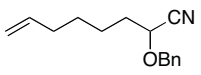
Supporting Information

Stereoselective Synthesis of Spirooxindole Amides through Nitrile Hydrozirconation

Chunliang Lu, Qing Xiao, and Paul E. Floreancig*
Department of Chemistry
University of Pittsburgh
Pittsburgh, Pennsylvania, 15260

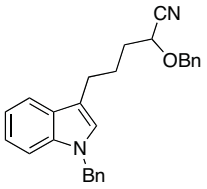
General Experimental:

Proton (^{1}H NMR) and carbon (^{13}C NMR) nuclear magnetic resonance spectra were recorded on a Bruker Avance 300 spectrometer at 300 MHz and 75 MHz, a Bruker Avance 400 spectrometer at 400 MHz and 100 MHz, a Bruker Avance 500 spectrometer at 500 MHz, a Bruker Avance 600 spectrometer at 600 MHz if specified. The chemical shifts are reported in parts per million (ppm) on the delta (δ) scale. The solvent peak was used as a reference value, for ^{1}H NMR: $CDCl_3$ = 7.27 ppm, DMSO = 2.50, for ^{13}C NMR: $CDCl_3$ = 77.23, DMSO = 39.52. Data are reported as follows: (s = singlet; d = doublet; t = triplet; q = quartet; sept = septet; dd = doublet of doublets; ddd = doublet of doublet of doublets; dddd = doublet of doublet of doublet of doublet; td = triplet of doublets; dtd = doublet of triplet of doublets; br = broad). High resolution and low resolution mass spectra were recorded on a VG 7070 spectrometer. Infrared (IR) spectra were collected on a Mattson Cygnus 100 spectrometer. Samples for IR were prepared as a thin film on a NaCl plate by dissolving the compound in CH_2Cl_2 and then evaporating the CH_2Cl_2. Tetrahydrofuran and diethyl ether were distilled from sodium and benzophenone. Methylene chloride was distilled under N_2 from CaH_2. All acid chlorides were freshly distilled prior to use. Analytical TLC was performed on E. Merck pre-coated (25 mm) silica gel 60F-254 plates. Visualization was done under UV (254 nm). Flash chromatography was done using ICN SiliTech 32-63 60 Å silica gel. Reagent grade ethyl acetate, diethyl ether, toluene and hexanes (commercial mixture) were purchased from EM Science and used as is for chromatography. All reactions were performed in oven or flame-dried glassware under argon with magnetic stirring unless otherwise noted. All the reactions that use the Schwartz reagent were performed under argon unless otherwise specified. All products in this manuscript are racemic mixtures but are drawn and named as single enantiomers to indicate their relative stereochemistry.



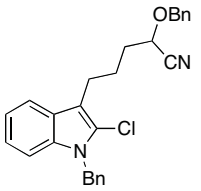
2-(Benzyloxy)oct-7-enenitrile (5)

To a solution of 6-heptenal (**4**) (168 mg, 1.5 mmol) and BnOTMS (649 mg, 3.6 mmol) in CH_2Cl_2 (2.5 mL) under argon was added $BiBr_3$ (34 mg, 0.075 mmol). The suspension was stirred overnight, and then TMSCN (394 mL, 3.1 mmol) and $BiBr_3$ (32 mg, 0.075 mmol) were added. The suspension was stirred for another 4 h then was quenched with saturated $NaHCO_3$. The mixture was extracted with EtOAc (3x), and the combined organic layer was washed with brine. The organic layer was dried over Na_2SO_4, concentrated at reduced pressure, and purified by flash chromatography (5% to 10% EtOAc in hexane) to give **5** as a colorless oil (277 mg, 81%).^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38-7.35 (m, 5H), 5.79 (ddt, 1H, *J* = 6.6, 10.2, 17.1 Hz), 5.02 (d, 1H, *J* = 17.1 Hz), 4.97 (d, 1H, *J* = 9.6 Hz), 4.86 (d, 1H, *J* = 11.7 Hz), 4.53 (d, 1H, *J* = 11.7 Hz), 4.16 (t, 1H, *J* = 6.6 Hz), 2.05 (q, 2H, *J* = 6.6 Hz), 1.91-1.85 (m, 2H), 1.54-1.48 (m, 2H), 1.46-1.37 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 138.4, 136.1, 128.8, 128.6, 128.3, 118.4, 115.0, 72.3, 67.7, 33.5, 33.4, 28.3, 24.3; IR (neat) 3068, 3033, 2930, 2864, 1640, 1456, 1100, 913, 740 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{15}H_{19}NO$ $[M]^+$ 229.1467, found 229.1460.



5-(1-Benzyl-1*H*-indol-3-yl)-2-(benzyloxy)pentanenitrile (6)

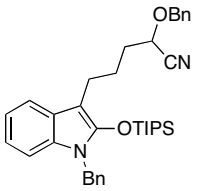
To a solution of **5** (1.90 g, 8.3 mmol) in CH_2Cl_2 (84 mL) was treated with O_3 at −78 °C until the blue color persisted. PPh_3 (8.7 g, 33.1 mmol) was then added and the solution was allowed to warm to rt. After stirring for 1 hour, the solvent was removed under reduced pressure, and the residue was purified by flash chromatography (5% to 40% EtOAc in hexane) to give the aldehyde as colorless oil (1.48 g, 78%). To a solution of the aldehyde (400 mg, 1.73 mmol) in HOAc (9 mL), was added 1-benzyl-1-phenylhydrazine hydrochloride (406 mg, 1.73 mmol). The solution was stirred at 100 °C for 1 h under N_2. The solution was cooled to rt and the solvent was removed under reduced pressure. The residue was diluted with EtOAc and washed with saturated $NaHCO_3$ solution (2x). The organic layer was dried over Na_2SO_4, concentrated under reduced pressure, and purified by flash chromatography (5% to 10% EtOAc in hexane) to give **6** as a slightly red oil (610 mg, 89%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.58 (d, 1H, *J* = 7.5 Hz), 7.37-7.25 (m, 9H), 7.18 (t, 1H, *J* = 7.2 Hz), 7.13-7.08 (m, 3H), 6.89 (s, 1H), 5.28 (s, 2H), 4.83 (d, 1H, *J* = 11.4 Hz), 4.49 (d, 1H, *J* = 11.4 Hz), 4.17 (t, 1H, *J* = 6.0 Hz), 2.80 (t, 2H, *J* = 6.3 Hz), 1.95-1.91 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.8, 136.8, 136.1, 128.9, 128.8, 128.5, 128.4, 128.1, 127.7, 126.9, 125.7, 121.9, 119.1, 118.5, 114.8, 109.8, 72.3, 67.7, 50.0, 33.3, 25.4, 24.5; IR (neat) 3030, 2926, 2866, 1466, 1454, 1331, 1101, 739 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{27}H_{26}N_2O$ $[M]^+$ 394.2045, found 394.2043.



5-(1-Benzyl-2-chloro-1*H*-indol-3-yl)-2-(benzyloxy)pentanenitrile (7)

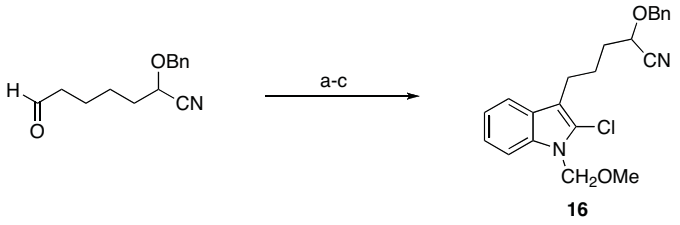
To a solution of **6** (250 mg, 0.63 mmol) in CH_2Cl_2 (5.3 mL) was added NCS (85 mg, 0.63 mmol) at room temperature under argon atmosphere. The solution was stirred for 1 h, and then the solvent was removed under reduced pressure. The residue was purified by flash chromatography (5% to 10% EtOAc in hexane) to give **7** as slightly yellow oil (217 mg, 80%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51 (d, 1H, *J* = 7.5 Hz), 7.37-7.33 (m, 4H), 7.29-7.22 (m, 5H), 7.17 (t, 1H, *J* = 7.5 Hz), 7.12 (t, 1H, *J* = 7.0 Hz), 7.08 (d,

2H, *J* = 7.0 Hz), 5.38 (s, 2H), 4.83 (d, 1H, *J* = 11.5 Hz), 4.49 (d, 1H, *J* = 11.5 Hz), 4.17 (t, 1H, *J* = 5.5 Hz), 2.84 (app s, 2H), 1.95-1.91 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.3, 136.1, 135.6, 128.9, 128.8, 128.6, 128.4, 127.6, 126.9, 126.5, 123.6, 122.3, 120.2, 118.4, 118.4, 111.0, 109.9, 72.4, 67.6, 47.0, 33.0, 25.0, 23.5; IR (neat) 3060, 3031, 2928, 2865, 1456, 1334, 1102, 739, 697 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{27}H_{25}N_2OCl$ $[M]^+$ 428.1655, found 428.1647.



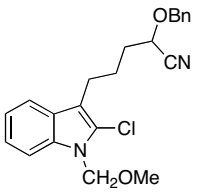
5-(1-Benzyl-2-((triisopropylsilyl)oxy)-1*H*-indol-3-yl)-2-(benzyloxy)pentanenitrile (8)

To a solution of **6** (135 mg, 0.34 mmol) in AcOH/concentrated HCl (16.3 mL, 4:1) was added DMSO (468 μL, 6.8 mmol) dropwise at room temperature. The solution was stirred for 1.5 hours, and then poured into saturated $NaHCO_3$ solution. The mixture was extracted with EtOAc (2x), and the combined organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure, the residue was purified by chromatography (10% to 30% EtOAc in hexane) to give the oxindole as yellow oil (84 mg, 60%). To a solution of the oxindole (838 mg, 2.04 mmol) in CH_2Cl_2 (17 mL) under argon at 0 °C were added Et_3N (566 μL, 4.08 mmol) and TIPSOTf (553 μL, 2.04 mmol). The ice bath was removed and the solution was stirred at rt for 1.5 h. The reaction was quenched with saturated $NaHCO_3$ solution. The aqueous layer was extracted with CH_2Cl_2 (2x), and then the combined organic layer was dried over Na_2SO_4. The mixture was filtered and concentrated, then the resulting residue was purified by flash chromatography (4% to 10% EtOAc in hexane with 0.5% Et_3N) to give **8** as a slightly yellow oil (1.09 g, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, 1H, *J* = 7.2 Hz), 7.38-7.32 (m, 5H), 7.24 (app d, 2H, *J* = 7.6 Hz), 7.20 (d, 1H, *J* = 7.2 Hz), 7.06-6.98 (m, 5H), 5.22 (s, 2H), 4.80 (d, 1H, *J* = 11.6 Hz), 4.46 (d, 1H, *J* = 11.6 Hz), 4.15 (t, 1H, *J* = 6.0 Hz), 2.73 (t, 2H, *J* = 7.0 Hz), 1.99-1.85 (m, 4H), 1.27 (septet, 3H, *J* = 7.6 Hz), 1.08 (d, 18H, *J* = 7.2 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.2, 137.8, 136.1, 131.6, 128.6, 128.6, 128.2, 127.4, 127.1, 126.3, 119.7, 119.4, 118.4, 117.5, 109.2, 93.1, 72.2, 67.8, 45.1, 33.5, 25.5, 23.2, 17.9, 13.8; IR (neat) 3061, 3031, 2946, 2867, 1620, 1578, 1469, 1414, 1339, 1008, 769, 737 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{47}N_2O_2Si$ $[M+H]^+$ 567.3407, found 567.3363.



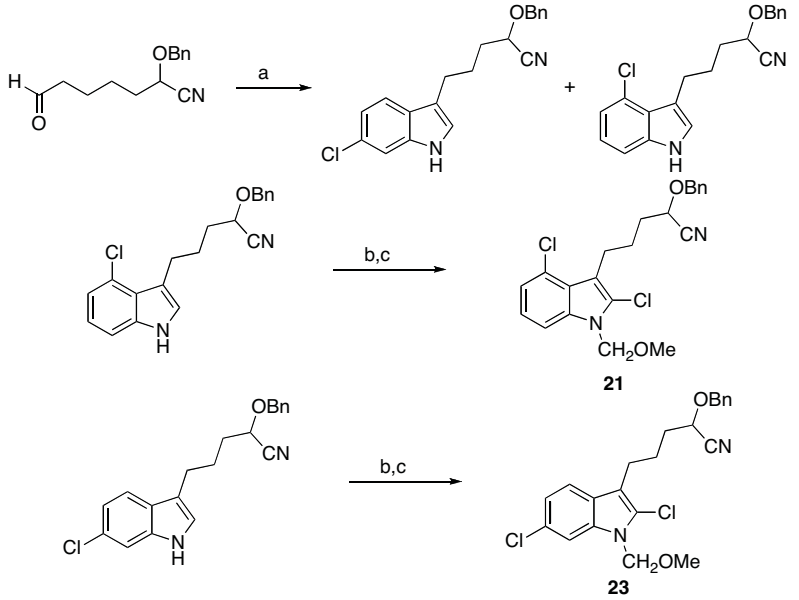
Reagents and conditions
a) $PhNHNH_2$, HOAc, 105 °C, 61%. b) NCS, CCl_4. c) NaH, THF, then MOMCl, 63% (two steps).

Scheme 1. Synthesis of *N*-methoxymethyl indole substrate.



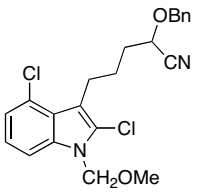
2-(Benzyloxy)-5-(2-chloro-1-(methoxymethyl)-1*H*-indol-3-yl)pentanenitrile (16)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.49 (d, 1H, J = 8.0 Hz), 7.43 (d, 1H, J = 8.0 Hz), 7.36-7.35 (m, 4H), 7.24 (d, 1H, J = 7.2 Hz), 7.17 (t, 1H, J = 7.2 Hz), 5.52 (s, 2H), 4.83 (d, 1H, J = 11.4 Hz), 4.50 (d, 1H, J = 11.4 Hz), 4.17 (t, 1H, J = 6.0 Hz), 3.29 (s, 3H), 2.80 (t, 2H, J = 6.0 Hz), 1.92-1.88 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 136.0, 135.9, 128.7, 128.5, 128.3, 127.1, 123.3, 122.7, 120.8, 118.4, 118.3, 112.0, 109.9, 73.9, 72.3, 67.5, 56.1, 32.9, 24.8, 23.3; IR (neat) 3032, 2935, 2360, 2340, 1455, 1322, 1099, 742, 698 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{22}H_{23}N_2O_2Cl$ $[M]^+$ 382.1448, found 382.1449.



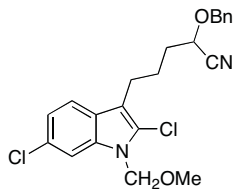
Reagents and conditions
a) *m*-ClPhNHNH$_2$•HCl, HOAc, reflux, 45%, 5:4 mixture of products. b) NCS, CCl_4. c) NaH, THF, then MOMCl, 43% for **21**, 47% for **23** (two steps).

Scheme 2. Preparation of chloroindole substrates.



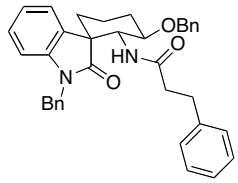
2-(Benzyloxy)-5-(2,6-dichloro-1-(methoxymethyl)-1H-indol-3-yl)pentanenitrile (21)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.43 (d, 1H, J = 1.5 Hz), 7.40-7.35 (m, 6H), 7.13 (dd, 1H, J = 1.5, 8.4 Hz), 5.47 (s, 2H), 4.83 (d, 1H, J = 11.7 Hz), 4.50 (d, 1H, J = 11.4 Hz), 4.16 (t, 1H, J = 5.7 Hz), 3.29 (s, 3H), 2.77 (t, 2H, J = 6.3 Hz), 1.89-1.88 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 136.2, 136.0, 128.8, 128.6, 128.4, 125.7, 123.9, 121.6, 119.4, 118.3, 112.2, 110.2, 74.1, 72.4, 67.5, 56.2, 33.0, 24.8, 23.4; IR (neat) 3064, 3032, 2935, 2868, 1465, 1394, 1334, 1099, 913, 807, 741 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{22}H_{22}N_2O_2Cl_2Na$ $[M+Na]^+$ 439.0956, found 439.0959.



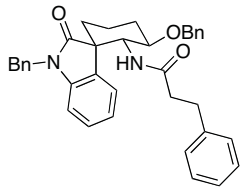
2-(Benzyloxy)-5-(2,4-dichloro-1-(methoxymethyl)-1H-indol-3-yl)pentanenitrile (23)

^{1}H NMR (300 MHz, $CDCl_3$) δ 7.38-7.32 (m, 6H), 7.14 (app d, 1H, *J* = 1.5 Hz), 7.13 (app s, 1H), 5.51 (s, 2H), 4.84 (d, 1H, *J* = 11.7 Hz), 4.52 (d, 1H, *J* = 11.4 Hz), 4.20 (t, 1H, *J* = 6.3 Hz), 3.29 (s, 3H), 3.02 (t, 2H, *J* = 6.9 Hz), 2.03-1.87 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 137.2, 136.1, 128.7, 128.4, 128.3, 125.6, 125.0, 123.9, 123.1, 122.0, 118.4, 112.4, 108.7, 74.2, 72.3, 67.7, 56.1, 32.9, 26.5, 24.0; IR (neat) 3062, 3031, 2939, 2867, 1457, 1430, 1323, 1187, 1102, 914, 739 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{22}H_{23}N_2O_2Cl_2$ $[M]^+$ 416.1058, found 416.1054.

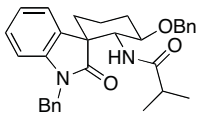


***N*-((1*S*,2*R*,3*R*)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (11)**

To a solution of **7** (98 mg, 0.23 mmol) in CH_2Cl_2 (2.3 mL) was added $Cp_2Zr(H)Cl$ (74 mg, 0.29 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (43 μL, 0.29 mmol) was added and the mixture was stirred overnight. The mixture was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (103 mg, 83%, 7.3:1). The faster eluting product **11** was the major diastereomer and was isolated as a white solid **(**mp 138.7 °C-140.8 °C**)**: ^{1}H NMR (300 MHz, $CDCl_3$) 7.39 (d, 1H, *J* = 7.5 Hz), 7.32-7.06 (m, 15H), 6.90 (d, 2H, *J* = 7.8 Hz), 6.70 (d, 1H, *J* = 7.2 Hz), 4.92 (d, 1H, *J* = 15.6 Hz), 4.86 (d, 1H, *J* = 9.9 Hz), 4.79 (d, 1H, *J* = 15.6 Hz), 4.67 (d, 1H, *J* = 12.0 Hz), 4.62 (t, 1H, *J* = 9.9 Hz), 4.45 (d, 1H, *J* = 12.0 Hz), 4.24 (dt, 1H, *J* = 4.5, 10.8 Hz), 2.58-2.37 (m, 3H), 2.19 (qt, 1H, *J* = 3.9, 13.2 Hz), 2.07-1.97 (m, 1H), 1.91-1.78 (m, 2H), 1.74-1.53 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.7, 171.9, 142.0, 141.1, 139.2, 136.3, 131.8, 129.0, 128.5, 128.5, 128.2, 127.9, 127.7, 127.4, 126.1, 123.9, 123.3, 108.6, 76.3, 90.9, 55.4, 54.4, 43.6, 38.1, 35.2, 31.3, 31.0, 19.0; IR (neat) 3323, 3060, 3029, 2931, 2864, 1699, 1655, 1611, 1543, 1492, 1366, 1027, 1100, 1028, 741 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{36}N_2O_3Na$ $[M+Na]^+$ 567.2624, found 567.2648.

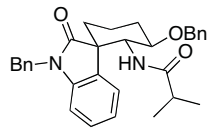


The slower eluting product was repurified by preparative TLC (10% EtOAc in CH_2Cl_2) to give minor diastereomer **12** as a white solid (mp 171.2 °C-175.0 °C):. ^{1}H NMR (400 MHz, DMSO) δ 7.60 (d, 1H, *J* = 7.2 Hz), 7.29-7.19 (m, 13H), 7.14-7.11 (m, 1H), 7.08-7.03 (m, 3H), 6.88 (d, 1H, *J* = 9.6 Hz), 6.86 (d, 1H, *J* = 7.6 Hz), 4.97 (d, 1H, *J* = 15.6 Hz), 4.68 (d, 1H, *J* = 15.6 Hz), 4.62 (d, 1H, *J* = 11.6 Hz), 4.47 (t, 1H, *J* = 10.4 Hz), 4.45 (d, 1H, *J* = 11.6 Hz), 3.84 (dt, 1H, *J* = 4.4, 10.8 Hz), 2.55 (t, 2H, *J* = 8.4 Hz), 2.36 (app d, 1H, *J* = 9.6 Hz), 2.21-2.13 (m, 1H), 2.06-1.98 (m, 1H), 1.94-1.85 (m, 2H), 1.81-1.77 (m, 1H), 1.50-1.42 (m, 2H); ^{13}C NMR (75 MHz, DMSO) δ 177.2, 171.2, 142.9, 141.4, 139.3, 136.6, 130.0, 128.4, 128.2, 128.0, 127.9, 127.2, 125.9, 125.7, 121.9, 108.9, 77.4, 70.6, 54.8, 54.0, 42.6, 36.9, 33.7, 31.1, 30.9, 19.7; IR (neat) 3272, 3061, 3028, 2925, 2854, 1712, 1650, 1609, 1546, 1464, 1363 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{36}N_2O_3Na$ $[M+Na]^+$ 567.2624, found 567.2604.

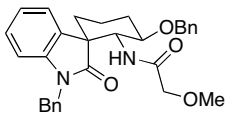


***N*-((1*S*,2*R*,3*R*)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)isobutyramide (13)**

To a solution of **7** (104 mg, 0.24 mmol) in CH_2Cl_2 (2.4 mL) was added $Cp_2Zr(H)Cl$ (78 mg, 0.30 mmol). The reaction mixture was stirred for 15 min. Isobutyryl chloride (31 μL, 0.30 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (100 mg, 87%, 3.6:1). The faster eluting product was the major diatereomer **13** and was isolated as a pale yellow oil: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, 1H, *J* = 7.5 Hz), 7.30-7.27 (m, 10H), 7.13 (t, 1H, *J* = 7.5 Hz), 7.05 (t, 1H, *J* = 7.5 Hz), 6.70 (d, 1H, *J* = 7.5 Hz), 4.98 (d, 1H, *J* = 15.5 Hz), 4.83 (d, 1H, *J* = 9.5 Hz), 4.78 (d, 1H, *J* = 15.5 Hz), 4.70 (d, 1H, *J* = 12.0 Hz), 4.60 (t, 1H, *J* = 10.0 Hz), 4.49 (t, 1H, *J* = 12.0 Hz), 4.28 (dt, 1H, *J* = 4.0, 10.5 Hz), 2.40 (d, 1H, *J* = 11.5 Hz), 2.23 (app q, 1H, *J* = 13.5 Hz), 1.90 (t, 1H, *J* = 13.5 Hz), 1.81 (app d, 1H, *J* = 13.5 Hz), 1.74-1.70 (m, 2H), 1.63-1.57 (m, 1H), 0.78 (d, 3H, *J* = 6.5 Hz), 0.42 (d, 3H, *J* = 6.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 178.8, 176.5, 142.0, 139.2, 136.4, 131.6, 129.0, 128.4, 128.0, 127.7, 127.6, 127.5, 124.0, 123.3, 108.4, 76.2, 71.0, 55.0, 54.6, 43.7, 35.9, 34.9, 31.2, 19.6, 19.1, 18.9; IR (neat) 3337, 3060, 3030, 2867, 1694, 1611, 1491, 1466, 1365, 1208, 1173, 1098, 740, 698 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{31}H_{34}N_2O_3$ $[M]^+$ 482.2569, found 482.2569.



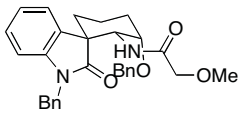
The slower eluting product was minor diastereomer **25** and was isolated as a white solid (mp 158.1 °C-161.2 °C): ^{1}H NMR (300 MHz, DMSO) δ 7.59 (d, 1H, *J* = 7.5 Hz), 7.27-7.22 (m, 11H), 7.07 (t, 1H, *J* = 7.2 Hz), 6.84 (t, 1H, *J* = 7.5 Hz), 6.70 (d, 1H, *J* = 9.6 Hz), 4.86 (d, 1H, *J* = 15.9 Hz), 4.78 (d, 1H, *J* = 15.9 Hz), 4.62 (d, 1H, *J* = 11.4 Hz), 4.47 (d, 1H, *J* = 11.4 Hz), 4.40 (t, 1H, *J* = 10.2 Hz), 3.86 (dt, 1H, *J* = 4.5, 10.5 Hz), 2.37 (app d, 1H, *J* = 14.1 Hz), 2.12 (quintet, 1H, *J* = 6.9 Hz), 1.90-1.76 (m, 3H), 1.47-1.41 (m, 2H), 0.74 (d, 3H, *J* = 6.6 Hz), 0.70 (d, 3H, *J* = 6.9 Hz); ^{13}C NMR (75 MHz, DMSO) δ 177.2, 175.6, 143.0, 139.2, 136.4, 130.0, 128.5, 127.9, 127.2, 127.0, 126.9, 125.9, 121.8, 108.8, 77.1, 70.5, 54.4, 54.1, 42.7, 33.8, 33.5, 31.0, 19.8, 19.6, 18.9; IR (neat) 3345, 3060, 3032, 2934, 2870, 1712, 1678, 1609, 1489, 1463, 1364, 1209, 1105, 743, 697 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{31}H_{34}N_2O_3$ $[M]^+$ 482.2569, found 482.2579.



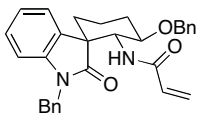
***N*-((1*S*,2*R*,3*R*)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-2-methoxyacetamide (14)**

To a solution of **7** (118 mg, 0.28 mmol) in CH_2Cl_2 (2.8 mL) was added $Cp_2Zr(H)Cl$ (89 mg, 0.34 mmol). The reaction mixture was stirred for 15 min. Methoxyacetyl chloride (31 μL, 0.34 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (61 mg, 46%, 9.1:1). The faster eluting product was major diastereomer **14** and was isolated as a white solid (mp 121.0 °C-123.8 °C): ^{1}H NMR (400 MHz, $CDCl_3$) 7.38 (d, 1H, *J* = 7.2 Hz), 7.34-7.25 (m, 10H), 7.11 (t, 1H, *J* = 7.6 Hz), 7.05 (d, 1H, *J* = 7.2

Hz), 6.61 (d, 1H, *J* = 7.2 Hz), 6.22 (d, 1H, *J* = 10.4 Hz), 4.99 (d, 1H, *J* = 15.6 Hz), 4.83 (d, 1H, *J* = 15.6 Hz), 4.72 (d, 1H, *J* = 11.6 Hz), 4.64 (t, 1H, *J* = 10.4 Hz), 4.52 (d, 1H, *J* = 11.6 Hz), 4.31 (dt, 1H, *J* = 4.4, 10.8 Hz), 3.61 (d, 1H, *J* = 15.2 Hz), 3.49 (d, 1H, *J* = 15.2 Hz), 3.07 (s, 3H), 2.42 (d, 1H, *J* = 12.8 Hz), 2.23 (qt, 1H, *J* = 3.6, 13.6 Hz), 1.91 (app dt, 1H, *J* = 4.0, 14.0 Hz), 1.84-1.80 (m, 1H), 1.71 (app dquint, 1H, *J* = 3.2, 13.6 Hz), 1.60-1.54 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 178.3, 169.5, 141.9, 139.0, 135.8, 131.6, 128.8, 128.2, 128.0, 127.6, 127.3, 127.2, 127.1, 123.5, 123.1, 108.6, 71.6, 71.2, 58.8, 54.8, 54.2, 43.6, 35.5, 30.9, 18.8; IR (neat) 3063, 3032, 2931, 1695, 1613, 1519, 1366, 1204, 1110, 1027, 741 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{32}N_2O_4Na$ $[M+Na]^+$ 507.2260, found 507.2279.

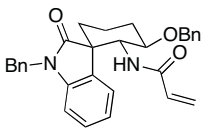


The slower eluting *syn*-diastereomer was repurified by preparative TLC (10% EtOAc in CH_2Cl_2): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, 1H, *J* = 7.2 Hz), 7.33-7.24 (m, 10H), 7.16 (t, 1H, *J* = 8.0 Hz), 7.07 (d, 1H, *J* = 10.4 Hz), 6.97 (t, 1H, *J* = 7.6 Hz), 6.70 (d, 1H, *J* = 7.6 Hz), 5.01 (d, 1H, *J* = 15.6 Hz), 4.80 (d, 1H, *J* = 15.6 Hz), 4.60 (dd, 1H, *J* = 4.0, 10.0 Hz), 4.57 (d, 1H, *J* = 12.0 Hz), 4.44 (d, 1H, *J* = 12.0 Hz), 4.05 (quintet, 1H, *J* = 4.0 Hz), 3.89 (d, 1H, *J* = 14.8 Hz), 3.82 (d, 1H, *J* = 14.8 Hz), 2.18-2.12 (m, 1H), 2.10-2.03 (m, 1H), 1.99-1.95 (m, 1H), 1.91-1.81 (m, 2H), 1.66-1.63 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 169.9, 142.6, 138.4, 136.1, 132.3, 129.0, 128.5, 128.1, 127.8, 127.7, 127.4, 124.9, 122.1, 109.5, 73.6, 72.2, 70.5, 59.5, 51.3, 49.4, 44.1, 29.9, 27.3, 19.0; IR (neat) 3061, 2938, 1711, 1681, 1610, 1465, 1360, 1110, 1026, 918 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{32}N_2O_4Na$ $[M+Na]^+$ 507.2260, found 507.2239.

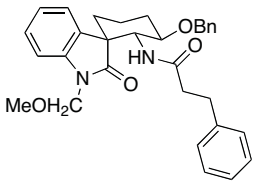


_N_-((1_S_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)acrylamide (15)

To a solution of **7** (109 mg, 0.25 mmol) in CH_2Cl_2 (2.5 mL) was added $Cp_2Zr(H)Cl$ (82 mg, 0.32 mmol). The reaction mixture was stirred for 15 min. Acryloyl chloride (26 μL, 0.32 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (62 mg, 53%, 20:1). The faster eluting product was major diastereomer **15** and was isolated as a white solid (mp 157.0 °C-161.2 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, 1H, *J* = 7.6 Hz), 7.32-7.21 (m, 10H), 7.13 (dt, 1H, *J* = 3.6, 7.6 Hz), 7.07 (dt, 1H, *J* = 3.6, 7.6 Hz), 6.67 (d, 1H, *J* = 7.6 Hz), 5.95 (dd, 1H, *J* = 3.6, 16.8 Hz), 5.60 (dd, 1H, *J* = 10.4, 17.2 Hz), 5.43 (dd, 1H, *J* = 3.6, 7.6 Hz), 4.99-4.95 (m, 2H), 4.80 (d, 1H, *J* = 15.6 Hz), 4.69 (d, 1H, *J* = 12.0 Hz), 4.67 (t, 1H, *J* = 10.0 Hz), 4.47 (d, 1H, *J* = 12.0 Hz), 4.25 (dt, 1H, *J* = 4.8, 10.4 Hz), 2.41 (app d, 1H, *J* = 3.2, 12.8 Hz), 2.18 (qt, 1H, *J* = 4.0, 13.6 Hz), 1.90 (dt, 1H, *J* = 4.0, 14.0 Hz), 1.81 (app d, 1H, *J* = 12.8 Hz), 1.72 (app dt, 1H, *J* = 3.2, 13.6 Hz), 1.65-1.55 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.7, 165.4, 142.0, 139.1, 136.2, 131.8, 130.8, 129.1, 128.5, 128.2, 127.9, 127.8, 127.2, 126.4, 123.8, 123.5, 108.7, 76.6, 91.0, 55.4, 54.4, 43.5, 35.4, 30.9, 19.1; IR (neat) 3289, 3060, 3031, 2930, 2863, 1701, 1611, 1540, 1492, 1365, 1206, 986, 739 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{30}N_2O_3Na$ $[M+Na]^+$ 489.2154, found 489.2176.

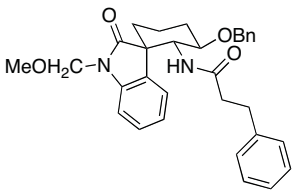


The slower eluting product was repurified by preparative TLC (10 % EtOAc in CH_2Cl_2) to give minor diastereomer **27** as a white solid (mp 222.6 °C-226.9 °C): ^{1}H NMR (400 MHz, DMSO) δ 7.63 (d, 1H, *J* = 7.6 Hz), 7.32-7.17 (m, 12H), 7.07 (d, 1H, *J* = 7.2 Hz), 6.78 (d, 1H, *J* = 8.0 Hz), 6.14 (dd, 1H, *J* = 9.6, 16.8 Hz), 6.01 (dd, 1H, *J* = 2.0, 16.8 Hz), 5.52 (dd, 1H, *J* = 2.4, 10.0 Hz), 5.08 (d, 1H, *J* = 16.0 Hz), 4.63-4.55 (m, 3H), 4.46 (d, 1H, *J* = 11.6 Hz), 3.90 (dt, 1H, *J* = 4.0, 10.8 Hz), 2.38 (app d, 1H, *J* = 11.6 Hz), 1.92-1.78 (m, 3H), 1.52-1.43 (m, 2H); ^{13}C NMR (100 MHz, DMSO) δ 177.1, 164.6, 142.8, 139.2, 136.2, 132.0, 129.9, 128.5, 128.0, 128.0, 127.2, 127.1, 126.8, 126.0, 125.0, 121.9, 109.0, 77.3, 70.7, 55.0, 54.0, 42.5, 33.8, 31.1, 30.7, 19.7; IR (neat) 3245, 3061, 2934, 2856, 1709, 1658, 1610, 1551, 1465, 1361, 734 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{30}N_2O_3Na$ $[M+Na]^+$ 489.2154, found 489.2141.

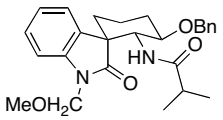


_N_-((1_S_,2_R_,3_R_)-3-(Benzyloxy)-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (17)

To a solution of **16** (83 mg, 0.26 mmol) in CH_2Cl_2 (2.6 mL) was added $Cp_2Zr(H)Cl$ (81 mg, 0.31 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (46 μL, 0.31 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (83 mg, 64%, 15:1). The faster eluting product was major diastereomer **17** and was isolated as a white solid (mp 163.0 °C-164.8 °C): ^{1}H NMR (300 MHz, $CDCl_3$) 7.41 (d, 1H, *J* = 7.2 Hz), 7.31-7.23 (m, 6H), 7.20-7.12 (m, 4H), 6.95-6.91 (m, 3H), 5.09 (d, 1H, *J* = 10.5 Hz), 5.04 (d, 1H, *J* = 10.5 Hz), 4.94 (d, 1H, *J* = 9.6 Hz), 4.67 (d, 1H, *J* = 12.0 Hz), 4.62 (t, 1H, *J* = 9.9 Hz), 4.44 (d, 1H, *J* = 12.0 Hz), 4.19 (dt, 1H, *J* = 4.5, 10.2 Hz), 3.27 (s, 3H), 2.55 (app dt, 1H, *J* = 3.0, 9.5 Hz), 2.38 (app d, 1H, *J* = 17.4 Hz), 2.19-2.08 (m, 1H), 2.06-1.93 (m, 2H), 1.87 (dd, 1H, *J* = 3.6, 12.9 Hz), 1.80-1.75 (m, 1H), 1.72-1.55 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.4, 172.0, 141.1, 139.1, 131.3, 128.6, 128.5, 128.3, 128.2, 127.7, 127.6, 124.0, 123.8, 109.0, 76.4, 71.2, 71.0, 56.3, 55.2, 55.0, 38.4, 35.7, 31.5, 30.9, 19.0; IR (neat) 3251, 3058, 2932, 2865, 1709, 1645, 1551,1492, 1362, 1088, 743 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{34}N_2O_4Na$ $[M+Na]^+$ 521.2416, found 521.2448.

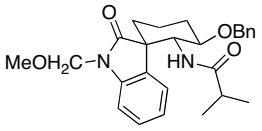


The slower eluting product was isolated as a white solid (mp 193.1 °C-196.8 °C): ^{1}H NMR (300 MHz, DMSO) δ 7.62 (d, 1H, *J* = 7.5 Hz), 7.35 (d, 1H, *J* = 7.2 Hz), 7.27-7.07 (m, 10H), 7.02 (app d, 1H, *J* = 6.9 Hz), 6.92 (d, 1H, *J* = 9.9 Hz), 4.99 (s, 2H), 4.62 (d, 1H, *J* = 11.7 Hz), 4.45 (d, 1H, *J* = 11.7 Hz), 4.40 (t, 1H, *J* = 10.2 Hz), 3.83 (dt, 1H, *J* = 3.9, 10.5 Hz), 3.10 (s, 3H), 2.36 (app d, 1H, *J* = 12.3 Hz), 2.11-1.99 (m, 2H), 1.87-1.75 (m, 4H), 1.47-1.40 (m, 2H); ^{13}C NMR (75 MHz, DMSO) δ 177.7, 171.2, 142.2, 141.4, 139.3, 129.6, 128.1, 128.0, 127.9, 127.2, 125.9, 125.7, 122.3, 109.3, 77.2, 70.7, 70.6, 55.3, 54.8, 54.3, 36.9, 33.7, 31.1, 31.0, 19.6; IR (neat) 3260, 3061, 3025, 2935, 2855, 1723, 1648, 1549, 1465, 1357, 1082, 741 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{34}N_2O_4Na$ $[M+Na]^+$ 521.2416, found 521.2440.

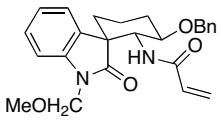


_N_-((1_S_,2_R_,3_R_)-3-(Benzyloxy)-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)isobutyramide (18)

To a solution of **16** (99 mg, 0.26 mmol) in CH_2Cl_2 (2.6 mL) was added $Cp_2Zr(H)Cl$ (84 mg, 0.32 mmol). The reaction mixture was stirred for 15 min. Isobutyryl chloride (34 μL, 0.32 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give the product as two diastereomers (59 mg, 51%, 11.8:1). The faster eluting isomer was major product **18**: ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38 (d, 1H, J = 7.5 Hz), 7.37-7.30 (m, 5H), 7.22 (t, 1H, J = 8.0 Hz), 7.12 (t, 1H, J = 7.5 Hz), 6.92 (d, 1H, J = 7.5 Hz), 5.12 (d, 1H, J = 10.5 Hz), 5.09 (d, 1H, J = 11.0 Hz), 4.90 (d, 1H, J = 10.0 Hz), 4.69 (d, 1H, J = 11.5 Hz), 4.60 (t, 1H, J = 10.0 Hz), 4.48 (d, 1H, J = 12.0 Hz), 4.22 (dt, 1H, J = 4.5, 10.5 Hz), 3.34 (s, 3H), 2.39 (d, 1H, J = 9.5 Hz), 2.15 (q, 1H, J = 13.5 Hz), 1.93-1.86 (m, 2H), 1.79 (app d, 1H, J = 14.0 Hz), 1.70 (app d, 1H, J = 14.0 Hz), 1.63-1.60 (m, 1H), 0.84 (d, 3H, J = 6.5 Hz), 0.60 (d, 3H, J = 6.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.6, 176.7, 141.3, 139.2, 131.2, 128.6, 128.5, 127.7, 127.6, 124.2, 123.8, 108.9, 76.3, 71.4, 71.1, 56.6, 55.2, 54.9, 36.0, 35.3, 31.1, 19.9, 19.1, 19.0; IR (neat) 3333, 3059, 2931, 2869, 1710, 1667, 1523, 1490, 1467, 1361, 1089, 744 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{26}H_{32}N_2O_4$ $[M]^+$ 436.2362, found 436.2366.



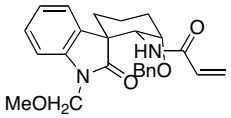
Slower eluting minor product: ^{1}H NMR (500 MHz, DMSO) δ 7.60 (d, 1H, J = 7.5 Hz), 7.34 (t, 1H, J = 7.5 Hz), 7.29-7.22 (m, 5H), 7.13 (t, 1H, J = 7.5 Hz), 7.07 (d, 1H, J = 8.0 Hz), 6.68 (d, 1H, J = 10.0 Hz), 4.99 (s, 2H), 4.60 (d, 1H, J = 11.5 Hz), 4.46 (d, 1H, J = 11.5 Hz), 4.33 (t, 1H, J = 10.0 Hz), 3.83 (dt, 1H, J = 5.0, 11.5 Hz), 3.14 (s, 3H), 2.35 (app d, 1H, J = 6.0 Hz), 2.09 (quintet, 1H, J = 6.5 Hz), 1.87-1.81 (m, 2H), 1.74 (m, 1H), 1.45-1.41 (m, 2H), 0.74 (d, 3H, J = 6.5 Hz), 0.67 (d, 3H, J = 7.0 Hz); ^{13}C NMR (75 MHz, DMSO) δ 177.8, 175.6, 142.3, 139.2, 129.6, 128.0, 127.9, 127.2, 127.1, 125.9, 122.3, 109.1, 77.0, 70.7, 70.5, 55.6, 54.5, 54.3, 33.6, 33.5, 31.0, 19.7, 19.6, 18.9; IR (neat) 3322, 3060, 2936, 2871, 1723, 1659, 1527, 1465, 1358, 1241, 1095, 915, 742, 698 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{26}H_{32}N_2O_4$ $[M]^+$ 436.2362, found 436.2360.



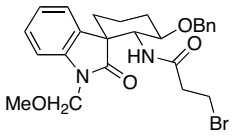
_N_-((1_S_,2_R_,3_R_)-3-(Benzyloxy)-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)acrylamide (19)

To a solution of **16** (98 mg, 0.26 mmol) in CH_2Cl_2 (2.6 mL) was added $Cp_2Zr(H)Cl$ (79 mg, 0.31 mmol). The reaction mixture was stirred for 15 min at room temperature. Acryloyl chloride (26 μL, 0.32 mmol) was added and the mixture was stirred for 30 min. $Sc(OTf)_3$ (13 mg, 0.026 mmol) was added and the solution was stirred for another 1.5 hours. The reaction was quenched with saturated $NaHCO_3$ solution. The mixture was extracted with EtOAc (3x), and the combined organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure, the residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give product as two diastereomers (49 mg, 46%, 8.2:1). The faster eluting product was major diastereomer **19** and was isolated as a white solid (mp 126.5 °C-128.8 °C): ^{1}H NMR (300 MHz, $CDCl_3$) 7.41 (d, 1H, J = 7.2 Hz), 7.31-7.20 (m, 6H),

7.12 (t, 1H, *J* = 7.2 Hz), 6.93 (d, 1H, *J* = 7.8 Hz), 6.01 (d, 1H, *J* = 16.8 Hz), 5.70 (dd, 1H, *J* = 10.5, 17.1 Hz), 5.45 (d, 1H, *J* = 10.2 Hz), 5.10 (app s, 2H), 5.04 (d, 1H, *J* = 9.9 Hz), 4.69 (d, 1H, *J* = 12.0 Hz), 4.67 (t, 1H, *J* = 10.0 Hz), 4.47 (d, 1H, *J* = 12.0 Hz), 4.22 (dt, 1H, *J* = 4.8, 10.8 Hz), 3.30 (s, 3H), 2.40 (app d, 1H, *J* = 12.3 Hz), 2.11 (dt, 1H, *J* = 3.6, 13.2 Hz), 1.89 (dt, 1H, *J* = 3.6, 13.8 Hz), 1.81-1.52 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.4, 165.5, 141.0, 139.0, 131.0, 130.8, 128.5, 128.4, 127.8, 127.6, 126.4, 123.9, 109.1, 76.6, 71.3, 71.0, 56.4, 55.2, 54.9, 35.9, 30.9, 19.0; IR (neat) 3291, 3059, 2934, 2864, 1711, 1664, 1612, 1540, 1362, 1230, 1089, 914, 744 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{28}N_2O_4Na$ $[M+Na]^+$ 443.1947, found 443.1939.

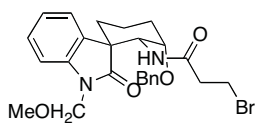


The slower eluting product was repurified by chromatography (10% to 25% EtOAc in CH_2Cl_2) to provide the minor diastereomer: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.37 (d, 1H, *J* = 7.5 Hz), 7.32-7.26 (m, 6H), 7.06 (app t, 2H, *J* = 7.5 Hz), 6.18 (dd, 1H, *J* = 1.8, 17.1 Hz), 6.08 (d, 1H, *J* = 9.9 Hz), 6.03 (d, 1H, *J* = 9.9 Hz), 5.60 (dd, 1H, *J* = 1.8, 10.2 Hz), 5.15 (d, 1H, *J* = 11.1 Hz), 5.10 (d, 1H, *J* = 11.1 Hz), 4.64 (dd, 1H, *J* = 4.2, 9.9 Hz), 4.55 (d, 1H, *J* = 11.7 Hz), 4.46 (d, 1H, *J* = 11.7 Hz), 4.02 (quintet, 1H, *J* = 4.2 Hz), 3.32 (s, 3H), 2.17-2.11 (m, 1H), 2.06-1.96 (m, 1H), 1.91-1.82 (m, 3H), 1.69-1.64 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 177.4, 165.6, 141.6, 138.3, 132.0, 131.1, 128.6, 128.6, 128.1, 127.8, 126.6, 124.7, 122.8, 109.8, 73.7, 71.6, 70.7, 56.4, 51.7, 50.2, 30.6, 27.4, 18.6; IR (neat) 3323, 3059, 2939, 1723, 1660, 1610, 1539, 1466, 1349, 1240, 1086, 744 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{28}N_2O_4Na$ $[M+Na]^+$ 443.1947, found 443.1955.

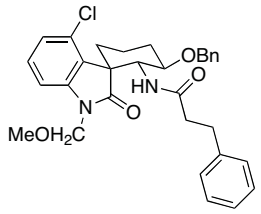


***N*-((1*S*, 2*R*, 3*R*)-3-(Benzyloxy)-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-bromopropanamide (20)**

To a solution of **16** (113 mg, 0.30 mmol) in CH_2Cl_2 (3.0 mL) was added $Cp_2Zr(H)Cl$ (95 mg, 0.37 mmol). The reaction mixture was stirred for 15 min. 3-Bromopropionyl chloride (37 μL, 0.37 mmol) was added and the mixture was stirred for 15 min, followed by addition of $Sc(OTf)_3$ (15 mg, 0.03 mmol). The solution was stirred for another 30 min, then was quenched with saturated $NaHCO_3$ solution. The mixture was extracted with EtOAc (3x), and the combined organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure the residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give the product as two diastereomers (80 mg, 54%, 6.7:1). The faster eluting product was the major diastereomer **20** and was isolated as a white solid (mp 169.8 °C-174.5 °C): ^{1}H NMR (300 MHz, $CDCl_3$) 7.33 (d, 1H, *J* = 7.5 Hz), 7.30-7.21 (m, 6H), 7.18 (d, 1H, *J* = 7.5 Hz), 7.08 (d, 1H, *J* = 7.5 Hz), 6.89 (d, 1H, *J* = 7.5 Hz), 5.06 (s, 2H), 5.01 (d, 1H, *J* = 9.9 Hz), 4.67 (d, 1H, *J* = 12.0 Hz), 4.54 (t, 1H, *J* = 9.9 Hz), 4.44 (d, 1H, *J* = 12.0 Hz), 4.18 (dt, 1H, *J* = 4.5, 10.5 Hz), 3.29 (s, 3H), 3.19 (t, 2H, *J* = 7.5 Hz), 2.43-2.33 (m, 2H), 2.21-2.13 (m, 1H), 2.11-2.02 (m, 1H), 1.85 (dt, 1H, *J* = 3.6, 14.1 Hz), 1.77-1.46 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.1, 169.1, 141.0, 138.9, 130.9, 128.4, 128.2, 127.6, 127.5, 123.7, 123.6, 109.0, 76.2, 71.1, 71.0, 56.3, 55.1, 54.7, 39.8, 35.5, 30.8, 26.9, 18.8; IR (neat) 3251, 3063, 2932, 1703, 1647, 1558, 1490, 1361, 1115, 1089 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{29}N_2O_4BrNa$ $[M+Na]^+$ 523.1208, found 523.1210.

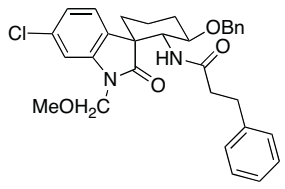


The slower eluting product was repurified by preparative TLC (20% EtOAc in CH_2Cl_2) to provide the minor diatereomer. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.36 (d, 1H, *J* = 7.2 Hz), 7.33-7.30 (m, 6H), 7.06 (app t, 2H, *J* = 7.5 Hz), 6.00 (d, 1H, *J* = 9.6 Hz), 5.15 (d, 1H, *J* = 10.8 Hz), 5.09 (d, 1H, *J* = 10.8 Hz), 4.55 (dd, 1H, *J* = 4.2, 10.2 Hz), 4.52 (d, 1H, *J* = 11.7 Hz), 4.46 (d, 1H, *J* = 11.7 Hz), 4.00 (quintet, 1H, *J* = 4.2 Hz), 3.50 (t, 2H, *J* = 6.9 Hz), 3.33 (s, 3H), 2.76-2.59 (m, 2H), 2.18-2.12 (m, 1H), 2.03-1.81 (m, 4H), 1.68-1.61 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 177.5, 169.8, 141.6, 138.3, 131.8, 128.7, 128.6, 128.2, 127.9, 124.8, 122.8, 109.8, 73.6, 71.6, 70.7, 56.5, 51.6, 50.3, 39.9, 30.6, 27.5, 27.3, 18.5; IR (neat) 3340, 3059, 2939, 2876, 1720, 1655, 1611, 1541, 1466, 1349, 1245, 1086, 914, 746 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{25}H_{29}N_2O_4BrNa$ $[M+Na]^+$ 523.1208, found 523.1165.



***N*-((1*S*,2*R*,3*R*)-3-(Benzyloxy)-4'-chloro-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (22)**

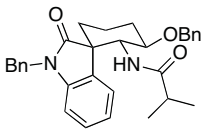
To a solution of **21** (82 mg, 0.20 mmol) in CH_2Cl_2 (2.0 mL) was added $Cp_2Zr(H)Cl$ (63 mg, 0.25 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (37 μL, 0.25 mmol) was added and the mixture was stirred overnight. The reaction was quenched with saturated $NaHCO_3$ solution, and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc, then 5% EtOAc in CH_2Cl_2) to give product **22** as single diastereomer (38 mg, 36%, white solid, mp 159.8 °C-161.6 °C): ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.30-7.08 (m, 10H), 6.98 (app d, 2H, *J* = 7.8 Hz), 6.84 (d, 1H, *J* = 7.5 Hz), 5.21 (t, 1H, *J* = 9.6 Hz), 5.06 (d, 1H, *J* = 10.8 Hz), 5.00 (d, 1H, *J* = 10.8 Hz), 4.88 (d, 1H, *J* = 9.3 Hz), 4.69 (d, 1H, *J* = 12.0 Hz), 4.44 (d, 1H, *J* = 12.0 Hz), 4.15 (dt, 1H, *J* = 4.5, 11.1 Hz), 3.26 (s, 3H), 2.72-2.60 (m, 3H), 2.37 (app d, 1H, *J* = 12.6 Hz), 2.21-1.97 (m, 3H), 1.75-1.54 (m, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 178.4, 171.8, 142.8, 141.0, 138.9, 131.8, 129.5, 128.4, 128.3, 128.1, 127.6, 127.5, 126.6, 126.0, 125.3, 107.6, 76.5, 71.1, 70.7, 56.3, 56.2, 52.1, 38.2, 31.3, 30.4, 29.8, 18.5; IR (neat) 3295, 3061, 3028, 2935, 2864, 1715, 1657, 1607, 1456, 1361, 1092 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{33}N_2O_4ClNa$ $[M+Na]^+$ 555.2027, found 555.2047.



***N*-((1*S*,2*R*,3*R*)-3-(Benzyloxy)-6'-chloro-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (24)**

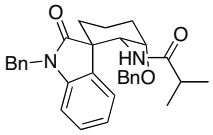
To a solution of **23** (95 mg, 0.23 mmol) in CH_2Cl_2 (2.3 mL) was added $Cp_2Zr(H)Cl$ (73 mg, 0.28 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (42 μL, 0.28 mmol) was added and the mixture was stirred overnight at rt. The reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and concentrated under reduced pressure. The residue was purified by column chromatography (15% EtOAc in hexane to 100% EtOAc) to give **24** as single diastereomer (61 mg, 50%, white solid, mp 193.0 °C-195.2 °C). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.35-7.11 (m, 10H), 6.95-6.93 (m, 3H), 5.01 (s, 2H), 4.95 (d, 1H, *J* = 9.6

Hz), 4.68 (d, 1H, *J* = 12.0 Hz), 4.58 (d, 1H, *J* = 9.9 Hz), 4.40 (d, 1H, *J* = 12.0 Hz), 4.17 (dt, 1H, *J* = 4.5, 10.5 Hz), 3.24 (s, 3H), 2.66-2.60 (m, 2H), 2.37 (app d, 1H, *J* = 9.9 Hz), 2.23-1.99 (m, 3H), 1.85 (dt, 1H, *J* = 3.9, 13.8 Hz), 1.77-1.62 (m, 2H), 1.54-1.49 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.1, 172.1, 142.1, 140.9, 139.0, 134.0, 129.6, 128.6, 128.5, 127.7, 126.2, 125.1, 123.6, 109.9, 76.2, 71.2, 70.9, 56.3, 54.9, 54.8, 38.2, 35.6, 31.3, 30.8, 18.9; IR (neat) 3249, 3057, 3028, 2935, 2869, 2362, 1707, 1647, 1610, 1549, 1448, 1094 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{33}N_2O_4ClNa$ $[M+Na]^+$ 555.2027, found 555.2028.



_N_-((1_R_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)isobutyramide (25)

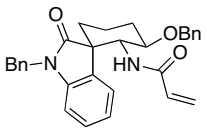
To a solution of **8** (120 mg, 0.21 mmol) in CH_2Cl_2 (2.1 mL) was added $Cp_2Zr(H)Cl$ (68 mg, 0.26 mmol). The reaction mixture was stirred for 15 min. Isobutyryl chloride (27 μL, 0.26 mmol) was added and the mixture was stirred for 20 min, followed by addition of $Sc(OTf)_3$ (103 mg, 0.21 mmol). After stirring overnight the reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and then concentrated under reduced pressure. The residue was purified by column chromatography (5% EtOAc in CH_2Cl_2 to 100%) to give the product as four diastereomers (69 mg, 68%). The fastest eluting product was a mixture of two inseparable diastereomers (12 mg, 1:0.72). By comparison to the available spectrum, they are **13** and its epimer at the benzyloxy position. The second fastest eluting product was repurified by preparative TLC (35% EtOAc in hexane) to yield the minor diastereomer (10 mg): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, 1H, *J* = 7.6 Hz), 7.38-7.21 (m, 10H), 7.15 (t, 1H, *J* = 7.6 Hz), 6.88 (t, 1H, *J* = 7.6 Hz), 6.71 (d, 1H, *J* = 7.6 Hz), 5.23 (d, 1H, *J* = 9.6 Hz), 4.96 (d, 1H, *J* = 15.6 Hz), 4.79 (d, 1H, *J* = 15.6 Hz), 4.74 (d, 1H, *J* = 11.6 Hz), 4.70 (dd, 1H, *J* = 3.6, 10.0 Hz), 4.37 (d, 1H, *J* = 11.2 Hz), 3.97-3.95 (m, 1H), 2.29 (app dt, 1H, *J* = 3.2, 14.4 Hz), 2.10-1.95 (m, 3H), 1.77-1.63 (m, 3H), 0.85 (d, 3H, *J* = 7.2 Hz), 0.81 (d, 3H, *J* = 6.8 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 179.4, 175.7, 143.5, 138.4, 136.3, 130.0, 128.9, 128.7, 128.4, 128.1, 128.0, 128.0, 127.7, 127.6, 122.0, 108.9, 76.0, 72.0, 53.3, 51.4, 44.2, 35.5, 34.3, 27.6, 19.5, 19.4, 15.9; IR (neat) 3349, 3060, 3031, 2929, 2869, 1715, 1678, 1609, 1494, 1466, 1364, 1207, 1089, 751 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{31}H_{34}N_2O_3$ $[M]^+$ 482.2569, found 482.2567. The third eluting product **25** was the major diastereomer (47 mg, 46%). All spectral data for this compound were identical to the minor product from the cyclization of **7**.



_N_-((1_R_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-2-methoxyacetamide (26)

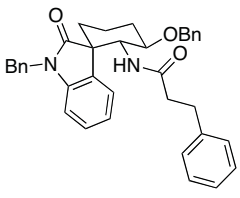
To a solution of **8** (114 mg, 0.20 mmol) in CH_2Cl_2 (2.0 mL) was added $Cp_2Zr(H)Cl$ (65 mg, 0.25 mmol). The reaction mixture was stirred for 15 min. Methoxyacetyl chloride (23 μL, 0.25 mmol) was added and the mixture was stirred for 20 min, followed by addition of $Sc(OTf)_3$ (96 mg, 0.20 mmol). After stirring overnight, the reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and then concentrated under reduced pressure. The residue was purified by column chromatography (5% EtOAc in CH_2Cl_2 to 100% EtOAc) to give product as four

diastereomers (65 mg, 67%). The fastest eluting product was minor diastereomer **14** (3 mg). The second fastest eluting product was the minor diastereomer (2 mg) which was the epimer of **14** at the benzyloxyl position as shown before. The last eluting fraction was a mixture of two inseparable diastereomers (60 mg, 1:2.1), which were repurified by preparative TLC (10% EtOAc in CH_2Cl_2) for characterization purpose, and give the third eluting product as the minor diastereomer, ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.90 (d, 1H, *J* = 7.2 Hz), 7.34-7.23 (m, 10H), 7.15 (t, 1H, *J* = 7.8 Hz), 6.87 (t, 1H, *J* = 7.2 Hz), 6.72 (d, 1H, *J* = 7.8 Hz), 6.45 (d, 1H, *J* = 10.2 Hz), 5.10 (d, 1H, *J* = 15.0 Hz), 4.75 (dd, 1H, *J* = 3.6, 10.2 Hz), 4.73 (d, 1H, *J* = 11.4 Hz), 4.42 (d, 1H, *J* = 11.4 Hz), 3.94 (m, 1H), 3.68 (d, 1H, *J* = 15.0 Hz), 3.49 (d, 1H, *J* = 15.0 Hz), 2.28 (app d, 1H, *J* = 13.8 Hz), 2.10-1.98 (m, 2H), 1.74 (app t, 1H, *J* = 13.2 Hz), 1.68 (app d, 2H, *J* = 11.9 Hz). The slow eluting product was the major diastereomer **26** and was isolated as a white solid (mp 164.2 °C-165.8 °C): ^{1}H NMR (600 MHz, DMSO) δ 7.61 (d, 1H, *J* = 7.8 Hz), 7.31-7.28 (m, 5H), 7.26-7.22 (m, 6H), 7.06 (d, 1H, *J* = 7.2 Hz), 6.92 (d, 1H, *J* = 7.8 Hz), 6.11 (d, 1H, *J* = 10.2 Hz), 5.00 (d, 1H, *J* = 15.6 Hz), 4.70 (d, 1H, *J* = 15.6 Hz), 4.64 (d, 1H, *J* = 12.0 Hz), 4.45 (d, 1H, *J* = 12.0 Hz), 4.43 (t, 1H, *J* = 10.8 Hz), 3.86 (dt, 1H, *J* = 4.2, 10.8 Hz), 3.57 (d, 1H, *J* = 15.6 Hz), 3.43 (d, 1H, *J* = 15.6 Hz), 2.81 (s, 3H), 2.41 (app d, 1H, *J* = 15.6 Hz), 1.93-1.78 (m, 3H), 1.51-1.44 (m, 2H); ^{13}C NMR (100 MHz, DMSO) δ 177.1, 168.2, 142.9, 139.1, 136.4, 129.4, 128.5, 128.4, 128.0, 127.3, 127.2, 127.1, 125.6, 122.0, 109.2, 77.2, 71.1, 70.2, 58.2, 54.1, 53.8, 42.7, 33.5, 30.7, 19.6; IR (neat) 3271, 3060, 3031, 2929, 2853, 1714, 1608, 1521, 1464, 1364, 1113, 1070, 737 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{30}H_{32}N_2O_4Na$ $[M+Na]^+$ 507.2260, found 507.2251.



_N_-((1_R_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)acrylamide (27)

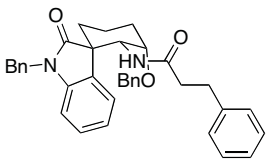
To a solution of **8** (105 mg, 0.19 mmol) in CH_2Cl_2 (1.9 mL) was added $Cp_2Zr(H)Cl$ (60 mg, 0.23 mmol). The reaction mixture was stirred for 15 min. Acryloyl chloride (19 μL, 0.23 mmol) was added and the mixture was stirred for 20 min, followed by addition of $Sc(OTf)_3$ (93 mg, 0.20 mmol). After stirring overnight , the reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and then concentrated under reduced pressure. The residue was purified by column chromatography (5% EtOAc in CH_2Cl_2 to 100% EtOAc) to give product as four diastereomers (33 mg, 38%). The fastest eluting product **15** was the minor diastereomer (1 mg). The second fastest eluting product was a mixture of two inseparable diastereomers (6 mg, 1:1). The third eluting product **27** was the major diastereomer (26 mg). This product showed identical spectral data to the minor product from the cyclization of **7**.



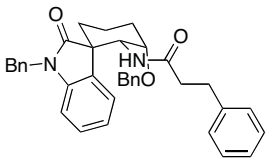
_N_-((1_R_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (12)

To a solution of **8** (113 mg, 0.20 mmol) in CH_2Cl_2 (2.0 mL) was added $Cp_2Zr(H)Cl$ (65 mg, 0.25 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (37 μL, 0.25 mmol) was added and the mixture was stirred for 20 min, followed by addition of $Sc(OTf)_3$ (98 mg, 0.20 mmol). After stirring overnight , the reaction was

quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4 and then concentrated under reduced pressure. The residue was purified by column chromatography (5% to 100% EtOAc in CH_2Cl_2) to give product as four diastereomers (72 mg, 66%). The fastest eluting product was a mixture of two inseparable diastereomers (13 mg, 1:1). By comparing with the available spectra, they are **11** and its epimer at the benzyloxy position.

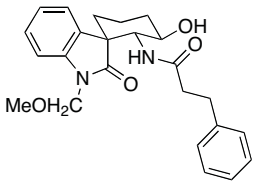


The second fastest eluting product was *syn*-diastereomer **28** (8 mg), ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, 1H, J = 7.6 Hz), 7.35-7.12 (m, 14H), 7.03 (app d, 2H, J = 7.2 Hz), 6.87 (dt, 1H, J = 3.6, 7.6 Hz), 6.71 (d, 1H, J = 8.0 Hz), 5.16 (d, 1H, J = 9.6 Hz), 5.05 (d, 1H, J = 15.6 Hz), 4.75 (dd, 1H, J = 4.0, 10.0 Hz), 4.68 (d, 1H, J = 15.6 Hz), 4.64 (d, 1H, J = 11.2 Hz), 4.20 (d, 1H, J = 11.2 Hz), 3.87-3.86 (m, 1H), 2.75-2.61 (m, 2H), 2.25 (d, 1H, J = 14.0 Hz), 2.20-2.12 (m, 1H), 2.09-1.93 (m, 3H), 1.76-1.72 (m, 1H), 1.66-1.62 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 179.3, 171.0, 143.4, 141.0, 138.4, 136.3, 129.9, 128.9, 128.7, 128.6, 128.4, 128.4, 128.2, 128.0, 128.0, 127.8, 127.6, 126.3, 122.1, 109.0, 76.2, 71.9, 53.2, 51.7, 44.2, 38.0, 34.3, 31.3, 27.7, 15.9; IR (neat) 3087, 3029, 2936, 2866, 1711, 1670, 1609, 1494, 1466, 1364, 733 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{36}N_2O_3Na$ $[M+Na]^+$ 567.2624, found 567.2598. The third eluting product **12** was the major diastereomer (51 mg). All spectral data for this compound were identical to those from the minor isomer of the cyclization of **7**.



_N_-((1_R_,2_R_,3_S_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (28)

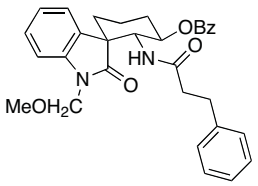
To a solution of **8** (62 mg, 0.11 mmol) in CH_2Cl_2 (1.1 mL) was added $Cp_2Zr(H)Cl$ (35 mg, 0.13 mmol). The reaction mixture was stirred for 15 min. Hydrocinnamoyl chloride (19 μL, 0.13 mmol) was added and the mixture was stirred for 20 min, followed by addition of $ZnCl_2$ (0.13 mL 1M solution). After stirring overnight at room temperature, the reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3x). The combined organic layer was dried over Na_2SO_4, and then concentrated under reduced pressure. The residue was purified by column chromatography (5% EtOAc in CH_2Cl_2 to 100% EtOAc) to give the product as four diastereomers (33 mg, 66%). The fastest eluting product was a mixture of two inseparable diastereomers (2 mg, 3:2). By comparing with the available spectrum, they are **11** and its epimer at the benzyloxy position. The second fastest eluting material was the major product **28** (22 mg) and the third eluting product **12** as the minor product (11 mg). All spectral data were consistent with products that had previously been prepared.



_N_-((1_S_,2_R_,3_R_)-3-Hydroxy-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide

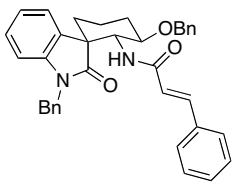
To a solution of **17** (50 mg, 0.10 mmol) in EtOH/EtOAc (2 mL, 1:1) was added Pd/C (7 mg). The atmosphere was exchanged with H_2 and the mixture was stirred for 24 h. The suspension was diluted with EtOAc then was filtered through a short pad of silica gel. Removal of the solvent provided the alcohol as a white solid (29 mg, 71%, mp 219.2 °C-220.8 °C) that was directly used for next step without further purification: ^{1}H NMR

(300 MHz, DMSO) δ 7.30 (d, 2H, *J* = 7.5 Hz), 7.22-6.89 (m, 7H), 5.08 (d, 1H, *J* = 10.8 Hz), 4.98 (d, 1H, *J* = 11.1 Hz), 4.40 (d, 1H, *J* = 5.1 Hz), 4.25-4.15 (m, 2H), 3.19 (s, 3H), 2.31-2.23 (m, 2H), 2.11-2.00 (m, 4H), 1.92-1.83 (m, 1H), 1.62-1.45 (m, 3H); ^{13}C NMR (75 MHz, DMSO) δ 178.1, 171.7, 141.5, 141.4, 131.4, 128.2, 127.9, 127.4, 125.6, 123.7, 122.2, 108.4, 70.5, 66.7, 56.9, 55.5, 53.9, 37.1, 34.8, 34.2, 31.3, 18.7; IR (neat) 3424, 3269, 2938, 1694, 1640, 1554, 1453, 1369, 1077 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{24}H_{28}N_2O_4Na$ $[M+Na]^+$ 431.1947, found 431.1955.



(1*S*,2*R*,3*R*)-1'-(Methoxymethyl)-2'-oxo-2-(3-phenylpropanamido)spiro[cyclohexane-1,3'-indolin]-3-yl benzoate (29)

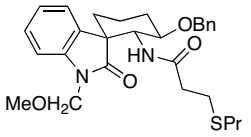
To a solution of the alcohol (11mg, 0.027 mmol) and a catalytic amout of DMAP in pyridine (0.5 mL) was added benzoyl chloride (31 μL, 0.27 mmol). The mixture was stirred for 30 h, then another portion of benzoyl choride (31 μL, 0.27 mmol) was added. After 18 h the temperature was raised to 60 °C. After stirring for 4 h the mixture was diluted with EtOAc, and then washed with saturated $NaHCO_3$ solution. After removal of the solvent, the residue was purified by flash chromatography (20% to 40% EtOAc in hexane) to yield benzoate **29** (10 mg, 72%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, 1H, *J* = 7.2 Hz), 8.02 (d, 2H, *J* = 7.2 Hz), 7.62 (t, 1H, *J* = 7.6 Hz), 7.55 (t, 1H, *J* = 7.6 Hz), 7.48 (t, 1H, *J* = 7.6 Hz), 7.45-7.40 (m, 3H), 7.16 (t, 1H, *J* = 7.6 Hz), 7.11-7.04 (m, 3H), 6.96 (d, 1H, *J* = 7.6 Hz), 6.80-6.78 (m, 2H), 5.97 (dt, 1H, *J* = 4.8, 10.8 Hz), 5.50 (d, 1H, *J* = 10.0 Hz), 5.12 (d, 1H, *J* = 10.8 Hz), 5.09 (d, 1H, *J* = 10.8 Hz), 4.83 (t, 1H, *J* = 10.4 Hz), 2.46-2.37 (m, 2H), 2.35-2.26 (m, 2H), 2.03-1.93 (m, 3H), 1.89-1.75 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.8, 172.3, 167.0, 141.3, 140.8, 133.8, 133.4, 130.7, 130.4, 130.1, 130.0, 128.7, 128.6, 128.5, 128.0, 126.1, 123.9, 123.8, 109.3, 71.9, 71.3, 56.4, 55.1, 54.8, 38.3, 35.5, 31.5, 31.2, 19.0; IR (neat) 3350, 3062,3030, 2935, 1713, 1613, 1537, 1361, 1273, 1117, 713 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{31}H_{32}N_2O_5Na$ $[M+Na]^+$ 535.2209, found 535.2236.



***N*-((1*S*,2*R*,3*R*)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)cinnamamide (30)**

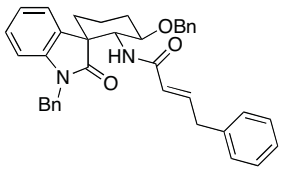
To a solution of **15** (30 mg, 0.06 mmol) in DMF (0.5 mL) in a sealed tube was added $Pd(OAc)_2$ (0.7 mg), PPh_3 (1.7 mg, 0.0064 mmol), iodobenzene (7.2 μL, 0.06 mmol) and Cs_2CO_3 (23 mg, 0.07 mmol). The atmosphere was exchanged with argon, then the tube was sealed and immersed in a preheated oil bath (120 °C). The reaction stirred for 12 h, then the mixture was diluted with EtOAc and washed with brine (2x). The organic layer was dried over Na_2SO_4 and the solvent was removed under reduced pressure. The residue was purified by chromatography (10% to 50% EtOAc in hexane) to yield **30** as a slightly red solid (25 mg, 72%, mp 185.4 °C-189.8 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, 1H, *J* = 8.0 Hz), 7.39-7.35 (m, 6H), 7.31-7.24 (m, 9H), 7.16-7.08 (m, 2H), 6.68 (d, 1H, *J* = 8.0 Hz), 5.82 (d, 1H, *J* = 15.6 Hz), 5.00 (app d, 2H, *J* = 15.6 Hz), 4.83 (d, 1H, *J* = 15.6 Hz), 4.76-4.71 (m, 2H), 4.49 (d, 1H, *J* = 12.0 Hz), 4.29 (dt, 1H, *J* = 4.8, 10.8 Hz), 2.44 (d, 1H, *J* = 12.8 Hz), 2.23 (qt, 1H, *J* = 3.6, 13.6 Hz), 1.94 (dt, 1H, *J* = 4.0, 14.0 Hz), 1.85 (app d, 1H, *J* = 14.0 Hz), 1.78-1.73 (m, 1H), 1.66-1.59 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 178.8, 165.6, 142.0, 141.0, 139.1, 136.3, 134.9, 131.9, 129.8, 129.0, 128.9, 128.5, 128.2,

128.0, 127.9, 127.8, 127.5, 127.3, 123.8, 123.4, 120.5, 108.8, 76.7, 71.0, 55.4, 54.5, 43.5, 35.3, 31.0, 19.1; IR (neat) 3304, 3060, 3030, 2932, 2864, 1699, 1663, 1612, 1492, 1366, 1209, 1027, 1098, 978, 910, 734 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{34}N_2O_3Na$ $[M+Na]^+$ 565.2467, found 565.2432.



_N_-((1_S_,2_R_,3_R_)-3-(Benzyloxy)-1'-(methoxymethyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-(propylthio)propanamide (31)

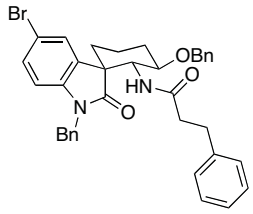
To a suspension of NaH (6 mg, 0.15 mmol) in THF (0.6 mL) at 0 °C under argon was added 1-propanethiol (10 μL, 0.11 mmol). After 15 min a solution of **19** (31 mg, 0.074 mmol) in THF (0.6 mL) was added dropwise at 0 °C. The ice bath was removed and the reaction stirred at for 1 h. The reaction mixture was quenched with water and extracted with EtOAc (2x). The combined organic layer was dried over Na_2SO_4 and the solvent was removed under reduced pressure. The residue was purified by chromatography (5% to 15% EtOAc in CH_2Cl_2) to give sulfide **31** (26 mg, 71%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, 1H, *J* = 7.2 Hz), 7.32-7.24 (m, 5H), 7.22 (d, 1H, *J* = 7.6 Hz), 7.11 (t, 1H, *J* = 7.6 Hz), 6.93 (d, 1H, *J* = 7.6 Hz), 5.25 (d, 1H, *J* = 9.6 Hz), 5.11 (d, 1H, *J* = 10.8 Hz), 5.08 (d, 1H, *J* = 10.8 Hz), 4.70 (d, 1H, *J* = 12.0 Hz), 4.58 (t, 1H, *J* = 10.0 Hz), 4.49 (d, 1H, *J* = 12.0 Hz), 4.21 (dt, 1H, *J* = 4.8, 10.8 Hz), 3.23 (s, 3H), 2.43-2.36 (m, 2H), 2.30-2.23 (m, 3H), 2.15-2.06 (m, 2H), 2.01-1.93 (m, 1H), 1.88 (dt, 1H, *J* = 3.6, 14.0 Hz), 1.78 (app d, 1H, *J* = 14.4 Hz), 1.71-1.68 (m, 1H), 1.60-1.55 (m, 1H), 1.47 (sextet, 2H, *J* = 7.2 Hz), 0.91 (t, 3H, *J* = 7.2 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.3, 171.2, 141.2, 139.1, 131.2, 128.5, 128.3, 127.7, 127.6, 123.9, 123.7, 109.0, 76.4, 71.3, 71.1, 56.4, 55.3, 54.9, 37.0, 35.6, 34.2, 31.0, 27.6, 22.9, 19.0, 13.6; IR (neat) 3247, 3061, 2932, 2869, 1706, 1643, 1555, 1491, 1362, 1294, 1116, 1088, 740 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{28}H_{36}N_2O_4NaS$ $[M+Na]^+$ 519.2293, found 519.2319.



(_E_)-_N_-((1_S_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-4-phenylbut-2-enamide (32)

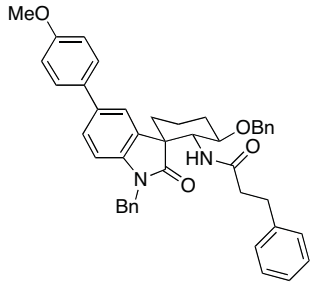
To a solution of **15** (23 mg, 0.05 mmol) in CH_2Cl_2 (1 mL) in a sealed tube were added the second generation Hoveyda-Grubbs catalyst (2 mg) and allylbenzene (19 μL, 0.15 mmol). The atmosphere was exchanged with argon, then the tube was immersed in a preheated oil bath (41 °C). The reaction was stirred for 18 h, then the solvent was removed under reduced pressure and the residue was purified by preparative TLC (5% EtOAc in CH_2Cl_2) to yield **32** (11 mg, 40%, 51% brsm) and starting material (5 mg): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 (d, 1H, *J* = 7.6 Hz), 7.33-7.22 (m, 13H), 7.16-7.06 (m, 4H), 6.75 (dt, 1H, *J* = 6.8, 15.2 Hz), 6.66 (d, 1H, *J* = 7.6 Hz), 5.27 (d, 1H, *J* = 15.2 Hz), 4.96 (d, 1H, *J* = 15.6 Hz), 4.91 (d, 1H, *J* = 10.0 Hz), 4.80 (d, 1H, *J* = 15.6 Hz), 4.70 (d, 1H, *J* = 12.0 Hz), 4.68 (t, 1H, *J* = 10.0 Hz), 4.47 (d, 1H, *J* = 12.0 Hz), 4.24 (dt, 1H, *J* = 4.4, 10.4 Hz), 3.39 (t, 1H, *J* = 6.4 Hz), 2.41 (d, 1H, *J* = 10.0 Hz), 2.19 (q, 1H, *J* = 13.2 Hz), 1.91 (dt, 1H, *J* = 3.6, 14.0 Hz), 1.82 (app d, 1H, *J* = 14.0 Hz), 1.74-1.70 (m, 1H), 1.62-1.55 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.8, 165.7, 143.1, 142.0, 139.1, 138.2, 136.2, 131.9, 129.0, 129.0, 128.9, 128.4, 128.1, 127.8, 127.8, 127.5, 127.2, 126.7, 124.6, 123.8, 123.4, 108.7, 76.7, 70.9, 55.3, 54.4, 43.5, 38.3, 35.5, 30.9, 19.1; IR (neat) 3416, 3060, 3029, 2931, 2864,

1696, 1640, 1612, 1537, 1493, 1365, 1174, 1098, 980 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{37}H_{36}N_2O_3Na$ $[M+Na]^+$ 579.2624, found 579.2679.



_N_-((1_S_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-5'-bromo-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide

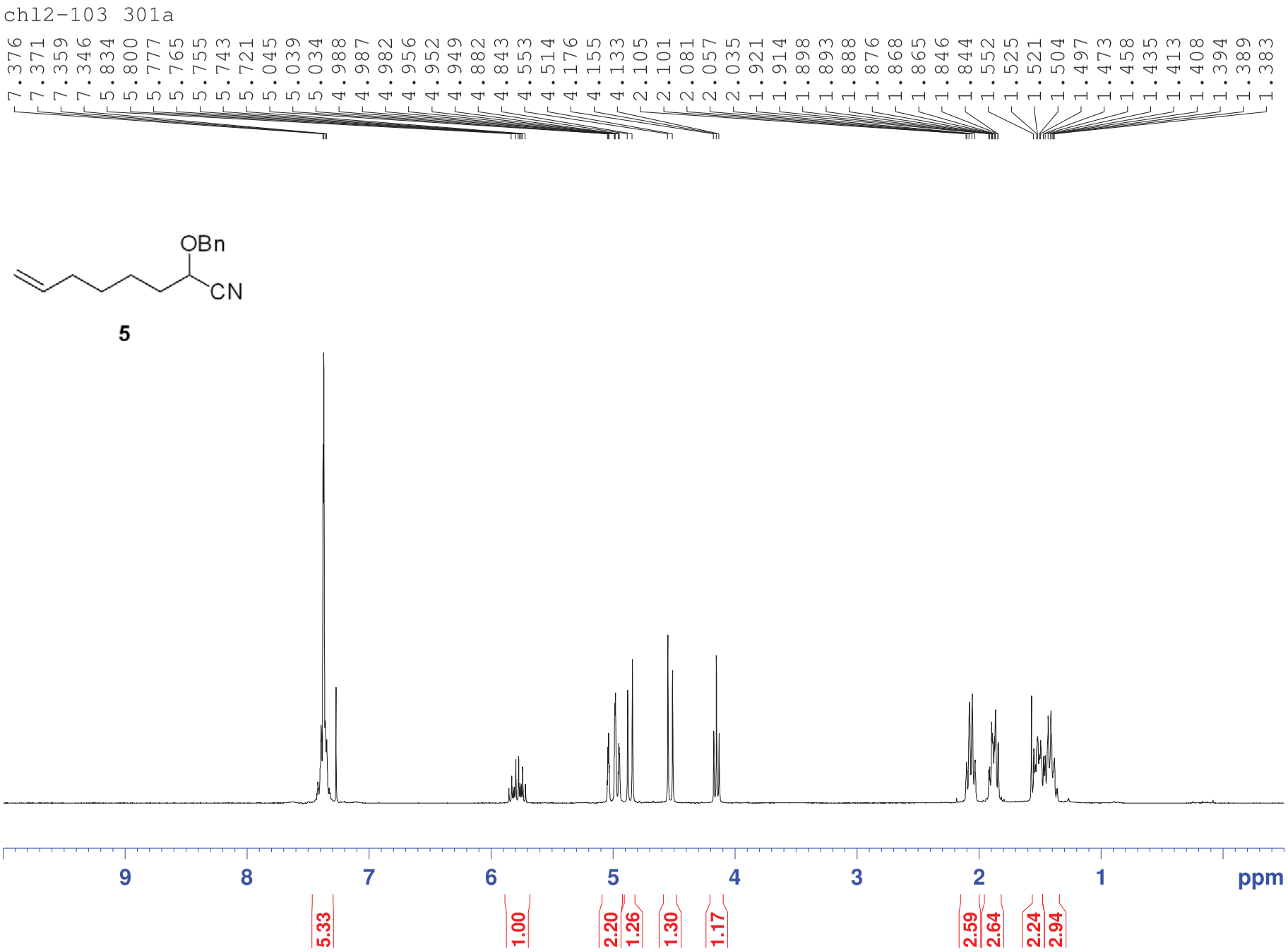
To a solution of **11** (250 mg, 0.46 mmol) in CH_2Cl_2 (9 mL) was added NBS (82 mg, 0.46 mmol) at 0 °C. The ice bath was removed and the mixture was stirred for 1h. NBS (20 mg, 0.11 mmol) was added and after 40 min the solvent was removed under reduced pressure. The residue was purified by chromatography (15% to 30% EtOAc in hexane) to give the aryl bromide as white solid (170 mg, 59%). ^{1}H NMR (400 MHz, $CDCl_3$) 7.51 (d, 1H, *J* = 2.0 Hz), 7.34-7.11 (m, 14H), 6.92 (app d, 2H, *J* = 6.8 Hz), 6.53 (d, 1H, *J* = 8.0 Hz), 4.89 (d, 1H, *J* = 16.0 Hz), 4.88 (d, 1H, *J* = 8.4 Hz), 4.74 (d, 1H, *J* = 15.6 Hz), 4.67 (d, 1H, *J* = 12.0 Hz), 4.57 (t, 1H, *J* = 10.0 Hz), 4.44 (d, 1H, *J* = 12.0 Hz), 4.21 (dt, 1H, *J* = 4.4, 10.4 Hz), 2.56 (t, 2H, *J* = 8.0 Hz), 2.39 (app dd, 1H, *J* = 3.2, 12.8 Hz), 2.16 (qt, 1H, *J* = 3.6, 9.2 Hz), 2.06 (quint, 1H, *J* = 7.6 Hz), 1.93 (app dd, 1H, *J* = 7.6, 14.8 Hz), 1.84 (dt, 1H, *J* = 4.0, 12.8 Hz), 1.79 (app d, 1H, *J* = 12.8 Hz), 1.71 (app dt, 1H, *J* = 3.2, 14.0 Hz), 1.62-1.52 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.1, 171.9, 141.0, 140.9, 139.0, 135.8, 133.9, 131.1, 129.1, 128.5, 128.4, 128.2, 127.6, 127.6, 127.3, 127.2, 126.1, 115.9, 110.0, 76.2, 70.7, 55.0, 54.6, 43.6, 38.0, 35.1, 31.2, 30.7, 18.9; IR (neat) 3306, 3062, 3029, 2931, 2864, 1702, 1606, 1484, 1426, 1358, 1205, 1169, 1098, 737 cm^{-1}; HRMS (ESI) *m/z* calcd for $C_{36}H_{35}N_2O_3NaBr$ $[M+Na]^+$ 645.1729, found 645.1726.

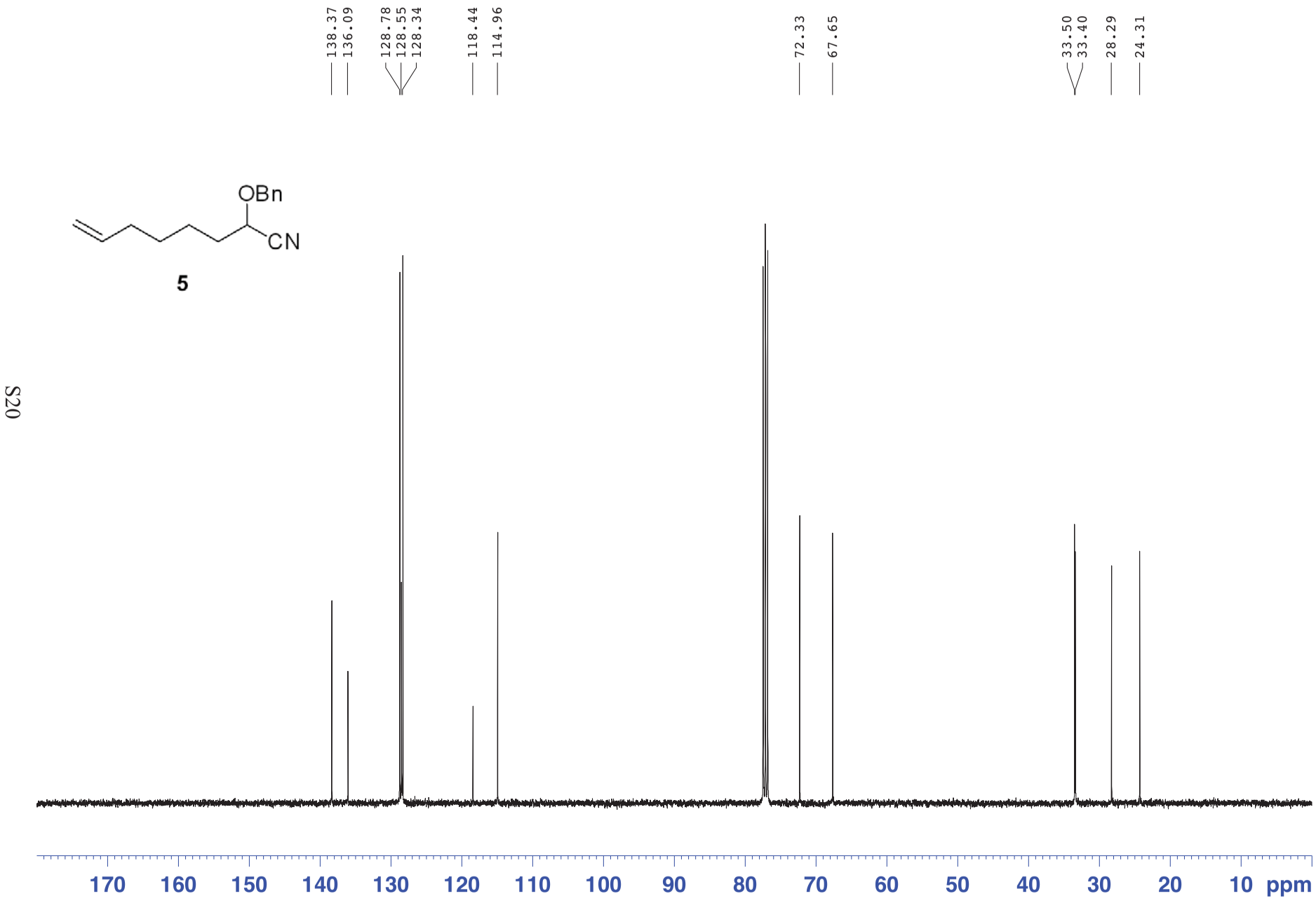


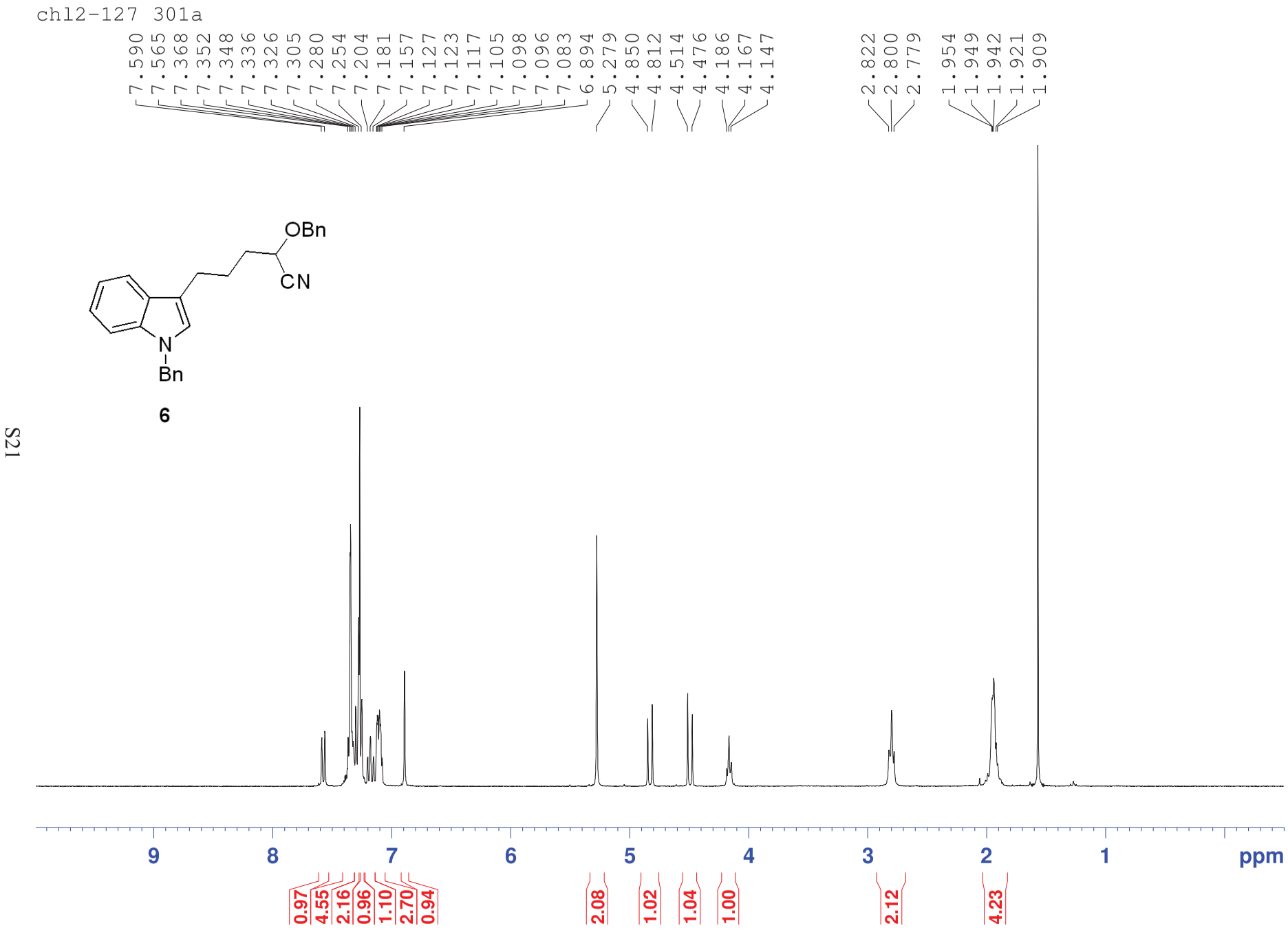
_N_-((1_S_,2_R_,3_R_)-1'-Benzyl-3-(benzyloxy)-5'-(4-methoxyphenyl)-2'-oxospiro[cyclohexane-1,3'-indolin]-2-yl)-3-phenylpropanamide (33)

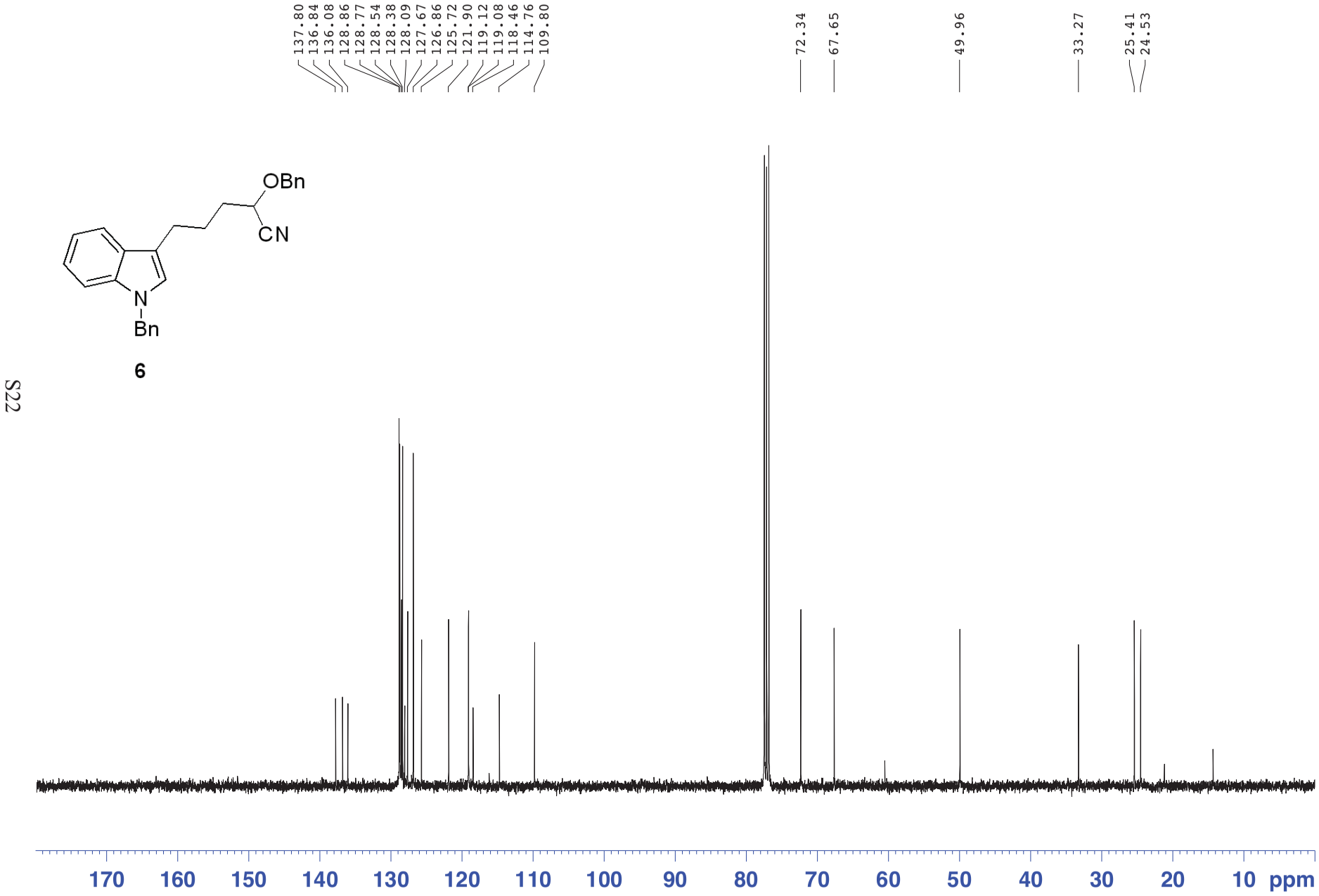
To a solution (40 mg, 0.06 mmol) of the aryl bromide in THF/H_2O (1 mL, 3:1) in a sealed tube was added $(PPh_3)_4Pd$ (7 mg, 0.006 mmol), 4-methoxyphenylboronic acid (20 mg, 0.13 mmol), and Na_2CO_3 (27 mg, 0.26 mmol). The atmosphere was exchanged for argon then the tube was sealed and immersed in a preheated oil bath (66 °C). The reaction stirred at 66 °C for 5 h, then the solution was extracted with EtOAc (2x). The combined organic layer was dried over Na_2SO_4. After removal of the solvent under reduced pressure, the residue was purified by flash chromatography (15% to 30% EtOAc in hexane) to give biaryl **33** (37 mg, 89%): ^{1}H NMR (300 MHz, $CDCl_3$) 7.60 (d, 1H, *J* = 1.8 Hz), 7.52 (app d, 2H, *J* = 8.7 Hz), 7.35-7.21 (m, 11H), 7.15-7.10 (m, 3H), 6.97 (app d, 2H, *J* = 8.7 Hz), 6.87 (app d, 2H, *J* = 7.8 Hz), 6.74 (d, 1H, *J* = 8.1 Hz), 5.00 (d, 1H, *J* = 10.2 Hz), 4.94 (d, 1H, *J* = 15.6 Hz), 4.84 (d, 1H, *J* = 15.6 Hz), 4.74 (t, 1H, *J* = 10.2 Hz), 4.71 (d, 1H, *J* = 12.0 Hz), 4.47 (d, 1H, *J* = 12.0 Hz), 4.29 (dt, 1H, *J* = 4.2, 10.5 Hz), 3.85 (s, 3H), 2.56-2.37 (m, 3H), 2.22 (qt, 1H, *J* = 3.6, 12.6 Hz), 2.14-2.04 (m, 1H), 2.00-1.83 (m, 3H), 1.80-1.69 (m, 2H), 1.61-1.56 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 178.7, 172.0, 159.1, 141.0, 140.8, 139.2, 136.3, 136.3, 133.8, 132.3, 129.1, 128.5, 128.5, 128.3, 128.2, 127.9, 127.5, 127.3, 126.6, 126.1, 122.9, 114.4, 108.7, 76.4, 70.8, 55.5, 55.3, 54.6, 43.7, 38.2, 35.4, 31.5, 31.0, 19.0; IR (neat) 3324, 3062, 3030, 2933, 2864, 1696, 1612, 1543, 1491, 1453, 1365, 1247, 1100,

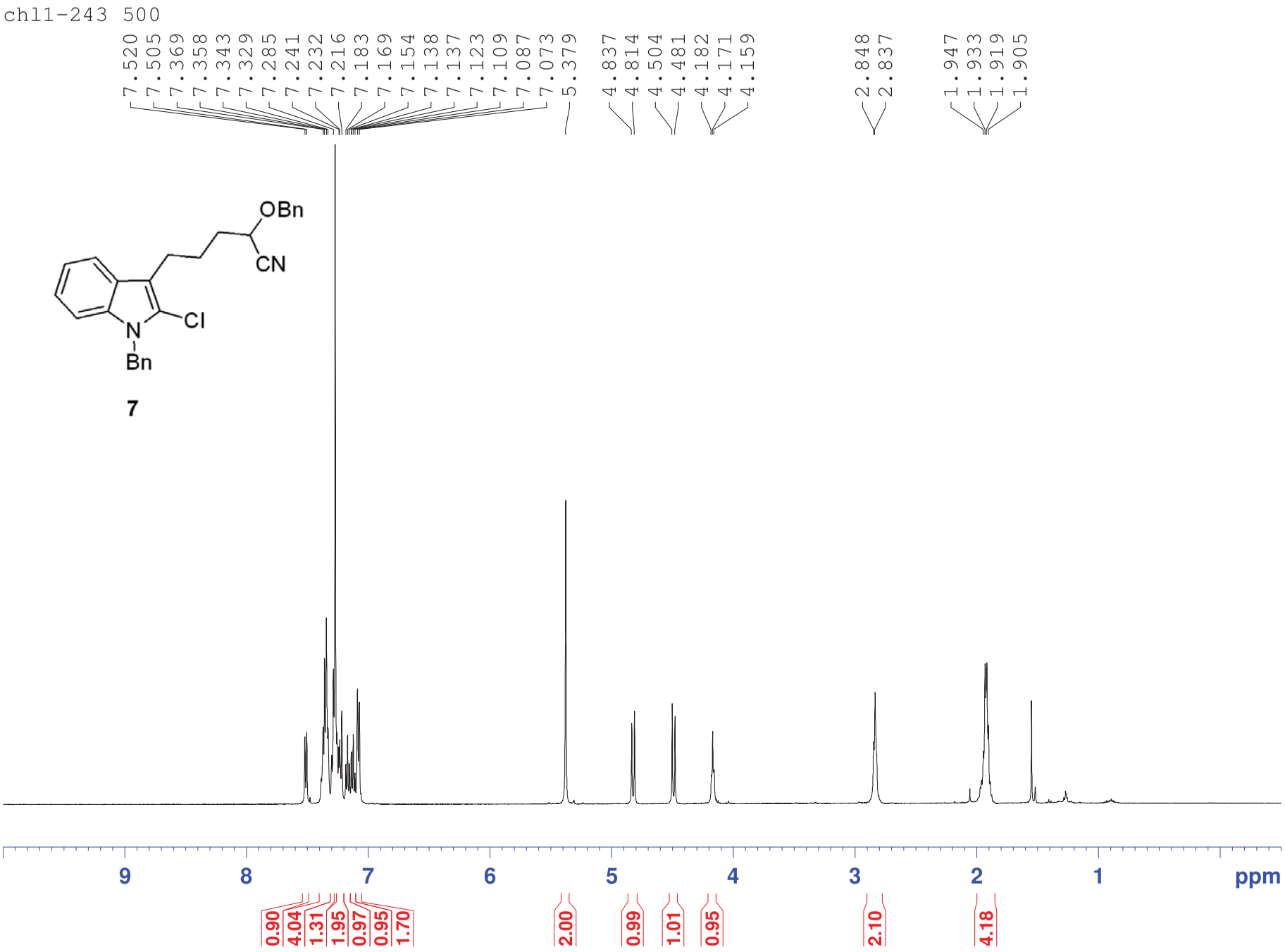
1027, 909, 813, 732 cm^{-1}; HRMS (EI) *m/z* calcd for $C_{43}H_{42}N_2O_4$ $[M]^+$ 650.3144, found 650.3148.


ch12-103 301a
7.376
7.371
7.359
7.346
5.834
5.800
5.777
5.765
5.755
5.743
5.721
5.045
5.039
5.034
4.988
4.987
4.982
4.956
4.952
4.949
4.882
4.843
4.553
4.514
4.176
4.155
4.133
2.105
2.101
2.081
2.057
2.035
1.921
1.914
1.898
1.893
1.888
1.876
1.868
1.865
1.846
1.844
1.552
1.525
1.521
1.504
1.497
1.473
1.458
1.435
1.413
1.408
1.394
1.389
1.383
OBn
CN
5
9
8
7
6
5
4
3
2
1
ppm
5.33
1.00
2.20
1.26
1.30
1.17
2.59
2.64
2.24
2.94


138.37
136.09
128.78
128.55
128.34
118.44
114.96
72.33
67.65
33.50
33.40
28.29
24.31
OBn
CN
5
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


ch12-127 301a
7.590
7.565
7.368
7.352
7.348
7.336
7.326
7.305
7.280
7.254
7.204
7.181
7.157
7.127
7.123
7.117
7.105
7.098
7.096
7.083
6.894
5.279
4.850
4.812
4.514
4.476
4.186
4.167
4.147
2.822
2.800
2.779
1.954
1.949
1.942
1.921
1.909
OBn
CN
N
Bn
6
9
8
7
6
5
4
3
2
1
ppm
0.97
4.55
2.16
0.96
1.10
2.70
0.94
2.08
1.02
1.04
1.00
2.12
4.23


137.80
136.84
136.08
128.86
128.77
128.54
128.38
128.09
127.67
126.86
125.72
121.90
119.12
119.08
118.46
114.76
109.80
72.34
67.65
49.96
33.27
25.41
24.53
OBn
CN
N
Bn
6
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


ch11-243 500
7.520
7.505
7.369
7.358
7.343
7.329
7.285
7.241
7.232
7.216
7.183
7.169
7.154
7.138
7.137
7.123
7.109
7.087
7.073
5.379
4.837
4.814
4.504
4.481
4.182
4.171
4.159
2.848
2.837
1.947
1.933
1.919
1.905
OBn
CN
Cl
N
Bn
7
9
8
7
6
5
4
3
2
1
ppm
0.90
4.04
1.31
1.95
0.97
0.95
1.70
2.00
0.99
1.01
0.95
2.10
4.18

ch11-243 C13 300

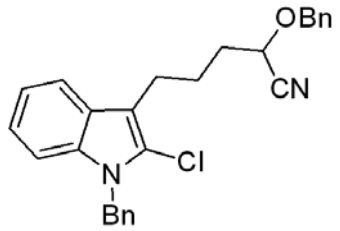
137.25
136.11
135.62
128.88
128.78
128.55
128.40
127.62
126.85
126.54
123.59
122.26
120.16
118.44
118.42
110.95
109.86

72.35
67.60

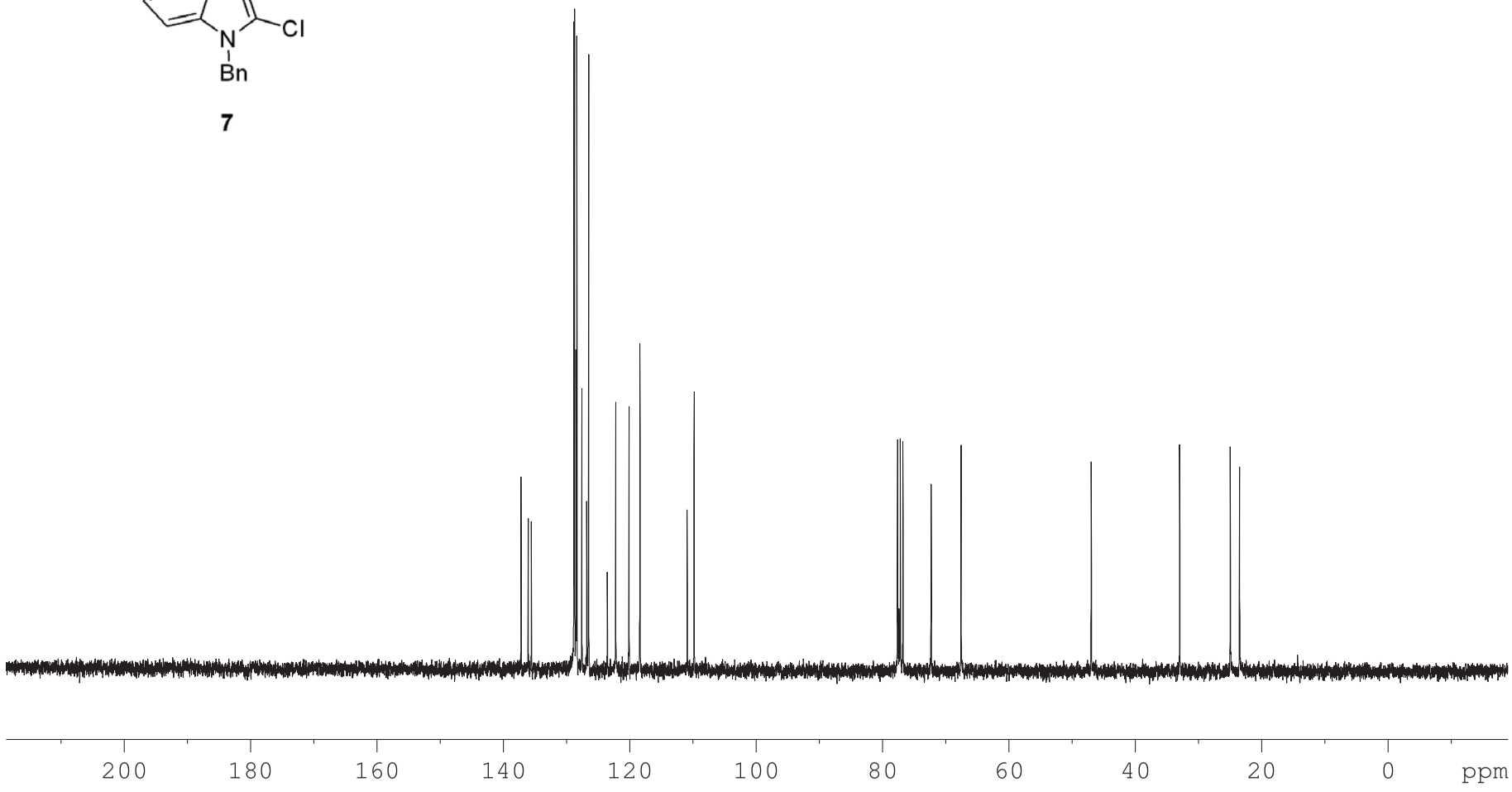
47.02

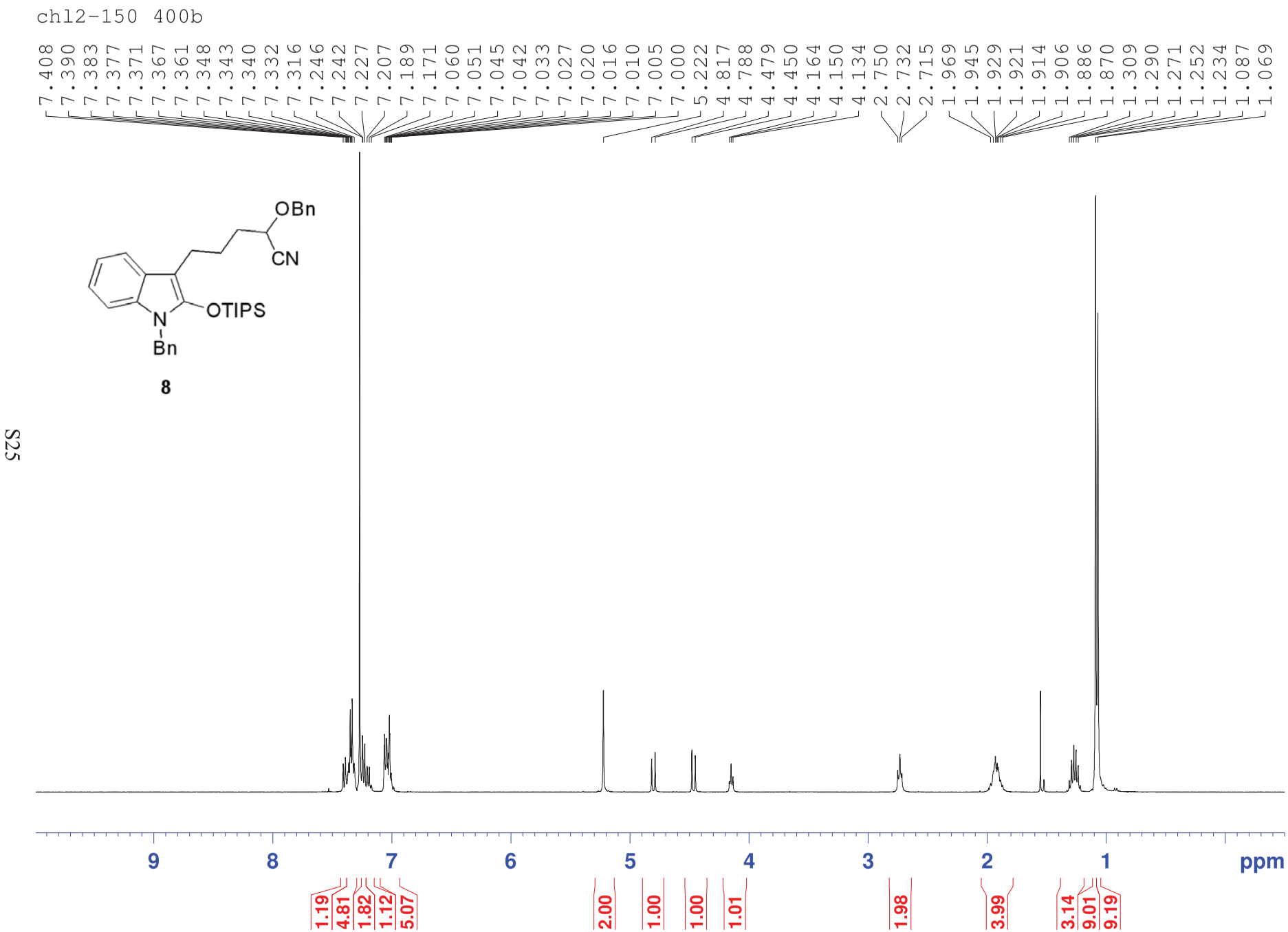
33.02

25.02
23.54



7




ch12-150 400b
7.408
7.390
7.383
7.377
7.371
7.367
7.361
7.348
7.343
7.340
7.332
7.316
7.246
7.242
7.227
7.207
7.189
7.171
7.060
7.051
7.045
7.042
7.033
7.027
7.020
7.016
7.010
7.005
7.000
5.222
4.817
4.788
4.479
4.450
4.164
4.150
4.134
2.750
2.732
2.715
1.969
1.945
1.929
1.921
1.914
1.906
1.886
1.870
1.309
1.290
1.271
1.252
1.234
1.087
1.069
OBn
CN
OTIPS
N
Bn
8
9
8
7
6
5
4
3
2
1
ppm
1.19
4.81
1.82
1.12
5.07
2.00
1.00
1.00
1.01
1.98
3.99
3.14
9.01
9.19

ch12-150 C13 400b

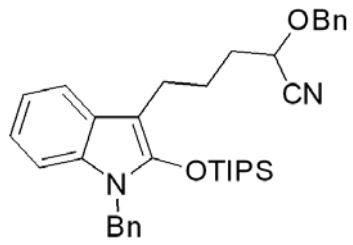
145.20
137.79
136.13
131.58
128.63
128.59
128.35
128.18
127.38
127.13
126.31
119.68
119.41
118.38
117.51
109.18
93.14

72.18
67.76

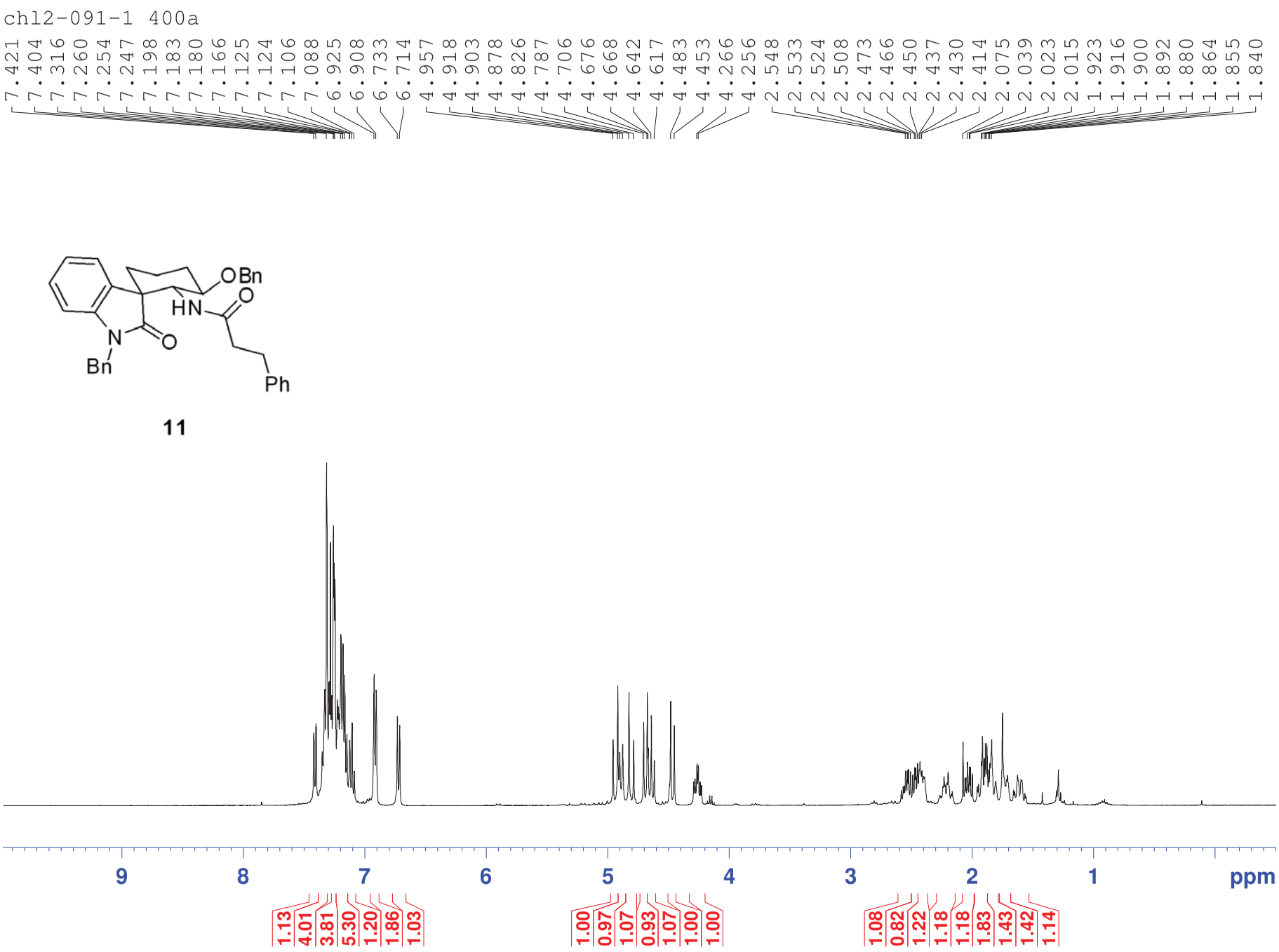
45.12

33.54

25.47
23.17
17.94
13.81

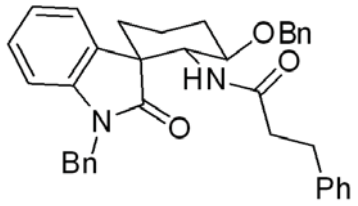


8


ch12-091-1 400a
7.421
7.404
7.316
7.260
7.254
7.247
7.198
7.183
7.180
7.166
7.125
7.124
7.106
7.088
6.925
6.908
6.733
6.714
4.957
4.918
4.903
4.878
4.826
4.787
4.706
4.676
4.668
4.642
4.617
4.483
4.453
4.266
4.256
2.548
2.533
2.524
2.508
2.473
2.466
2.450
2.437
2.430
2.414
2.075
2.039
2.023
2.015
1.923
1.916
1.900
1.892
1.880
1.864
1.855
1.840
OBn
HN
O
N
O
Bn
Ph
11
9
8
7
6
5
4
3
2
1
ppm
1.13
4.01
3.81
5.30
1.20
1.86
1.03
1.00
0.97
1.07
0.93
1.07
1.00
1.00
1.08
0.82
1.22
1.18
1.18
1.83
1.43
1.42
1.14

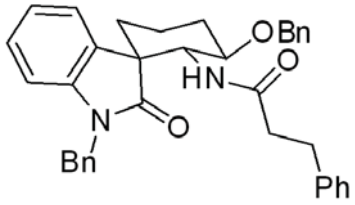
ch12-091-1 C13 400a

178.69
171.87
141.98
141.09
139.17
136.34
131.78
129.03
128.52
128.47
128.21
128.15
127.92
127.71
127.58
127.35
126.12
123.93
123.32
108.57
76.34
70.92
55.38
54.43
43.59
38.07
35.18
31.30
30.97
19.03

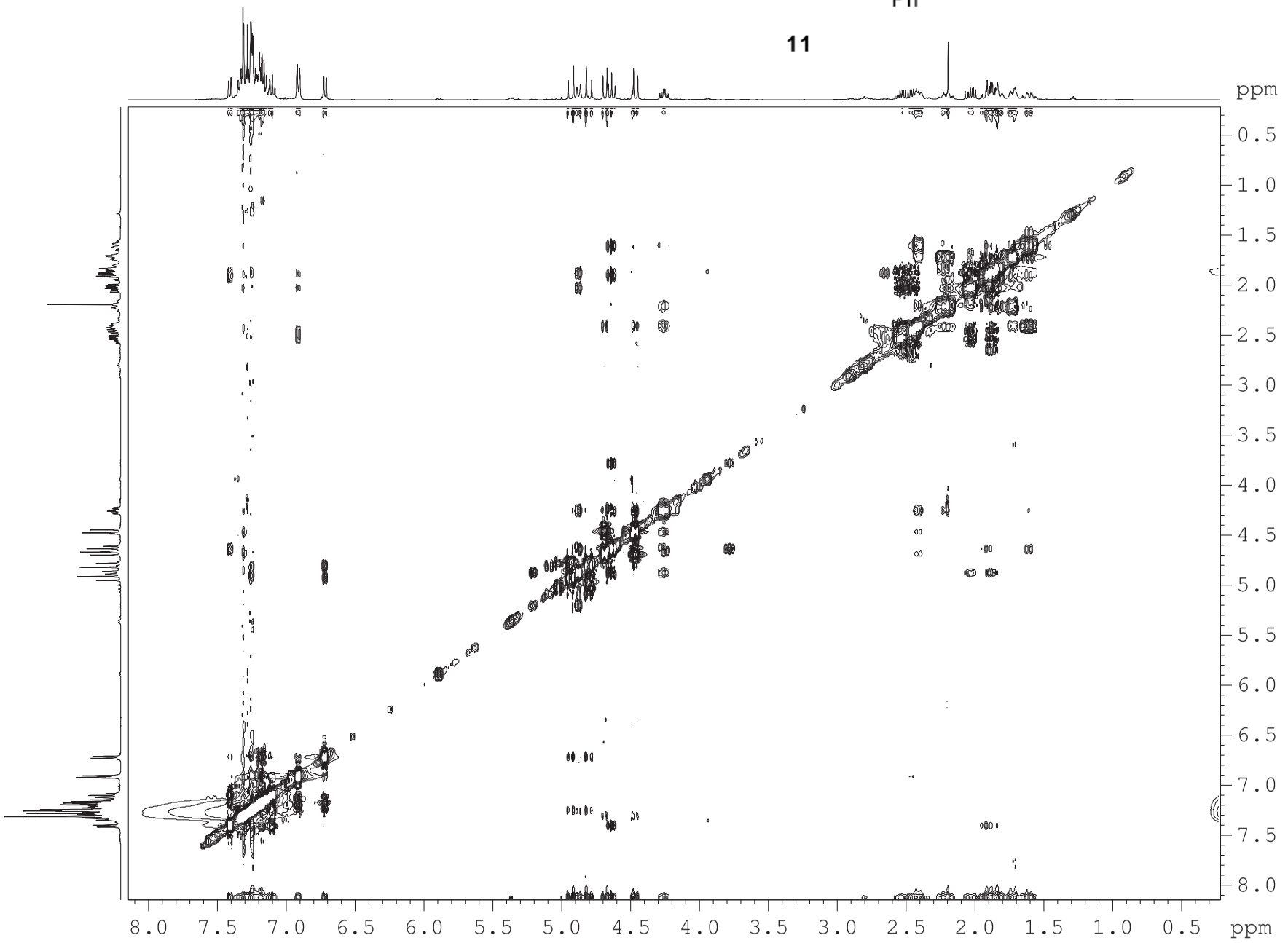


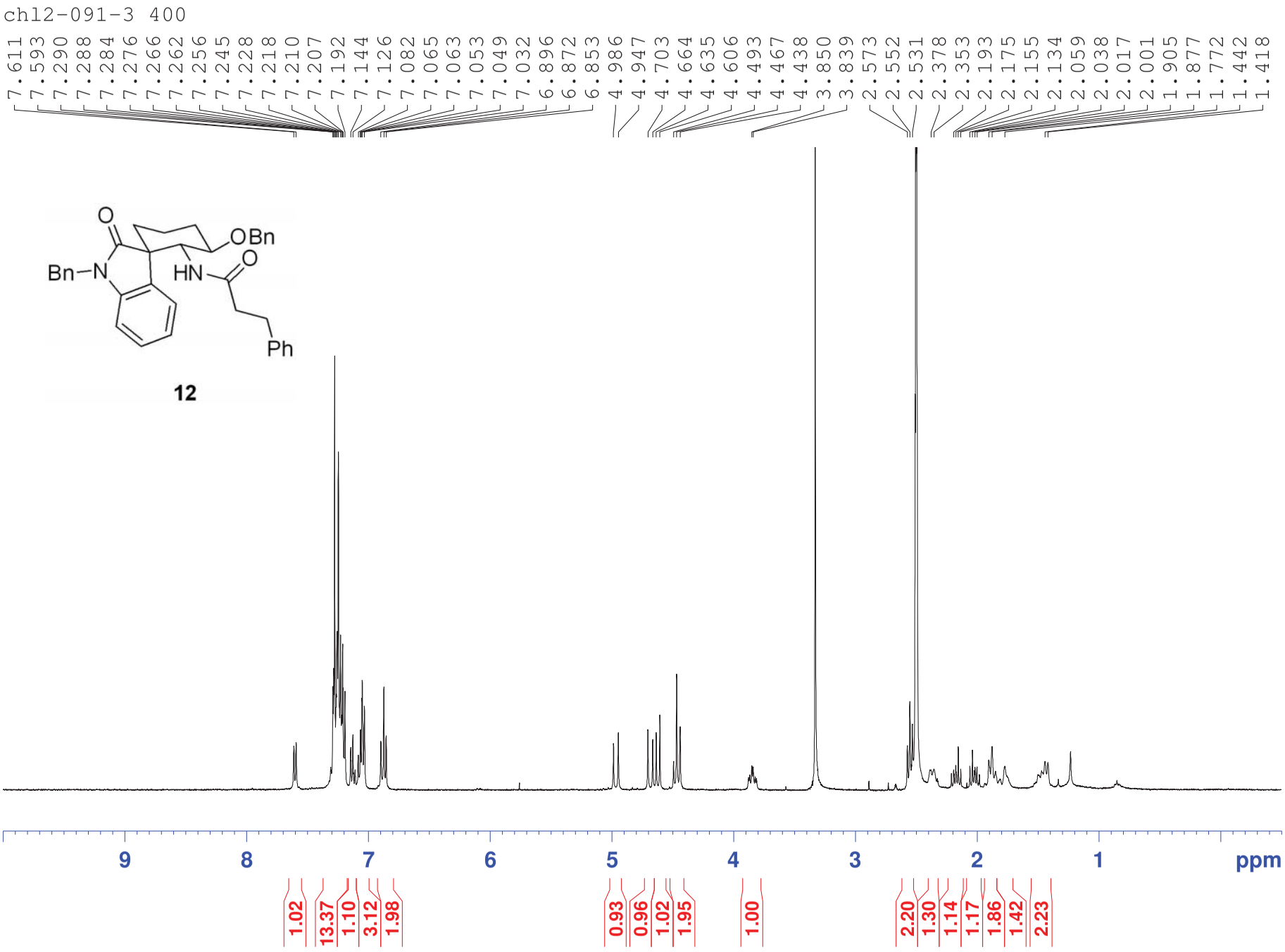
11

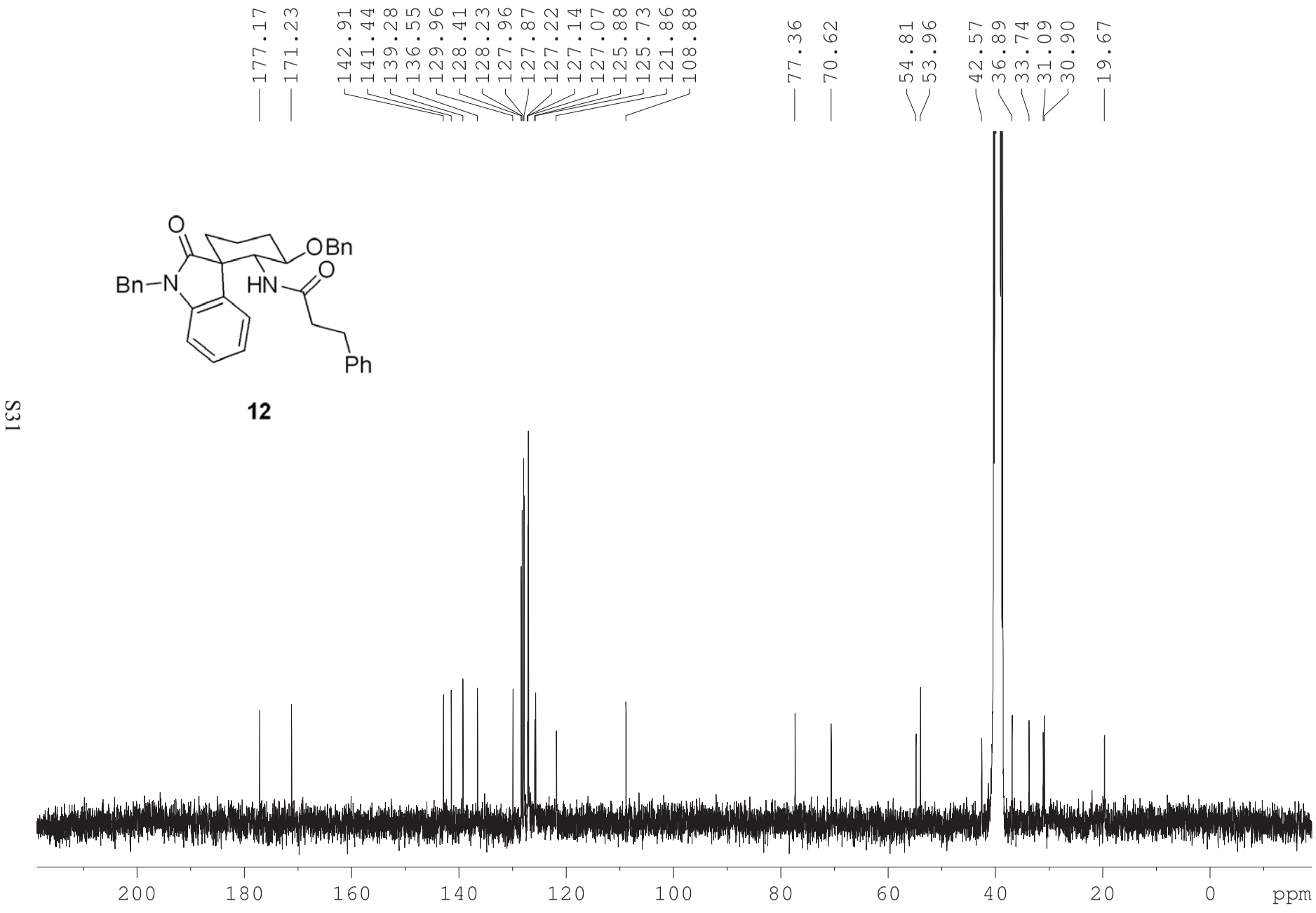
ch12-169 NOESY 400a

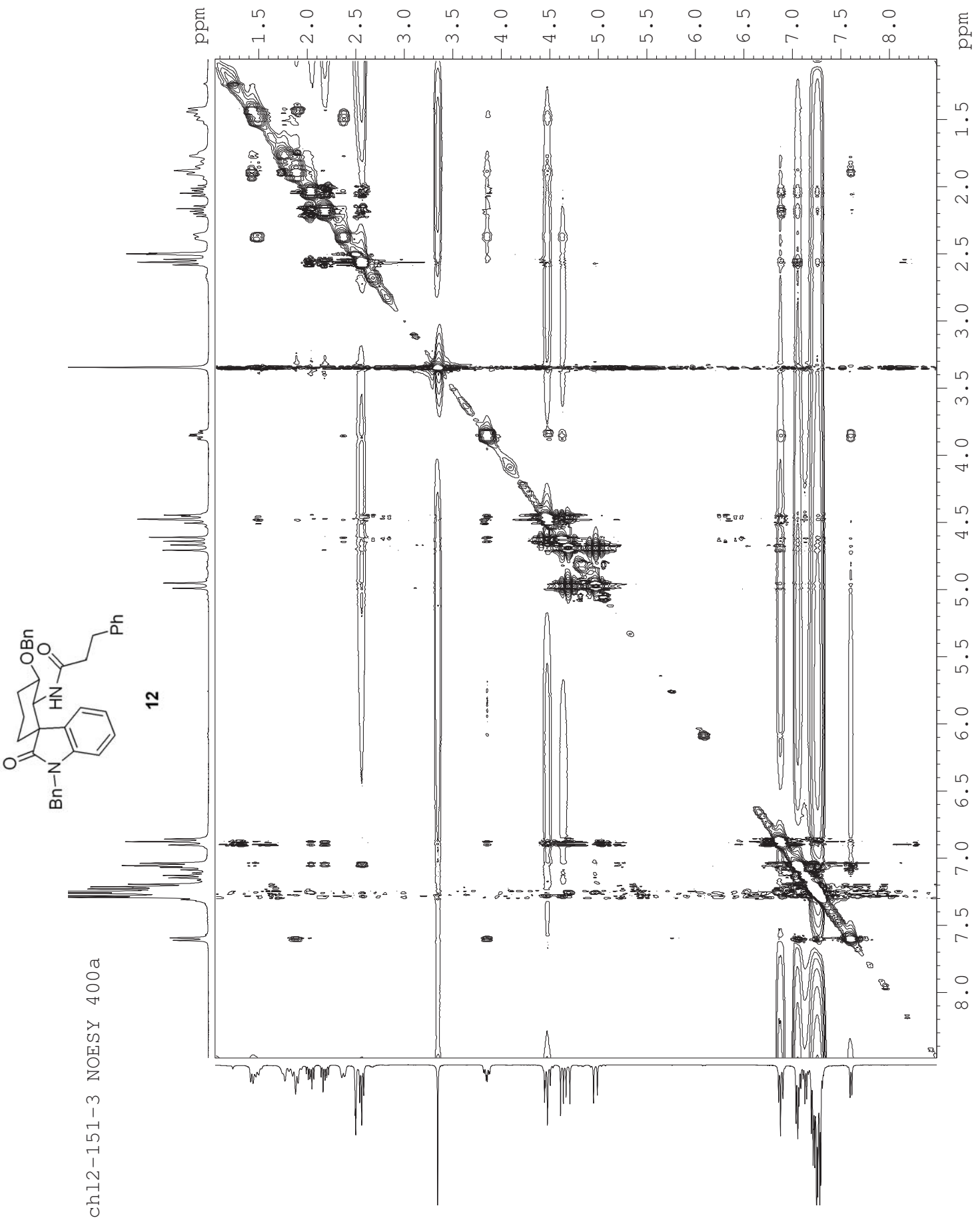


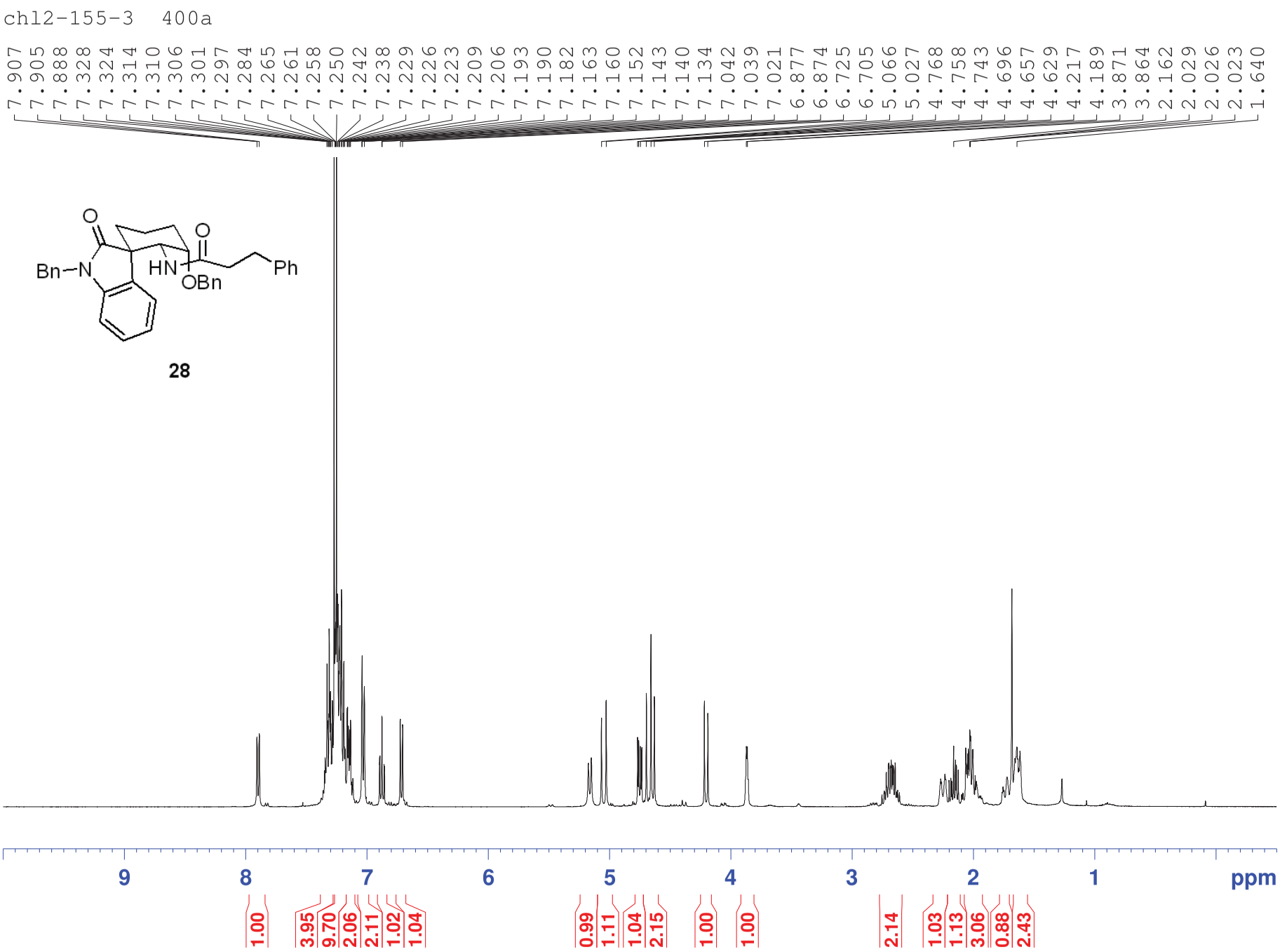
11

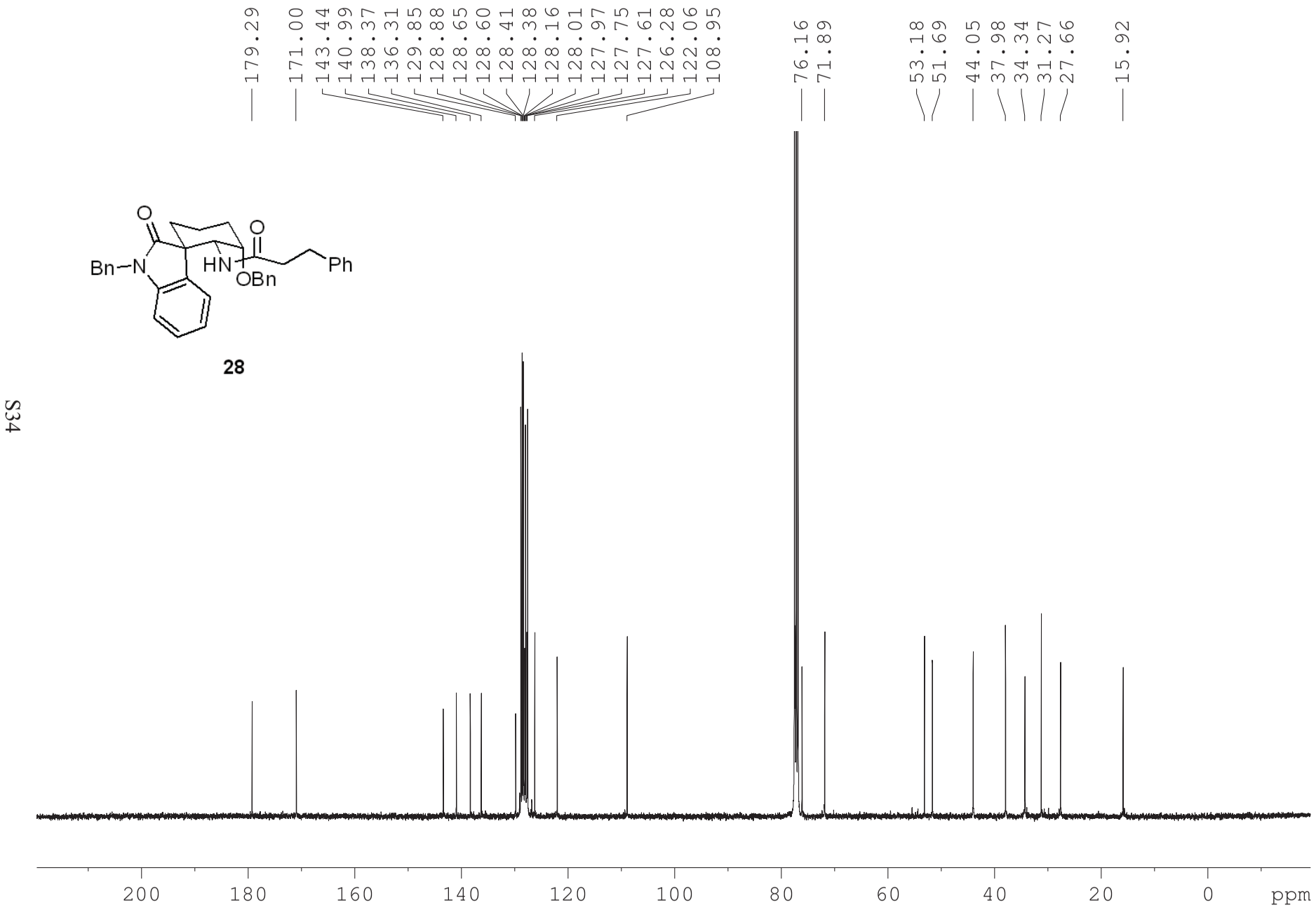



ch12-091-3 400
7.611
7.593
7.290
7.288
7.284
7.276
7.266
7.262
7.256
7.245
7.228
7.218
7.210
7.207
7.192
7.144
7.126
7.082
7.065
7.063
7.053
7.049
7.032
6.896
6.872
6.853
4.986
4.947
4.703
4.664
4.635
4.606
4.493
4.467
4.438
3.850
3.839
2.573
2.552
2.531
2.378
2.353
2.193
2.175
2.155
2.134
2.059
2.038
2.017
2.001
1.905
1.877
1.772
1.442
1.418
O
OBn
Bn–N
HN
O
Ph
12
9
8
7
6
5
4
3
2
1
ppm
1.02
13.37
1.10
3.12
1.98
0.93
0.96
1.02
1.95
1.00
2.20
1.30
1.14
1.17
1.86
1.42
2.23

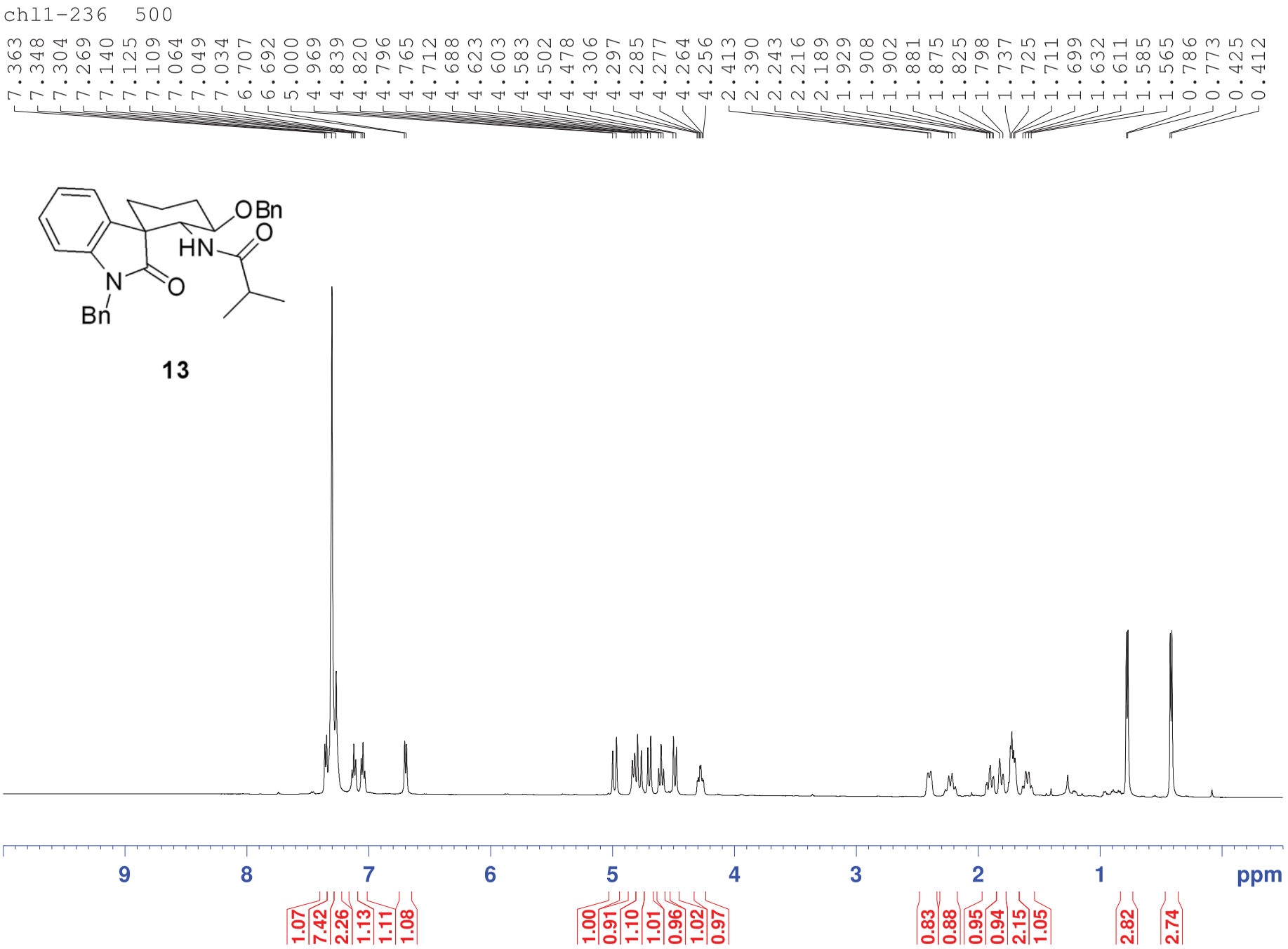

ch12-091-3 C13 300
177.17
171.23
142.91
141.44
139.28
136.55
129.96
128.41
128.23
127.96
127.87
127.22
127.14
127.07
125.88
125.73
121.86
108.88
77.36
70.62
54.81
53.96
42.57
36.89
33.74
31.09
30.90
19.67
O
OBn
Bn–N
HN
O
Ph
12
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-151-3 NOESY 400a
12
OBn
Ph
HN
Bn–N
ppm
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0


ch12-155-3 400a
7.907
7.905
7.888
7.328
7.324
7.314
7.310
7.306
7.301
7.297
7.284
7.265
7.261
7.258
7.250
7.242
7.238
7.229
7.226
7.223
7.209
7.206
7.193
7.190
7.182
7.163
7.160
7.152
7.143
7.140
7.134
7.042
7.039
7.021
6.877
6.874
6.725
6.705
5.066
5.027
4.768
4.758
4.743
4.696
4.657
4.629
4.217
4.189
3.871
3.864
2.162
2.029
2.026
2.023
1.640
Bn
N
HN
OBn
Ph
O
O
28
9
8
7
6
5
4
3
2
1
ppm
1.00
3.95
9.70
2.06
2.11
1.02
1.04
0.99
1.11
1.04
2.15
1.00
1.00
2.14
1.03
1.13
3.06
0.88
2.43

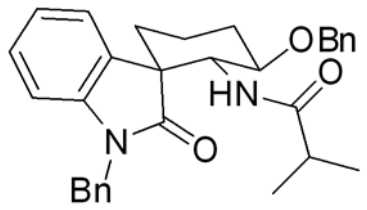

ch12-155-3 C13 400a
179.29
171.00
143.44
140.99
138.37
136.31
129.85
128.88
128.65
128.60
128.41
128.38
128.16
128.01
127.97
127.75
127.61
126.28
122.06
108.95
76.16
71.89
53.18
51.69
44.05
37.98
34.34
31.27
27.66
15.92
Bn
N
HN
OBn
Ph
28
200
180
160
140
120
100
80
60
40
20
0
ppm

ch12-155-3 NOESY 400a
Bn–N
HN
OBn
Ph
O
O
O
28
ppm
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
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
ppm


ch11-236 500
7.363
7.348
7.304
7.269
7.140
7.125
7.109
7.064
7.049
7.034
6.707
6.692
5.000
4.969
4.839
4.820
4.796
4.765
4.712
4.688
4.623
4.603
4.583
4.502
4.478
4.306
4.297
4.285
4.277
4.264
4.256
2.413
2.390
2.243
2.216
2.189
1.929
1.908
1.902
1.881
1.875
1.825
1.798
1.737
1.725
1.711
1.699
1.632
1.611
1.585
1.565
0.786
0.773
0.425
0.412
OBn
O
HN
N
O
Bn
13
9
8
7
6
5
4
3
2
1
ppm
1.07
7.42
2.26
1.13
1.11
1.08
1.00
0.91
1.10
1.01
0.96
1.02
0.97
0.83
0.88
0.95
0.94
2.15
1.05
2.82
2.74

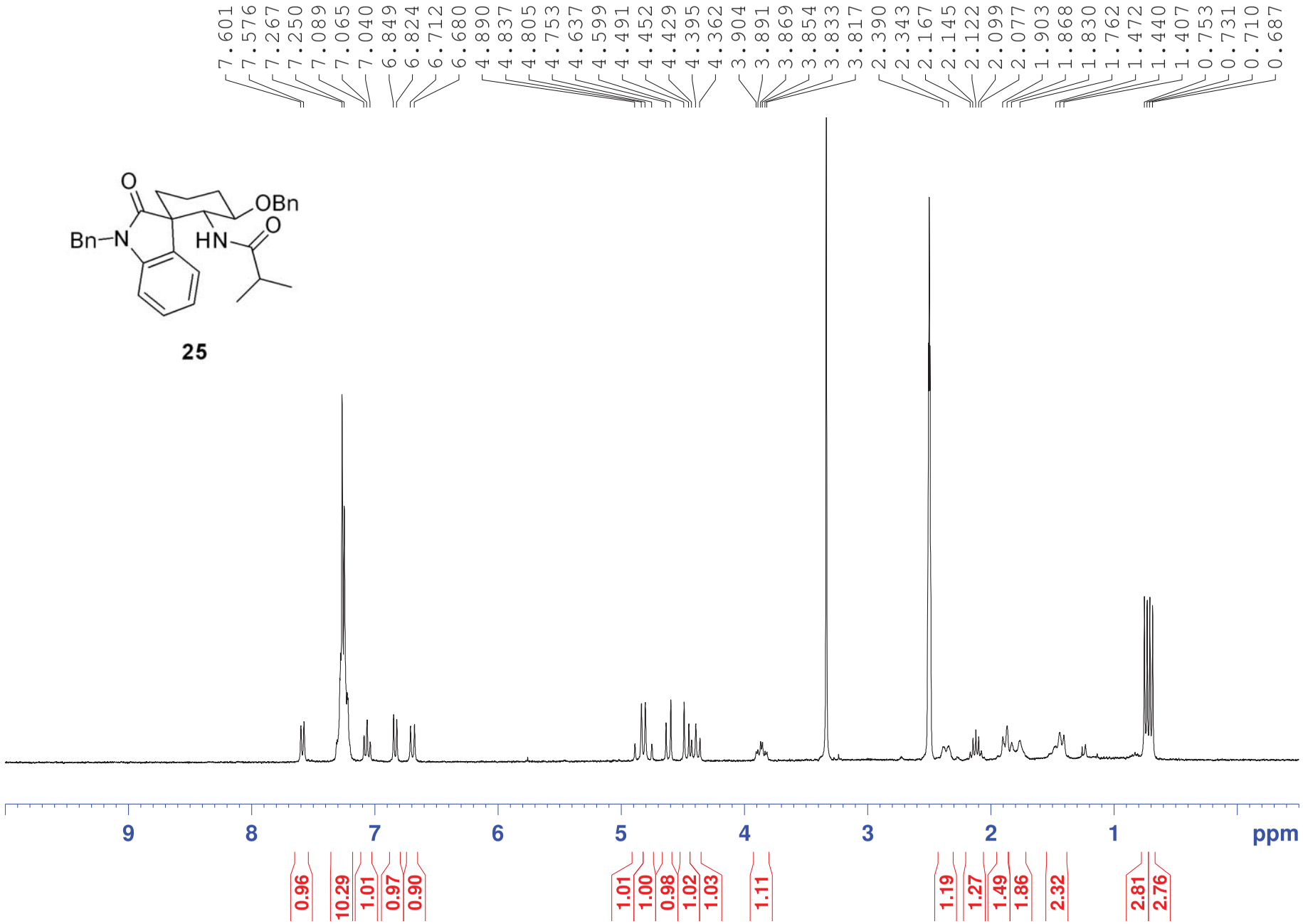
ch11-236-1 C13 301

178.750
176.558
141.978
139.158
136.431
131.641
129.025
128.406
127.967
127.707
127.580
127.528
124.037
123.272
108.352
76.160
70.951
54.971
54.563
43.649
35.855
34.917
31.068
19.630
19.062
18.936



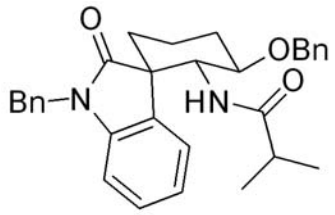
13

200 180 160 140 120 100 80 60 40 20 0 ppm

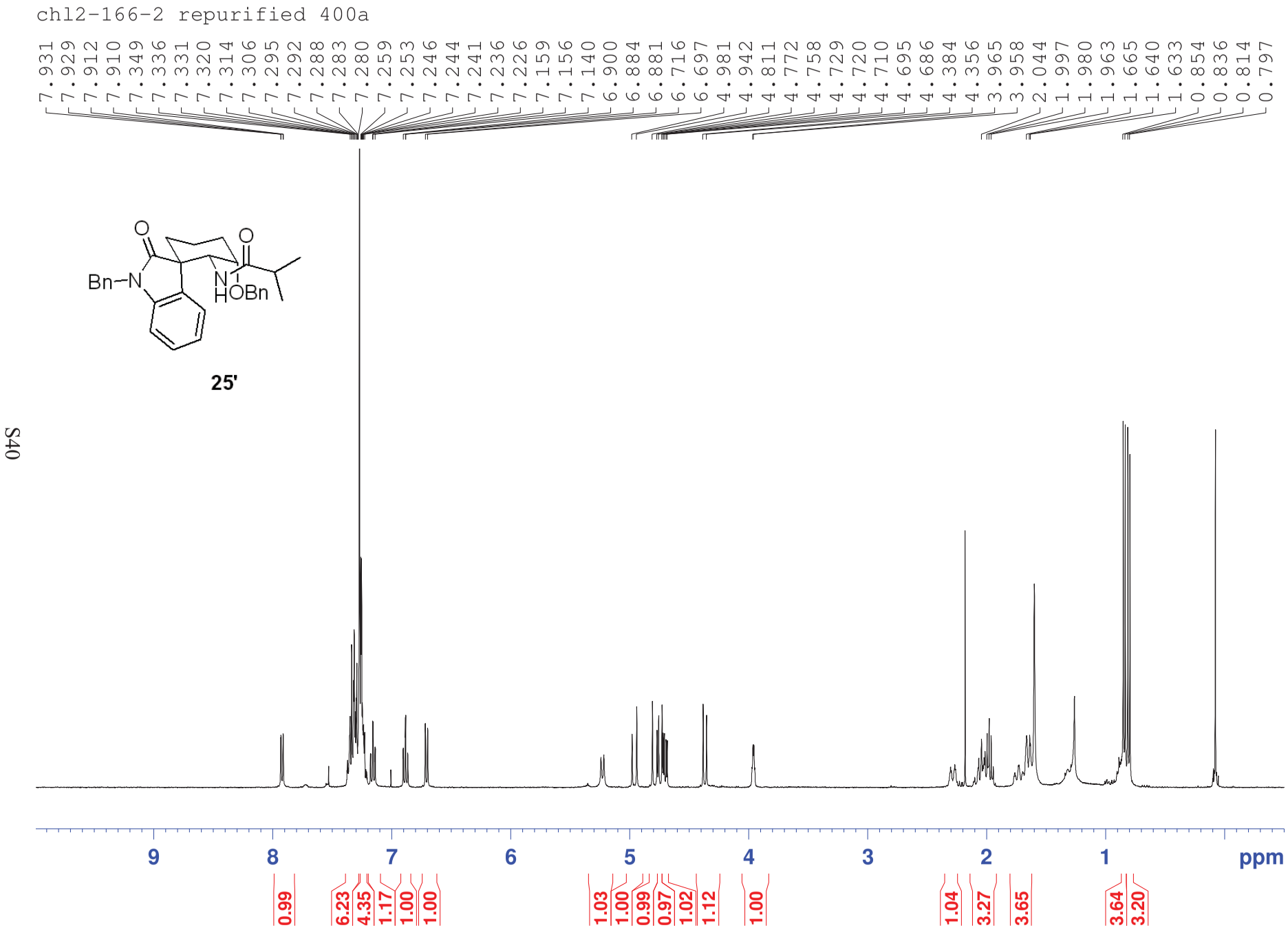

ch11-236-2 301
7.601
7.576
7.267
7.250
7.089
7.065
7.040
6.849
6.824
6.712
6.680
4.890
4.837
4.805
4.753
4.637
4.599
4.491
4.452
4.429
4.395
4.362
3.904
3.891
3.869
3.854
3.833
3.817
2.390
2.343
2.167
2.145
2.122
2.099
2.077
1.903
1.868
1.830
1.762
1.472
1.440
1.407
0.753
0.731
0.710
0.687
O
OBn
Bn–N
HN
O
25
9
8
7
6
5
4
3
2
1
ppm
0.96
10.29
1.01
0.97
0.90
1.01
1.00
0.98
1.02
1.03
1.11
1.19
1.27
1.49
1.86
2.32
2.81
2.76

ch11-236-2 C13 300

177.19
175.60
142.96
139.20
136.40
129.97
128.45
127.91
127.87
127.19
127.02
126.97
125.86
121.77
108.76
77.13
70.46
54.37
54.09
42.65
33.80
33.53
30.99
19.77
19.64
18.93

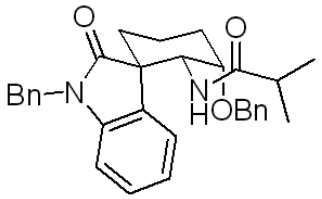


25


ch12-166-2 repurified 400a
7.931
7.929
7.912
7.910
7.349
7.336
7.331
7.320
7.314
7.306
7.295
7.292
7.288
7.283
7.280
7.259
7.253
7.246
7.244
7.241
7.236
7.226
7.159
7.156
7.140
6.900
6.884
6.881
6.716
6.697
4.981
4.942
4.811
4.772
4.758
4.729
4.720
4.710
4.695
4.686
4.384
4.356
3.965
3.958
2.044
1.997
1.980
1.963
1.665
1.640
1.633
0.854
0.836
0.814
0.797
Bn–N
O
O
N
HOBn
25'
9
8
7
6
5
4
3
2
1
ppm
0.99
6.23
4.35
1.17
1.00
1.00
1.03
1.00
0.99
0.97
1.02
1.12
1.00
1.04
3.27
3.65
3.64
3.20

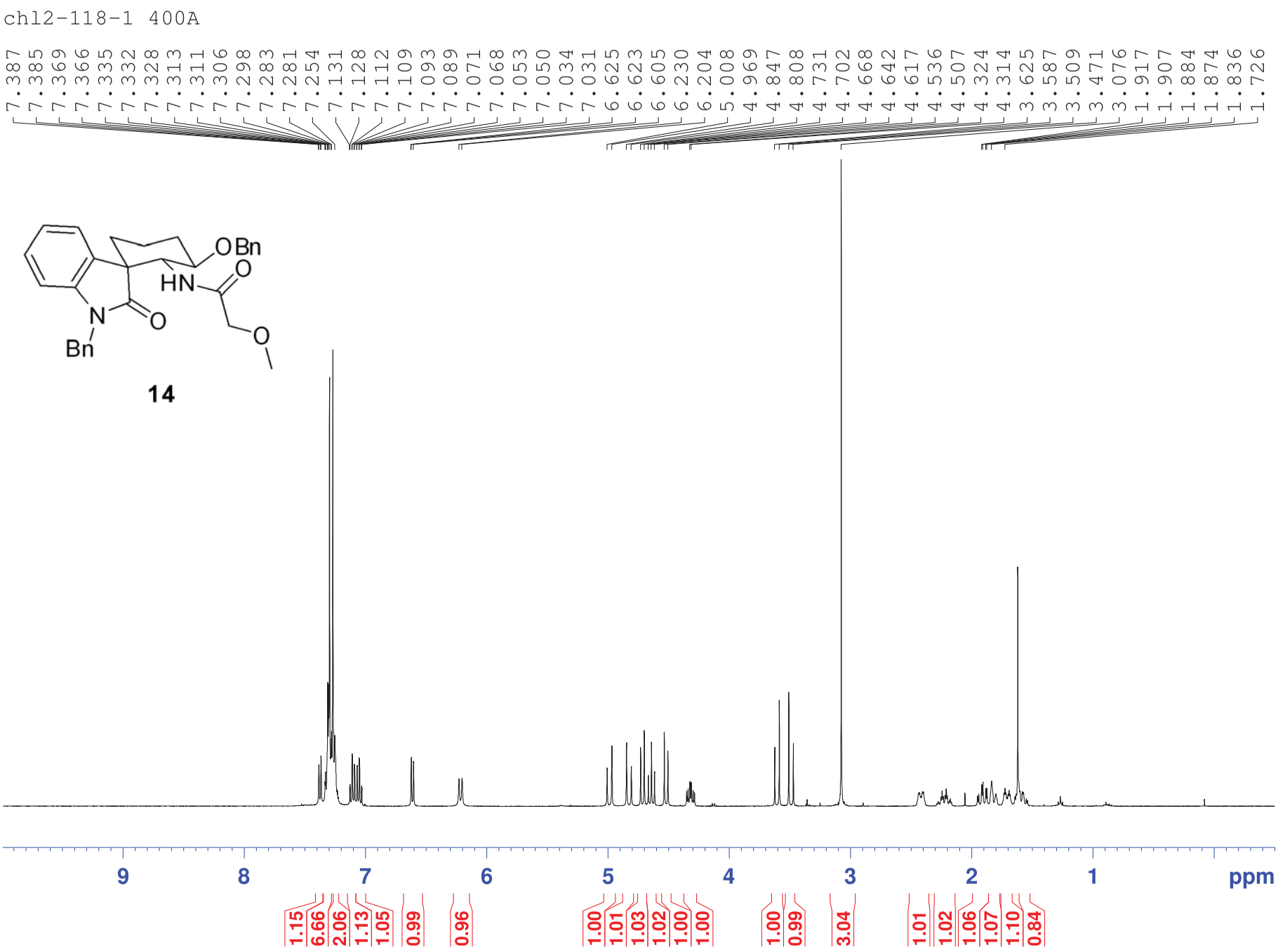
ch12-166-2 C13 400a

179.40
175.72
143.53
138.35
136.26
129.97
128.88
128.68
128.36
128.07
128.00
127.96
127.73
127.59
122.02
108.93
76.04
71.99
53.25
51.39
44.15
35.47
34.31
27.57
19.54
19.42
15.94



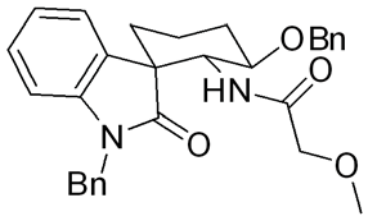
25'

200 180 160 140 120 100 80 60 40 20 0 ppm

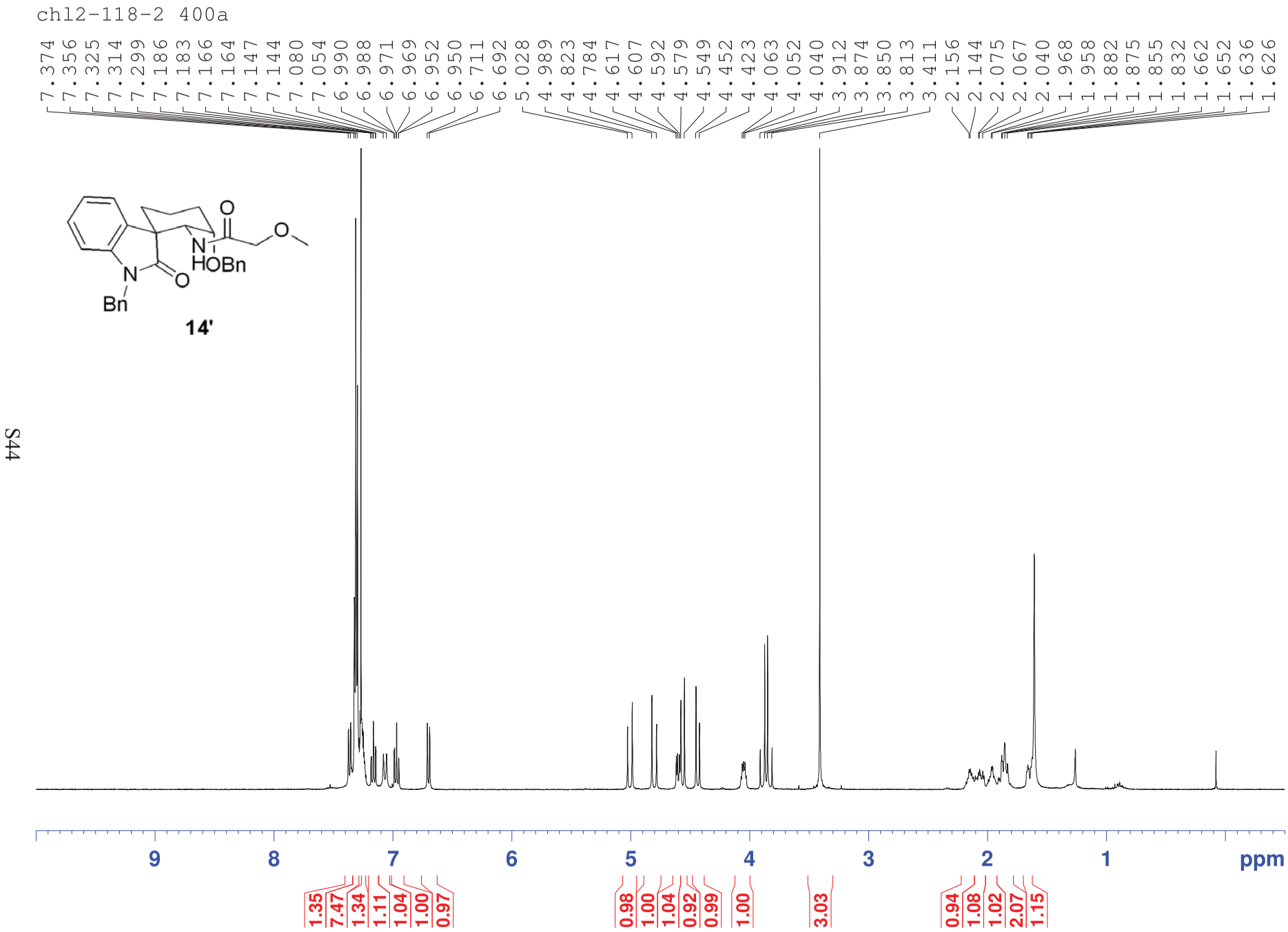

ch12-118-1 400A
7.387
7.385
7.369
7.366
7.335
7.332
7.328
7.313
7.311
7.306
7.298
7.283
7.281
7.254
7.131
7.128
7.112
7.109
7.093
7.089
7.071
7.068
7.053
7.050
7.034
7.031
6.625
6.623
6.605
6.230
6.204
5.008
4.969
4.847
4.808
4.731
4.702
4.668
4.642
4.617
4.536
4.507
4.324
4.314
3.625
3.587
3.509
3.471
3.076
1.917
1.907
1.884
1.874
1.836
1.726
OBn
O
HN
N
O
Bn
O
14
9
8
7
6
5
4
3
2
1
ppm
1.15
6.66
2.06
1.13
1.05
0.99
0.96
1.00
1.01
1.03
1.02
1.00
1.00
1.00
0.99
3.04
1.01
1.02
1.06
1.07
1.10
0.84

ch12-118-1 C13 400a

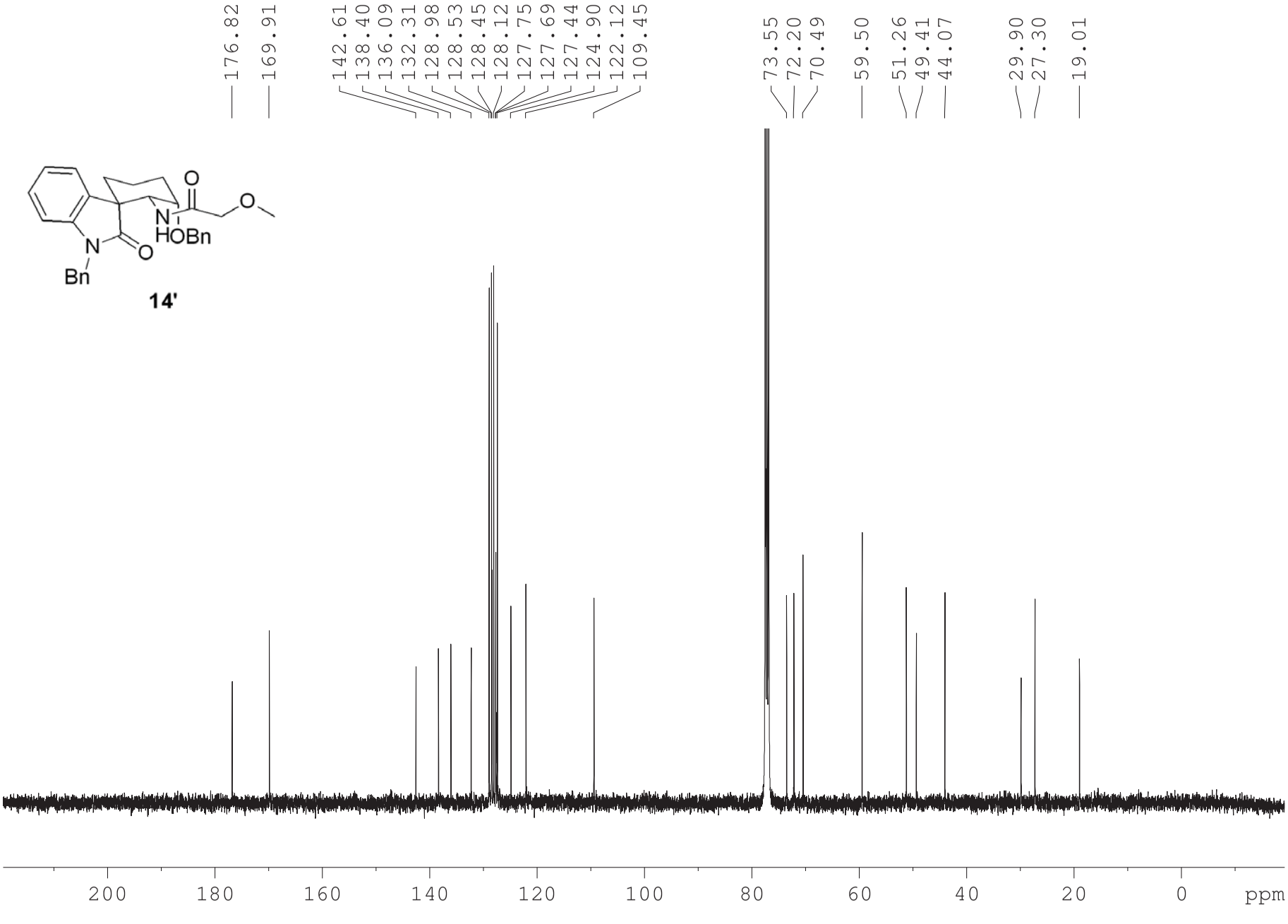
178.31
169.45
141.88
139.01
135.79
131.56
128.81
128.23
127.99
127.60
127.27
127.22
127.09
123.45
123.08
108.64
71.65
71.21
58.82
54.84
54.16
43.56
35.50
30.93
18.82



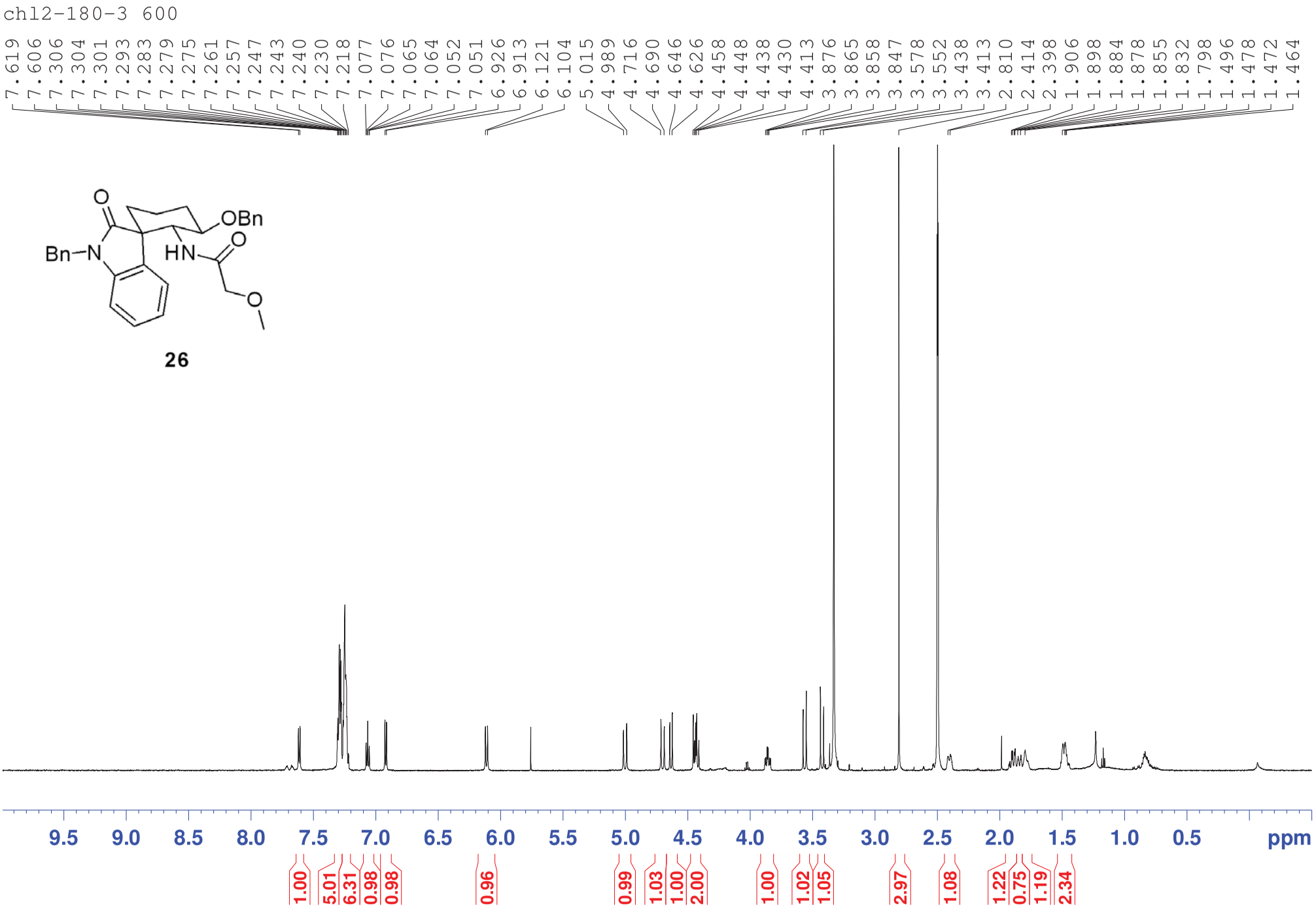
14

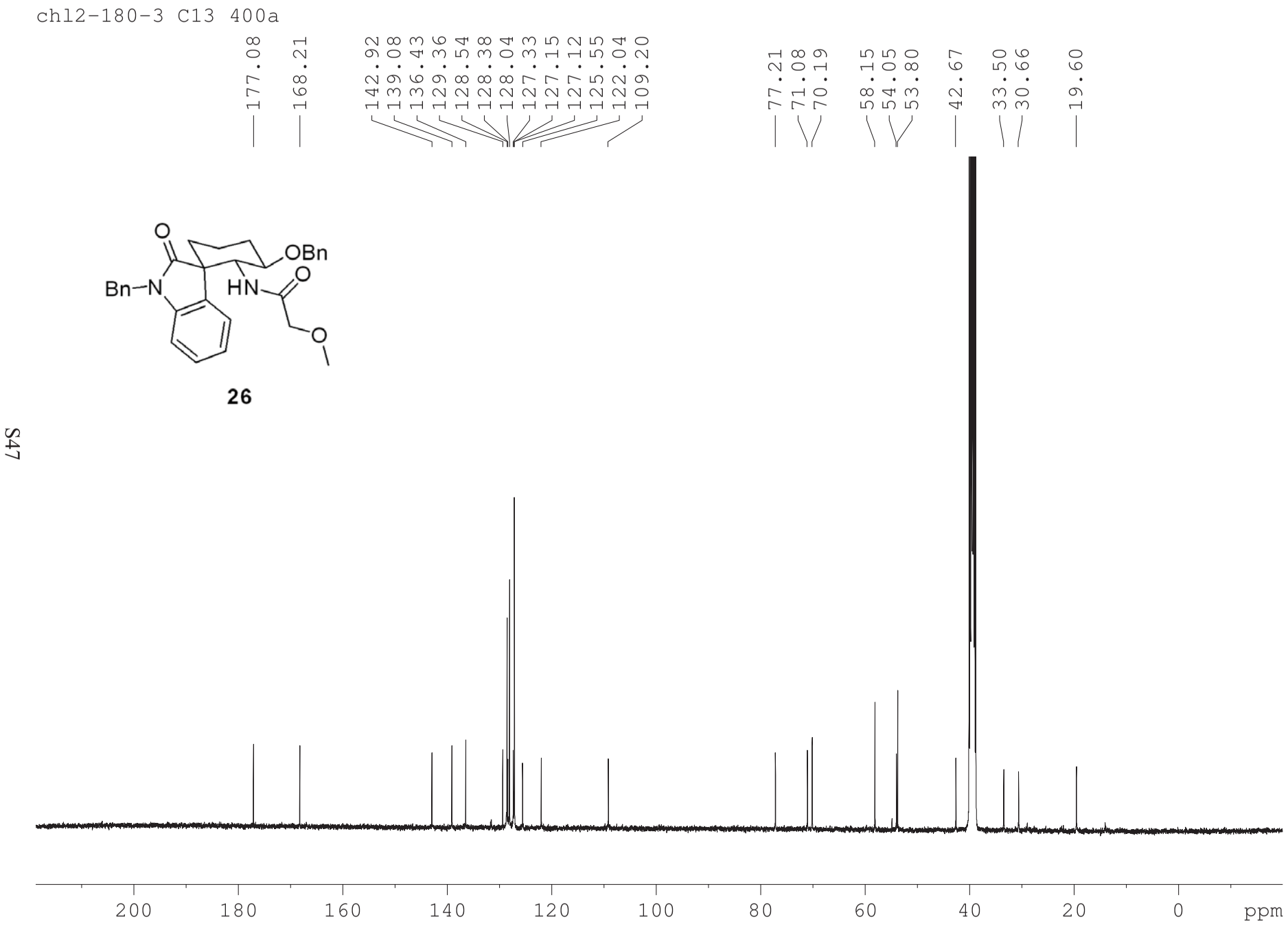

ch12-118-2 400a
7.374
7.356
7.325
7.314
7.299
7.186
7.183
7.166
7.164
7.147
7.144
7.080
7.054
6.990
6.988
6.971
6.969
6.952
6.950
6.711
6.692
5.028
4.989
4.823
4.784
4.617
4.607
4.592
4.579
4.549
4.452
4.423
4.063
4.052
4.040
3.912
3.874
3.850
3.813
3.411
2.156
2.144
2.075
2.067
2.040
1.968
1.958
1.882
1.875
1.855
1.832
1.662
1.652
1.636
1.626
O
O
N
HOBn
N
O
Bn
14'
9
8
7
6
5
4
3
2
1
ppm
1.35
7.47
1.34
1.11
1.04
1.00
0.97
0.98
1.00
1.04
0.92
0.99
1.00
3.03
0.94
1.08
1.02
2.07
1.15

ch12-118-2 C13

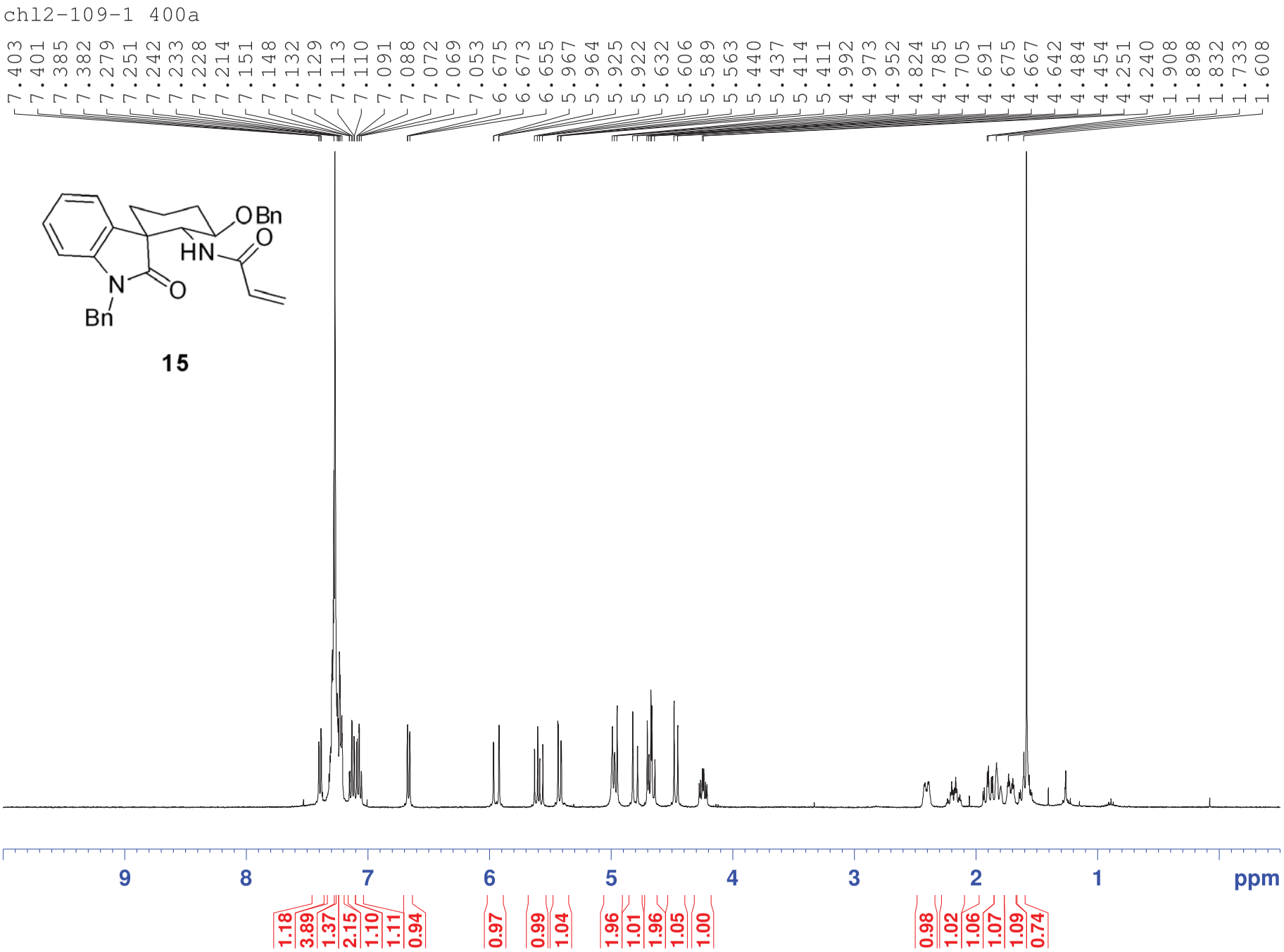


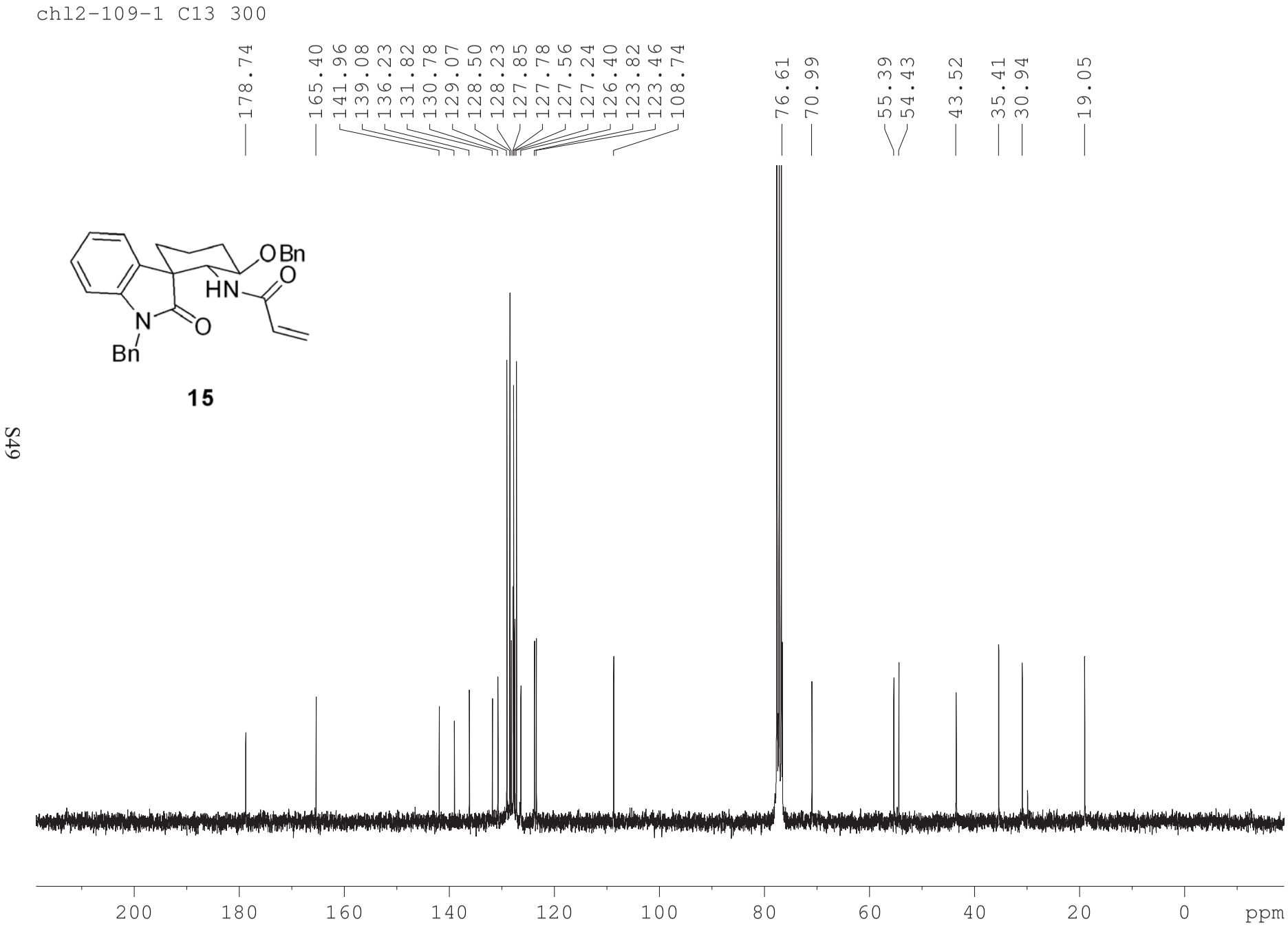
14'

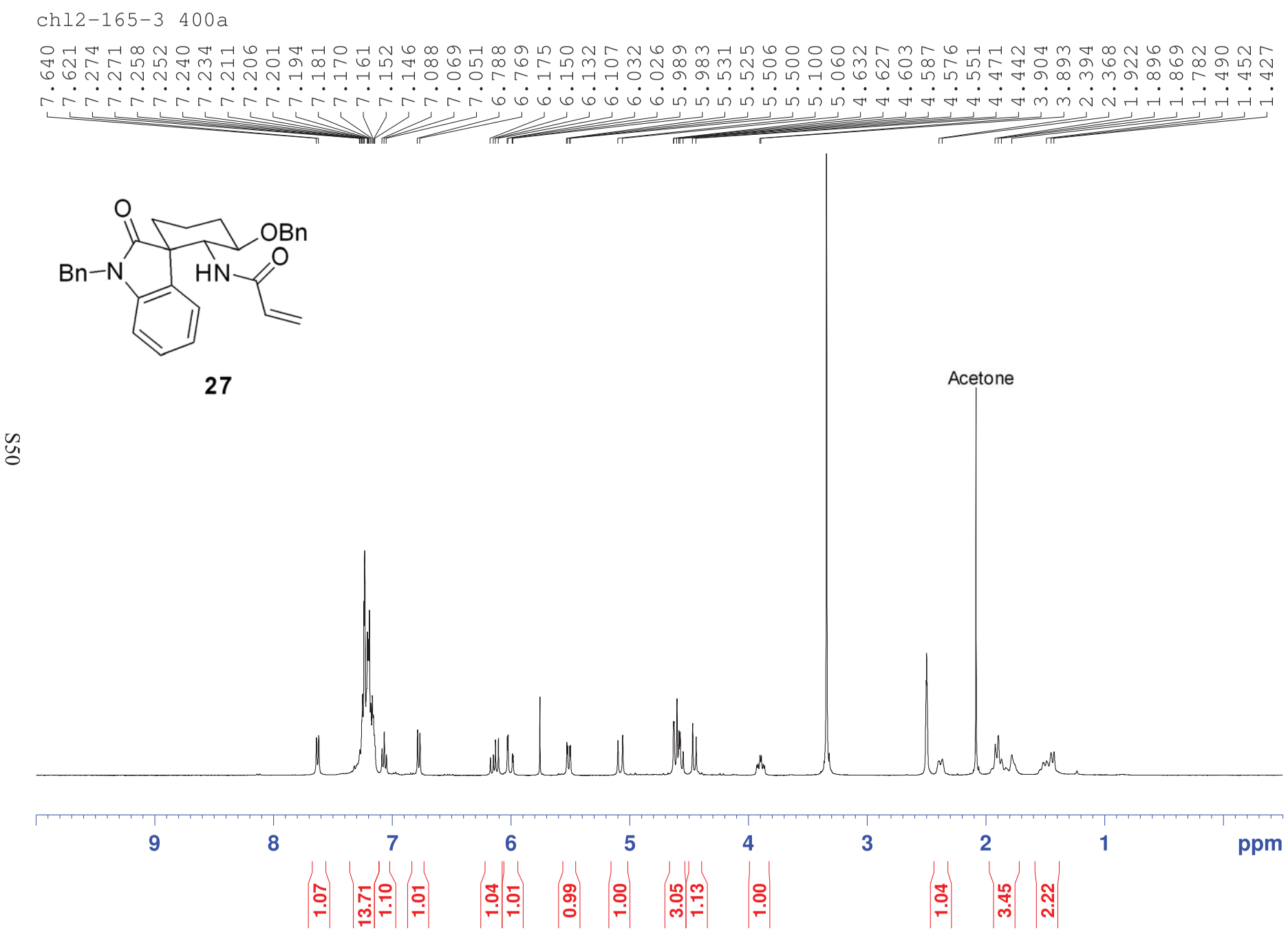

ch12-180-3 600
7.619
7.606
7.306
7.304
7.301
7.293
7.283
7.279
7.275
7.261
7.257
7.247
7.243
7.240
7.230
7.218
7.077
7.076
7.065
7.064
7.052
7.051
6.926
6.913
6.121
6.104
5.015
4.989
4.716
4.690
4.646
4.626
4.458
4.448
4.438
4.430
4.413
3.876
3.865
3.858
3.847
3.578
3.552
3.438
3.413
2.810
2.414
2.398
1.906
1.898
1.884
1.878
1.855
1.832
1.798
1.496
1.478
1.472
1.464
O
OBn
Bn–N
HN
O
O
26
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.00
5.01
6.31
0.98
0.98
0.96
0.99
1.03
1.00
2.00
1.00
1.02
1.05
2.97
1.08
1.22
0.75
1.19
2.34

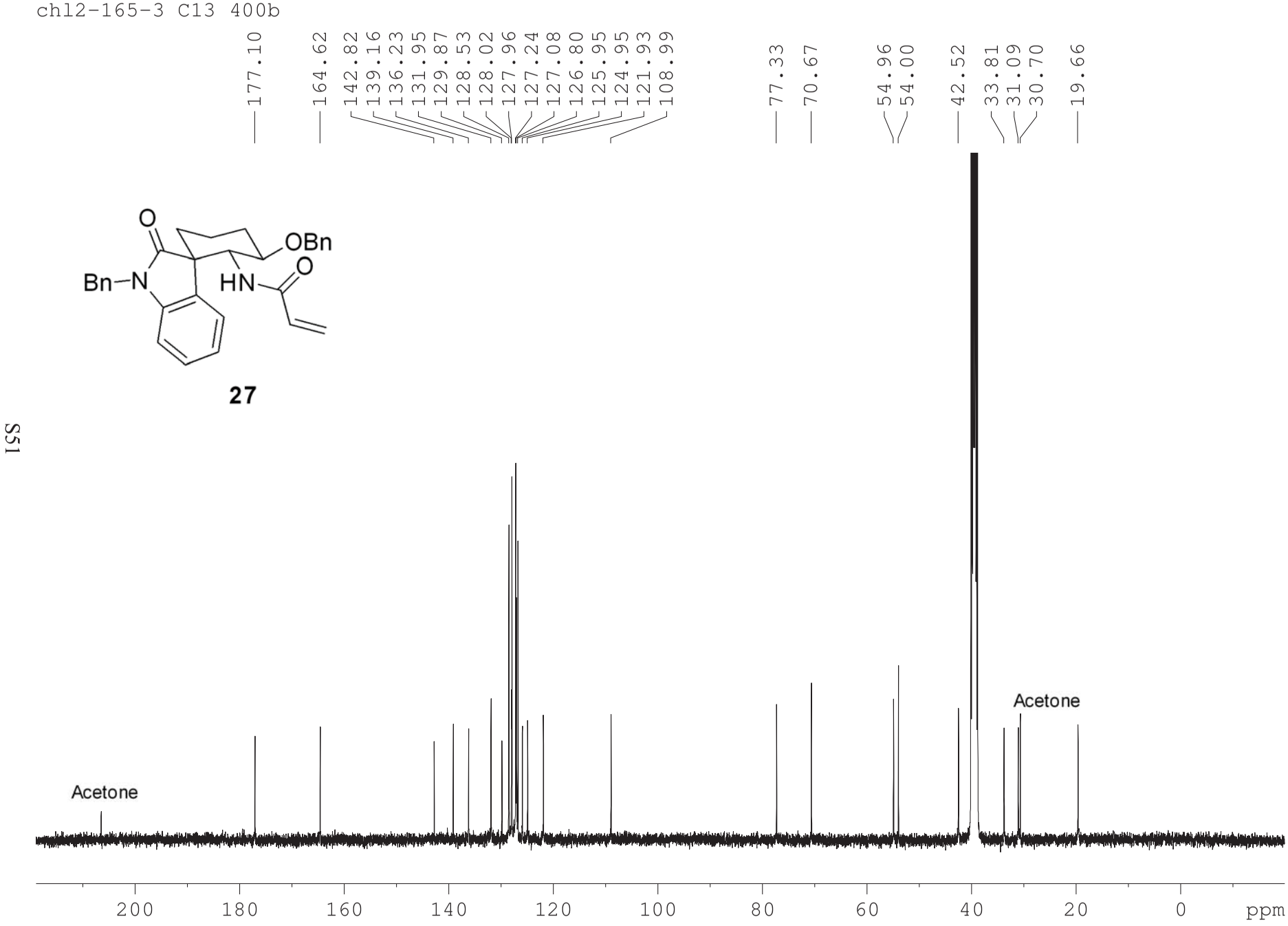

ch12-180-3 C13 400a
177.08
168.21
142.92
139.08
136.43
129.36
128.54
128.38
128.04
127.33
127.15
127.12
125.55
122.04
109.20
77.21
71.08
70.19
58.15
54.05
53.80
42.67
33.50
30.66
19.60
O
OBn
Bn–N
HN
O
O
200
180
160
140
120
100
80
60
40
20
0
ppm

26

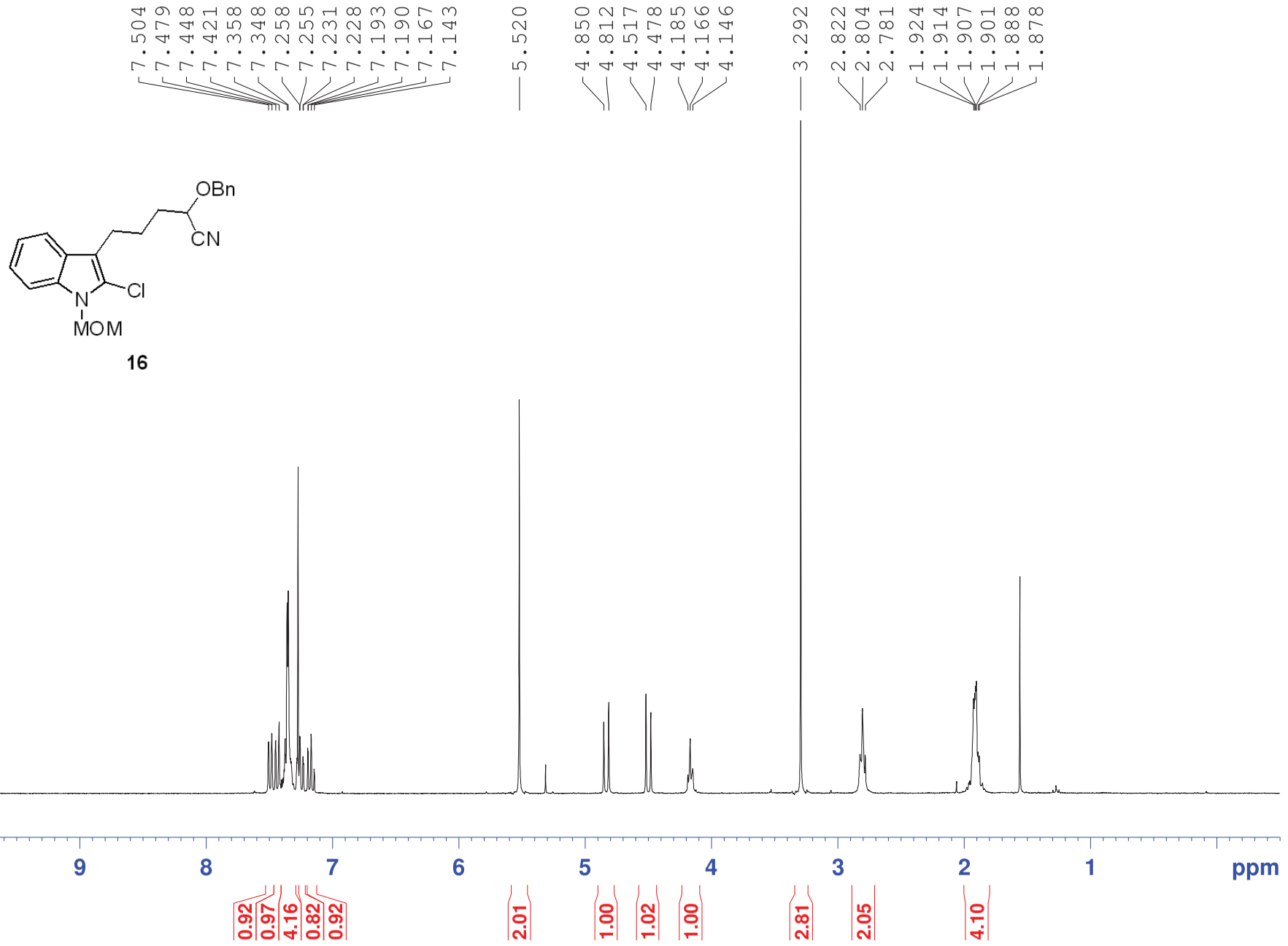

ch12-109-1 400a
7.403
7.401
7.385
7.382
7.279
7.251
7.242
7.233
7.228
7.214
7.151
7.148
7.132
7.129
7.113
7.110
7.091
7.088
7.072
7.069
7.053
6.675
6.673
6.655
5.967
5.964
5.925
5.922
5.632
5.606
5.589
5.563
5.440
5.437
5.414
5.411
4.992
4.973
4.952
4.824
4.785
4.705
4.691
4.675
4.667
4.642
4.484
4.454
4.251
4.240
1.908
1.898
1.832
1.733
1.608
OBn
O
HN
N
O
Bn
15
9
8
7
6
5
4
3
2
1
ppm
1.18
3.89
1.37
2.15
1.10
1.11
0.94
0.97
0.99
1.04
1.96
1.01
1.96
1.05
1.00
0.98
1.02
1.06
1.07
1.09
0.74


ch12-109-1 C13 300
178.74
165.40
141.96
139.08
136.23
131.82
130.78
129.07
128.50
128.23
127.85
127.78
127.56
127.24
126.40
123.82
123.46
108.74
76.61
70.99
55.39
54.43
43.52
35.41
30.94
19.05
OBn
O
HN
N
O
Bn
15
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-165-3 400a
7.640
7.621
7.274
7.271
7.258
7.252
7.240
7.234
7.211
7.206
7.201
7.194
7.181
7.170
7.161
7.152
7.146
7.088
7.069
7.051
6.788
6.769
6.175
6.150
6.132
6.107
6.032
6.026
5.989
5.983
5.531
5.525
5.506
5.500
5.100
5.060
4.632
4.627
4.603
4.587
4.576
4.551
4.471
4.442
3.904
3.893
2.394
2.368
1.922
1.896
1.869
1.782
1.490
1.452
1.427
O
OBn
Bn
N
HN
O
27
Acetone
9
8
7
6
5
4
3
2
1
ppm
1.07
13.71
1.10
1.01
1.04
1.01
0.99
1.00
3.05
1.13
1.00
1.04
3.45
2.22


ch12-165-3 C13 400b
177.10
164.62
142.82
139.16
136.23
131.95
129.87
128.53
128.02
127.96
127.24
127.08
126.80
125.95
124.95
121.93
108.99
77.33
70.67
54.96
54.00
42.52
33.81
31.09
30.70
19.66
O
OBn
Bn–N
HN
O
27
Acetone
Acetone
200
180
160
140
120
100
80
60
40
20
0
ppm

ch11-242


7.504
7.479
7.448
7.421
7.358
7.348
7.258
7.255
7.231
7.228
7.193
7.190
7.167
7.143
5.520
4.850
4.812
4.517
4.478
4.185
4.166
4.146
3.292
2.822
2.804
2.781
1.924
1.914
1.907
1.901
1.888
1.878
OBn
CN
Cl
N
MOM
16
9
8
7
6
5
4
3
2
1
ppm
0.92
0.97
4.16
0.82
0.92
2.01
1.00
1.02
1.00
2.81
2.05
4.10

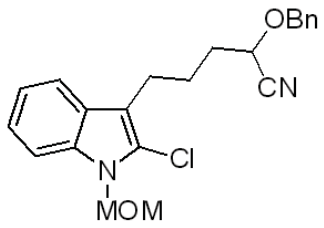
ch11-242 C13 300

136.03
135.94
128.71
128.49
128.33
127.11
123.30
122.67
120.81
118.39
118.31
112.00
109.90

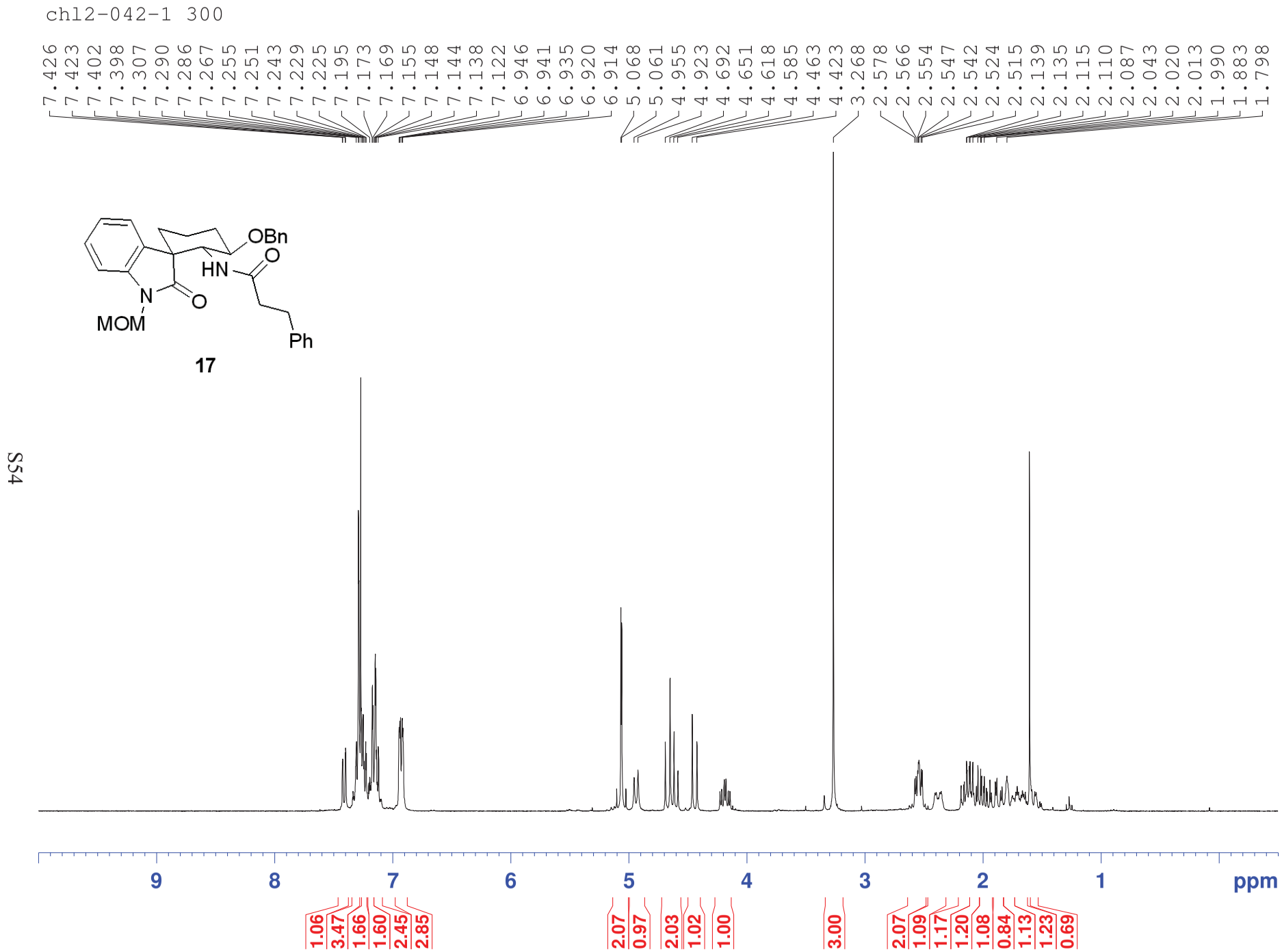
73.93
72.29
67.50

56.05

32.95
24.77
23.32

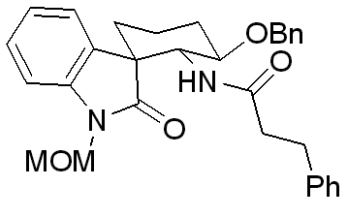


16


ch12-042-1 300
7.426
7.423
7.402
7.398
7.307
7.290
7.286
7.267
7.255
7.251
7.243
7.229
7.225
7.195
7.173
7.169
7.155
7.148
7.144
7.138
7.122
6.946
6.941
6.935
6.920
6.914
5.068
5.061
4.955
4.923
4.692
4.651
4.618
4.585
4.463
4.423
3.268
2.578
2.566
2.554
2.547
2.542
2.524
2.515
2.139
2.135
2.115
2.110
2.087
2.043
2.020
2.013
1.990
1.883
1.798
OBn
O
HN
N
O
MOM
Ph
17
9
8
7
6
5
4
3
2
1
ppm
1.06
3.47
1.66
1.60
2.45
2.85
2.07
0.97
2.03
1.02
1.00
3.00
2.07
1.09
1.17
1.20
1.08
0.84
1.13
1.23
0.69

ch12-042-1 C13 300

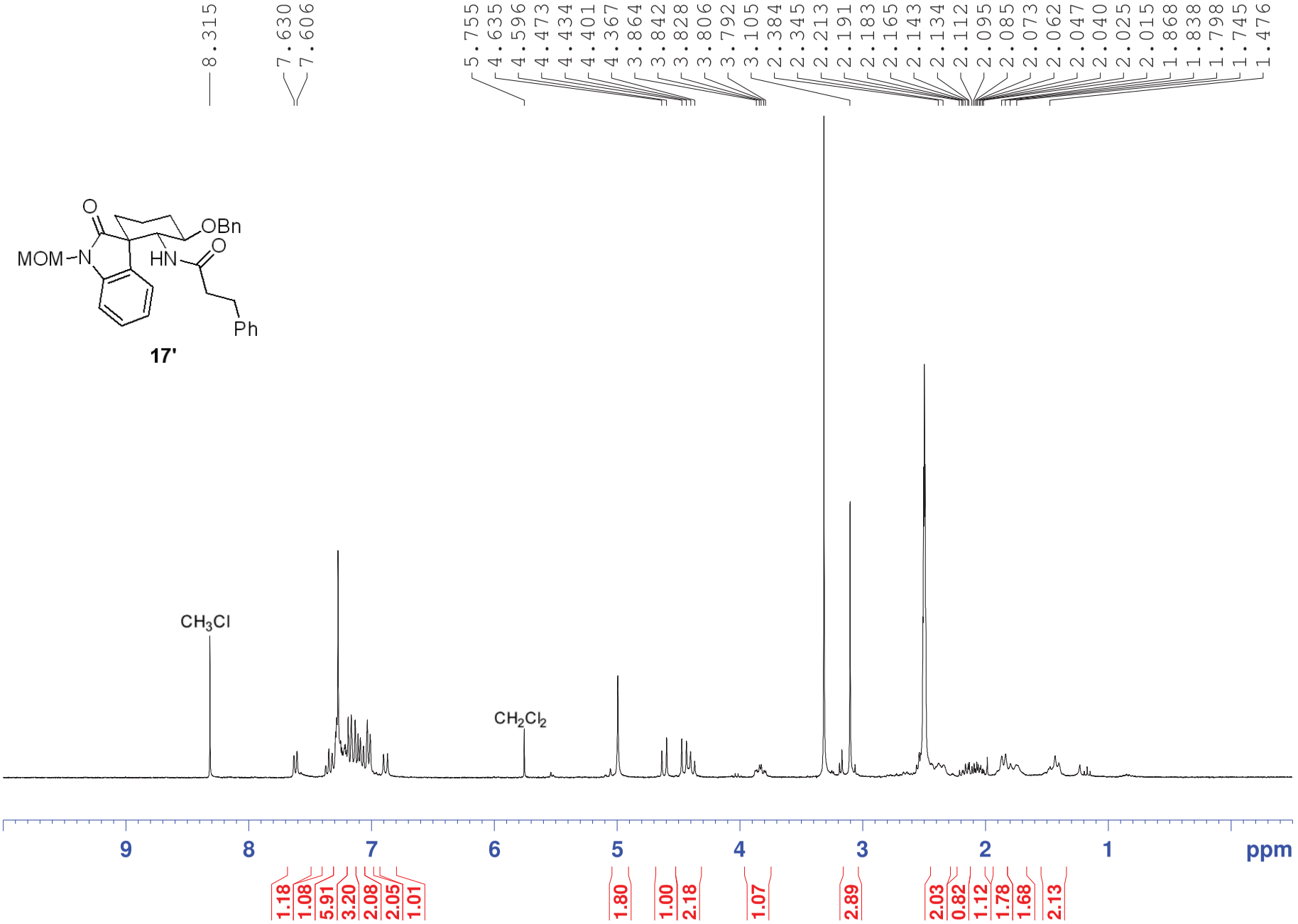
179.38
171.96
141.10
139.13
131.28
128.60
128.50
128.34
128.20
127.68
127.62
126.16
124.03
123.78
109.03
76.42
71.22
70.98
56.34
55.16
54.98
38.44
35.67
31.50
30.94
19.00

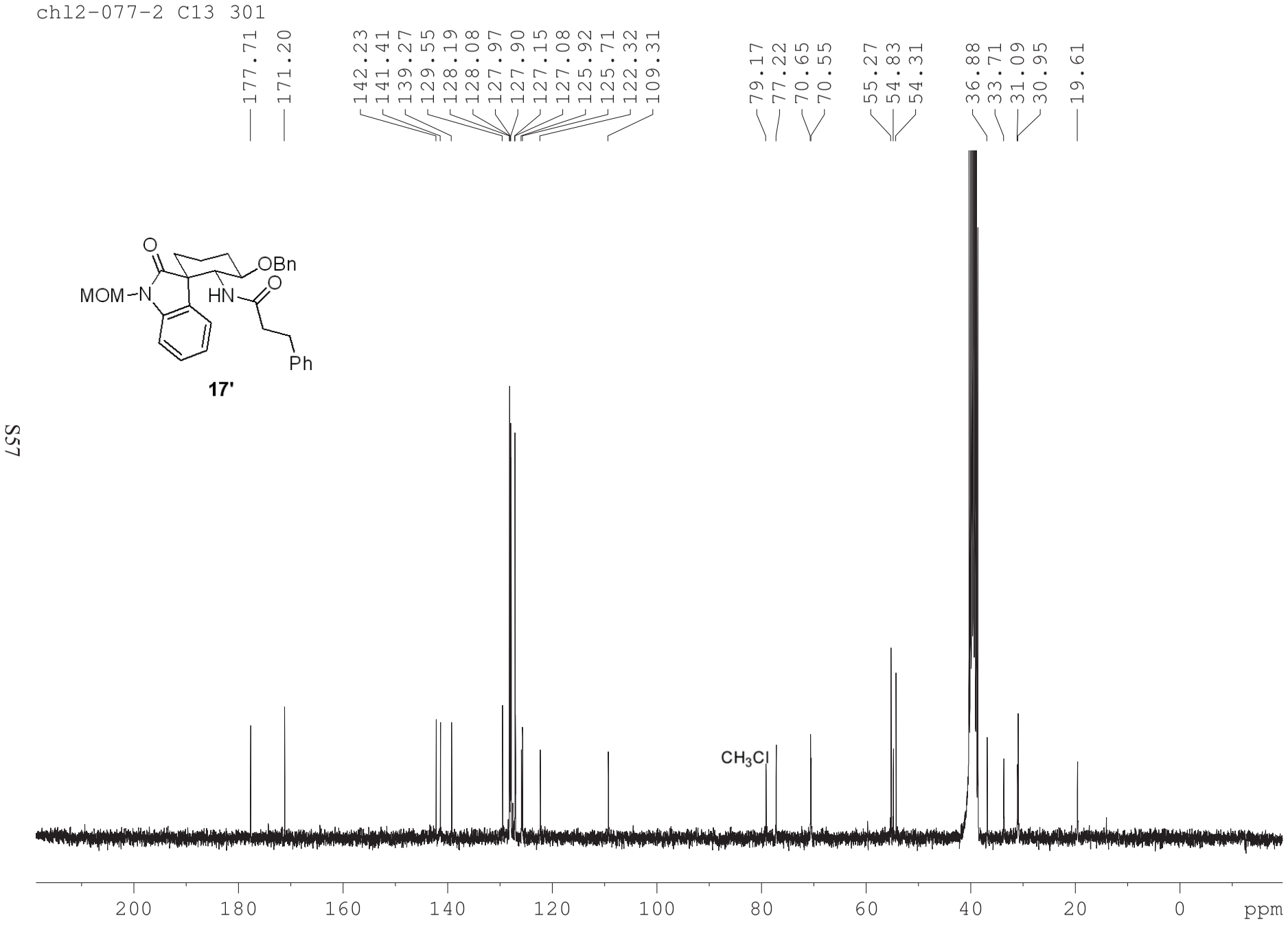


17

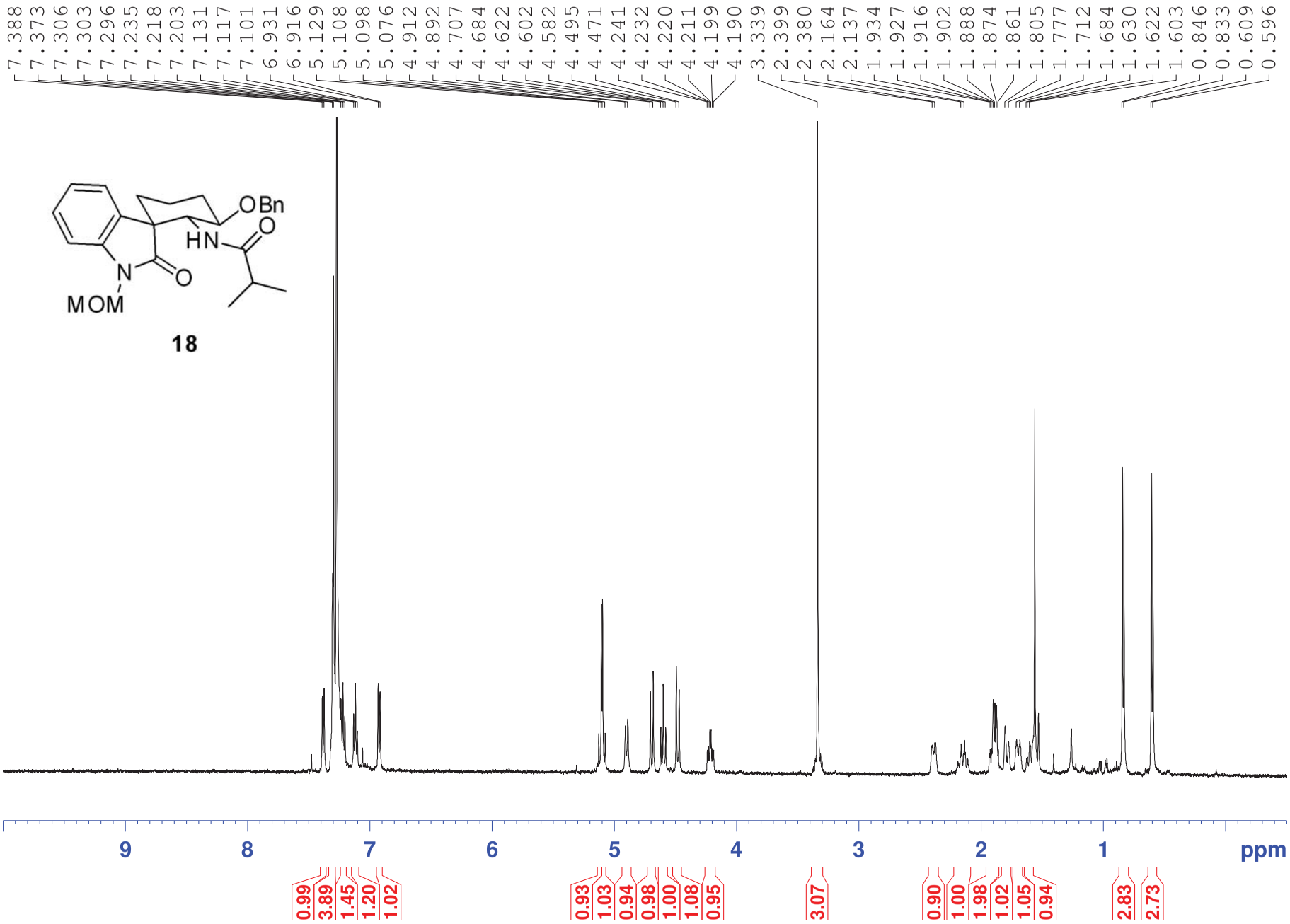
200 180 160 140 120 100 80 60 40 20 0 ppm

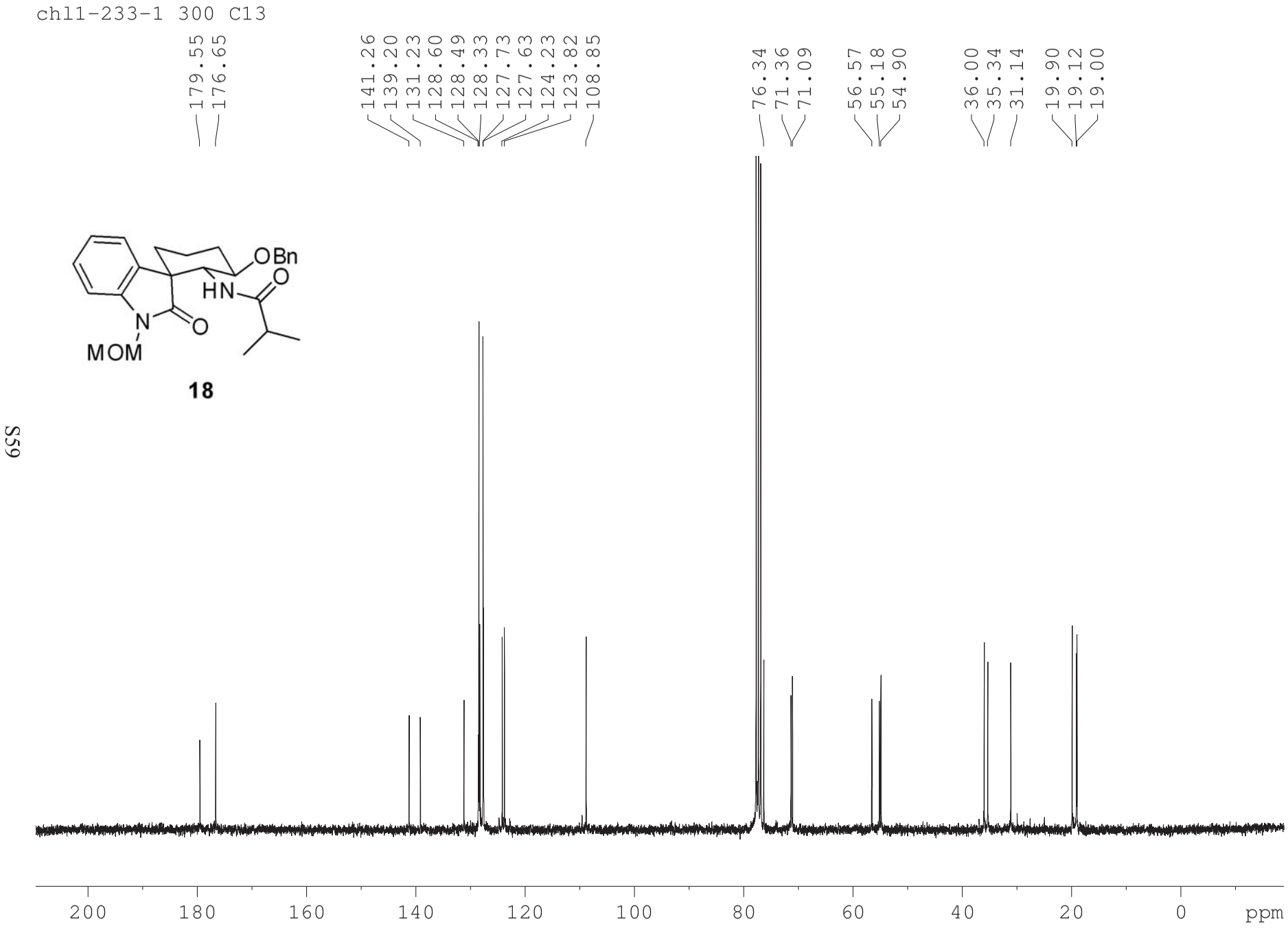
ch12-077-2 301

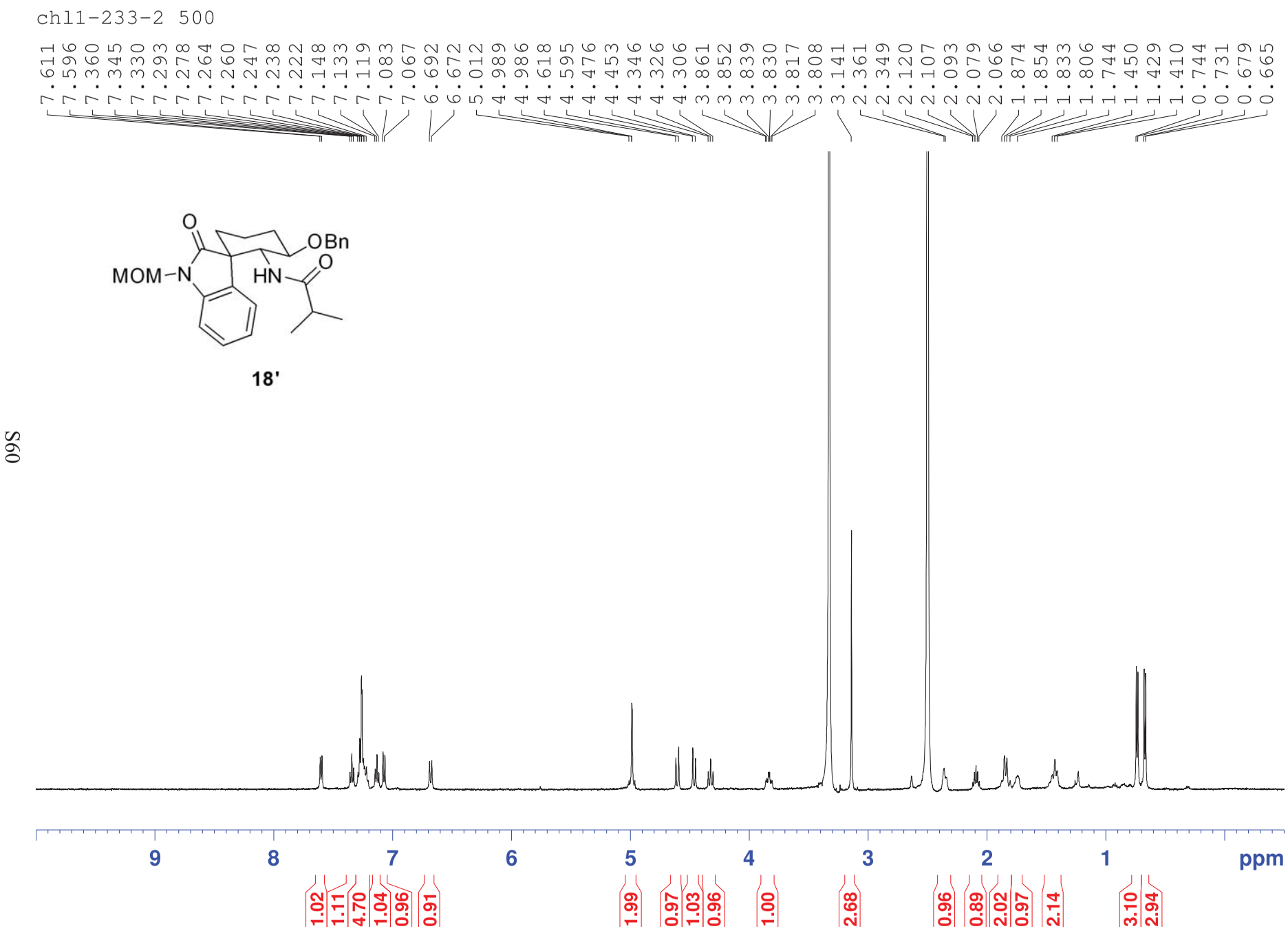


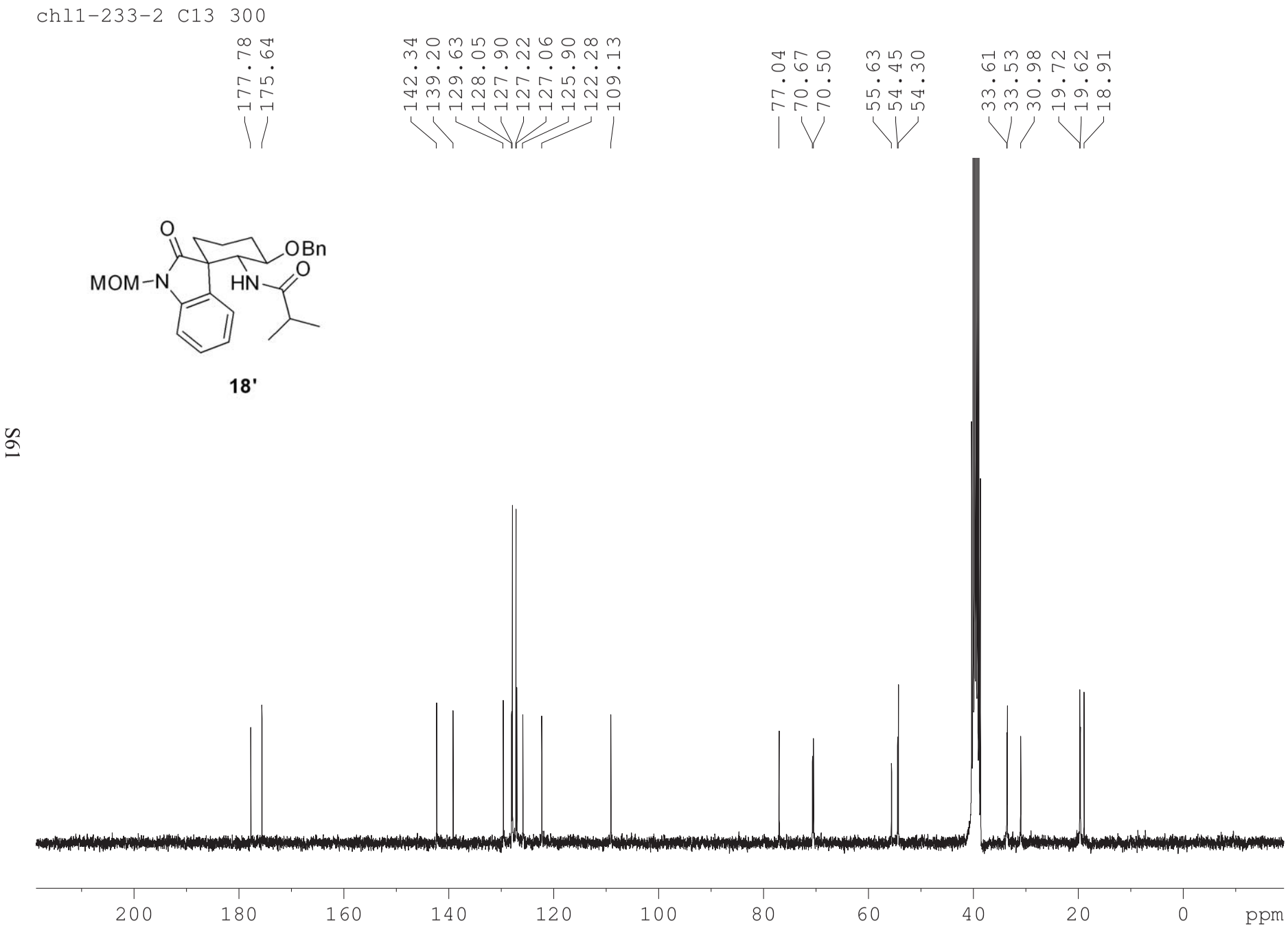

ch12-077-2 C13 301
177.71
171.20
142.23
141.41
139.27
129.55
128.19
128.08
127.97
127.90
127.15
127.08
125.92
125.71
122.32
109.31
79.17
77.22
70.65
70.55
55.27
54.83
54.31
36.88
33.71
31.09
30.95
19.61
O
OBn
MOM–N
HN
O
Ph
17'
CH3Cl
200
180
160
140
120
100
80
60
40
20
0
ppm

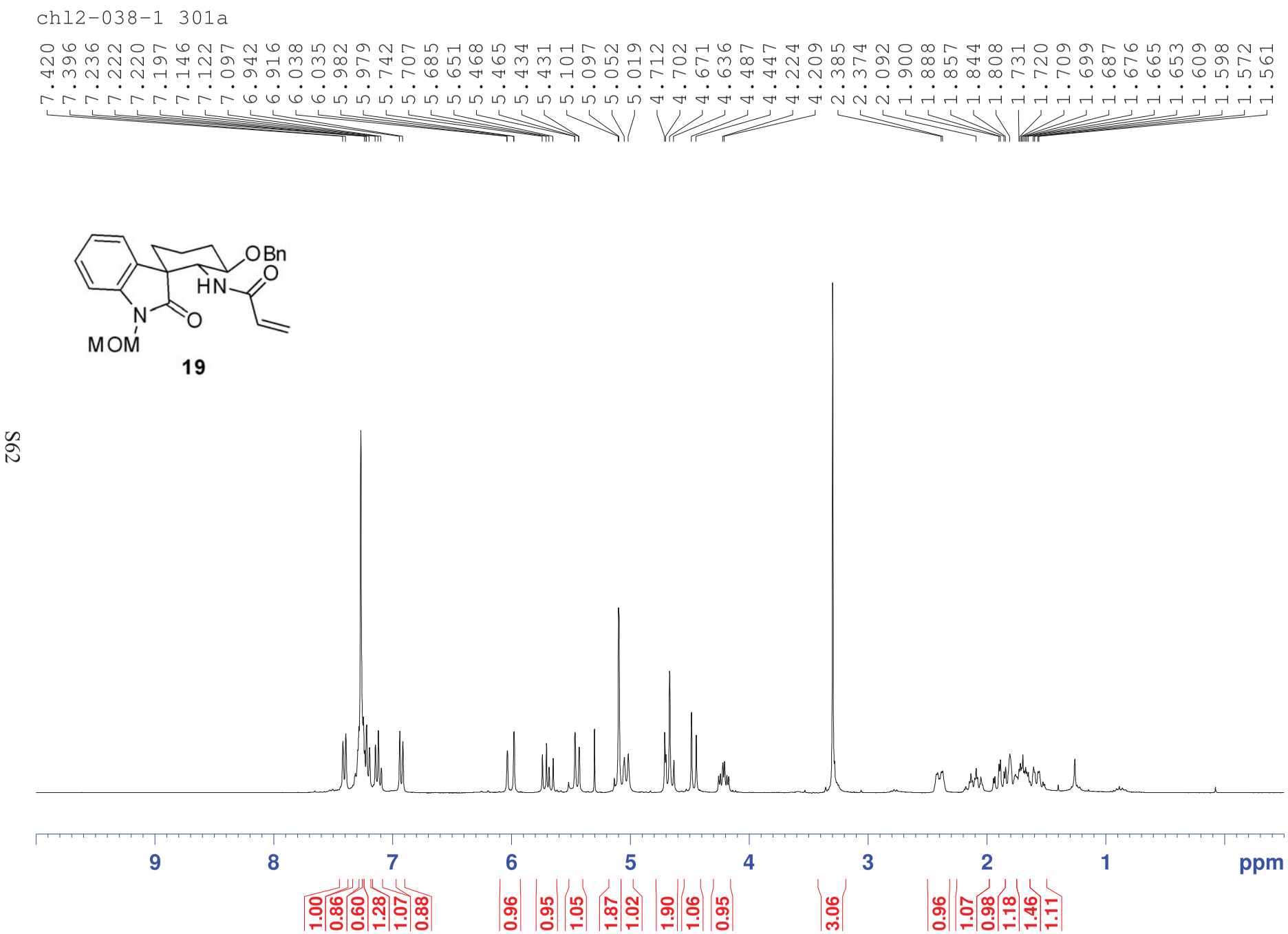
ch11-233-1 500

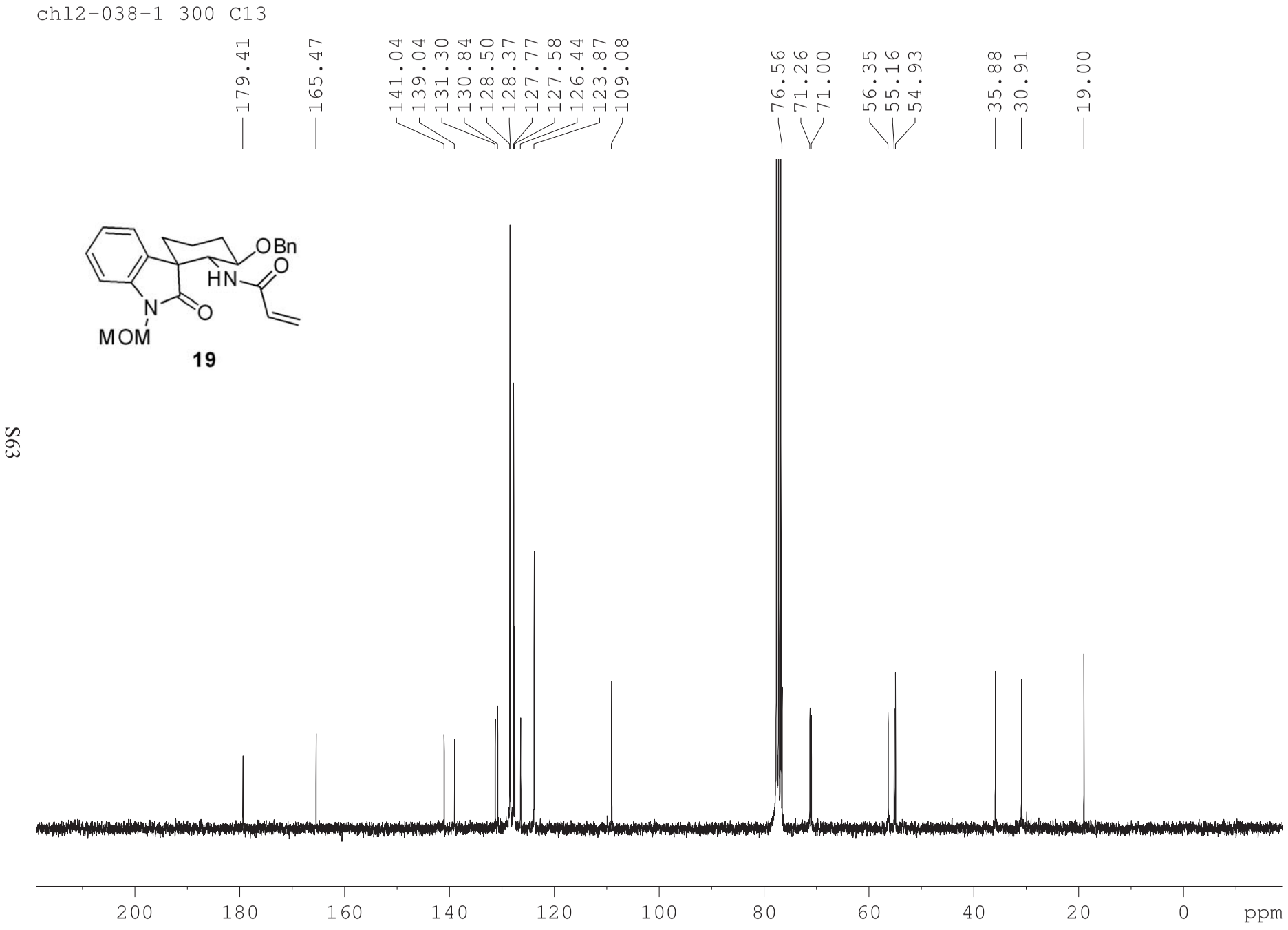



ch11-233-1 300 C13
179.55
176.65
141.26
139.20
131.23
128.60
128.49
128.33
127.73
127.63
124.23
123.82
108.85
76.34
71.36
71.09
56.57
55.18
54.90
36.00
35.34
31.14
19.90
19.12
19.00
OBn
HN
O
N
O
MOM
18
200
180
160
140
120
100
80
60
40
20
0
ppm


ch11-233-2 500
7.611
7.596
7.360
7.345
7.330
7.293
7.278
7.264
7.260
7.247
7.238
7.222
7.148
7.133
7.119
7.083
7.067
6.692
6.672
5.012
4.989
4.986
4.618
4.595
4.476
4.453
4.346
4.326
4.306
3.861
3.852
3.839
3.830
3.817
3.808
3.141
2.361
2.349
2.120
2.107
2.093
2.079
2.066
1.874
1.854
1.833
1.806
1.744
1.450
1.429
1.410
0.744
0.731
0.679
0.665
O
OBn
MOM–N
HN
O
18'
9
8
7
6
5
4
3
2
1
ppm
1.02
1.11
4.70
1.04
0.96
0.91
1.99
0.97
1.03
0.96
1.00
2.68
0.96
0.89
2.02
0.97
2.14
3.10
2.94

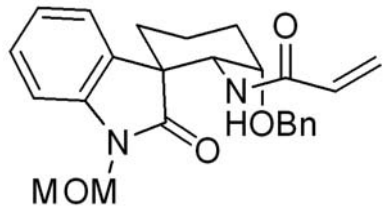

ch11-233-2 C13 300
177.78
175.64
142.34
139.20
129.63
128.05
127.90
127.22
127.06
125.90
122.28
109.13
77.04
70.67
70.50
55.63
54.45
54.30
33.61
33.53
30.98
19.72
19.62
18.91
O
OBn
MOM–N
HN
O
18'
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-038-1 301a
7.420
7.396
7.236
7.222
7.220
7.197
7.146
7.122
7.097
6.942
6.916
6.038
6.035
5.982
5.979
5.742
5.707
5.685
5.651
5.468
5.465
5.434
5.431
5.101
5.097
5.052
5.019
4.712
4.702
4.671
4.636
4.487
4.447
4.224
4.209
2.385
2.374
2.092
1.900
1.888
1.857
1.844
1.808
1.731
1.720
1.709
1.699
1.687
1.676
1.665
1.653
1.609
1.598
1.572
1.561
OBn
O
HN
N
O
MOM
19
9
8
7
6
5
4
3
2
1
ppm
1.00
0.86
0.60
1.28
1.07
0.88
0.96
0.95
1.05
1.87
1.02
1.90
1.06
0.95
3.06
0.96
1.07
0.98
1.18
1.46
1.11


ch12-038-1 300 C13
179.41
165.47
141.04
139.04
131.30
130.84
128.50
128.37
127.77
127.58
126.44
123.87
109.08
76.56
71.26
71.00
56.35
55.16
54.93
35.88
30.91
19.00
OBn
HN
O
N
O
MOM
19
200
180
160
140
120
100
80
60
40
20
0
ppm

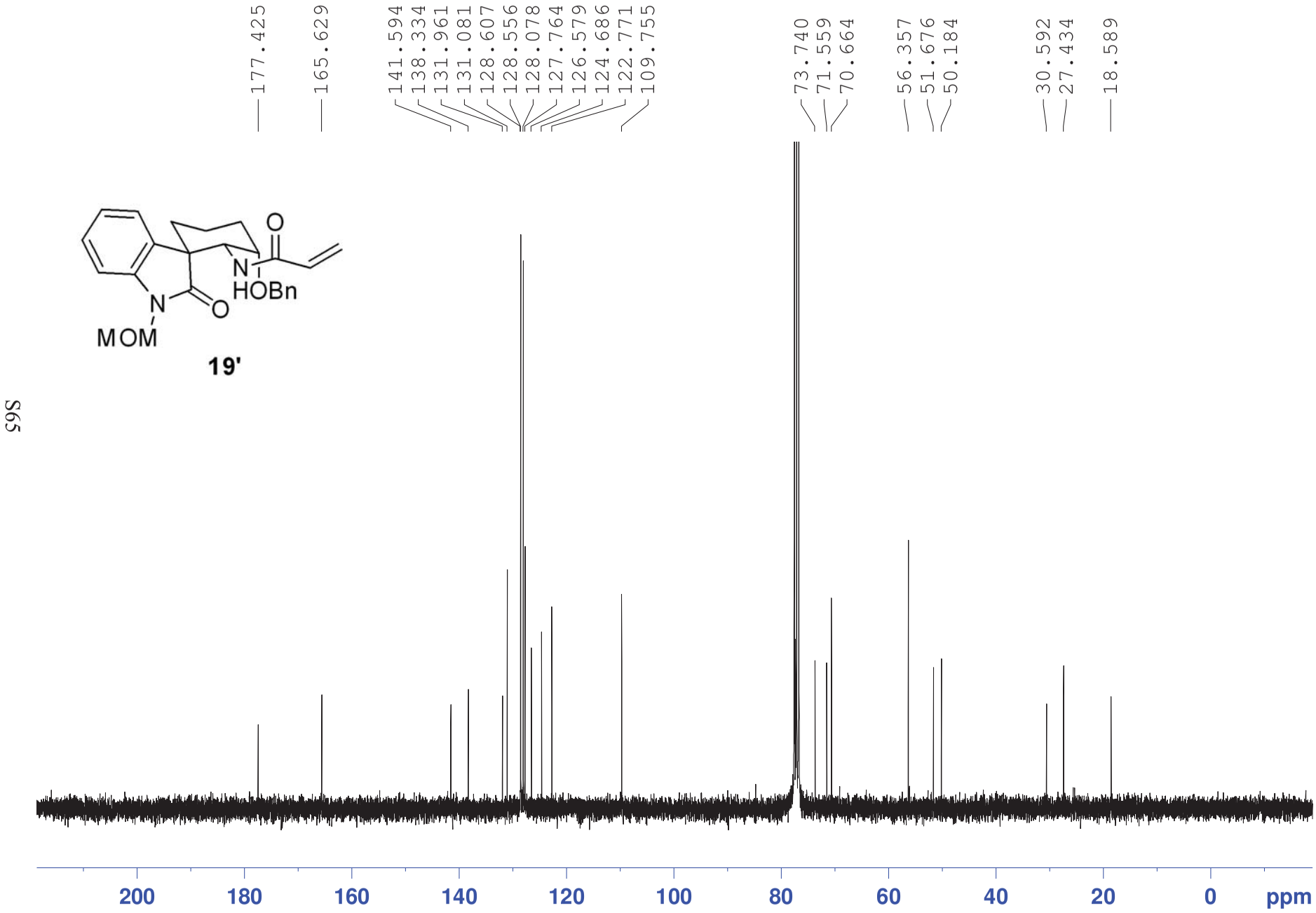
ch12-079 301a

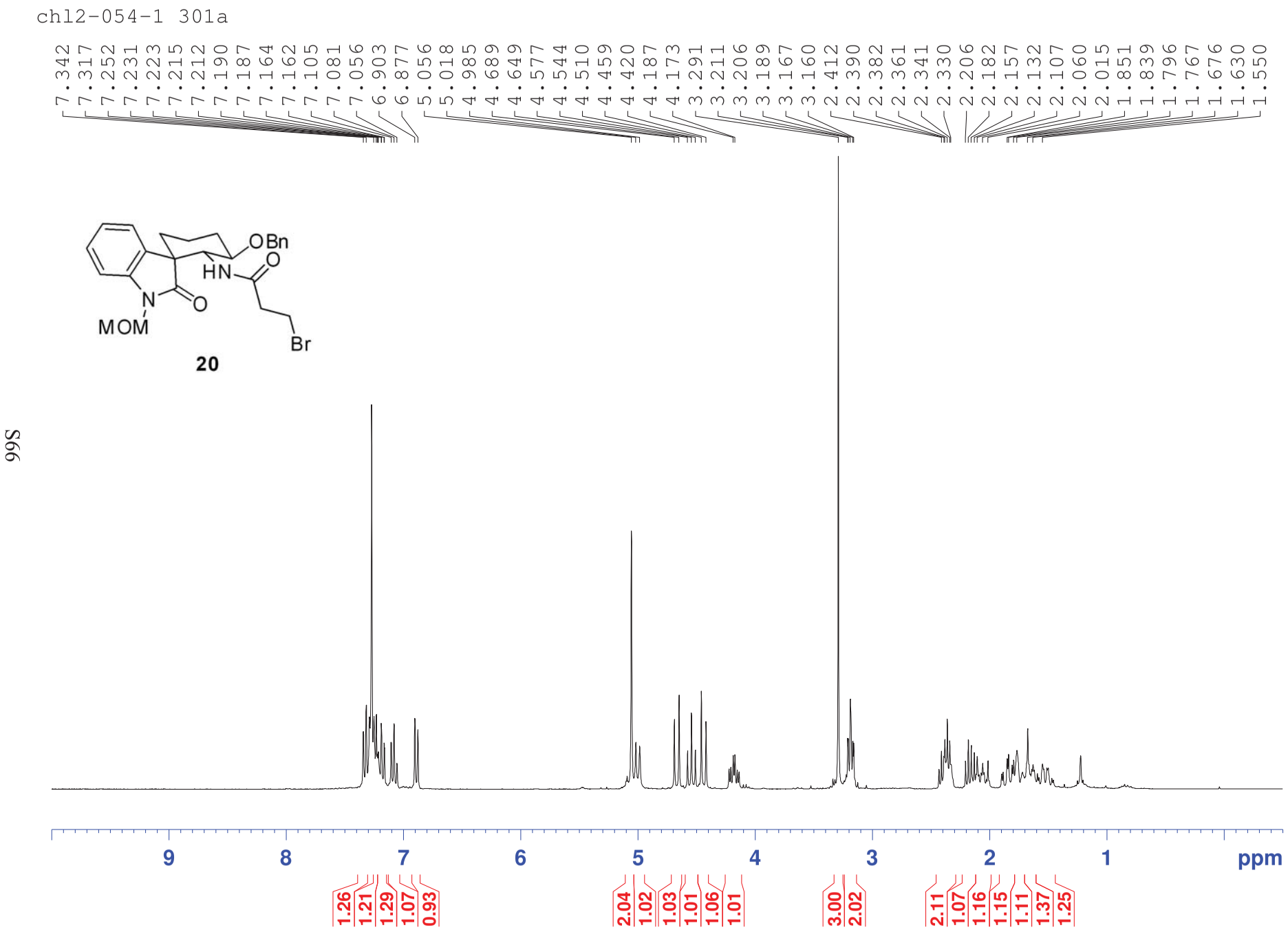
7.387
7.362
7.300
7.087
7.063
7.037
6.209
6.203
6.152
6.147
6.099
6.066
6.042
6.009
5.616
5.610
5.582
5.577
5.171
5.134
5.118
5.081
4.666
4.652
4.633
4.619
4.566
4.527
4.483
4.444
4.035
4.021
4.008
3.994
3.319
2.155
2.146
2.136
2.125
2.056
2.020
2.006
1.973
1.959
1.914
1.900
1.883
1.870
1.854
1.843
1.815
1.690
1.678
1.669
1.643

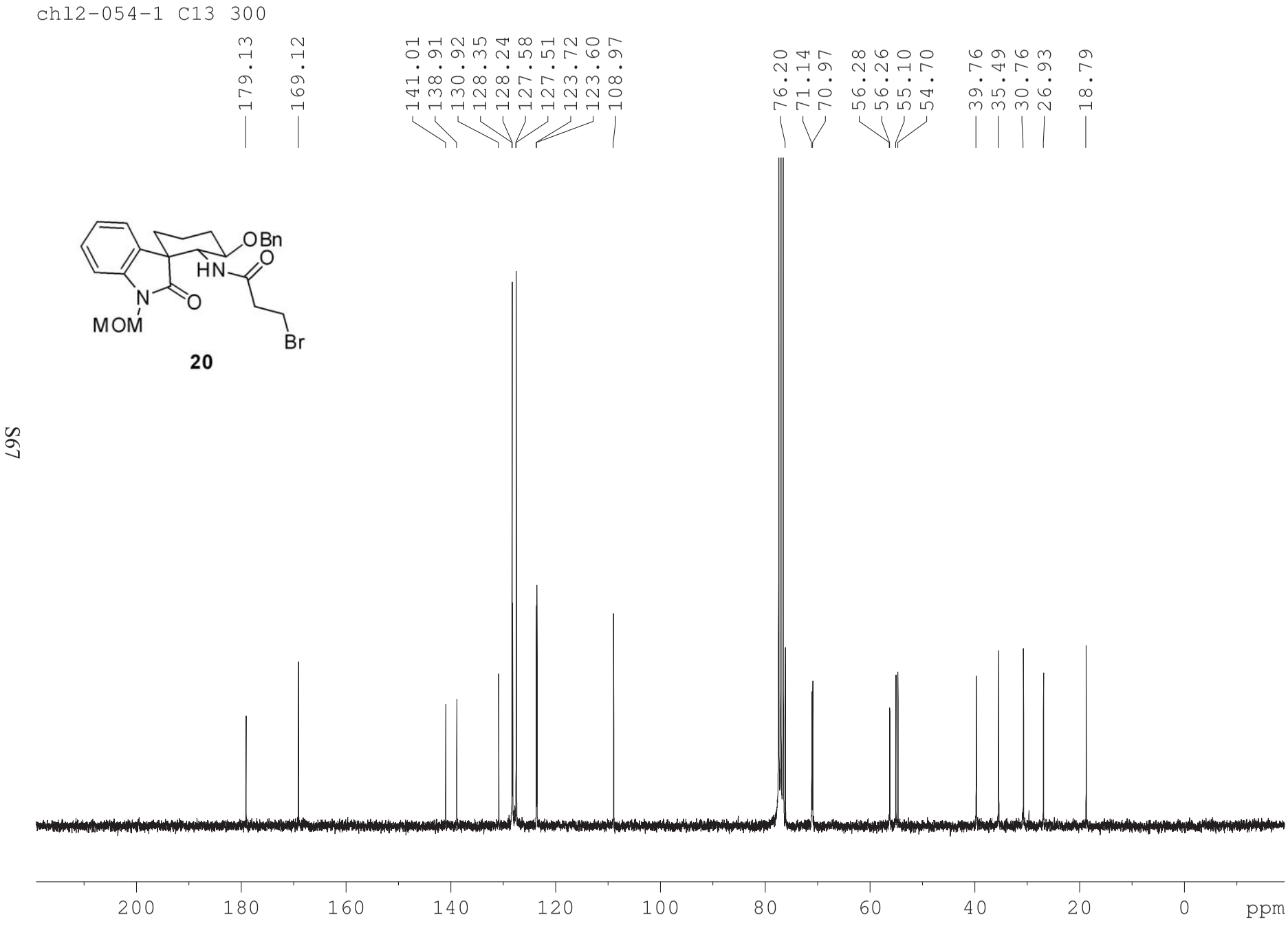


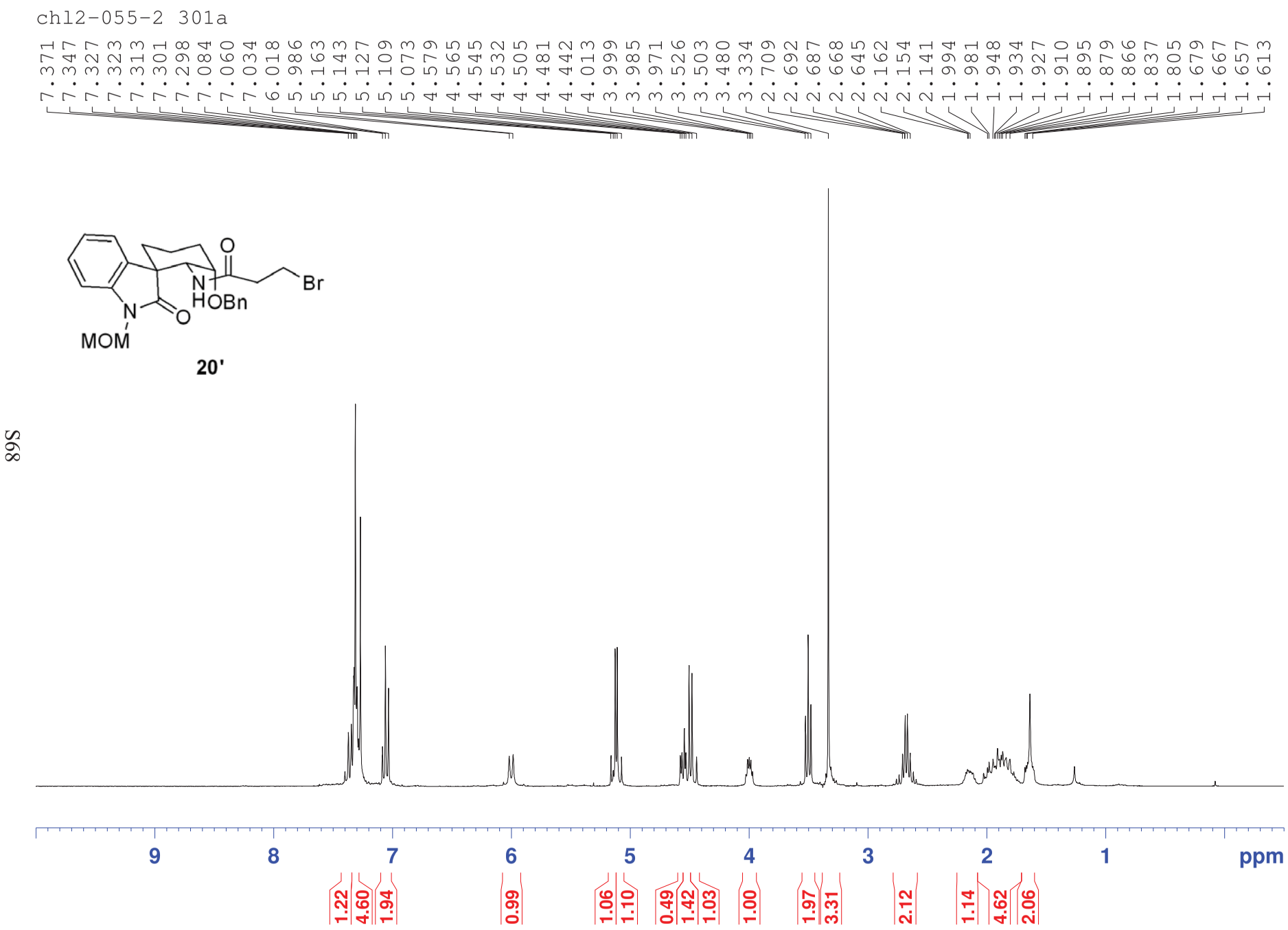
19'

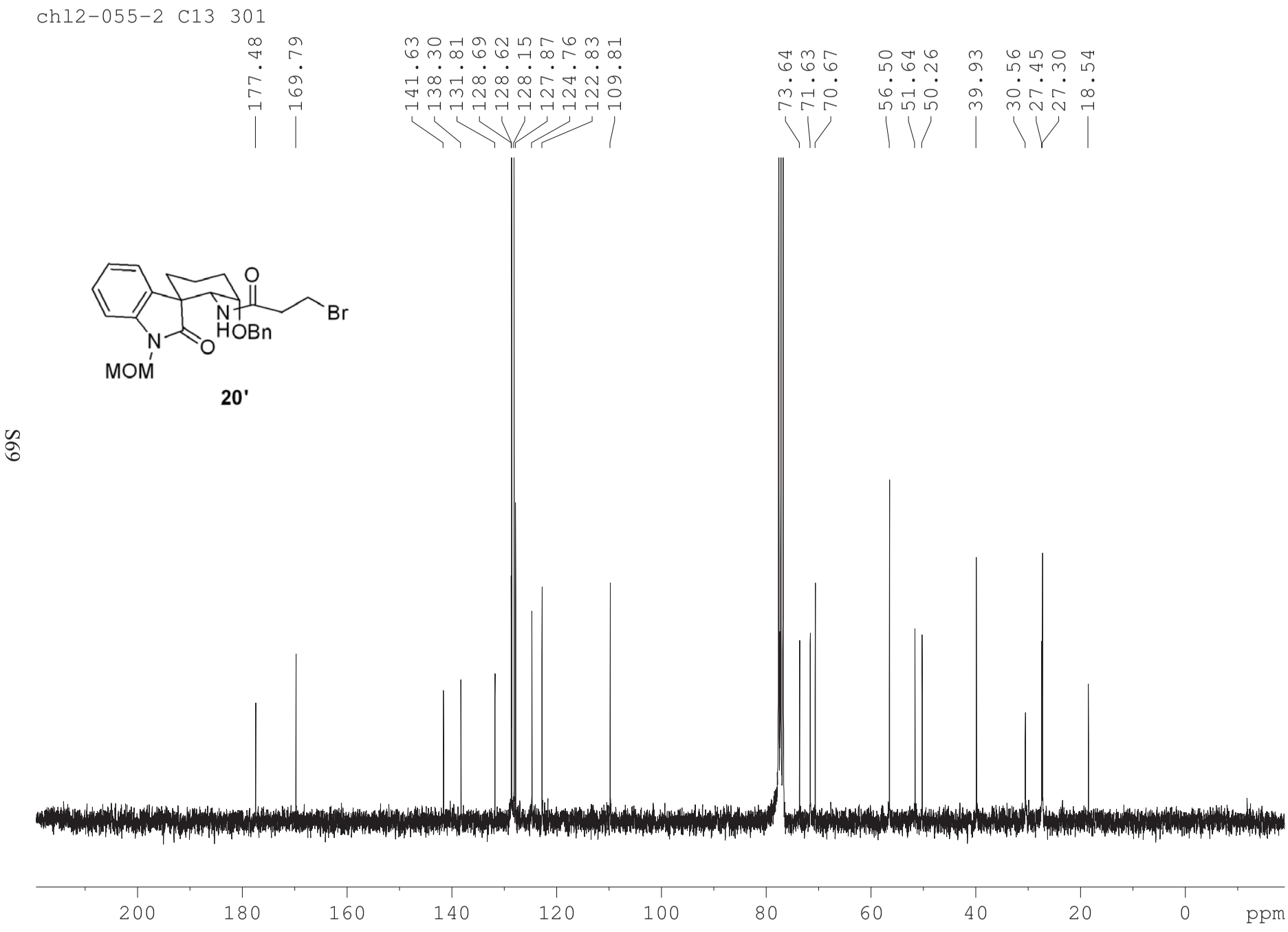
ch12-079 C13

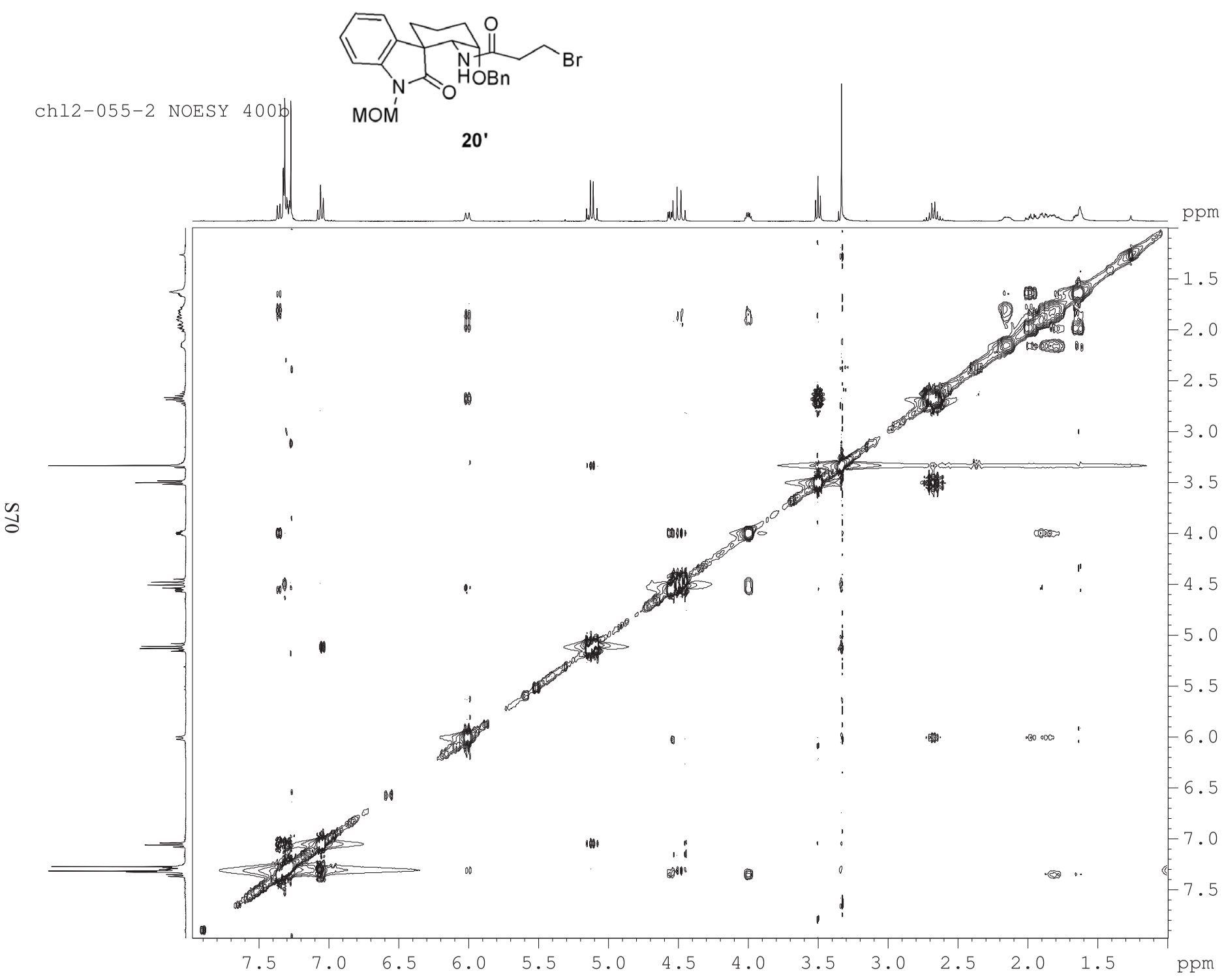

177.425
165.629
141.594
138.334
131.961
131.081
128.607
128.556
128.078
127.764
126.579
124.686
122.771
109.755
73.740
71.559
70.664
56.357
51.676
50.184
30.592
27.434
18.589
O
N
HOBn
N
O
MOM
19'
200
180
160
140
120
100
80
60
40
20
0
ppm

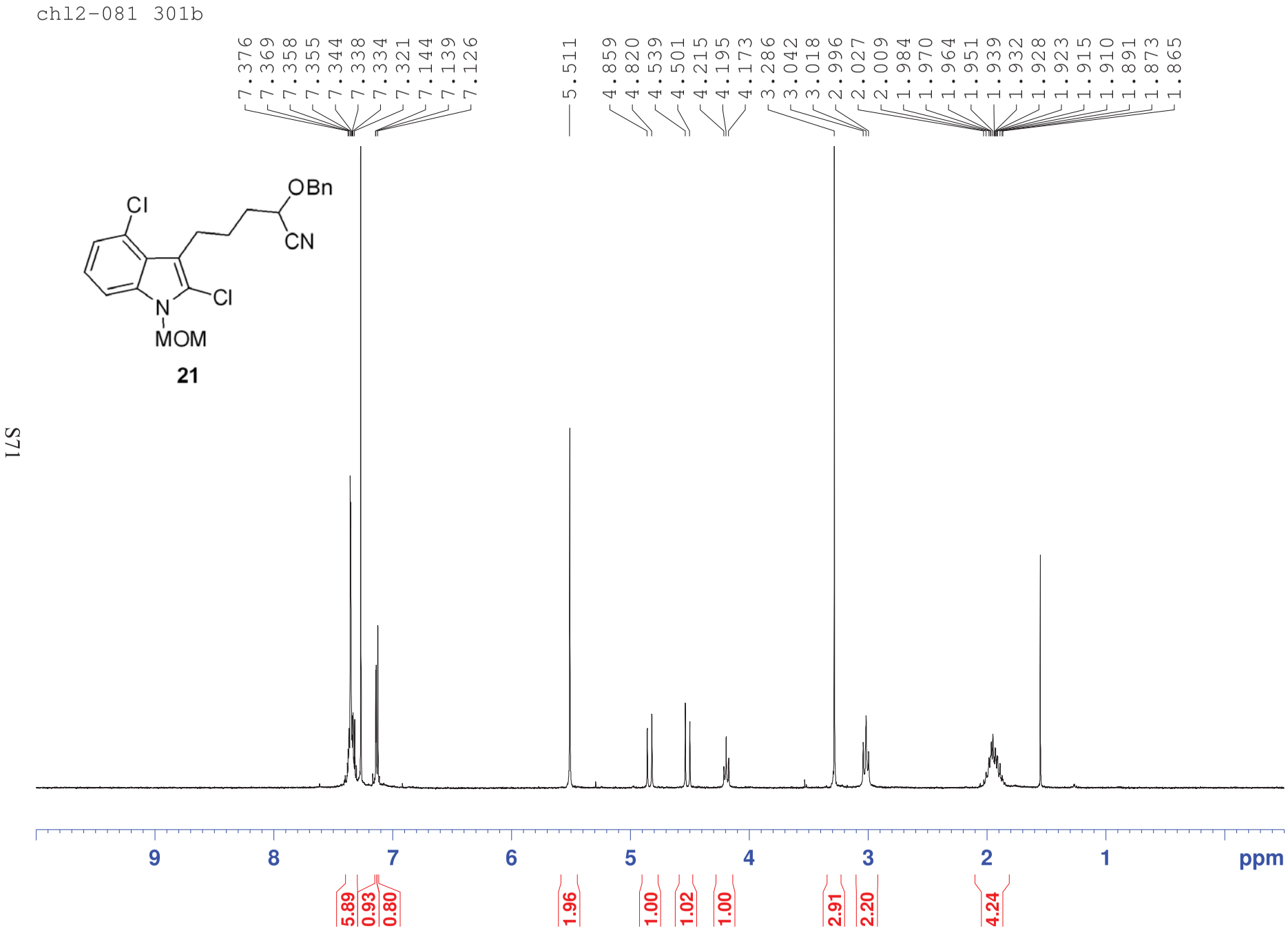

ch12-054-1 301a
7.342
7.317
7.252
7.231
7.223
7.215
7.212
7.190
7.187
7.164
7.162
7.105
7.081
7.056
6.903
6.877
5.056
5.018
4.985
4.689
4.649
4.577
4.544
4.510
4.459
4.420
4.187
4.173
3.291
3.211
3.206
3.189
3.167
3.160
2.412
2.390
2.382
2.361
2.341
2.330
2.206
2.182
2.157
2.132
2.107
2.060
2.015
1.851
1.839
1.796
1.767
1.676
1.630
1.550
OBn
HN
O
N
O
MOM
Br
20
9
8
7
6
5
4
3
2
1
ppm
1.26
1.21
1.29
1.07
0.93
2.04
1.02
1.03
1.01
1.06
1.01
3.00
2.02
2.11
1.07
1.16
1.15
1.11
1.37
1.25

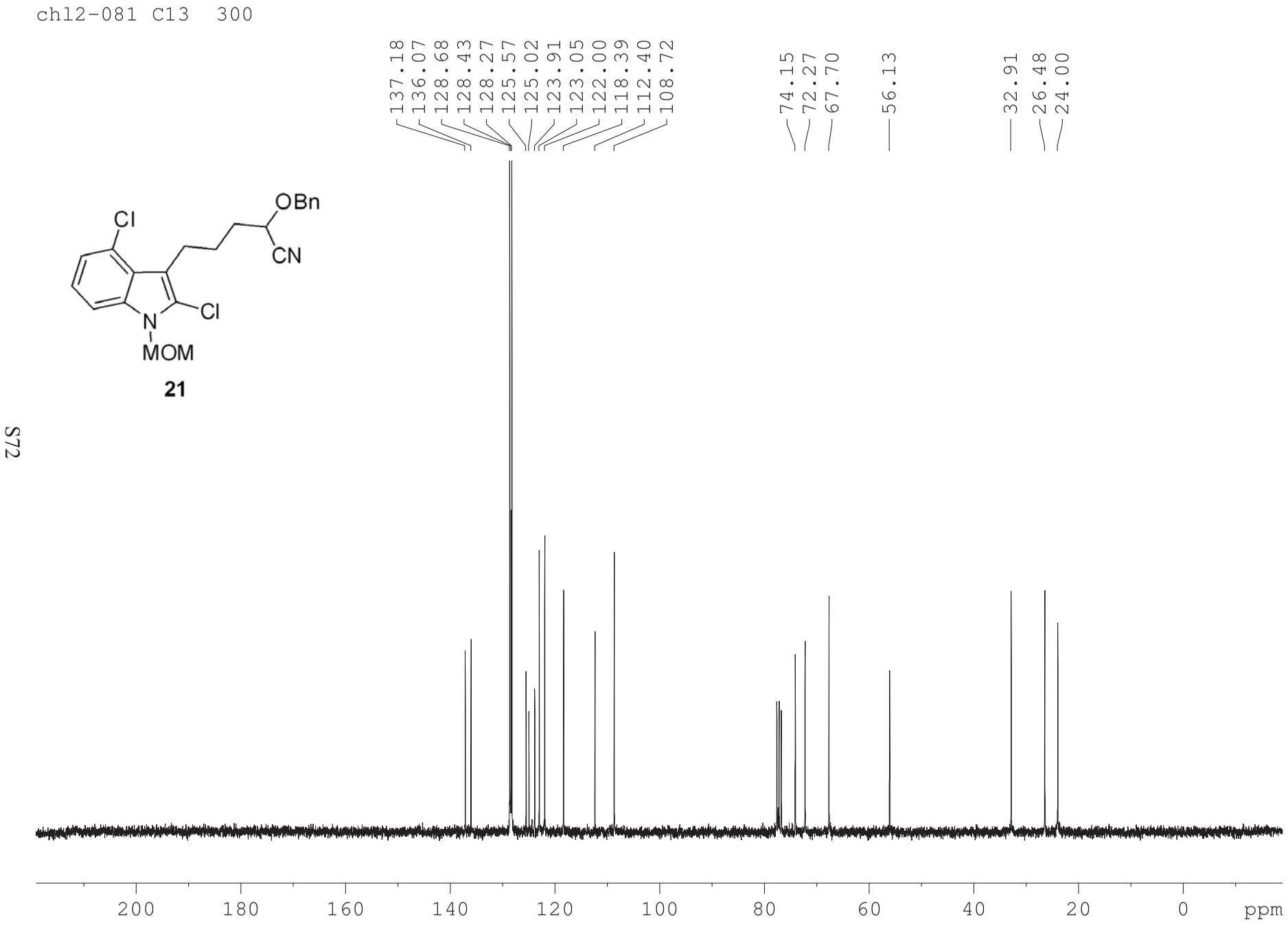

ch12-054-1 C13 300
179.13
169.12
141.01
138.91
130.92
128.35
128.24
127.58
127.51
123.72
123.60
108.97
76.20
71.14
70.97
56.28
56.26
55.10
54.70
39.76
35.49
30.76
26.93
18.79
OBn
HN
O
N
O
MOM
Br
20
200
180
160
140
120
100
80
60
40
20
0
ppm

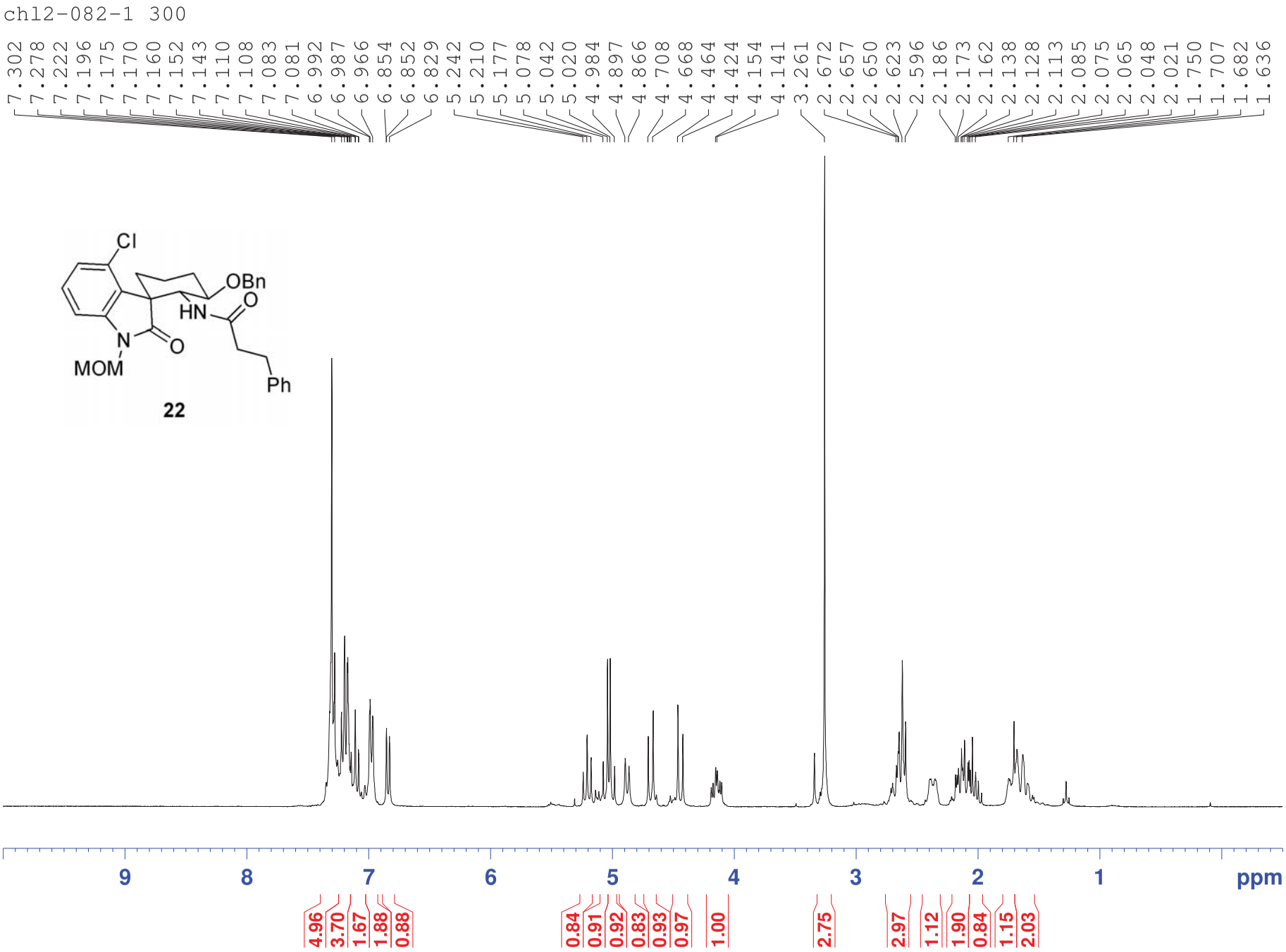

ch12-055-2 301a
7.371
7.347
7.327
7.323
7.313
7.301
7.298
7.084
7.060
7.034
6.018
5.986
5.163
5.143
5.127
5.109
5.073
4.579
4.565
4.545
4.532
4.505
4.481
4.442
4.013
3.999
3.985
3.971
3.526
3.503
3.480
3.334
2.709
2.692
2.687
2.668
2.645
2.162
2.154
2.141
1.994
1.981
1.948
1.934
1.927
1.910
1.895
1.879
1.866
1.837
1.805
1.679
1.667
1.657
1.613
O
N
HOBn
Br
N
O
MOM
20'
9
8
7
6
5
4
3
2
1
ppm
1.22
4.60
1.94
0.99
1.06
1.10
0.49
1.42
1.03
1.00
1.97
3.31
2.12
1.14
4.62
2.06

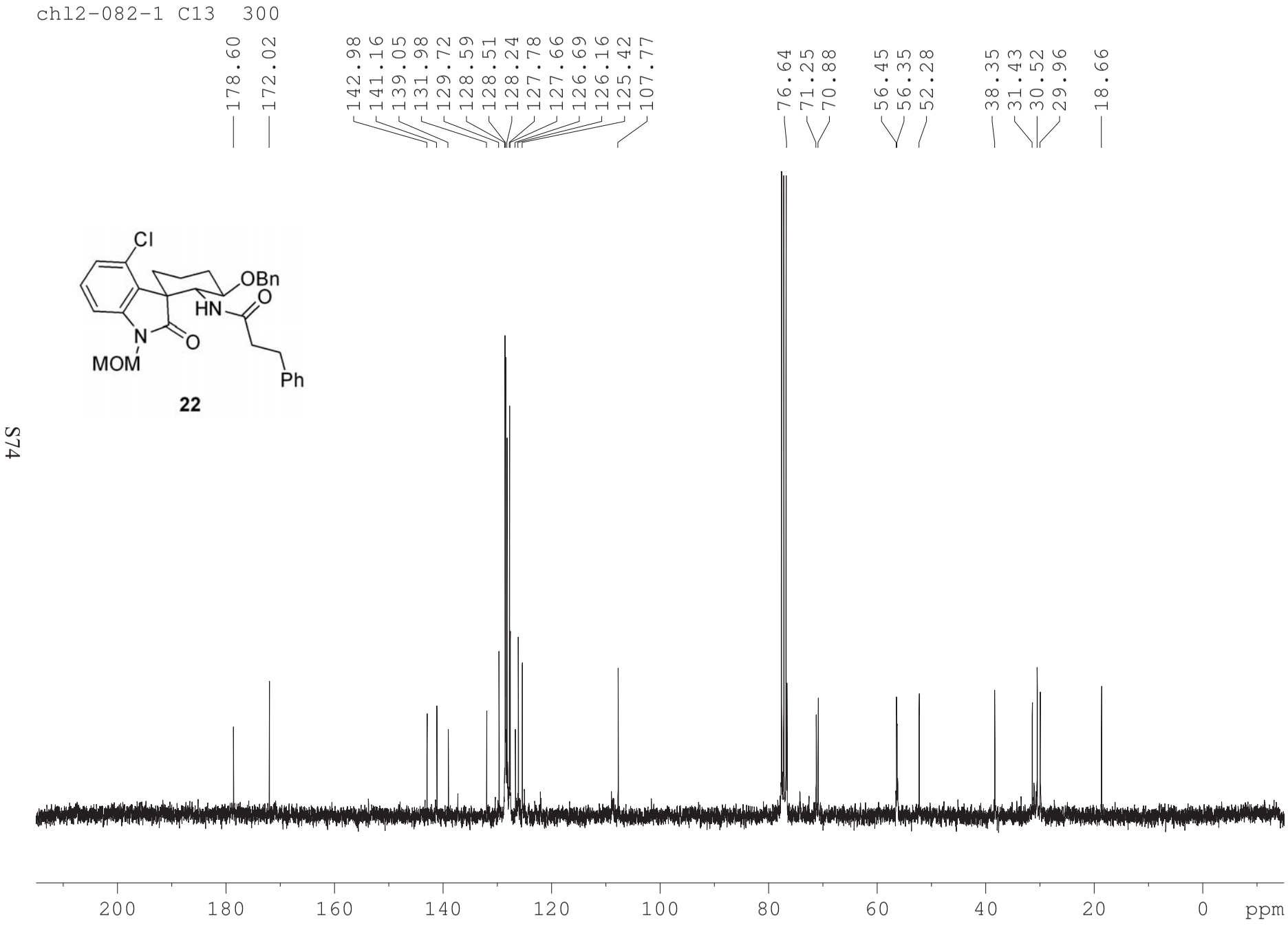

ch12-055-2 C13 301
177.48
169.79
141.63
138.30
131.81
128.69
128.62
128.15
127.87
124.76
122.83
109.81
73.64
71.63
70.67
56.50
51.64
50.26
39.93
30.56
27.45
27.30
18.54
O
N
HOBn
Br
N
O
MOM
20'
200
180
160
140
120
100
80
60
40
20
0
ppm

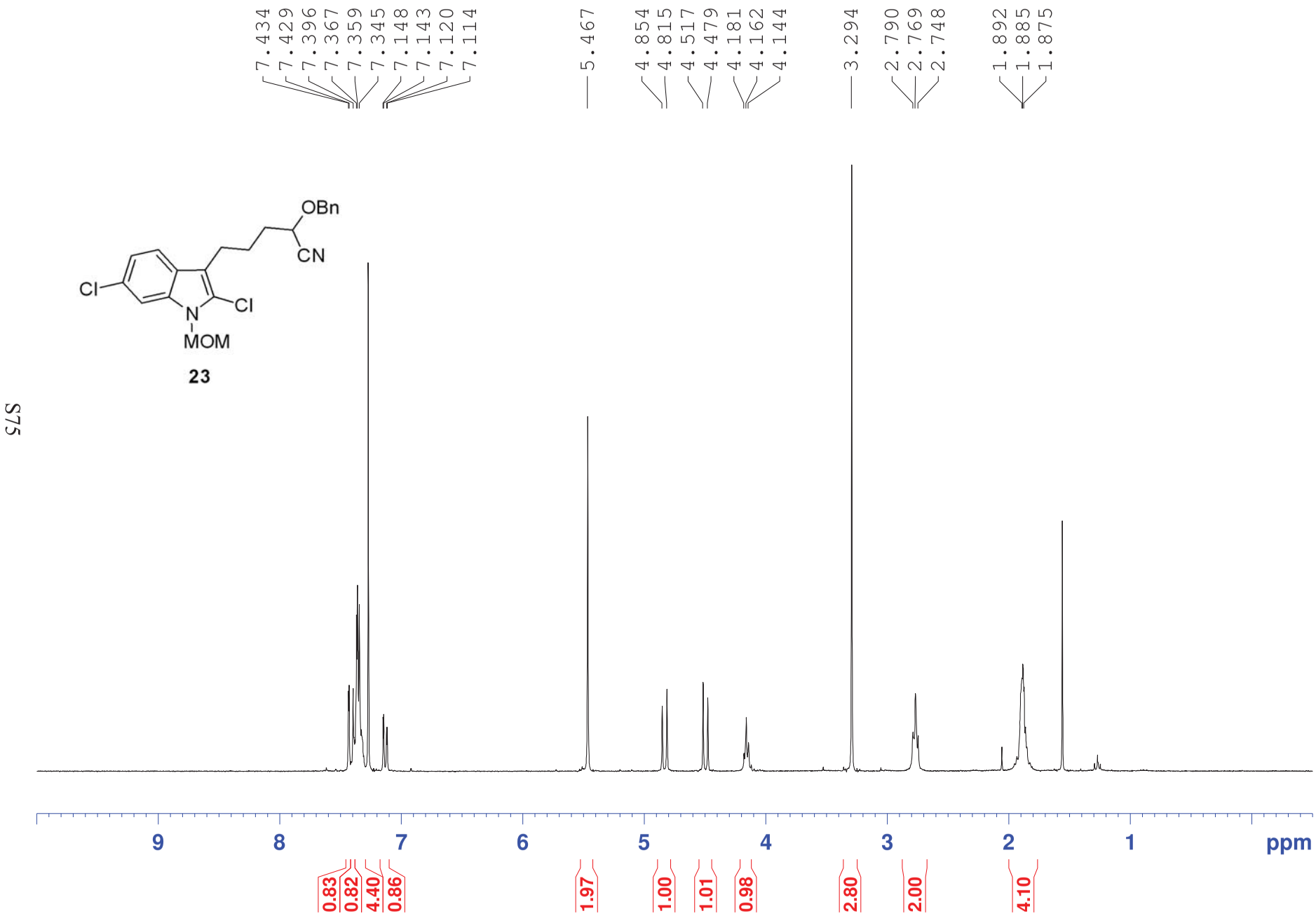

ch12-055-2 NOESY 400b
MOM
N
O
N
HOBn
O
Br
20'
S70
ppm
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
ppm


ch12-081 301b
7.376
7.369
7.358
7.355
7.344
7.338
7.334
7.321
7.144
7.139
7.126
5.511
4.859
4.820
4.539
4.501
4.215
4.195
4.173
3.286
3.042
3.018
2.996
2.027
2.009
1.984
1.970
1.964
1.951
1.939
1.932
1.928
1.923
1.915
1.910
1.891
1.873
1.865
Cl
OBn
CN
Cl
N
MOM
21
9
8
7
6
5
4
3
2
1
ppm
5.89
0.93
0.80
1.96
1.00
1.02
1.00
2.91
2.20
4.24


ch12-081 C13 300
137.18
136.07
128.68
128.43
128.27
125.57
125.02
123.91
123.05
122.00
118.39
112.40
108.72
74.15
72.27
67.70
56.13
32.91
26.48
24.00
Cl
OBn
CN
Cl
N
MOM
21
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-082-1 300
7.302
7.278
7.222
7.196
7.175
7.170
7.160
7.152
7.143
7.110
7.108
7.083
7.081
6.992
6.987
6.966
6.854
6.852
6.829
5.242
5.210
5.177
5.078
5.042
5.020
4.984
4.897
4.866
4.708
4.668
4.464
4.424
4.154
4.141
3.261
2.672
2.657
2.650
2.623
2.596
2.186
2.173
2.162
2.138
2.128
2.113
2.085
2.075
2.065
2.048
2.021
1.750
1.707
1.682
1.636
Cl
OBn
HN
O
N
O
MOM
Ph
22
9
8
7
6
5
4
3
2
1
ppm
4.96
3.70
1.67
1.88
0.88
0.84
0.91
0.92
0.83
0.93
0.97
1.00
2.75
2.97
1.12
1.90
0.84
1.15
2.03


ch12-082-1 C13 300
178.60
172.02
142.98
141.16
139.05
131.98
129.72
128.59
128.51
128.24
127.78
127.66
126.69
126.16
125.42
107.77
76.64
71.25
70.88
56.45
56.35
52.28
38.35
31.43
30.52
29.96
18.66
Cl
OBn
HN
O
N
O
MOM
Ph
22
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-073 301a
7.434
7.429
7.396
7.367
7.359
7.345
7.148
7.143
7.120
7.114
5.467
4.854
4.815
4.517
4.479
4.181
4.162
4.144
3.294
2.790
2.769
2.748
1.892
1.885
1.875
OBn
CN
Cl
Cl
N
MOM
23
9
8
7
6
5
4
3
2
1
ppm
0.83
0.82
4.40
0.86
1.97
1.00
1.01
0.98
2.80
2.00
4.10

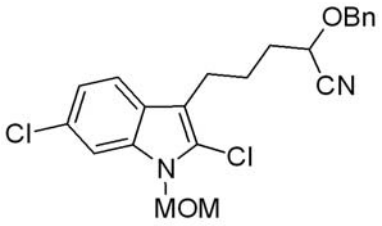
ch12-073 repurify C13 301b

136.24
136.00
128.81
128.62
128.42
125.70
123.93
121.57
119.38
118.30
112.23
110.21

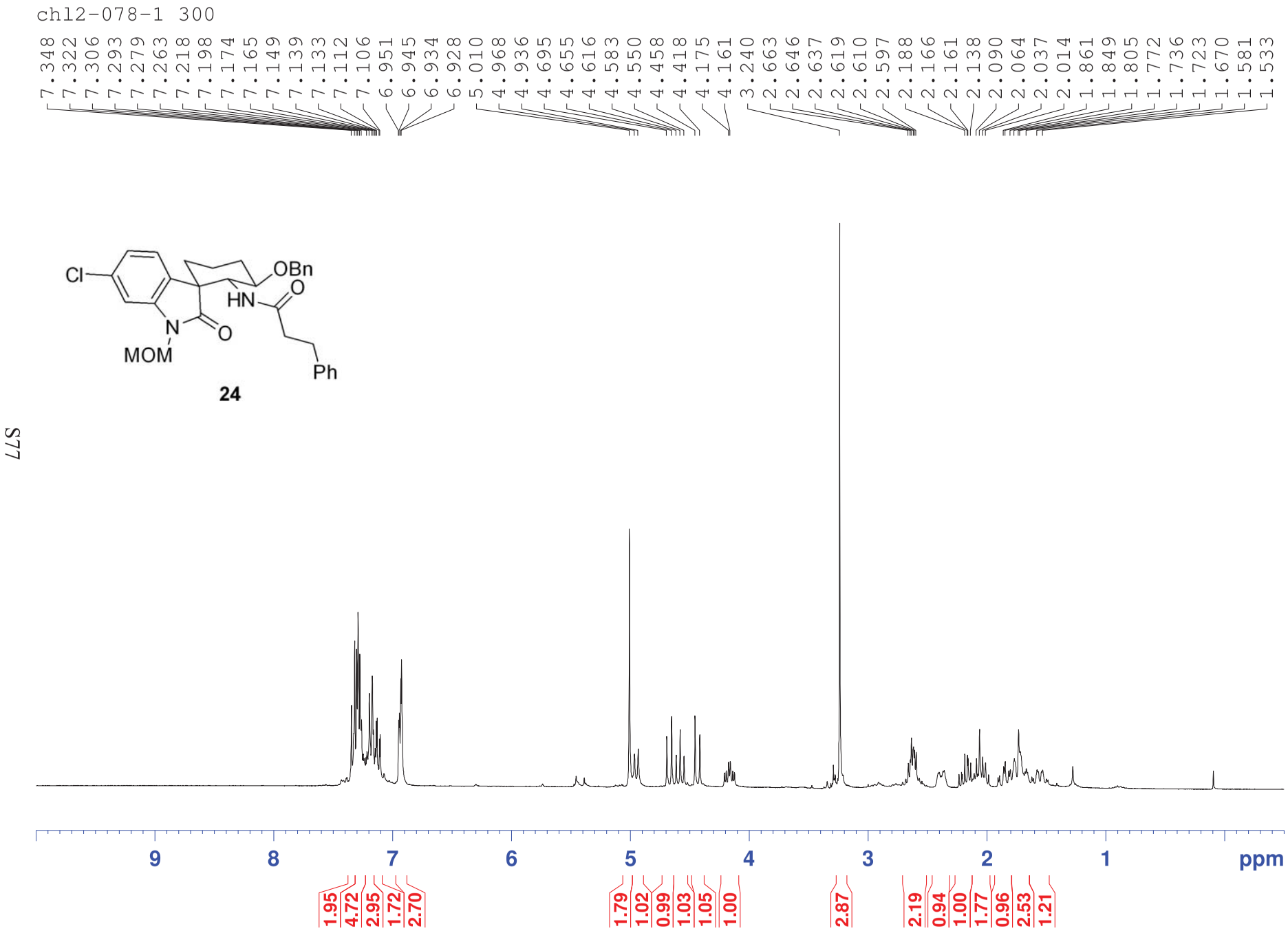
74.14
72.41
67.48

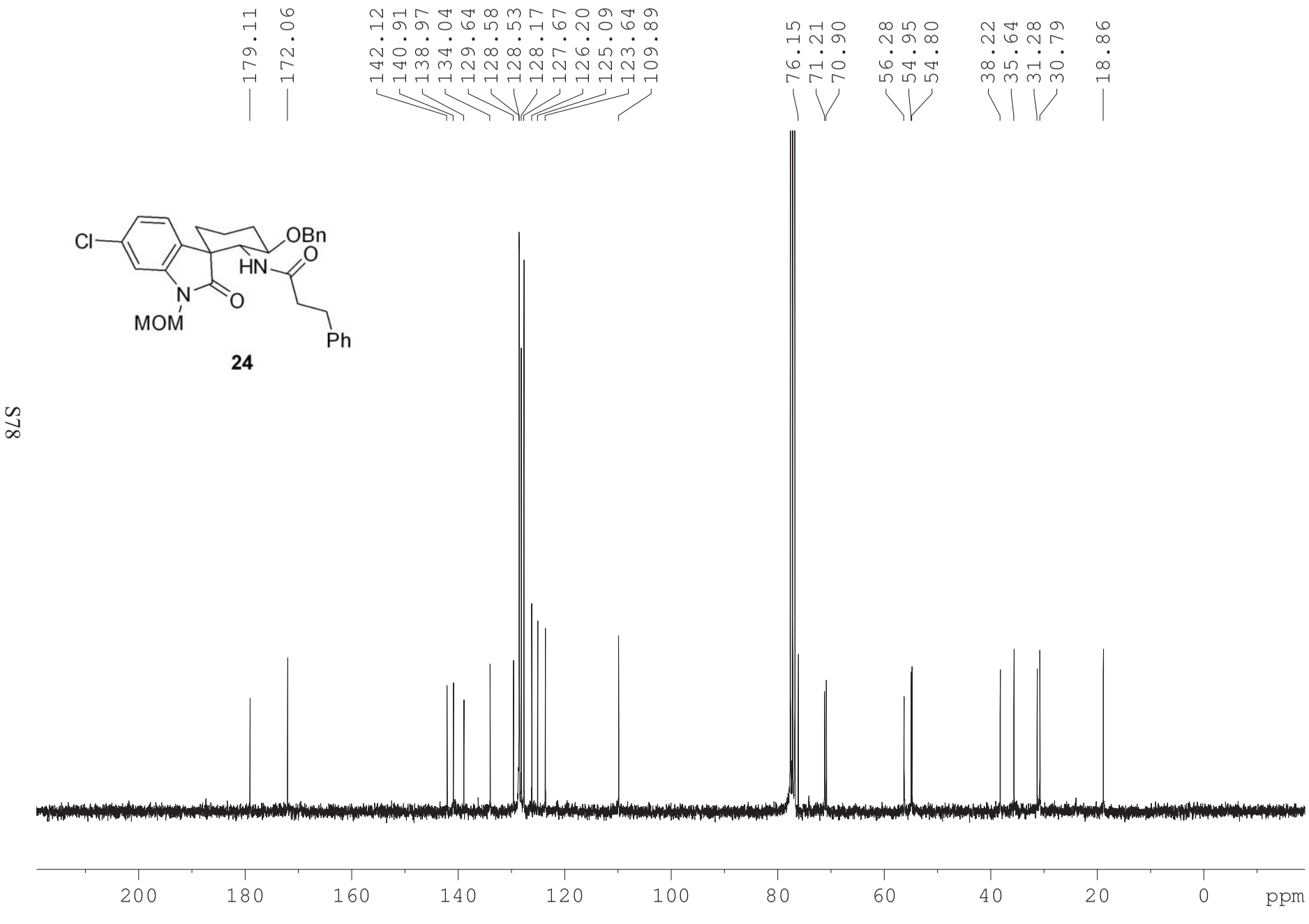
56.23

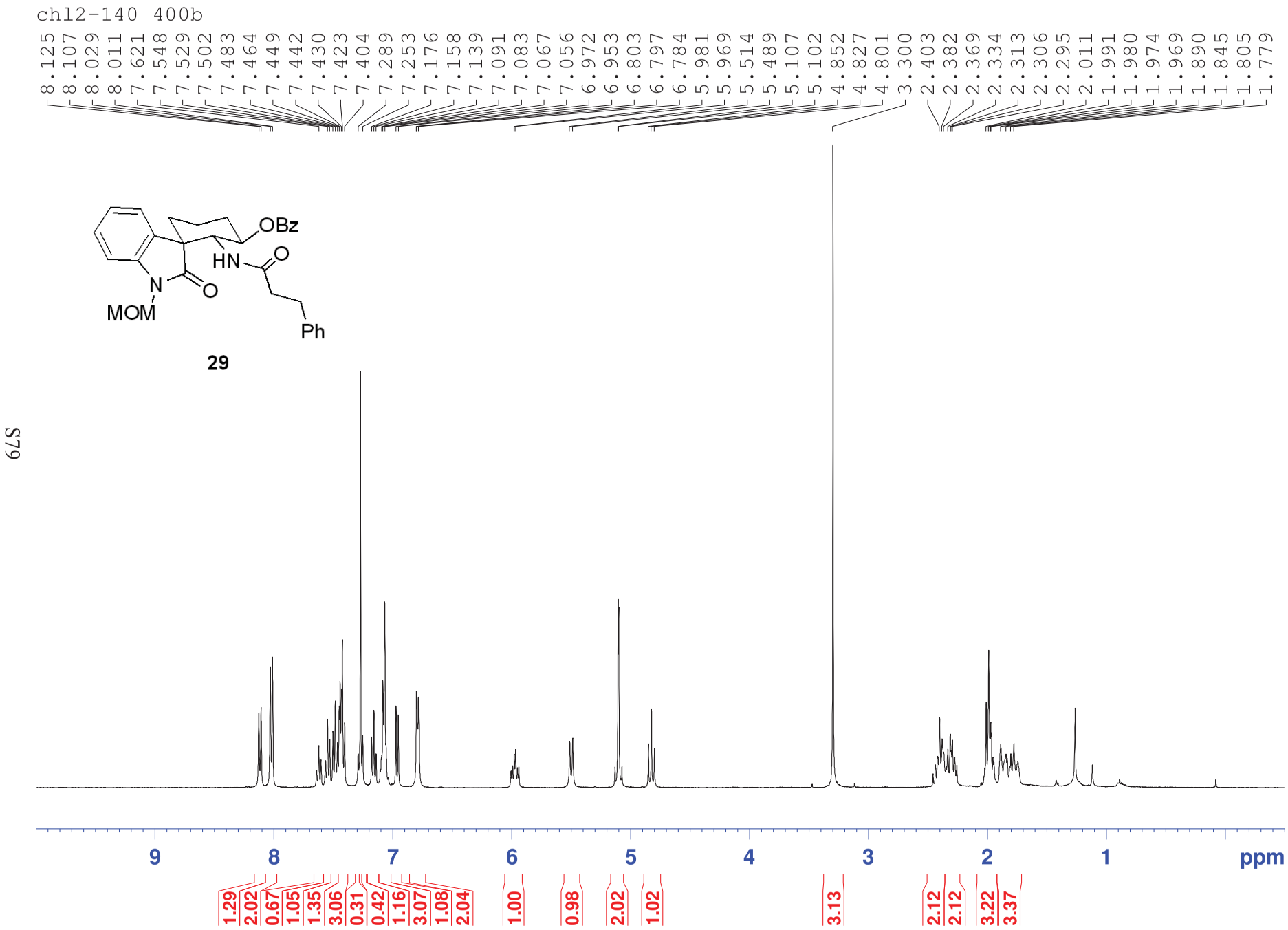
32.97
24.78
23.35

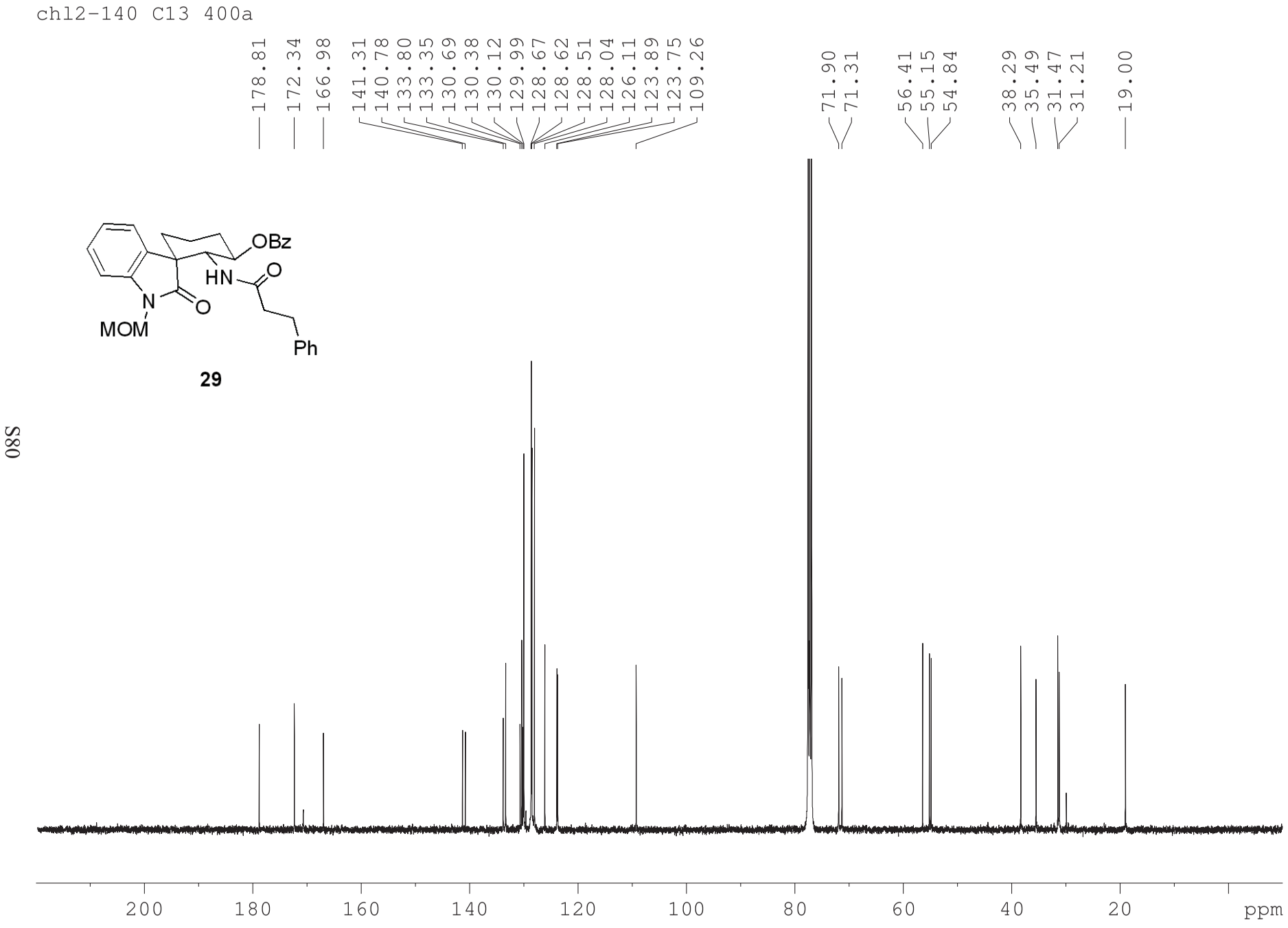


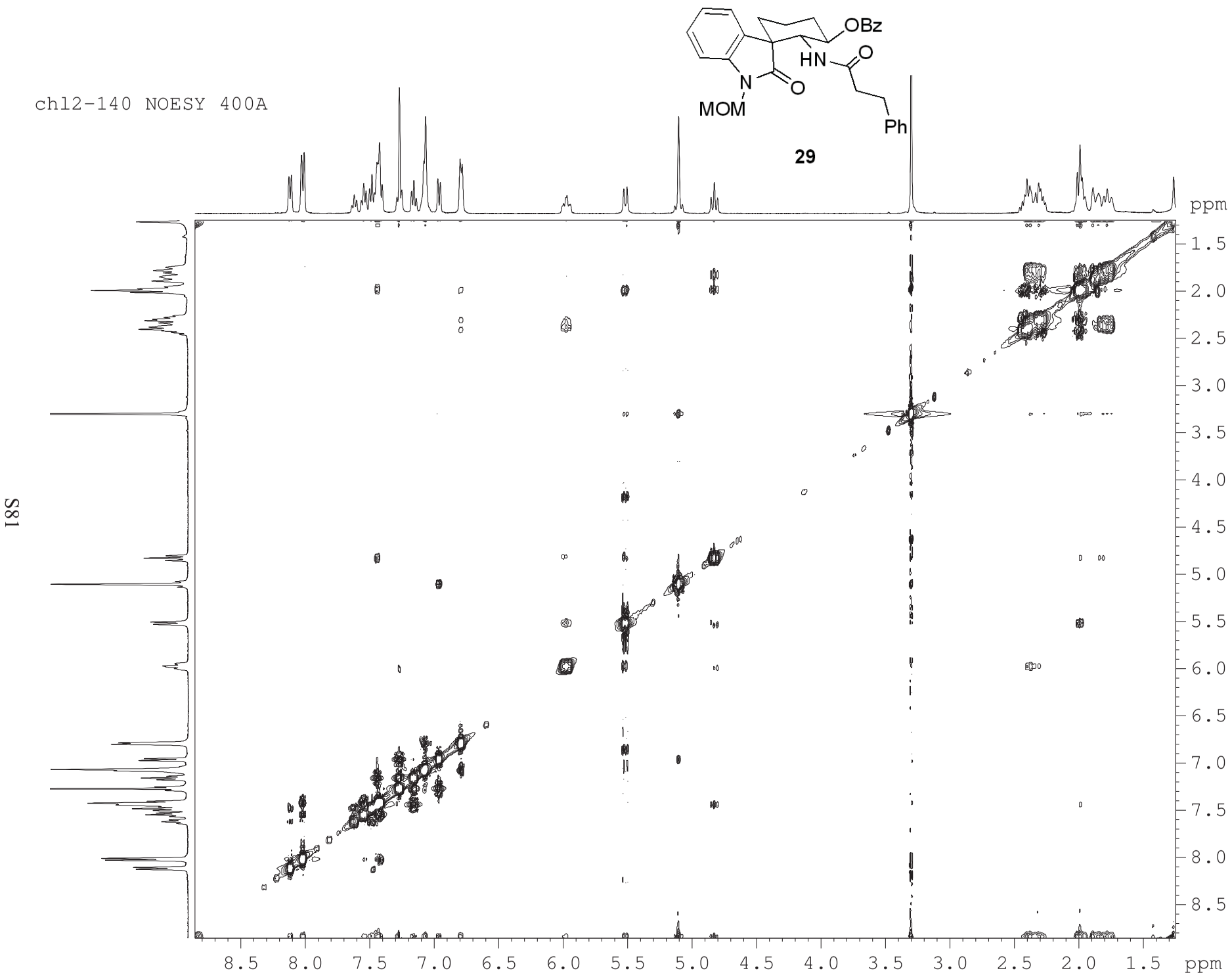
23

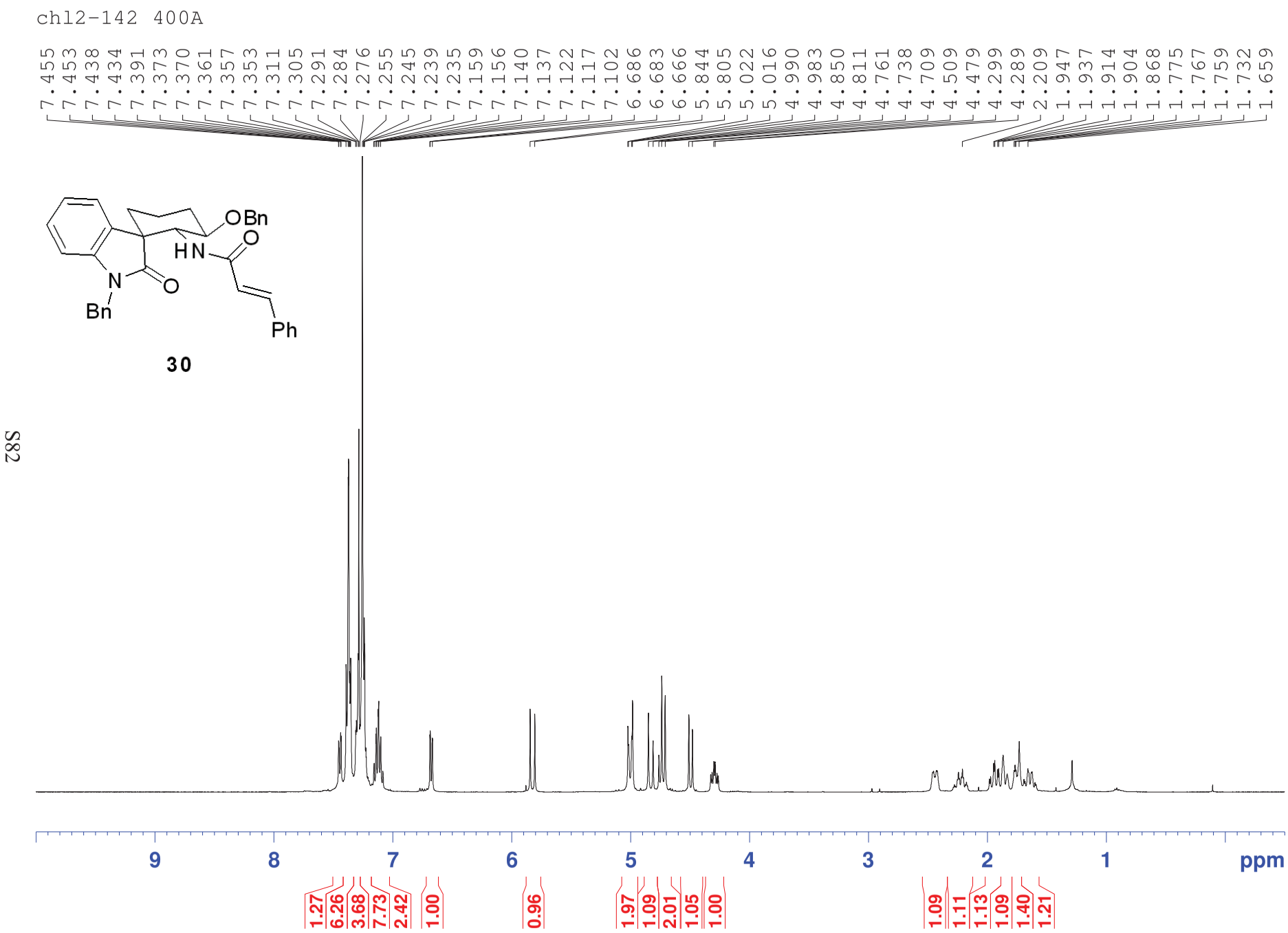

ch12-078-1 300
7.348
7.322
7.306
7.293
7.279
7.263
7.218
7.198
7.174
7.165
7.149
7.139
7.133
7.112
7.106
6.951
6.945
6.934
6.928
5.010
4.968
4.936
4.695
4.655
4.616
4.583
4.550
4.458
4.418
4.175
4.161
3.240
2.663
2.646
2.637
2.619
2.610
2.597
2.188
2.166
2.161
2.138
2.090
2.064
2.037
2.014
1.861
1.849
1.805
1.772
1.736
1.723
1.670
1.581
1.533
Cl
OBn
HN
O
N
O
MOM
Ph
24
9
8
7
6
5
4
3
2
1
ppm
1.95
4.72
2.95
1.72
2.70
1.79
1.02
0.99
1.03
1.05
1.00
2.87
2.19
0.94
1.00
1.77
0.96
2.53
1.21


ch12-078-1 C13 300
179.11
172.06
142.12
140.91
138.97
134.04
129.64
128.58
128.53
128.17
127.67
126.20
125.09
123.64
109.89
76.15
71.21
70.90
56.28
54.95
54.80
38.22
35.64
31.28
30.79
18.86
Cl
OBn
HN
O
N
O
MOM
Ph
24
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-140 400b
8.125
8.107
8.029
8.011
7.621
7.548
7.529
7.502
7.483
7.464
7.449
7.442
7.430
7.423
7.404
7.289
7.253
7.176
7.158
7.139
7.091
7.083
7.067
7.056
6.972
6.953
6.803
6.797
6.784
5.981
5.969
5.514
5.489
5.107
5.102
4.852
4.827
4.801
3.300
2.403
2.382
2.369
2.334
2.313
2.306
2.295
2.011
1.991
1.980
1.974
1.969
1.890
1.845
1.805
1.779
OBz
HN
O
N
O
MOM
Ph
29
S79
9
8
7
6
5
4
3
2
1
ppm
1.29
2.02
0.67
1.05
1.35
3.06
0.31
0.42
1.16
3.07
1.08
2.04
1.00
0.98
2.02
1.02
3.13
2.12
2.12
3.22
3.37

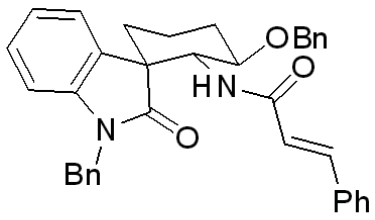

ch12-140 C13 400a
178.81
172.34
166.98
141.31
140.78
133.80
133.35
130.69
130.38
130.12
129.99
128.67
128.62
128.51
128.04
126.11
123.89
123.75
109.26
71.90
71.31
56.41
55.15
54.84
38.29
35.49
31.47
31.21
19.00
OBz
HN
O
N
O
MOM
Ph
29
S80
200
180
160
140
120
100
80
60
40
20
ppm


ch12-140 NOESY 400A
OBz
HN
O
N
O
MOM
Ph
29
ppm
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
ppm
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

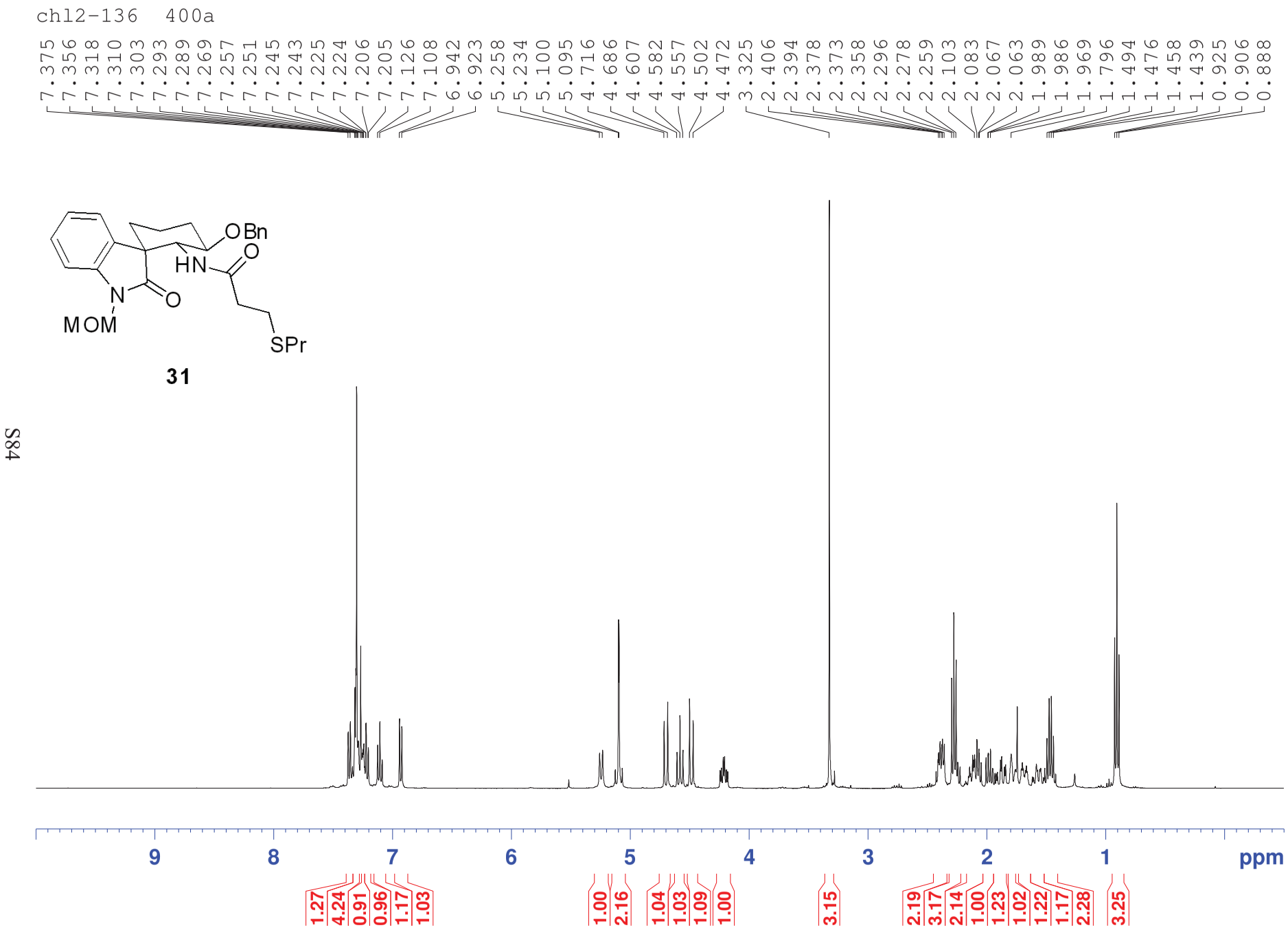

ch12-142 400A
7.455
7.453
7.438
7.434
7.391
7.373
7.370
7.361
7.357
7.353
7.311
7.305
7.291
7.284
7.276
7.255
7.245
7.239
7.235
7.159
7.156
7.140
7.137
7.122
7.117
7.102
6.686
6.683
6.666
5.844
5.805
5.022
5.016
4.990
4.983
4.850
4.811
4.761
4.738
4.709
4.509
4.479
4.299
4.289
2.209
1.947
1.937
1.914
1.904
1.868
1.775
1.767
1.759
1.732
1.659
OBn
O
HN
N
O
Bn
Ph
30
S82
9
8
7
6
5
4
3
2
1
ppm
1.27
6.26
3.68
7.73
2.42
1.00
0.96
1.97
1.09
2.01
1.05
1.00
1.09
1.11
1.13
1.09
1.40
1.21

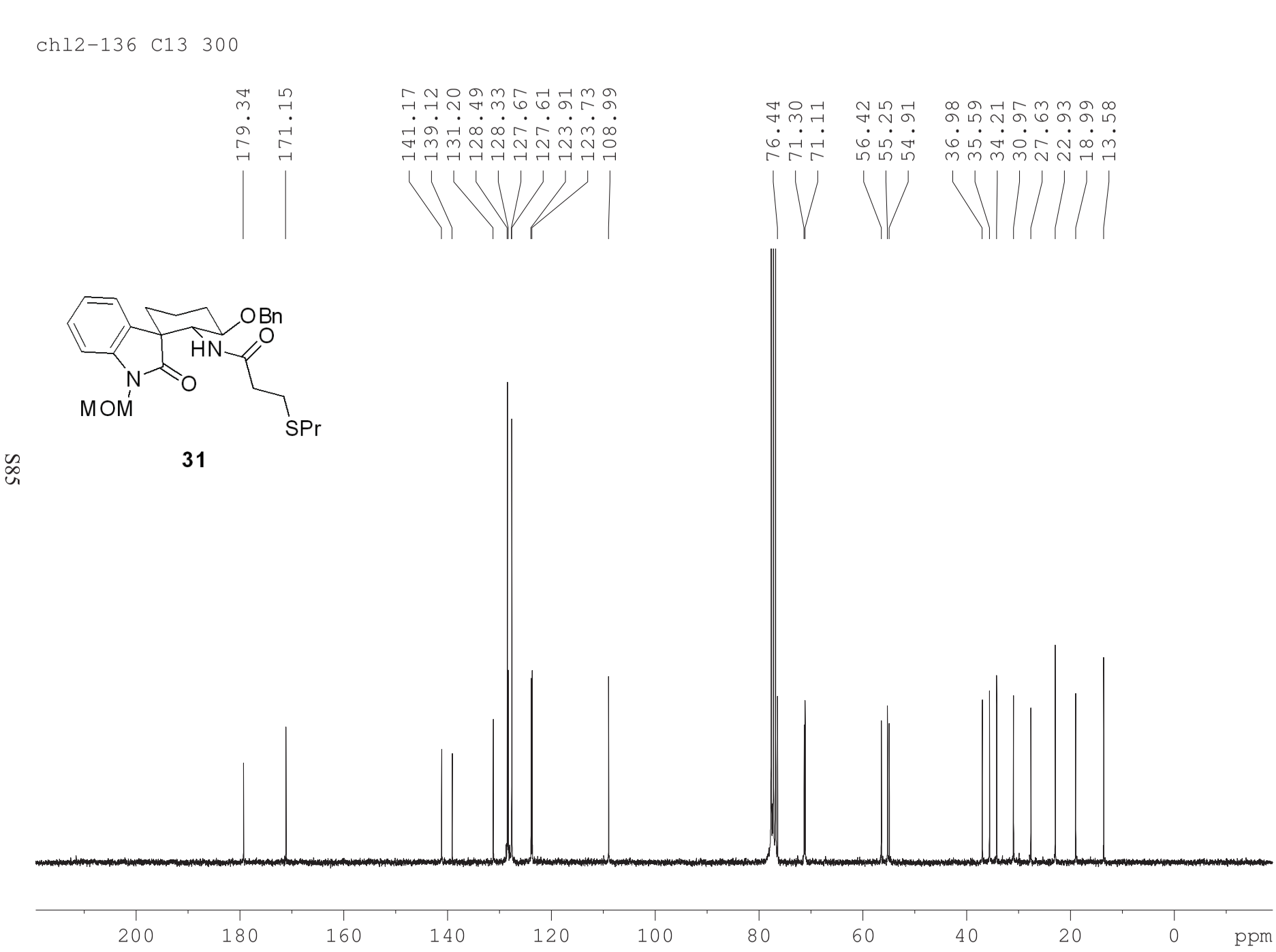
ch12-142 C13 300

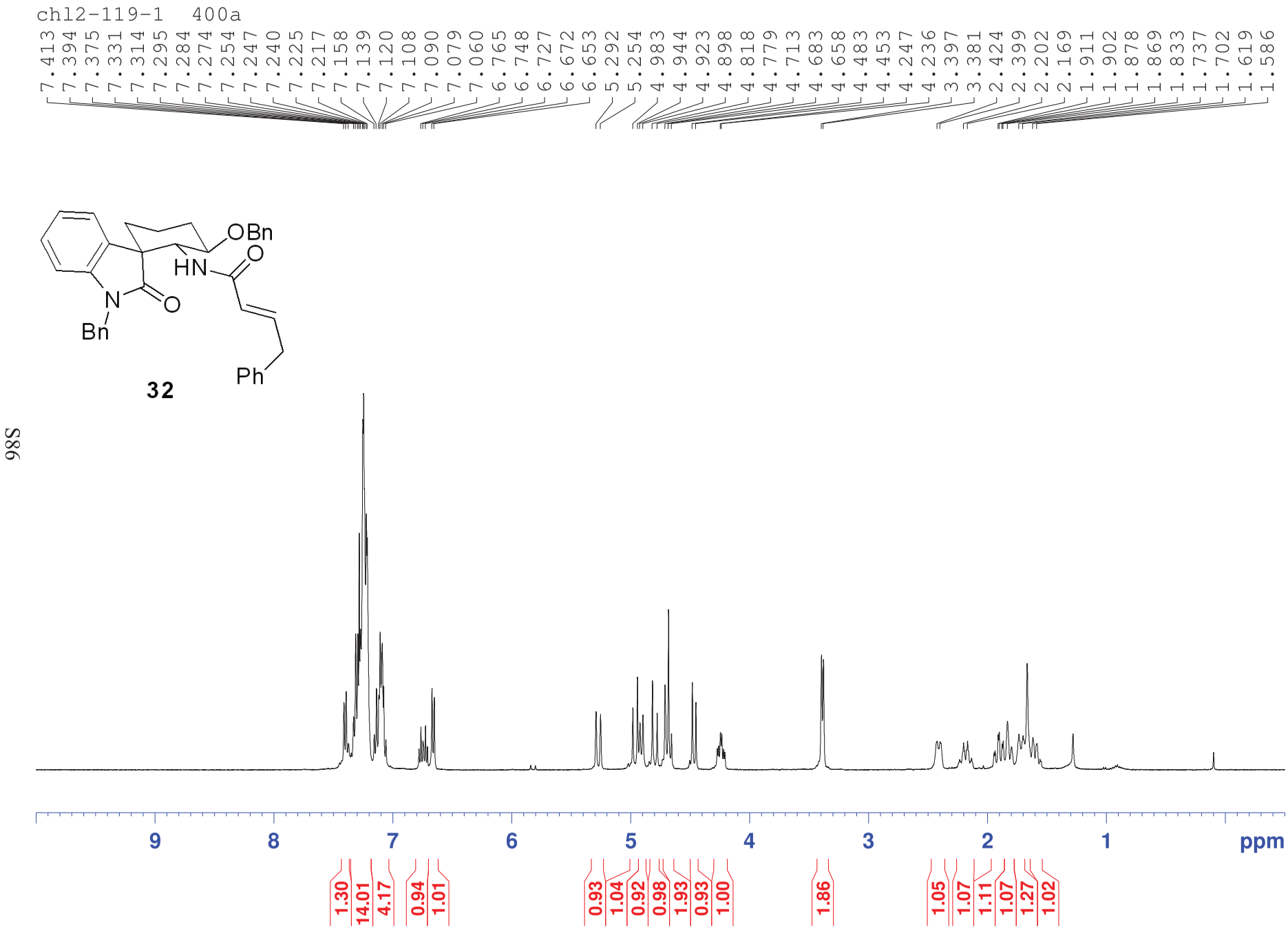
178.79
165.63
141.96
141.02
139.09
136.28
134.92
131.89
129.76
129.03
128.90
128.48
128.22
127.97
127.91
127.79
127.52
127.28
123.79
123.44
120.54
108.75
76.69
71.00
55.44
54.48
43.47
35.34
30.98
19.08



30

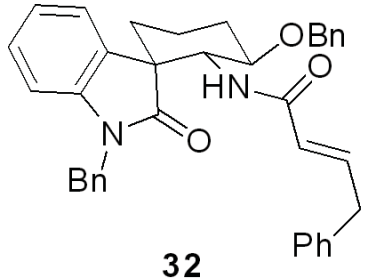

ch12-136 400a
7.375
7.356
7.318
7.310
7.303
7.293
7.289
7.269
7.257
7.251
7.245
7.243
7.225
7.224
7.206
7.205
7.126
7.108
6.942
6.923
5.258
5.234
5.100
5.095
4.716
4.686
4.607
4.582
4.557
4.502
4.472
3.325
2.406
2.394
2.378
2.373
2.358
2.296
2.278
2.259
2.103
2.083
2.067
2.063
1.989
1.986
1.969
1.796
1.494
1.476
1.458
1.439
0.925
0.906
0.888
OBn
O
HN
N
O
MOM
SPr
31
9
8
7
6
5
4
3
2
1
ppm
1.27
4.24
0.91
0.96
1.17
1.03
1.00
2.16
1.04
1.03
1.09
1.00
3.15
2.19
3.17
2.14
1.00
1.23
1.02
1.22
1.17
2.28
3.25


ch12-136 C13 300
179.34
171.15
141.17
139.12
131.20
128.49
128.33
127.67
127.61
123.91
123.73
108.99
76.44
71.30
71.11
56.42
55.25
54.91
36.98
35.59
34.21
30.97
27.63
22.93
18.99
13.58
OBn
HN
O
N
O
MOM
SPr
31
200
180
160
140
120
100
80
60
40
20
0
ppm


ch12-119-1 400a
7.413
7.394
7.375
7.331
7.314
7.295
7.284
7.274
7.254
7.247
7.240
7.225
7.217
7.158
7.139
7.120
7.108
7.090
7.079
7.060
6.765
6.748
6.727
6.672
6.653
5.292
5.254
4.983
4.944
4.923
4.898
4.818
4.779
4.713
4.683
4.658
4.483
4.453
4.247
4.236
3.397
3.381
2.424
2.399
2.202
2.169
1.911
1.902
1.878
1.869
1.833
1.737
1.702
1.619
1.586
OBn
O
HN
N
O
Bn
Ph
32
S86
9
8
7
6
5
4
3
2
1
ppm
1.30
14.01
4.17
0.94
1.01
0.93
1.04
0.92
0.98
1.93
0.93
1.00
1.86
1.05
1.07
1.11
1.07
1.27
1.02

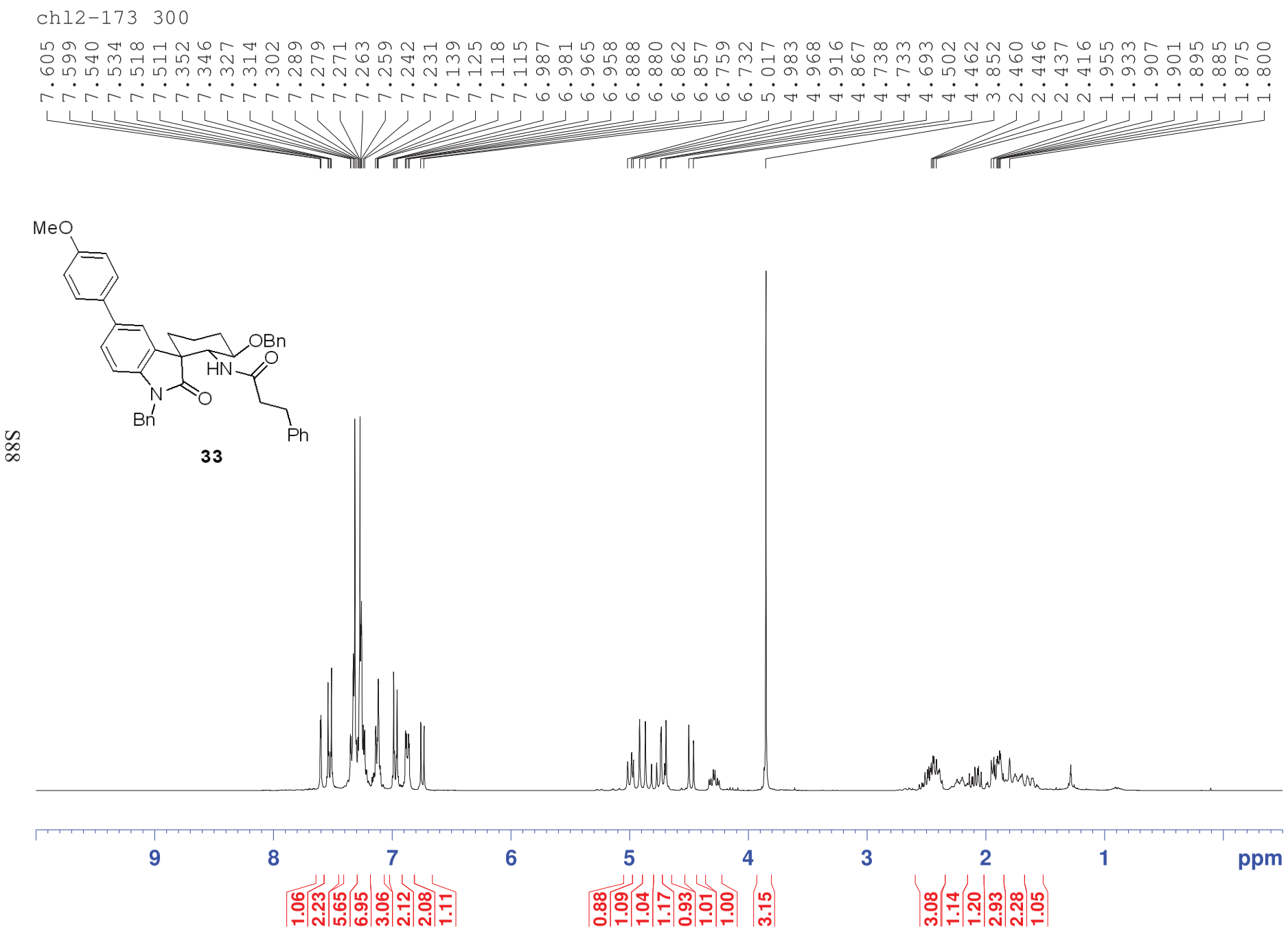
ch12-119-1 C13 400a

178.77
165.69
143.09
141.96
139.10
138.24
136.23
131.92
129.03
129.00
128.79
128.43
128.15
127.78
127.75
127.50
127.17
126.71
124.57
123.78
123.43
108.70
76.68
70.87
55.32
54.42
43.47
38.28
35.47
30.90
19.06



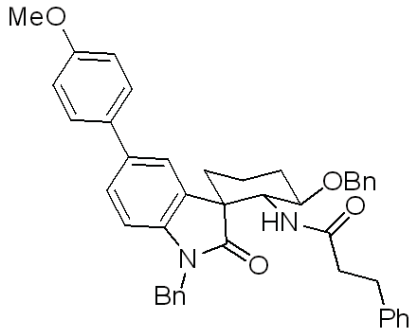
32

200 180 160 140 120 100 80 60 40 20 0 ppm


ch12-173 300
7.605
7.599
7.540
7.534
7.518
7.511
7.352
7.346
7.327
7.314
7.302
7.289
7.279
7.271
7.263
7.259
7.242
7.231
7.139
7.125
7.118
7.115
6.987
6.981
6.965
6.958
6.888
6.880
6.862
6.857
6.759
6.732
5.017
4.983
4.968
4.916
4.867
4.738
4.733
4.693
4.502
4.462
3.852
2.460
2.446
2.437
2.416
1.955
1.933
1.907
1.901
1.895
1.885
1.875
1.800
MeO
OBn
HN
O
N
O
Bn
Ph
33
S88
9
8
7
6
5
4
3
2
1
ppm
1.06
2.23
5.65
6.95
3.06
2.12
2.08
1.11
0.88
1.09
1.04
1.17
0.93
1.01
1.00
3.15
3.08
1.14
1.20
2.93
2.28
1.05

ch12-173 C13 300

178.73
172.01
159.07
141.03
140.83
139.20
136.31
136.29
133.83
132.27
129.05
128.47
128.45
128.27
128.18
127.94
127.53
127.33
126.56
126.07
122.86
114.38
108.72
76.41
70.80
55.53
55.34
54.58
43.70
38.23
35.39
31.45
30.99
19.04



33

200 180 160 140 120 100 80 60 40 20 0 ppm