A Highly Active Catalyst for Pd-Catalyzed Amination Reactions: Cross-Coupling Reactions Using Aryl Mesylates and the Highly Selective Monoarylation of Primary Amines

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Supporting Information

General Reagent Information

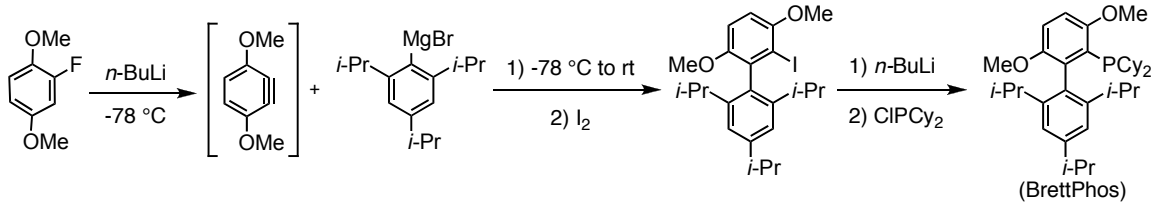
All reactions were carried out under an argon atmosphere. The methylamine solution, 1,4-dioxane, THF, and *tert*-butanol were purchased from Aldrich Chemical Co. in Sure-Seal bottles and were used as recieved. Dibutyl ether was purchased from Aldrich Chemical Co., anhydrous and was distilled from sodium metal. $Pd(OAc)_2$ was a gift from BASF and aryl halides and amines were purchased from Aldrich Chemical Co., Alfa Aesar, Parkway Scientific, or TCI America. The 1,4-dimethoxyfluorobenzene was purchased from Synquest Labs, Inc. and used as received. All amines that were a liquid and the aryl chlorides used in Table 5 were distilled from calcium hydride and stored under argon. Amines that were a solid and all other aryl halides were used as purchased without furthur purification. Distilled water was degassed by brief (30 sec) sonication under vacuum. Both potassium carbonate and sodium *tert*-butoxide were purchased from Aldrich Chemical Co. and used as received. The bulk of the bases were stored in an N_2 glovebox. Small portions were taken outside the box in glass vials and weighed in the air. Ligands **2**[1] and **3**[2] and precatalyst **6**[3] were synthesized using literature procedures.

General Analytical Information

All compounds were characterized by ^{1}H NMR, ^{13}C NMR, and IR spectroscopy. Copies of the ^{1}H and ^{13}C spectra can be found at the end of the Supporting Information. Nuclear Magnetic Resonance spectra were recorded on a Varian 300 MHz instrument and Bruker 400 MHz instrument. All ^{1}H NMR experiments are reported in δ units, parts per million (ppm), and were measured relative to the signals for residual chloroform (7.26 ppm) in the deuterated solvent, unless otherwise stated. All ^{13}C NMR spectra are reported

in ppm relative to deuterochloroform (77.23 ppm), unless otherwise stated, and all were obtained with ^{1}H decoupling. All IR spectra was taken on a Perkin – Elmer 2000 FTIR. All GC analyses were performed on a Agilent 6890 gas chromatograph with an FID detector using a J & W DB-1 column (10 m, 0.1 mm I.D.). Elemental analyses were performed by Atlantic Microlabs Inc., Norcross, GA.

Synthesis of 1 (BrettPhos)



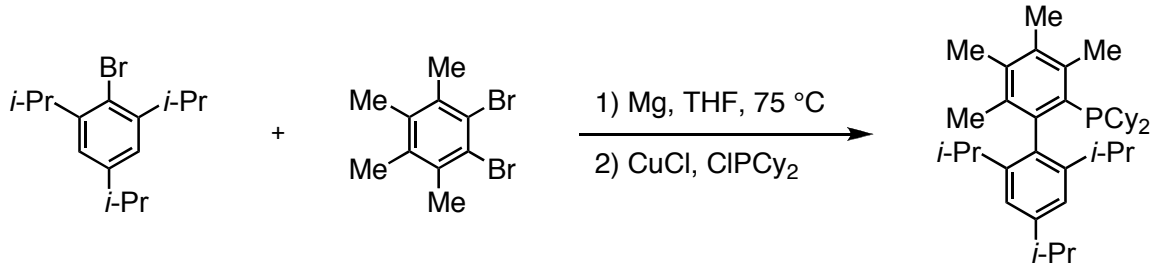
2-iodo-2',4',6'-triisopropyl-3,6-dimethoxybiphenyl An oven-dried three-neck 500 mL round bottom flask, which was equipped with a magnetic stir bar and charged with magnesium shavings (1.48 g, 61 mmol), was fitted with a reflux condenser, glass stopper, and rubber septum. The flask was purged with argon and then THF (120 mL) and 2,4,6-triisopropylbromobenzene (14.48 g, 51.2 mmol) were added via syringe. The reaction was heated to reflux and 1,2-dibromethane (40 uL) was added via syringe. The reaction mixture was allowed to stir at reflux for 1 h and was then cooled to room temperature. A separate oven-dried 1 L round bottom flask, which was equipped with a magnetic stir bar and fitted with a septum, was purged with argon and then THF (300 mL) and 1,4-dimethoxy-2-fluorobenzene (8 g, 51.2 mmol) were added to the flask via syringe. The reaction vessel was cooled via a -78 °C bath and n-BuLi (2.5 M in Hexane, 20.5 mL, 51.2 mmol) was added in a dropwise fashion over a 15 min period. The solution was stirred for an additional 30 min and the Grignard reagent, which was prepared in the first reaction vessel, was added via cannula over a 20 min period and the reaction mixture was allowed to stir at -78 °C for 1 h. The reaction mixture was slowly warmed to room temperature where it was stirred for an additional 1.5 h. The mixture was then cooled to 0 °C and a solution of Iodine in THF (1 M, 61 mL, 61 mmol) was added via syringe over a 15 min period and then the dark red solution was warmed to room temperature and stirred for 1 h. The solvent was removed with the aid of a rotary evaporator, and the remaining dark brown oil was taken up in CH_2Cl_2, washed with a

saturated solution of sodium sulfite, and with brine. The organic layer was then dried over $MgSO_4$, filtered, and the solvent was removed with the aid of a rotary evaporator to give a yellow solid. The crude material was recrystallized from EtOAc to yield the product as white crystals (3.430 g). The mother liquor was then concentrated and the remaining yellow solid was recrystallized from EtOAc to yield additional white crystals (3.728 g, 31% overall yield), mp 189 – 191 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.07 (s, 2H), 6.90 (d, *J* = 9.0 Hz, 1H), 6.81 (d, *J* = 9.0 Hz, 1H), 3.90 (s, 3H), 3.67 (s, 3H), 2.98 (septet, *J* = 7.0 Hz, 1H), 2.39 (septet, *J* = 7.0 Hz, 2H), 1.33 (d, *J* = 7.0 Hz, 6H), 1.20 (d, 7.0 Hz, 6H), 1.02 (d, *J* = 7.0 Hz, 6H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 152.7, 152.5, 148.4, 145.9, 136.4, 136.1, 121.0, 110.3, 109.4, 96.6, 57.0, 55.8, 34.3, 31.1, 24.8, 24.3, 23.9 ppm. IR (neat, cm^{-1}): 2957, 2865, 1567, 1460, 1428, 1257, 1032, 755. Anal. Calcd. for $C_{23}H_{31}IO_2$: C, 59.23; H, 6.70. Found: C, 59.23; H, 6.72.

1 (BrettPhos) An oven-dried 25 mL round bottom flask, which was equipped with a magnetic stir bar and charged with 2-iodo-2',4',6'-triisopropyl-3,6-dimethoxybiphenyl (1 g, 2.15 mmol), was evacuated and backfilled with argon (this process was repeated a total of 3 times). THF (10 mL) was added via syringe and the reaction was cooled to -78 °C and n-BuLi (2.5 M in Hexane, 940 μL, 2.36 mmol) was added in a dropwise fashion over a 10 min period. The solution was stirred for 30 min and then the $ClPCy_2$ (527 mg, 2.26 mmol) was added via syringe over 10 min. The reaction mixture was stirred for 1 h at -78 °C and then warmed slowly to room temperature where it was stirred for an additional 1.5 h. The solution was filtered through a plug of celite layered on a plug of silica (eluting with EtOAc) and then the solvent was removed with the aid of a rotary evaporator to give a white solid. The crude material was recrystallized from acetone to yield the desired product as white crystals. The mother liquor was then concentrated and the remaining white solid was recrystallized from acetone to yield additional white crystals (1.012 g total, 88% yield), mp 191 – 193 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 6.96 (s, 2H), 6.85 (d, *J* = 9.0 Hz, 1H), 6.78 (d, *J* = 9.0 Hz, 1H), 3.82 (s, 3H), 3.56 (s, 3H), 2.93 (septet, *J* = 7.0 Hz, 1H), 2.42 (septet, *J* = 7.0 Hz, 2H), 2.19 (m, 2H), 1.82 – 1.60 (m, 8H), 1.41 – 0.90 (m, 12H), 1.31 (d, *J* = 7.0 Hz, 6H), 1.16 (d, *J* = 7.0 Hz, 6H), 0.92 (d, *J* = 7.0 Hz, 6H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 156.5, 156.5, 152.5, 152.4, 147.1,

146.2, 146.1, 139.5, 139.0, 132.9, 132.8, 127.0, 126.6, 120.4, 120.3, 110.9, 108.8, 55.3, 54.9, 54.8, 36.9, 36.7, 34.0, 33.3, 32.9, 31.2, 31.0, 30.7, 28.2, 28.1, 27.9, 27.7, 26.7, 25.3, 24.2, 23.8 ppm (Observed complexity is due to P-C splitting). ^{31}P NMR (121 MHz, $CDCl_3$) δ: -1.62 ppm. IR (neat, cm^{-1}): 3378, 2849, 1654, 1654, 1457, 1423, 1384, 1249, 1053. Anal. Calcd. for $C_{35}H_{53}O_2P$: C, 78.32; H, 9.95. Found: C, 78.44; H, 10.09.

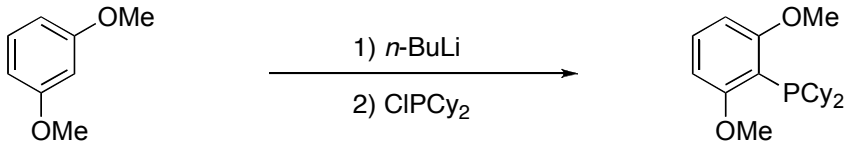
Synthesis of 4



Ligand 4 An oven-dried three-neck 250 mL round bottom flask, which was equipped with a magnetic stir bar and charged with magnesium shavings (559 mg, 24.3 mmol), was fitted with a reflux condenser, addition funnel, and glass stopper. The flask was purged with argon and then THF (15 mL) and 2,4,6-triisopropylbromobenzene (2.83 g, 10 mmol) were added via syringe. The reaction mixture was heated to reflux and 1,2-dibromethane (40 uL) was added via syringe. The reaction was allowed to stir at reflux for 1 h and then the addition funnel, which was charged with 1,2-dibromo-3,4,5,6-tetramethylbenzene (2.92 g, 10 mmol) in 40 mL of THF, was opened and the solution was added over a 1 h period. The mixture was stirred for 5 h at reflux and then cooled to room temperature where CuCl (1.0 g, 10 mmol) was added quickly to the reaction mixture. Next, $ClPCy_2$ (2.65 mL, 10 mmol) was then added in a dropwise fashion and the reaction mixture was heated to 75 °C for 60 h. The reaction mixture was then cooled to room temperature, diluted with EtOAc, washed 3 times with 30% NH_4OH, dried over $MgSO_4$, and concentrated under reduced pressure. The crude material was recrystallized from benzene to yield the product as a white solid (1.507 g, 28% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.36 (s, 5H), 7.15 (s, 2H), 2.99 (septet, J = 7.0 Hz, 1H), 2.44 (s, 3H), 2.35-2.14 (m, 11H), 1.98 (s, 2H), 1.80-1.44 (m, 14H), 1.39-1.04 (m, 22H), 0.91 (d, J = 6.5 Hz, 6H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 150.9, 145.8, 145.4, 144.6, 140.0, 138.5, 135.8, 135.6, 135.5, 135.5, 128.6, 124.3, 40.2, 39.9, 35.4, 35.2, 34.5, 30.7, 29.5,

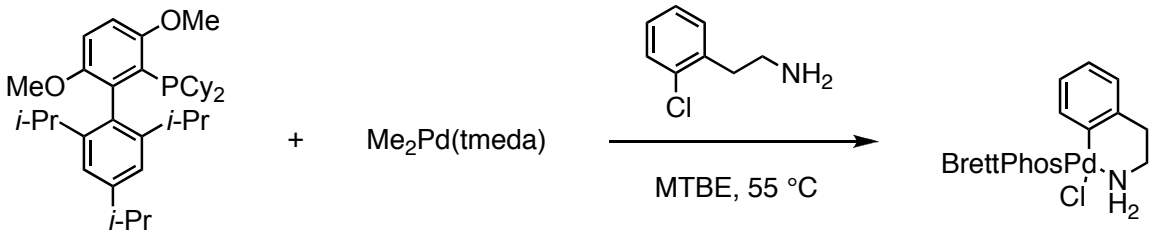
27.8, 27.7, 27.4, 27.2, 25.9, 25.0, 24.6, 21.2, 20.8, 17.7, 17.3 ppm (Observed complexity is due to P-C splitting). ^{31}P NMR (121 MHz, $CDCl_3$) δ: 16.33 ppm.

Synthesis of 5



Ligand 5 To a 0 °C solution of 1,3-dimethoxybenzene (2.0 mL, 15.3 mmol) in THF (35 mL) was added *n*-BuLi (6.20 mL, 2.5 M in hexanes, 15.5 mmol) via syringe over a 10 min period. The mixture was then allowed to warm to room temperature and stirred for 5 h. The mixture was re-cooled to 0 °C and $ClPCy_2$ (3.07 mL, 13.9 mmol) was added via syringe over a 10 min period. The reaction mixture was allowed to warm to room temperature where it was stirred for 12 h. The solution was then filtered through a plug of silica, eluting with EtOAc, and concentrated under reduced pressure to yield the product as a white solid (4.89 g, 96% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.21 (t, J = 8.0 Hz, 1H), 6.46 (d, J = 8.0 Hz, 2H), 3.74 (s, 6H), 2.26 (m, 2H), 1.86 (m, 2H), 1.70 (m, 2H), 1.56 (m, 4H), 1.42-0.89 (m, 12H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 164.5, 164.4, 131.1, 111.6, 111.2, 104.1, 55.8, 34.3, 34.1, 32.5, 32.2, 30.5, 30.4, 27.6, 27.5, 27.5, 27.3, 26.7 ppm (Observed complexity is due to P-C splitting). ^{31}P NMR (121 MHz, $CDCl_3$) δ: -11.8 ppm. IR (neat, cm^{-1}): 2921, 2847, 1581, 1463, 1428, 1242, 1103, 777.

Synthesis of 6



Precatalyst 6 An oven-dried schlenk tube, which was equipped with a magnetic stir bar and fitted with a rubber septum, was charged with Me_2Pd(TMEDA) (253 mg, 1 mmol) and **1** (537 mg, 1 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and the 2-(2-chorophenyl)ethylamine (156 mg, 1 mmol) and MTBE (8 mL) were added via syringe and the reaction mixture was heated to 55 °C for 5 h. The reaction mixture was then cooled to 0 °C and a white precipate was

filtered and washed with cold MTBE. The white product was then taken up in CH_2Cl_2 and concentrated under reduced pressure (done to remove any remaining MTBE) to yield the product as a white solid (645 mg, 93% yield). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.17 (s, 2H), 7.09-6.84 (m, 6H), 3.85 (s, 3H), 3.38 (s, 3H), 3.17-0.00 (m, 49 H) ppm. ^{31}P NMR (121 MHz, $CDCl_3$) δ: 42.2 ppm. IR (neat, cm^{-1}): 3303, 2929, 1658, 1462, 1384, 1256, 1010, 755.

Experimental Procedures for Examples Described in *Table 1*

General Procedure Using the Precatalysts: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with the precatalyst (1 mol%), ligand (1 mol%), 4-*t*-butylphenyl methanesulfonate (0.5 mmol, 114 mg), and K_2CO_3 (97 mg, 0.7 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aniline (55 μL, 0.6 mmol) and *tert*-butanol (6 mL) were added via syringe. The solution was heated to 110 °C for 4 h, cooled to room temperature, diluted with Ethyl acetate, and washed with water. Dodecane was then added as an internal standard and the reaction was analyzed by GC.

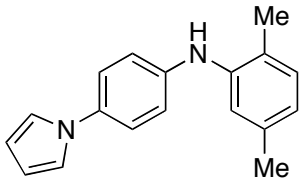
General Procedure for Water-Mediated Catalyst Preactivation: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with $Pd(OAc)_2$ (1 mol%) and ligand (3 mol%). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and the *tert*-butanol (1 mL) and degassed H_2O (8 mol%) were added via syringe. After addition of the water, the solution was heated to 110 °C for 1 min.

A second oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a Teflon septum, was charged with 4-*t*-butylphenyl methanesulfonate (0.5 mmol, 114 mg) and K_2CO_3 (97 mg, 0.7 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aniline (55 μL, 0.6 mmol) and *tert*-butanol (5 mL) were added via syringe and the activated catalyst solution was transferred from the first reaction vessel into the second via cannula. The solution was heated to 110 °C for 4 h, cooled to room temperature, diluted with Ethyl acetate, and

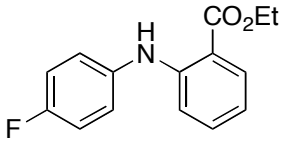
washed with water. Dodecane was then added as an internal standard and the reaction was analyzed by GC.

Experimental Procedures for Examples Described in *Table 2*

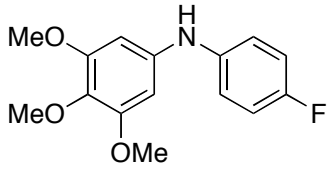
General Procedure A: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with **5** (1 mol%) **1** (1 mol%) and K_2CO_3 (97 mg, 0.7 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aryl mesylate (0.5 mmol), amine (0.6 mmol), and *tert*-butanol (6 mL) were added via syringe (aryl chlorides or amines that were solids at room temperature were added with the catalyst and base). The solution was heated to 110 °C until the starting material was completely consumed as monitored by GC. The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, concentrated in vacuo, and purified via the Biotage SP4 (silica-packed 25+M cartridge).



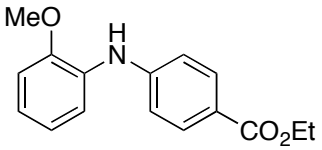
***N*-(4-(1*H*-pyrrol-1-yl)phenyl)-2,5-dimethylaniline** (Table 2, entry 1) Following general procedure A, a mixture of 4-(1H-pyrrol-1-yl)phenylmethanesulfonate (119 mg, 0.5 mmol), 2,5-dimethylaniline (75 μL, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a white solid (138 mg, 95%), mp 97-98 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.31 (d, J = 9.0 Hz, 2H), 7.14 (d, J = 7.5 Hz, 1H), 7.04 (m, 5H), 6.82 (d, J = 7.5 Hz, 1H), 6.37 (t, J = 2.5 Hz, 2H), 5.40 (s, 1H), 2.33 (s, 3H), 2.27 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 142.4, 141.1, 136.9, 134.4, 131.2, 125.6, 123.3, 122.3, 119.9, 119.8, 118.5, 110.0, 21.5, 17.8 ppm. IR (neat, cm^{-1}): 3386, 2920, 1519, 1310, 1072, 829, 726. Anal. Calcd. for $C_{18}H_{18}N_2$: C, 82.41; H, 6.92. Found: C, 82.03; H, 7.03.



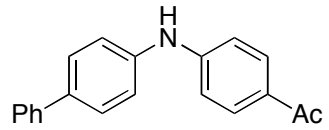
Ethyl 2-(4-fluorophenylamino)benzoate (Table 2, entry 2) Following general procedure A, a mixture of 4-fluorophenylmethanesulfonate (95 mg, 0.5 mmol), ethyl 2-aminobenzoate (89 μL, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-20% EtOAc/hexanes) to provide the title compound as a yellow oil (118 mg, 91%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.44 (s, 1H), 7.99 (d, *J* = 8.0 Hz, 1H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.21 (m, 2H), 7.07 (m, 3H), 6.73 (t, *J* = 7.5 Hz, 1H), 4.37 (q, *J* = 7.5 Hz, 2H), 1.42 (t, *J* = 7.5 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 168.8, 161.3, 158.1, 148.8, 136.9, 136.9, 134.4, 131.9, 125.4, 125.3, 117.1, 116.5, 116.2, 113.6, 112.0, 60.9, 14.6 ppm. IR (neat, cm^{-1}): 3316, 2982, 1683, 1583, 1513, 1455, 1260, 1233, 1082, 749. Anal. Calcd. for $C_{15}H_{14}FNO_2$: C, 69.49; H, 5.44. Found: C, 70.14; H, 5.64.



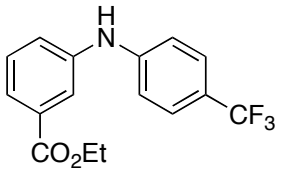
***N*-(4-fluorophenyl)-3,4,5-trimethoxyaniline** (Table 2, entry 3) Following general procedure A, a mixture of 3,4,5-trimethoxyphenylmethanesulfonate (131 mg, 0.5 mmol), 4-fluoroaniline (57 μL, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 5-40% EtOAc/hexanes) to provide the title compound as a yellow oil (120 mg, 87%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 6.99 (m, 4H), 6.22 (s, 2H), 5.57 (s, 1H), 3.80 (s, 3H), 3.78 (s, 6H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 159.7, 156.5, 154.1, 140.5, 139.6, 132.5, 120.4, 120.3, 116.4, 116.1, 95.2, 61.3, 56.2 ppm. IR (neat, cm^{-1}): 3360, 2937, 1597, 1499, 1454, 1216, 1129, 1007, 785. Anal. Calcd. for $C_{15}H_{16}FNO_3$: C, 64.97; H, 5.82. Found: C, 65.24; H, 6.00.



ethyl 4-(2-methoxyphenylamino)benzoate[4] (Table 2, entry 4). Following general procedure A, a mixture of 2-methoxyphenylmethanesulfonate (101 mg, 0.5 mmol), ethyl 4'-aminobenzoate (99 mg, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a clear oil (117 mg, 87%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.96 (d, *J* = 9.0 Hz, 2H), 7.41 (d, *J* = 7.0 Hz, 1H), 7.09 (d, *J* = 9.0 Hz, 2H), 6.97 (m, 3H), 6.42 (s, 1H), 4.35 (q, *J* = 7.0 Hz, 2H), 3.87 (s, 3H), 1.39 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 166.8, 149.7, 147.7, 131.6, 130.8, 122.4, 121.7, 121.0, 117.9, 115.4, 111.1, 60.7, 55.8, 14.7 ppm. IR (neat, cm^{-1}): 3354, 2979, 1704, 1593, 1526, 1276, 1175, 1105, 1027, 746.



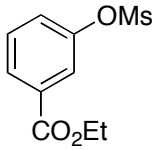
1-(4-(biphenyl-4-ylamino)phenyl)ethanone (Table 2, entry 5). Following general procedure A, a mixture of 4-biphenylmethanesulfonate (124 mg, 0.5 mmol), 4'-aminoacetophenone (81 mg, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 15-50% EtOAc/hexanes) to provide the title compound as a white solid (139 mg, 97%), mp 136-139 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.90 (d, *J* = 9.0 Hz, 2H), 7.59 (m 4H), 7.45 (t, *J* = 7.0 Hz, 2H), 7.35 (t, *J* = 7.0 Hz, 1H), 7.25 (d, *J* = 9.0 Hz, 2H), 7.05 (d, *J* = 9.0 Hz, 2H), 6.35 (s 1H), 2.55 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 196.8, 148.4, 140.7, 140.2, 136.2, 130.9, 129.3, 129.1, 128.4, 127.3, 127.0, 120.9, 114.9, 26.5 ppm. IR (neat, cm^{-1}): 3324, 1656, 1586, 1524, 1487, 1339, 1278, 1178, 827, 763.



ethyl 3-(4-(trifluoromethyl)phenylamino)benzoate (Table 2, entry 6). Following general procedure A, a mixture of ethyl 3-(methylsulfonyloxy)benzoate (122 mg, 0.5 mmol), 4-(trifluoromethyl)aniline (75 μL, 0.6 mmol), K_2CO_3 (97 mg, 0.7 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and *t*-BuOH (6 mL) was heated to 110 °C for 16 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a white solid (144 mg, 93%), mp 106-108 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.81 (s, 1H), 7.71 (d, *J* = 7.0 Hz, 1H), 7.49 (d, *J* = 8.5 Hz, 2H), 7.36 (m, 2H), 7.07 (d, *J* = 8.5 Hz, 2H), 6.13 (s 1H), 4.38 (q, *J* = 7.0 Hz, 2H), 1.39 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 166.7, 146.3, 141.8, 132.1, 130.1, 129.8, 127.1, 127.0, 127.0, 126.9, 126.6, 123.8, 123.8, 123.0, 122.6, 122.2, 120.6, 116.0, 61.5, 14.5 ppm. IR (neat, cm^{-1}): 3358, 1701, 1620, 1543, 1333, 1158, 1108, 1070, 751. Anal. Calcd. for $C_{16}H_{14}F_3O_2N$: C, 62.13; H, 4.56. Found: C, 61.97; H, 4.46.

Synthesis of Aryl Mesylates

All known aryl mesylates were synthesized using literature procedures.[5]



Ethyl 3-(methylsulfonyloxy)benzoate To a stirred solution of ethyl 3-hydroxybenzoate (3.32 g, 20 mmol) in dichloromethane (20 mL) cooled to 0 °C was added triethylamine (4.17 mL, 30 mmol). To this was added mesyl chloride (1.94 mL, 25 mmol) dropwise over 15 min. The reaction was stirred at 0 °C for 15 min then quenched with water and the phases separated. The aqueous layer was extracted with dichloromethane and the combined organics were dried over $MgSO_4$ and concentrated in vacuo. The crude material was purified via the Biotage SP4 (silica-packed 25+M; 0-50% EtOAc/hexanes) to provide the title compound as a white solid (2.698 g, 55%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.98 (m, 1H), 7.89 (s, 1H), 7.47 (m, 2H), 4.35 (q, *J* = 7.0 Hz, 2H), 3.16 (s, 3H), 1.37 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 165.3, 149.3, 132.9,

130.3, 128.7, 126.9, 123.2, 61.8, 37.8, 14.5 ppm. IR (neat, cm^{-1}): 1721, 1384, 1369 1268, 1194, 1168, 1098, 936, 840, 798.

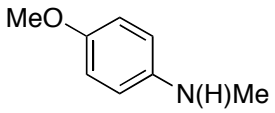
Experimental Procedures for Examples Described In *Table 4*.

Procedure B: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with the precatalyst (0.01 equiv.) and NaO*t*-Bu (120 mg, 1.2 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aryl chloride (1.0 mmol), 2M methylamine solution in THF (1 mL, 2.0 mmol), and *t*-BuOH (1mL) were added in succession via syringe (aryl chlorides that were solids at room temperature were added with the precatalyst and base). The solution was allowed to stir at room temperature until starting aryl chloride was completely consumed as monitored by GC. The reaction mixture was then diluted with ethyl acetate, washed with aqueous NH_4Cl, dried over Na_2SO_4, concentrated in vacuo, and purified via column chromatography on silica gel.

Procedure C: General procedure A was used with the following modification: 2M methylamine solution in THF (1 mL, 2.0 mmol), and *t*-BuOH (4 mL) were premixed and added to the reaction vessel.

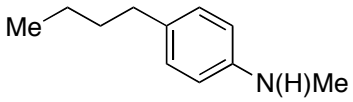
Procedure D: An oven-dried Schlenk tube, which was equipped with a magnetic stir bar was charged with the precatalyst (0.003 or 0.001 equiv.), BrettPhos (0.003 or 0.001 equiv.), and NaO*t*-Bu (120 mg, 1.2 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aryl chloride (1.0 mmol), 2M methylamine solution in THF (1 mL, 2.0 mmol), and *t*-BuOH (1mL) were added in succession via syringe (aryl chlorides that were solids at room temperature were added with the precatalyst and base). The Schlenk tube was sealed with a Teflon stopper and heated to 80 ºC for 12 h. The reaction mixture was then diluted with ethyl acetate, washed with aqueous NH_4Cl, dried over Na_2SO_4, concentrated in vacuo, and purified via column chromatography on silica gel.

Procedure E: General procedure C was used with the following modification: 2M methylamine solution in THF (1 mL, 2.0 mmol), and *t*-BuOH (4 mL) were premixed and added to the reaction vessel.



4-Methoxy-*N*-methylaniline. *(RT, 1% Pd):* Following general procedure B, a mixture of 4-chloroanisole (123 μL, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (8 mg, 0.01 mmol), and *t*-BuOH (1 mL) was stirred at room temperature for 2 h. The crude product was purified via column chromatography (20:1 CH_2Cl_2/MeOH) to provide the title compound as a yellow liquid that turned into a tan solid upon standing (126 mg, 92%).

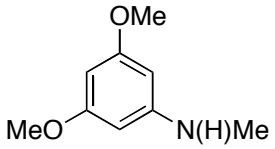
(80 ºC, 0.3% Pd): Following general procedure D, a mixture of 4-chloroanisole (123 μL, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (2.4 mg, 0.003 mmol), BrettPhos (1.5 mg, 0.003 mmol), and *t*-BuOH (1 mL) was stirred at 80 ºC for 12h. The crude product was purified via column chromatography (20:1 CH_2Cl_2/MeOH) to provide the title compound as a yellow liquid that turned into a tan solid upon standing (124 mg, 91%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.80 (dt, *J* = 9.0, 2.3 Hz, 2H), 6.59 (dt, *J* = 9.0, 2.3 Hz, 2H), 3.76 (s, 3H), 3.46 (bs, 1H), 2.81 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 152.2, 143.9, 115.1, 113.8, 56.1, 31.8 ppm.



4-Butyl-*N*-methylaniline. *(RT, 1% Pd):* Following general procedure B, a mixture of 4-chlorobutylbenzene (169 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (8 mg, 0.01 mmol), and *t*-BuOH (1 mL) was stirred at room temperature for 2 h. The crude product was purified via column chromatography (90:10 Hexanes/EtOAc) to provide the title compound as a colorless liquid (162 mg, 98%).

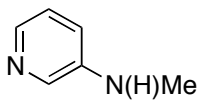
(80 ºC, 0.1% Pd): Following general procedure D, a mixture of 4-

chlorobutylbenzene (169 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (0.8 mg, 0.001 mmol), BrettPhos (0.5 mg, 0.001 mmol), and *t*-BuOH (1 mL) was stirred at 80 ºC for 12 h. The crude product was purified via column chromatography (90:10 Hexanes/EtOAc) to provide the title compound as a colorless liquid (164 mg, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.09 (m, 2H), 6.63 (m, 2H), 3.63 (bs, 1H), 2.87 (s, 3H), 2.59 (t, *J* = 7.7 Hz, 2H), 1.63 (m, 2H), 1.43 (m, 2H), 1.00 (t, *J* = 7.4 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 147.5, 131.9, 129.2, 112.6, 34.9, 34.2, 31.2, 22.5, 14.7
ppm.



3,5-Dimethoxy-*N*-methylaniline. *(RT, 1% Pd):* Following general procedure B, a mixture of 3,5-dimethoxychlorobenzene (173 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (8 mg, 0.01 mmol), and *t*-BuOH (1 mL) was stirred at room temperature for 2 h. The crude product was purified via column chromatography (80:20 to 50:50 Hexanes/EtOAc gradient) to provide the title compound as a pale yellow liquid (150 mg, 90%).

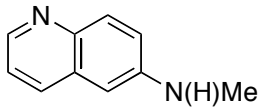
(80 ºC, 0.3% Pd): Following general procedure D, a mixture of 3,5-dimethoxychlorobenzene (173 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (2.4 mg, 0.003 mmol), BrettPhos (1.5 mg, 0.003 mmol), and *t*-BuOH (1 mL) was stirred at 80 ºC for 12h. The crude product was purified via column chromatography (80:20 to 50:50 Hexanes/EtOAc gradient) to provide the title compound as a pale yellow liquid (162 mg, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 5.89 (t, *J* = 2.2 Hz, 1H), 5.80 (t, *J* = 2.2 Hz, 2H), 3.76 (s, 7H), 2.81 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 161.9, 151.5, 91.4, 89.7, 55.3, 30.9 ppm.



***N*-Methylpyridin-3-amine.** *(RT, 1% Pd):* Following general procedure C, a mixture of 3-chloropyridine (95 μL, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120

mg, 1.2 mmol), BrettPhos precatalyst (8 mg, 0.01 mmol), and *t*-BuOH (4 mL) was stirred at room temperature for 2 h. The crude product was purified via column chromatography (10:1 CH_2Cl_2/MeOH) to provide the title compound as a pale yellow liquid (97 mg, 90%). The isolated product was a 35:1 mixture of mono:diarylation methylamine.

(80 ºC, 0.3% Pd): Following general procedure E, a mixture of 3-chloropyridine (95 μL, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (2.4 mg, 0.003 mmol), BrettPhos (1.5 mg, 0.003 mmol), and *t*-BuOH (4 mL) was stirred at 80 ºC for 12h. The crude product was purified via column chromatography (10:1 CH_2Cl_2/MeOH) to provide the title compound as a pale yellow liquid (96 mg, 89%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.02 (d, *J* = 2.9, 1H), 7.95 (dd, *J* = 4.7, 1.3, 1H), 7.09 (dd, *J* = 8.3, 4.7, 1H), 6.86 (ddd, *J* = 8.2, 2.9, 1.3, 1H), 3.79 (bs, 1H), 2.85 (d, *J* = 5.1, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 145.3, 138.9, 136.0, 123.9, 118.2, 30.5 ppm.



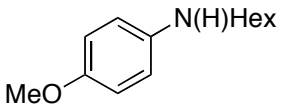
***N*-methylquinolin-6-amine.** *(RT, 1% Pd):* Following general procedure B, a mixture of 6-chloroquinoline (164 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (8 mg, 0.01 mmol), and *t*-BuOH (1 mL) was stirred at room temperature for 17 h. The crude product was purified via column chromatography (99:1 to 97:3 CH_2Cl_2/MeOH gradient) to provide the title compound as a viscous yellow oil (150 mg, 95%).

(80 ºC, 0.3% Pd): Following general procedure D, a mixture of 6-chloroquinoline (164 mg, 1.0 mmol), 2M methylamine (1 mL, 2.0 mmol), NaO*t*-Bu (120 mg, 1.2 mmol), BrettPhos precatalyst (2.4 mg, 0.003 mmol), BrettPhos (1.5 mg, 0.003 mmol), and *t*-BuOH (1 mL) was stirred at 80 ºC for 12h. The crude product was purified via column chromatography (99:1 to 97:3 CH_2Cl_2/MeOH gradient) to provide the title compound as a viscous yellow oil (144 mg, 91%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.62 (dd, *J* = 4.2, 1.7 Hz, 1H), 7.94 (d, *J* = 8.3 Hz, 1H), 7.88 (d, *J* = 9.1 Hz, 1H), 7.26 (dd, *J* = 8.3, 4.2 Hz, 1H), 7.09 (dd, *J* = 9.1, 2.6 Hz, 1H), 6.68 (d, *J* = 2.6 Hz, 1H), 4.19 (bs, 1H), 2.93 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 147.4, 146.1, 143.3, 133.9, 130.3, 130.2, 121.5, 102.4, 30.8 ppm.

Experimental Procedures for Examples Described in *Table 5*

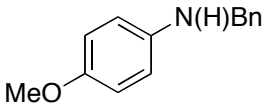
General Procedure F: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with **5** (0.05 mol%) **1** (0.05 mol%) and NaO*t*-Bu (1.15 g, 12 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aryl chlorodie (10 mmol), amine (14 mmol), and Bu_2O (3 mL) were added via syringe. The solution was heated to 85 °C until the starting material was completely consumed as monitored by GC. The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, concentrated in vacuo, and purified via the Biotage SP4 (silica-packed 100 g snap cartridge).

General Procedure G: An oven-dried test tube, which was equipped with a magnetic stir bar, was taken into a nitrogen filled dry-box and charged with NaO*t*-Bu (115 mg, 1.2 mmol), amine (1.2 mmol), aryl chloride (1.0 mmol), and Bu_2O (1 mL). A solution of **1** and **5** in toluene (50 μL, 0.02M, 0.01 mol% **1**, 0.01 mol% **5**) was added and then the reaction vessel was sealed, removed from the dry-box and heated to 110 °C until the starting material was completely consumed as monitored by GC. The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, concentrated in vacuo, and purified via the Biotage SP4 (silica-packed 25+M cartridge).

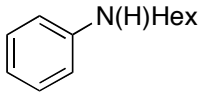


***N*-hexyl-4-methoxyaniline** (Table 5, entry 1) Following general procedure F, a mixture of 4-chloroanisole (1.23 mL, 10 mmol), hexylamine (1.83 mL, 14 mmol), NaO*t*-Bu (1.15 g, 12 mmol), **5** (4 mg, 0.05 mol%), **1** (2.5 mg, 0.05 mol%), and Bu_2O (3 mL) was heated to 85 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 100 g; 0-50% EtOAc/hexanes) to provide the title compound as a yellow oil (1.828 g, 88%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 6.84 (d, *J* = 9.0 Hz, 2H), 6.62 (d, *J* = 9.0 Hz, 2H), 3.78 (s, 3H), 3.40 (s, 1H), 3.09 (t, *J* = 7.0 Hz, 2H), 1.64 (pentet, *J* = 7.5 Hz, 2H), 1.42 (m, 6H), 0.97 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 152.2, 143.2, 115.1, 114.2,

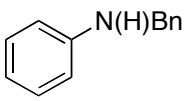
56.0, 45.3, 32.0, 30.0, 27.2, 23.0, 14.4 ppm. IR (neat, cm^{-1}): 3394, 2929, 2857, 2831, 1513, 1466, 1237, 1180, 1040, 819. 520.



***N*-benzyl-4-methoxyaniline** (Table 5, entry 2) Following general procedure F, a mixture of 4-chloroanisole (1.23 mL, 10 mmol), benzylamine (1.52 mL, 14 mmol), NaO*t*-Bu (1.15 g, 12 mmol), **5** (4 mg, 0.05 mol%), **1** (2.5 mg, 0.05 mol%), and Bu_2O (3 mL) was heated to 85 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-50% EtOAc/hexanes) to provide the title compound as a yellow oil (2.059 g, 97%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.63 - 7.52 (m, 5H), 7.06 (d, *J* = 9.0 Hz, 2H), 6.81 (d, *J* = 9.0 Hz, 2H), 4.46 (s, 2H), 4.05 (s, 1H), 3.92 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 152.6, 143.1, 140.5, 129.2, 128.1, 127.7, 115.4, 114.6, 56.1, 49.5 ppm. IR (neat, cm^{-1}): 3414, 3029, 2832, 1513, 1453, 1235, 1036, 820, 743, 698. Anal. Calcd. for $C_{14}H_{15}NO$: C, 78.84; H, 7.09. Found: C, 78.61; H, 7.10.

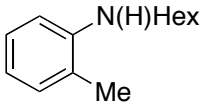


***N*-Hexylaniline** (Table 5, entry 3) Following general procedure F, a mixture of chlorobenzene (1.02 mL, 10 mmol), hexylamine (1.83 mL, 14 mmol), NaO*t*-Bu (1.15 g, 12 mmol), **5** (4 mg, 0.05 mol%), **1** (2.5 mg, 0.05 mol%), and Bu_2O (3 mL) was heated to 85 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 50 g; 0-50% EtOAc/hexanes) to provide the title compound as a clear oil (1.607 g, 91%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.33 (t, *J* = 7.5 Hz, 2H), 6.85 (t, *J* = 7.5 Hz, 1H), 6.74 (d, *J* = 7.5 Hz, 2H), 3.70 (s, 1H), 3.23 (t, *J* = 7.0 Hz, 2H), 1.74 (pentet, *J* = 7.0 Hz, 2H), 1.51 (m, 6H), 1.09 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: ppm 148.9, 129.6, 117.4, 113.0, 44.4, 32.1, 29.9, 27.3, 23.1, 14.5. IR (neat, cm^{-1}): 3412, 2956, 2928, 1603, 1507, 1321, 1259, 748, 692. Anal. Calcd. for $C_{12}H_{19}N$: C, 81.30; H, 10.80. Found: C, 81.37; H, 10.73.

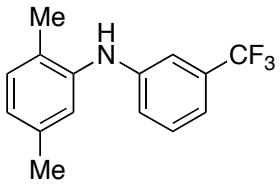


***N*-benzylaniline** (Table 5, entry 4) Following general procedure F, a mixture of chlorobenzene (1.02 mL, 10 mmol), benzylamine (1.52 mL, 14 mmol), NaO*t*-Bu (1.15 g,

12 mmol), **5** (4 mg, 0.05 mol%), **1** (2.5 mg, 0.05 mol%), and Bu_2O (3 mL) was heated to 85 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-50% EtOAc/hexanes) to provide the title compound as a yellow oil (1.646 g, 90%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.69 – 7.61 (m, 5H), 7.53 (t, *J* = 7.5 Hz, 2H), 7.09 (t, *J* = 7.5 Hz, 1H), 6.92 (d, *J* = 7.5 Hz, 2H), 4.57 (s, 2H), 4.22 (s, 1H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 148.8, 140.2, 129.9, 129.3, 128.1, 127.8, 118.1, 113.5, 48.7 ppm. IR (neat, cm^{-1}): 3419, 3052, 3026, 2841, 1603, 1506, 1453, 1325, 750, 693. Anal. Calcd. for $C_{13}H_{13}N$: C, 85.21; H, 7.15. Found: C, 85.04; H, 7.15.

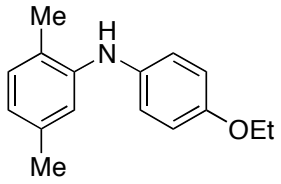


***N*-hexyl-2-methylaniline** (Table 5, entry 5) Following general procedure F, a mixture of 2-chlorotoluene (1.17 mL, 10 mmol), hexylamine (1.82 mL, 14 mmol), NaO*t*-Bu (1.15 g, 12 mmol), **5** (4 mg, 0.05 mol%), **1** (2.5 mg, 0.05 mol%), and Bu_2O (3 mL) was heated to 85 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 50 g snap; 0-50% EtOAc/hexanes) to provide the title compound as a clear oil (1.732 g, 91%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.33 (t, *J* = 7.5 Hz, 1H), 7.25 (d, *J* = 7.5 Hz, 1H), 6.83 (m, 2H), 3.61 (s, 1H), 3.33 (t, *J* = 7.0 Hz, 2H), 2.32 (s, 3H), 1.85 (septet, *J* = 7.0 Hz, 2H), 1.58 (m, 6H), 1.14 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 146.8, 130.4, 127.6, 122.0, 117.0, 110.0, 44.4, 32.2, 30.0, 27.4, 23.2, 17.9, 14.5 ppm. IR (neat, cm^{-1}): 3430, 2956, 2924, 2856, 1607, 1514, 1473, 1317, 1260, 745. Anal. Calcd. for $C_{13}H_{21}N$: C, 81.61; H, 11.06. Found: C, 81.81; H, 11.02.

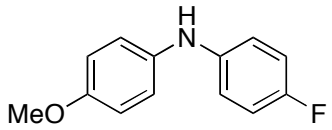


2,5-dimethyl-*N*-(3-(trifluoromethyl)phenyl)aniline (Table 5, entry 6) Following general procedure G, a mixture of 2-chloro-*p*-xylene (134 μL, 1.0 mmol), 3-(trifluoromethyl)aniline (150 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), **5** (0.08 mg, 0.01 mol%), **1** (0.05 mg, 0.01 mol%), and Bu_2O (1 mL) was heated to 110 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a clear oil (248 mg, 94%). ^{1}H NMR

(300 MHz, $CDCl_3$) δ: 7.38 (t, *J* = 8.0 Hz, 1H), 7.22 (d, *J* = 8.0 Hz, 1H), 7.16 (m, 3H), 7.08 (d, *J* = 8.0 Hz, 1H), 6.95 (d, *J* = 8.0 Hz, 1H), 5.53 (s, 1H), 2.39 (s, 3H), 2.28 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 145.5, 139.8, 137.1, 132.6, 132.2, 131.8, 131.8, 131.4, 130.1, 130.0, 127.5, 126.4, 124.9, 124.9, 124.8, 122.8, 122.1, 122.0, 119.2, 119.1, 116.3, 116.3, 112.8, 21.4, 17.7 ppm. IR (neat, cm^{-1}): 3391, 3021, 2924, 1613, 1485, 1337, 1165, 1124, 787, 699. Anal. Calcd. for $C_{15}H_{14}F_3N$: C, 67.91; H, 5.32. Found: C, 68.02; H, 5.31.

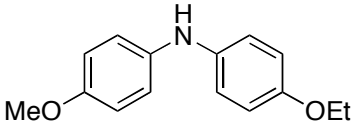


***N*-(4-ethoxyphenyl)-2,5-dimethylaniline** (Table 5, entry 7) Following general procedure G, a mixture of 2-chloro-*p*-xylene (134 μL, 1.0 mmol), 4-ethoxyaniline (154 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), **5** (0.08 mg, 0.01 mol%), **1** (0.05 mg, 0.01 mol%), and Bu_2O (1 mL) was heated to 110 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a white solid (235 mg, 98%), mp 56-58 °C. ^1H NMR (300 MHz, $CDCl_3$) δ: 7.10 (m, 3H), 6.95 (m, 3H), 6.72 (d, *J* = 7.5 Hz, 1H), 5.26 (s, 1H), 4.09 (q, *J* = 7.0 Hz, 2H), 2.33 (s, 3H), 2.29 (s, 3H), 1.51 (t, *J* = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 154.7, 143.5, 136.8, 136.5, 130.9, 122.5, 121.0, 116.1, 116.1, 115.6, 64.1, 21.6, 17.7, 15.3 ppm. IR (neat, cm^{-1}): 3402, 2978, 2923, 1511, 1478, 1292, 1238, 1117, 1049, 798. Anal. Calcd. for $C_{16}H_{19}NO$: C, 79.63; H, 7.94. Found: C, 79.70; H, 8.01.

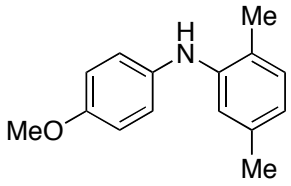


4-fluoro-*N*-(4-methoxyphenyl)aniline (Table 5, entry 8) Following general procedure G, a mixture of 4-chloroanisole (123 μL, 1.0 mmol), 4-fluoroaniline (114 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), **5** (0.08 mg, 0.01 mol%), **1** (0.05 mg, 0.01 mol%), and Bu_2O (1 mL) was heated to 110 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound

as a white solid (209 mg, 94%), mp 59-60 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.03 – 6.86 (m, 8H), 5.41 (s, 1H), 3.81 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 159.0, 155.8, 155.2, 141.4, 136.8, 121.4, 118.0, 117.9, 116.2, 115.9, 115.0, 55.8 ppm. IR (neat, cm^{-1}): 3391, 3007, 1508, 1314, 1243, 1221, 1027, 814, 772, 591. Anal. Calcd. for $C_{13}H_{12}FNO$: C, 71.87; H, 5.57. Found: C, 71.89; H, 5.62.



4-ethoxy-*N*-(4-methoxyphenyl)aniline (Table 5, entry 9) Following general procedure G, a mixture of 4-chloroanisole (123 μL, 1.0 mmol), 4-ethoxyaniline (154 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), **5** (0.08 mg, 0.01 mol%), **1** (0.05 mg, 0.01 mol%), and Bu_2O (1 mL) was heated to 110 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a white solid (229 mg, 94%), mp 73-75 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 6.95 (m, 4H), 6.84 (m, 4H), 5.34 (s, 1H), 4.01 (q, J = 7.0 Hz, 2H), 3.80 (s, 3H), 1.43 (t, J = 7.0 Hz, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 154.4, 153.8, 138.2, 138.1, 119.8, 119.7, 115.7, 114.9, 64.1, 55.9, 15.3 ppm. IR (neat, cm^{-1}): 3421, 2983, 2956, 1513, 1298, 1253, 1116, 1052, 1037, 814. Anal. Calcd. for $C_{15}H_{17}NO_2$: C, 74.05; H, 7.04. Found: C, 73.95; H, 7.06.

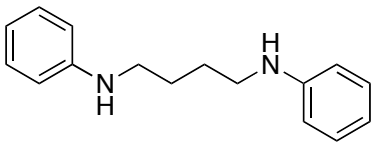


***N*-(4-methoxyphenyl)-2,5-dimethylaniline** (Table 5, entry 10) Following general procedure G, a mixture of 4-chloroanisole (123 μL, 1.0 mmol), 2,5-dimethylaniline (149 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), **5** (0.08 mg, 0.01 mol%), **1** (0.05 mg, 0.01 mol%), and Bu_2O (1 mL) was heated to 110 °C for 1 h. The crude product was purified via the Biotage SP4 (silica-packed 25+M; 0-30% EtOAc/hexanes) to provide the title compound as a white solid (220 mg, 97%), mp 40-41 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.11 (m, 3H), 6.96 (m, 3H), 6.75 (d, J = 7.5 Hz, 1H), 5.27 (s, 1H), 3.88 (s, 3H), 2.33 (s, 3H), 2.30 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 155.3, 143.5, 136.8, 136.7, 131.0, 122.7, 122.5, 121.1, 116.2, 115.0, 55.9, 21.7, 17.7 ppm. IR (neat, cm^{-1}): 3400, 2921,

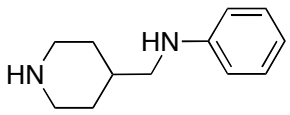
1579, 1511, 1463, 1292, 1241, 1037, 828, 800. Anal. Calcd. for $C_{15}H_{17}NO$: C, 79.26; H, 7.54. Found: C, 79.11; H, 7.59.

Experimental Procedures for Examples Described in *Table 6*

General Procedure H: An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with **5** (1 mol%) **1** (1 mol%) and NaO*t*-Bu (2.0 equiv). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then the aryl chlorodie (1.0 equiv), amine (1.2 equiv), and dioxane (1 mL/mmol) were added via syringe. The solution was heated to 80 °C until the starting material was completely consumed as monitored by GC. The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, concentrated in vacuo, and purified via the Biotage SP4 (silica-packed 50 g snap cartridge).

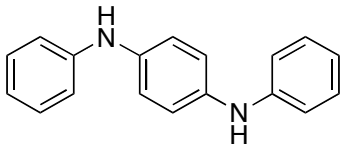


***N*^{1},*N*^{4}-diphenylbutane-1,4-diamine** (Table 6, entry 1) Following general procedure H, a mixture of chlorobenzene (51 μL, 0.5 mmol), *N*^{1}-phenylbutane-1,4-diamine (98 mg, 0.6 mmol), NaO*t*-Bu (97 mg, 1.0 mmol), **5** (4 mg, 1 mol%), **1** (2.5 mg, 1 mol%), and dioxane (0.5 mL) was heated to 80 °C for 2 h. The crude product was purified via the Biotage SP4 (silica-packed 50 g snap; 0-75% EtOAc/hexanes) to provide the title compound as a clear oil (108 mg, 91%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.28 (t, *J* = 7.0 Hz, 4H), 6.80 (t, *J* = 7.0 Hz, 2H), 6.68 (d, *J* = 7.0 Hz, 4H), 3.68 (s, 2H), 3.22 (m, 4H), 1.78 (m, 4H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 148.6, 129.6, 117.6, 113.1, 44.0, 27.4 ppm. IR (neat, cm^{-1}): 3407, 3050, 2934, 2861, 1603, 1507, 1477, 1321, 1257, 1179, 749, 693. Anal. Calcd. for $C_{16}H_{20}N_2$: C, 79.96; H, 8.39. Found: C, 80.20; H, 8.48.



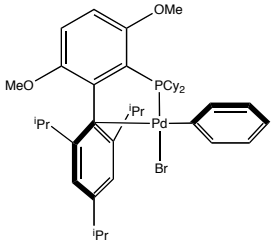
***N*-(piperidin-4-ylmethyl)aniline** (Table 6, entry 2) Following general procedure H, a mixture of chlorobenzene (102 μL, 1.0 mmol), 4-(aminomethyl)piperidine (137 mg, 1.2

mmol), NaO*t*-Bu (192 mg, 2.0 mmol), **5** (8 mg, 1 mol%), **1** (5 mg, 1 mol%), and dioxane (1 mL) was heated to 80 °C for 15 h. The crude product was purified via the Biotage SP4 (silica-packed 50 g snap; 7 - 9% MeOH/CH_2Cl_2) to provide the title compound as a white solid (159 mg, 84%), mp 60 – 61 °C. ^{1}H NMR (300 MHz, DMSO) δ: 7.02 (t, *J* = 7.5 Hz, 2H), 6.52 (d, *J* = 8.0 Hz, 2H), 6.46 (t, *J* = 8.0 Hz, 1H), 5.58 (s, 1H), 3.11 (s, 1H), 2.92 (d, *J* = 11.5 Hz, 2H), 2.82 (t, *J* = 6.0 Hz, 2H), 2.41 (t, *J* = 10 Hz, 2H), 1.64 (m, 3H), 1.02 (m 2H) ppm. ^{13}C NMR (75 MHz, DMSO) δ: 149.8, 129.5, 115.8, 112.5, 50.0, 46.5, 36.2, 31.7 ppm. IR (neat, cm^{-1}): 3326, 2919, 1602, 1509, 1427, 1325, 1263, 749, 694.



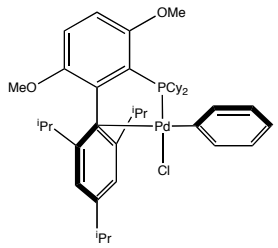
***N*^{1},*N*^{4}-diphenylbenzene-1,4-diamine** (Table 5, entry 3) Following general procedure H, a mixture of chlorobenzene (102 μL, 1.0 mmol), *N*^{1}-phenylbenzene-1,4-diamine (221 mg, 1.2 mmol), NaO*t*-Bu (192 mg, 2.0 mmol), **5** (8 mg, 1 mol%), **1** (5 mg, 1 mol%), and dioxane (1 mL) was heated to 80 °C for 2 h. The crude product was purified via the Biotage SP4 (silica-packed 50 g snap; 0-50% EtOAc/Hexane) to provide the title compound as a off-white solid (260 mg, 99%), mp 152-154 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.27 (t, *J* = 7.5 Hz, 4H), 7.08 (s, 4H), 7.00 (d, *J* = 8.0 Hz, 4H), 6.90 (t, *J* = 7.5 Hz, 2H), 5.59 (s, 2H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$) δ: 144.7, 137.4, 129.6, 121.2, 120.2, 116.5 ppm. IR (neat, cm^{-1}): 3389, 1601, 1512, 1496, 1382, 1313, 1271, 820, 742, 695. Anal. Calcd. for $C_{18}H_{16}N_2$: C, 83.04; H, 6.19. Found: C, 82.81; H, 6.22.

Synthesis of 12, 13 and 14



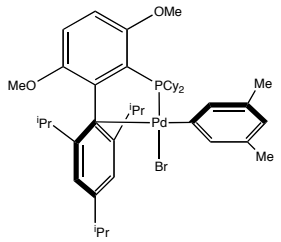
BrettPhosPdPhBr 12. In a nitrogen filled glovebox, a solution of BrettPhos (**1,** 23.6 mg, 44 μmol), bromobenzene (30 μL) and THF[9] (2 mL) was added to solid (COD)Pd($CH_2SiPhMe_2$)$_2$[10,11] (20.4 mg, 40 μmol) in an oven-dried 20 mL vial. The vial

was capped, and the resulting yellow solution was allowed to stand for 48 h at rt. After this time, pentane[12] (8 mL) was layered on top of the THF solution and the vial was allowed to stand for 24 h resulting in the formation of crystals. After 24 h, the crystals were collected via vacuum filtration in the glovebox, and dried under vacuum to provide **2** (24 mg, 75%) as light-yellow needles as a THF mono-solvate: ^{1}H NMR (400 MHz, CD_2Cl_2, mixture of rotomers) δ 7.26–7.29 (m, 2H – minor), 7.00–7.06 (m, major and minor), 6.82–6.92 (m, major and minor), 6.75–6.79 (m, 1H – minor, 1H – major), 4.33 (s, 3H – minor), 3.79 (s, 3H –major), 3.59 (s, 3H – minor), 3.33 (s, 3H – major), 3.00–3.08 (m, 1H – major), 2.88–2.92 (m, 1H – major), 2.72–2.82 (m, 2H – major), 2.46–2.53 (m, 2H – major), 2.32–2.37 (m, 2H –minor), 1.50–1.90 (m, major and minor), 1.05–1.45 (m), 0.75–0.90 (m, 12H – major and minor), 0.55–0.65 (m, 2H – minor); ^{31}P NMR (162 MHz, CD_2Cl_2, mixture of rotomers) δ 44.9 (minor), 36.9 (major).



BrettPhosPdPhCl 13. In a nitrogen filled glovebox, a solution of BrettPhos (**1,** 51.0 mg, 96 μmol), chlorobenzene (100 μL) and THF (4 mL) was added to solid (COD)Pd($CH_2SiPhMe_2$)$_2$ (40.8 mg, 80 μmol) in an oven-dried 20 mL vial. The vial was capped, and the resulting yellow solution was allowed to stand for 48 h at rt. After this time, pentane (14 mL) was layered on top of the THF solution and the vial was allowed to stand for 24 h resulting in the formation of crystals. After 24 h, the crystals were collected via vacuum filtration in the glovebox, and dried under vacuum to provide **3** (42 mg, 69%) as light-yellow microcrystalline powder: ^{1}H NMR (400 MHz, CD_2Cl_2, mixture of rotomers) δ 7.28–7.30 (m, 2H – minor), 7.07–7.10 (m, 2H – minor), 7.04 (s, 2H – major), 7.02 (s, 2H – minor), 6.82–6.92 (m, major and minor), 6.76–6.82 (m, 1H – minor, 1H – major), 4.29 (s, 3H – minor), 3.79 (s, 3H –major), 3.59 (s, 3H – minor), 3.34 (s, 3H – major), 2.96–3.03 (m, 1H – major), 2.88–2.95 (m, 1H – major), 2.71–2.80 (m, 2H – major), 2.46–2.53 (m, 2H – major), 2.32–2.37 (m, 2H –minor), 1.50–1.90 (m, major and

minor), 1.08–1.45 (m), 0.78–0.92 (m, major and minor), 0.55–0.65 (m, 2H – minor); ^{31}P NMR (162 MHz, CD_2Cl_2, mixture of rotomers) δ 46.8 (minor), 38.6 (major). Anal Calc for $C_{41}H_{58}ClO_2PPd$: C, 65.16; H, 7.74;. Found: C, 65.42; H, 7.53.



BrettPhosPd(3,5-dimethylphenyl)Br 14. In a nitrogen filled glovebox, a solution of BrettPhos (**1,** 172 mg, 321 μmol), 3,5-dimethylbromobenzene (225 μL) and THF (15 mL) was added to solid (COD)Pd($CH_2SiPhMe_2$)$_2$ (150 mg, 292 μmol) in an oven-dried 100 mL round bottom flask. The flask was capped, and the resulting yellow solution was allowed to stand for 48 h at rt. After this time, pentane (60 mL) was layered on top of the THF solution and the vial was allowed to stand for 24 h resulting in the formation of crystals. After 24 h, the crystals were collected via vacuum filtration in the glovebox, and dried under vacuum to provide **3** (185 mg, 77%) as light-yellow microcrystalline powder as a THF mono-solvate: ^{1}H NMR (400 MHz, CD_2Cl_2, mixture of rotomers) δ 7.01–7.08 (m, 2H – major, 4H – minor), 6.90 (s, 2H – minor), 6.89 (dd, *J* = 9.2, 2.8, 1H – major), 6.83 (d, *J* = 8.8 Hz, 1H –major), 6.64 (s, 2H –major), 6.41 (s, 1H – minor, 2H – major), 4.31 (s, 3H – minor), 3.78 (s, 3H –major), 3.59 (s, 3H – minor), 3.32 (s, 3H – major), 3.03–3.06 (m, 1H – major), 2.88–2.92 (m, 1H – major), 2.70–2.79 (m, 2H – major), 2.45–2.51 (m, 2H – major), 2.32-2.37 (m, 2H –minor), 2.14 (s, 6H –major), 2.12 (s, 6H – minor), 1.50–1.90 (m, major and minor), 1.05–1.45 (m), 0.75–0.90 (m, 12H – major and minor), 0.55–0.65 (m, 2H – minor); ^{31}P NMR (162 MHz, CD_2Cl_2, mixture of rotomers) δ 45.0 (minor), 37.5 (major). Anal Calc $C_{43}H_{62}BrO_2PPd$: C, 62.36; H, 7.55. Found: C, 62.52; H, 7.68.

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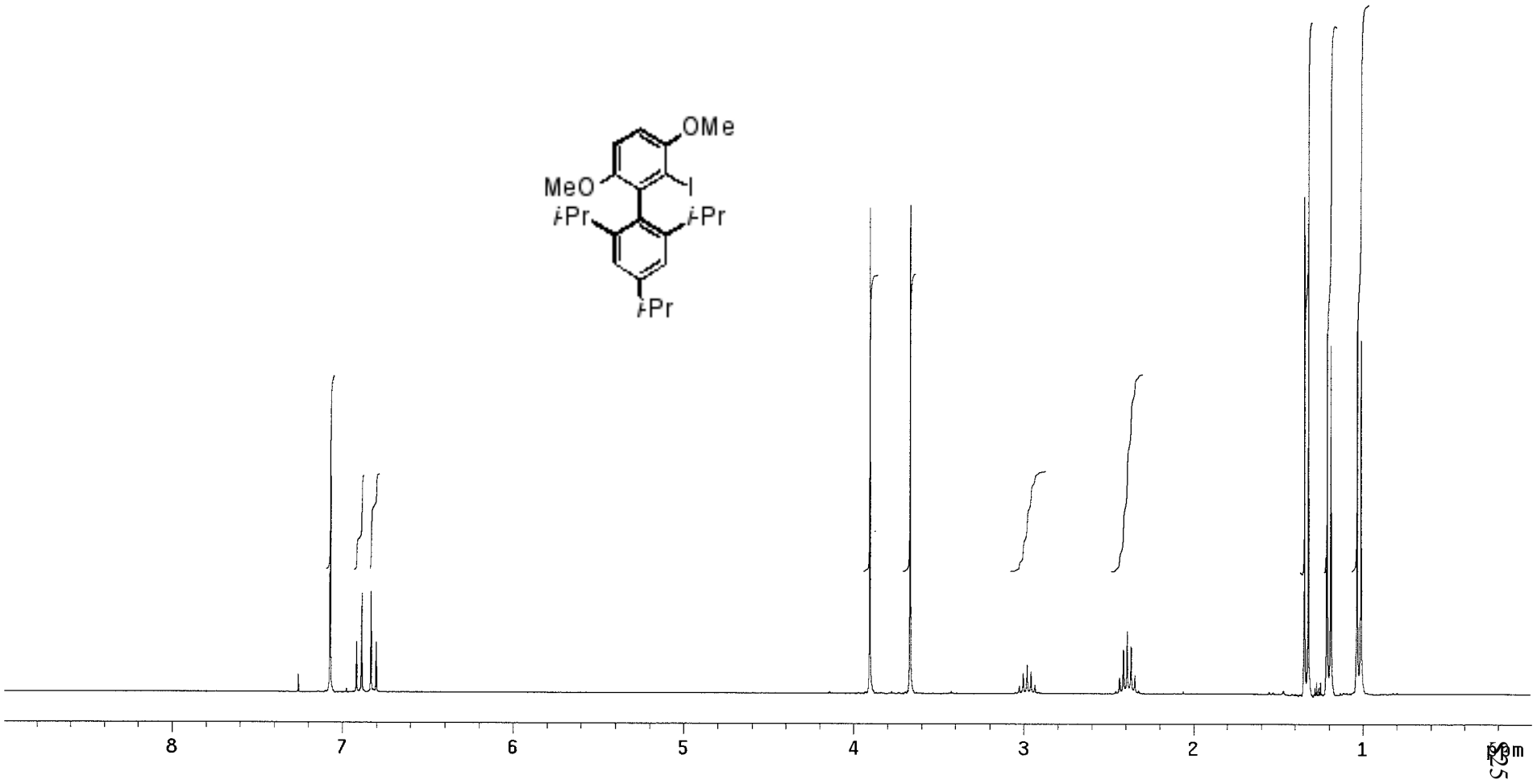
7) Brown, F. J.; Bernstein, P. R.; Cronk, L. A.; Dosset, D. L.; Hebbel, K. C.; Maduskuie, T. P.; Shapiro, H. S.; Vacek, E. P.; Yee, Y. K.; Willard, A. K.; Krell, R. D.; Snyder, D. W. *J. Med. Chem.* **1989**, *32*, 807.
8) Watanabe, T.; Tanaka, Y.; Sekiya, K.; Akita, Y.; Ohta, A. *Synthesis* **1980**, 39.
9) THF used in this experiment was prepared as escribed in the general procedures, then sparged with N_2 for 30 mins and stored over activated 3Å molecular sieves in a glovebox prior to use.
10) Pan, Y.; Young, G. B. *J. Organomet. Chem.* **1999**, *577*, 257.
11) COD = 1,5-cycloocatadiene
12) Aldrich Sure-Seal, N_2 sparged and stored over activated 3Å molecular sieves in a glovebox.

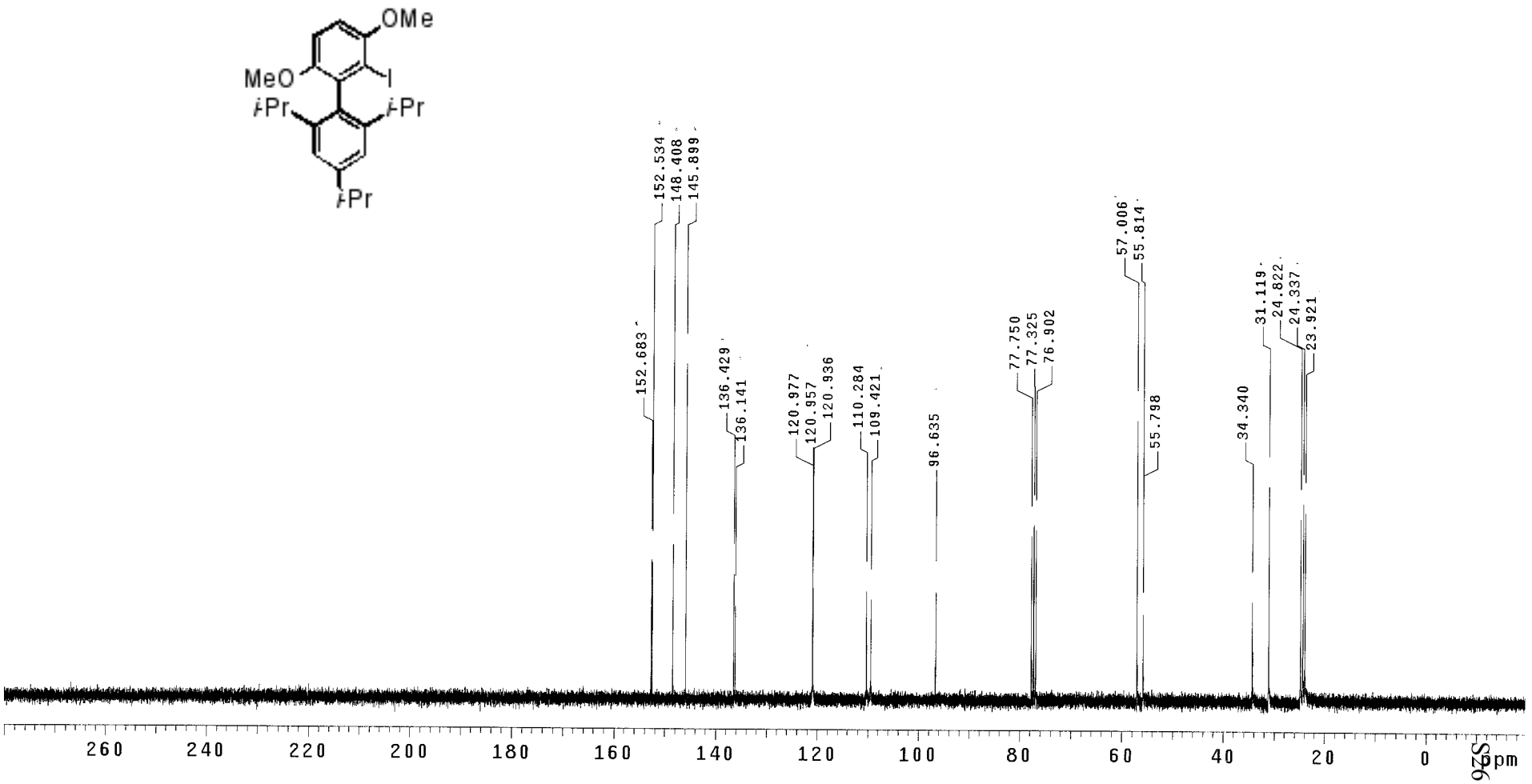
BF-III-266

Pulse Sequence: s2pul



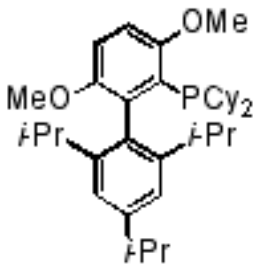
BF-III-266-13C

Pulse Sequence: s2pul



BrettPhos

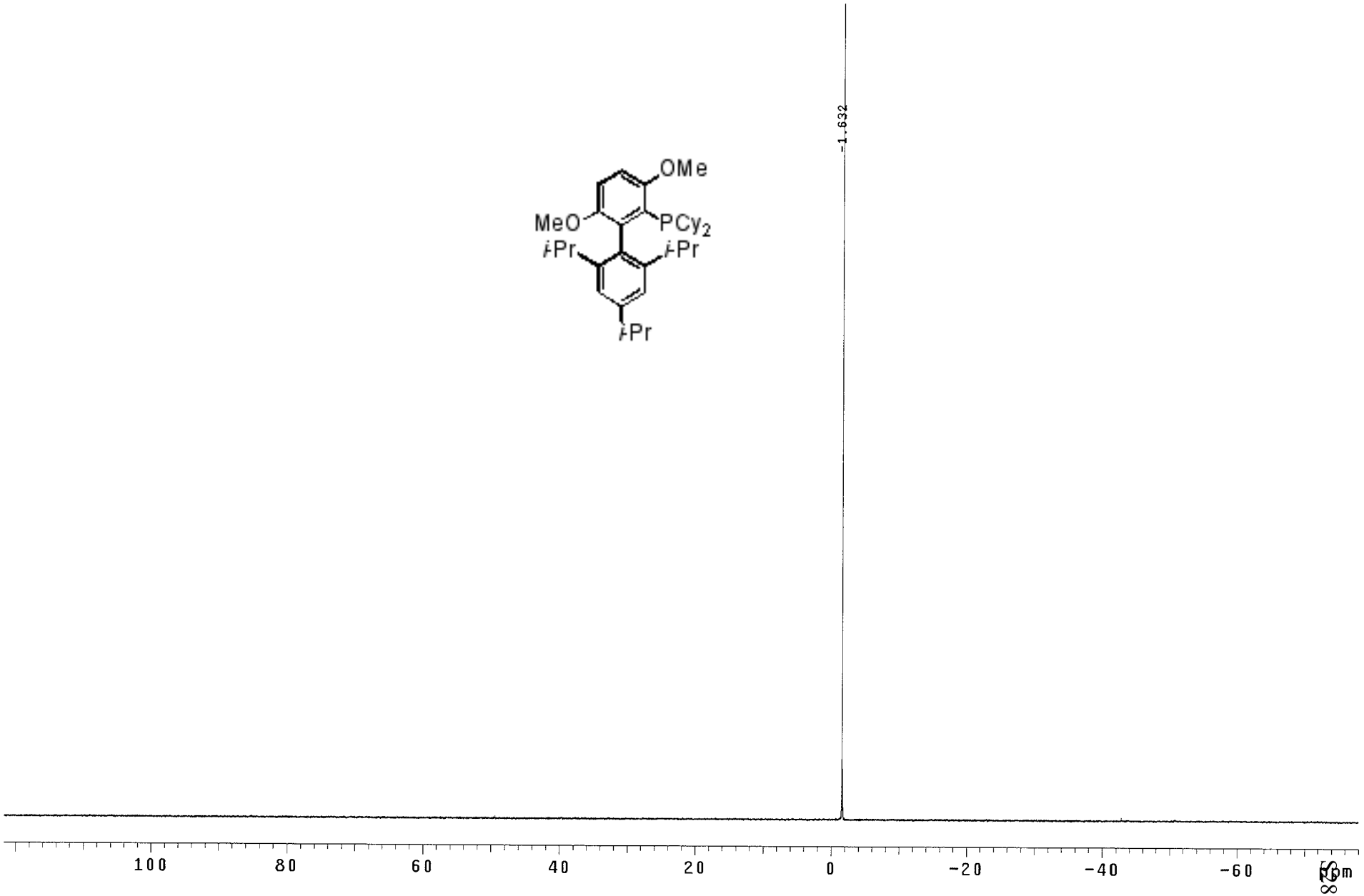
Pulse Sequence: s2pul



S7

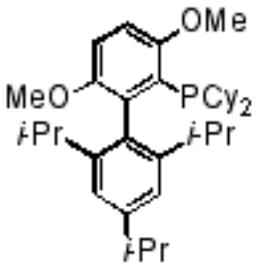
BrettPhos

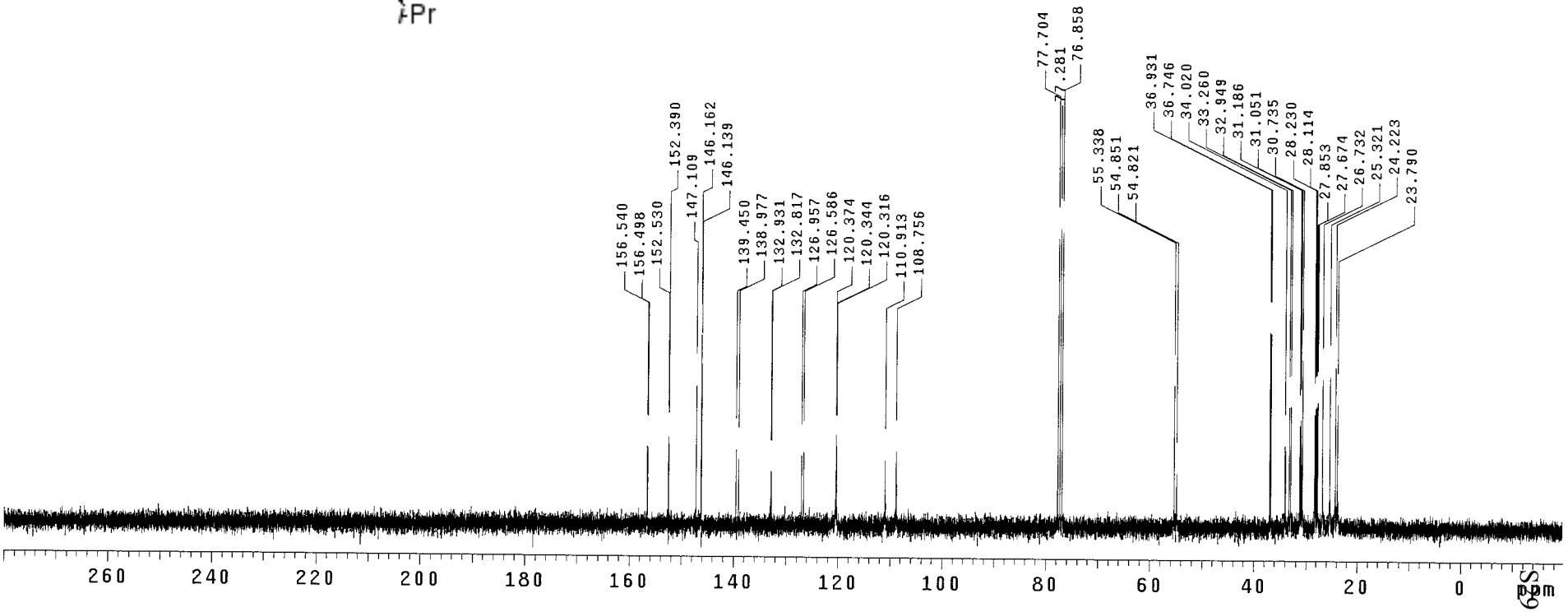
Pulse Sequence: s2pul



BrettPhosII

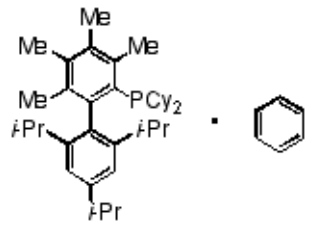
Pulse Sequence: s2pul





Me4XPhos

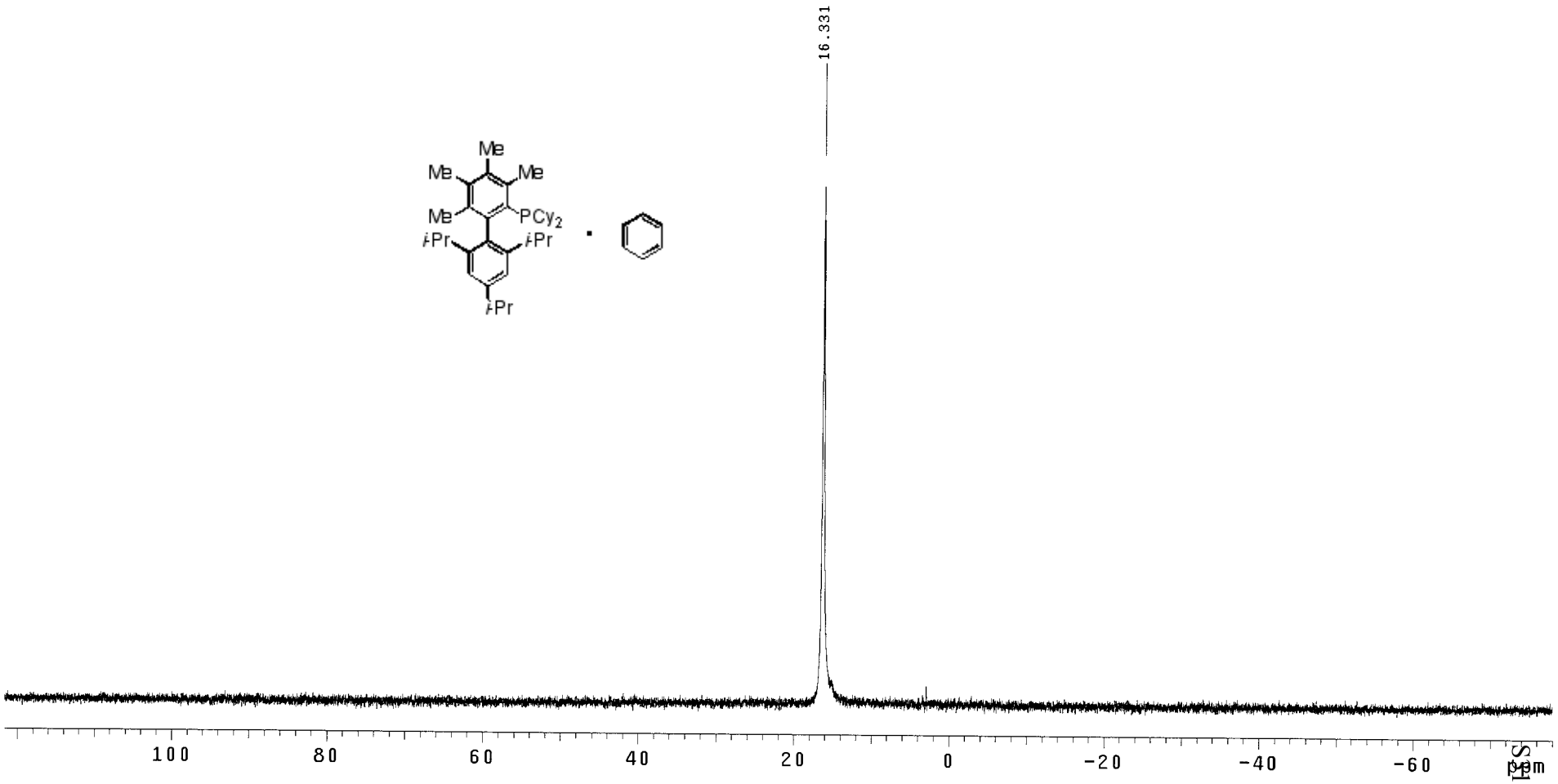
Pulse Sequence: s2pul



P-31 STANDARD PARAMETERS
PHOSPHATE REGION

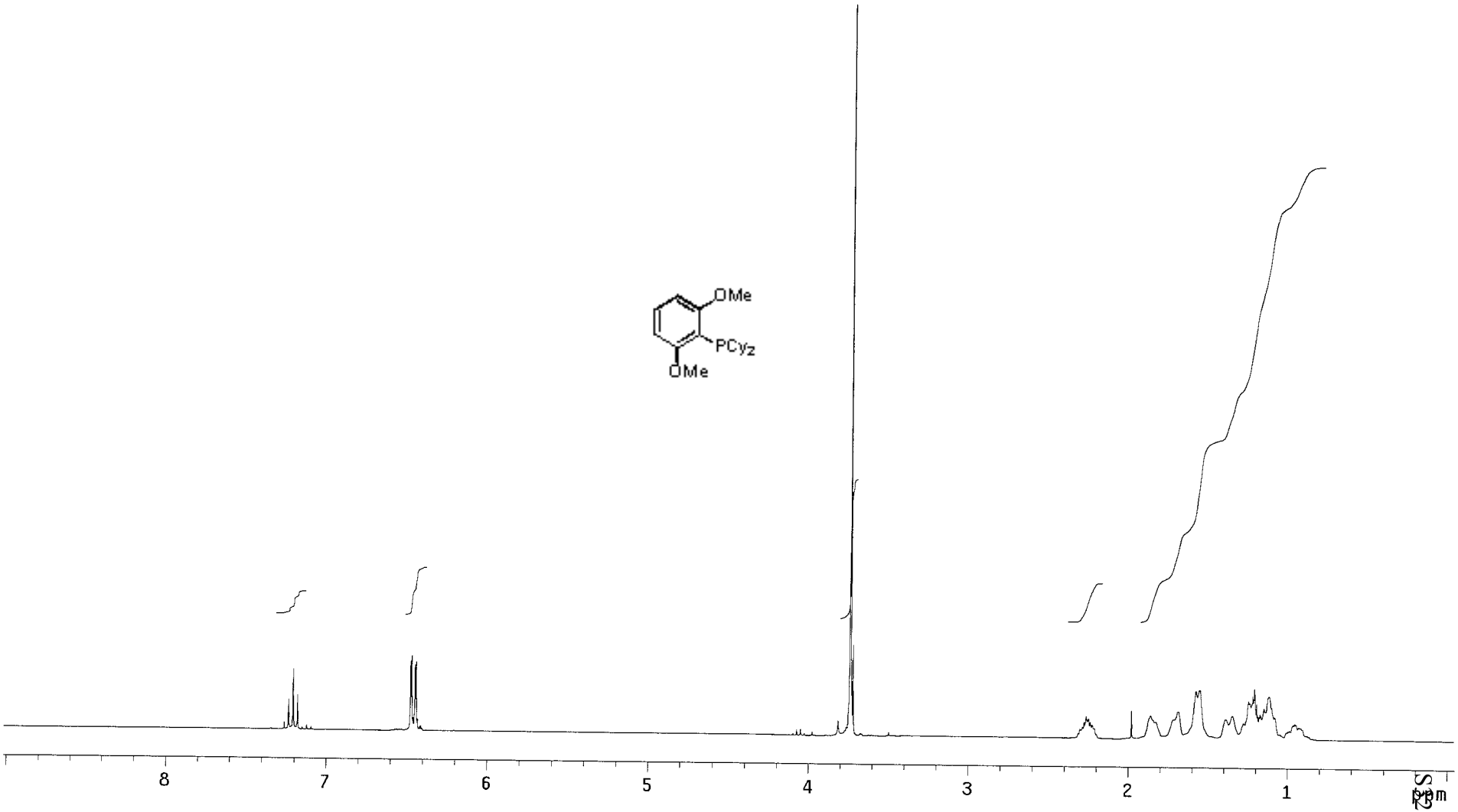
Pulse Sequence: s2pul

Me4YRu05



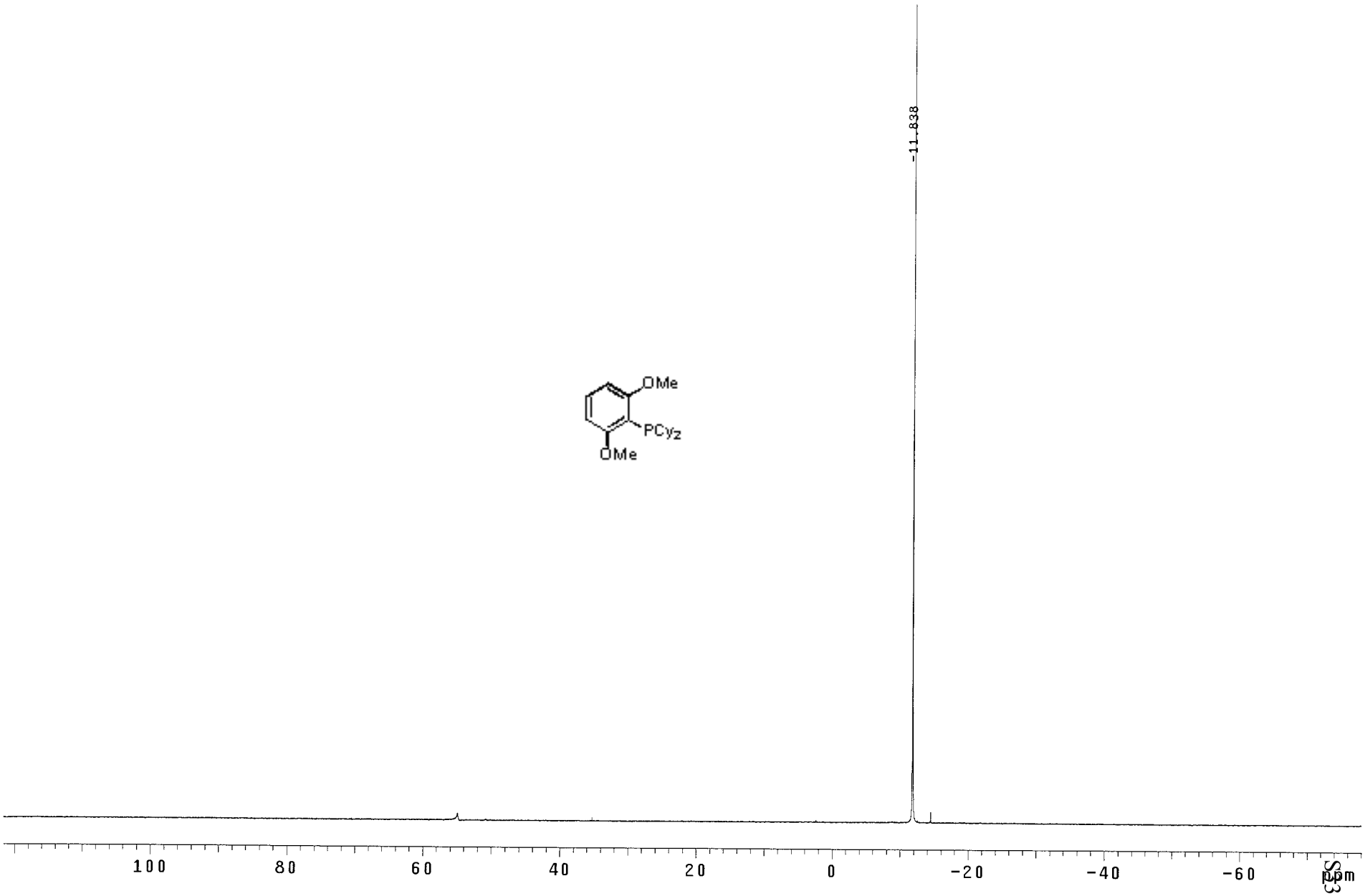
5forpaper

Pulse Sequence: s2pul



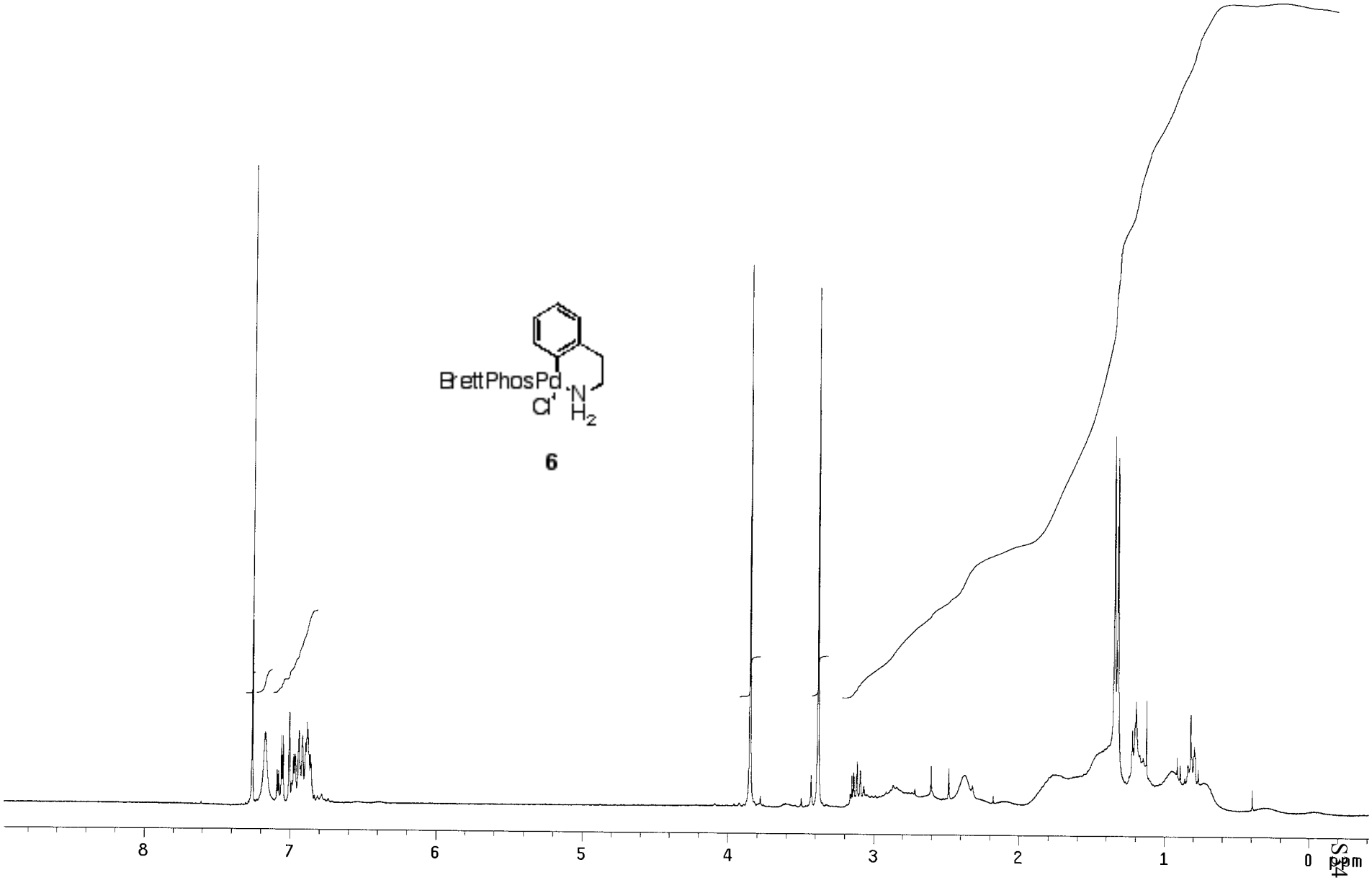
5forPaper

Pulse Sequence: s2pul



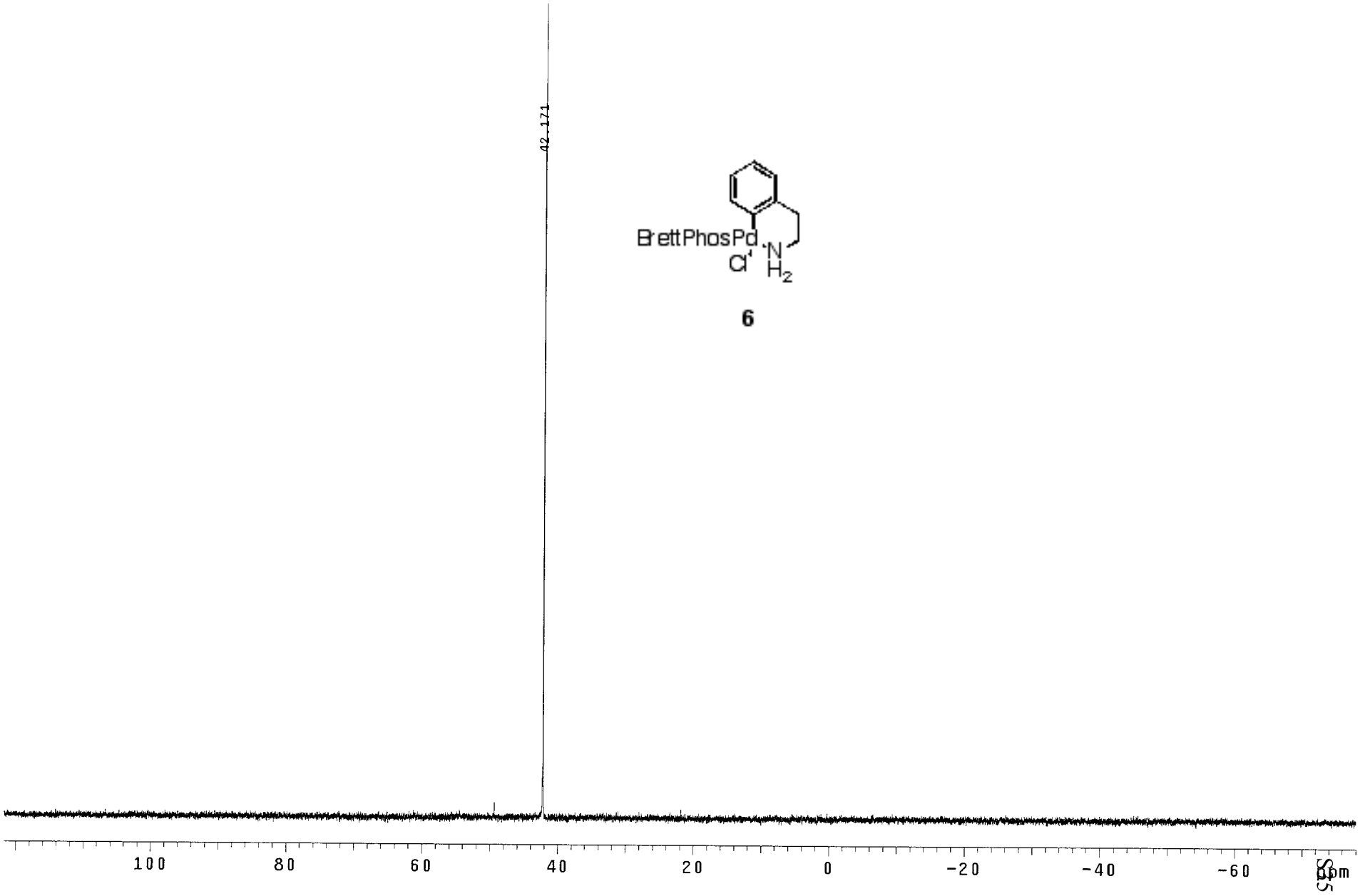
BrettPhosPrecat

Pulse Sequence: s2pul



BrettPhosPrecatII31P

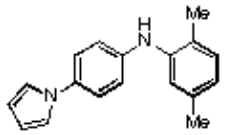
Pulse Sequence: s2pul

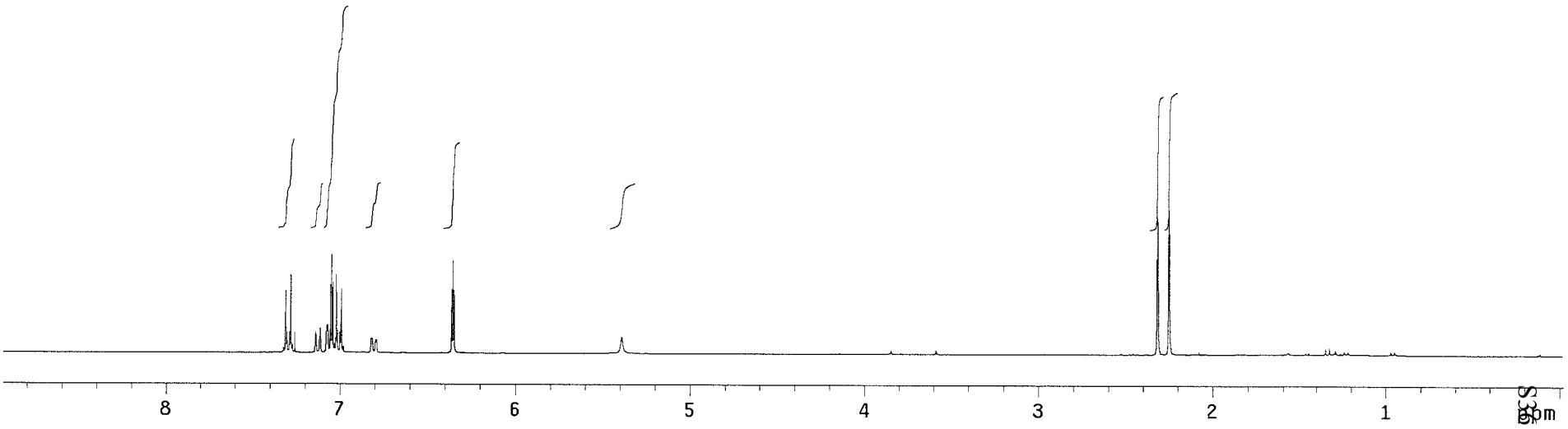


6

BF-III-104

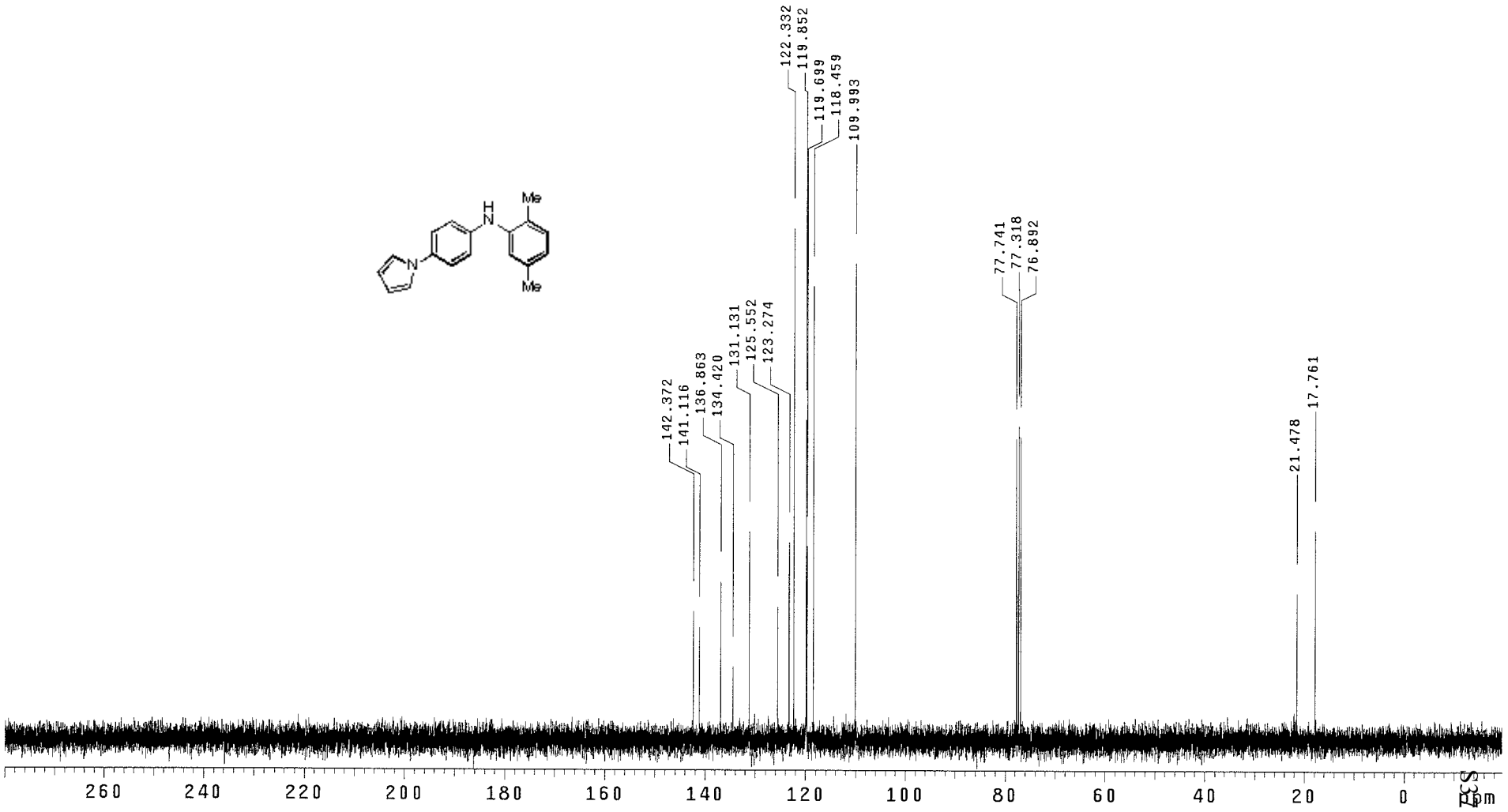
Pulse Sequence: s2pul





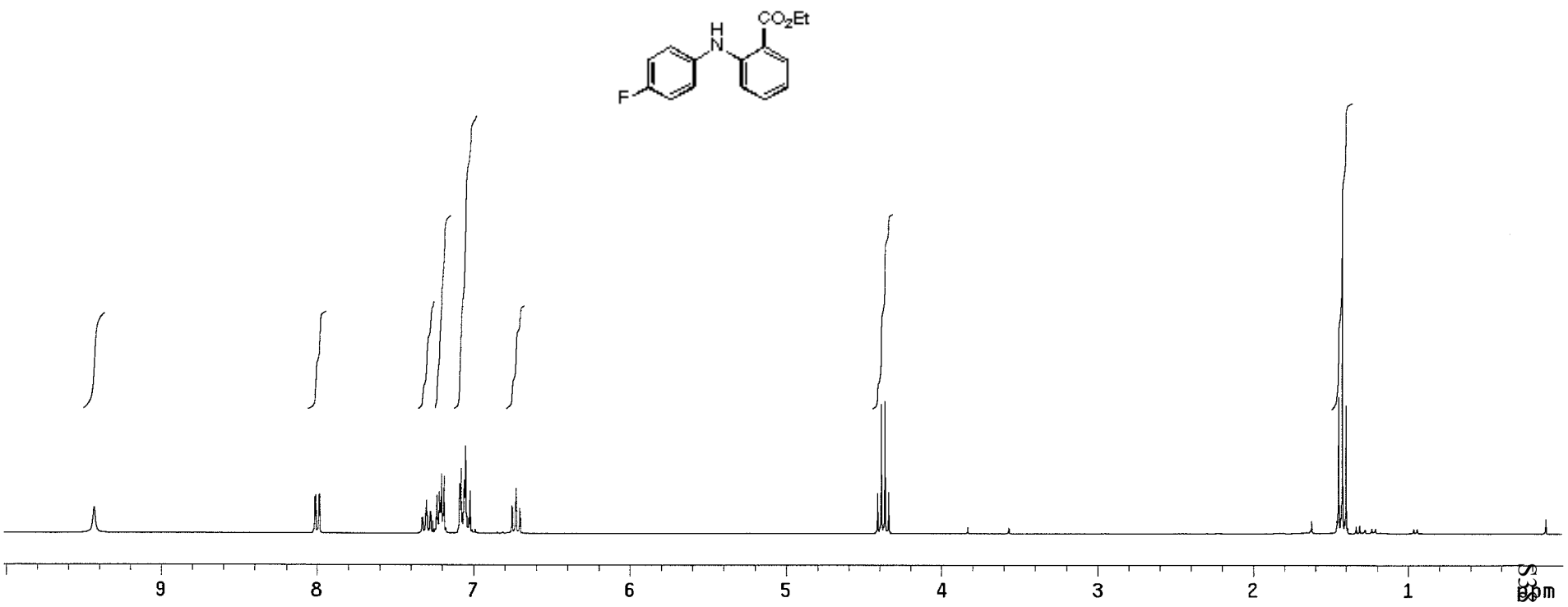
BF-III-104-13C

Pulse Sequence: s2pul



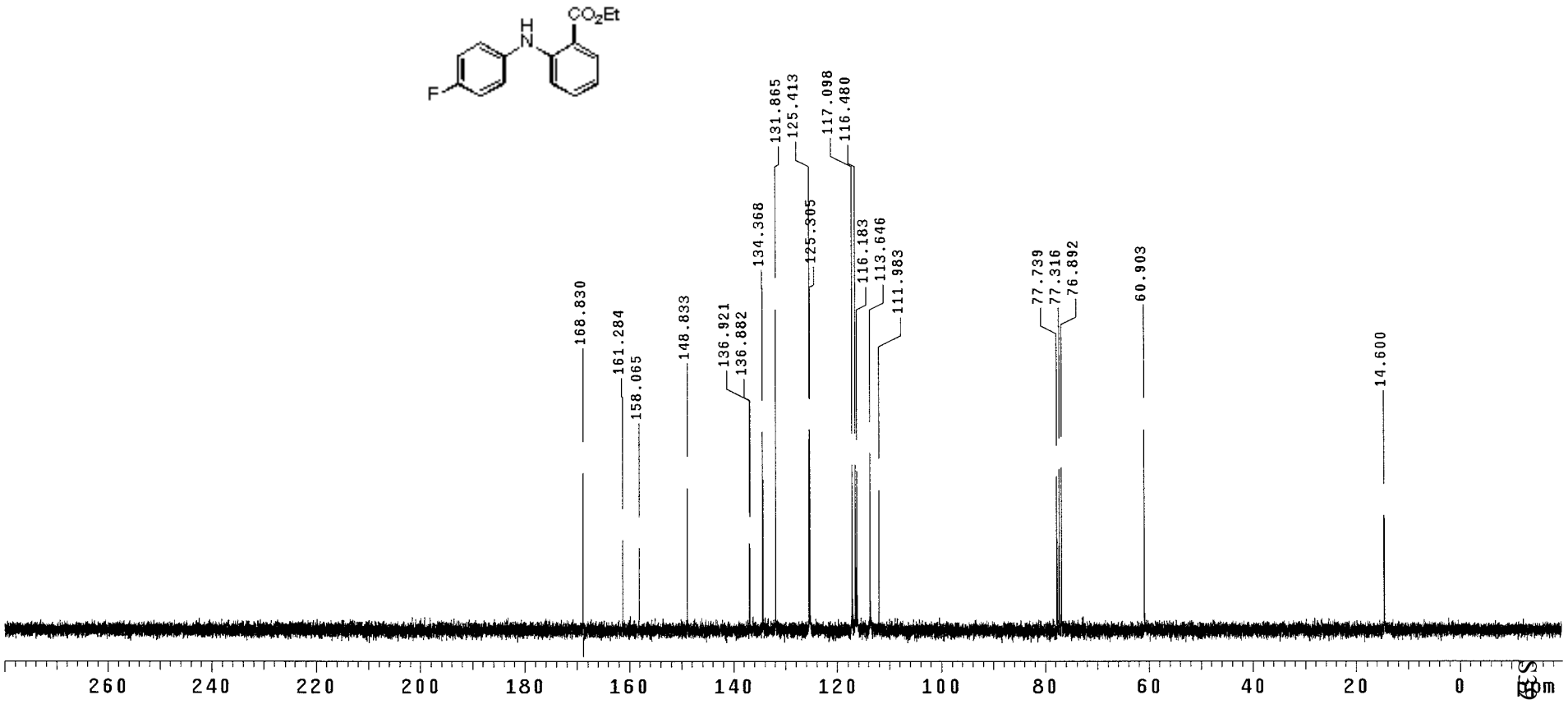
BF-III-157

Pulse Sequence: s2pul



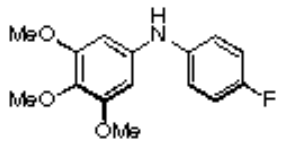
BF-III-157-13C

Pulse Sequence: s2pul



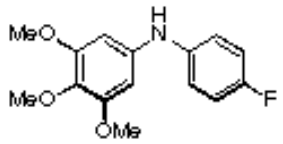
BF-III-158

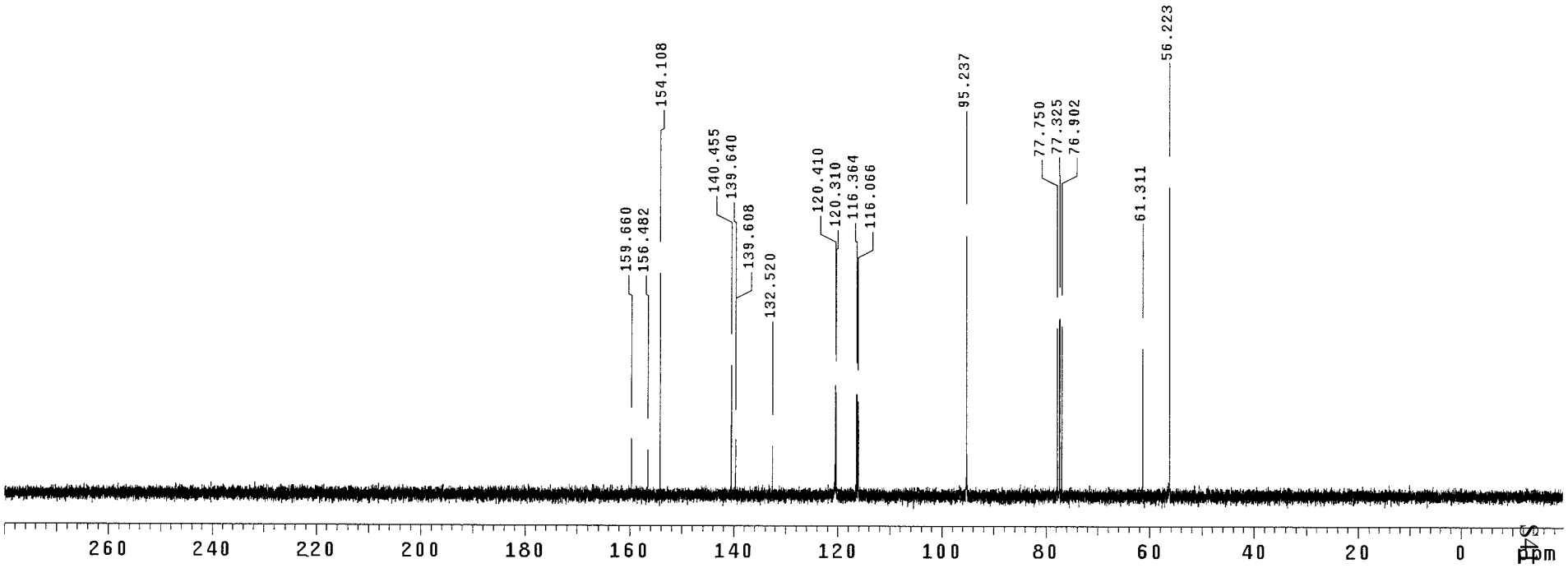
Pulse Sequence: s2pul



BF-III-158-13C

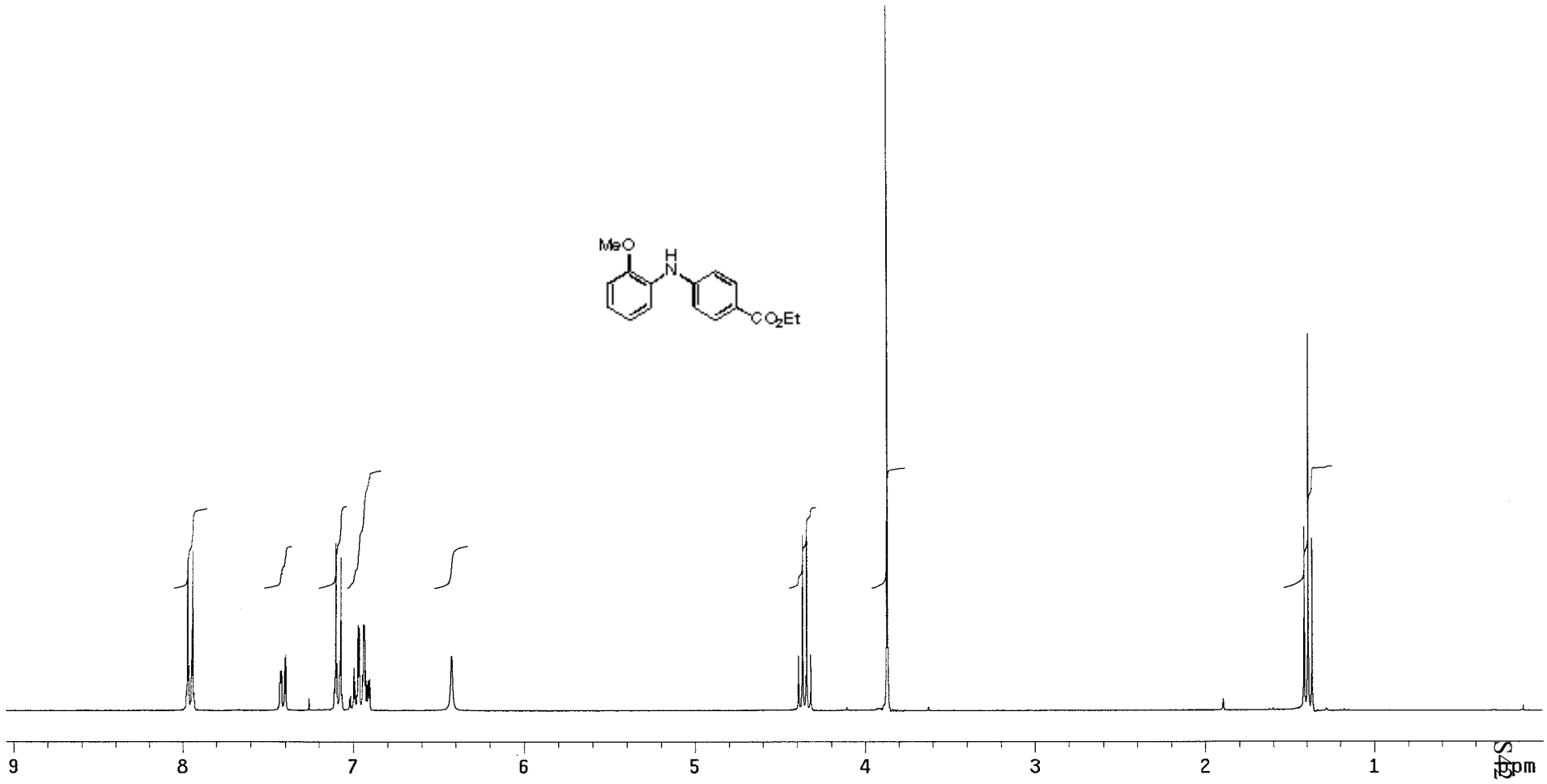
Pulse Sequence: s2pul





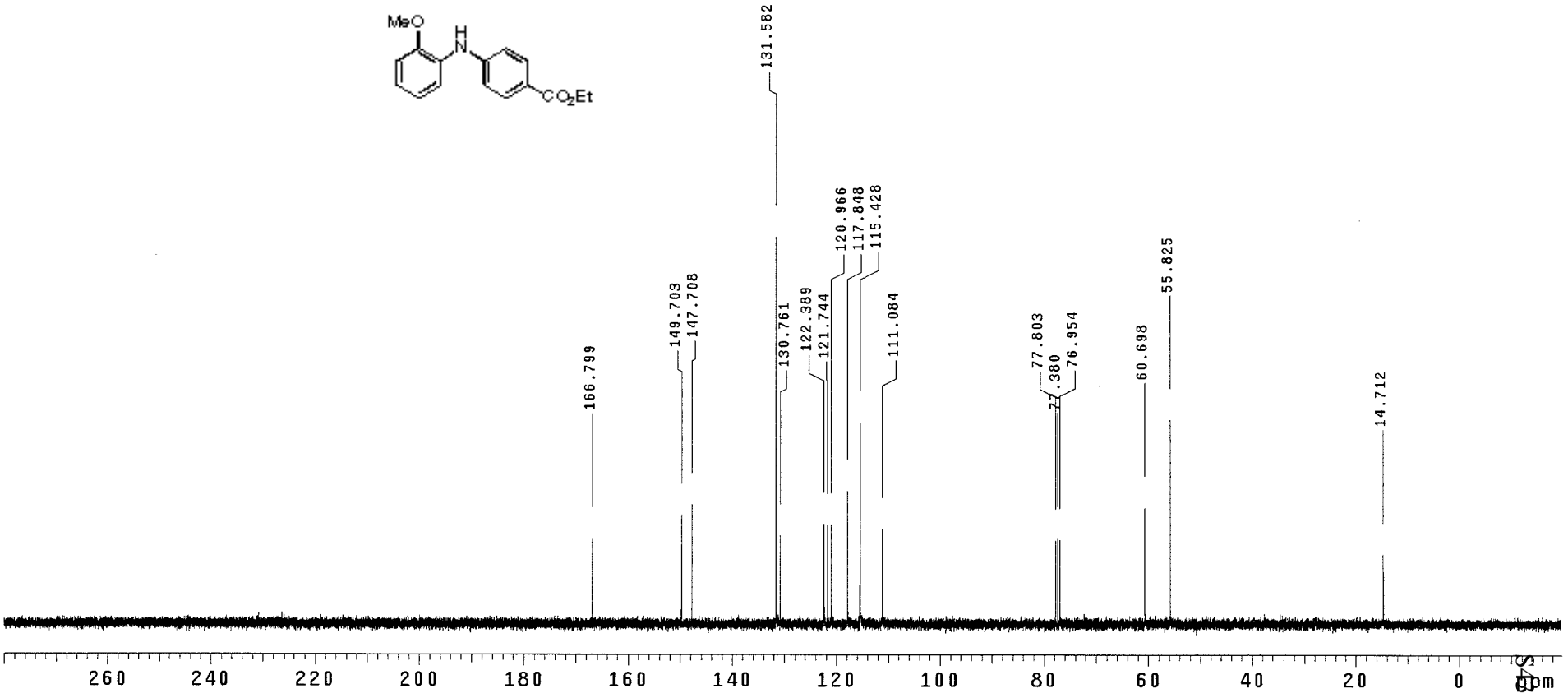
BF-III-161

Pulse Sequence: s2pul



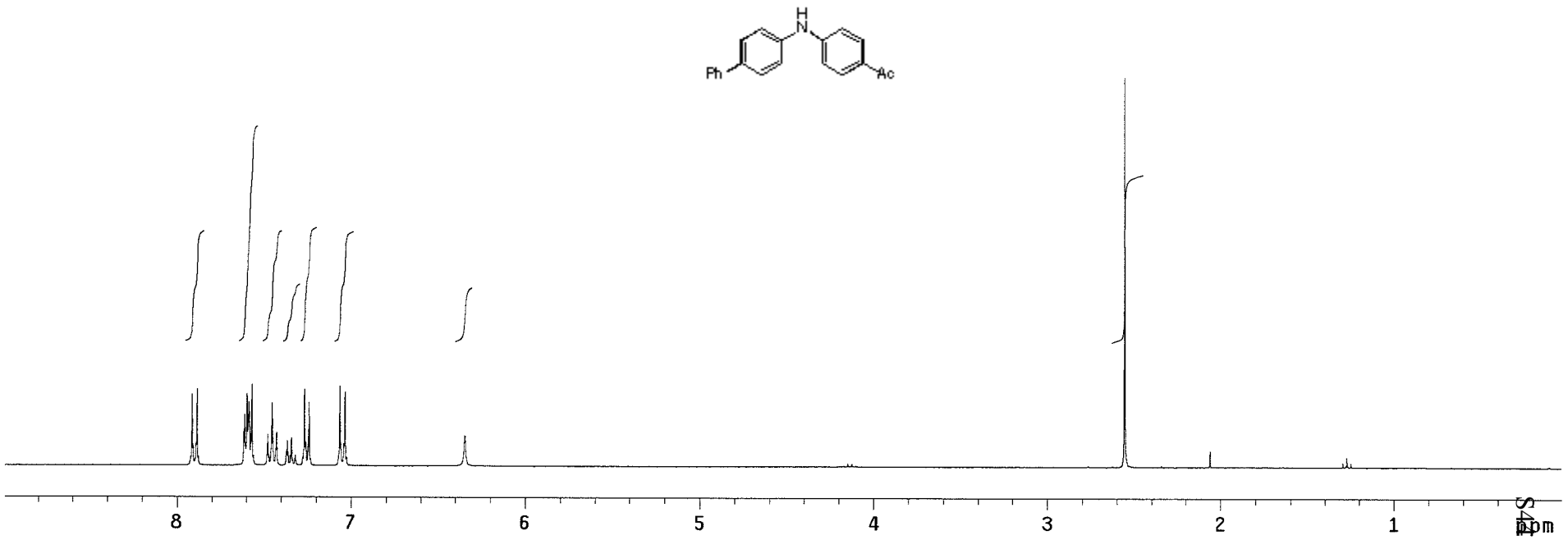
BF-III-131-13C

Pulse Sequence: s2pul



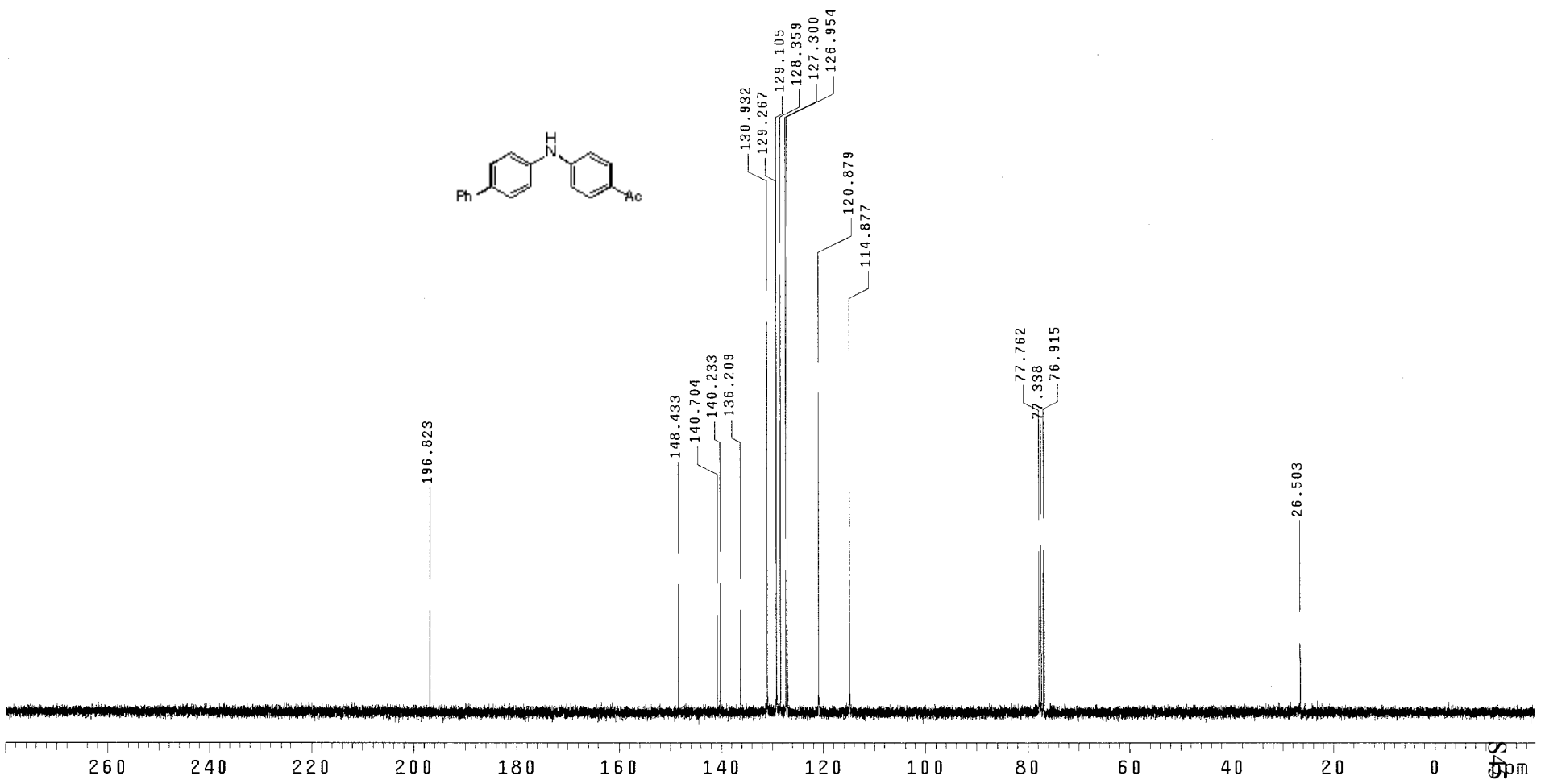
BF-III-159

Pulse Sequence: s2pul



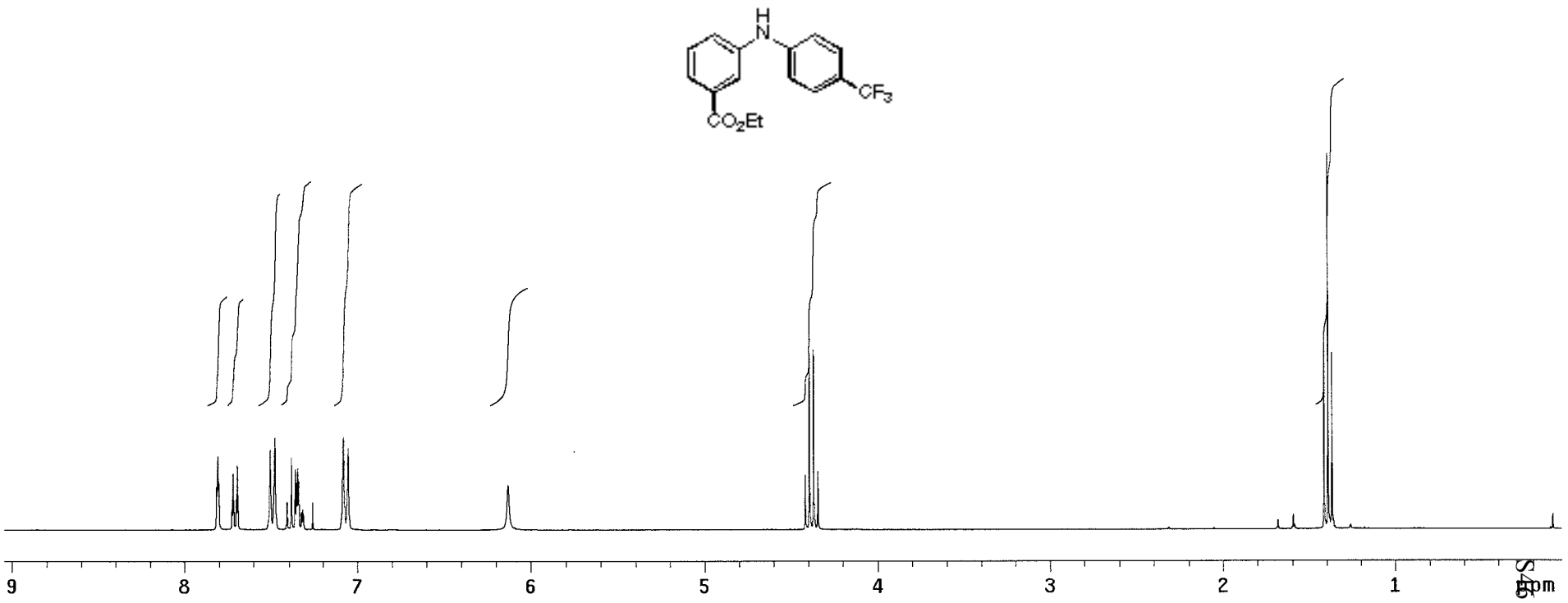
BF-III-109-13C

Pulse Sequence: s2pul



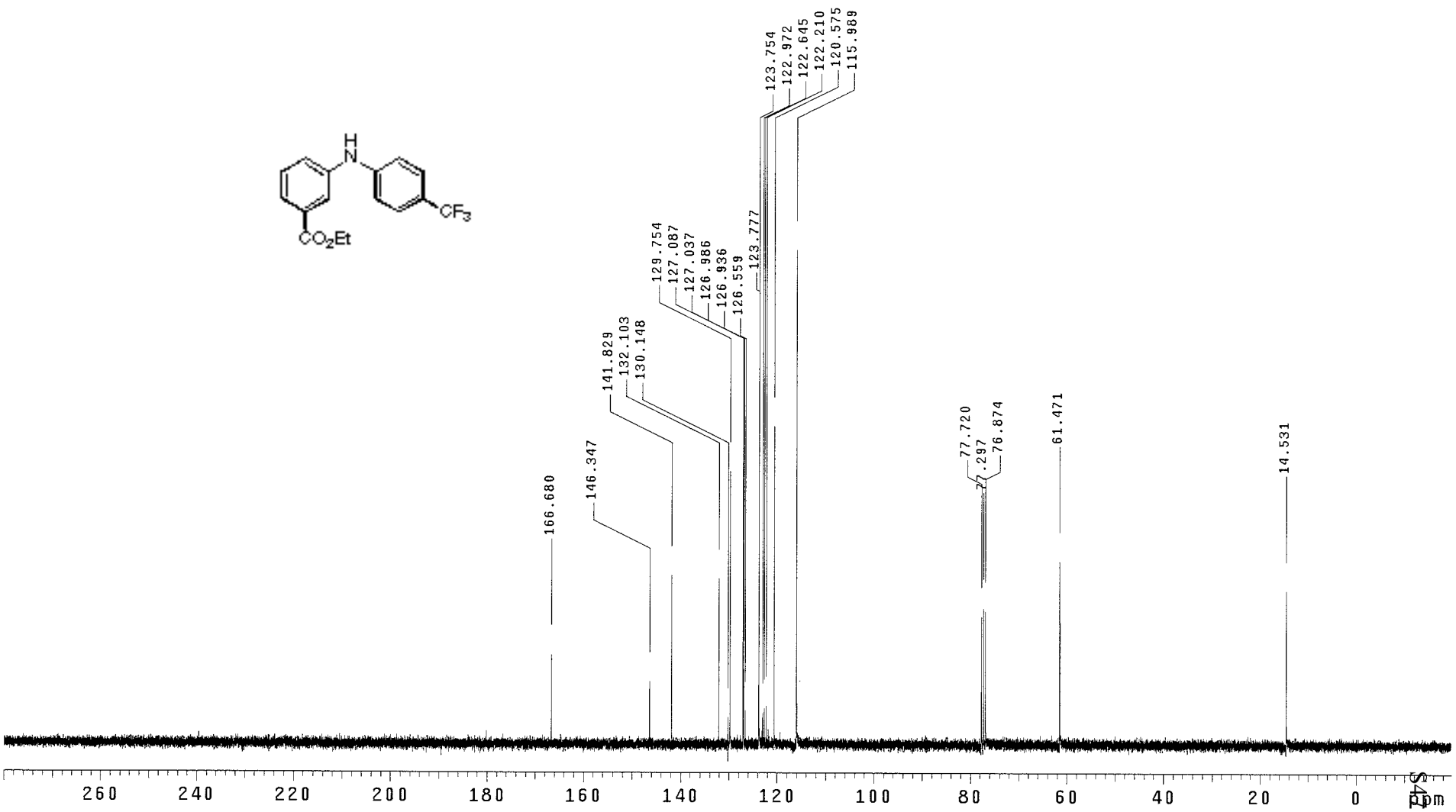
BF-III-138

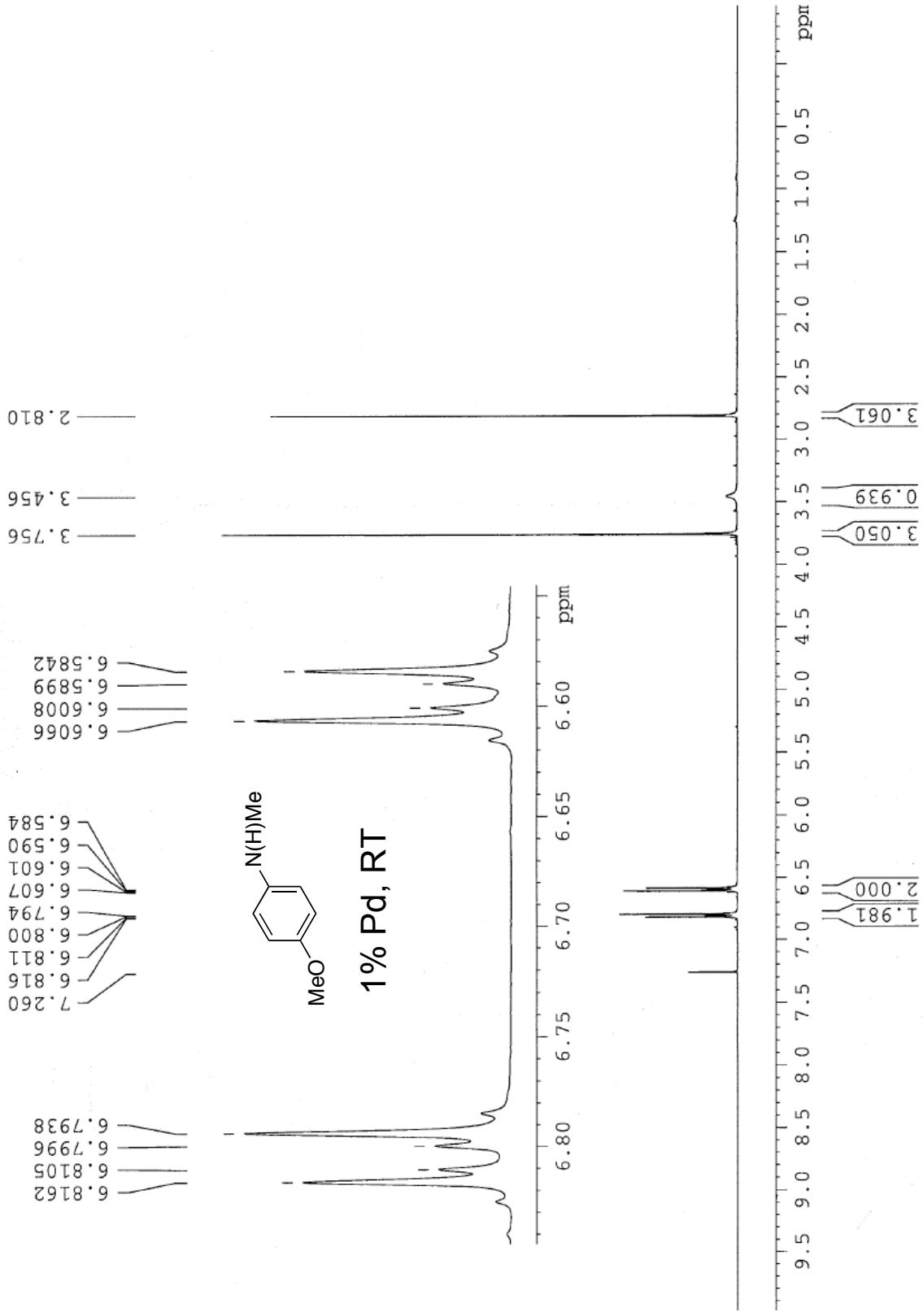
Pulse Sequence: s2pul

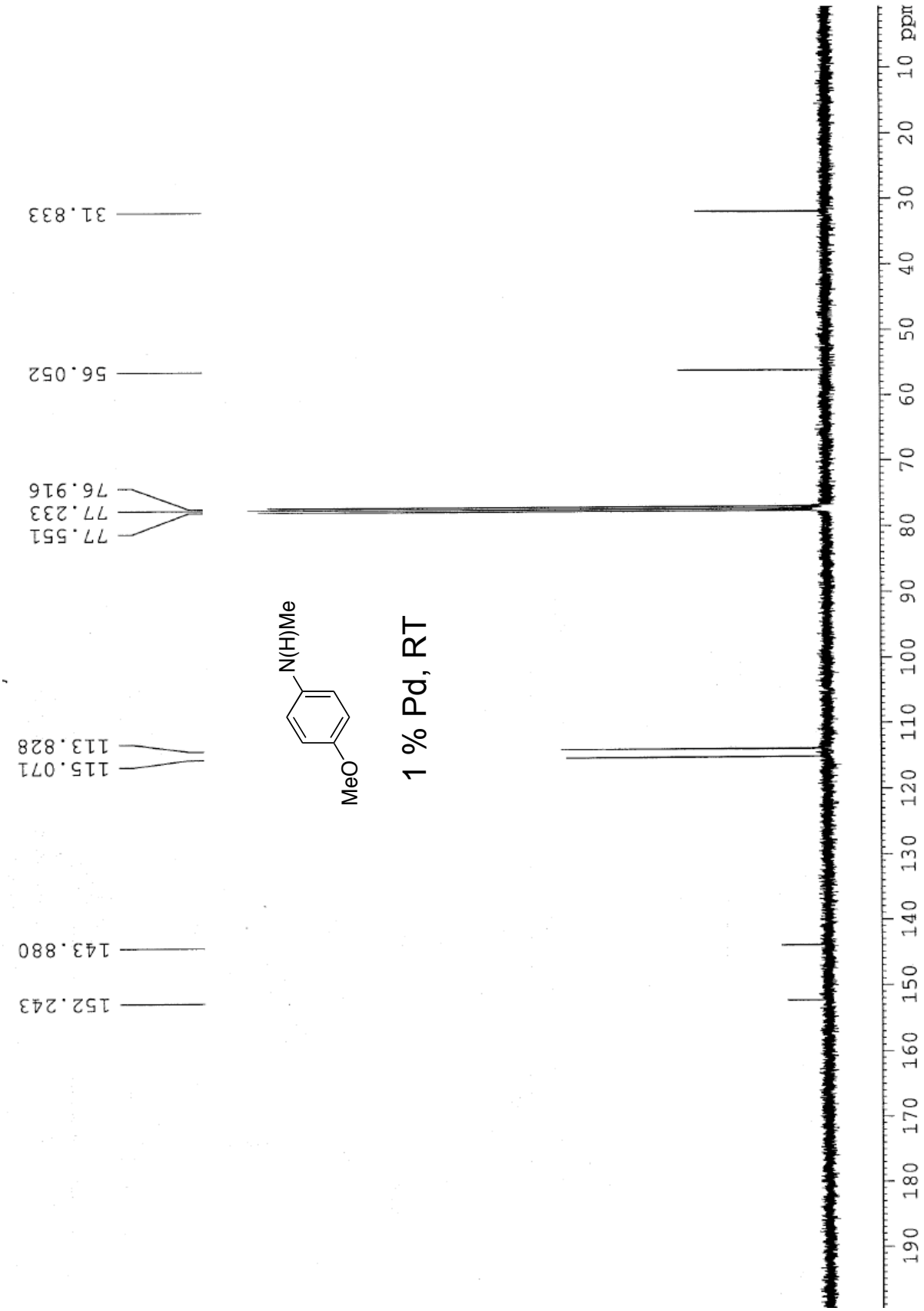


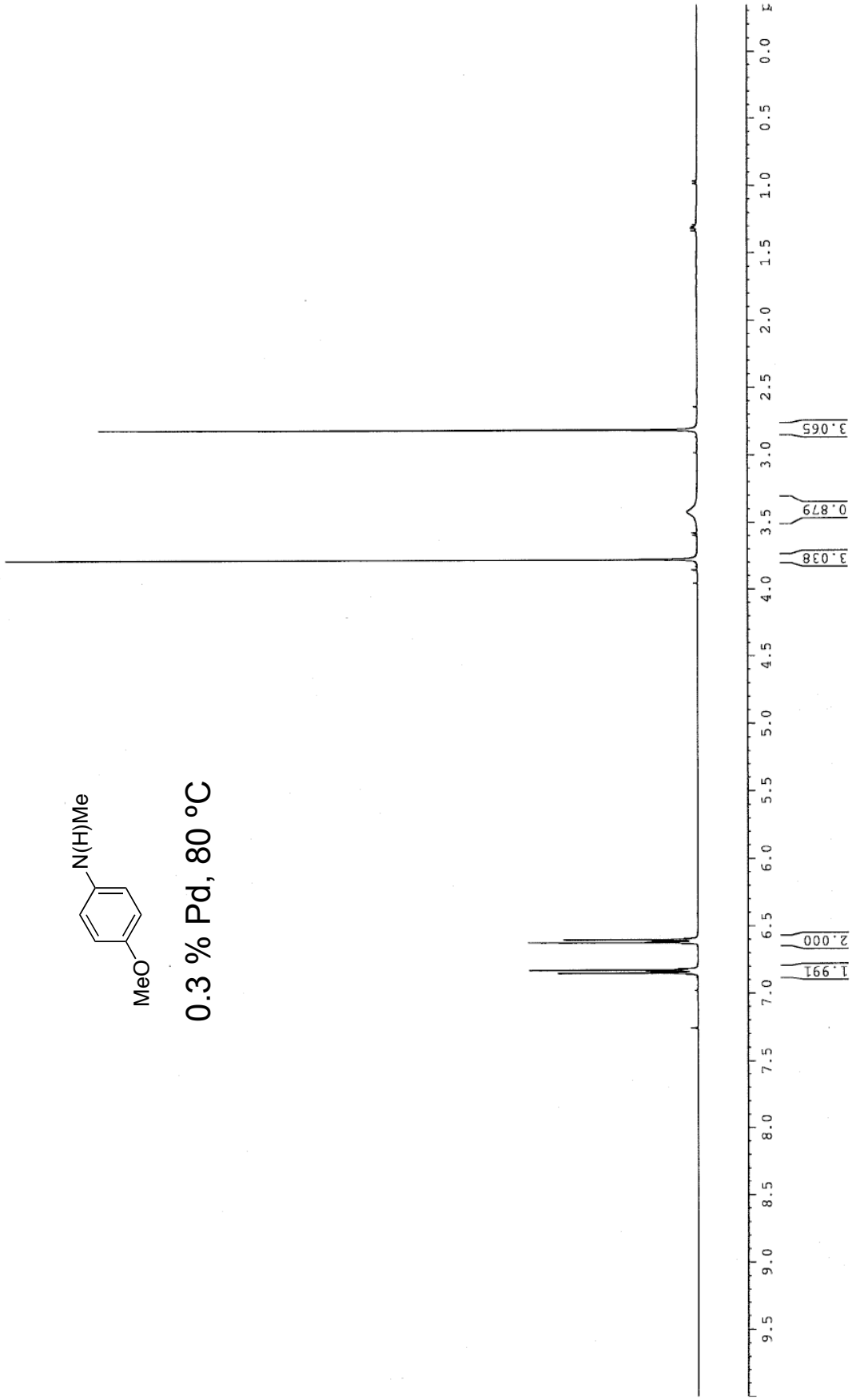
BF-III-93-13C

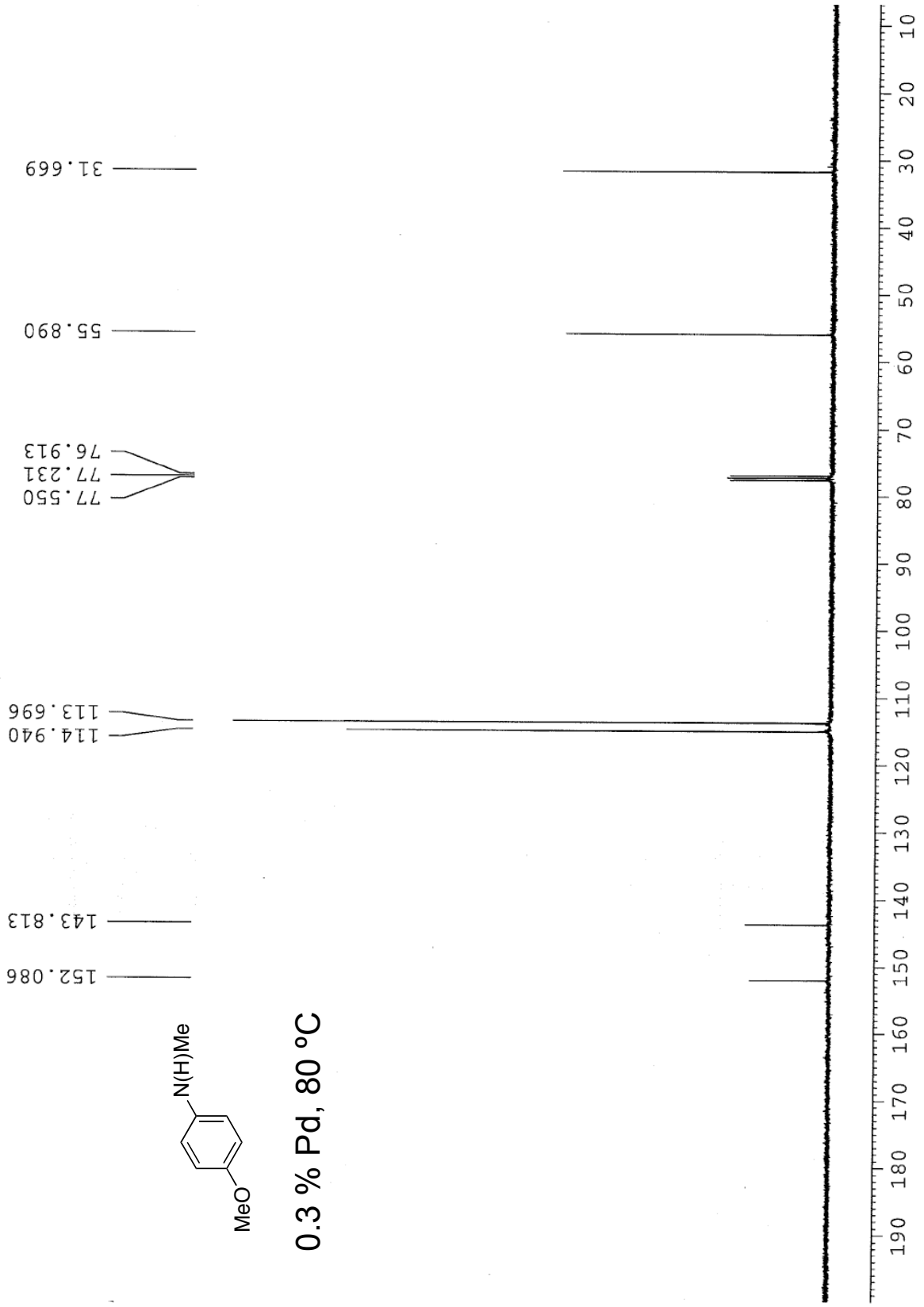
Pulse Sequence: s2pul

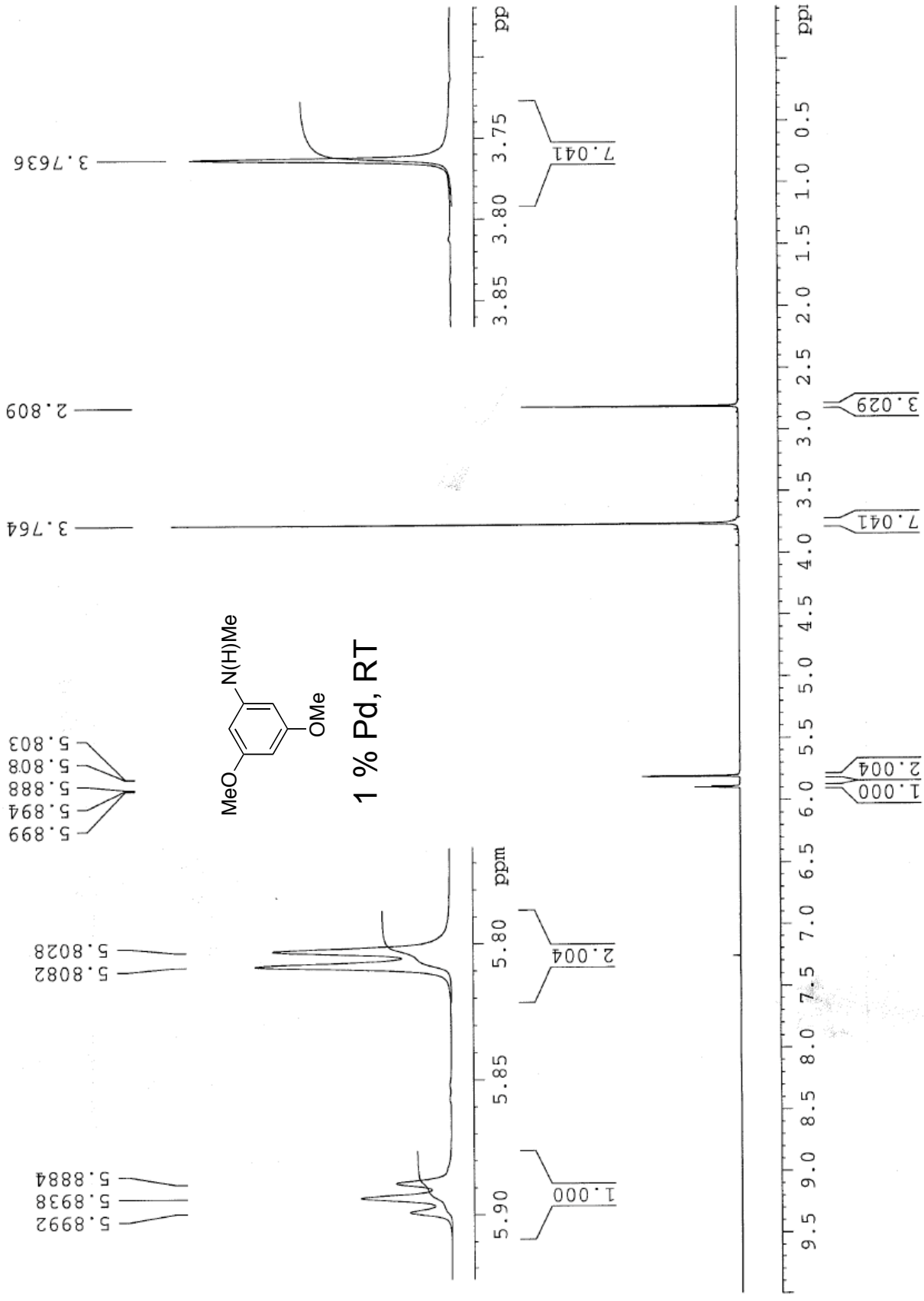


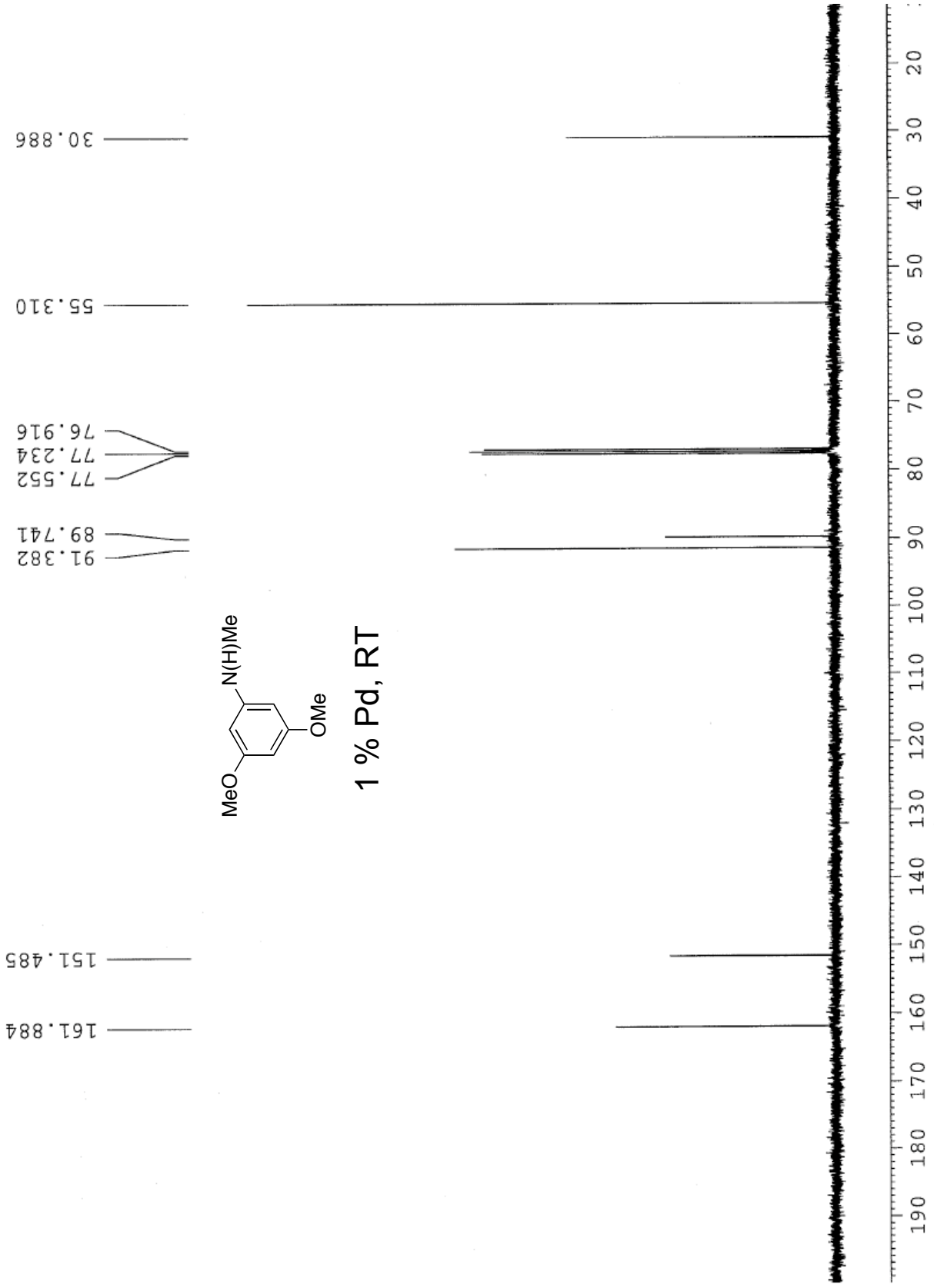

1% Pd, RT
N(H)Me
MeO
2.810
3.456
3.756
6.8162
6.8105
6.7996
6.7938
7.260
6.816
6.811
6.800
6.794
6.607
6.601
6.590
6.584
6.6066
6.6008
6.5899
6.5842
1.981
2.000
3.061
0.939
3.050
ppm

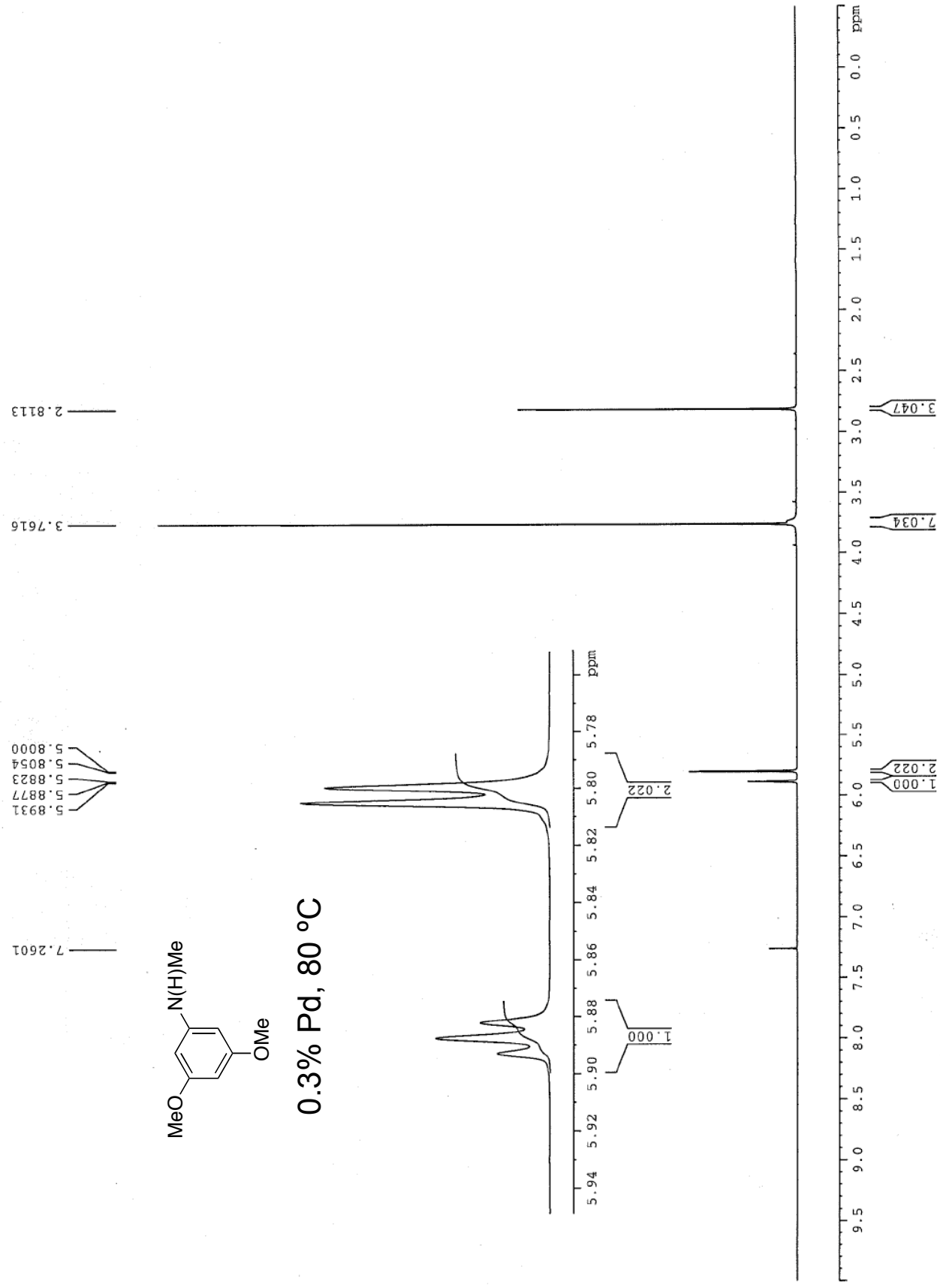

31.833
56.052
76.916
77.233
77.551
113.828
115.071
143.880
152.243
N(H)Me
MeO
1 % Pd, RT
10 ppm

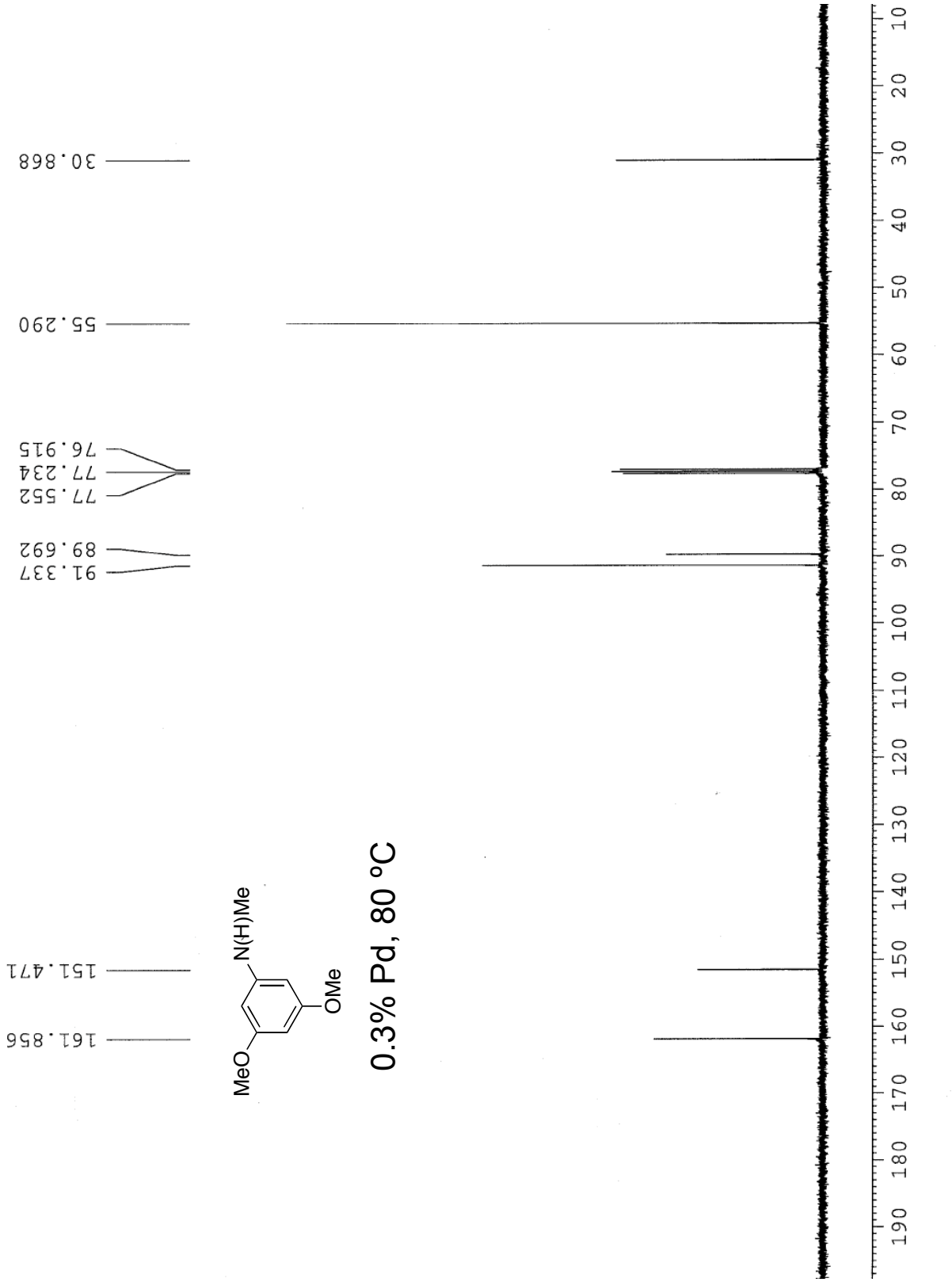

N(H)Me
MeO
0.3 % Pd, 80 °C
3.065
0.879
3.038
2.000
1.991

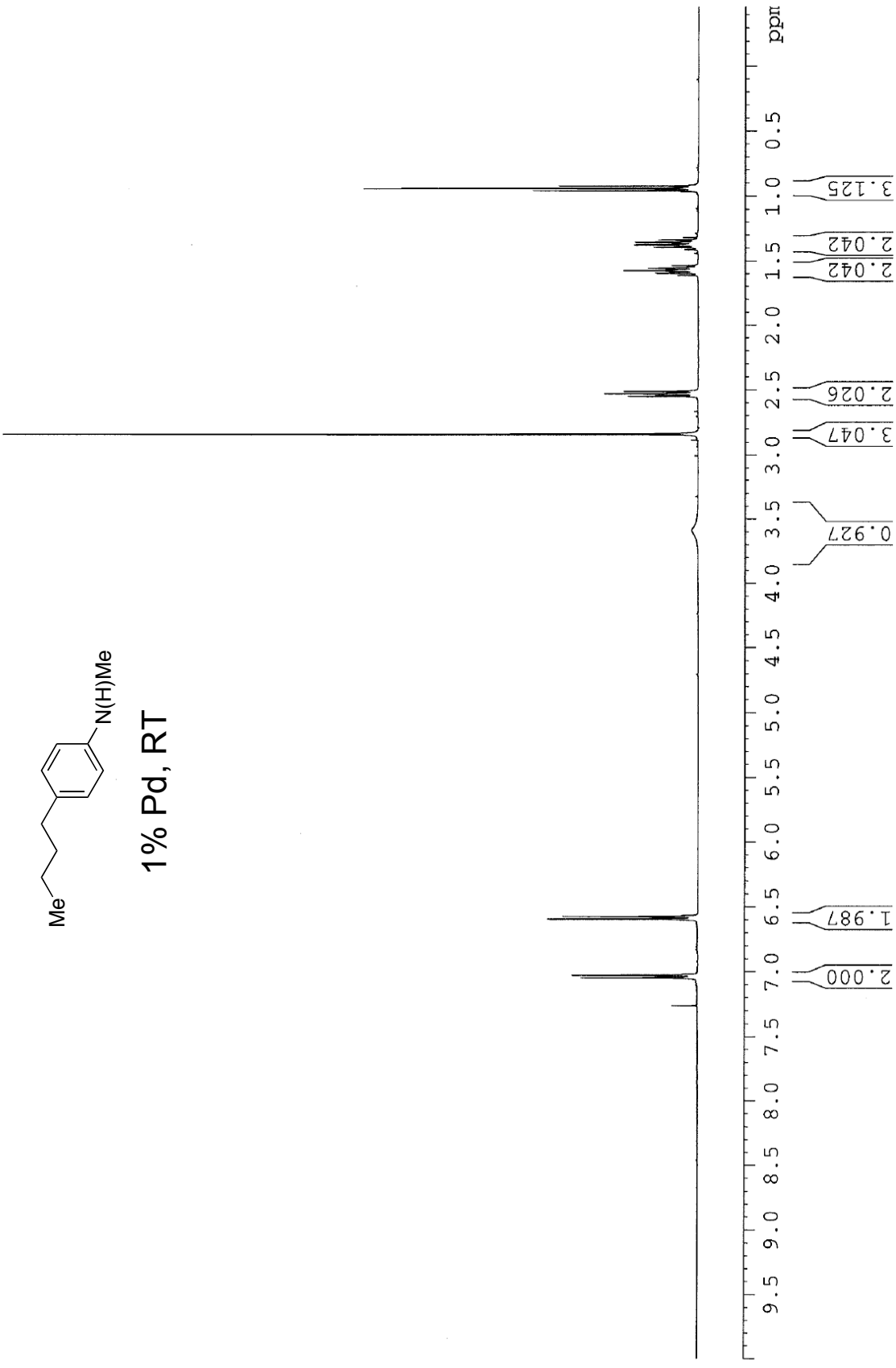

31.669
55.890
76.913
77.231
77.550
113.696
114.940
143.813
152.086
N(H)Me
MeO
0.3 % Pd, 80 °C
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

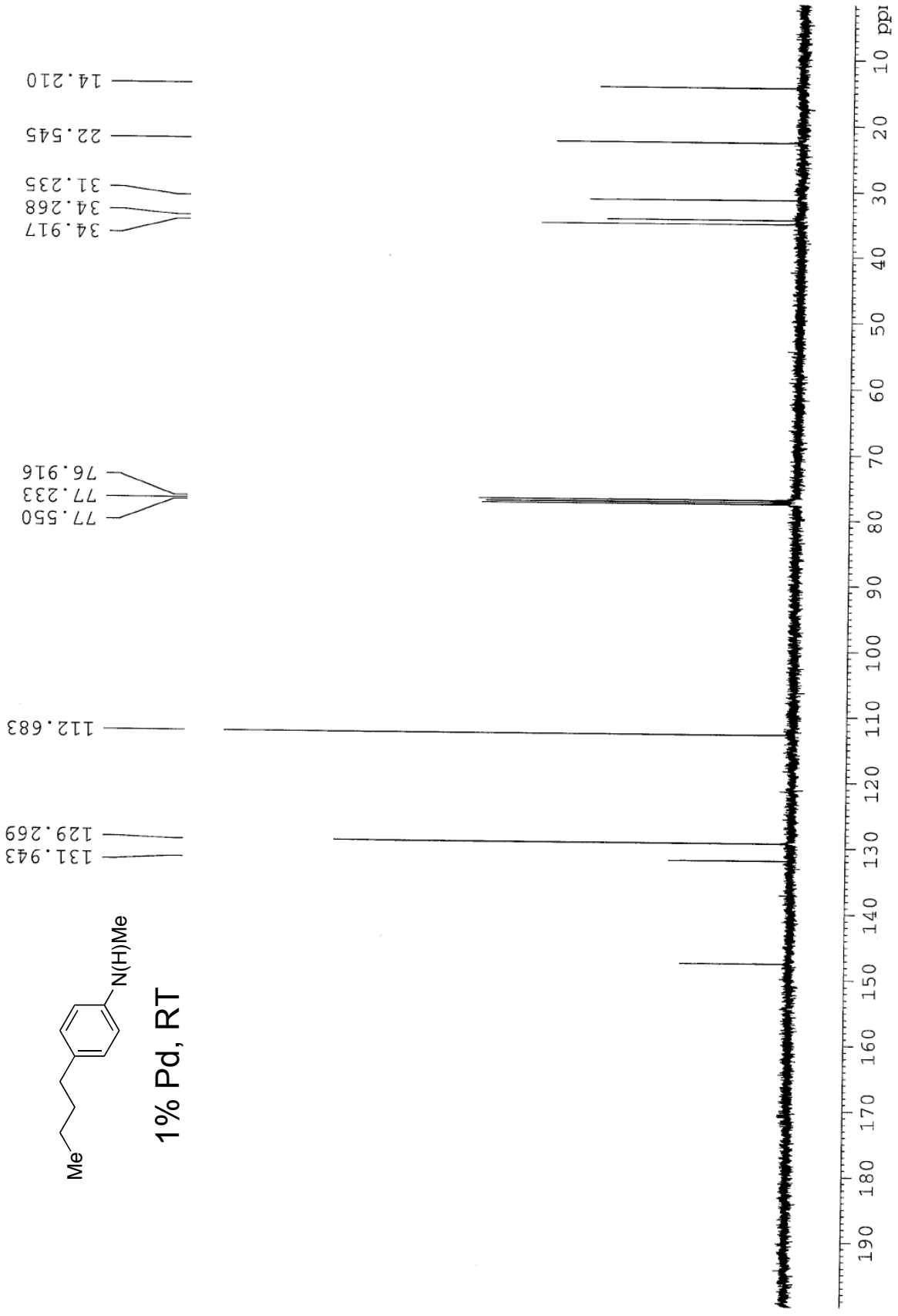

1 % Pd, RT
N(H)Me
OMe
MeO
3.764
2.809
3.7636
5.899
5.894
5.888
5.808
5.803
5.8082
5.8028
5.8992
5.8938
5.8884
7.041
3.029
1.000
2.004
ppm

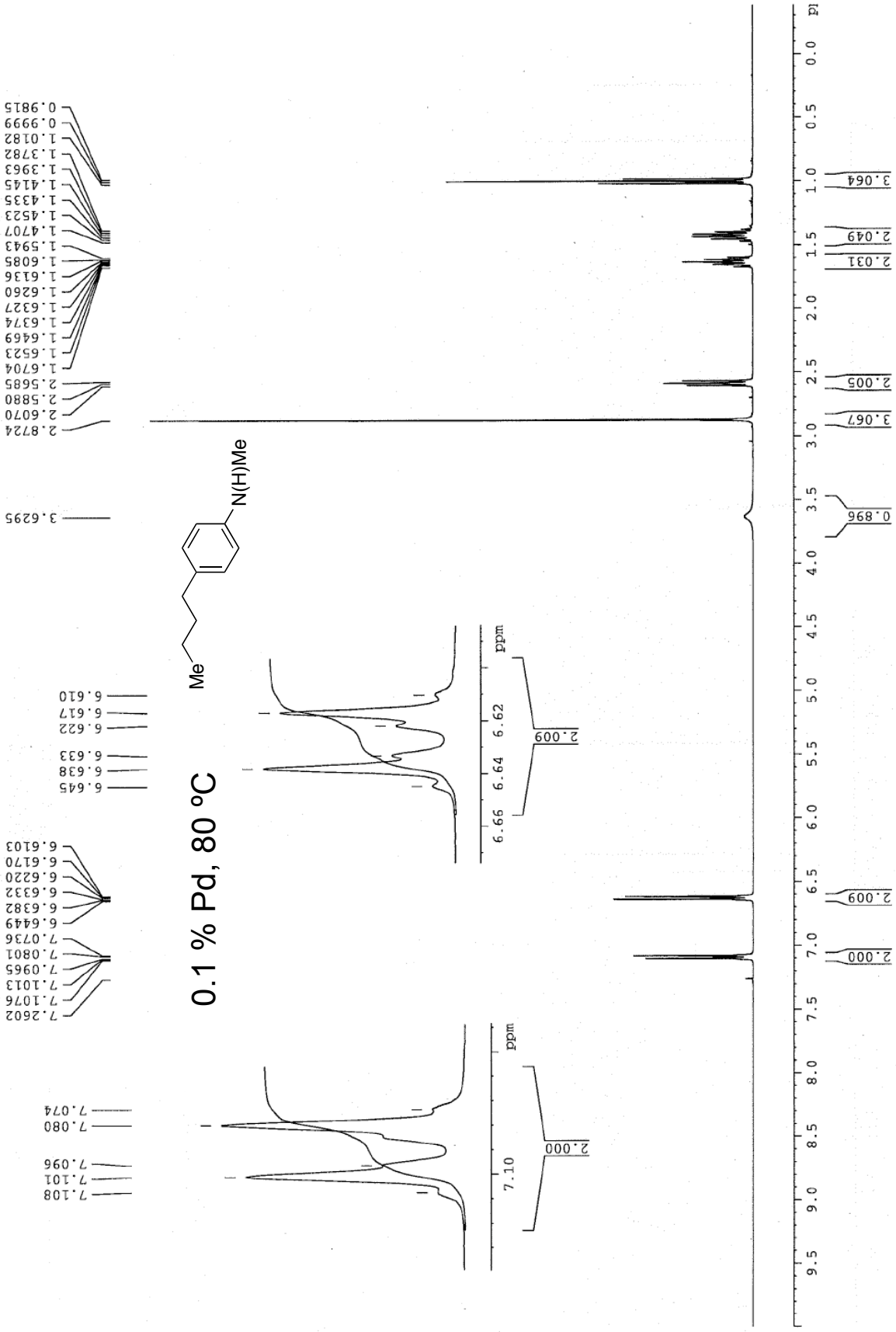

30.886
55.310
76.916
77.234
77.552
89.741
91.382
151.485
161.884
N(H)Me
OMe
MeO
1 % Pd, RT
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

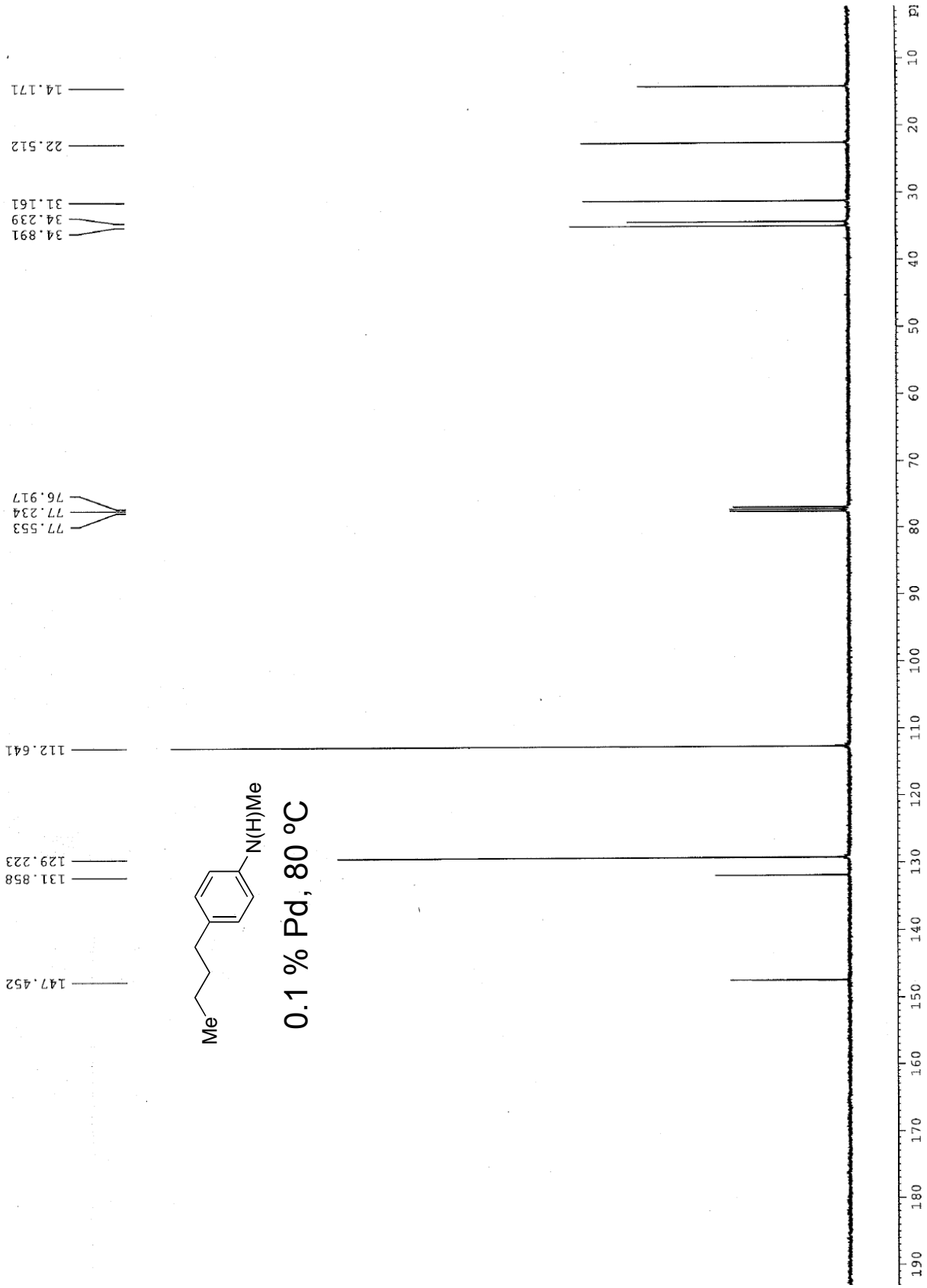

0.3% Pd, 80 °C
N(H)Me
OMe
MeO
2.8113
3.7616
7.2601
5.8931
5.8777
5.8823
5.8054
5.8000
3.047
7.034
1.000
2.022
2.022
1.000
ppm

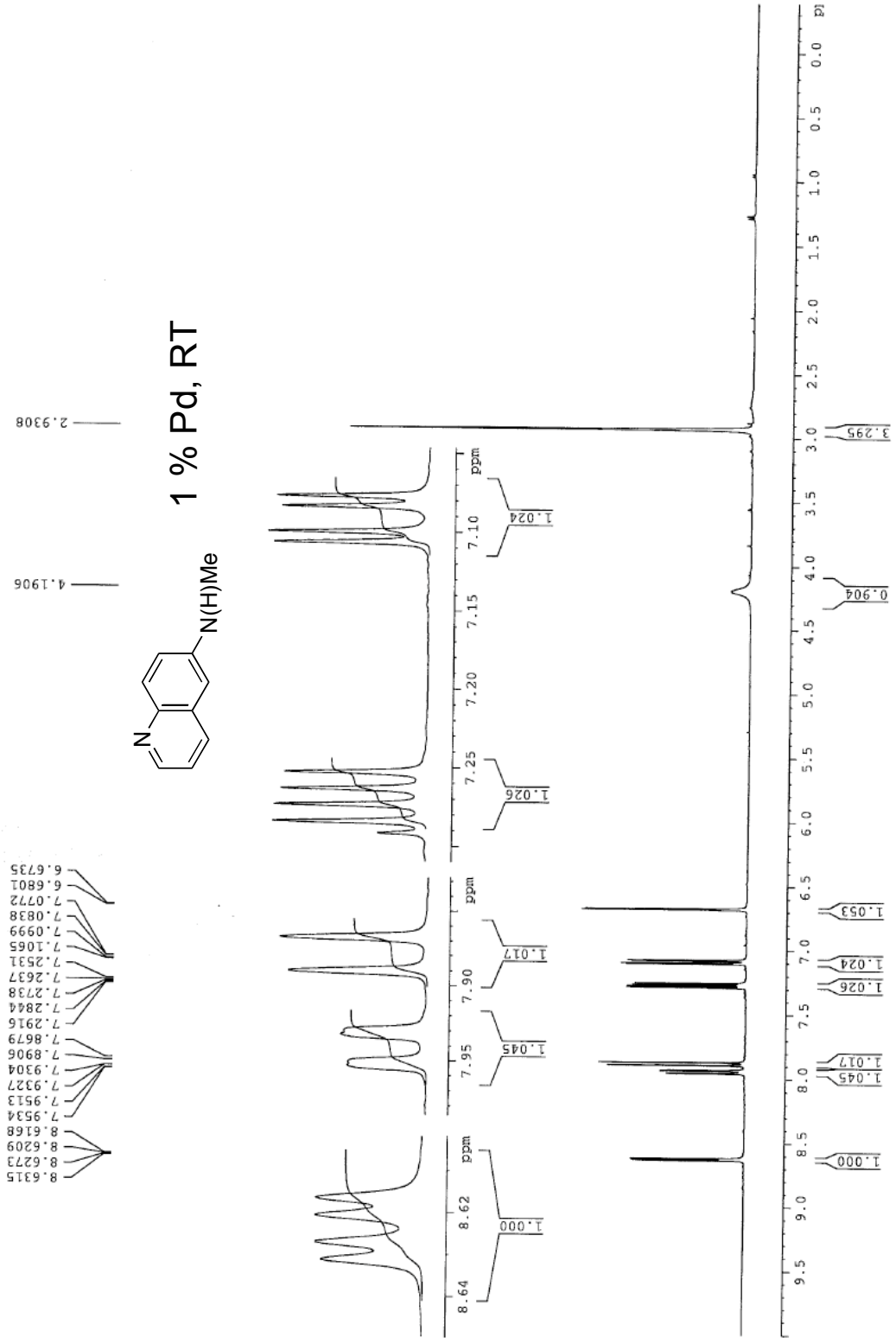

30.868
55.290
76.915
77.234
77.552
89.692
91.337
151.471
161.856
N(H)Me
OMe
MeO
0.3% Pd, 80 °C
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

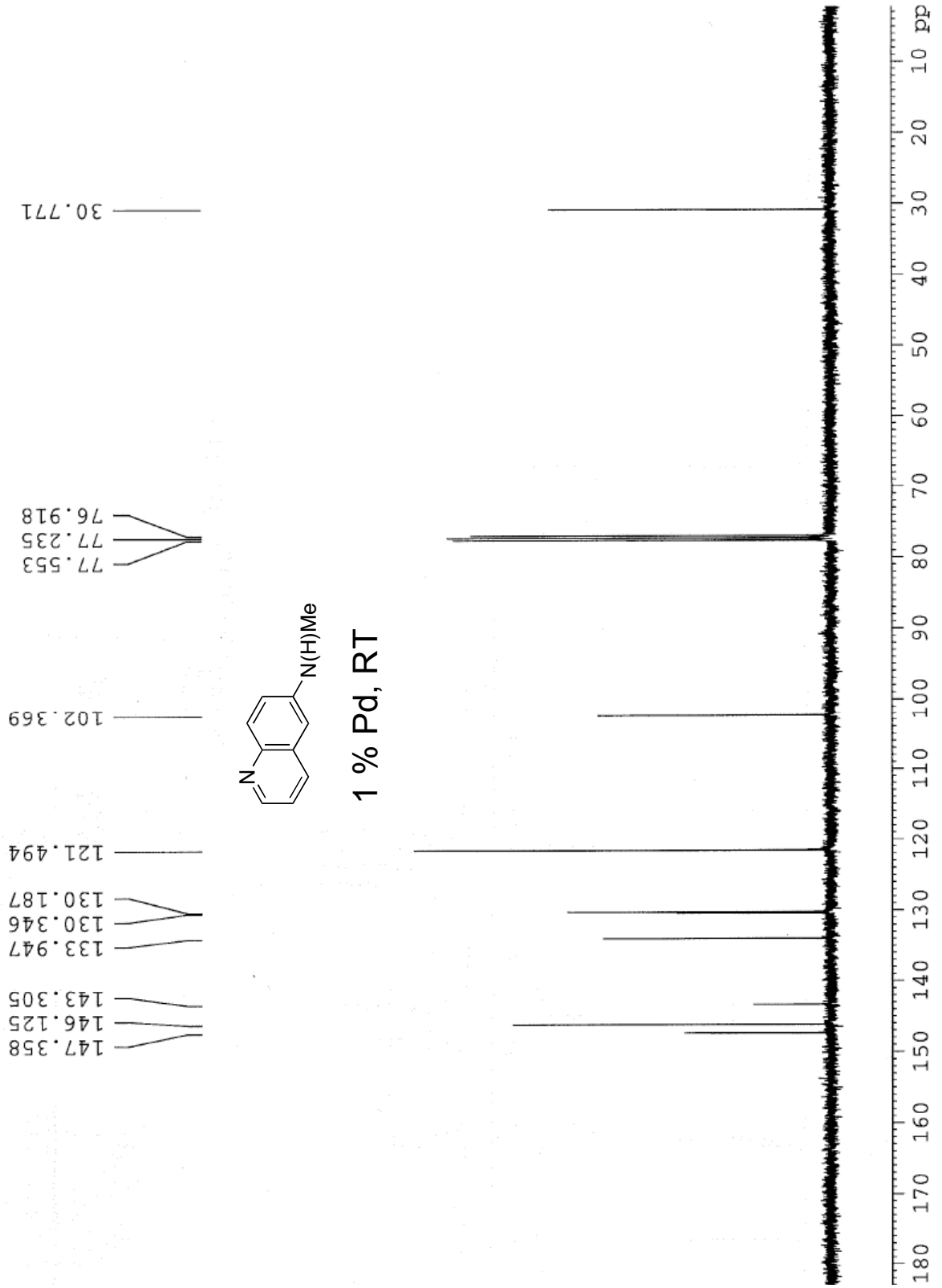

N(H)Me
Me
1% Pd, RT
ppm
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
2.000
1.987
0.927
3.047
2.026
2.042
2.042
3.125

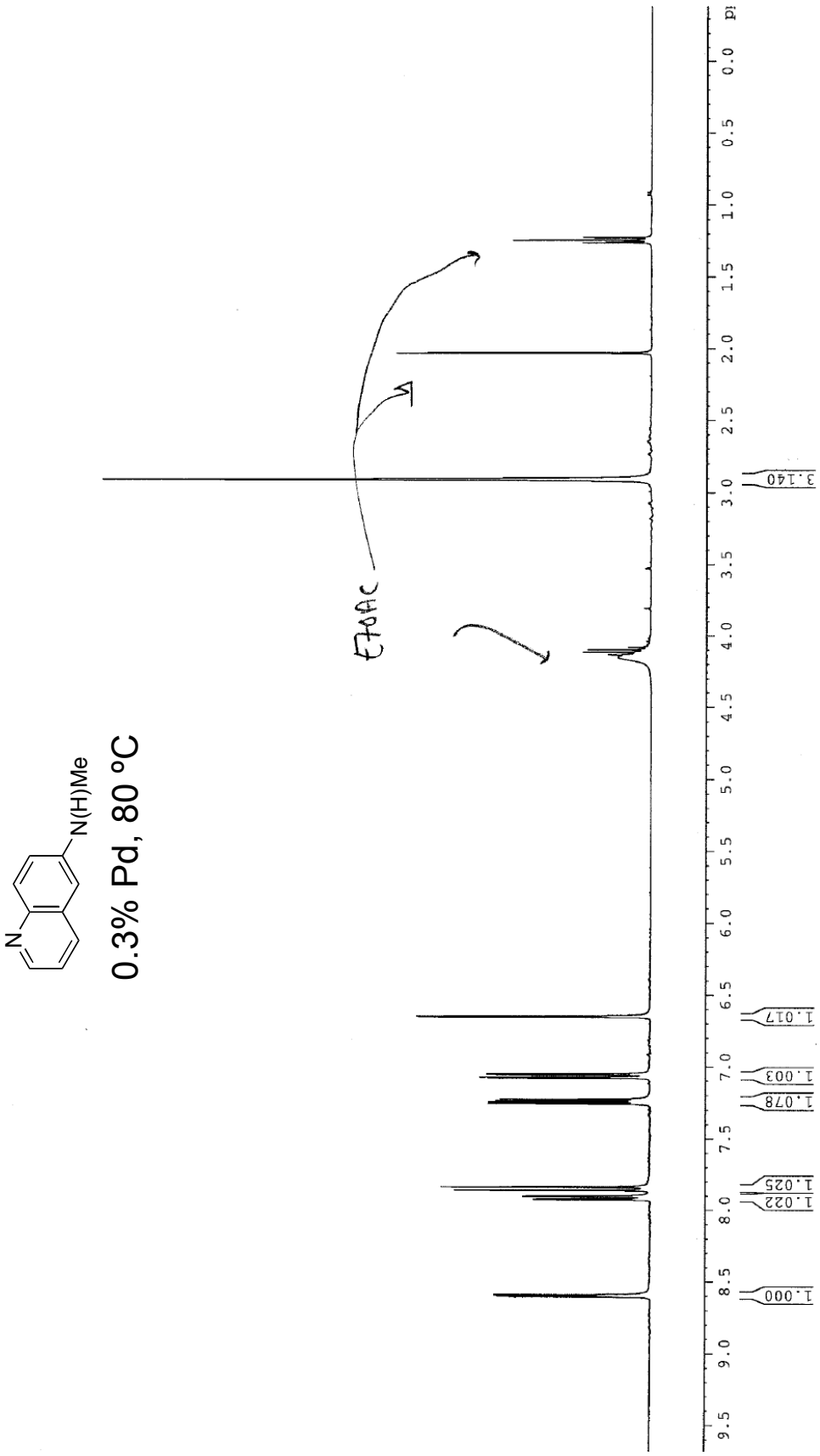

14.210
22.545
31.235
34.268
34.917
77.550
77.233
76.916
112.683
129.269
131.943
N(H)Me
Me
1% Pd, RT
10 ppm

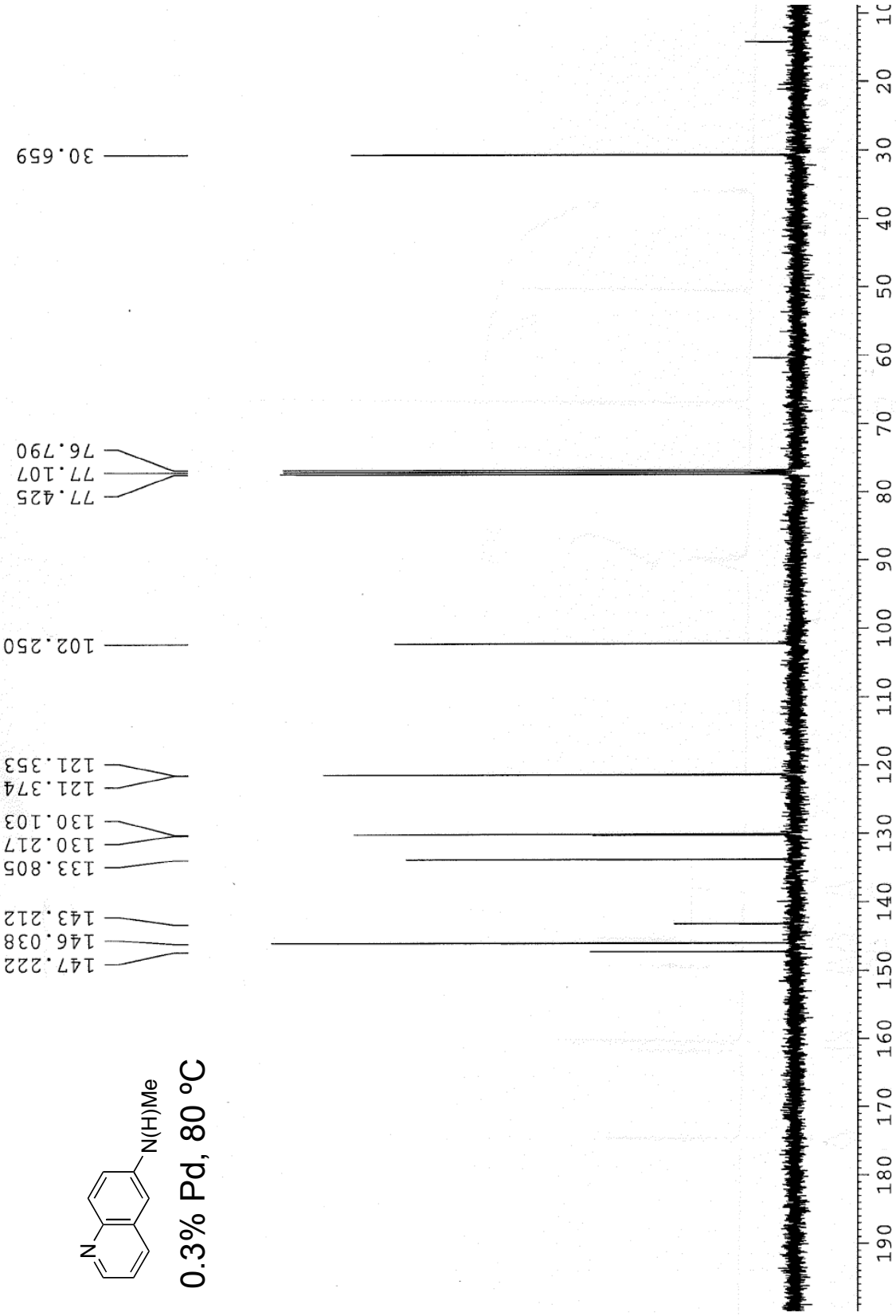

0.1 % Pd, 80 °C
N(H)Me
Me
ppm

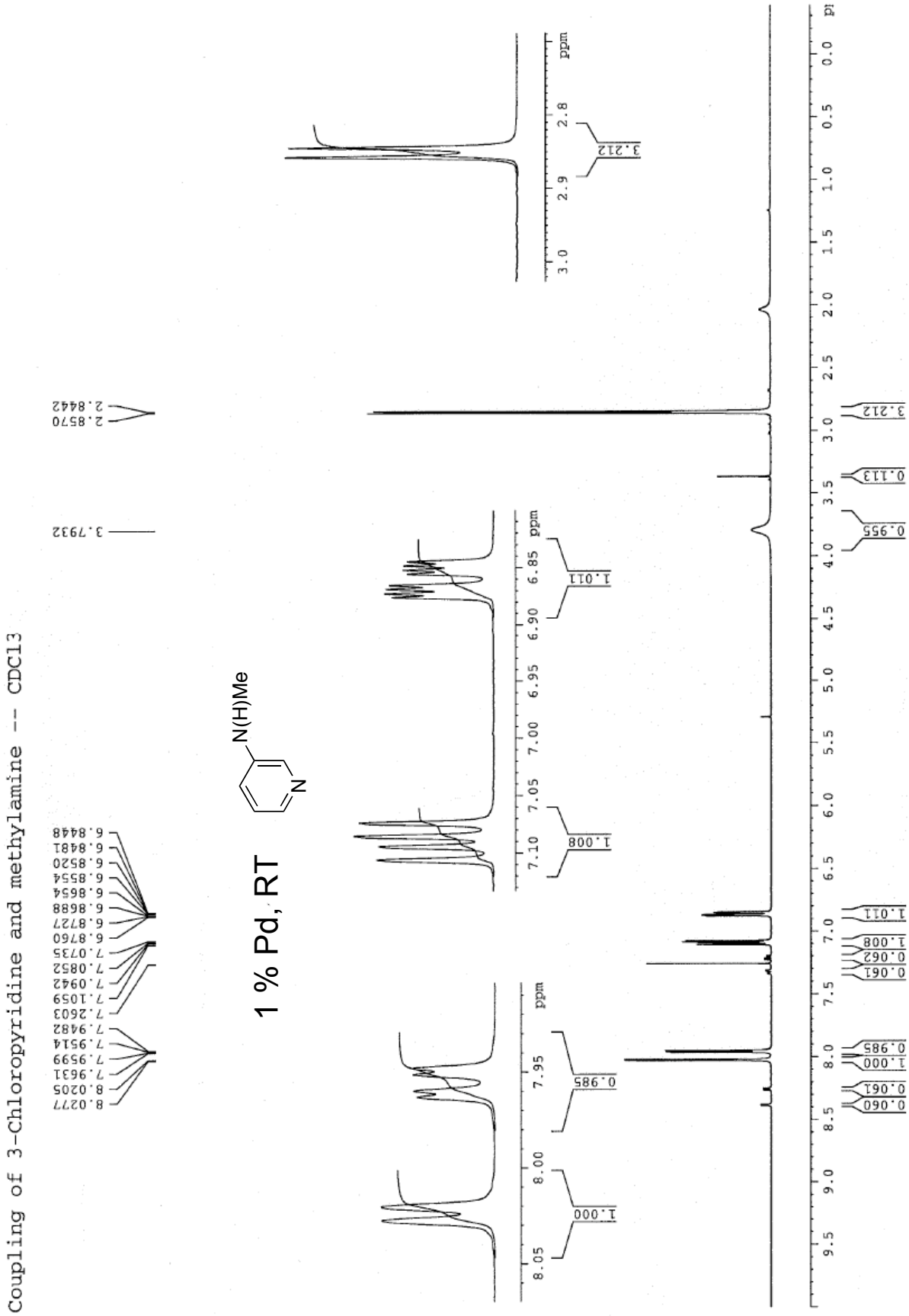

14.171
22.512
31.161
34.239
34.891
76.917
77.234
77.553
112.641
129.223
131.858
147.452
N(H)Me
Me
0.1 % Pd, 80 °C

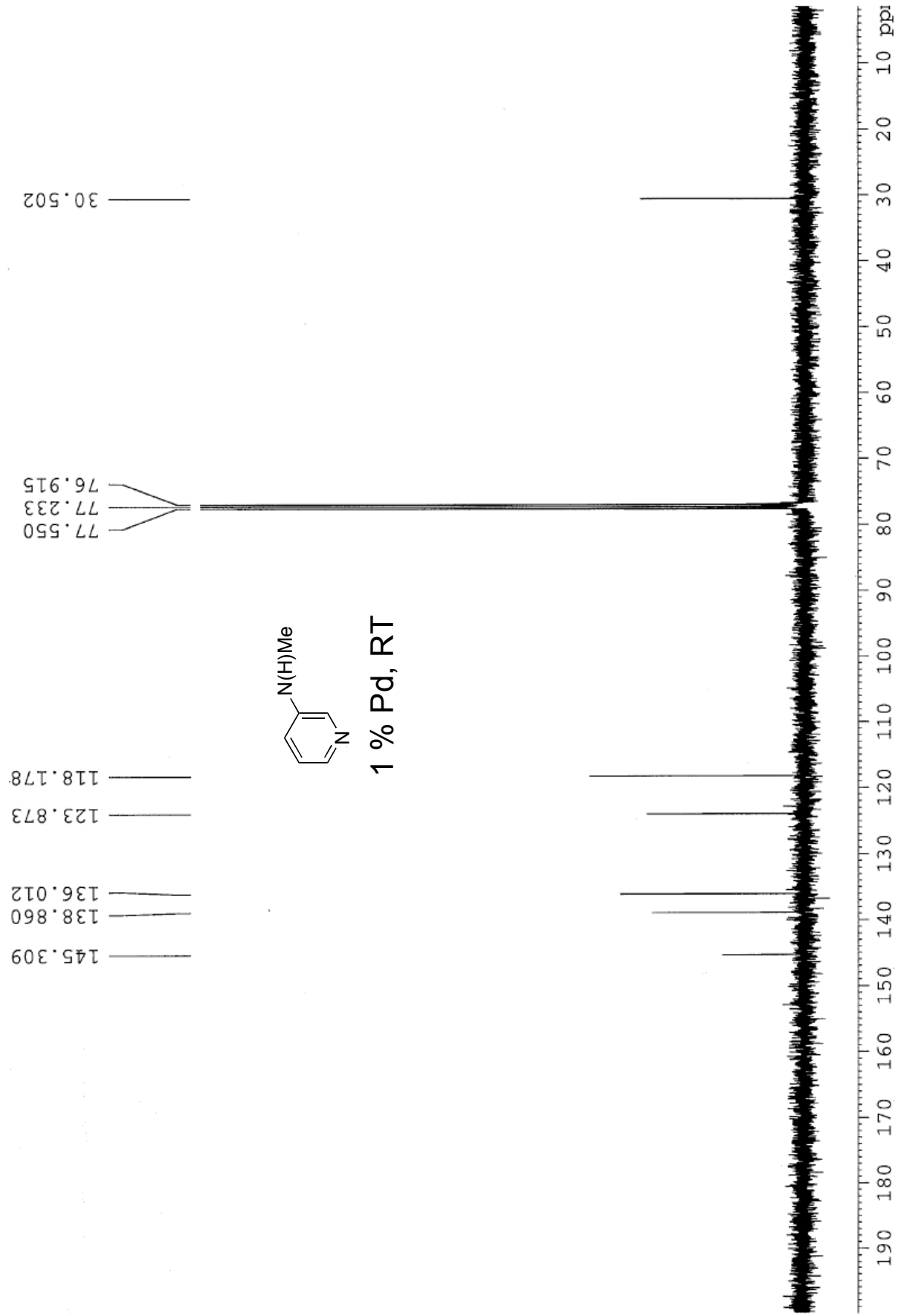

1 % Pd, RT
N(H)Me
N
2.9308
4.1906
8.6315
8.6273
8.6209
8.6168
7.9534
7.9513
7.9327
7.9304
7.8906
7.8679
7.2916
7.2844
7.2738
7.2637
7.2531
7.1065
7.0999
7.0838
7.0772
6.6801
6.6735
1.000
1.045
1.017
1.026
1.024
1.053
0.904
3.295
ppm

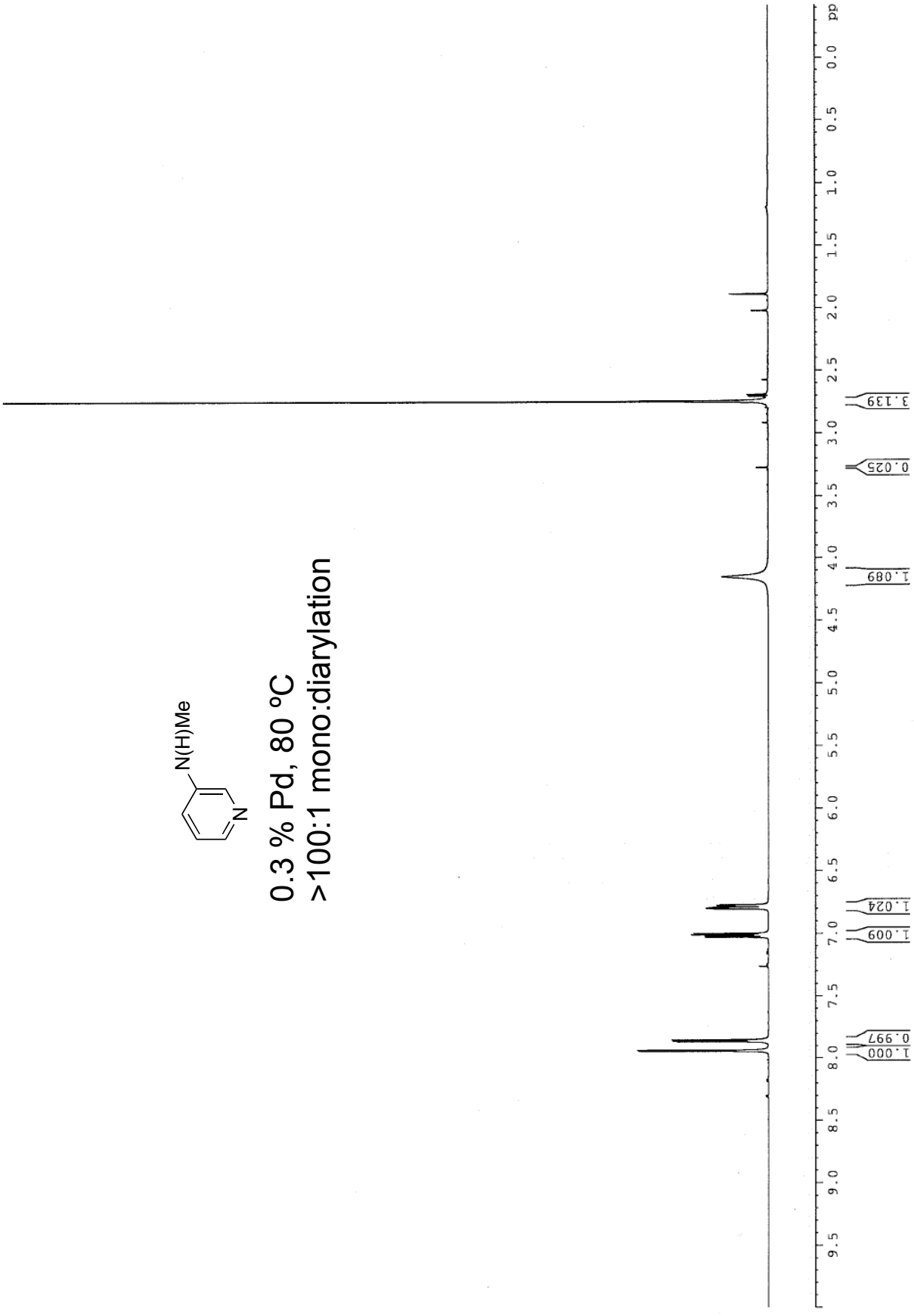

30.771
76.918
77.235
77.553
102.369
121.494
130.187
130.346
133.947
143.305
146.125
147.358
N(H)Me
N
1 % Pd, RT
ppm

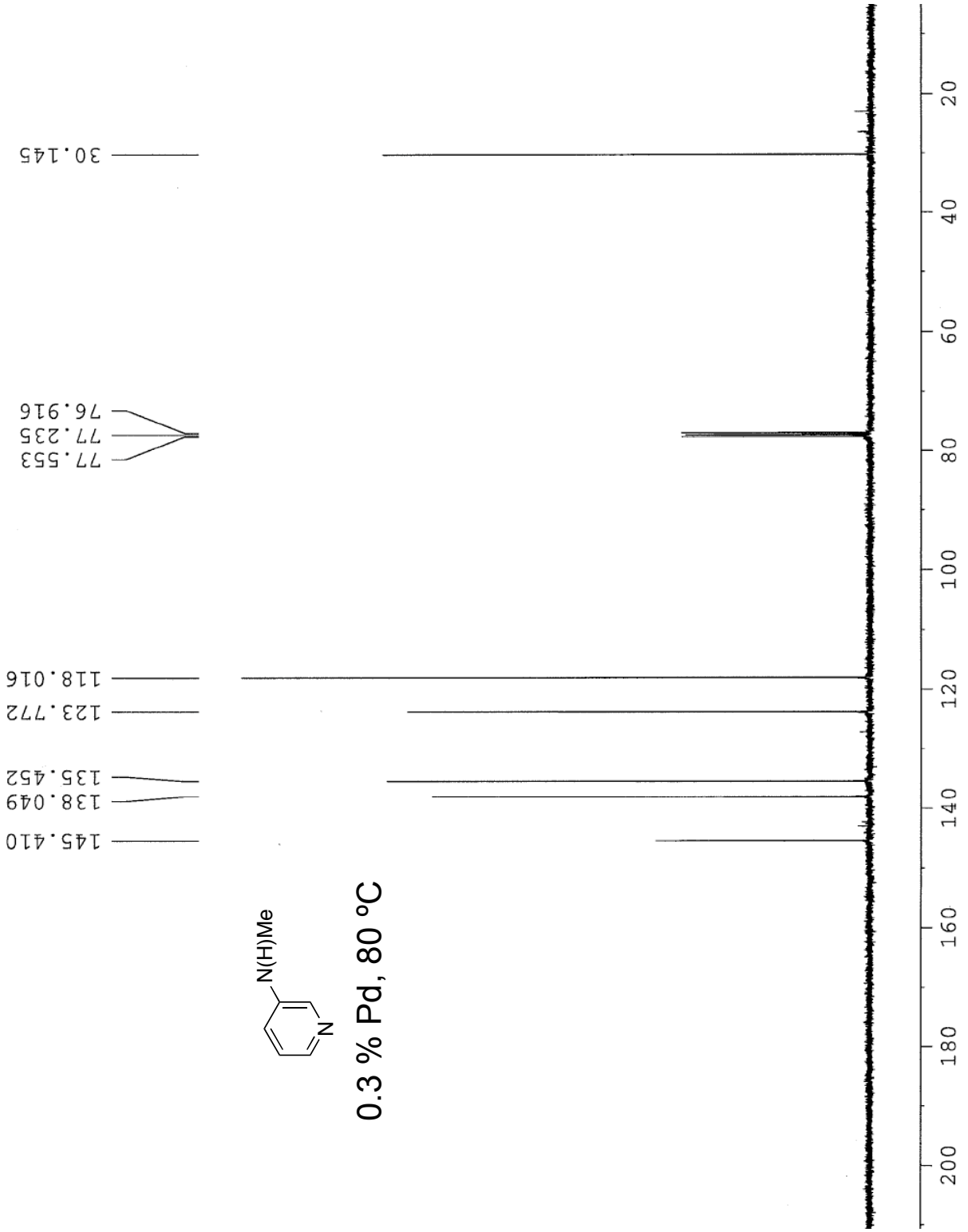

N(H)Me
N
0.3% Pd, 80 °C
EtOAc
1.000
1.022
1.025
1.078
1.003
1.017
3.140


N(H)Me
N
0.3% Pd, 80 °C
147.222
146.038
143.212
133.805
130.217
130.103
121.374
121.353
102.250
77.425
77.107
76.790
30.659


Coupling of 3-Chloropyridine and methylamine -- CDCl3
8.0277
8.0205
7.9631
7.9599
7.9514
7.9482
7.2603
7.1059
7.0942
7.0852
7.0735
6.8760
6.8727
6.8688
6.8654
6.8554
6.8520
6.8481
6.8448
3.7932
2.8570
2.8442
N(H)Me
N
1 % Pd, RT
ppm
1.000
0.985
1.008
1.011
3.212
0.955
0.113
0.061
0.062
1.008
1.011
1.000
0.985
0.060
0.061


30.502
77.550
77.233
76.915
118.178
123.873
136.012
138.860
145.309
N(H)Me
N
1 % Pd, RT
ppm

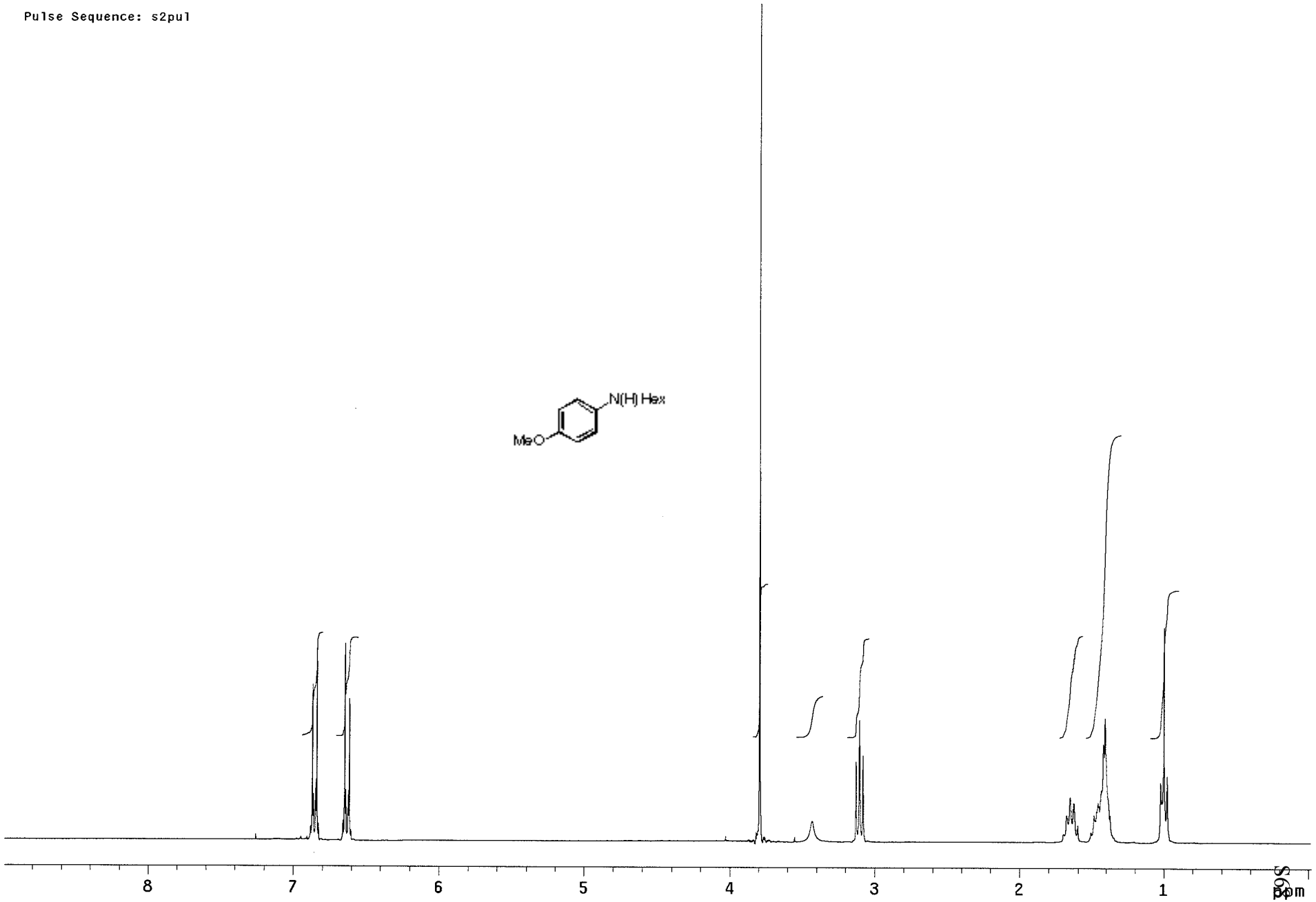

N(H)Me
N
0.3 % Pd, 80 ºC
>100:1 mono:diarylation
1.000
0.997
1.009
1.024
1.089
0.025
3.139
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm


145.410
138.049
135.452
123.772
118.016
77.553
77.235
76.916
30.145
N(H)Me
N
0.3 % Pd, 80 °C
200
180
160
140
120
100
80
60
40
20

55

BF-IV-~~50~~

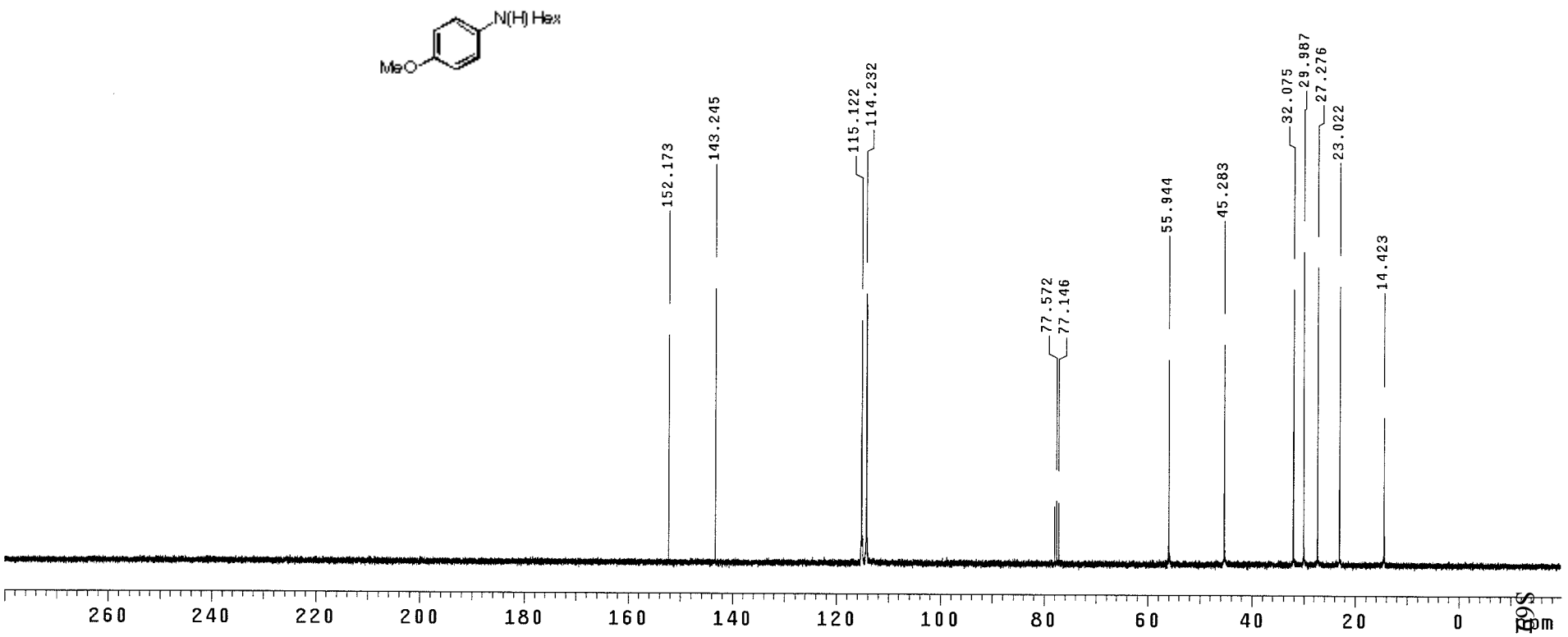
Pulse Sequence: s2pul



55

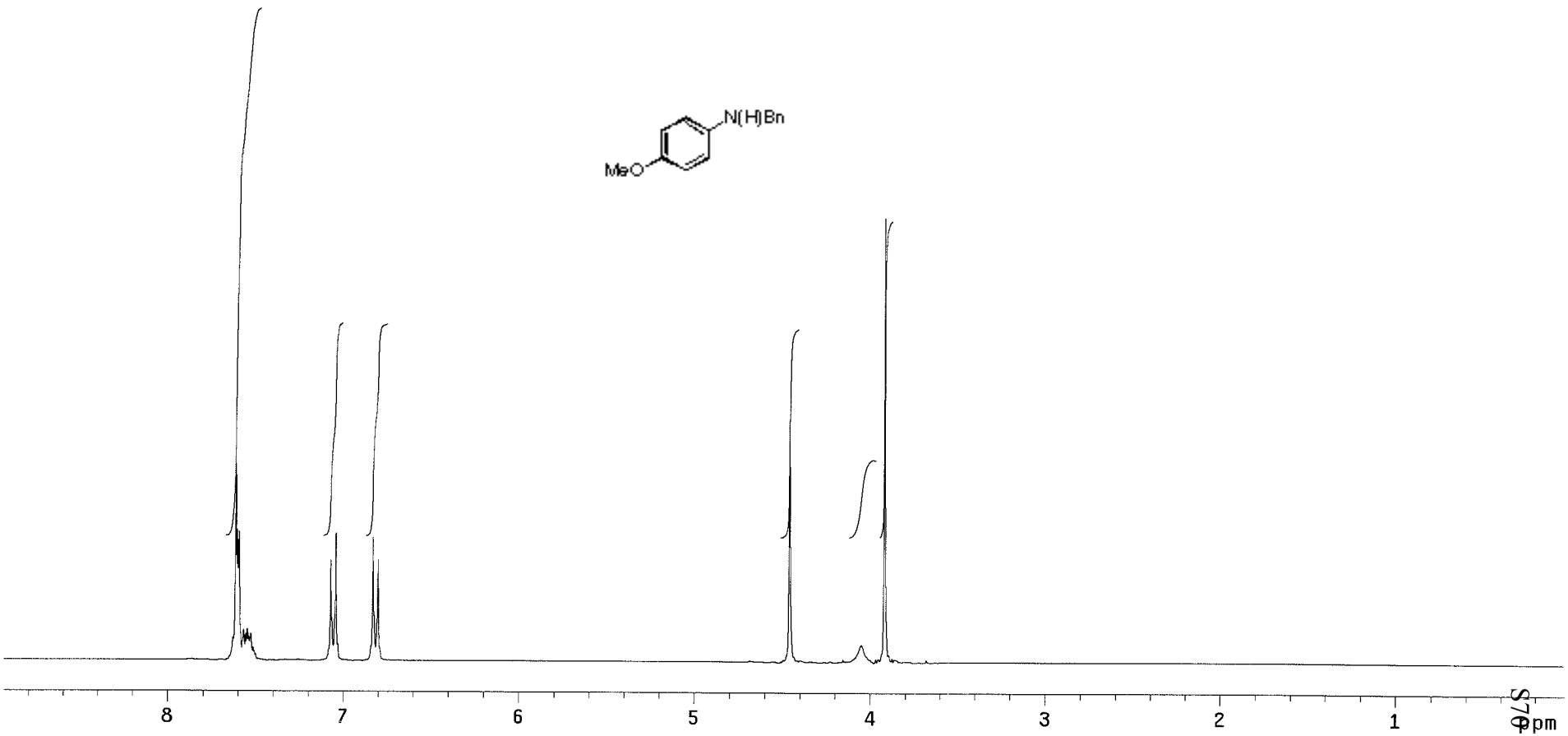
BF-IV-50-13C

Pulse Sequence: s2pul



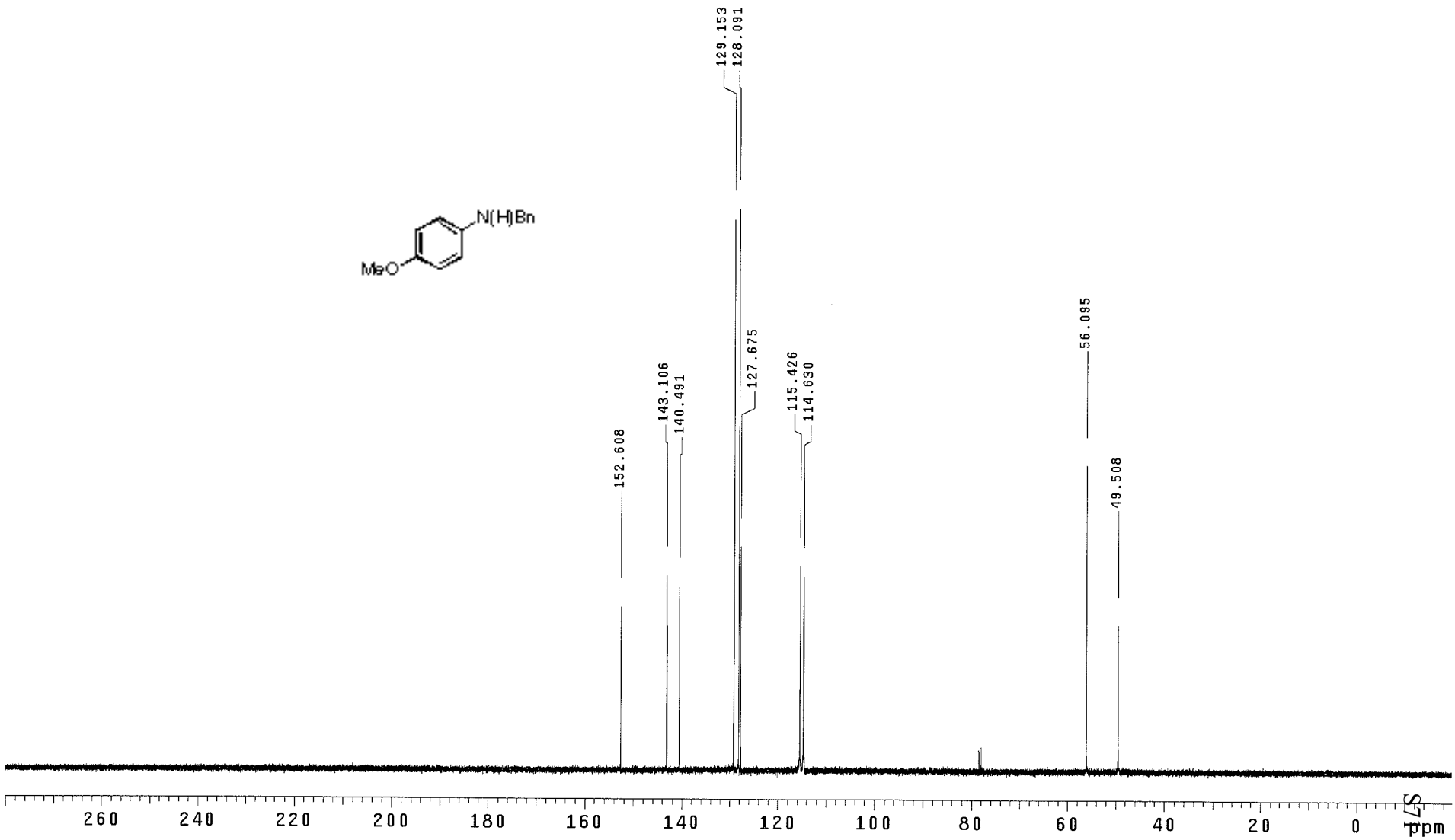
BF-III-281

Pulse Sequence: s2pul



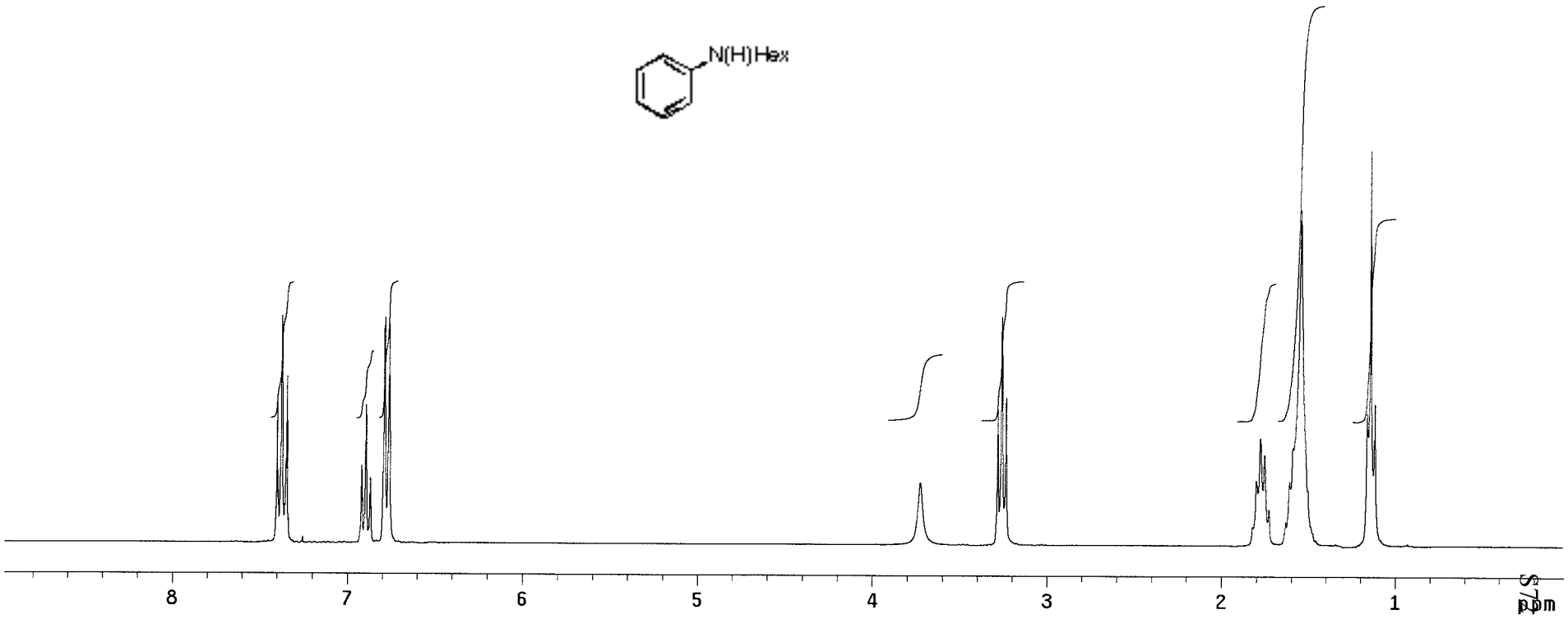
BF-III-281-13C

Pulse Sequence: s2pul



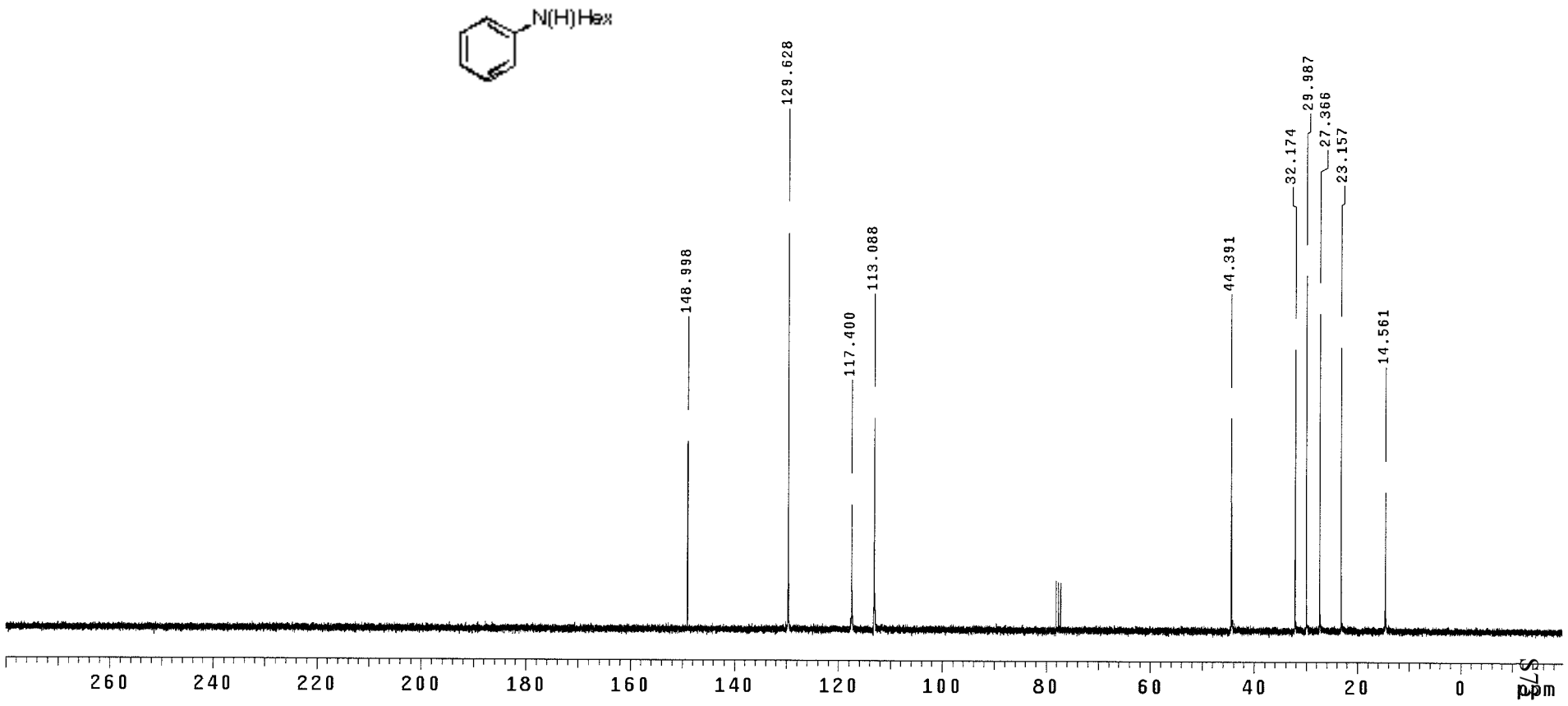
BF-IV-54

Pulse Sequence: s2pul



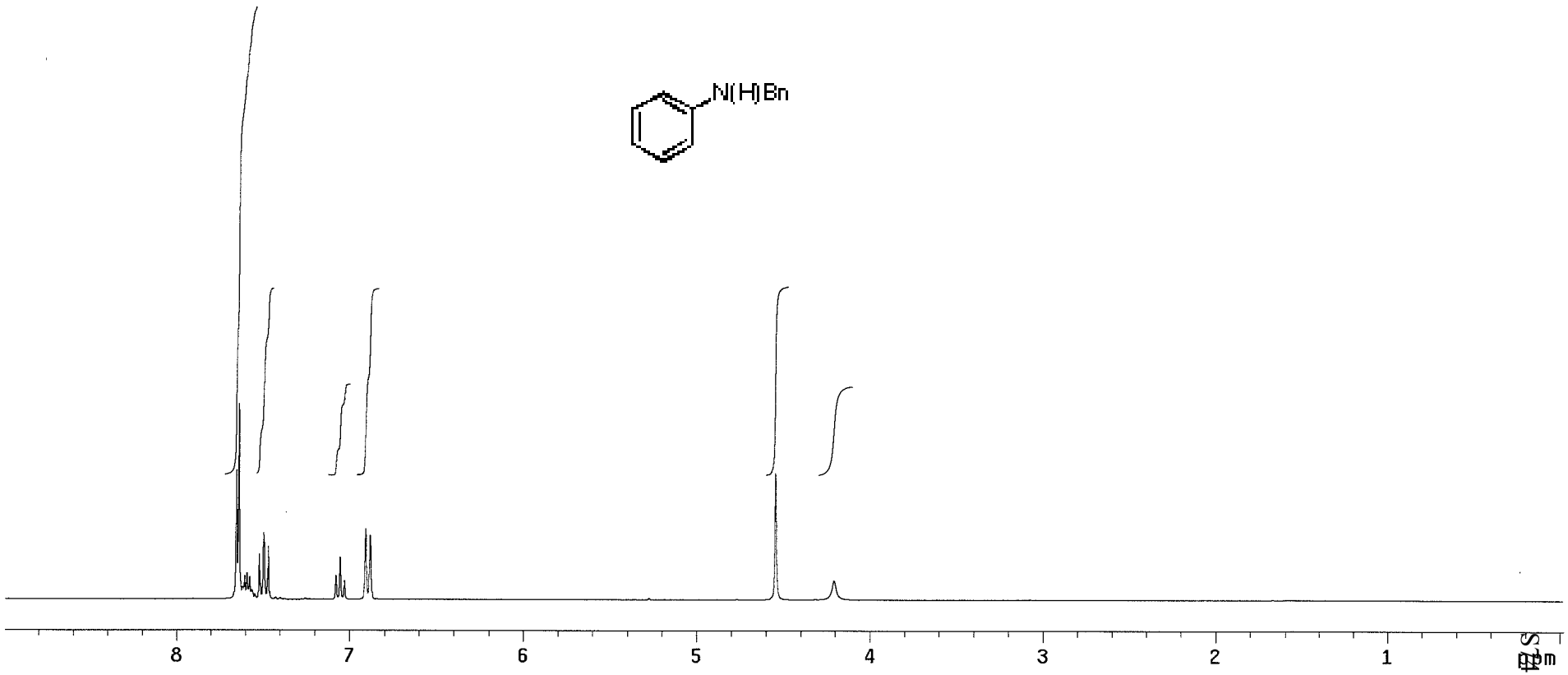
BF-IV-54-13C

Pulse Sequence: s2pul



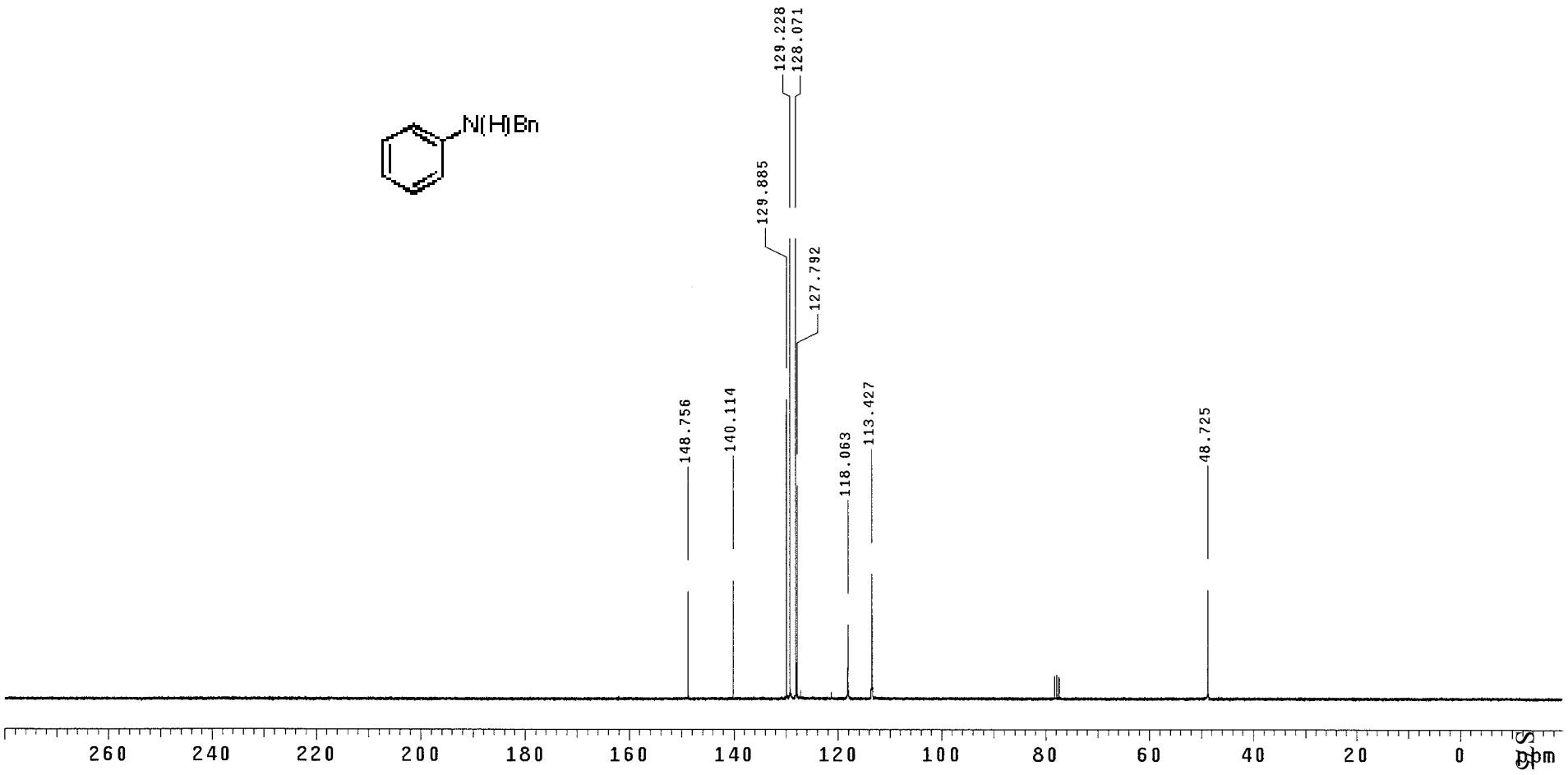
BF-IV-37

Pulse Sequence: s2pul



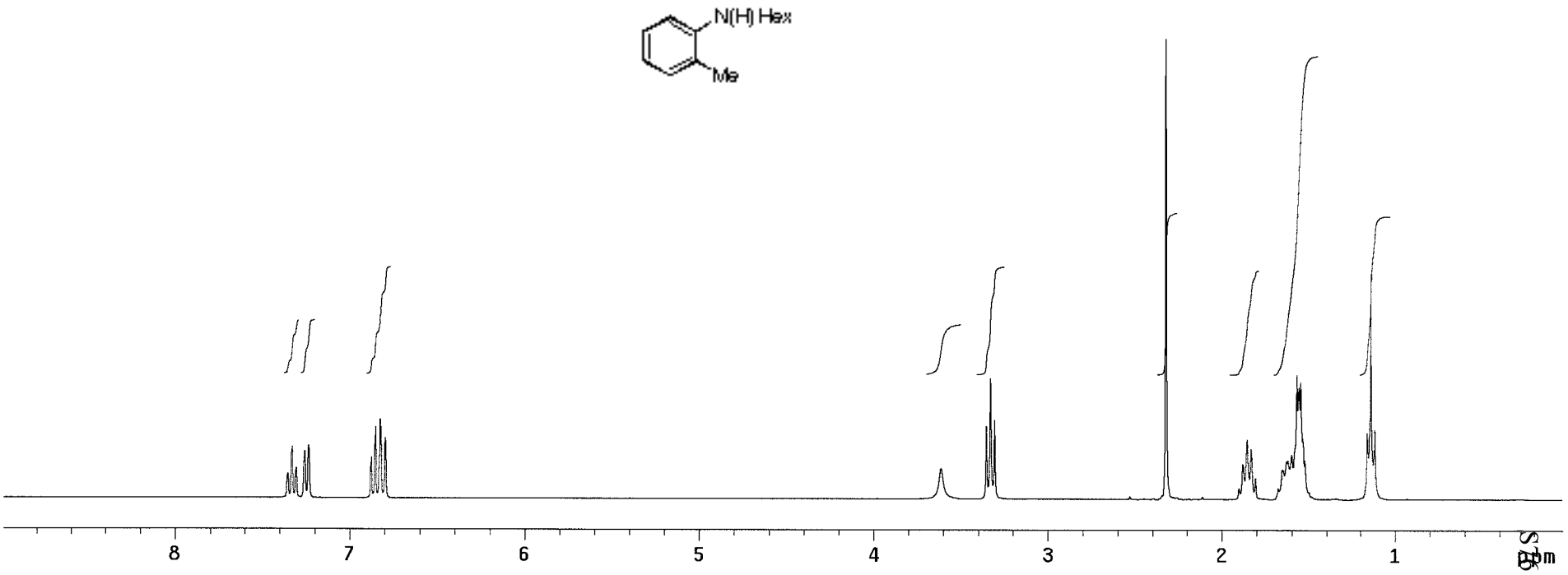
BF-IV-37-13C

Pulse Sequence: s2pul



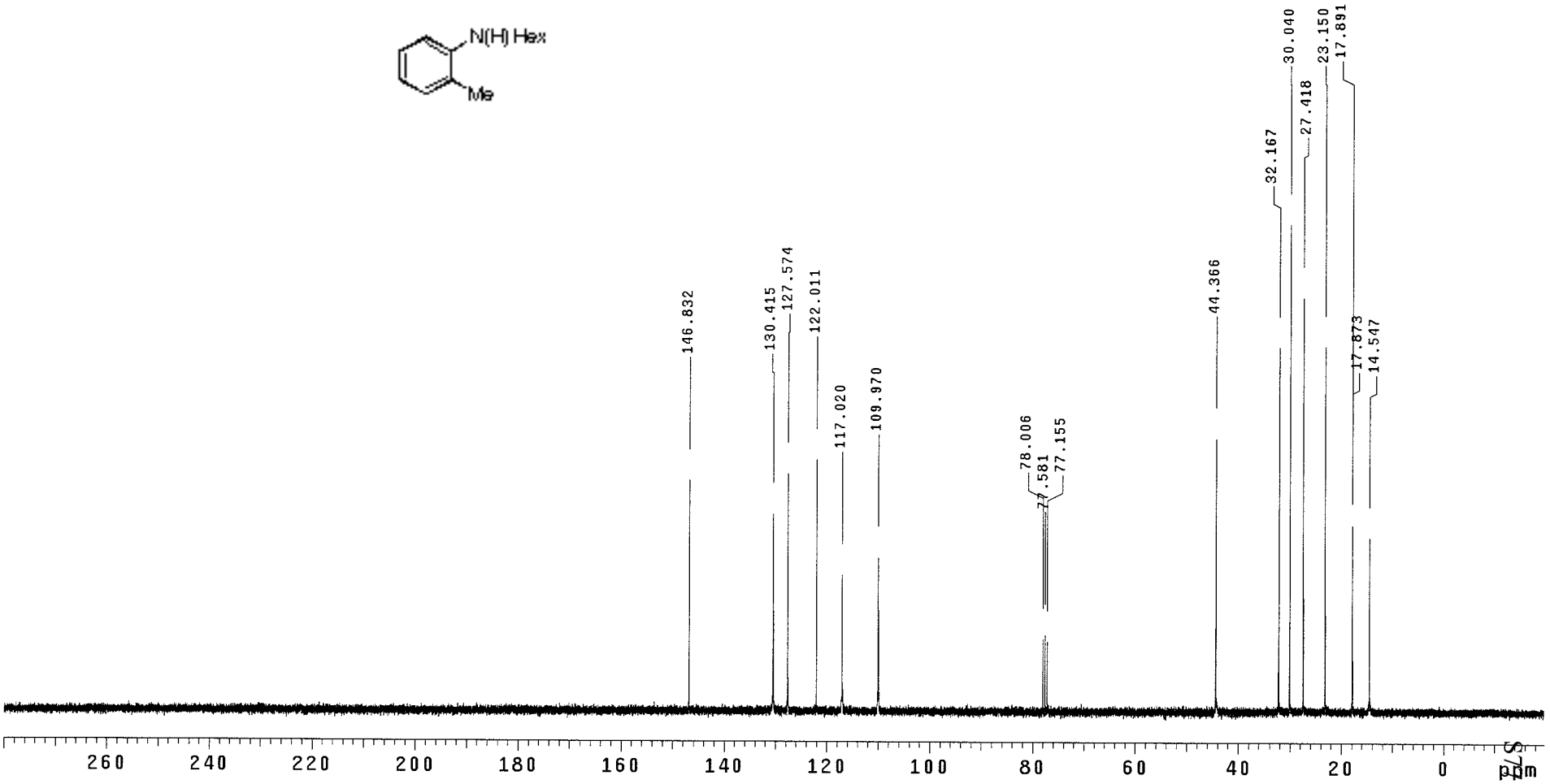
BF-IV-29

Pulse Sequence: s2pul



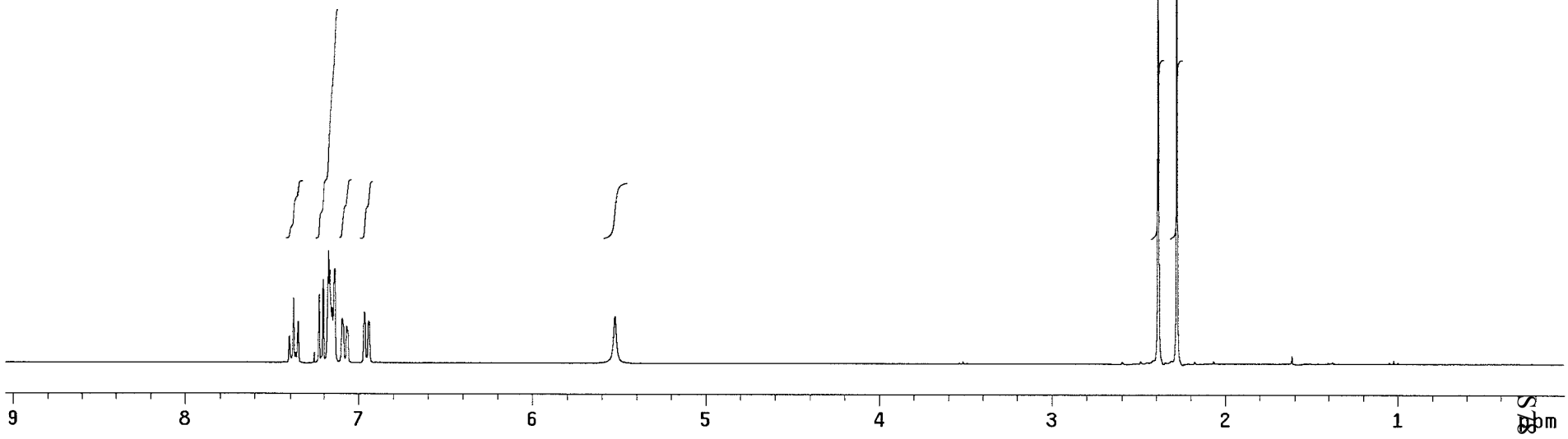
BF-IV-29-13C

Pulse Sequence: s2pul



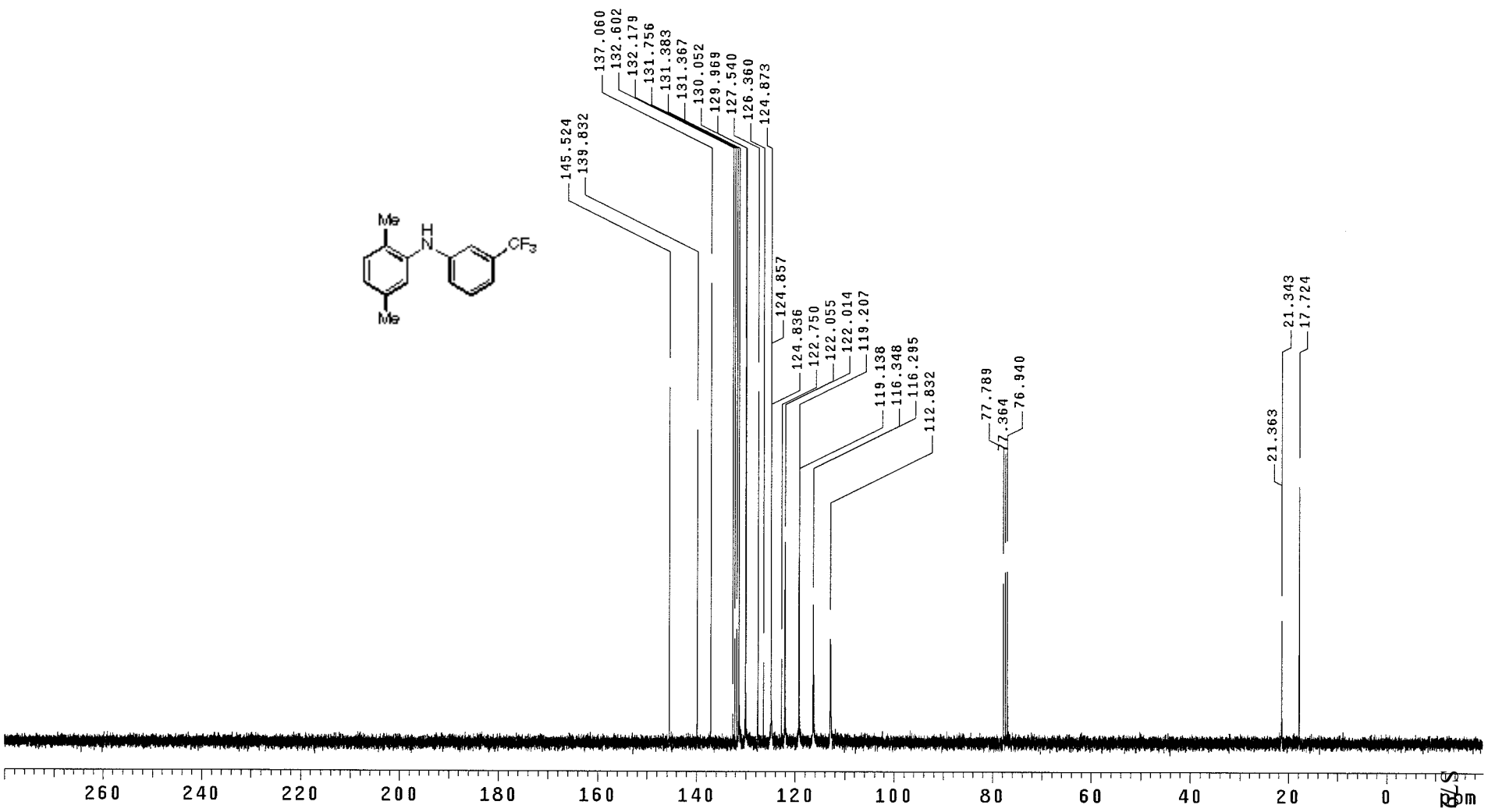
BF-III-277

Pulse Sequence: s2pul



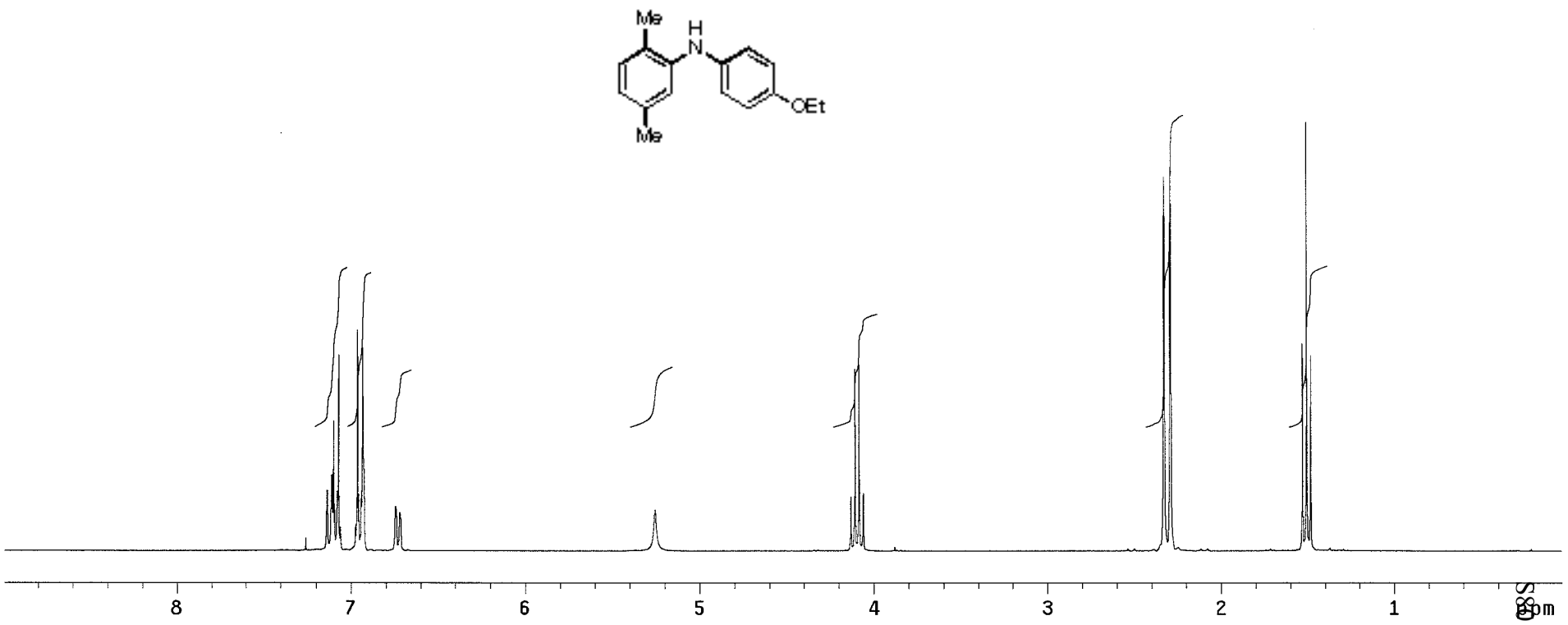
BF-III-277-13C

Pulse Sequence: s2pul



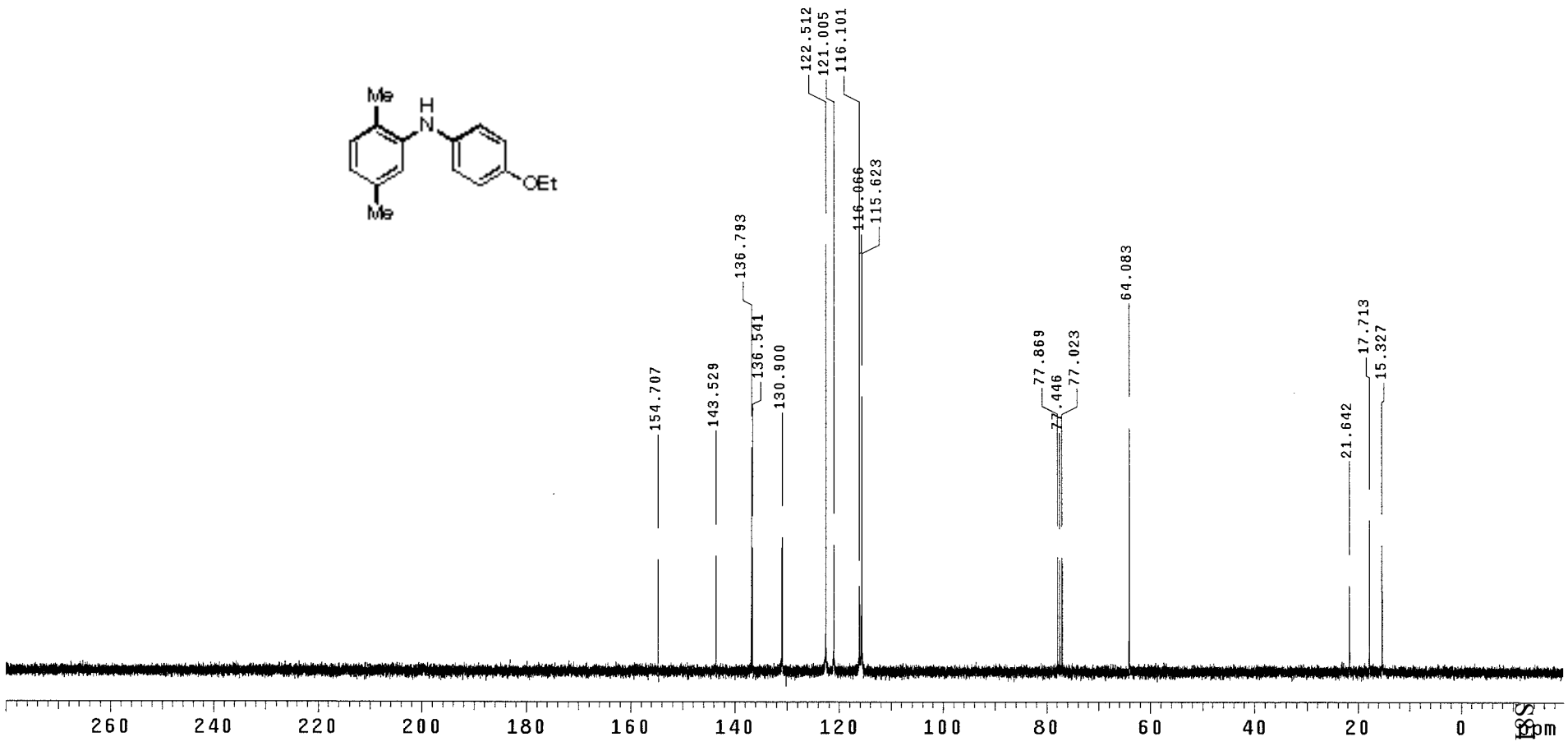
BF-III-183

Pulse Sequence: s2pul



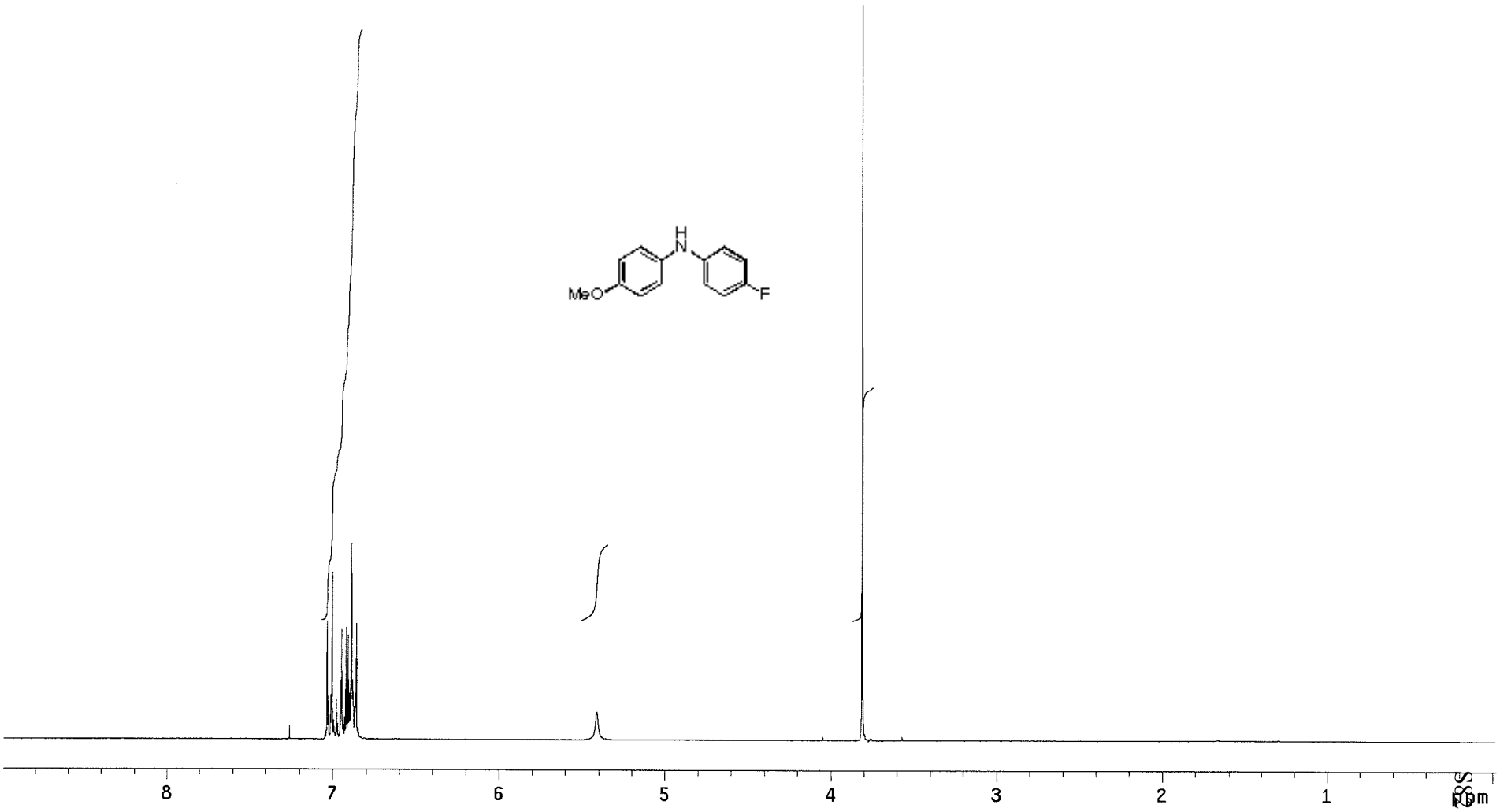
BF-III-183-13C

Pulse Sequence: s2pul



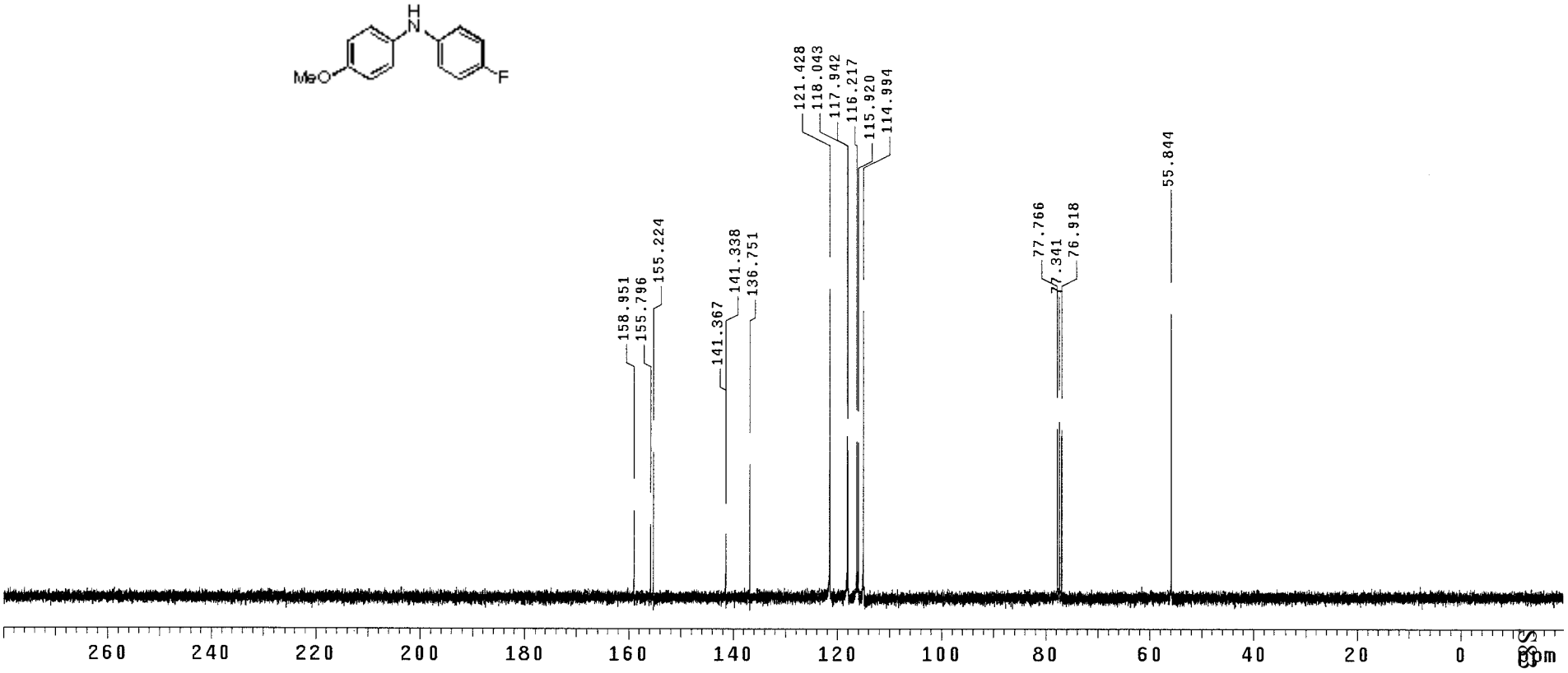
BF-III-187

Pulse Sequence: s2pul



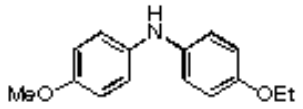
BF-III-187-13C

Pulse Sequence: s2pul



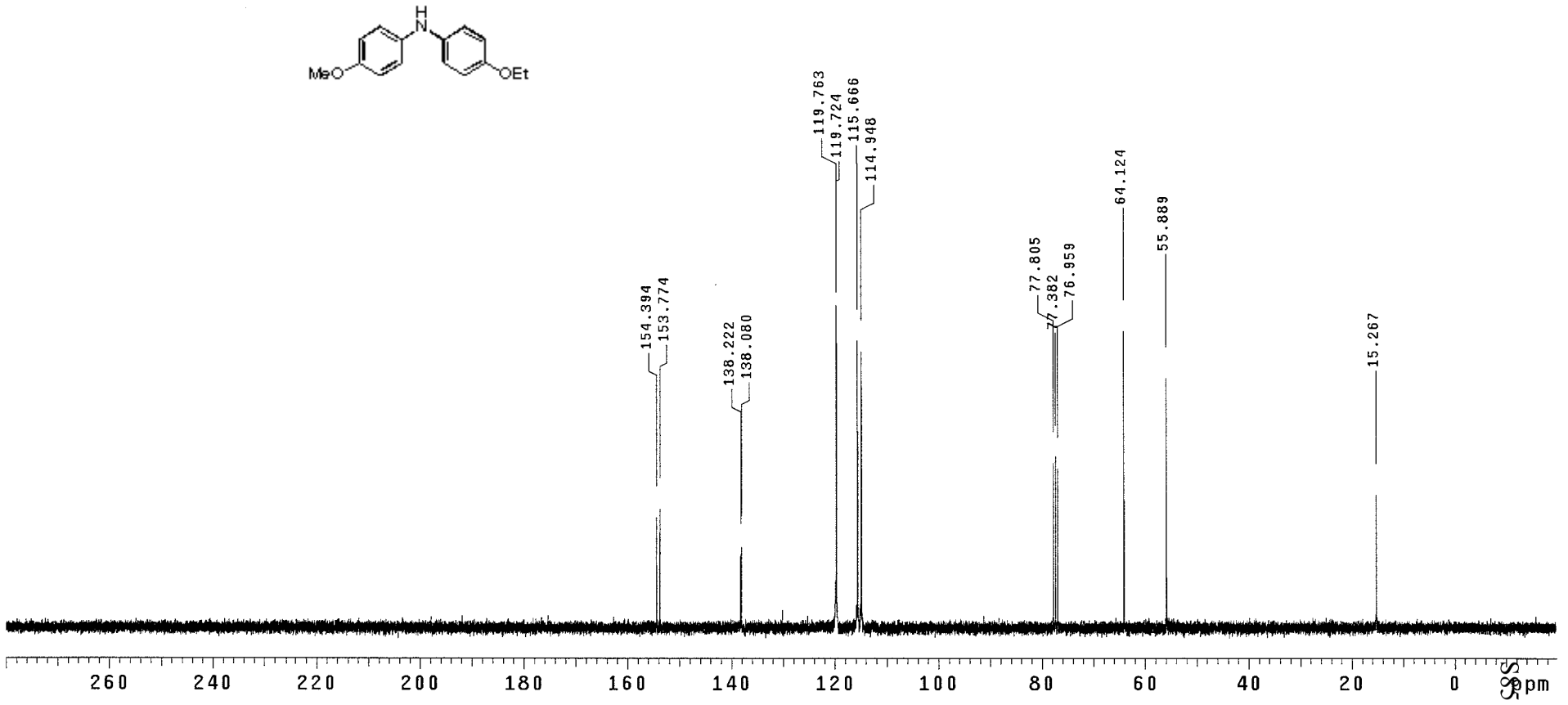
BF-III-184

Pulse Sequence: s2pul



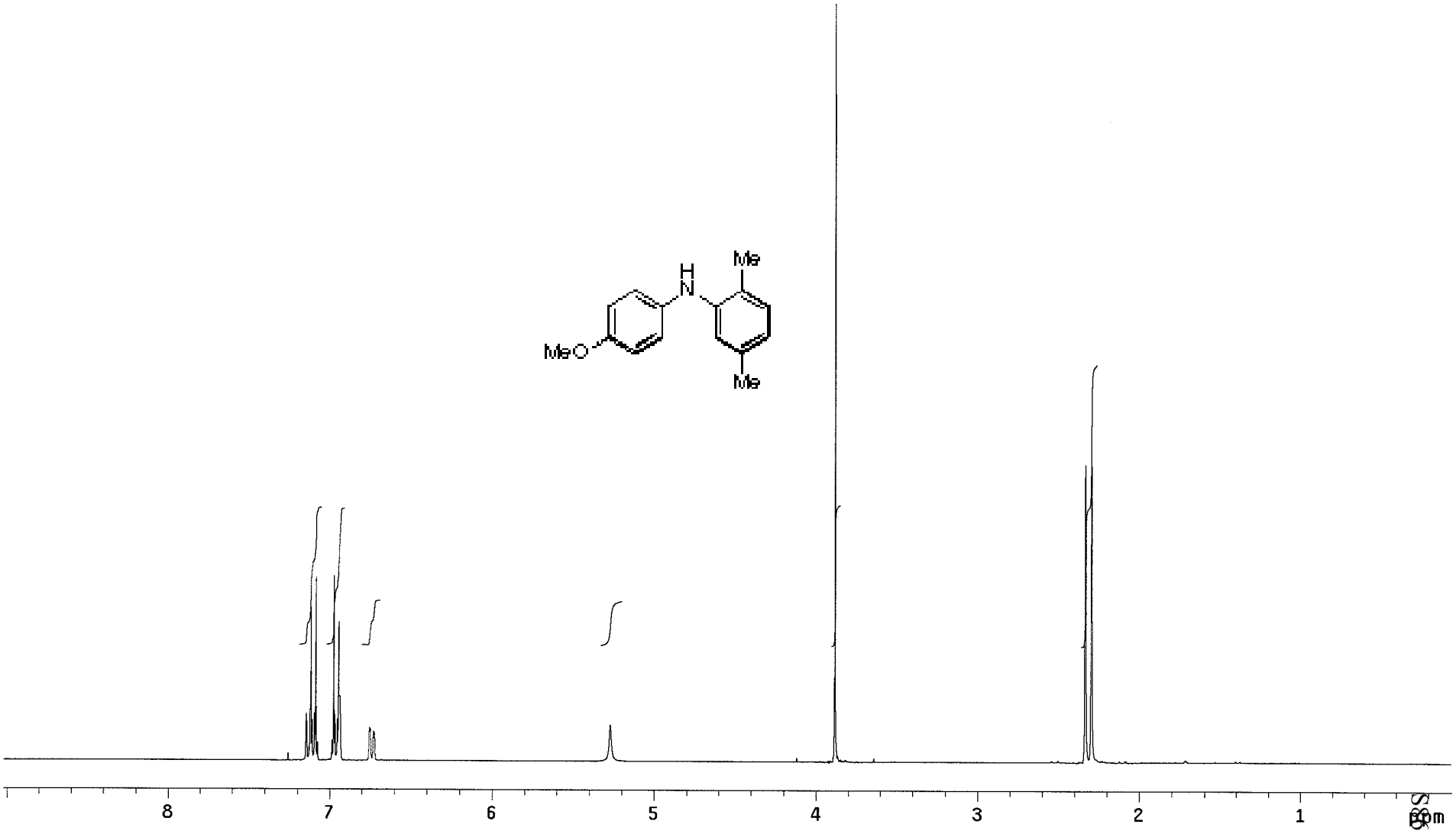
BF-III-184-13C

Pulse Sequence: s2pul



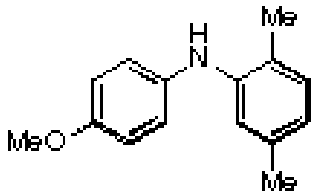
BF-III-276

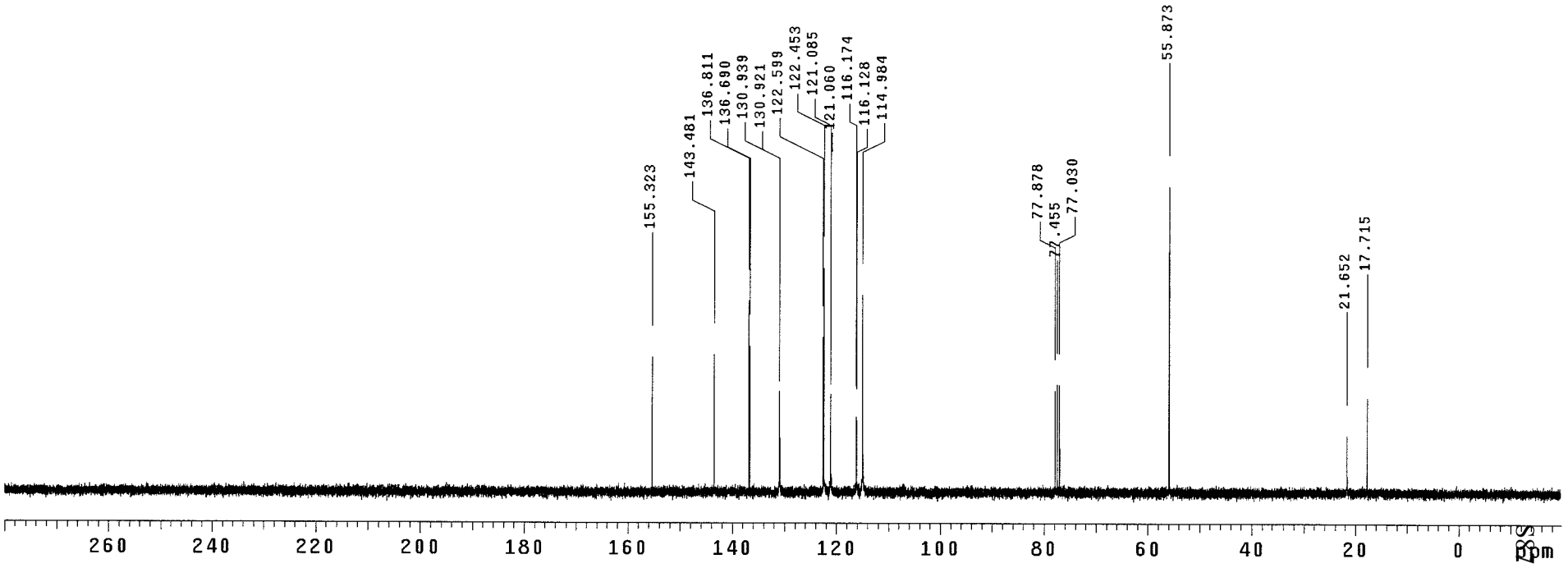
Pulse Sequence: s2pul



BF-III-276-13C

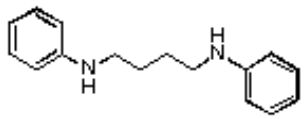
Pulse Sequence: s2pul

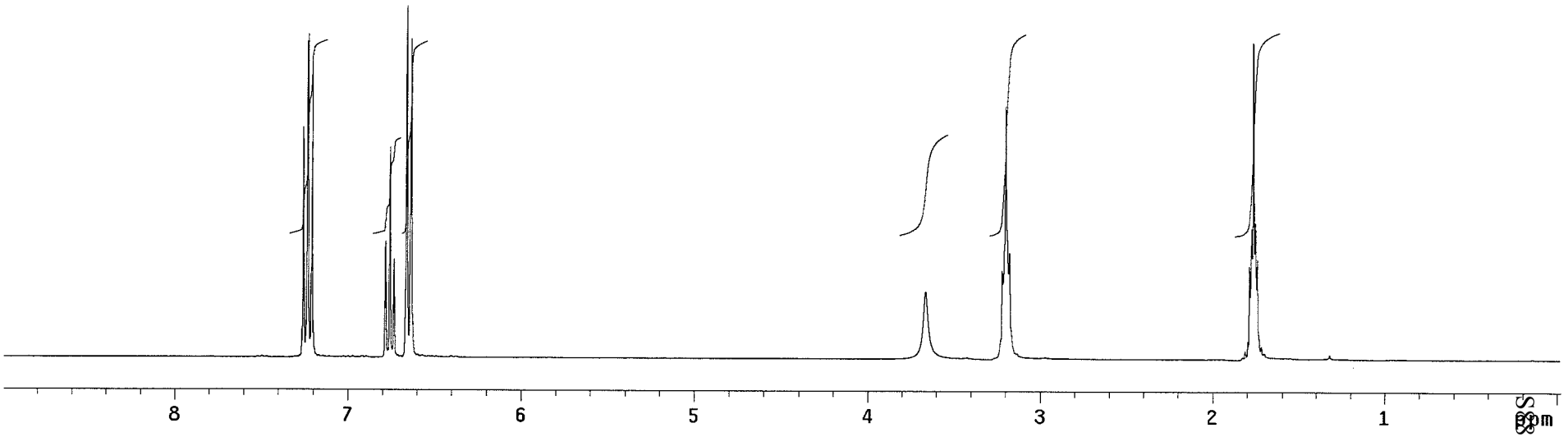




BF-III-140

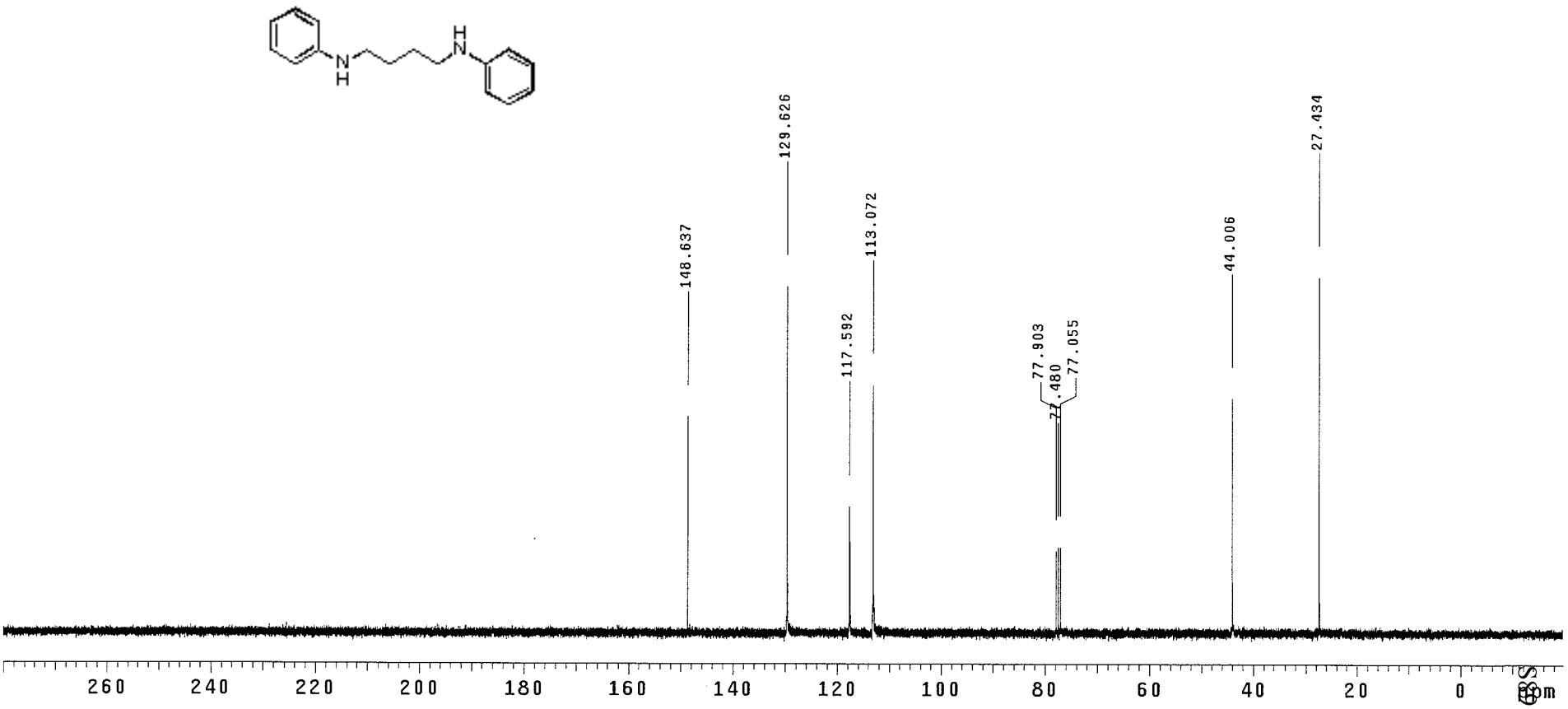
Pulse Sequence: s2pul





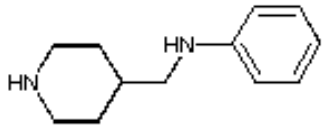
BF-III-275-13C

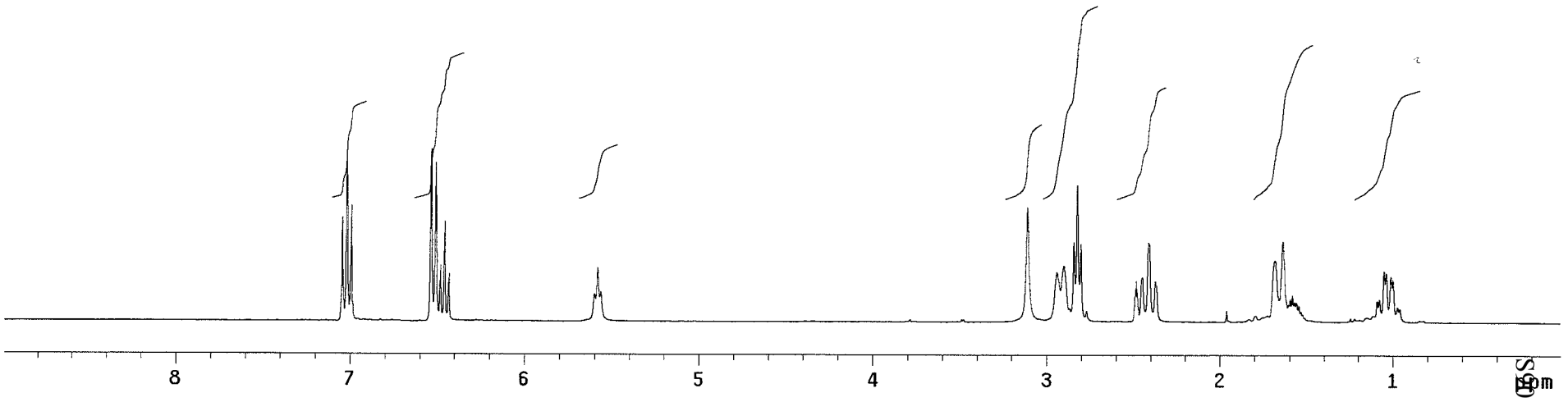
Pulse Sequence: s2pul



BF-III-124

Pulse Sequence: s2pul

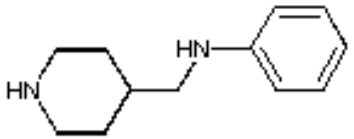


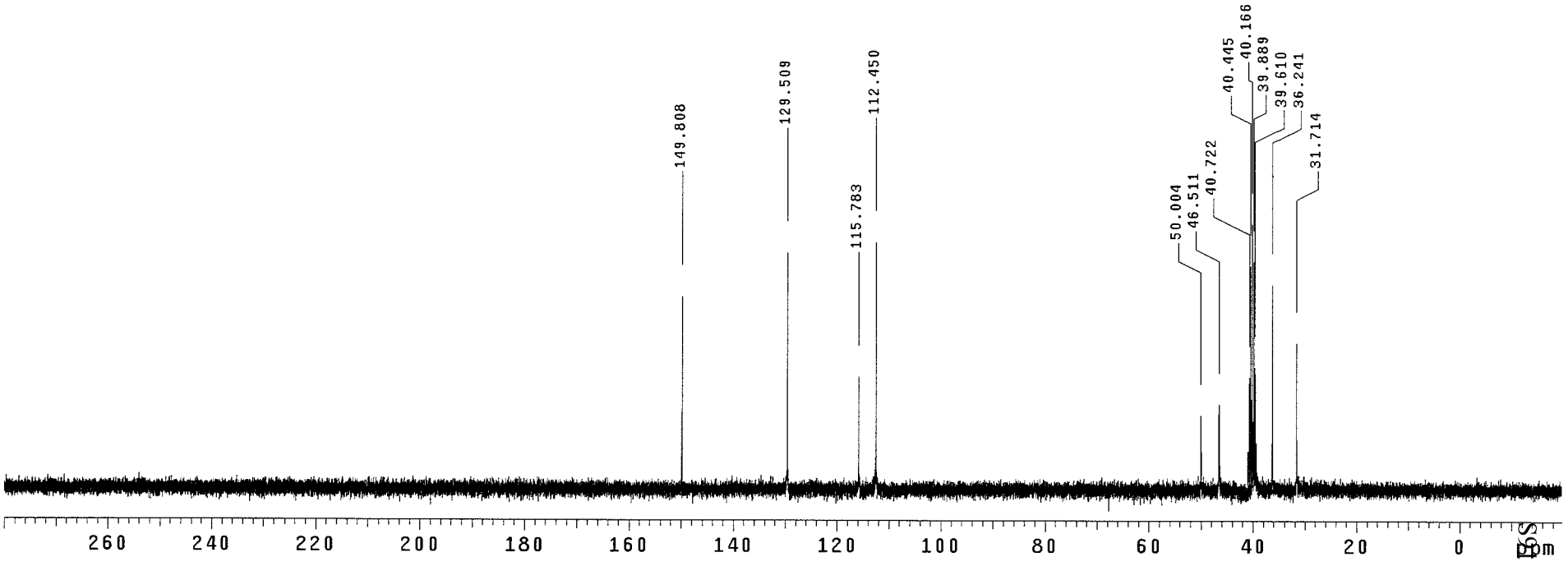


13C OBSERVE

Pulse Sequence: s2pul

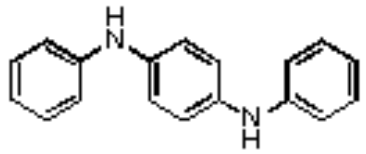
BF-III - 124-13C

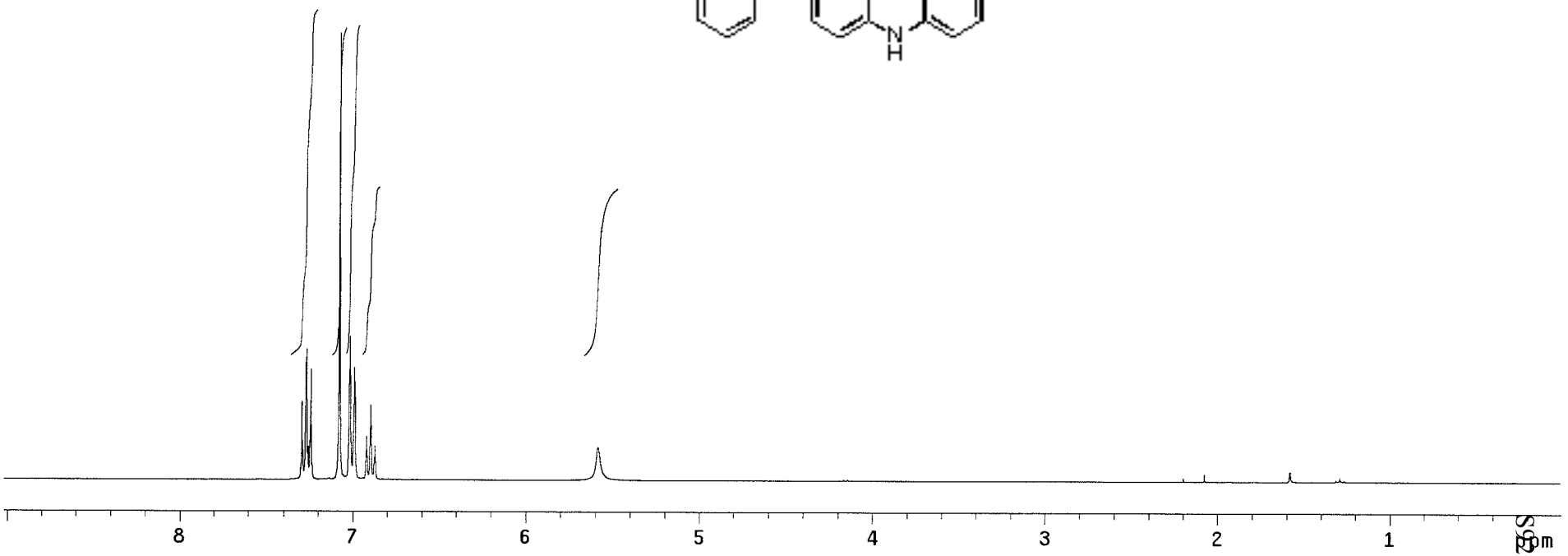




BF-III-sel

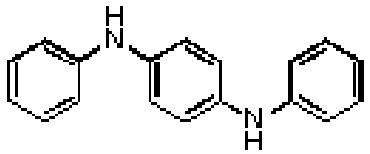
Pulse Sequence: s2pul

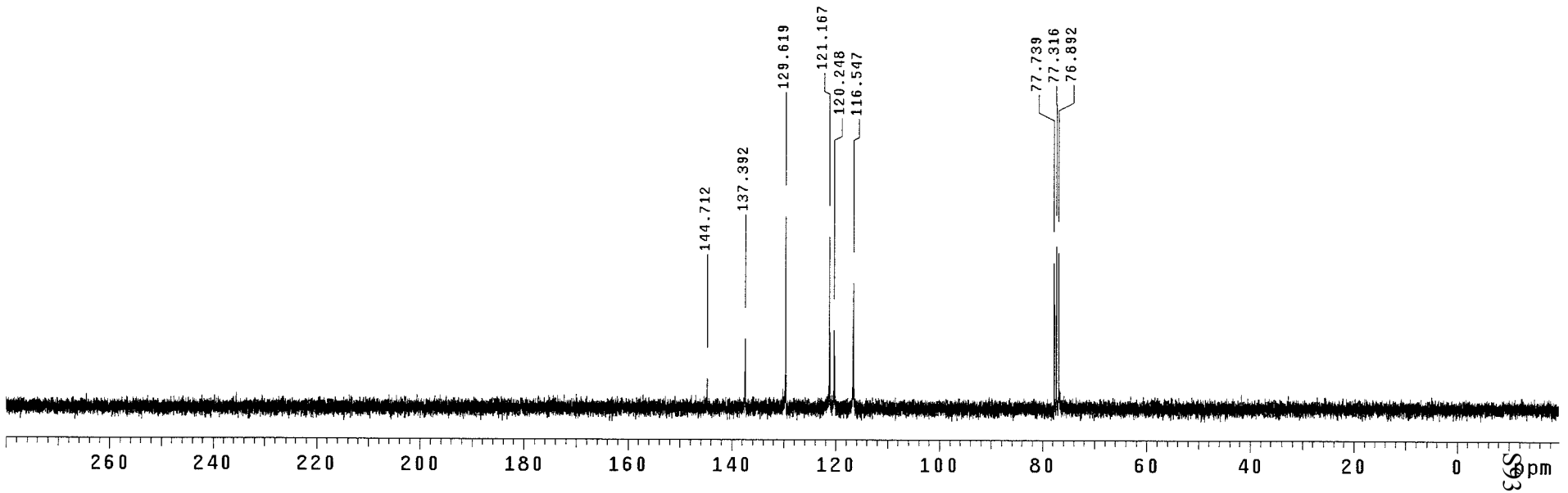


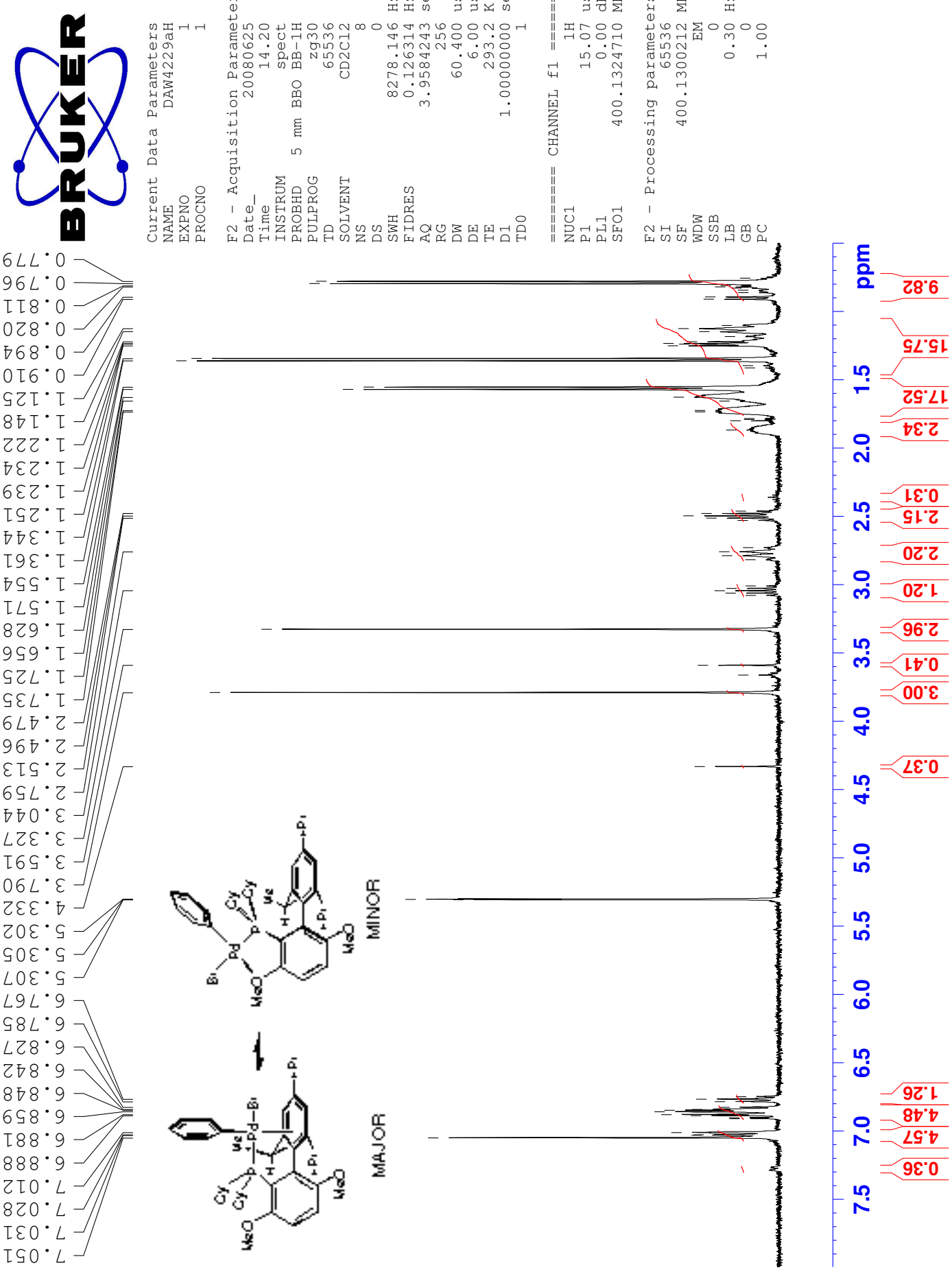


BF-III-274-13C

Pulse Sequence: s2pul






BRUKER
Current Data Parameters
NAME DAW4229aH
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20080625
Time 14.20
INSTRUM spect
PROBHD 5 mm BBO BB-1H
PULPROG zg30
TD 65536
SOLVENT CD2Cl2
NS 8
DS 0
SWH 8278.146 Hz
FIDRES 0.126314 Hz
AQ 3.9584243 sec
RG 256
DW 60.400 usec
DE 6.00 usec
TE 293.2 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 15.07 usec
PL1 0.00 dB
SFO1 400.1324710 MHz
F2 - Processing parameters
SI 65536
SF 400.1300212 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
MINOR
MAJOR
ppm
9.82
15.75
17.52
2.34
0.31
2.15
2.20
1.20
2.96
0.41
3.00
0.37
1.26
4.48
4.57
0.36
0.779
0.796
0.811
0.820
0.894
0.910
1.125
1.148
1.222
1.234
1.239
1.251
1.344
1.361
1.554
1.571
1.628
1.656
1.725
1.735
2.479
2.496
2.513
2.759
3.044
3.327
3.591
3.790
4.332
5.302
5.305
5.307
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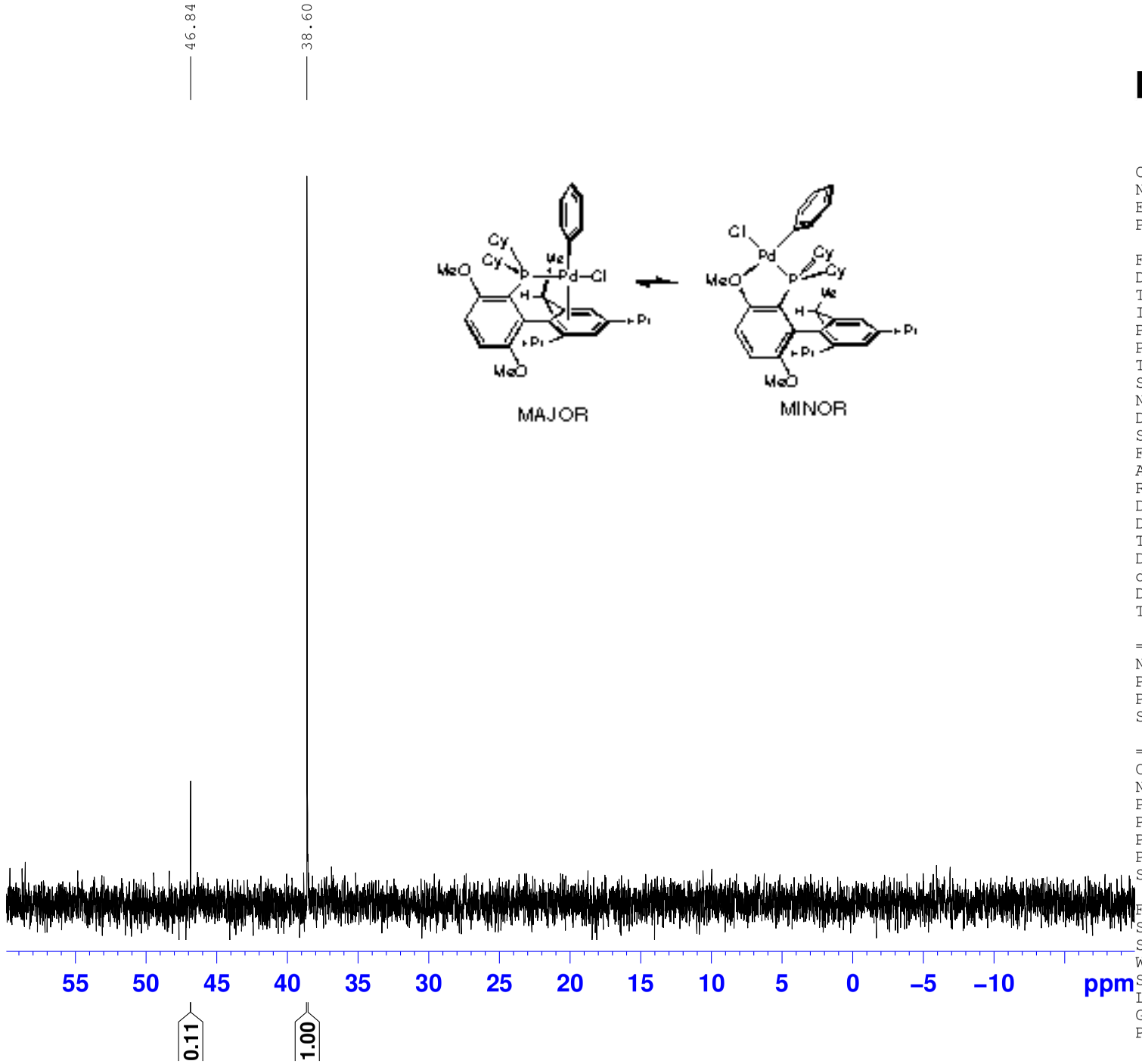
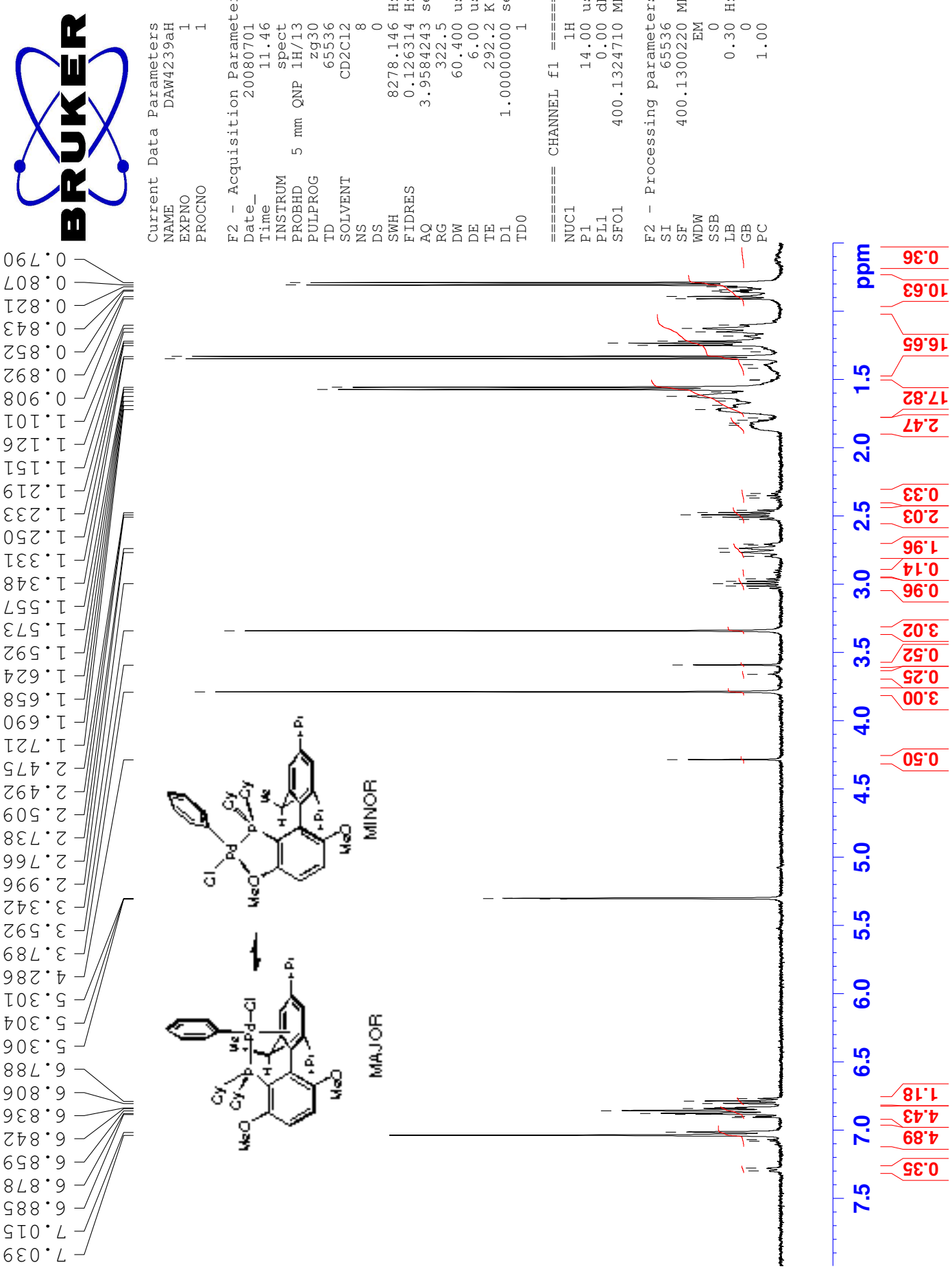
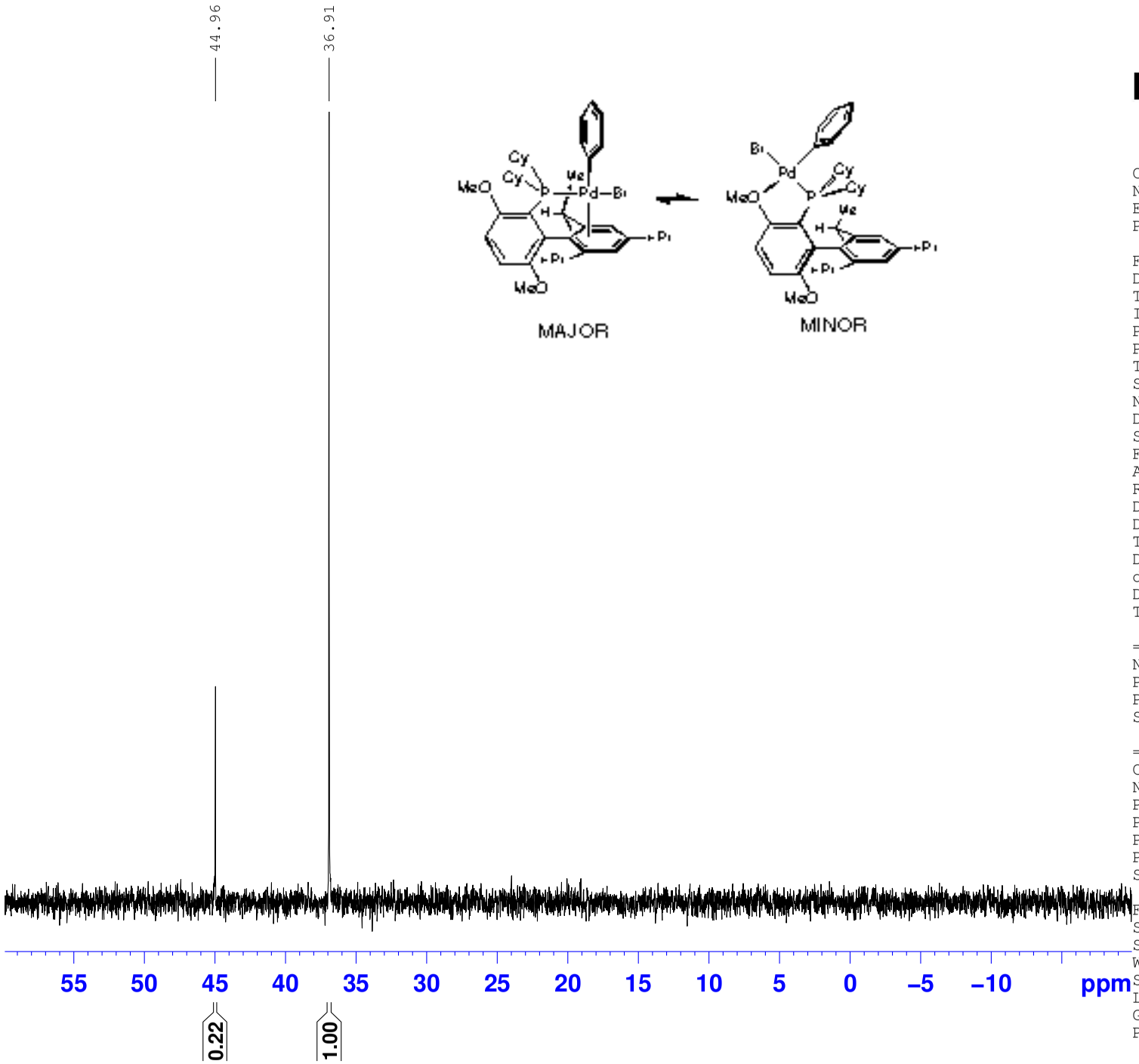
6.881
6.888
7.012
7.028
7.031
7.051

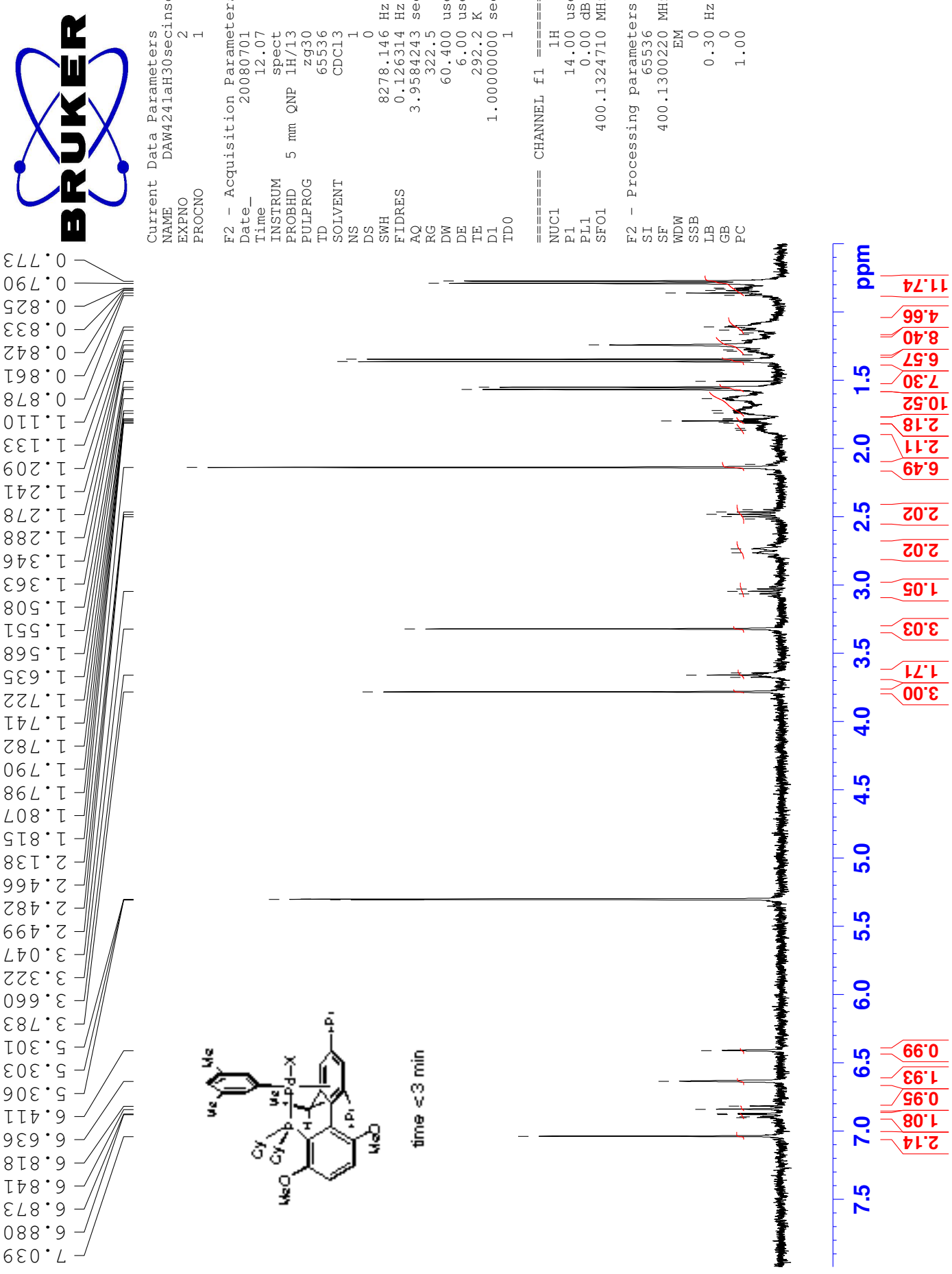


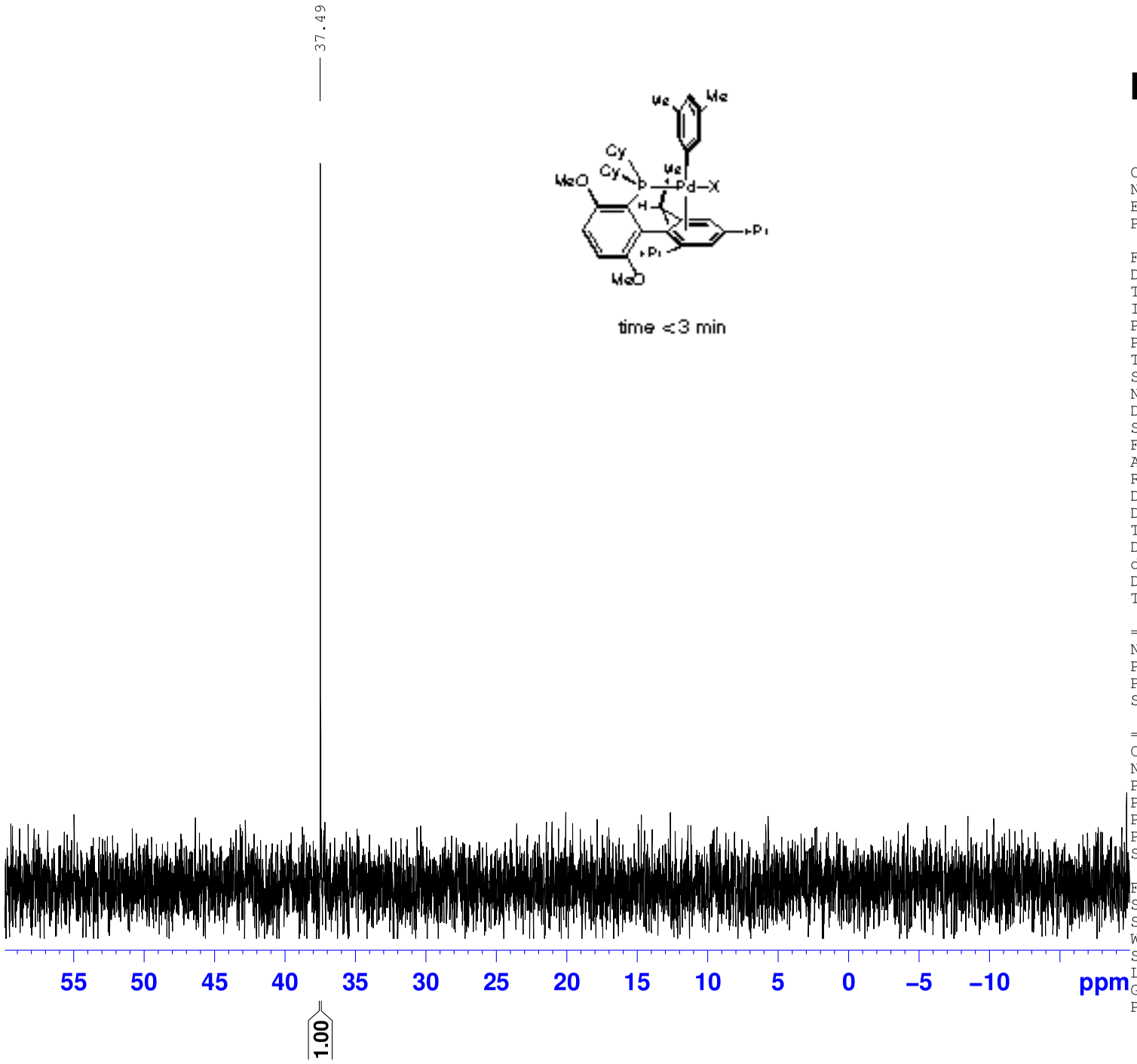

```
Current Data Parameters
NAME           DAW4239aP
EXPNO                  1
PROCNO                 1

F2 - Acquisition Parameters
Date_           20080701
Time               11.43
INSTRUM            spect
PROBHD   5 mm QNP 1H/13
PULPROG          zgpg30
TD                65536
SOLVENT           CD2Cl2
NS                    32
DS                     0
SWH            64935.066 Hz
FIDRES          0.990830 Hz
AQ              0.5046772 sec
RG                11585.2
DW                 7.700 usec
DE                 6.00 usec
TE                292.2 K
D1           2.00000000 sec
d11          0.03000000 sec
DELTA        1.89999998 sec
TD0                    1

======== CHANNEL f1 ========
NUC1                 31P
P1                9.25 usec
PL1               3.00 dB
SFO1        161.9674940 MHz

======== CHANNEL f2 ========
CPDPRG2          waltz16
NUC2                 1H
PCPD2            90.00 usec
PL2               0.00 dB
PL12             16.10 dB
PL13             19.00 dB
SFO2        400.1316000 MHz

F2 - Processing parameters
SI                65536
SF          161.9755024 MHz
WDW                  EM
SSB                   0
LB                 1.00 Hz
GB                    0
PC                 1.40
```


Current Data Parameters
NAME DAW4239aH
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20080701
Time 11.46
INSTRUM spect
PROBHD 5 mm QNP 1H/13
PULPROG zg30
TD 65536
SOLVENT CD2Cl2
NS 8
DS 0
SWH 8278.146 Hz
FIDRES 0.126314 Hz
AQ 3.9584243 sec
RG 322.5
DW 60.400 usec
DE 6.00 usec
TE 292.2 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 14.00 usec
PL1 0.00 dB
SFO1 400.1324710 MHz
F2 - Processing parameters
SI 65536
SF 400.1300220 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
MINOR
MAJOR
ppm
0.36
10.63
16.65
17.82
2.47
0.33
2.03
1.96
0.14
0.96
3.02
0.52
0.25
3.00
0.50
0.35
4.89
4.43
1.18




```
Current Data Parameters
NAME            DAW4229aP
EXPNO                   1
PROCNO                  1

F2 - Acquisition Parameters
Date_            20080625
Time                14.14
INSTRUM             spect
PROBHD    5 mm BBO BB-1H
PULPROG            zgpg30
TD                  65536
SOLVENT            CD2Cl2
NS                      32
DS                       0
SWH             64935.066 Hz
FIDRES          0.990830 Hz
AQ              0.5046772 sec
RG                20642.5
DW                  7.700 usec
DE                  6.00 usec
TE                 293.2 K
D1            2.00000000 sec
d11           0.03000000 sec
DELTA         1.89999998 sec
TD0                     1

======== CHANNEL f1 ========
NUC1                  31P
P1                 10.00 usec
PL1                 0.00 dB
SFO1         161.9674942 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                   1H
PCPD2               90.00 usec
PL2                 -1.00 dB
PL12                14.52 dB
PL13                18.00 dB
SFO2         400.1316005 MHz

F2 - Processing parameters
SI                  32768
SF           161.9755930 MHz
WDW                    EM
SSB                     0
LB                   1.00 Hz
GB                      0
PC                   1.40
```

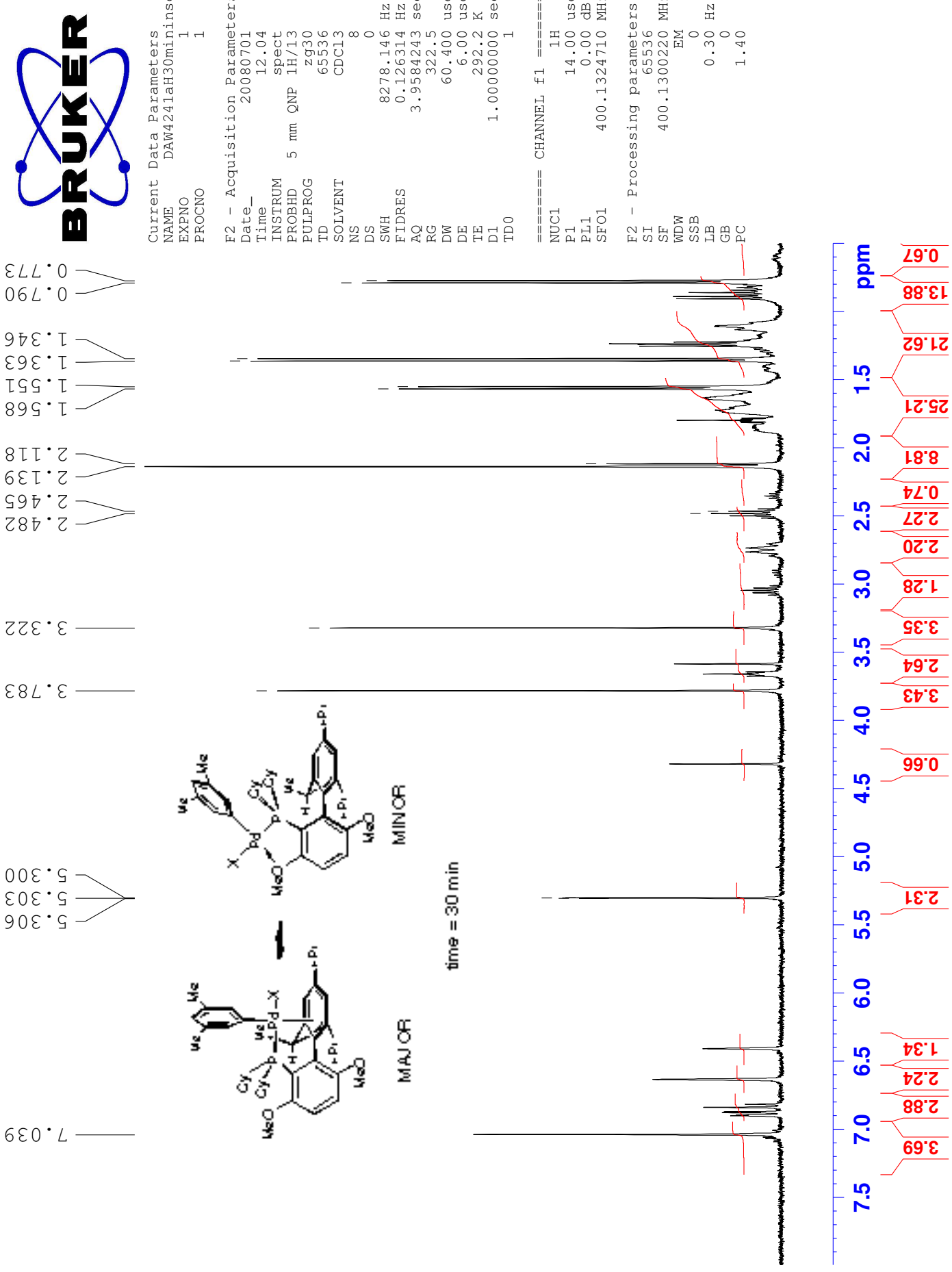

Current Data Parameters
NAME DAW4241aH30secinsoln
EXPNO 2
PROCNO 1
F2 - Acquisition Parameters
Date_ 20080701
Time 12.07
INSTRUM spect
PROBHD 5 mm QNP 1H/13
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 1
DS 0
SWH 8278.146 Hz
FIDRES 0.126314 Hz
AQ 3.9584243 sec
RG 322.5
DW 60.400 usec
DE 6.00 usec
TE 292.2 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 14.00 usec
PL1 0.00 dB
SFO1 400.1324710 MHz
F2 - Processing parameters
SI 65536
SF 400.1300220 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00
time <3 min
ppm
11.74
6.49
2.11
2.18
10.52
7.30
6.57
8.40
4.66
2.14
1.08
0.95
1.93
0.99
3.00
1.71
3.03
1.05
2.02
2.02
2.02
2.50
6.49
2.11
2.18
10.52
7.30
6.57
8.40
4.66
0.99
1.93
0.95
1.08
2.14
3.00
1.71
3.03
1.05
2.02
2.02
2.02
2.50

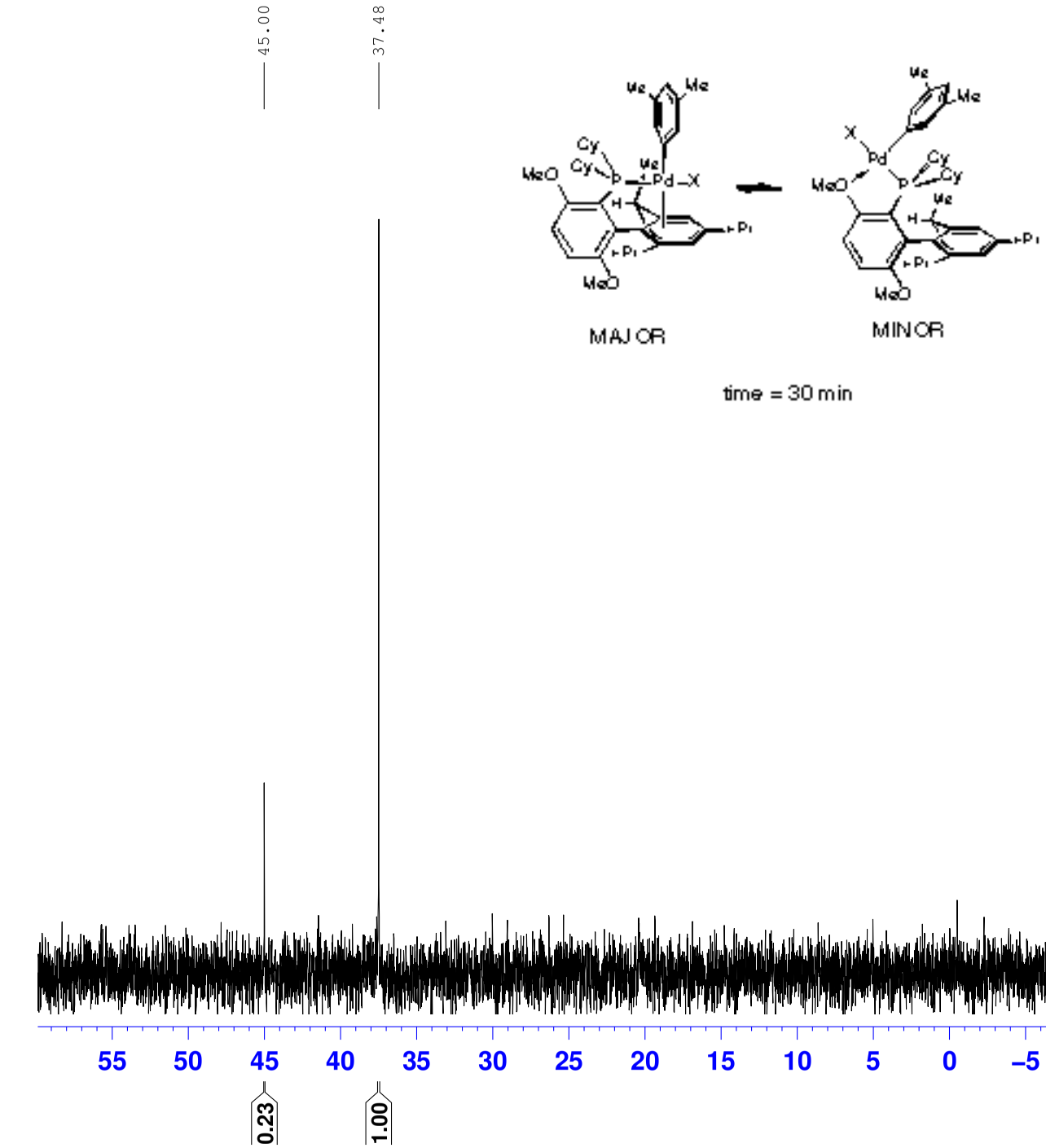


time <3 min

BRUKER

```
Current Data Parameters
NAME      DAW4241aP30secinsoln
EXPNO                        1
PROCNO                       1

F2 - Acquisition Parameters
Date_              20080701
Time                 12.10
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG             zgpg30
TD                   65536
SOLVENT              CD2Cl2
NS                      35
DS                       0
SWH              64935.066 Hz
FIDRES            0.990830 Hz
AQ                0.5046772 sec
RG                   9195.2
DW                    7.700 usec
DE                    6.00 usec
TE                   300.0 K
D1               2.00000000 sec
d11              0.03000000 sec
DELTA            1.89999998 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   31P
P1                    9.25 usec
PL1                   3.00 dB
SFO1          161.9674940 MHz

======== CHANNEL f2 ========
CPDPRG2            waltz16
NUC2                   1H
PCPD2                90.00 usec
PL2                   0.00 dB
PL12                 16.10 dB
PL13                 19.00 dB
SFO2          400.1316000 MHz

F2 - Processing parameters
SI                   65536
SF            161.9755024 MHz
WDW                     EM
SSB                      0
LB                    1.00 Hz
GB                       0
PC                    1.40
```


Current Data Parameters
NAME DAW4241aH30mininsoln
EXPNO 1
PROCNO 1
F2 - Acquisition Parameters
Date_ 20080701
Time 12.04
INSTRUM spect
PROBHD 5 mm QNP 1H/13
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 8
DS 0
SWH 8278.146 Hz
FIDRES 0.126314 Hz
AQ 3.9584243 sec
RG 322.5
DW 60.400 usec
DE 6.00 usec
TE 292.2 K
D1 1.00000000 sec
TD0 1
======== CHANNEL f1 ========
NUC1 1H
P1 14.00 usec
PL1 0.00 dB
SFO1 400.1324710 MHz
F2 - Processing parameters
SI 65536
SF 400.1300220 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.40
0.773
0.790
1.346
1.363
1.551
1.568
2.118
2.139
2.465
2.482
3.322
3.783
5.300
5.303
5.306
7.039
ppm
0.67
13.88
21.62
25.21
8.81
0.74
2.27
2.20
1.28
3.35
2.64
3.43
0.66
2.31
1.34
2.24
2.88
3.69
MINOR
MAJOR
time = 30 min




```
Current Data Parameters
NAME      DAW4241aP30mininsoln
EXPNO                        1
PROCNO                       1

F2 - Acquisition Parameters
Date_              20080701
Time                 12.00
INSTRUM              spect
PROBHD    5 mm QNP 1H/13
PULPROG             zgpg30
TD                   65536
SOLVENT            CD2Cl2
NS                      32
DS                       0
SWH              64935.066 Hz
FIDRES            0.990830 Hz
AQ                0.5046772 sec
RG                   9195.2
DW                    7.700 usec
DE                    6.00 usec
TE                   292.2 K
D1             2.00000000 sec
d11            0.03000000 sec
DELTA          1.89999998 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                   31P
P1                    9.25 usec
PL1                   3.00 dB
SFO1         161.9674940 MHz

======== CHANNEL f2 ========
CPDPRG2           waltz16
NUC2                   1H
PCPD2                90.00 usec
PL2                   0.00 dB
PL12                 16.10 dB
PL13                 19.00 dB
SFO2         400.1316000 MHz

F2 - Processing parameters
SI                   65536
SF           161.9755024 MHz
WDW                     EM
SSB                      0
LB                    1.00 Hz
GB                       0
PC                    1.40
```