Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information

Ag(I)-Catalyzed Dearomatizing Spirocyclization/Nucleophile Addition Cascade Reactions of Indole-tethered Ynones

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1. General Methods:

Materials: All glassware was oven-dried (90 °C). Unless mentioned, chemicals & solvents were purchased in high purity grade from commercial suppliers and used without further purification.

Chromatography: Thin layer chromatography (TLC) was carried out on Merck silica plates (60F– 254), and components were visualized by observation under UV light or by treating the plates with p-anisaldehyde followed by heating. Silica gel chromatography was performed using silica gel (60–120 or 100-200 mesh).

Characterization: NMR spectra for the characterization of compounds were recorded on Bruker Avance DPX FT-NMR 400 MHz instrument (^{1}H) at 400 MHz and (^{13}C) at 100 MHz respectively. ^{19}F NMR was recorded at 376 MHz. Chemical shifts (δ) are reported in ppm, using the residual solvent peak in DMSO-d_6 (δ_H = 2.50 and δ_C = 39.52 ppm), $CDCl_3$ (δ_H = 7.26 and δ_C = 77.16 ppm), CD_3OD (δ_H = 3.31 and δ_C = 49.00 ppm) and as internal reference and coupling constants (*J*) are given in hertz (Hz). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, dd = doublet of doublet, ddd = doublet of doublets of doublets, t = triplet, q = quartet, m = multiplet. High-Resolution Mass Spectra (HRMS) were recorded using a Waters XEVO-G2-XS-Q-TOF mass spectrometer.

Experimental details. Unless mentioned, reactions were performed in an open atmosphere at room temperature (25-30 °C) in a 5 mL glass vial.

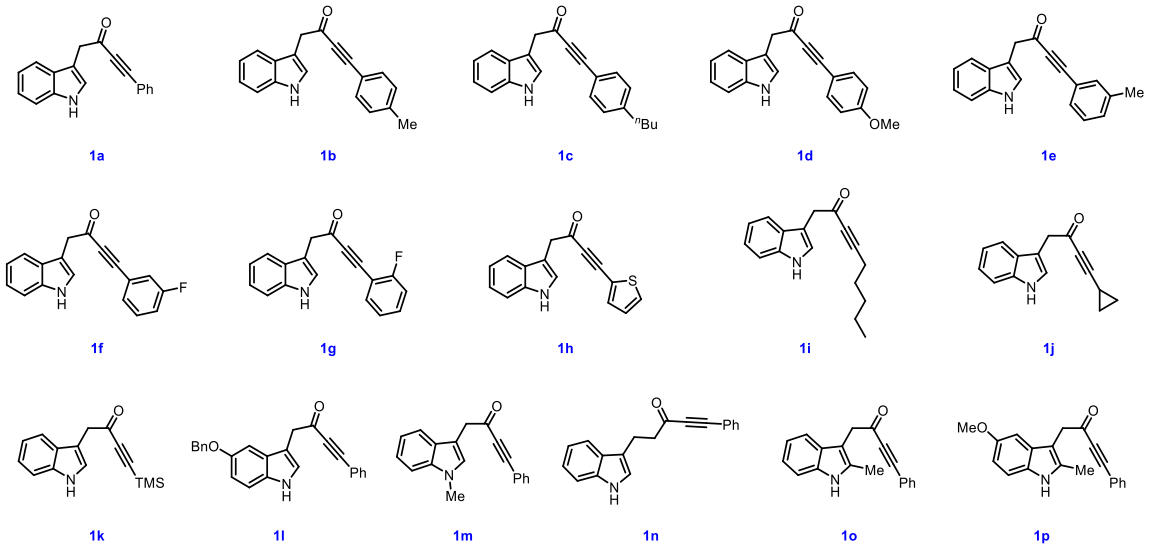


Figure S1: Indole-tethered ynones utilized in this study

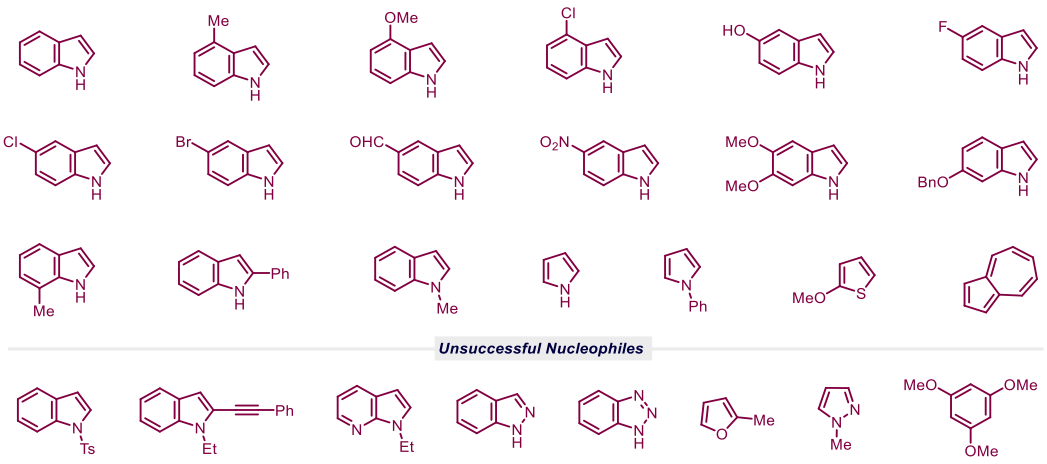
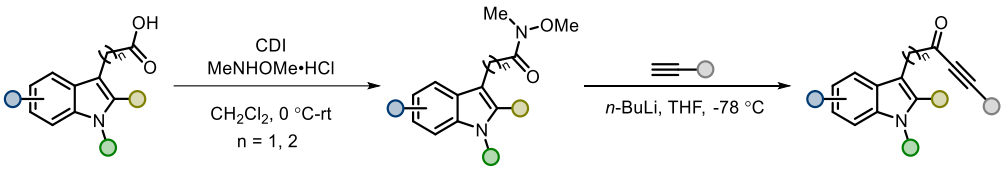


Figure S2: C-Nucleophiles utilized in this study

2. Synthesis of Starting Materials (Scheme S1):

Indole-tethered ynones utilized in this study were synthesized in two steps according to the previously reported literature procedures.[1,2]



Scheme S1: Synthesis of indole-tethered ynones

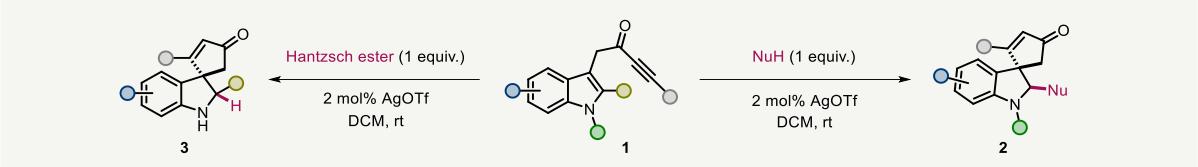
General procedure for the synthesis of Weinreb amides: To a suspension under Ar of carboxylic acids (1.0 equiv.) in CH_2Cl_2 was added portion-wise at 0 °C CDI (1.2 equiv.) and the resulting mixture was stirred at RT for 2 h. The mixture was then cooled to 0 °C and N,O-dimethylhydroxylamine hydrochloride (1.5 equiv.) was added portionwise and the resulting mixture was stirred at RT for additional 12 h. The mixture was diluted with water, extracted with CH_2Cl_2 and the aqueous phase was then discarded. The combined organic layers were washed with 1 N HCl and the acidic aqueous phase was extracted with CH_2Cl_2. The combined organic layers were washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Obtained solids were washed with petroleum ether twice which afforded the desired Weinreb amides.

General procedure for the synthesis of Ynones: To a solution of terminal alkyne (2.5 equiv.) in THF at −78 °C under argon was added *n*-BuLi (3.0 equiv.). The resulting solution was stirred at −78 °C for 30 min, then transferred via cannula to a cooled (−78 °C) solution of the corresponding Weinreb amide (1.0 equiv.) in THF. The mixture was stirred at −78 °C for 5 min then warmed to −10 °C and stirred for a further 1 h. The reaction was then re-cooled to

−78 °C and quenched with sat. aq. NH_4Cl, allowed to warm to room temperature, diluted with water, extracted with ethyl acetate, dried over Na_2SO_4 and concentrated in vacuo. Purification by flash column chromatography afforded the desired ynones as well as recovered alkyne.

3. General Experimental Procedure:

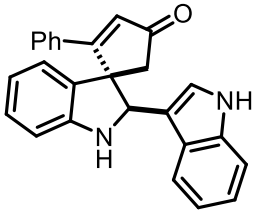
Procedure for the Synthesis of Spiroindolines from Indole-tethered Ynones (GP1):



To the solution of indole-tethered ynone **1** (1.0 equiv.) and indole (or other hetero- and carbocycles/ Hantzsch ester) (1.0 equiv.) in DCM (0.15 M) was added AgOTf (2.0 mol %). The resulting mixture was stirred at room temperature. Progress of the reaction was monitored periodically by TLC. Upon completion, water was added to the reaction mixture. The organic layer was extracted with DCM. The combined organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. Silica gel column purification by using ethyl acetate and petroleum ether mixture as eluent afforded the desired products.

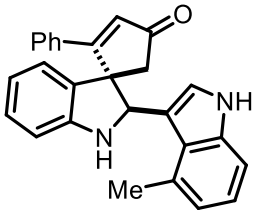
4. Characterization Data of Synthesized Compounds:

2'-(1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2a): Reaction of



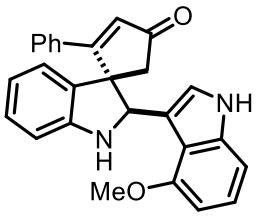
ynone **1a** (50 mg, 0.192 mmol), indole (23 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2a** as pale brown solid (71 mg, 98% yield); R_f : 0.5 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.06 (s, 1H), 7.77-7.55 (m, 2H), 7.53-7.38 (m, 3H), 7.37-7.29 (m, 1H), 7.26 (s, 1H), 7.15-6.96 (m, 3H), 6.93-6.86 (m, 1H), 6.85-6.71 (m, 2H), 6.69-6.62 (m, 2H), 6.31 (d, J = 2.01 Hz, 1H), 5.57 (d, J = 2.07 Hz, 1H), 2.80 (d, J = 18.44 Hz, 1H), 2.04 (d, J = 18.44 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 206.5, 175.1, 150.9, 136.8, 134.0, 133.7, 131.1, 130.8, 129.5, 129.3, 128.9, 126.7, 124.7, 123.0, 121.7, 119.3, 119.1, 118.9, 112.9, 112.2, 109.7, 63.9, 60.6, 49.0 ppm; HRMS (ESI): calcd. for $C_{26}H_{21}N_2O$ $[M+H]^+$: 377.1654, found 377.1656.

2'-(4-methyl-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2b):



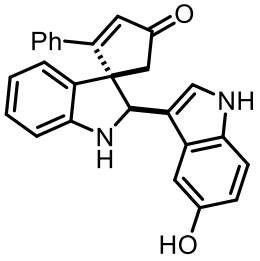
Reaction of ynone **1a** (50 mg, 0.192 mmol), 4-methylindole (25.3 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2b** as yellow solid (74 mg, 98% yield); R_f : 0.55 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.17 (s, 1H), 7.58-7.52 (m, 2H), 7.44-7.34 (m, 3H), 7.29-7.25 (m, 1H), 7.22-7.18 (m, 1H), 7.10-7.05 (m, 1H), 6.95-6.90 (m, 1H), 6.85-6.80 (m, 1H), 6.69-6.62 (m, 3H), 6.60-6.54 (m, 1H), 6.40 (s, 1H), 5.77 (s, 1H), 2.71 (d, J = 18.54 Hz, 1H), 2.18 (d, J = 18.52 Hz, 1H), 2.12 (s, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 206.0, 176.4, 150.9, 136.9, 133.7, 132.1, 130.5, 129.0, 128.9, 128.8, 128.6, 125.2, 125.1, 123.2, 121.2, 121.0, 117.6, 115.2, 109.9, 108.0, 62.7, 61.0, 49.8, 20.8 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1815.

2'-(4-methoxy-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2c):



Reaction of ynone **1a** (50 mg, 0.192 mmol), 4-methoxyindole (28.4 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2c** as yellow solid (69 mg, 88% yield); R_f : 0.45 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.09 (s, 1H), 7.71-7.61 (m, 2H), 7.44-7.33 (m, 3H), 7.26 (s, 1H), 7.06-7.00 (m, 1H), 6.95-6.88 (m, 2H), 6.77-6.64 (m, 2H), 6.60 (s, 1H), 6.57-6.50 (m, 1H), 6.32-6.22 (m, 2H), 5.99 (s, 1H), 3.13 (s, 3H), 2.81 (d, J = 18.26 Hz, 1H), 2.06 (d, J = 18.22 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 206.0, 175.7, 153.6, 151.0, 137.9, 133.8, 133.1, 130.1, 128.8, 128.5, 128.4, 128.3, 123.1, 122.1, 117.6, 116.4, 114.1, 108.3, 105.0, 98.9, 63.0, 60.3, 54.0, 49.3 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O_2$ $[M+H]^+$: 407.1760, found 407.1757.

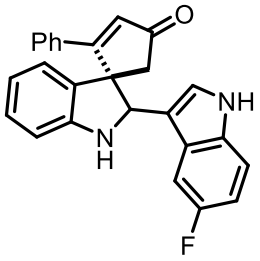
2'-(5-hydroxy-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2e):



Reaction of ynone **1a** (50 mg, 0.192 mmol), 5-hydroxyindole (25.7 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2e** as yellow solid (73.2 mg, 97% yield); R_f : 0.2 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.76 (s, 1H), 8.60 (s, 1H), 7.66-7.60 (m, 2H), 7.48-7.38 (m, 3H), 7.15-7.03 (m, 3H), 6.92-6.86 (m, 1H), 6.74-6.67 (m, 2H), 6.66-6.55 (m, 3H), 6.32 (s, 1H), 5.44 (s, 1H), 2.83 (d, J = 18.41 Hz, 1H), 2.05 (d, J = 18.36 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz,

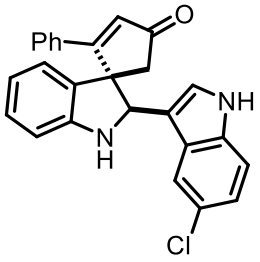
DMSO-d_6) δ 206.0, 174.8, 150.8, 150.3, 133.6, 131.2, 130.5, 130.4, 129.2, 128.9, 128.6, 127.3, 124.6, 122.9, 118.1, 112.0, 111.8, 111.7, 109.1, 103.7, 63.9, 60.5, 49.0 ppm; HRMS (ESI): calcd. for $C_{26}H_{21}N_2O_2$ $[M+H]^+$: 393.1603, found 393.1607.

2'-(5-fluoro-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2f):



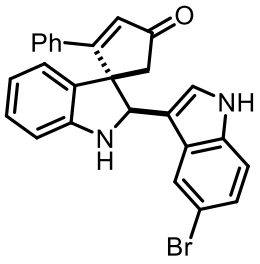
Reaction of ynone **1a** (50 mg, 0.192 mmol), 5-fluoroindole (26 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2f** as brown solid (73.5 mg, 97% yield); R_f : 0.34 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.22 (s, 1H), 7.72-7.61 (m, 2H), 7.52-7.41 (m, 3H), 7.38-7.29 (m, 2H), 7.15-7.08 (m, 1H), 6.97-6.82 (m, 2H), 6.80-6.61 (m, 4H), 6.37 (s, 1H), 5.50 (s, 1H), 2.77 (d, J = 18.38 Hz, 1H), 2.06 (d, J = 18.36 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.6, 174.1, 156.5 (d, J = 231.58 Hz), 150.6, 133.7, 133.2 (d, J = 22.24 Hz), 130.7, 130.6, 129.0 (d, J = 30.54 Hz), 128.5, 126.6, 126.5, 122.7, 118.5, 112.8 (d, J = 9.89 Hz), 112.6 (d, J = 4.58 Hz), 109.6, 109.3, 103.5 (d, J = 23.59 Hz), 63.5, 60.2, 48.5 ppm; ^{19}F NMR (376 MHz, DMSO-d_6) δ -124.8 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_2OF$ $[M+H]^+$: 395.1560, found 395.1553.

2'-(5-chloro-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2g):



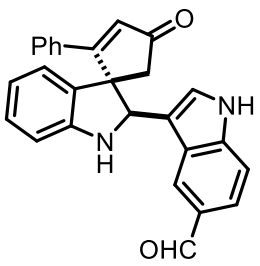
Reaction of ynone **1a** (50 mg, 0.192 mmol), 5-chloroindole (29.2 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2g** as pale brown solid (74.3 mg, 94% yield); R_f : 0.32 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.32 (s, 1H), 7.69-7.62 (m, 2H), 7.50-7.42 (m, 3H), 7.38-7.34 (m, 2H), 7.15-7.10 (m, 1H), 7.06-7.00 (m, 2H), 6.96-6.92 (m, 1H), 6.79-6.75 (m, 1H), 6.73 (s, 1H), 6.68 (t, J = 7.37 Hz, 1H), 6.39 (d, J = 2.44 Hz, 1H), 5.51 (d, J = 2.40 Hz, 1H), 2.77 (d, J = 18.44 Hz, 1H), 2.05 (d, J = 18.42 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.6, 174.0, 150.6, 134.9, 133.8, 133.4, 130.9, 130.8, 129.3, 129.0, 128.6, 127.6, 126.2, 123.4, 122.8, 121.3, 118.7, 118.3, 113.4, 112.1, 109.5, 63.6, 60.3, 48.5 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_2OCl$ $[M+H]^+$: 411.1264, found 411.1265.

2'-(5-bromo-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2h):



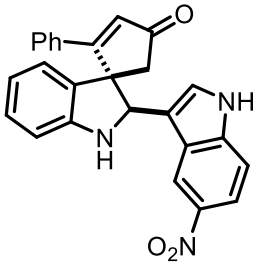
Reaction of ynone **1a** (50 mg, 0.192 mmol), 5-bromoindole (37.8 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2h** as yellow solid (84 mg, 96% yield); R_f : 0.29 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.32 (s, 1H), 7.69-7.62 (m, 2H), 7.52-7.43 (m, 3H), 7.35-7.29 (m, 2H), 7.18-7.10 (m, 3H), 6.97-6.91 (m, 1H), 6.78-6.74 (m, 1H), 6.72 (s, 1H), 6.69 (t, *J* = 7.37 Hz, 1H), 6.38 (d, *J* = 2.71 Hz, 1H), 5.50 (d, *J* = 2.82 Hz, 1H), 2.76 (d, *J* = 18.47 Hz, 1H), 2.04 (d, *J* = 18.42 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.6, 174.0, 150.5, 135.1, 133.8, 133.4, 131.0, 130.8, 129.3, 129.0, 128.6, 128.2, 126.1, 123.8, 122.8, 121.3, 118.7, 113.9, 112.0, 111.3, 109.6, 63.5, 60.3, 48.4 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_2OBr$ $[M+H]^+$: 455.0759, found 455.0751.

3-(4-oxo-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-2'-yl)-1*H*-indole-5-carbaldehyde



(2i): Reaction of ynone **1a** (50 mg, 0.192 mmol), indole-5-carboxaldehyde (28 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2i** as yellow solid (61.5 mg, 79% yield); R_f : 0.20 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.64 (d, *J* = 1.72 Hz, 1H), 9.73 (s, 1H), 7.73-7.65 (m, 2H), 7.63 (s, 1H), 7.61-7.51 (m, 1H), 7.51-7.45 (m, 4H),7.44 (d, *J* = 2.14 Hz, 1H), 7.14 (ddd, *J* = 15.23, 7.70, 1.22 Hz, 1H), 6.98-6.94 (m, 1H), 6.80-6.76 (m, 1H), 6.73-6.67 (m, 2H), 6.44 (d, *J* = 3.22 Hz, 1H), 5.61 (d, *J* = 2.97 Hz, 1H), 2.76 (d, *J* = 18.44 Hz, 1H), 2.06 (d, *J* = 18.45 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.5, 192.1, 173.9, 150.5, 139.9, 133.8, 133.4, 131.1, 130.8, 129.4, 129.0, 128.6, 128.5, 126.6, 126.3, 124.6, 122.8, 121.4, 118.8, 114.5, 112.6, 109.6, 63.5, 60.3, 48.5 ppm; HRMS (ESI): calcd. for $C_{27}H_{21}N_2O_2$ $[M+H]^+$: 405.1603, found 405.1597.

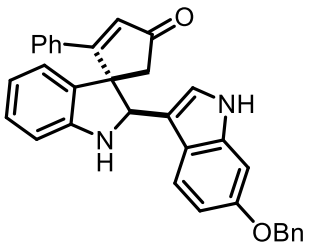
2'-(5-nitro-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2j):



Reaction of ynone **1a** (50 mg, 0.192 mmol), 5-nitroindole (31.3 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2j** as yellow solid (60 mg, 74% yield); R_f : 0.21 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.87 (s, 1H), 8.08-8.04 (m, 1H), 7.95 (dd, *J* = 9.01, 2.18 Hz, 1H), 7.72-7.66 (m, 2H), 7.57 (d, *J* = 1.97 Hz, 1H), 7.54-7.44 (m, 4H), 7.15 (t, *J* = 7.58 Hz,

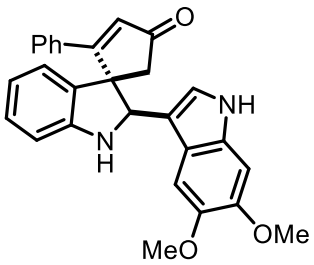
1H), 6.97 (d, *J* = 7.34 Hz, 1H), 6.79 (d, *J* = 7.81 Hz, 1H), 6.74 (s, 1H), 6.71 (t, *J* = 7.34 Hz, 1H), 6.47 (d, *J* = 3.26 Hz, 1H), 5.58 (d, *J* = 3.11 Hz, 1H), 2.71 (d, *J* = 18.43 Hz, 1H), 2.07 (d, *J* = 18.446 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 205.2, 173.7, 150.4, 140.4, 139.6, 133.7, 133.2, 131.0, 130.7, 129.3, 129.0, 128.6, 128.3, 125.5, 122.8, 118.9, 116.7, 116.2, 115.2, 112.3, 109.7, 63.3, 60.2, 48.4 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_3O_3$ $[M+H]^+$: 422.1505, found 422.1503.

2'-(6-(benzyloxy)-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one



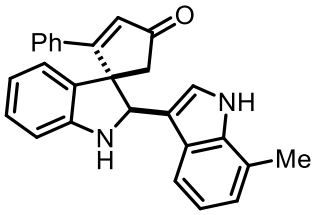
(2k): Reaction of ynone **1a** (50 mg, 0.192 mmol), 6-benzyloxyindole (43 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2k** as brown solid (86.5 mg, 93% yield); R_f : 0.42 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.89 (s, 1H), 7.68-7.61 (m, 2H), 7.48-7.28 (m, 8H), 7.14-7.07 (m, 2H), 6.96-6.88 (m, 3H), 6.75-6.71 (m, 1H), 6.70-6.62 (m, 2H), 6.60-6.55 (m, 1H), 6.34 (s, 1H), 5.51 (s, 1H), 5.05 (s, 2H), 2.81 (d, *J* = 18.48 Hz, 1H), 2.04 (d, *J* = 18.42 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 205.9, 174.5, 154.6, 150.7, 137.6, 137.2, 133.7, 133.5, 130.6, 130.6, 129.2, 128.9, 128.5, 127.8, 127.7, 123.1, 122.8, 121.0, 119.8, 118.4, 112.7, 109.5, 109.2, 96.1, 69.6, 63.7, 60.3, 48.8 ppm; HRMS (ESI): calcd. for $C_{33}H_{27}N_2O_2$ $[M+H]^+$: 483.2073, found 483.2071.

2'-(5,6-dimethoxy-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one



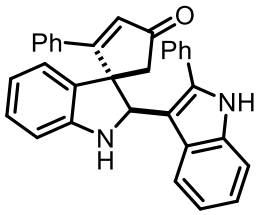
(2l): Reaction of ynone **1a** (50 mg, 0.192 mmol), 5,6-dimethoxyindole (34.2 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2l** as brown solid (79 mg, 94% yield); R_f : 0.18 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.77 (s, 1H), 7.75-7.68 (m, 2H), 7.48-7.40 (m, 3H), 7.18-7.07 (m, 2H), 6.92-6.85 (m, 2H), 6.76-6.72 (m, 2H), 6.68-6.62 (m, 1H), 6.31-6.29 (m, 2H), 5.57 (d, *J* = 2.67 Hz, 1H), 3.71 (s, 3H), 3.43 (s, 3H), 2.88 (d, *J* = 18.48 Hz, 1H), 2.03 (d, *J* = 18.46 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 205.8, 174.1, 150.7, 146.3, 144.0, 134.0, 133.3, 130.8, 130.6, 129.3, 128.8, 128.4, 122.6, 119, 118.4, 112.6, 109.2, 101.0, 95.2, 63.6, 60.0, 55.6, 55.6, 48.5 ppm; HRMS (ESI): calcd. for $C_{28}H_{25}N_2O_3$ $[M+H]^+$: 437.1865, found 437.1870.

2'-(7-methyl-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2m):



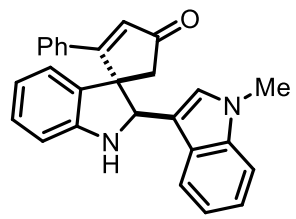
Reaction of ynone **1a** (50 mg, 0.192 mmol), 7-methylindole (25.3 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2m** as brown solid (73 mg, 97% yield); R_f : 0.51 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 11.07 (s, 1H), 7.68-7.64 (m, 2H), 7.49-7.41 (m, 3H), 7.26 (d, *J* = 2.28 Hz, 1H), 7.14-7.08 (m, 1H), 6.90 (d, *J* = 7.08 Hz, 1H), 6.85-6.81 (m, 2H), 6.75-6.70 (m, 2H), 6.68 (s, 1H), 6.66-6.63 (m, 1H), 6.35 (d, *J* = 2.68 Hz, 1H), 5.57 (d, *J* = 2.59 Hz, 1H), 2.82 (d, *J* = 18.46 Hz, 1H), 2.41 (s, 3H), 2.04 (d, *J* = 18.48 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d$_6$) δ 206.3, 175.0, 151.0, 136.4, 134.2, 133.9, 131.0, 130.9, 129.6, 129.3, 128.9, 126.4, 124.4, 123.1, 122.2, 121.2, 119.3, 118.7, 117.1, 113.6, 109.6, 64.0, 60.6, 49.1, 17.2 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1814.

2-phenyl-2'-(2-phenyl-1*H*-indol-3-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2n):



Reaction of ynone **1a** (50 mg, 0.192 mmol), 2-phenylindole (37.3 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2n** as yellow solid (84 mg, 96% yield); R_f : 0.63 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 11.38 (s, 1H), 7.42-7.32 (m, 5H), 7.31-7.21 (m, 8H), 7.14-7.09 (m, 2H), 6.96-6.88 (m, 2H), 6.65-6.58 (m, 3H), 6.39 (s, 1H), 5.27 (s, 1H), 2.85 (d, *J* = 18.52 Hz, 1H), 2.37 (d, *J* = 18.54, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d$_6$) δ 206.1, 176.6, 151.0, 137.1, 136.4, 133.5, 132.3, 131.8, 130.2, 129.1, 129.0, 128.8, 128.6, 128.5, 128.4, 127.9, 127.4, 122.7, 121.7, 121.0, 119.2, 117.3, 111.6, 110.7, 107.8, 61.8, 60.6, 50.6 ppm; HRMS (ESI): calcd. for $C_{32}H_{25}N_2O$ $[M+H]^+$: 453.1967, found 453.1965.

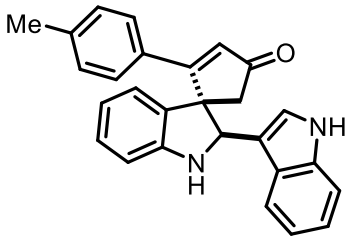
2'-(1-methyl-1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2o):



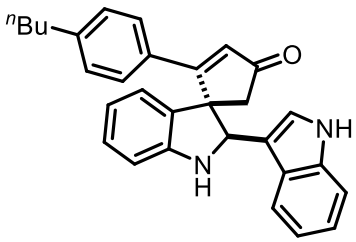
Reaction of ynone **1a** (50 mg, 0.192 mmol), 1-methylindole (25.3 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2o** as yellow solid (68.5 mg, 91% yield); R_f : 0.54 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 7.69-7.62 (m, 2H), 7.50-7.42 (m, 3H), 7.39-7.35 (m, 1H), 7.30 (s, 1H), 7.14-7.06 (m, 2H), 7.03-6.98 (m, 1H), 6.93-6.81 (m, 2H), 6.76-6.63 (m, 3H),

6.35 (d, *J* = 2.46 Hz, 1H), 5.57 (d, *J* = 2.47 Hz, 1H), 3.74 (s, 3H), 2.82 (d, *J* = 18.48 Hz, 1H), 2.05 (d, *J* = 18.43 Hz, 1H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 205.9, 174.5, 150.6, 137.0, 133.8, 133.5, 130.64, 130.60, 129.2, 128.9, 128.8, 128.6, 126.7, 122.7, 121.4, 119.2, 118.8, 118.4, 111.9, 110.1, 109.2, 63.4, 60.2, 48.8, 32.6 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1812.

2'-(1*H*-indol-3-yl)-2-(p-tolyl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2p): Reaction of ynone **1b** (65 mg, 0.237 mmol), indole (43 mg, 0.237 mmol) and AgOTf (1.2 mg, 0.004 mmol) following the GP1 afforded the title compound **2p** as brown solid (91 mg, 98% yield); R_f : 0.45 (40% Ethyl Acetate-Petroleum Ether); ^1H NMR (400 MHz, DMSO-d_6) δ 11.09 (d, *J* = 1.96 Hz, 1H), 7.61-7.56 (m, 2H), 7.36-7.31 (m, 1H), 7.29-7.23 (m, 3H), 7.10 (ddd, *J* = 15.26, 7.65, 1.25 Hz, 1H), 7.06-7.00 (m, 2H), 6.88 (d, *J* = 6.90 Hz, 1H), 6.81 (ddd, *J* = 15.05, 7.52, 0.90 Hz, 1H), 6.73 (d, *J* = 7.61 Hz, 1H), 6.65 (s, 1H), 6.64 (ddd, *J* = 14.81, 7.38, 0.95 Hz, 1H), 6.36 (d, *J* = 2.92 Hz, 1H), 5.60 (d, *J* = 2.73 Hz, 1H), 2.81 (d, *J* = 18.39 Hz, 1H), 2.33 (s, 3H), 2.02 (d, *J* = 18.34 Hz, 1H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 205.6, 174.4, 150.6, 140.6, 136.5, 133.9, 130.6, 129.7, 129.4, 129.2, 128.4, 126.4, 124.3, 122.6, 121.2, 119.1, 118.6, 118.2, 112.7, 111.7, 109.1, 63.7, 60.1, 48.7, 21.0 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1812.

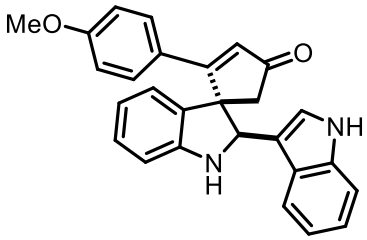


2-(4-butylphenyl)-2'-(1*H*-indol-3-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2q): Reaction of ynone **1c** (89 mg, 0.282 mmol), indole (33 mg, 0.282 mmol) and AgOTf (1.4 mg, 0.005 mmol) following the GP1 afforded the title compound **2q** as pale brown solid (110 mg, 90% yield); R_f : 0.50 (40% Ethyl Acetate-Petroleum Ether); ^1H NMR (400 MHz, DMSO-d_6) δ 11.08 (d, *J* = 2.05 Hz, 1H), 7.61-7.56 (m, 2H), 7.36-7.32 (m, 1H), 7.29-7.23 (m, 3H), 7.10 (ddd, *J* = 15.24, 7.65, 1.22 Hz, 1H), 7.05-7.00 (m, 2H), 6.91-6.87 (m, 1H), 6.81 (ddd, *J* = 14.98, 6.92, 0.96 Hz, 1H), 6.73 (d, *J* = 7.65 Hz, 1H), 6.65 (s, 1H), 6.64 (ddd, *J* = 14.64, 7.23, 0.98 Hz, 1H), 6.36 (d, *J* = 2.91 Hz, 1H), 5.59 (d, *J* = 2.72 Hz, 1H), 2.81 (d, *J* = 18.41 Hz, 1H), 2.60 (t, *J* = 7.61 Hz, 2H), 2.03 (d, *J* = 18.41 Hz, 1H), 1.60-1.51 (m, 2H), 1.34-1.23 (m, 2H), 0.87 (t, *J* = 7.39 Hz, 3H) ppm; $^{13}C\{^1H\}$ NMR (100 MHz, DMSO-d_6) δ 205.7, 174.5, 150.6, 145.4, 136.5, 134.0, 130.8, 129.7, 129.2, 128.8, 128.4, 126.4, 124.3, 122.6, 121.2, 119.1, 118.6, 118.3, 112.7, 111.7, 109.1, 63.7, 60.1,



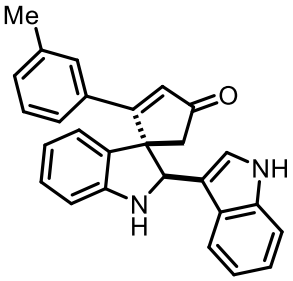
48.7, 34.6, 32.7, 21.8, 13.8 ppm; HRMS (ESI): calcd. for $C_{30}H_{29}N_2O$ $[M+H]^+$: 433.2280, found 433.2271.

2'-(1*H*-indol-3-yl)-2-(4-methoxyphenyl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2r):



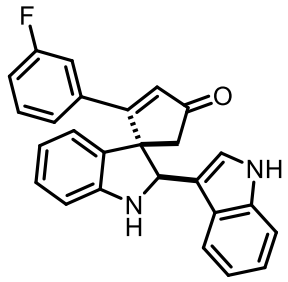
Reaction of ynone **1d** (55 mg, 0.190 mmol), indole (22.3 mg, 0.190 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2r** as brown solid (74 mg, 96% yield); R_f : 0.2 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.08 (d, *J* = 2.03 Hz, 1H), 7.70-7.65 (m, 2H), 7.35-7.31 (m, 1H), 7.30-7.27 (m, 1H), 7.10 (ddd, *J* = 15.36, 7.66, 1.24 Hz, 1H), 7.05-6.99 (m, 4H), 6.87 (d, *J* = 6.92 Hz, 1H), 6.81 (ddd, *J* = 15.02, 7.55, 0.89 Hz, 1H), 6.73 (d, *J* = 7.64 Hz, 1H), 6.64 (ddd, *J* = 14.80, 7.44, 0.92 Hz, 1H), 6.61 (s, 1H), 6.37 (d, *J* = 2.90 Hz, 1H), 5.61 (d, *J* = 2.73 Hz, 1H), 3.79 (s, 3H), 2.81 (d, *J* = 18.38 Hz, 1H), 2.00 (d, *J* = 18.33 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.3, 174.0, 161.0, 150.5, 136.5, 134.1, 131.0, 128.5, 128.3, 126.4, 125.5, 124.3, 122.6, 121.2, 119.0, 118.6, 118.2, 114.3, 112.7, 111.7, 109.1, 63.8, 60.0, 55.4, 48.6 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O_2$ $[M+H]^+$: 407.1760, found 407.1762.

2'-(1*H*-indol-3-yl)-2-(*m*-tolyl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2s): Reaction of



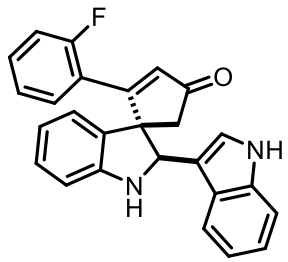
ynone **1e** (50 mg, 0.182 mmol), indole (21.4 mg, 0.182 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2s** as pale brown solid (68 mg, 95% yield); R_f : 0.43 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.08 (d, *J* = 1.58 Hz, 1H), 7.51 (s, 1H), 7.42-7.25 (m, 5H), 7.15-7.01 m, 3H), 6.94-6.88 (m, 1H), 6.82 (ddd, *J* = 14.95, 7.40, 0.76 Hz, 1H), 6.73 (d, *J* = 7.71 Hz, 1H), 6.68-6.63 (m, 2H), 6.35 (d, *J* = 2.85 Hz, 1H), 5.56 (d, *J* = 2.74 Hz, 1H), 2.80 (d, *J* = 18.42 Hz, 1H), 2.28 (s, 3H), 2.06 (d, *J* = 18.41 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.8, 174.8, 150.7, 138.1, 136.5, 133.8, 133.5, 131.2, 130.3, 129.9, 128.6, 128.5, 126.4, 126.2, 124.3, 122.7, 121.3, 119.2, 118.6, 118.3, 112.7, 111.8, 109.1, 63.6, 60.3, 48.7, 21.2 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1811.

2-(3-fluorophenyl)-2'-(1*H*-indol-3-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2t):



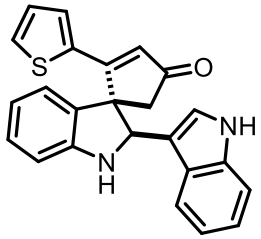
Reaction of ynone **1f** (50 mg, 0.180 mmol), indole (21.1 mg, 0.180 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2t** as pale brown solid (66 mg, 93% yield); R_f : 0.46 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.10 (d, J = 1.92 Hz, 1H), 7.54-7.48 (m, 2H), 7.47-7.42 (m, 1H), 7.36-7.30 (m, 2H), 7.28 (d, J = 2.38 Hz, 1H), 7.12 (ddd, J = 15.33, 7.62, 1.25 Hz, 1H), 7.08-7.01 (m, 2H), 6.94 (d, J = 6.83 Hz, 1H), 6.84 (ddd, J = 15.12, 7.53, 0.90 Hz, 1H), 6.77 (s, 1H), 6.73 (d, J = 7.60 Hz, 1H), 6.66 (ddd, J = 14.86, 7.39, 0.94 Hz, 1H), 6.39 (d, J = 2.76 Hz, 1H), 5.52 (d, J = 2.57 Hz, 1H), 2.80 (d, J = 18.49 Hz, 1H), 2.10 (d, J = 18.49 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 205.7, 172.7 (d, J = 2.30 Hz), 161.9 (d, J = 243.91 Hz), 150.8, 136.6, 135.7 (d, J = 7.76 Hz), 133.1, 131.5, 130.9 (d, J = 8.37 Hz) , 128.7, 126.3, 125.3 (d, J = 2.29 Hz), 122.9, 121.3, 119.1, 118.7, 118.3, 117.3 (d, J = 21.23 Hz), 115.6 (d, J = 22.92 Hz), 112.6, 111.8, 109.2, 63.6, 60.2, 48.7 ppm; ^{19}F NMR (376 MHz, DMSO-d_6) δ -107.02 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_2OF$ $[M+H]^+$: 395.1560, found 395.1562.

2-(2-fluorophenyl)-2'-(1*H*-indol-3-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2u):



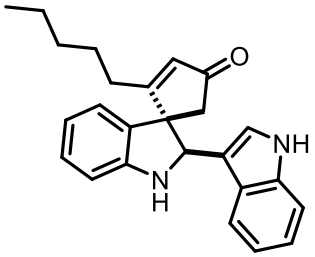
Reaction of ynone **1g** (75 mg, 0.270 mmol), indole (31.7 mg, 0.270 mmol) and AgOTf (1.4 mg, 0.005 mmol) following the GP1 afforded the title compound **2u** as pale brown solid (102 mg, 95% yield); R_f : 0.41 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.11 (d, J = 1.71 Hz, 1H), 7.54-7.41 (m, 2H), 7.38-7.34 (m, 1H), 7.30-7.24 (m, 2H), 7.19-7.09 (m, 3H), 7.05 (ddd, J = 15.16, 7.10, 0.96 Hz, 1H), 7.01-6.96 (m, 1H), 6.85 (ddd, J = 15.01, 7.10, 0.87 Hz, 1H), 6.72-6.66 (m, 2H), 6.51 (d, J = 3.20 Hz, 1H), 5.42 (s, 1H), 2.72 (d, J = 18.48 Hz, 1H), 2.12 (d, J = 18.46 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 206.1, 167.6 (d, J = 2.27 Hz), 161.6, 159.1, 150.8, 136.6, 134.1 (d, J = 9.18 Hz), 132.6, 132.1 (d, J = 9.09 Hz), 130.1, 127.4 (d, J = 250.0 Hz), 124.4, 124.3 (d, J = 3.37 Hz), 122.7, 121.8 (d, J = 11.77 Hz), 121.3, 119.1, 118.7, 118.2, 116.8 (d, J = 23.51 Hz), 112.6, 111.8, 109.1, 63.3, 61.5, 47.7 ppm; HRMS (ESI): calcd. for $C_{26}H_{20}N_2OF$ $[M+H]^+$: 395.1560, found 395.1558.

2'-(1*H*-indol-3-yl)-2-(thiophen-2-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2v):



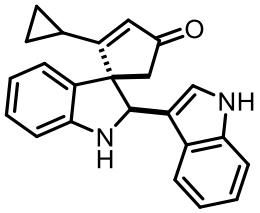
Reaction of ynone **1h** (70 mg, 0.263 mmol), indole (30.9 mg, 0.263 mmol) and AgOTf (1.4 mg, 0.005 mmol) following the GP1 afforded the title compound **2v** as yellow solid (93 mg, 92% yield); R_f : 0.43 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.09 (s, 1H), 7.88 (dd, *J* = 5.08, 0.91 Hz, 1H), 7.54 (d, *J* = 2.92 Hz, 1H), 7.36-7.30 (m, 2H), 7.20 (dd, *J* = 8.80, 3.81, 1H), 7.15-7.09 (m, 2H), 7.05-7.01 (m, 1H), 6.92 (d, *J* = 7.22 Hz, 1H), 6.83 (ddd, *J* = 14.68, 7.57, 1.04 Hz, 1H), 6.72 (d, *J* = 7.74 Hz, 1H), 6.63 (ddd, *J* = 14.73, 7.38, 0.82 Hz, 1H), 6.52 (s, 1H), 6.39 (d, *J* = 2.78 Hz, 1H), 5.65 (d, *J* = 2.74 Hz, 1H), 2.82 (d, *J* = 18.27 Hz, 1H), 2.03 (d, *J* = 18.32 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 204.7, 168.1, 151.3, 136.5, 136.2, 132.7, 132.1, 131.4, 128.7, 128.4, 127.8, 126.5, 124.4, 123.6, 121.2, 118.9, 118.6, 118.1, 112.3, 111.7, 109.0, 64.6, 60.2, 47.7 ppm; HRMS (ESI): calcd. for $C_{24}H_{19}N_2OS$ $[M+H]^+$: 383.1218, found 383.1217.

2'-(1*H*-indol-3-yl)-2-pentylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2w): Reaction of



ynone **1i** (50 mg, 0.197 mmol), indole (23.1 mg, 0.197 mmol) and AgOTf (1 mg, 0.004 mmol) following the GP1 afforded the title compound **2w** as brown solid (66 mg, 90% yield); R_f : 0.55 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.06 (d, *J* = 1.67 Hz, 1H), 7.35 (d, *J* = 8.12 Hz, 1H), 7.30-7.27 (m, 1H), 7.21 (d, *J* = 7.95 Hz, 1H), 7.09-7.02 (m, 2H), 6.90-6.82 (m, 2H), 6.66-6.62 (m, 2H), 6.19 (d, *J* = 1.85 Hz, 1H), 5.95 (s, 1H), 5.26 (d, *J* = 1.91 Hz, 1H), 2.72-2.61 (m, 1H), 2.51 (d, *J* = 18.43 Hz, 1H), 2.30-2.21 (m, 1H), 1.97 (d, *J* = 18.35 Hz, 1H), 1.70-1.51 (m, 2H), 1.37-1.24 (m, 4H), 0.86 (t, *J* = 7.20 Hz, 3H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d_6) δ 206.4, 184.0, 151.6, 136.7, 132.0, 128.4, 128.3, 126.1, 124.5, 122.7, 121.2, 119.5, 118.7, 117.7, 113.6, 111.7, 108.7, 63.5, 61.0, 46.6, 31.0, 28.9, 26.4, 21.9, 13.9 ppm; HRMS (ESI): calcd. for $C_{25}H_{27}N_2O$ $[M+H]^+$: 371.2123, found 371.2125.

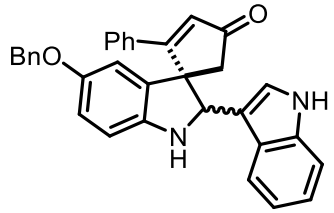
2-cyclopropyl-2'-(1*H*-indol-3-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2x):



Reaction of ynone **1j** (65 mg, 0.291 mmol), indole (34.1 mg, 0.291 mmol) and AgOTf (1.5 mg, 0.006 mmol) following the GP1 afforded the title compound **2x** as pale brown solid (97 mg, 98% yield); R_f : 0.37 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6)

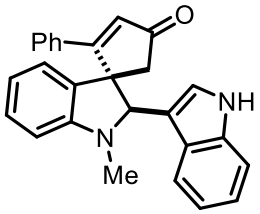
δ) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) *δ* 11.07 (d, *J* = 1.82 Hz, 1H), 7.42-7.33 (m, 2H), 7.31 (d, *J* = 2.41 Hz, 1H), 7.09-7.03 (m, 2H), 6.93-6.86 (m, 2H), 6.70-6.65 (m, 2H), 6.21 (bs, 1H), 5.60 (s, 1H), 5.52 (s, 1H), 2.56 (d, *J* = 18.30 Hz, 1H), 1.91 (d, *J* = 18.23 Hz, 1H), 1.75-1.69 (m, 1H), 1.36-1.29 (m, 1H), 1.15-1.08 (m, 1H), 1.01-0.95 (m, 1H), 0.94-0.86 (m, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) *δ* 205.9, 188.3, 151.6, 136.6, 132.7, 128.3, 126.3, 124.4, 122.9, 122.4, 121.2, 119.6, 118.7, 118.1, 113.0, 111.7, 109.0, 63.9, 61.5, 46.7, 13.7, 13.6, 11.5 ppm; HRMS (ESI): calcd. for $C_{23}H_{21}N_2O$ $[M+H]^+$: 341.1654, found 341.1653.

5'-(benzyloxy)-2'-(1*H*-indol-3-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one



(2z): Reaction of ynone **1l** (80 mg, 0.219 mmol), indole (25.7 mg, 0.219 mmol) and AgOTf (1.1 mg, 0.004 mmol) following the GP1 afforded the title compound **2z** in an inseparable diastereomeric mixture (dr = 4:1) as brown solid (94 mg, 89% yield); R_f : 0.37 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) *δ* 11.09 (d, *J* = 1.75 Hz, 1H), 7.72-7.66 (m, 2H), 7.55-7.45 (m, 3H), 7.40-7.27 (m, 7H), 7.25-7.20 (m, 2H), 7.07-7.00 (m, 2H), 6.85-6.80 (m, 1H), 6.706.67 (m, 2H), 6.02 (d, *J* = 3.62 Hz, 1H), 5.57 (d, *J* = 3.17 Hz, 1H), 4.95 (dd, *J* = 33.02 Hz, 11.96 Hz, 2H), 2.85 (d, *J* = 18.42 Hz, 1H), 2.08 (d, *J* = 18.41 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) *δ* 205.6, 174.0, 151.9, 144.8, 137.5, 136.4, 135.0, 133.4, 130.8, 130.5, 129.2, 128.8, 128.3, 127.7, 126.4, 124.4, 119.0, 118.5, 115.2, 112.6, 111.7, 110.3, 110.0, 70.0, 64.1, 60.6, 48.2 ppm; HRMS (ESI): calcd. for $C_{33}H_{27}N_2O_2$ $[M+H]^+$: 483.2073, found 483.2067.

2'-(1*H*-indol-3-yl)-1'-methyl-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2aa):



Reaction of ynone **1m** (100 mg, 0.365 mmol), indole (42.9 mg, 0.365 mmol) and AgOTf (1.9 mg, 0.007 mmol) following the GP1 afforded the title compound **2aa** as yellow solid (132.5 mg, 93% yield); R_f : 0.6 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) *δ* 11.18 (bs, 1H), 7.60-7.29 (m, 7H), 7.23 (ddd, *J* = 15.40, 7.73, 1.26 Hz, 1H), 7.10-6.91 (m, 3H), 6.85-6.74 (m, 3H), 6.69 (s, 1H), 5.04 (bs, 1H), 2.83 (bs, 1H), 2.66 (s, 3H), 2.08 (d, *J* = 18.40 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) *δ* 205.6, 173.7, 151.9, 136.6, 133.5, 131.2, 130.6, 129.2, 129.0, 128.6, 128.4, 128.2, 128.1, 128.0, 127.9, 126.9, 125.2, 122.6, 121.5, 119.3, 112.0, 109.2, 108.8, 71.7, 55.0, 48.6, 34.5 ppm; HRMS (ESI): calcd. for $C_{27}H_{21}N_2O$ $[M-H]^-$: 389.1654, found 389.1651.

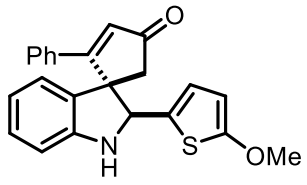
2'-(1*H*-indol-3-yl)-2-phenylspiro[cyclohexane-1,3'-indolin]-2-en-4-one (2ab): Reaction of ynone **1n** (70 mg, 0.256 mmol), indole (30 mg, 0.256 mmol) and AgOTf (1.3 mg, 0.005 mmol) following the GP1 afforded the title compound **2ab** as pale brown solid (86 mg, 86% yield); R_f : 0.62 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 11.04 (d, *J* = 1.76 Hz, 1H), 7.42-7.38 (m, 3H), 7.33 (d, *J* = 8.13 Hz, 1H), 7.28-7.24 (m, 2H), 7.17-7.11 (m, 2H), 7.10-7.06 (m, 2H), 7.02 (ddd, *J* = 15.21, 7.66, 0.92 Hz, 1H), 6.83 (ddd, *J* = 15.03, 7.66, 0.85 Hz, 1H), 6.75-6.66 (m, 2H), 6.29 (d, *J* = 2.95 Hz, 1H), 6.19 (s, 1H), 5.58 (d, *J* = 2.85 Hz, 1H), 2.47-2.36 (m, 1H), 2.08-1.95 (m, 2H), 1.84-1.75 (m, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d$_6$) δ 197.9, 162.8, 150.6, 139.3, 136.4, 131.2, 130.6, 129.0, 128.7, 128.4, 128.3, 126.5, 124.3, 123.9, 121.1, 119.6, 118.5, 117.6, 112.1, 111.6, 109.3, 64.6, 53.3, 32.7, 30.5 ppm; HRMS (ESI): calcd. for $C_{27}H_{23}N_2O$ $[M+H]^+$: 391.1810, found 391.1809.

2-phenyl-2'-(1*H*-pyrrol-2-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2ae): Reaction of ynone **1a** (100 mg, 0.385 mmol), pyrrole (25.9 mg, 0.385 mmol) and AgOTf (2 mg, 0.007 mmol) following the GP1 afforded the title compound **2ae** as brown solid (115 mg, 91% yield); R_f : 0.55 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 10.8 (s, 1H), 7.56-7.52 (m, 2H), 7.45-7.35 (m, 3H), 7.12-7.08 (m, 1H), 6.91 (d, *J* = 7.30 Hz, 1H), 6.75-6.70 (m, 2H), 6.69-6.65 (m, 2H), 6.42 (bs, 1H), 5.94 (dd, *J* = 5.50, 2.50 Hz, 1H), 5.64 (s, 1H), 5.17 (s, 1H), 2.47 (d, *J* = 18.45 Hz, 1H), 2.00 (d, *J* = 18.42 Hz, 1H) ppm; ^{13}C{^{1}H} NMR (100 MHz, DMSO-d$_6$) δ 205.5, 173.7, 150.4, 133.5, 133.1, 130.9, 130.4, 129.0, 128.8, 128.53, 128.50, 123.0, 118.8, 117.7, 109.6, 107.8, 105.9, 64.0, 61.0, 48.5 ppm; HRMS (ESI): calcd. for $C_{22}H_{17}N_2O$ $[M-H]^-$: 325.1341, found 325.1342.

2-phenyl-2'-(1-phenyl-1*H*-pyrrol-2-yl)spiro[cyclopentane-1,3'-indolin]-2-en-4-one (2af): Reaction of ynone **1a** (50 mg, 0.192 mmol), pyrrole (27.6 mg, 0.192 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2af** as brown solid (60 mg, 77% yield); R_f : 0.66 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d$_6$) δ 7.28-7.23 (m, 1H), 7.15-7.05 (m, 5H), 7.04 (ddd, *J* = 15.21, 7.52, 1.17 Hz, 1H), 7.00-6.92 (m, 4H), 6.77 (dd, *J* = 4.52, 1.91 Hz, 1H), 6.71-6.66 (m, 2H), 6.54 (ddd, *J* = 14.80, 7.42, 0.75 Hz, 1H), 6.42 (dd, *J* = 3.41, 1.80 Hz, 1H), 6.36 (d, *J* = 2.81 Hz, 1H), 6.32 (s, 1H), 6.21 (dd, *J* = 6.33, 2.70 Hz,

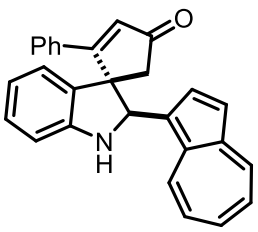
1H), 5.50 (d, *J* = 2.68 Hz, 1H), 2.63 (d, *J* = 18.52 Hz, 1H), 2.04 (d, *J* = 18.50 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 205.3, 173.6, 150.1, 139.0, 133.0, 132.3, 131.8, 130.1, 129.4, 129.0, 128.6, 128.5, 128.2, 127.5, 126.0, 123.9, 122.7, 118.3, 110.2, 108.8, 108.6, 61.5, 60.1, 49.3 ppm; HRMS (ESI): calcd. for $C_{28}H_{23}N_2O$ $[M+H]^+$: 403.1810, found 403.1816.

2'-(5-methoxythiophen-2-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2ag):



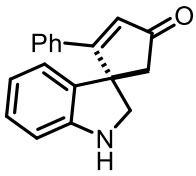
Reaction of ynone **1a** (100 mg, 0.385 mmol), 2-methoxythiophene (44 mg, 0.385 mmol) and AgOTf (2 mg, 0.007 mmol) following the GP1 afforded the title compound **2ag** as yellow solid (129 mg, 89% yield); R_f : 0.69 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.21 (m, 5H), 7.16-7.05 (m, 2H), 6.98-6.93 (m, 1H), 6.79-6.70 (m, 2H), 6.51 (s, 1H), 6.31 (d, *J* = 3.50 Hz, 1H), 5.92 (d, *J* = 3.68 Hz, 1H), 5.25 (s, 1H), 3.74 (s, 3H), 2.91 (d, *J* = 18.82 Hz, 1H), 2.16 (d, *J* = 18.81 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, $CDCl_3$) δ 206.7, 174.4, 165.8, 148.9, 133.9, 133.4, 132.3, 130.4, 129.0, 128.99, 128.95, 127.4, 123.3, 122.4, 120.8, 110.4, 103.5, 65.8, 61.6, 60.2, 48.0 ppm; HRMS (ESI): calcd. for $C_{23}H_{20}NO_2S$ $[M+H]^+$: 374.1215, found 374.1219.

2'-(azulen-1-yl)-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (2ah): Reaction of



ynone **1a** (50 mg, 0.193 mmol), azulene (24.7 mg, 0.193 mmol) and AgOTf (1 mg, 0.003 mmol) following the GP1 afforded the title compound **2ah** as dark blue solid (64 mg, 86% yield); R_f : 0.71 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.38 (d, *J* = 9.29 Hz, 1H), 8.01-7.96 (m, 1H), 7.75-7.60 (m, 4H), 7.56-7.47 (m, 3H), 7.45-7.40 (m, 1H), 7.25-7.13 (m, 2H), 6.98-6.86 (m, 2H), 6.82-6.69 (m, 2H), 6.63 (s, 1H), 6.52 (d, *J* = 3.02 Hz, 1H), 5.97 (d, *J* = 3.02 Hz, 1H), 2.54 (d, *J* = 18.53 Hz, 1H), 2.08 (d, *J* = 18.39 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 205.3, 174.0, 150.7, 141.3, 138.5, 137.4, 137.3, 135.9, 133.7, 133.6, 133.4, 131.0, 130.8, 129.3, 129.0, 128.6, 126.6, 123.5, 122.8, 122.1, 118.8, 117.4, 109.5, 64.1, 61.0, 48.9 ppm; HRMS (ESI): calcd. for $C_{28}H_{22}NO$ $[M+H]^+$: 388.1701, found 388.1701.

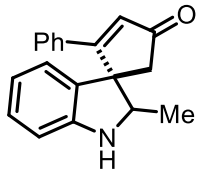
2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (3a): Reaction of ynone **1a** (100 mg,



0.385 mmol), Hantzsch ester (97.7 mg, 0.385 mmol) and AgOTf (2 mg, 0.007 mmol) following the GP1 afforded the title compound **3a** as pale yellow oil (92 mg, 91% yield); R_f : 0.5 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30-7.25 (m, 3H), 7.24-7.20 (m, 2H), 7.18 (s, 1H), 7.06

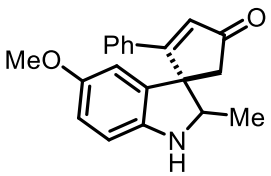
(ddd, *J* = 15.23, 7.65, 1.20 Hz, 1H), 6.90-6.87 (m, 1H), 6.72-6.66 (m, 2H), 6.51 (s, 1H), 3.92 (d, *J* = 9.92 Hz, 1H), 3.51 (d, *J* = 9.95 Hz, 1H), 2.88 (d, *J* = 18.72 Hz, 1H), 2.75 (d, *J* = 18.72 Hz, 1H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, CD_3OD) δ 206.4, 175.2, 151.4, 133.3, 133.0, 130.5, 129.4, 128.7, 128.6, 128.5, 122.2, 117.9, 109.2, 57.4, 55.5, 55.3 ppm; HRMS (ESI): calcd. for $C_{18}H_{16}NO$ $[M+H]^+$: 262.1232, found 262.1229.

2'-methyl-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (3b): Reaction of ynone **1o**



(100 mg, 0.365 mmol), Hantzsch ester (92.7 mg, 0.365 mmol) and AgOTf (2 mg, 0.007 mmol) following the GP1 afforded the title compound **3b** as pale yellow oil (95 mg, 94% yield); R_f : 0.6 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.35-7.27 (m, 3H), 7.24-7.18 (m, 2H), 7.04 (dt, *J* = 7.60, 1.24 Hz, 1H), 6.98 (d, *J* = 7.29 Hz, 1H), 6.64-6.59 (m, 2H), 6.49 (s, 1H), 5.97 (d, *J* = 3.29 Hz, 1H), 4.08-4.02 (m, 1H), 3.06 (d, *J* = 18.65 Hz, 1H), 2.65 (d, *J* = 18.70 Hz, 1H), 1.03 (d, *J* = 6.66 Hz, 3H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, DMSO-d_6) δ 206.2, 176.8, 151.9, 135.6, 132.2, 130.9, 130.0, 128.7, 128.3, 128.2, 123.5, 118.3, 109.3, 65.0, 58.3, 53.2, 15.3 ppm; HRMS (ESI): calcd. for $C_{19}H_{18}NO$ $[M+H]^+$: 276.1388, found 276.1392.

5'-methoxy-2'-methyl-2-phenylspiro[cyclopentane-1,3'-indolin]-2-en-4-one (3c): Reaction



of ynone **1p** (100 mg, 0.329 mmol), Hantzsch ester (83.5 mg, 0.329 mmol) and AgOTf (1.7 mg, 0.006 mmol) following the GP1 afforded the title compound **3c** as yellow oil (53 mg, 54% yield); R_f : 0.45 (40% Ethyl Acetate-Petroleum Ether); ^{1}H NMR (400 MHz, CD_3OD) δ 7.34-7.28 (m, 1H), 7.27-7.19 (m, 4H), 6.78-6.74 (m, 1H), 6.67 (s, 1H), 6.65 (d, *J* = 6.28 Hz, 1H), 6.40 (s, 1H), 4.08 (q, *J* = 6.71 Hz, 1H), 3.69 (s, 3H), 3.16 (d, *J* = 18.92 Hz, 1H), 2.67 (d, *J* = 18.98 Hz, 1H), 1.12 (d, *J* = 6.71 Hz, 3H) ppm; $^{13}C\{^{1}H\}$ NMR (100 MHz, CD_3OD) δ 209.5, 180.4, 155.7, 146.9, 137.1, 135.0, 131.9, 131.1, 129.4, 129.3, 115.7, 112.5, 110.5, 67.2, 60.9, 56.3, 53.9, 15.6 ppm; HRMS (ESI): calcd. for $C_{20}H_{20}NO_2$ $[M+H]^+$: 306.1494, found 306.1495.

5. Special Note:

During the $^{13}C\{^{1}H\}$ NMR data acquisition of compound **2x**, we used sample concentration of ~0.8(M), relaxation time was 4 sec., and 3820 scans. In lower concentrations and with less relaxation time, many peaks were absent. The reason for this abnormality is currently unclear.

6. X-ray Structures:

Crystal data and structure refinement for **2c**: CCDC: 2296145

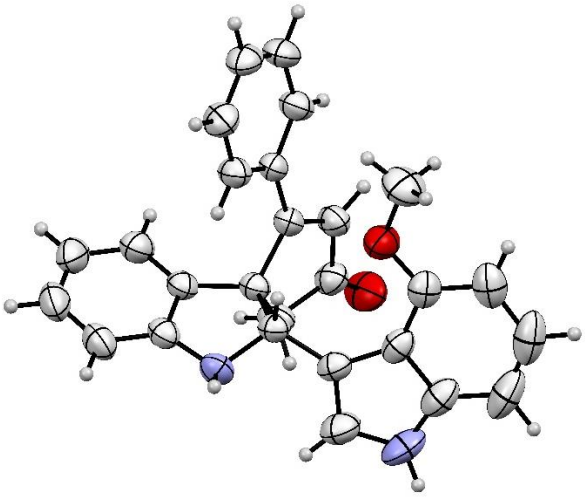


Figure S3: ORTEP representation of compound **2c**.

The ellipsoid contour % probability levels in the caption for the image of **2c** was 50%.

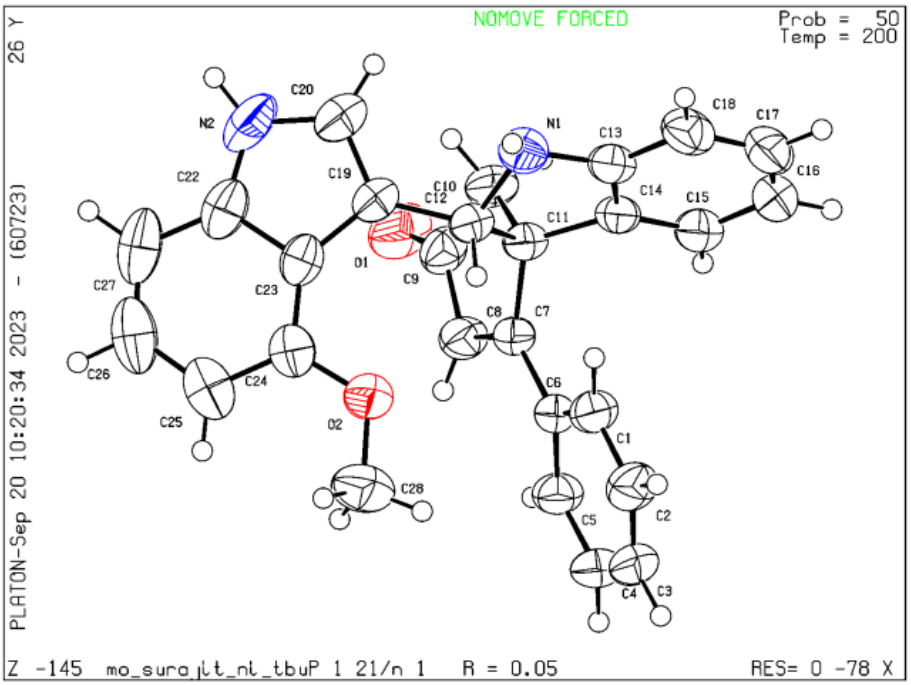


Table S1 Crystal data and structure refinement for 2c.

Identification code	2c
Empirical formula	$C_{27}H_{22}N_2O_2$
Formula weight	406.46

Temperature/K	200.0
Crystal system	monoclinic
Space group	$P2_1/n$
a/Å	15.1135(6)
b/Å	10.4102(4)
c/Å	15.4220(5)
α/°	90
β/°	119.0150(10)
γ/°	90
Volume/Å^3	2121.88(14)
Z	4
ρ_{calc}g/cm^3	1.272
μ/mm^{-1}	0.081
F(000)	856.0
Crystal size/mm^3	0.2 × 0.11 × 0.07
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.944 to 56.628
Index ranges	$-20 \leq h \leq 20$, $-13 \leq k \leq 13$, $-20 \leq l \leq 20$
Reflections collected	51553
Independent reflections	5280 [R_{int} = 0.0384, R_{sigma} = 0.0178]
Data/restraints/parameters	5280/0/278
Goodness-of-fit on F^2	1.077
Final R indexes [I>=2σ (I)]	R_1 = 0.0499, wR_2 = 0.1208
Final R indexes [all data]	R_1 = 0.0615, wR_2 = 0.1278
Largest diff. peak/hole / e Å^{-3}	0.19/-0.17

Crystal data and structure refinement for **2m**: CCDC: 2296148

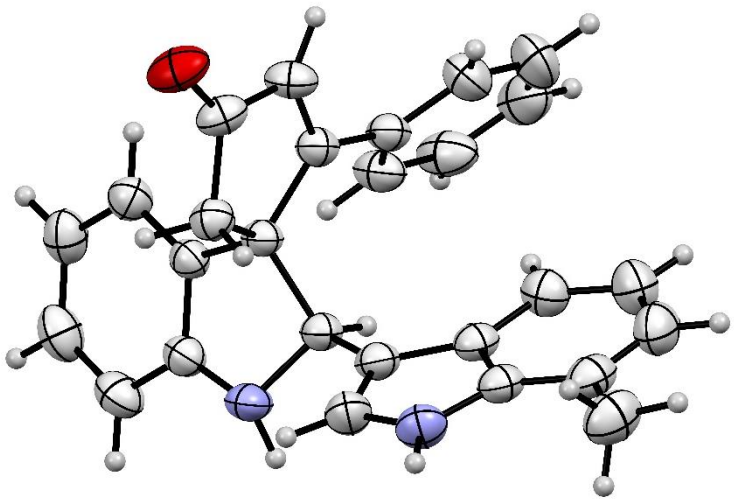


Figure S4: ORTEP representation of compound **2m**.

The ellipsoid contour % probability levels in the caption for the image of **2m** was 50%.

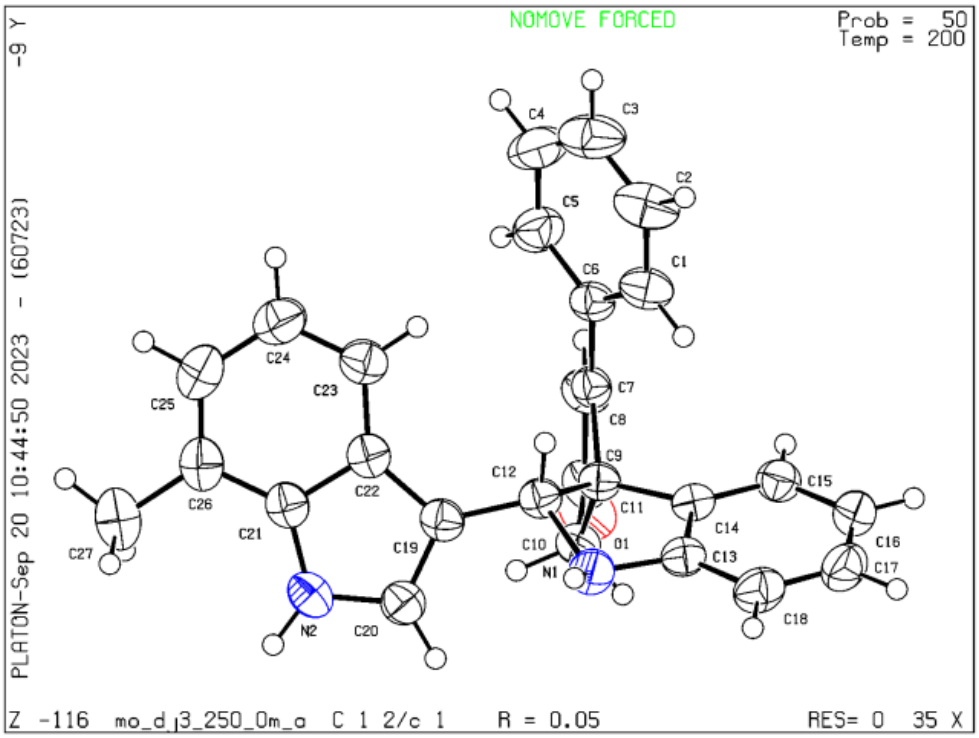


Table S2 Crystal data and structure refinement for 2m.

Identification code	2m
Empirical formula	$C_{27}H_{22}N_2O$
Formula weight	390.46
Temperature/K	200(2)
Crystal system	monoclinic
Space group	C2/c
a/Å	37.641(3)
b/Å	7.1425(6)
c/Å	15.2538(12)
α/°	90
β/°	99.978(3)
γ/°	90
Volume/Å^3	4039.0(6)
Z	8
ρ_{calc}g/cm^3	1.284
μ/mm^{-1}	0.078
F(000)	1648.0
Crystal size/mm^3	0.22 × 0.12 × 0.09
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.424 to 56.516
Index ranges	$-47 \le h \le 45$, $-9 \le k \le 9$, $-16 \le l \le 20$
Reflections collected	12385

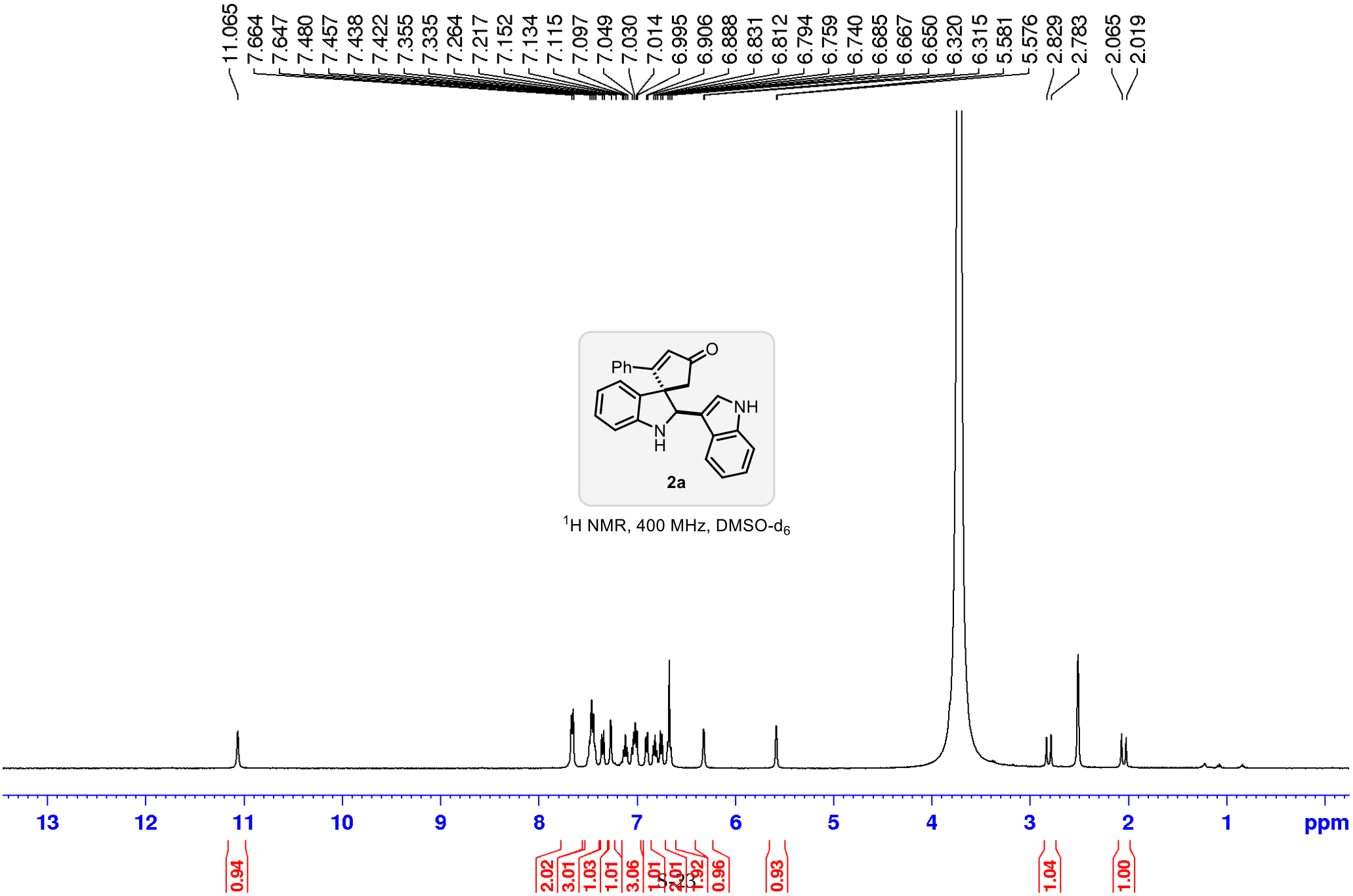
Independent reflections	4339 [R_{int} = 0.0530, R_{sigma} = 0.0605]
Data/restraints/parameters	4339/0/278
Goodness-of-fit on F^2	1.033
Final R indexes [I>=2σ (I)]	R_1 = 0.0531, wR_2 = 0.1229
Final R indexes [all data]	R_1 = 0.0857, wR_2 = 0.1374
Largest diff. peak/hole / e $Å^{-3}$	0.16/-0.18

7. References:

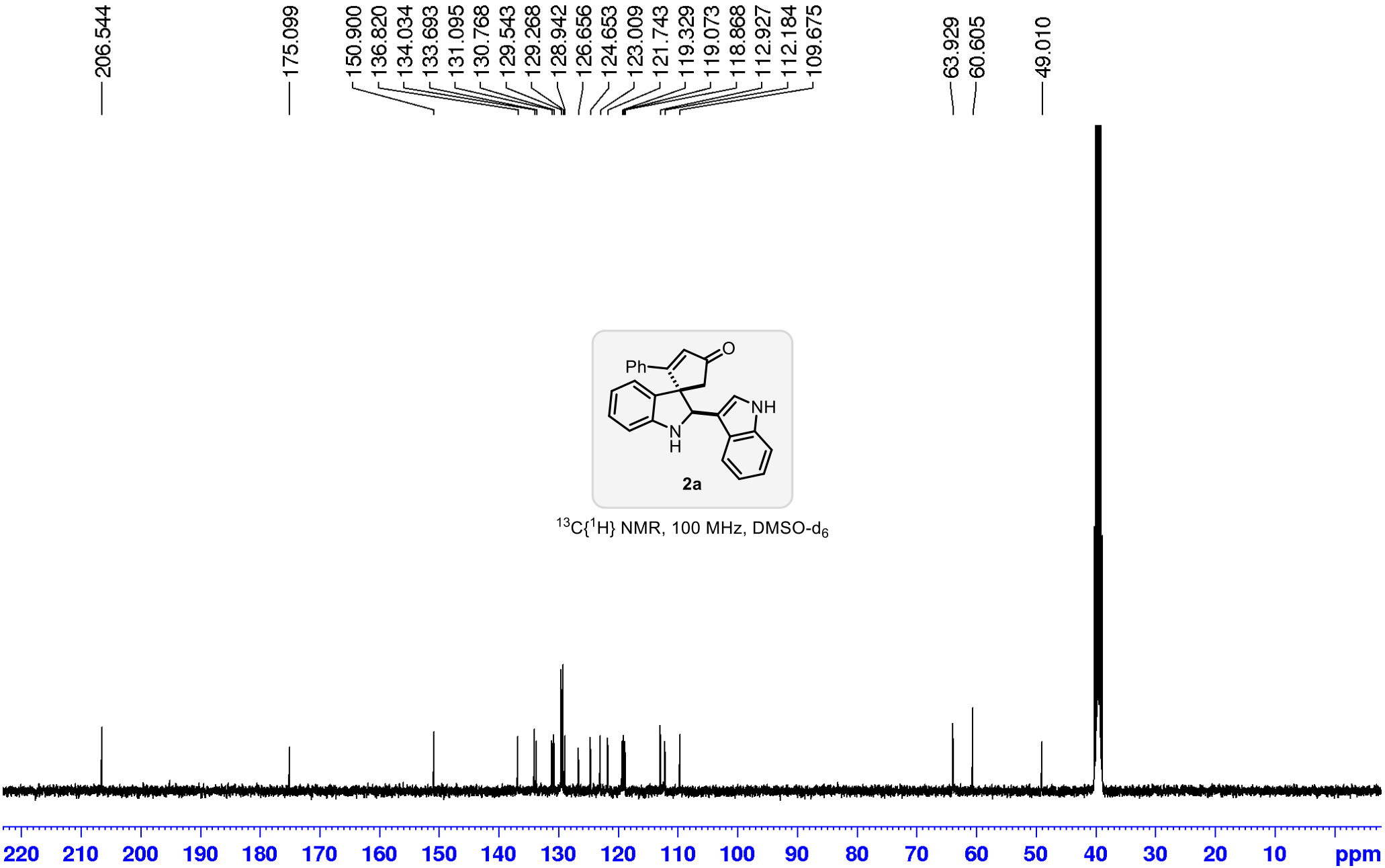
1. (a) James, M. J.; Cuthbertson, J. D.; O'Brien, P.; Taylor, R. J. K.; Unsworth. *Angew. Chem., Int. Ed.* **2015**, *54*, 7640. (b) Liddon, J. T. R.; Clarke, A. K.; Taylor, R. J. K.; Unsworth, W. P. *Org. Lett.* **2016**, *18*, 6328. (c) James, M. J.; Clubley, R. E.; Palate, K. Y.; Procter, T. J.; Wyton, A. C.; O'Brien, P.; Taylor, R. J. K.; Unsworth, W. P. *Org. Lett.* **2015**, *17*, 4372.

2. Ru, G.-X.; Zhang, M.; Zhang, T.-T.; Jiang, X.-L.; Gao, G.-Q.; Zhu, X.-H.; Wang, S.; Fan, C.-L.; Li, X.; Shen, W.-B. *Org. Chem. Front.* **2022**, *9*, 2621.

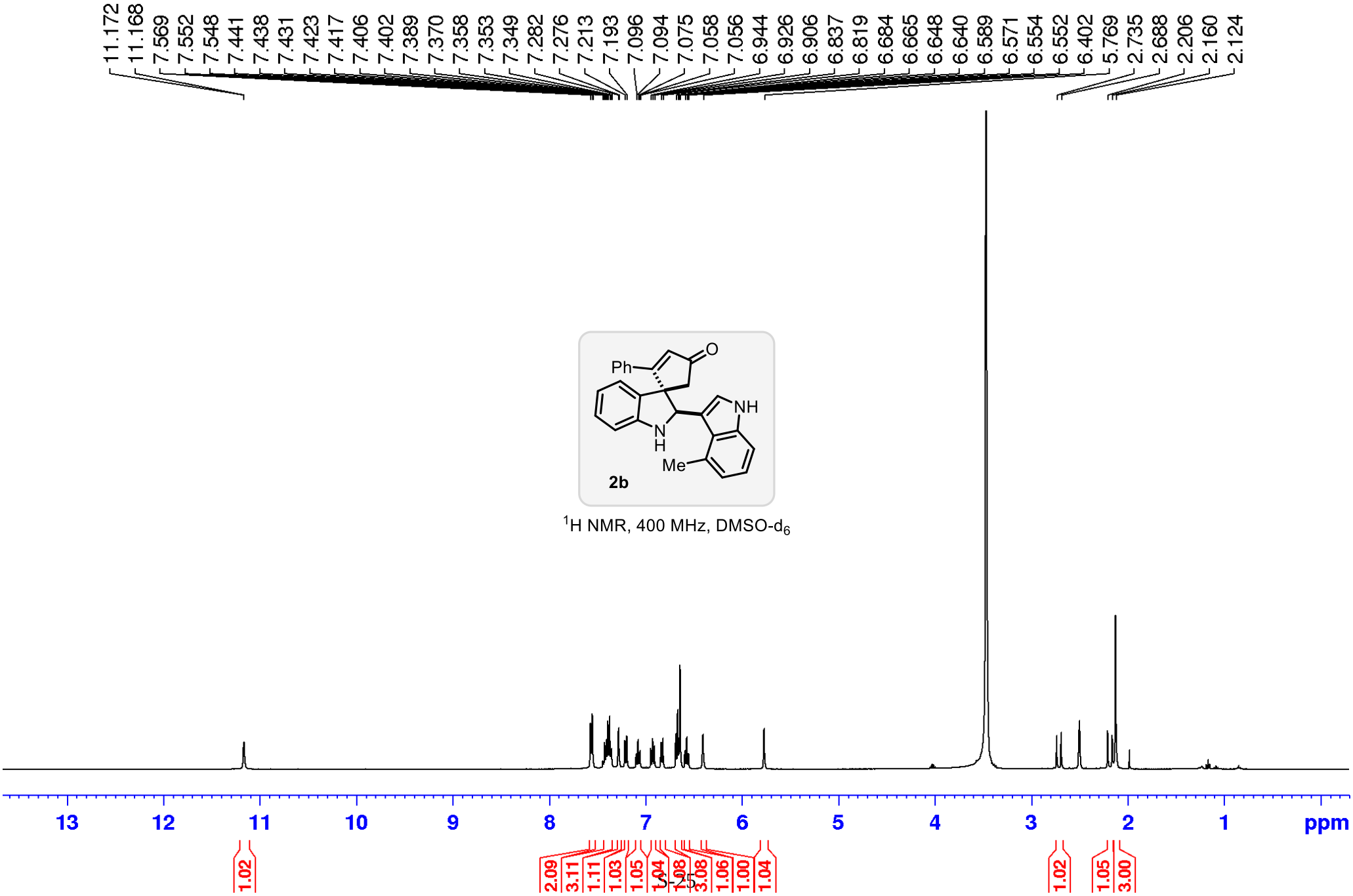
Copies of ^{1}H and ^{13}C NMR Spectra



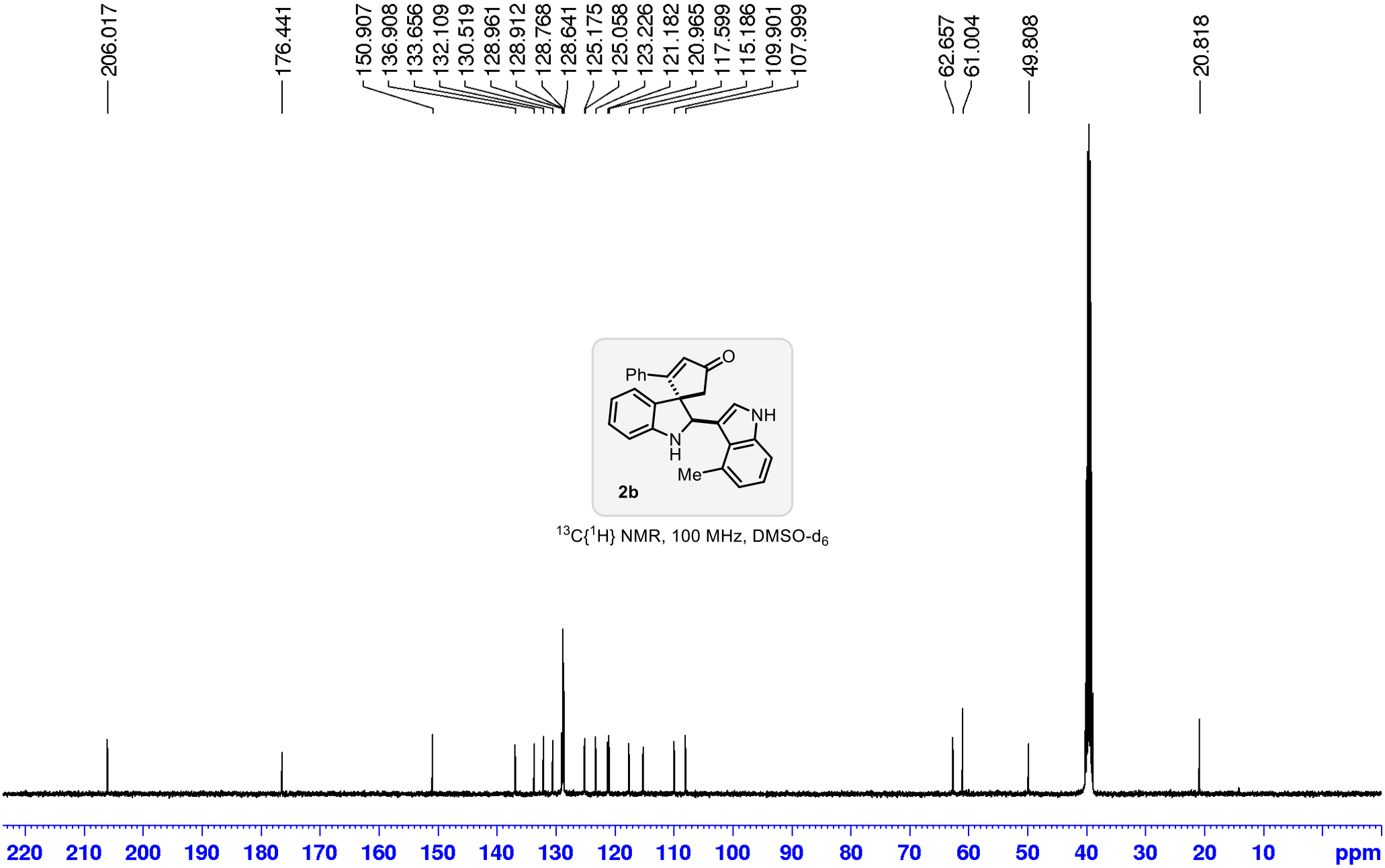
^{1}H NMR, 400 MHz, DMSO-d_6



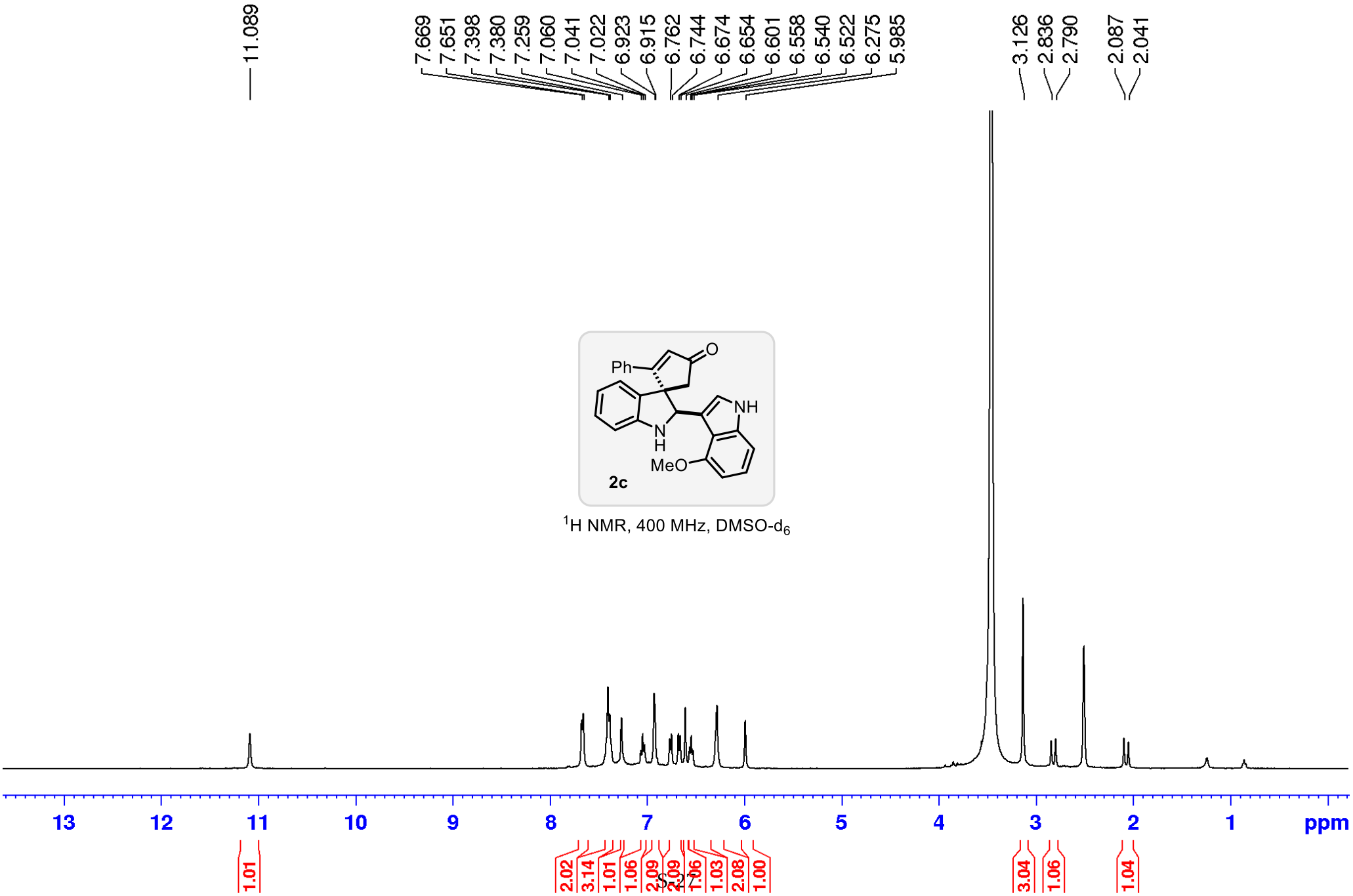
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



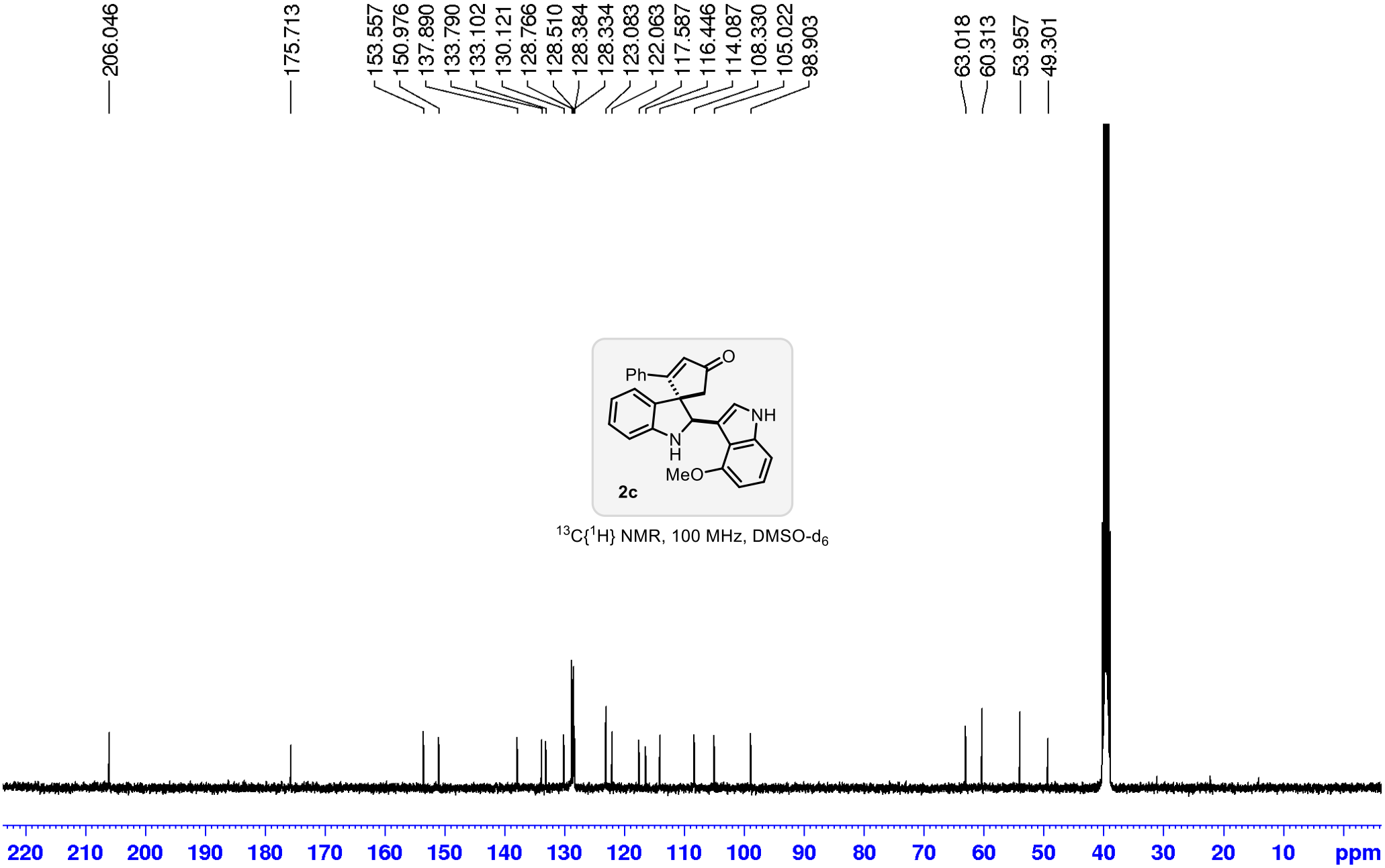
^{1}H NMR, 400 MHz, DMSO-d_6



$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



^{1}H NMR, 400 MHz, DMSO-d$_6$



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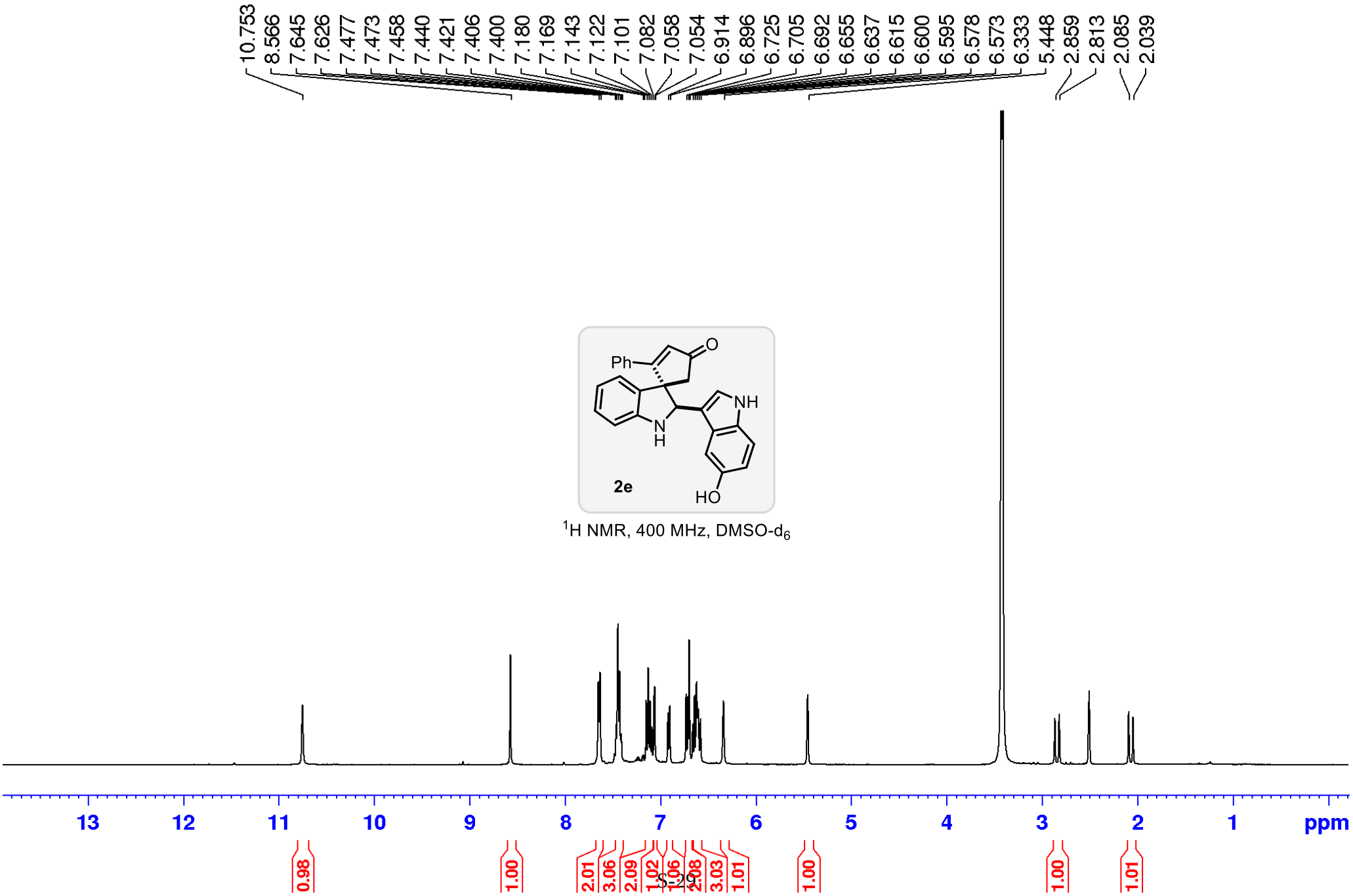
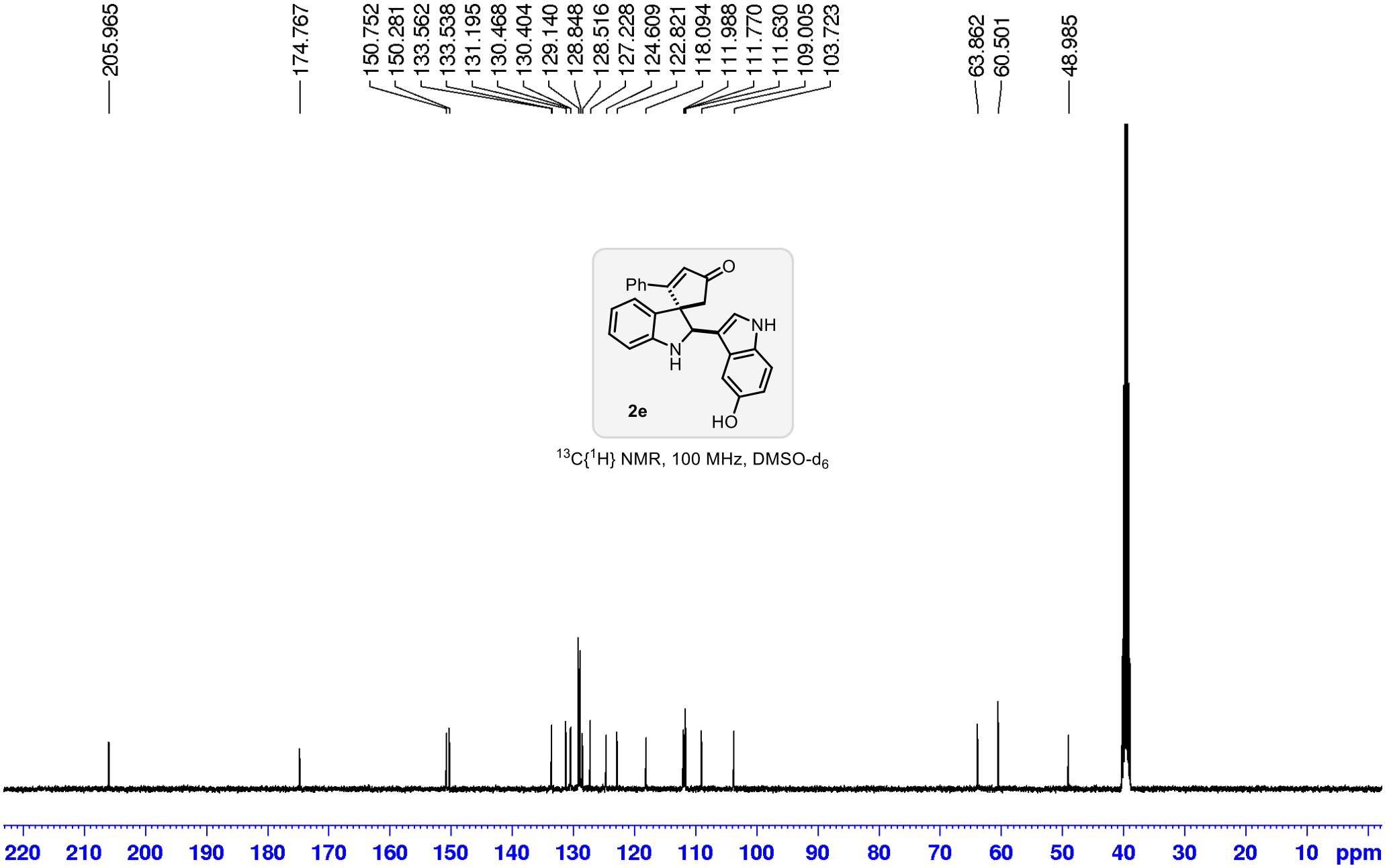
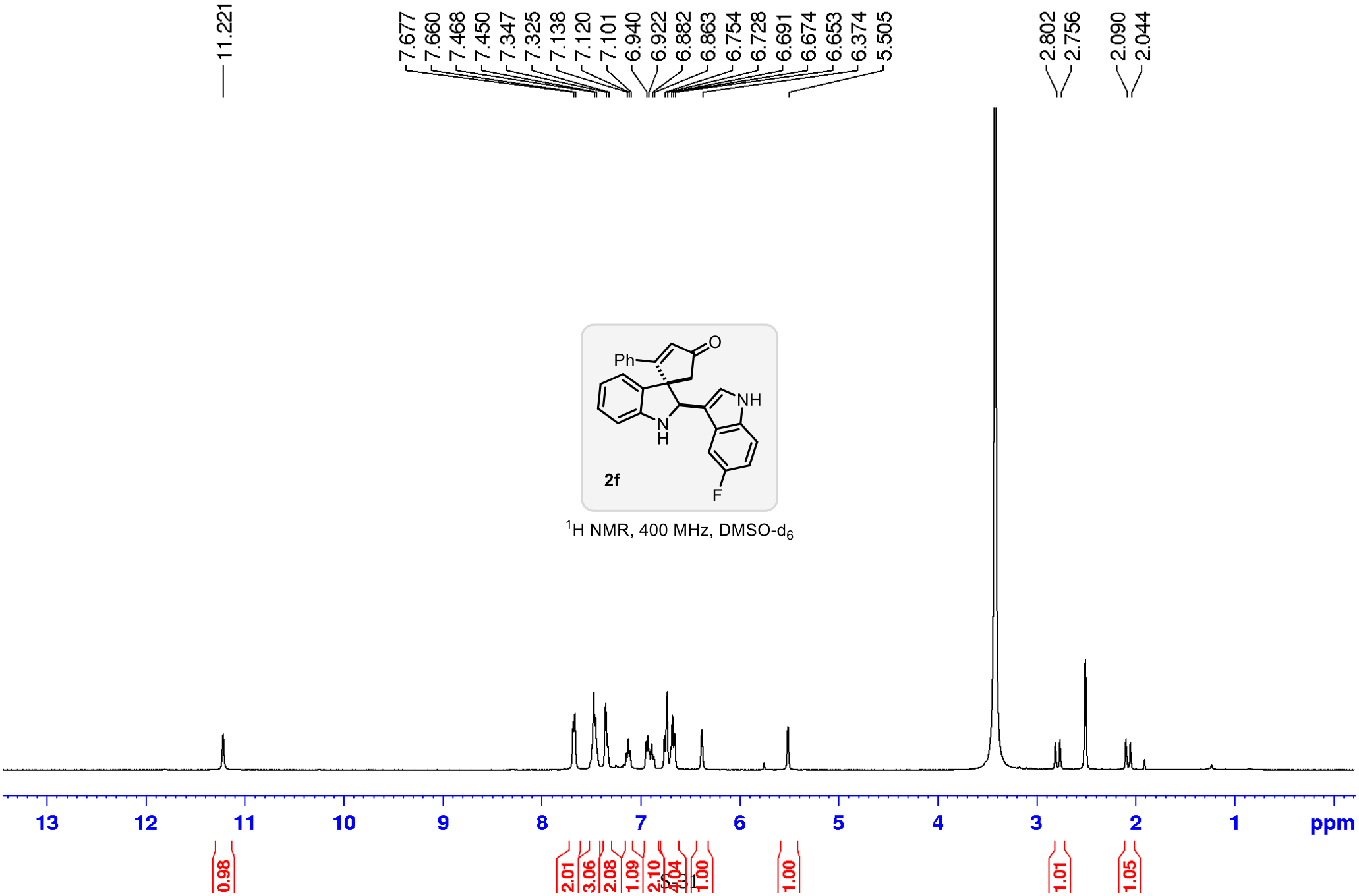


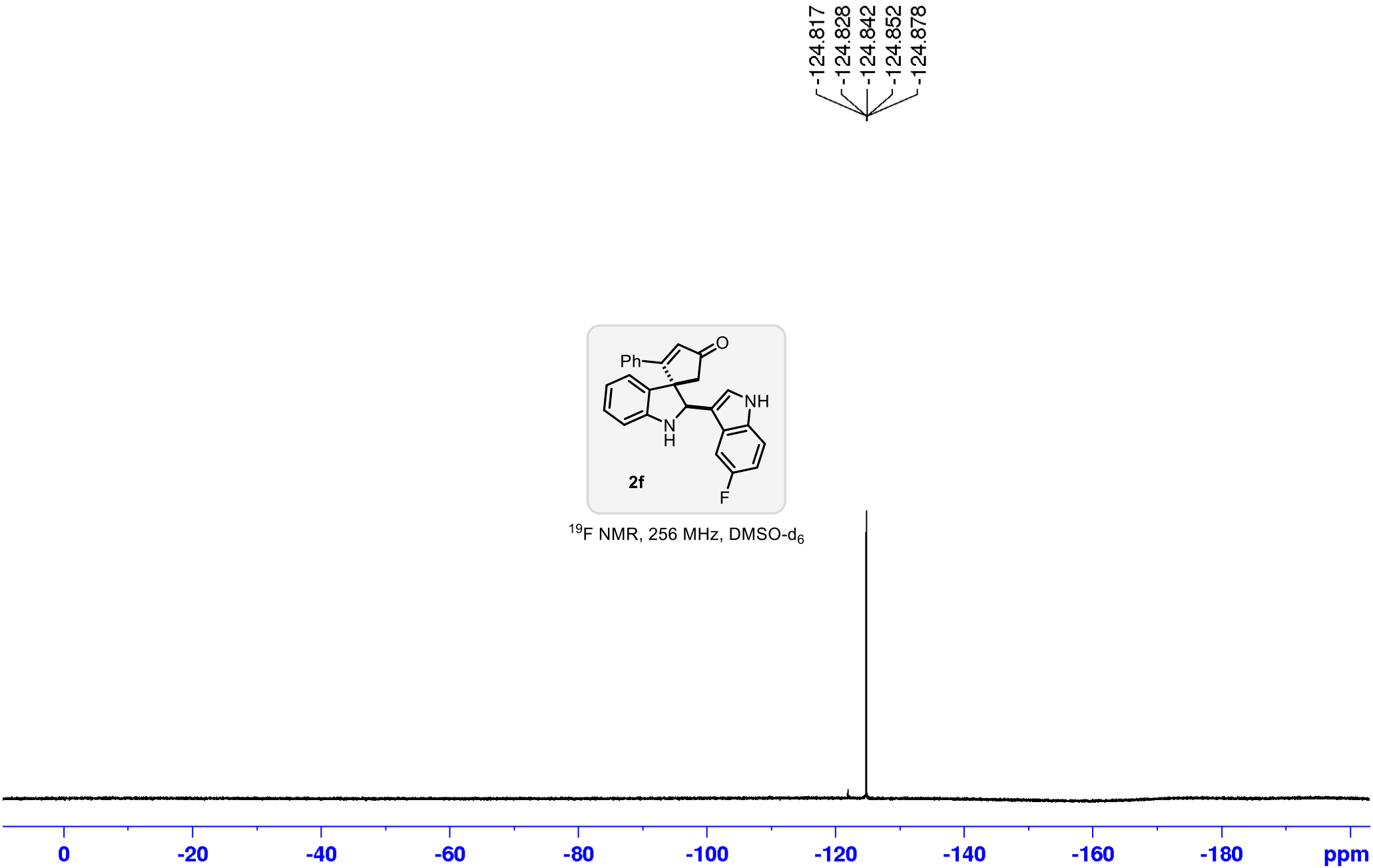
^{1}H NMR, 400 MHz, DMSO-d_6



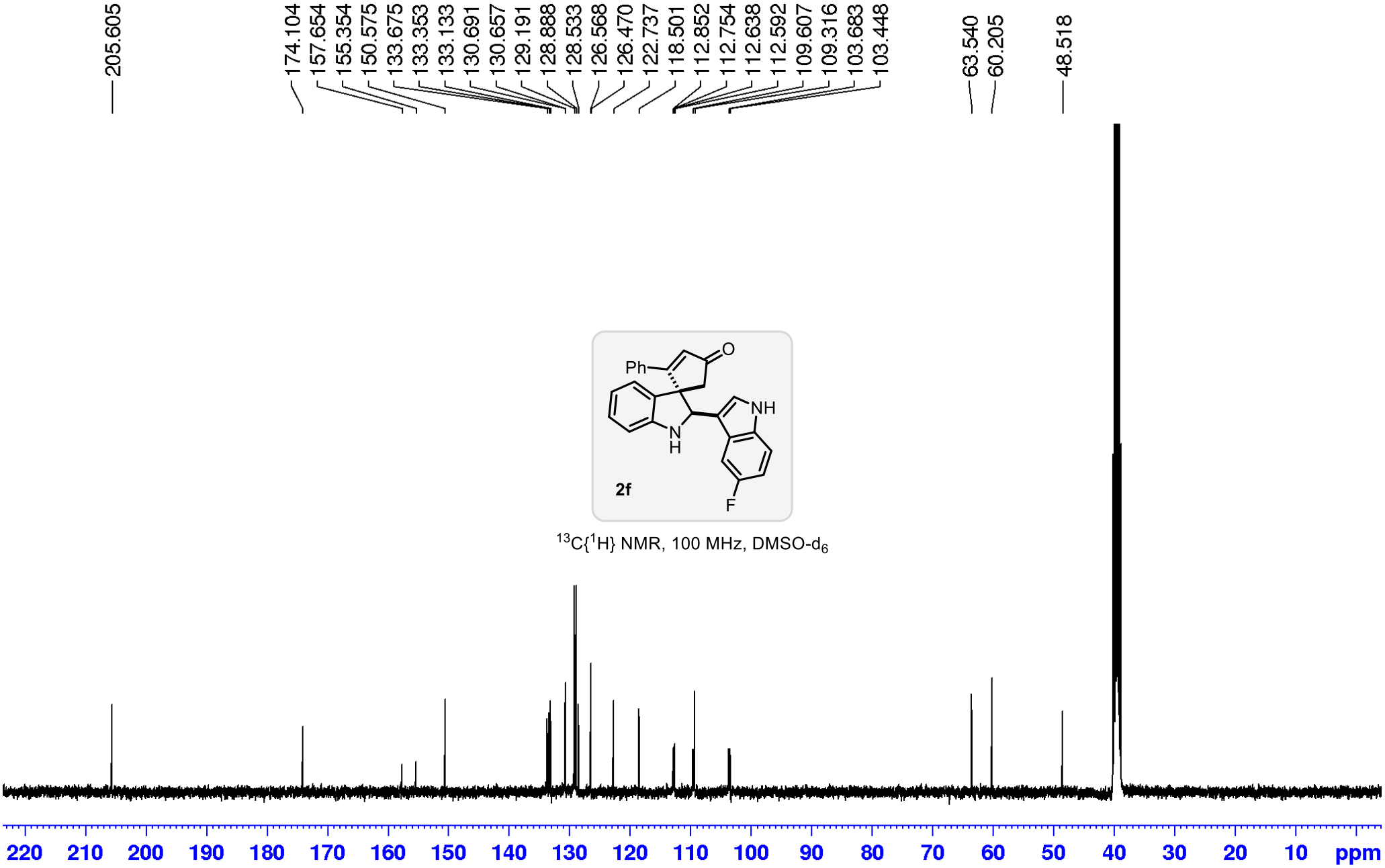
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



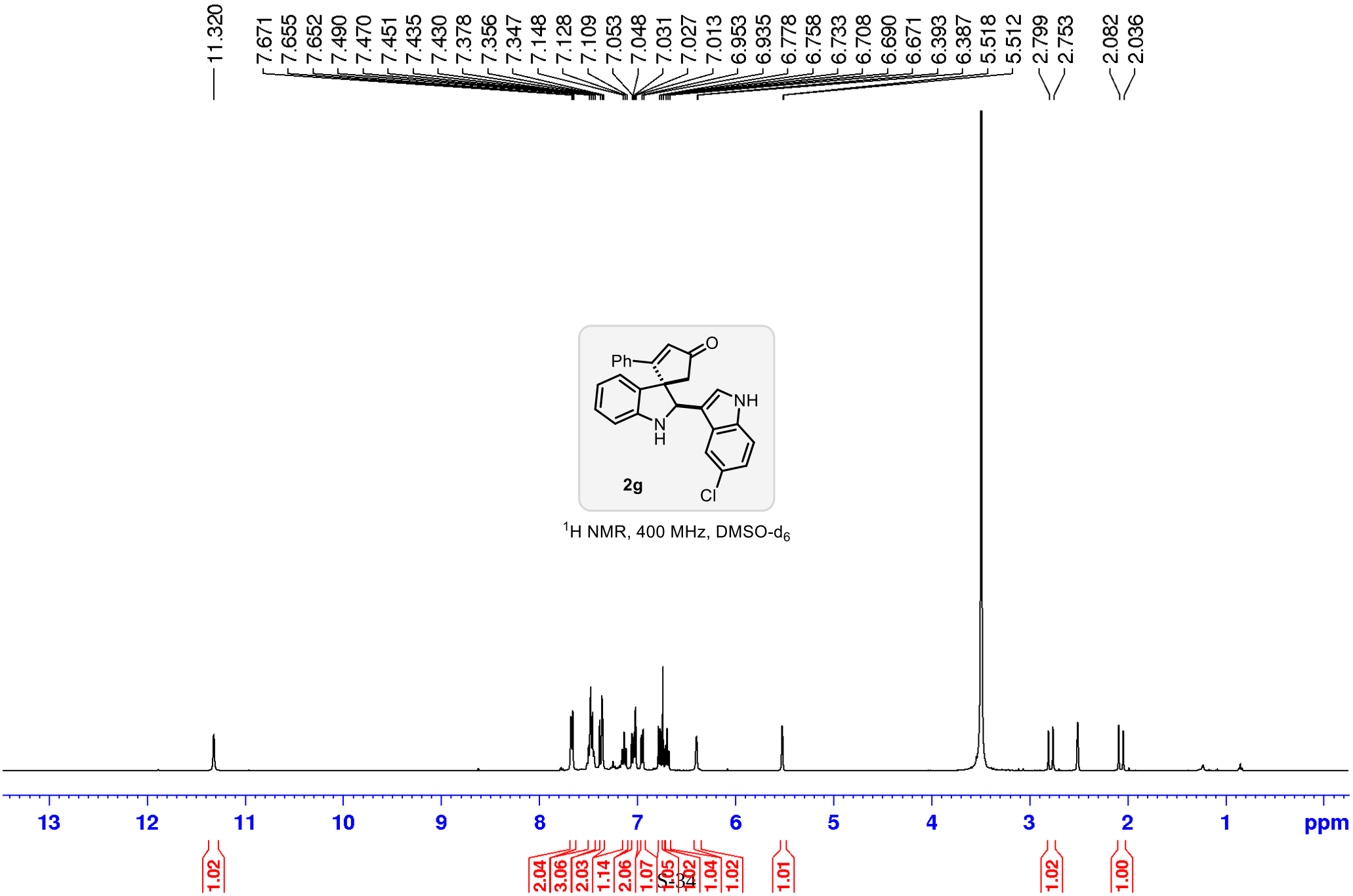
^{1}H NMR, 400 MHz, DMSO-d_6



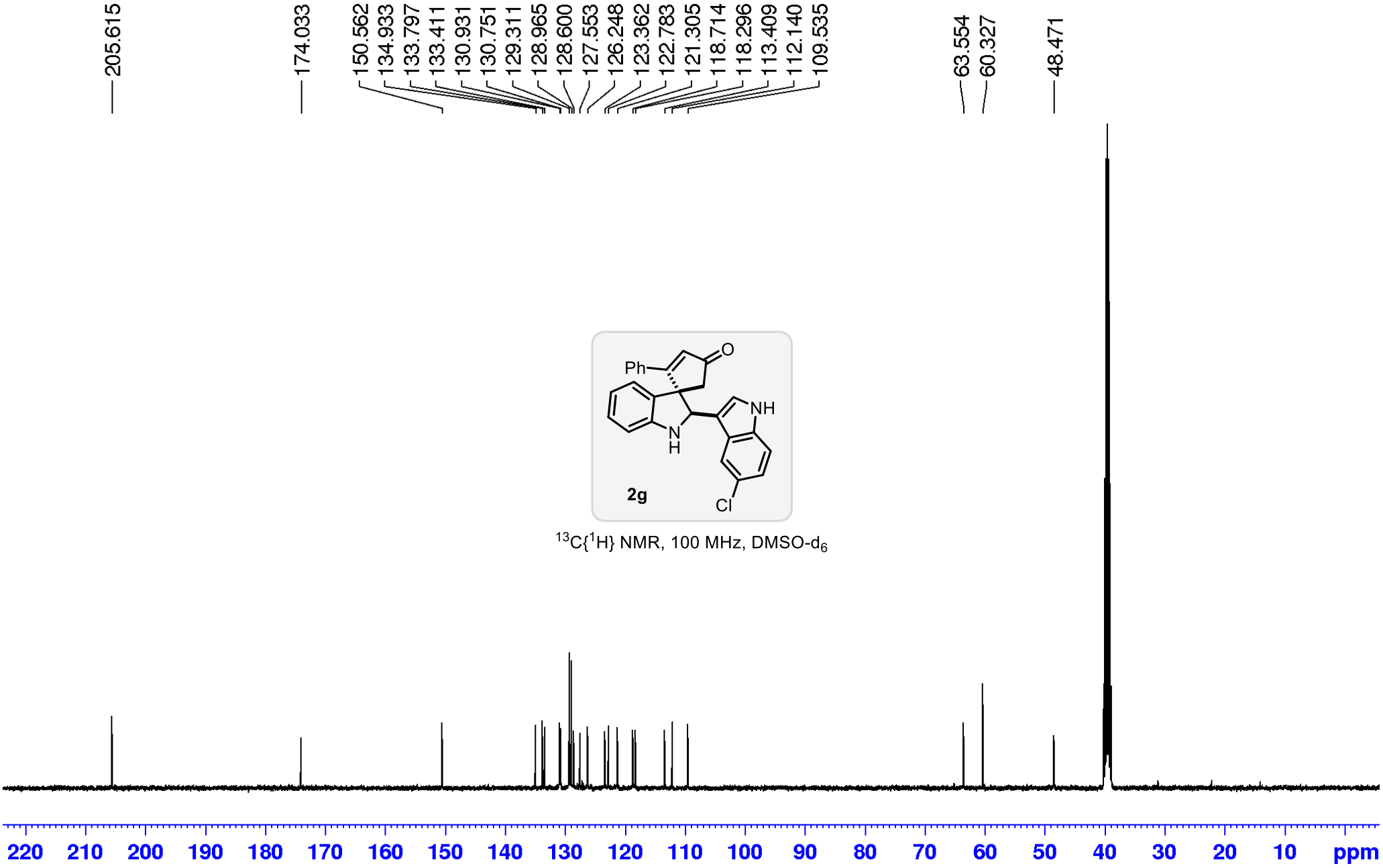
^{19}F NMR, 256 MHz, DMSO-d_6



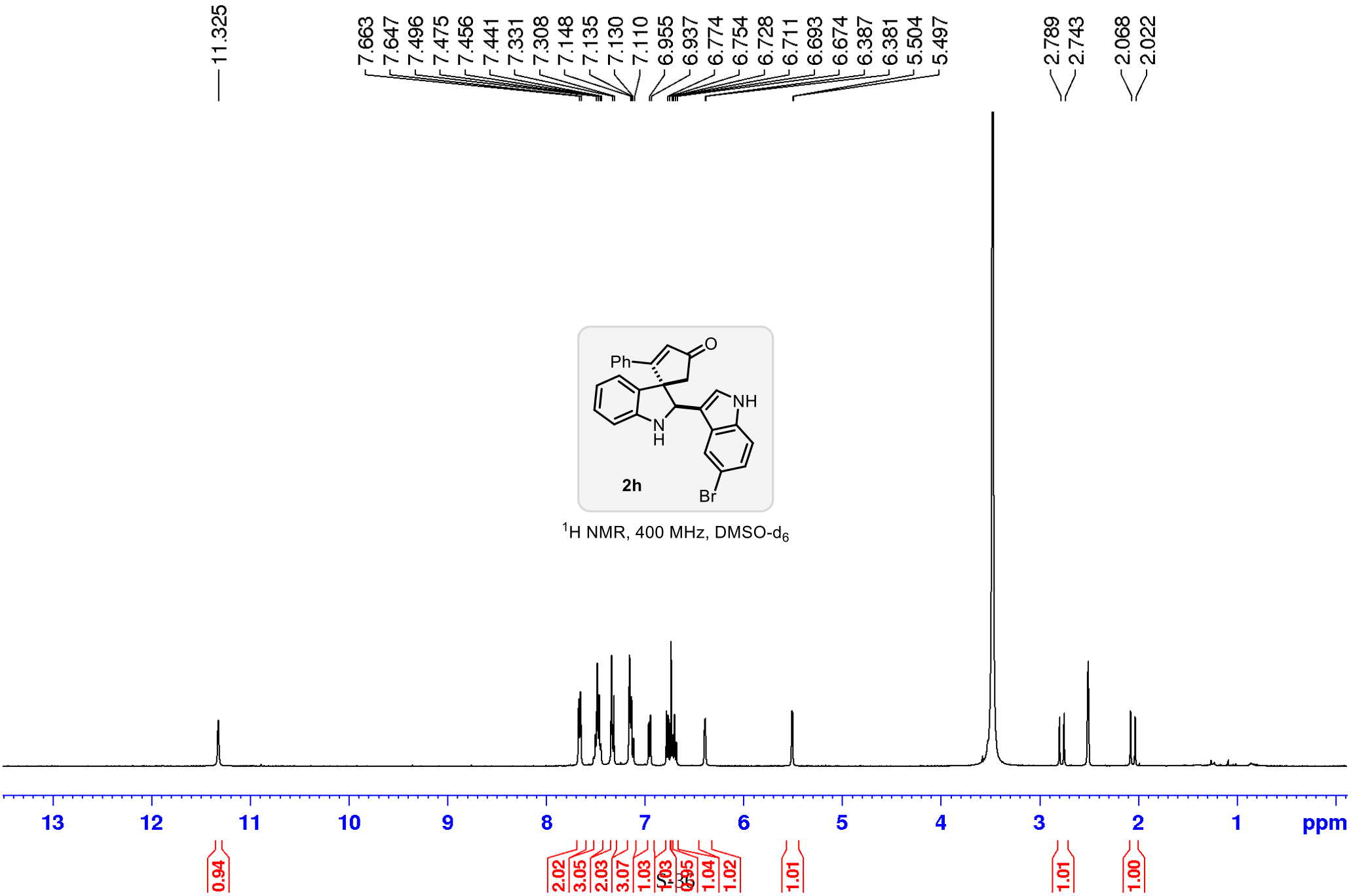
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



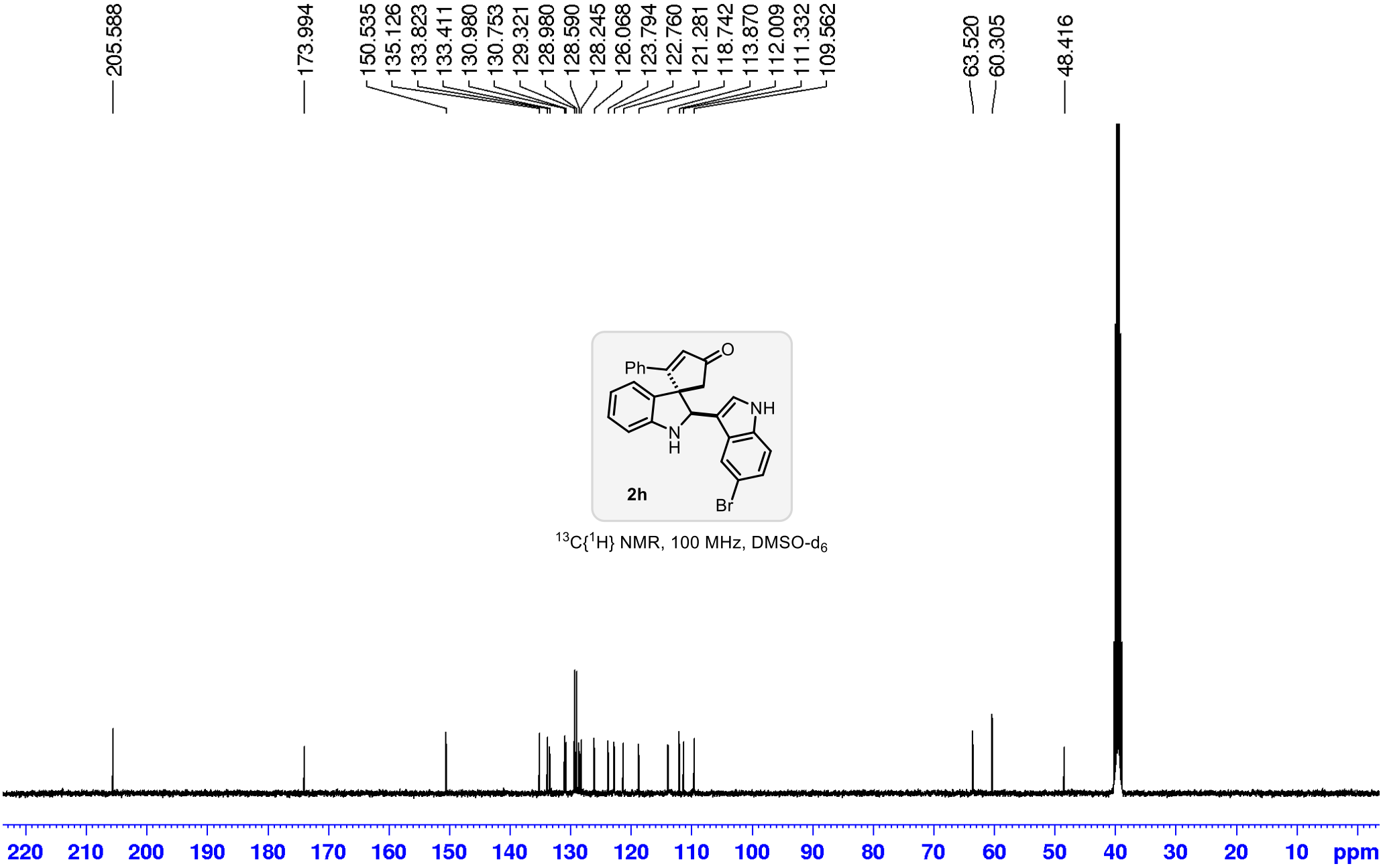
^{1}H NMR, 400 MHz, DMSO-d_6



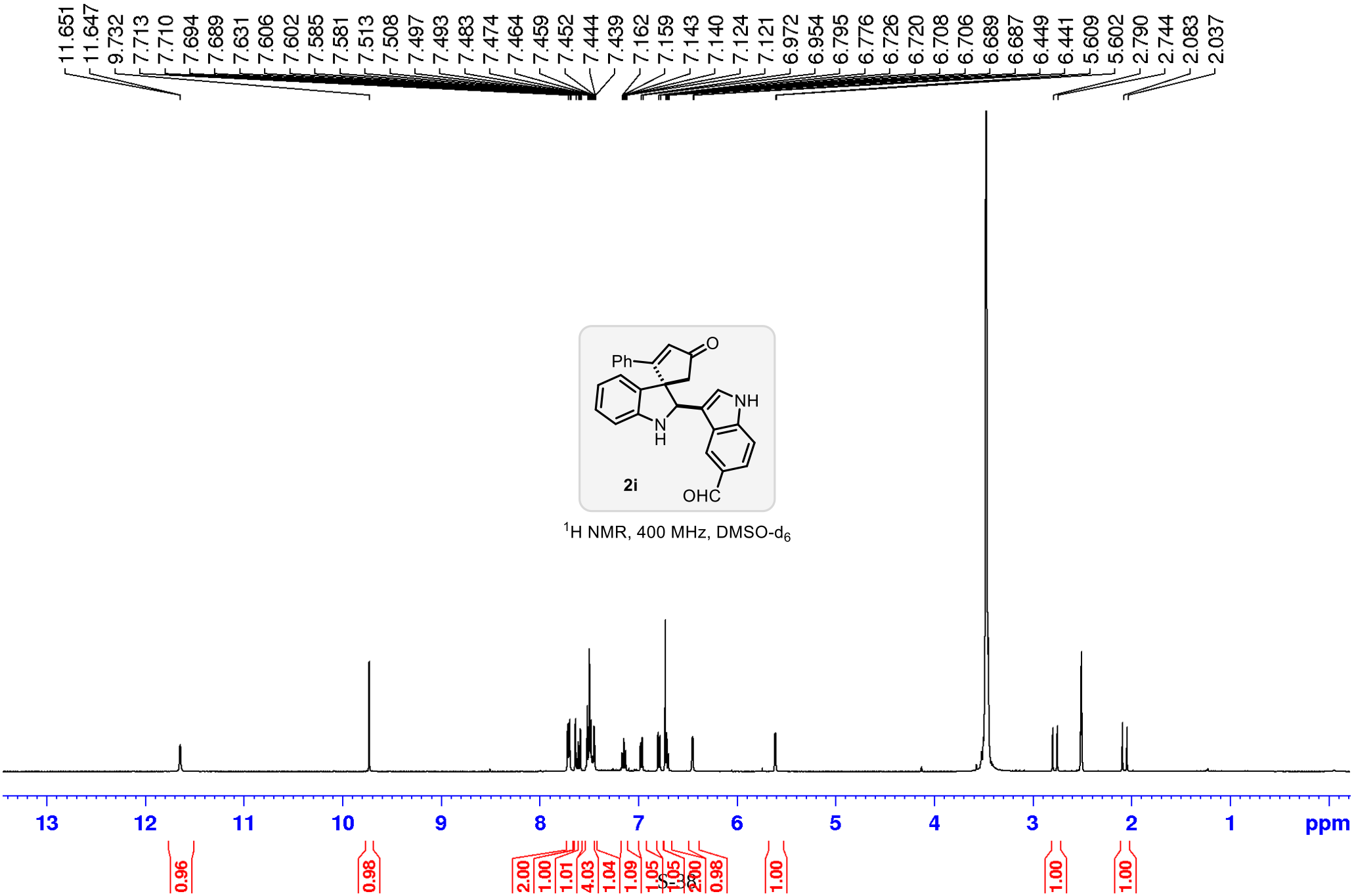
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



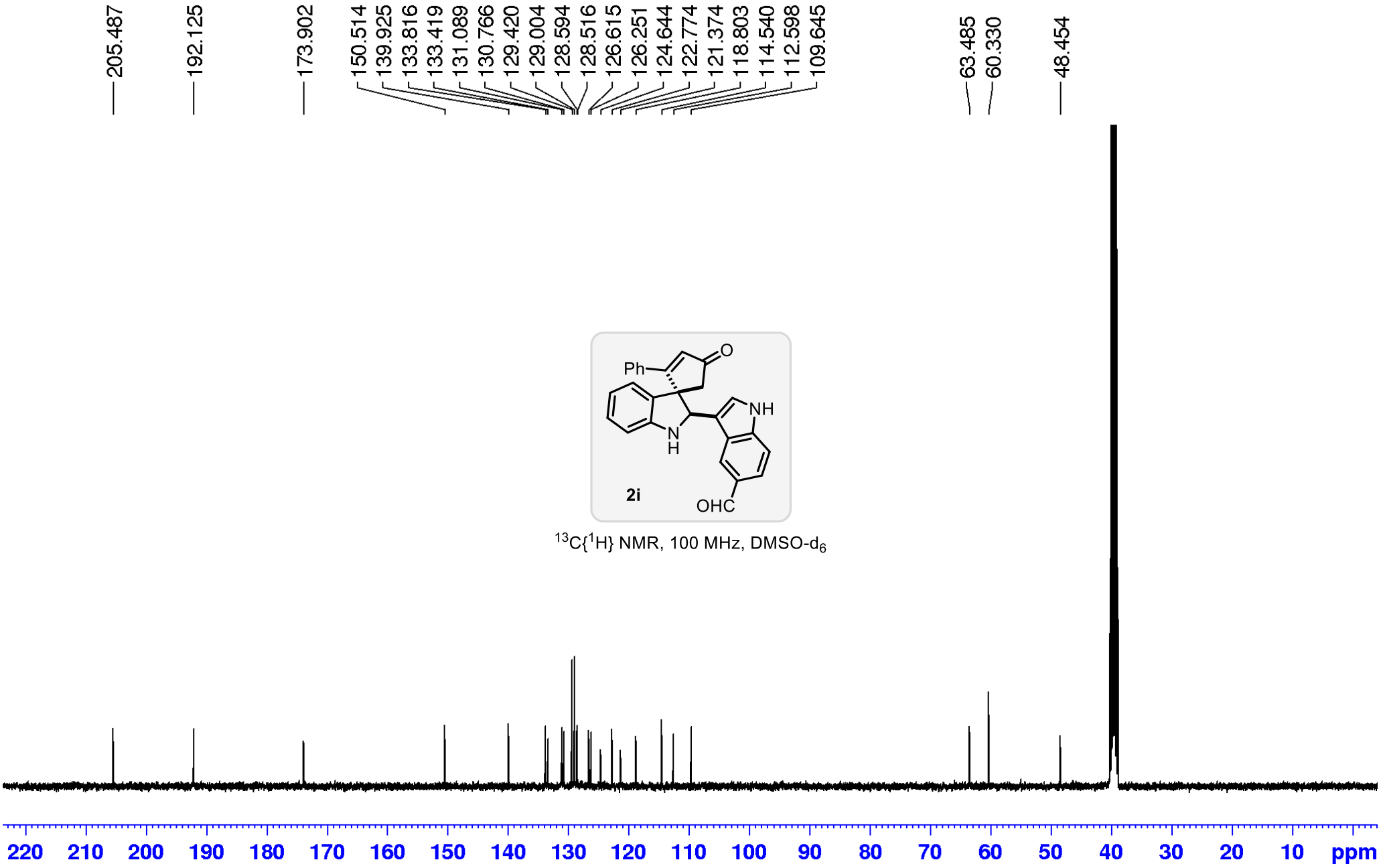
^{1}H NMR, 400 MHz, DMSO-d_6



$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



^{1}H NMR, 400 MHz, DMSO-d$_6$



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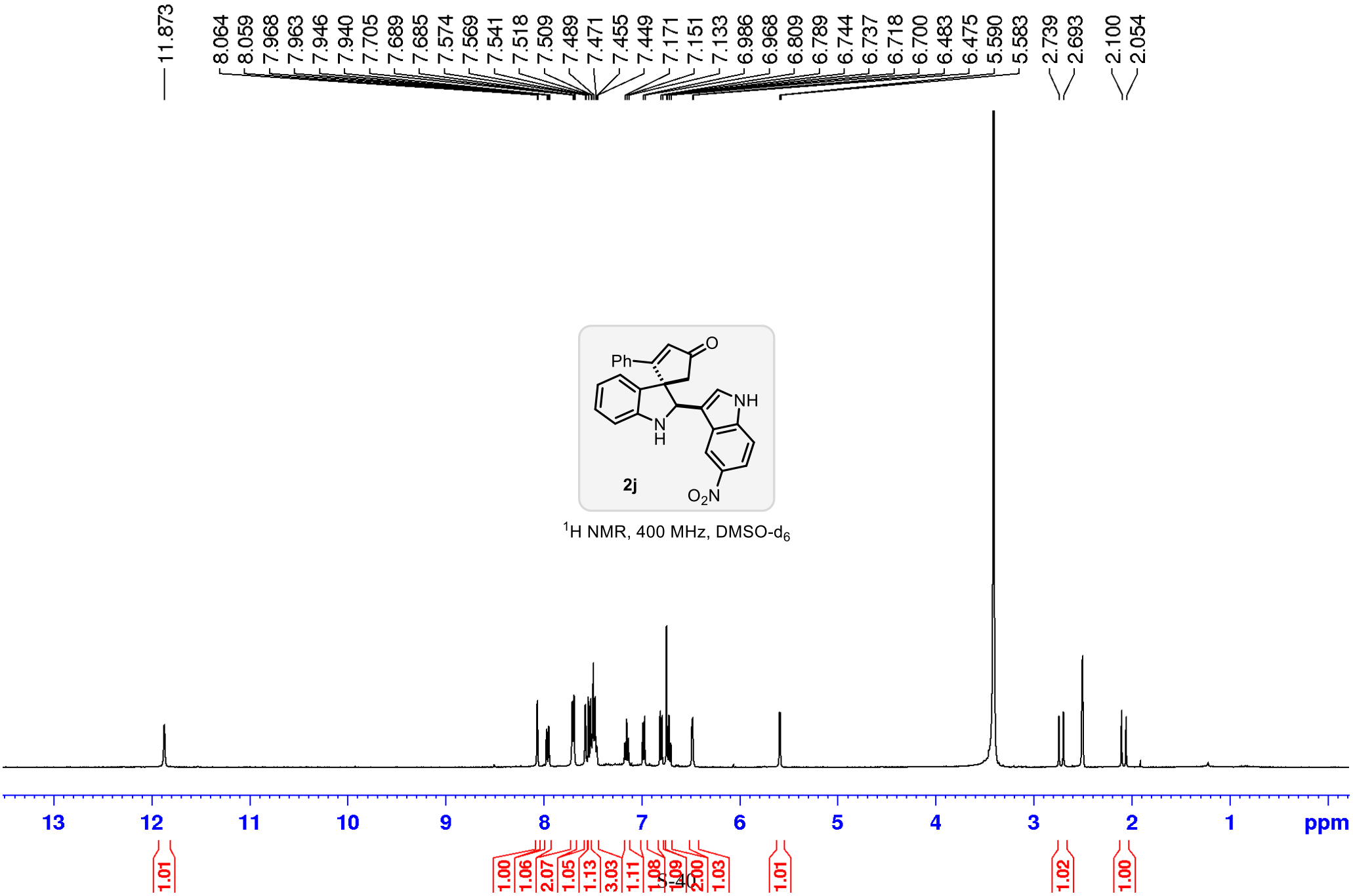
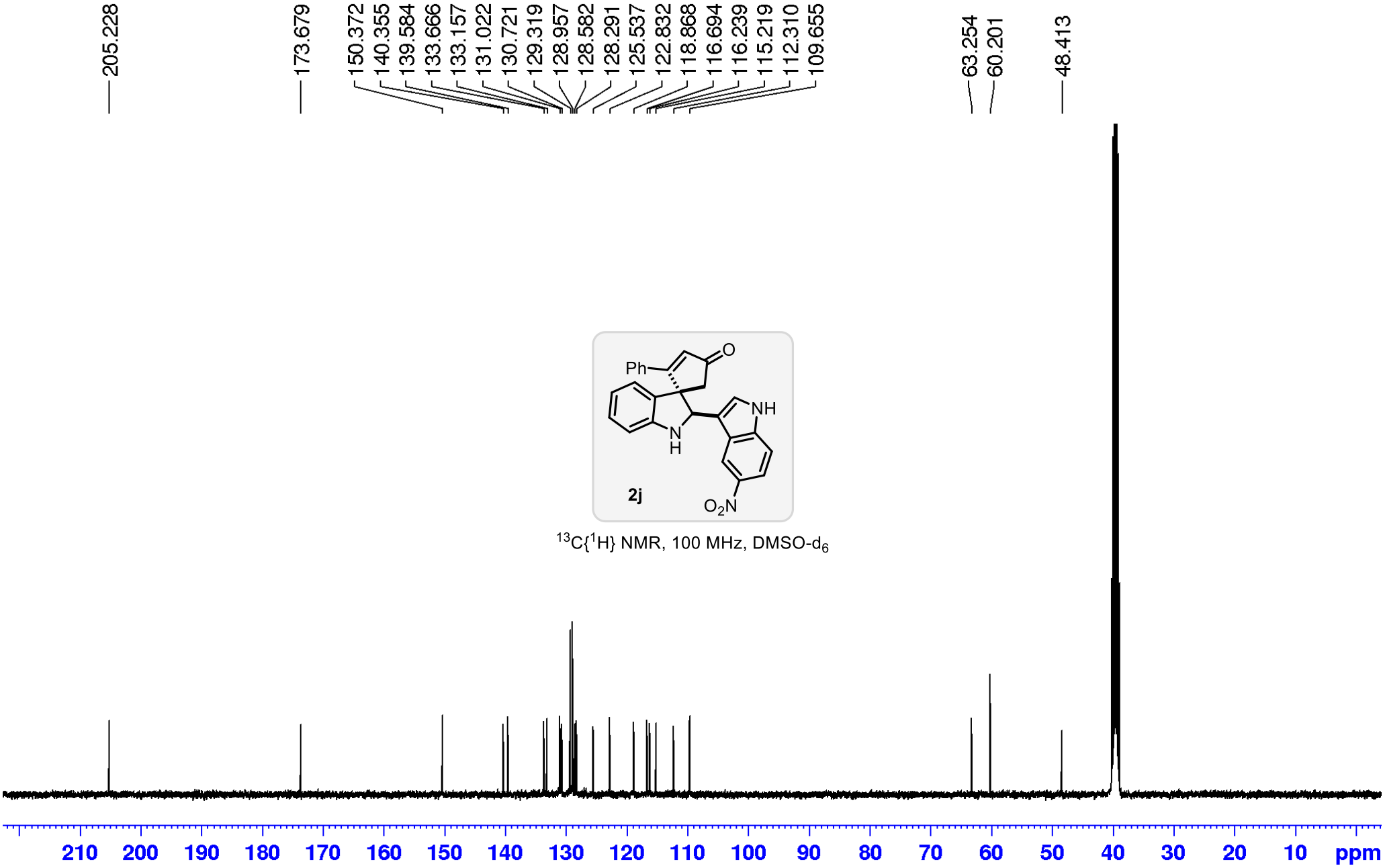


^{1}H NMR, 400 MHz, DMSO-d_6



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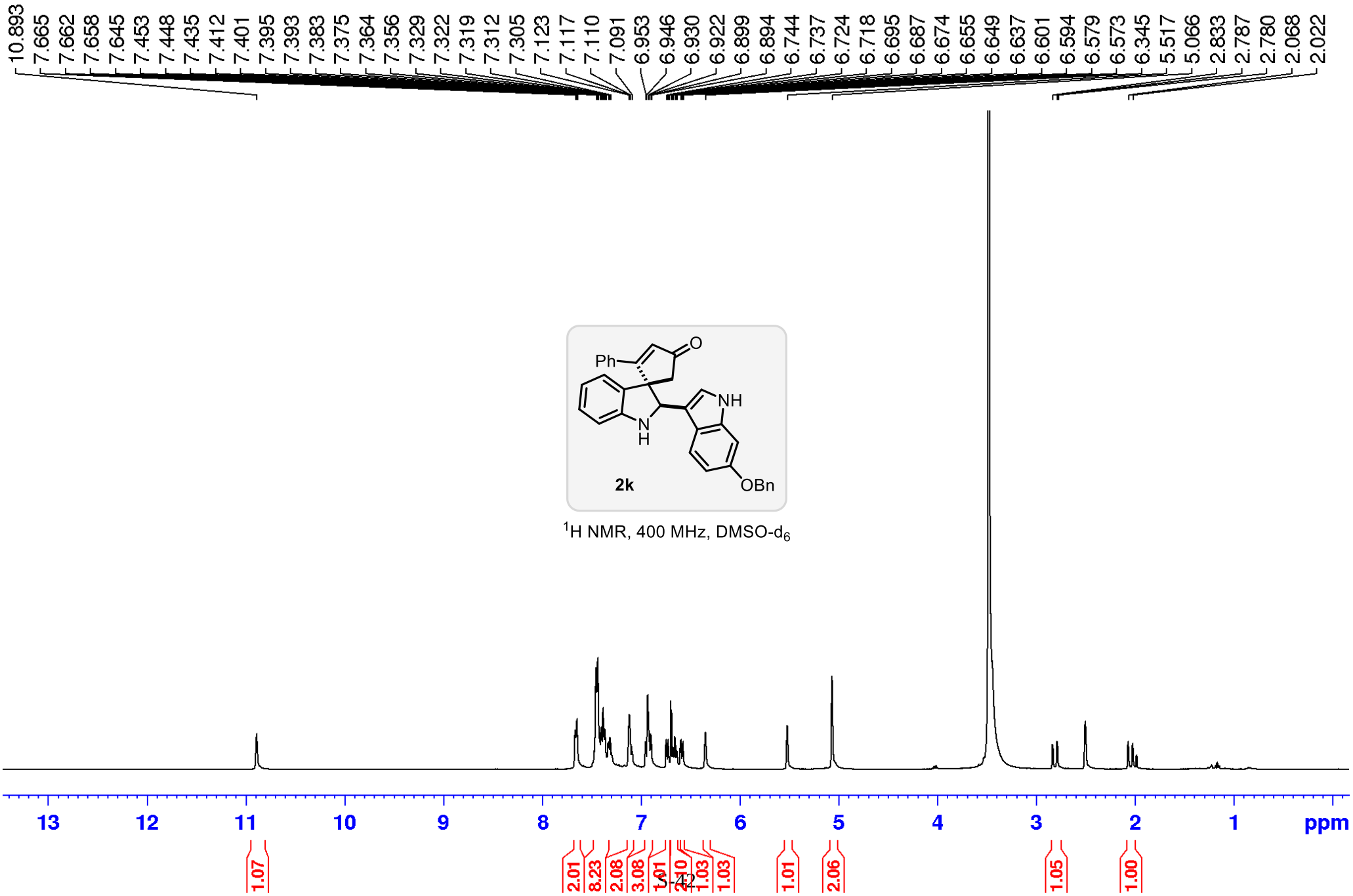

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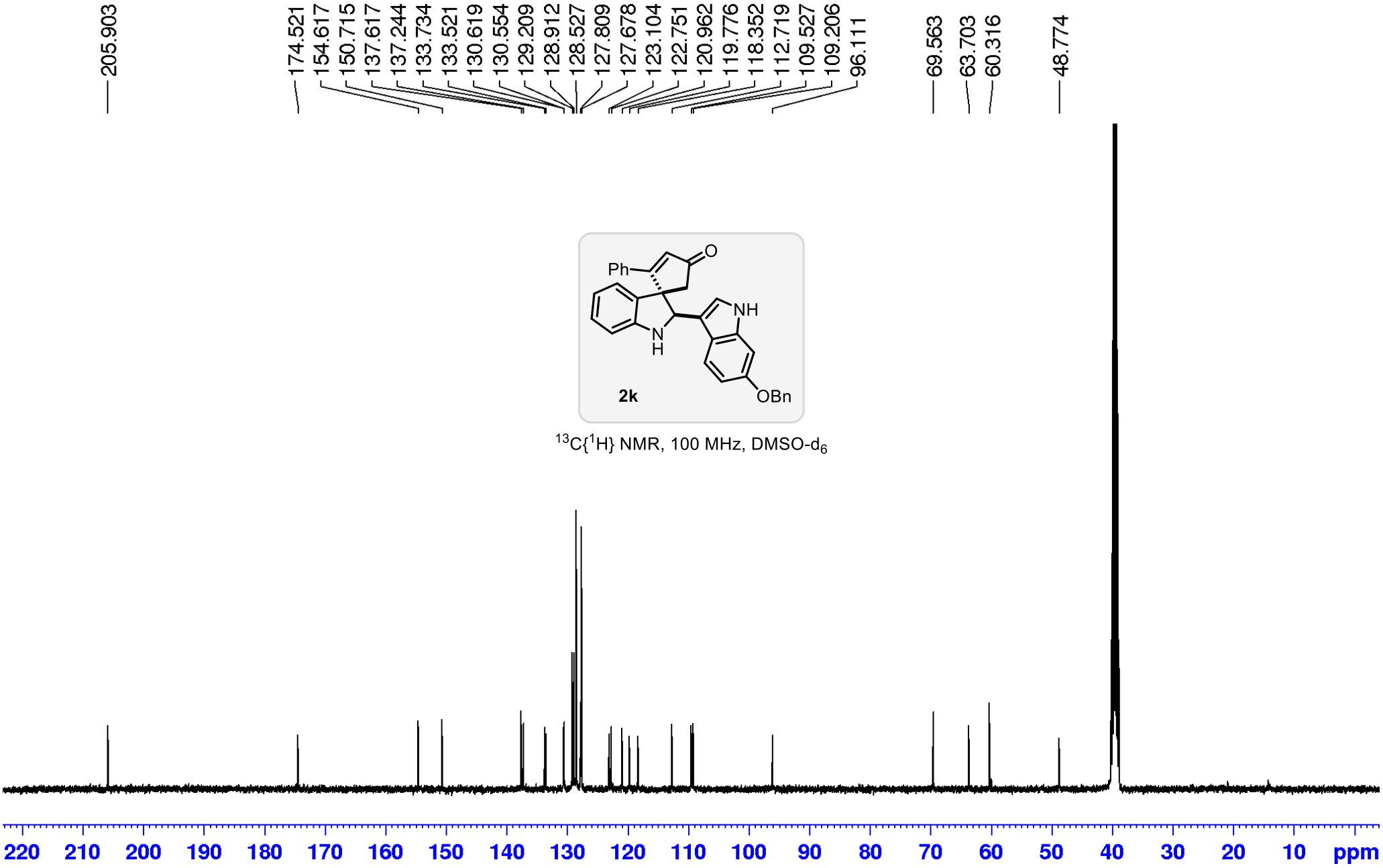

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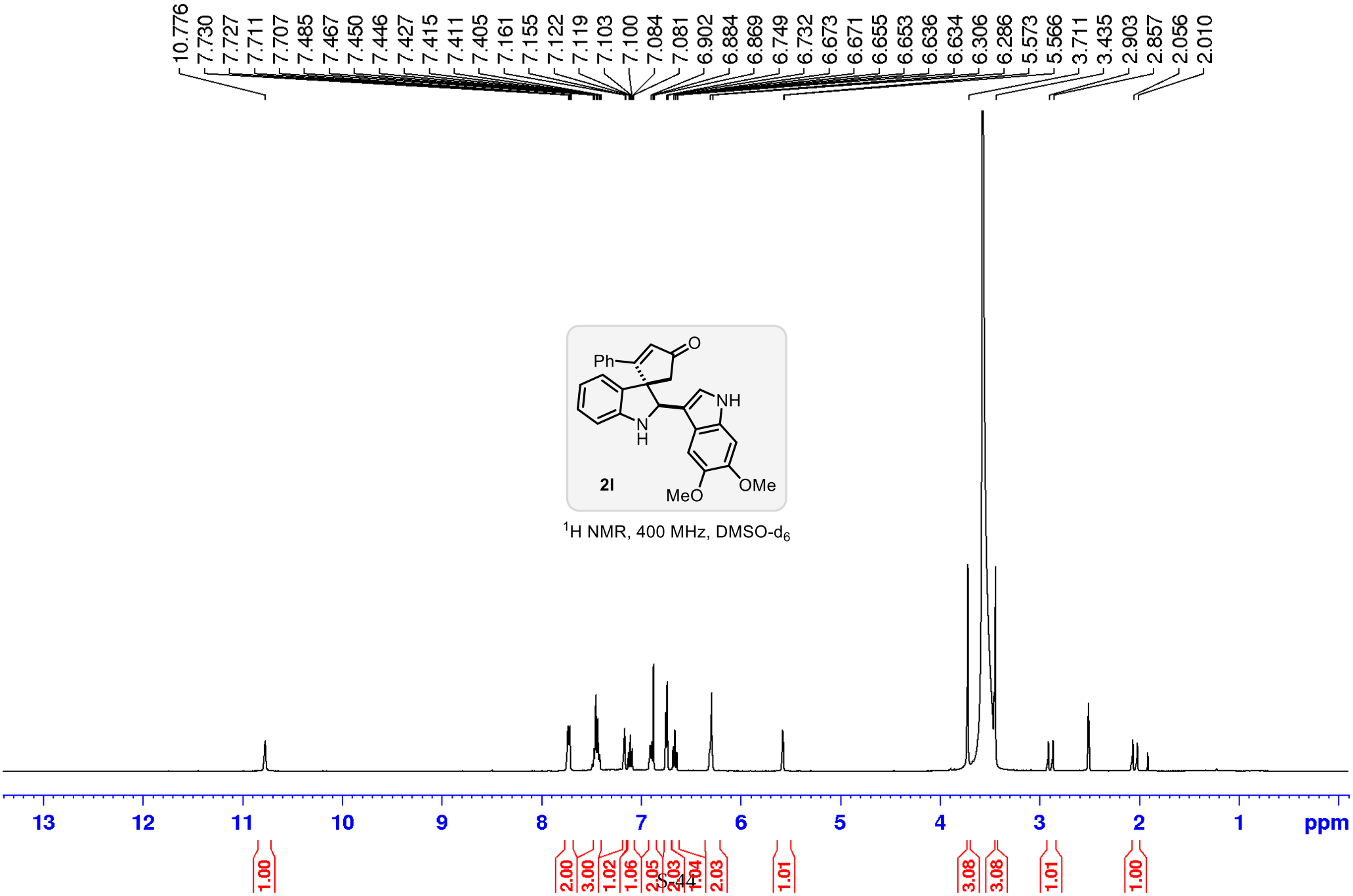

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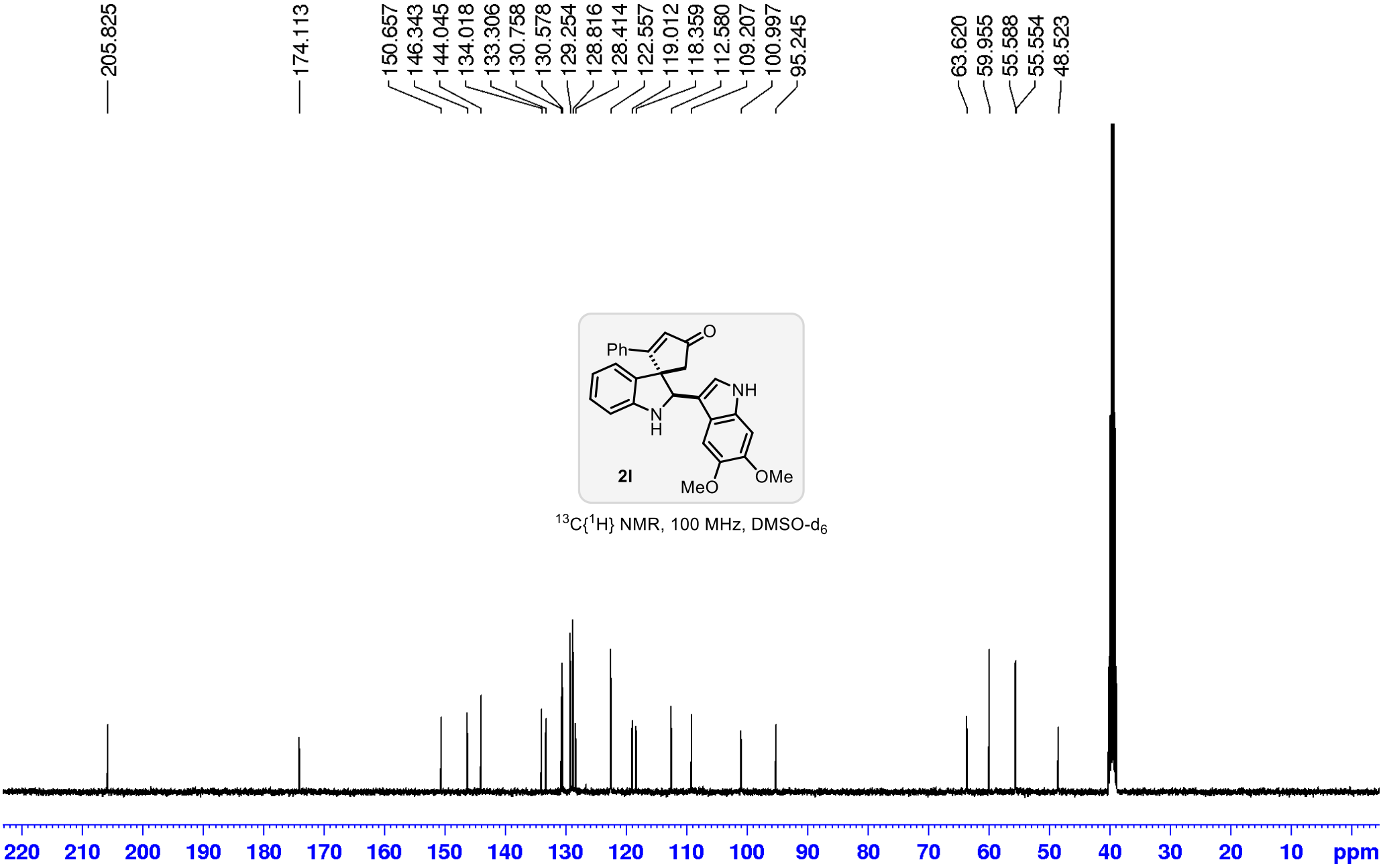
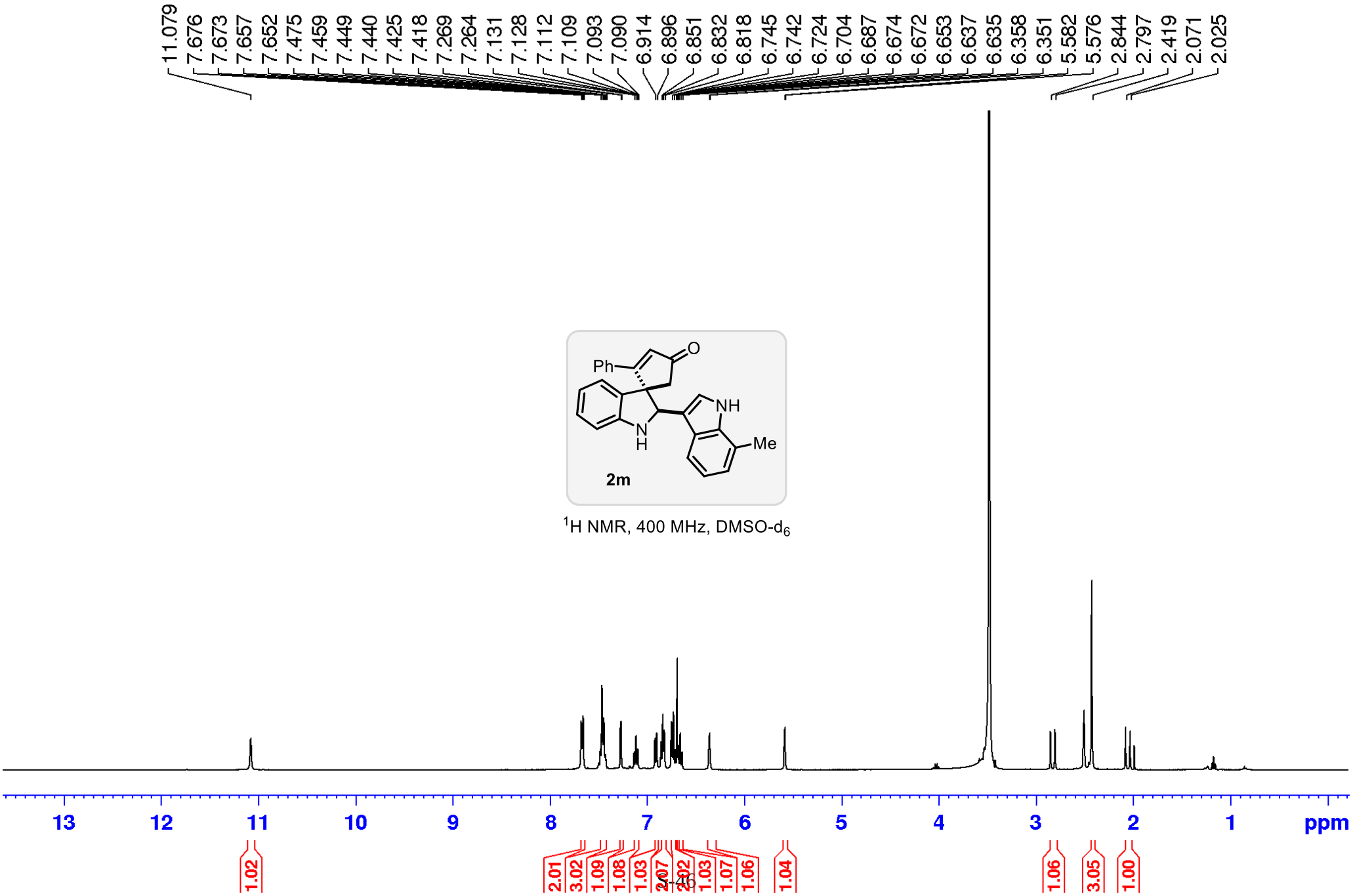
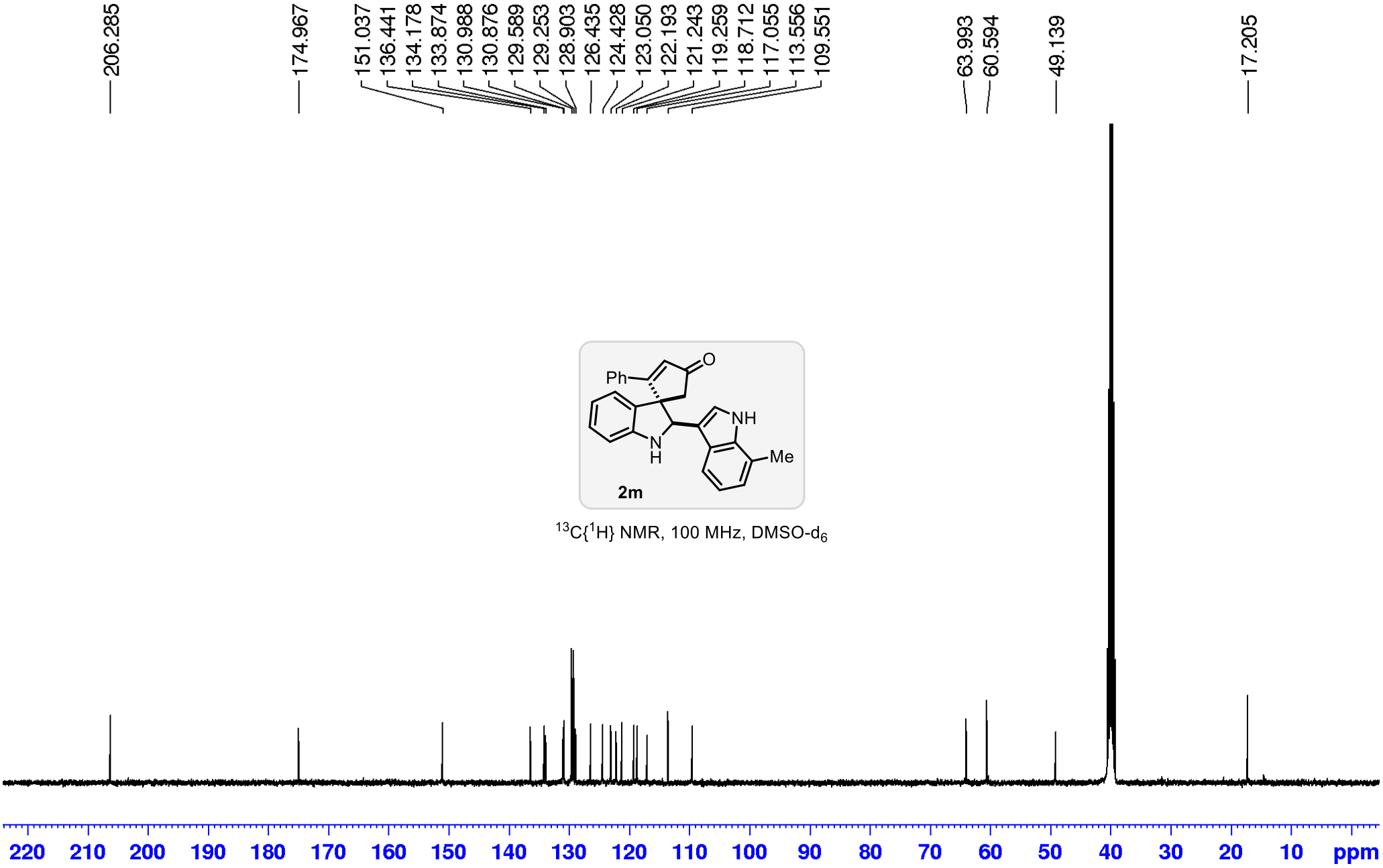


$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



^{1}H NMR, 400 MHz, DMSO-d_6



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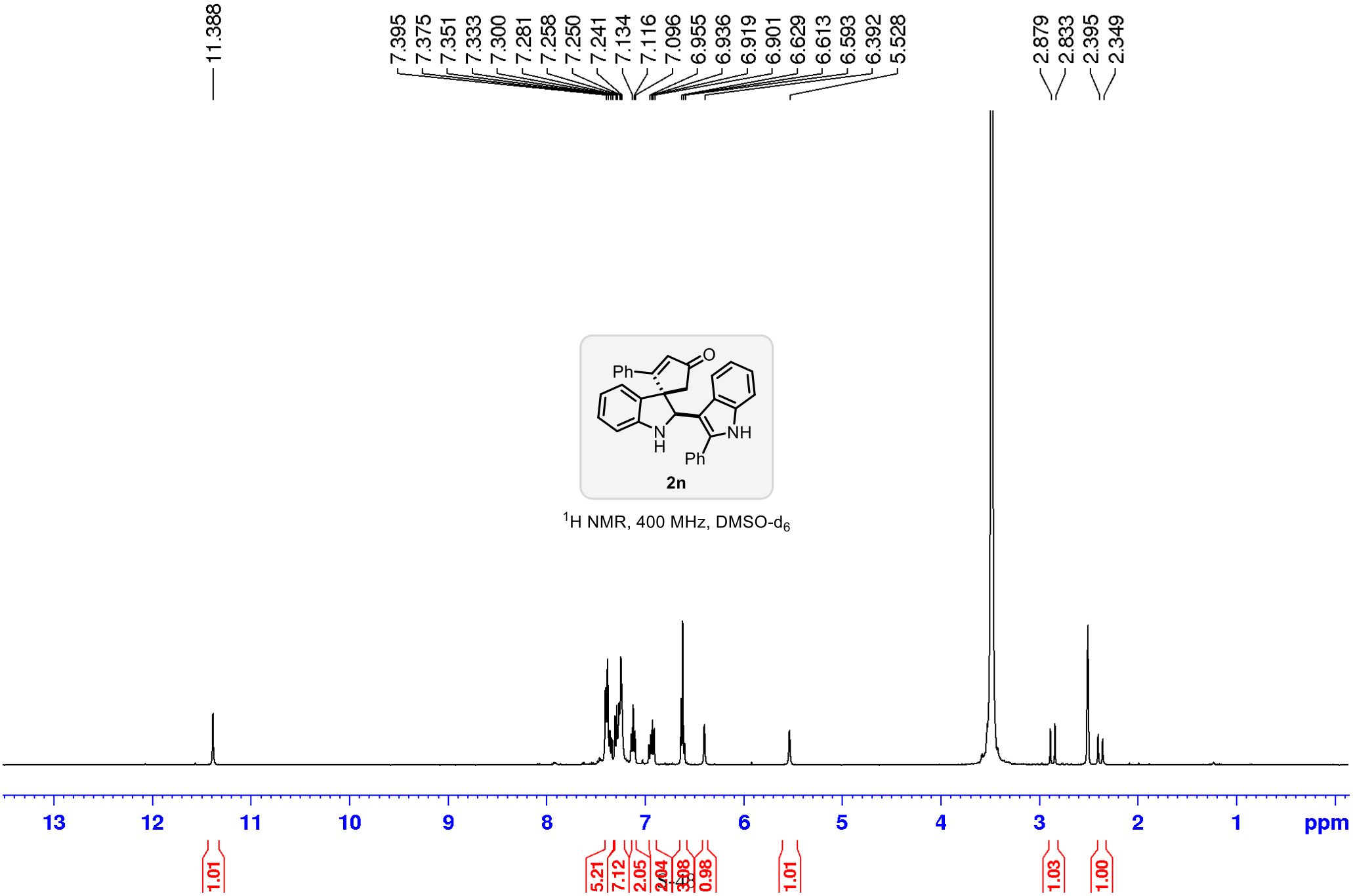
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6.936
6.919
6.901
6.629
6.613
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6.392
5.528
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2.833
2.395
2.349
Ph
O
N
H
NH
Ph
2n
1H NMR, 400 MHz, DMSO-d6
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10
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8
7
6
5
4
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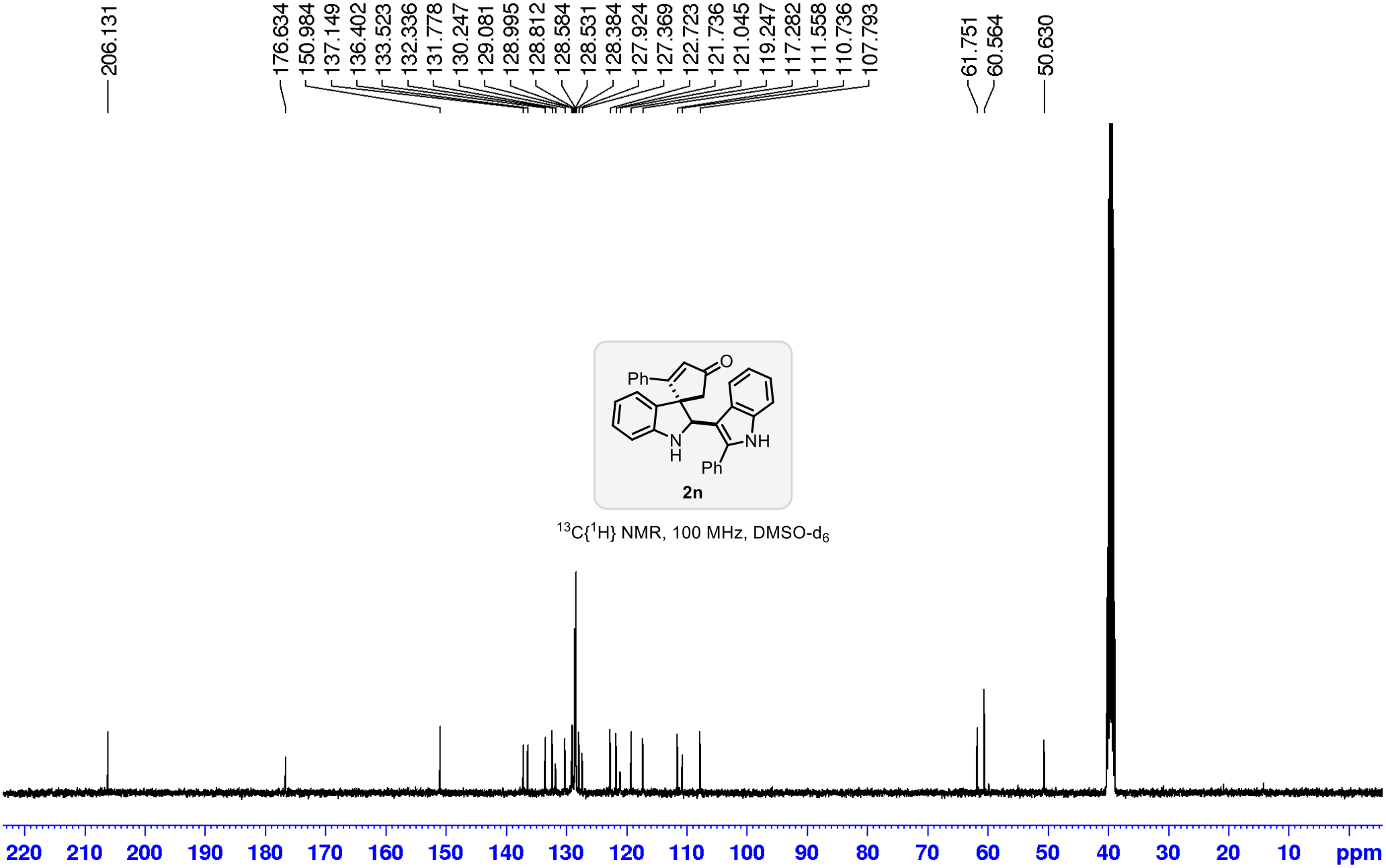

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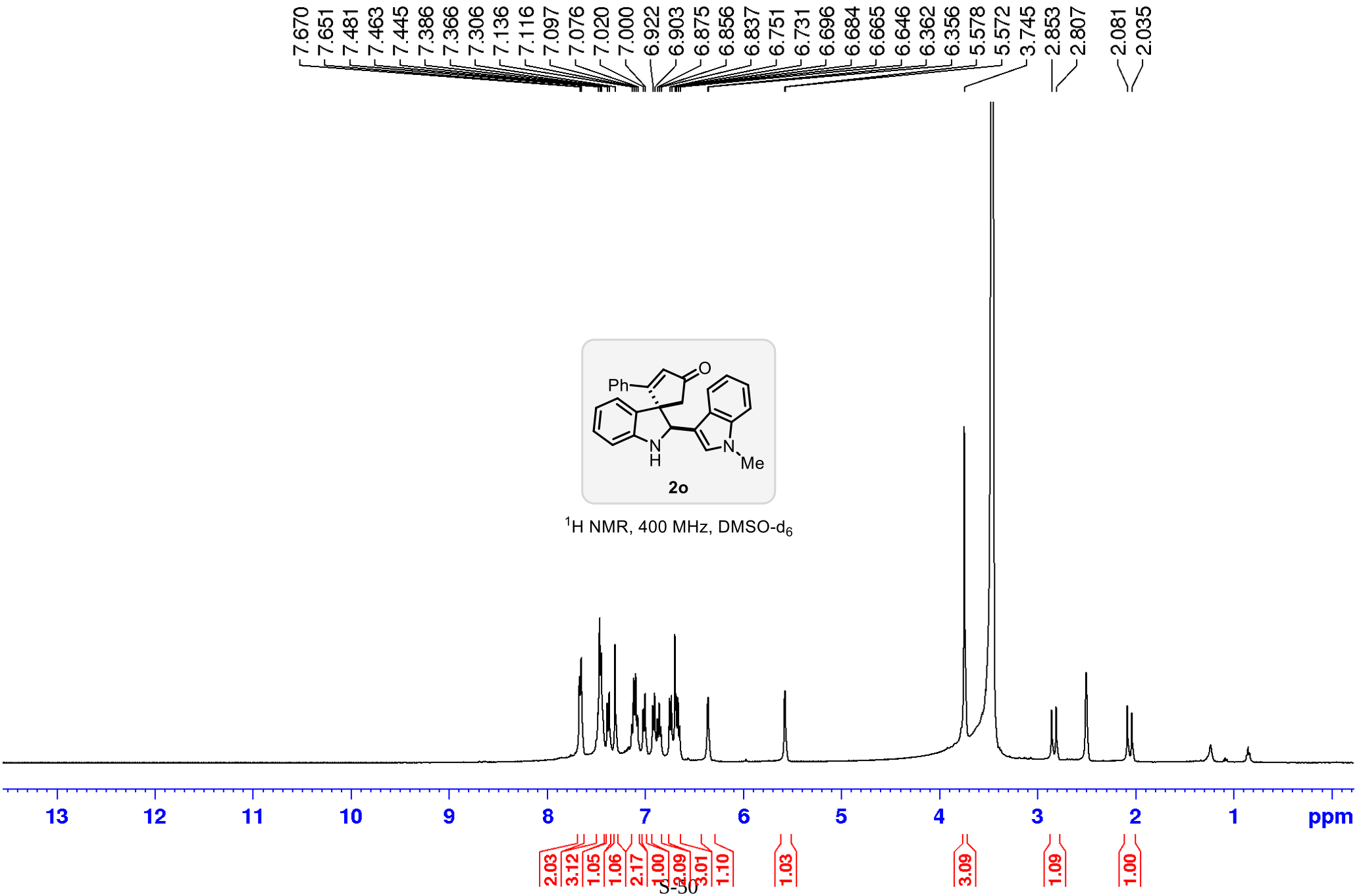
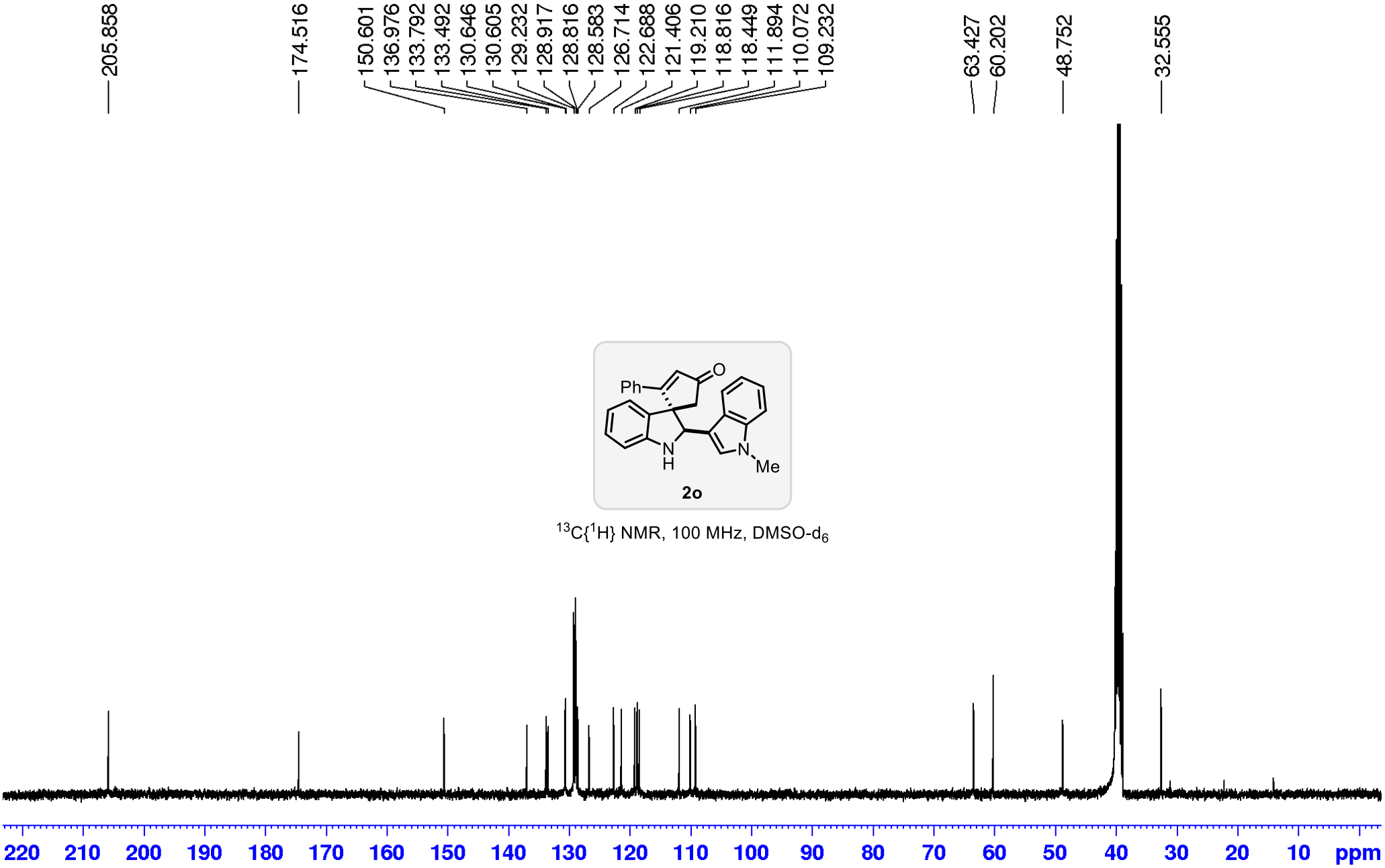
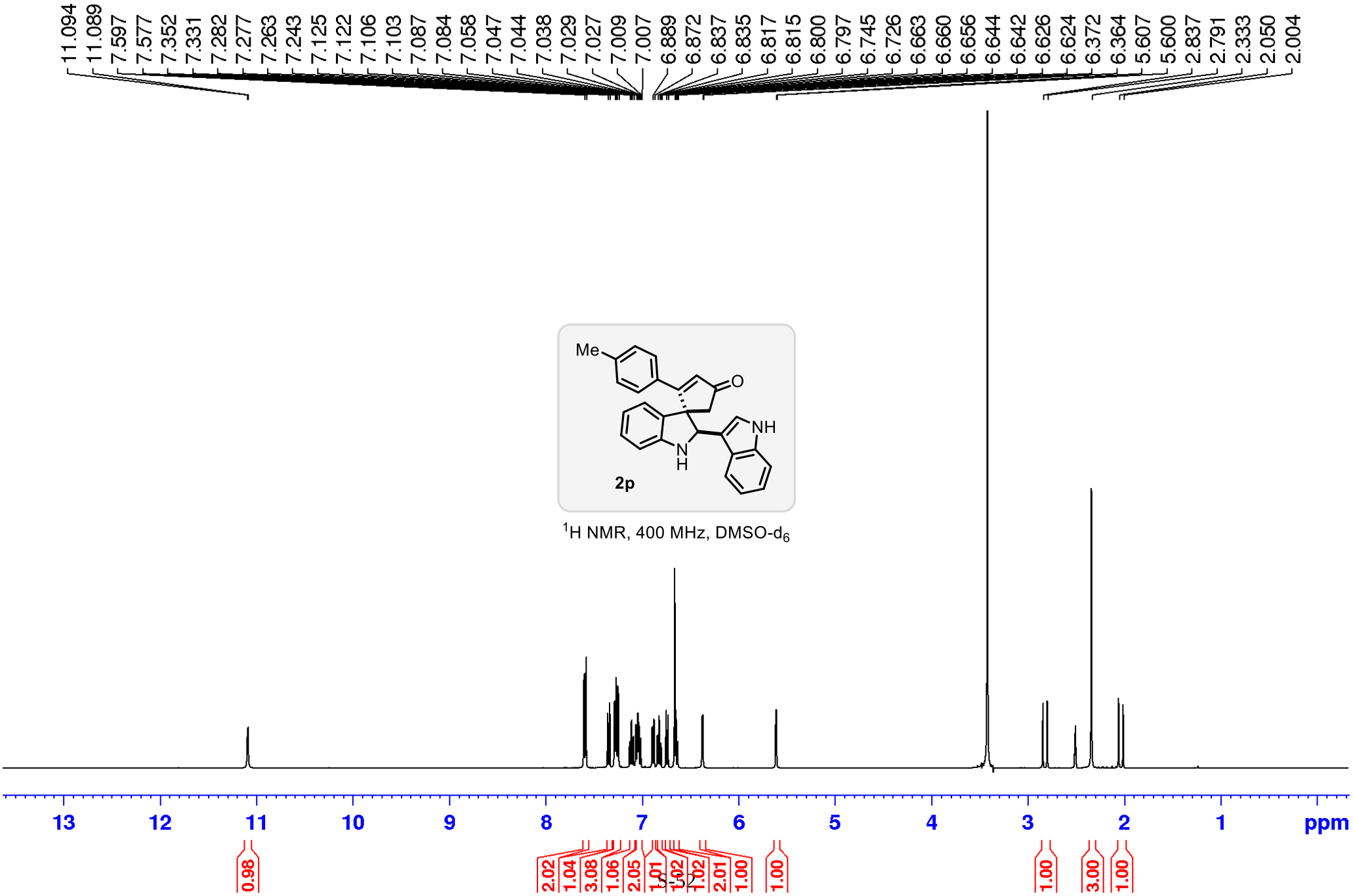


^{1}H NMR, 400 MHz, DMSO-d_6

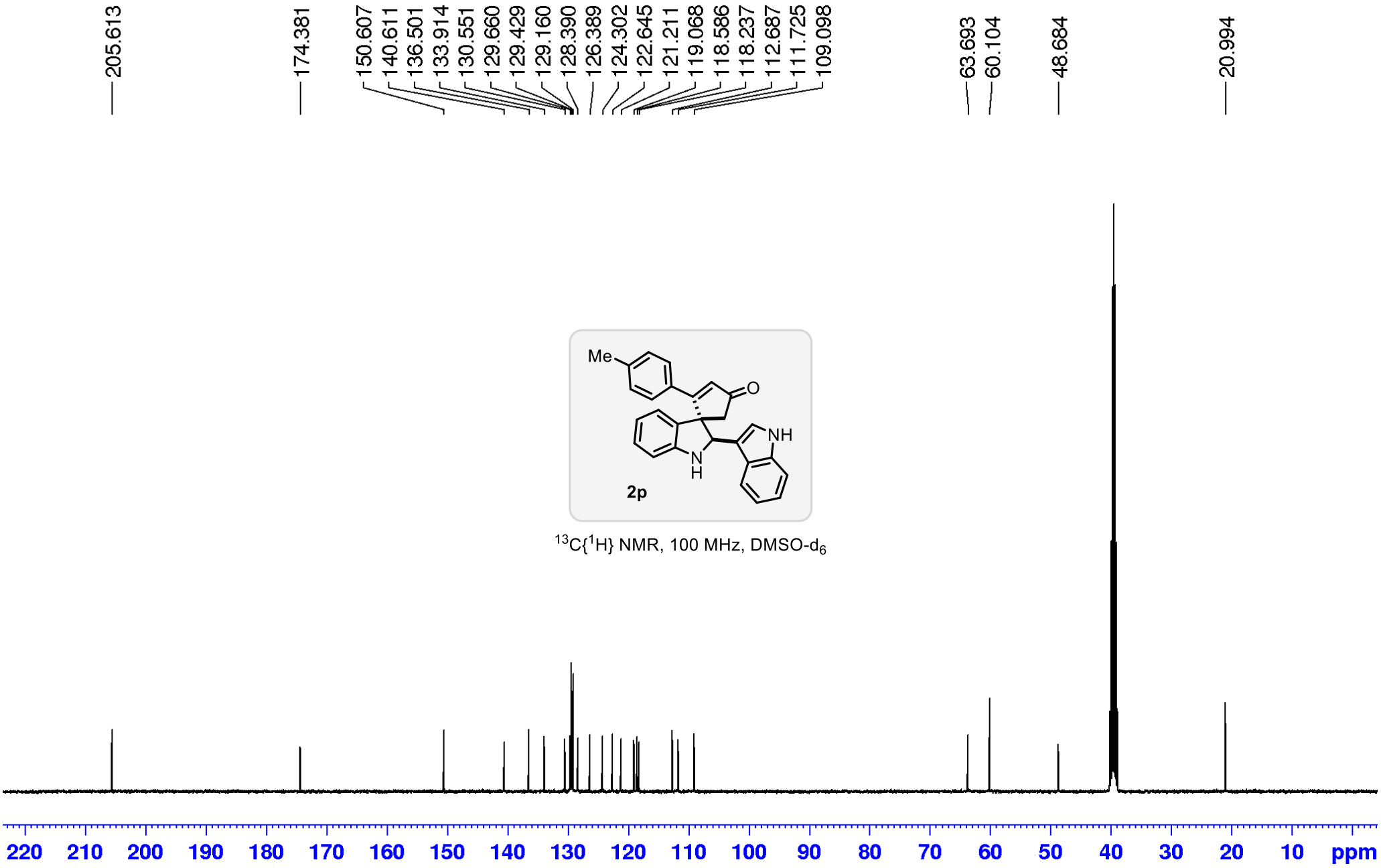


2o

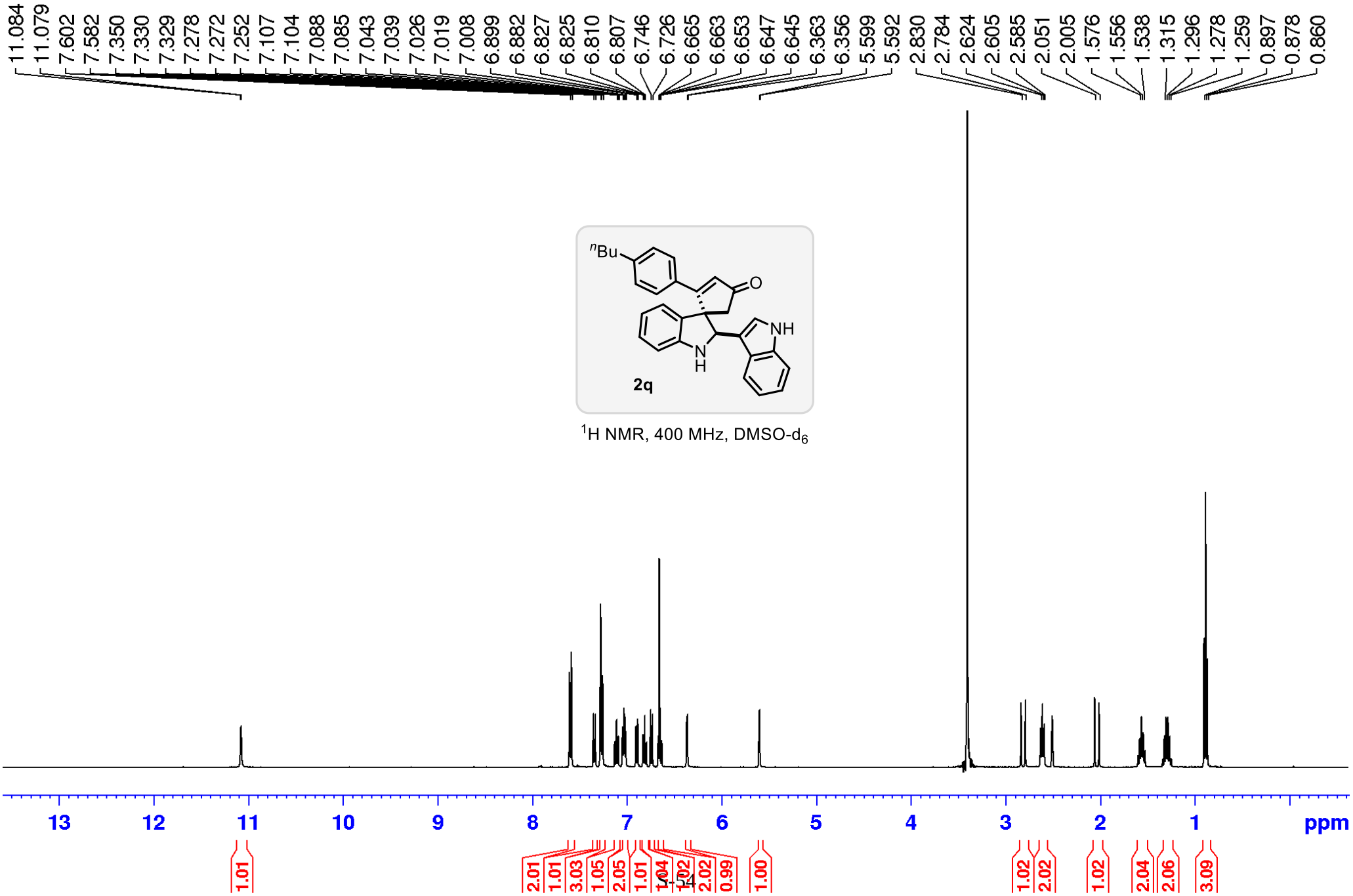
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



^{1}H NMR, 400 MHz, DMSO-d_6



$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6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0.878
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ppm
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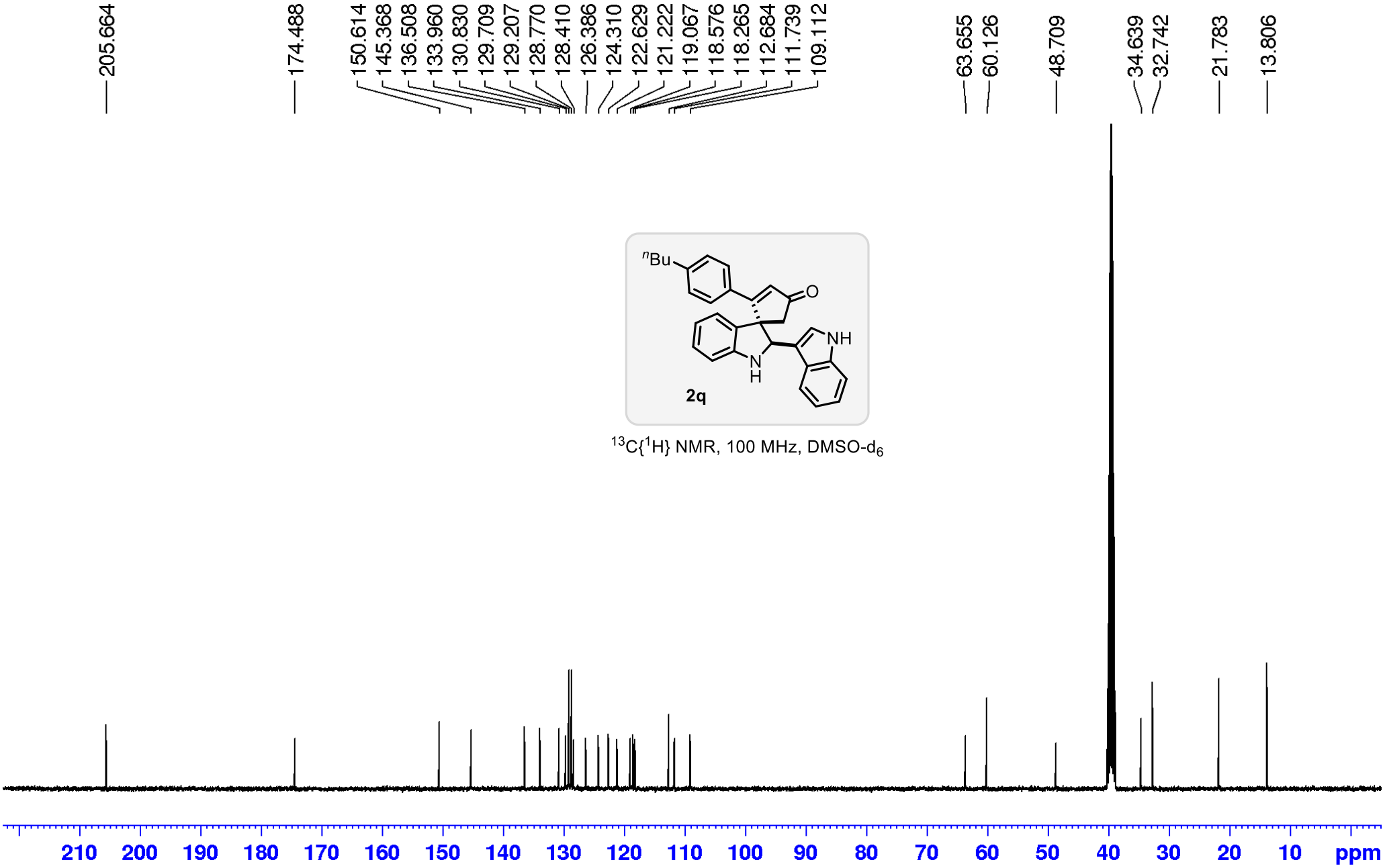
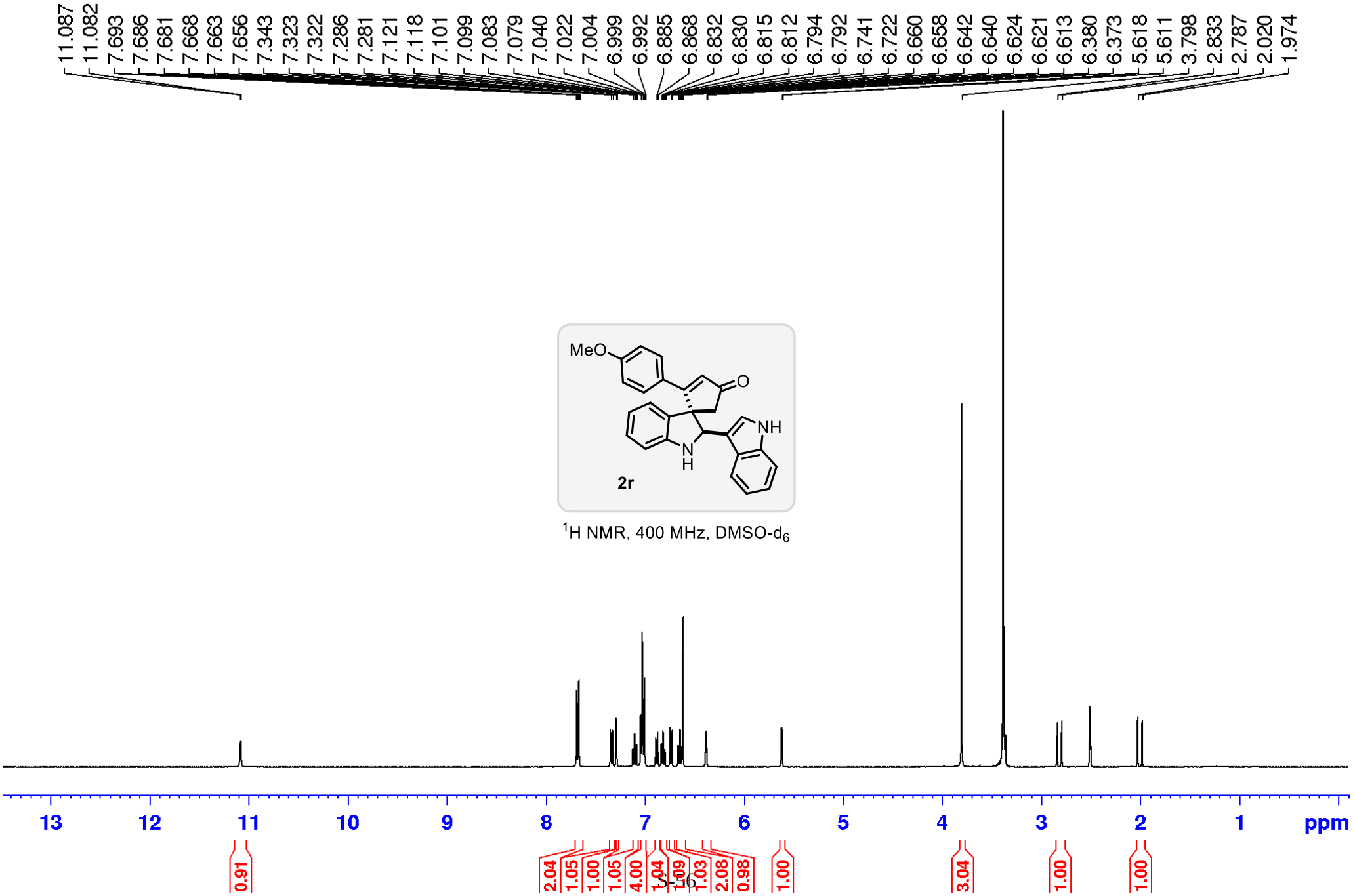
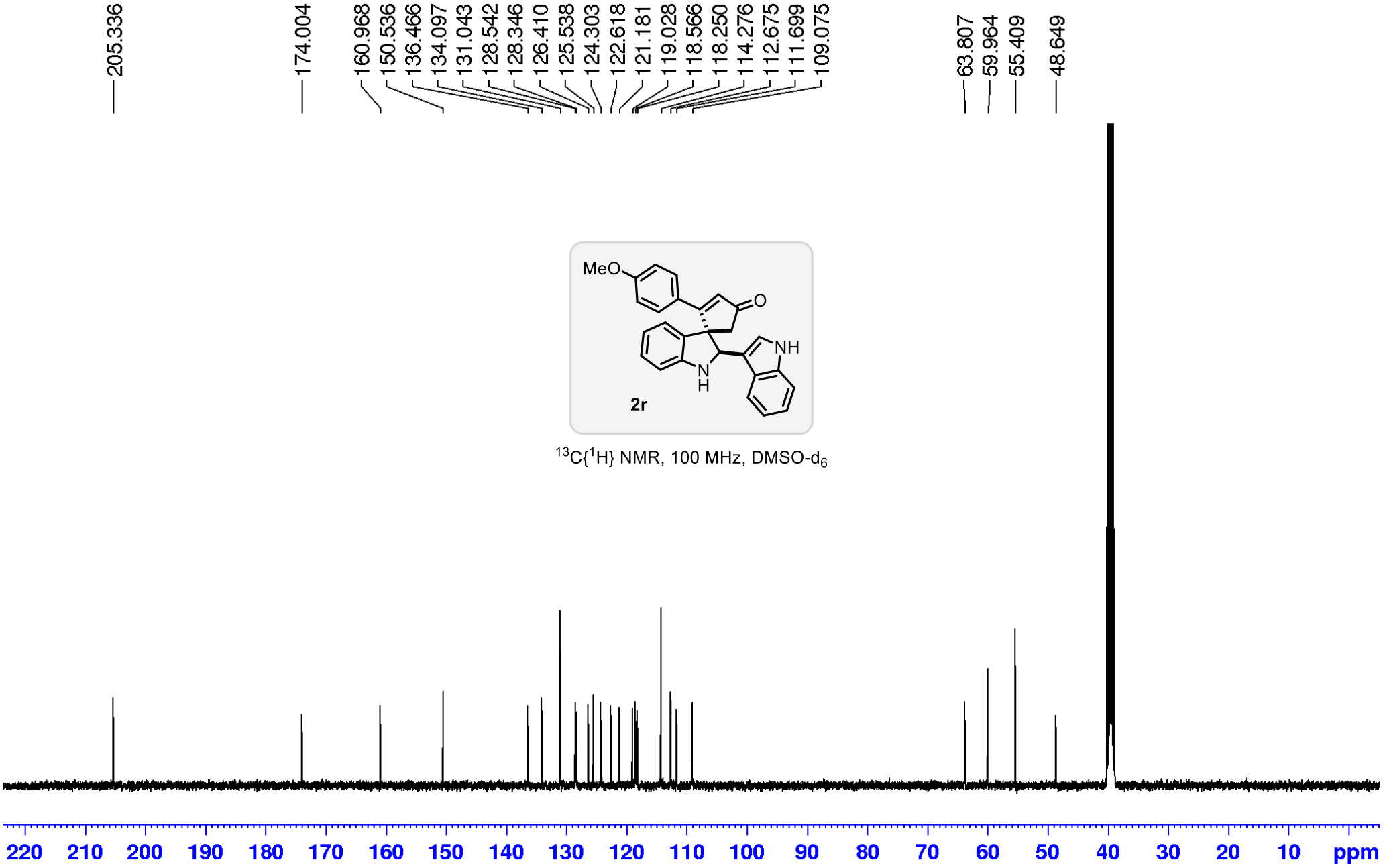


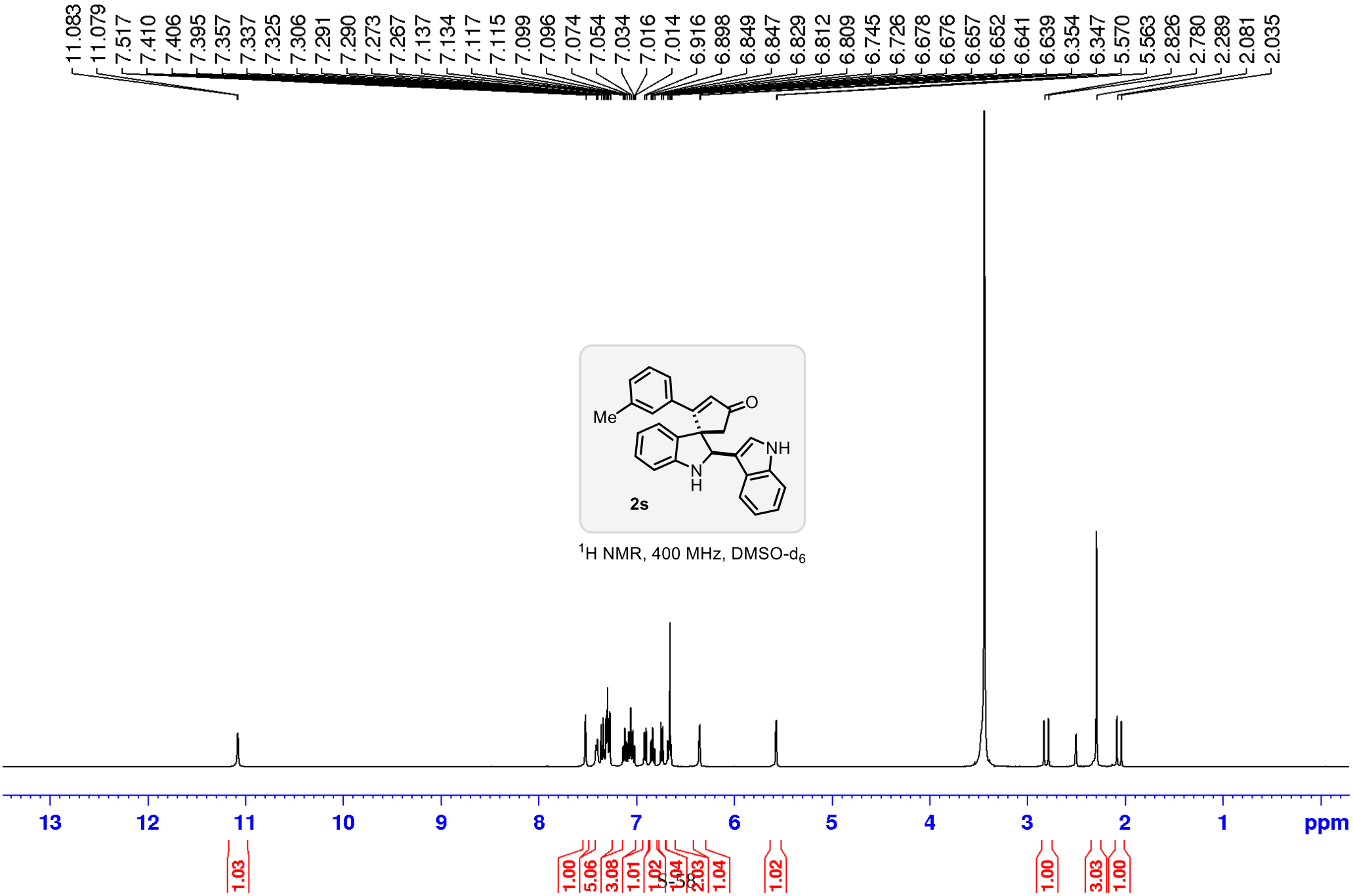
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



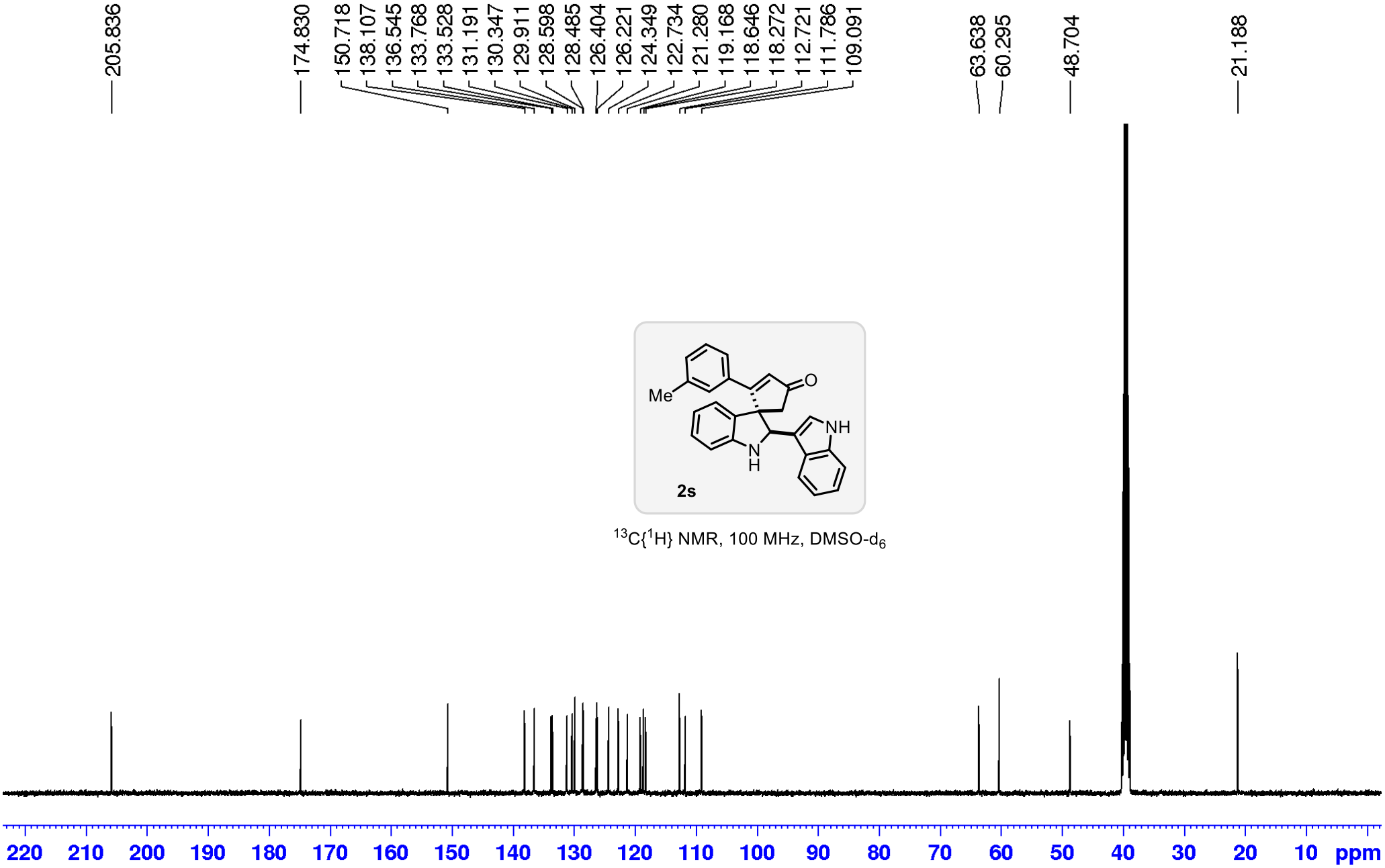
^{1}H NMR, 400 MHz, DMSO-d_6



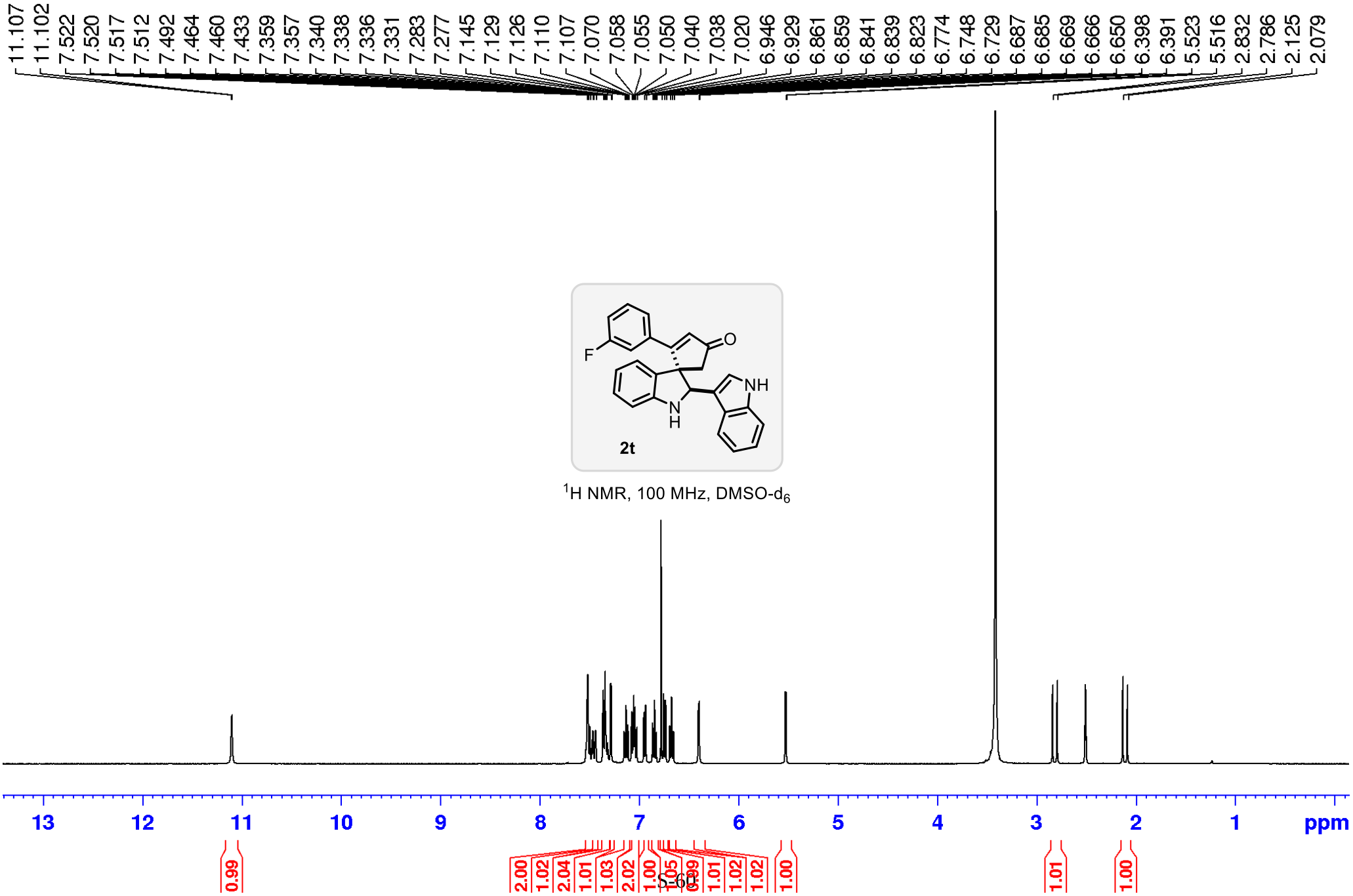
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



^{1}H NMR, 400 MHz, DMSO-d_6



$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6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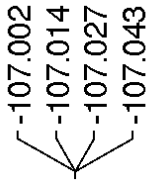
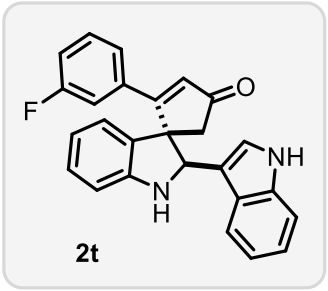
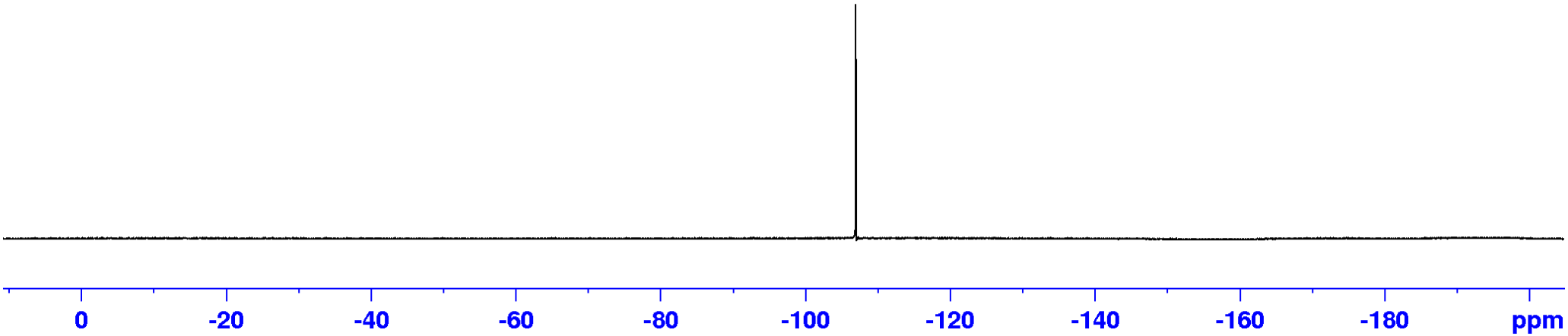
7.331
7.283
7.277
7.145
7.129
7.126
7.110
7.107
7.070
7.058
7.055
7.050
7.040
7.038
7.020
6.946
6.929
6.861
6.859
6.841
6.839
6.823
6.774
6.748
6.729
6.687
6.685
6.669
6.666
6.650
6.398
6.391
5.523
5.516
2.832
2.786
2.125
2.079
F
O
NH
N
H
2t
1H NMR, 100 MHz, DMSO-d6
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
0.99
2.00
1.02
2.04
1.01
1.03
2.02
1.00
1.05
0.99
1.01
1.02
1.02
1.00
1.01
1.00

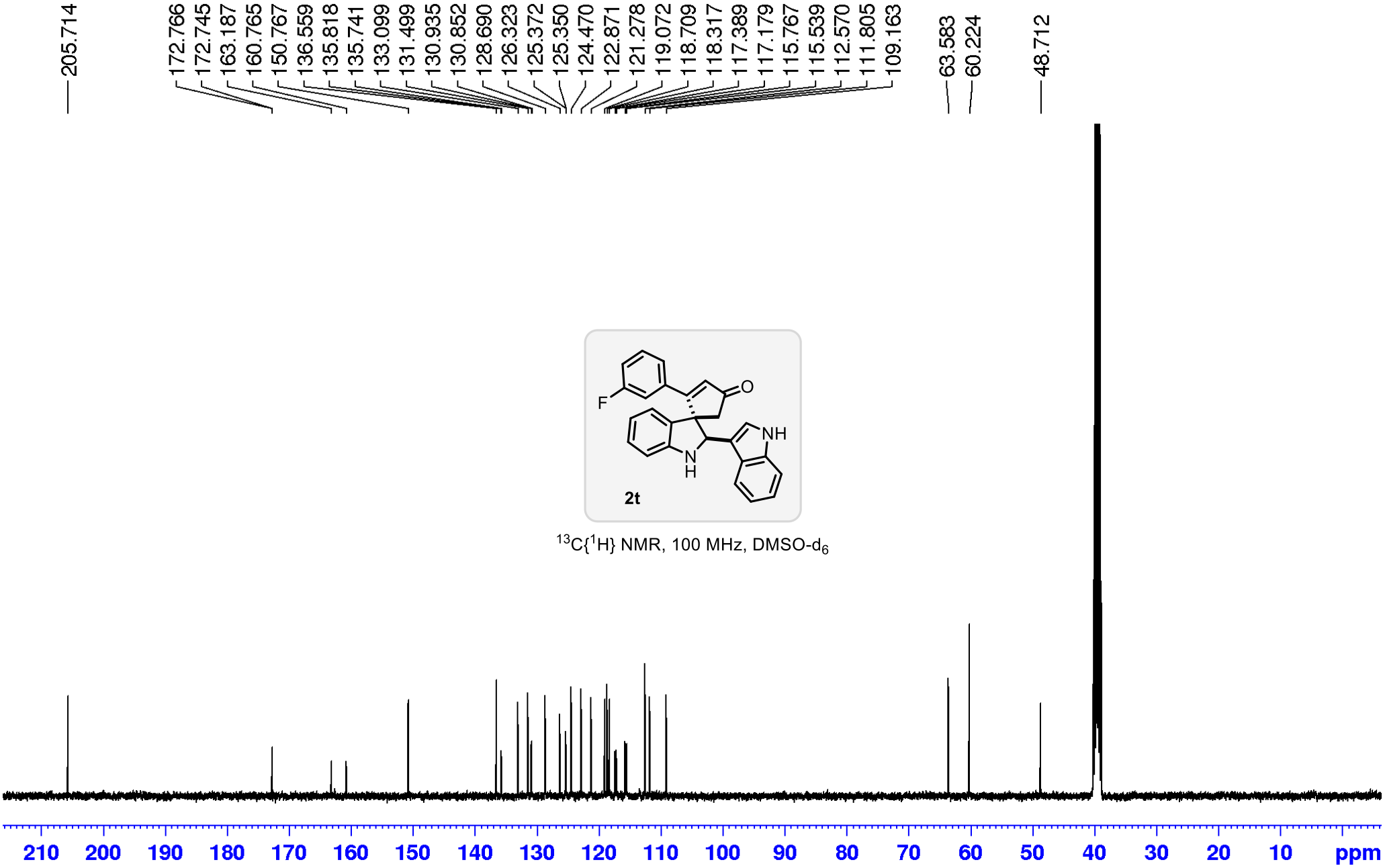




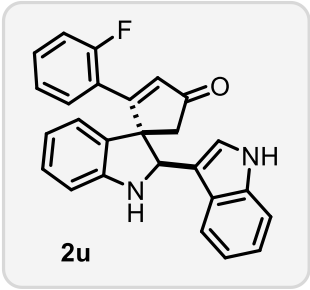
2t

^{19}F NMR, 376 MHz, DMSO-d_6



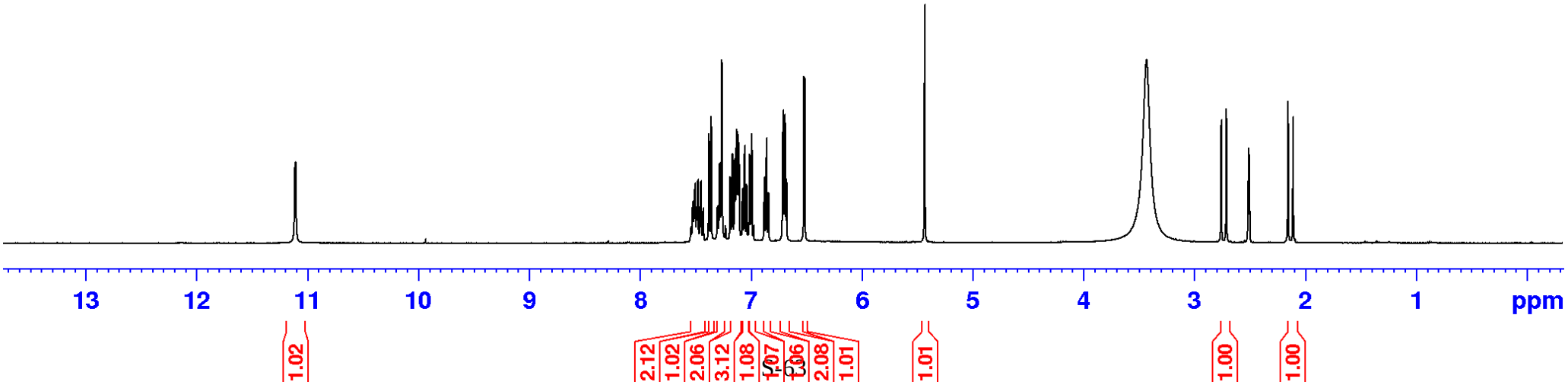


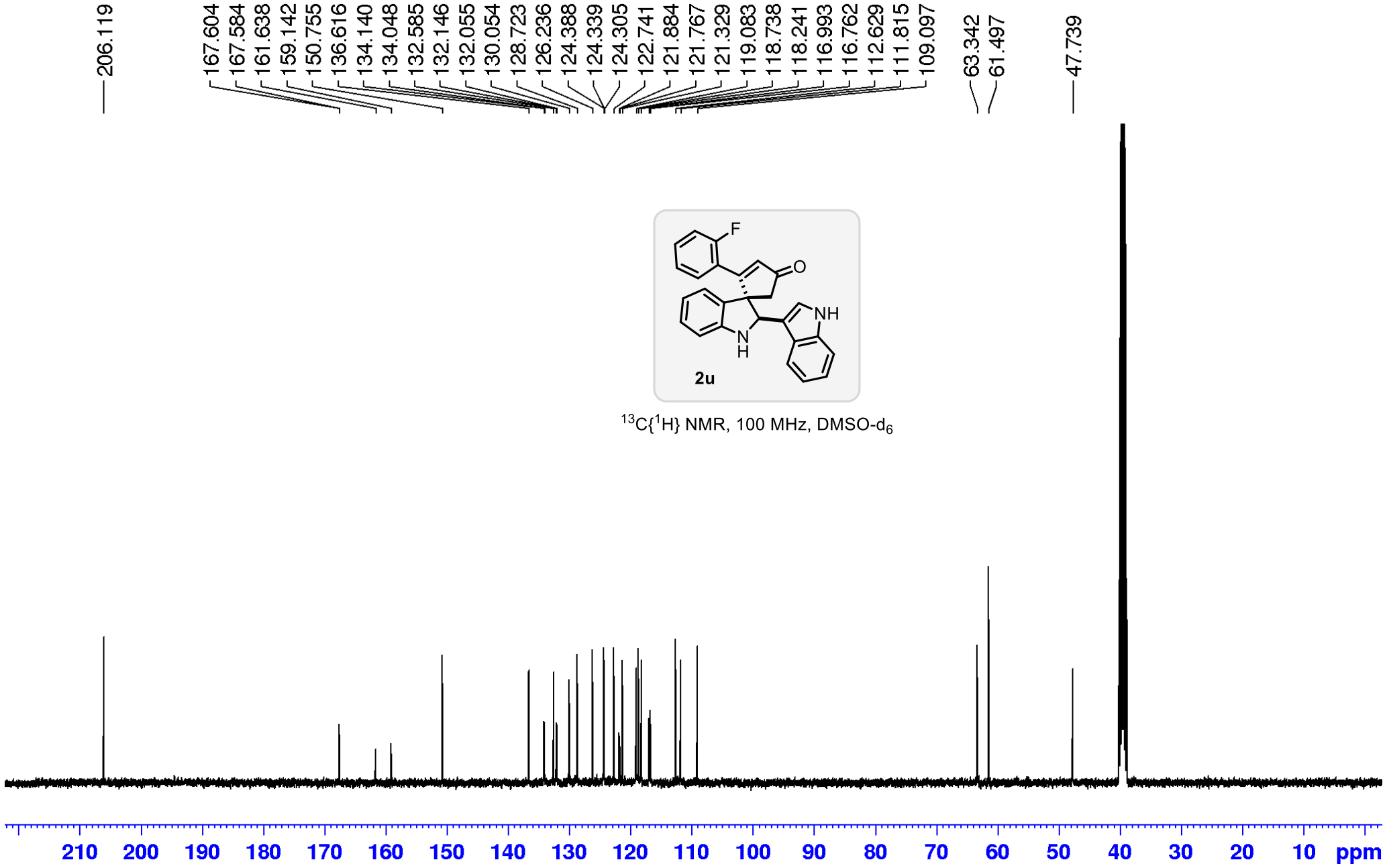
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



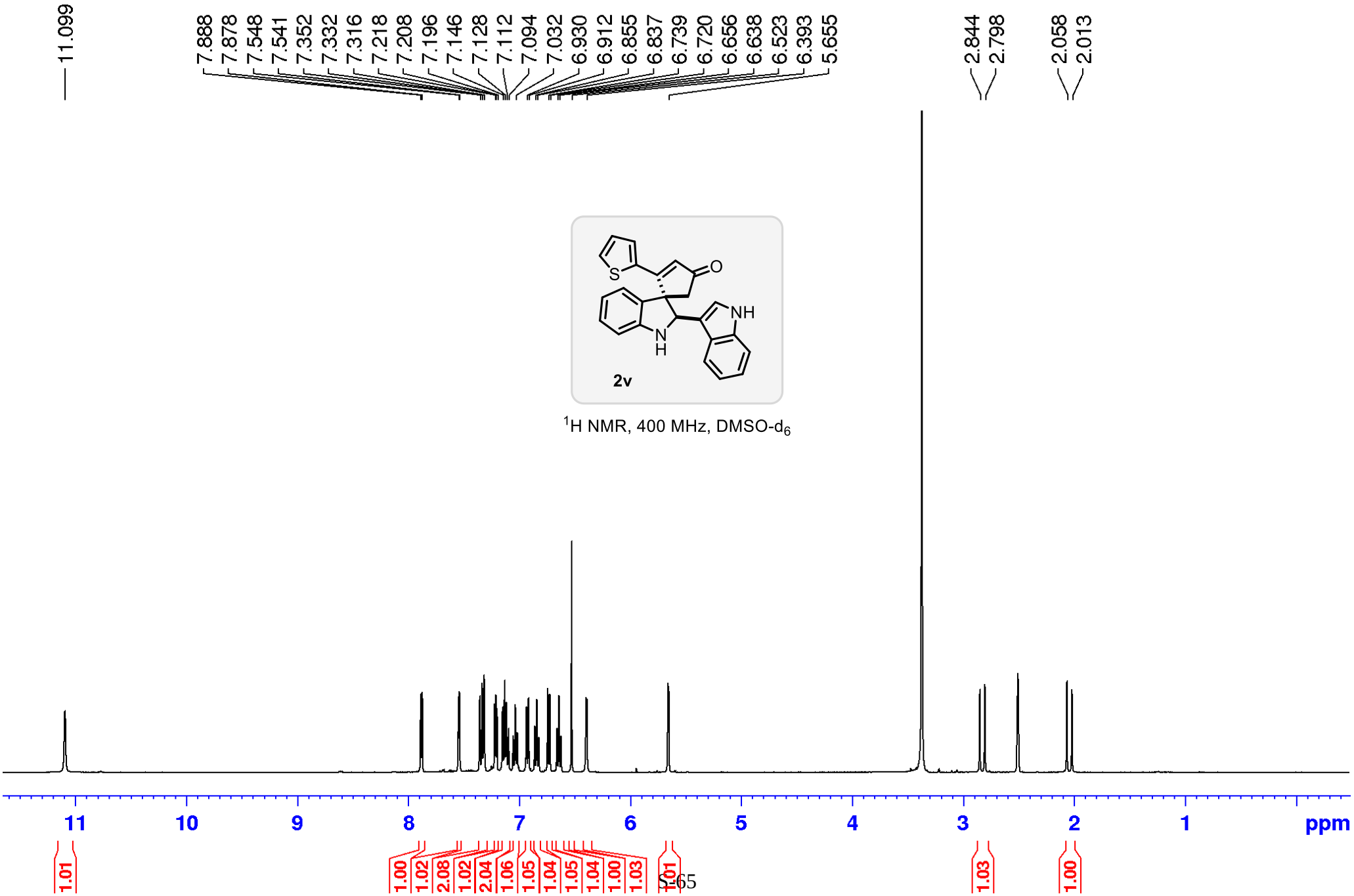
2u

^{1}H NMR, 100 MHz, DMSO-d_6

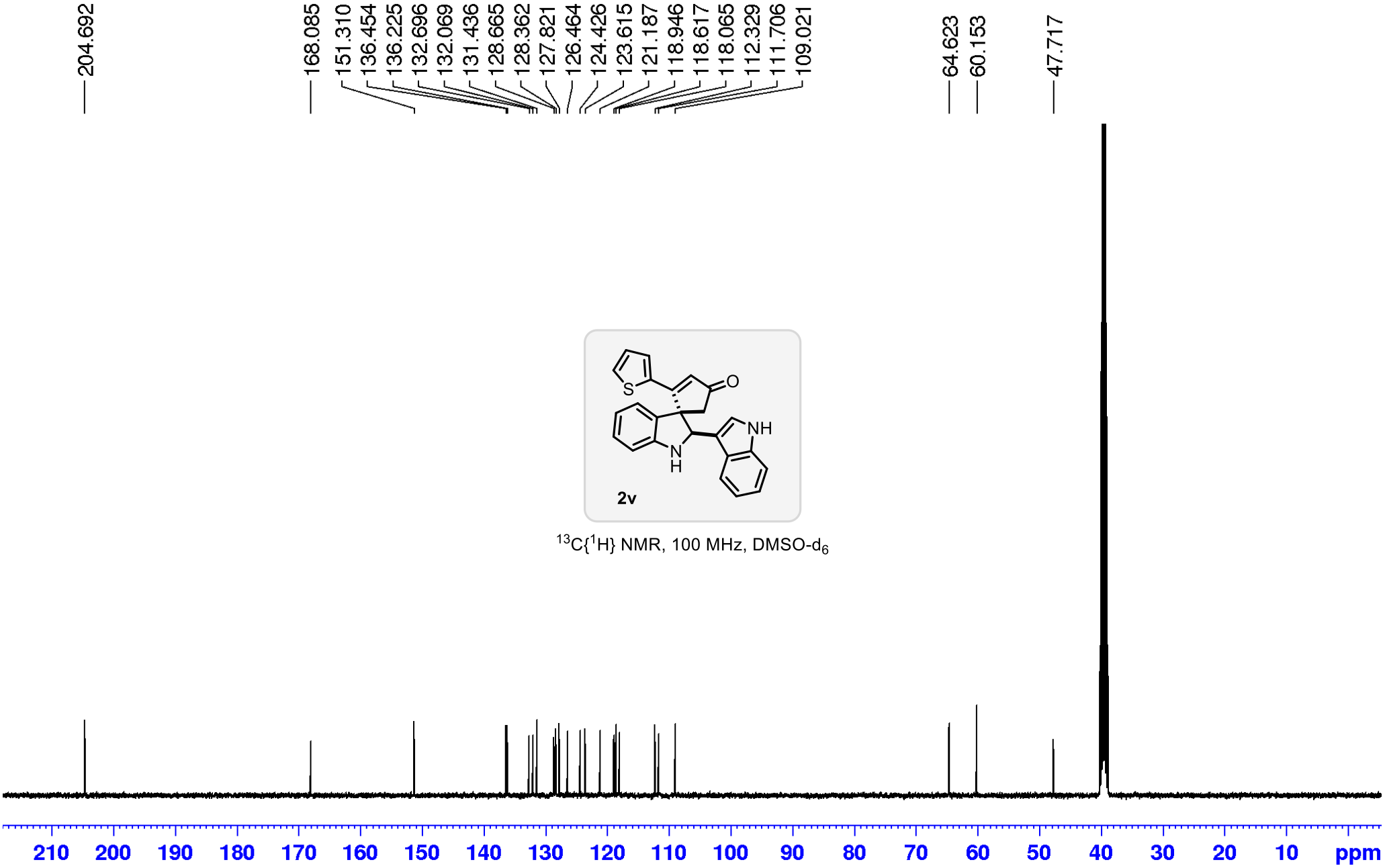




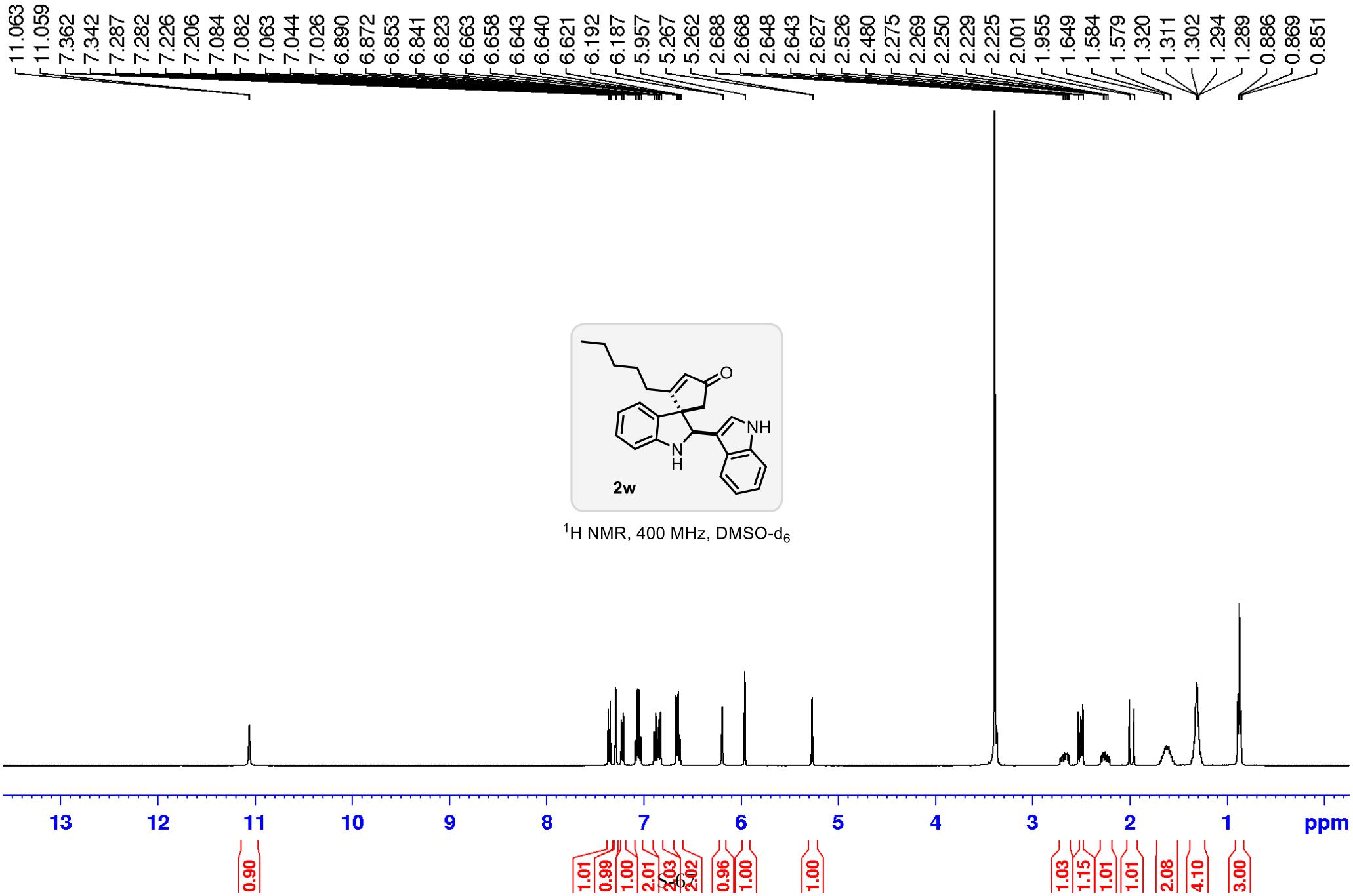
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6



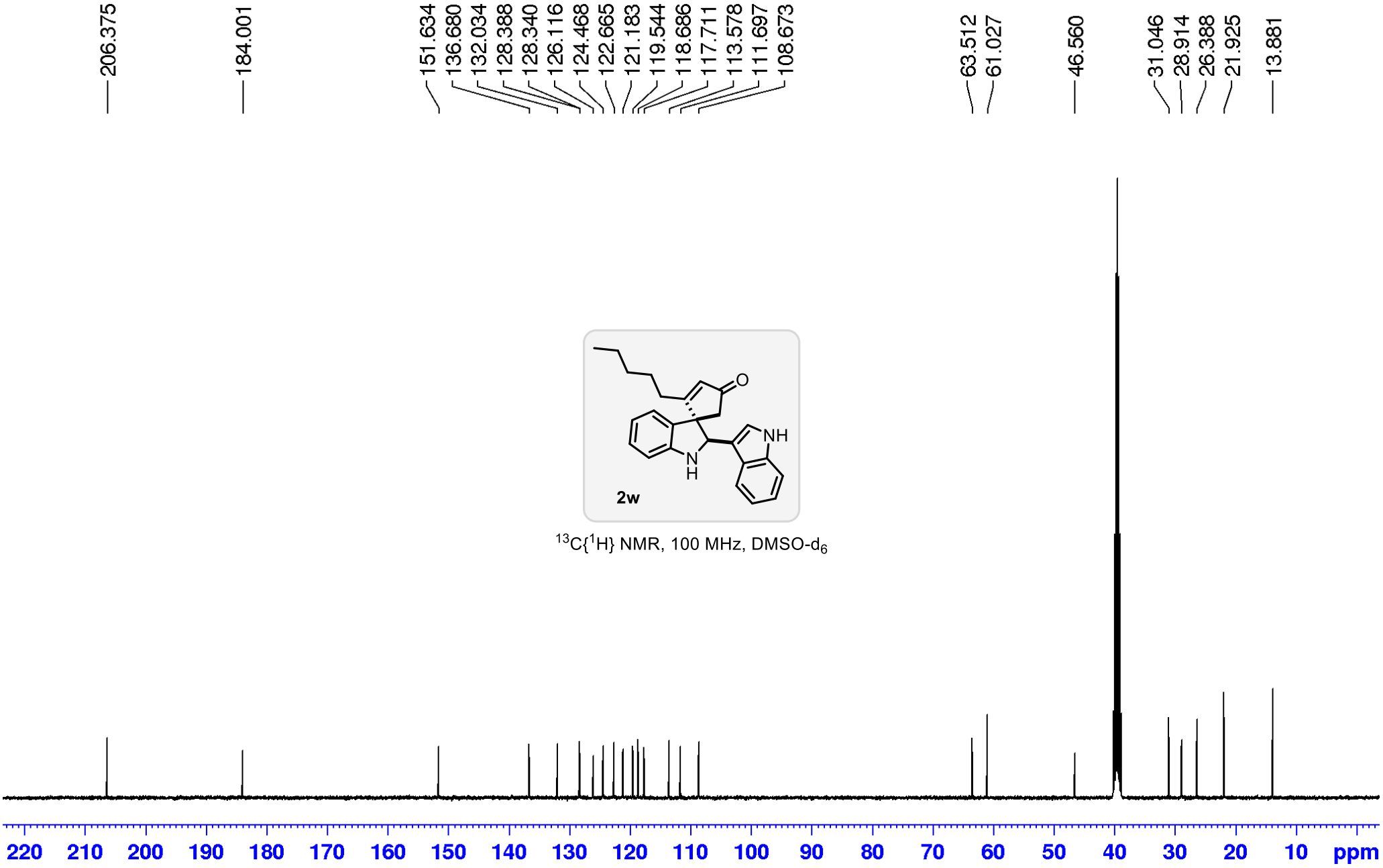
^{1}H NMR, 400 MHz, DMSO-d_6



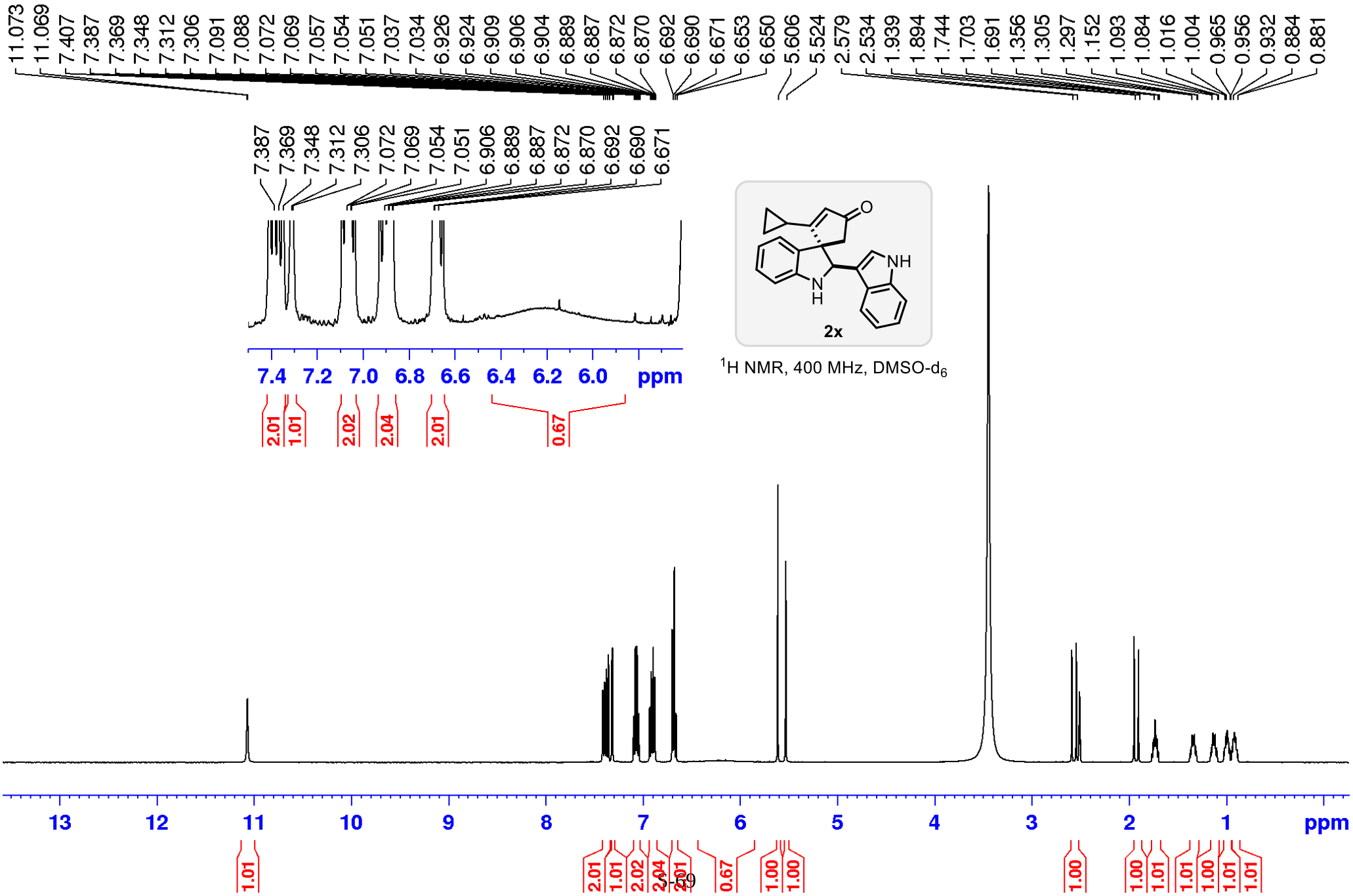
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6

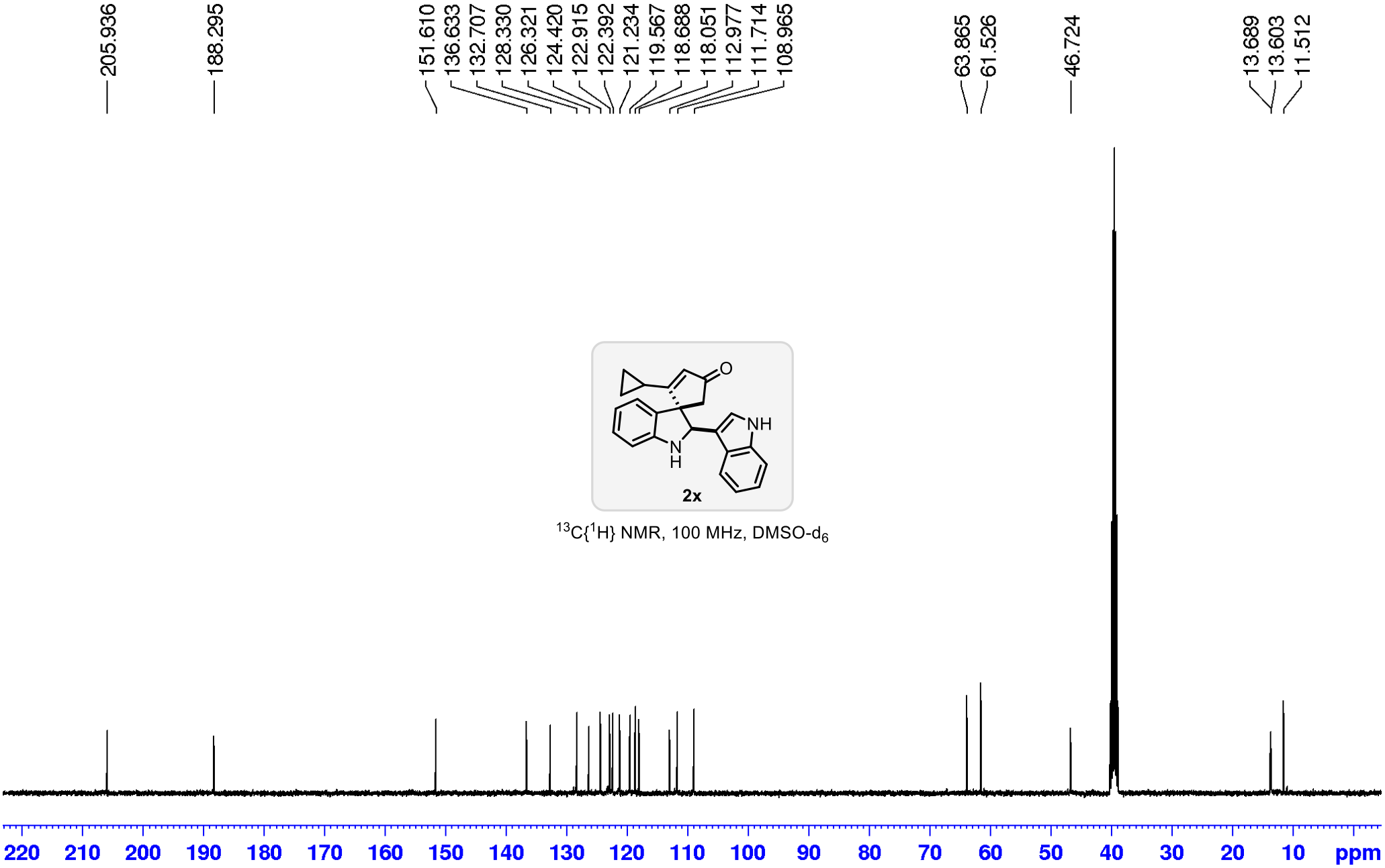


^{1}H NMR, 400 MHz, DMSO-d$_6$

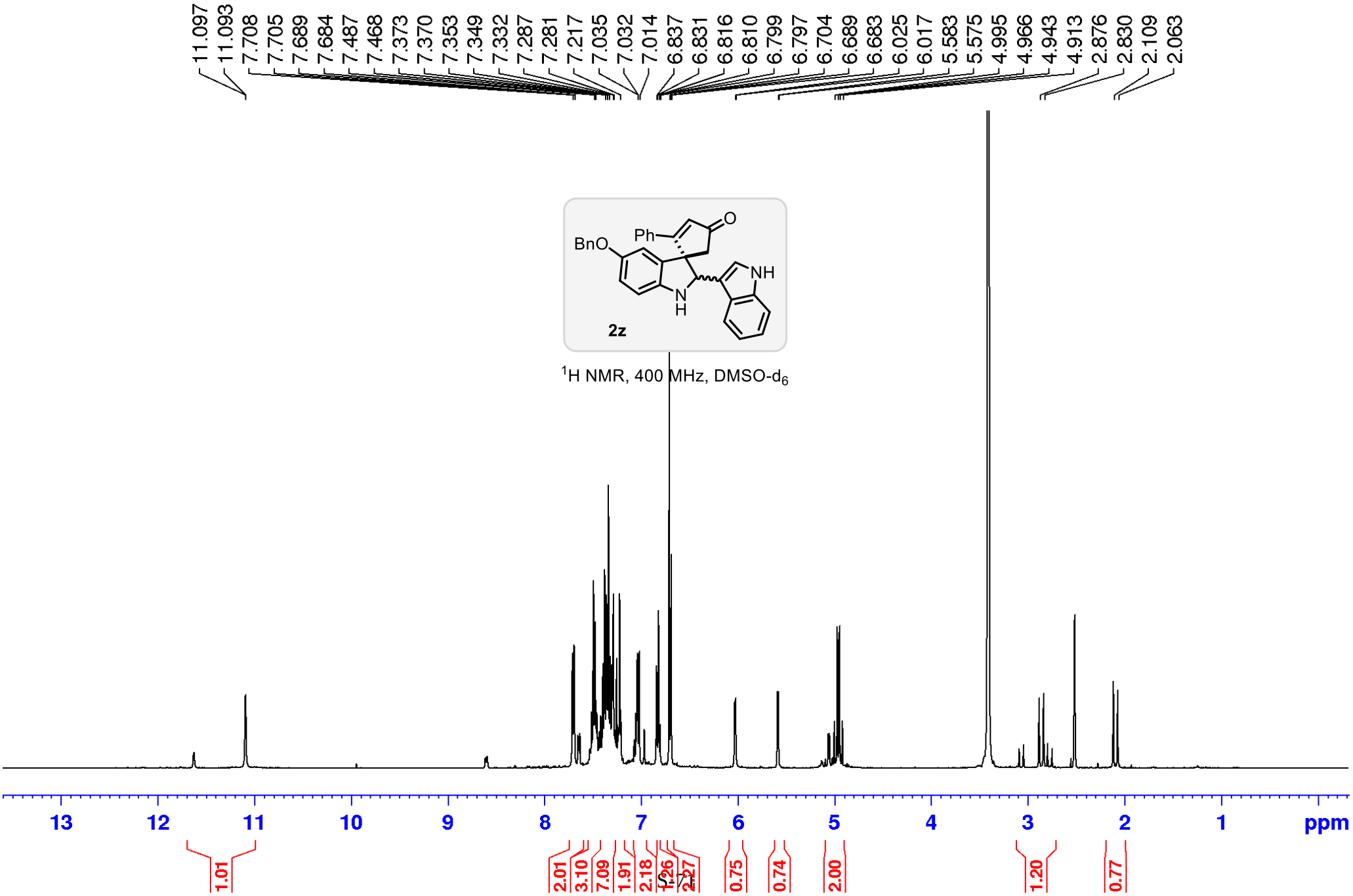


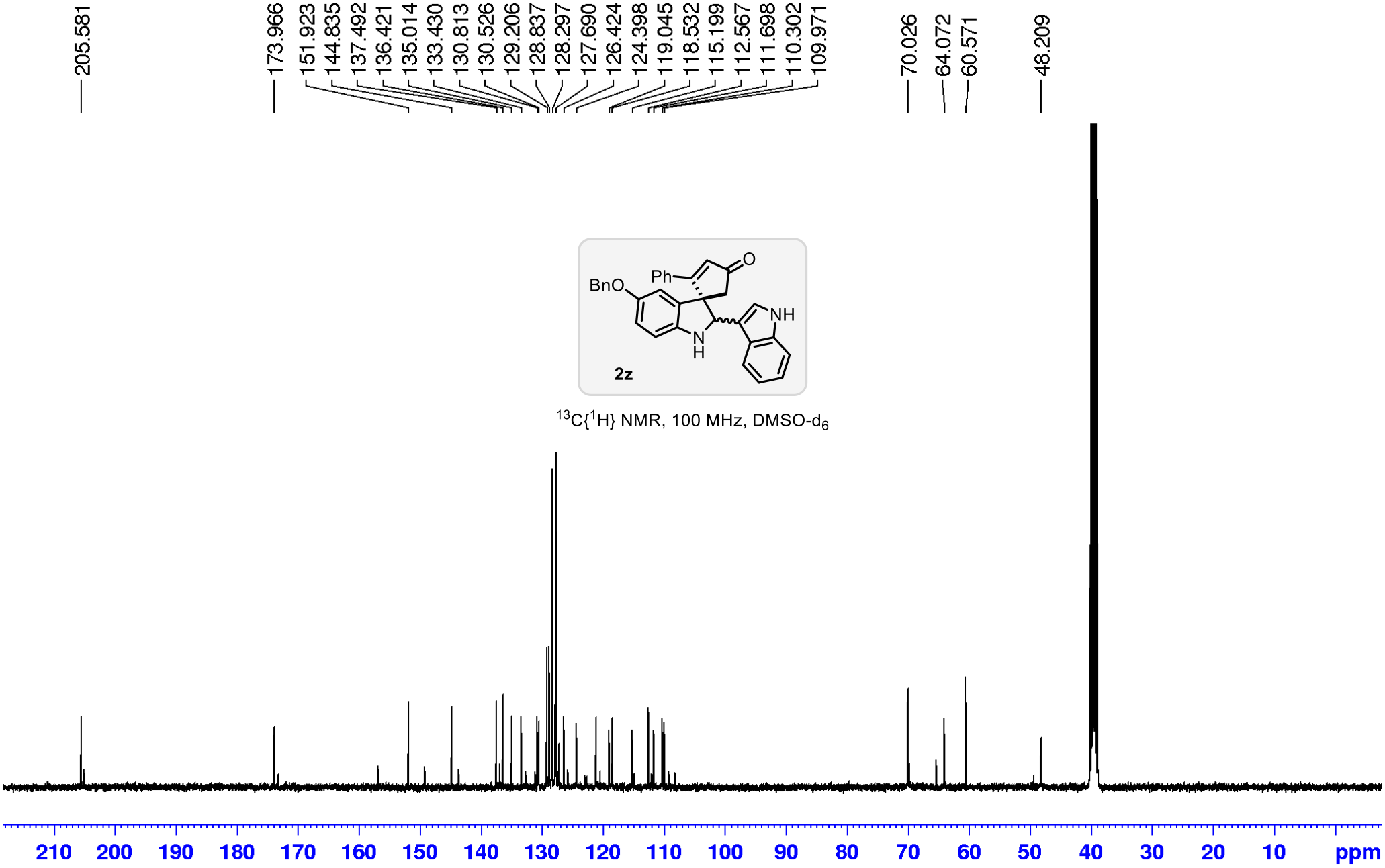
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6


11.073
11.069
7.407
7.387
7.369
7.348
7.312
7.306
7.091
7.088
7.072
7.069
7.057
7.054
7.051
7.037
7.034
6.926
6.924
6.909
6.906
6.904
6.889
6.887
6.872
6.870
6.692
6.690
6.671
6.653
6.650
5.606
5.524
2.579
2.534
1.939
1.894
1.744
1.703
1.691
1.356
1.305
1.297
1.152
1.093
1.084
1.016
1.004
0.965
0.956
0.932
0.884
0.881
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
ppm
2.01
1.01
2.02
2.04
2.01
0.67
O
NH
N
H
2x
^{1}H NMR, 400 MHz, DMSO-d$_6$
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.01
2.01
1.01
2.02
2.04
2.01
0.67
1.00
1.00
1.00
1.00
1.00
1.01
1.00
1.01
1.01

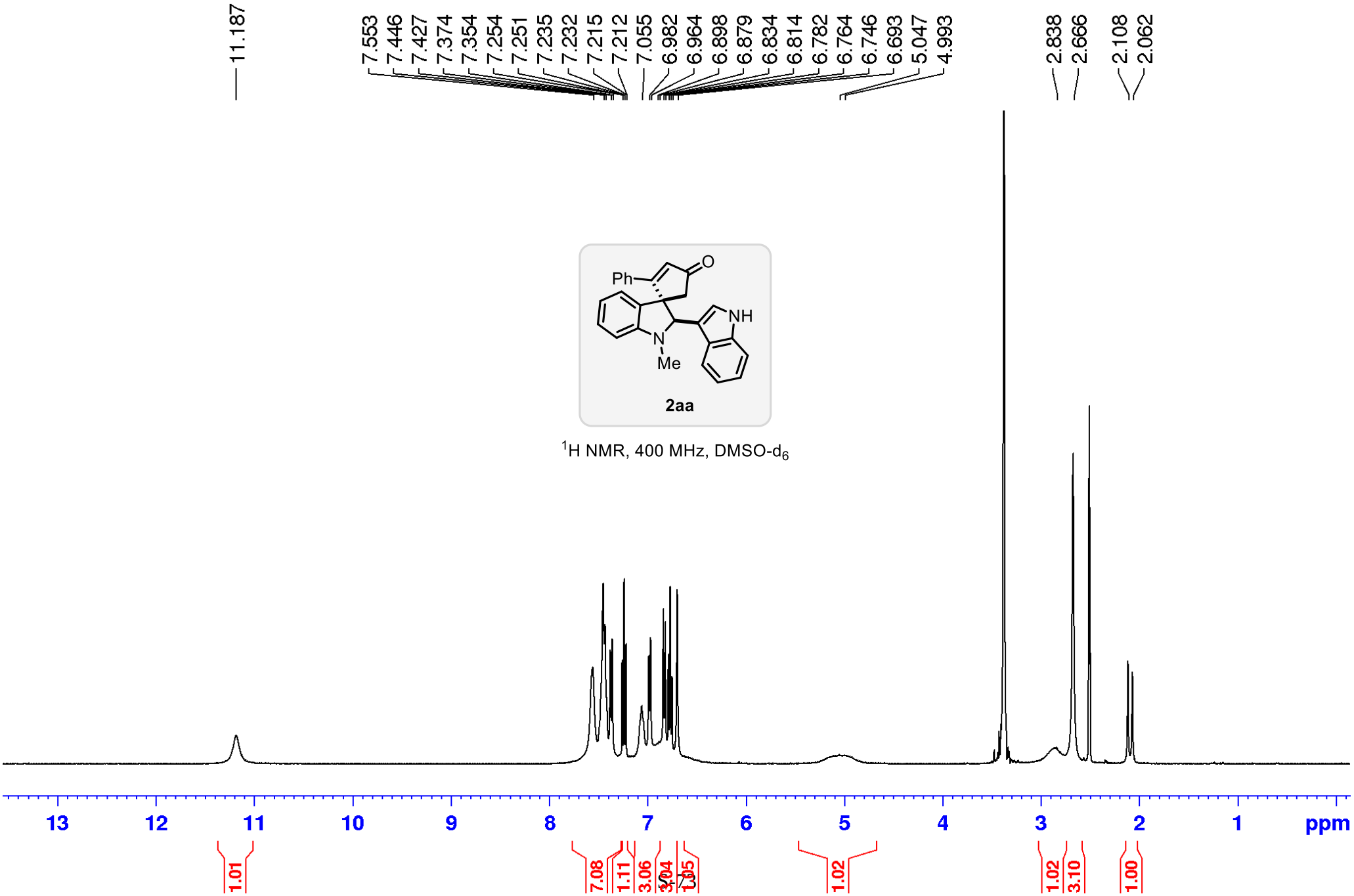


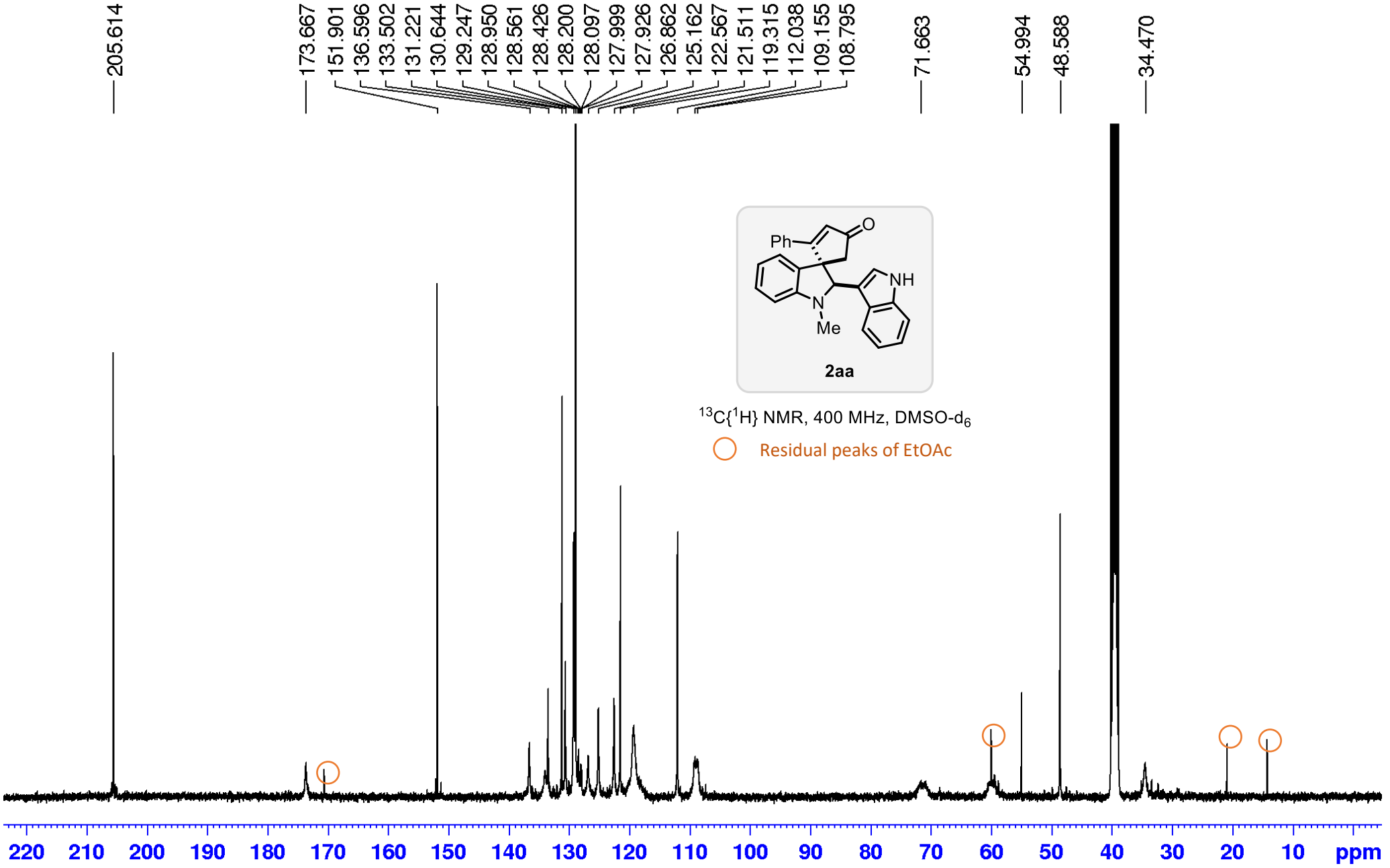
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6

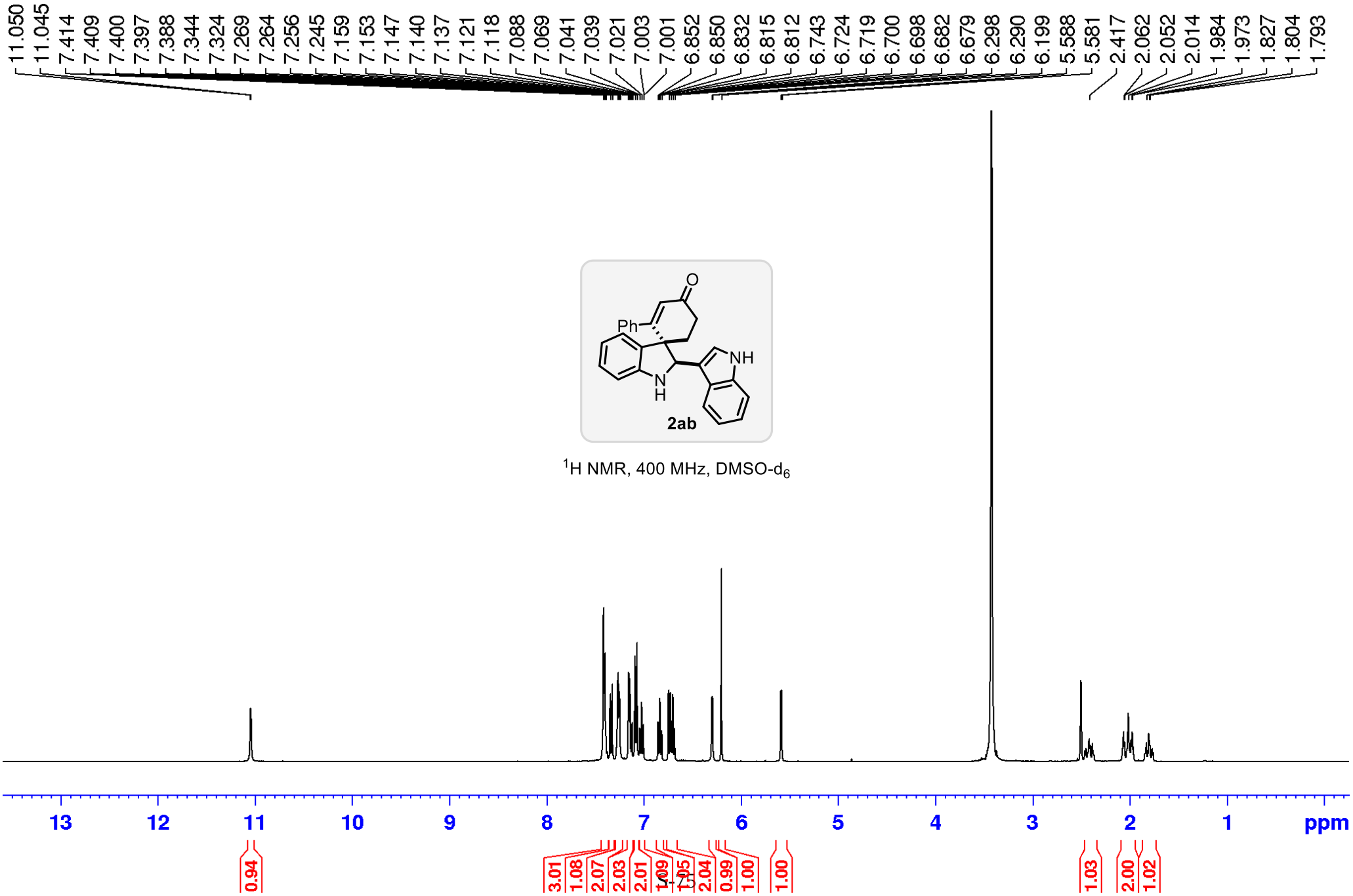

11.097
11.093
7.708
7.705
7.689
7.684
7.487
7.468
7.373
7.370
7.353
7.349
7.332
7.287
7.281
7.217
7.035
7.032
7.014
6.837
6.831
6.816
6.810
6.799
6.797
6.704
6.689
6.683
6.025
6.017
5.583
5.575
4.995
4.966
4.943
4.913
2.876
2.830
2.109
2.063
BnO
Ph
O
NH
N
H
2z
1H NMR, 400 MHz, DMSO-d6
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.01
2.01
3.10
7.09
1.91
2.18
1.26
2.27
0.75
0.74
2.00
1.20
0.77

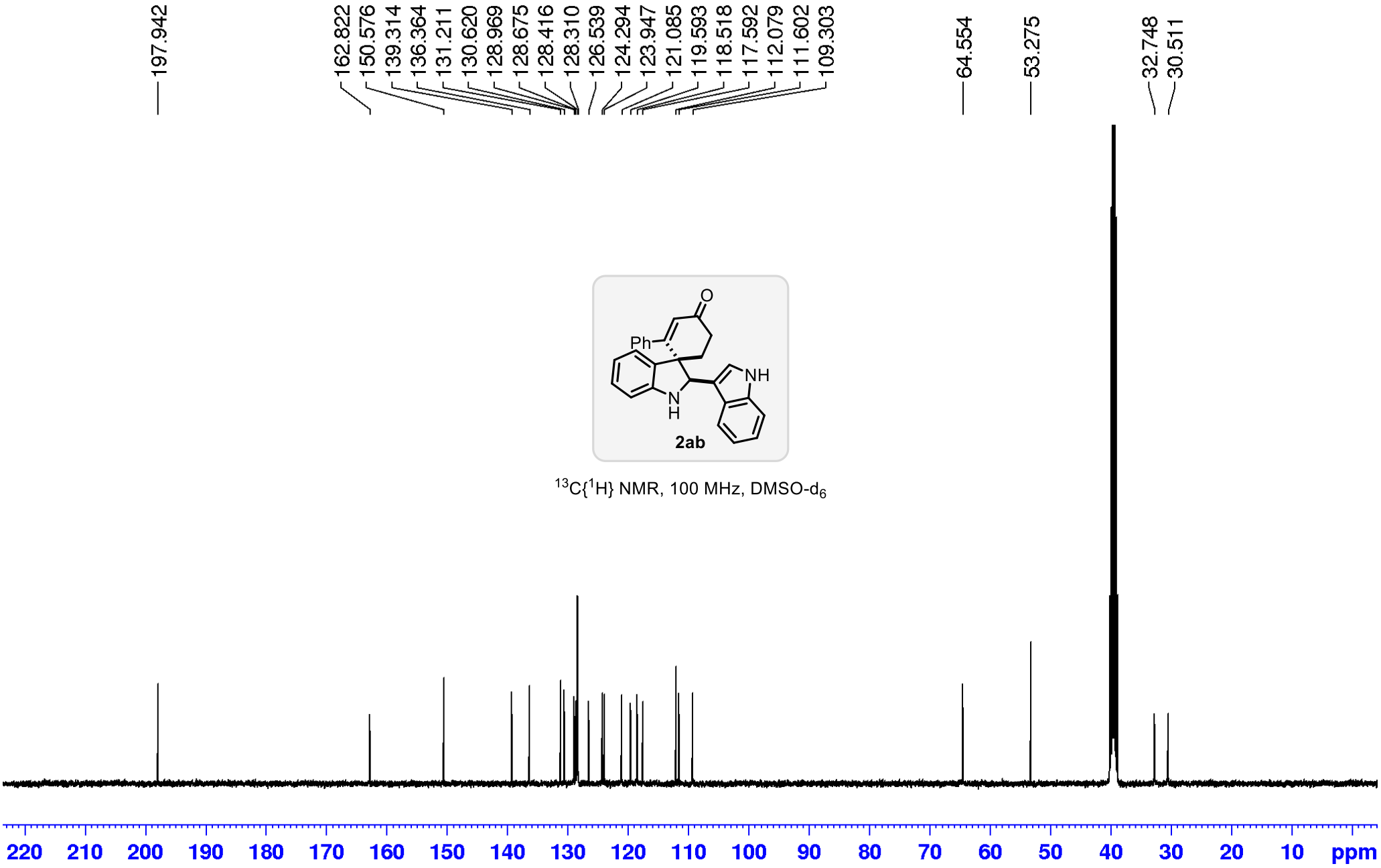


$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6

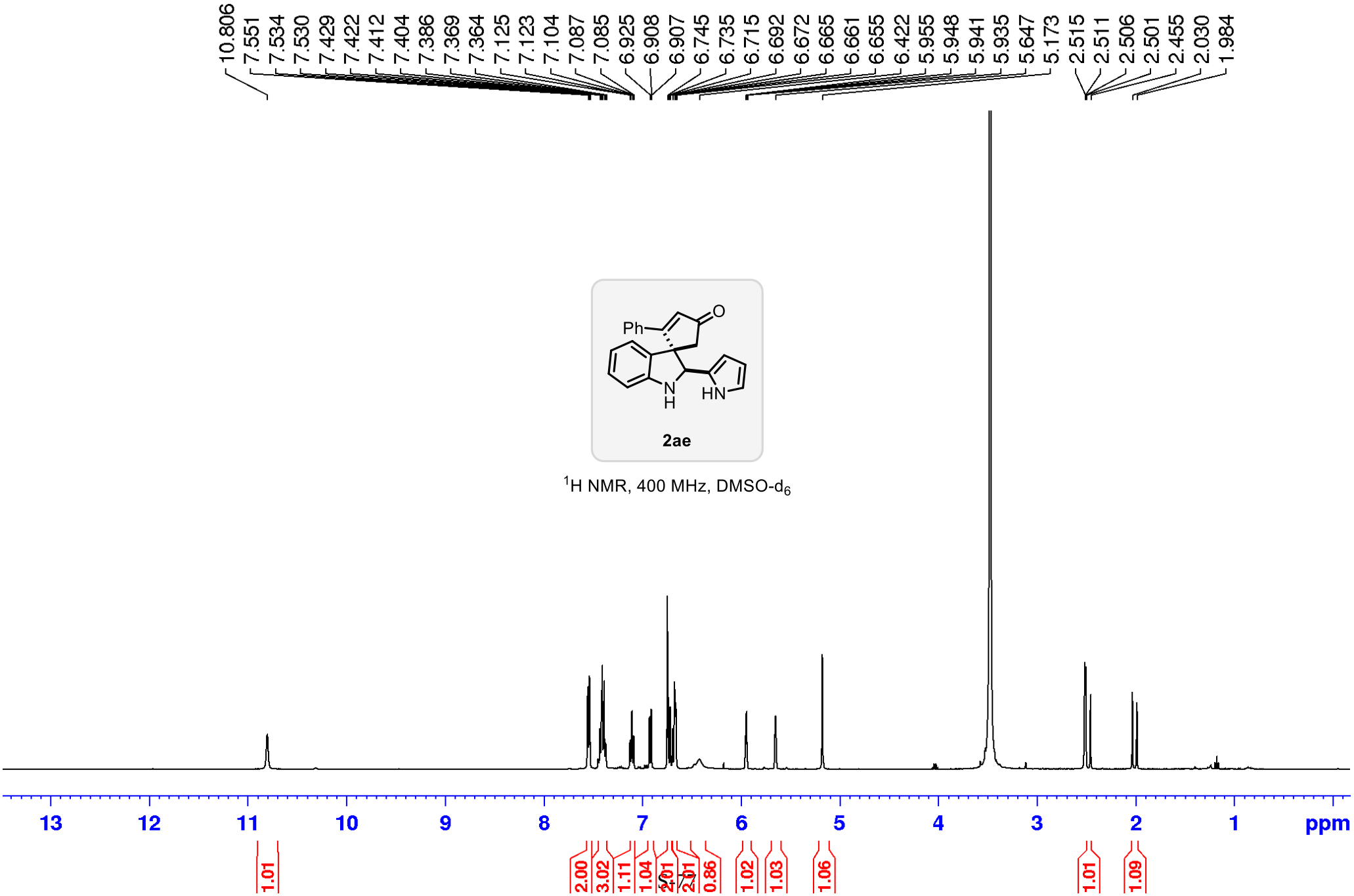

11.187
7.553
7.446
7.427
7.374
7.354
7.254
7.251
7.235
7.232
7.215
7.212
7.055
6.982
6.964
6.898
6.879
6.834
6.814
6.782
6.764
6.746
6.693
5.047
4.993
2.838
2.666
2.108
2.062
Ph
O
NH
N
Me
2aa
1H NMR, 400 MHz, DMSO-d6
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.01
7.08
1.11
3.06
3.04
1.05
1.02
1.02
3.10
1.00

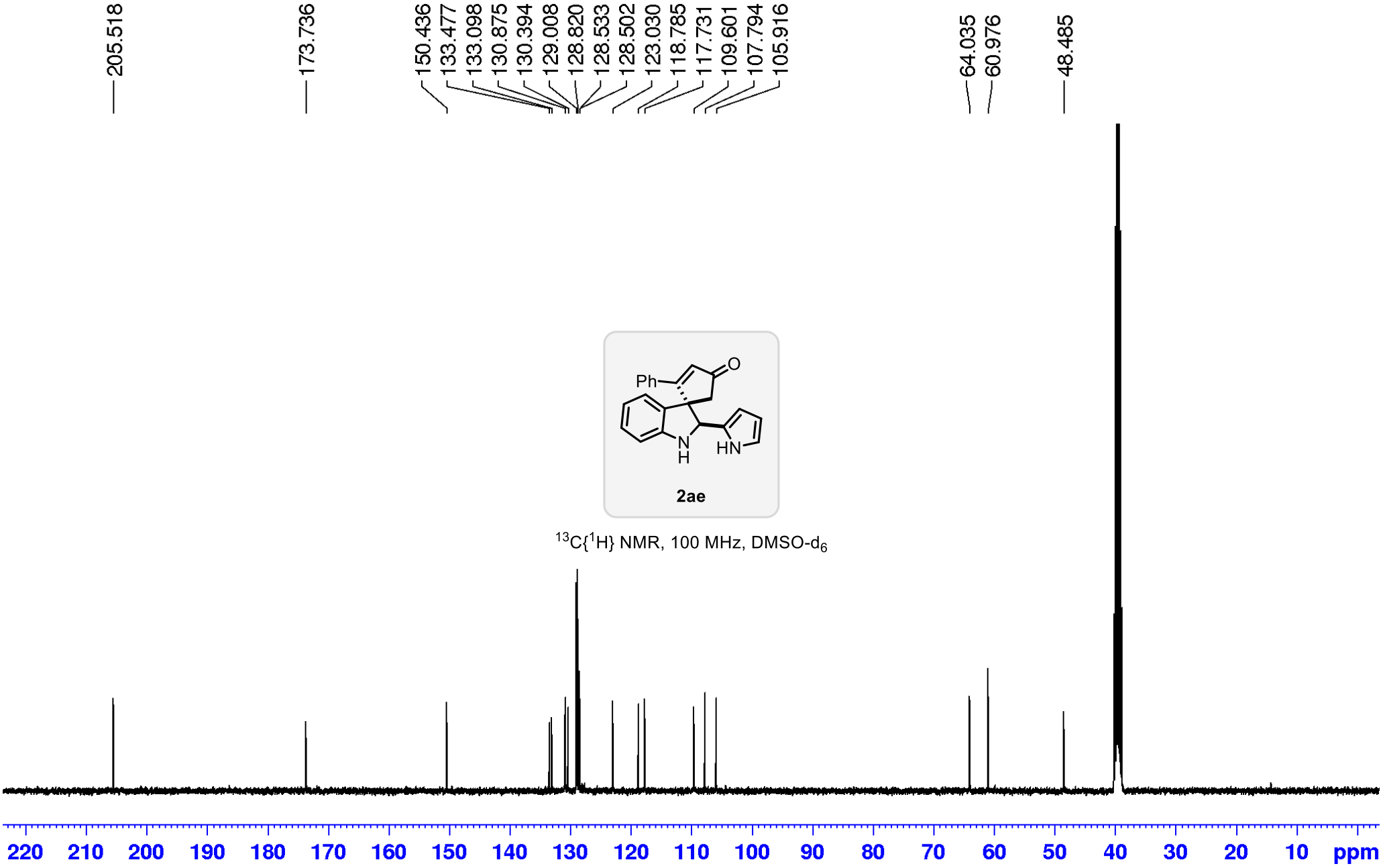

205.614
173.667
151.901
136.596
133.502
131.221
130.644
129.247
128.950
128.561
128.426
128.200
128.097
127.999
127.926
126.862
125.162
122.567
121.511
119.315
112.038
109.155
108.795
71.663
54.994
48.588
34.470
Ph
O
NH
N
Me
2aa
13C{1H} NMR, 400 MHz, DMSO-d6
Residual peaks of EtOAc
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

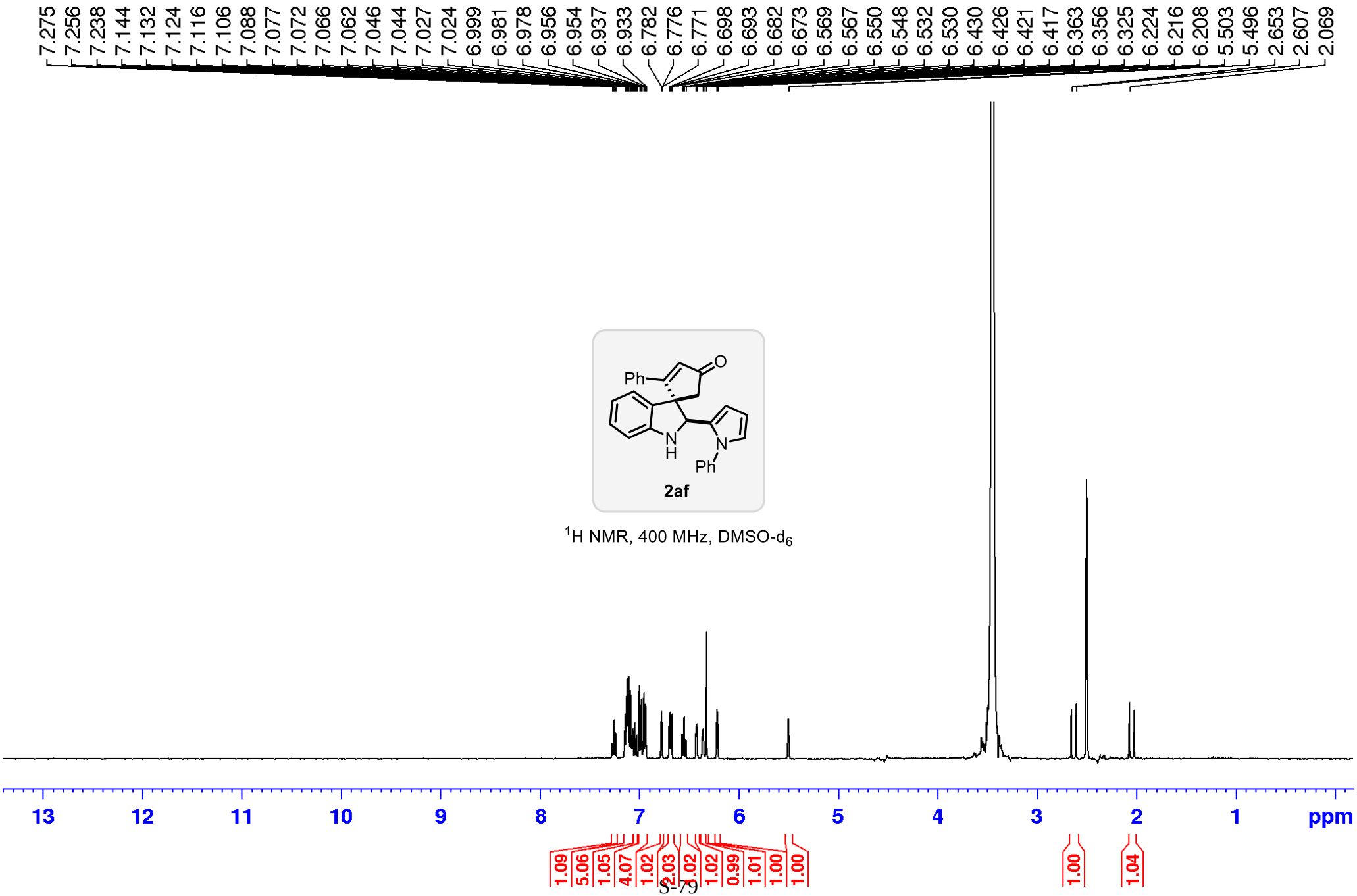

11.050
11.045
7.414
7.409
7.400
7.397
7.388
7.344
7.324
7.269
7.264
7.256
7.245
7.159
7.153
7.147
7.140
7.137
7.121
7.118
7.088
7.069
7.041
7.039
7.021
7.003
7.001
6.852
6.850
6.832
6.815
6.812
6.743
6.724
6.719
6.700
6.698
6.682
6.679
6.298
6.290
6.199
5.588
5.581
2.417
2.062
2.052
2.014
1.984
1.973
1.827
1.804
1.793
O
Ph
NH
N
H
2ab
^{1}H NMR, 400 MHz, DMSO-d$_6$
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
0.94
3.01
1.08
2.07
2.03
2.01
1.09
1.05
2.04
0.99
1.00
1.00
1.03
2.00
1.02



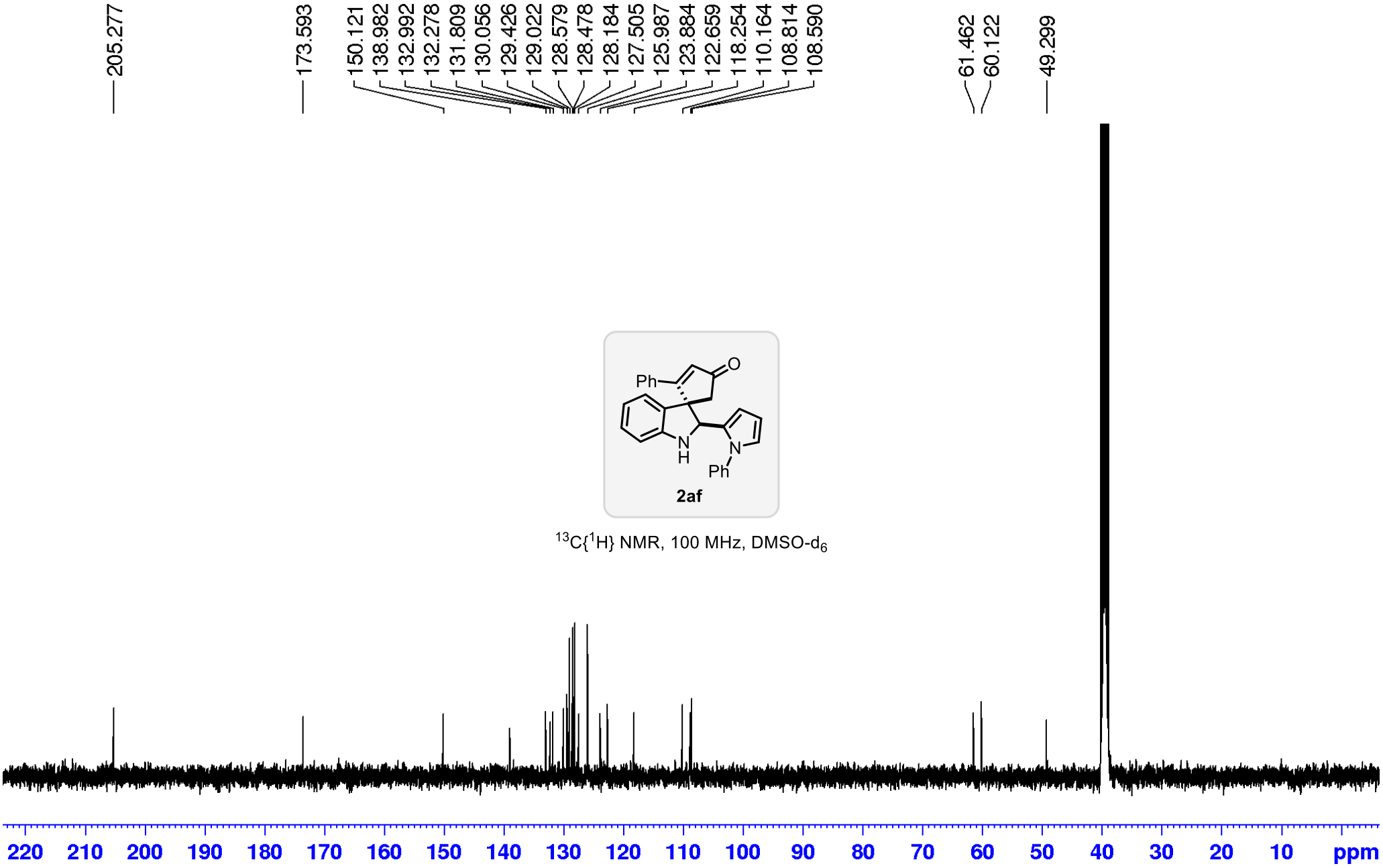
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6


10.806
7.551
7.534
7.530
7.429
7.422
7.412
7.404
7.386
7.369
7.364
7.125
7.123
7.104
7.087
7.085
6.925
6.908
6.907
6.745
6.735
6.715
6.692
6.672
6.665
6.661
6.655
6.422
5.955
5.948
5.941
5.935
5.647
5.173
2.515
2.511
2.506
2.501
2.455
2.030
1.984
Ph
O
N
H
HN
2ae
^{1}H NMR, 400 MHz, DMSO-d$_6$
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.01
2.00
3.02
1.11
1.04
2.01
2.01
0.86
1.02
1.03
1.06
1.01
1.09


205.518
173.736
150.436
133.477
133.098
130.875
130.394
129.008
128.820
128.533
128.502
123.030
118.785
117.731
109.601
107.794
105.916
64.035
60.976
48.485
Ph
O
N
H
HN
2ae
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

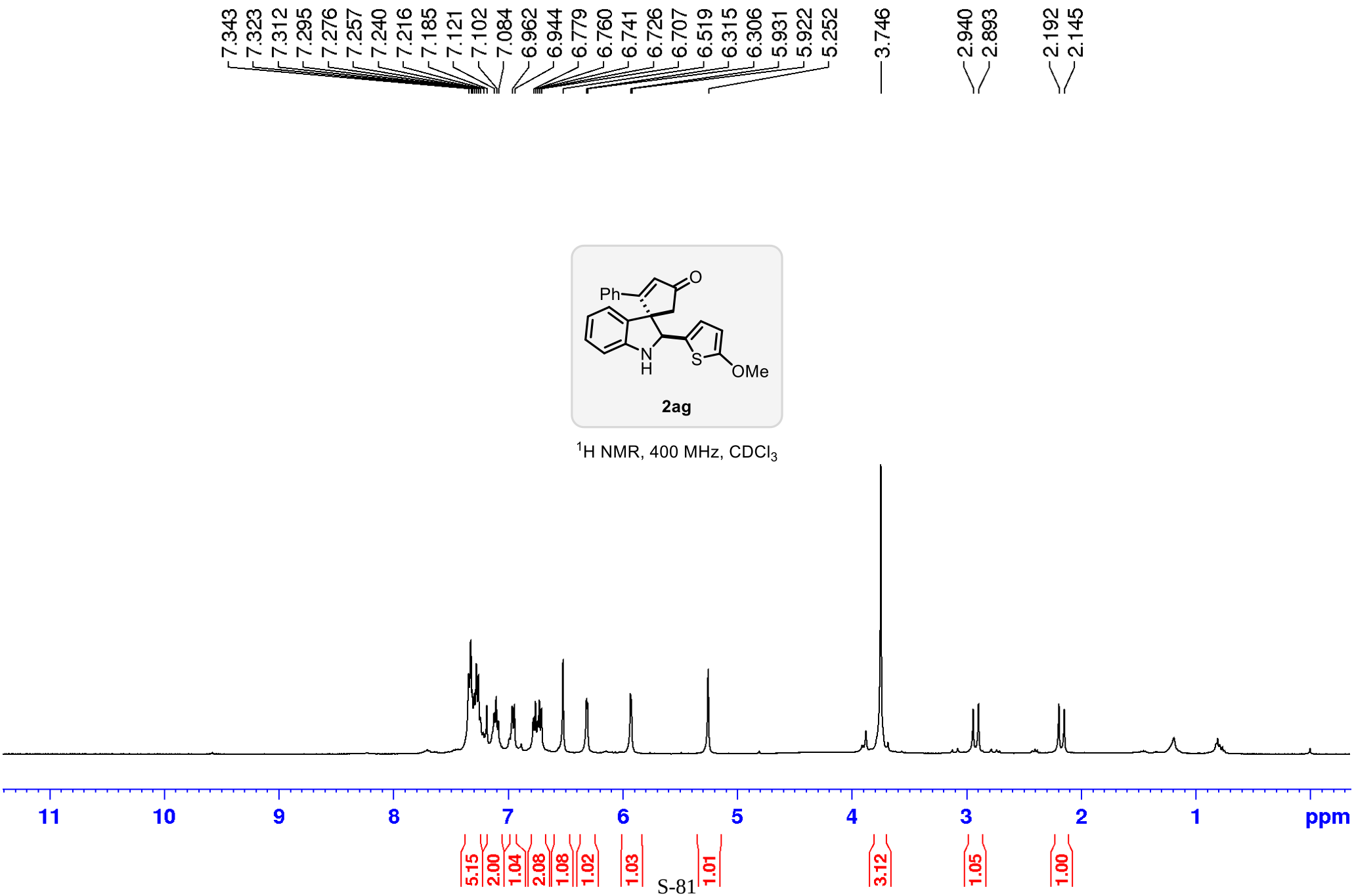


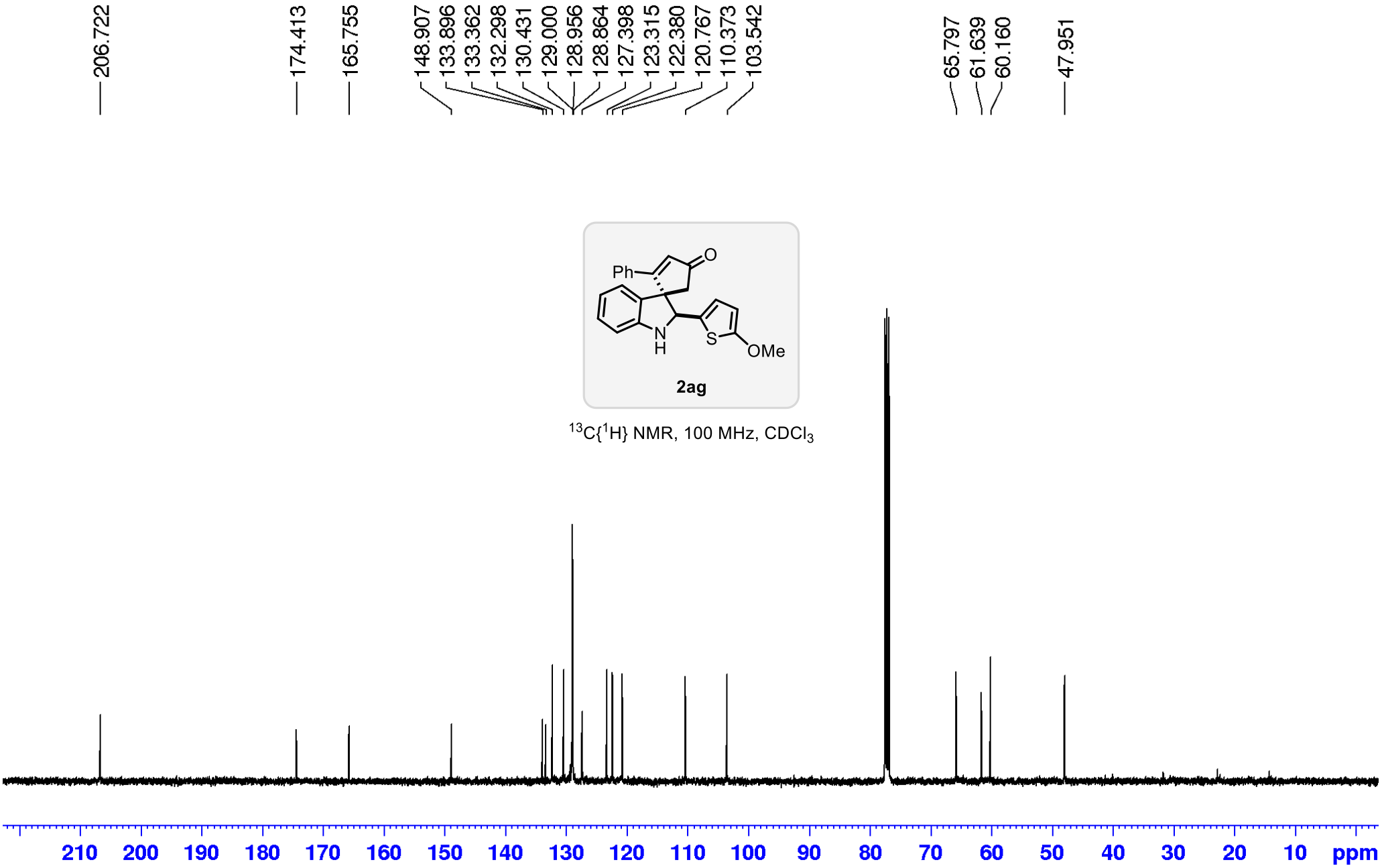
^{1}H NMR, 400 MHz, DMSO-d_6

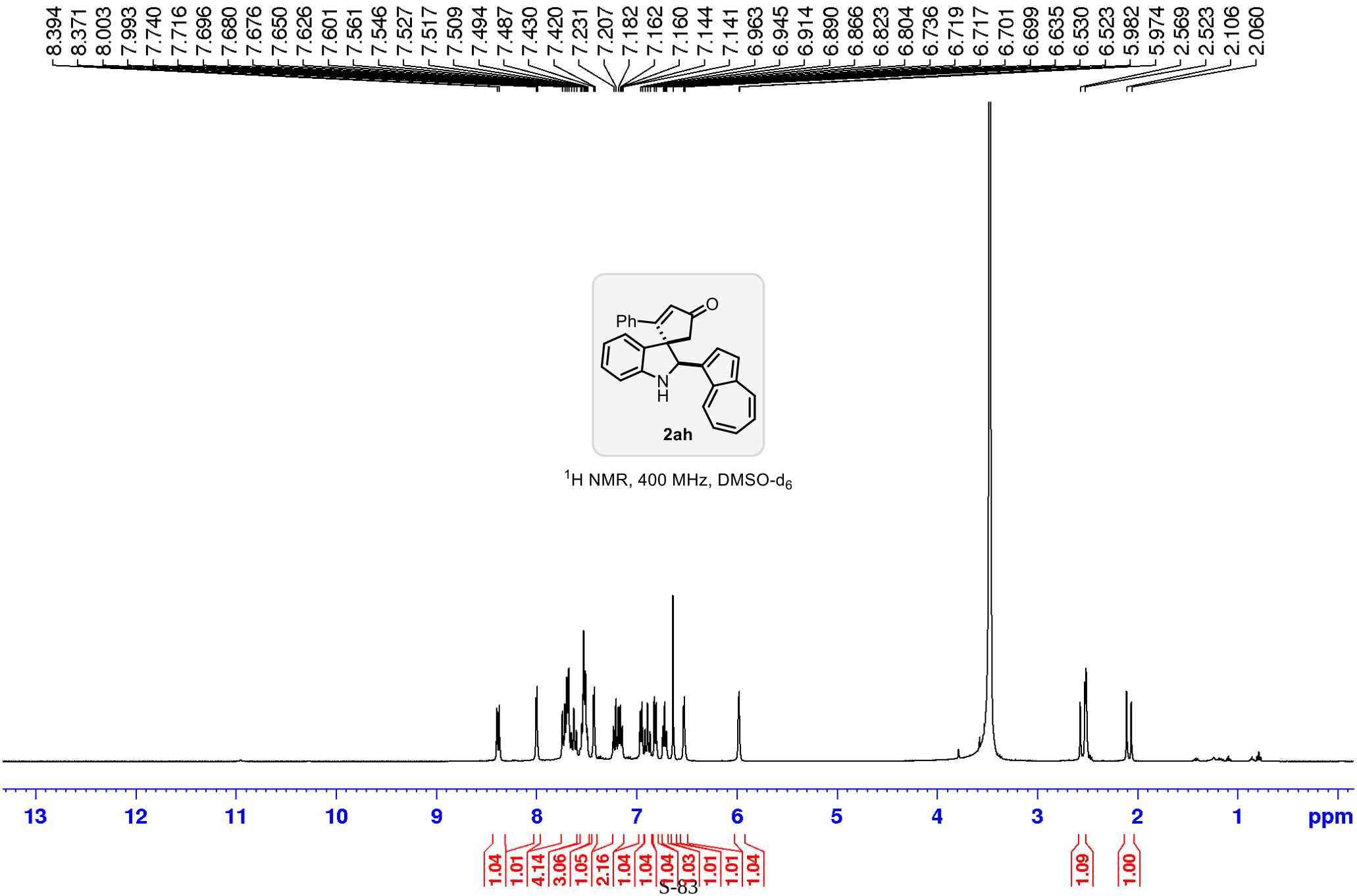


2af

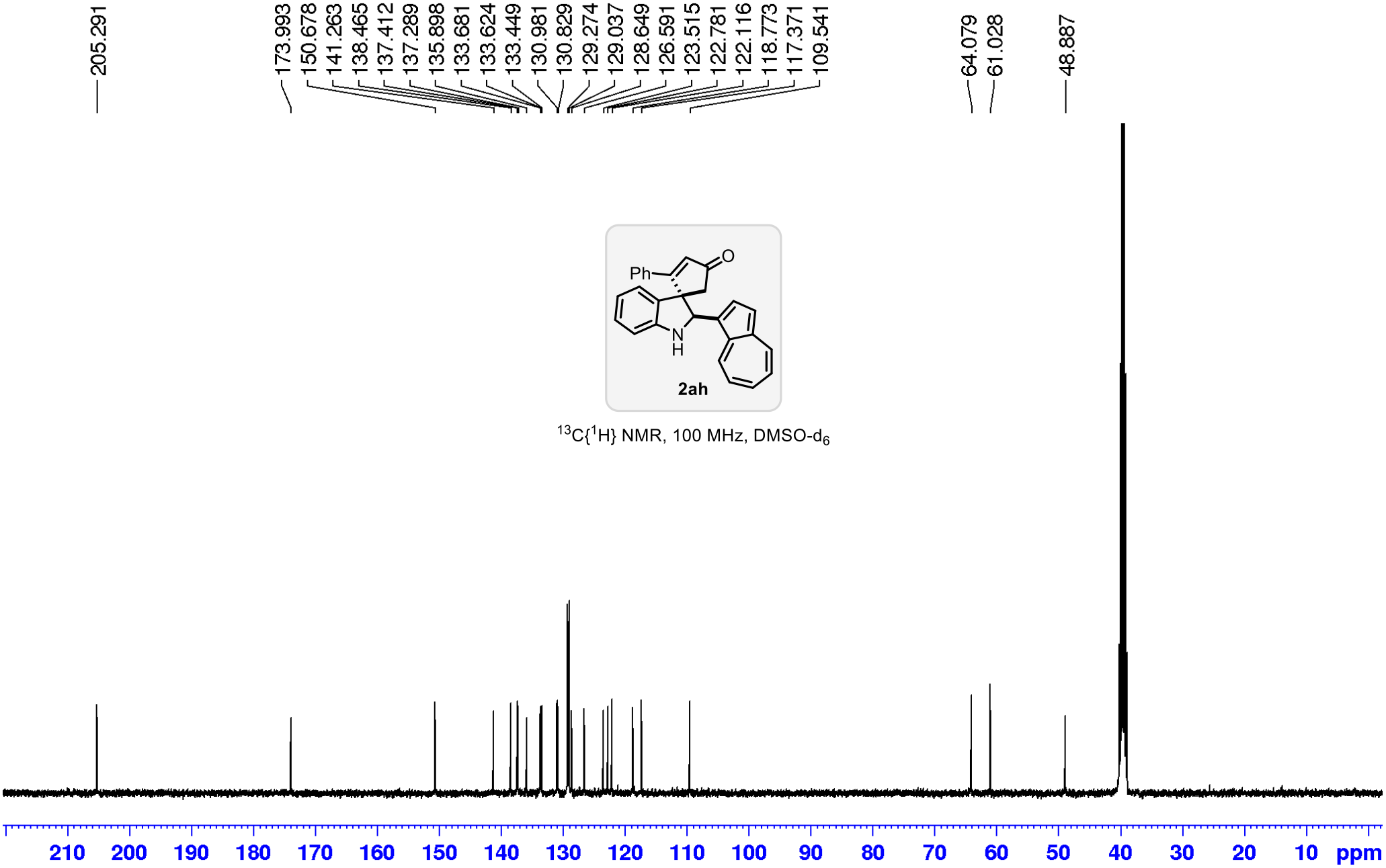
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6


7.343
7.323
7.312
7.295
7.276
7.257
7.240
7.216
7.185
7.121
7.102
7.084
6.962
6.944
6.779
6.760
6.741
6.726
6.707
6.519
6.315
6.306
5.931
5.922
5.252
3.746
2.940
2.893
2.192
2.145
Ph
O
N
H
S
OMe
2ag
1H NMR, 400 MHz, CDCl3
11
10
9
8
7
6
5
4
3
2
1
ppm
5.15
2.00
1.04
2.08
1.08
1.02
1.03
1.01
3.12
1.05
1.00

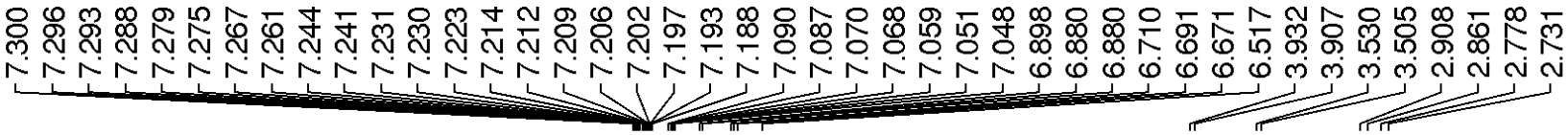

206.722
174.413
165.755
148.907
133.896
133.362
132.298
130.431
129.000
128.956
128.864
127.398
123.315
122.380
120.767
110.373
103.542
65.797
61.639
60.160
47.951
Ph
O
N
H
S
OMe
2ag
$^{13}C\{^{1}H\}$ NMR, 100 MHz, $CDCl_3$
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

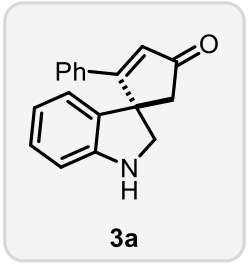


^{1}H NMR, 400 MHz, DMSO-d_6



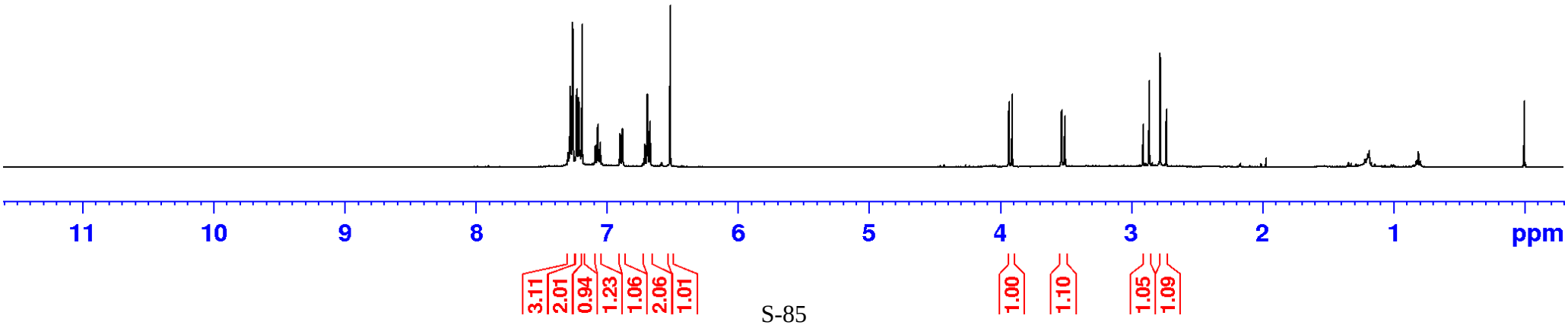
$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6

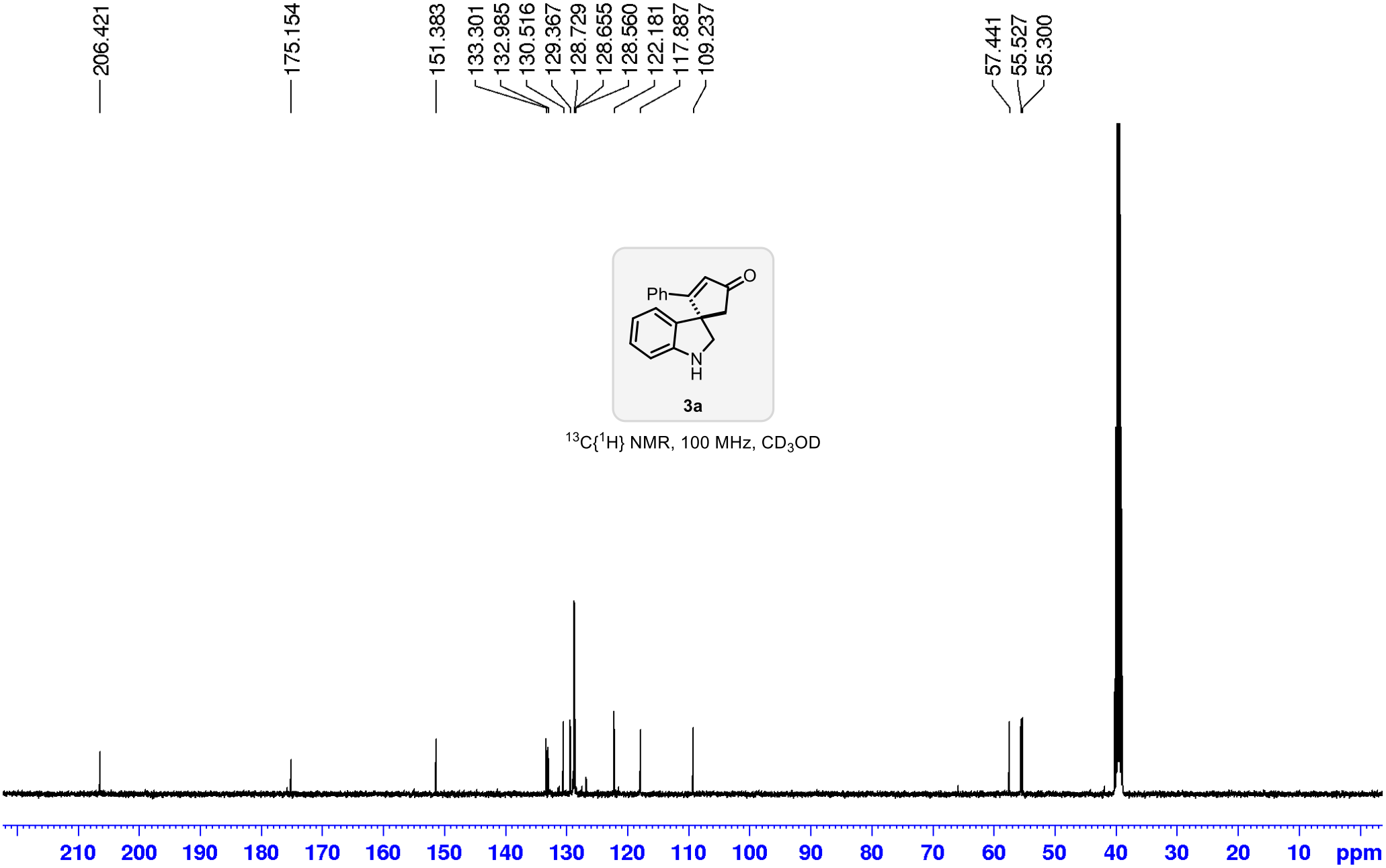




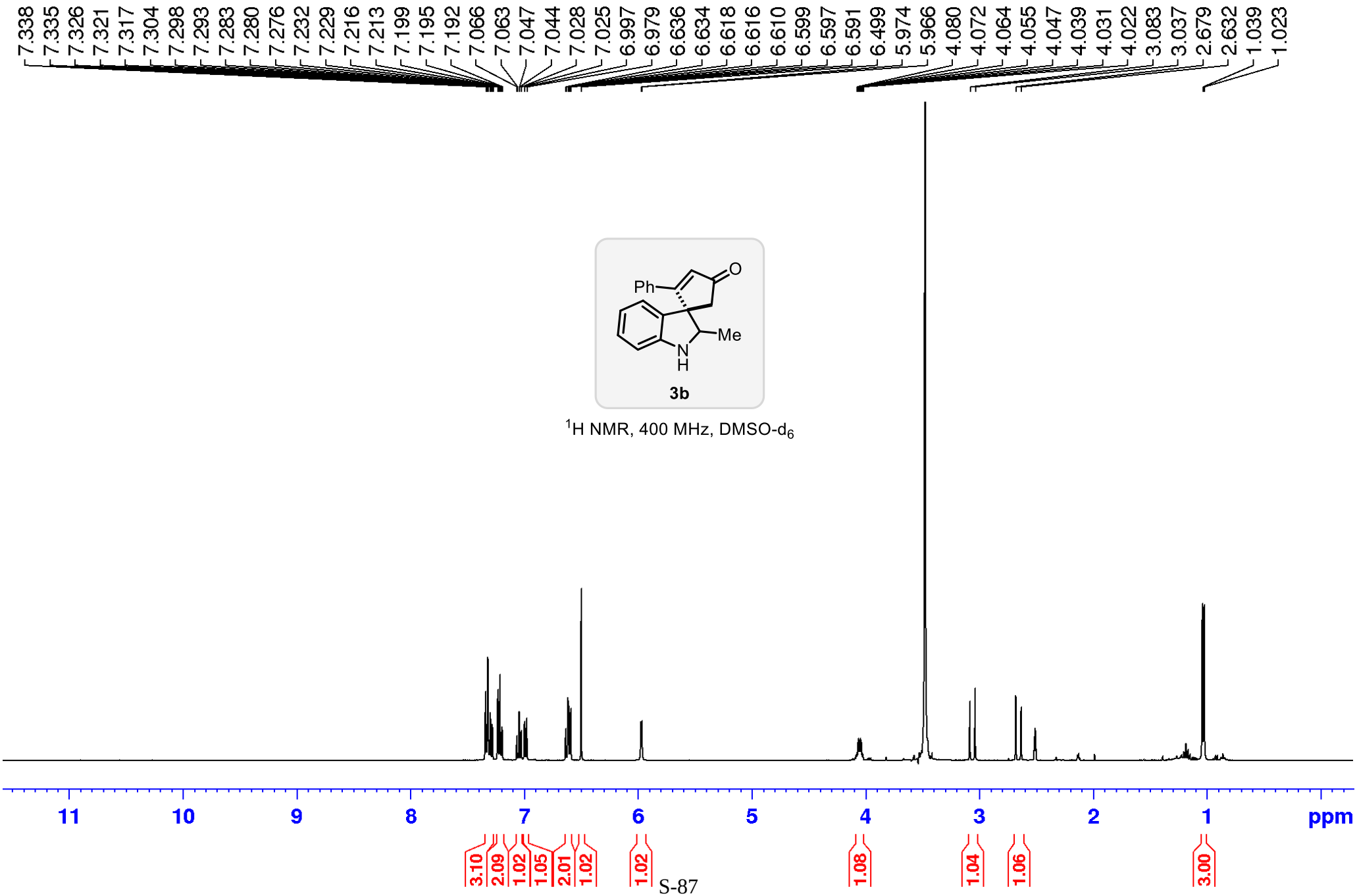
3a

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

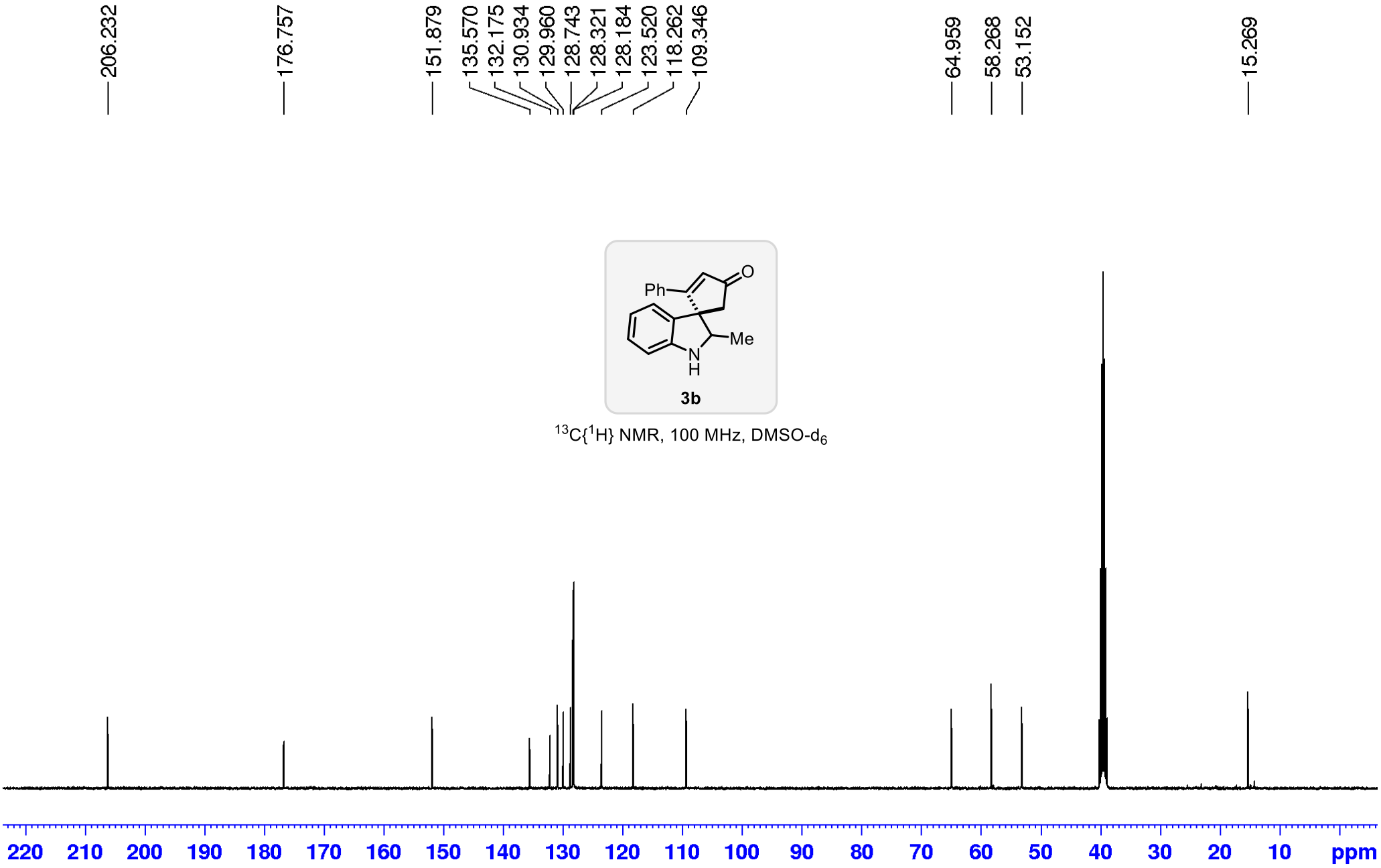




$^{13}C\{^{1}H\}$ NMR, 100 MHz, CD_3OD

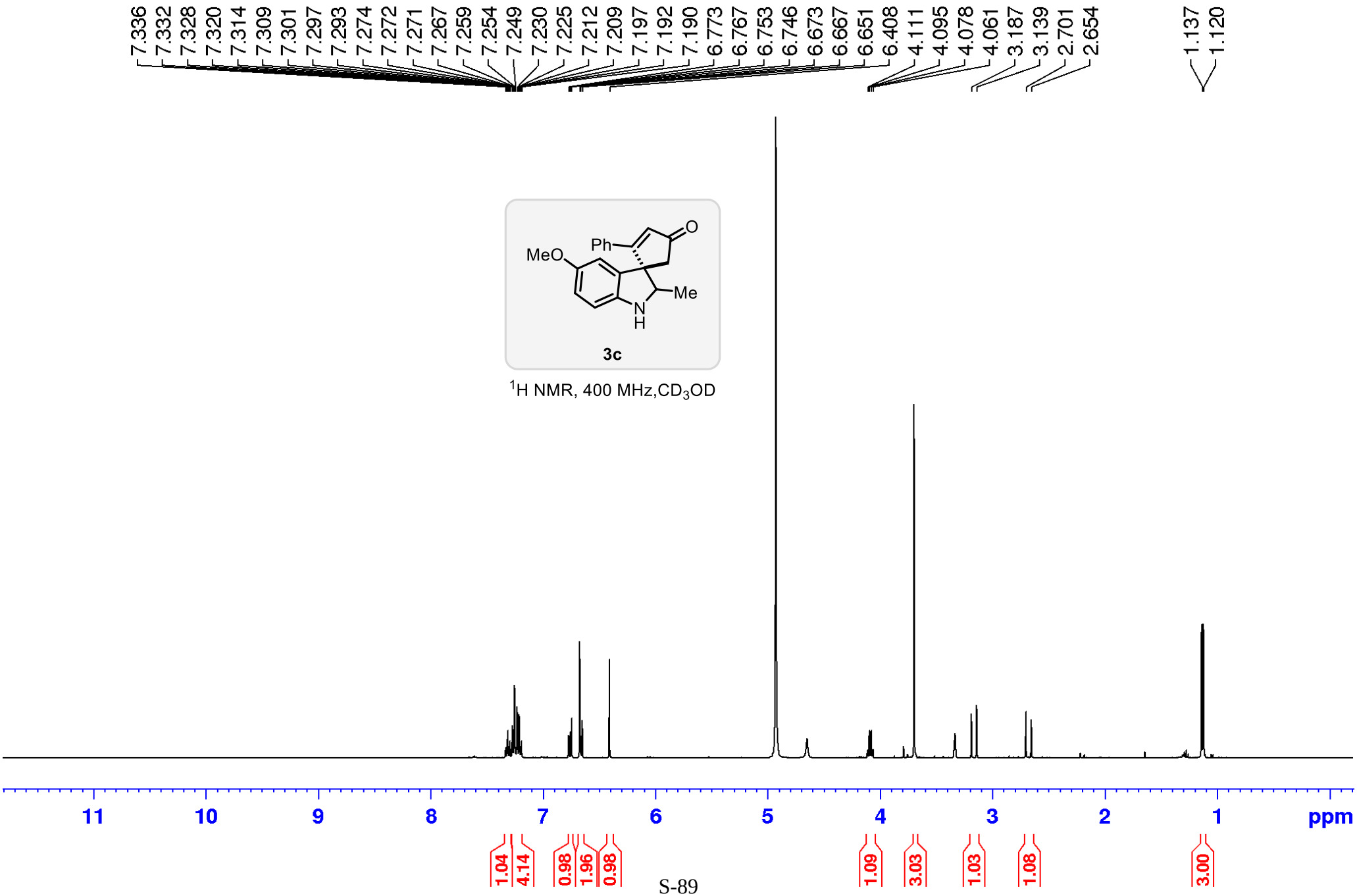


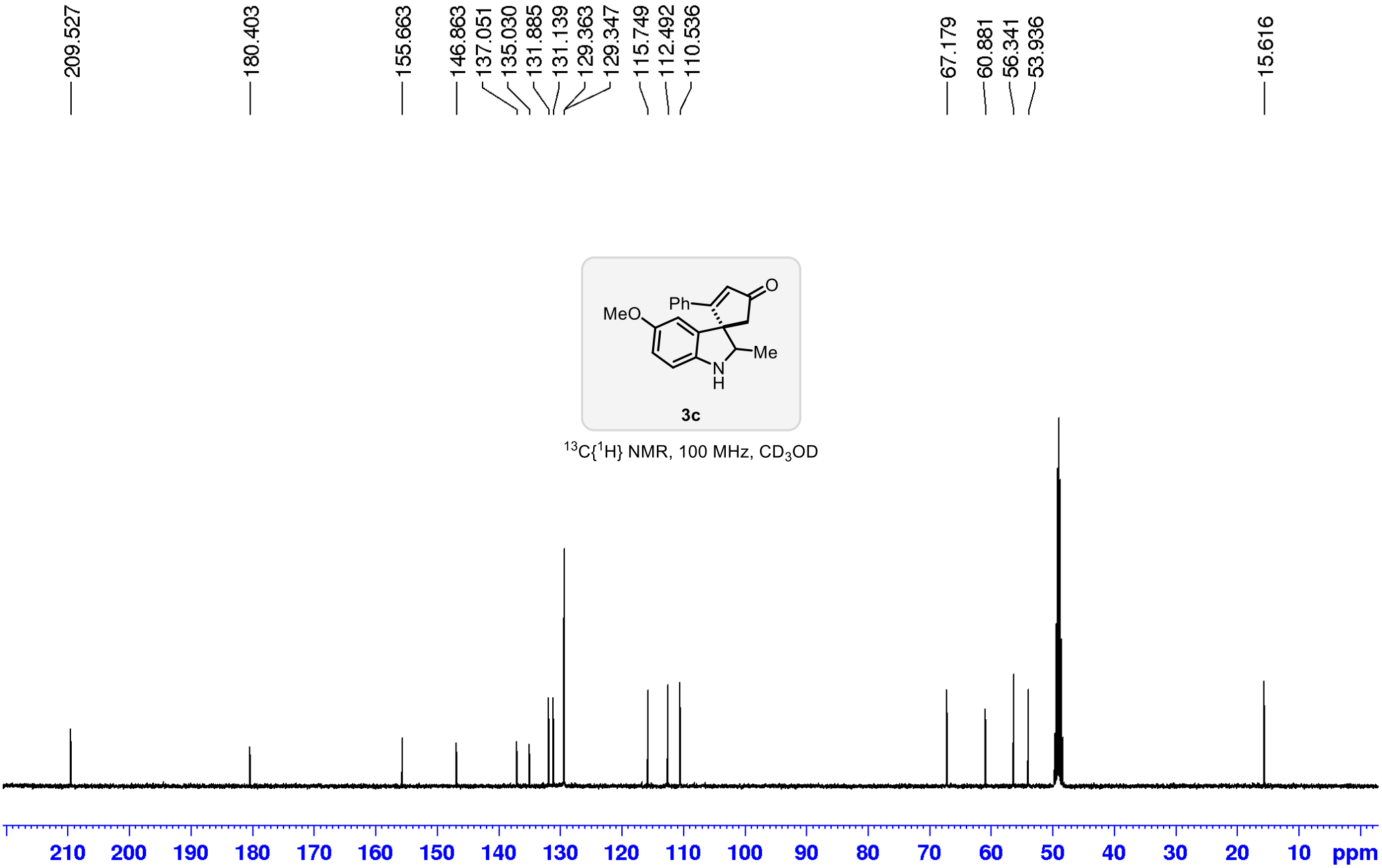
^{1}H NMR, 400 MHz, DMSO-d_6



3b

$^{13}C\{^{1}H\}$ NMR, 100 MHz, DMSO-d_6


7.336
7.332
7.328
7.320
7.314
7.309
7.301
7.297
7.293
7.274
7.272
7.271
7.267
7.259
7.254
7.249
7.230
7.225
7.212
7.209
7.197
7.192
7.190
6.773
6.767
6.753
6.746
6.673
6.667
6.651
6.408
4.111
4.095
4.078
4.061
3.187
3.139
2.701
2.654
1.137
1.120
MeO
Ph
O
Me
N
H
3c
1H NMR, 400 MHz,CD3OD
11
10
9
8
7
6
5
4
3
2
1
ppm
1.04
4.14
0.98
1.96
0.98
1.09
3.03
1.03
1.08
3.00


209.527
180.403
155.663
146.863
137.051
135.030
131.885
131.139
129.363
129.347
115.749
112.492
110.536
67.179
60.881
56.341
53.936
15.616
MeO
Ph
O
Me
N
H
3c
$^{13}C\{^{1}H\}$ NMR, 100 MHz, CD_3OD
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm