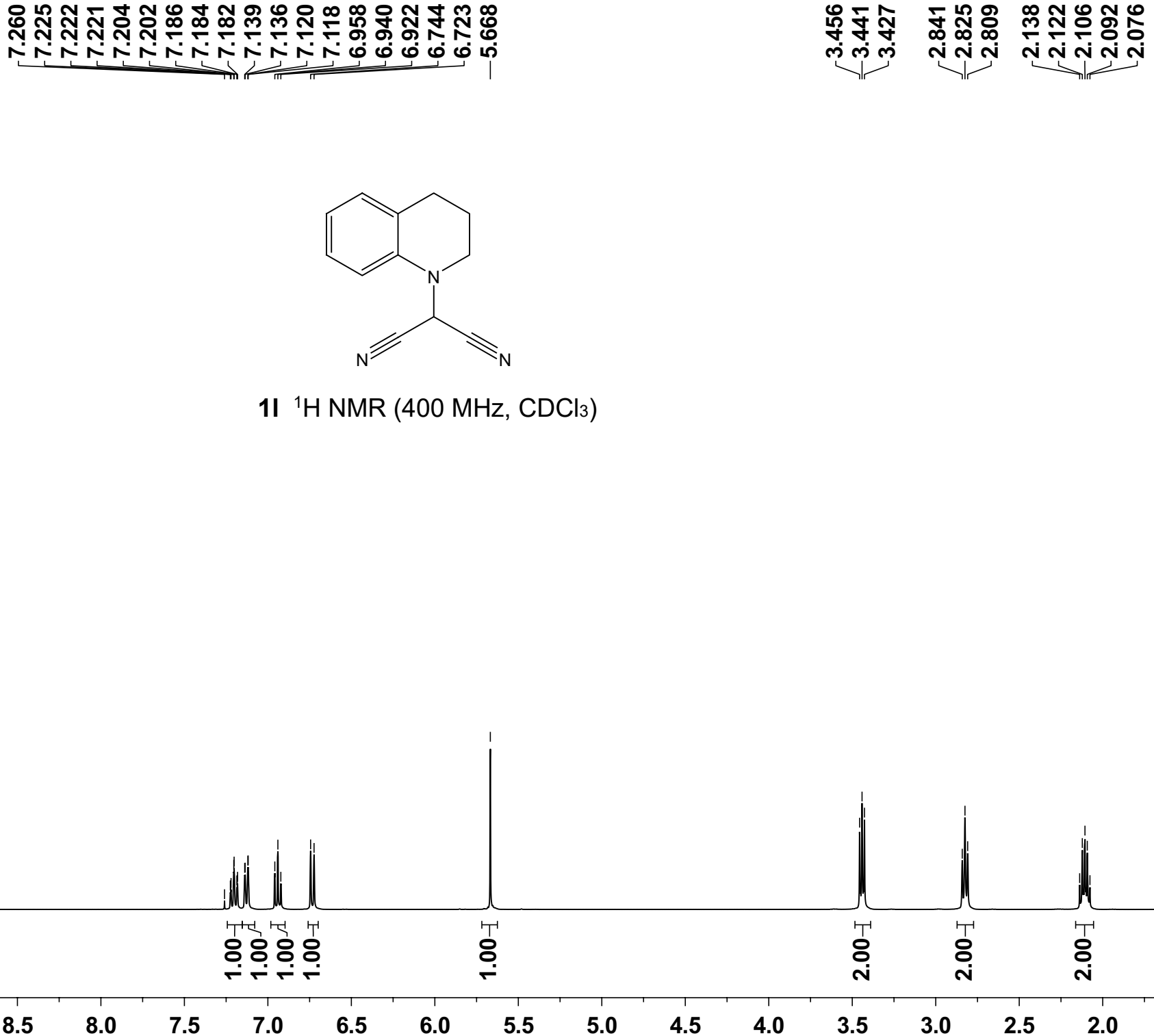
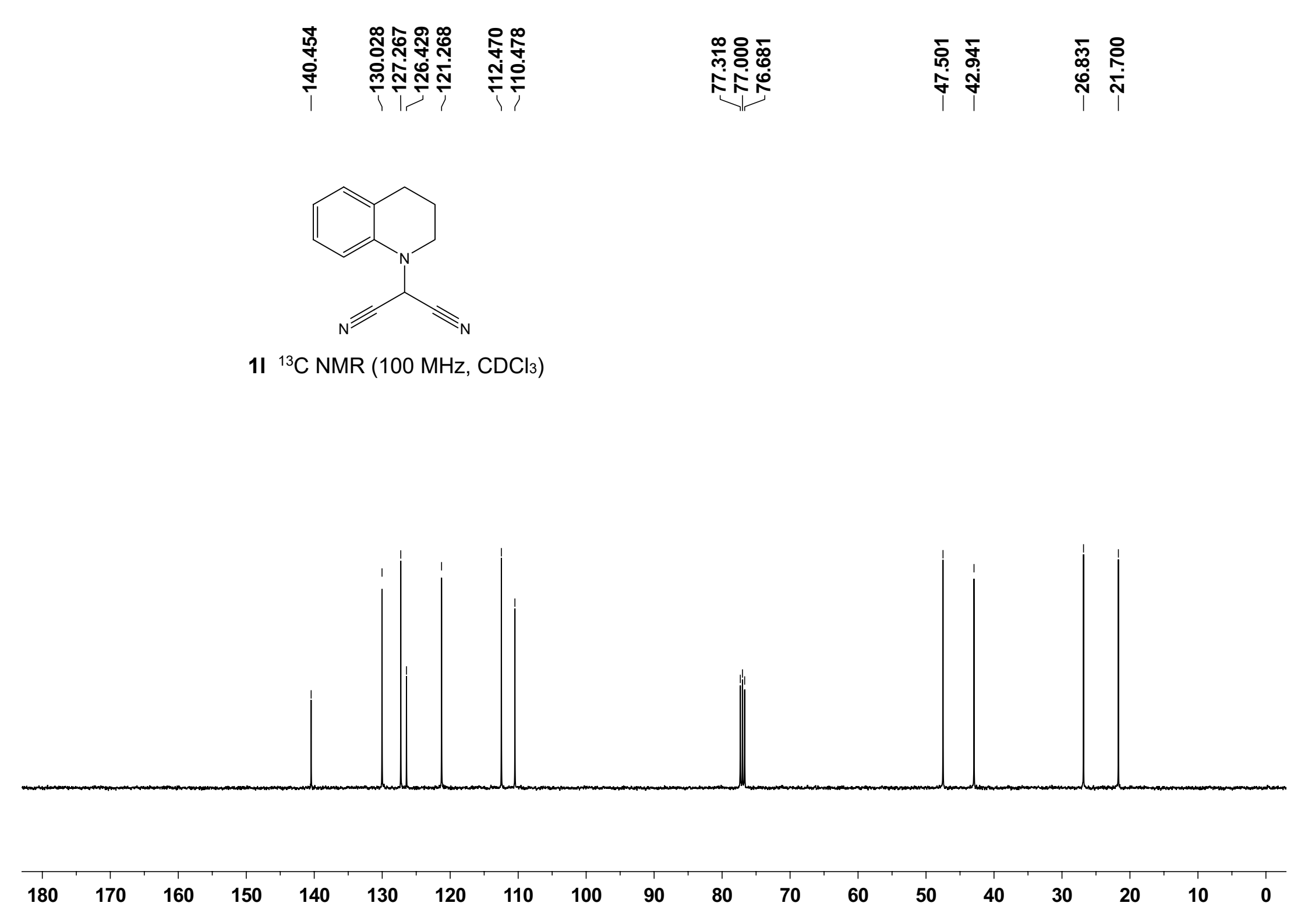


1k ^{13}C NMR (100 MHz, $CDCl_3$)



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



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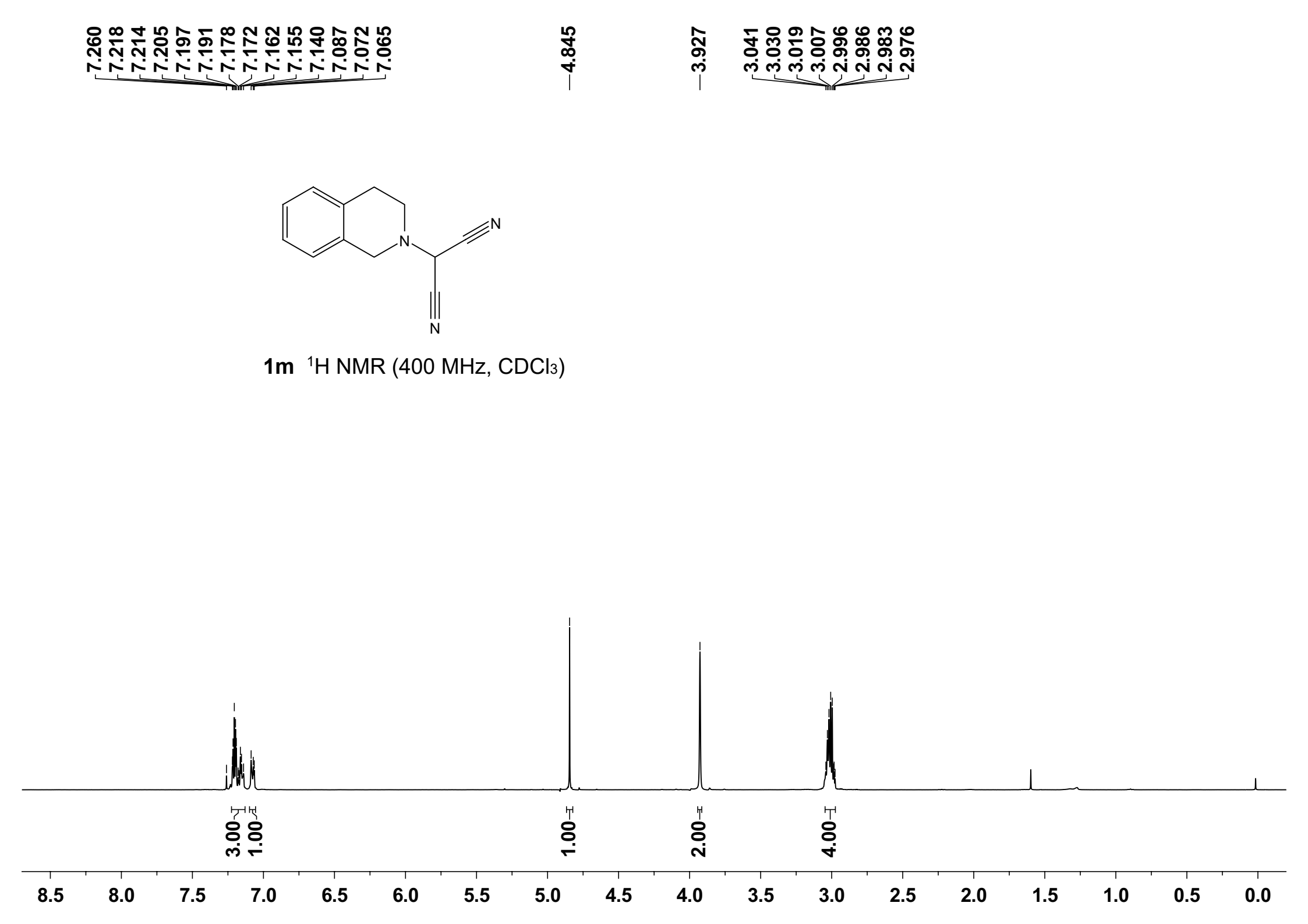

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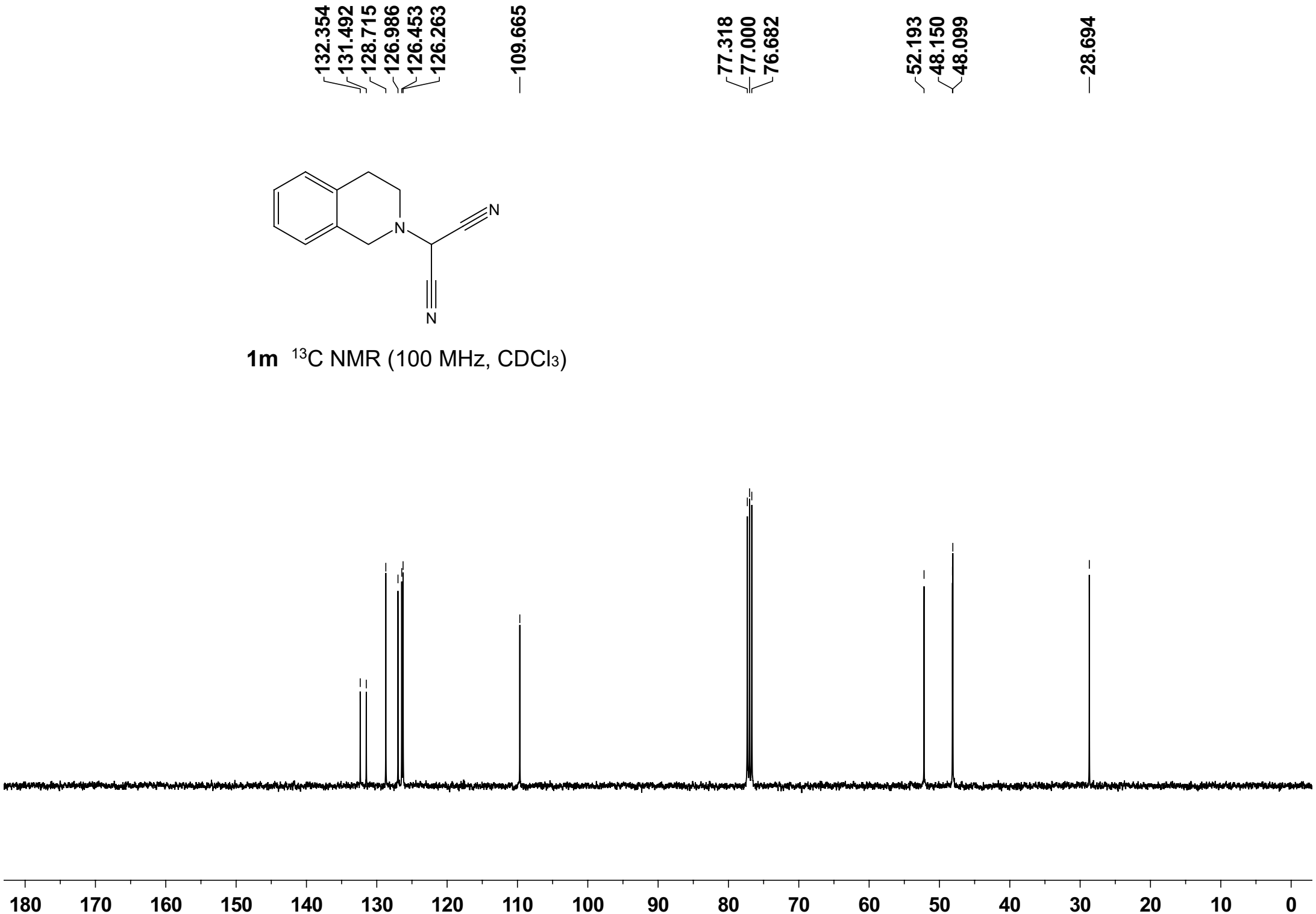

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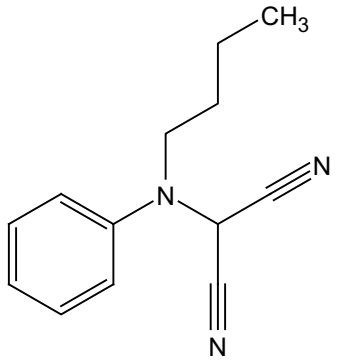

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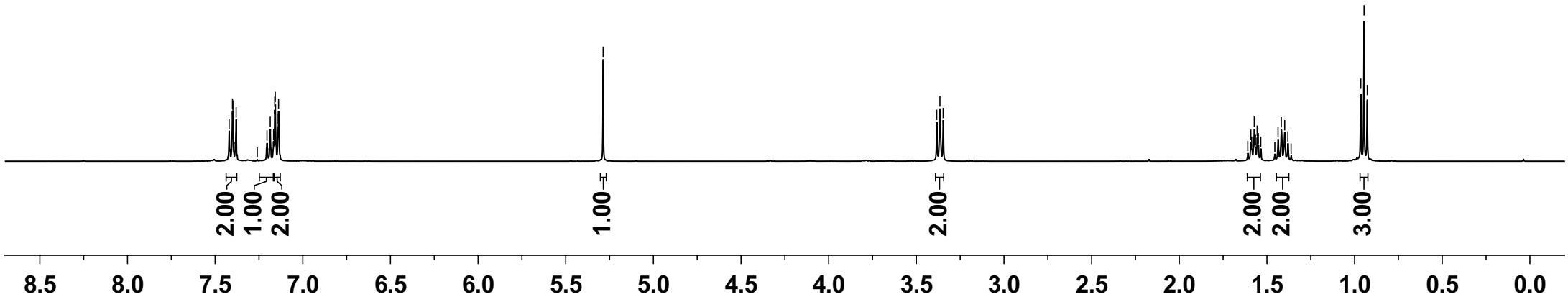

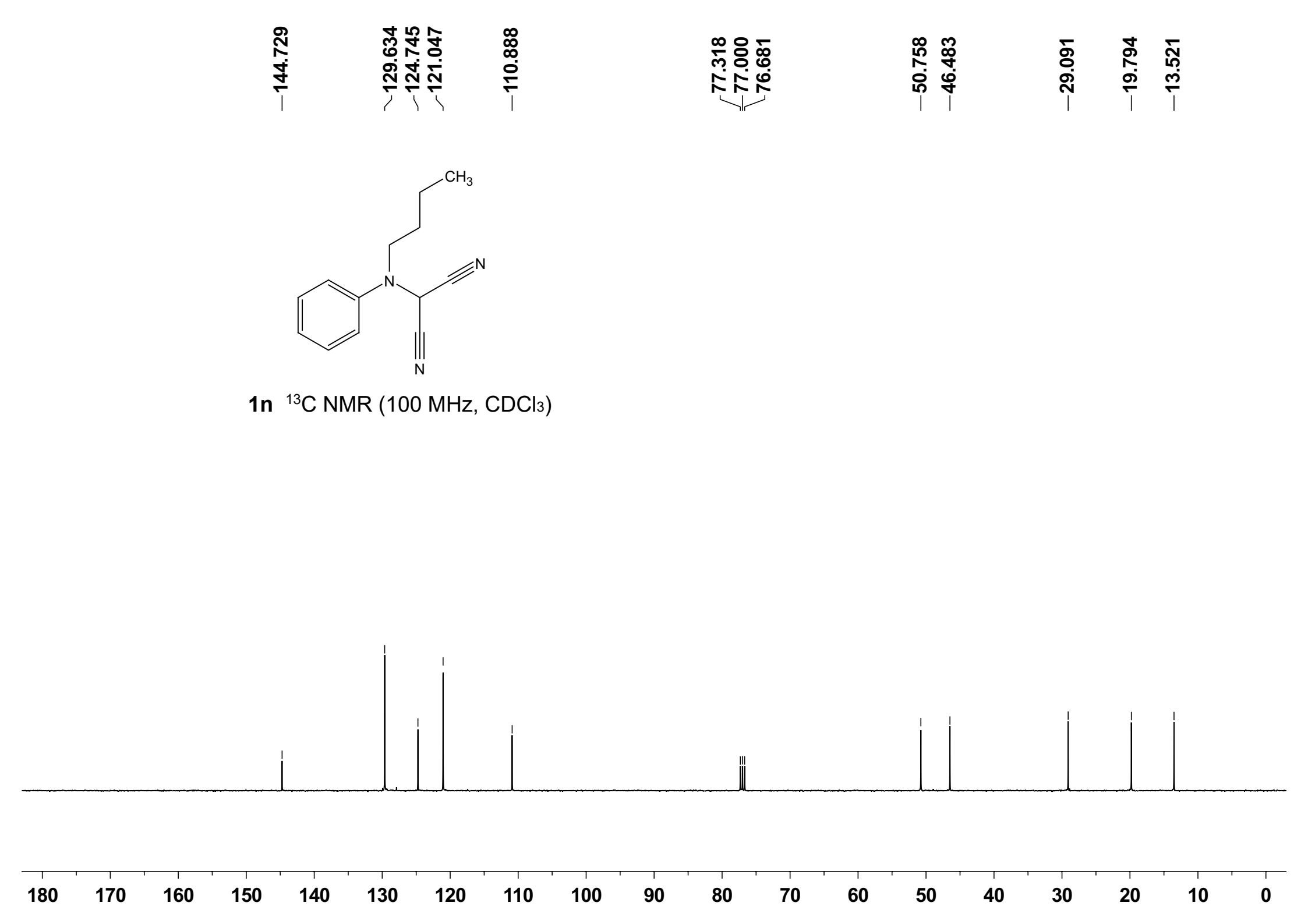

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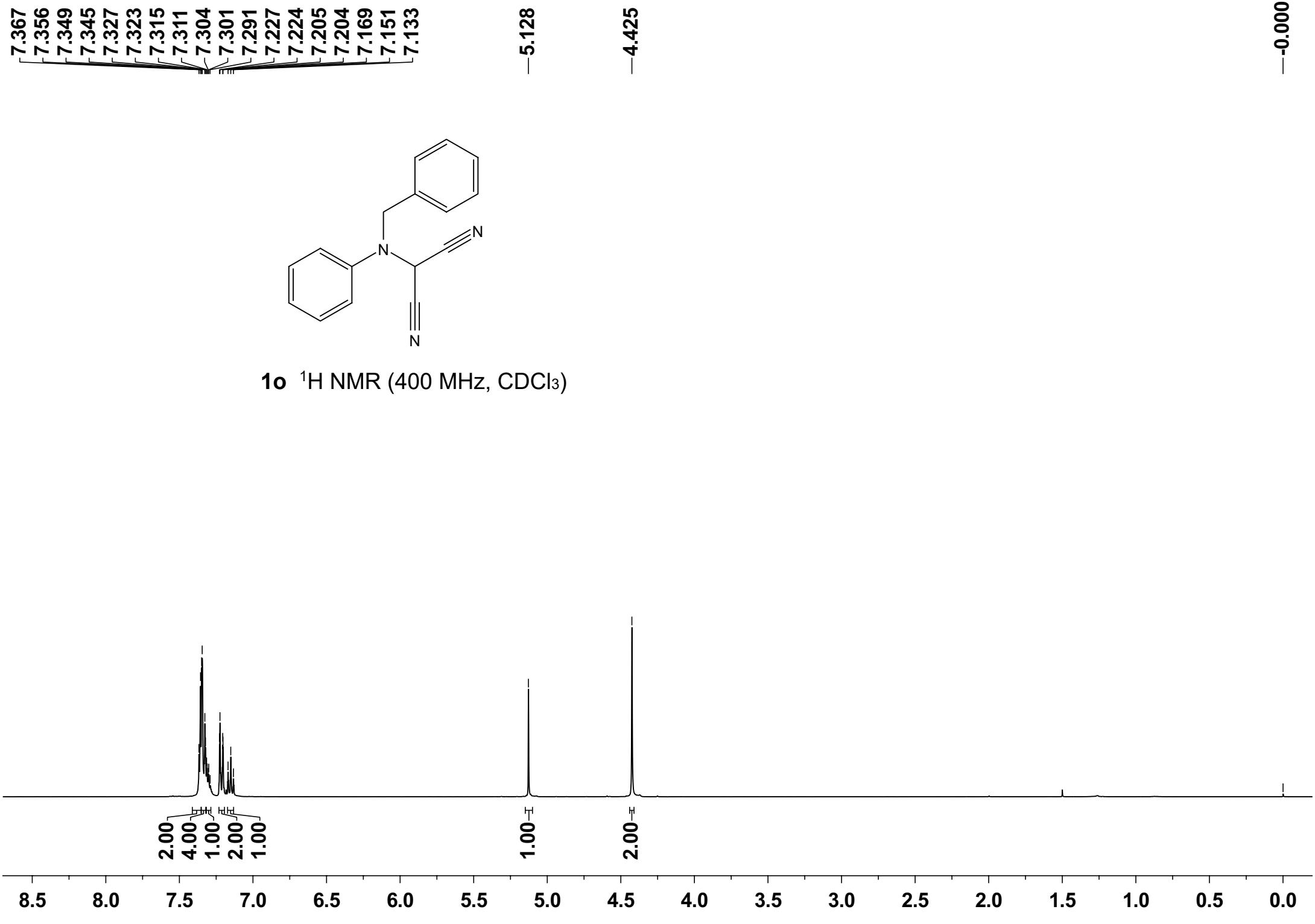
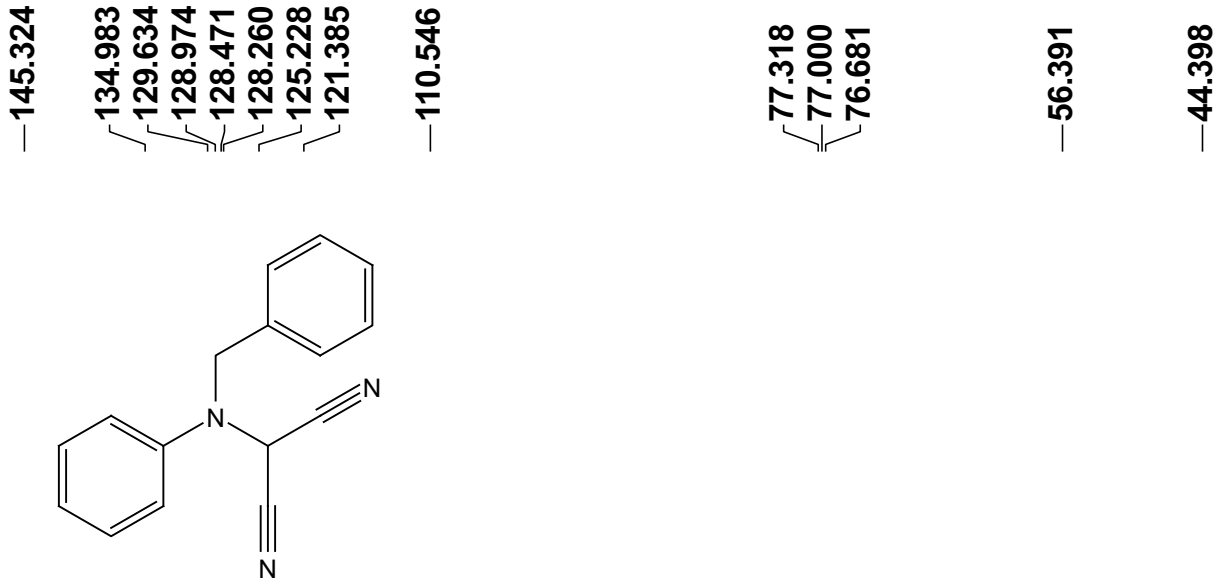
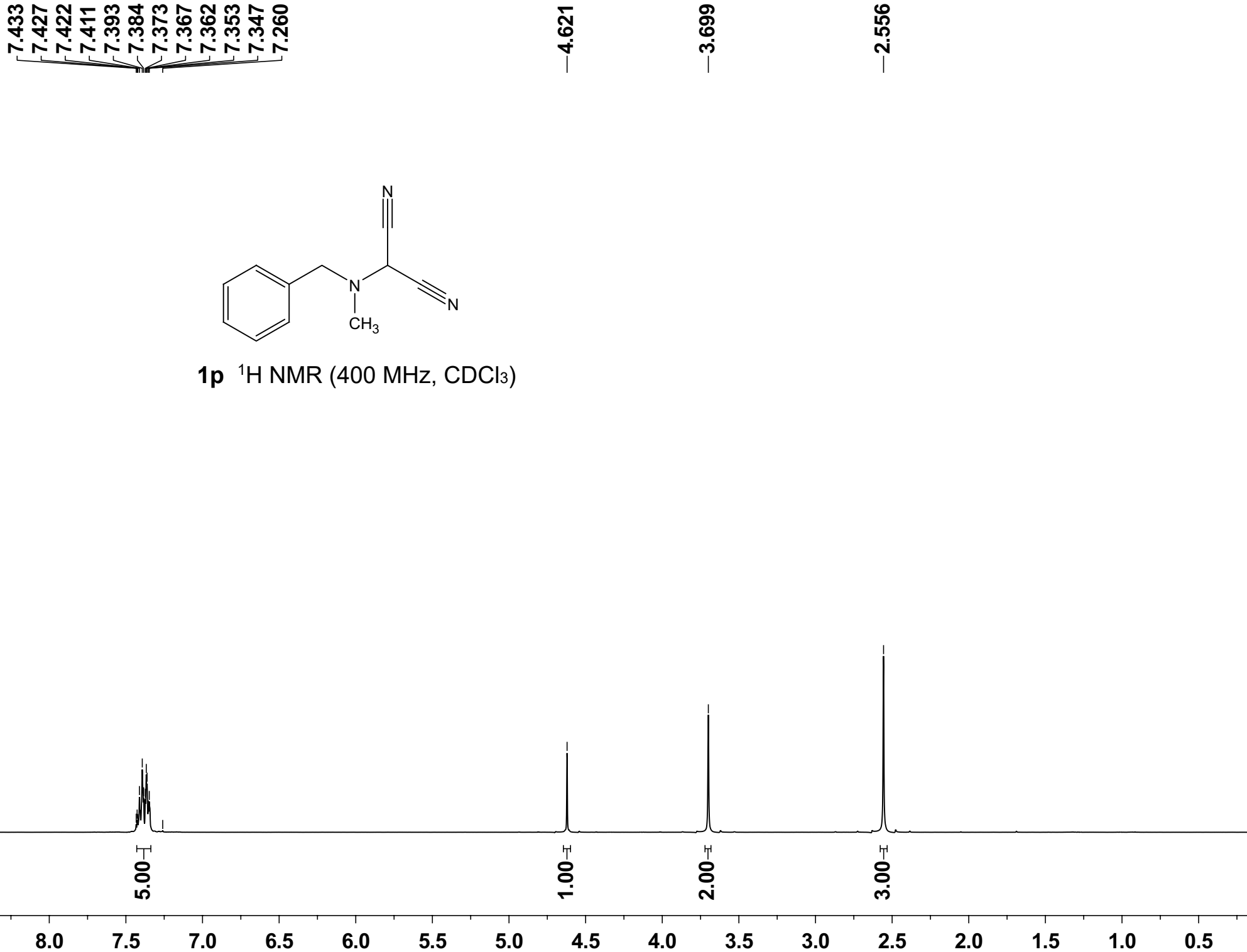


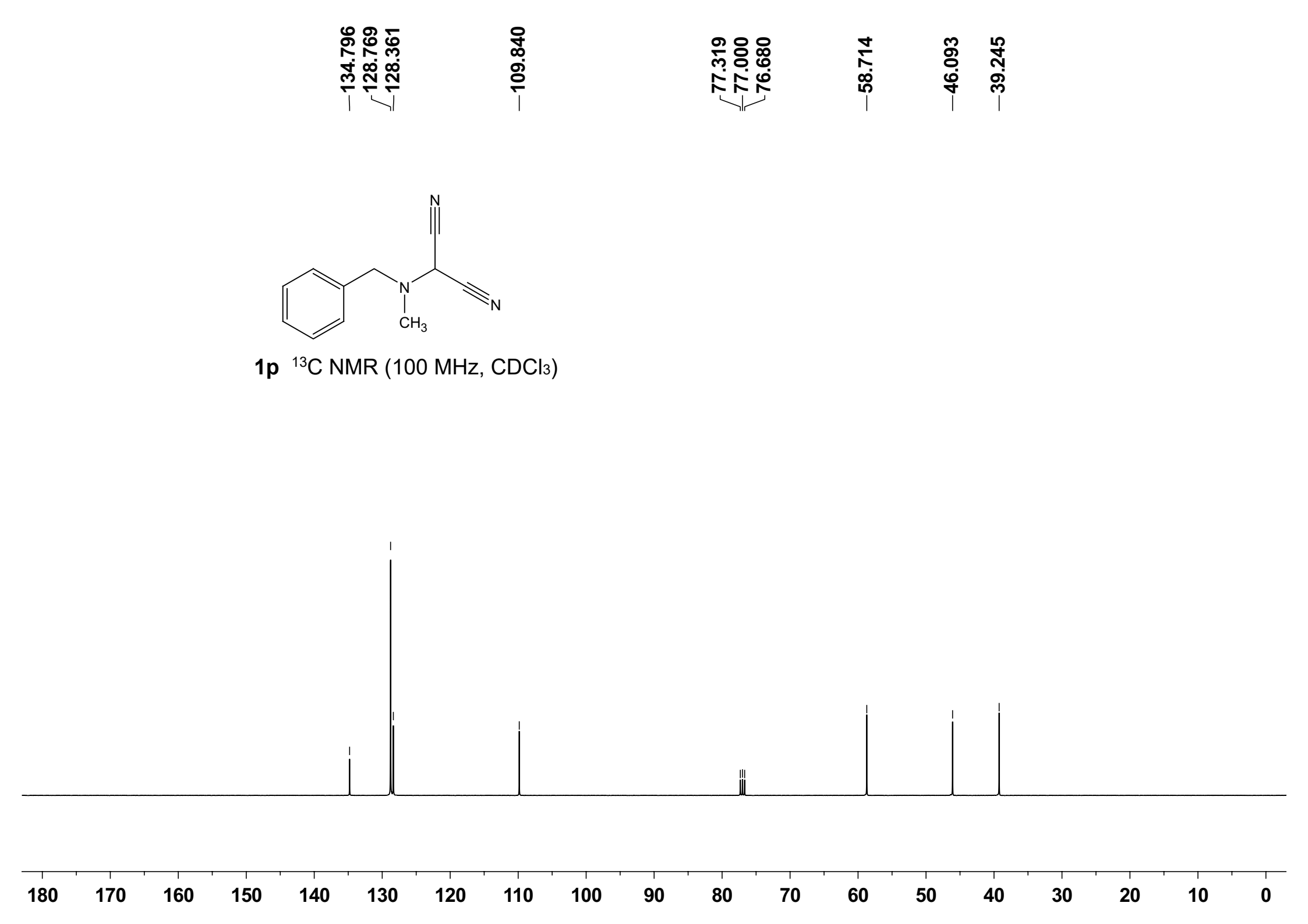
1o ^{1}H NMR (400 MHz, $CDCl_3$)



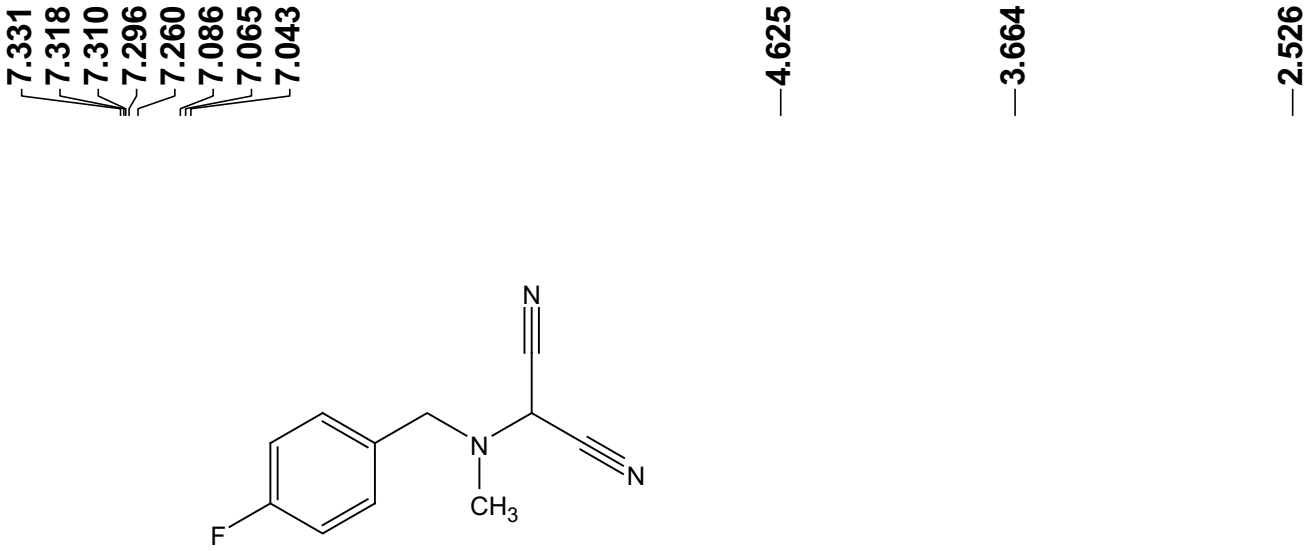
1o ^{13}C NMR (100 MHz, $CDCl_3$)



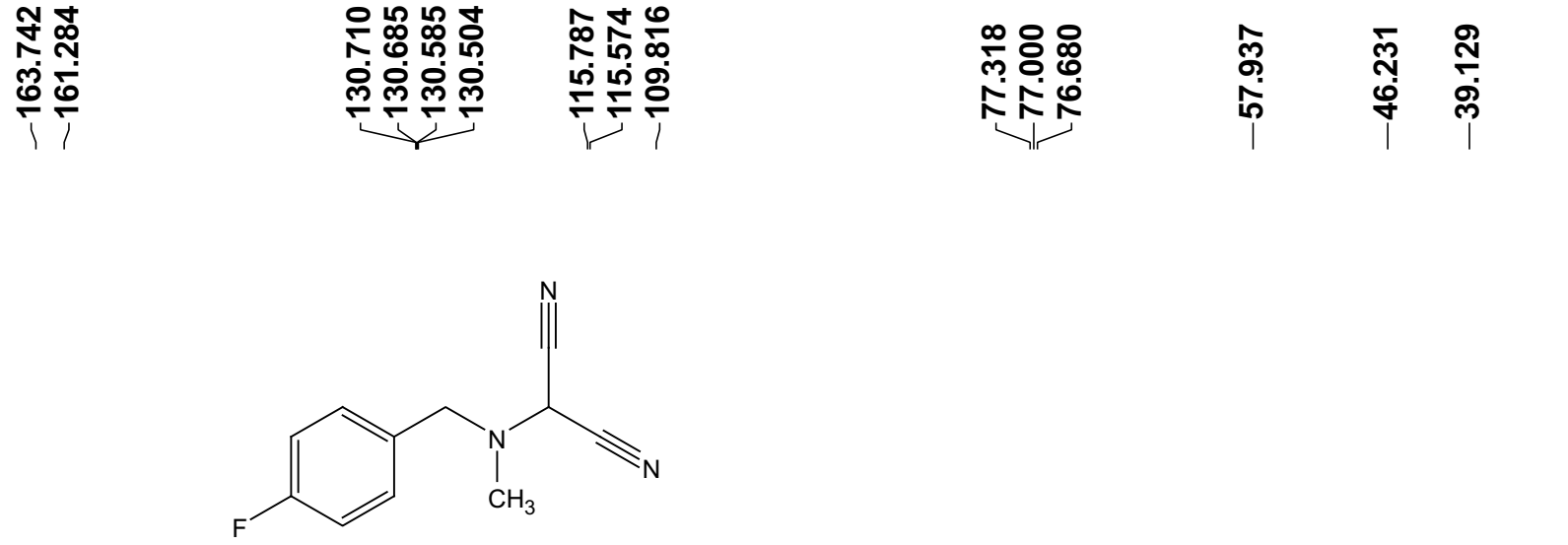
1p ^{1}H NMR (400 MHz, $CDCl_3$)



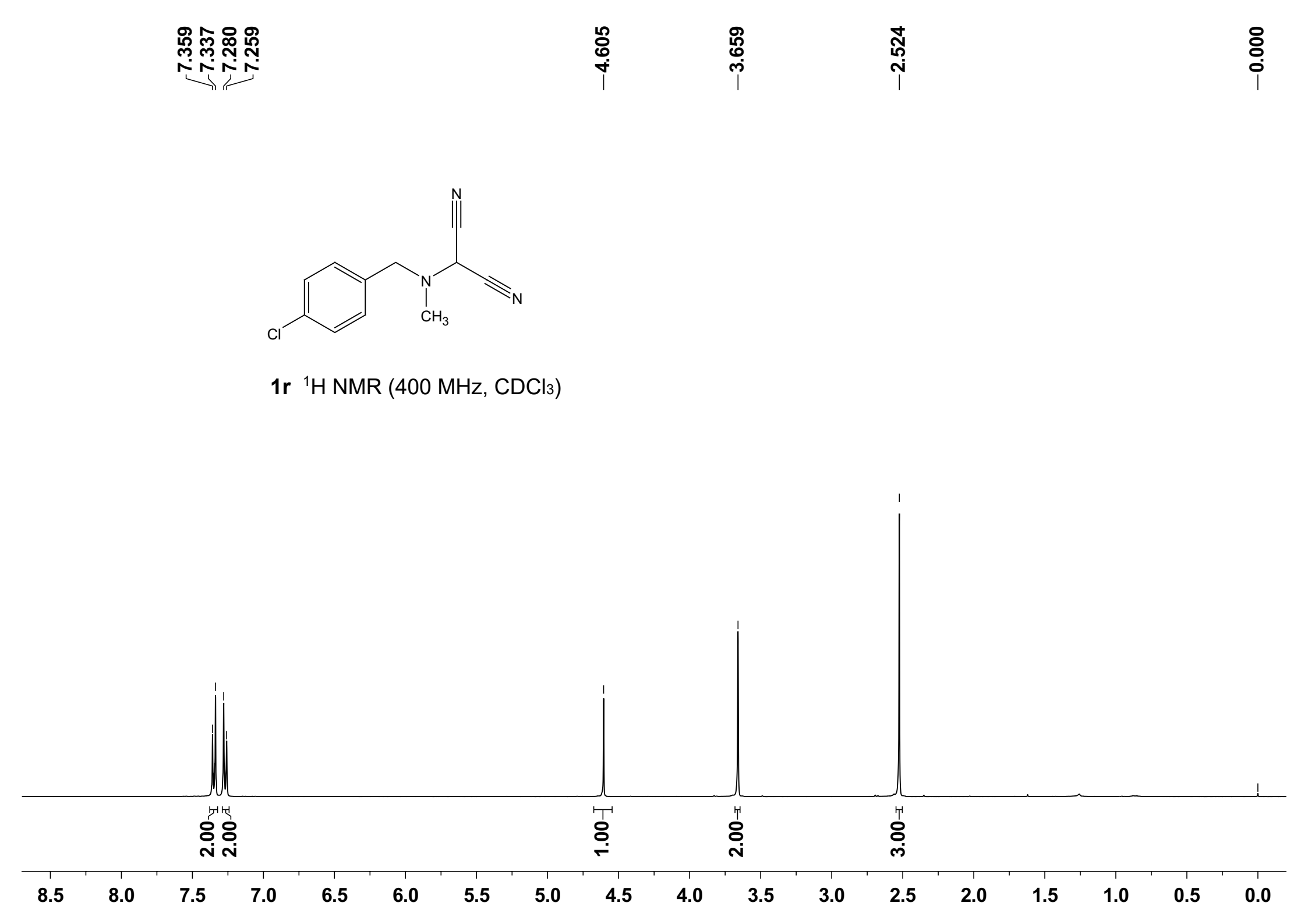
1p ^{13}C NMR (100 MHz, $CDCl_3$)



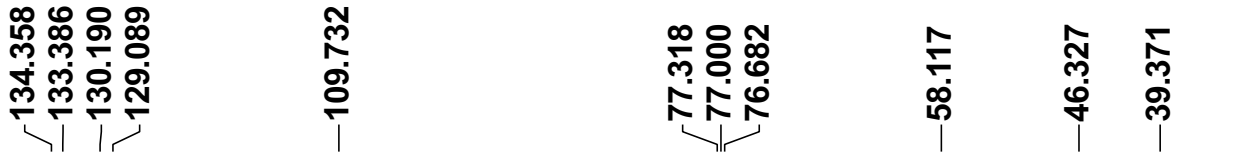
1q ^{1}H NMR (400 MHz, $CDCl_3$)

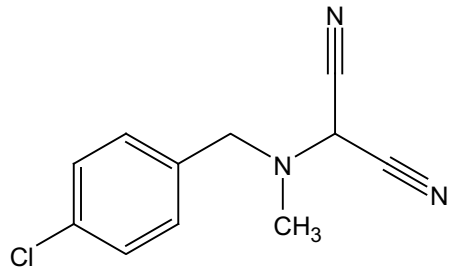


1q ^{13}C NMR (100 MHz, $CDCl_3$)



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





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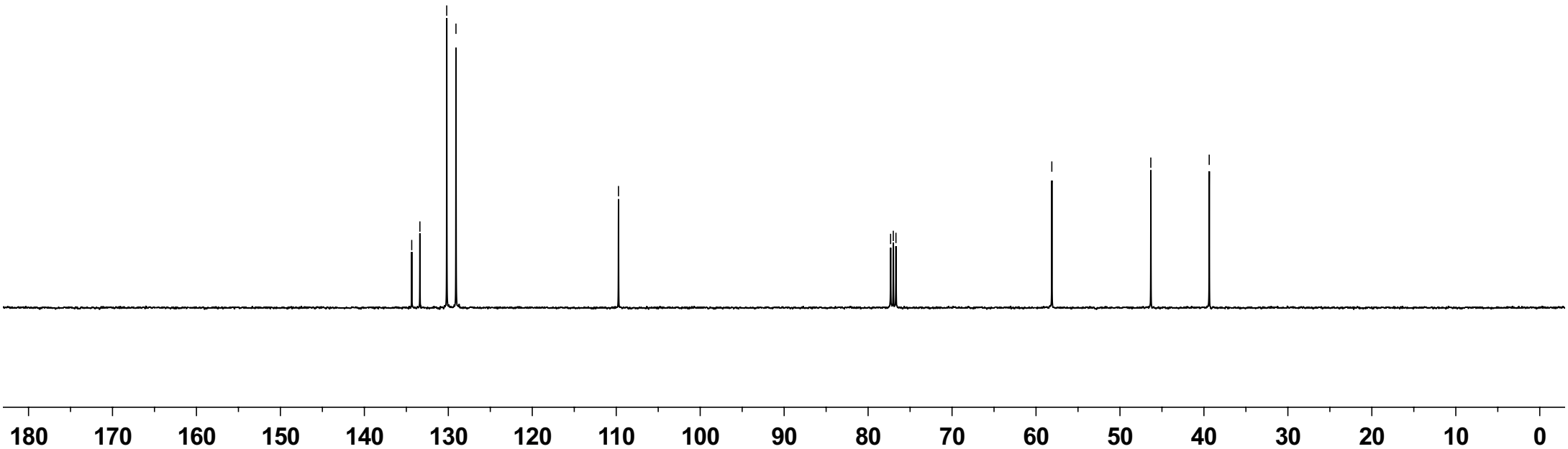
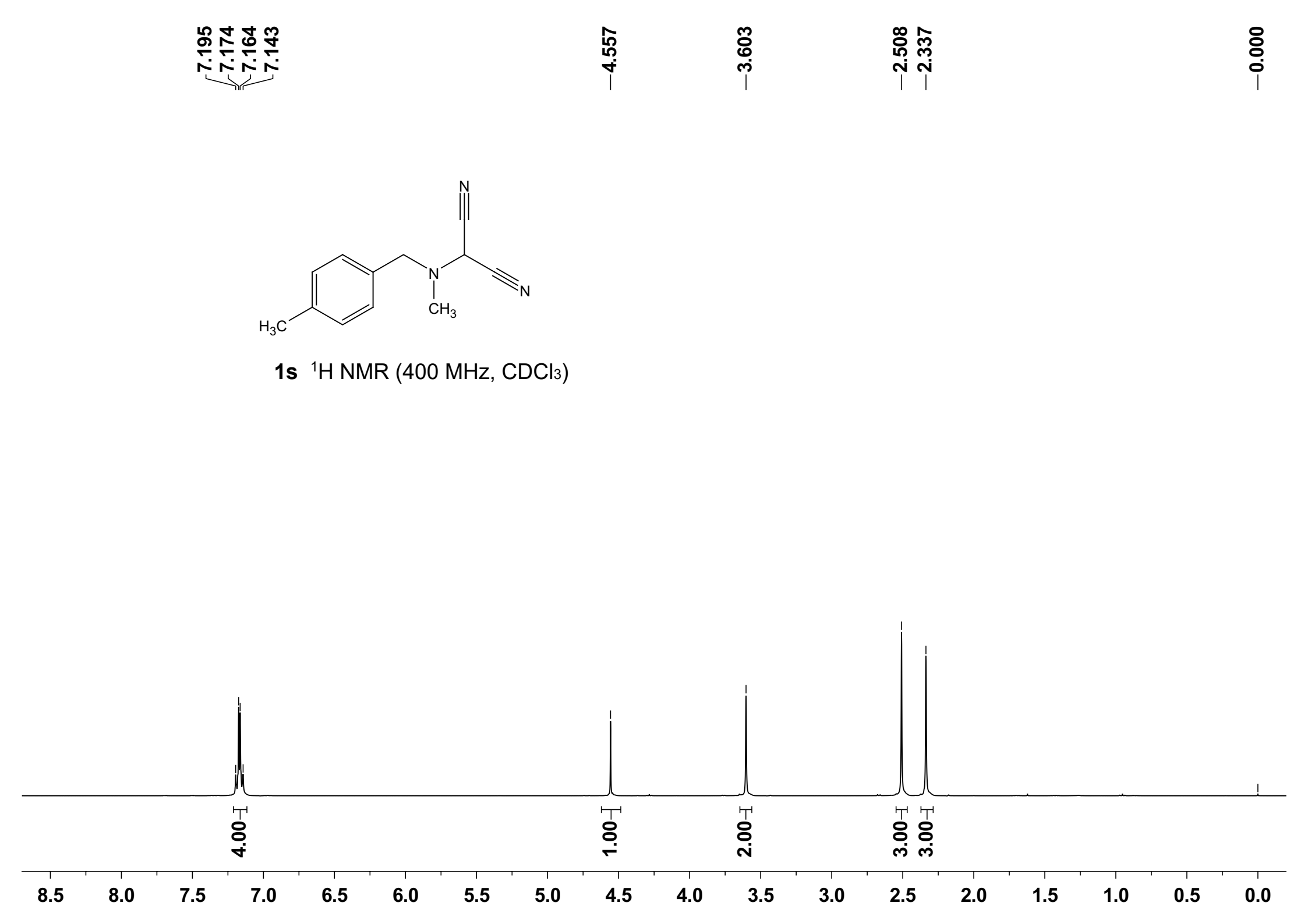
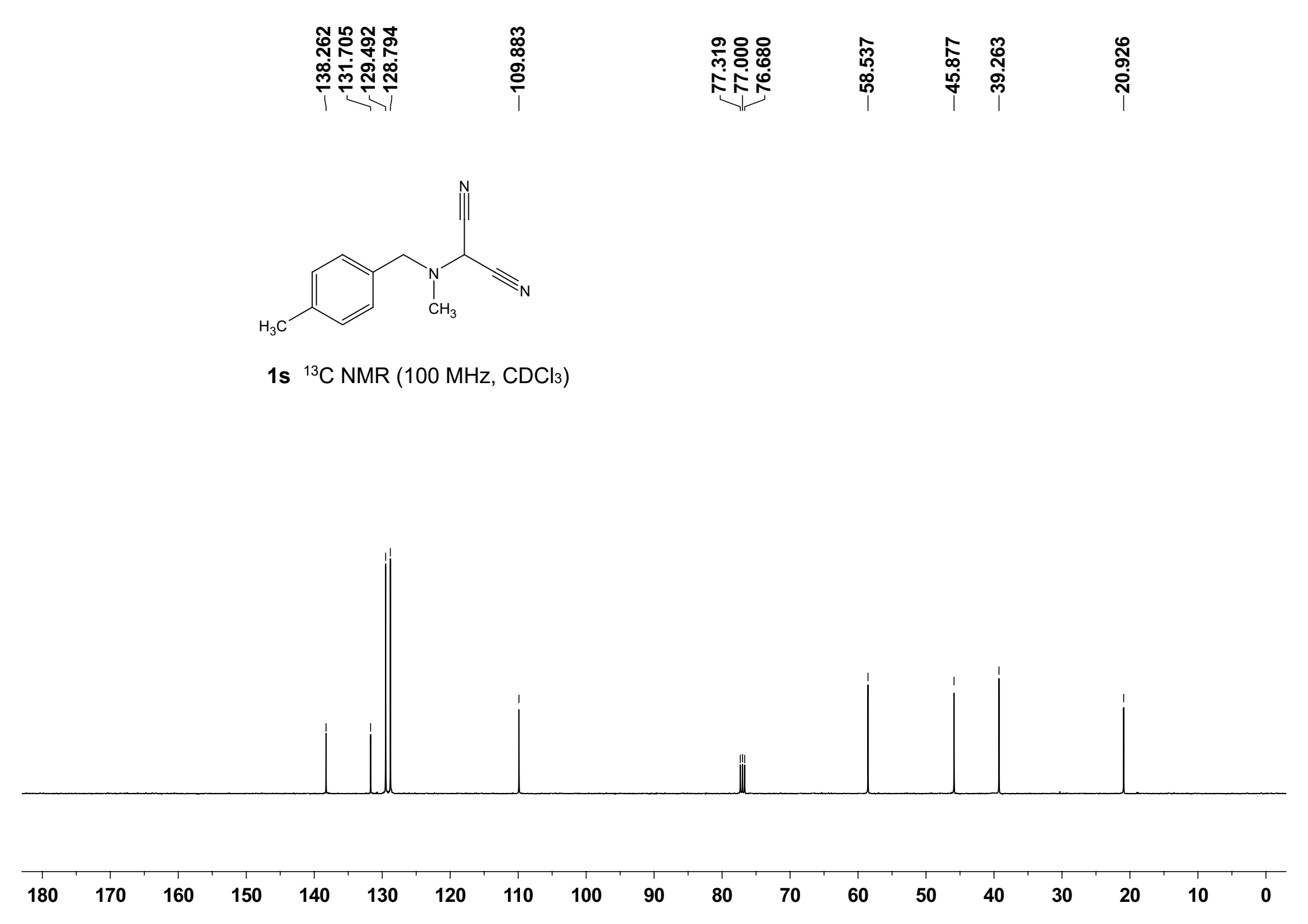
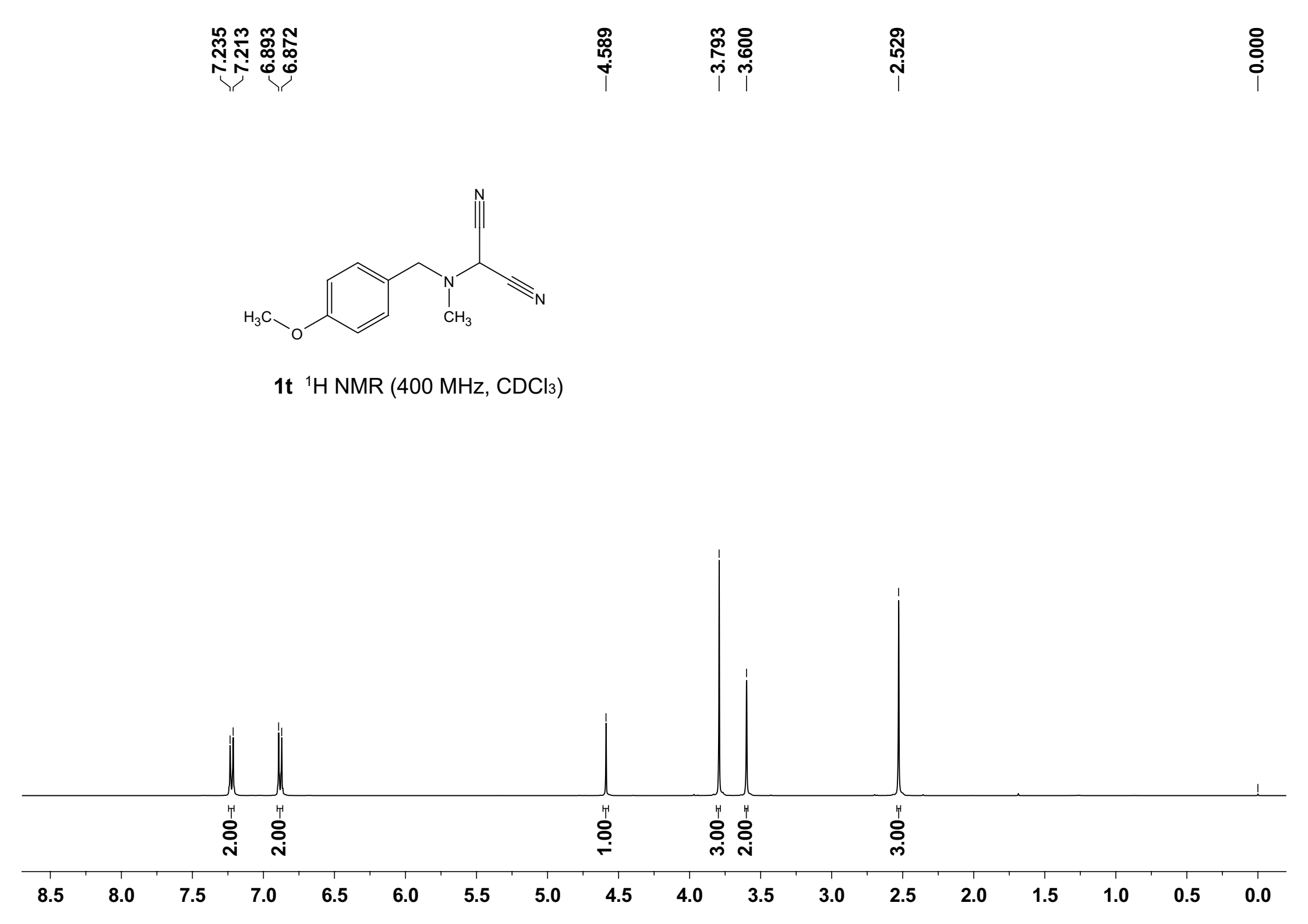




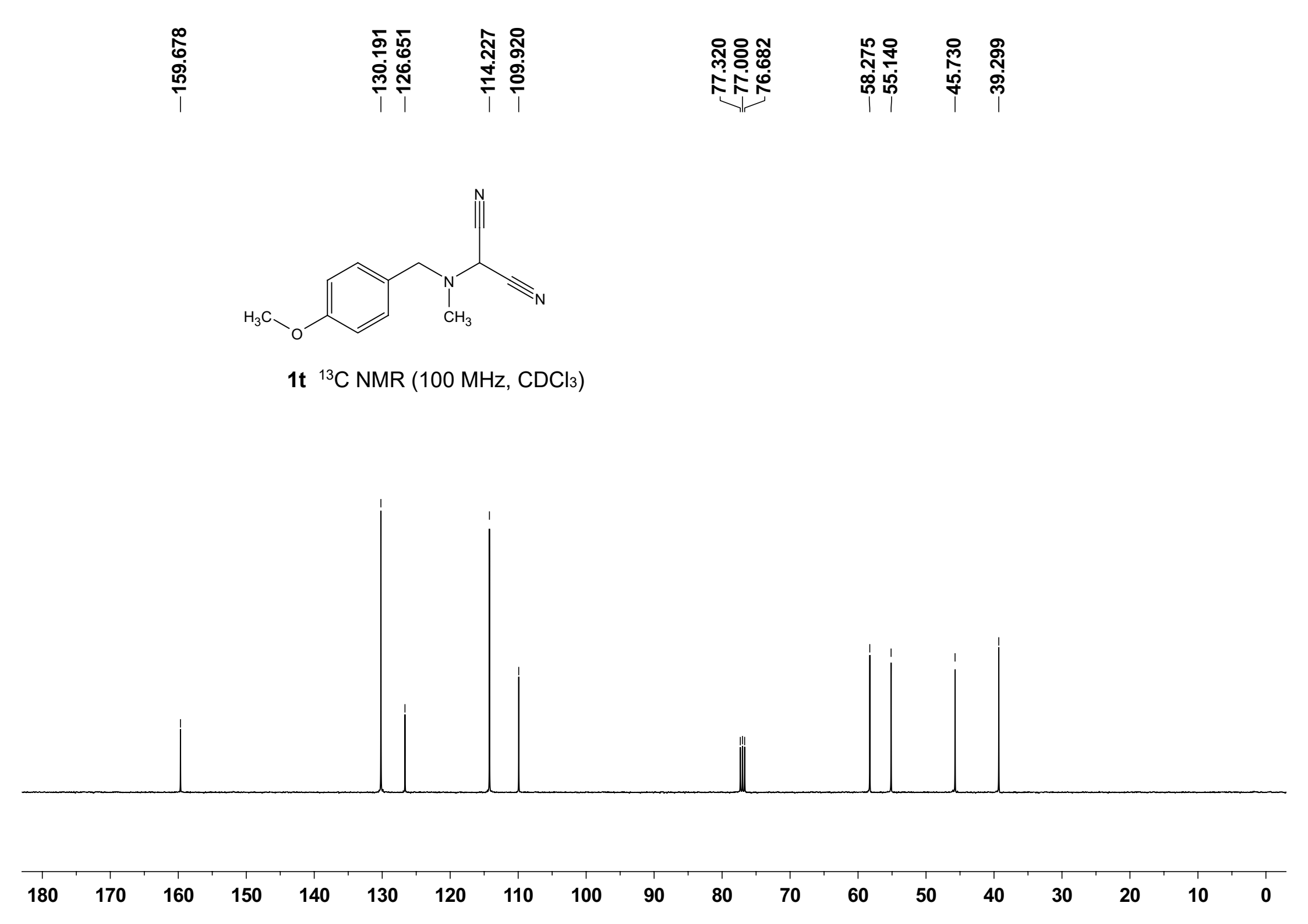
1s ^{1}H NMR (400 MHz, $CDCl_3$)



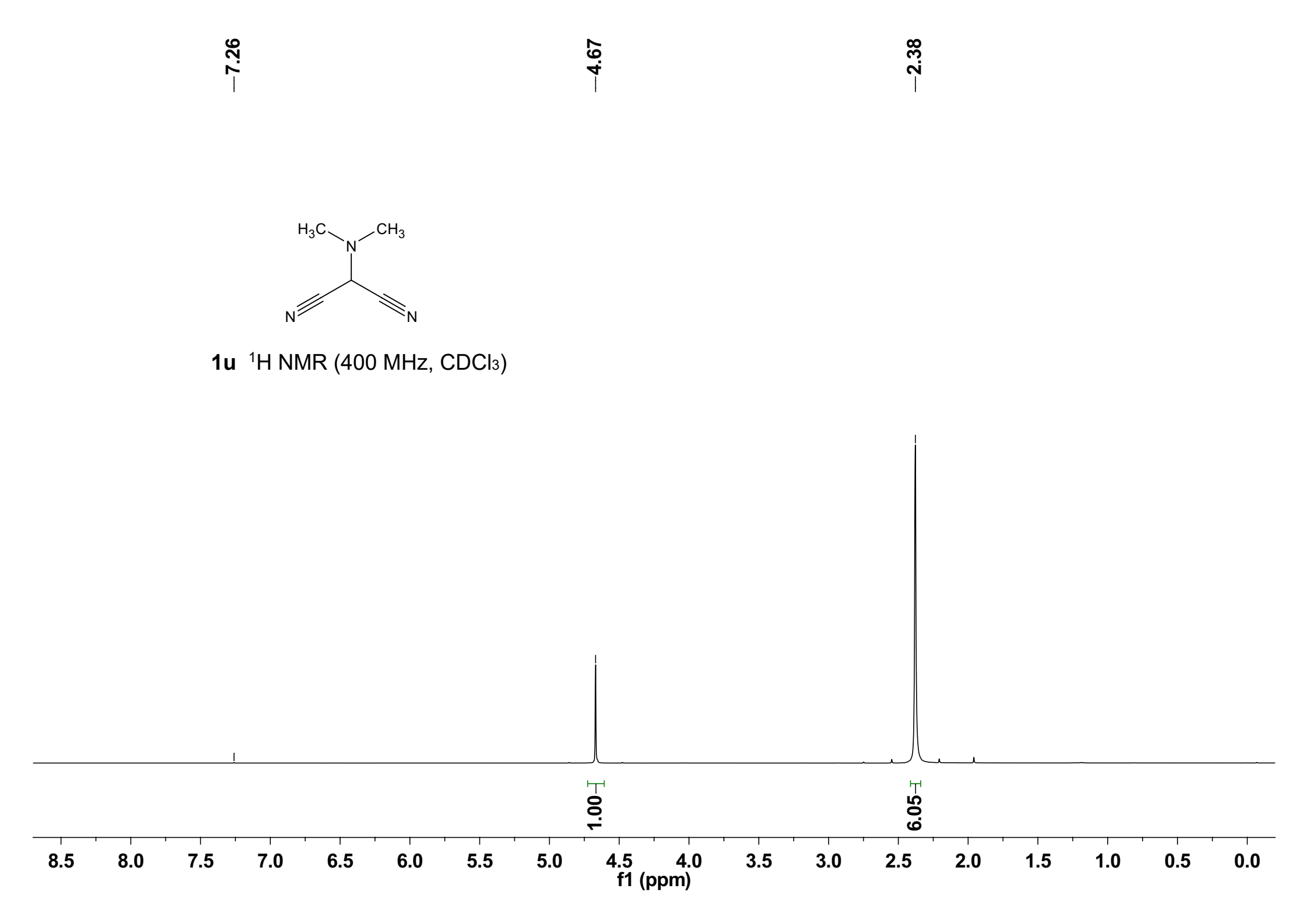
1s ^{13}C NMR (100 MHz, $CDCl_3$)

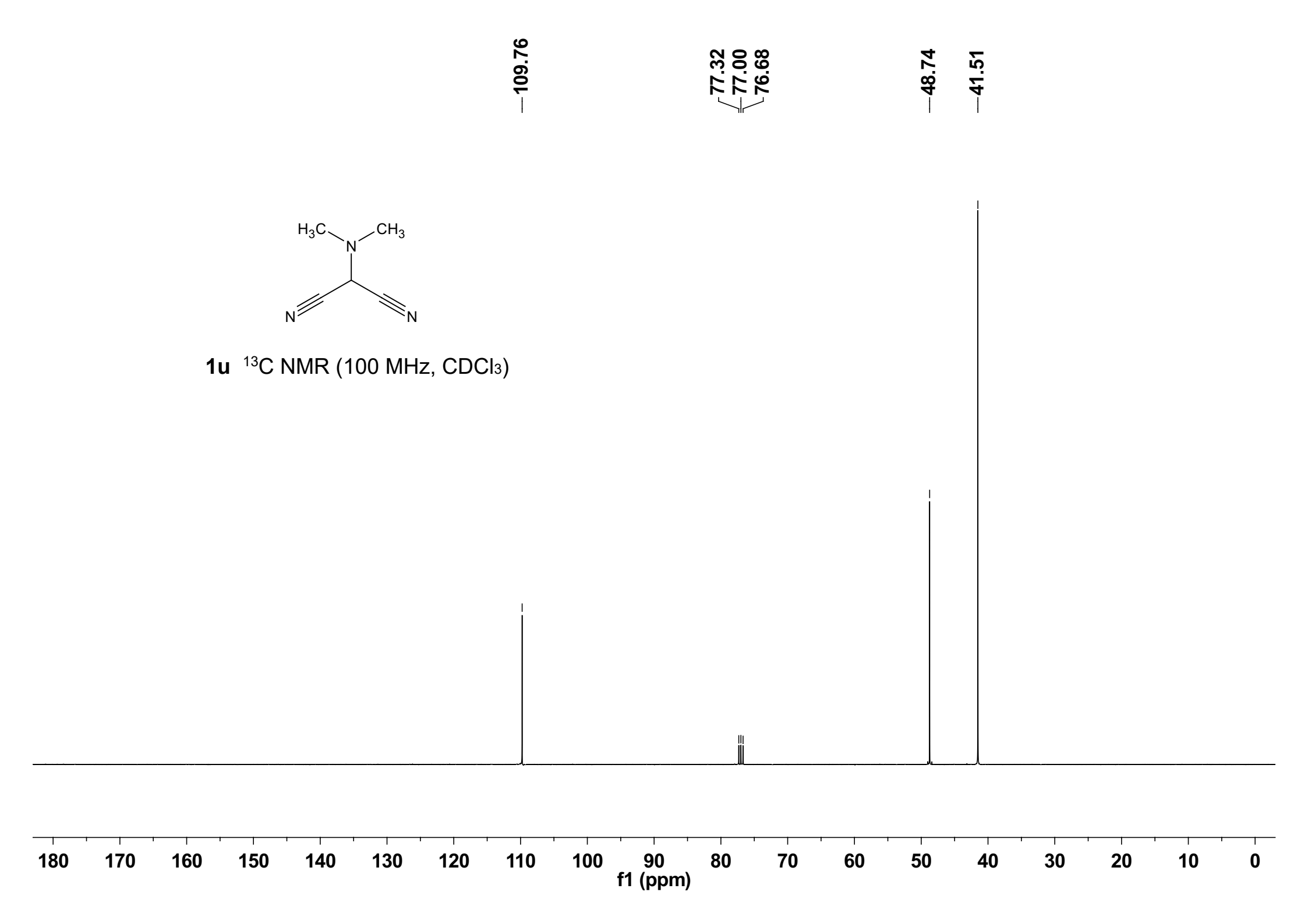


1t ^{1}H NMR (400 MHz, $CDCl_3$)

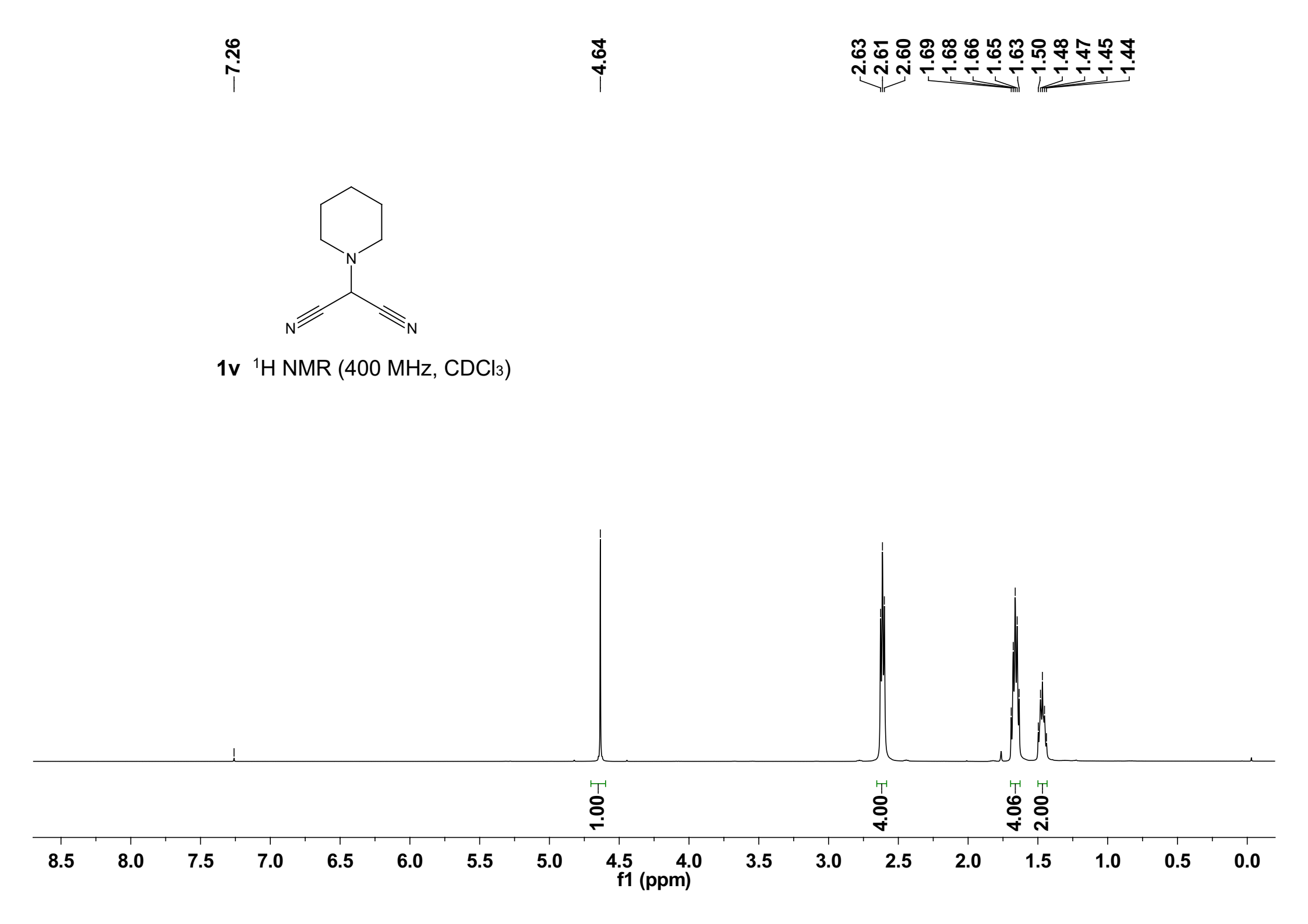


1t ^{13}C NMR (100 MHz, $CDCl_3$)

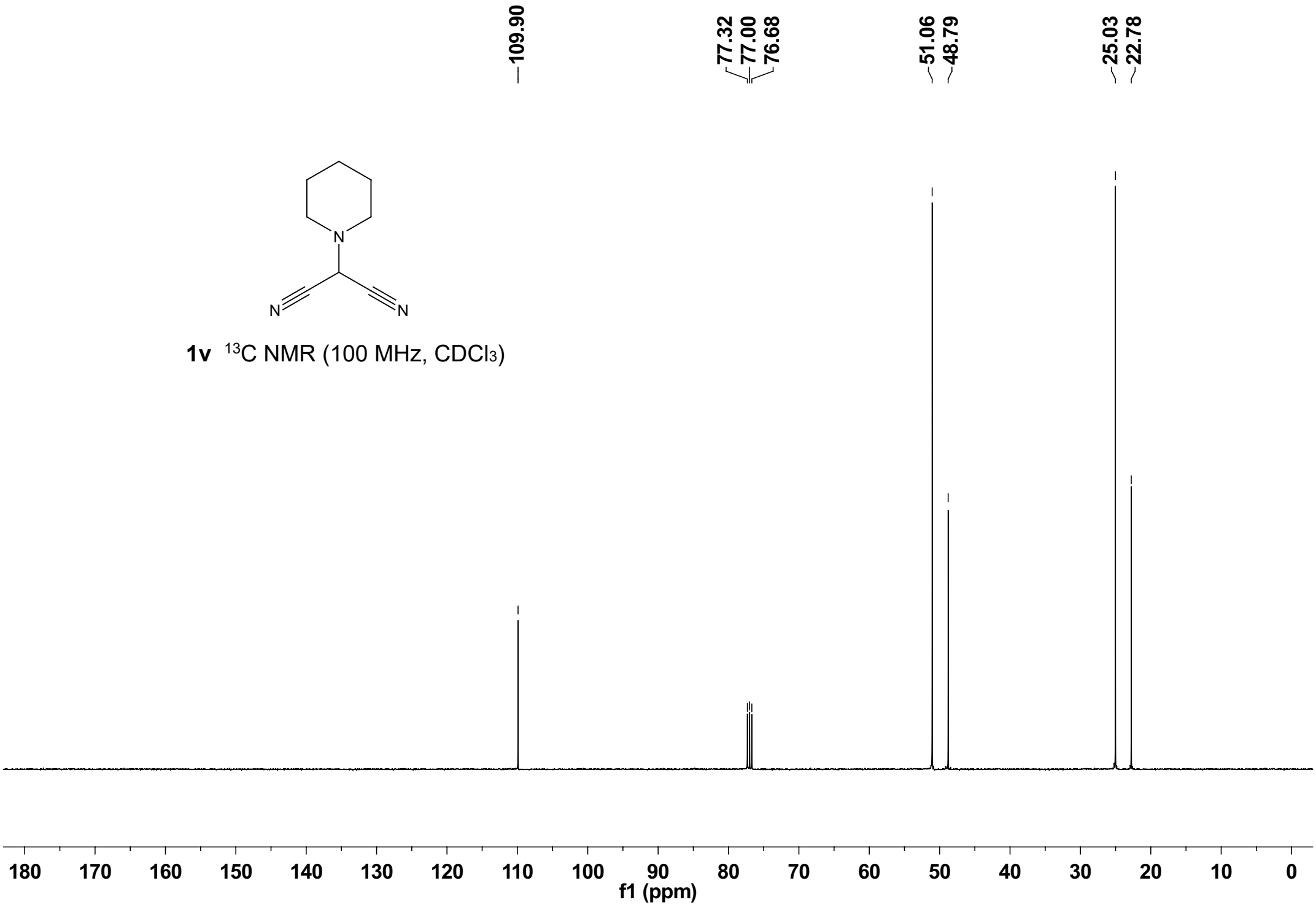

7.26
4.67
2.38
H3C
N
CH3
N
N
1u 1H NMR (400 MHz, CDCl3)
1.00
6.05
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



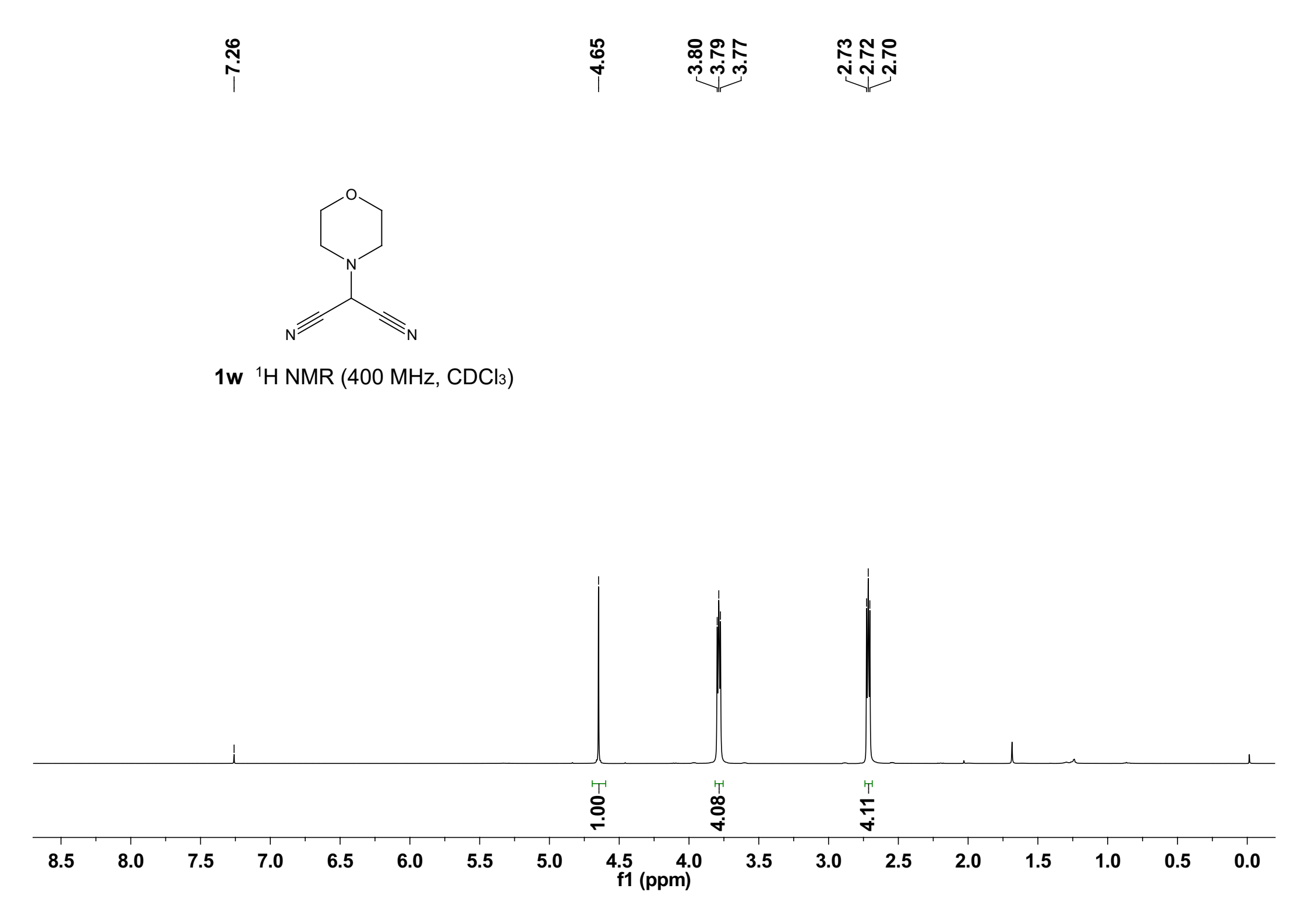
1u ^{13}C NMR (100 MHz, $CDCl_3$)



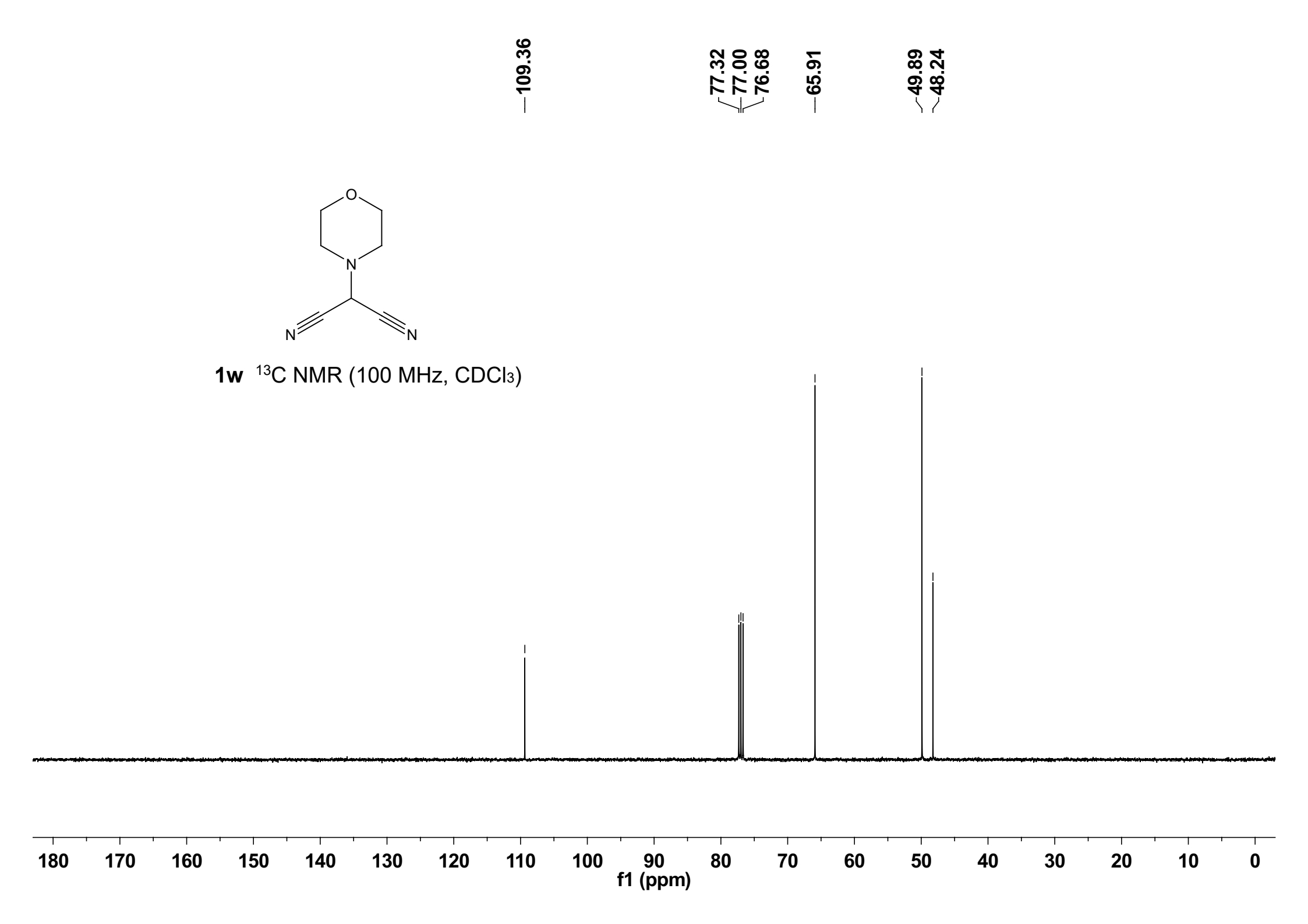
1v ^{1}H NMR (400 MHz, $CDCl_3$)

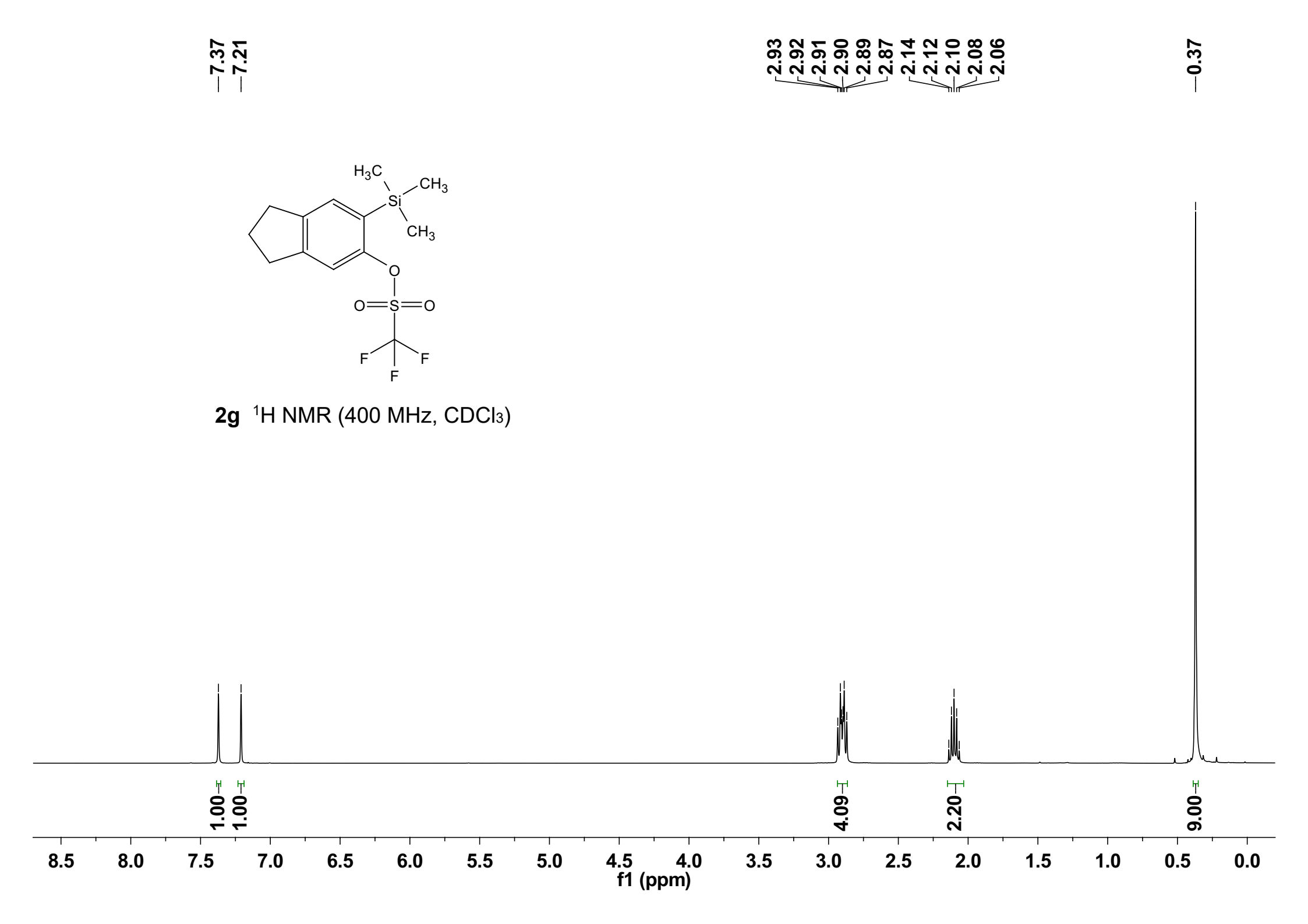


1v ^{13}C NMR (100 MHz, $CDCl_3$)

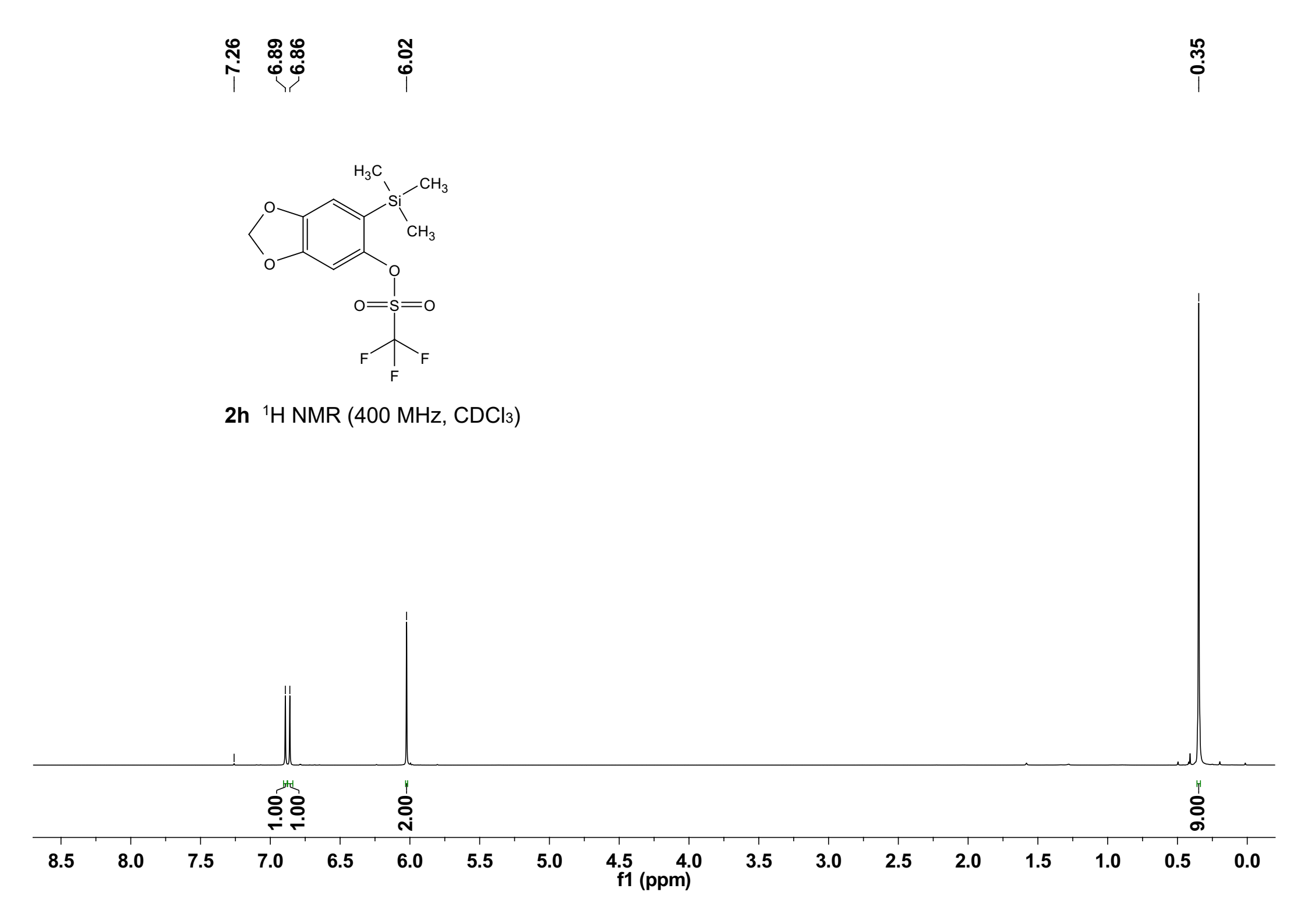


1w ^{1}H NMR (400 MHz, $CDCl_3$)

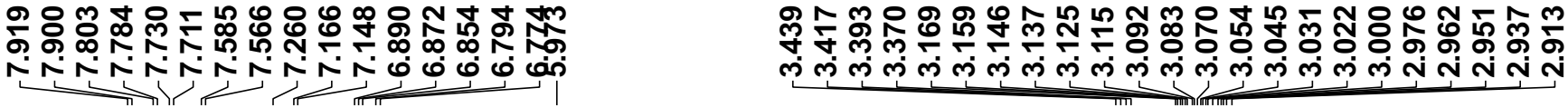

109.36
77.32
77.00
76.68
65.91
49.89
48.24
O
N
N
N
1w 13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

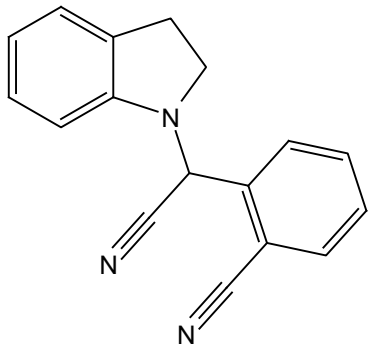


2g ^{1}H NMR (400 MHz, $CDCl_3$)

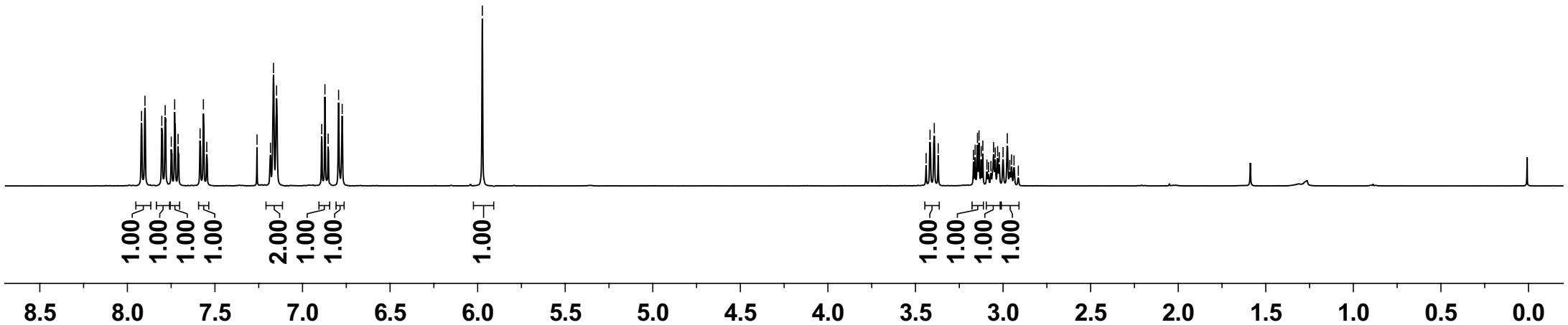


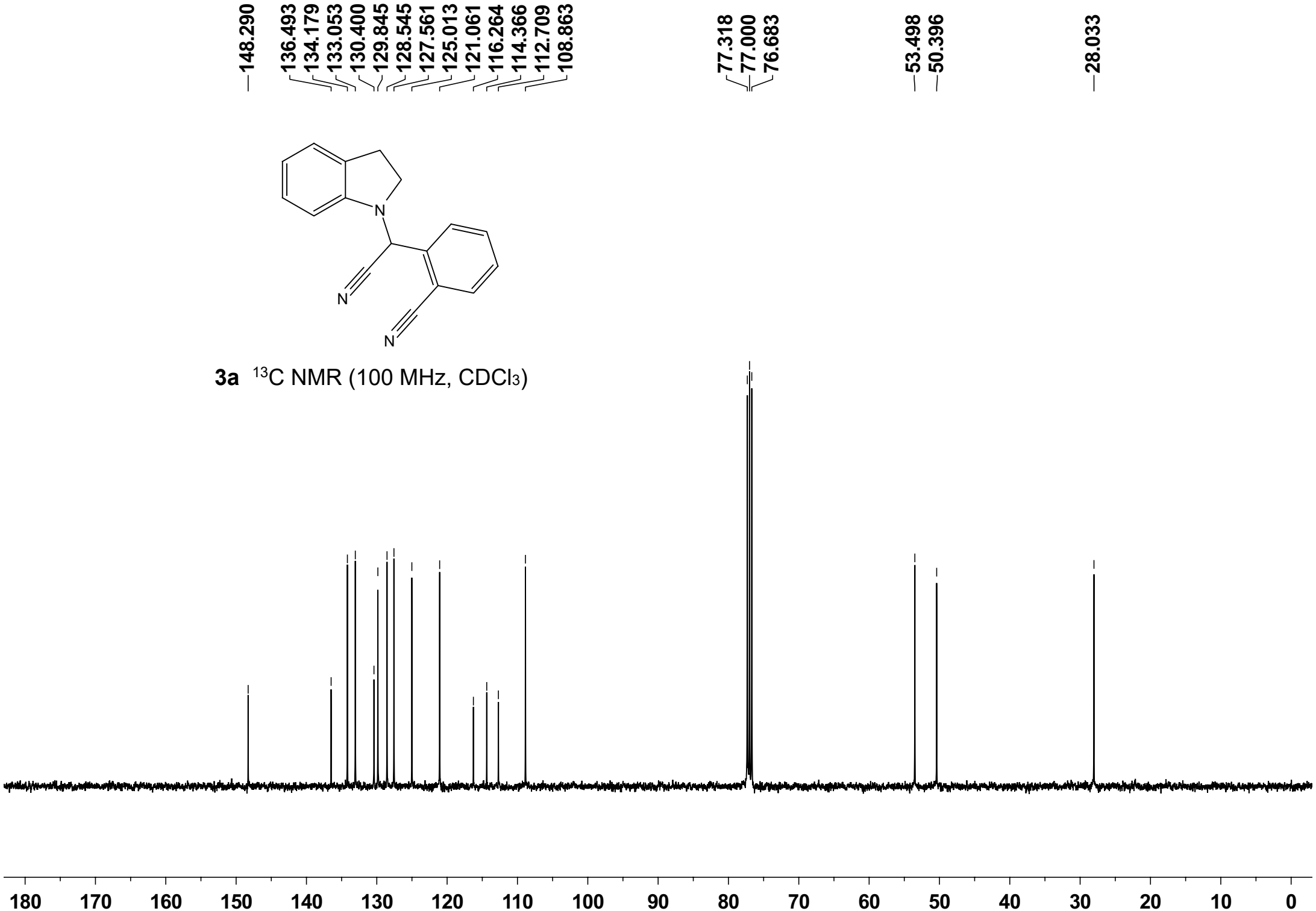
2h ^{1}H NMR (400 MHz, $CDCl_3$)



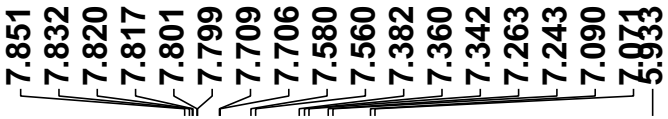


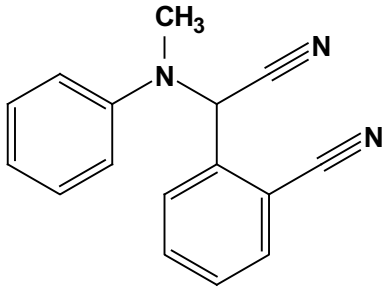
3a ^{1}H NMR (400 MHz, $CDCl_3$)



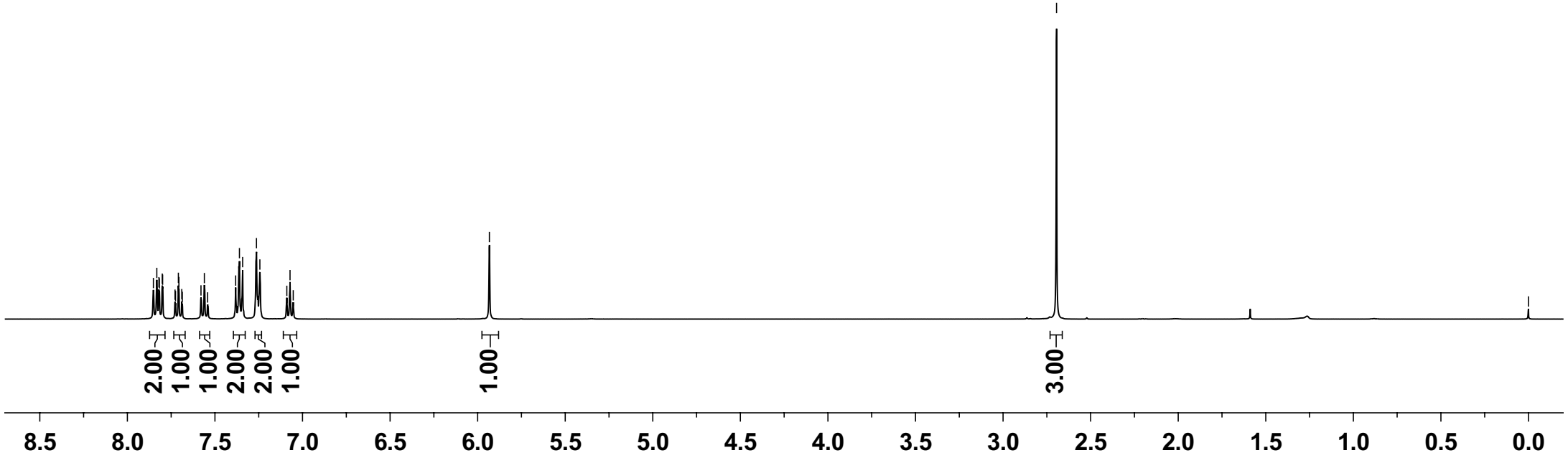


3a ^{13}C NMR (100 MHz, $CDCl_3$)





3b ^{1}H NMR (400 MHz, $CDCl_3$)



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132.950
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116.703
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77.318
77.000
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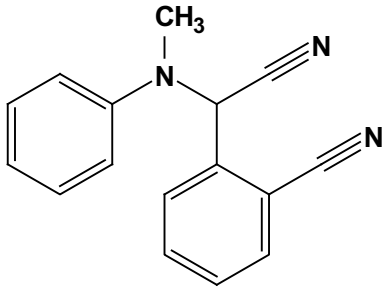
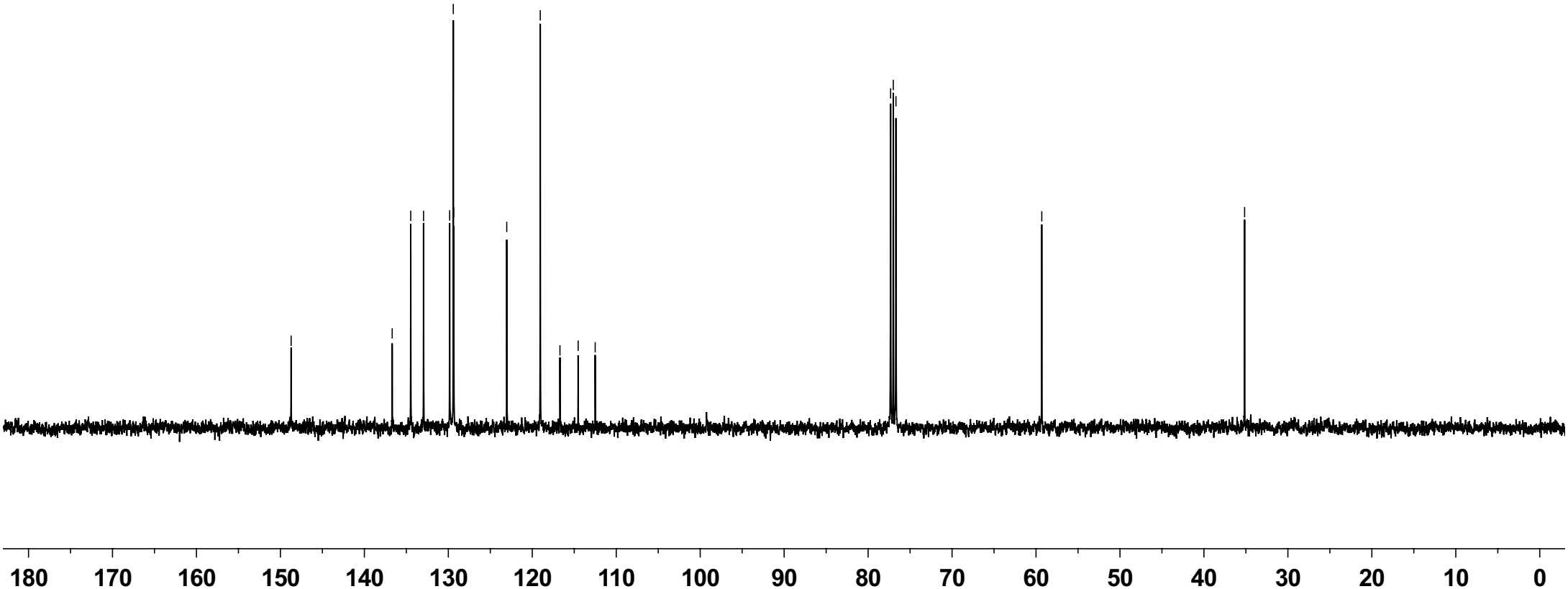
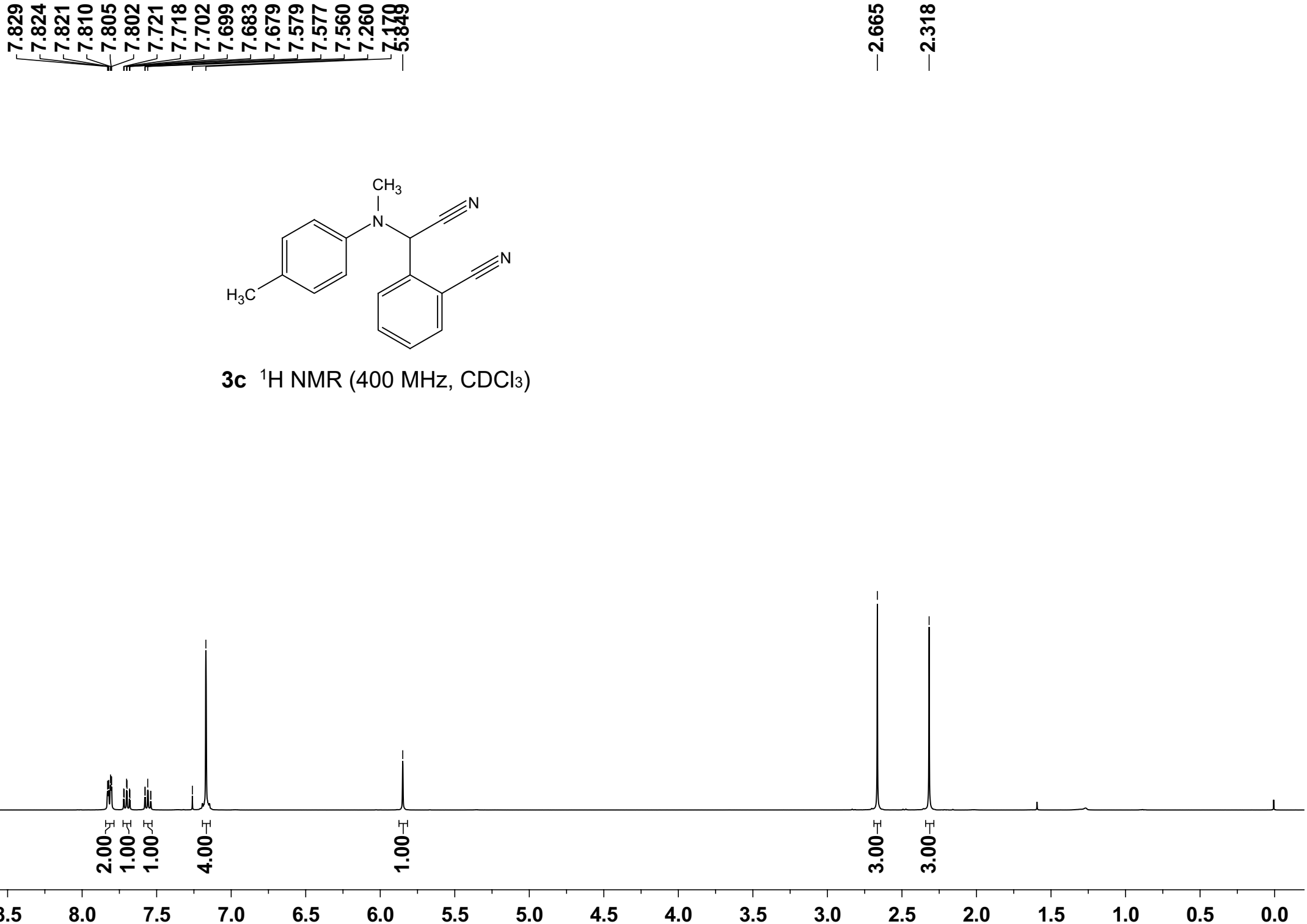
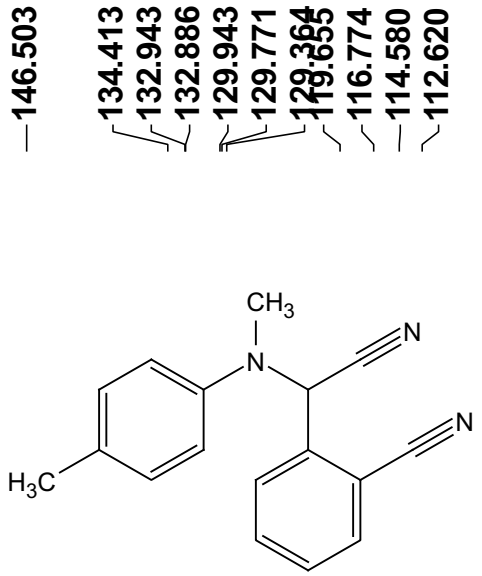


3b ^{13}C NMR (100 MHz, $CDCl_3$)

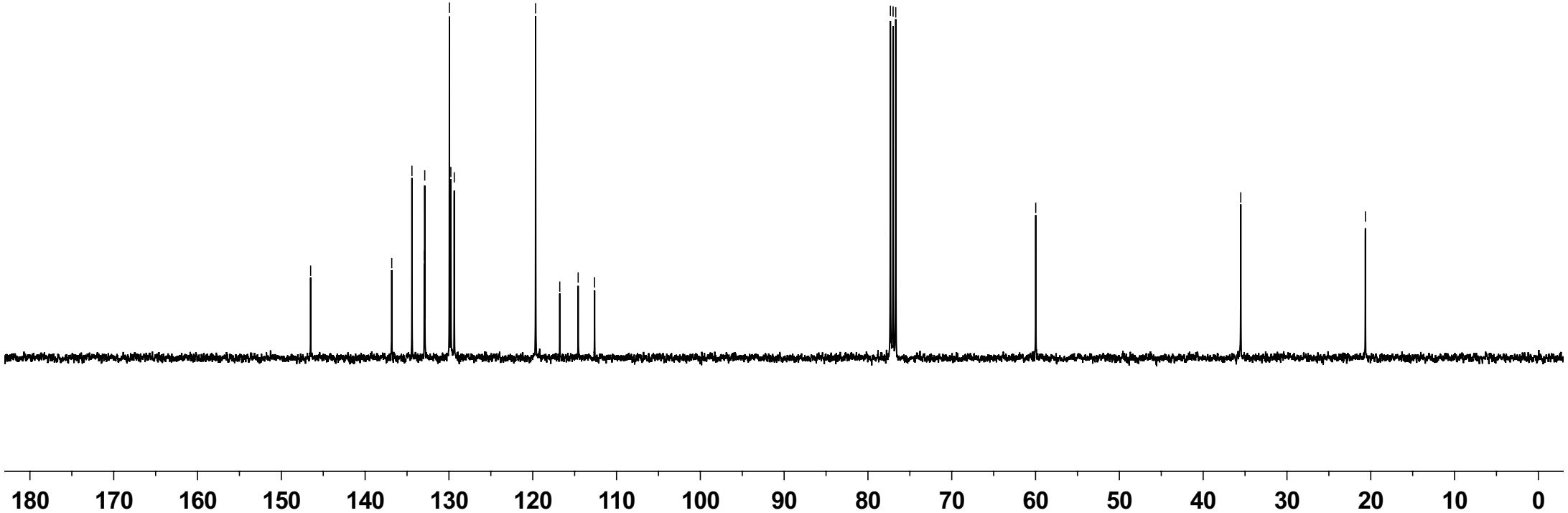


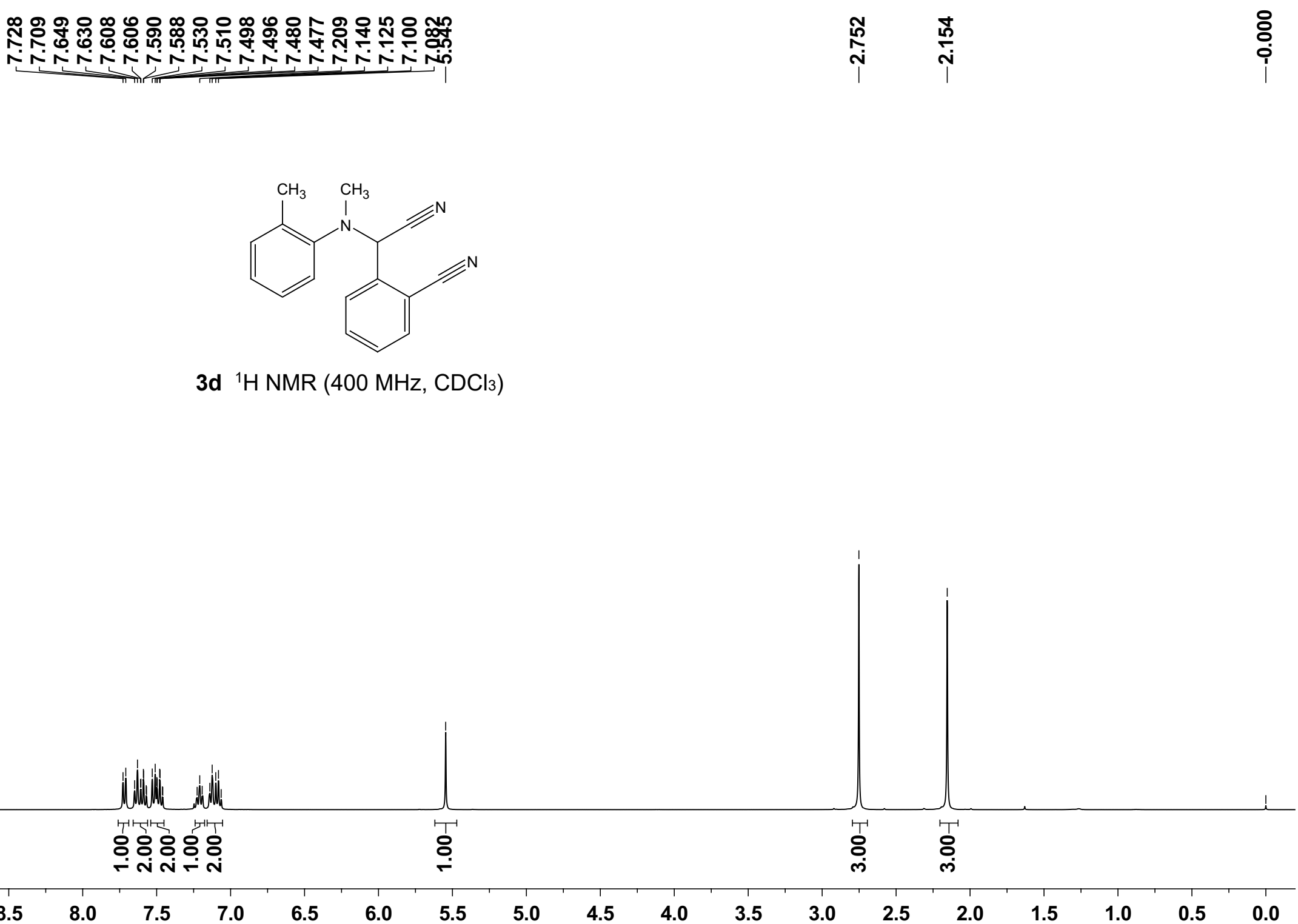


3c ^{1}H NMR (400 MHz, $CDCl_3$)

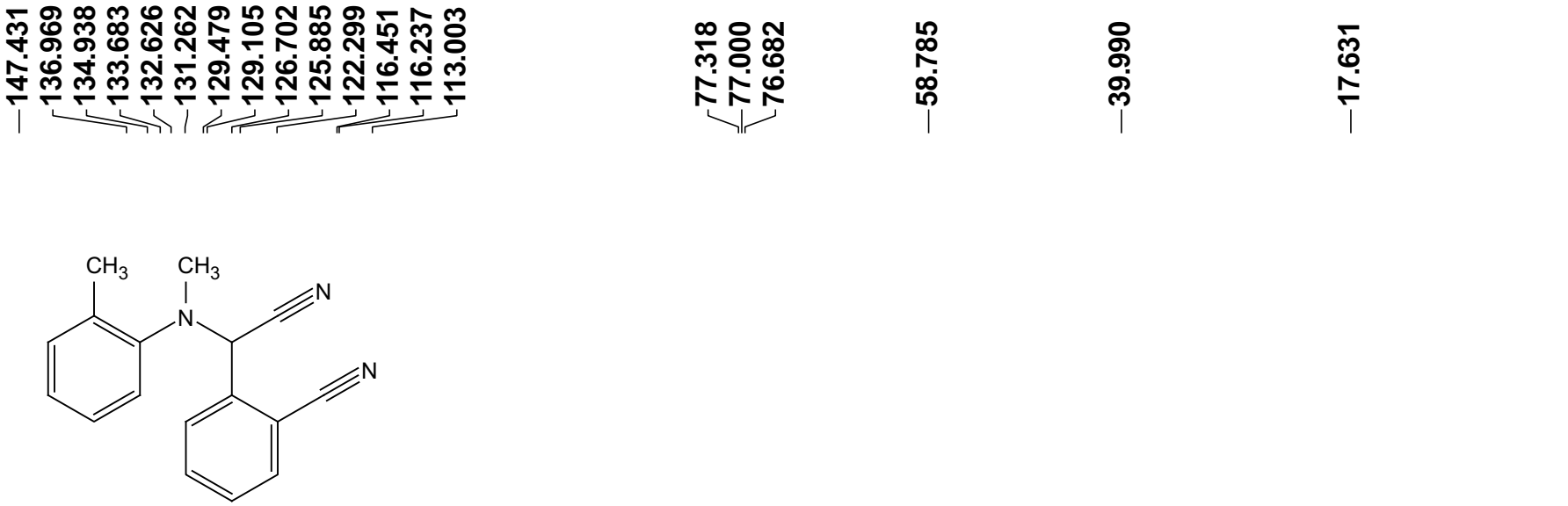


3c ^{13}C NMR (100 MHz, $CDCl_3$)

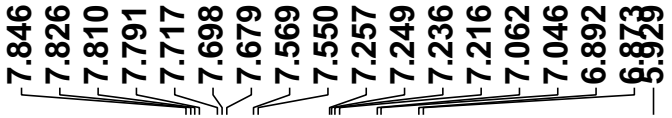


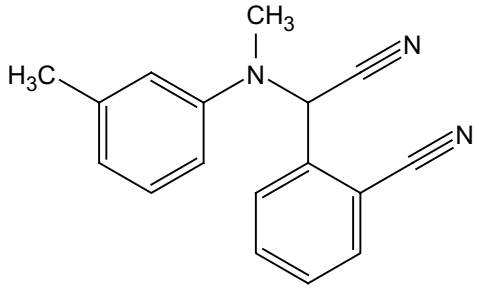


3d ^{1}H NMR (400 MHz, $CDCl_3$)



3d ^{13}C NMR (100 MHz, $CDCl_3$)





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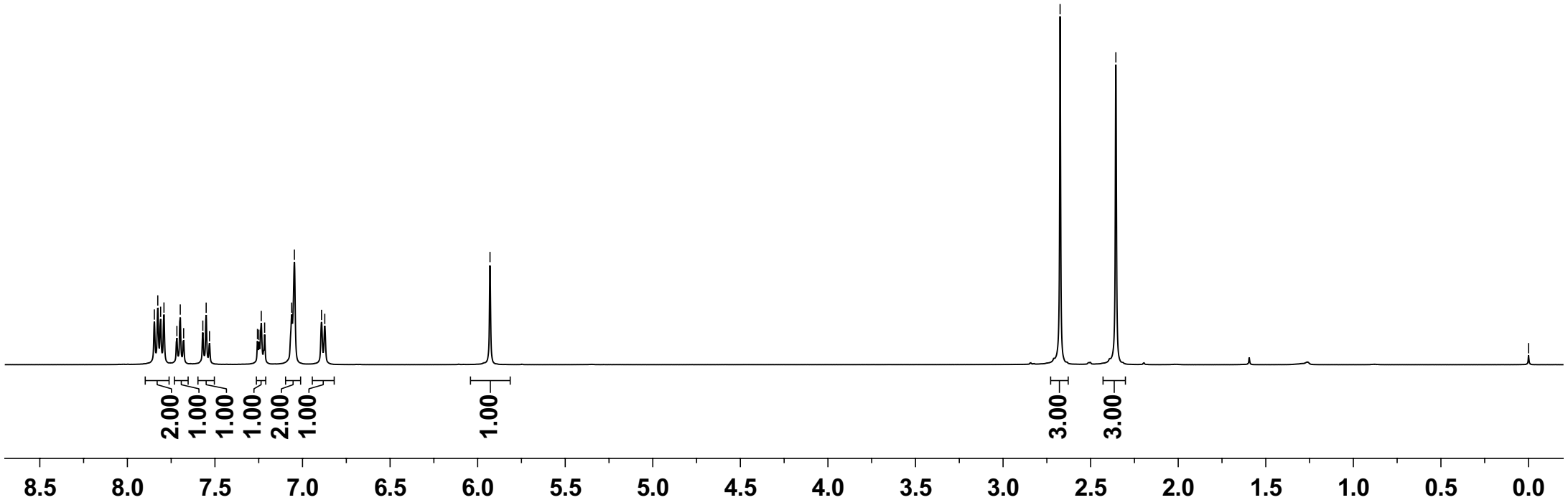
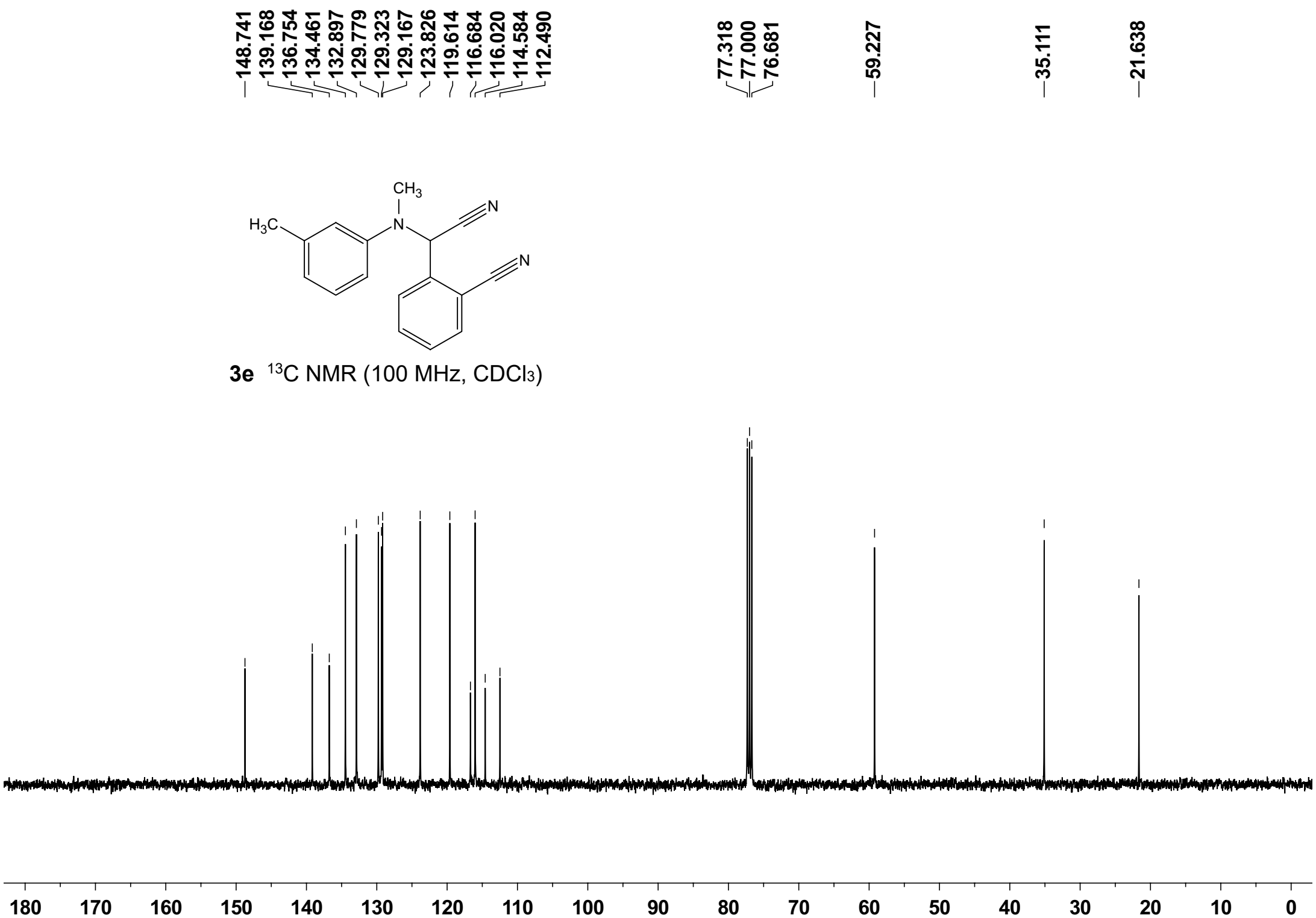
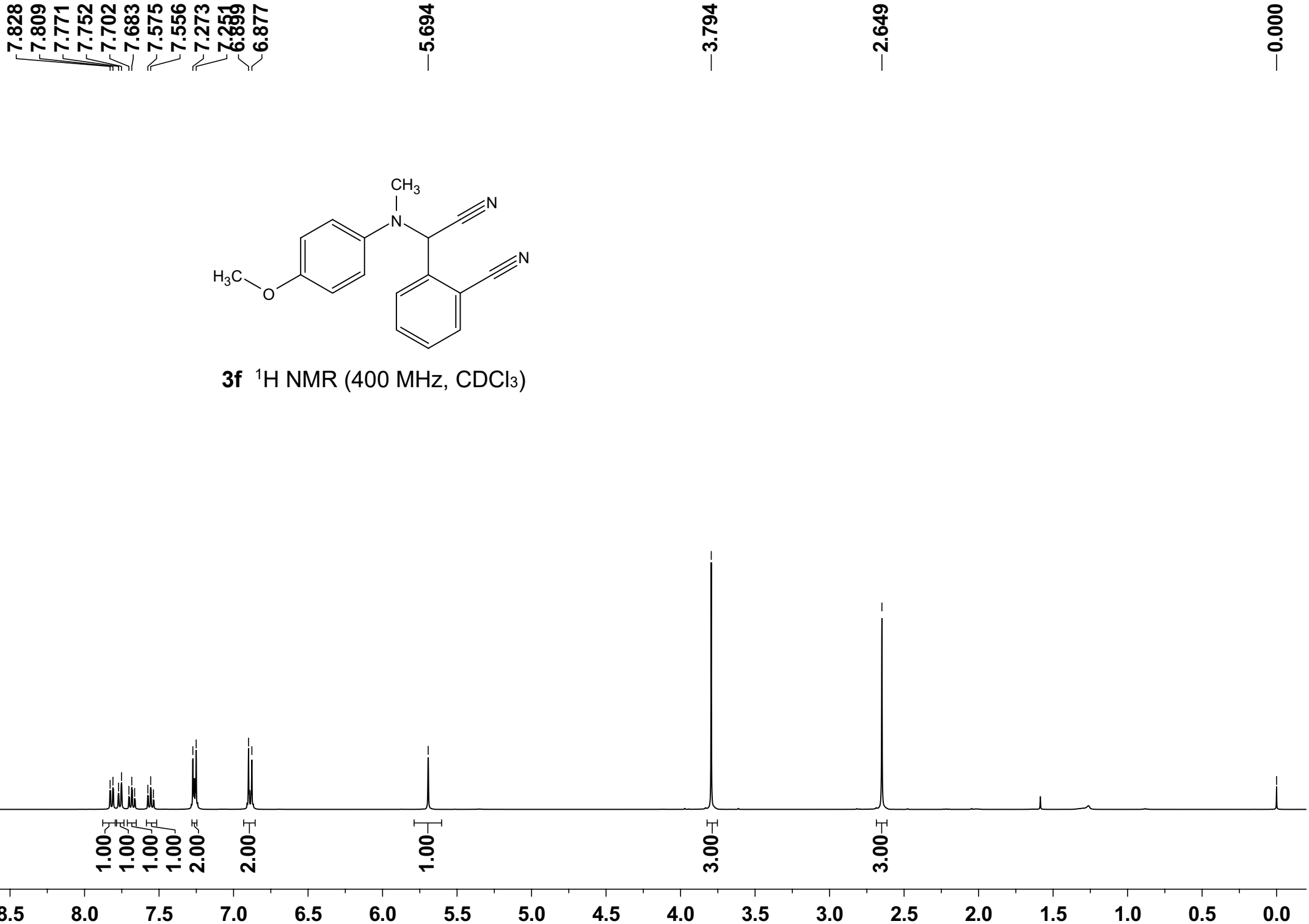
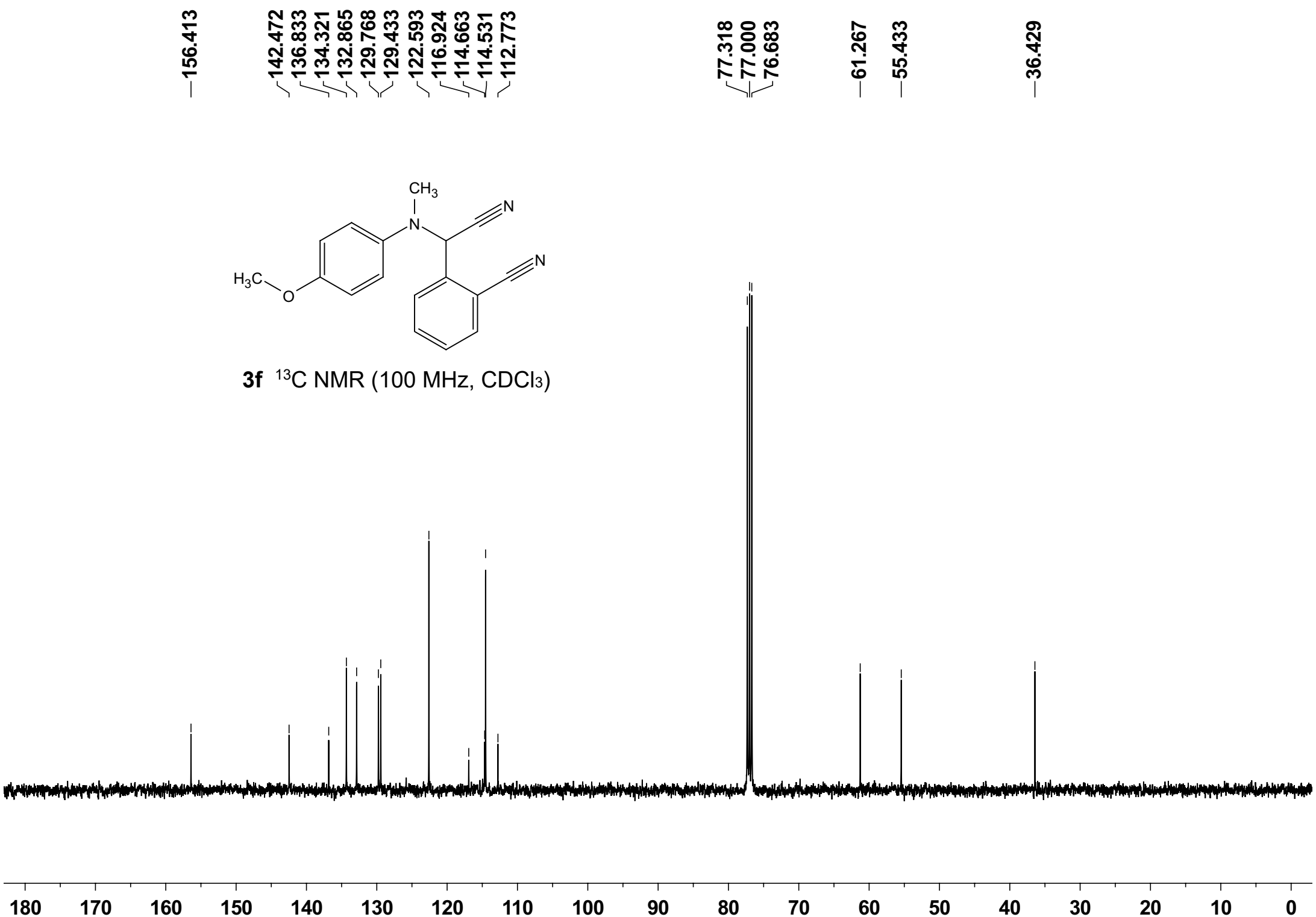




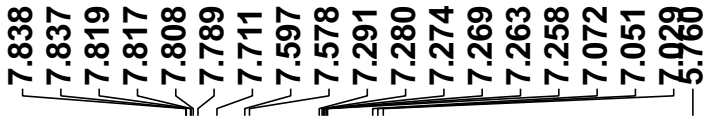
3e ^{13}C NMR (100 MHz, $CDCl_3$)

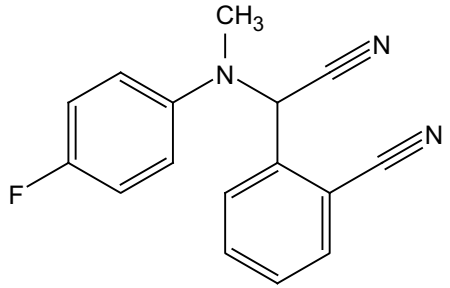


3f ^{1}H NMR (400 MHz, $CDCl_3$)



3f ^{13}C NMR (100 MHz, $CDCl_3$)





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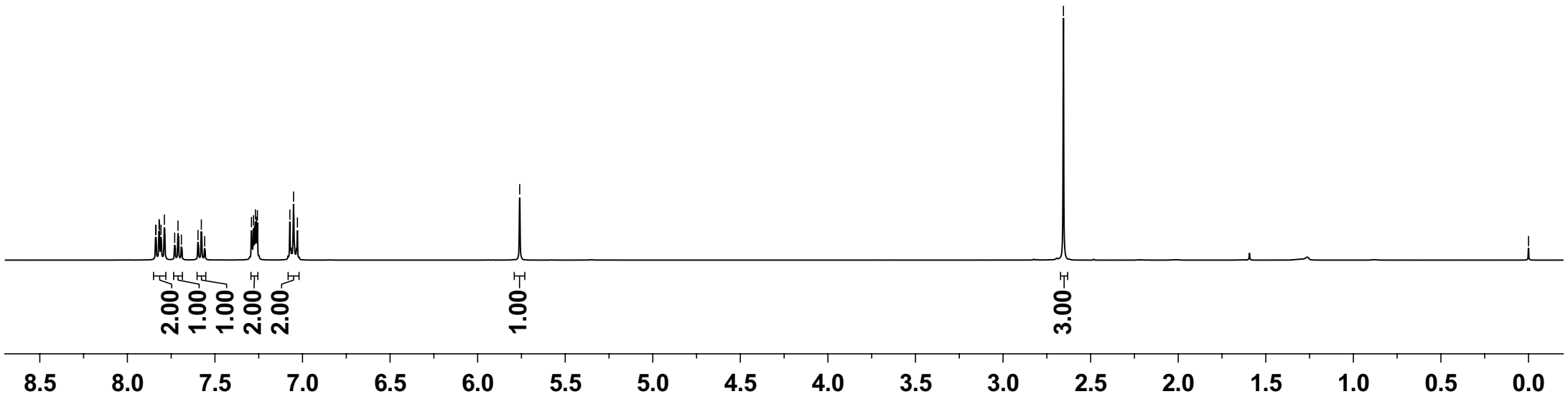
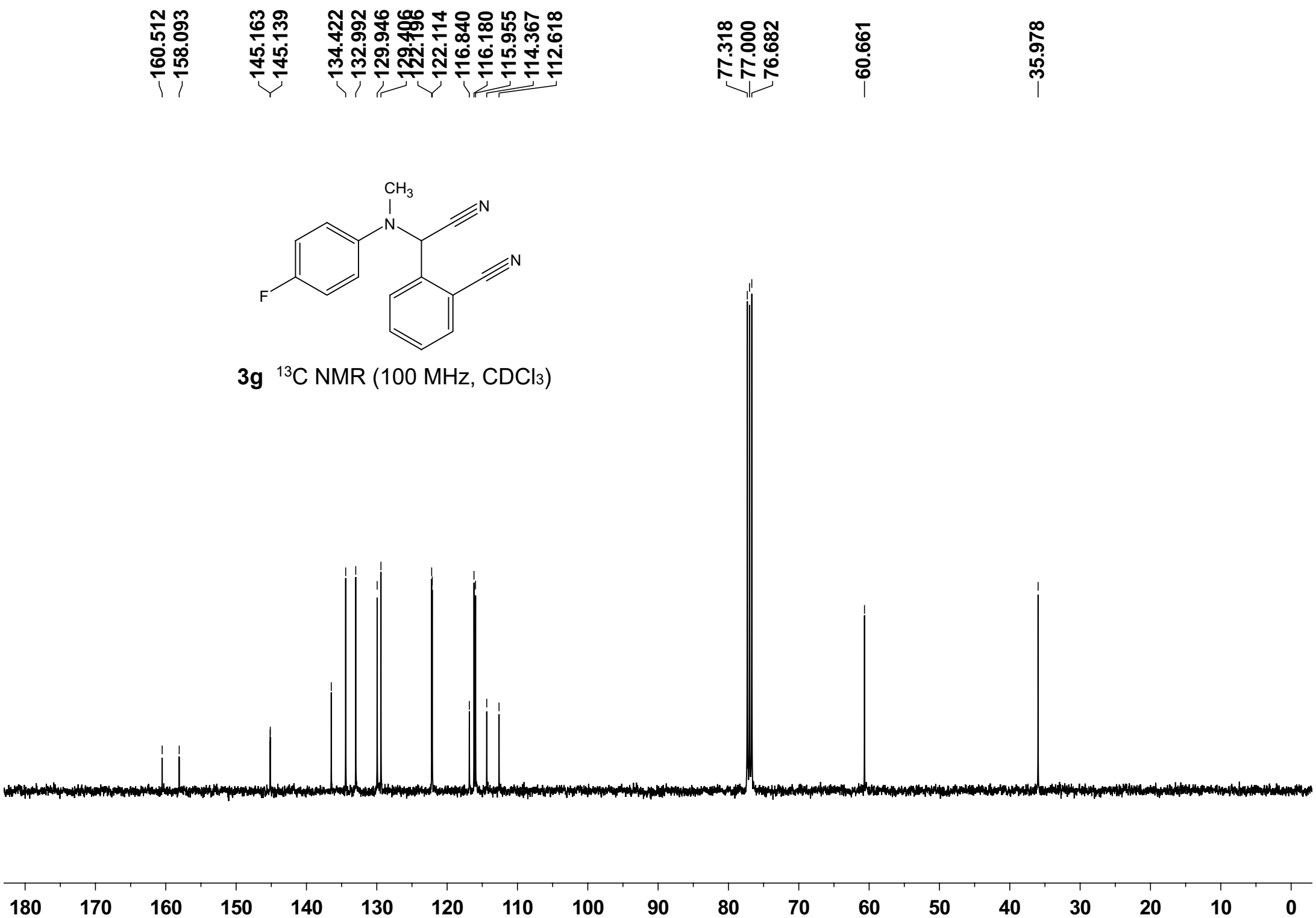
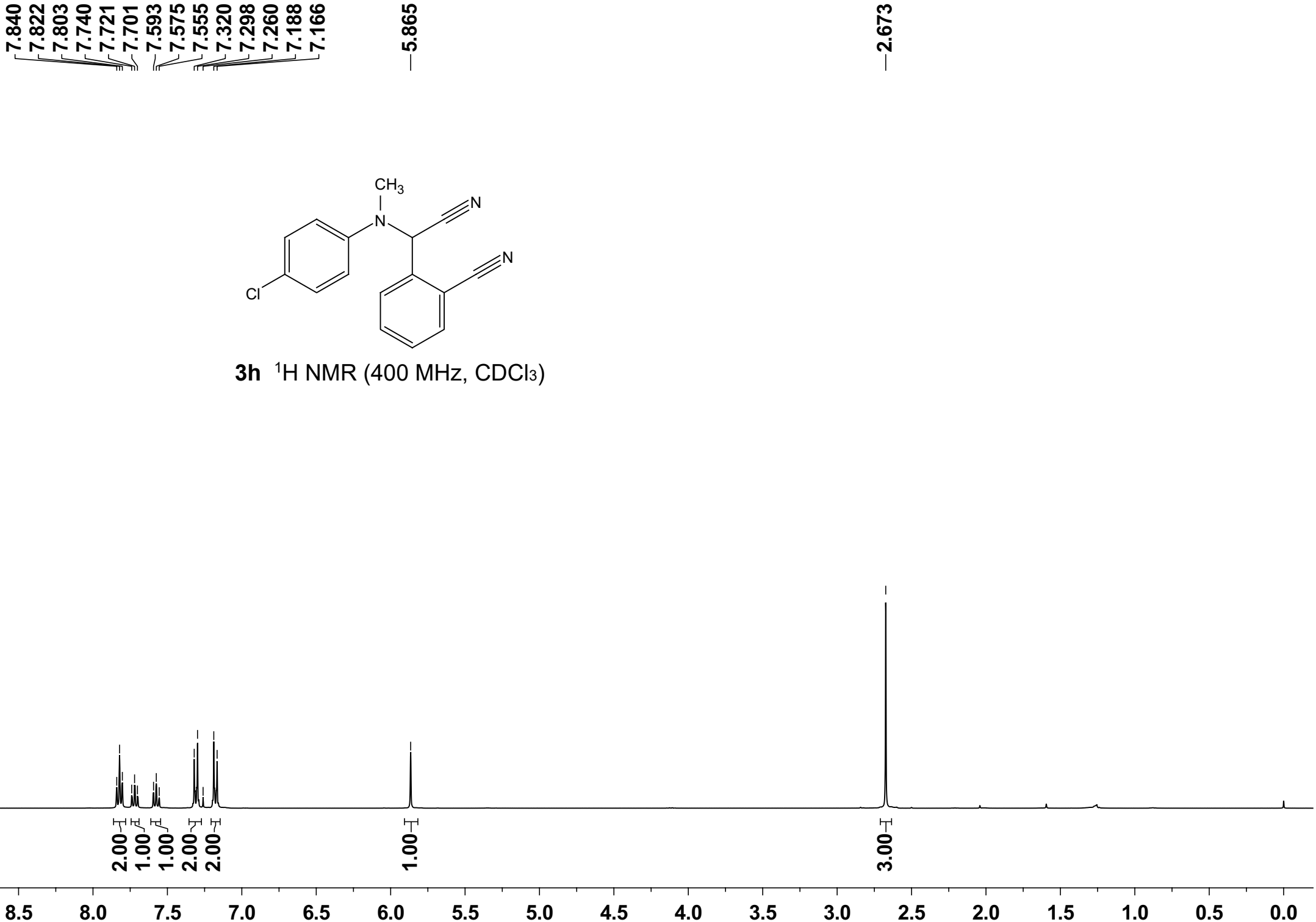
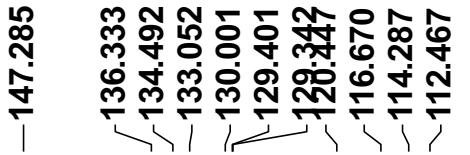


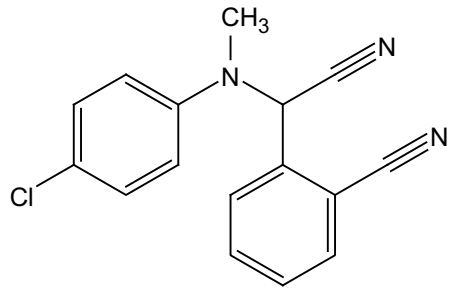


3g ^{13}C NMR (100 MHz, $CDCl_3$)



3h ^{1}H NMR (400 MHz, $CDCl_3$)





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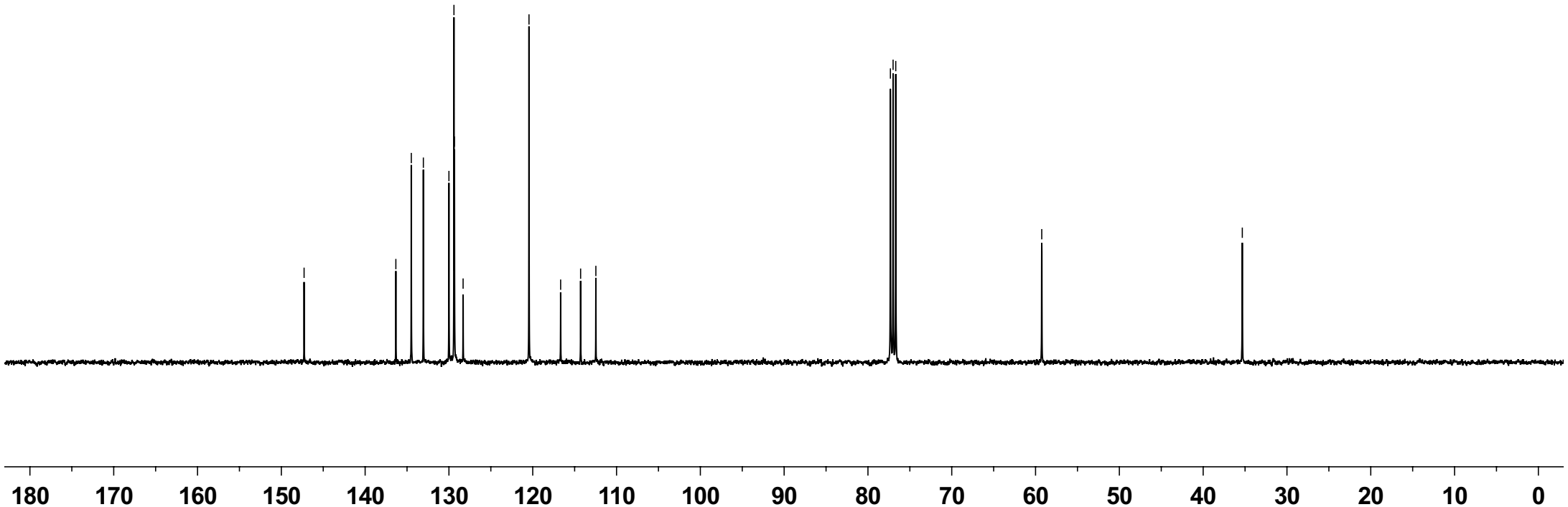
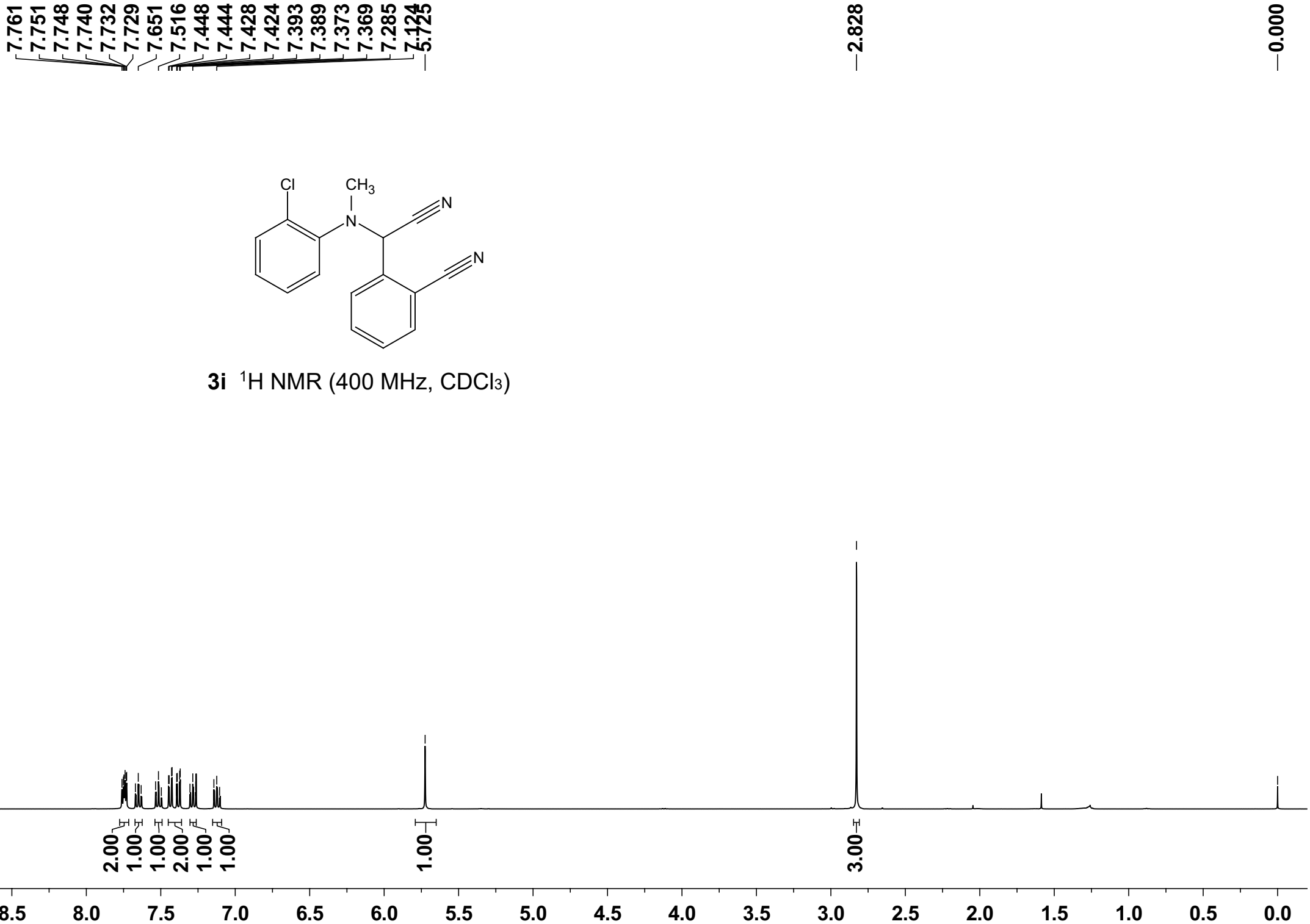
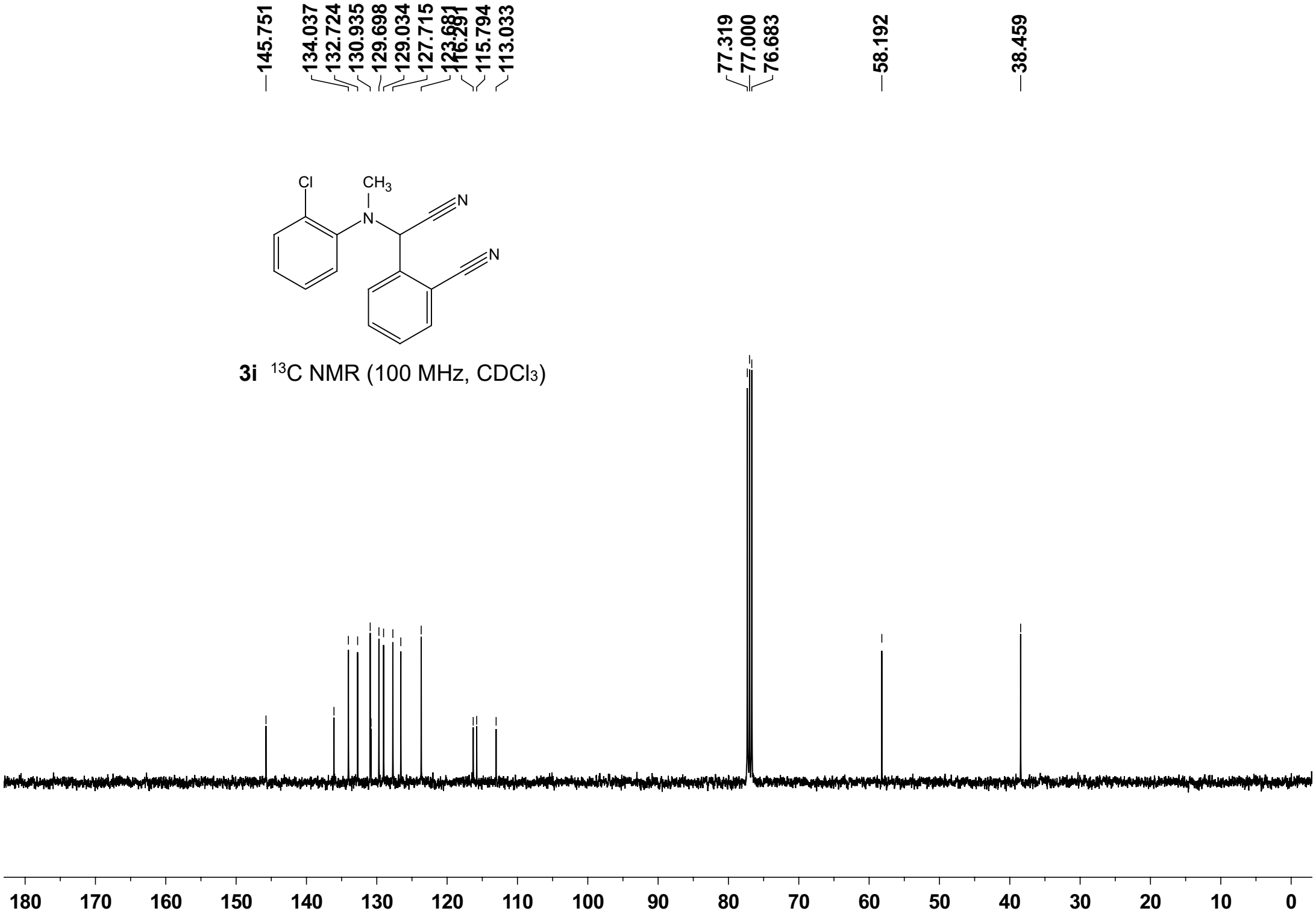
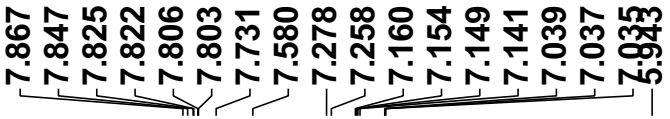


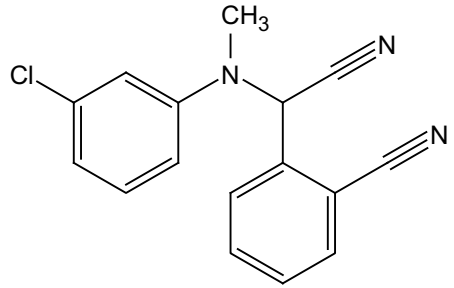


3i ^{1}H NMR (400 MHz, $CDCl_3$)



3i ^{13}C NMR (100 MHz, $CDCl_3$)





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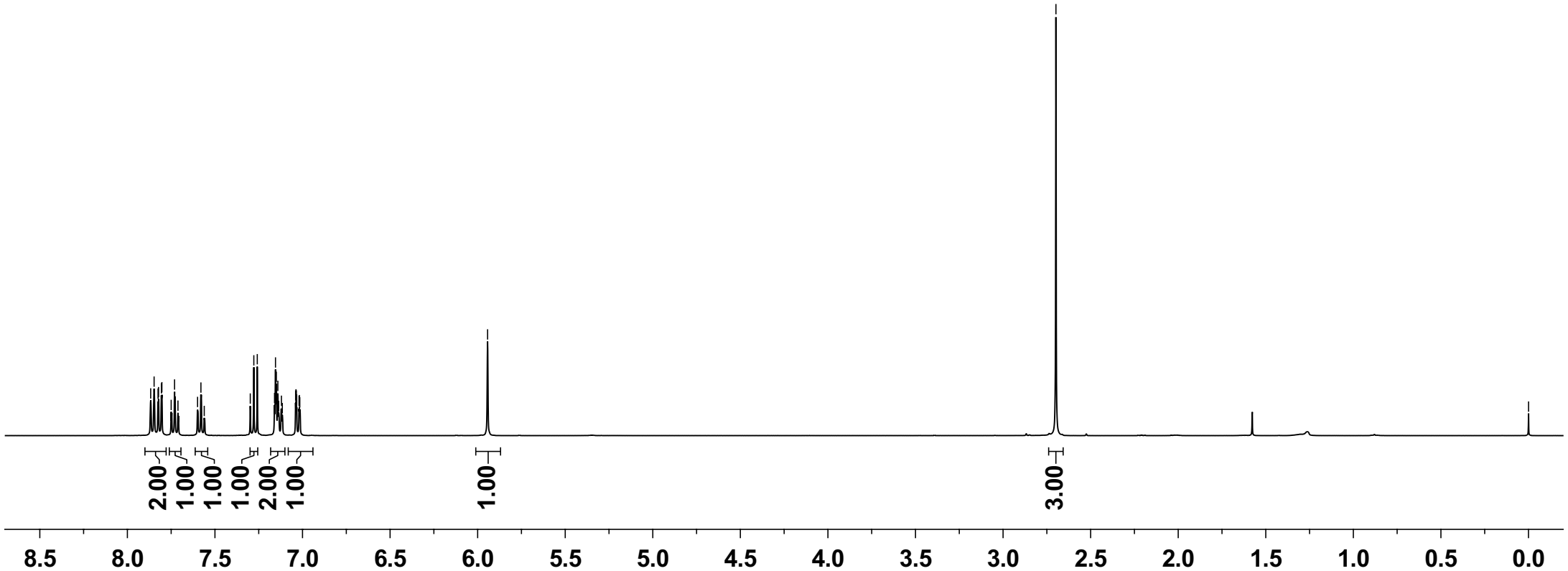

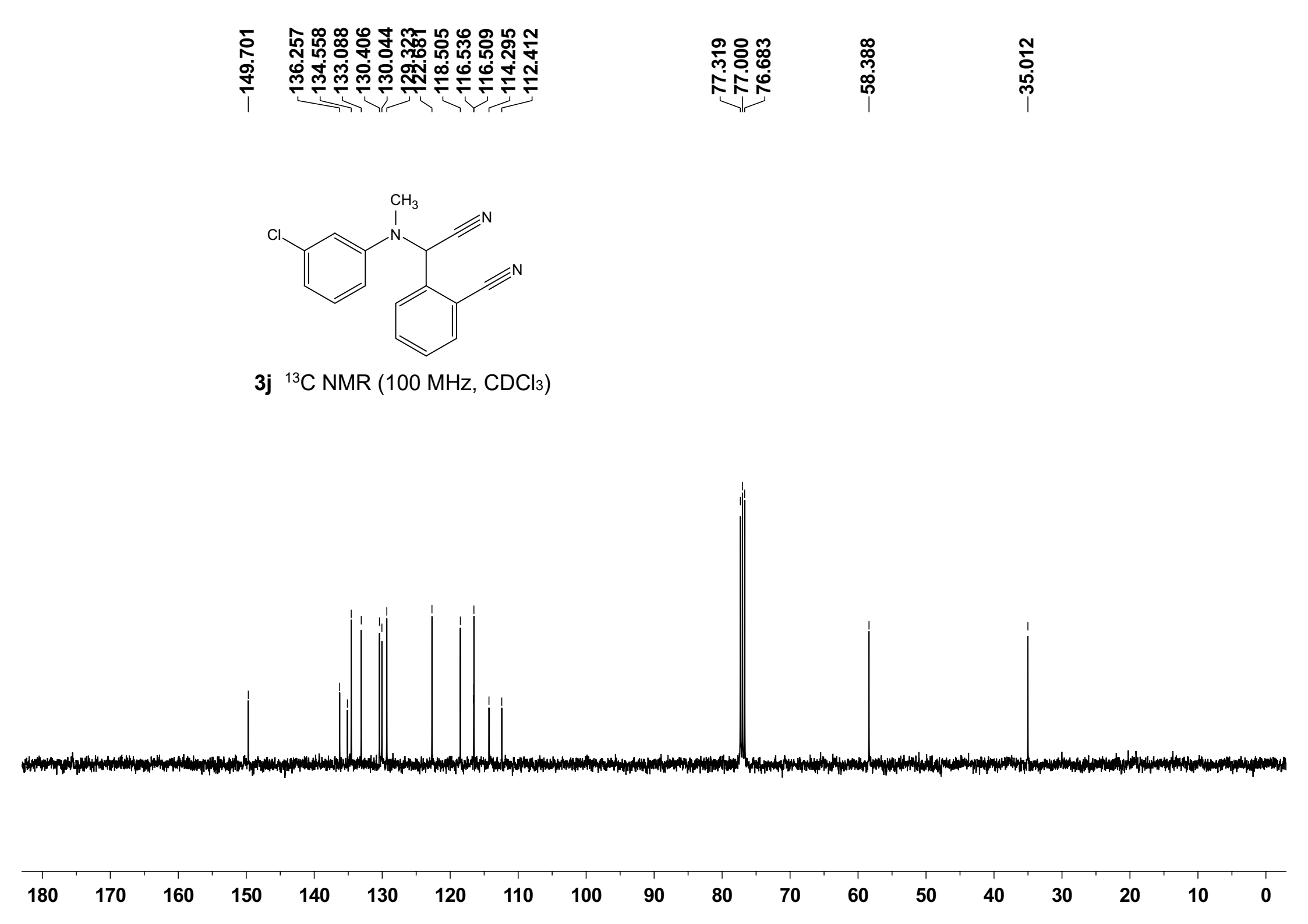

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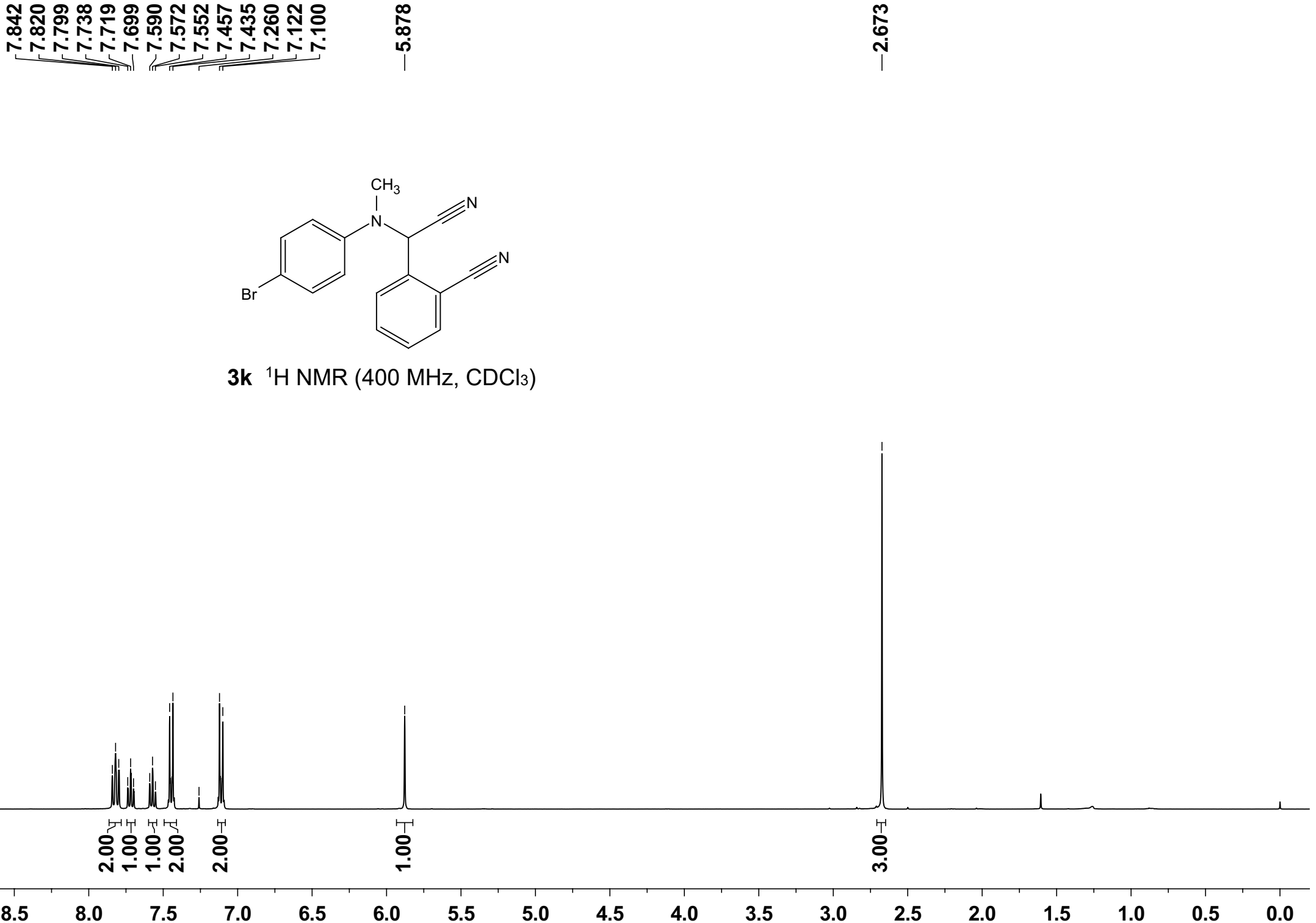
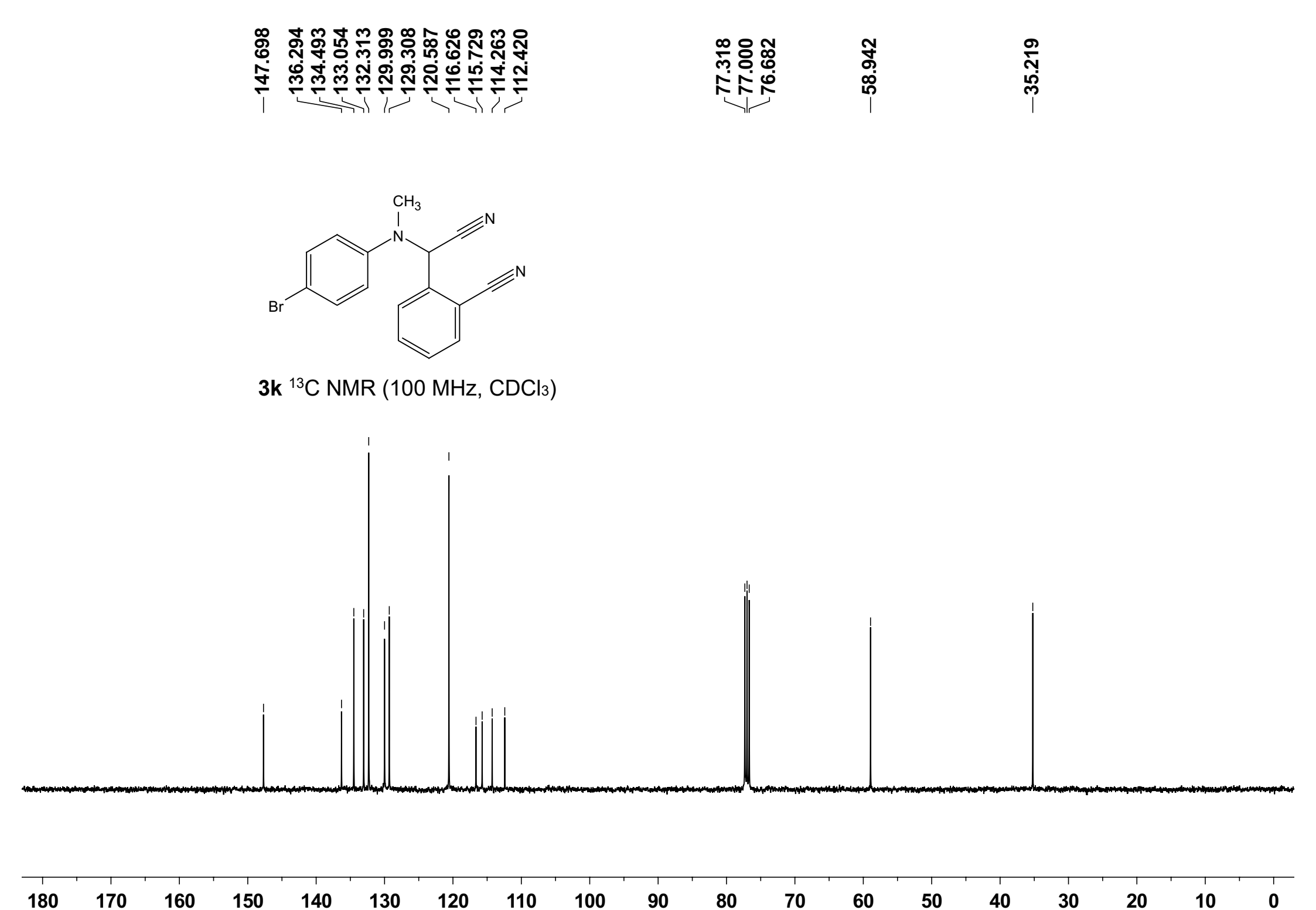


3k ^{1}H NMR (400 MHz, $CDCl_3$)



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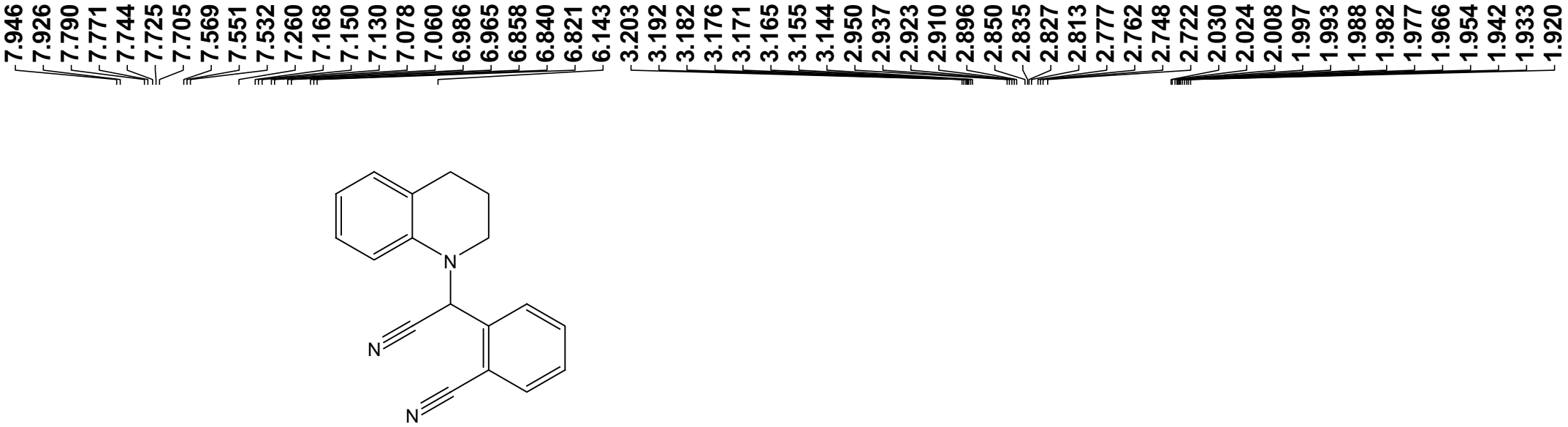
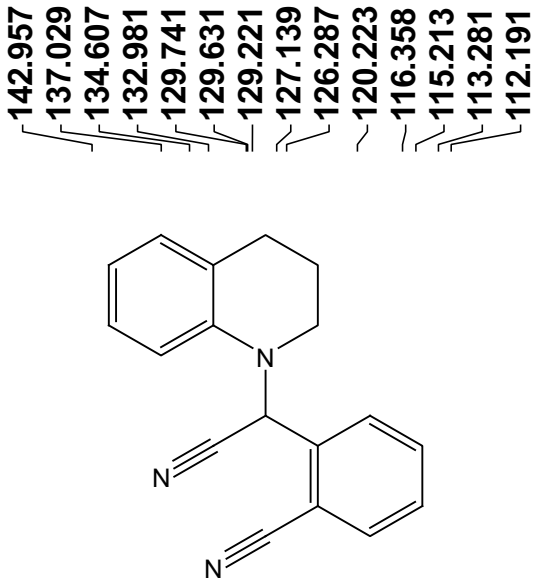
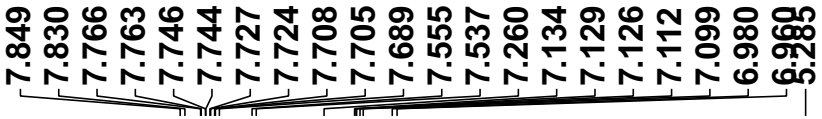
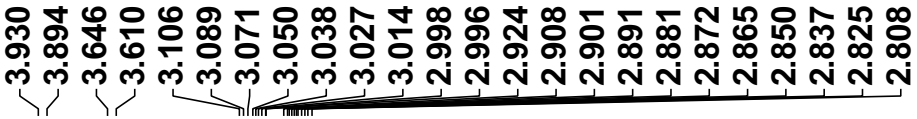


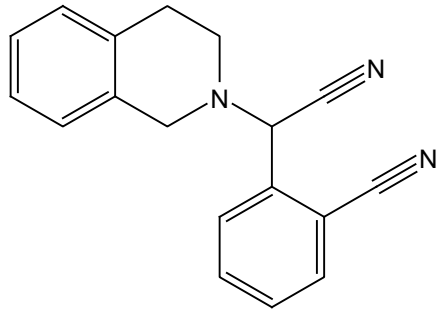
3l ^{1}H NMR (400 MHz, $CDCl_3$)



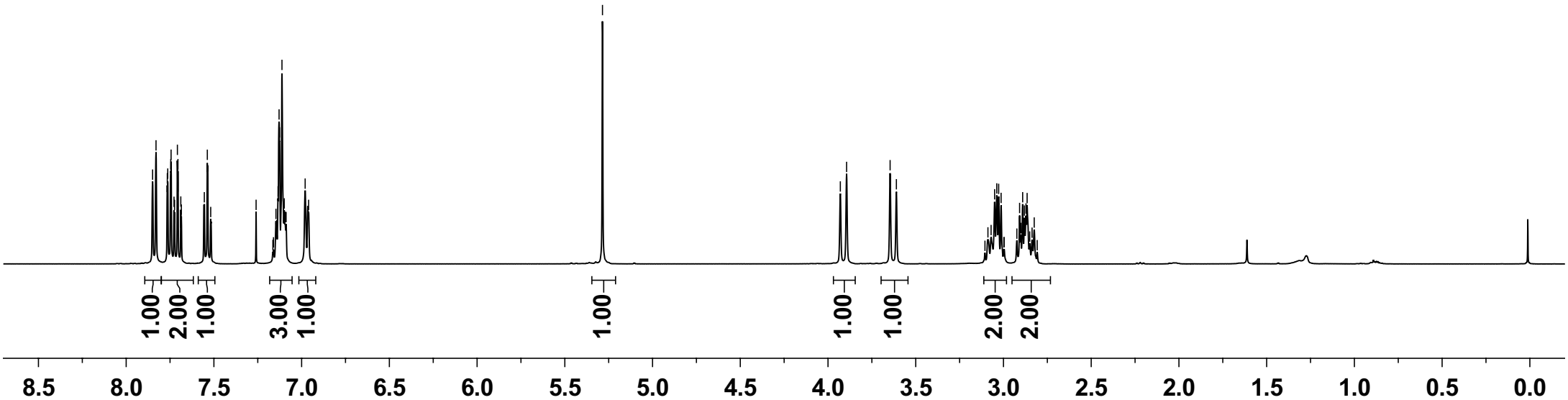
3l ^{13}C NMR (100 MHz, $CDCl_3$)

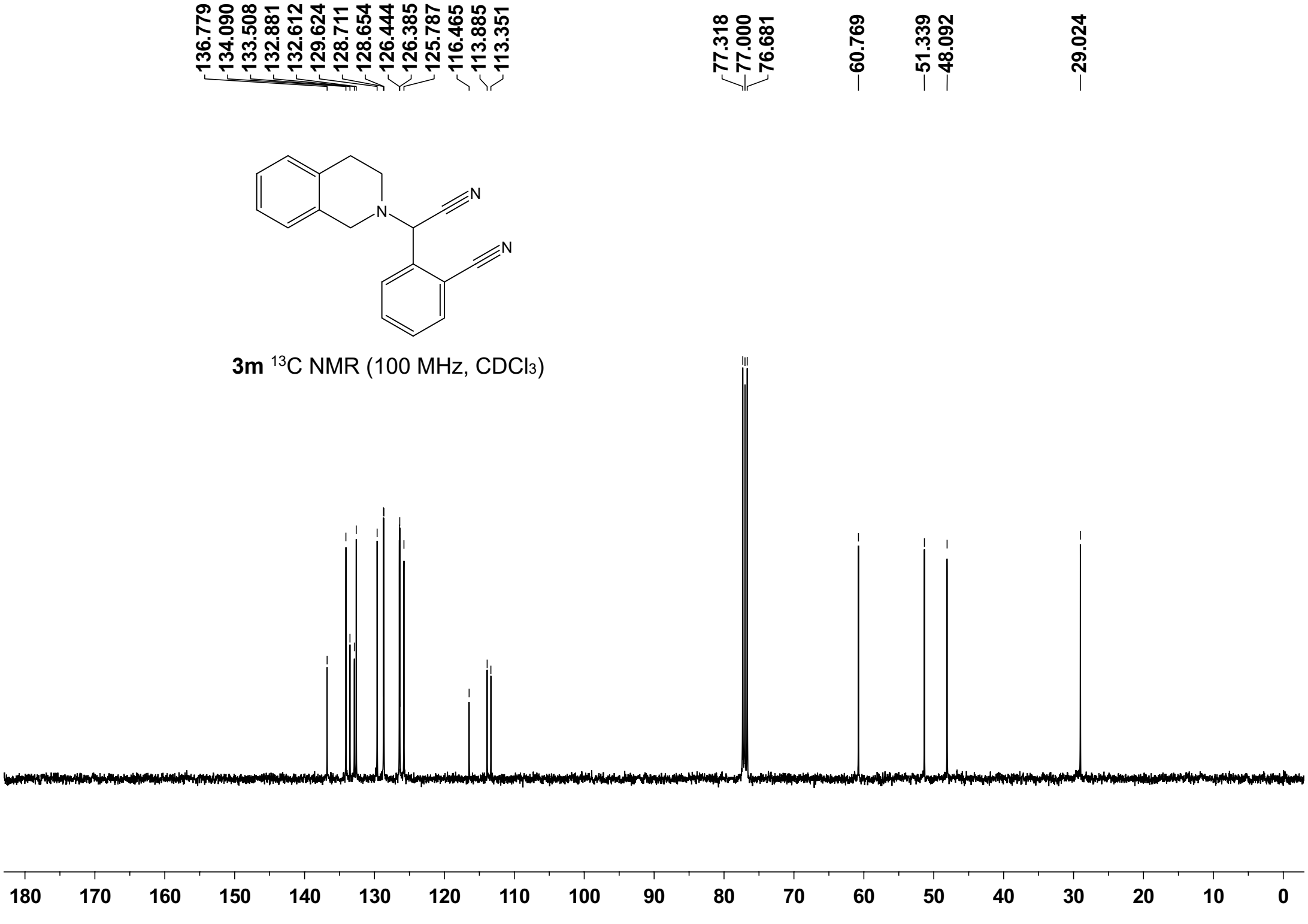




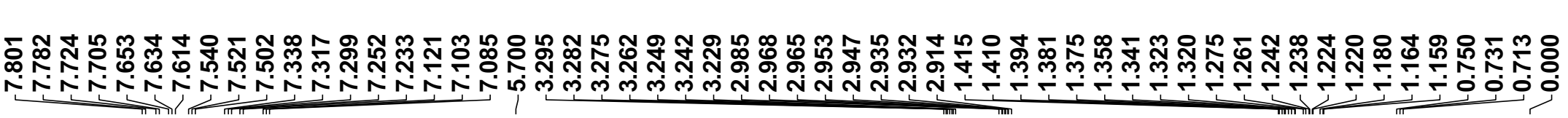


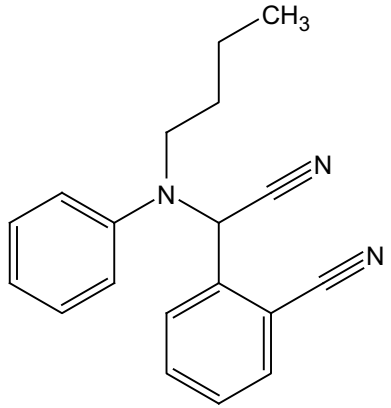
3m ^{1}H NMR (400 MHz, $CDCl_3$)



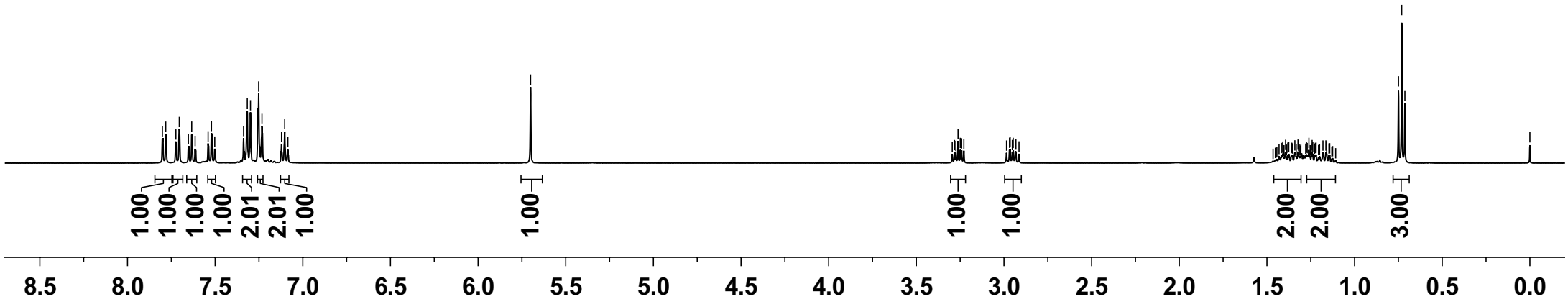


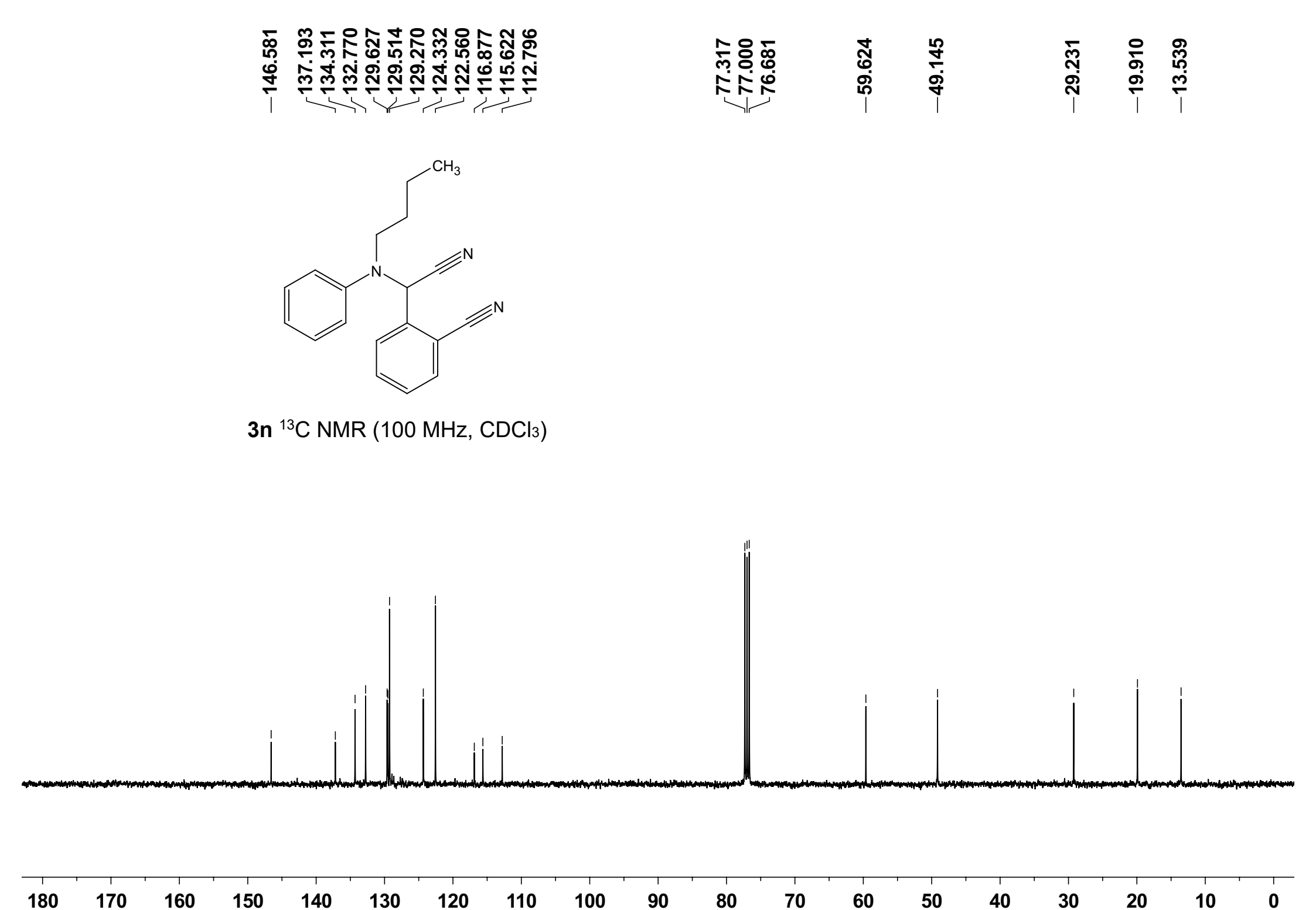
3m ^{13}C NMR (100 MHz, $CDCl_3$)



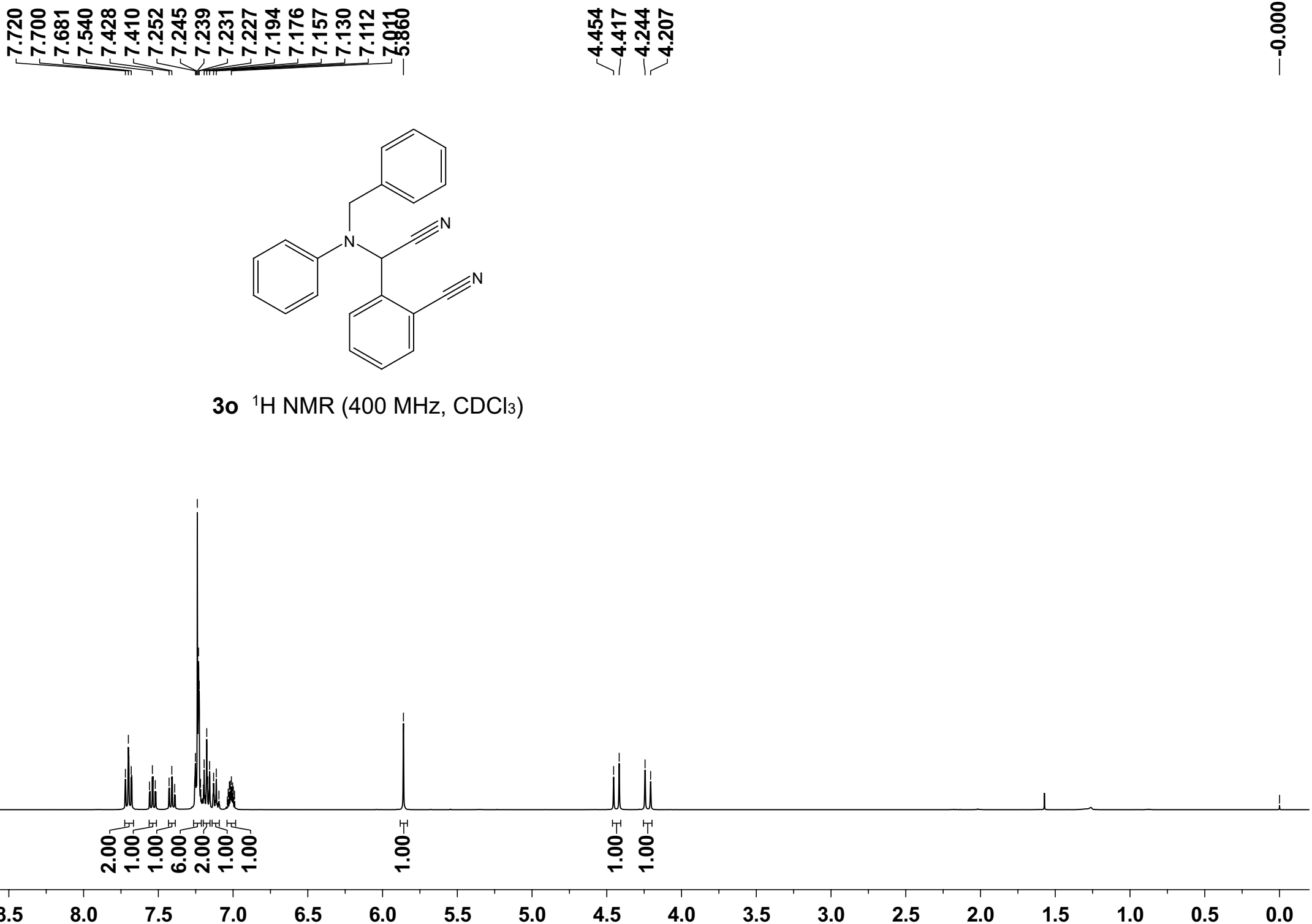


3n ^{1}H NMR (400 MHz, $CDCl_3$)

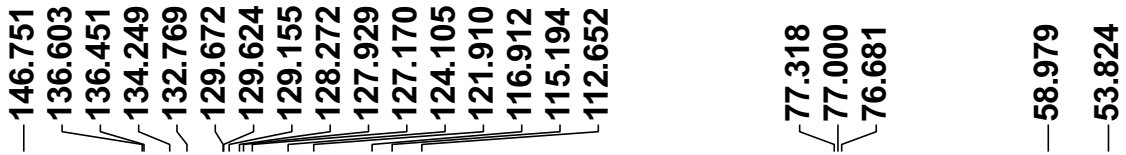


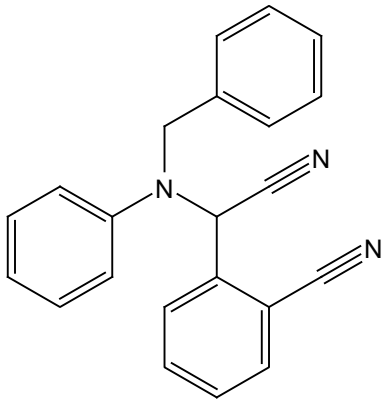


3n ^{13}C NMR (100 MHz, $CDCl_3$)

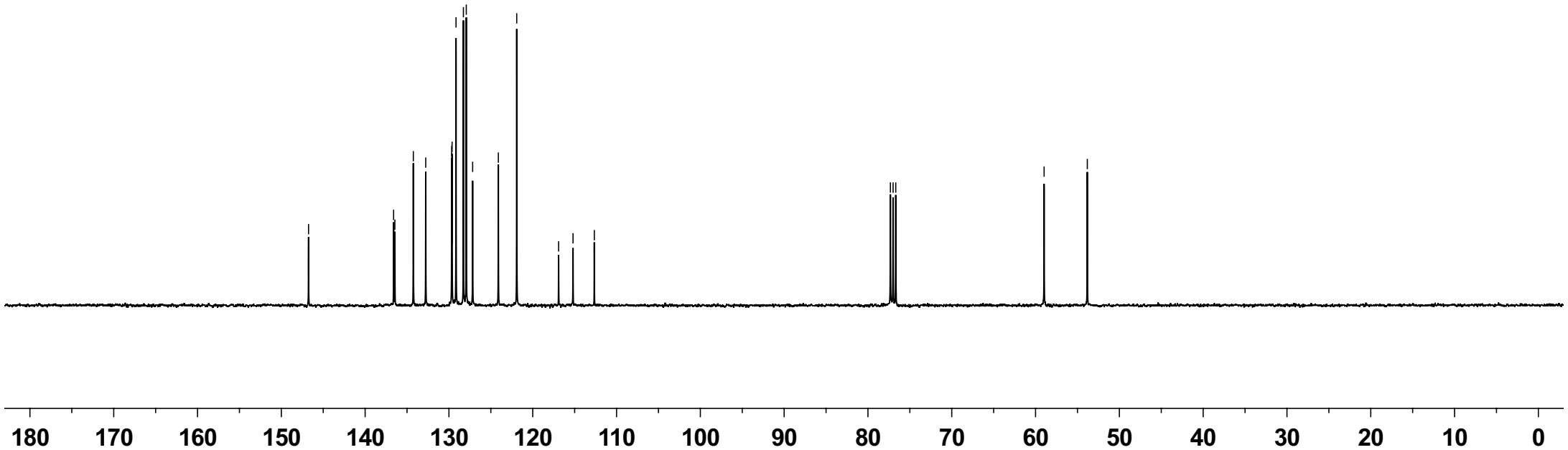


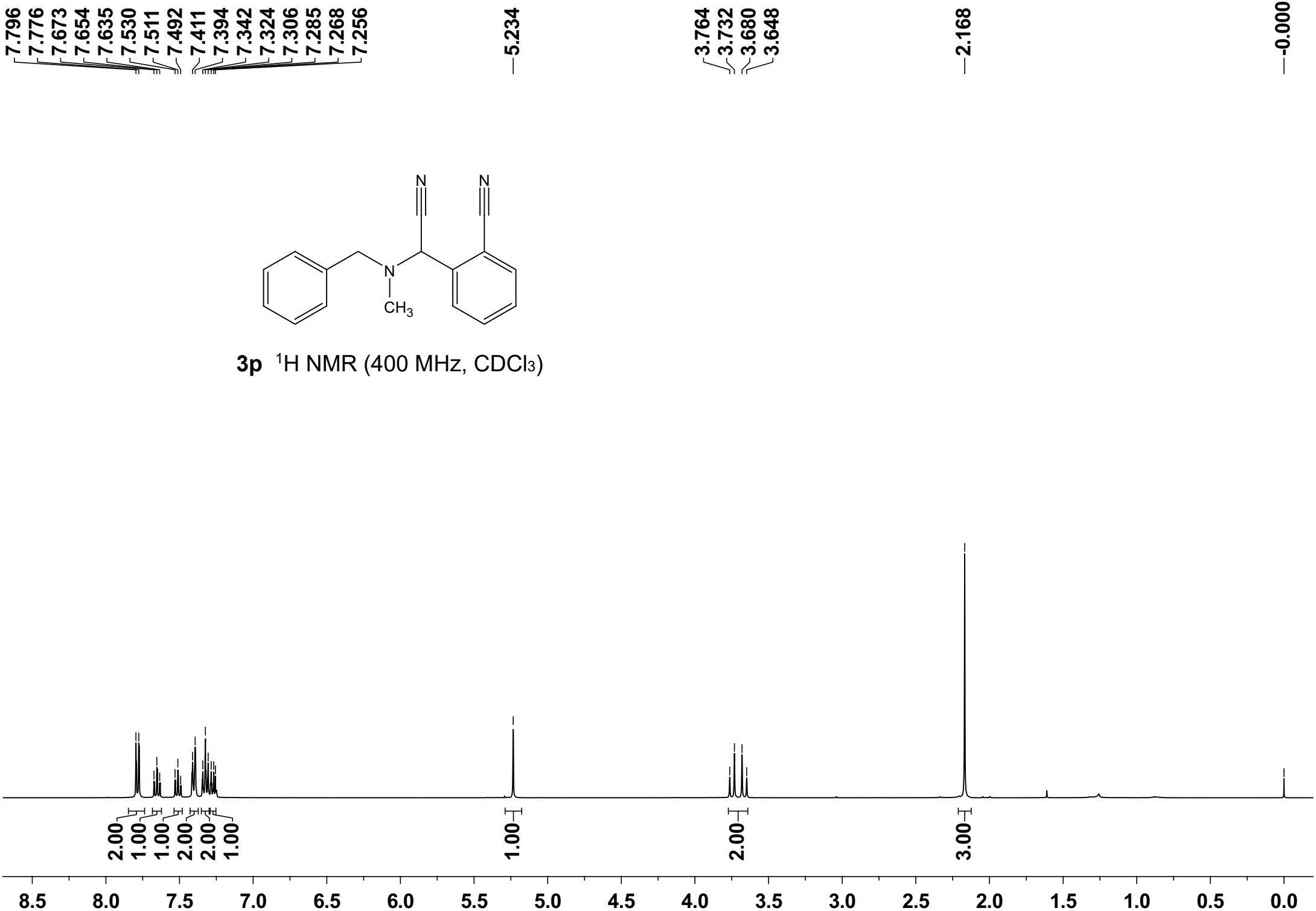
3o ^{1}H NMR (400 MHz, $CDCl_3$)



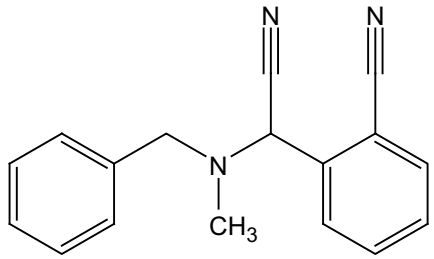


3o ^{13}C NMR (100 MHz, $CDCl_3$)

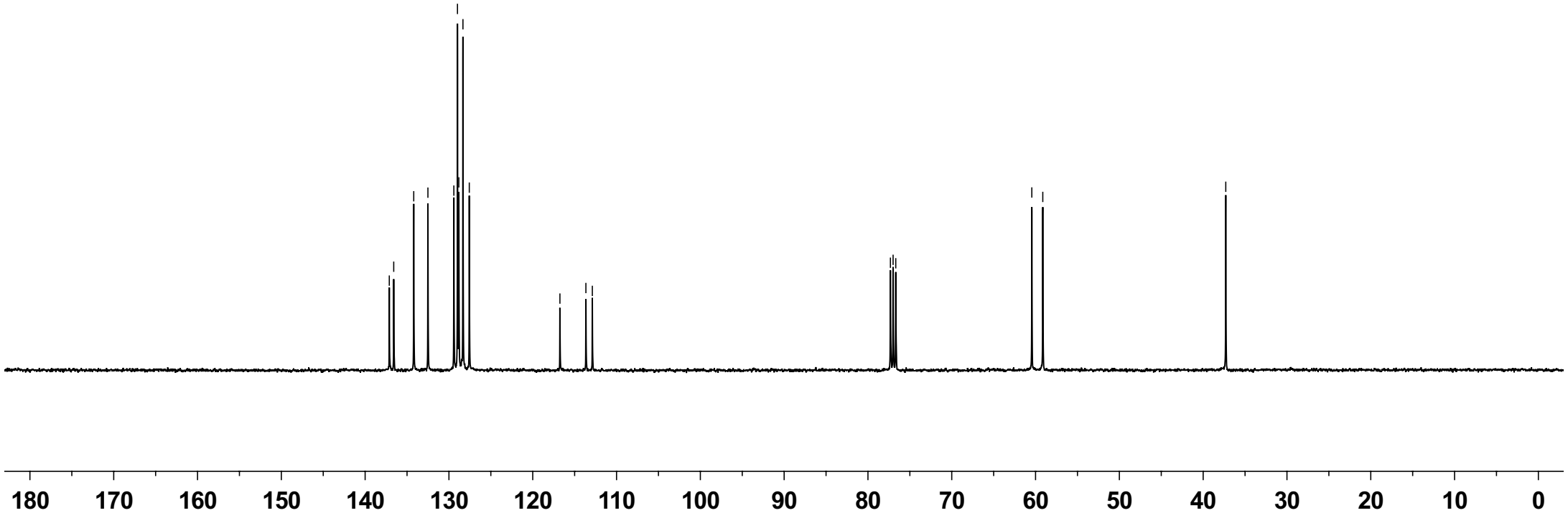


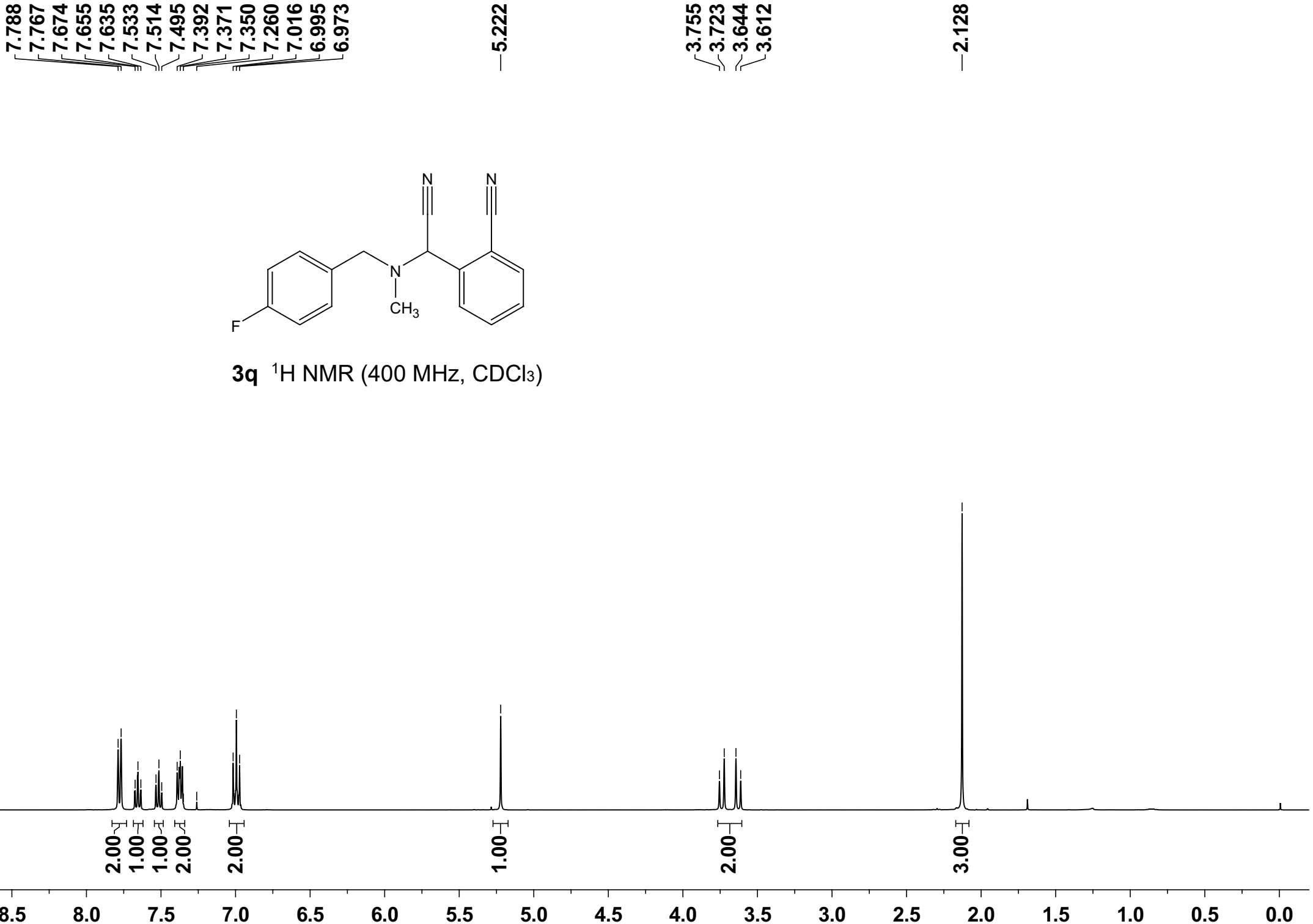


3p ^{1}H NMR (400 MHz, $CDCl_3$)

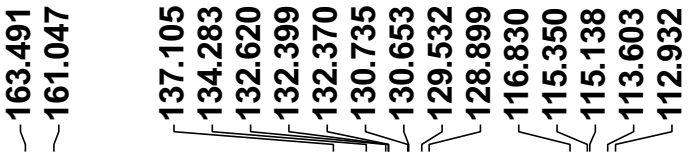


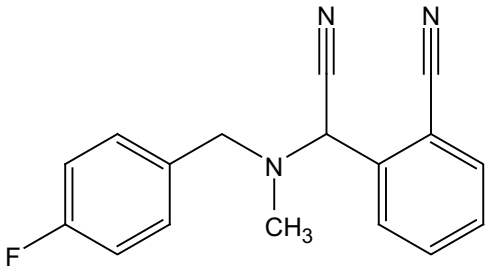
3p ^{13}C NMR (100 MHz, $CDCl_3$)



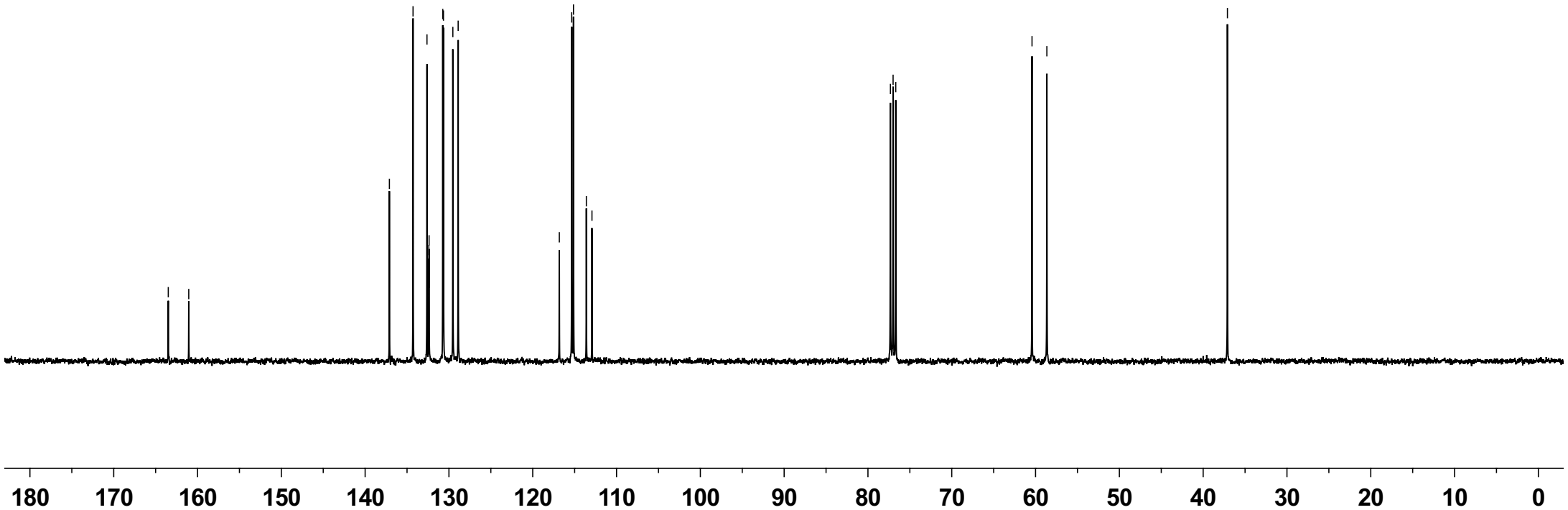


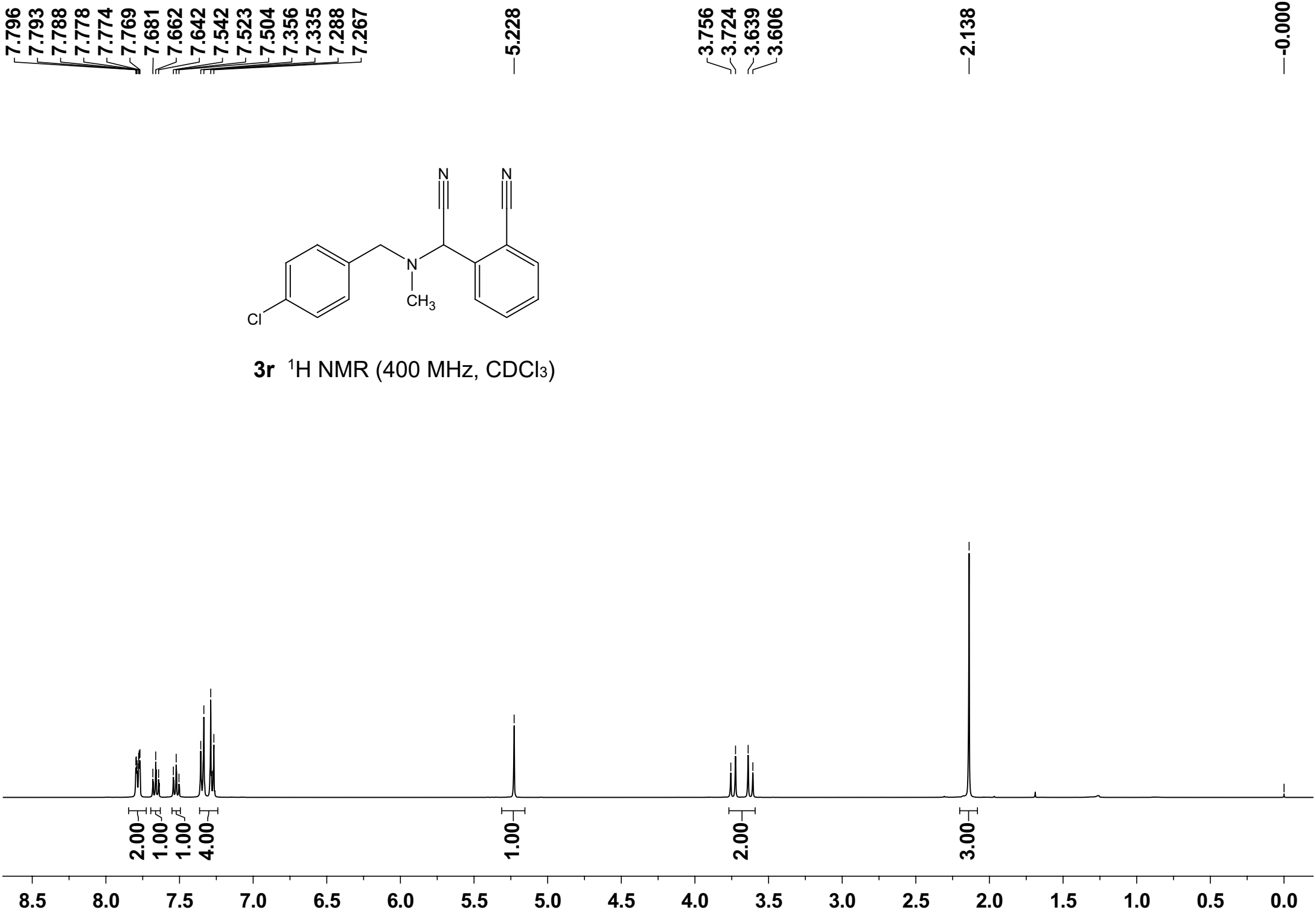
3q ^{1}H NMR (400 MHz, $CDCl_3$)



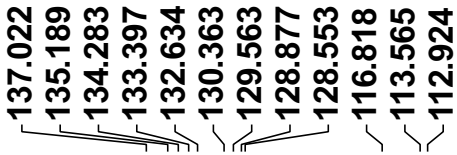


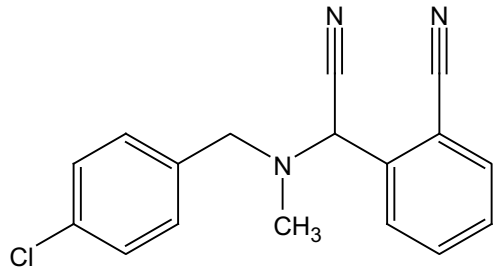
3q ^{13}C NMR (100 MHz, $CDCl_3$)



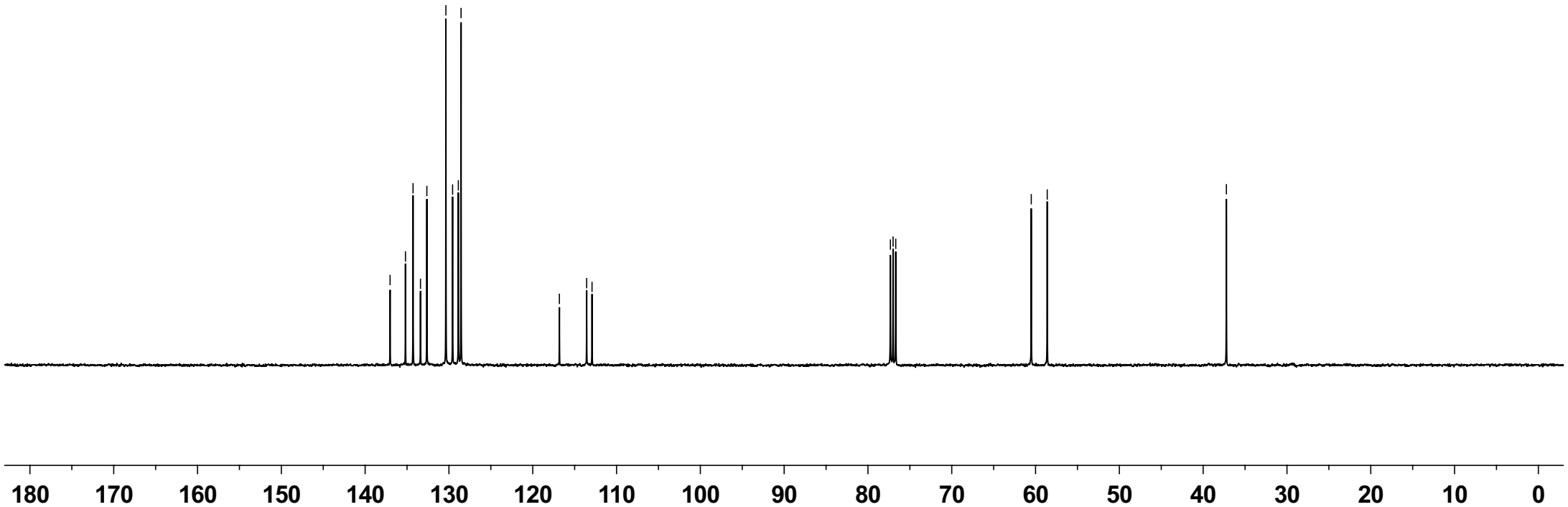


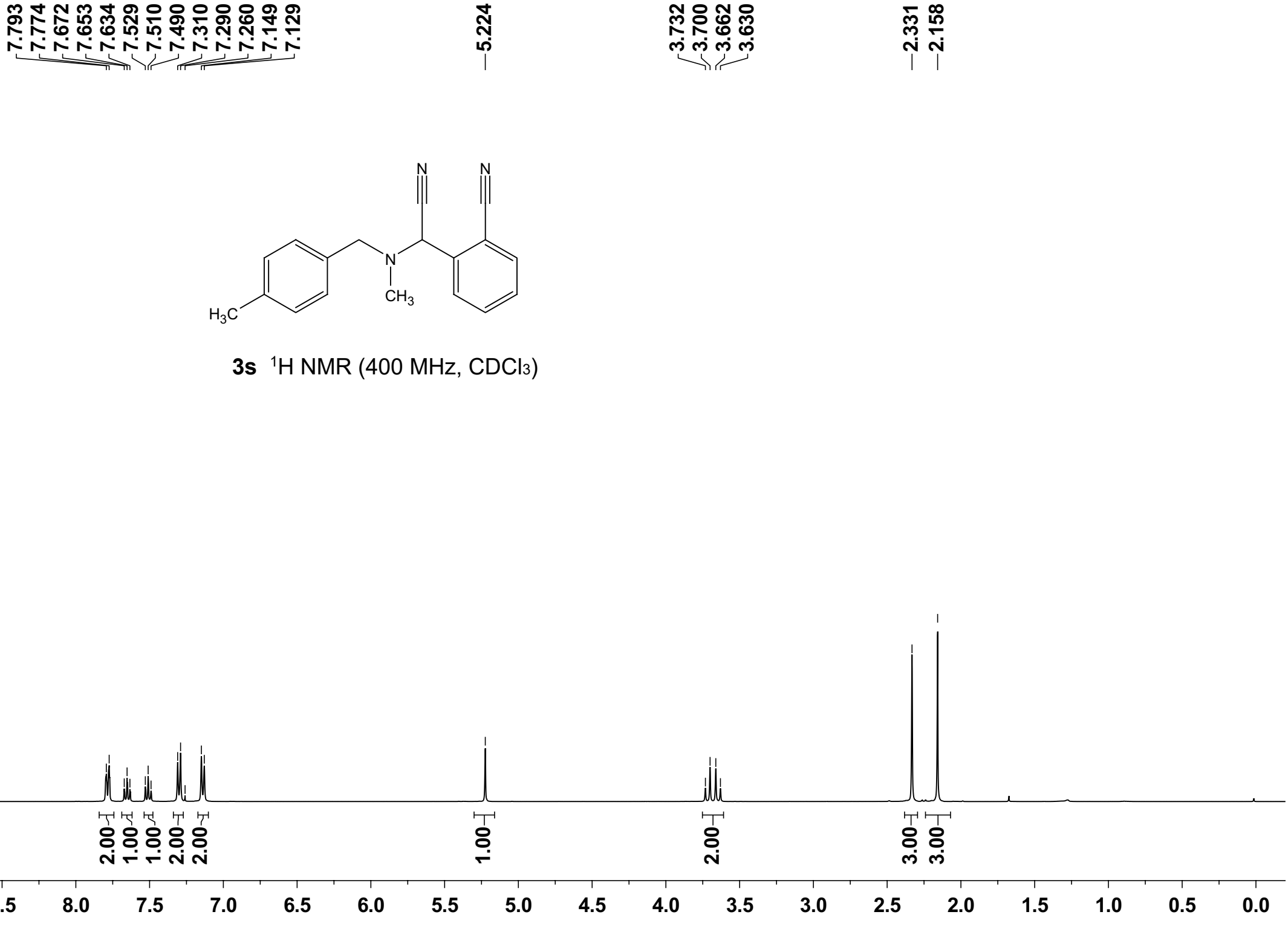
3r ^{1}H NMR (400 MHz, $CDCl_3$)



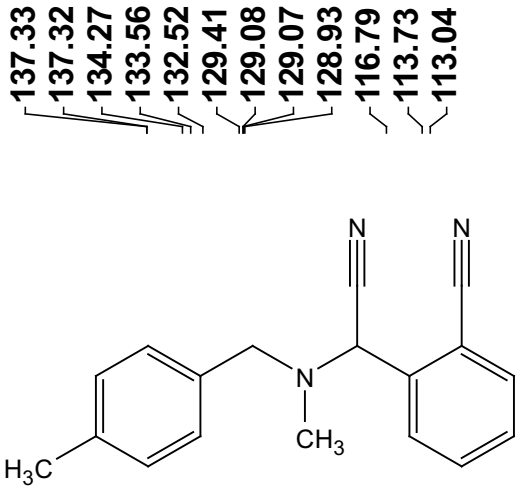


3r ^{13}C NMR (100 MHz, $CDCl_3$)

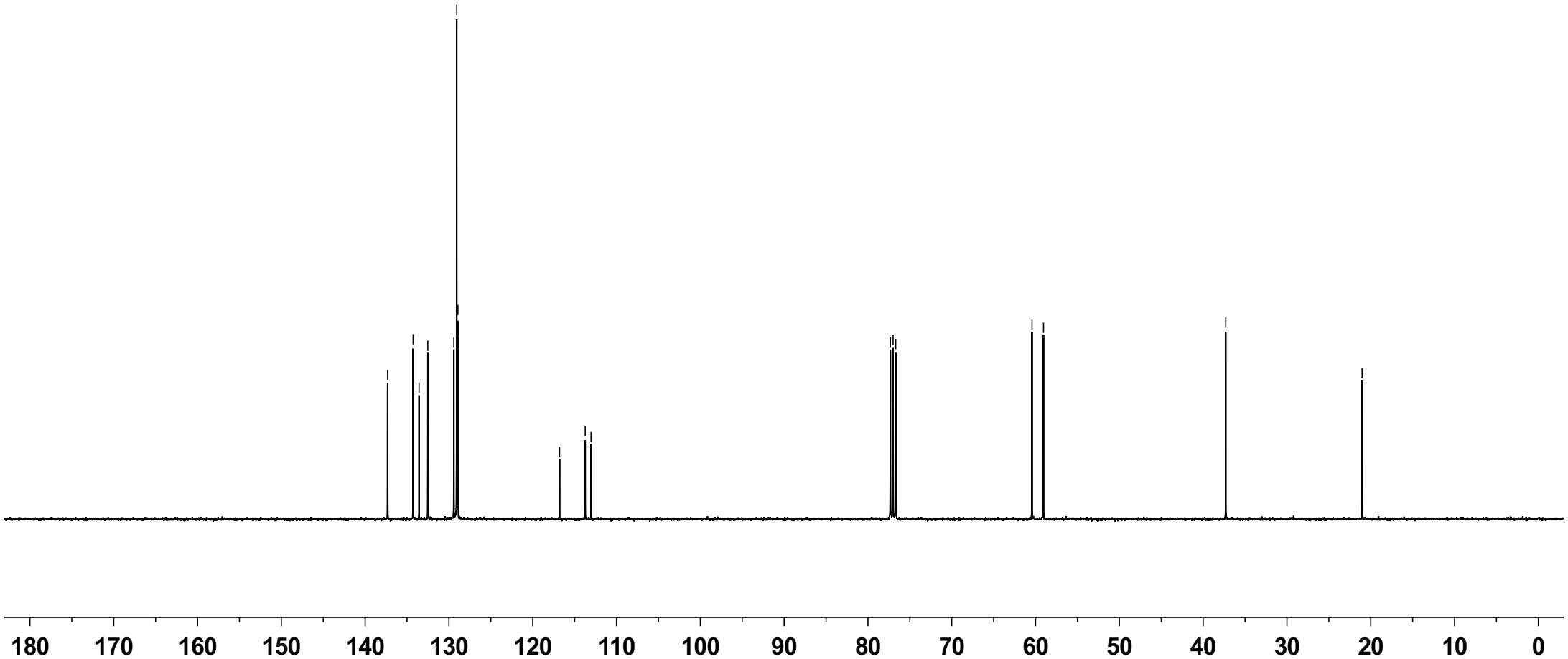


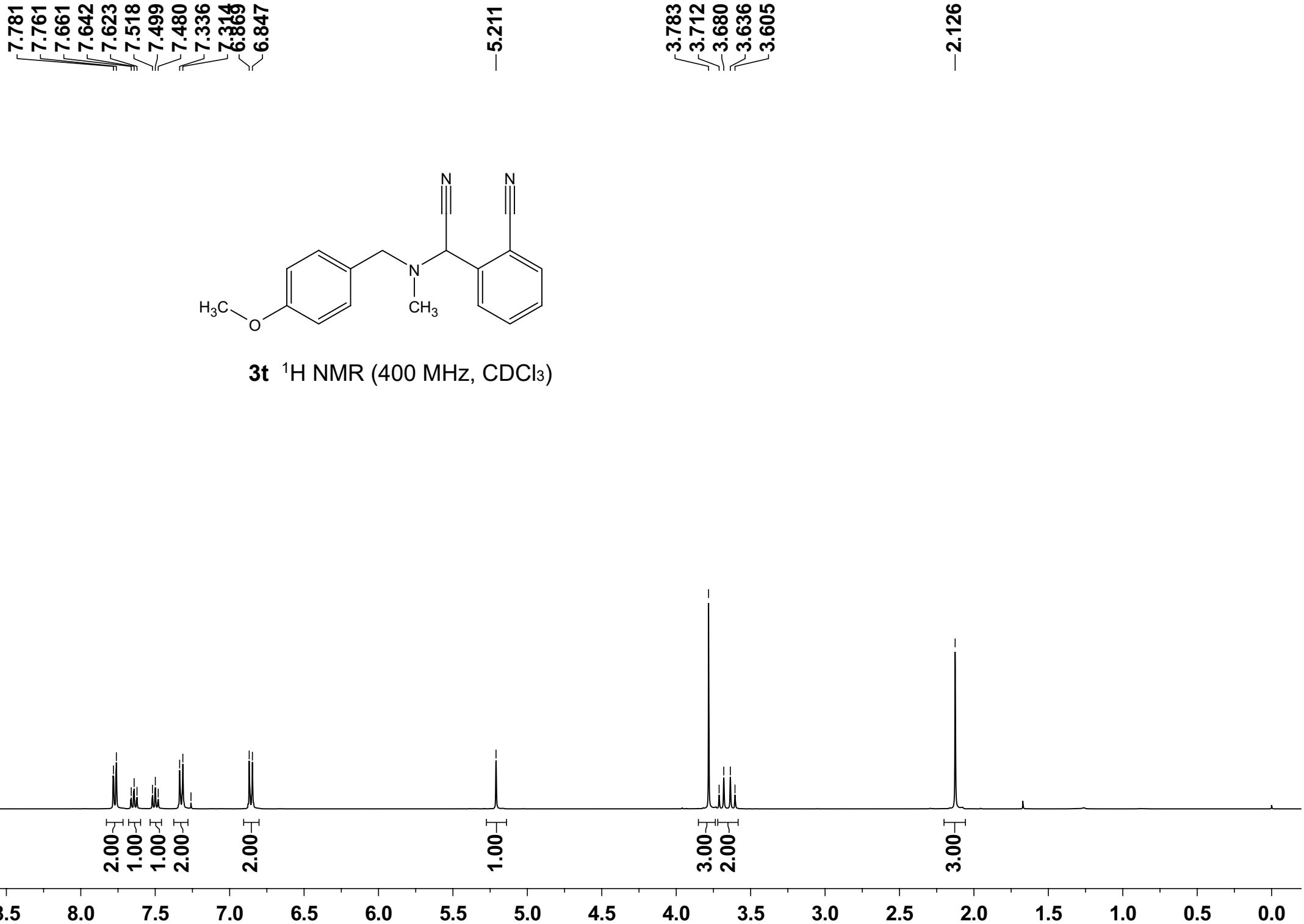


3s ^{1}H NMR (400 MHz, $CDCl_3$)

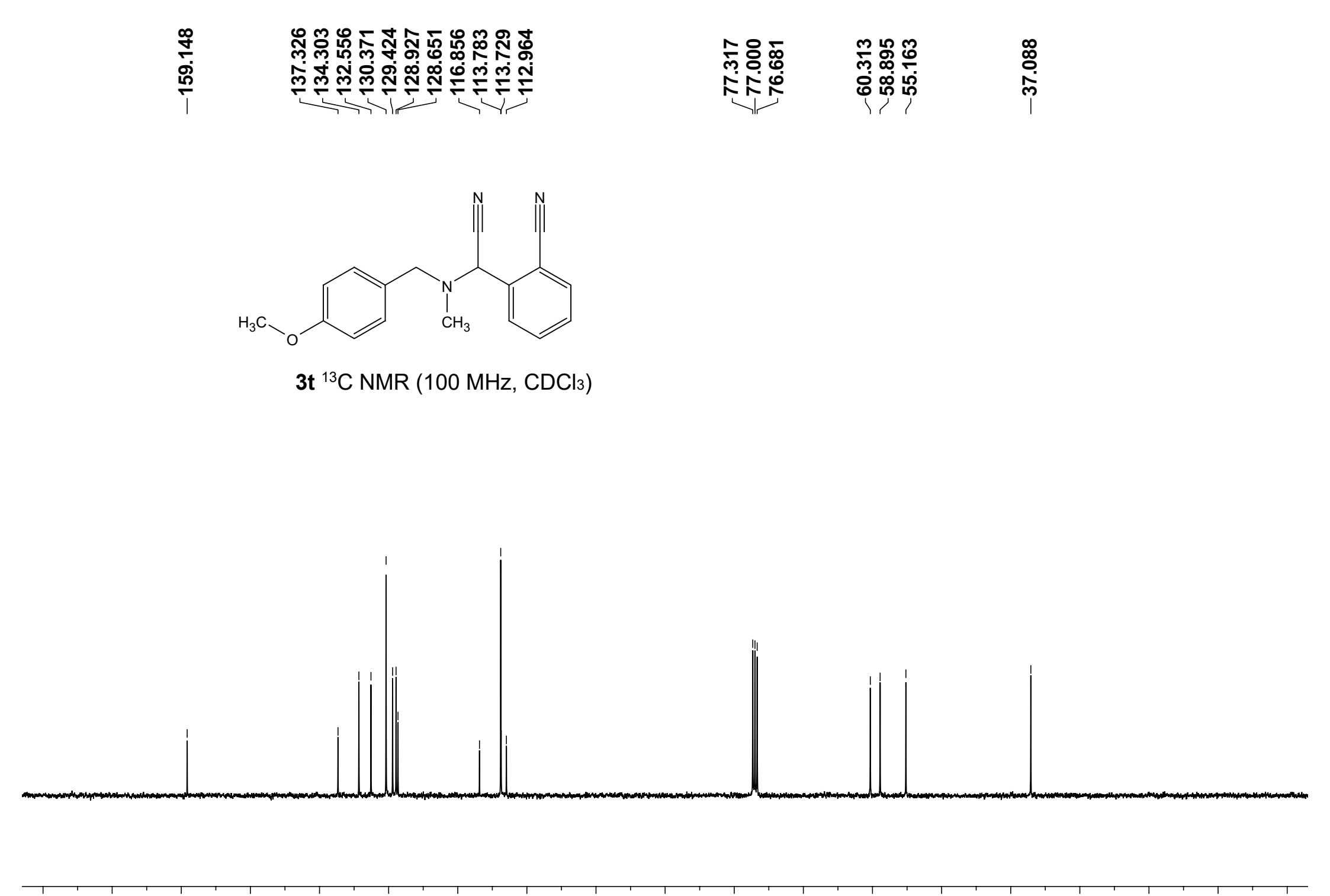


3s ^{13}C NMR (100 MHz, $CDCl_3$)

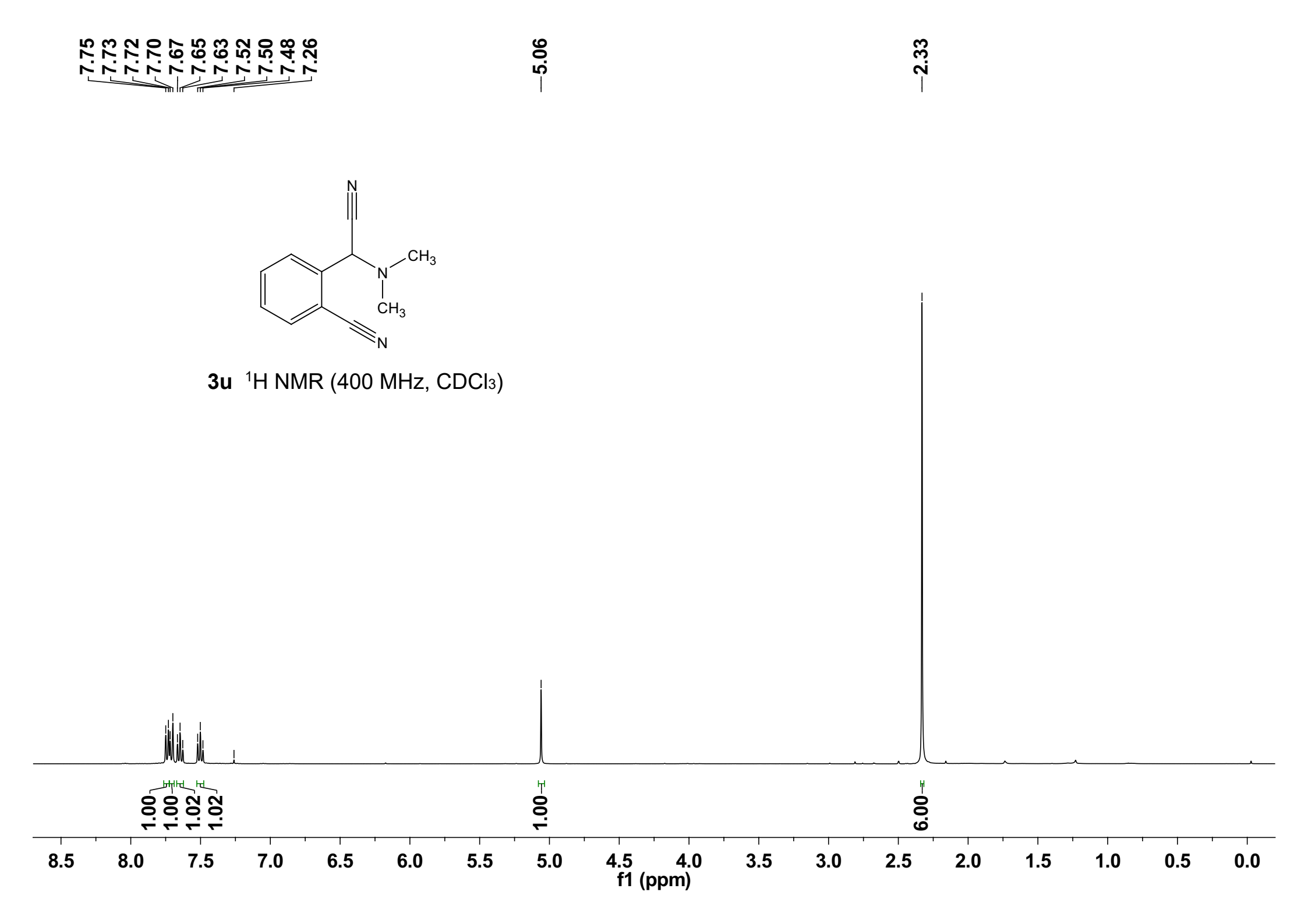




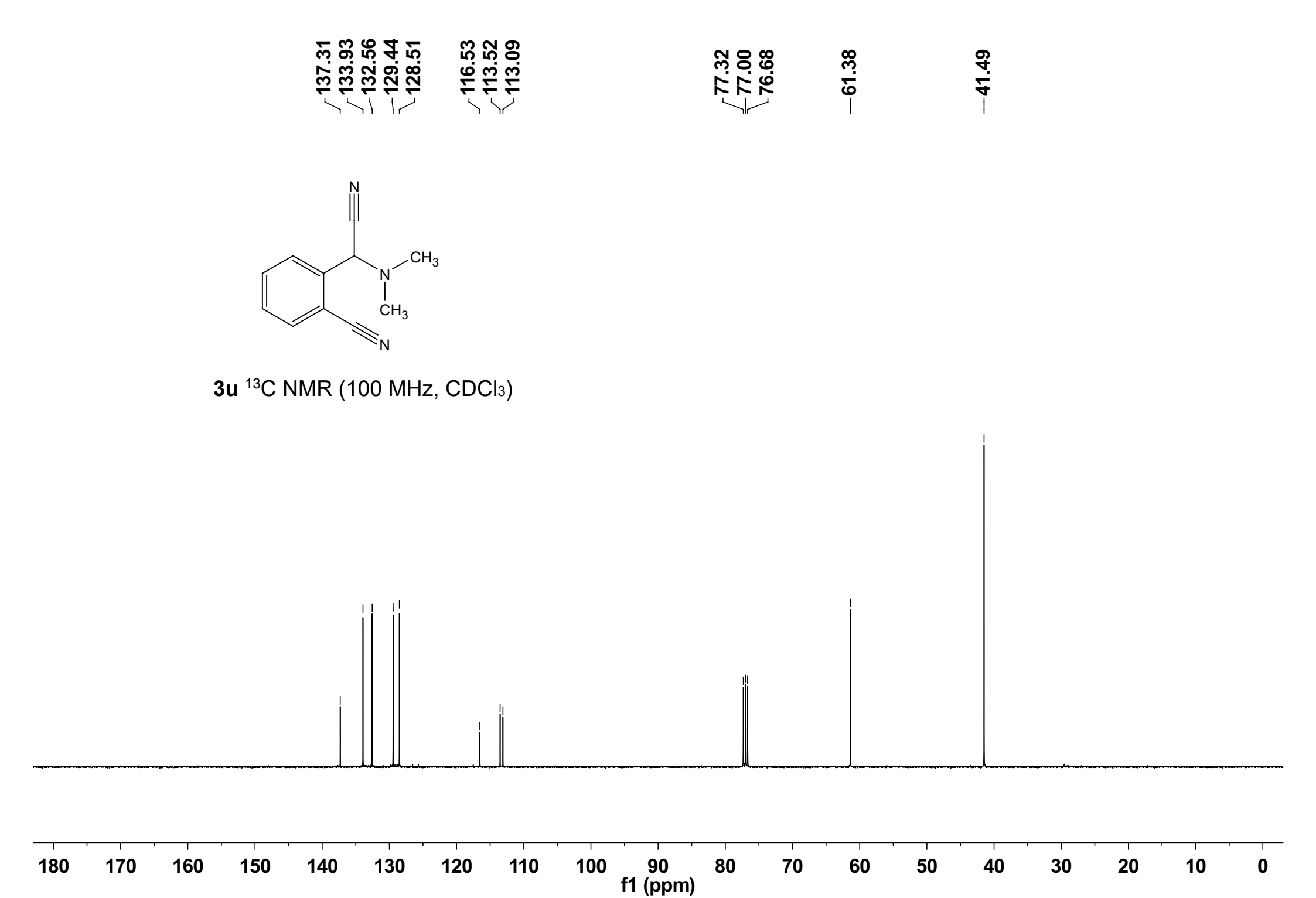
3t ^{1}H NMR (400 MHz, $CDCl_3$)



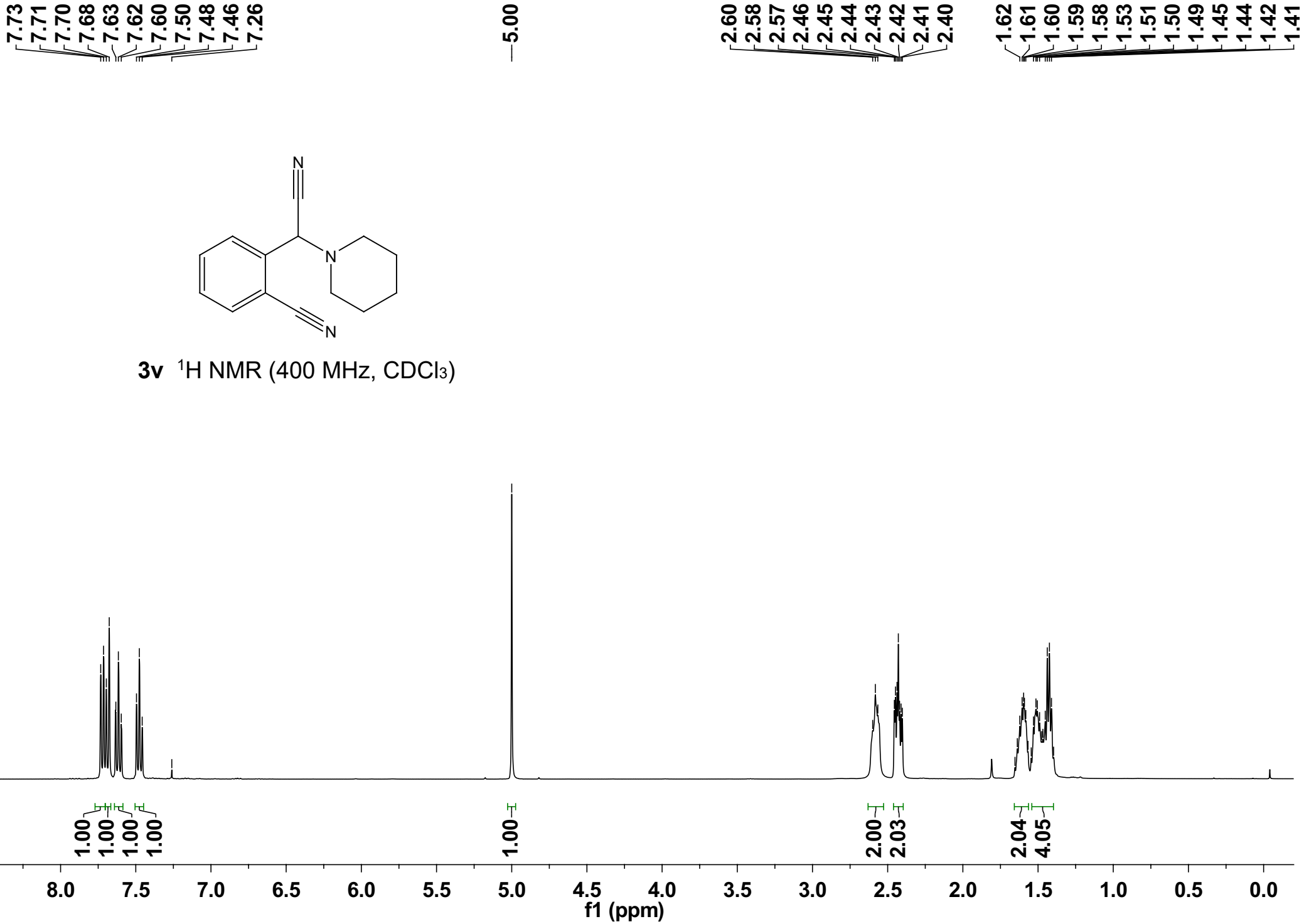
3t ^{13}C NMR (100 MHz, $CDCl_3$)



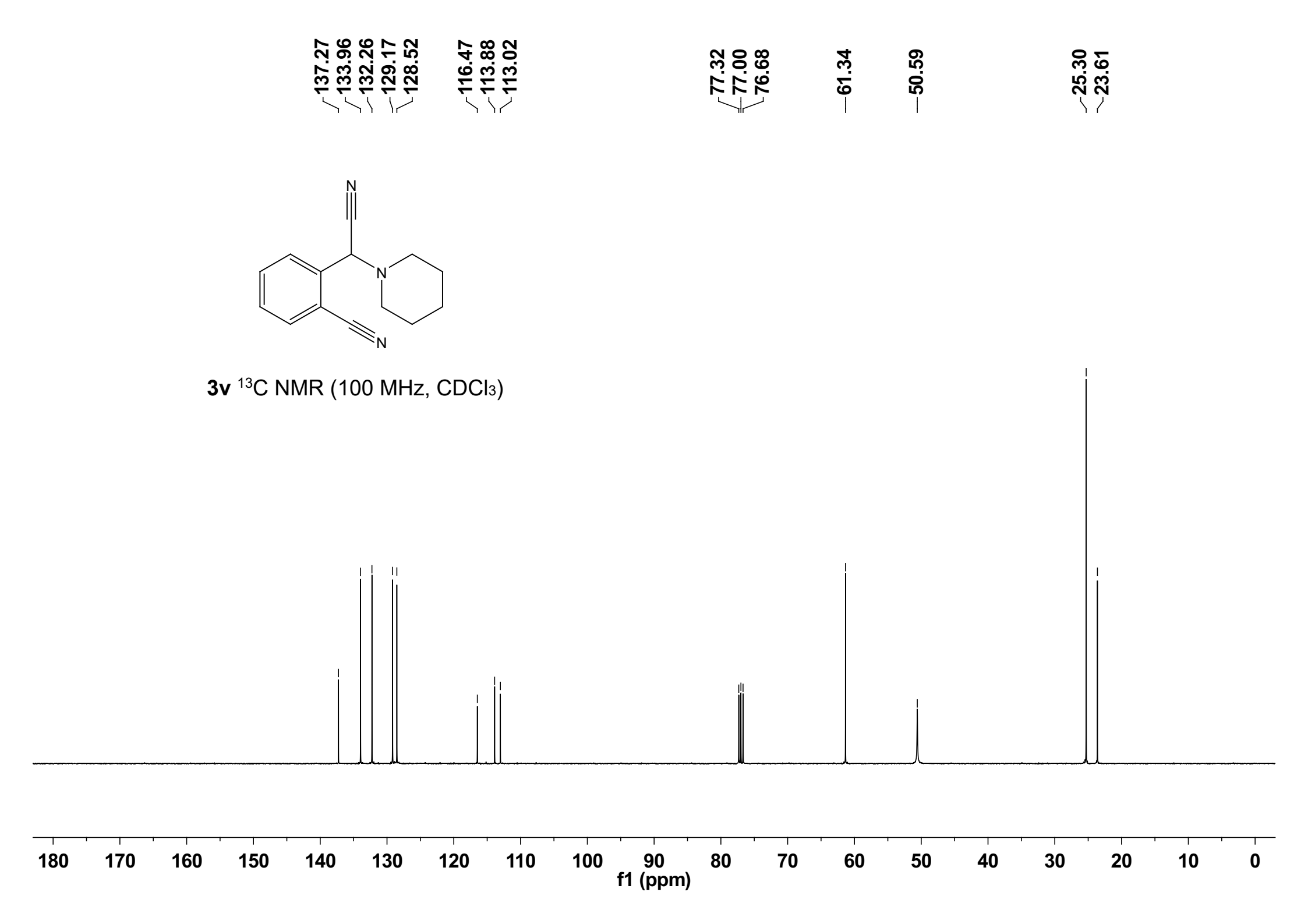
3u ^{1}H NMR (400 MHz, $CDCl_3$)

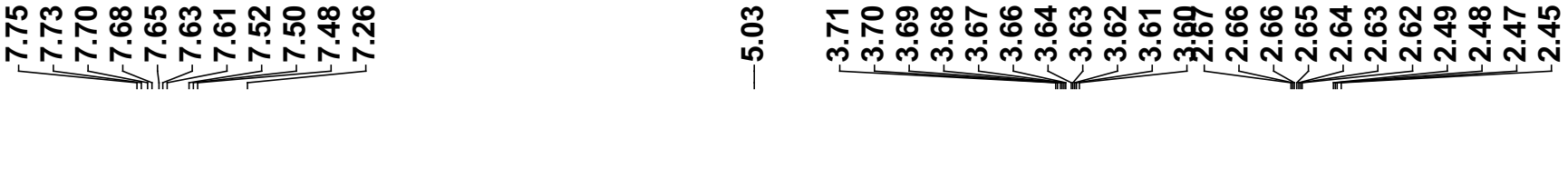


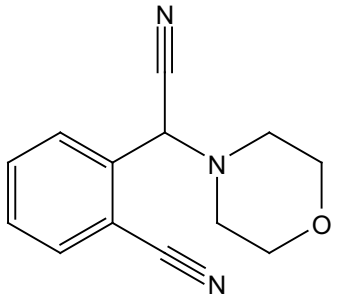
3u ^{13}C NMR (100 MHz, $CDCl_3$)



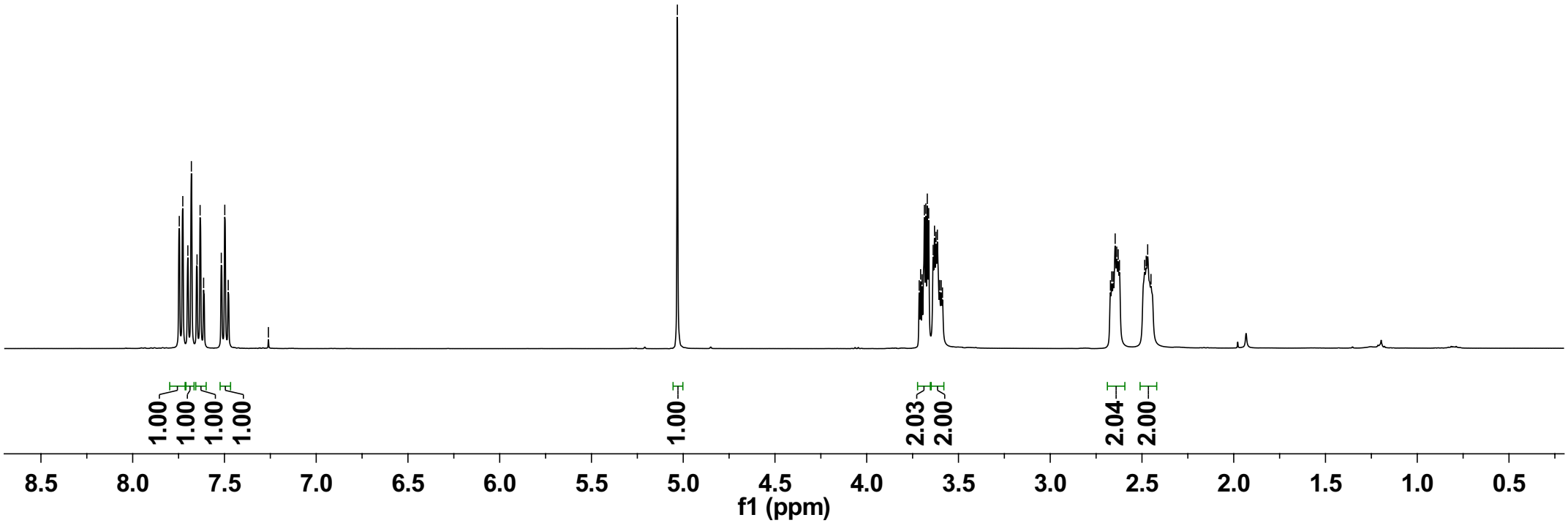
3v ^{1}H NMR (400 MHz, $CDCl_3$)

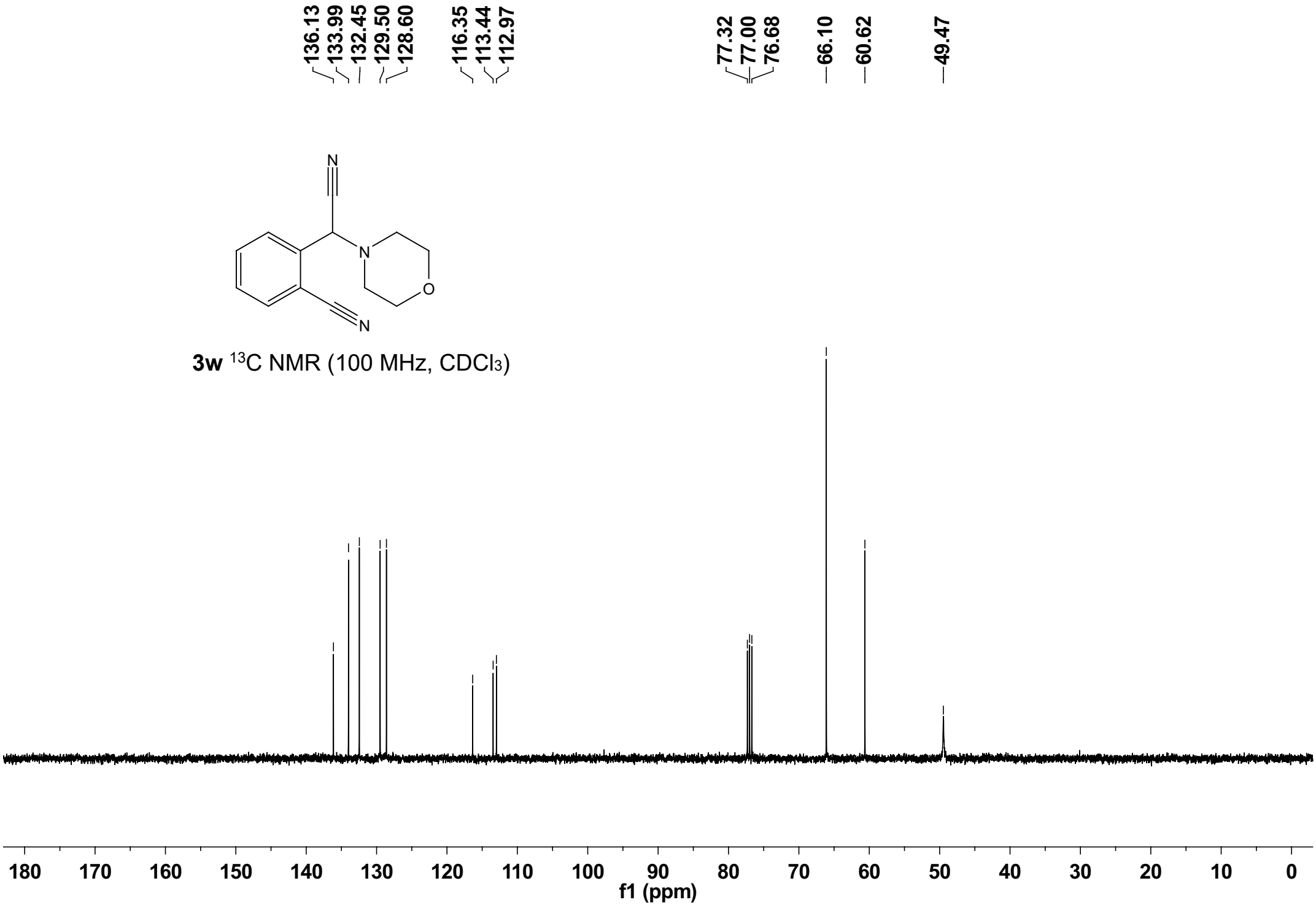

137.27
133.96
132.26
129.17
128.52
116.47
113.88
113.02
77.32
77.00
76.68
61.34
50.59
25.30
23.61
N
N
N
3v 13C NMR (100 MHz, CDCl3)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)



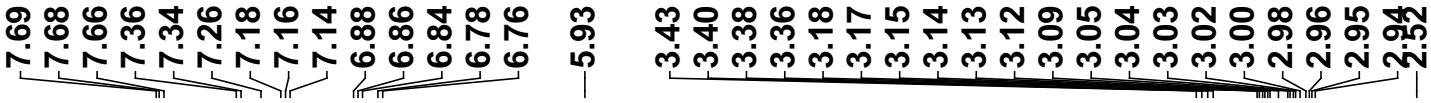


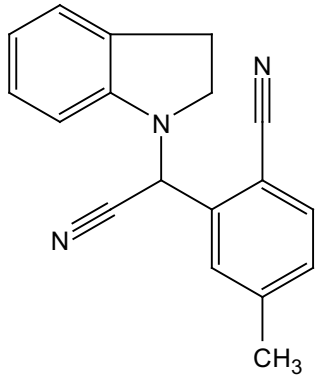
3w ^{1}H NMR (400 MHz, $CDCl_3$)



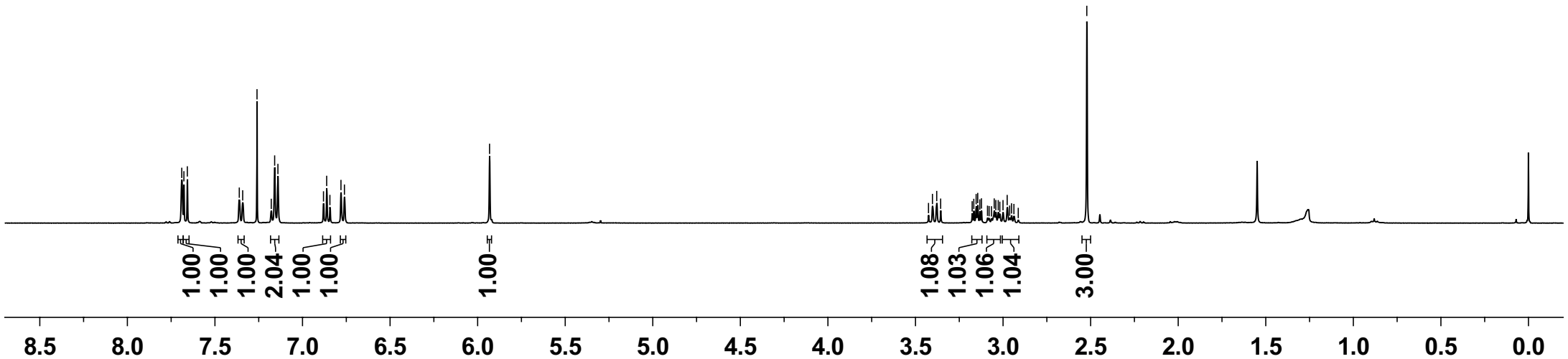


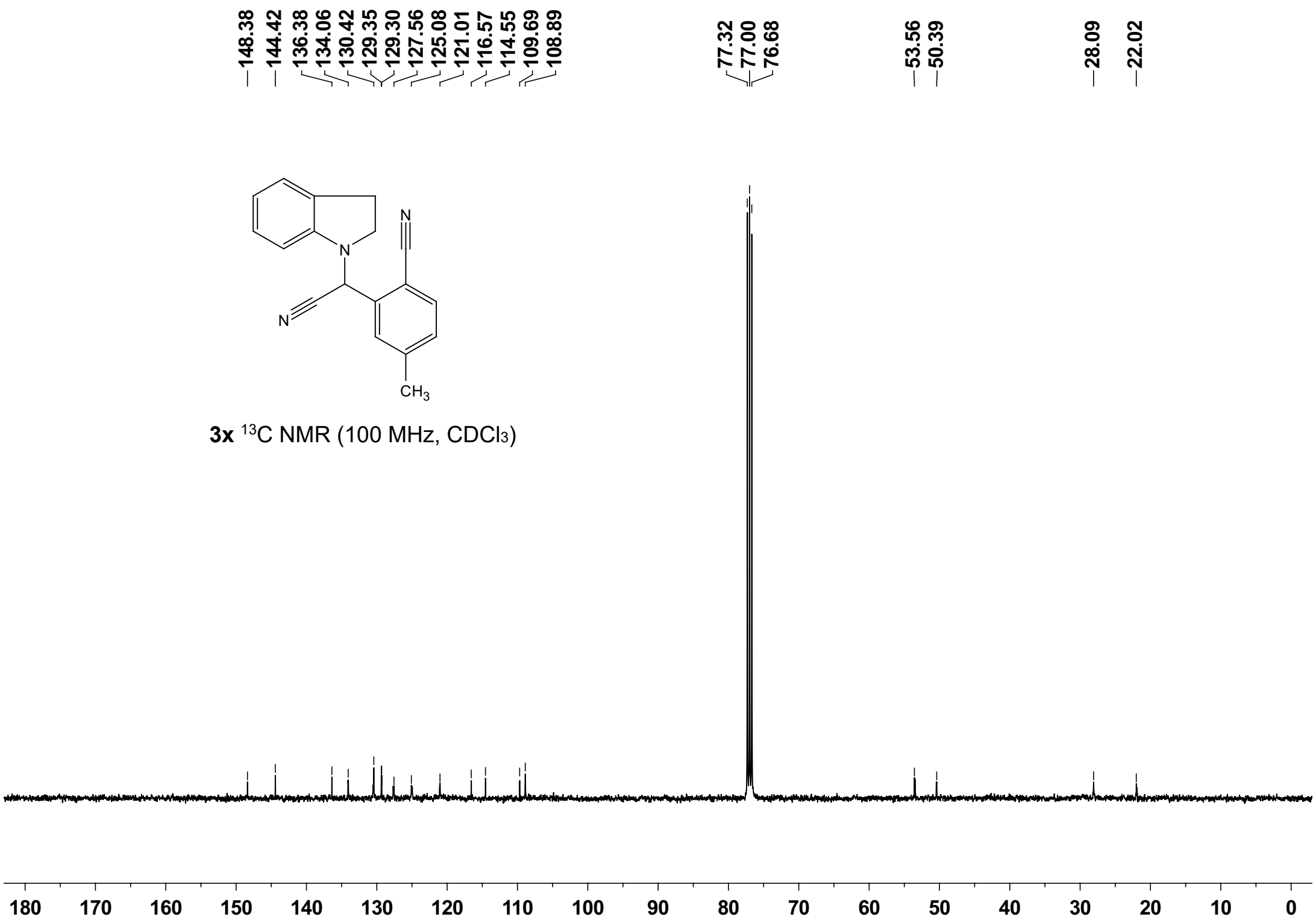
3w ^{13}C NMR (100 MHz, $CDCl_3$)



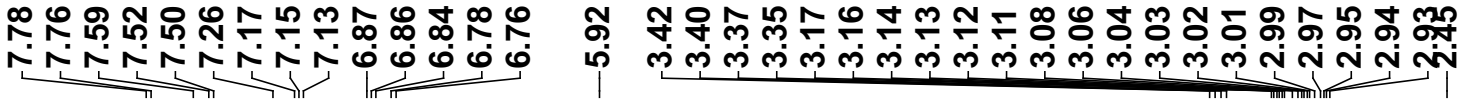


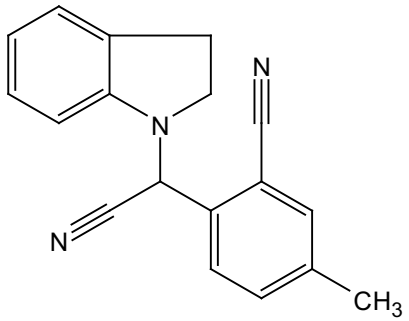
3x ^{1}H NMR (400 MHz, $CDCl_3$)



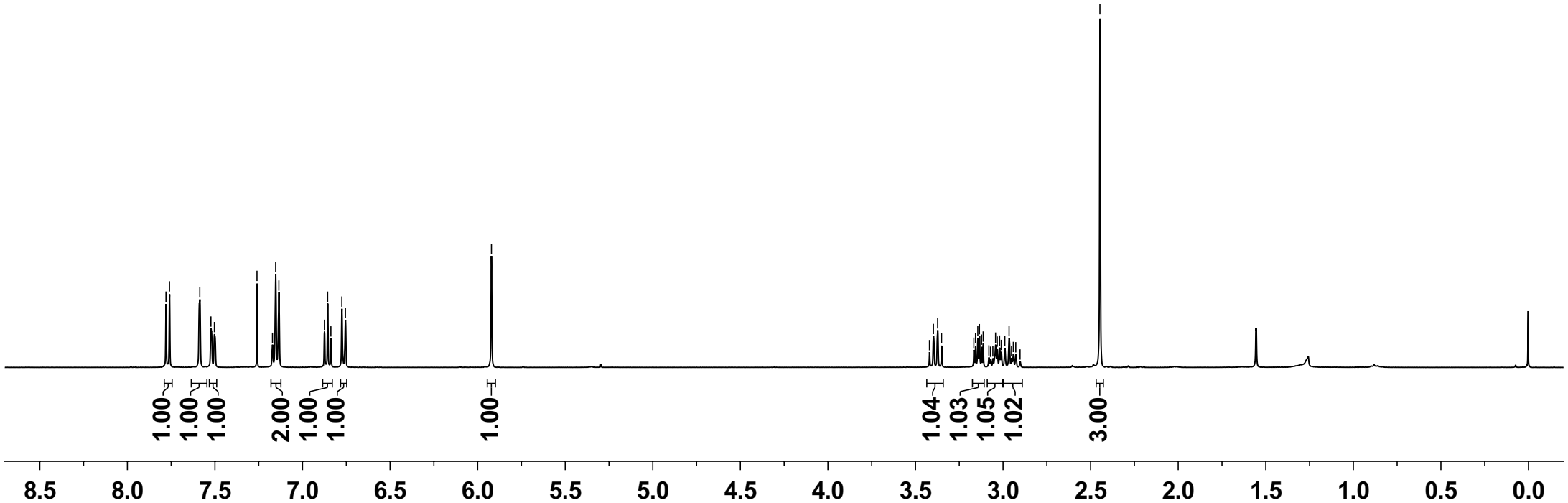


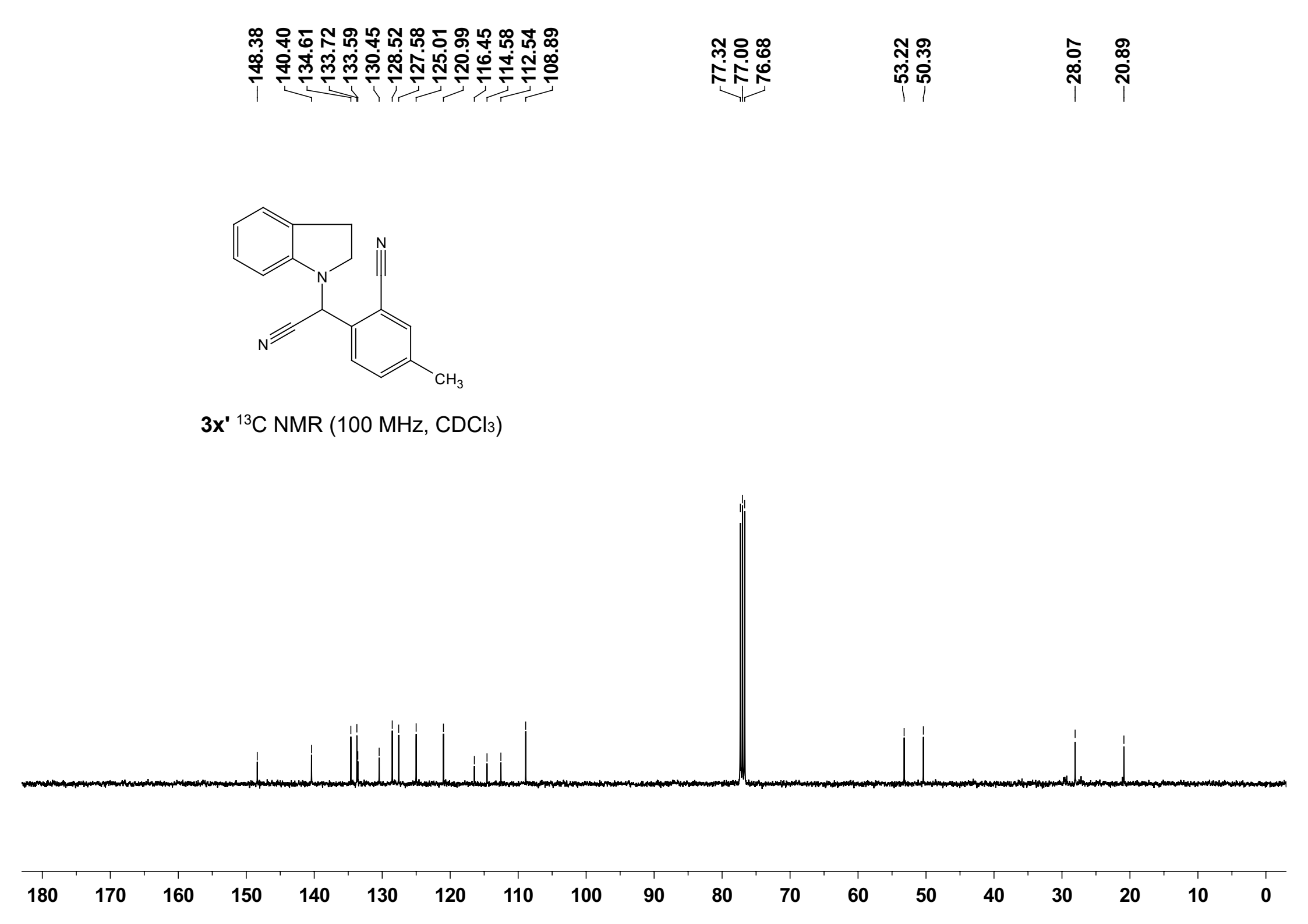
3x ^{13}C NMR (100 MHz, $CDCl_3$)



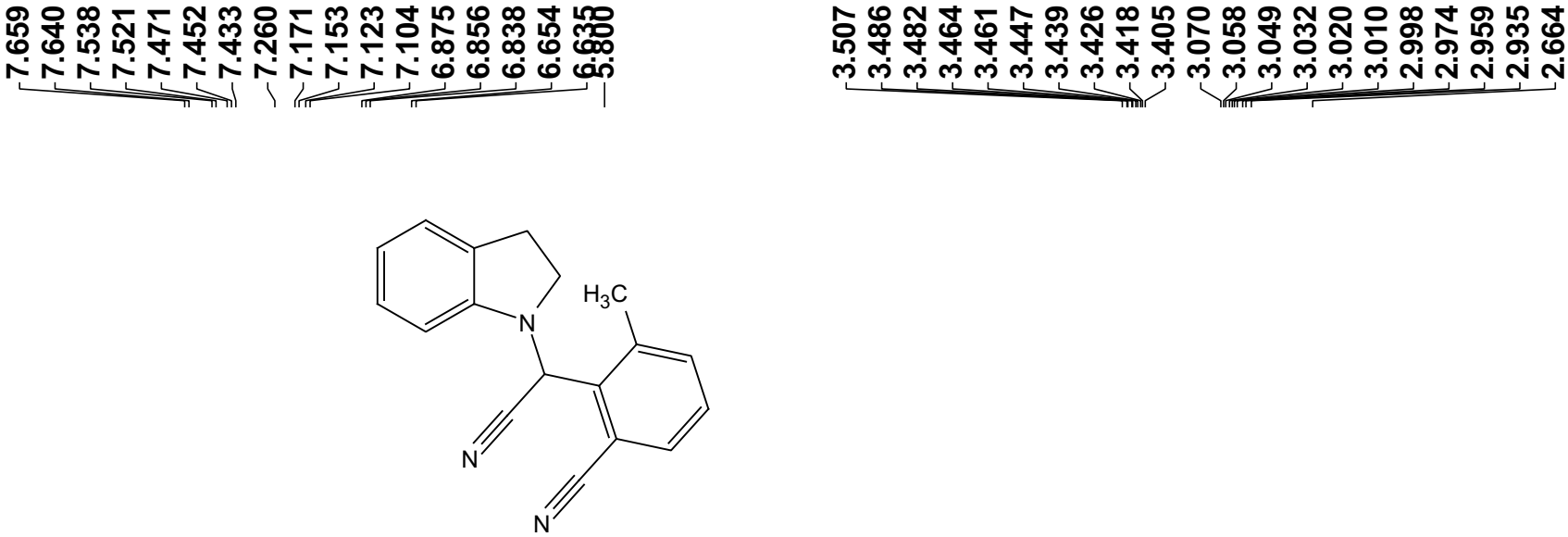


3x' ^{1}H NMR (400 MHz, $CDCl_3$)

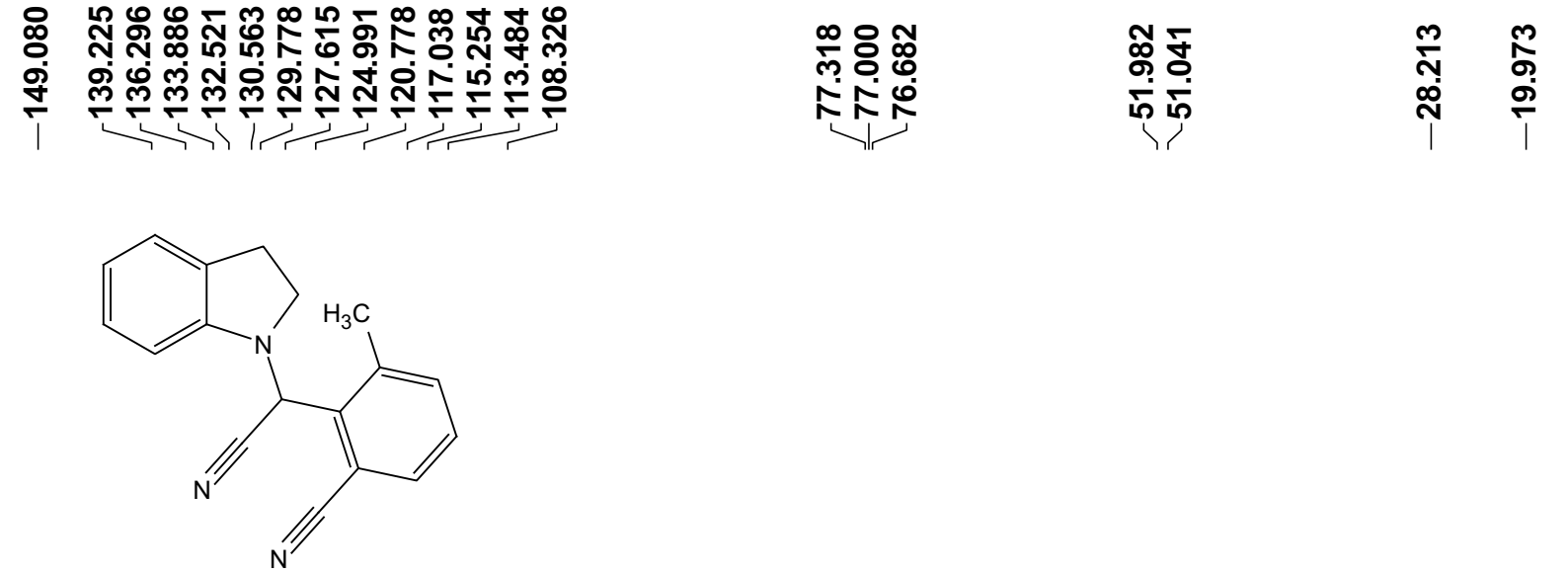




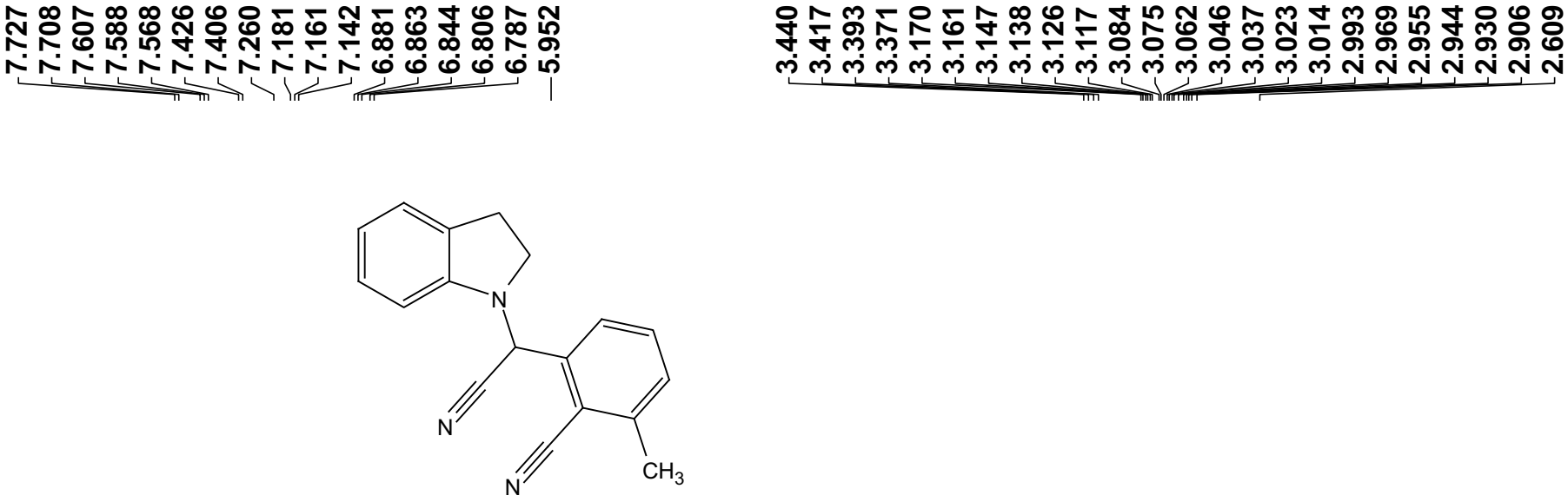
3x' ^{13}C NMR (100 MHz, $CDCl_3$)



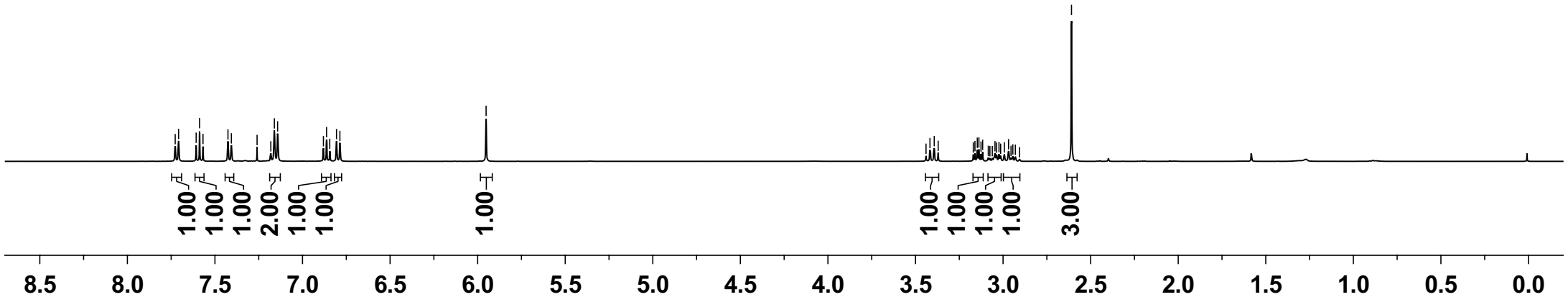
3y ^{1}H NMR (400 MHz, $CDCl_3$)

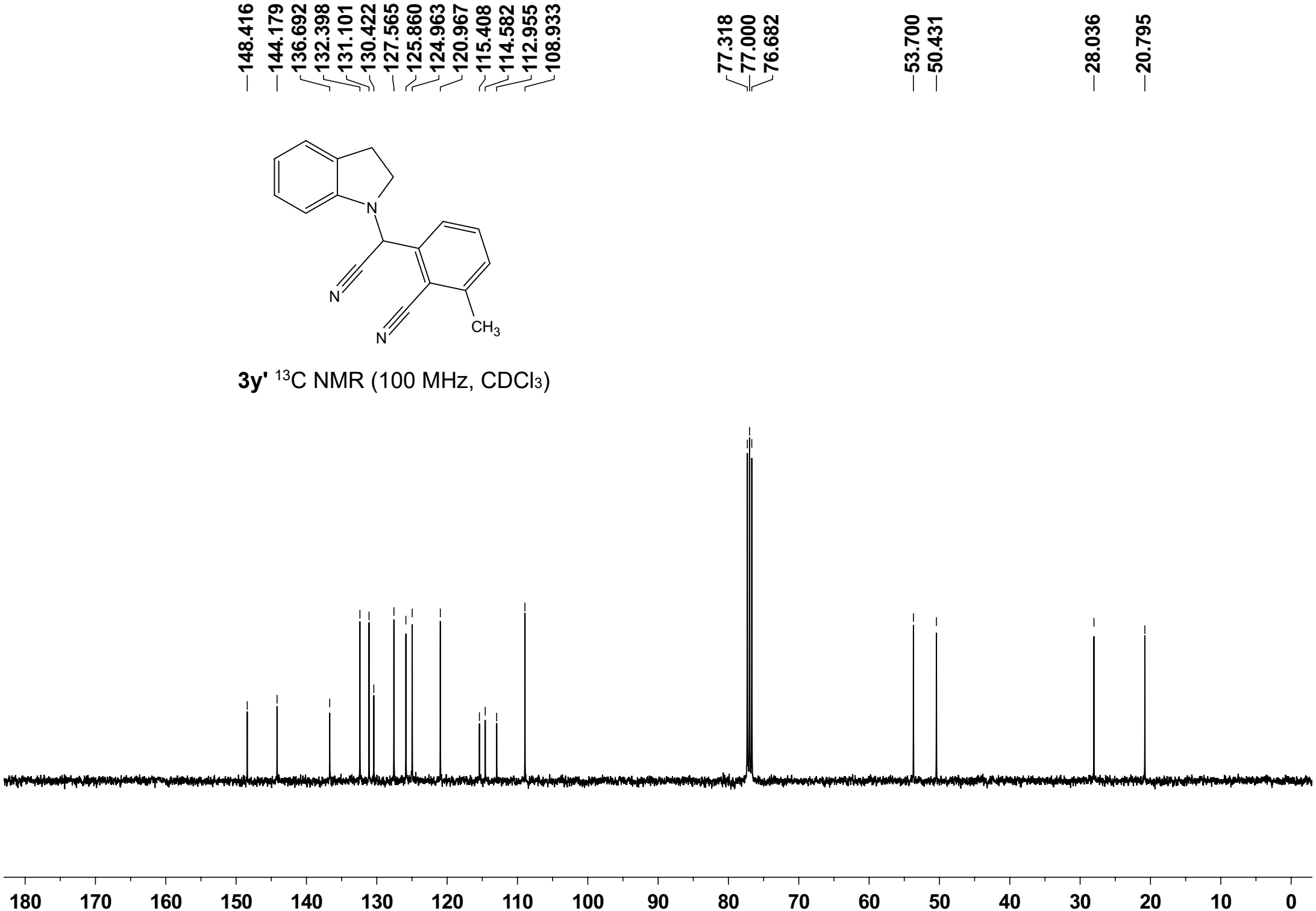


3y ^{13}C NMR (100 MHz, $CDCl_3$)

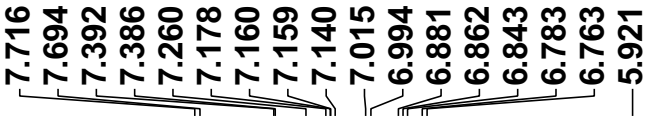


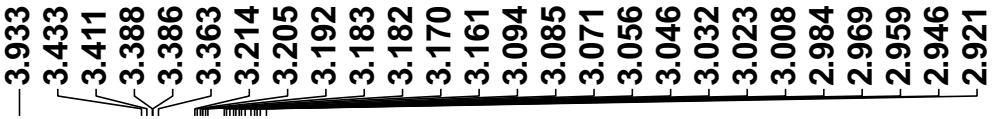
3y' ^{1}H NMR (400 MHz, $CDCl_3$)

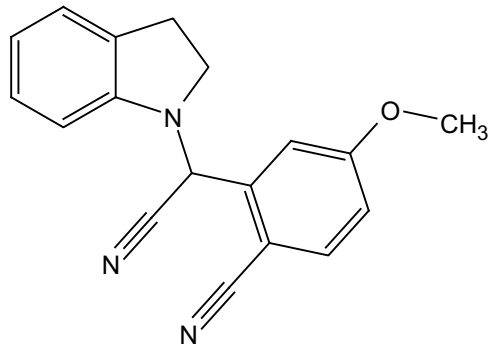




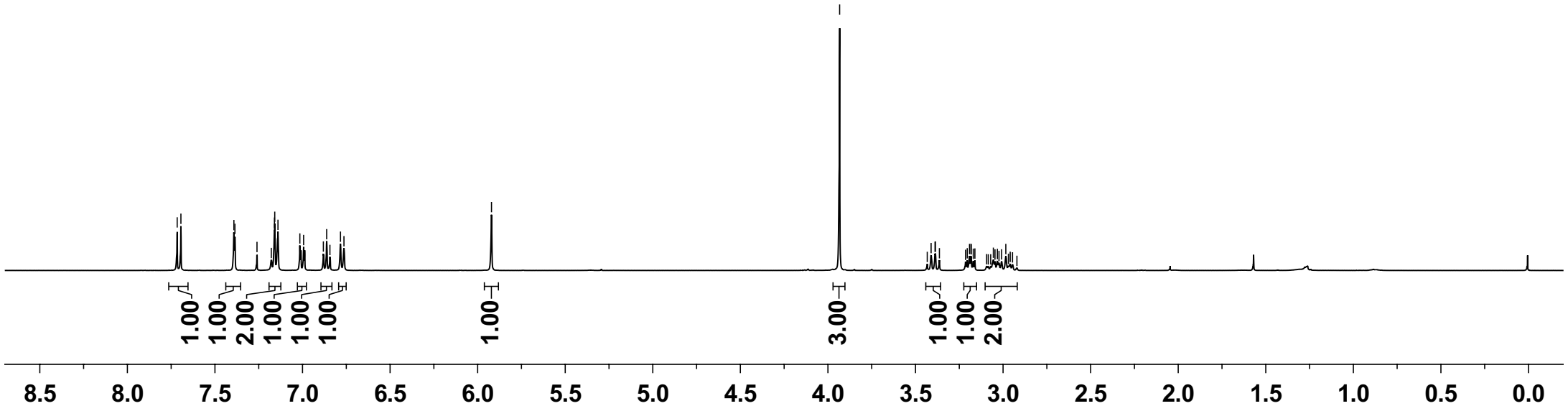
3y' ^{13}C NMR (100 MHz, $CDCl_3$)

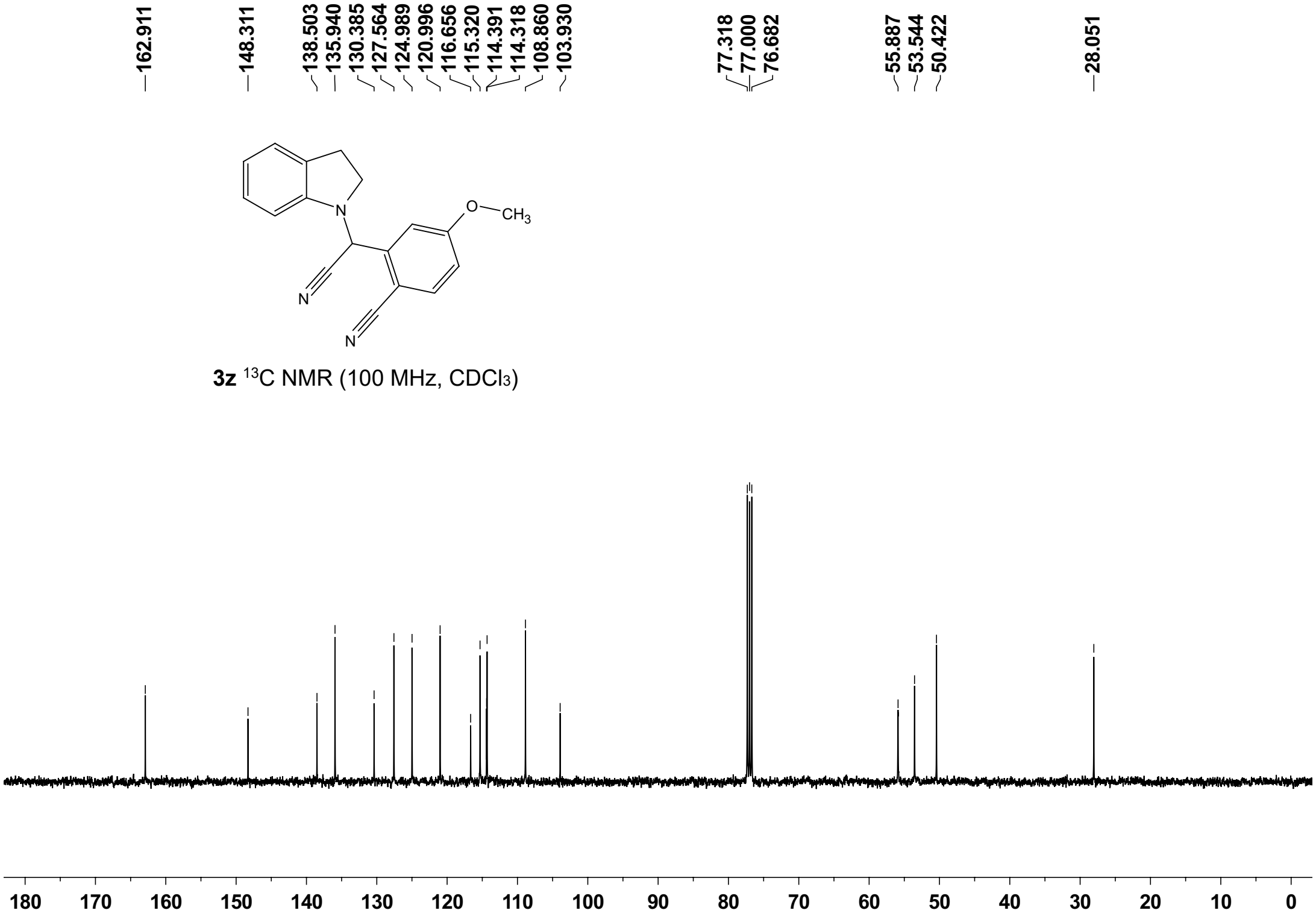




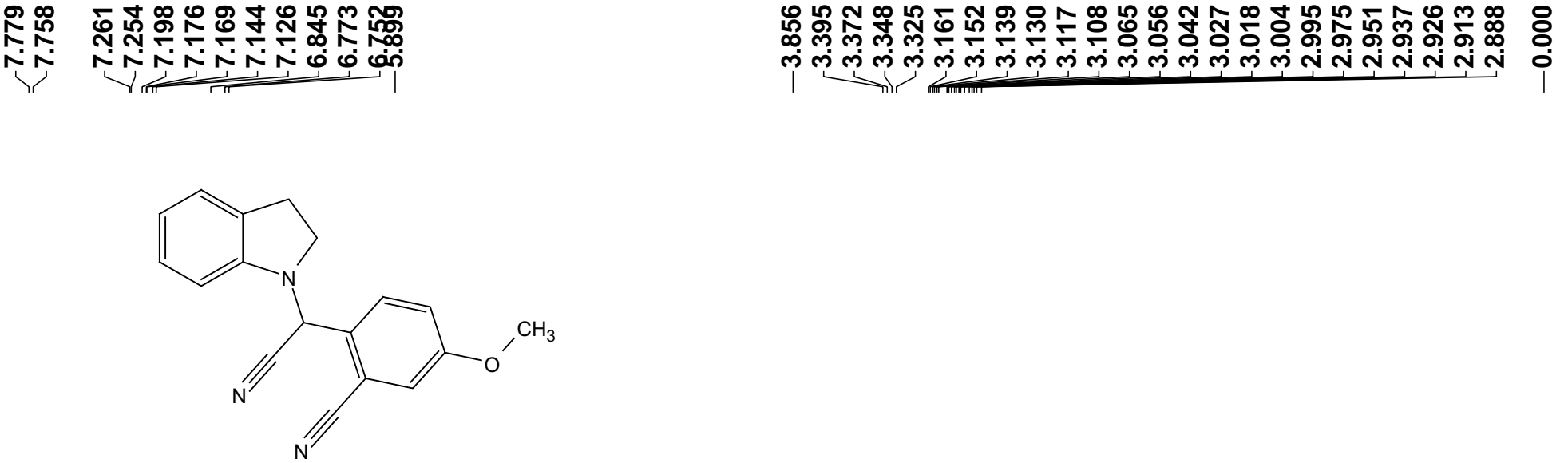


3z ^{1}H NMR (400 MHz, $CDCl_3$)

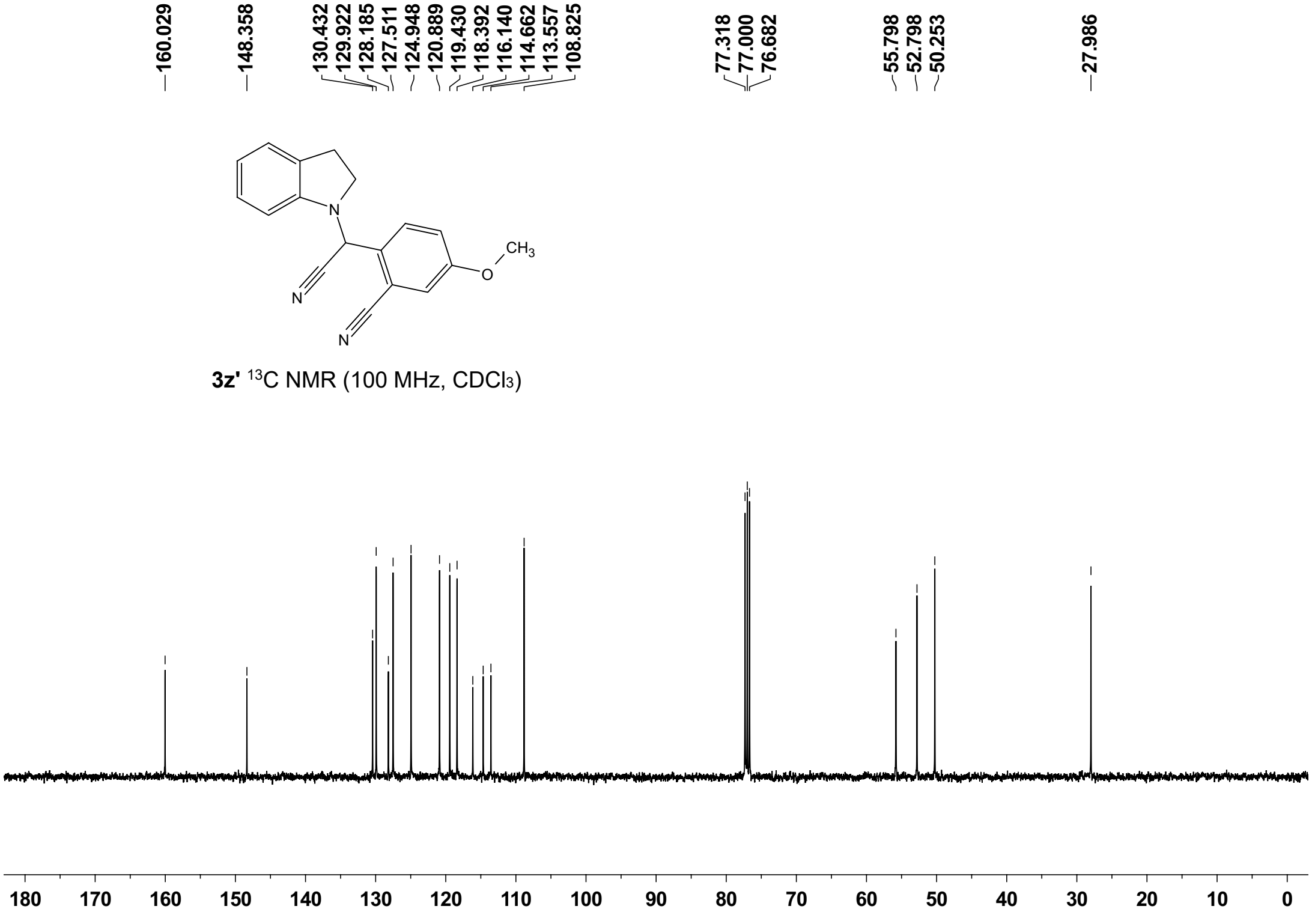




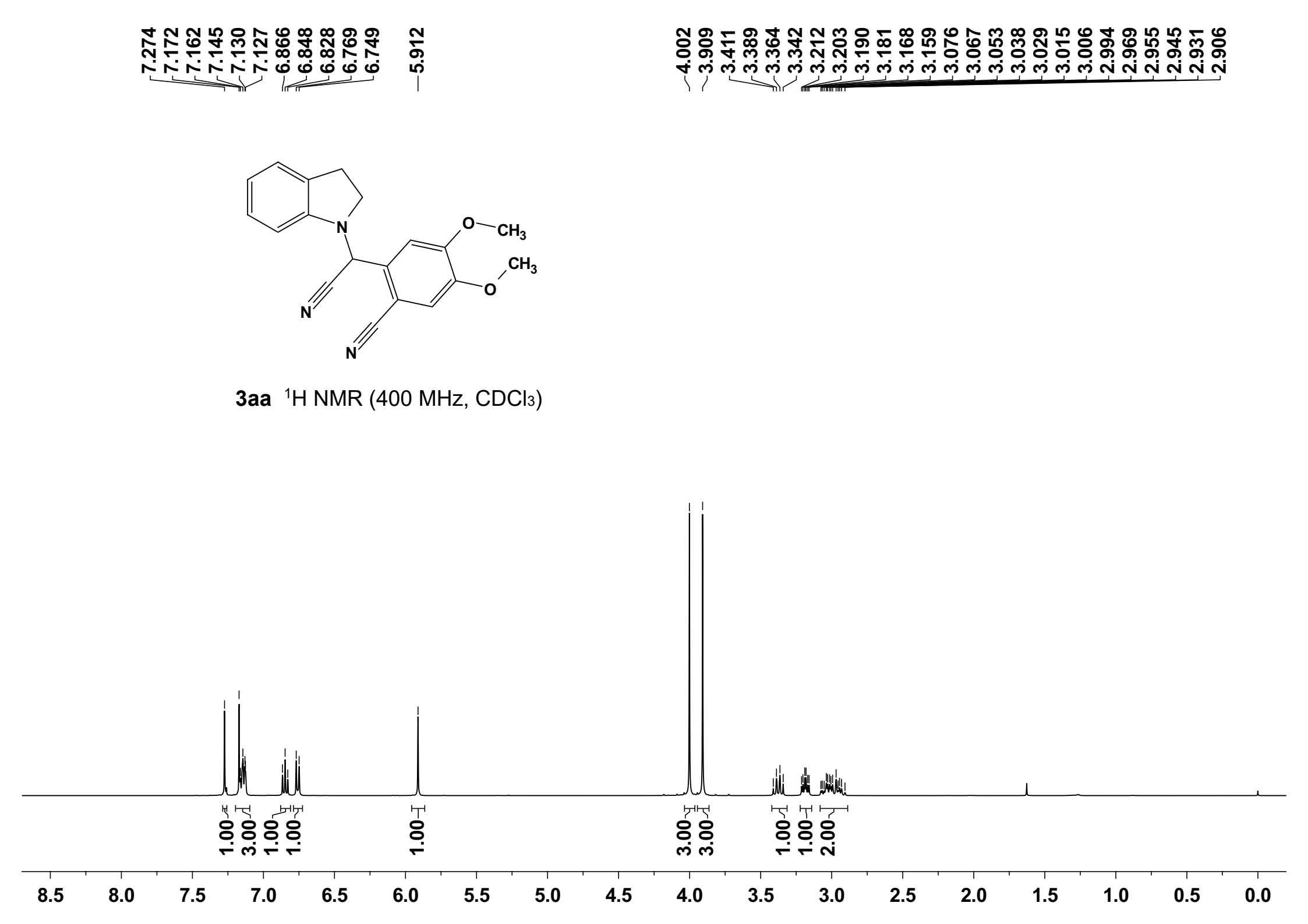
3z ^{13}C NMR (100 MHz, $CDCl_3$)



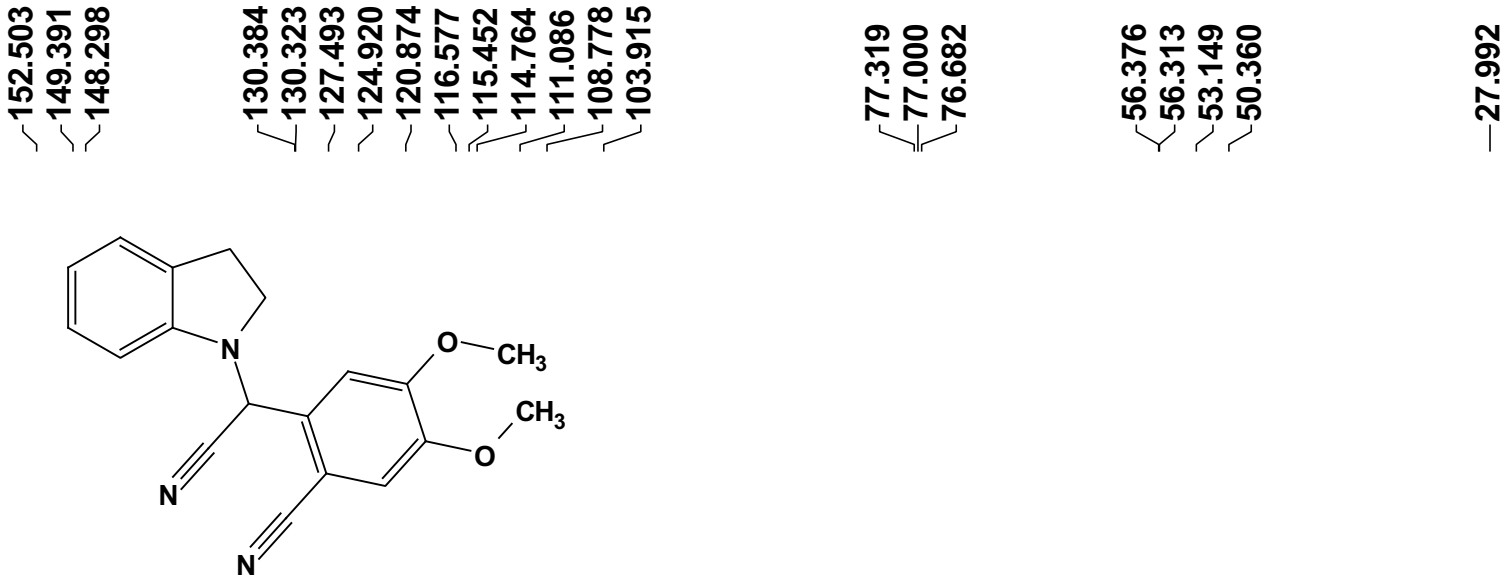
3z' ^{1}H NMR (400 MHz, $CDCl_3$)



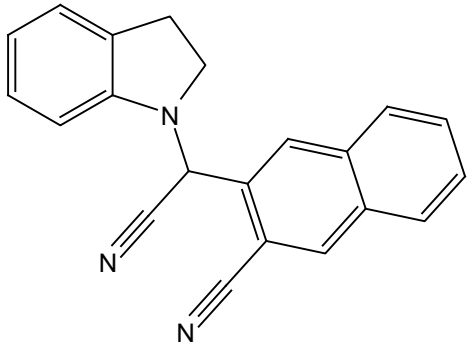
3z' ^{13}C NMR (100 MHz, $CDCl_3$)



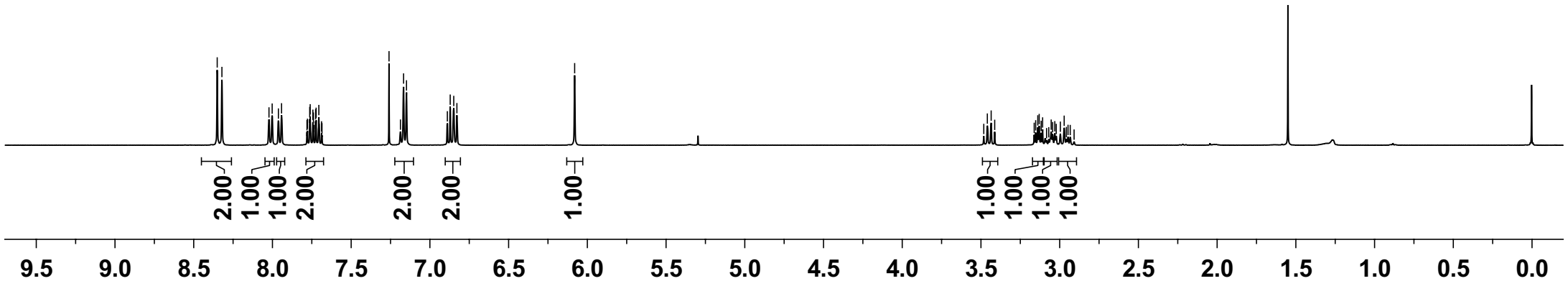
3aa ^{1}H NMR (400 MHz, $CDCl_3$)

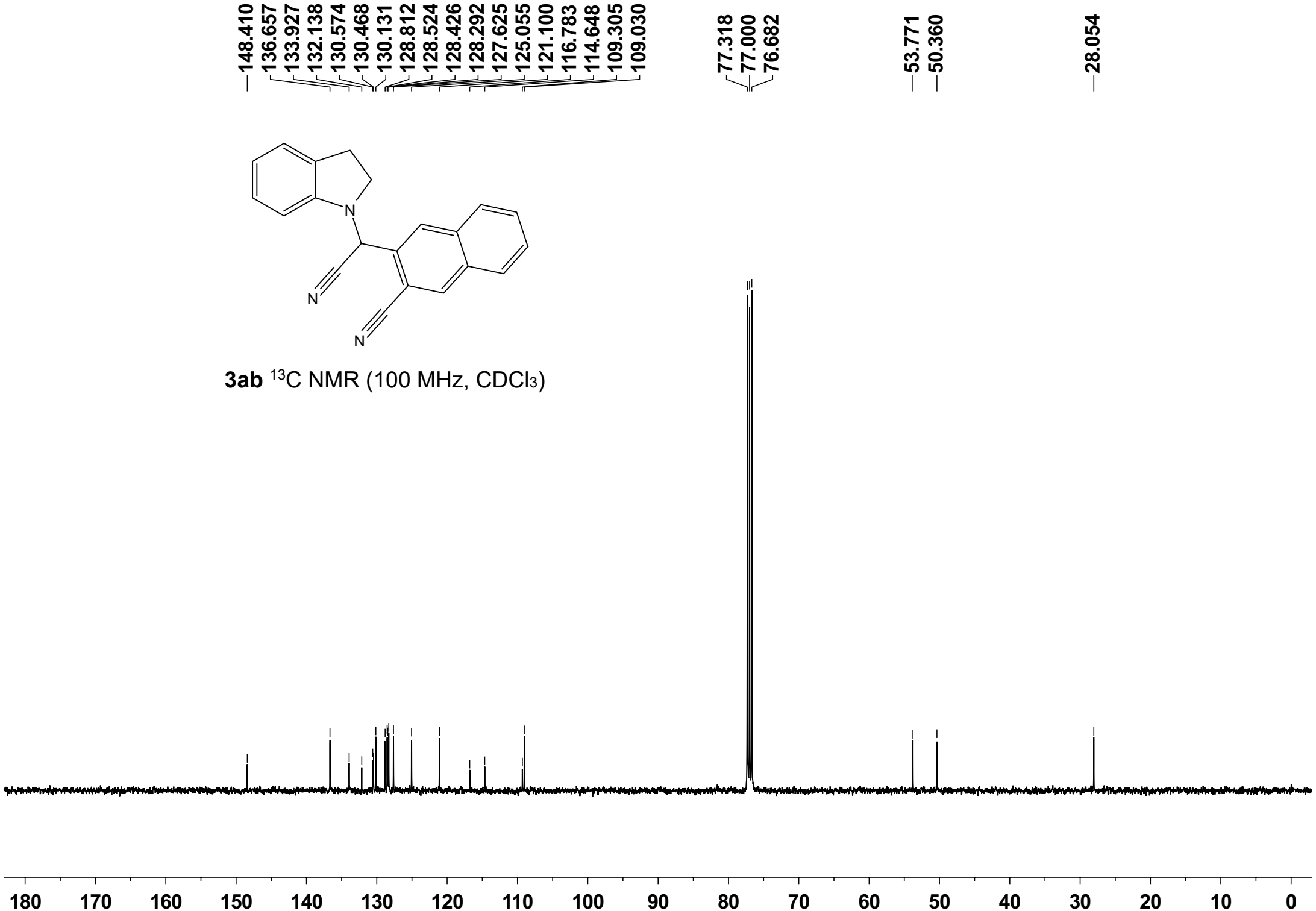


3aa ^{13}C NMR (100 MHz, $CDCl_3$)

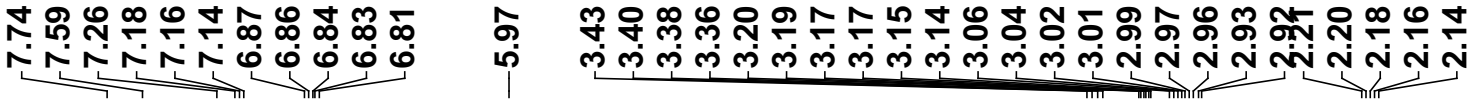


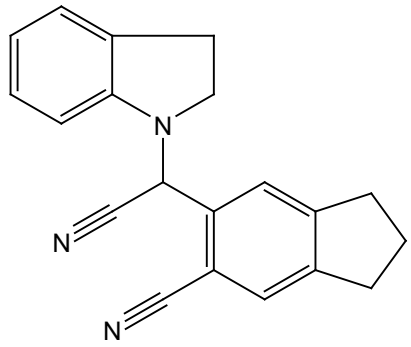
3ab ^{1}H NMR (400 MHz, $CDCl_3$)



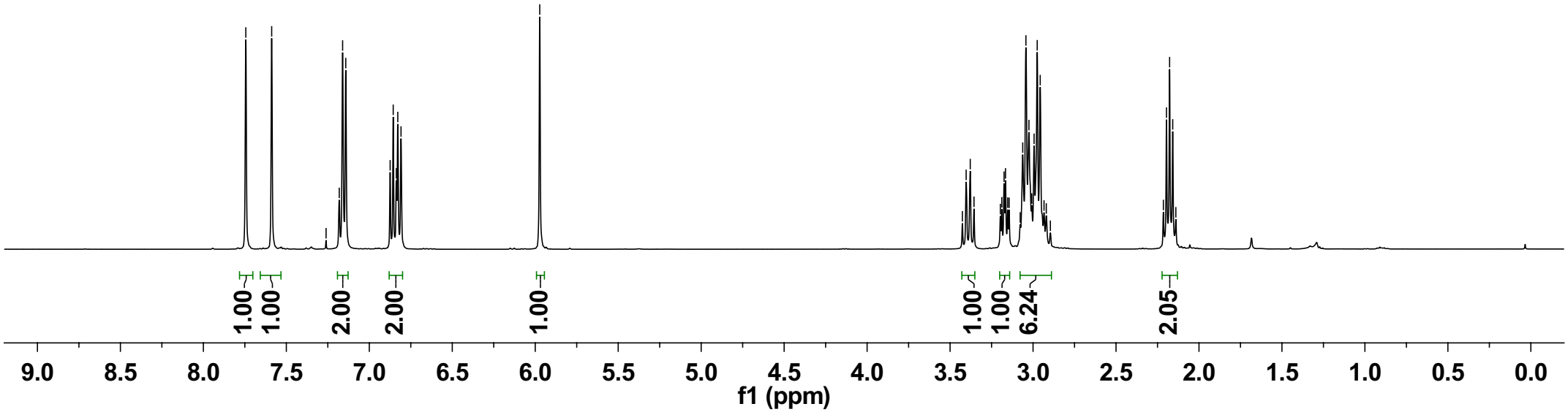


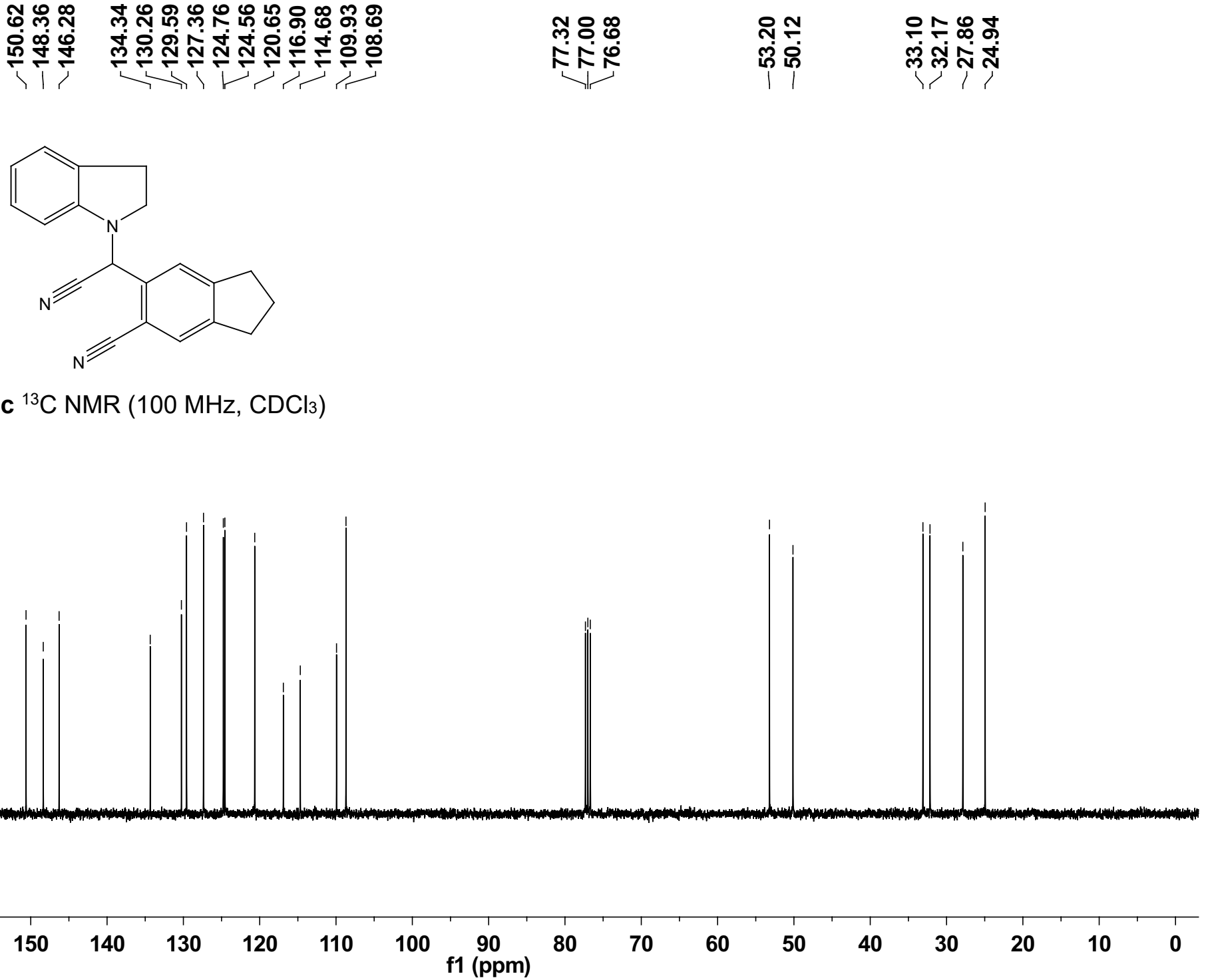
3ab ^{13}C NMR (100 MHz, $CDCl_3$)



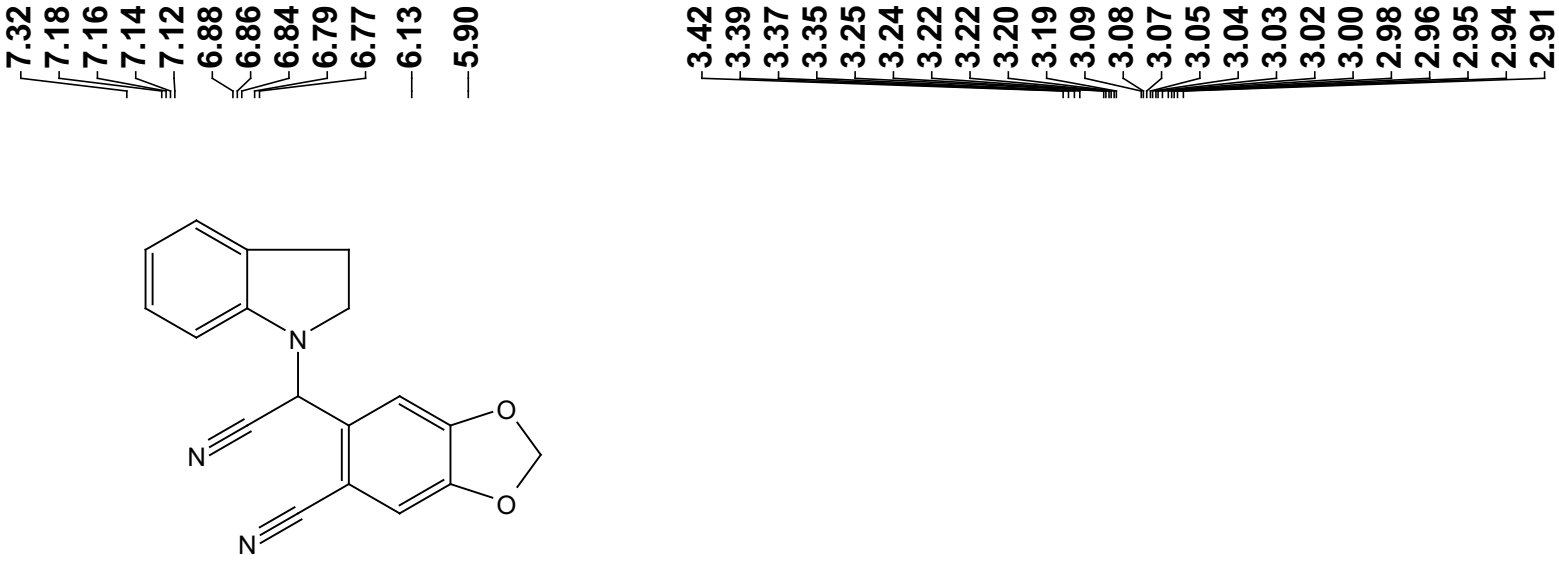


3ac ^{1}H NMR (400 MHz, $CDCl_3$)

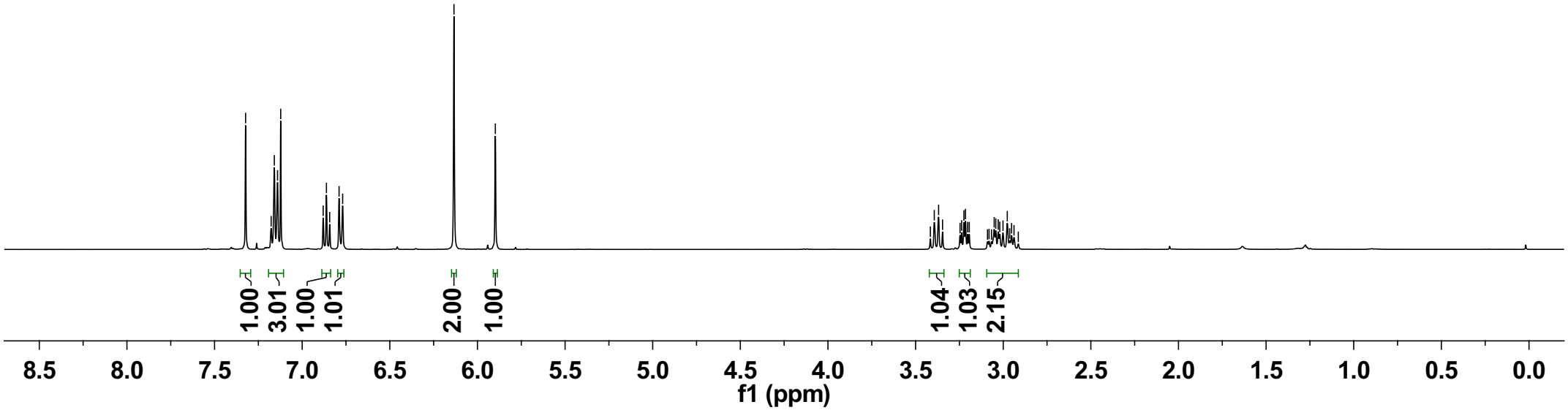


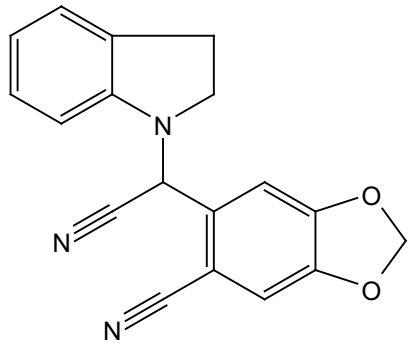


3ac ^{13}C NMR (100 MHz, $CDCl_3$)

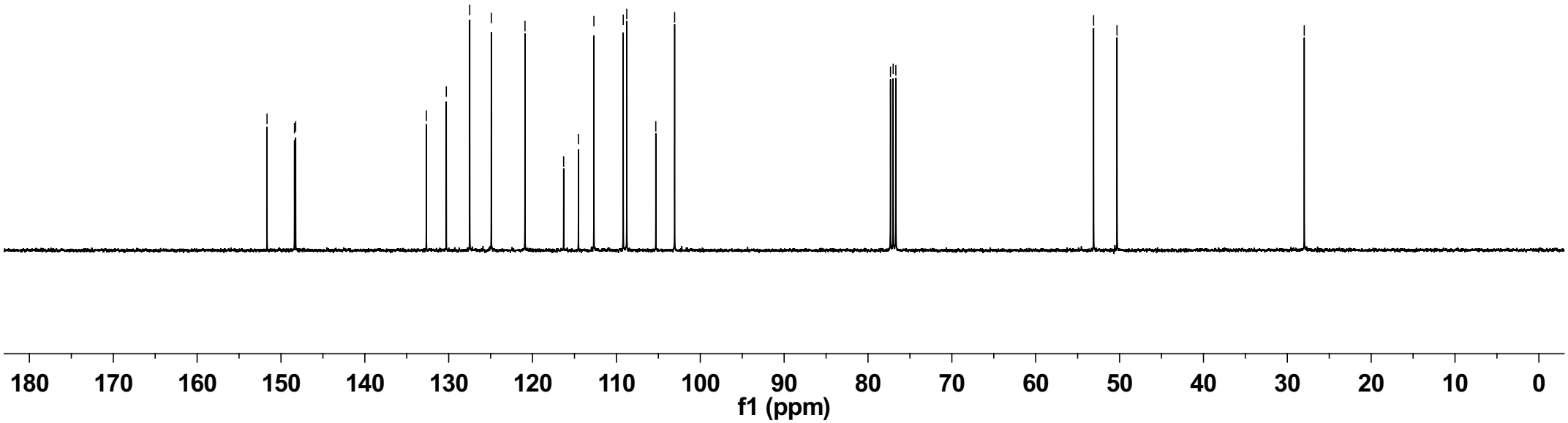


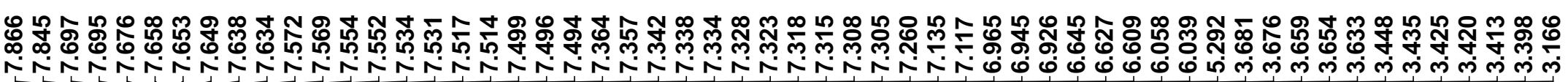
3ad ^{1}H NMR (400 MHz, $CDCl_3$)

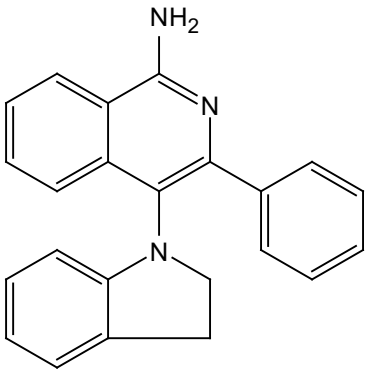




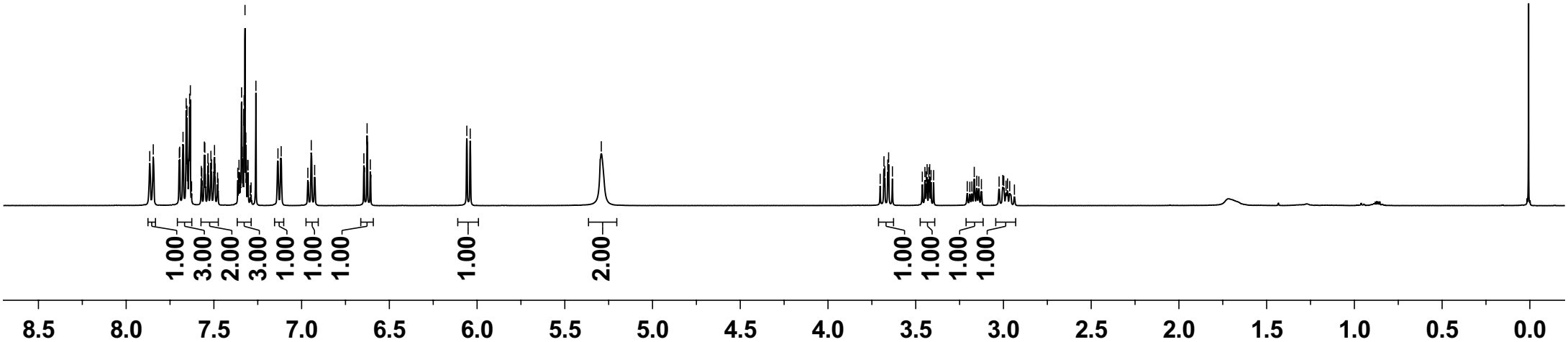
3ad ^{13}C NMR (100 MHz, $CDCl_3$)

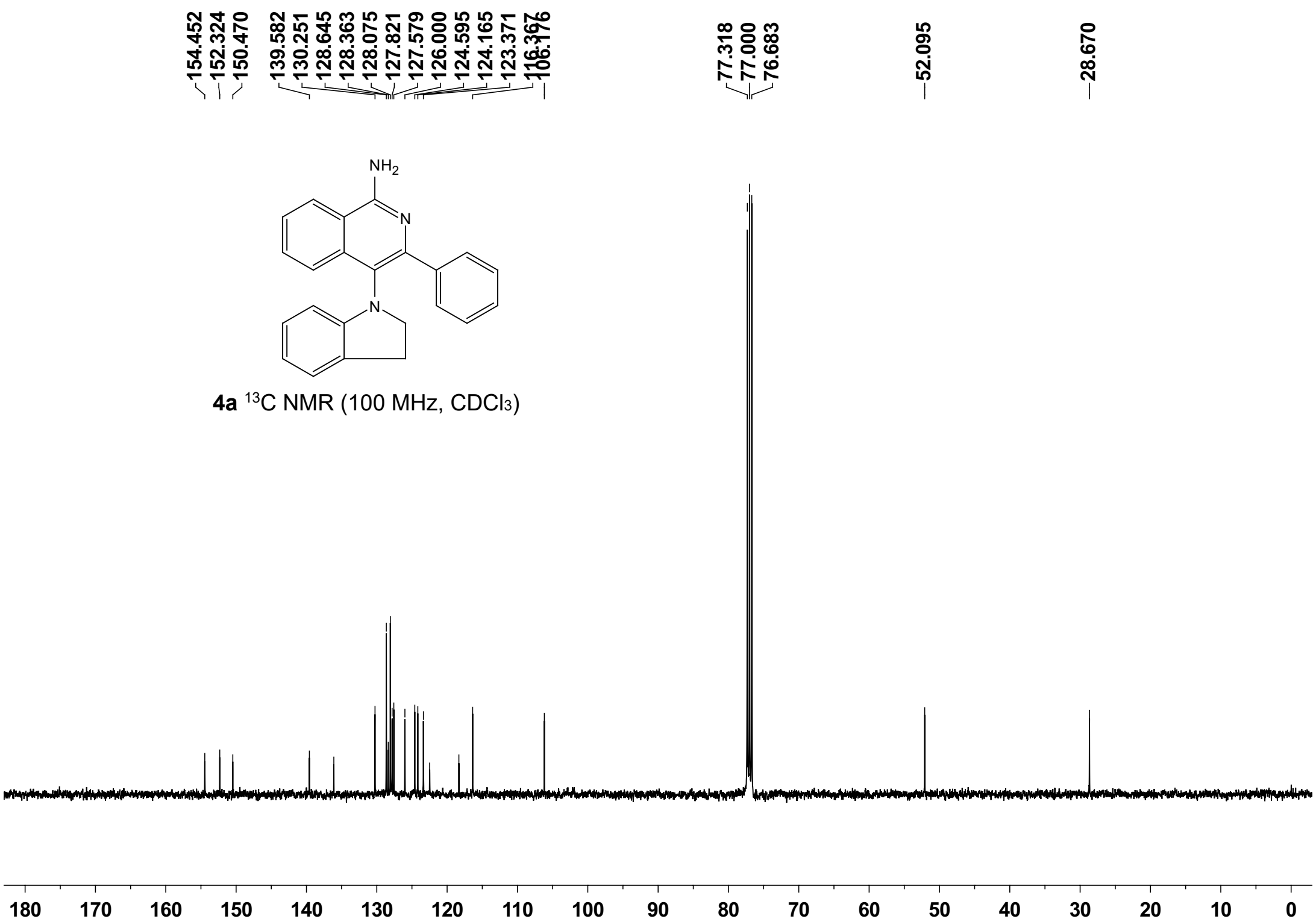




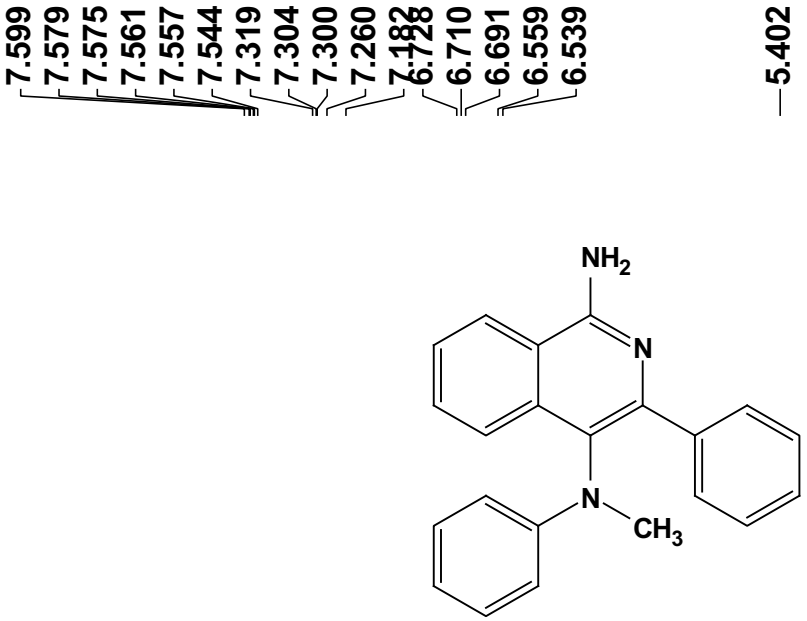


4a ^{1}H NMR (400 MHz, $CDCl_3$)

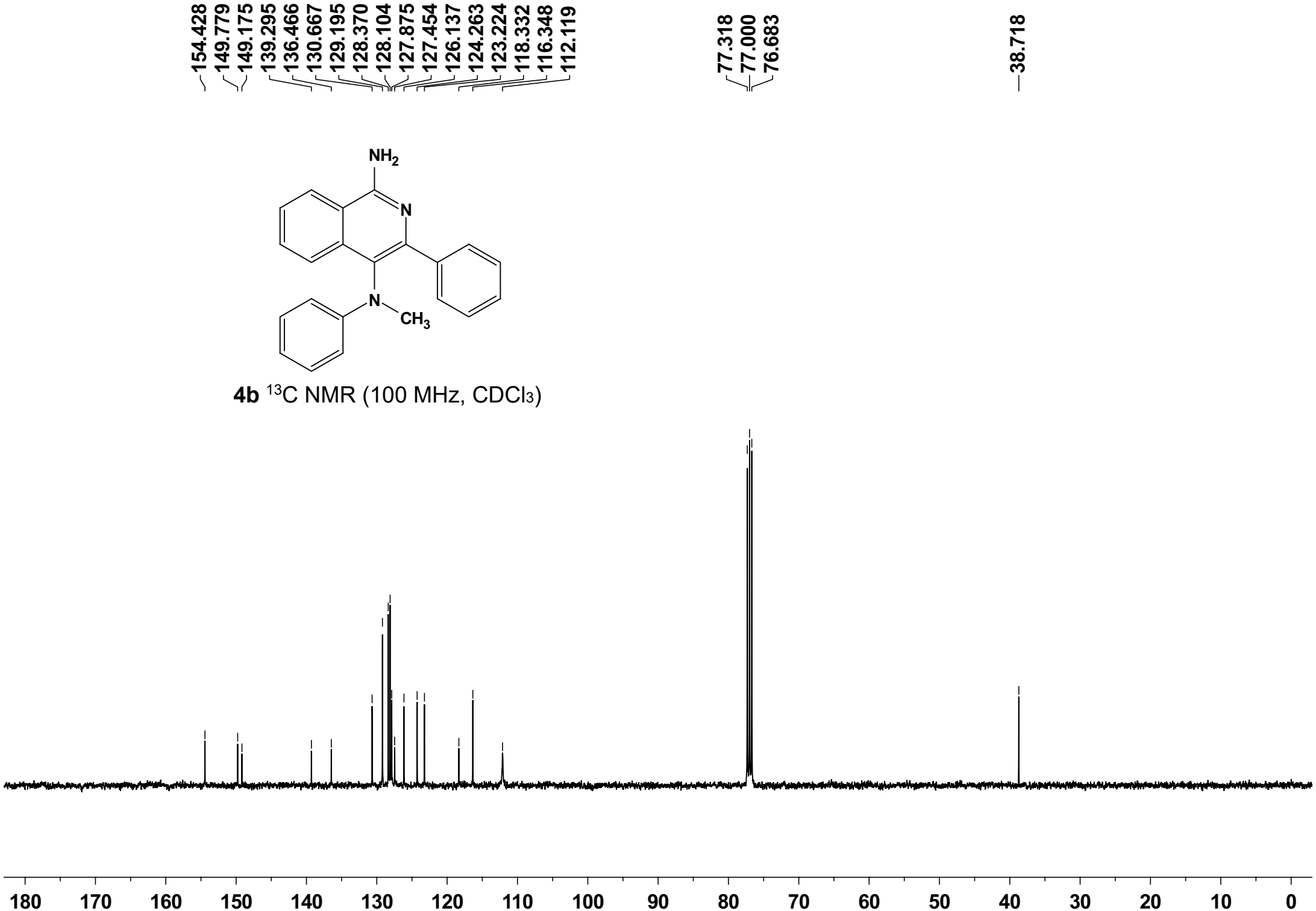




4a ^{13}C NMR (100 MHz, $CDCl_3$)



4b ^{1}H NMR (400 MHz, $CDCl_3$)



4b ^{13}C NMR (100 MHz, $CDCl_3$)