Palladium-Catalyzed Coupling of Functionalized Primary and Secondary Amines with Aryl and Heteroaryl Halides: Two Ligands Suffice in Most Cases

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Supporting Information

General Reagent Information

All reactions were carried out under an argon atmosphere. 1,4-dioxane (dioxane), *tert*-butanol (*t*-BuOH) and 1,2-dimethoxyethane (DME) were purchased from Aldrich Chemical Co. in Sure-Seal bottles and were used as received. Anhydrous toluene and tetrahydrofuran (THF) were purchased from J. T. Baker in CYCLE-TAINER® solvent delivery kegs and vigorously purged with argon for 2 h. The solvent was further purified by passing it through two packed columns of neutral alumina under argon. Both potassium carbonate (K_2CO_3) and sodium *tert*-butoxide (NaO*t*-Bu) were purchased from Aldrich Chemical Co. Potassium *tert*-butoxide (KO*t*-Bu) was purchased from Acros. Powdered K_3PO_4 was purchased from Riedel-de Haën. *Anhydrous finely powdered* Cs_2CO_3 was a generous gift from Chemetall. The bulk of the bases were stored under nitrogen in a Vacuum Atmospheres glovebox. Small portions (~3 g) were removed from the glovebox in glass vials, stored in the air in a desiccator filled with anhydrous calcium sulfate, and weighed in the air. Lithium bis(trimethylsilyl)amide (LHMDS) solution (1.0 M) in THF was purchased from Aldrich. A solution in 1,4-dioxane was prepared freshly from solid LHMDS (Aldrich) prior to use. Aryl halides and amines were purchased from commercial sources (unless otherwise stated) and, when necessary, filtered through neutral alumina or distilled prior to use. Flash column chromatography was performed using a Biotage SP4 Flash Purification System using KP-Sil silica cartridges. In all cases, ethyl acetate was used to transfer the crude reaction material onto the silica gel samplet. A gradient elution using hexane and ethyl acetate was performed, based on the recommendation from the Biotage TLC Wizard.

General Analytical Information. All compounds were characterized by ^{1}H NMR, ^{13}C NMR spectroscopy. Copies of the ^{1}H NMR, ^{13}C NMR can be found at the end of the Supporting Information. Nuclear Magnetic Resonance spectra were recorded on a Bruker 400 MHz instrument. All ^{1}H NMR experiments are reported in 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 units, parts per million (ppm), and were measured relative to the signals for residual chloroform (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 Microlab Inc., Norcross, GA 30091.

Experimental Procedure.

General procedure for the Pd-catalyzed C-N bond formation between Primary Amine and Aryl Halides.

General procedure A. An oven-dried screw cap test tube was charged with a magnetic stir bar, BrettPhos precatalyst[1] **3** (2 mg, 0.0025 mmol, 0.25 mol% or as indicated), BrettPhos[1] **1** (1.3 mg, 0.0025 mmol, 0.25 mol% or as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated) and primary amine (1.2 mmol). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by 2 mL (or, as indicated) 1,4-dioxane solution (or, as indicated) of LHMDS (2.4 mmol or, as indicated) by syringe. The tube was placed in a preheated oil bath at 100 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 2 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with CH_2Cl_2, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) eluting with a mixture of hexane and ethyl acetate.

General procedure B. An oven-dried screw cap test tube was charged with a magnetic stir bar, BrettPhos precatalyst[1] **3** (as indicated), BrettPhos **1** (as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated), primary amine (1.2 mmol) and K_2CO_3 (2.4 mmol or, as indicated). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by *t*-BuOH (2 mL) by syringe. The tube was placed in a preheated oil bath at 110 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 24 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

General procedure C. An oven-dried screw cap test tube was charged with a magnetic stir bar, BrettPhos precatalyst **3** (2 mg, 0.0025 mmol, 0.25 mol% or as indicated), BrettPhos **1** (1.3 mg, 0.0025 mmol, 0.25 mol% or as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated), primary amine (1.2 mmol) and NaO*t*-Bu (1.2 mmol or, as indicated). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by 1,4-dioxane (2 mL) by syringe. The tube was placed in a preheated oil bath at 110 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 2 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with CH_2Cl_2, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

General procedure D. An oven-dried test tube, which was equipped with a magnetic stir bar, was charged with the precatalyst was charged with the BrettPhos precatalyst **3** (8.0 mg, 0.01 mmol, 1 mol%), BrettPhos **1** (5.4 mg, 0.01 mmol, 1 mol%), and base (2.4 mmol) and aminoacid (1.2 -1.4 mmol). The vessel was evacuated and backfilled with nitrogen (this process was repeated a total of 3 times) and then solven, and the aryl chloride (1.0 mmol) were added via syringe. The solution was heated to 110

°C (or, as indicated) until the starting material was completely consumed as monitored by HPLC. The reaction mixture then was allowed to cool to room temperature. To the reaction mixture were added water and 1 M HCl to adjust the pH *ca* 4. Then, the mixture was extracted with CH_2Cl_2 (3 x 20.0 mL). The organic layer was dried over Na_2SO_4. The solvent was evaporated, and the crude product was purified via the Biotage SP4 (silica-packed SNAP cartridge, KP-Sil, 10 g).

General procedure E. An oven-dried screw cap test tube was charged with a magnetic stir bar, (4 mg, 0.005 mmol, 0.5 mol% or as indicated), BrettPhos **1** (2.7 mg, 0.005 mmol, 0.5 mol% or as indicated), aryl iodide (if solid; 1.0 mmol), primary amine (1.2 mmol) and Cs_2CO_3 (2.4 mmol or, as indicated). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by toluene (2 mL) by syringe. The tube was placed in a preheated oil bath at 110 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 24 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

General procedure for the Pd-catalyzed C-N bond formation between Secondary Amine and Aryl Halides.

General procedure F. An oven-dried screw cap test tube was charged with a magnetic stir bar, RuPhos precatalyst[2] **4** (2.3 mg, 0.005 mmol, 0.5 mol% or as indicated), RuPhos **2** (3.6 mg, 0.005 mmol, 0.5 mol% or as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated), secondary amine (1.2 mmol) and NaO*t*-Bu (1.2 mmol or, as indicated). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by THF (2 mL) by syringe. The tube was placed in a preheated oil bath at 85 ºC and the reaction mixture was stirred vigorously for 24 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with CH_2Cl_2, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

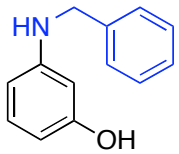
General procedure G. An oven-dried screw cap test tube was charged with a magnetic stir bar, RuPhos precatalyst **4** (2.3 mg, 0.005 mmol, 0.5 mol% or as indicated), RuPhos **2** (3.6 mg, 0.005 mmol, 0.5 mol% or as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated) and secondary amine (1.2 mmol) and Cs_2CO_3 (1.2 mmol or, as indicated). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by 2 mL *t*-BuOH (or, as indiacted) by syringe. The tube was placed in a preheated oil bath at 85 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 16 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with ethyl acetate, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

General procedure H. An oven-dried screw cap test tube was charged with a magnetic stir bar, BrettPhos precatalyst **3** (2 mg, 0.0025 mmol, 0.25 mol% or as

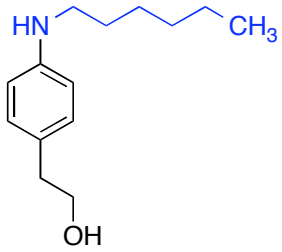
indicated), BrettPhos **1** (1.3 mg, 0.0025 mmol, 0.25 mol% or as indicated), 1.0 mmol (if solid) aryl chloride (or, as indicated) and primary amine (1.2 mmol). The tube was evacuated and refilled with argon (three times). Under a counterflow of argon, remaining liquid reagents were added, followed by 2.2 mL THF solution of LHMDS (2.2 mmol, 1.0 M in THF) by syringe. The tube was placed in a preheated oil bath at 65 ºC (or, at indicated temperature) and the reaction mixture was stirred vigorously for 8 h (or, for indicated period of time). The reaction mixture was then cooled to room temperature, diluted with CH_2Cl_2, washed with water, dried over Na_2SO_4, concentrated in vacuo, and purified via the Biotage SP4 (silica- packed SNAP cartridge, KP-Sil, 10 g) using mixture of hexane and ethyl acetate.

General procedure I. To a screwcap vial was added RuPhos (**2**), RuPhos precatalyst (**4**), NaO*t*-Bu (115 mg, 1.2 mmol), aryl chloride (1 mmol, when solid) and amine (1.2 mmol, where solid). The vial was sealed with a teflon screwcap then evacuated and filled with argon for 3 cycles. THF (2 mL), aryl chloride (1 mmol, when liquid) and amine (1.2 mmol, when liquid) were added via syringe, and the reaction heated at 85 °C for 4 h. After cooling to room temperature the reaction was poured into sat. $NaHCO_3$ and extracted with 3 portions of EtOAc. The combined organic layers then washed with brine, dried over $MgSO_4$, filtered and concentrated, yielding the title compounds after purification.

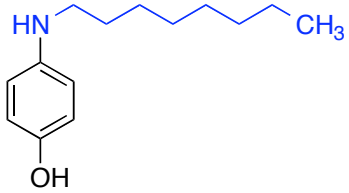
General procedure J. To a screwcap vial was added RuPhos (**2**) (1.15 mg, 0.25 mol%), RuPhos precatalyst (**4**) (1.8 mg, 0.25 mol%), K_3PO_4 (255 mg, 1.2 mmol) and aryl chloride (1 mmol, when solid). The vial was sealed with a teflon screwcap then evacuated and filled with argon for 3 cycles. *t*-Butanol (2 mL), benzyl piperazine-1-carboxylate (232 μL, 1.2 mmol) and aryl chloride (1 mmol, when liquid) were added via syringe, and the reaction heated at 110 °C for 16 h. After cooling to room temperature, the reaction was poured into 1M HCl (10 mL) and extracted with EtOAc. The acid layer was basified with NaOH, extracted with 3 portions of EtOAc and the combined organic layers then washed with brine, dried over $MgSO_4$, filtered and concentrated, yielding the title compounds after purification.



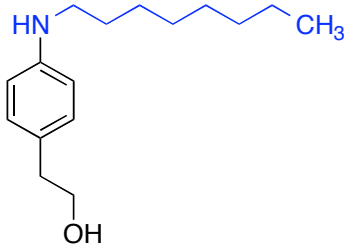
3-(benzylamino)phenol (Table 1, entries 1a and 1b).[3] The general procedure A was followed for 5 h. Isolation and biotage purification afforded the title compound as a dark-brown oil (185 mg, 93%, entry **1a**). The general procedure A with aryl bromide for 5 h was followed. Isolation and biotage purification afforded the title compound in 92% yield (entry **1b**). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.32 (d, 4H, J = 8.0), 7.29-7.27 (m, 1H), 7.00 (t, 1H, J = 8.0), 6.22-6.17 (m, 2H), 6.09 (t, 1H, J = 2.0), 4.24 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 156.8, 149.7, 139.2, 130.3, 128.7, 127.6, 127.3, 106.1, 104.9, 100.1, 48.3. IR (KBr disc, cm^{-1}): 3384, 1619, 1515, 1452, 1179, 1028, 909, 827, 731, 698.



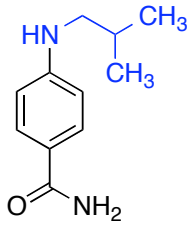
2-(4-Hexylaminophenyl)ethanol (Table 1, entry 1c). The general procedure A with 0.5 mol% catalyst and LHMDS (368 mg, 2.2 mmol) for 30 min at 90 °C was followed. Isolation and biotage purification afforded the title compound as a pale yellow solid (203 mg, 92%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.01 (d, 2H, J = 8.5), 6.55 (d, 2H, J = 8.5), 3.77 (t, 2H, J = 6.5), 3.53 (br-s, 1H), 3.06 (t, 2H, J = 7), 2.73 (t, 2H, J = 6.5), 1.54-1.63 (m, 2H), 1.25-1.41 (m, 6H), 0.88 (t, 3H, J = 6.9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 147.4, 130.0, 126.8, 113.2, 64.1, 44.4, 38.4, 31.8, 29.7, 27.0, 22.8, 14.2. Anal. Calcd for $C_{14}H_{23}NO$: C, 75.97; H, 10.47. Found: C, 76.09; H, 10.44. m.p. 37-38 °C.



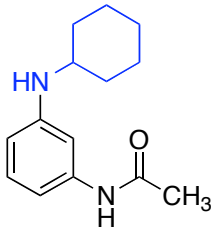
4-(octylamino)phenol (Table 1, entry 1d).[3] The general procedure A with 0.5 mol% catalyst for 6 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (155 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.65 (s, 2H), 6.53 (s, 2H), 4.47 (s, 2H), 3.01 (s, 2H), 1.56 (t, 2H, J = 8.0), 1.35-1.18 (m, 10H), 0.86 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 129.6, 117.0, 116.4, 115.1, 45.7, 32.0, 29.8, 29.6, 29.5, 27.4, 23.6, 22.9, 14.3. IR (KBr disc, cm^{-1}): 3315, 2926, 2855, 1603, 1515, 1468, 1376, 1237, 822. m.p. 73 ºC (74-76 ºC).



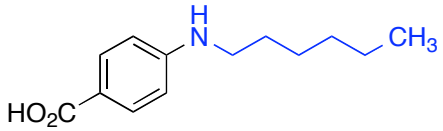
2-(4-(octylamino)phenyl)ethanol (Table 1, entry 1e).[3] The general procedure A with 0.5 mol% catalyst for 20 min was followed. Isolation and biotage purification afforded the title compound as a reddish-yellow solid (210 mg, 84%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.00 (d, 2H, J = 8.0), 6.54 (d, 2H, J = 8.0), 3.74 (t, 2H, J = 8.0), 3.05 (t, 2H, J = 8.0), 2.71 (t, 2H, J = 8.0), 1.60-1.56 (m, 2H), 1.37-1.24 (m, 12H), 0.87 (t, 3H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ:147.2, 129.9, 126.6, 113.0, 64.0, 44.2, 38.3, 31.9, 29.6, 29.5, 29.3, 27.2, 22.7, 14.2. IR (KBr disc, cm^{-1}): 3373, 2953, 2919, 2850, 1617, 1584, 1522, 1485, 1466, 1384, 1318, 1279, 1264, 1245, 1188, 1136, 1117, 1047, 1021, 824, 793, 756, 722, 606, 522, 444, 408. m.p. 50 ºC.



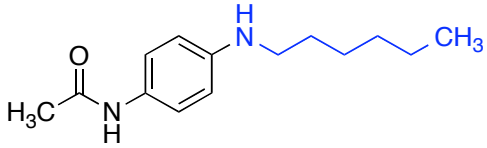
4-(isobutylamino)benzamide (Table 1, entry 1f).[3] The general procedure A for 3 h was followed. Isolation and biotage purification afforded the title compound as a white solid (167 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.63-7.60 (m, 2H), 6.53-6.50 (m, 2H), 6.06 (s, 2H), 2.92 (t, 2H, J = 6.0), 1.84 (septet, 1H, J = 6.7), 0.94 (d, 6H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.7, 151.6, 129.3, 120.9, 111.5, 51.2, 28.0, 20.4. IR (KBr disc, cm^{-1}): 3402, 3192, 2961, 1643, 1614, 1570, 1529, 1471, 1397, 1332, 1263, 1189, 1152, 1123, 834, 791. m.p. 134 ºC.



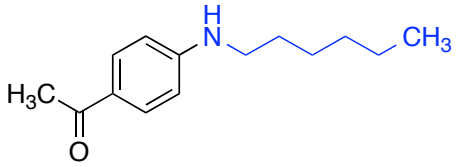
***N*-(3-(cyclohexylamino)phenyl)acetamide (Table 1, entry 1g)**.[3] The general procedure A with 0.05 mol% catalyst for 16 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (187 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.57 (s, 1H), 7.03-6.98 (m, 2H), 6.58 (d, 1H, J = 8.0), 6.29 (dd, 1H, J = 8.0, J = 4.0), 3.55 (s, 1H), 3.21-3.15 (m, 1H), 2.09 (s, 2H), 1.98 (d, 2H, J = 8.0), 1.72-1.68 (m, 2H), 1.61-1.58 (m, 1H), 1.36-1.26 (m, 2H), 1.22-1.06 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.6, 148.1, 139.1, 129.6, 108.9, 108.1, 104.7, 51.6, 33.4, 25.9, 25.0, 24.7. IR (KBr disc, cm^{-1}): 3310, 2930, 2853, 1666, 1614, 1554, 1481, 1449, 1417, 1371, 1319, 1276, 1195, 1166, 1148, 1114, 1022, 991, 961, 910, 888, 846, 768, 732, 691. 405. m.p. 124 ºC (124-125 ºC) .



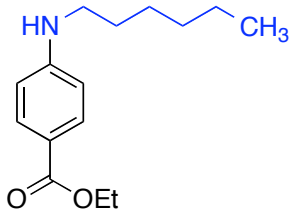
4-*N*-Hexylaminobenzoic acid (Table 1, entry 1h). The general procedure A with 0.5 mol% catalyst, LHMDS (368 mg, 2.2 mmol) and dioxane (1 mL) at 90 °C for 1 h was followed. Isolation and biotage purification afforded the title compound as a pale yellow solid (217 mg, 98%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 11.97 (s, 1H), 7.65 (d, 2H, J = 8.8), 6.54 (d, 2H, J = 8.8), 6.42 (t, 1H, J = 5.3), 3.04 (q, 2H, J = 6.5), 1.53 (quint, 2H, J = 7.2), 1.20-1.40 (m, 6H), 0.87 (t, 3H, J = 6.9). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 167.6, 152.7, 131.2, 116.6, 110.7, 42.4, 31.2, 28.5, 26.4, 22.2, 14.0. Anal. Calcd for $C_{13}H_{19}NO_2$: C, 70.56; H, 8.65. Found: C, 70.30; H, 8.64. m.p. 123-125 °C.



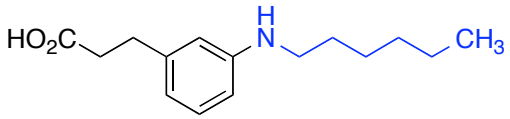
4-*N*-Hexylamino-acetanilide (Table 1, entry 1i). The general procedure A with 0.5 mol% catalyst and LHMDS (368 mg, 2.2 mmol) at 90 °C for 30 min was followed. Isolation and biotage purification (CH_2Cl_2/methanol) afforded the title compound as a pale yellow solid as a white solid (215 mg, 92%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.50 (s, 1H), 7.23 (d, 2H, J = 8.8), 6.46 (d, 2H, J = 8.8), 5.31 (t, 1H, J = 5.6), 2.93 (q, 2H, J = 6.6), 1.95 (s, 3H), 1.51 (quint, 2H, J = 7.2), 1.23-1.40 (m, 6H), 0.87 (t, 3H, J = 6.9). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 167.2, 145.4, 128.3, 120.9, 111.7, 43.2, 31.2, 28.8, 26.5, 23.7, 22.2, 14.0. m.p. 104-105 °C.



4'-*N*-Hexylamino-acetophenone (Table 1, entry 1j). The general procedure A with 0.5 mol% catalyst, LHMDS (368 mg, 2.2 mmol) and dioxane (1 mL) at 80 °C for 30 min. was followed. Isolation and biotage purification (CH_2Cl_2/methanol) afforded the title compound as a pale yellow solid as a yellow solid (191 mg, 87%). ^{1}H NMR (400 M, $CDCl_3$) δ: 7.80 (d, 2H, J = 8.8), 6.52 (d, 2H, J = 8.8), 4.16 (br-s, 1H), 3.13-3.18 (m, 2H), 2.48 (s, 3H), 1.55-1.65 (m, 2H), 1.25-1.45 (m, 6H), 0.87 (t, 3H, J = 6.9). ^{13}C NMR (100 M, $CDCl_3$) δ: 196.5, 152.5, 131.0, 126.5, 111.4, 43.5, 31.7, 29.4, 26.9, 26.2, 22.8, 14.2. IR (neat, cm^{-1}): 3352, 2926, 1648, 1590, 1362, 1282, 1180, 954, 829. m.p. 76-77 °C.

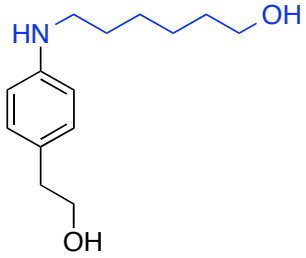


Ethyl 4-(hexylamino)benzoate (Table 1, entry 1k). The general procedure B with 1.2 mol% catalyst for 24 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow solid (190 mg, 76%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.83 (d, 2H, J = 8.0), 6.50 (d, 2H, J = 8.0), 4.29 (q, 2H, J = 10.0), 4.07 (s, 1H), 3.12 (q, 2H, J = 10.0), 1.59 (pent, 2H, J = 8.0), 1.40-1.27 (m, 9H), 0.87 (t, 3H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.1, 152.3, 131.7, 118.5, 111.5, 60.3, 43.6, 31.8, 29.5, 26.9, 22.8, 14.7, 14.2. IR (KBr disc, cm^{-1}): 3375, 2933, 2854, 1680, 1603, 1577, 1533, 1476, 1423, 1369, 1343, 1312, 1282, 1266, 1174, 1108, 841, 773, 730, 701. Anal. Calcd for $C_{15}H_{23}NO_2$: C, 72.25; H, 9.30. Found: C, 72.46; H, 9.37. m.p. 90 ºC.

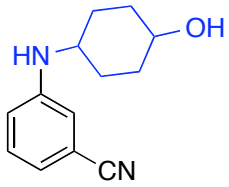


3-[3-(Hexylamino)phenyl]propanoic acid (Table 1, entry 1l). The general procedure A with 0.5 mol% catalyst, LHMDS (368 mg, 2.2 mmol) and dioxane (1 mL) for 30 min at 90 °C was followed. Isolation and biotage purification afforded the title compound as a pale yellow oil (197 mg, 79%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.08 (dd, 1H, J = 8.2 and 7.6), 6.52 (d, 1H, J = 7), 6.42-6.48 (m, 2H), 4.85 (br-s, 1H), 3.07 (t, 2H, J = 7), 2.86 (t, 2H, J = 8), 2.64 (t, 2H, J = 8), 1.59 (quint, 2H, J = 7.3,), 1.25-1.42 (m, 6H), 0.88 (t, 3H,

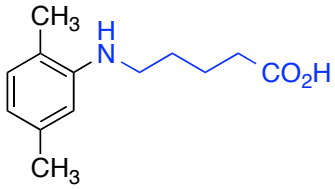
J = 6.8). ^{13}C NMR (400 MHz, $CDCl_3$) δ: 179.1, 148.6, 141.6, 129.5, 117.6, 113.2, 111.3, 44.4, 35.9, 31.8, 31.0, 29.6, 27.0, 22.8, 14.2. IR (neat, cm^{-1}): 3399, 2955, 2929, 2857, 1710, 1607, 1590, 1259, 697.



6-((4-(2-hydroxyethyl)phenyl)amino)hexan-1-ol (Table 2, entry 2a). The general procedure A with 1 mol% catalyst, LHMDS (3.4 mmol) and dioxane (3 mL) for 21 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (170 mg, 72%, entry **2a**). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.99 (d, 2H, J = 8.0), 6.54-6.51 (m, 2H), 3.74 (t, 2H, J = 6.0), 3.59 (t, 2H, J = 6.0), 3.05 (t, 3H, J = 6.0), 2.71 (t, 2H, J = 6.0), 1.60-1.50 (m, 6H), 1.38 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 147.3, 130.0, 126.9, 113.2, 64.1, 63.0, 44.3, 38.5, 32.8, 29.7, 27.1, 25.8. IR (KBr disc, cm^{-1}): 3382, 2931, 2855, 1691, 1658, 1614, 1519, 1479, 1317, 1044, 814, 697, 672. Anal. Calcd for $C_{14}H_{23}NO_2$: C, 70.85; H, 9.77. Found: C, 70.69; H, 9.73. m.p. 47 ºC.

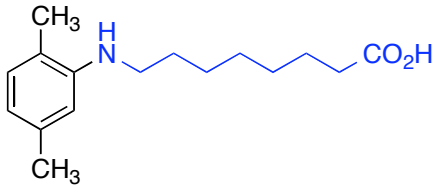


3-((4-hydroxycyclohexyl)amino)benzonitrile (Table 2, entry 2b). The general procedure A with 1 mol% catalyst and dioxane (3 mL) for 21 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (162 mg, 75%, entry **2a**). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.12-7.07 (m, 1H), 6.79 (d, 1H, J = 8.0), 6.67 (s, 2H), 4.05-3.97 (m, 1H), 3.58 (m, 1H), 3.13 (s, 1H), 2.97 (s, 1H), 2.02-1.93 (m, 4H), 1.39-1.30 (m, 2H), 1.18-1.09 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 171.7, 147.9, 130.2, 120.2, 119.9, 117.8, 115.1, 112.7, 69.9, 60.7, 51.0, 37.5, 34.0, 33.8, 30.8, 21.3, 14.4. IR (KBr disc, cm^{-1}): 3375, 2934, 2859, 2227, 1700, 1653, 1602, 1582, 1559, 1521, 1489, 1456, 1337, 1053, 991, 960, 778, 683.

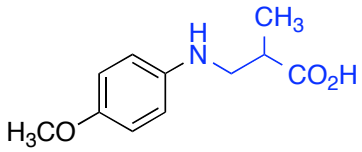


5-(2,5-Dimethoxyphenylamino)pentanoic acid (Table 2, entry 2c). The general procedure D with sodium tert-butoxide (230 mg, 2.4 mmol) and dioxane (5 mL) at 110 °C for 20 h was followed. Isolation and biotage purification afforded the title compound as a white solid (210 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.91 (d, 1H, J = 7), 6.46 (d, 1H, J = 7), 6.41 (s, 1H), 3.16 (t, 2H, J = 7), 2.42 (t, 2H, J = 7), 2.28 (s, 3H), 2.07 (s, 3H), 1.81-1.65 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 180.1, 146.1, 136.9, 130.1, 119.2, 117.8, 110.9, 43.7, 33.9, 29.1, 22.4, 21.8, 17.2. IR (neat, cm^{-1}): 3420, 2919, 2858,

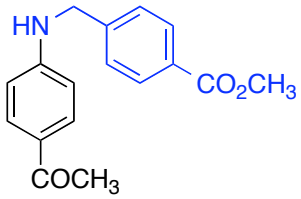
1703, 1616, 1584, 1521, 1297, 1279, 1215, 800. Anal. Calcd for $C_{13}H_{19}NO_2$: C, 70.56; H, 8.65. Found: C, 70.57; H, 8.61. m.p. 72-73 °C.



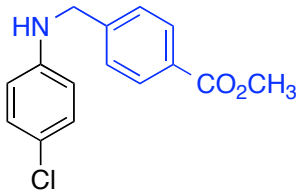
8-(2,5-Dimethoxyphenylamino)octanoic acid (Table 2, entry 2d). The general procedure D with sodium tert-butoxide (230 mg, 2.4 mmol) and dioxane (5 mL) at 110 °C for 20 h was followed. Isolation and biotage purification afforded the title compound as a white solid (247 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.91 (d, 1H, J = 7.4), 6.44 (d, 1H, J = 7.4), 6.41 (s, 1H), 3.11 (t, 2H, J = 7), 2.34 (t, 2H, J = 8), 2.27 (s, 3H), 2.07 (s, 3H), 1.65-1.60 (m, 4H), 1.43-1.35 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 180.4, 146.3, 136.9, 130.0, 119.0, 117.6, 110.9, 44.2, 34.3, 29.7, 29.3, 29.2, 27.2, 24.8, 21.8, 17.2. IR (neat, cm^{-1}): 3424, 2930, 2857, 1705, 1614, 1525, 1425, 1318, 1230, 1196, 790. Anal. Calcd for $C_{16}H_{25}NO_2$: C, 72.96; H, 9.57. Found: C, 72.54; H, 9.52. m.p. 77-78 °C.



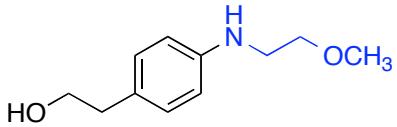
3-(4-Methoxyphenylamino)-2-methylpropanoic acid (Table 2, entry 2e). The general procedure D with potassium tert-butoxide (269 mg, 2.4 mmol) and toluene (1 mL) at 100 °C for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow oil (176 mg, 84%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.77 (d, 2H, J = 8.8), 6.66 (d, 2H, J = 8.8), 5.65 (br-s, 2H), 3.73 (s, 3H), 3.33 (dd, 1H, J = 13 and 8.8), 3.19 (dd, 1H, J = 13 and 5.1), 2.81-2.72 (m, 1H), 1.23 (d, 3H, J = 7.1). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 180.4, 153.4, 140.5, 116.0, 115.0, 55.8, 49.0, 38.9, 15.0. IR (neat, cm^{-1}): 3379, 2936, 1710, 1514, 1463, 1236, 1033, 822.



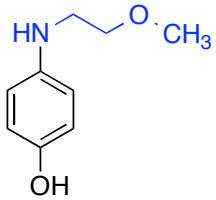
Methyl 4-(((4-acetylphenyl)amino)methyl)benzoate (Table 2, entry 2f). The general procedure E with toluene (3 mL) for 17 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (247 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.97 (d, 2H, J = 12.0), 7.76 (d, 2H, J = 8.0), 7.36 ((d, 2H, J = 8.0), 6.53 (d, 2H, J = 8.0), 4.85 (s, 1H), 4.44 (d, 2H, J = 4.0), 3.86 (s, 3H), 2.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ:196.5, 166.8, 151.7, 143.7, 130.8, 130.1, 129.4, 127.2, 127.0, 111.7, 52.2, 47.2, 26.1. IR (KBr disc, cm^{-1}): 3339, 1708, 1656, 1595, 1527, 1423, 1361,1335, 1283, 1180, 1113, 1019, 959, 850, 825, 764, 718. Anal. Calcd for $C_{17}H_{17}NO_3$: C, 72.07; H, 6.05. Found: C, 72.04; H, 5.99. m.p. 141 ºC.



Methyl 4-(((4-chlorophenyl)amino)methyl)benzoate (Table 2, entry 2g). The general procedure E with toluene (3 mL) for 17 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (247 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.99-7.97 (m, 2H), 7.38 (d, 2H, J = 8.0), 7.08-7.06 (m, 2H), 6.49-6.47 (m, 2H), 4.34 (s, 2H), 4.19 (s, 1H), 3.88 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.1, 146.5, 144.6, 130.2, 129.4, 127.3, 122.5, 114.2, 52.3, 48.2. IR (KBr disc, cm^{-1}) 3388, 2955, 2848, 2361, 1714, 1598, 1506, 1466, 1437, 1416, 1316, 1278, 1179, 1103, 1081, 1019, 962, 845, 830, 805, 762, 701, 627, 508. m.p. 112 ºC.

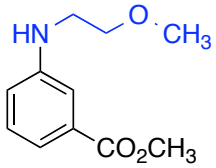


2-[4-(2-Methoxyethylamino)phenyl]ethanol (Table 2, entry 2h). An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with the BrettPhos precatalyst (4 mg, 0.05 mol%), BrettPhos (2.7 mg, 0.05 mol%). Then, the tube was taken into a globebox (a needle was inserted in the septum) and the tube was charged with lithium bis(trimethylsilyl)amide (LHMDS) (3.68 g, 22 mmol). Then, dibutyl ether (nBu_2O) (5 mL), 4-chlorophenethyl alcohol (1.35 mL, 10 mmol), 2-methoxyethylamine (1.22 mL, 14 mmol) were added. The tube was resealed inside a glovebox and removed from the glovebox. The solution was heated to 90 °C for 18h. The reaction mixture then was allowed to cool to room temperature. To the reaction mixture was added 1 M HCl (20 mL). The mixture was stirred at room temperature for 20 min and was then extracted with CH_2Cl_2 (3 x 50.0 mL). The organic layer was separated and dried over Na_2SO_4. The solvent was evaporated, and the crude product was purified via the Biotage SP4 (silica-packed 40+M cartridge; EtOAc/hexanes) to provide the title compound as a pale yellow oil (1.48 g, 76%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.02 (d, 2H, J = 8), 6.58 (d, 2H, J = 8), 3.96 (br-s, 1H), 3.77 (q, 2H, J = 6), 3.58 (t, 2H, J = 5), 3.37 (s, 3H), 3.25 (t, 2H, J = 5), 2.74 (t, 2H, J = 7). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 146.7, 129.8, 127.4, 113.4, 71.0, 63.9, 58.7, 43.7, 38.3. IR (neat, cm^{-1}): 3376, 2931, 1617, 1521, 1321, 1118, 1046, 817.

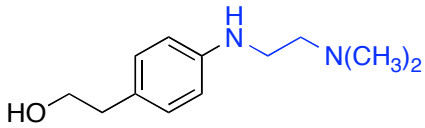


4-((2-methoxyethyl)amino)phenol (Table 2, entry 2i). The general procedure A with 0.5 mol% catalyst for 6h was followed. Isolation and biotage purification afforded the title compound as a brown liquid (130 mg, 78%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.65 (d, 2H, J = 8.0), 6.53 (d, 2H, J = 8.0), 4.61 (s, 2H), 3.57 (t, 2H, J = 4.0), 3.36 (s, 3H), 3.20 (t, 2H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 148.3, 142.0, 119.8, 116.2, 116.1, 115.2,

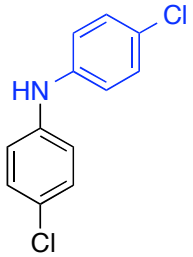
71.0, 58.8, 44.8. IR (KBr disc, cm^{-1}): 3351, 2932, 2284, 1658, 1598, 1514, 1366, 1236, 1118, 1022, 823.



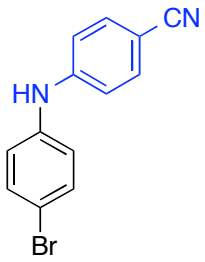
Methyl 3-((2-methoxyethyl)amino)benzoate (Table 2, entry 2j). The general procedure B with 1.5 mol% catalyst for 24 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (125 mg, 65%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 7.34 (d, 1H, J = 8.0), 7.25 (s, 1H), 7.18 (t, 1H, J = 8.0), 6.77 (dd, 1H, J = 8.0, J = 4.0), 4.21 (s, 1H), 3.84 (s, 3H), 3.56 (t, 2H, J = 6.0), 3.34 (s, 3H), 3.28 (s, 2H). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 108.4, 101.7, 95.8, 95.1, 91.5, 91.2, 89.7, 75.0, 70.8, 68.5, 65.5. IR (KBr disc, cm^{-1}): 3394, 2950, 2929, 2893, 2360, 1719, 1606, 1588, 1513, 1491, 1439, 1385, 1334, 1286, 1245, 1193, 1108, 996, 938, 870, 846, 805, 754, 685, 546.



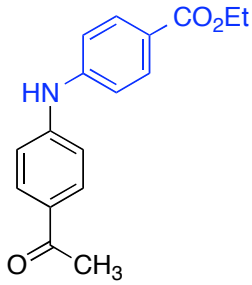
2-{[4-(2-Dimethylamino)ethylamino]phenyl}ethanol (Table 2, entry 2k). The general procedure A with 0.5 mol% catalyst, LHMDS (368 mg, 2.2 mmol) and dioxane (1 mL) for 30 min at 100 °C was followed. Isolation and biotage purification afforded the title compound as a yellow oil (192 mg, 92%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.02 (d, 2H, J = 8), 6.58 (d, 2H, J = 8.4), 4.20 (br-s, 1H), 3.77 (t, 2H, J = 6.6), 3.05-3.15 (m, 2H), 2.74 (t, 2H, J = 6.5), 2.52 (t, 2H, J = 5.9), 2.22 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 147.0, 129.8, 127.1, 113.1, 63.9, 58.1, 45.2, 41.3, 38.5. IR (neat, cm^{-1}): 3364, 2941, 2860, 2826, 1617, 1521, 1467, 1257, 1046, 818.



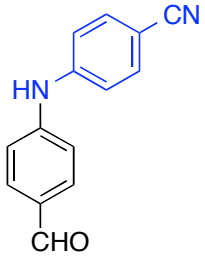
bis(4-chlorophenyl)amine (Table 3, entry 3a).[4] The general procedure E with 0.1 mol% catalyst for 15 h was followed. Isolation and biotage purification afforded the title compound as a brownish-purple solid (236 mg, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.22 (t, 2H, J = 4.0), 7.19 (t, 2H, J = 4.0), 6.49 (t, 2H, J = 6.0), 6.92 (t, 2H, J = 6.0), 5.62 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 141.6, 129.6, 126.2, 119.3. IR (KBr disc, cm^{-1}) 3416, 1591, 1505, 1322, 1093, 819, 677, 505, 406. m.p. 77 ºC (77 ºC).



4-((4-bromophenyl)amino)benzonitrile (Table 3, entry 3b). The general procedure E with 0.5 mol% catalyst for 16 h was followed. Isolation and biotage purification afforded the title compound as a white-brown solid (217 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.47-7.41 (m, 4H), 7.03-7.01 (m, 2H), 6.95-6.92 (m, 2H), 6.08 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 147.6, 139.4, 134.0, 132.8, 122.7, 119.9, 116.4, 115.4, 102.3. IR (KBr disc, cm^{-1}): 3345, 2214, 1610, 1586, 1519, 1486, 1385, 1331, 1172, 1075, 1009, 815, 544, 488. Anal. Calcd for $C_{13}H_9BrN_2$: C, 57.17; H, 3.32. Found: C, 57.33; H, 3.25. m.p. 131 ºC.

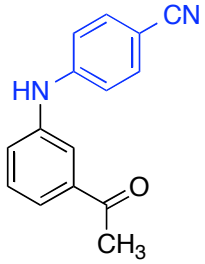


Ethyl 4-((4-acetylphenyl)amino)benzoate (Table 3, entries 3c and 3d). The general procedure E with 0.1 mol% catalyst for 15 h was followed. Isolation and biotage purification afforded the title compound as a white solid (249 mg, 88%, entry **3c**). The general procedure B with 1 mol% catalyst for 21 h was followed. Isolation and biotage purification afforded the title compound as a white solid (271 mg, 96%, entry **3d**). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.95 (d, 2H, J = 8.0), 7.87 (d, 2H, J = 8.0), 7.13-7.10 (m, 4H), 6.82 (s, 1H), 4.32 (q, 2H, J = 6.7), 2.52 (s, 3H), 1.34 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.9, 166.5, 146.6, 145.8, 131.6, 130.7, 130.6, 123.7, 117.4, 116.7, 60.9, 26.5, 14.6. IR (KBr disc, cm^{-1}): 3333, 1701, 1590, 1526, 1430, 1340, 1273, 1173, 1106, 958, 834, 768, 668, 591. Anal. Calcd for $C_{17}H_{17}NO_3$: C, 72.07; H, 6.05. Found: C, 72.17; H, 6.11. m.p. 136 ºC.

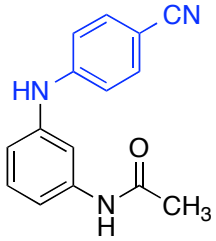


4-((4-formylphenyl)amino)benzonitrile (Table 3, entry 3e). The general procedure B with 1.5 mol% catalyst for 14 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (168 mg, 76%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.76 (s, 1H), 9.48 (s, 1H), 7.77 (d, 2H, J = 8.0), 7.66 (d, 2H, J = 8.0), 7.24 (d, 4H, J = 8.0). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 191.3, 147.7, 146.3, 134.2, 132.1, 129.9, 120.0,

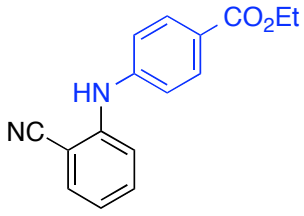
117.9, 102.5. IR (KBr disc, cm^{-1}): 3338, 2218, 1682, 1587, 1525, 1384, 1338, 1223, 1164, 822, 544. Anal. Calcd for $C_{14}H_{10}N_2O$: C, 75.66; H, 4.54. Found: C, 75.62; H, 4.62. m.p. 162 ºC.



4-((3-acetylphenyl)amino)benzonitrile (Table 3, entry 3f). The general procedure B with 1 mol% catalyst for 14 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (221 mg, 76%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.72 (t, 1H, J = 2.0), 7.62-7.60 (m, 1H), 7.47-7.34 (m, 4H), 7.00-6.98 (m, 2H), 6.51 (s, 1H), 2.57 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 198.1, 147.6, 141.1, 138.7, 134.0, 130.1, 125.1, 123.8, 120.0, 115.6, 114.6, 102.4, 27.0. IR (KBr disc, cm^{-1}): 3338, 2217, 1680, 1590, 1526, 1487, 1446, 1408, 1384, 1335, 1271, 1208, 1174, 908, 828, 789, 687, 587, 544, 501. Anal. Calcd for $C_{15}H_{12}N_2O$: C, 76.25; H, 5.12. Found: C, 75.85; H, 5.08. m.p. 103 ºC.

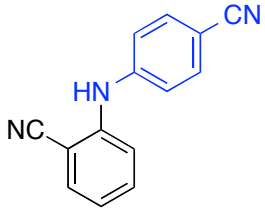


***N*-(3-((4-cyanophenyl)amino)phenyl)acetamide (Table 3, entry 3g)**. The general procedure A with 1.5 mol% catalyst for 24 h was followed. Isolation and biotage purification afforded the title compound as a dark-brown solid (176 mg, 70%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.90 (s, 1H), 8.97 (s, 1H), 7.76-7.50 (m, 3H), 7.27 (t, 1H, J = 10), 7.24-6.93 (m, 3H), 6.86 (d, 1H, J = 4.0), 1.83 (s, 3H). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 169.0, 148.8, 141.6, 140.9, 134.3, 130.1, 120.6, 115.4, 115.0, 110.8, 99.8, 24.7. IR (KBr disc, cm^{-1}): 3317, 2216, 1672, 1597, 1529, 1434, 1339, 1173, 830, 780, 691, 544.

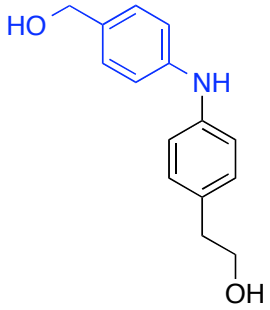


Ethyl 4-((2-cyanophenyl)amino)benzoate (Table 3, entry 3h). The general procedure B with 1 mol% catalyst for 21 h was followed. Isolation and biotage purification afforded the title compound as a brownish-yellow solid (253 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.98 (d, 2H, J = 8.0), 7.55-7.53 (m, 1H), 7.44-7.37 (m, 2H), 7.13 (d, 2H, J = 8.0), 6.98-6.94 (m, 1H), 6.53 (s, 1H), 4.34 (q, 2H, J = 8.0), 1.36 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 166.1, 145.1, 144.8, 134.0, 133.4, 131.4, 124.6, 121.3, 118.1,

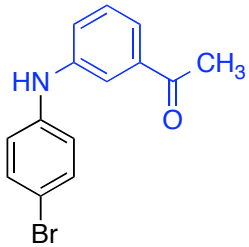
117.2, 116.6, 101.1, 60.8, 14.4. IR (KBr disc, cm^{-1}): 3330, 2982, 2221, 1708, 1611, 1593, 1573, 1520, 1470, 1454, 1367, 1324, 1278, 1176, 1106, 1020, 849, 757, 699. Anal. Calcd for $C_{30}H_{23}N_5O_2$: C, 72.16; H, 5.30. Found: C, 72.22; H, 5.14. m.p. 112-116 ºC.



2-((4-cyanophenyl)amino)benzonitrile (Table 3, entry 3i).[5] The general procedure B with 1.5 mol% catalyst for 14 h was followed. Isolation and biotage purification afforded the title compound as a pale-yellow solid (210 mg, 96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.59-7.54 (m, 2H), 7.51-7.46 (m, 1H), 7.40-7.37 (m, 1H), 7.13 (d, 2H, J = 8.0), 7.04 (t, 1H, J = 8.0), 6.64-6.60 (m, 1H), 4.14 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 145.4, 144.3, 134.2, 134.0, 133.8, 122.7, 119.3, 118.2, 118.1, 117.1, 114.6, 105.1, 102.7. IR (KBr disc, cm^{-1}): 3318, 2221, 1609, 1591, 1571, 1518, 1489, 1471, 1453, 1325, 1294, 1174, 828, 757. m.p. 155 ºC (156-157 ºC).

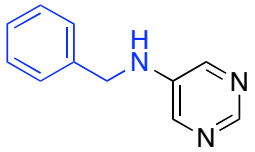


2-(4-((4-(hydroxymethyl)phenyl)amino)phenyl)ethanol (Table 3, entry 3j). The general procedure A with 0.5 mol% catalyst, LHMDS (3.4 mmol) for 24 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (219 mg, 90%). ^{1}H NMR (400 MHz, d_6-DMSO): 7.97 (s, 1H), 7.09 (t, 1H, J = 8.0), 7.03 (d, 2H, J = 8.0), 6.95 (t, 3H, J = 8.0), 6.83 (d, 1H, J = 8.0), 6.66 (d, 1H, J = 8.0), 5.08 (t, 1H, J = 6.0), 4.59 (t, 1H, J = 4.0), 3.51 (q, 2H, J = 6.6), 2.59 (t, 2H, J = 8.0). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 144.3, 140.0, 141.8, 131.3, 129.9, 129.2, 117.8, 114.9, 114.5, 63.5, 62.9, 38.9. IR (KBr disc, cm^{-1}): 3323, 2931, 1605, 1517, 1488, 1401, 1323, 1242, 1167, 1114, 1044, 937, 820, 781, 695, 668. Anal. Calcd for $C_{15}H_{17}NO_2$: C, 74.05; H, 7.04. Found: C, 73.59; H, 7.09.

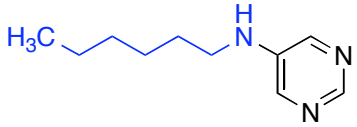


1-(3-((4-bromophenyl)amino)phenyl)ethanone (Table 3, entry 3k). The general procedure E with 0.1 mol% catalyst for 15 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (182 mg, 63%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.58 (t, 1H, J = 2.0), 7.48-7.46 (m, 1H), 7.35-7.29 (m, 3H), 7.22-7.18

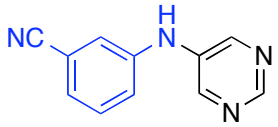
(m, 1H), 6.94-6.91 (m, 2H), 5.92 (s, 1H), 2.54 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ:198.4, 143.4, 141.8, 138.6, 132.6, 129.8, 122.2, 121.6, 119.9, 117.0, 113.8, 27.0. IR (KBr disc, cm^{-1}): 3374, 3331, 1683, 1580, 1533, 1490, 1430, 1389, 1356, 1336, 1272, 1209, 1072, 982, 896, 830, 807, 771, 745, 683, 588, 496. Anal. Calcd for $C_{14}H_{12}BrNO$: C, 57.95; H, 4.17. Found: C, 58.17; H, 4.06. m.p. 117 ºC.



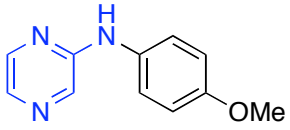
***N*-benzylpyrimidin-5-amine (Table 4, entry 4a)**. The general procedure B with a mixture of 5-bromopyrimidine (0.5 mmol), benzylamine (0.6 mmol), K_2CO_3 (0.7 mmol), **5** (8 mg, 2 mol%), **1** (5 mg, 2 mol%), and *t*-BuOH (1 mL) at 110 °C for 24 h was followed. The crude product was purified via the biotage to provide the title compound as a white solid (87 mg, 94%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.58 (s, 1H), 8.11 (s, 2H) 7.33 (m, 5H), 4.42 (bs, 1H), 4.34 (s, 2H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 148.8, 141.9, 141.1, 137.8, 129.2, 128.1, 127.6, 47.7. IR (neat, cm^{-1}): 3246, 3044, 1575, 1435, 1418, 1309, 1200, 701. m.p. 109-110 °C.



***N*-hexylpyrimidin-5-amine (Table 4, entry 4b)**. The general procedure B with a mixture of 5-bromopyrimidine (0.5 mmol), hexylamine (0.6 mmol), K_2CO_3 (0.7 mmol), **5** (8 mg, 2 mol%), **1** (5 mg, 2 mol%), and *t*-BuOH (1 mL) at 110 °C for 24 h was followed. The crude product was purified via the biotage to provide the title compound as a white solid (86 mg, 96%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.55 (s, 1H), 8.07 (s, 2H), 3.80 (s, 1H), 3.12 (q, J = 7.0 Hz, 2H), 1.62 (pentet, J = 8.0 Hz, 2H), 1.32 (m, 6H), 0.88 (m, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 148.4, 142.2, 140.8, 43.4, 31.7, 29.4, 26.9, 22.8, 14.3. IR (neat, cm^{-1}): 3247, 3052, 2931, 2853, 1580, 1434, 1416, 1319, 1204, 870, 725, 629. m.p. 88-89 °C.

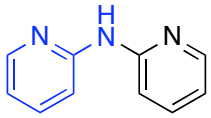


3-(pyrimidin-5-ylamino)benzonitrile (Table 4, entry 4c). The general procedure B with 5-bromopyrimidine (1 mmol), K_2CO_3 (1.4 mmol) at 110 °C for 2 h was followed. The crude product was purified via the biotage to provide the title compound as a white solid (185 mg, 94%). ^{1}H NMR (300 MHz, DMSO) δ: 8.86 (s, 1H), 8.72 (s, 1H), 8.61 (s, 2H), 7.44 (m, 3H), 7.30 (m, 3H). ^{13}C NMR (75 MHz, DMSO) δ: 151.5, 146.2, 143.5, 138.0, 131.4, 124.9, 122.0, 119.7, 119.5, 113.0. IR (neat, cm^{-1}): 3383, 2226, 1572, 1534, 1498, 1428, 1384, 1339, 797, 718. Anal. Calcd. for $C_{11}H_8N_4$: C, 67.34; H, 4.11. Found: C, 67.54; H, 4.15. m.p. 190-191 °C.

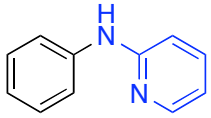


***N*-(4-methoxyphenyl)pyrazin-2-amine (Table 4, entry 4d)**. The general procedure B with K_2CO_3 (1.4 mmol) at 110 °C for 4 h was followed. The crude product was purified

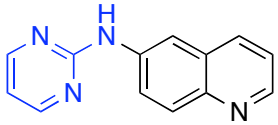
via the biotage to provide the title compound as a white solid (187 mg, 93%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.09 (s, 1H), 8.04 (m, 1H), 7.91 (d, *J* = 3.0 Hz, 1H), 7.30 (d, *J* = 9.0 Hz, 2H), 6.91 (d, *J* = 9.0 Hz, 2H), 6.76 (s, 1H), 3.81 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 156.9, 153.5, 142.2, 134.5, 132.4, 132.0, 124.0, 114.9, 55.8. IR (neat, cm^{-1}): 3200, 2949, 1584, 1547, 1427, 1334, 1245, 1144, 1035, 829. m.p. 131-133 °C.



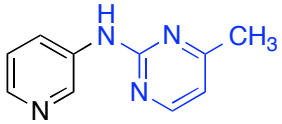
Dipyridin-2-ylamine (Table 4, entry 4e).[6] The general procedure B with K_2CO_3 (1.4 mmol) at 110 °C for 2 h was followed. The crude product was purified via the biotage to provide the title compound as a white solid (156 mg, 93%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.95 (s, 1H), 8.28 (d, *J* = 5.0 Hz, 2H), 7.58 (m, 4H), 6.83 (m, 2H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 154.6, 147.9, 138.0, 116.5, 112.1. IR (neat, cm^{-1}): 3264, 3092, 3022, 1596, 1487, 1441, 1352, 763, 730. m.p. 89 °C (85-94 °C).



***N*-phenylpyridin-2-amine (Table 4, entry 4f)**.[3] The general procedure A with 0.5 mol% catalyst, LHMDS (1.2 mmol) for 18 h was followed. Isolation and biotage purification afforded the title compound as a white solid (166 mg, 98%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.41 (d, 2H, J = 4.0), 8.13 (s, 1H), 7.62-7.59 (m, 2H), 7.35-7.31 (m, 2H), 7.06-7.02 (m, 1H), 6.68 (t, 1H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 160.5, 158.2, 139.7, 129.2, 123.0, 120.0, 112.6. IR (KBr disc, cm^{-1}): 3257, 3056, 1618, 1577, 1537, 1497, 1449, 1411, 1360, 1253, 1175, 1075, 1028, 996, 973, 900, 795, 780, 751, 696, 668, 641, 616, 598, 523, 503. m.p. 110 ºC (109-110 ºC).

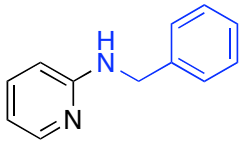


***N*-(pyrimidin-2-yl)quinolin-6-amine (Table 4, entry 4g)**. The general procedure B with K_2CO_3 (1.4 mmol) at 110 °C for 2 h was followed. The crude product was purified via the biotage to provide the title compound as a white solid (206 mg, 93%). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 8.78 (d, *J* = 4.0 Hz, 1H), 8.50 (d, *J* = 4.5 Hz, 2H), 8.38 (d, *J* = 2.5 Hz, 1H), 8.10 (m, 3H), 7.72 (d, *J* = 9.0 Hz, 1H), 7.34 (dd, *J* = 4.0 Hz, *J* = 8.5 Hz, 1H), 6.79 (t, *J* = 4.5 Hz, 1H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 160.3, 158.3, 148.9, 145.2, 137.7, 135.7, 130.3, 129.3, 124.0, 121.7, 114.4, 113.3. IR (neat, cm^{-1}): 3270, 1580, 1540, 1501, 1448, 1430, 1413, 833, 795. Anal. Calcd. for $C_{13}H_{10}N_4$: C, 70.26; H, 4.54. Found: C, 70.08; H, 4.51. m.p. 152-154 °C.

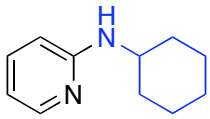


4-methyl-*N*-(pyridin-3-yl)pyrimidin-2-amine (Table 4, entry 4h). The general procedure A with 0.6 mol% catalyst, LHMDS (1.2 mmol) at 110 ºC for 18 h was followed. Isolation and biotage purification afforded the title compound as a white solid (168 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.69-8.68 (m, 1H), 8.36 (s, 1H), 8.25-

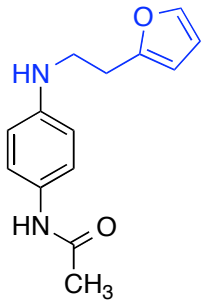
8.20 (m, 3H), 7.19 (dd, 1H, J = 8.0, J = 8.0), 6.58 (d, 1H, J = 4.0), 2.35 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.6, 160.1, 157.7, 143.3, 141.2, 136.9, 126.2, 123.6, 112.9, 24.4. IR (KBr disc, cm^{-1}): 3262, 3190, 3077, 2923, 1614, 1544, 1483, 1460, 1420, 1370, 1339, 1316, 1290, 1258, 1239, 1193, 1126, 1101, 1027, 990, 905, 797, 708, 677, 644, 609, 546. Anal. Calcd for $C_{10}H_{10}N_4$: C, 64.50; H, 5.41. Found: C, 64.58; H, 5.35. m.p. 90 ºC.



***N*-benzylpyridin-2-amine (Table 4, entry 4i)**.[3] The general procedure A with 0.25 mol% catalyst, LHMDS (1.2 mmol) for 5 min was followed. Isolation and biotage purification afforded the title compound as a white solid (160 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.07 (dd, 1H, J = 8.0, J = 4.0), 7.21-7.42 (m, 6H), 6.54-6.57 (m, 1H), 6.34 (d, 1H, J = 8.0), 5.00 (s, 1H), 2.27 (d, 2H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 158.7, 148.3, 139.2, 137.5, 128.7, 127.4, 127.2, 113.2, 106.8, 46.3. IR (KBr disc, cm^{-1}): 3225, 1602, 1575, 1530, 1455, 1442, 1338, 1292, 1162, 770, 748, 698. m.p. 92-94 ºC (94-95 ºC).

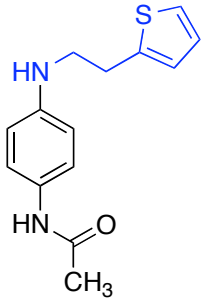


***N*-cyclohexylpyridin-2-amine (Table 4, entry 4j)**.[3] The general procedure A with 0.25 mol% catalyst, LHMDS (1.2 mmol) for 12 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow solid (140 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.03 (m, 1H), 7.31-7.37 (m, 1H), 6.46-6.49 (m, 1H), 6.31 (d, 1H, J = 8.0), 4.41 (s, 1H), 3.46-3.52 (m, 1H), 1.11-2.01 (m, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 158.2, 148.3, 137.3, 112.4, 106.7, 50.1, 33.4, 25.8, 24.9. IR (KBr disc, cm^{-1}): 3264, 2923, 1653, 1609, 1559, 1520, 1487, 1418, 731. m.p. 108 ºC (105 ºC).

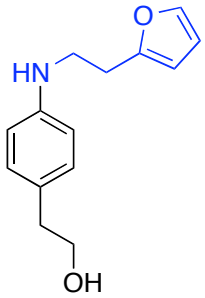


***N*-(4-((2-(furan-2-yl)ethyl)amino)phenyl)acetamide (Table 5, entry 5a)**. The general procedure A with 0.25 mol% catalyst, aryl bromide, LHMDS (2.25 mmol) and dioxane (5 mL) for 3 h was followed. Isolation and biotage purification afforded the title compound as a red liquid (220 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.96 (s, 1H), 7.30 (s, 1H), 7.25-7.22 (m, 2H), 6.51-6.48 (m, 2H), 6.27-6.26 (m, 1H), 6.04 (d, 1H, J = 4.0), 3.71 (s, 1H), 3.33 (t, 2H, J = 6.0), 2.87 (t, 2H, J = 6.0), 2.03 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.0, 153.5, 145.2, 141.7, 128.8, 122.7, 113.3, 110.5, 106.5, 42.9, 28.1, 24.3. IR (KBr disc, cm^{-1}): 3295, 3141, 2925, 1873, 1659, 1604, 1519, 1479, 1407, 1371,

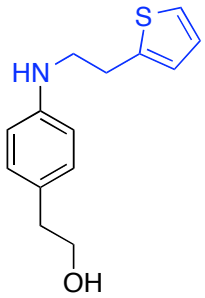
1314, 1272, 1212, 1178, 1145, 1121, 1079, 1006, 966, 924, 884, 823, 734, 600. Anal. Calcd for $C_{14}H_{16}N_2O_2$: C, 68.83; H, 6.60. Found: C, 68.22; H, 6.56.



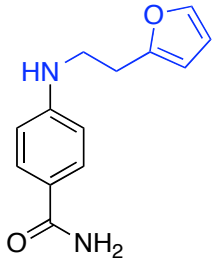
***N*-(4-((2-(thiophen-2-yl)ethyl)amino)phenyl)acetamide (Table 5, entry 5b)**. The general procedure A with 0.5 mol% catalyst, aryl bromide for 12 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (247 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.24 (d, 3H, J = 8.0), 7.14 (d, 1H, J = 4.0), 6.93-6.91 (m, 1H), 6.82 (d, 1H, J = 4.0), 6.56-6.53 (m, 2H), 3.71 (s, 1H), 3.37 (t, 2H, J = 6.0), 3.08 (t, 2H, J = 6.0), 2.09 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.4, 145.1, 141.9, 128.6, 127.2, 125.5, 124.1, 122.6, 113.5, 45.7, 29.8, 24.4. IR (KBr disc, cm^{-1}): 3293, 1657, 1604, 1517, 1406, 1370, 1313, 1249, 822, 698, 516. Anal. Calcd for $C_{14}H_{16}N_2OS$: C, 64.58; H, 6.19. Found: C, 64.47; H, 6.07. m.p. 76 ºC.



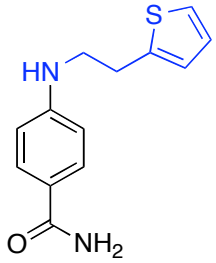
2-(4-((2-(furan-2-yl)ethyl)amino)phenyl)ethanol (Table 5, entry 5c). The general procedure A with 0.25 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 12 h was followed. Isolation and biotage purification afforded the title compound as a red liquid (203 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34-7.33 (m, 1H), 7.03 (d, 2H, J = 8.0), 6.59-6.56 (m, 2H), 6.31-6.30 (m, 1H), 6.08-6.07 (m, 1H), 3.74 (t, 2H, J = 4.0), 3.39 (t, 2H, J = 8.0), 2.92 (t, 2H, J = 8.0), 2.73 (t, 2H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 153.6, 146.7, 141.7, 130.1, 127.5, 113.5, 110.5, 106.5, 64.1, 42.8, 38.5, 28.2. IR (KBr disc, cm^{-1}): 3385, 3021, 2932, 1616, 1521, 1479, 1411, 1385, 1320, 1253, 1211, 1183, 1145, 1121, 1046, 1008, 924, 884, 814, 734, 600, 527. Anal. Calcd for $C_{14}H_{17}NO_2$: C, 72.70; H, 7.41. Found: C, 72.60; H, 7.47.



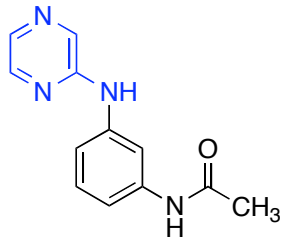
2-(4-((2-(thiophen-2-yl)ethyl)amino)phenyl)ethanol (Table 5, entry 5d). The general procedure A with 0.5 mol% catalyst, LHMDS (2.25 mmol) for 16 h was followed. Isolation and biotage purification afforded the title compound as a red solid (231 mg, 94%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.16 (dd, 1H, J = 4.0), 7.03 (d, 2H, J = 8.0), 6.95 (dd, 1H, J = 8.0, J = 4.0), 6.86-6.84 (m, 1H), 6.58 (d, 2H, J = 12.0), 3.76 (t, 2H, J = 8.0), 3.40 (t, 2H, J = 8.0), 3.10 (t, 2H, J = 8.0), 2.74 (t, 2H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 146.4, 141.8, 130.0, 127.3, 127.0, 125.4, 124.0, 113.4, 64.0, 45.4, 38.3, 29.7. IR (KBr disc, cm^{-1}): 3375, 3019, 2932, 2872, 1615, 1520, 1477, 1437, 1410, 1319, 1253, 1184, 1120, 1045, 848, 817, 699. Anal. Calcd for $C_{14}H_{17}NOS$: C, 67.98; H, 6.93. Found: C, 67.85; H, 6.85. m.p. 50 ºC.



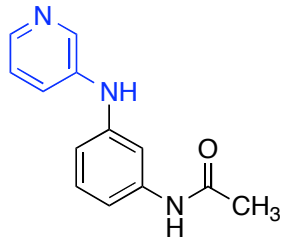
4-((2-(furan-2-yl)ethyl)amino)benzamide (Table 5, entry 5e). The general procedure A with 0.25 mol% catalyst and LHMDS (2.3 mmol) for 12 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (189 mg, 82%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 7.62 (d, 2H, J = 8.0), 7.55 (s, 1H), 7.49-7.48 (m, 1H), 6.87 (s, 1H), 6.51 (d, 2H, J = 8.0), 6.32 (dd, 1H, J = 4.0), 6.22 (t, 1H, J = 6.0), 6.15-6.14 (m, 1H), 3.29 (q, 1H, J = 6.7), 2.82 (t, 2H, J = 8.0). ^{13}C NMR (100 MHz, d_6-DMSO) δ:168.7, 153.9, 151.6, 142.1, 129.8, 121.6, 111.3, 111.1, 106.7, 41.8, 28.0. IR (KBr disc, cm^{-1}): 3381, 3171, 1639, 1608, 1529, 1397, 1333, 1192, 1152, 725. Anal. Calcd for $C_{13}H_{14}N_2O_2$: C, 67.81; H, 6.13. Found: C, 67.74; H, 6.05. m.p. 109 ºC.



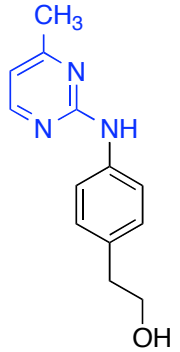
4-((2-(thiophen-2-yl)ethyl)amino)benzamide (Table 5, entry 5f). The general procedure A with 0.5 mol% catalyst for 21 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (221 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.64 (d, 2H, J = 8.0), 7.15-7.14 (m, 1H), 6.94-6.91 (m, 1H), 6.82 (s, 1H), 6.55 (d, 2H, J = 8.0), 5.93 (s, 2H), 4.22 (t, 1H, J = 6.0), 3.44 (q, 2H, J = 6.7), 3.10 (t, 2H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.6, 151.0, 141.4, 129.5, 127.3, 125.7, 124.3, 121.8, 112.1, 44.8, 29.7. IR (KBr disc, cm^{-1}): 3380, 3175, 1640, 1607, 1572, 1527, 1483, 1434, 1395, 1331, 1279, 1189, 1151, 846, 830, 803, 702, 628, 535, 488. Anal. Calcd for $C_{13}H_{14}N_2OS$: C, 63.39; H, 5.73. Found: C, 63.30; H, 5.67. m.p. 102 ºC.



***N*-(3-(pyrazin-2-ylamino)phenyl)acetamide (Table 5, entry 5g)**. The general procedure A with 1 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 16 h was followed. Isolation and biotage purification afforded the title compound as a brownish-white solid (204 mg, 89%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.87 (s, 1H), 9.45 (s, 1H), 8.20 (s, 1H), 8.05 (s, 1H), 7.93 (s, 1H), 7.85 (s, 1H), 7.42 (d, 1H, J = 8.0), 7.13-7.10 (m, 2H), 1.99 (s, 3H). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 168.8, 152.8, 141.4, 141.3, 140.2, 135.6, 133.9, 129.3, 113.6, 112.9, 109.5, 24.5. IR (KBr disc, cm^{-1}): 3304, 1667, 1612, 1550, 1523, 1484, 1428, 1355, 1165, 1144, 1005, 779. Anal. Calcd for $C_{12}H_{12}N_4O$: C, 63.15; H, 5.30. Found: C, 63.06; H, 5.20. m.p. 149 ºC.

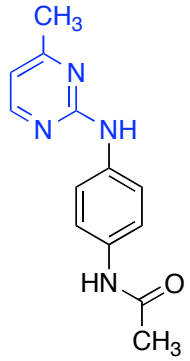


***N*-(3-(pyridin-3-ylamino)phenyl)acetamide (Table 5, entry 5h)**. The general procedure A with 1 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 20 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (220 mg, 97%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.85 (s, 1H), 8.36 (s, 1H), 8.33 (d, 1H, J = 4.0), 7.98 (dd, 1H, J = 4.0, J = 4.0), 7.49 (t, 1H, J = 2.0), 7.43-7.41 (m, 1H), 7.18 (dd, 1H, J = 8.0, J = 4.0), 7.11 (t, 1H, J = 8.0), 7.02-6.98 (m, 1H), 6.72-6.68 (m, 1H), 1.98 (s, 3H). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 168.7, 153.9, 151.6, 142.1, 129.8, 121.6, 111.3, 111.1, 106.7, 28.0. IR (KBr disc, cm^{-1}): 3286, 1669, 1611, 1581, 1548, 1485, 1435, 1370, 1304, 1163, 1022, 782, 692. Anal. Calcd for $C_{13}H_{13}N_3O$: C, 68.70; H, 5.77. Found: C, 68.35; H, 5.97. m.p. 121 ºC.

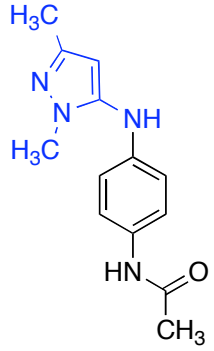


2-(4-((4-methylpyrimidin-2-yl)amino)phenyl)ethanol (Table 5, entry 5i). The general procedure A with 0.25 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 5 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (200 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.18 (d, 1H, J = 8.0), 7.59 (s, 1H),

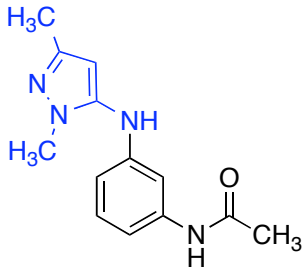
7.48 (d, 2H, J = 12.0), 7.12 (d, 2H, J = 8.0), 6.52 (d, 1H, J = 4.0), 3.77 (t, 2H, J = 6.0), 2.77 (t, 2H, J = 8.0), 2.58 (s, 1H), 2.33 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.4, 160.2, 157.6, 138.2, 132.9, 129.6, 120.1, 112.2, 63.8, 38.8, 24.4. IR (KBr disc, cm^{-1}): 3288, 3113, 2933, 1581, 1567, 1532, 1461, 1420, 1370, 1330, 1285, 1244, 1199, 1116, 1046, 794, 677, 575, 546, 521. Anal. Calcd for $C_{13}H_{15}N_3O$: C, 68.10; H, 6.59. Found: C, 68.30; H, 6.65. m.p. 59 ºC.



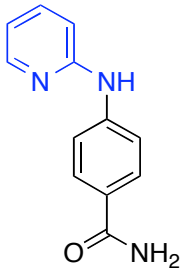
***N*-(4-((4-methylpyrimidin-2-yl)amino)phenyl)acetamide (Table 5, entry 5j)**. The general procedure A with 0.25 mol% catalyst, aryl bromide and LHMDS (2.3 mmol) and dioxane (5 mL) for 5 h was followed. Isolation and biotage purification afforded the title compound as a white solid (143 mg, 60%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.76 (s, 1H), 9.40 (s, 1H), 8.23 (d, 1H, J = 8.0), 7.61 (d, 2H, J = 8.0), 7.40 (d, 2H, J = 8.0), 6.62 (d, 1H, J = 4.0), 2.28 (s, 3H), 1.96 (s, 3H). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 168.4, 168.0, 160.5, 158.1, 136.7, 133.8, 120.1, 119.7, 112.1, 24.5, 24.3. IR (KBr disc, cm^{-1}): 3274, 1665, 1567, 1551, 1514, 1461, 1409, 1384, 1316, 840. Anal. Calcd for $C_{13}H_{14}N_4O$: C, 64.45; H, 5.82. Found: C, 63.98; H, 6.10. m.p. 164 ºC.



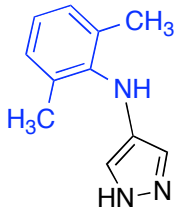
***N*-(4-((1,3-dimethyl-1*H*-pyrazol-5-yl)amino)phenyl)acetamide (Table 5, entry 5k)**. The general procedure A with 0.5 mol% catalyst, aryl bromide and LHMDS (2.25 mmol) and dioxane (5 mL) for 18 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (231 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.51 (s, 1H), 7.25 (d, 2H, J = 8.0), 6.62 (d, 2H, J = 12.0), 6.04 (s, 1H), 5.69 (s, 1H), 3.50 (s, 3H), 2.14 (s, 3H), 2.03 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.1, 147.6, 142.0, 141.5, 131.0, 122.3, 115.4, 97.4, 34.7, 24.2, 14.2. IR (KBr disc, cm^{-1}): 3261, 3041, 2243, 1664, 1611, 1563, 1514, 1445, 1417, 1371, 1305, 1272, 1249, 1177, 1114, 1015, 966, 910, 831, 732, 672. m.p. 55 ºC.



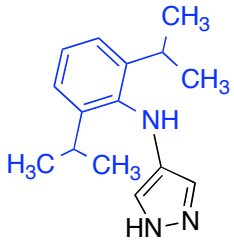
***N*-(3-((1,3-dimethyl-1*H*-pyrazol-5-yl)amino)phenyl)acetamide (Table 5, entry 5l)**. The general procedure A with 1 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 3 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (239 mg, 98%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.49 (s, 1H), 7.07-7.02 (m, 2H), 6.92 (d, 1H, J = 8.0), 6.41 (d, 1H, J = 8.0), 5.88 (s, 1H), 5.75 (s, 1H), 3.50 (s, 3H), 2.15 (s, 3H), 2.08 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.2, 147.7, 147.5, 145.7, 141.2, 139.6, 130.0, 111.5, 110.4, 106.3, 98.6, 34.7, 34.0, 24.6, 14.2, 13.9. IR (KBr disc, cm^{-1}): 3264, 3067, 1670, 1612, 1557, 1494, 1371, 1277, 1197, 1164, 1017, 910, 865, 777, 732, 691, 646. Anal. Calcd for $C_{13}H_{16}N_4O$: C, 63.91; H, 6.60. Found: C, 63.76; H, 6.88. m.p. 142 ºC.



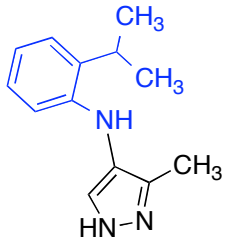
4-(pyridin-2-ylamino)benzamide (Table 5, entry 5m).[7] The general procedure A with 0.25 mol% catalyst, LHMDS (2.3 mmol) and dioxane (5 mL) for 5 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (189 mg, 89%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 9.89 (s, 1H), 8.48 (d, 2H, J = 4.0), 7.78 (s, 6H), 7.15 (s, 1H), 6.85 (t, 1H, J = 6.0). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 168.1, 160.2, 158.6, 143.7, 128.7, 127.1, 117.9, 113.5. IR (KBr disc, cm^{-1}): 3414, 2252, 2126, 1668, 1579, 1530, 1449, 1418, 1386, 1247, 1189, 1027, 825, 763, 628.



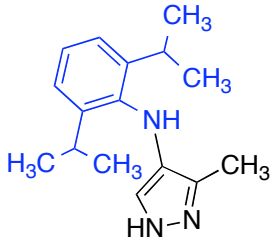
***N*-(2,6-dimethylphenyl)-1*H*-pyrazol-4-amine (Table 6, entry 6a)**. The general procedure A with 3 mol% catalyst, LHMDS (2.2 mL of 1.0 M solution in THF) and aryl bromide for 20 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (166 mg, 89%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.07 (s, 2H), 7.03 (d, 2H, J = 8.0), 6.95-6.91 (m, 1H), 4.67 (s, 1H), 2.18 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 142.1, 131.9, 130.9, 129.0, 123.9, 18.5. IR (KBr disc, cm^{-1}): 3186, 2945, 1582, 1473, 1375, 1263, 1129, 1095, 1001, 942, 838, 767. m.p. 75 ºC.



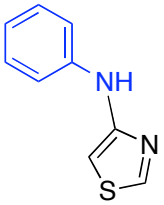
***N*-(2,6-diisopropylphenyl)-1*H*-pyrazol-4-amine (Table 6, entry 6b)**. The general procedure A with 4 mol% catalyst, LHMDS (2.2 mL of 1.0 M solution in THF) and aryl bromide for 20 h was followed. Isolation and biotage purification afforded the title compound as a pale-white solid (183 mg, 75%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.23-7.13 (m, 3H), 7.00 (s, 2H), 4.62 (s, 1H), 3.20 (septet, 2H, J = 7.3), 1.23 (d, 12H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 144.9, 138.9, 133.7, 125.9, 124.0, 28.1, 24.1. IR (KBr disc, cm^{-1}): 3190, 1962, 2868, 1582, 1459, 1383, 1256, 1129, 1057, 1002, 940, 835, 778, 498. Anal. Calcd for $C_{15}H_{21}N_3$: C, 74.03; H, 8.70. Found: C, 73.85; H, 8.66. m.p. 142 ºC.



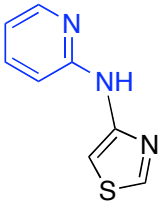
***N*-(2-isopropylphenyl)-3-methyl-1*H*-pyrazol-4-amine (Table 6, entry 6c)**. The general procedure A with 3 mol% catalyst, LHMDS (2.2 mL of 1.0 M solution in THF) and aryl bromide for 20 h was followed. Isolation and biotage purification afforded the title compound as a red liquid (198 mg, 92%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.49 (s, 1H), 7.21-7.18 (m, 1H), 7.03-6.99 (m, 1H), 6.77 (t, 1H, J = 8.0), 6.53 (dd, 1H, J = 8.0), 4.91 (s, 1H), 3.02-2.98 (m, 1H), 2.19 (s, 3H), 1.34 (d, 6H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 144.2, 132.0, 126.7, 125.2, 121.5, 118.3, 112.3, 27.4, 22.6, 22.4, 9.8. IR (KBr disc, cm^{-1}): 3417, 3165, 2960, 1583, 1500, 1448, 1381, 1359, 1293, 1253, 1161, 1081, 1038, 993, 939, 749. Anal. Calcd for $C_{13}H_{17}N_3$: C, 72.52; H, 7.96. Found: C, 71.97; H, 8.10.



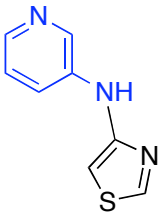
***N*-(2,6-diisopropylphenyl)-3-methyl-1*H*-pyrazol-4-amine (Table 6, entry 6d)**. The general procedure A with 3 mol% catalyst, amine (0.6 mmol), aryl bromide (0.5 mmol), LHMDS (1.1 mL of 1.0 M solution in THF) for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (86 mg, 67%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.13 (s, 3H), 6.70 (s, 1H), 4.32 (s, 1H), 3.15 (septet, 2H, J = 7.3), 2.23 (s, 3H), 2.13 (d, 12H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 143.8, 139.5, 129.8, 125.1, 123.7, 27.9, 23.8, 23.7, 10.2. IR (KBr disc, cm^{-1}): 3183, 2961, 2868, 1584, 1458, 1382, 1352, 1256, 1155, 1100, 1057, 938, 737, 668. Anal. Calcd for $C_{16}H_{23}N_3$: C, 74.67; H, 9.01. Found: C, 74.52; H, 8.98. m.p. 82 ºC.



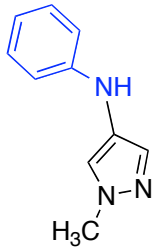
***N*-phenylthiazol-4-amine (Table 6, entry 6e)**. The general procedure C with 3 mol% catalyst, amine (0.6 mmol), aryl bromide (0.5 mmol), NaO*t*-Bu (0.6 mmol) and dioxane (1 mL) for 23 h at 65 ºC was followed. Isolation and biotage purification afforded the title compound as a black solid (60 mg, 68%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.59 (d, 1H, J = 4.0), 7.28 (t, 2H, J = 8.0), 7.11 (d, 2H, J = 8.0), 6.92 (t 1H, J = 8.0), 6.62 (s, 1H), 6.47 (d, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 154.3, 151.1, 142.4, 129.4, 121.1, 116.8, 91.3. IR (KBr disc, cm^{-1}): 3265, 3142, 3068, 1601, 1537, 1496, 1445, 1411, 1384, 1316, 1247, 1168, 878, 803, 756, 689, 645, 498, 481. m.p. 72 ºC.



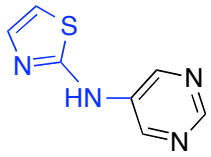
***N*-(pyridin-2-yl)thiazol-4-amine (Table 6, entry 6f)**. The general procedure C with 4 mol% catalyst, amine (1 mmol), aryl bromide (0.5 mmol), NaO*t*-Bu (1 mmol) and dioxane (1 mL) for 20 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow solid (64 mg, 72%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.76 (s, 1H), 8.70 (d, 1H, J = 4.0), 8.56 (d, 2H, J = 4.0), 7.71 (d, 1H, J = 4.0), 6.76 (t, 1H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.0, 158.1, 150.5, 150.0, 112.7, 97.2. IR (KBr disc, cm^{-1}): 3458, 3372, 3230, 3069, 1683, 1626, 1605, 1579, 1490, 1437, 1358, 1269, 1206, 1145, 997, 959, 886, 850, 786, 687. m.p. 145 ºC.



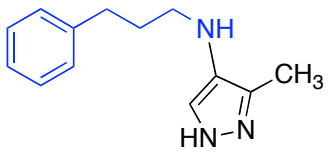
***N*-(pyridin-3-yl)thiazol-4-amine (Table 6, entry 6g)**. The general procedure C with 4 mol% catalyst, amine (0.6 mmol), aryl bromide (0.5 mmol), NaO*t*-Bu (0.65 mmol) and dioxane (4 mL) for 20 h at 65 ºC was followed. Isolation and biotage purification afforded the title compound as a brown solid (49 mg, 60%). ^{1}H NMR (400 MHz, CD_3CN) δ: 8.71 (s, 1H), 8.43 (s. 1H), 8.05 (s, 1H), 7.63-7.61 (m, 1H), 7.46 (s, 1H), 7.20-7.18 (m, 1H), 6.58 (s, 1H). ^{13}C NMR (100 MHz, CD_3CN) δ: 151.9, 141.1, 139.7, 138.6, 123.6, 122.0, 117.3, 94.1. IR (KBr disc, cm^{-1}): 3254, 3059, 1589, 1552, 1484, 1432, 1411, 1283, 1238, 1128, 1049, 857, 800. Anal. Calcd for $C_8H_7N_3S$: C, 54.22; H, 3.98. Found: C, 54.21; H, 3.94. m.p. 100 ºC.



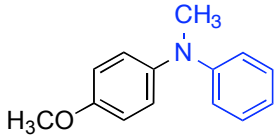
1-methyl-*N*-phenyl-1*H*-pyrazol-4-amine (Table 6, entry 6h). The general procedure C with 3 mol% catalyst, amine (0.6 mmol), aryl bromide (0.5 mmol), NaO*t*-Bu (0.6 mmol) and dioxane (1 mL) for 23 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow solid (82 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.38 (s, 1H), 7.29 (s, 1H), 7.17-7.13 (m, 2H), 6.75-6.71 (m, 3H,), 5.03 (s, 1H), 3.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 146.9, 135.5, 129.3, 124.8, 118.6, 113.5, 39.4. IR (KBr disc, cm^{-1}): 3281, 3105, 1595, 1574, 1520, 1499, 1381, 1362, 1316, 1257, 1169, 1021, 984, 858, 756, 696, 649. m.p. 124 ºC.



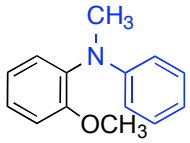
***N*-(pyrimidin-5-yl)thiazol-2-amine (Table 6, entry 6i)**. The general procedure B with 9 mol% catalyst, amine (0.6 mmol), aryl bromide (0.5 mmol), K_2CO_3 (1.2 mmol) and *t*-BuOH (2 mL) was followed. Isolation and biotage purification afforded the title compound as a brown solid (45 mg, 51%). ^{1}H NMR (400 MHz, d_6-DMSO) δ: 10.85 (s, 1H), 9.72 (s, 2H), 8.72 (s, 1H), 7.29 (d,1H), 7.01 (d, 1H, J = 4.0). ^{13}C NMR (100 MHz, d_6-DMSO) δ: 163.4, 151.6, 145.1, 139.6, 137.1, 111.0. IR (KBr disc, cm^{-1}): 2885, 1618, 1579, 1545, 1528, 1430, 1416, 1295, 1188, 864, 711. Anal. Calcd for $C_7H_6N_4S$: C, 47.18; H, 3.39. Found: C, 48.09; H, 3.27. m.p. 145 ºC.



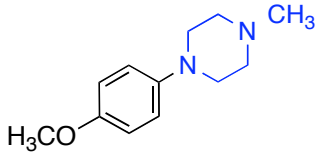
3-methyl-*N*-(3-phenylpropyl)-1*H*-pyrazol-4-amine (Table 6, entry 6j). The general procedure A with 3 mol% catalyst, LHMDS (2.2 mL of 1.0 M solution in THF) for 22 h at 90 ºC was followed. Isolation and biotage purification afforded the title compound as a brown solid (159 mg, 74%). ^{1}H NMR (400 MHz, $CDCl_3$) δ:7.27 (t, 3H, J = 6.0), 7.19 (d, 3H, J = 8.0), 7.02 (s, 1H), 2.98 (t, 2H, J = 6.0), 2.70 (t, 2H, J = 8.0), 2.14 (s, 3H), 1.95-1.89 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 141.9, 130.2, 128.5, 126.0, 48.0, 33.5, 31.4, 10.1. IR (KBr disc, cm^{-1}): 3177, 3025, 2933, 1653, 1602, 1522, 1496, 1454, 1384, 1355, 1184, 1090, 992, 938, 747, 700, 492. Anal. Calcd for $C_{13}H_{17}N_3$: C, 72.52; H, 7.96. Found: C, 71.84; H, 7.76.



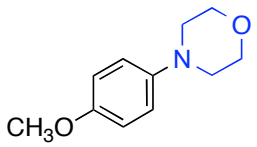
4-methoxy-*N*-methyl-*N*-phenylaniline (Table 7, entry 7a).[8] General procedure F was followed using 4-chloroanisole (337 μL, 2.5 mmol), *N*–methylaniline (327 μL, 3 mmol), NaO*t*-Bu (288 mg, 3 mmol), THF (5 mL), RuPhos (**2**) (0.12 mg, 0.01 mol%) and RuPhos precatalyst (**4**) (0.18 mg, 0.01 mol%), with a reaction time of 4 h. Isolation afforded the title compound as a light yellow oil (529 mg, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 - 7.13 (m, 2H), 7.13 - 7.03 (m, 2H), 6.93 - 6.84 (m, 2H), 6.84 - 6.73 (m, 3H), 3.81 (d, *J* = 1.9 Hz, 4H), 3.25 (d, *J* = 0.5 Hz, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 156.22, 149.68, 142.16, 128.88, 126.22, 118.25, 115.61, 114.71, 55.46, 40.44. IR (KBr disc, cm^{-1}): 2951, 2834, 1596, 1507, 1341, 1241, 1181, 1131, 1034, 834, 791, 750, 694.



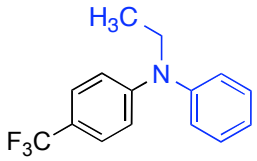
2-methoxy-*N*-methyl-*N*-phenylaniline (Table 7, entry 7b).[9] The general procedure F with 0.05 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow liquid (202 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.28-7.22 (m, 4H), 7.04-7.01 (m, 2H), 6.77-6.70 (m, 3H), 3.81 (s, 3H), 3.27 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 156.3, 149.6, 137.1, 129.4, 129.0, 127.3, 121.6, 117.5, 113.7, 112,9, 55.9, 39.3. IR (KBr disc, cm^{-1}): 2918, 2048, 1918, 1700, 1576, 1497, 1341, 1109, 1027, 990, 872, 784, 744. Anal. Calcd for $C_{14}H_{15}NO$: C, 78.84; H, 7.09. Found: C, 79.01; H, 7.15.



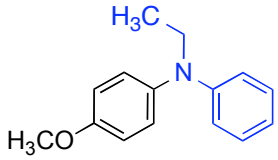
1-(4-methoxyphenyl)-4-methylpiperazine (Table 7, entry 7c).[10] General procedure F was followed using 4-chloroanisole (135 μL, 1 mmol), *N*–methylpiperazine (133 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), THF (2 mL), RuPhos (**2**) (0.42 mg, 0.1 mol%) and RuPhos precatalyst (**4**) (0.78 mg, 0.1 mol%), with a reaction time of 4 h. Isolation afforded the title compound as an orange solid (188 mg, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.86 - 6.79 (m, 2H), 6.79 - 6.63 (m, 2H), 3.68 (s, 3H), 3.02 (dd, *J* = 11.6, 6.6 Hz, 4H), 2.49 (dd, *J* = 17.8, 12.9 Hz, 4H), 2.27 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.45, 145.39, 117.83, 114.10, 55.20, 54.99, 50.27, 45.89. IR (KBr disc, cm^{-1}): 2791, 1513, 1451, 1287, 1250, 1148, 1037, 832. m.p. 65 °C



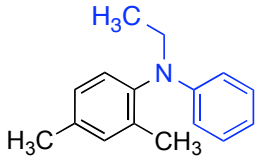
4-(4-methoxyphenyl)morpholine (Table 7, entry 7d).[11] General procedure F was followed using 4-chloroanisole (135 μL, 1 mmol), morpholine (116 μL, 1.2 mmol), NaO*t*-Bu (115 mg, 1.2 mmol), THF (2 mL), RuPhos (**2**) (0.21 mg, 0.05 mol%) and RuPhos precatalyst (**4**) (0.39 mg, 0.05 mol%), with a reaction time of 4 h. Isolation afforded the title compound as a colourless solid (188 mg, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.99 - 6.69 (m, 4H), 3.95 - 3.80 (m, 4H), 3.78 (s, 3H), 3.11 - 2.93 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.76, 145.46, 117.59, 114.29, 66.85, 55.34, 50.60. IR (KBr disc, cm^{-1}): 2971, 2854, 1517, 1453, 1266, 1121, 1030, 818. m.p. 70 °C



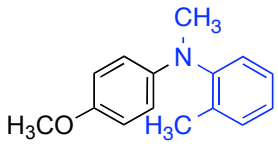
***N*-ethyl-*N*-phenyl-4-(trifluoromethyl)aniline (Table 7, entry 7e)**.[12] The general procedure F with 0.01 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (212 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.44 (t, 4H, J = 8.0), 7.24 (t, 3H, J = 6.0), 6.84 (d, 2H, J = 12.0), 3.86-3.81 (m, 2H), 1.29 (t, 3H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.8, 146.5, 130.2, 126.8, 126.6, 126.5, 125.6, 114.7, 46.8, 12.6. IR (KBr disc, cm^{-1}): 3061, 2977, 1617, 1594, 1522, 1495, 1452, 1383, 1328, 1272, 1241, 1195, 1163, 1119, 1071, 1026, 1005, 942, 825, 768, 711, 699, 621, 594, 568, 503.



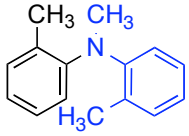
***N*-ethyl-4-methoxy-*N*-phenylaniline (Table 7, entry 7f)**.[12] The general procedure F with 0.05 mol% catalyst for 16 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow liquid (195 mg, 86%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.27 (t, 2H, J = 4.0), 7.17 (d, 2H, J = 8.0), 7.00-6.97 (m, 2H), 6.83 (d, 3H, J = 8.0), 3.87 (s, 3H), 3.79 (q, 2H, J = 6.0), 1.29 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 156.9, 149.0, 140.6, 129.3, 128.0, 118.0, 115.2, 55.7, 46.8, 12.9. IR (KBr disc, cm^{-1}): 3059, 3038, 2971, 2933, 2835, 2056, 1924, 1596, 1574, 1506, 1464, 1442, 1373, 1348, 1241, 1181, 1132, 1100, 1079, 1060, 1036, 991, 890, 870, 833, 776, 749, 694, 640, 578, 559, 521, 502. Anal. Calcd for $C_{15}H_{17}NO$: C, 79.26; H, 7.54. Found: C, 79.40; H, 7.61.



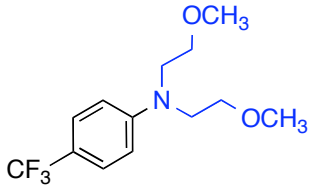
***N*-ethyl-2,4-dimethyl-*N*-phenylaniline (Table 7, entry 7g)**. The general procedure F with 0.1 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (158 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.23-7.16 (m, 3H), 7.07-7.00 (m, 2H), 6.72-6.70 (m, 1H), 6.55-6.52 (m, 2H), 3.68 (q, 2H, J = 6.0), 2.35 (s, 3H), 2.12 (s, 3H), 1.27 (t, 3H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 148.5, 145.0, 137.3, 134.3, 131.4, 130.5, 129.3, 127.5, 116.4, 112.8, 45.9, 21.2, 17.8, 13.1. IR (KBr disc, cm^{-1}): 3023, 2973, 2923, 2869, 1666, 1597, 1575, 1498, 1450, 1412, 1371, 1346, 1269, 1189, 1156, 1142, 1124, 1092, 1062, 1033, 993, 867, 811, 777, 747, 693. Anal. Calcd for $C_{16}H_{19}N$: C, 85.28; H, 8.50. Found: C, 85.10; H, 8.42.



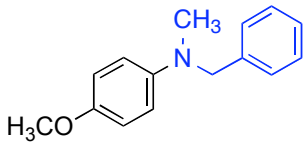
***N*-(4-methoxyphenyl)-*N*,2-dimethylaniline (Table 7, entry 7h)**.[13] The general procedure F with 0.3 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a brown liquid (207 mg, 91%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.30 (d, 1H, J = 8.0), 7.25 (d, 1H, J = 8.0), 7.18 (t, 2H, J = 8.0), 6.83-6.81 (m, 2H), 6.60-6.57 (m, 2H), 3.78 (s, 3H), 3.23 (s, 3H), 2.19 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 152.2, 148.1, 144.3, 136.5, 131.6, 127.6, 125.9, 115.3, 114.8, 56.0, 40.1, 18.3. IR (KBr disc, cm^{-1}): 2949, 1578, 1507, 1378, 1239, 1181, 1115, 1074, 1038, 875, 819, 776, 729, 677, 578, 522. Anal. Calcd for $C_{15}H_{17}NO$: C, 79.26; H, 7.54. Found: C, 79.26; H, 7.69.



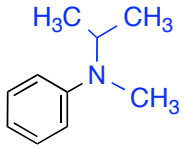
***N*,2-dimethyl-*N*-(*o*-tolyl)aniline (Table 7, entry 7i)**. The general procedure F with 0.3 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as an orange solid (196 mg, 93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.19-7.15 (m, 4H), 7.02 (d, 2H, J = 8.0), 6.98 (d, 2H, J = 8.0), 3.13 (s, 3H), 2.11 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.3, 132.7, 131.7, 126.9, 123.2, 122.0, 41.6, 18.9. IR (KBr disc, cm^{-1}): 3065, 3018, 2950, 2864, 2802, 2361, 1599, 1578, 1490, 1474, 1376, 1315, 1287, 1268, 1235, 1193, 1129, 1102, 1052, 988, 874, 769, 753, 728, 719. Anal. Calcd for $C_{15}H_{17}N$: C, 85.26; H, 8.11. Found: C, 85.45; H, 8.08. m.p. 69 ºC.



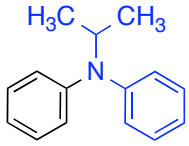
***N*,*N*-bis(2-methoxyethyl)-4-(trifluoromethyl)aniline (Table 7, entry 7j)**. The general procedure F with 0.05 mol% catalyst for 2 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (263 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.41 (d, 2H, J = 12.0), 6.71 (d, 2H, J = 8.0), 3.60-3.52 (m, 8H), 3.33 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.4, 126.8, 126.7, 124.1, 117.7, 117.3, 111.1, 70.1, 59.1, 51.1. IR (KBr disc, cm^{-1}): 2930, 2891, 1721, 1616, 1572, 1532, 1452, 1401, 1331, 1279, 1198, 1164, 1116, 1071, 1014, 962, 819, 712, 638, 592, 509.



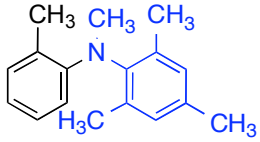
***N*-benzyl-4-methoxy-*N*-methylaniline (Table 7, entry 7k)**.[14] The general procedure F with 0.1 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (216 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.37-7.28 (m, 5H), 6.88-6.78 (m, 4H), 4.47 (s, 2H), 3.78 (s, 3H), 2.96 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 152.0 145.0, 139.5, 128.8, 127.4, 127.1, 115.0, 114.8, 58.2, 56.0, 39.3. IR (KBr disc, cm^{-1}): 3028, 2934, 2831, 1678, 1605, 1514, 1453, 1355, 1296, 1245, 1181, 1117, 1075, 1039, 947, 814, 734, 697. Anal. Calcd for $C_{15}H_{17}NO$: C, 79.26; H, 7.54. Found: C, 78.47; H, 7.57.



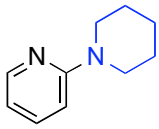
***N*-isopropyl-*N*-methylaniline (Table 7, entry 7l)**. The general procedure F with 2 mmol amine was followed. Isolation and biotage purification afforded the title compound as a colorless liquid (119 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.25-7.21 (m, 2H), 6.81-6.78 (m, 2H), 6.71-6.67 (m, 1H), 4.09 (q, 1H, J = 8.0), 2.72 (s, 3H), 1.16 (d, 6H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.4, 129.3, 116.6, 113.6, 49.1, 30.0, 19.5. IR (KBr disc, cm^{-1}): 2917, 2849, 1713, 1673, 1598, 1503, 1450, 1287, 1232, 1111, 749, 698.



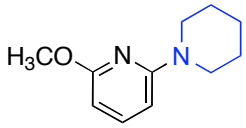
***N*-isopropyl-*N*-phenylaniline (Table 7, entry 7m)**.[15] The general procedure F was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (186 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.38 (t, 4H, J = 8.0), 7.10 (t, 2H, J = 8.0), 6.98 (d, 4H, J = 8.0), 4.44 (m, 1H), 1.27 (d, 6H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 146.5, 129.5, 123.2, 121.9, 48.1, 21.4. IR (KBr disc, cm^{-1}): 3069, 3035, 2972, 2933, 2874, 1662, 1588, 1573, 1494, 1460, 1386, 1364, 1347, 1291, 1233, 1195, 1171, 1125, 1072, 1038, 1026, 1000, 987, 890, 868, 770, 747, 703, 618, 563.



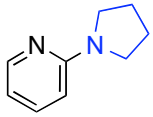
***N*,2,4,6-tetramethyl-*N*-(*o*-tolyl)aniline (Table 7, entry 7n)**. The general procedure F for 16 h was followed. Isolation and biotage purification afforded the title compound as a white solid (229 mg, 96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.21 (d, 1H, J = 8.0), 6.98 (d, 2H, J = 8.0), 6.85 (s, 2H), 6.79 (d, 1H, J = 4.0), 3.19 (s, 3H), 2.29 (s, 3H), 2.07 (s, 6H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.4, 144.3, 136.1, 135.3, 132.3, 129.8, 127.0, 119.2, 115.7, 40.6, 21.1, 20.4, 19.1. IR (KBr disc, cm^{-1}): 2951, 2805, 2360, 1599, 1485, 1375, 1326, 1288, 1231, 1171, 1117, 1059, 1033, 990, 853, 762, 746, 715, 669, 607, 583. Anal. Calcd for $C_{17}H_{21}N$: C, 85.30; H, 8.84. Found: C, 85.08; H, 8.75. m.p. 79-83 ºC.



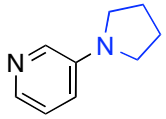
2-(piperidin-1-yl)pyridine (Table 8, entry 8a).[16] The general procedure F with 0.1 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a colorless liquid (146 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.13-8.11 (m, 1H), 7.40-7.36 (m, 1H), 6.59 (d, 1H, J = 8.0), 6.51-6.48 (m, 1H), 3.47 (s, 4H), 1.59 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.9, 148.1, 137.5, 112.6, 107.3, 46.5, 52.7, 24.9. IR (KBr disc, cm^{-1}): 3002, 2933, 2853, 1717, 1596, 1562, 1484, 1438, 1385, 1360, 1311, 1269, 1246, 1224, 1165, 1130, 1094, 1051, 1025, 978, 954, 932, 854, 770, 731, 627, 524.



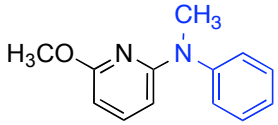
2-methoxy-6-(piperidin-1-yl)pyridine (Table 8, entry 8b). The general procedure F with 0.025 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a red oil (173 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34 (t, 1H, J = 8.0), 6.13 (d, 1H, J = 8.0), 5.99 (d, 1H, J = 8.0), 3.84 (s, 3H), 3.48 (s, 4H), 1.60 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 163.2, 158.7, 140.2, 98.3, 97.2, 53.1, 46.5, 25.7, 25.0. IR (KBr disc, cm^{-1}): 2935, 2853, 1596, 1463, 1413, 1385, 1277, 1248, 1227, 1154, 1127, 1072, 1026, 981, 971, 854, 777, 721. Anal. Calcd for $C_{11}H_{16}N_2O$: C, 68.72; H, 8.39. Found: C, 68.58; H, 8.56.



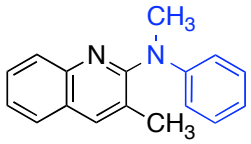
2-(pyrrolidin-1-yl)pyridine (Table 8, entry 8c).[17] The general procedure F with 0.1 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a colorless liquid (138 mg, 93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.12-8.10 (m, 1H), 7.40-7.35 (m, 1H), 6.46 (t, 1H, J = 6.0), 6.30 (d, 1H, J = 8.0), 3.40 (m, 4H), 1.96 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.5, 148.4, 137.1, 111.2, 106.7, 46.8, 25.7. IR (KBr disc, cm^{-1}): 2968, 2851, 2361, 1707, 1598, 1555, 1499, 1484, 1444, 1385, 1347, 1300, 1242, 1155, 993, 769, 733, 668, 467.



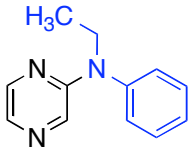
3-(pyrrolidin-1-yl)pyridine (Table 8, entry 8d).[17] The general procedure F with 1 mol% catalyst for 12 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (129 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.95 (m, 1H), 7.89 (d, 1H, J = 4.0), 7.07 (dd, 1H, J = 8.0, J = 4.0), 6.78-6.75 (m, 1H), 3.28-3.24 (m, 4H), 2.01-1.96 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 143.9, 136.9, 134.4, 123.7, 117.9, 47.4, 25.6. IR (KBr disc, cm^{-1}): 3391, 3037, 2969, 2839, 1586, 1559, 1494, 1462, 1431, 1375, 1246, 1178, 1159, 1111, 1051, 1004, 959, 792, 708, 614.



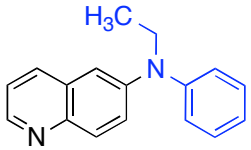
6-methoxy-*N*-methyl-*N*-phenylpyridin-2-amine (Table 8, entry 8e).[16] The general procedure F with 0.025 mol% catalyst for 3 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (201 mg, 94%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.40-7.36 (m, 2H), 7.29-7.19 (m, 4H), 6.08-6.05 (m, 2H), 3.90 (s, 3H), 3.49 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 163.4, 157.8, 147.0, 139.6, 129.7, 126.6, 126.5, 125.4, 100.4, 97.5, 53.3, 38.3. IR (KBr disc, cm^{-1}): 3005, 2945, 1602, 1582, 1498, 1464, 1406, 1360, 1300, 1283, 1150, 1117, 1093, 1035, 982, 965, 811, 729. Anal. Calcd for $C_{13}H_{14}N_2O$: C, 72.87; H, 6.59. Found: C, 73.01; H, 6.59.



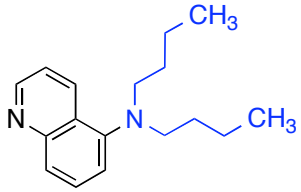
***N*,3-dimethyl-*N*-phenylquinolin-2-amine (Table 8, entry 8f)**. The general procedure F with 0.6 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a brown solid (211 mg, 85%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.91 (d, 1H, J = 8.0), 7.73 (s, 1H), 7.64 (d, 1H, J = 8.0), 7.57 (t, 1H, J = 8.0), 7.36 (t, 1H, J = 8.0), 7.25 (t, 2H, J = 6.0), 7.00 (t, 1H, J = 8.0), 6.93 (d, 2H, J = 8.0), 3.57 (s, 3H), 1.91 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 158.7, 149.5, 146.6, 138.3, 129.4, 128.6, 127.6, 127.1, 126.6, 126.2, 124.6, 122.9, 122.0, 41.6, 20.0. IR (KBr disc, cm^{-1}): 3059, 2963, 1621, 1595, 1560, 1492, 1471, 1431, 1400, 1353, 1298, 1283, 1170, 1137, 1106, 1046, 1010, 903, 858, 792, 727, 755, 698, 618, 585, 515, 481. Anal. Calcd for $C_{17}H_{16}N_2$: C, 82.22; H, 6.49. Found: C, 82.02; H, 6.53. m.p. 57 ºC.



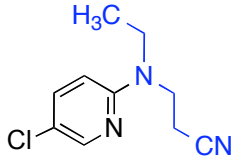
***N*-ethyl-*N*-phenylpyrazin-2-amine (Table 8, entry 8g)**. The general procedure F for 12 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (192 mg, 96%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.00-7.99 (m, 1H), 7.72 (t, 2H, J = 8.0), 7.39-7.35 (m, 2H), 7.24-7.22 (m, 1H), 7.19-7.17 (m, 2H), 3.90 (q, 2H, J = 8.0), 1.15 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 154.5, 143.7,141.6, 133.1, 132.5, 130.4, 127.8, 127.0, 45.1, 12.9. IR (KBr disc, cm^{-1}): 3431, 3057, 2974, 2931, 2871, 1899, 1598, 1574, 1517, 1496, 1480, 1454, 1419, 1375, 1354, 1315, 1282, 1255, 1203, 1178, 1153, 1138, 1094, 1070, 1053, 1026, 997, 914, 825, 785, 767, 700, 637, 572. Anal. Calcd for $C_{12}H_{13}N_3$: C, 72.33; H, 6.58. Found: C, 72.44; H, 6.65.



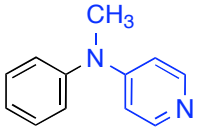
***N*-ethyl-*N*-phenylquinolin-6-amine (Table 8, entry 8h)**. The general procedure F with 0.2 mol% catalyst for 16 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (235 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.64 (s, 1H), 7.87-7.85 (m, 2H), 7.31-7.28 (m, 3H), 7.22-7.19 (m, 1H), 7.11-7.04 (m, 4H), 3.86-3.81 (m, 2H), 1.25-1.21 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 147.6, 147.2, 146.1, 144.1, 134.5, 130.1, 129.9, 129.8, 124.3, 124.2, 123.7, 121.5, 111.2, 47.0, 12.8. IR (KBr disc, cm^{-1}): 3391, 3034, 2972, 2932, 2871, 1936, 1620, 1591, 1494, 1465, 1436, 1384, 1349, 1253, 1180, 1155, 1120, 1091, 1032, 957, 929, 829, 767, 700, 617. Anal. Calcd for $C_{17}H_{16}N_2$: C, 82.22; H, 6.49. Found: C, 81.54; H, 6.70.



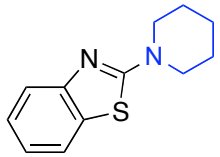
***N*,*N*-dibutylquinolin-5-amine (Table 8, entry 8i)**. The general procedure F with 1 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a brown liquid (210 mg, 82%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.81-8.80 (m, 1H), 8.55 (d, 1H, J = 8.0), 7.76 (d, 1H, J = 8.0), 7.54 (t, 1H, J = 8.0),7.29-7.27 (m, 1H), 7.12 (d, 1H, J = 8.0), 3.02 (t, 4H, J = 4.0), 1.42-1.37 (m, 4H), 1.24-1.16 (m, 4H), 0.81-0.75 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.2, 149.8, 149.0, 132.9, 129.2, 126.4, 124.6, 120.3, 118.5, 54.4, 29.3, 20.6, 14.1. IR (KBr disc, cm^{-1}): 3064, 3031, 2957, 2931, 2862, 1608, 1589, 1572, 1497, 1468, 1398, 1378, 1314, 1277, 1200, 1161, 1132, 1079, 1055, 1023, 925, 901, 802, 744, 692, 603, 585.



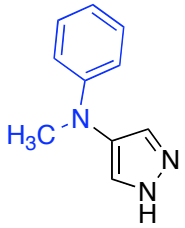
3-((5-chloropyridin-2-yl)(ethyl)amino)propanenitrile (Table 8, entry 8j). The general procedure G with 1 mol% catalyst, 2 mmol amine and 2 mmol Cs_2CO_3 for 24 h was followed. Isolation and biotage purification afforded the title compound as a light-yellow liquid (154 mg, 74%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.00 (s, 1H), 7.35 (dd, 1H, J = 8.0, J = 4.0), 6.42 (d, 1H, J = 8.0), 3.73 (t, 2H, J = 6.0), 3.44 (q, 2H, J = 6.7), 2.66 (t, 2H, J = 6.0), 1.14 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 155.4, 146.5, 137.4, 119.6, 119.2, 106,9, 45.3, 44.9, 16.8, 12.6. IR (KBr disc, cm^{-1}): 2975, 2248, 1592, 1552, 1495, 1412, 1373, 1324, 1283, 1218, 1186, 1138, 1114, 1078, 1044, 998, 920, 808, 776, 755, 638, 608, 515. Anal. Calcd for $C_{10}H_{12}ClN_3$: C, 57.28; H, 5.77. Found: C, 57.58; H, 5.80.



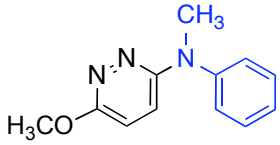
***N*-methyl-*N*-phenylpyridin-4-amine (Table 8, entry 8k)**.[18] The general procedure F was followed. Isolation and biotage purification afforded the title compound as a colorless liquid (130 mg, 71%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.44 (d, 2H, J = 4.0), 6.66 (t, 2H, J = 6.0), 6.50 (t, 1H, J = 8.0), 6.44 (d, 2H, J = 8.0), 5.78 (d, 2H, J = 8.0), 2.54 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 153.2, 149.3, 145.6, 129.4, 126.1, 125.9, 107.7, 38.9. IR (KBr disc, cm^{-1}): 3372, 3035, 1606, 1587, 1551, 1538, 1506, 1495, 1453, 1433, 1364, 1364, 1241, 1225, 1137, 1078, 1025, 991, 877, 810, 771, 700, 597, 570, 533.



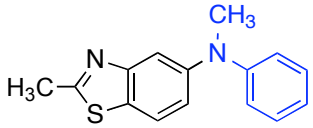
2-(piperidin-1-yl)benzo[*d*]thiazole (Table 8, entry 8l).[19] The general procedure F with NaO*t*-Bu (1.4 mmol) at room temperature for 12 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (181 mg, 83%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.56-7.49 (m, 2H), 7.26-7.22 (m, 1H), 7.01 (t, 1H, J = 8.0), 3.57 (s, 4H), 1.66 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ:169.1, 153.2, 130.9, 126.1, 121.2, 120.8, 119.0, 49.8, 25.5, 24.5. IR (KBr disc, cm^{-1}): 2936, 2852, 1595, 1563, 1535, 1444, 1384, 1338, 1290, 1258, 1239, 1209, 1123, 1012, 751, 724. m.p. 93-95 ºC (94 ºC).



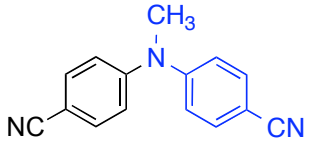
***N*-methyl-*N*-phenyl-1*H*-pyrazol-4-amine (Table 8, entry 8m)**. The general procedure H with SPhos precatalyst[2] (2 mol%), SPhos (2 mol%), amine (0.6 mmol), aryl bromide (0.5 mmol), LHMDS (1.1 mL of 1.0 M solution in THF) for 24 h at 100 ºC was followed. Isolation and biotage purification afforded the title compound as a yellow solid (73 mg, 84%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.51 (s, 2H), 7.22-7.18 (m, 3H), 6.85-7.83 (m, 2H), 6.79-6.76 (m, 1H), 3.22 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.5, 131.8, 129.0, 118.4, 114.6, 41.0. IR (KBr disc, cm^{-1}): 3175, 2949, 1599, 1580, 1498, 1372, 1294, 1154, 996, 942, 750, 693, 668. Anal. Calcd for $C_{10}H_{11}N_3$: C, 69.34; H, 6.40. Found: C, 68.44; H, 6.62. m.p. 53 °C.



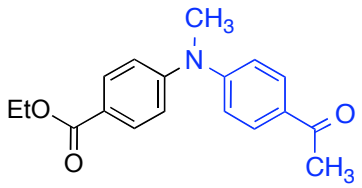
6-methoxy-*N*-methyl-*N*-phenylpyridazin-3-amine (Table 8, entry 8n).[16] The general procedure G with 0.25 mol% catalyst for 18 h was followed. Isolation and biotage purification afforded the title compound as a white solid (196 mg, 91%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.31 (t, 2H, J = 8.0), 7.15-7.11 (m, 3H), 6.76 (d, 1H, J = 12.0), 6.60 (d, 1H, J = 12.0), 3.96 (s, 3H), 3.45 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 160.2, 156.9, 146.7, 130.1, 126.0, 125.9, 120.5, 118.9, 54.4, 39.3. IR (KBr disc, cm^{-1}): 2948, 1596, 1495, 1548, 1495, 1472, 1435, 1404, 1355, 1296, 1198, 1172, 1139, 1065, 1013, 871, 832, 807, 769, 700, 592. m.p. 80 ºC (76-77 ºC).



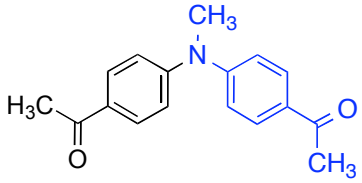
***N*,2-dimethyl-*N*-phenylbenzo[*d*]thiazol-5-amine (Table 8, entry 8o)**. The general procedure G with 1.5 mol% catalyst for 18 h was followed. Isolation and biotage purification afforded the title compound as a white solid (226 mg, 89%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.61-7.58 (m, 2H), 7.28-7.24 (m, 2H), 7.05-7.02 (m, 3H), 6.95 (t, 1H, J = 8.0), 3.34 (s, 3H), 2.78 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.0, 155.0, 149.3, 148.2, 129.5, 128.3, 121.9, 121.8, 121.6, 120.9, 119.4, 113.4, 40.9, 20.4. IR (KBr disc, cm^{-1}): 3059, 2921, 2812, 1593, 1547, 1523, 1495, 1464, 1429, 1343, 1291, 1254, 1205, 1172, 1123, 1073, 1052, 1027, 1001, 942, 837, 806, 753, 699, 644. Anal. Calcd for $C_{15}H_{14}N_2S$: C, 70.83; H, 5.55. Found: C, 71.03; H, 5.50. m.p. 84 ºC.



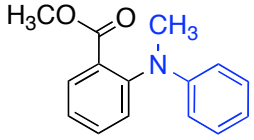
4,4'-(methylazanediyl)dibenzonitrile (Table 9, entry 9a).[20] The general procedure G with 0.2 mol% catalyst 20 h was followed. Isolation and biotage purification afforded the title compound as a white solid (198 mg, 85%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.52 (d, 4H, J = 6), 7.08 (d, 4H, J = 6), 3.38 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.8, 133.8, 120.8, 119.3, 105.1, 40.2.IR (KBr disc, cm^{-1}): 3081, 2916, 2221, 1611, 1594, 1553, 1504, 1344, 1306, 1275, 1259, 1178, 1142, 1104, 1066, 961, 909, 871, 827, 729. Anal. Calcd for $C_{15}H_{11}N_3$: C, 77.23; H, 4.75. Found: C, 77.04; H, 4.70. m.p. 151 ºC (153 ºC).



Ethyl 4-((4-acetylphenyl)(methyl)amino)benzoate (Table 9, entry 9b). The general procedure G with 0.2 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a yellow solid (290 mg, 98%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.95 (d, 2H, J = 8.0), 7.84 (d, 2H, J = 8.0), 7.09 (d, 2H, J = 8.0), 7.01 (d, 2H, J = 12.0), 4.31 (q, 2H, J = 8.0), 3.38 (s, 3H), 2.50 (s, 3H), 1.34 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.8, 166.4, 151.9, 151.5, 131.3, 130.3, 124.6, 121.0, 118.8, 61.0, 40.2, 26.5, 14.6. IR (KBr disc, cm^{-1}): 2981, 1709, 1673, 1611, 1591, 1562, 1509, 1475, 1428, 1357, 1312, 1273, 1181, 1106, 1064, 1019, 956, 875, 837, 772, 708, 595, 513. Anal. Calcd for $C_{18}H_{19}NO_3$: C, 72.71; H, 6.44. Found: C, 72.59; H, 6.41. m.p. 89 ºC.

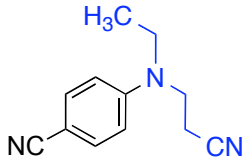


1,1'-((methylazanediyl)bis(4,1-phenylene))diethanone (Table 9, entry 9c). The general procedure G with 0.2 mol% catalyst was followed. Isolation and biotage purification afforded the title compound as a brown solid (248 mg, 93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.87 (d, 4H, J = 8), 7.07 (d, 4H, J = 8), 3.40 (s, 3H), 2.52 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 196.8, 151.7, 131.1, 130.3, 120.0, 40.2, 26.6. IR (KBr disc, cm^{-1}): 1661, 1587, 1510, 1426, 1358, 1309, 1267, 1185, 1137, 1110, 956, 875, 831, 584. Anal. Calcd for $C_{17}H_{17}NO_2$: C, 76.36; H, 6.41. Found: C, 76.10; H, 6.37. m.p. 108 ºC.

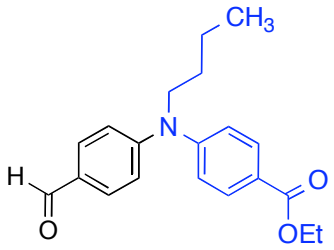


Methyl 2-(methyl(phenyl)amino)benzoate (Table 9, entry 9d). The general procedure G with 1.5 mol% catalyst for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (169 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.81-7.78 (m, 1H), 7.52 (t, 1H, J = 8.0), 7.29-7.24 (m, 2H), 7.18-7.14 (m, 2H), 6.74 (t, 1H, J = 4.0), 6.65-6.62 (m, 2H), 3.58 (s, 3H), 3.28 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.7, 149.4, 148.3, 133.5, 131.6, 129.4, 129.2, 129.1, 125.4, 118.2, 114.5, 52.3, 40.6. IR (KBr disc, cm^{-1}): 3026, 2949, 1884, 2814, 1730, 1594, 1578, 1501, 1490, 1453, 1433, 1349, 1293, 1247, 1188, 1159, 1127, 1097, 1081, 1040, 991, 965, 871, 821,

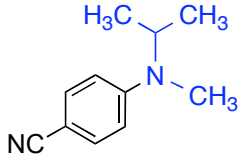
773, 750, 715, 694, 656. Anal. Calcd for $C_{15}H_{15}NO_2$: C, 74.67; H, 6.27. Found: C, 74.39; H, 6.25.



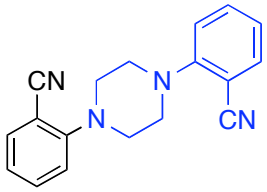
4-((2-cyanoethyl)(ethyl)amino)benzonitrile (Table 9, entry 9e). The general procedure G for 18 h was followed. Isolation and biotage purification afforded the title compound as a white solid (130 mg, 65%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.46 (d, 2H, J = 8.0), 6.62 (d, 2H, J = 12.0), 3.67 (t, 2H, J = 8.0), 3.50-3.47 (m, 2H), 2.60 (t, 2H, J = 6.0), 1.19 (t, 3H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.4, 134.1, 120.3, 117.9, 111.7, 99.0, 46.4, 45.7, 16.3, 12.3. IR (KBr disc, cm^{-1}): 2976, 2360, 2210, 1606, 1521, 1404, 1369, 1278, 1177, 1002, 816, 548. m.p. 85-88 ºC.



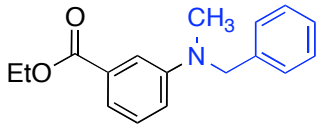
Ethyl 4-(butyl(4-formylphenyl)amino)benzoate (Table 9, entry 9f). The general procedure G with 0.2 mol% catalyst for 19 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (257 mg, 79%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.76 (s, 1H), 7.99 (d, 2H, J = 8.0), 7.69 (d, 2H, J = 10.0), 7.15 (d, 2H, J = 8.0), 6.92 (d, 2H, J = 6.0), 4.32 (q, 2H, J = 6.0), 3.76 (t, 2H, J = 8.0), 1.67-1.61 (m, 2H), 1.36-1.30 (m, 5H), 0.89 (t, 3H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 190.6, 166.2, 152.6, 150.4, 131.8, 131.5, 128.8, 126.0, 123.6, 117.5, 61.1, 52.4, 29.7, 20.4, 14.6, 14.0. IR (KBr disc, cm^{-1}): 2959, 2932, 2873, 2731, 1710, 1610, 1591, 1561, 1509, 1465, 1418, 1366, 1311, 1274, 1214, 1168, 1141. 1107, 1018, 879, 832, 772, 733, 704. Anal. Calcd for $C_{20}H_{23}NO_3$: C, 73.82; H, 7.12. Found: C, 73.76; H, 7.07.



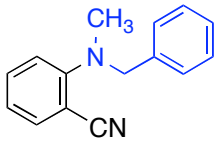
4-(isopropyl(methyl)amino)benzonitrile (Table 9, entry 9g).[21] The general procedure G with 1 mol% catalyst for 12 h was followed. Isolation and biotage purification afforded the title compound as a white solid (130 mg, 82%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.30 (d, 2H, J = 8.0), 6.56 (d, 2H, J = 8.0), 4.04-4.00 (m, 1H), 2.66 (s, 3H), 1.07 (d, 6H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 152.3, 133.6, 120.9, 111.8, 96.9, 48.4, 29.9, 19.7. IR (KBr disc, cm^{-1}): 2974, 2212, 1605, 1519, 1483, 1394, 1350, 1219, 1182, 1127, 1046, 1004, 937, 817, 774. Anal. Calcd for $C_{11}H_{14}N_2$: C, 75.82; H, 8.10. Found: C, 75.84; H, 8.26. m.p. 47 ºC (46 ºC).



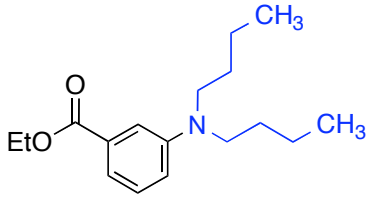
2,2'-(piperazine-1,4-diyl)dibenzonitrile (Table 9, entry 9h). The general procedure G with 1 mol% catalyst in THF for 20 h was followed. Isolation and biotage purification afforded the title compound as a white solid (207 mg, 72%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.56-7.54 (m, 2H), 7.49-7.47 (m, 2H), 7.06-7.00 (m, 4H), 3.38 (s, 8H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 155.7, 134.5, 134.2, 122.5, 119.2, 118.6, 106.6, 51.9. IR (KBr disc, cm^{-1}): 2818, 2219, 1595, 1570, 1489, 1447, 1372, 1337, 1285, 1256, 1225, 1167, 1140, 1106, 1038, 941, 764, 718. Anal. Calcd for $C_{18}H_{16}N_4$: C, 74.98; H, 5.59. Found: C, 74.14; H, 5.89. m.p. 149 ºC.



Ethyl 3-(benzyl(methyl)amino)benzoate (Table 9, entry 9i). The general procedure G with 1.5 mmol amine and 3 mol% catalyst in THF for 22 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (245 mg, 91%). Ethyl benzoate was found in 3% yield from this reaction. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.52-7.51 (m, 1H), 7.44 (d, 1H, J = 8.0), 7.35-7.23 (m, 6H), 6.91 (dd, 1H, J = 8.0), 4.57 (s, 2H), 4.37 (q, 2H, J = 8.0), 3.07 (s, 3H), 1.39 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.3, 149.7, 138.6, 131.4, 129.2, 128.7, 127.1, 126.8, 117.6, 116.7, 113.1, 60.9, 56.5, 38.7, 14.5. IR (KBr disc, cm^{-1}): 3063, 3029, 2981, 2903, 1716, 1602, 1578, 1496, 1451, 1424, 1375, 1268, 1214, 1174, 1083, 1109, 1083, 1027, 988, 955, 863, 800, 753, 732, 697, 684, 668, 608, 555, 458. Anal. Calcd for $C_{17}H_{19}NO_2$: C, 75.81; H, 7.11. Found: C, 75.58; H, 7.14.

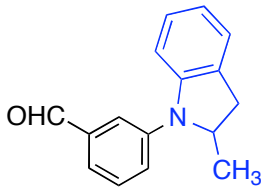


2-(benzyl(methyl)amino)benzonitrile (Table 9, entry 9j).[22] The general procedure G with 1 mol% catalyst in THF for 19 h was followed. Isolation and biotage purification afforded the title compound as a colorless liquid (198 mg, 89%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.54-7.52 (m, 1H), 7.41-7.32 (m, 5H), 7.29-7.26 (m, 1H), 6.94-6.87 (m, 2H), 4.50 (s, 2H), 2.91 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 154.9, 137.4, 135.0, 133.7, 128.6, 127.9, 127.5, 120.1, 119.5, 118.4, 102.5, 59.7, 40.1. IR (KBr disc, cm^{-1}): 3584, 2214, 1595, 1487, 1451, 1423, 1358, 1180, 1113, 1046, 942.

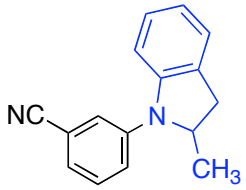


Ethyl 3-(dibutylamino)benzoate (Table 9, entry 9k). The general procedure G with 5 mol% catalyst in THF for 24 h was followed. Isolation and biotage purification afforded

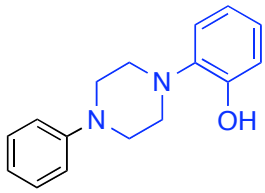
the title compound as a colorless liquid (211 mg, 76%). Ethyl benzoate was found in 6% yield from this reaction. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.32-7.20 (m, 3H), 6.79-6.77 (m, 1H), 4.31 (q, 2H, J = 8.0), 3.29-3.25 (m, 4H), 1.58-1.51 (m, 4H), 1.38-1.31 (m, 7H), 0.94 (t, 6H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.8, 148.3, 131.4, 129.2, 116.3, 116.0, 112.7, 60.9, 50.9, 29.5, 20.5, 14.5, 14.2. IR (KBr disc, cm^{-1}): 2958, 2933, 2873, 1718, 1602, 1576, 1497, 1456, 1367, 1289, 1265, 1217, 1179, 1110, 1084, 1032, 993, 933, 863, 798, 751, 686, 668. Anal. Calcd for $C_{17}H_{27}NO_2$: C, 73.61; H, 9.81. Found: C, 73.78; H, 9.99.



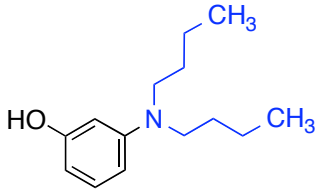
3-(2-methylindolin-1-yl)benzaldehyde (Table 9, entry 9l). The general procedure G with 1 mol% catalyst for 22 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (206 mg, 87%). Benzaldehyde was found in 3% yield from this reaction. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.98 (s, 1H), 7.72 (s, 1H), 7.54-7.48 (m, 3H), 7.16 (d, 1H, J = 8.0), 7.06 (t, 1H, J = 8.0), 6.93 (d, 1H, J = 8.0), 6.78 (t, 1H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 192.6, 147.2, 144.5, 137.8, 130.1, 127.4, 126.2, 125.5, 123.9, 120.1, 119.9, 109.0, 59.7, 37.2, 20.3. IR (KBr disc, cm^{-1}): 3049, 2968, 2845, 2727, 1699, 1592, 1489, 1462, 1392, 1284, 1248, 1224, 1182, 1156, 1106, 1058, 1027, 987, 931, 852, 816, 788, 747, 715, 692, 669, 648. Anal. Calcd for $C_{16}H_{15}NO$: C, 80.98; H, 6.37. Found: C, 80.76; H, 6.33.



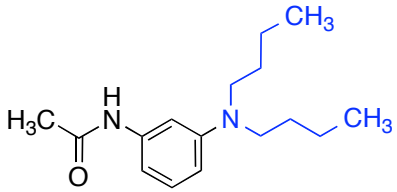
3-(2-methylindolin-1-yl)benzonitrile (Table 9, entry 9m). The general procedure G with 1 mol% catalyst for 24 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (220 mg, 94%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.47 (d, 1H, J = 12.0), 7.40 (t, 1H, J = 8.0), 7.21 (dd, 1H, J = 14.0, J = 8.0), 7.09 (t, 1H, J = 8.0), 6.96 (d, 1H, J = 8.0), 6.82 (t, 1H, J = 8.0), 4.40-4.35 (m, 1H), 3.37 (dd, 1H, J = 12.0, J = 8.0), 2.73 (dd, 1H, J = 12.0, J = 8.0), 1.33 (d, 2H, J = 4.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 146.0, 144.2, 130.2, 127.3, 125.5, 124.7, 123.5, 122.1, 120.4, 119.1, 113.2, 109.3, 59.5, 37.0, 20.1. IR (KBr disc, cm^{-1}): 3072, 2969, 2849, 2229, 1590, 1574, 1489, 1461, 1432, 1376, 1309, 1284, 1249, 1224, 1179, 1162, 1091, 1057, 1028, 1002, 983, 905, 786, 748, 720, 686, 600, 498. Anal. Calcd for $C_{16}H_{14}N_2$: C, 82.02; H, 6.02. Found: C, 82.26; H, 5.94.



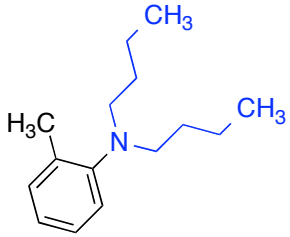
2-(4-phenylpiperazin-1-yl)phenol (Table 10, entry 10a). The general procedure H with 0.15 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (178 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.31-7.27 (t, 2H), 7.21-7.19 (d, 1H), 7.12-7.08 (m, 1H), 6.99-6.96 (m, 4H), 6.92-6.86 (m, 2H), 3.33 (t, 4H, J = 6.0), 3.03 (t, 4H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 151.7, 151.4, 139.0, 129.4, 126.9, 121.6, 120.4, 116.6, 114.4, 52.9, 50.3. IR (KBr disc, cm^{-1}): 3174, 2831, 1594, 1505, 1493, 1453, 1378, 1315, 1262, 1225, 1180, 1134, 1095, 930, 774, 760, 701. Anal. Calcd for $C_{16}H_{18}N_2O$: C, 75.56; H, 7.13. Found: C, 75.61; H, 7.17.



3-(dibutylamino)phenol (Table 10, entry 10b).[23] The general procedure H with 1.5 mol% catalyst for 8 h was followed. Isolation and biotage purification afforded the title compound as a red liquid (195 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.01 (t, 1H, J = 8.0), 6.22 (d, 1H, J = 8.0), 6.09 (t, 2H, J = 8.0), 3.20 (t, 4H, J = 8.0), 1.57-1.49 (m, 4H), 1.36-1.28 (m, 4H), 0.92 (t, 7H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 156.9, 150.0, 130.2, 104.9, 102.4, 98.8, 51.1, 29.6, 20.6, 14.2. IR (KBr disc, cm^{-1}): 2958, 2932, 2872, 1620, 1512, 1462, 1402, 1367, 1243, 1197, 1110, 1029, 942, 821, 751, 689.

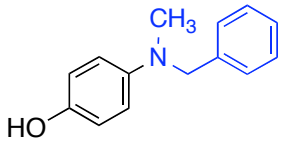


***N*-(3-(dibutylamino)phenyl)acetamide (Table 10, entry 10c)**. The general procedure H with 1.5 mol% catalyst for 8 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (240 mg, 92%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.66 (s, 1H), 7.08-7.01 (m, 2H), 6.61 (d, 1H, J = 8.0), 6.35 (dd, 1H, J = 8.0), 3.22-3.18 (m, 4H), 2.12 (s, 3H), 1.56-1.45 (m, 4H), 1.35-1.28 (m, 4H), 0.91 (t, 6H, J = 6.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.7, 149.0, 139.4, 129.6, 108.0, 106.9, 103.5, 51.0, 29.6, 24.9, 20.6, 14.2. IR (KBr disc, cm^{-1}): 3302, 2957, 2932, 2872, 1662, 1613, 1583, 1554, 1499, 1457, 1369, 1322, 1273, 1177, 1147, 1111, 1035, 989, 930, 853, 764, 690, 535.

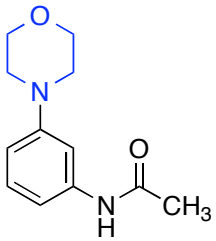


***N*,*N*-dibutyl-2-methylaniline (Table 10, entry 10d)**.[24] The general procedure H with 2 mol% SPhos precatalyst and 2 mol% SPhos for 12 h at room temperature was followed. Isolation and biotage purification afforded the title compound as a light-yellow liquid (164 mg, 75%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.14 (t, 2H, J = 8.0), 7.07 (t, 1H, J = 8.0), 6.94 (t, 1H, J = 8.0), 2.88 (t, 4 H, J = 8.0), 2.27 (s, 3H), 1.39-1.33 (m, 4H), 1.29-1.20 (m, 4H), 0.84 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.8, 135.2, 131.1, 126.2, 123.2,

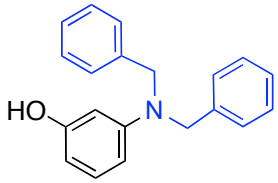
122.3, 54.0, 29.7, 20.7, 18.6, 14.3. IR (KBr disc, cm^{-1}): 2957, 2931, 2861, 1599, 1492, 1460, 1376, 1209, 1166, 1110, 765, 727.



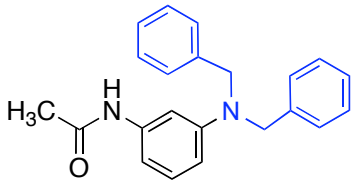
4-(benzyl(methyl)amino)phenol (Table 10, entry 10e). The general procedure H with 1 mol% catalyst for 24 h was followed. Isolation and biotage purification afforded the title compound as a black solid (151 mg, 71%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34-7.27 (m, 5H), 6.73 (s,br, 2H), 5.77 (s, 1H), 4.42 (s, br, 1H), 2.89 (s, br, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 128.7, 128.5, 127.6, 127.4, 127.0, 115.2, 113.9, 39.1. IR (KBr disc, cm^{-1}): 3352, 3028, 2889, 2805, 1603, 1514, 1452, 1355, 1230, 1116, 1075, 1028, 1003, 947, 817, 732, 697, 601, 517, 458. Anal. Calcd for $C_{14}H_{15}NO$: C, 78.84; H, 7.09. Found: C, 78.82; H, 7.09. m.p. 53 ºC.



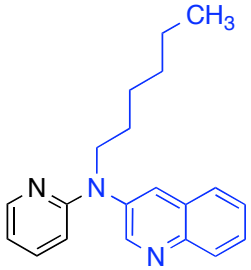
***N*-(3-morpholinophenyl)acetamide (Table 10, entry 10f)**.[23] The general procedure H with 0.15 mol% catalyst for 20 h was followed. Isolation and biotage purification afforded the title compound as a white solid (176 mg, 80%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.88 (s, 1H), 7.28 (s, 1H), 7.13 (t, 1H, J = 8.0), 6.84 (d, 1H, J = 8.0), 6.60 (d, 1H, J = 8.0), 3.76 (t, 4H, J = 4.0), 3.07 (t, 4H, J = 4.0), 2.10 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.0, 152.1, 139.3, 129.7, 111.6, 111.5, 107.5, 67.0, 49.3, 24.8. IR (KBr disc, cm^{-1}): 3296, 2857, 1662, 1610, 1554, 1497, 1424, 1372, 1301, 1251, 1198, 1121, 1024, 995, 941, 880, 772, 688. m.p. 160 ºC (159-160 ºC).



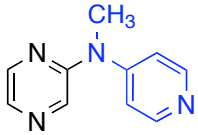
3-(dibenzylamino)phenol (Table 10, entry 10g).[25] The general procedure H with 1.5 mol% catalyst for 22 h was followed. Isolation and biotage purification afforded the title compound as a brown solid (250 mg, 87%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34-7.24 (m, 10H), 7.00 (t, 1H, J = 8.0), 6.33 (dd, 1H, J = 8.0), 6.18-6.15 (m, 2H), 4.61 (s, 4H), 3.70 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.1, 151.0, 138.7, 130.4, 128.9, 128.8, 127.6, 127.1, 126.8, 105.3, 104.2, 99.8, 54.3, 52.7. IR (KBr disc, cm^{-1}): 3359, 3061, 3028, 2862, 1617, 1505, 1452, 1395, 1361, 1298, 1266, 1170, 1075, 1028, 990, 967, 911, 820, 736, 696.



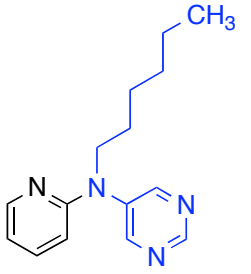
***N*-(3-(dibenzylamino)phenyl)acetamide (Table 10, entry 10h)**.[26] The general procedure H with 1.5 mol% catalyst for 22 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (258 mg, 78%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.04-7.24 (m, 12H), 7.04 (t, 2H, J = 8.0), 6.81-6.89 (m, 2H), 6.45 (d, 1H, J = 8.0), 4.60 (s, 4H), 2.10 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.6, 150.0, 139.2, 138.5, 129.9, 129.2, 128.9, 127.1, 126.8, 120.1, 108.8, 104.0, 54.3, 24.8. IR (KBr disc, cm^{-1}): 3300, 3029, 1663, 1610, 1552, 1495, 1451, 1363, 1320, 1254, 1176, 1028, 990, 963, 730, 695. m.p. 143 ºC (143-144 ºC).



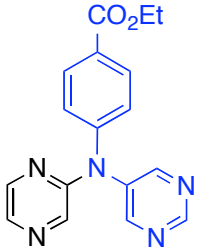
***N*-hexyl-*N*-(pyridin-2-yl)quinolin-3-amine (Table 11, entry 11a)**. The general procedure F with 1 mol% catalyst, amine (1 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (107 mg, 70%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.81 (d, 1H, J = 4.0), 8.21-8.19 (m, 1H), 8.07 (d, 1H, J = 12.0), 7.92 (d, 1H, J = 4.0), 7.73 (d, 1H, J = 8.0), 7.66-7.62 (m, 1H), 7.53-7.49 (m, 1H), 7.35-7.31 (m, 1H), 6.66-6.63 (m, 1H), 6.49 (d, 1H, J = 8.0), 4.01 (t, 2H, J = 8.0), 1.70-1.66 (m, 2H), 1.35-1.22 (m, 6H), 0.84-0.80 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 158.2, 151.3, 148.3, 145.8, 139.4, 137.4, 130.7, 129.4, 129.0, 128.9, 127.5, 127.2, 114.4, 109.4, 50.8, 31.8, 28.2, 26.9, 22.8, 14.2. IR (KBr disc, cm^{-1}): 2928, 2857, 1591, 1561, 1477, 1428, 1390, 1331, 1305, 1259, 1224, 1197, 1141, 1072, 982, 786, 769, 752, 617. Anal. Calcd for $C_{20}H_{23}N_3$: C, 78.65; H, 7.59. Found: C, 78.38; H, 7.56.



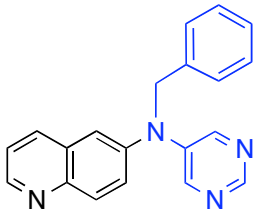
***N*-methyl-*N*-(pyridin-4-yl)pyrazin-2-amine (Table 11, entry 11b)**. The general procedure F with 1 mol% catalyst for 12 h was followed. Isolation and biotage purification afforded the title compound as a white solid (152 mg, 82%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.43-8.40 (m, 3H), 8.20 (m, 1H), 8.04 (m, 1H), 7.06-7.05 (m, 2H), 3.47 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 153.7, 152.1, 151.1, 142.4, 136.9, 136.5, 115.3, 37.1. IR (KBr disc, cm^{-1}): 3394, 2361, 1597, 1574, 1518, 1502, 1478, 1403, 1360, 1304, 1272, 1226, 1154, 1079, 1052, 1000, 898, 823, 753, 640. Anal. Calcd for $C_{10}H_{10}N_4$: C, 64.50; H, 5.41. Found: C, 64.57; H, 5.51. m.p. 67 ºC.



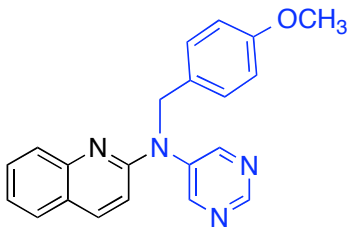
***N*-hexyl-*N*-(pyridin-2-yl)pyrimidin-5-amine (Table 11, entry 11c)**. The general procedure F with 1 mol% catalyst, amine (1 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (122 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.87 (s, 1H), 8.60 (s, 2H), 8.15-8.13 (m, 1H), 7.42-7.38 (m, 1H), 6.70-6.67 (m, 1H), 6.58 (d, 1H, J = 8.0), 3.84 (t, 2H, J = 8.0), 1.64-1.58 (m, 2H), 1.27-1.21 (m, 6H), 0.80-0.77 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.1, 153.8, 153.3, 148.4, 140.9, 137.9, 115.8, 109.7, 50.4, 31.7, 27.9, 26.7, 22.7, 14.2. IR (KBr disc, cm^{-1}): 3046, 2956, 2929, 2858, 1590, 1564, 1476, 1441, 1420, 1373, 1306, 1257, 1226, 1189, 1154. Anal. Calcd for $C_{15}H_{20}N_4$: C, 70.28; H, 7.86. Found: C, 70.39; H, 7.88.



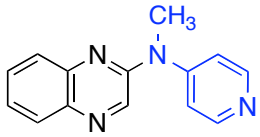
Ethyl 4-(pyrazin-2-yl(pyrimidin-5-yl)amino)benzoate (Table 11, entry 11d). The general procedure G with 0.25 mol% catalyst, amine[19] (0.6 mmol), aryl chloride (0.5 mmol), Cs_2CO_3 (0.6 mmol) and *t*-BuOH (1.5 mL) for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (145 mg, 90%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.96 (s, 1H), 8.58 (s, 2H), 8.17 (d, 2H, J = 8.0), 8.16 (s, 1H), 8.06 (d, 1H, J = 4.0), 7.23 (d, 2H, J = 8.0), 4.34 (q, 2H, J = 8.0), 1.36 (t, 3H, J = 8.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.7, 154.6, 153.5, 146.9, 142.2, 139.7, 138.4, 136.7, 132.2, 128.9, 125.8, 61.5, 14.5. IR (KBr disc, cm^{-1}): 2982, 1714, 1606, 1574, 1522, 1508, 1473, 1425, 1407, 1367, 1324, 1275, 1176, 1148, 1106, 1006, 853, 772, 724, 709.



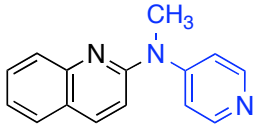
***N*-benzyl-*N*-(pyrimidin-5-yl)quinolin-6-amine (Table 11, entry 11e)**. The general procedure F with 1 mol% catalyst, amine[27] (0.5 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) and THF (2 mL) for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (137 mg, 88%). Quinoline was found in 3% yield from this reaction. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.82-8.81 (m, 1H), 8.71 (s, 1H), 8.43 (s, 2H), 8.06 (d, 1H, J = 8.0), 7.98 (d, 1H, J = 8.0), 7.58 (dd, 1H, J = 8.0, J = 4.0), 7.53-7.52 (m, 1H), 7.37-7.24 (m, 6H), 5.09 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 151.0, 150.0, 146.3, 145.9, 144.1, 141.8, 136.9, 135.4, 131.8, 129.5, 129.3, 127.9, 126.7, 126.1, 122.0, 119.2, 56.4. IR (KBr disc, cm^{-1}): 3030, 1621, 1594, 1567, 1498, 1427, 1380, 1224, 1122, 839, 723, 696. Anal. Calcd for $C_{20}H_{16}N_4$: C, 76.90; H, 5.16. Found: C, 76.41; H, 5.27. m.p. 74 ºC.



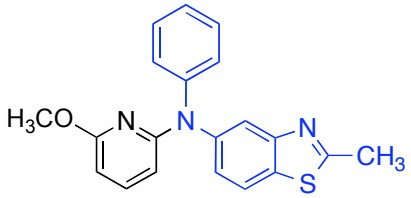
***N*-(4-methoxybenzyl)-*N*-(pyrimidin-5-yl)quinolin-2-amine (Table 11, entry 11f)**. The general procedure F with 1.5 mol% catalyst, amine[28] (0.5 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) and THF (3 mL) for 12 h was followed. Isolation and biotage purification afforded the title compound as a white solid (128 mg, 75%). Quinoline was found in 4% yield from this reaction. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.96 (s, 1H), 8.65 (s, 2H), 7.88 (d, 1H, J = 6.0), 7.77 (d, 1H, J = 6.0), 7.52-7.71 (m, 2H), 7.10-7.42 (m, 3H), 6.78 (t, 3H, J = 8.0), 5.32 (s, 2H), 3.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.2, 155.4, 154.8, 154.1, 147.5, 140.4, 138.2, 130.2, 129.7, 129.2, 127.5, 124.5, 124.0, 114.3, 111.5, 55.4, 52.9. IR (KBr disc, cm^{-1}): 1617, 1603, 1559, 1504, 1476, 1418, 1387, 1319, 1247, 1175, 1033, 812, 757, 730. Anal. Calcd for $C_{21}H_{18}N_4O$: C, 73.67; H, 5.30. Found: C, 73.46; H, 5.47. m.p. 121 ºC.



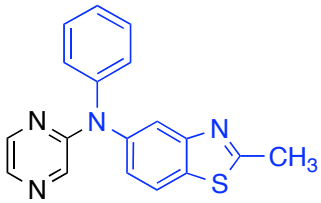
***N*-methyl-*N*-(pyridin-4-yl)quinoxalin-2-amine (Table 11, entry 11g)**. The general procedure F with 1 mol% catalyst, amine (0.6 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) and THF (2 mL) for 24 h at 45 ºC was followed. Isolation and biotage purification afforded the title compound as a yellow solid (87 mg, 75%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.63 (s, 1H), 8.49 (d, 2H, J = 4.0), 7.90 (d, 1H, J = 8.0), 7.90 (d, 1H, J = 8.0), 7.61 (t, 1H, J = 8.0), 7.49 (t, 1H, J = 6.0), 7.12 (d, 2H, J = 4.0), 3.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 152.1, 151.3, 141.5, 139.4, 138.4, 130.6, 129.0, 127.5, 127.0, 116.2, 55.7, 37.4. IR (KBr disc, cm^{-1}): 3407, 3032, 2930, 1596, 1575, 1550, 1498, 1433, 1407, 1383, 1360, 1312, 1224, 1152, 1118, 1058, 992, 977, 923, 822, 763, 682, 612, 580, 563, 483. Anal. Calcd for $C_{14}H_{12}N_4$: C, 71.17; H, 5.12. Found: C, 70.93; H, 5.38. m.p. 85 ºC.



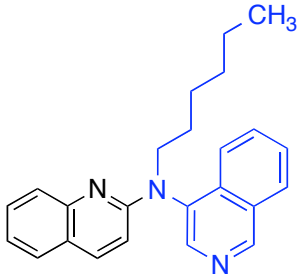
***N*-methyl-*N*-(pyridin-4-yl)quinolin-2-amine (Table 11, entry 11h)**. The general procedure F with SPhos precatalyst (3 mol%), SPhos (3 mol%), amine (0.6 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) and THF (1.5 mL) for 24 h at 45 ºC was followed. Isolation and biotage purification afforded the title compound as a white solid (103 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.42-8.40 (m, 2H), 7.91 (d, 1H, J-8.0), 7.84 (d, 1H, J = 8.0), 7.67 (d, 1H, J = 8.0), 7.62-7.58 (m, 1H), 7.36 (t, 1H, J = 8.0), 7.23-7.20 (m, 1H), 7.07-7.06 (m, 2H), 3.65 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 156.0, 153.0, 150.8, 147.8, 137.5, 130.1, 127.8, 127.6, 125.1, 124.9, 115.1, 115.0, 37.4. IR (KBr disc, cm^{-1}): 3046, 1618, 1606, 1588, 1551, 1498, 1472, 1430, 1383, 1364, 1310, 1223, 1142, 1114, 1068, 991, 922, 827, 811, 758. Anal. Calcd for $C_{15}H_{13}N_3$: C, 76.57; H, 5.57. Found: C, 76.40; H, 5.59. m.p. 93 ºC.



***N*-(6-methoxypyridin-2-yl)-2-methyl-*N*-phenylbenzo[*d*]thiazol-5-amine (Table 11, entry 11i)**. The general procedure G with 0.25 mol% catalyst, amine[19] (0.6 mmol), aryl chloride (0.5 mmol), Cs_2CO_3 (0.6 mmol) and *t*-BuOH (1.5 mL) for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (161 mg, 93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.66-7.61 (m, 2H), 7.27-7.20 (m, 3H), 7.18-7.13 (m, 3H), 7.04 (t, 1H, J = 8.0), 6.14 (d, 2H, J = 6.0), 3.54 (s, 3H), 2.71 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.3, 162.2, 156.3, 153.8, 145.3, 143.9, 139.3, 130.7, 128.6, 126.3, 124.1, 123.6, 120.7, 119.5, 103.7, 101.0, 52.6, 19.6. IR (KBr disc, cm^{-1}): 1580, 1525, 1494, 1456, 1435, 1412, 1345, 1254, 1223, 1147, 1043, 1005, 783, 756, 723, 697, 550. Anal. Calcd for $C_{20}H_{17}N_3OS$: C, 69.14; H, 4.93. Found: C, 68.78; H, 4.88.

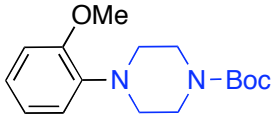


2-methyl-*N*-phenyl-*N*-(pyrazin-2-yl)benzo[*d*]thiazol-5-amine (Table 11, entry 11j). The general procedure G with 0.25 mol% catalyst, amine[19] (0.6 mmol), aryl chloride (0.5 mmol), Cs_2CO_3 (0.6 mmol) and *t*-BuOH (1.5 mL) for 20 h was followed. Isolation and biotage purification afforded the title compound as a yellow solid (141 mg, 89%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.31 (s, 1H), 7.25 (s, 1H), 7.16 (s, 1H), 6.94-6.92 (m, 2H), 6.53 (t, 2H, J = 8.0), 6.42-6.35 (m, 4H), 1.96 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.9, 154.5, 153.9, 143.9, 142.5, 141.2, 135.5, 135.0, 132.1, 129.3, 126.0, 125.4, 123.0, 121.5, 119.5, 19.6. IR (KBr disc, cm^{-1}): 3424, 3057, 1592, 1571, 1552, 1516, 1493, 1473, 1456, 1408, 1340, 1322, 1304, 1274, 1233, 1196, 1174, 1146, 1068, 1003. Anal. Calcd for $C_{18}H_{14}N_4S$: C, 67.90; H, 4.43. Found: C, 67.93; H, 4.39. m.p. 89-92 ºC.

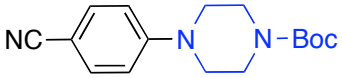


***N*-hexyl-*N*-(isoquinolin-4-yl)quinolin-2-amine (Table 11, entry 11k)**. The general procedure F with 1 mol% catalyst, amine (0.6 mmol), aryl chloride (0.5 mmol), NaO*t*-Bu (0.6 mmol) and THF (2 mL) for 18 h was followed. Isolation and biotage purification afforded the title compound as a yellow liquid (135 mg, 76%). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.27 (s, 1H), 8.53 (s, 1H), 8.06 (s, 1H), 7.83-7.77 (m, 2H), 7.61-7.50 (m, 5H), 6.16 (d, 1H, J = 12.0). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.1, 152.1, 148.1, 144.3, 137.1, 136.2, 134.7, 131.3, 130.1, 129.7, 128.5, 128.1, 127.5, 127.1, 123.5, 122.8, 122.6, 111.5, 50.7, 31.8, 28.3, 26.9, 22.8, 14.3. IR (KBr disc, cm^{-1}): 3049, 2954, 2928, 2856, 1619,

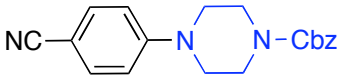
1605, 1579, 1559, 1503, 1479, 1455, 1425, 1402, 1333, 1296, 1259, 1229, 1160, 1143, 1118, 1017, 964, 901, 864, 815, 788, 753, 616. Anal. Calcd for $C_{24}H_{25}N_3$: C, 81.09; H, 7.09. Found: C, 80.47; H, 7.03.



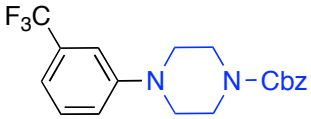
***tert*-butyl 4-(2-methoxyphenyl)piperazine-1-carboxylate (Table 12, entry 12a).** The general procedure I using RuPhos (**2**) (1.15 mg, 0.25 mol%), RuPhos precatalyst (**4**) (1.8 mg, 0.25 mol%), 2-chloroanisole (127 μL, 1mmol) and *tert*-butyl piperazine-1-carboxylate (223 mg, 1.2 mmol) was followed. Isolated as a light yellow solid (277 mg, 95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 - 6.93 (m, 2H), 6.93 - 6.70 (m, 2H), 3.82 (s, 3H), 3.60 (s, 4H), 2.99 (s, 4H), 1.45 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.44, 151.90, 140.07, 123.47, 120.75, 118.42, 111.04, 79.41, 55.11, 50.44, 43.41 (d, J = 117.1 Hz), 28.14. IR (KBr disc, cm^{-1}): 2975, 1696, 1501, 1421, 1242, 1173, 1029, 923, 747. m.p. 68 - 69 °C



***tert*-butyl 4-(4-cyanophenyl)piperazine-1-carboxylate (Table 12, entry 12b).** The general procedure I using RuPhos (**2**) (0.92 mg, 0.2 mol%), RuPhos precatalyst (**4**) (1.44 mg, 0.2 mol%), 4-chlorobenzonitrile (138 mg, 1mmol) and *tert*-butyl piperazine-1-carboxylate (223 mg, 1.2 mmol) was followed. Isolated as a colourless solid (286 mg, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (dd, J = 8.9, 1.5 Hz, 2H), 6.93 - 6.59 (m, 2H), 3.60 - 3.35 (m, 4H), 3.31 - 3.09 (m, 4H), 1.39 (d, J = 1.3 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.13, 152.78, 133.05, 119.52, 114.03, 99.97, 79.69, 46.58, 42.52 (d, J = 88.8 Hz), 27.98. IR (KBr disc, cm^{-1}): 2980, 2214, 1700, 1605, 1517, 1419, 1365, 1244, 1167, 1002, 918, 822, 546. m.p. 117-119 ºC.

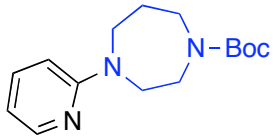


Benzyl 4-(4-cyanophenyl)piperazine-1-carboxylate (Table 12, entry 12c). The general procedure J using 4-chlorobenzonitrile (138 mg, 1mmol) was followed. The title compound was isolated as a light orange solid (311 mg, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) d 7.34 (dd, J = 8.8, 6.8 Hz, 2H), 7.31 - 7.16 (m, 5H), 6.70 (d, J = 8.8 Hz, 2H), 5.20 - 4.88 (s, 2H), 3.53 (d, J = 3.7 Hz, 4H), 3.17 (bs, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.58, 152.57, 136.10, 133.00, 128.12, 128.05, 127.70, 127.46, 119.49, 114.00, 99.94, 66.77, 46.38, 42.70. IR (KBr disc, cm^{-1}): 2859, 2215, 1700, 1604, 1517, 1429, 1238, 1179. m.p. 116 °C

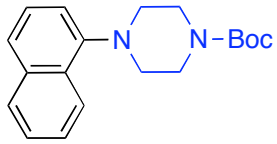


Benzyl 4-(3-(trifluoromethyl)phenyl)piperazine-1-carboxylate (Table 12, entry 12d). The general procedure J using 3-chlorobenzotrifluoride (136 μL, 1mmol) was followed. The title compound was isolated as a yellow oil (298 mg, 82%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 - 7.29 (m, 6H), 7.13 (d, J = 7.1 Hz, 2H), 7.09 - 7.00 (m, 1H), 5.29 - 5.06 (m, 2H), 3.81 - 3.58 (m, 4H), 3.17 (s, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.03, 151.19, 136.52, 131.34 (q, J = 31.6 Hz), 129.60, 128.47, 128.05, 127.88, 124.23 (d, J =

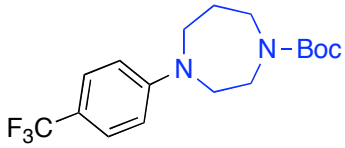
272.4 Hz), 119.28, 116.37, 112.61, 67.20, 48.66, 43.45. IR (KBr disc, cm^{-1}): 2830, 1702, 1609, 1497, 1431, 1320, 1233, 1164, 1122, 953, 697.



***tert*-butyl 4-(pyridin-2-yl)-1,4-diazepane-1-carboxylate (Table 12, entry 12e).** The general procedure I using RuPhos (**2**) (2.3 mg, 0.5 mol%), RuPhos precatalyst (**4**) (3.6 mg, 0.5 mol%), 2-chloropyridine (97 μL, 1mmol) and *tert*-butyl 1,4-diazepane-1-carboxylate (236 μL, 1.2 mmol) was followed. Isolated as a light yellow oil (261 mg, 94%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (ddd, J = 5.0, 1.9, 0.7 Hz, 1H), 7.36 (t, J = 7.8 Hz, 1H), 6.46 (dd, J = 12.4, 7.2 Hz, 2H), 3.79 - 3.65 (m, 2H), 3.65 - 3.45 (m, 4H), 3.33 - 3.21 (m, 1H), 3.17 (t, J = 6.2 Hz, 1H), 1.90 (p, J = 6.2 Hz, 2H), 1.36 (d, J = 21.5 Hz, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.08, 157.03, 155.17, 154.90, 148.02, 147.93, 137.19, 111.55, 105.45, 105.39, 79.21, 48.69, 48.34, 47.09, 46.92, 46.45, 45.99, 45.62, 28.22, 28.13, 25.07, 24.74. IR (KBr disc, cm^{-1}): 2973, 1694, 1596, 1494, 1442, 1414, 1365, 1240, 1167, 928, 769.



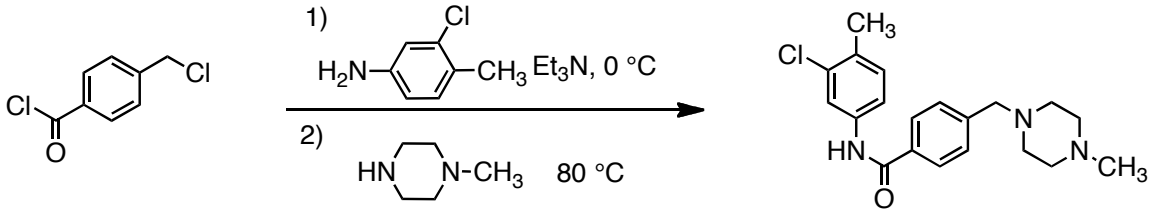
***tert*-butyl 4-(naphthalen-1-yl)piperazine-1-carboxylate (Table 12, entry 12f).** The general procedure I using RuPhos (**2**) (0.46 mg, 0.1 mol%), RuPhos precatalyst (**4**) (0.72 mg, 0.1 mol%), 1-chloronaphthalene (136 μL, 1mmol) and *tert*-butyl piperazine-1-carboxylate (223 mg, 1.2 mmol) was followed. Isolated as a colourless oil (288 mg, 92%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 - 8.16 (m, 1H), 7.90 - 7.77 (m, 1H), 7.59 (d, J = 8.2 Hz, 1H), 7.51 (dqd, J = 8.4, 6.8, 1.6 Hz, 2H), 7.45 - 7.35 (m, 1H), 7.06 (dd, J = 7.4, 0.9 Hz, 1H), 4.32 - 3.30 (bs, 4H), 3.06 (s, 4H), 1.57 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.70, 149.16, 134.54, 128.61, 128.27, 125.73, 125.62, 125.34, 123.66, 123.12, 114.65, 79.57, 52.69, 44.48, 43.51, 28.30. IR (KBr disc, cm^{-1}): 2974, 1692, 1419, 1398, 1364, 1248, 1168, 1123, 1011, 773.



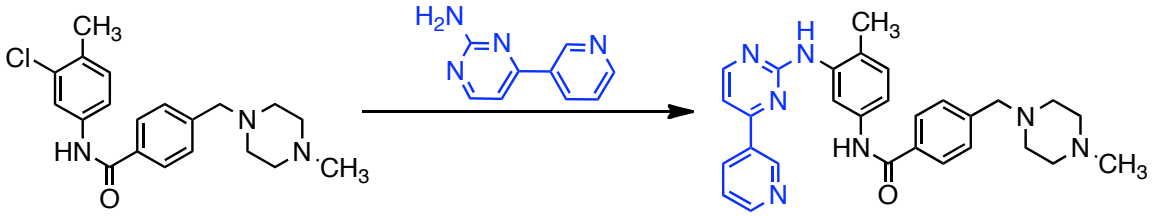
***tert*-butyl 4-(4-(trifluoromethyl)phenyl)-1,4-diazepane-1-carboxylate (Table 12, entry 12e).** The general procedure I using RuPhos (**2**) (0.23 mg, 0.05 mol%), RuPhos precatalyst (**4**) (0.36 mg, 0.05 mol%), 4-chlorobenzotrifluoride (133 μL, 1mmol) and *tert*-butyl 1,4-diazepane-1-carboxylate (236 μL, 1.2 mmol) was followed. Isolated as a colourless solid by chromatography using Biotage SP4 system, eluting with 25% EtOAc in hexanes (301 mg, 88%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, J = 8.8 Hz, 2H), 6.65 (d, J = 8.5 Hz, 2H), 3.62 - 3.41 (m, 6H), 3.27 (t, J = 5.9 Hz, 1H), 3.16 (t, J = 6.1 Hz, 1H), 2.03 - 1.72 (m, 2H), 1.37 (s, 5H), 1.29 (s, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.07, 154.69, 149.36, 149.25, 126.58, 126.28, 123.59, 117.82, 117.43, 117.11, 116.78, 110.74, 110.58, 79.48, 50.12, 49.82, 48.62, 47.87, 45.96, 45.89, 45.60, 45.41, 28.11, 27.96, 24.44,

24.19. ^{19}F NMR (376 MHz, $CDCl_3$) δ -61.50. IR (KBr disc, cm^{-1}): 2974, 1691, 1616, 1529, 1416, 1237, 1197, 1162, 1107, 1070. m.p. 70 °C

Synthesis of Gleevec®



***N*-(3-chloro-4-methylphenyl)-4-((4-methylpiperazin-1-yl)methyl)benzamide** A 20 mL schlenk flask, which was equipped with a magnetic stir bar and septum, was charged with 3-chloro-4-methylaniline (146 mL, 1.2 mmol), triethylamine (278 mL, 2.0 mmol), and THF (5 mL) and was evacuated and backfilled with argon. The reaction mixture was cooled to 0 °C and a solution of 4-(chloromethyl)benzoylchloride in THF (2 mL, 0.5 M, 1.0 mmol) was added over a ten minute period. The solution was stirred at 0 °C for 2 h and then 1-methylpiperazine (1.107 mL, 10 mmol) was added via syringe and the reaction vessel was sealed with a Teflon screw cap and heated to 80 °C for 12 h. The reaction was diluted with cold water and a white precipitate crashed out. The precipitate was filtered and washed with cold water (100 mL) to yield the product as a white solid (251 mg, 73%), mp 143-145 °C.^{1}H NMR (300 MHz, $CDCl_3$) δ: 7.99 (s, 1H), 7.78 (d, J = 8.0 Hz, 2H), 7.71 (s, 1H), 7.40 (d, J = 8.5 Hz, 3H), 7.16 (d, J = 8.0 Hz, 1H), 3.54 (s, 2H), 2.47 (bs, 8H), 2.32 (s, 3H), 2.29 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 165.9, 143.0, 137.0, 134.7, 133.6, 132.3, 131.2, 129.6, 127.3, 121.1, 118.8, 62.7, 55.3, 53.2, 46.2, 19.8. IR (neat, cm^{-1}): 2938, 2804, 1650, 1594, 1527, 1503, 1384, 1308, 1011, 815.



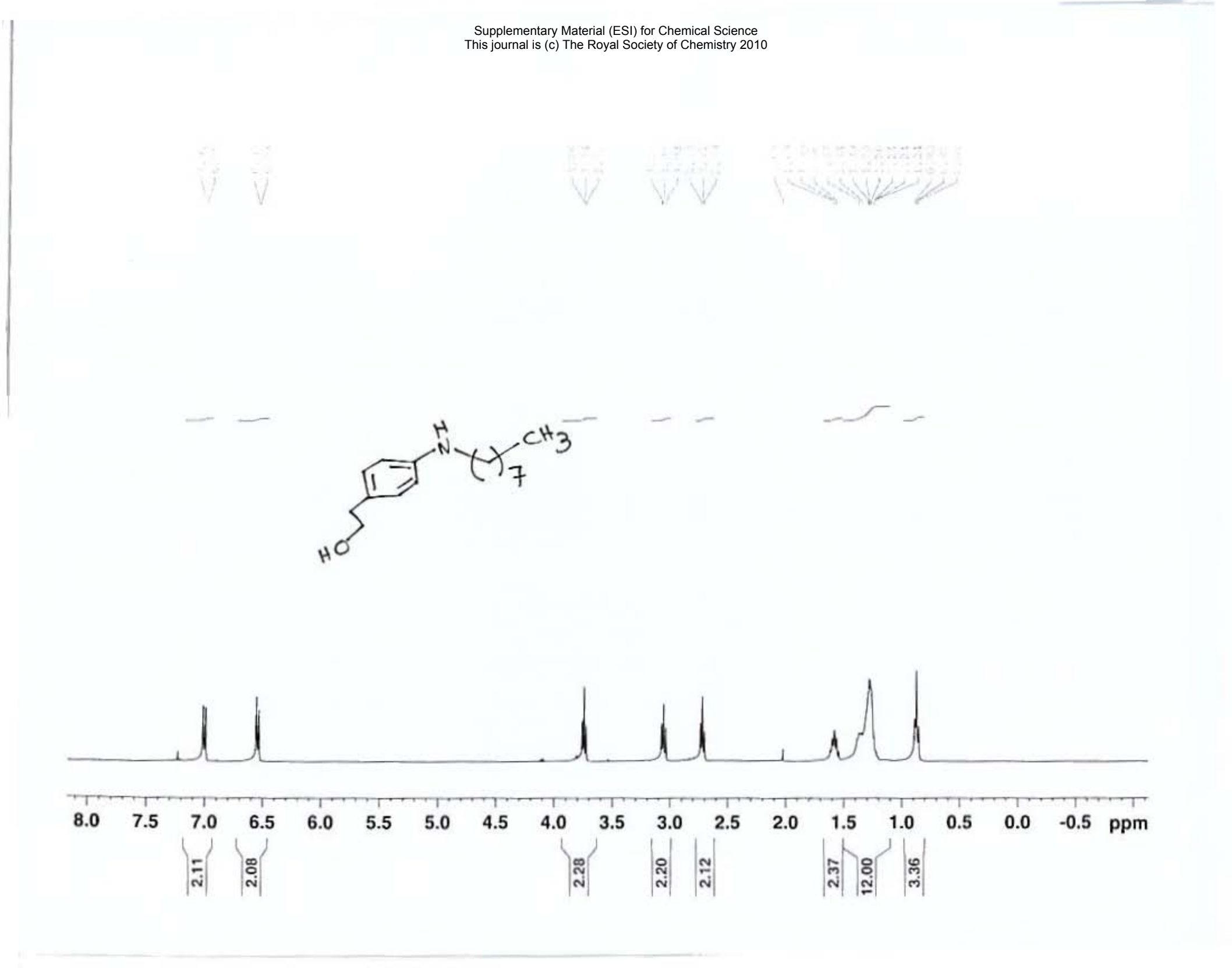
Imatinib Base An oven-dried test tube, which was equipped with a magnetic stir bar and fitted with a teflon septum, was charged with **3** (8 mg, 2 mol%), **1** (5 mg, 2 mol%), K_2CO_3 (152 mg, 1.1 mmol), aryl chloride (179 mg, 0.5 mmol), and 4-(pyridin-3-yl)pyrimidin-2-amine (103 mg, 0.6 mmol). The vessel was evacuated and backfilled with argon (this process was repeated a total of 3 times) and then *tert*-butanol (1 mL) was added via syringe. The solution was heated to 110 °C for 6 h. 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 (30-100% MeOH/H_2O, reverse phase 60 g cartridge) to provide the title compound as a white solid (207 mg, 84%), mp 206-208 °C (lit.[x] mp 207-210). ^{1}H NMR (300 MHz, $CDCl_3$) δ: 9.20 (s, 1H), 8.65 (d, J = 5.0 Hz, 1H), 8.55 (s, 1H), 8.46 (m, 2H), 8.14 (s, 1H), 7.80 (d, J = 8.5 Hz, 2H), 7.38 (m, 3H), 7.28 (m, 1H), 7.13 (m, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ: 165.8, 162.9, 160.8, 159.2, 151.7, 148.7, 142.7, 138.0, 136.9, 135.2, 134.1, 132.9, 131.0, 129.5, 127.3, 124.5,

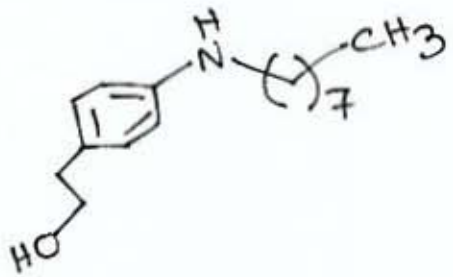
124.0, 115.7, 113.5, 108.5, 62.8, 55.3, 53.4, 46.3, 18.0. IR (neat, cm^{-1}): 3283, 2939, 2802, 1652, 1578, 1555, 1531, 1452, 1418, 1290, 731.

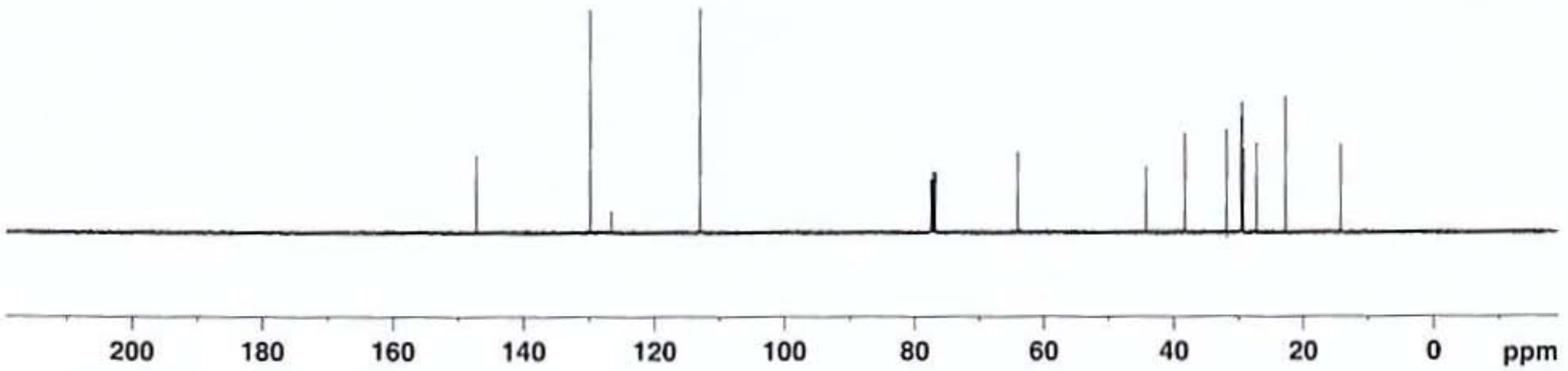
References:

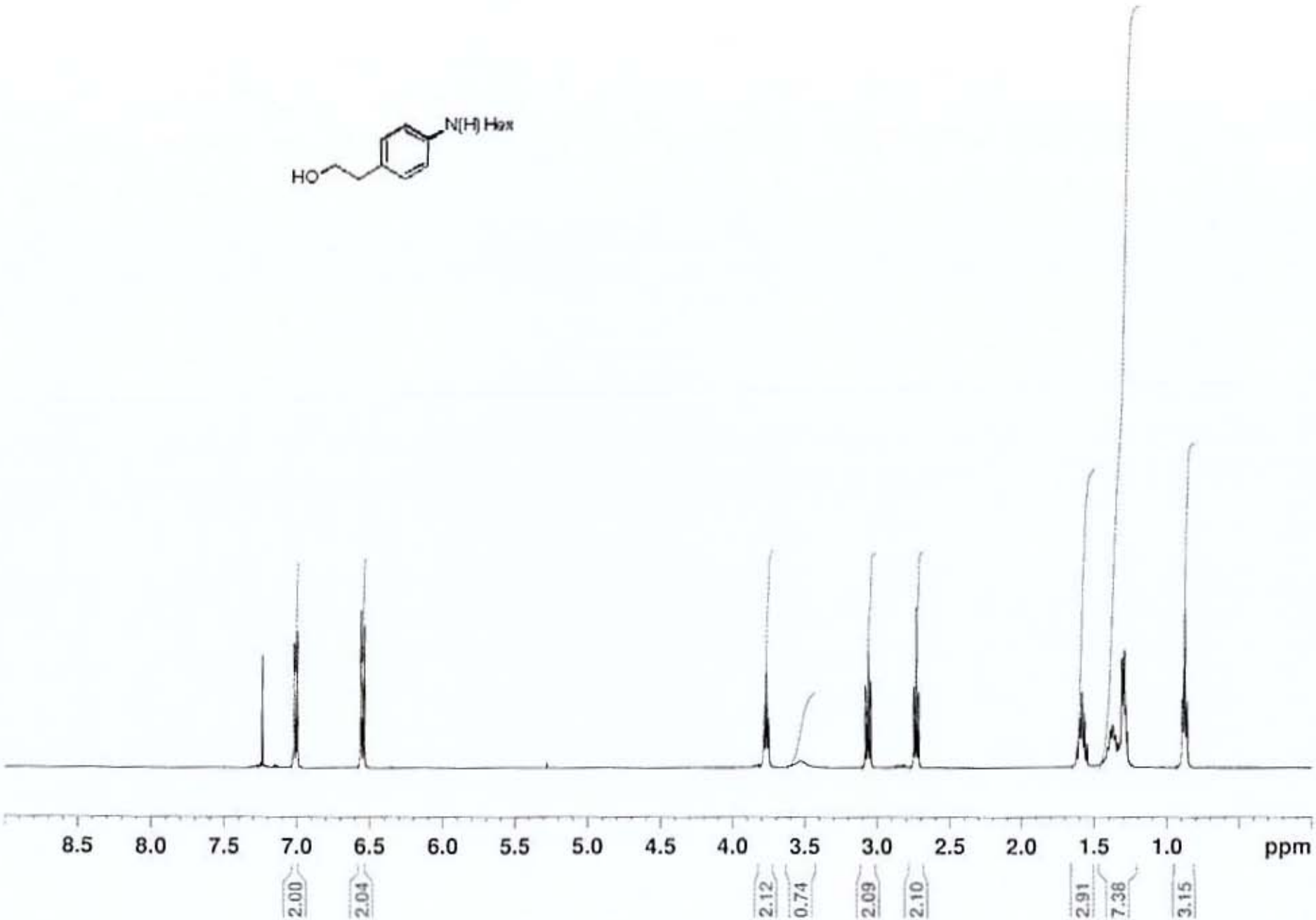
1. B. P. Fors, D. A. Watson, M. R. Biscoe and S. L. Buchwald, *J. Am. Chem. Soc.*, 2008, **130**, 13552-13554.
2. M. R. Biscoe, B. P. Fors and S. L. Buchwald, *J. Am. Chem. Soc.*, 2008, **130**, 6686-6687.
3. Q. Shen, T. Ogata and J. F. Hartwig, *J. Am. Chem. Soc.*, 2008, **130**, 6586-6596.
4. P. Mulder, I. Arends, D. Santoro and H. G. Korth, *J. Org. Chem.*, 2003, **68**, 4247-4257.
5. J. H. Gorvin, *J. Chem. Soc. Perkin Trans. I* 1988, 1331-1335.
6. J. J. Yin, M. M. Zhao, M. A. Huffman and J. M. McNamara, *Org. Lett.*, 2002, **4**, 3481-3484.
7. Y. D. Ward and V. Farina, *Tetrahedron Lett.*, 1996, **37**, 6993-6996.
8. B. P. Fors, N. R. Davis and S. L. Buchwald, *J. Am. Chem. Soc.*, 2009, **131**, 5766-5768.
9. C. Xu, Z. Q. Wang, W. J. Fu, X. H. Lou, Y. F. Li, F. F. Cen, H. J. Ma and B. M. Ji, *Organometallics*, 2009, **28**, 1909-1916.
10. J. P. Wolfe, H. Tomori, J. P. Sadighi, J. J. Yin and S. L. Buchwald, *J. Org. Chem.*, 2000, **65**, 1158-1174.
11. K. W. Anderson, M. Mendez-Perez, J. Priego and S. L. Buchwald, *J. Org. Chem.*, 2003, **68**, 9563-9573.
12. K. Kamikawa, S. Sugimoto and M. Uemura, *J. Org. Chem.*, 1998, **63**, 8407-8410.
13. U. Nettekoven, F. Naud, A. Schnyder and H. U. Blaser, *Synlett*, 2004, 2549-2552.
14. J. P. Wolfe and S. L. Buchwald, *J. Org. Chem.*, 1996, **61**, 1133-1135.
15. M. Prashad, X. Y. Mak, Y. G. Liu and O. Repic, *J. Org. Chem.*, 2003, **68**, 1163-1164.
16. M. G. Organ, M. Abdel-Hadi, S. Avola, I. Dubovyk, N. Hadei, E. A. B. Kantchev, C. J. O'Brien, M. Sayah and C. Valente, *Chem.-Eur. J.*, 2008, **14**, 2443-2452.
17. B. Gradel, E. Brenner, R. L. Schneider and Y. Fort, *Tetrahedron Lett.*, 2001, **42**, 5689-5692.
18. J. P. Wolfe and S. L. Buchwald, *J. Am. Chem. Soc.*, 1997, **119**, 6054-6058.
19. M. D. Charles, P. Schultz and S. L. Buchwald, *Org. Lett.*, 2005, **7**, 3965-3968.
20. T. Murase and M. Fujita, *J. Org. Chem.*, 2005, **70**, 9269-9278.
21. K. A. Zachariasse, S. I. Druzhinin, W. Bosch and R. Machinek, *J. Am. Chem. Soc.*, 2004, **126**, 1705-1715.
22. C. M. Seong, C. M. Park, J. Choi and N. S. Park, *Tetrahedron Lett.*, 2009, **50**, 1029-1031.
23. M. C. Harris, X. H. Huang and S. L. Buchwald, *Org. Lett.*, 2002, **4**, 2885-2888.
24. N. Marion, O. Navarro, J. G. Mei, E. D. Stevens, N. M. Scott and S. P. Nolan, *J. Am. Chem. Soc.*, 2006, **128**, 4101-4111.
25. Z. Q. Wang, Z. J. Diwu, J. Francisco-Reyes and G. G. Yi, *Chem. Lett.*, 2005, **34**, 404-405.
26. F. G. Singleton and C. B. Pollard, *J. Am. Chem. Soc.*, 1941, **63**, 998-999.

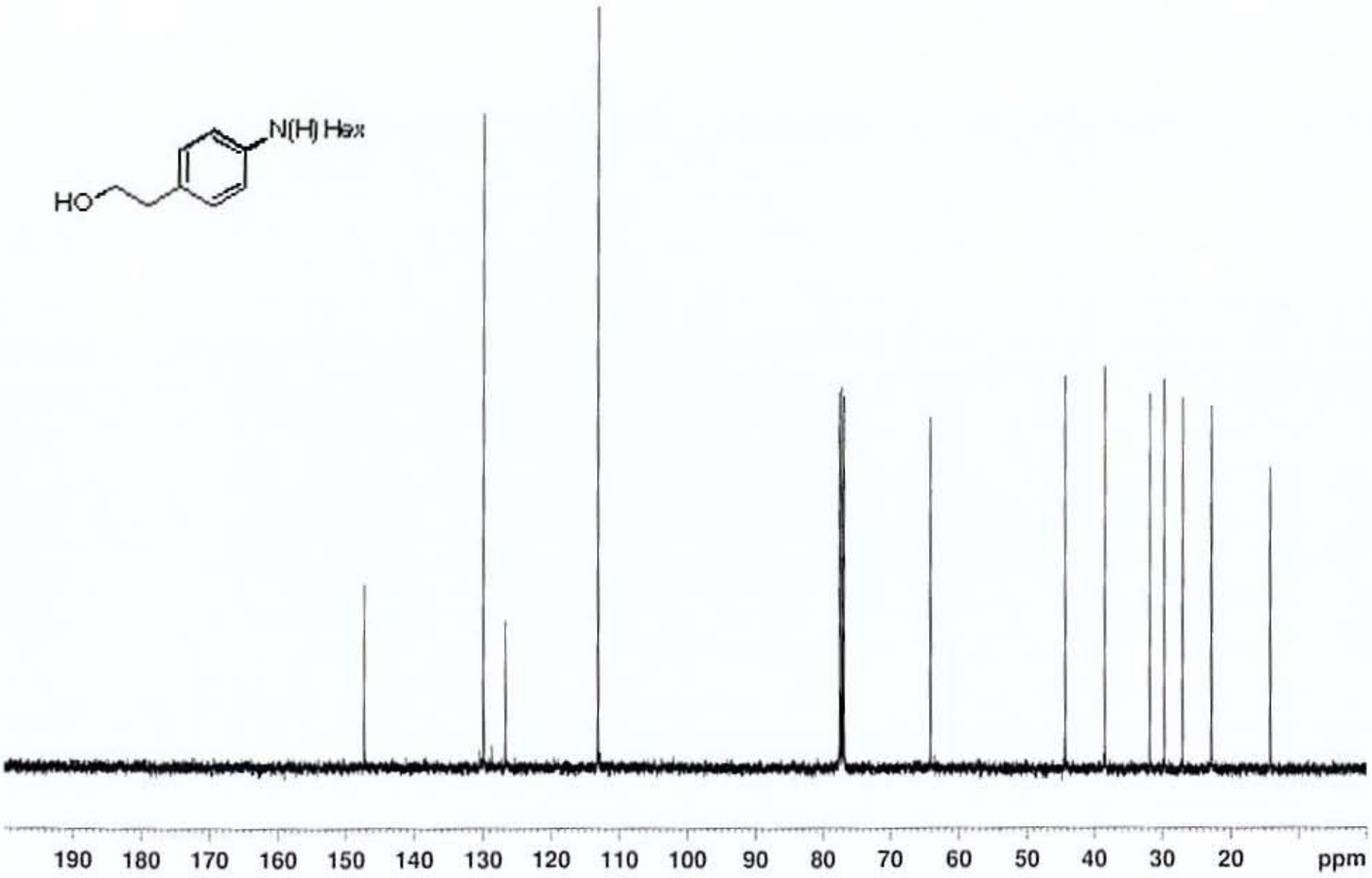
27. Z. J. Zhang, J. C. Mao, D. Zhu, F. Wu, H. L. Chen and B. S. Wan, *Tetrahedron*, 2006, **62**, 4435-4443.
28. F. Y. Kwong and S. L. Buchwald, *Org. Lett.*, 2003, **5**, 793-796.

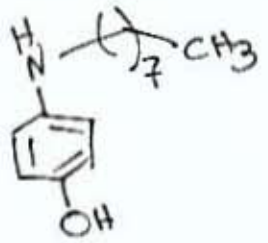


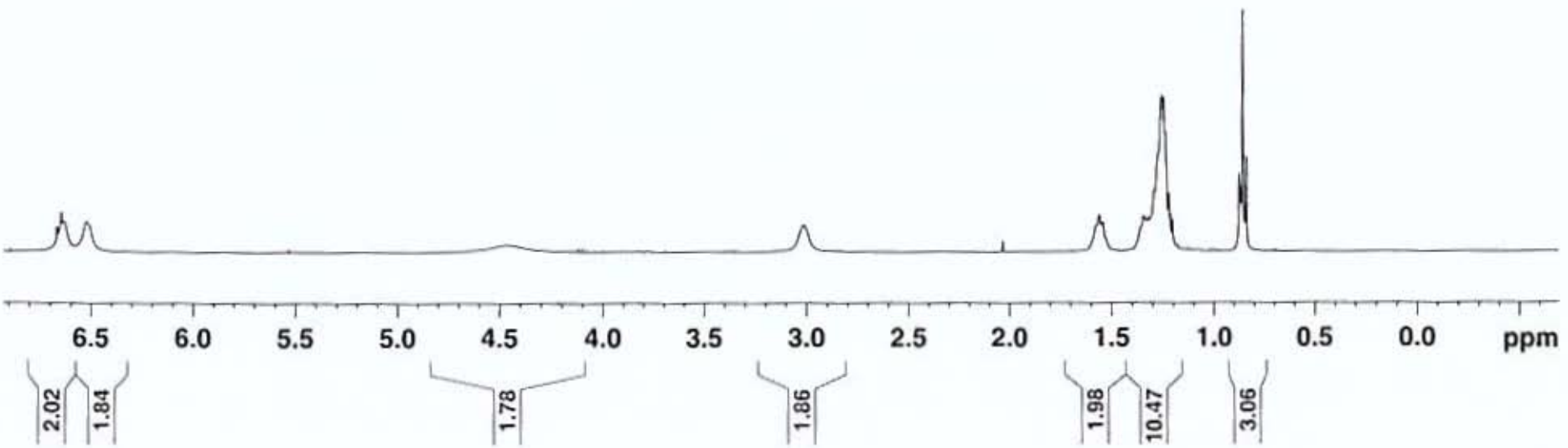


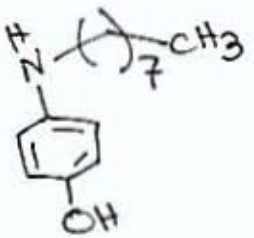


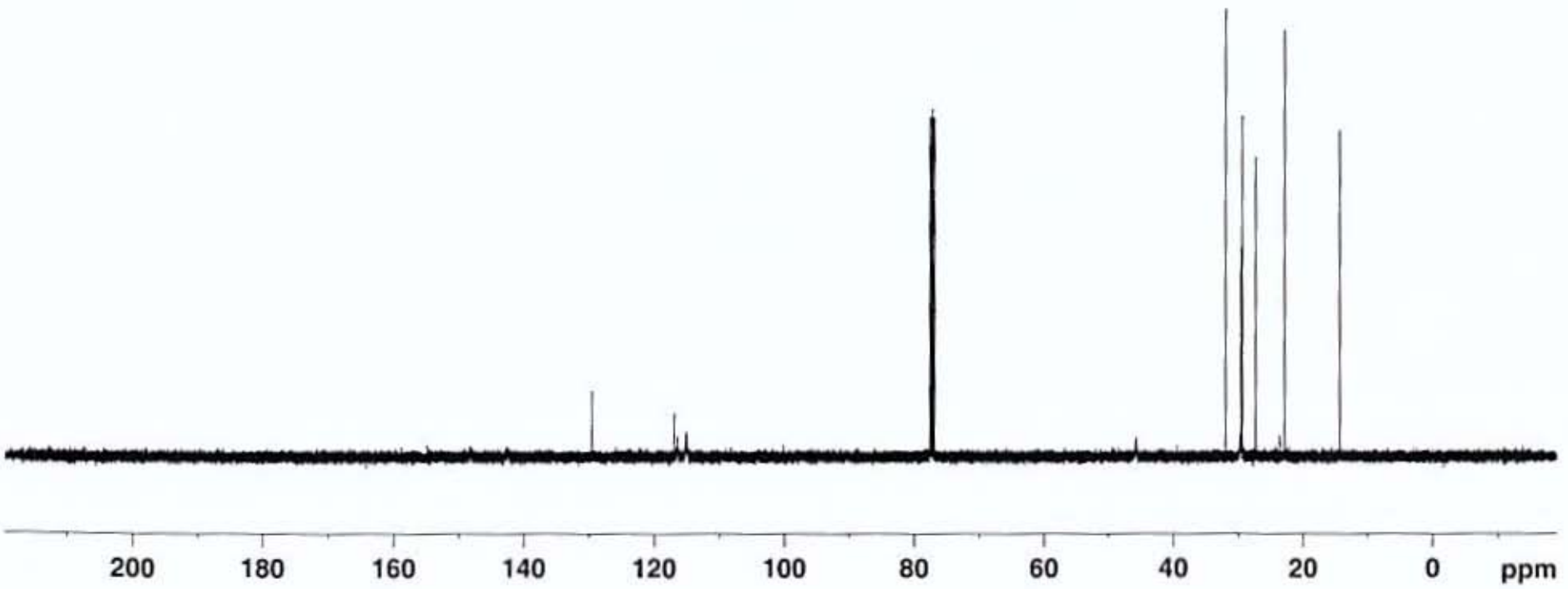


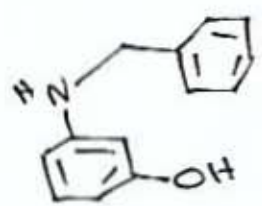


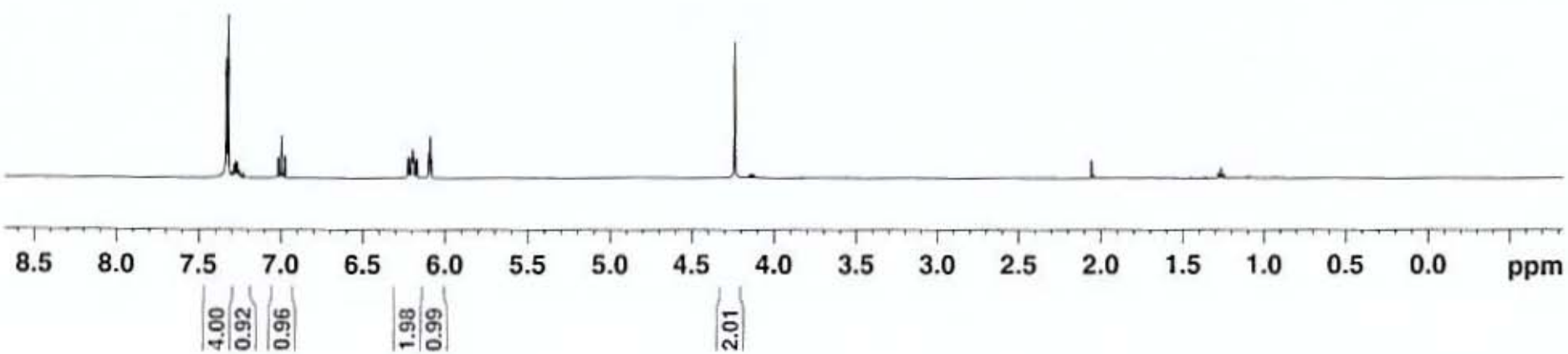

H
N
7
CH3
OH

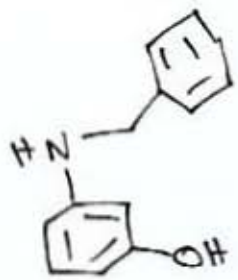

6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.02
1.84
1.78
1.86
1.98
10.47
3.06

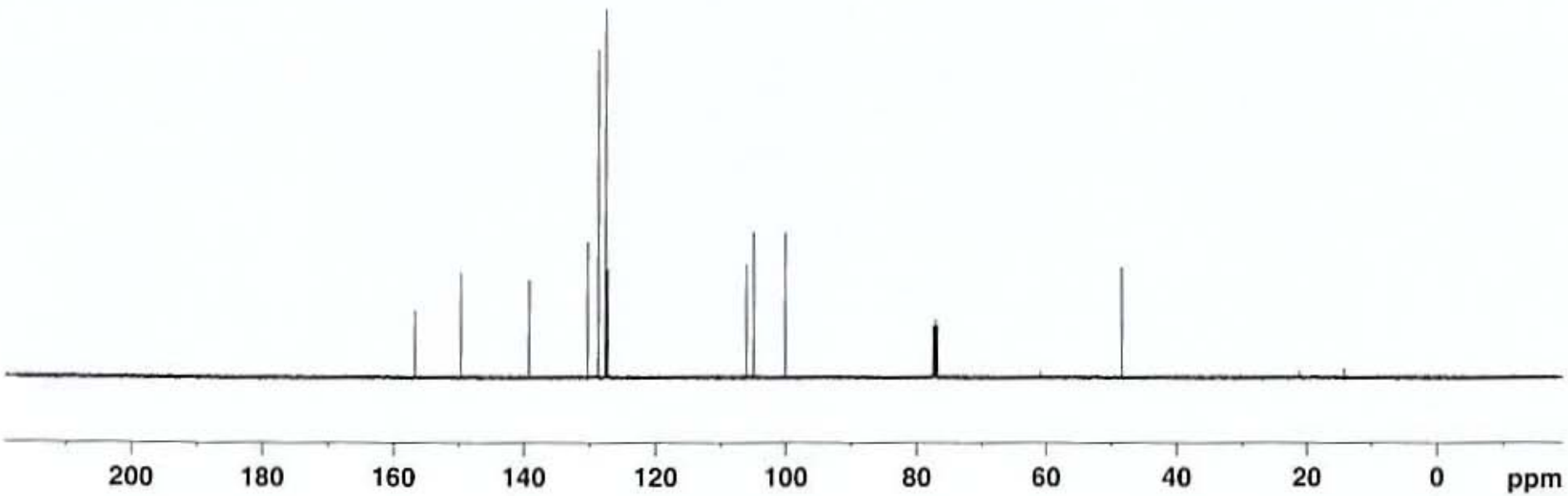


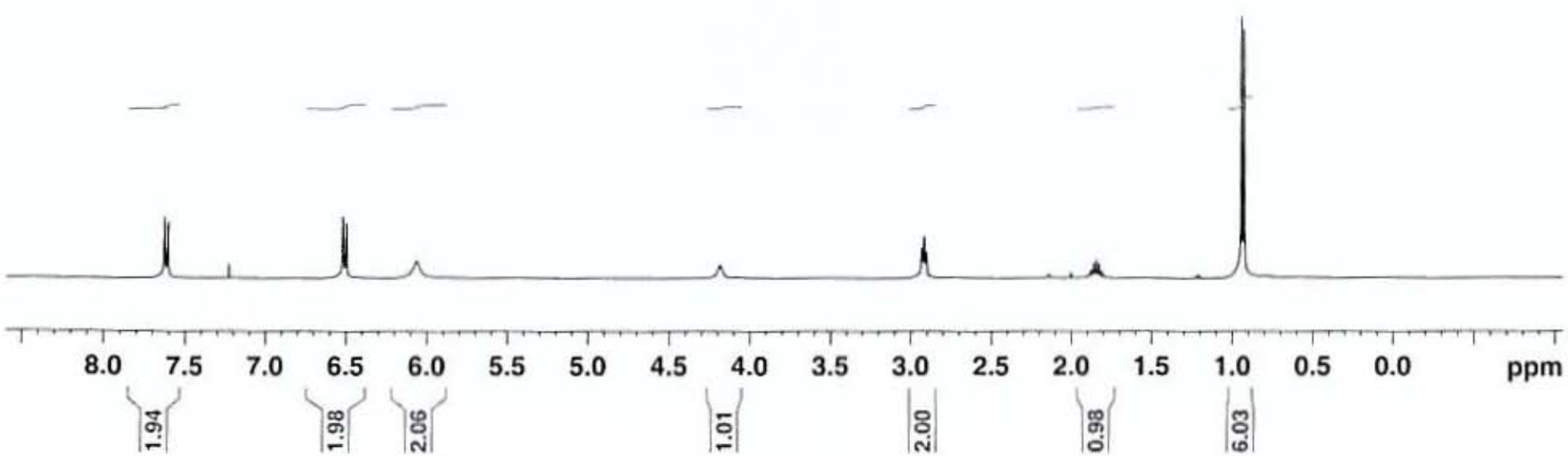


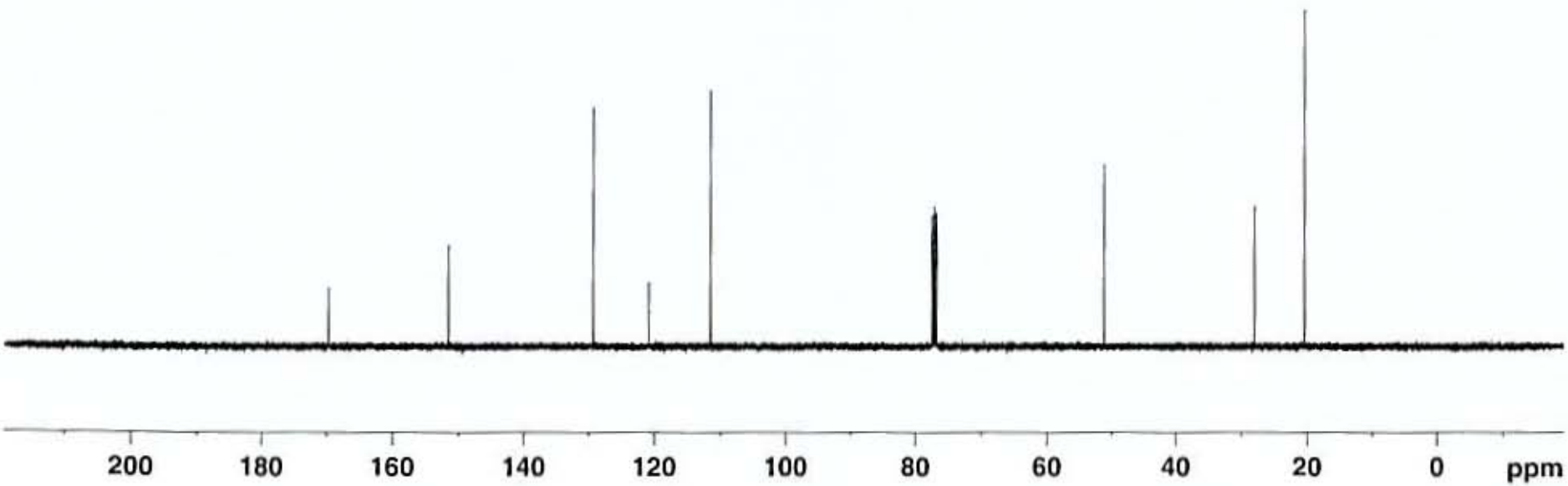


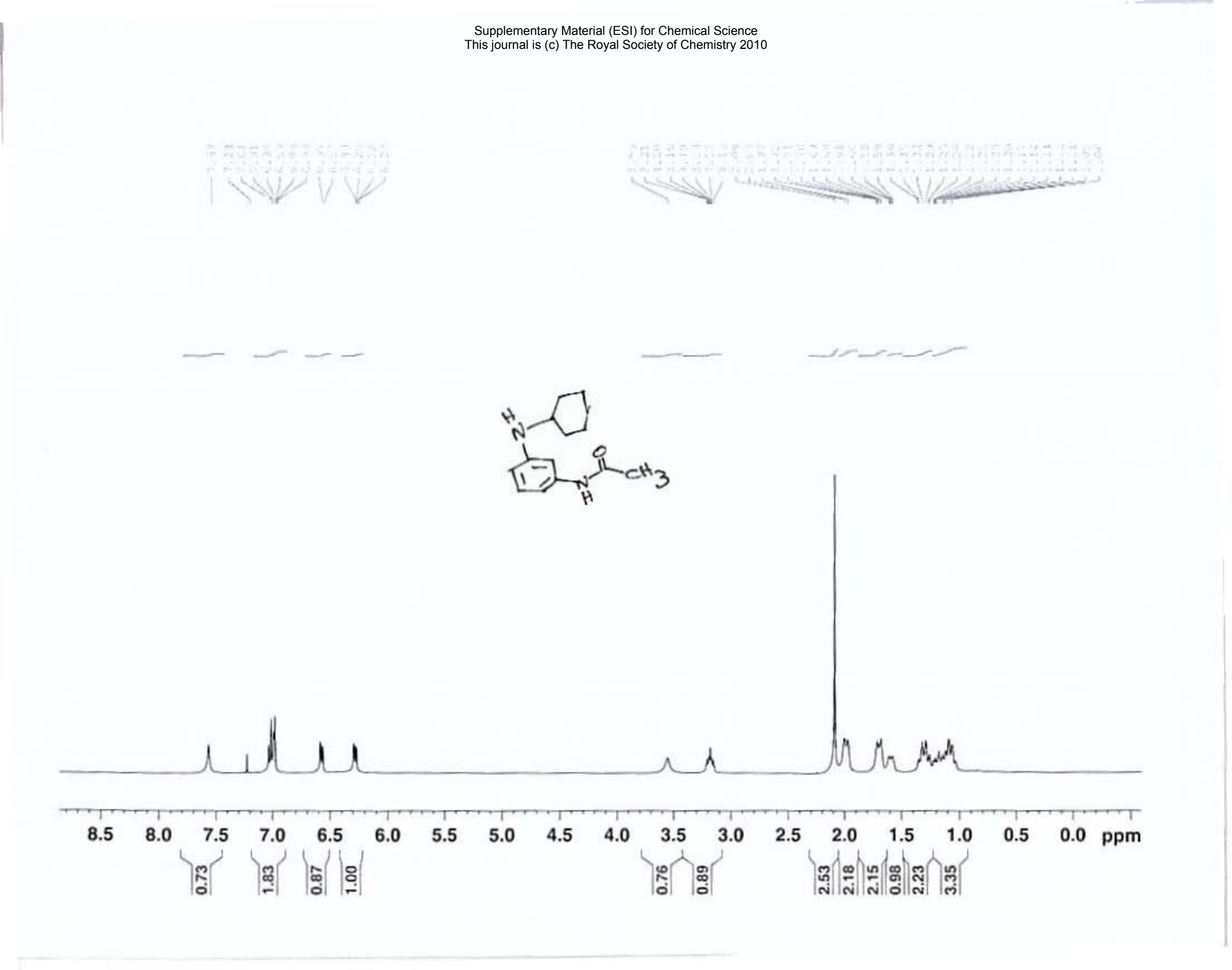


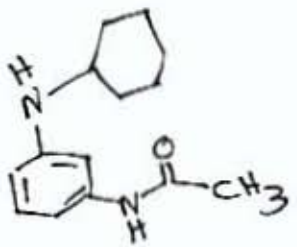


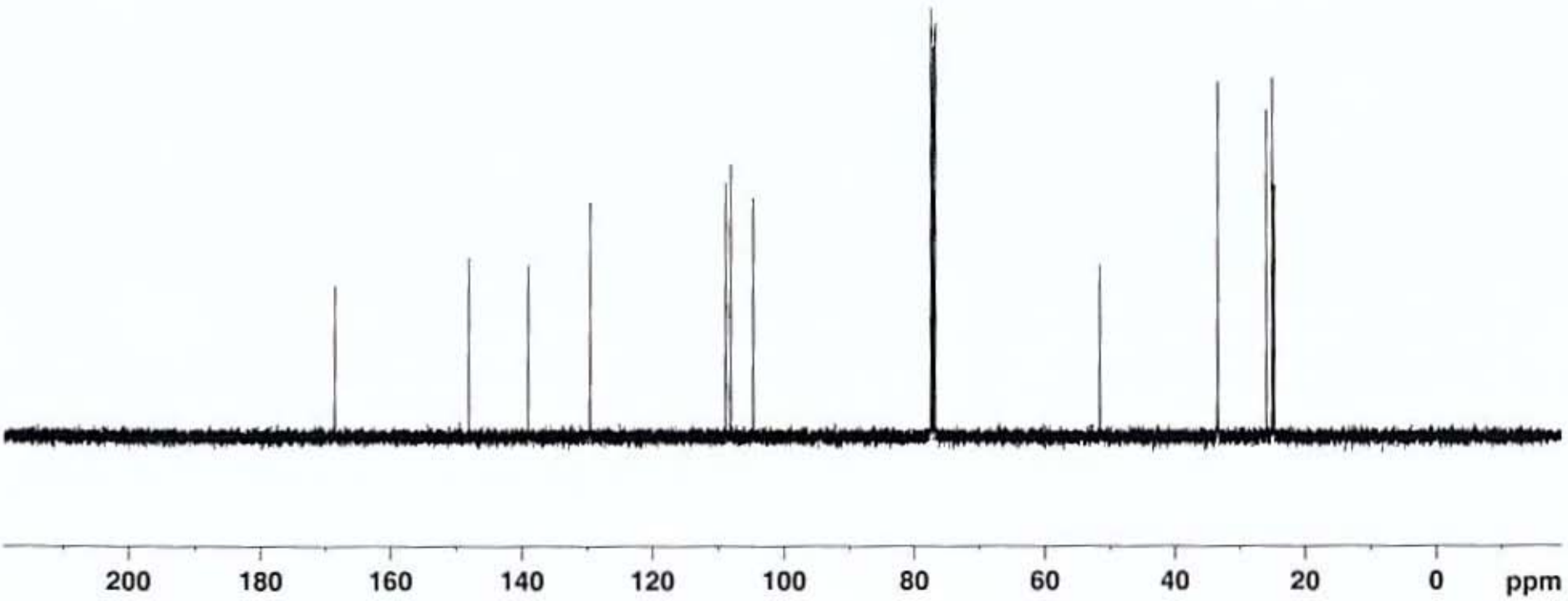


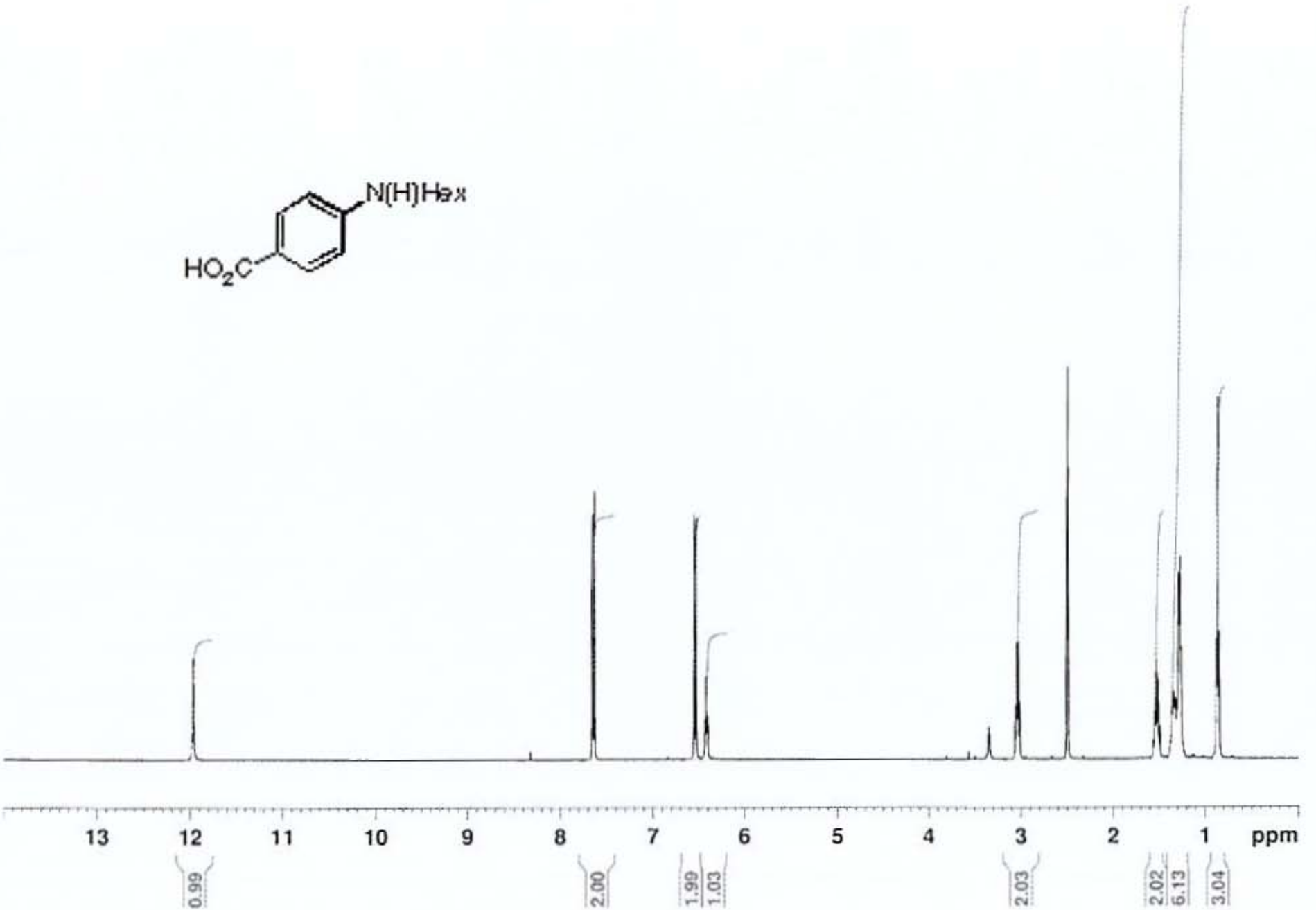


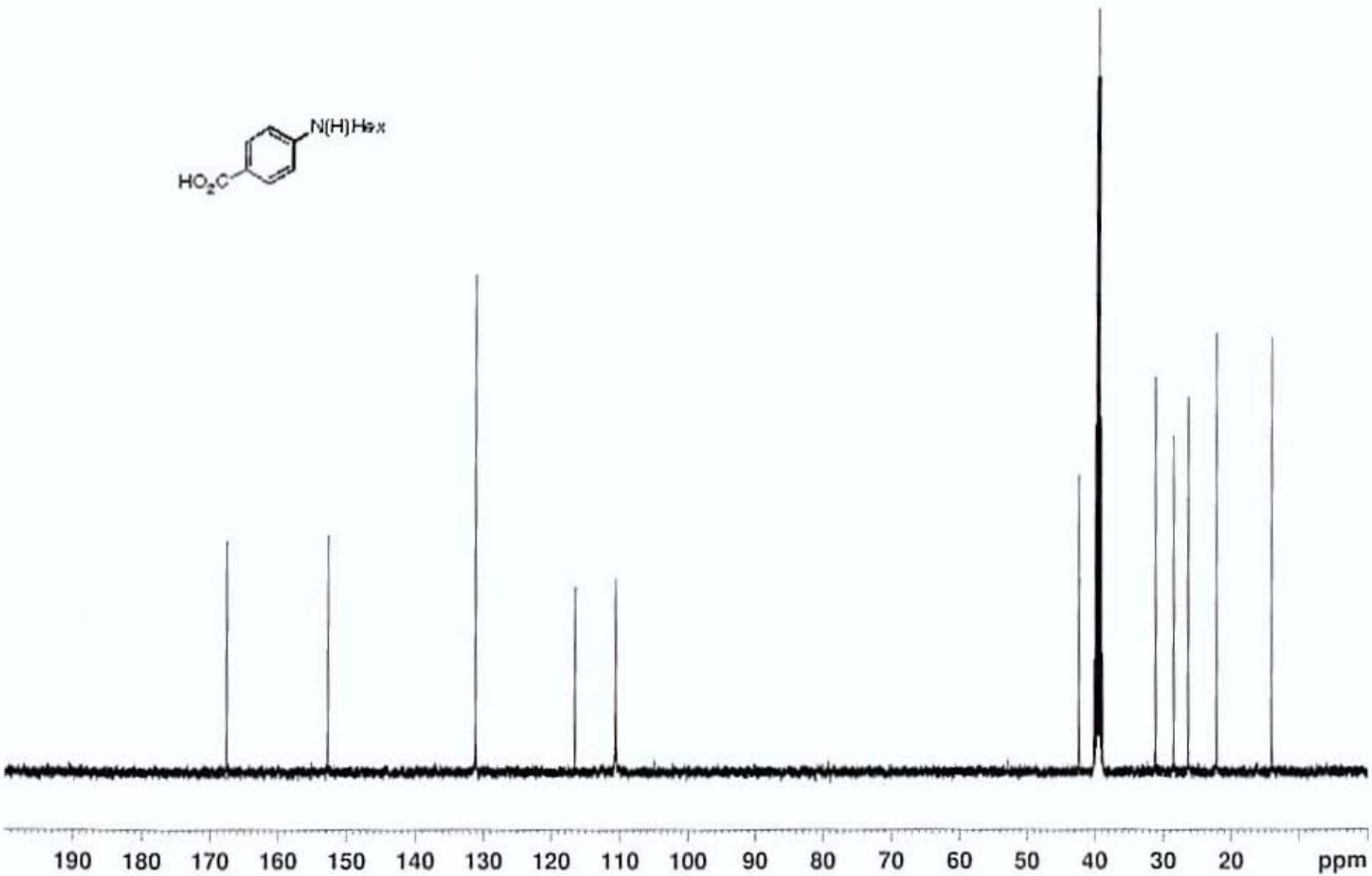


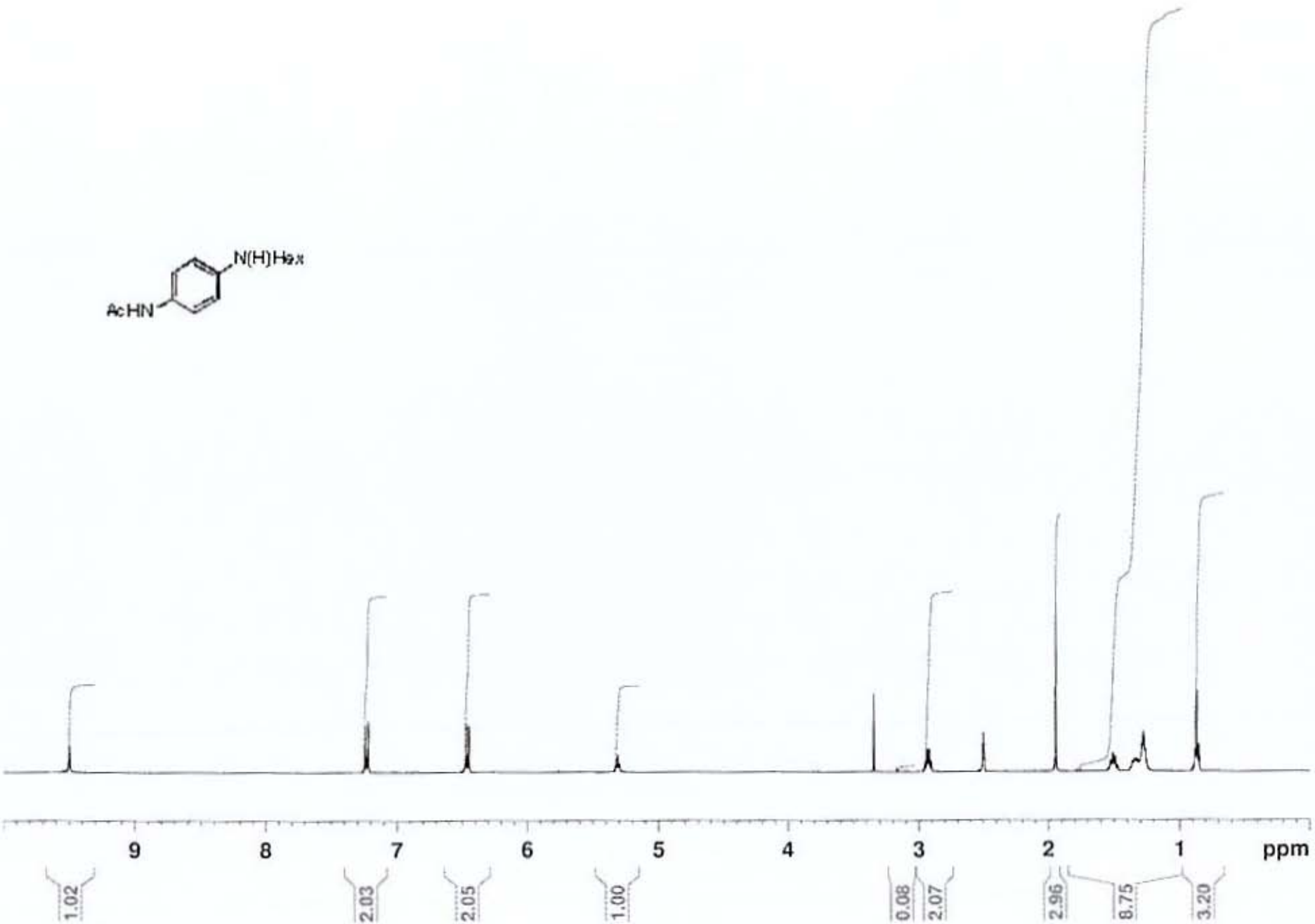


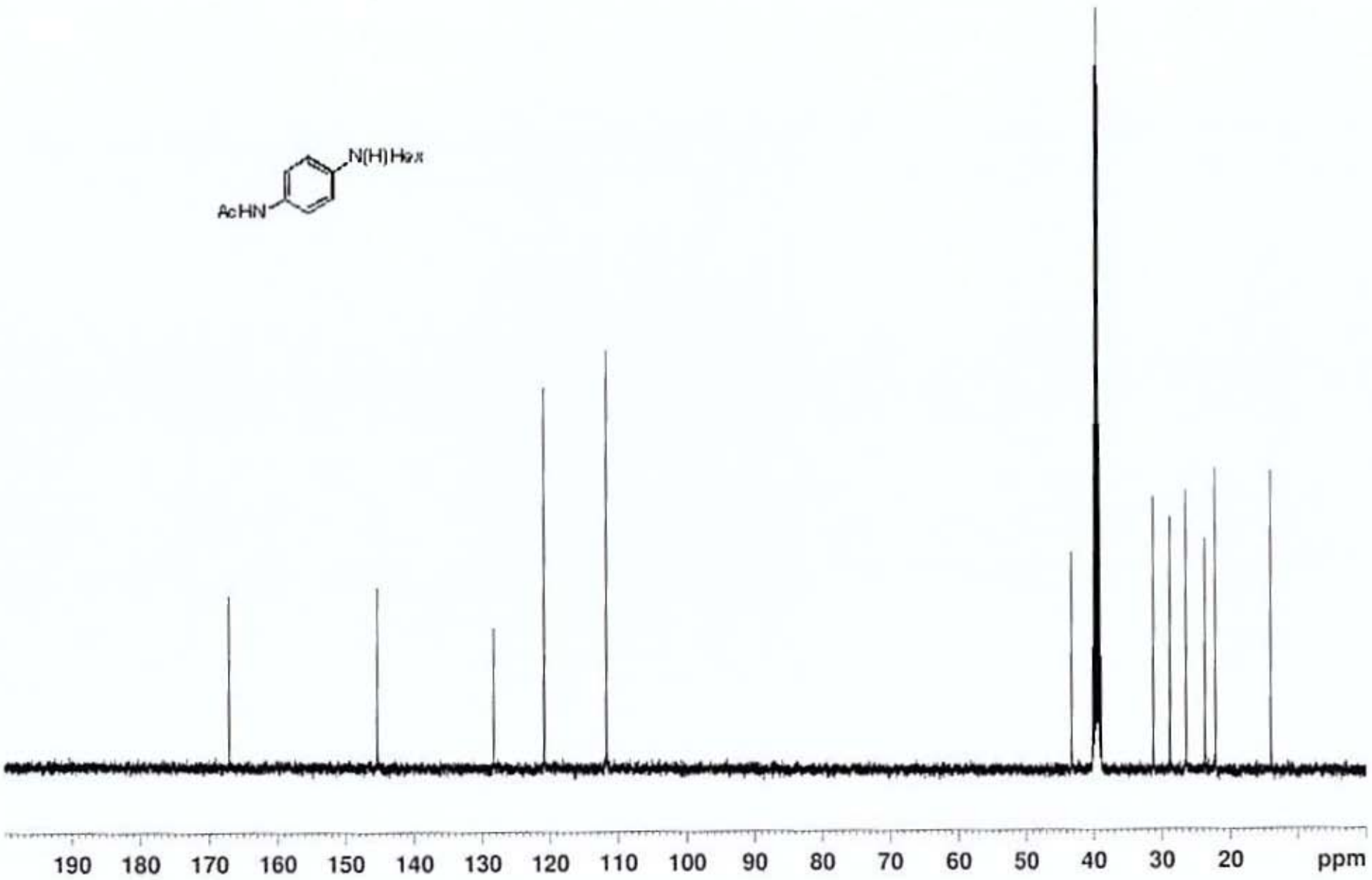


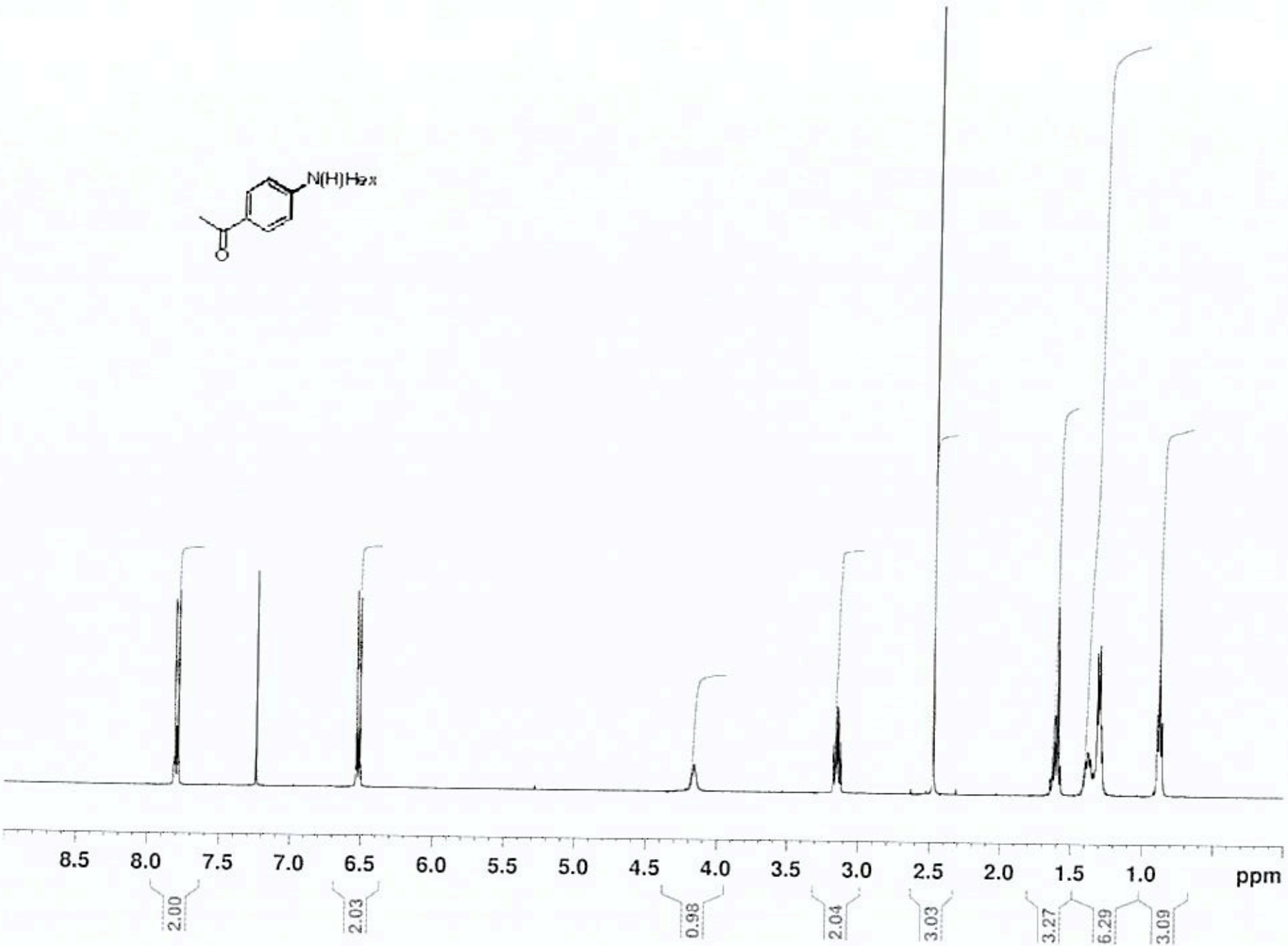


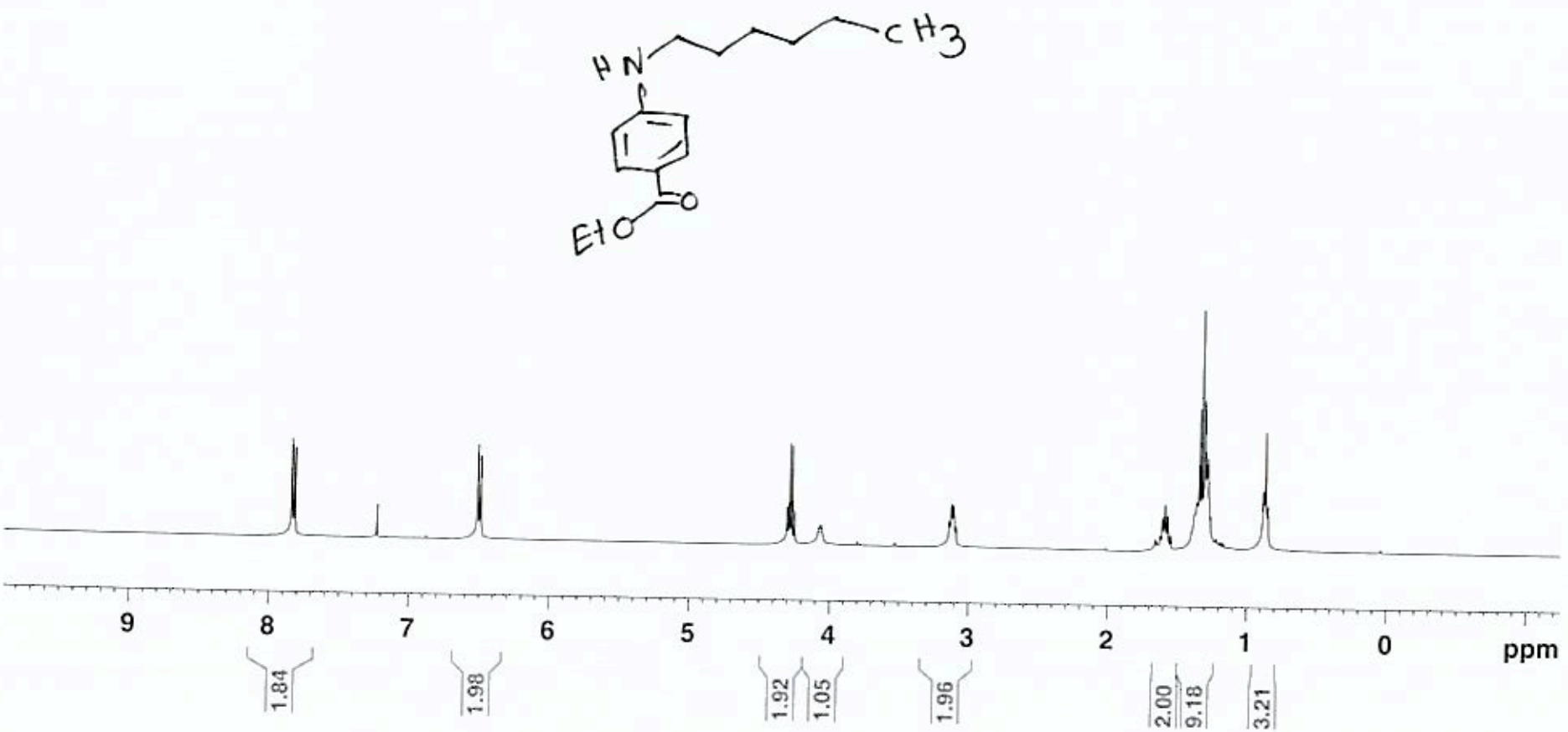


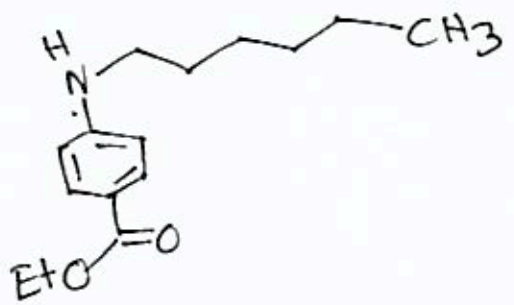


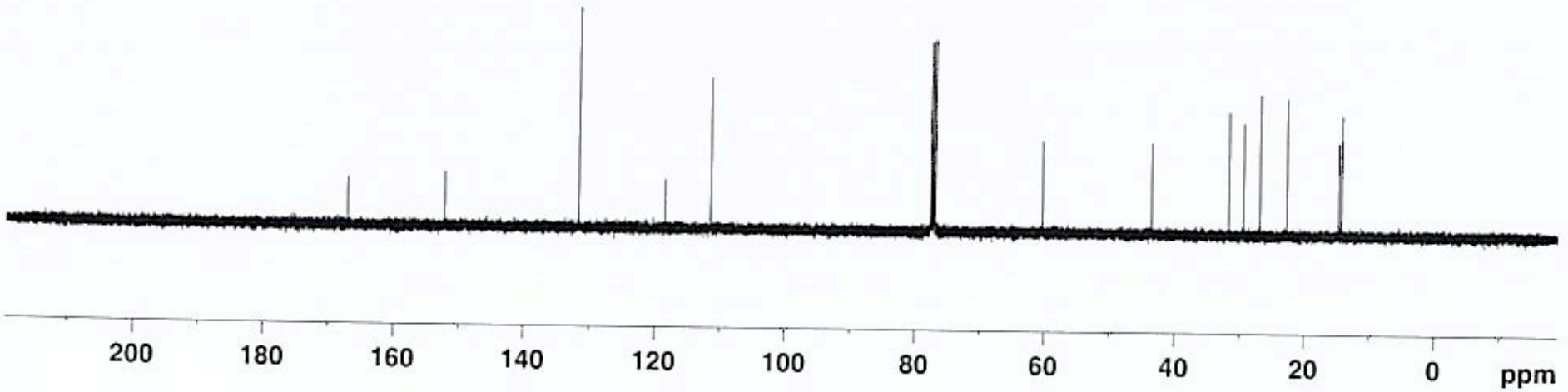


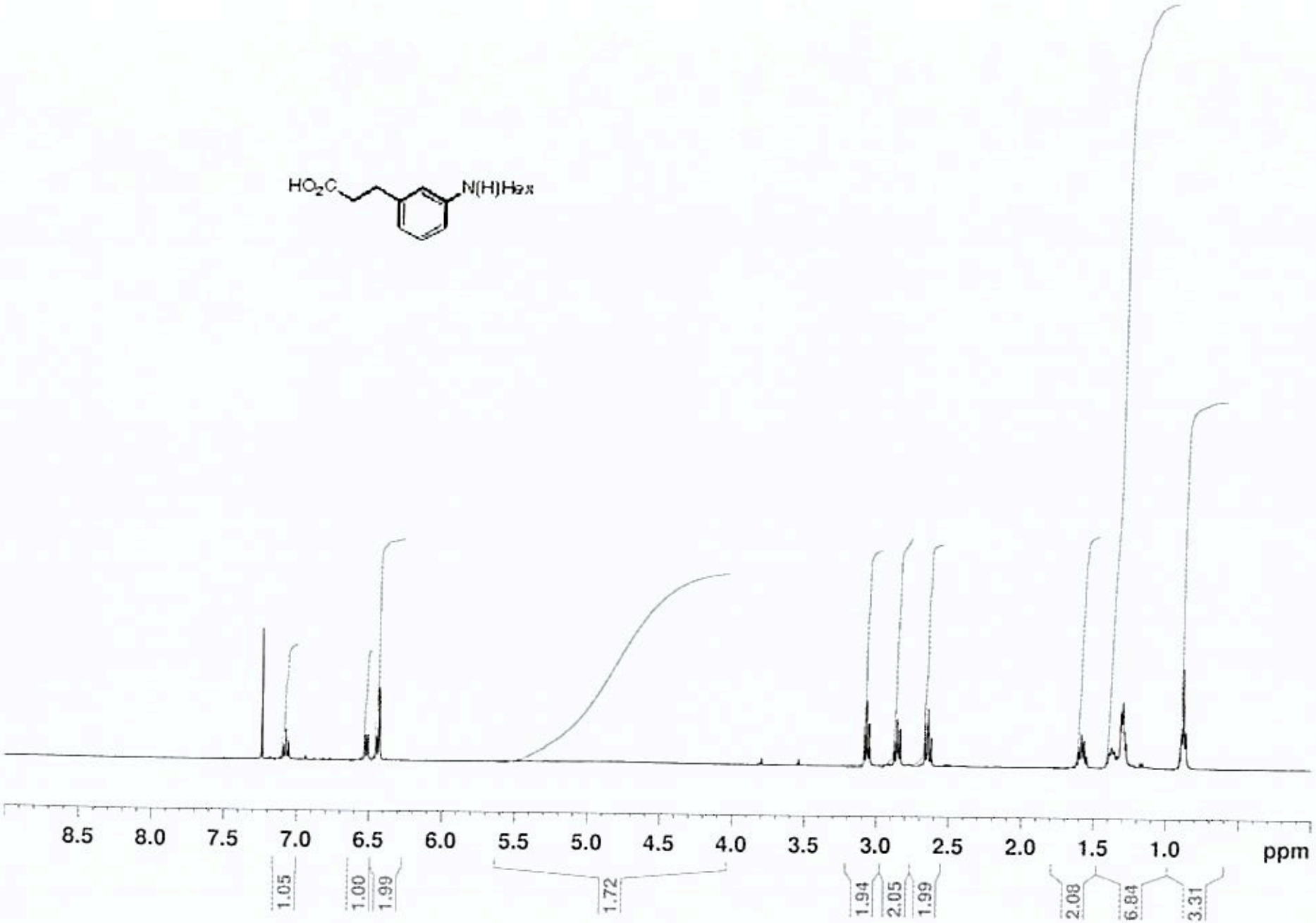


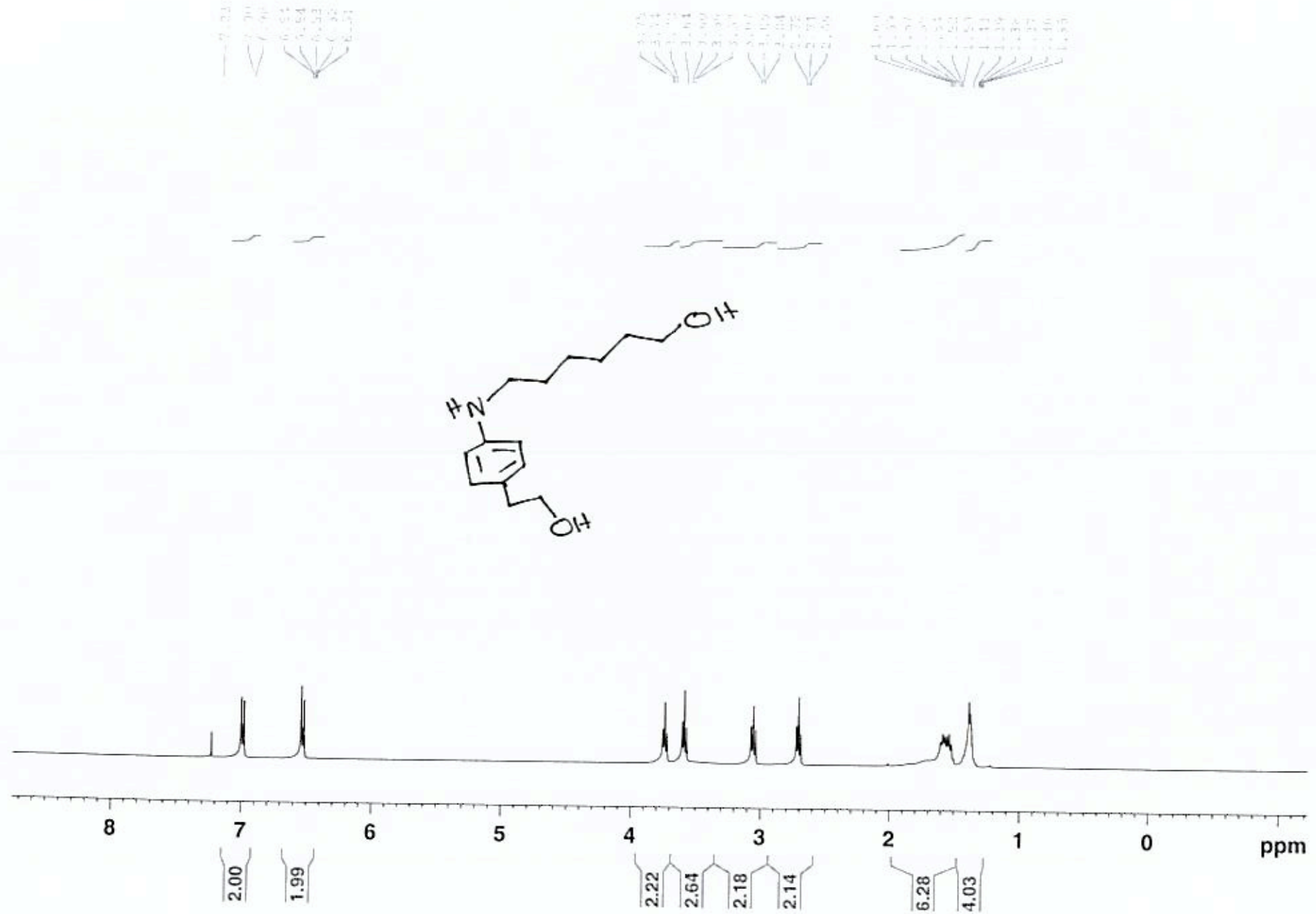

N(H)H2x
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.00
2.03
0.98
2.04
3.03
3.27
6.29
3.09

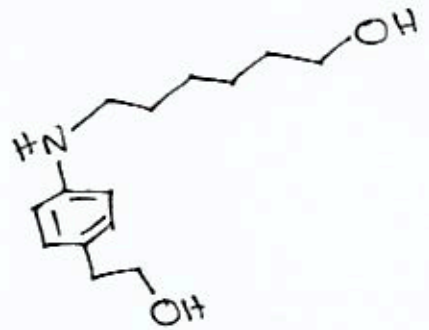

HN
CH3
EtO
O
9
8
7
6
5
4
3
2
1
0
ppm
1.84
1.98
1.92
1.05
1.96
2.00
9.18
3.21

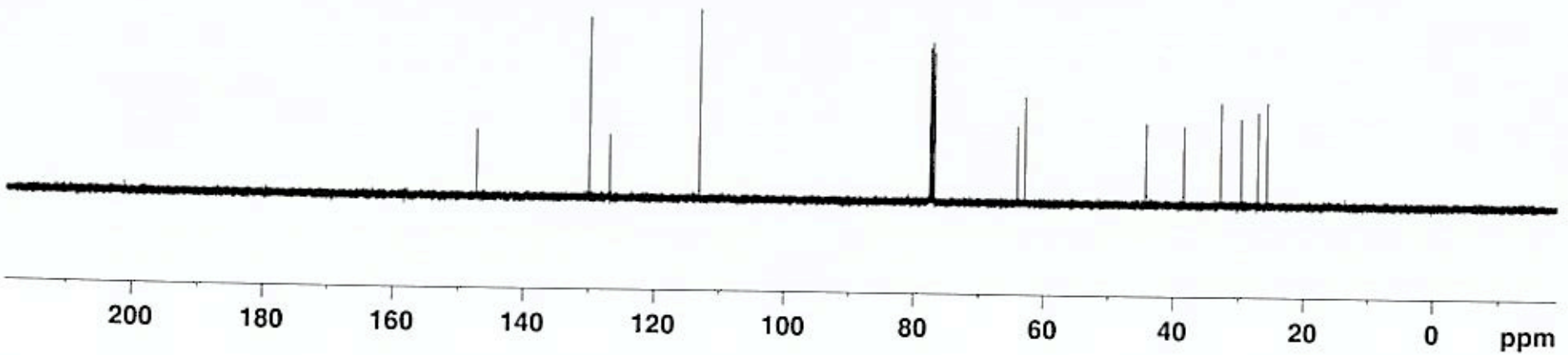


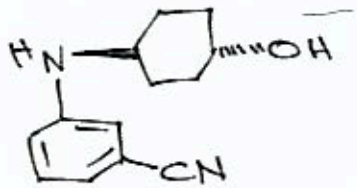


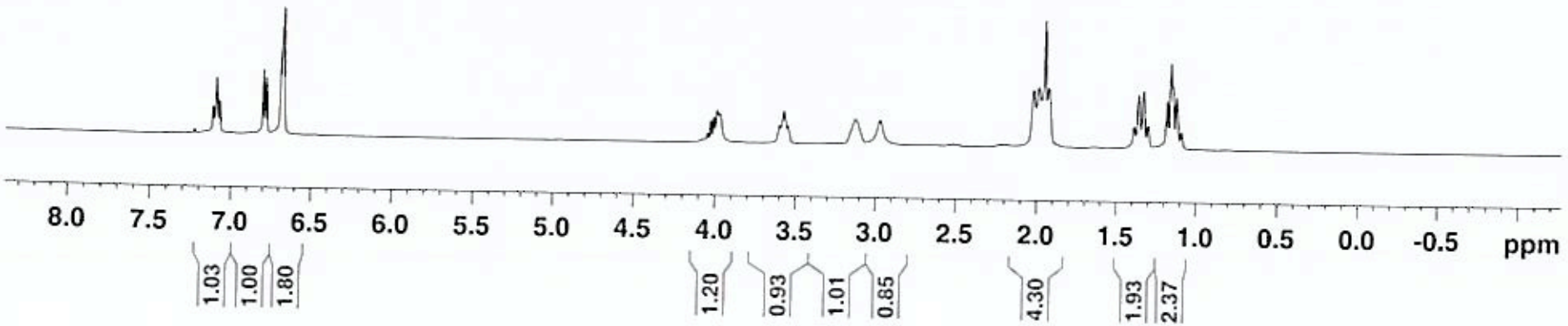

HO2C
N(H)Hex
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
1.05
1.00
1.99
1.72
1.94
2.05
1.99
2.08
6.84
3.31

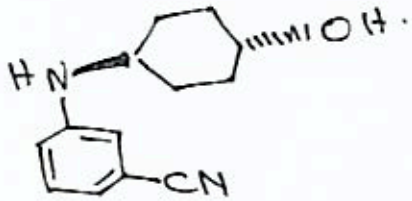

OH
H2N
OH
8
7
6
5
4
3
2
1
0
ppm
2.00
1.99
2.22
2.64
2.18
2.14
6.28
4.03

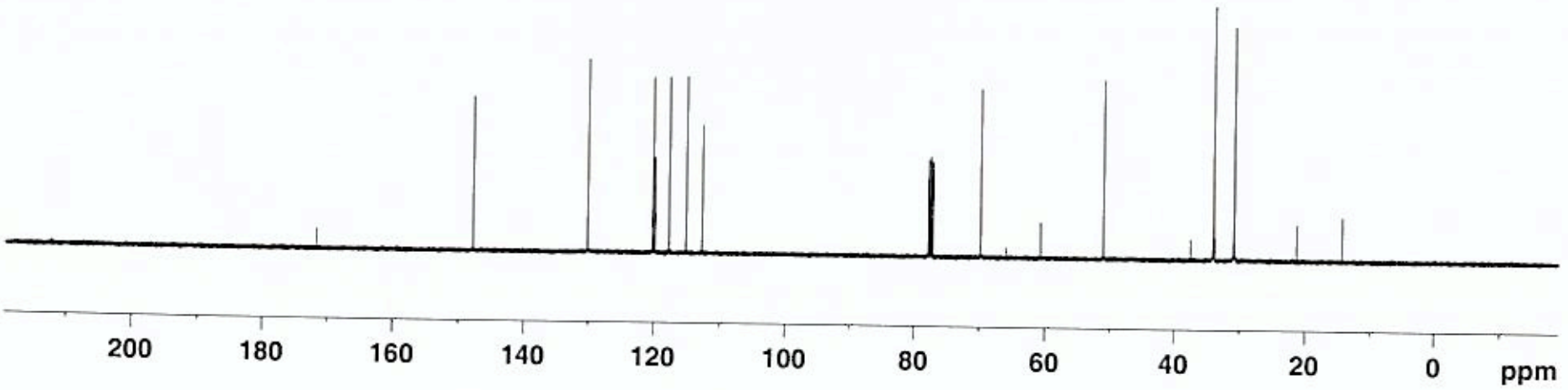

OH
HN
OH

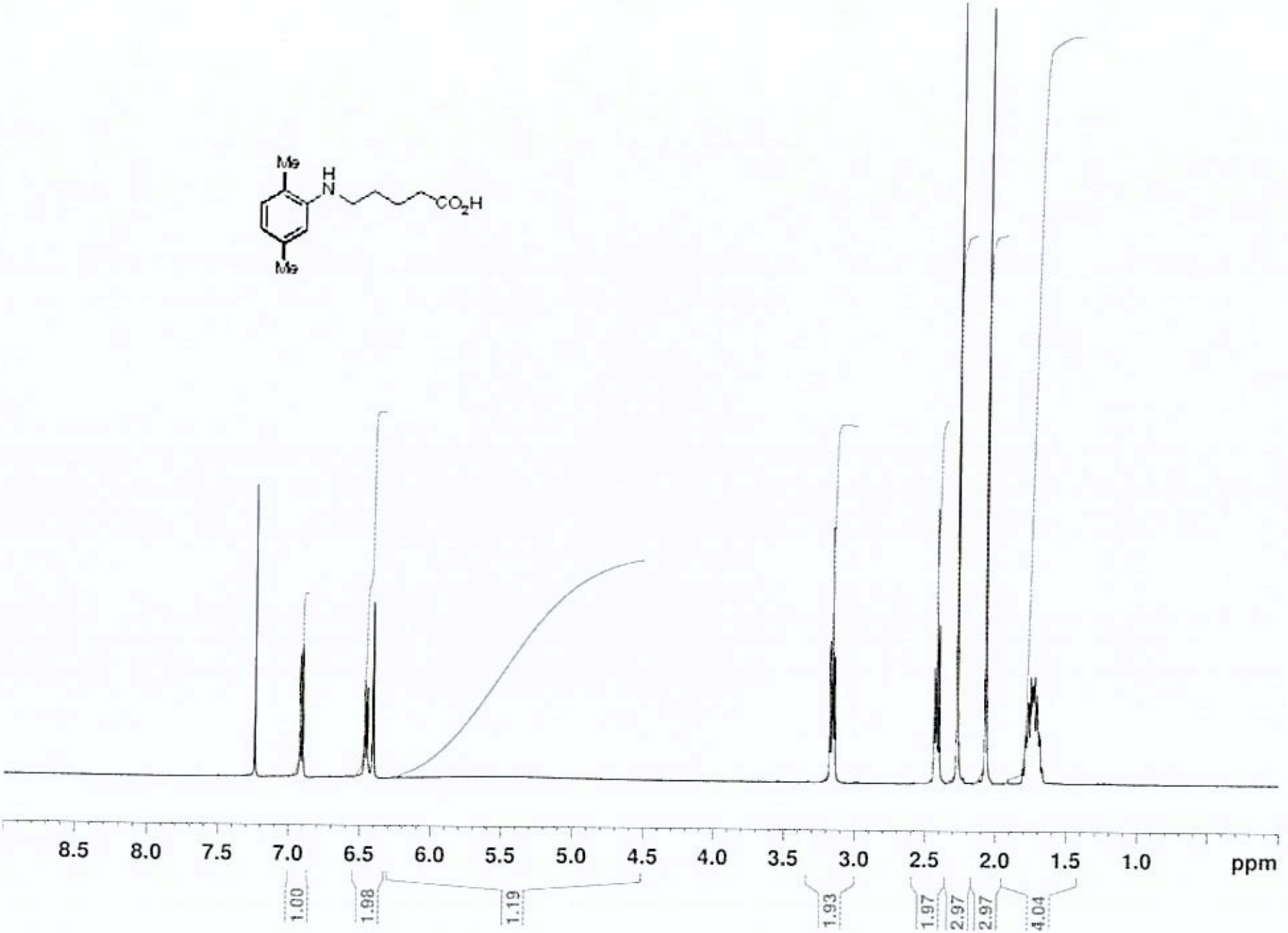

200
180
160
140
120
100
80
60
40
20
0
ppm

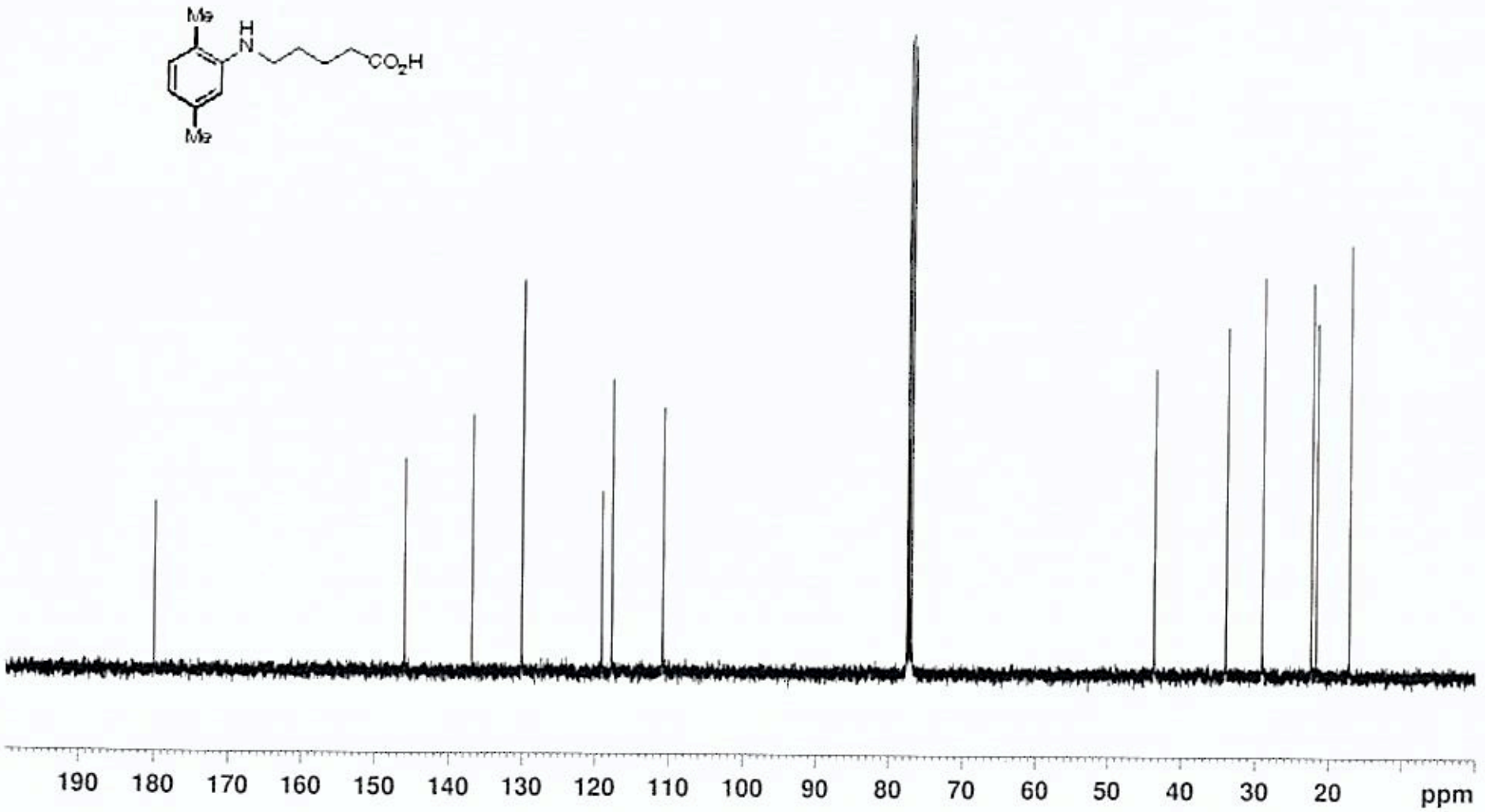

HN
OH
CN

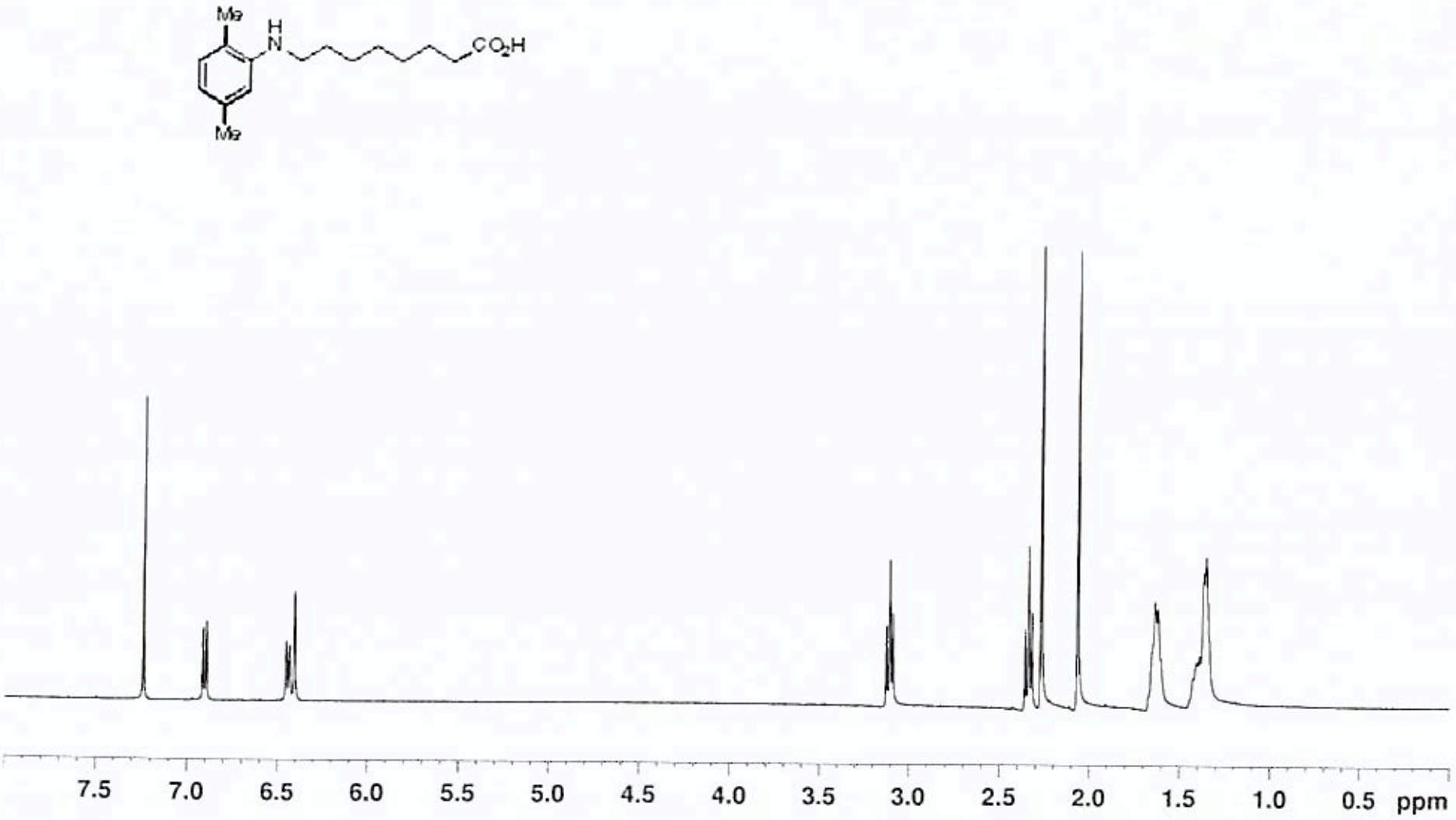

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
ppm
1.03
1.00
1.80
1.20
0.93
1.01
0.85
4.30
1.93
2.37

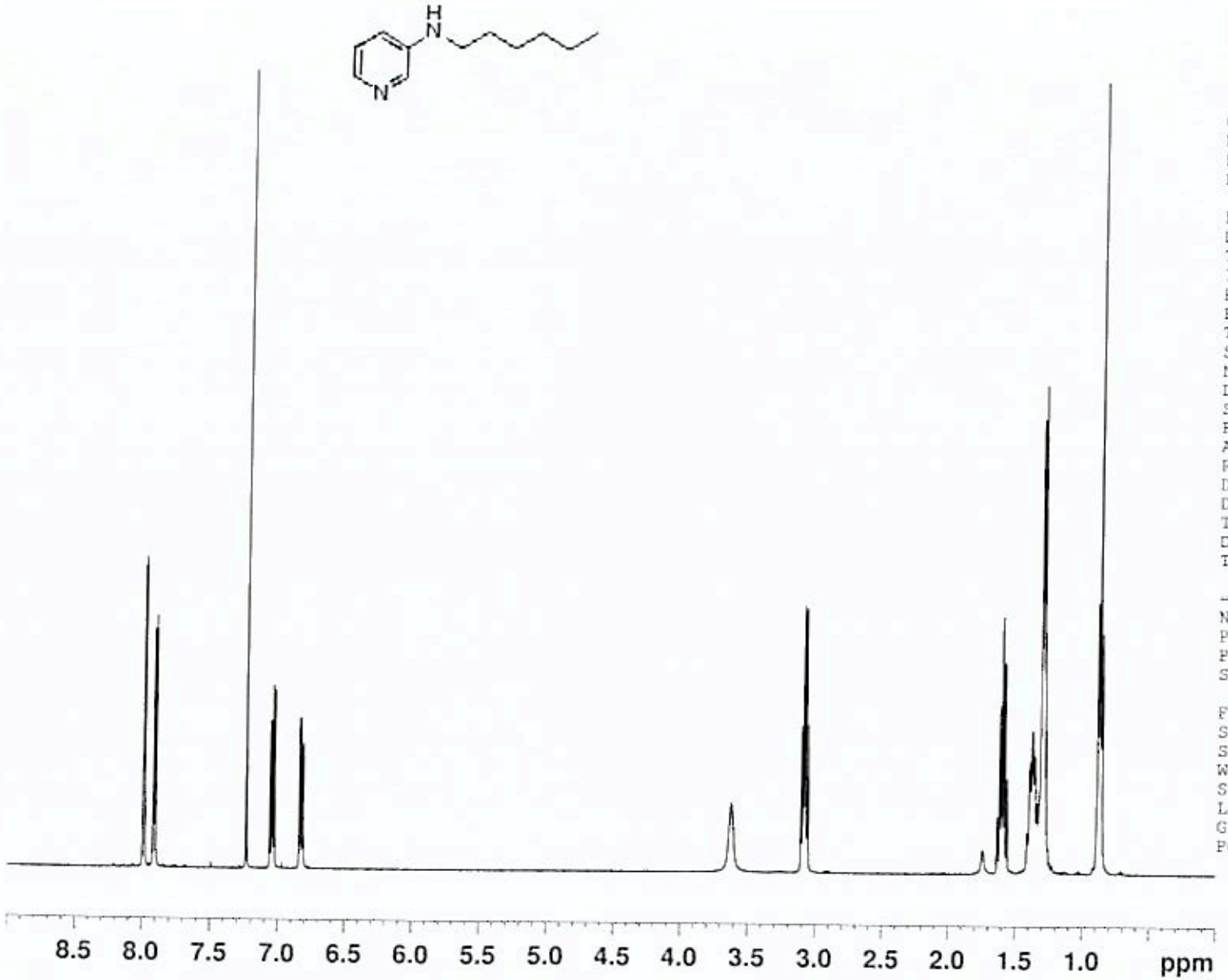

H N
OH
CN


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


Me
H
N
CO2H
Me
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
ppm
1.00
1.98
1.19
1.93
1.97
2.97
2.97
4.04

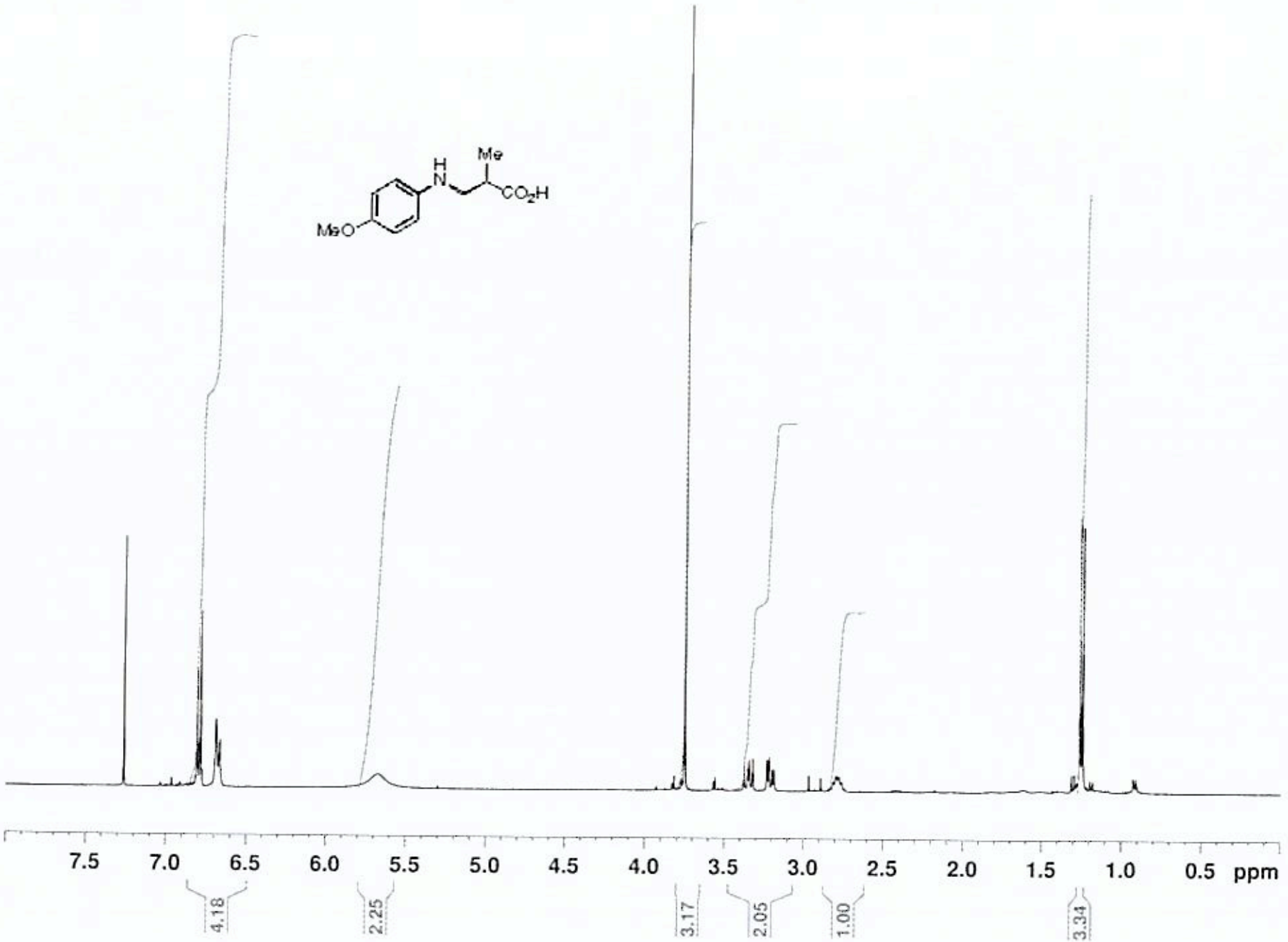

Me
H
N
CO2H
Me
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

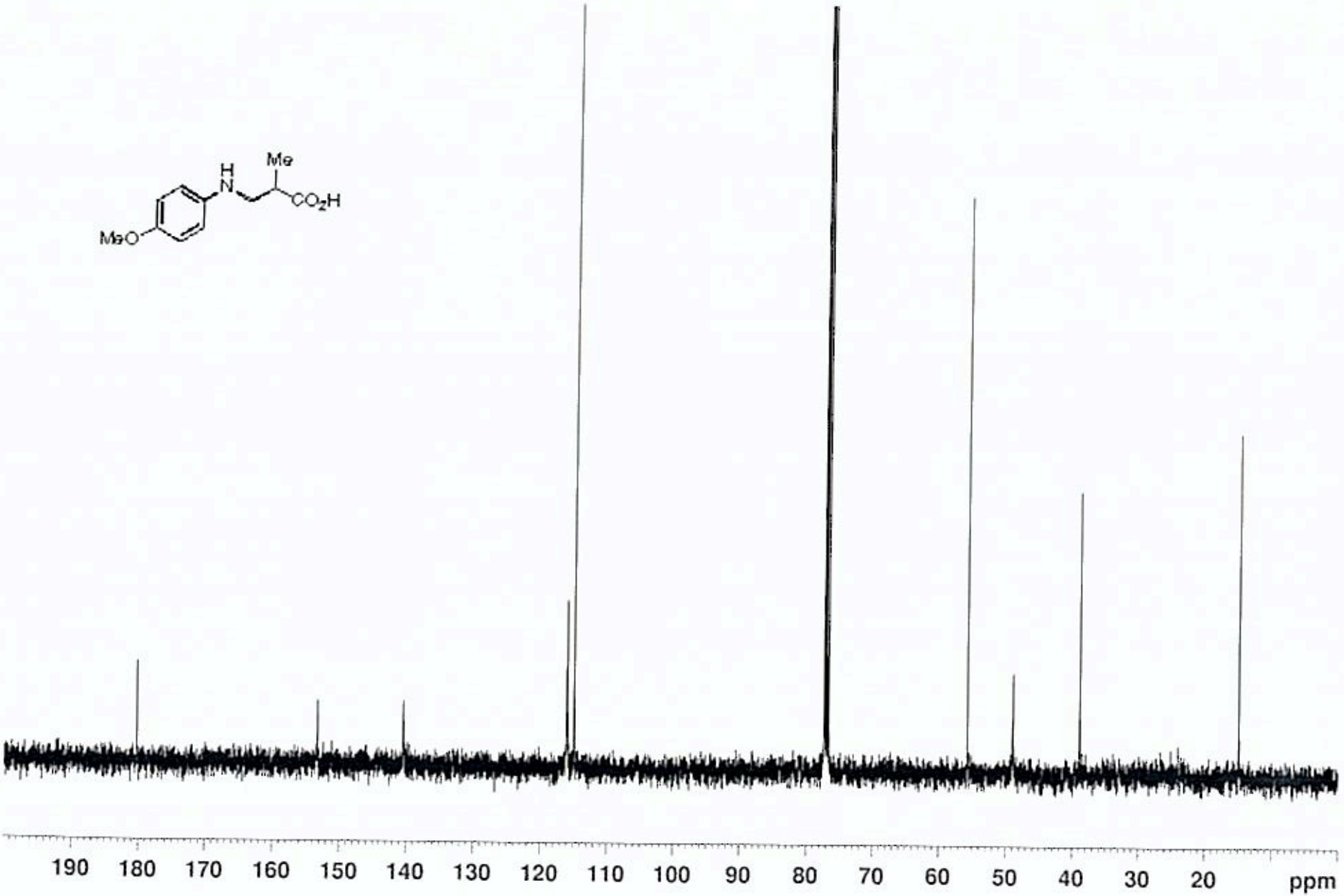

Me
H
N
CO2H
Me
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm

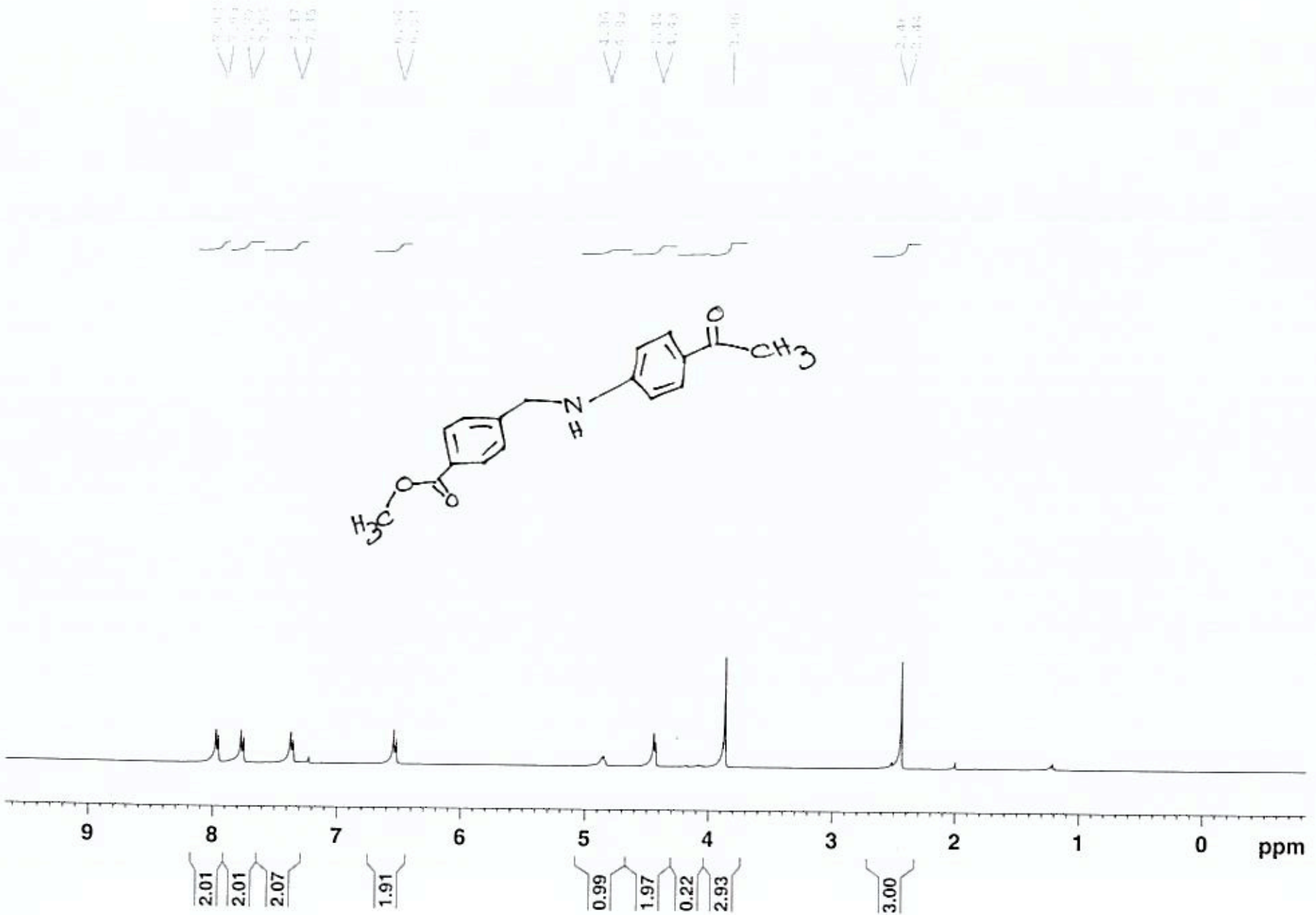


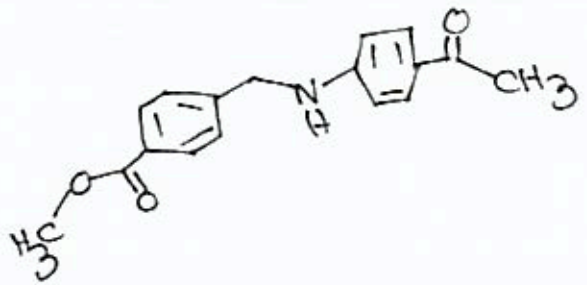
BRUKER

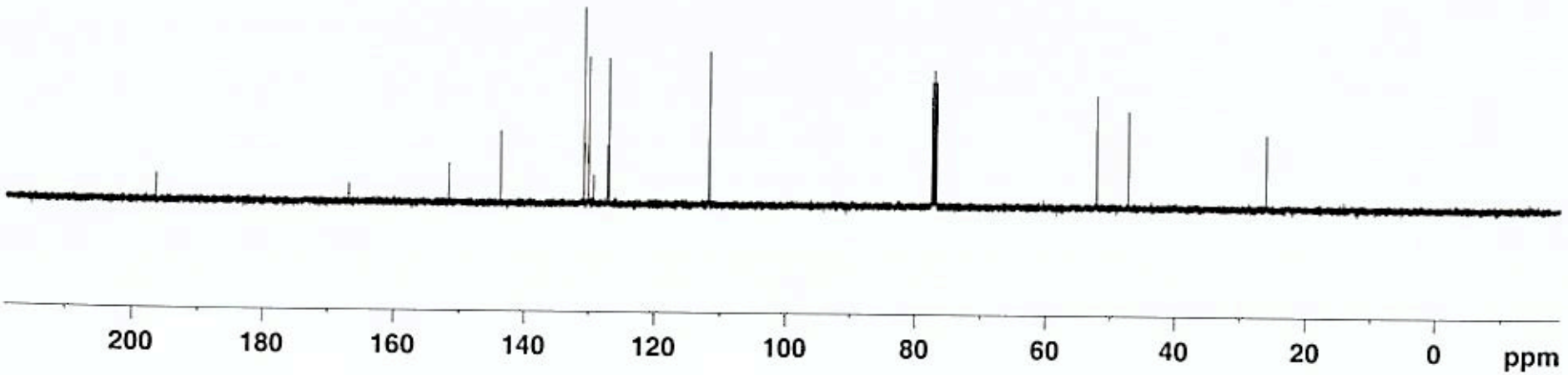
```
Current Data Parameters
NAME                  YNY-1-176-1
EXPNO                           1
PROCNO                          1

F2 - Acquisition Parameters
Date_                    20080303
Time                        17.03
INSTRUM                     spect
PROBHD    5 mm QNP 1H/13
PULPROG                      zg30
TD                          65536
SOLVENT                     CDCl3
NS                             16
DS                              2
SWH                      8278.146 Hz
FIDRES                   0.126314 Hz
AQ                       3.9584243 sec
RG                           287.4
DW                          60.400 usec
DE                           6.00 usec
TE                          291.2 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                400.1300190 MHz
WDW                            EM
SSB                             0
LB                           0.30 Hz
GB                              0
PC                           1.00
```

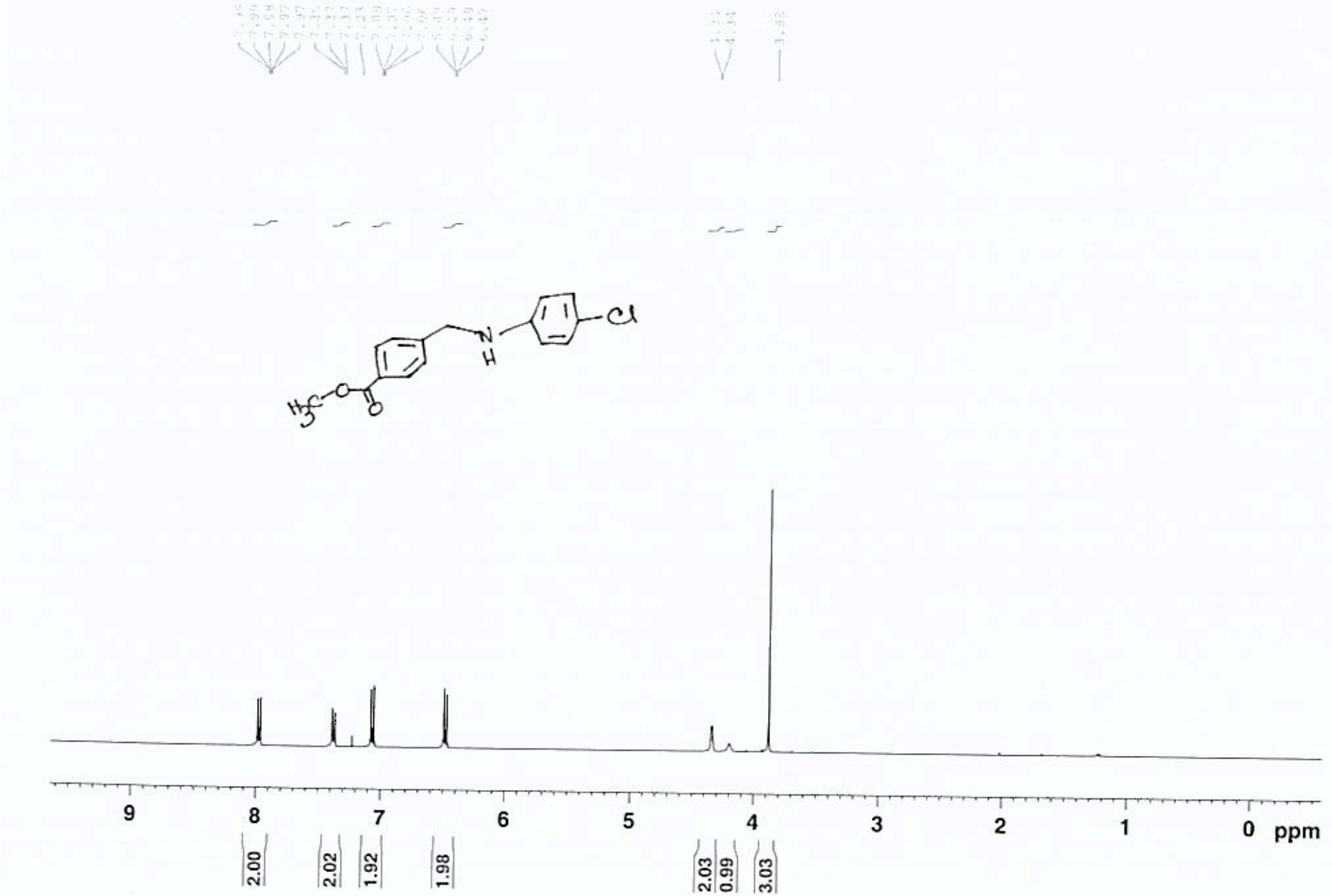

Me
H
N
CO2H
MeO
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
4.18
2.25
3.17
2.05
1.00
3.34

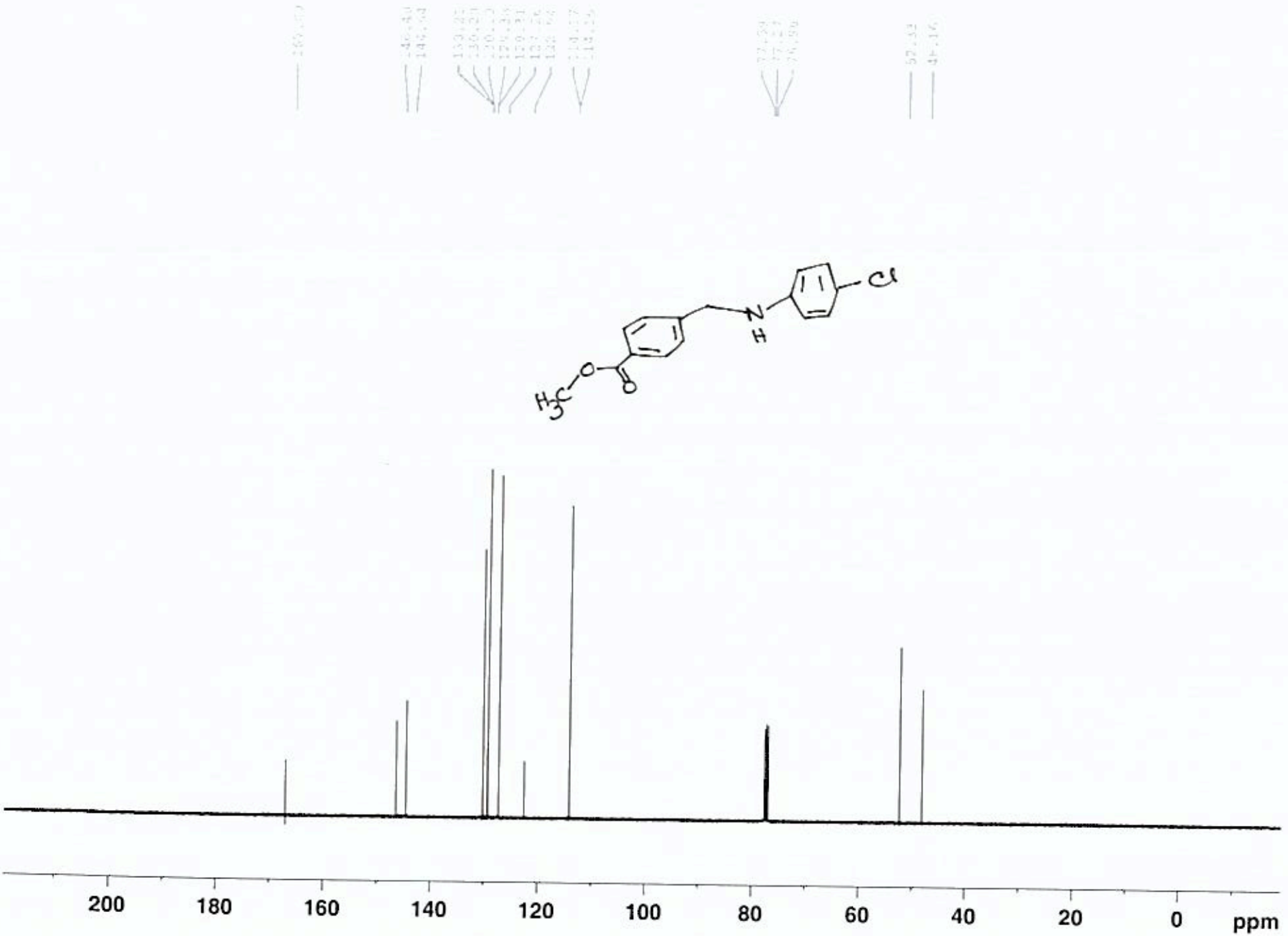

Me
H
N
CO2H
MeO
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm


O
CH3
N
H
O
O
H3C
9
8
7
6
5
4
3
2
1
0
ppm
2.01
2.01
2.07
1.91
0.99
1.97
0.22
2.93
3.00


O
CH3
N
H
O
O
H3C


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


Cl
H
N
O
O
9
8
7
6
5
4
3
2
1
0
ppm
2.00
2.02
1.92
1.98
2.03
0.99
3.03


Cl
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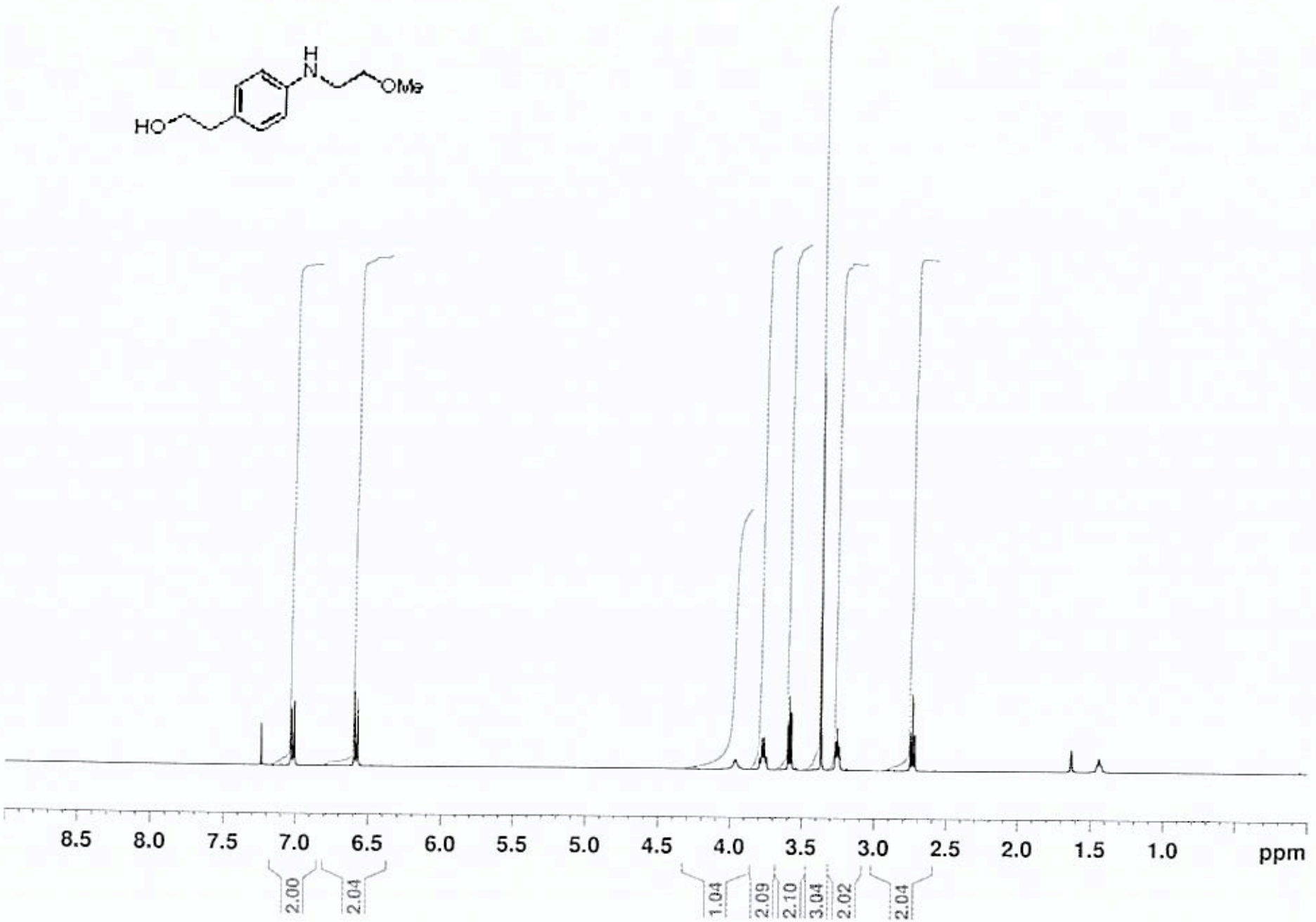
H
O
O
H3C
200
180
160
140
120
100
80
60
40
20
0
ppm


HO
H
N
OMe
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7.5
7.0
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5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
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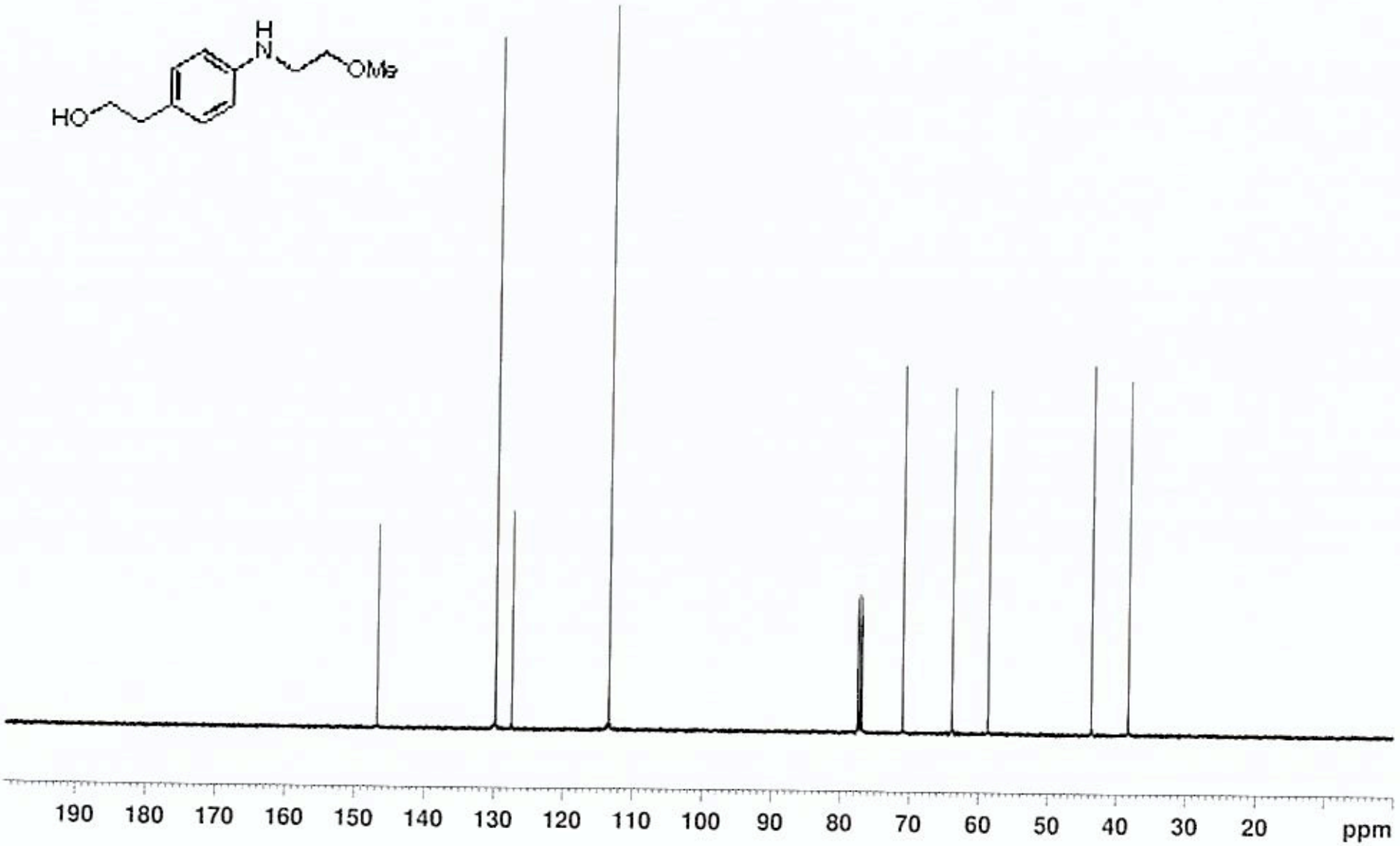
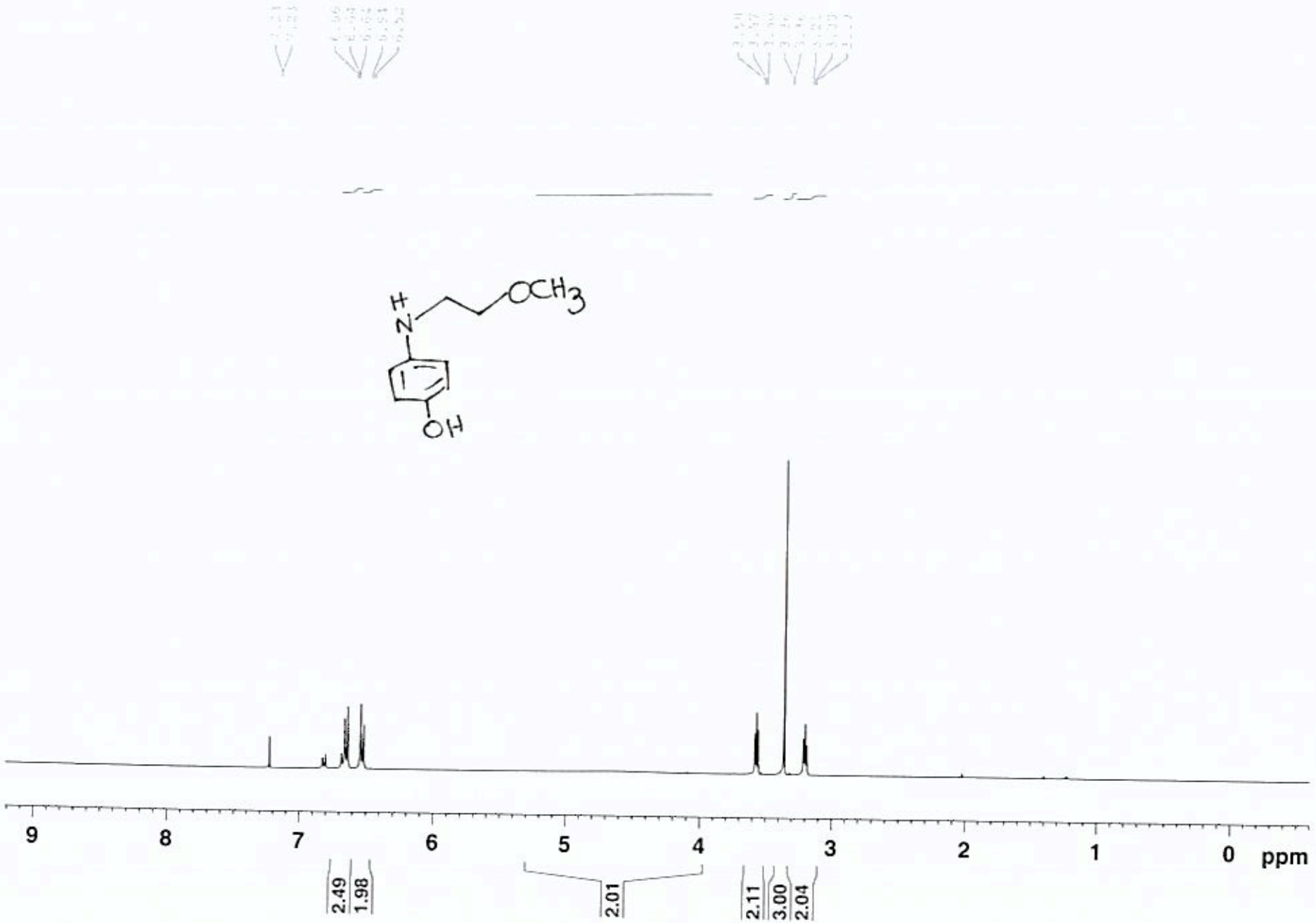
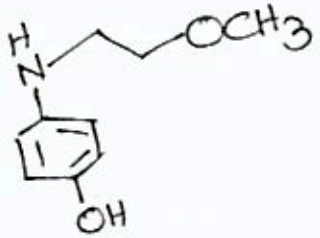
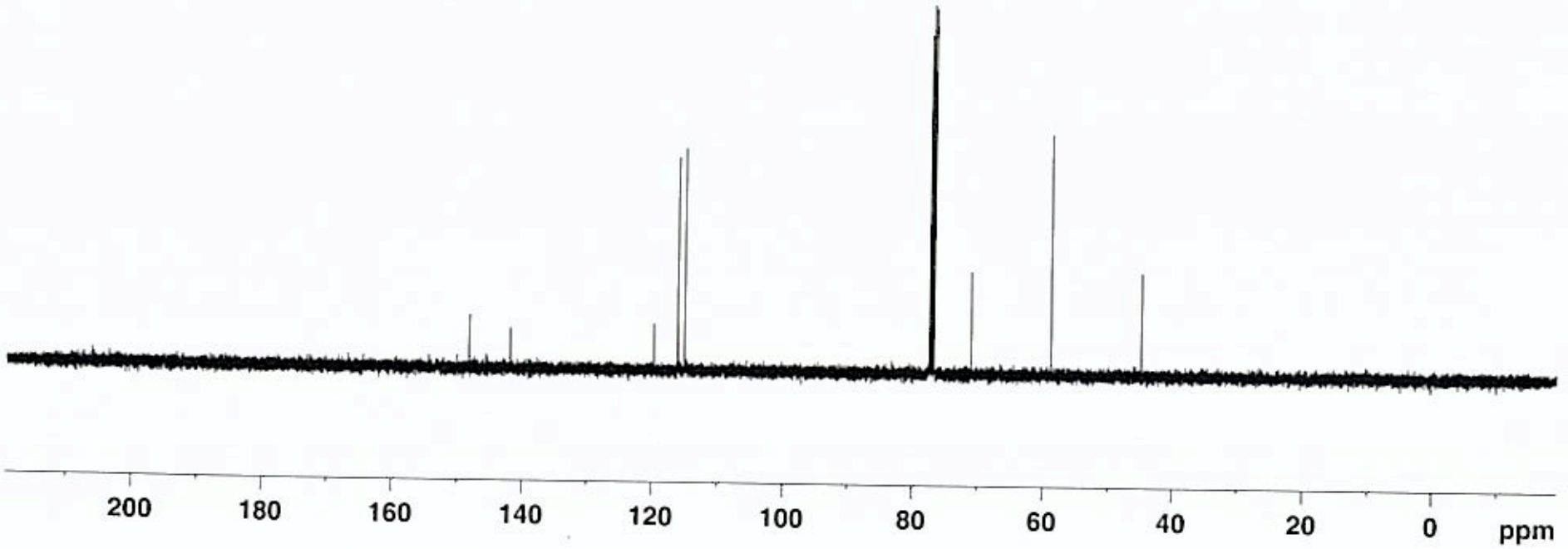
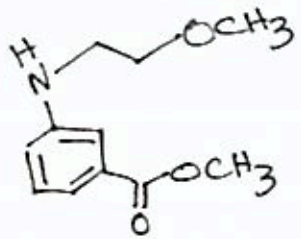
1.0
ppm
2.00
2.04
1.04
2.09
2.10
3.04
2.02
2.04

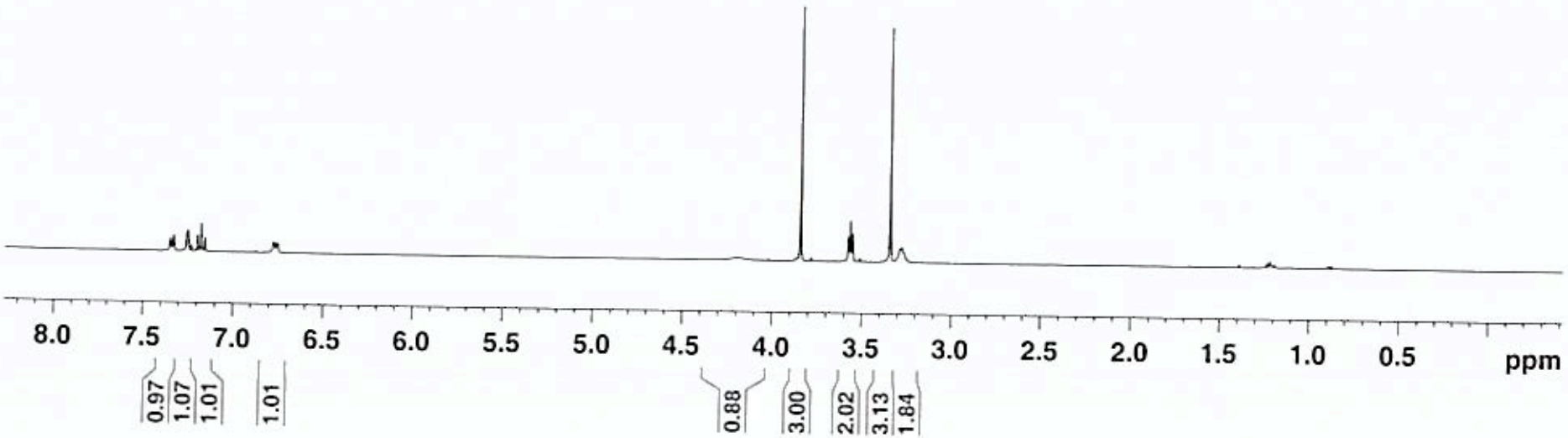


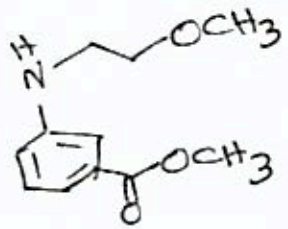

H
N
OCH3
OH
9
8
7
6
5
4
3
2
1
0
ppm
2.49
1.98
2.01
2.11
3.00
2.04

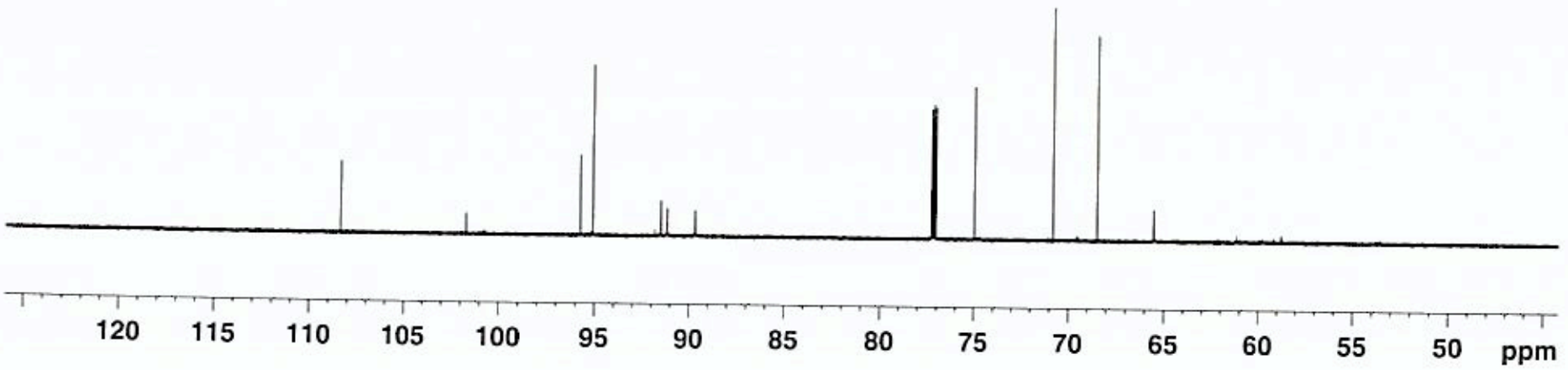


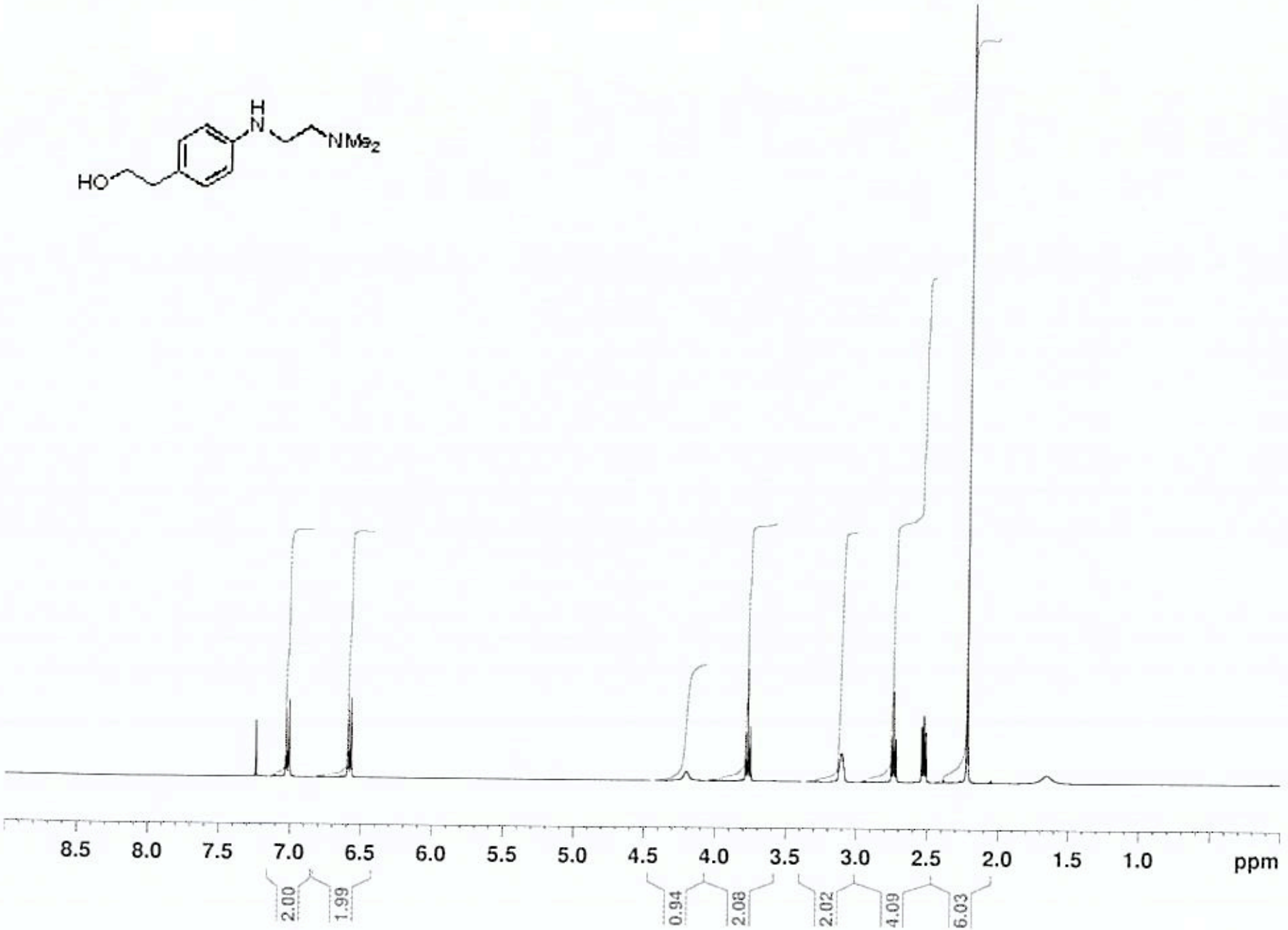


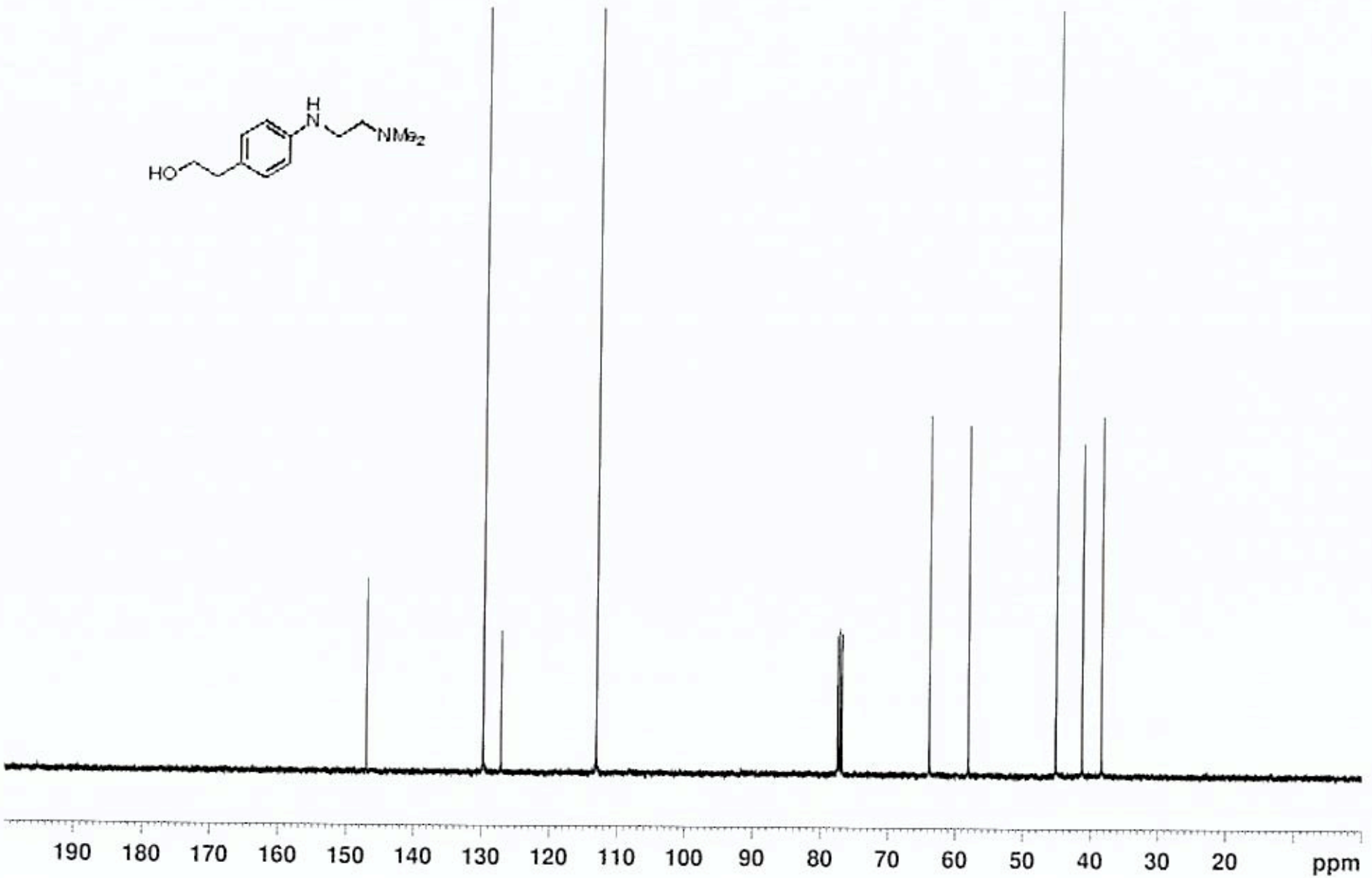

H
N
OCH3
OCH3
O

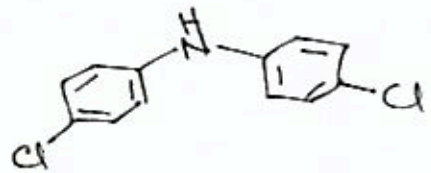

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
0.97
1.07
1.01
1.01
0.88
3.00
2.02
3.13
1.84

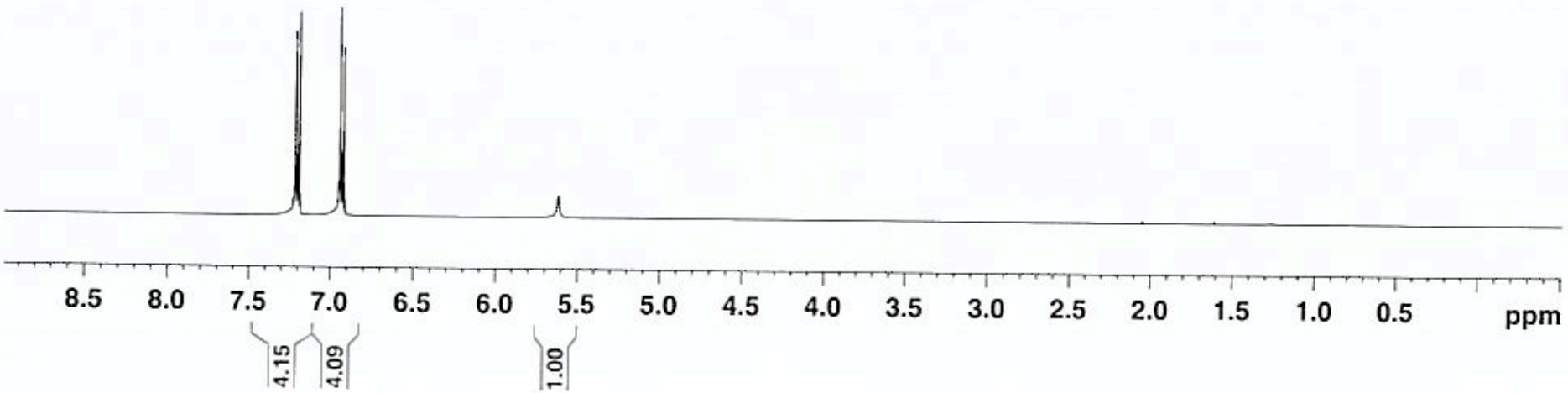

H
N
OCH3
OCH3
O

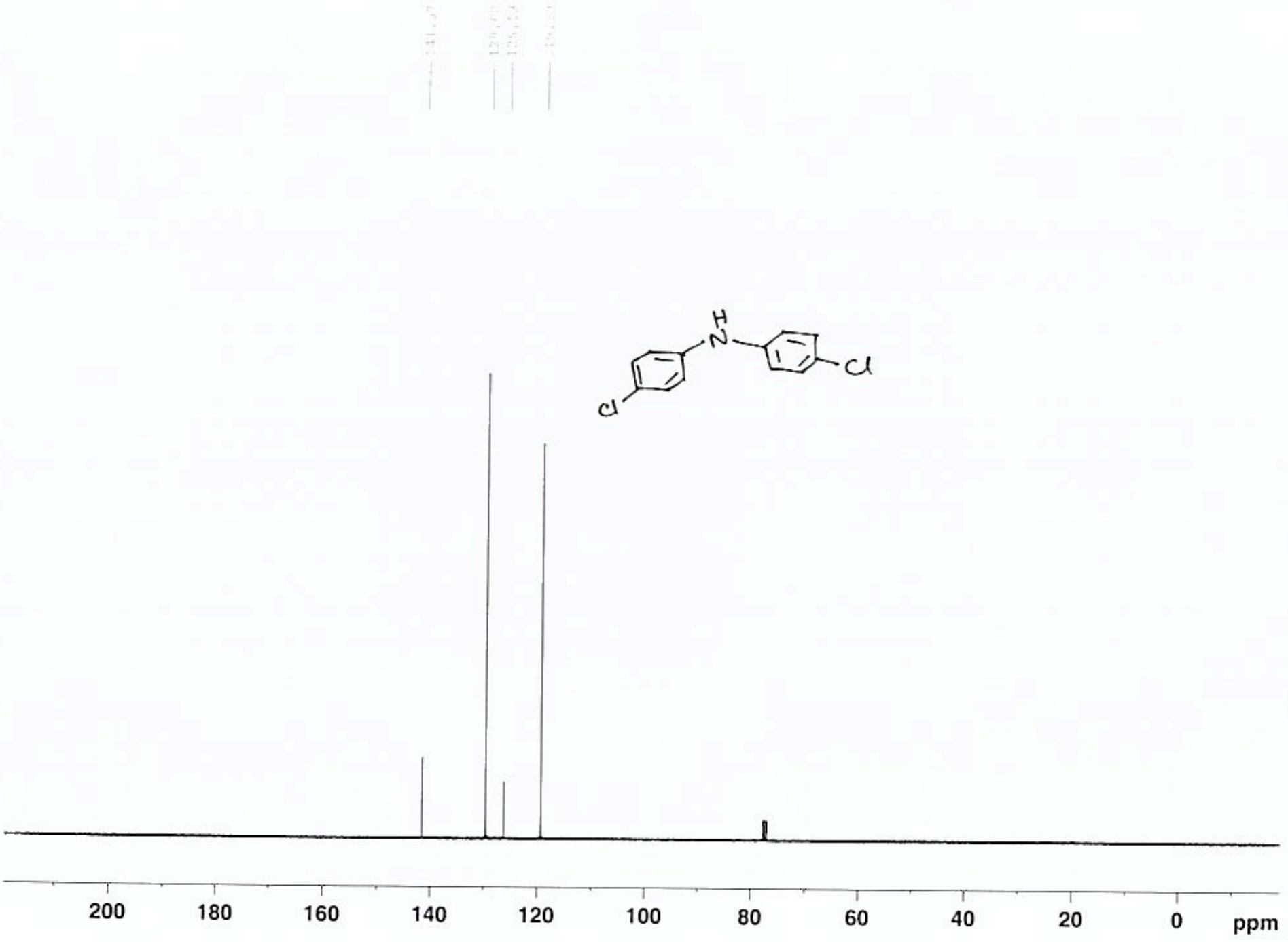

120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
ppm

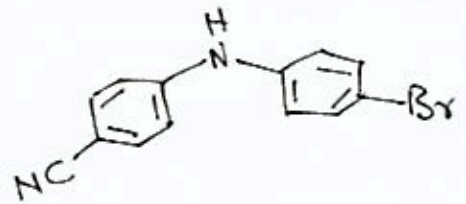

HO
H
N
NMe2
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
2.00
1.99
0.94
2.08
2.02
4.09
6.03

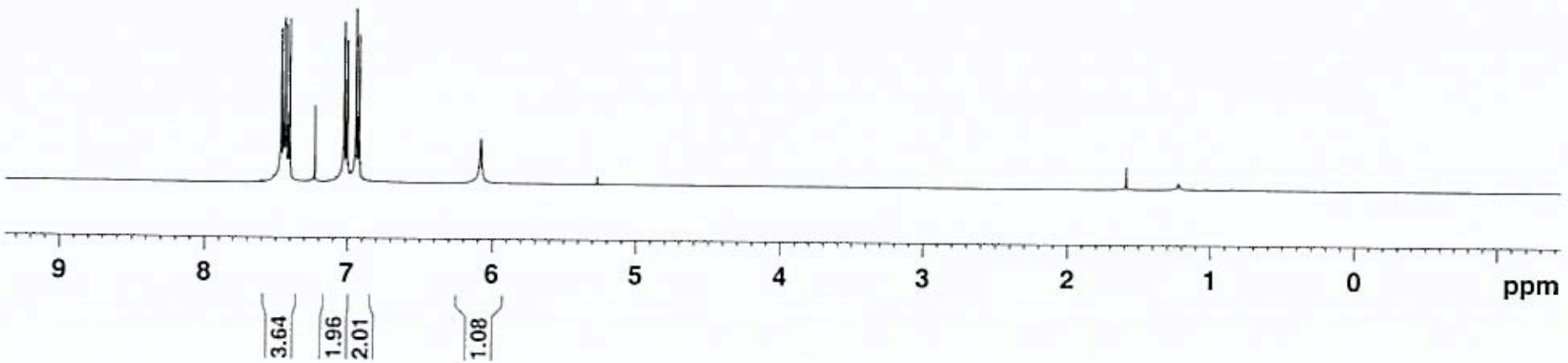

HO
H
N
NMe2
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
ppm

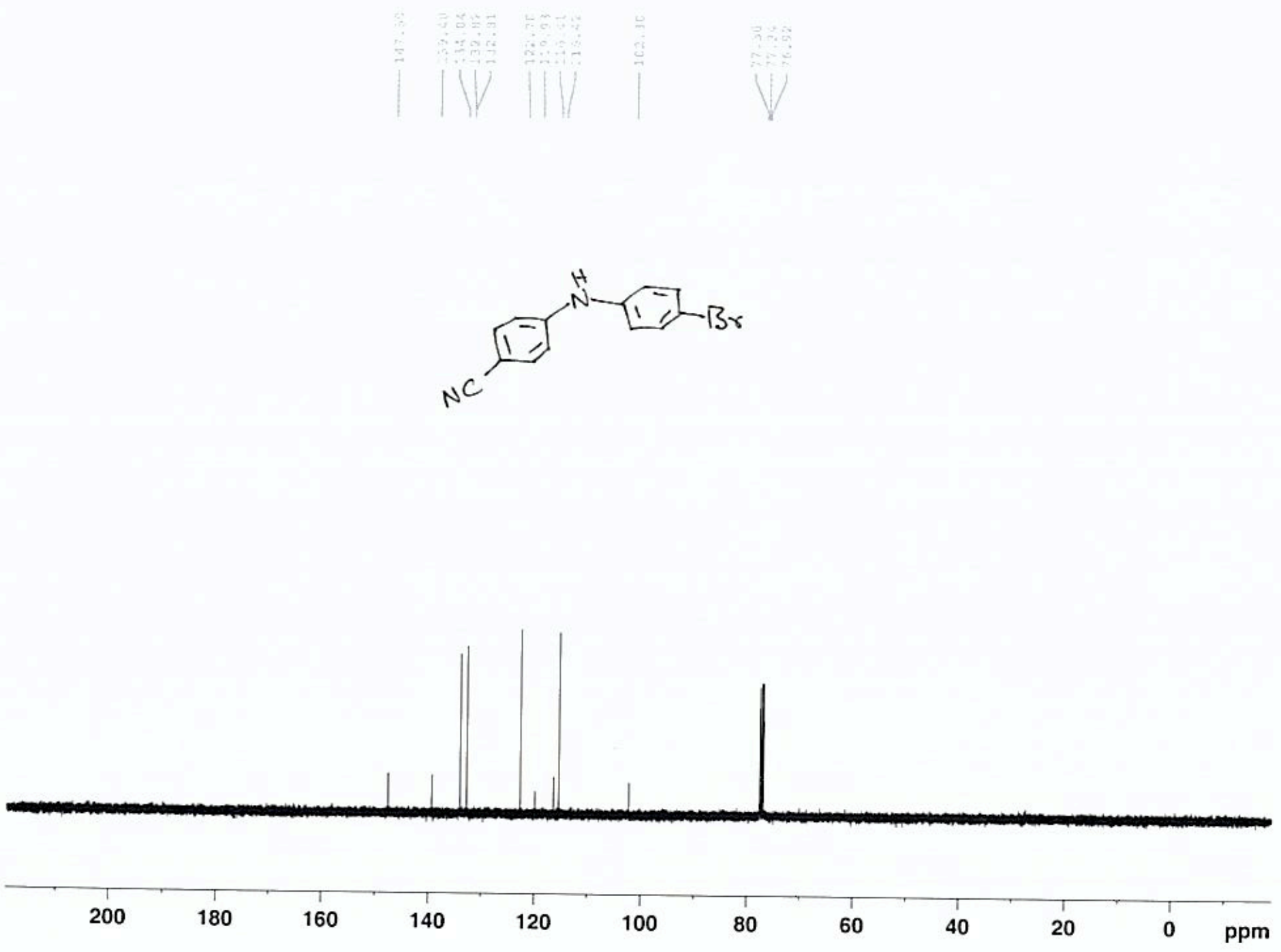


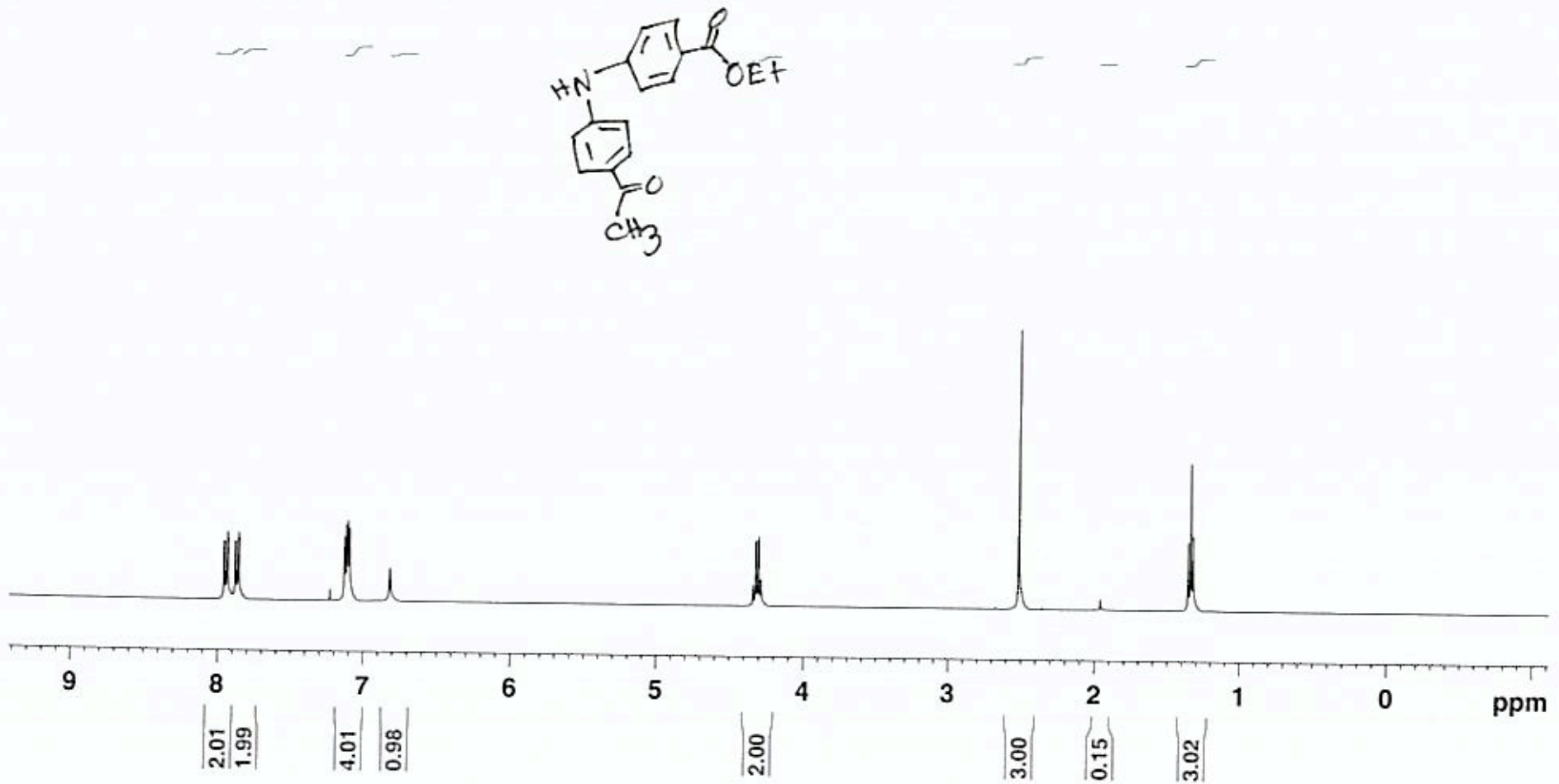

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
4.15
4.09
1.00

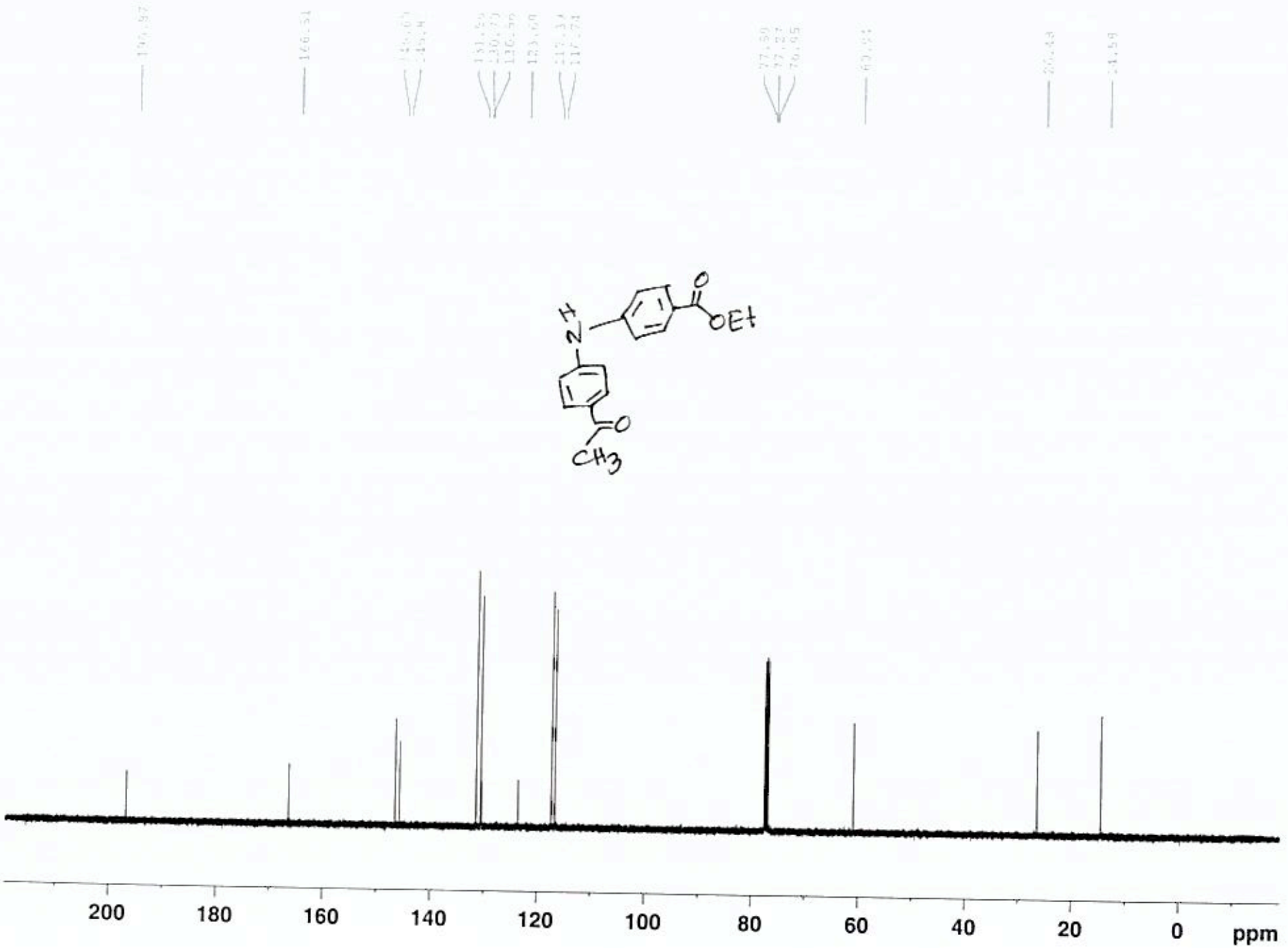

H
N
Cl
Cl
200
180
160
140
120
100
80
60
40
20
0
ppm

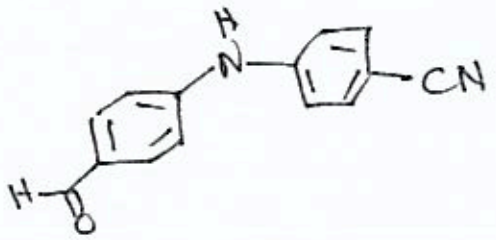

H
N
Br
NC

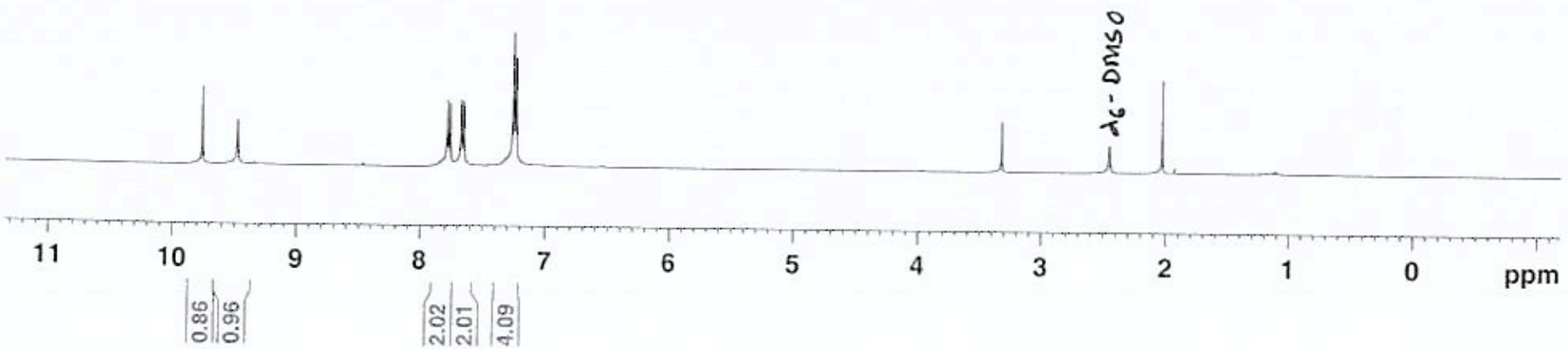

9
8
7
6
5
4
3
2
1
0
ppm
3.64
1.96
2.01
1.08

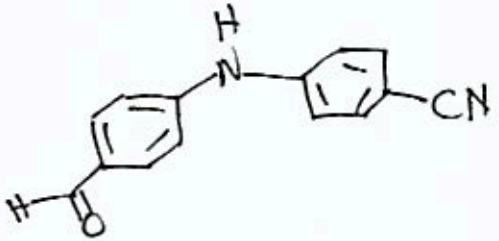

147.39
139.40
134.04
132.96
132.81
122.76
119.93
119.61
119.42
103.16
77.30
77.04
76.92
H
N
Br
NC
200
180
160
140
120
100
80
60
40
20
0
ppm

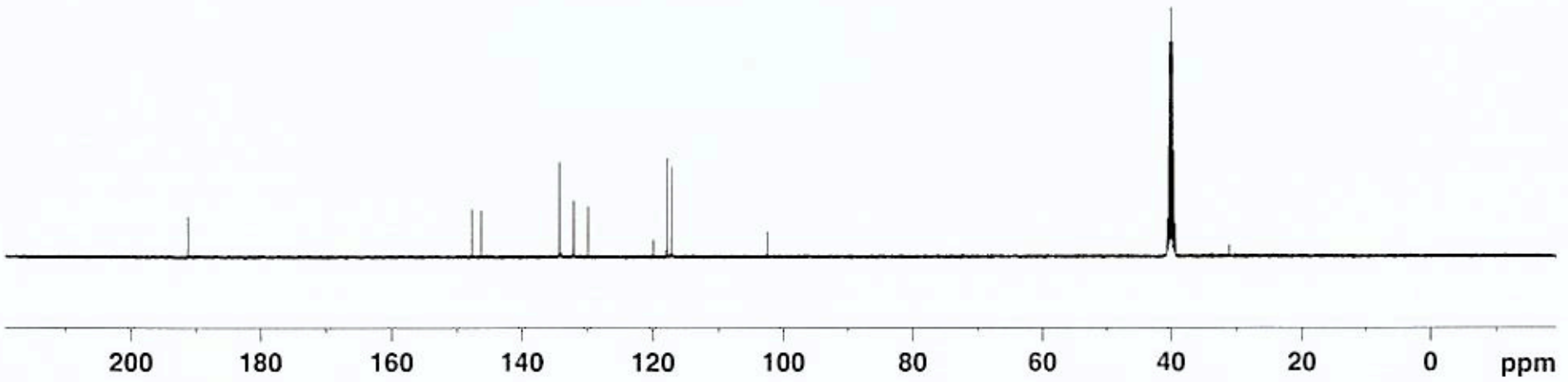

HN
OEt
O
CH3
9
8
7
6
5
4
3
2
1
0
ppm
2.01
1.99
4.01
0.98
2.00
3.00
0.15
3.02

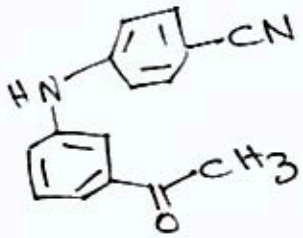

O
OEt
H
N
O
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

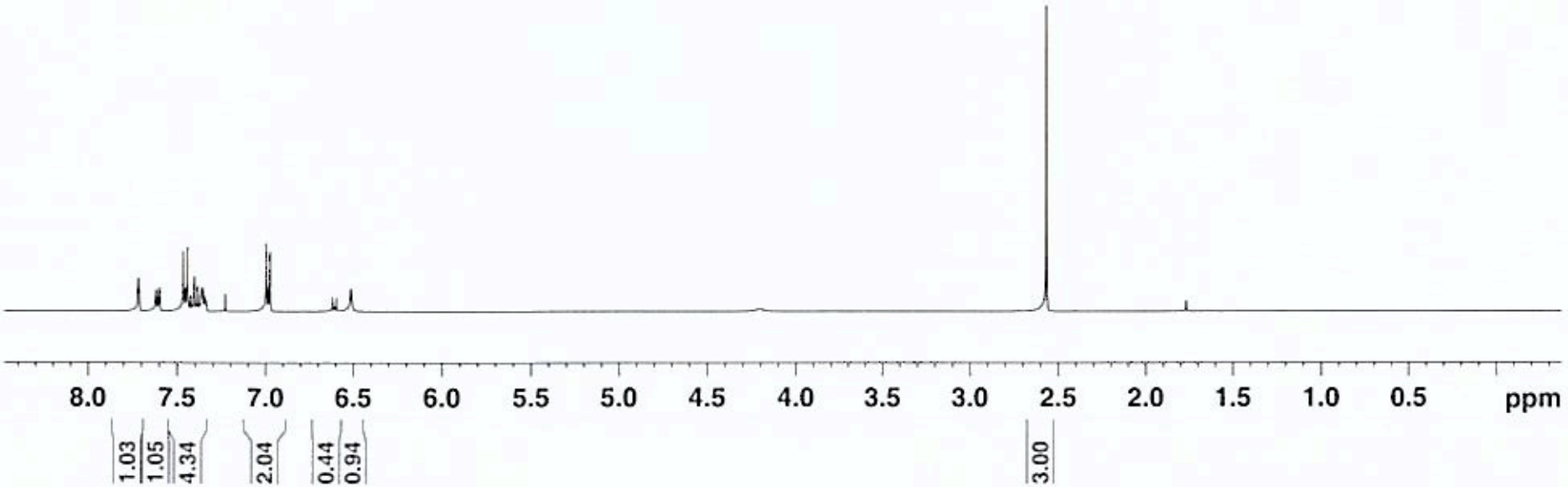

H
N
CN
H
O

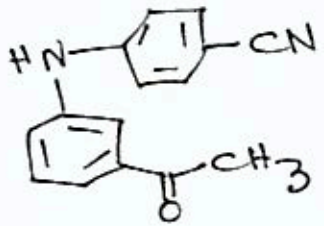

d6 - DMSO
11
10
9
8
7
6
5
4
3
2
1
0
ppm
0.86
0.96
2.02
2.01
4.09

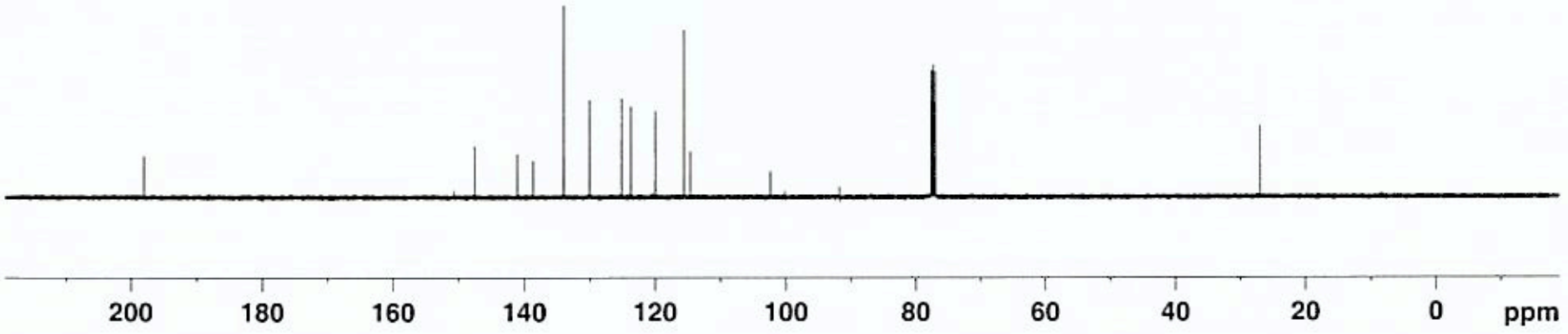

H
N
CN
H
O

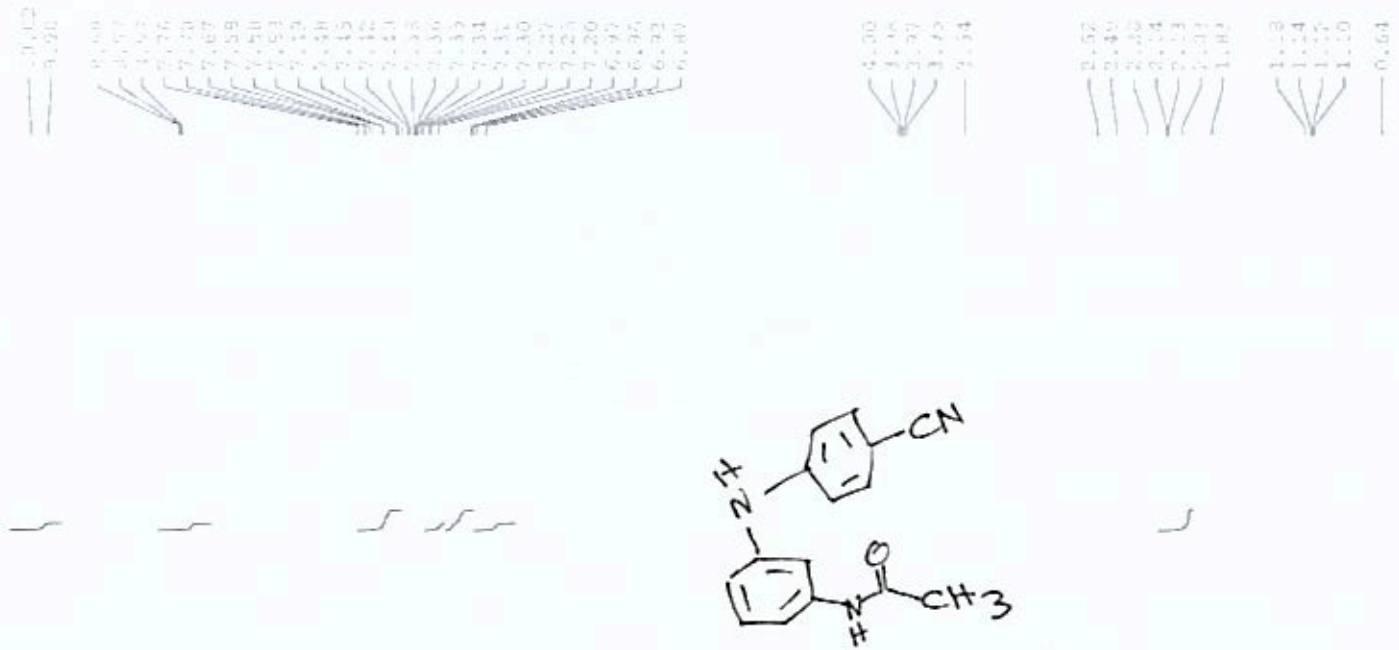

200
180
160
140
120
100
80
60
40
20
0
ppm

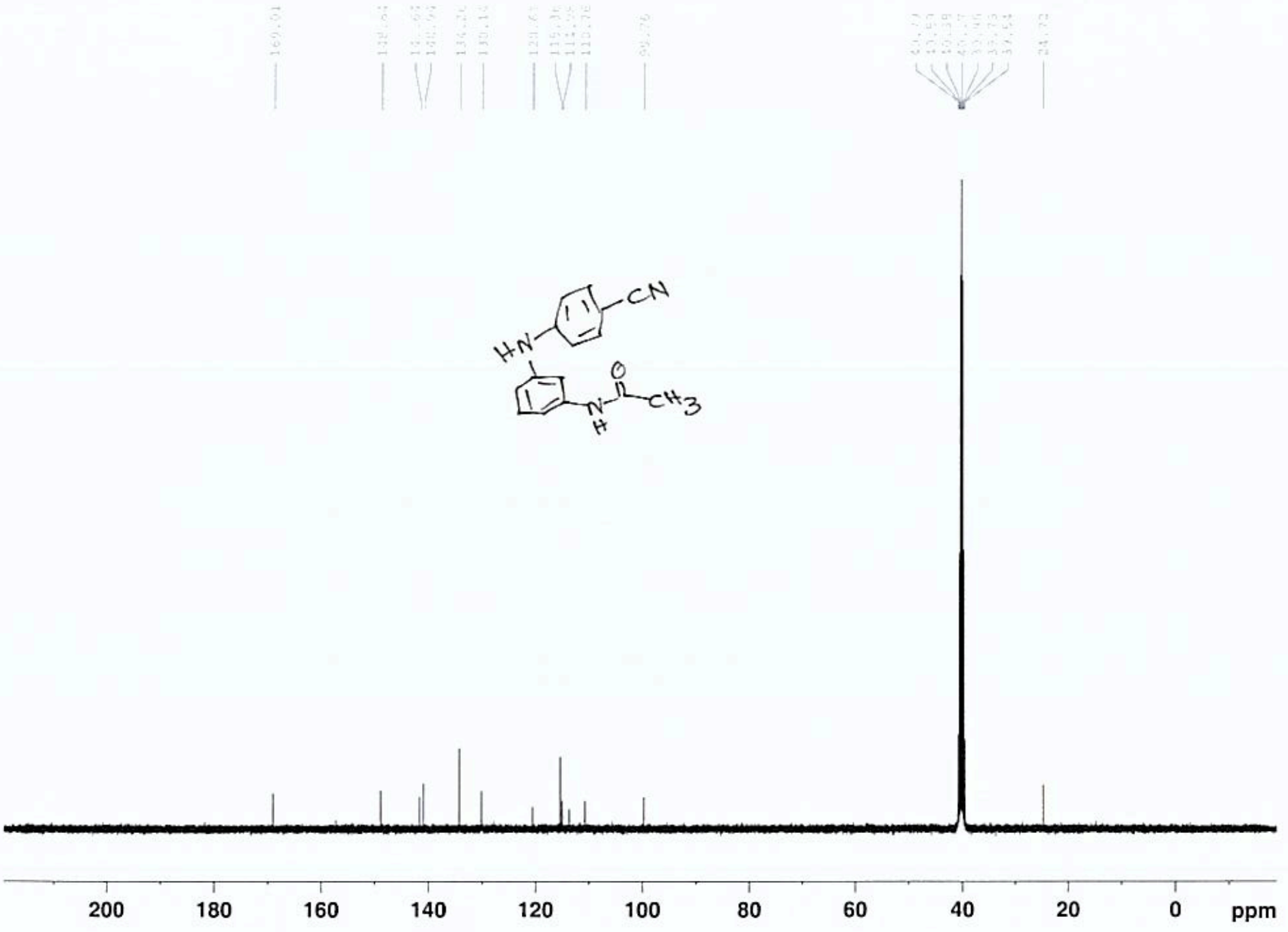

CN
HN
CH3
O

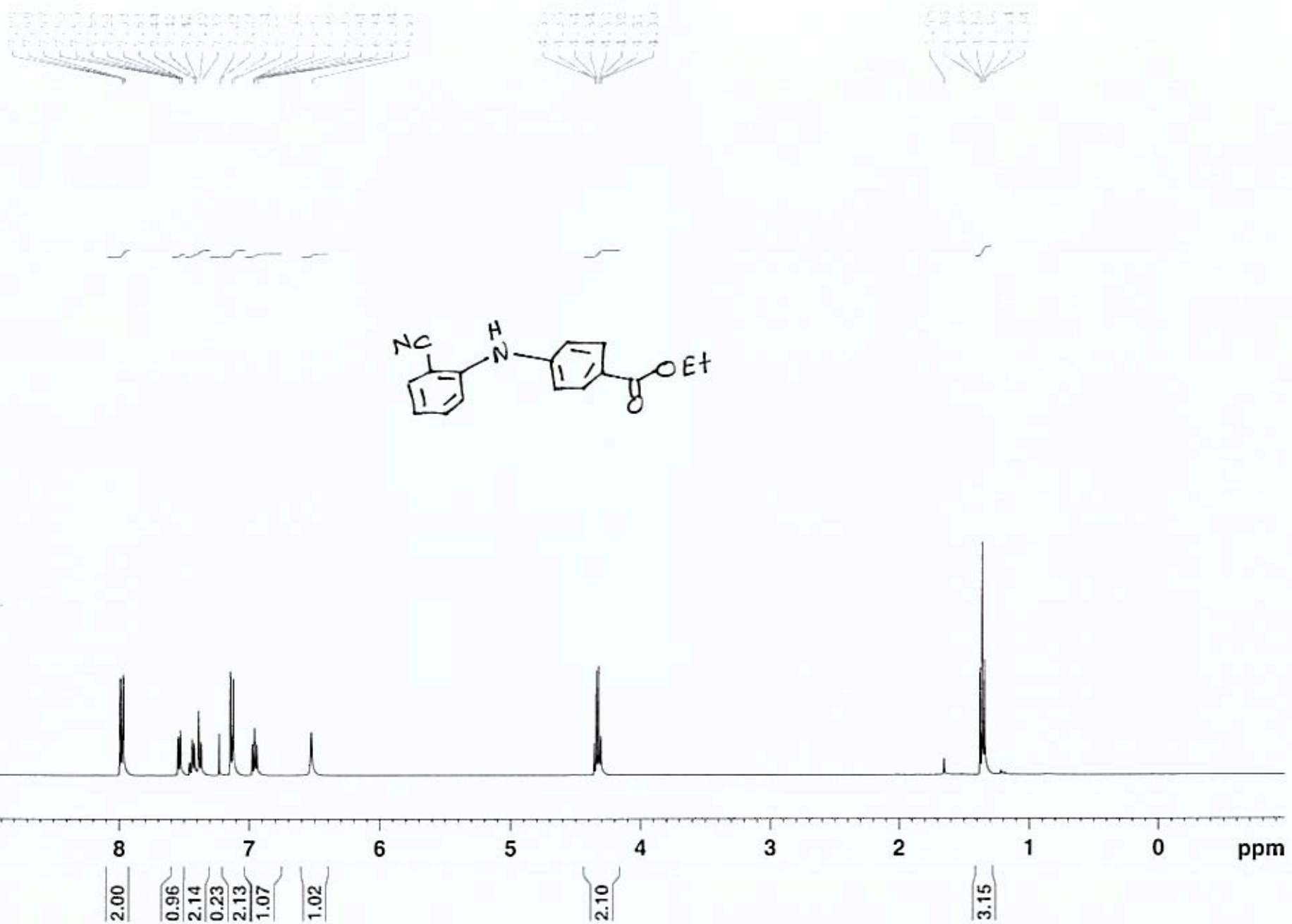

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.03
1.05
4.34
2.04
0.44
0.94
3.00

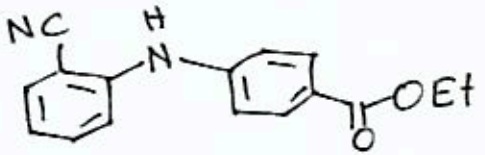


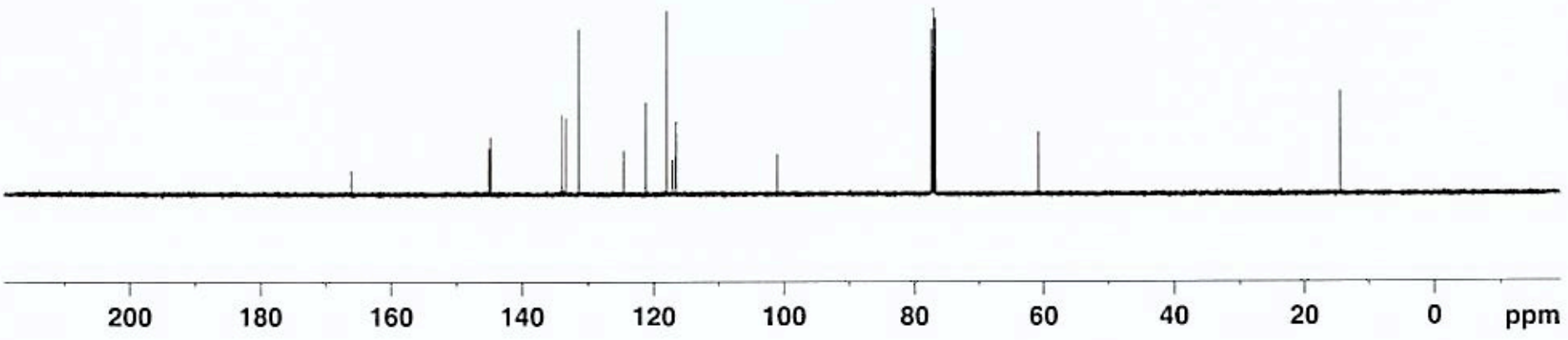


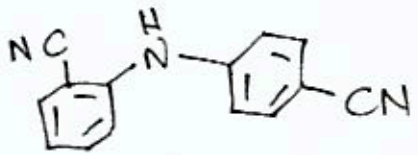

CN
CH3
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.01
0.99
2.93
1.11
2.83
1.08
3.05

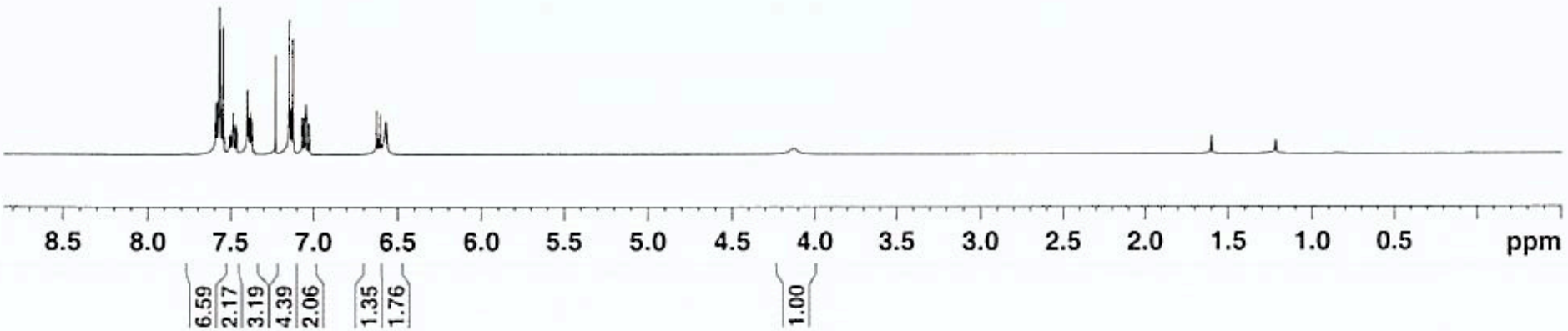

CN
HN
O
N
H
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

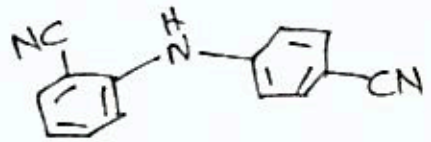

NC
H
N
OEt
O
9
8
7
6
5
4
3
2
1
0
ppm
2.00
0.96
2.14
0.23
2.13
1.07
1.02
2.10
3.15

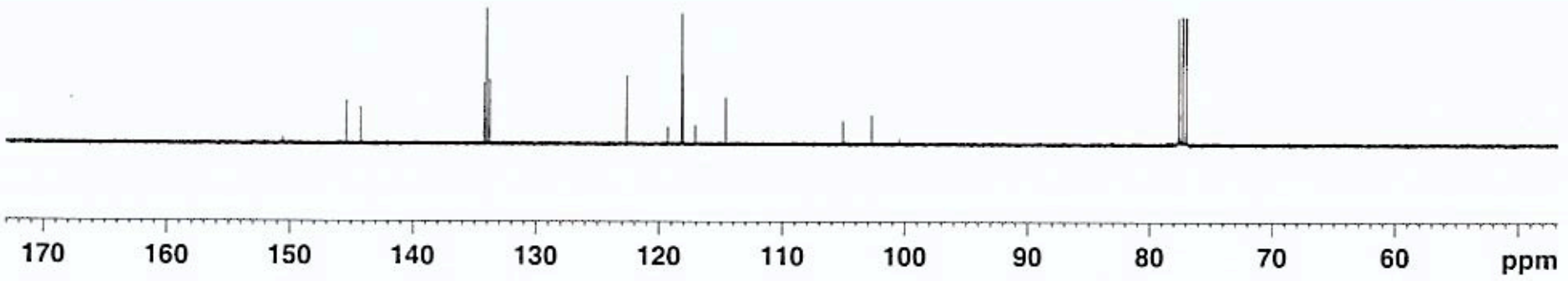

NC
H
N
OEt
O

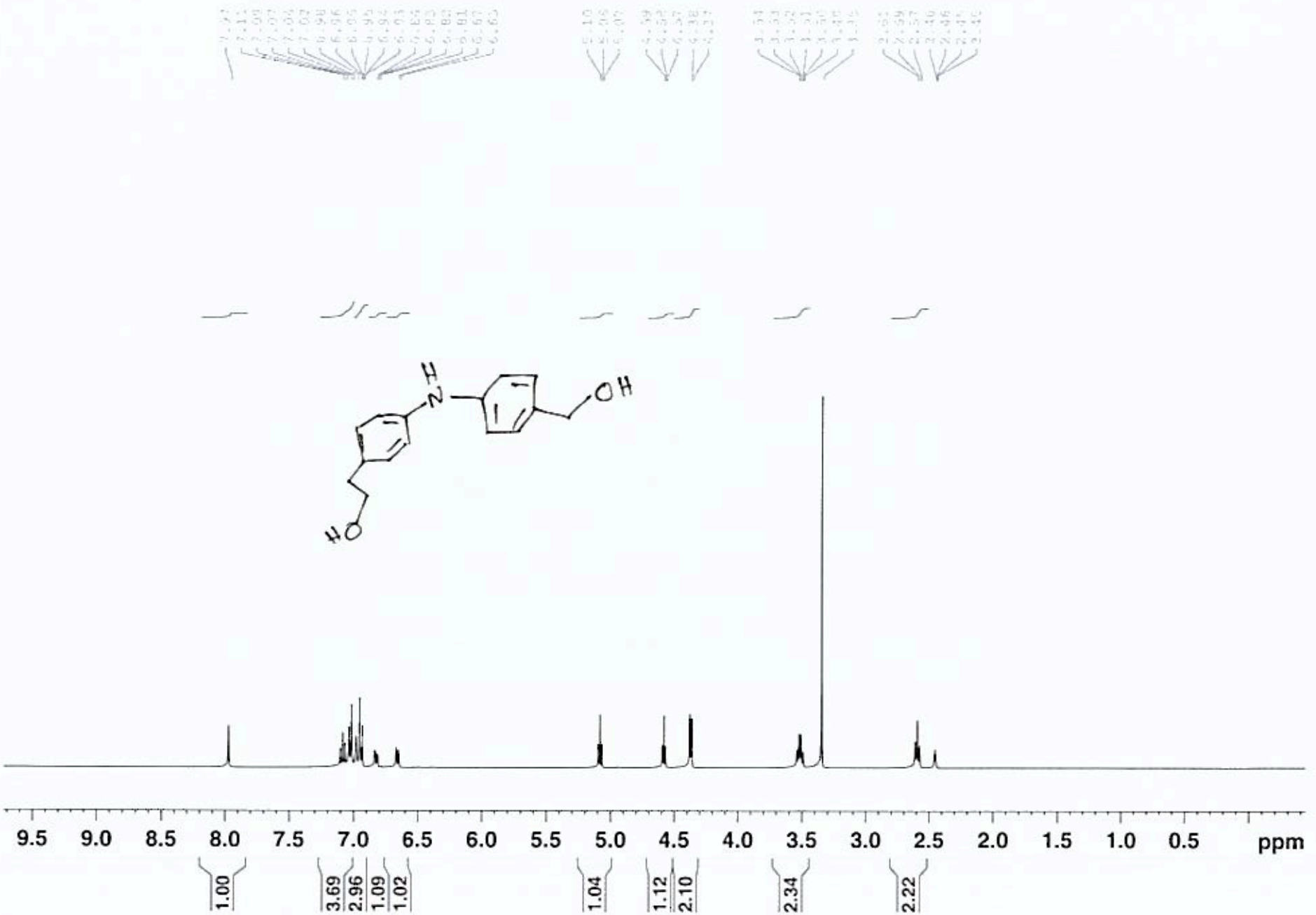

200
180
160
140
120
100
80
60
40
20
0
ppm

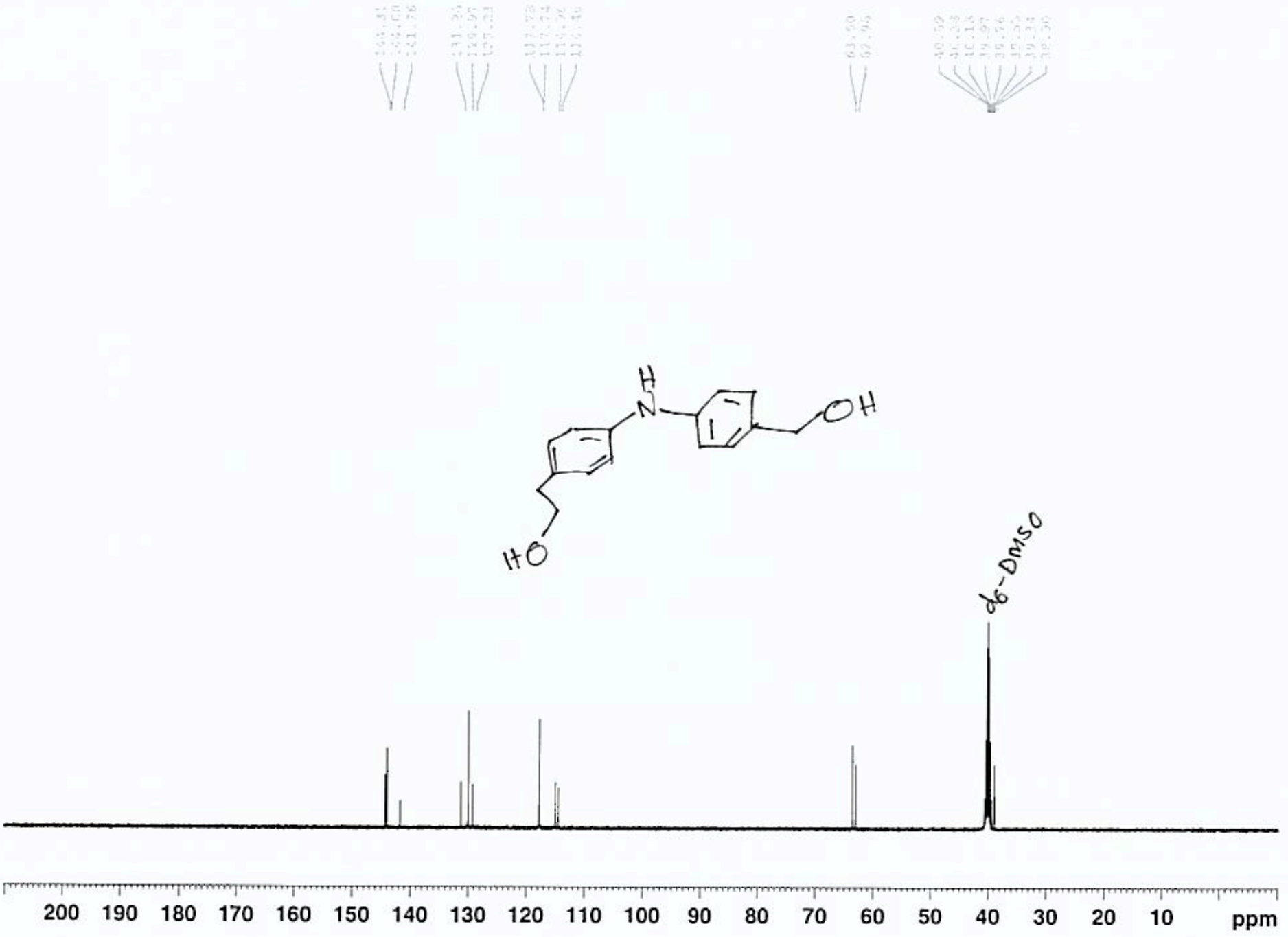

NC
NH
CN

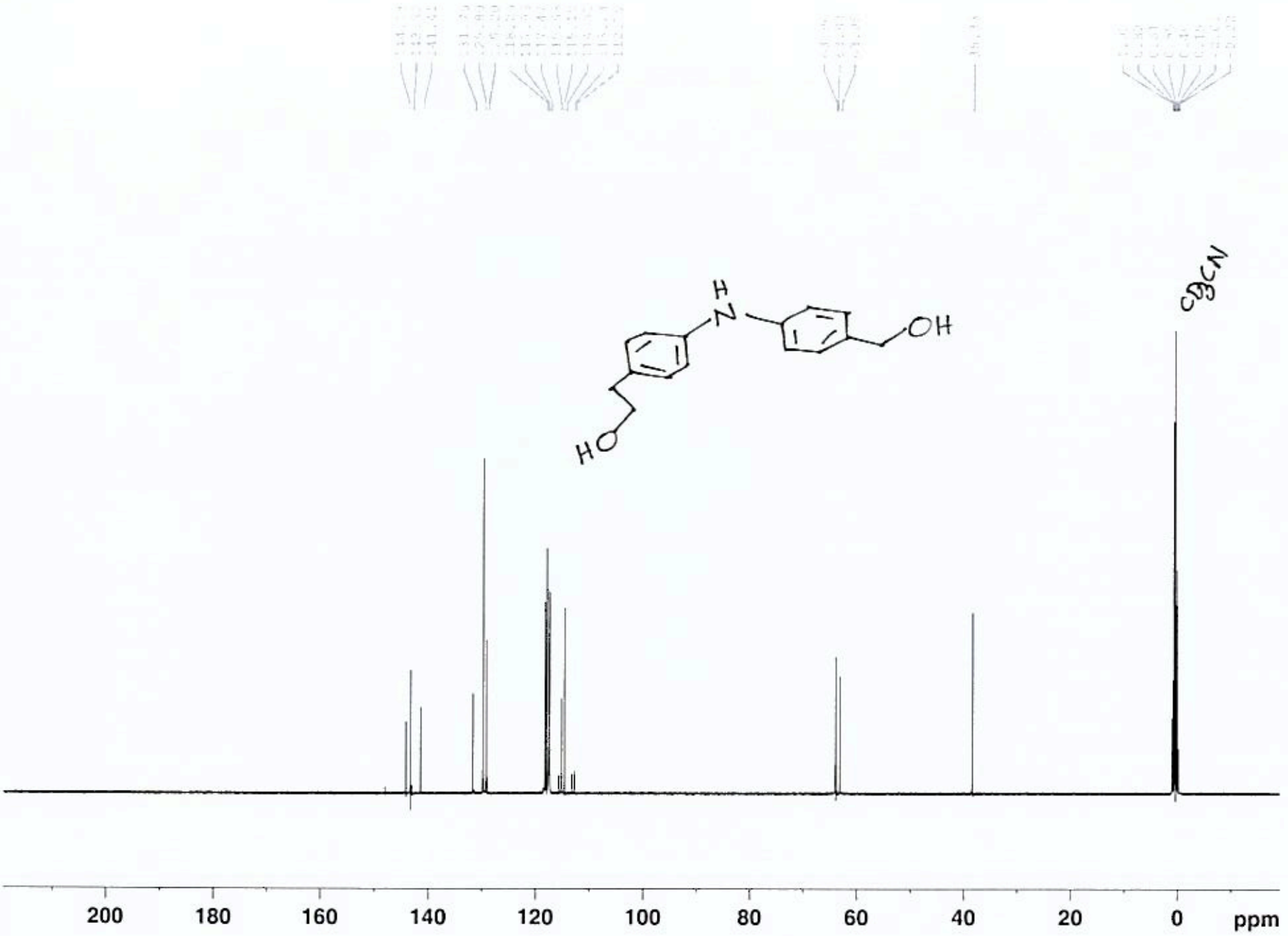

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
6.59
2.17
3.19
4.39
2.06
1.35
1.76
1.00

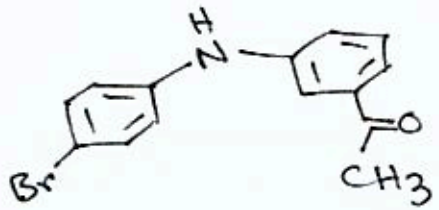


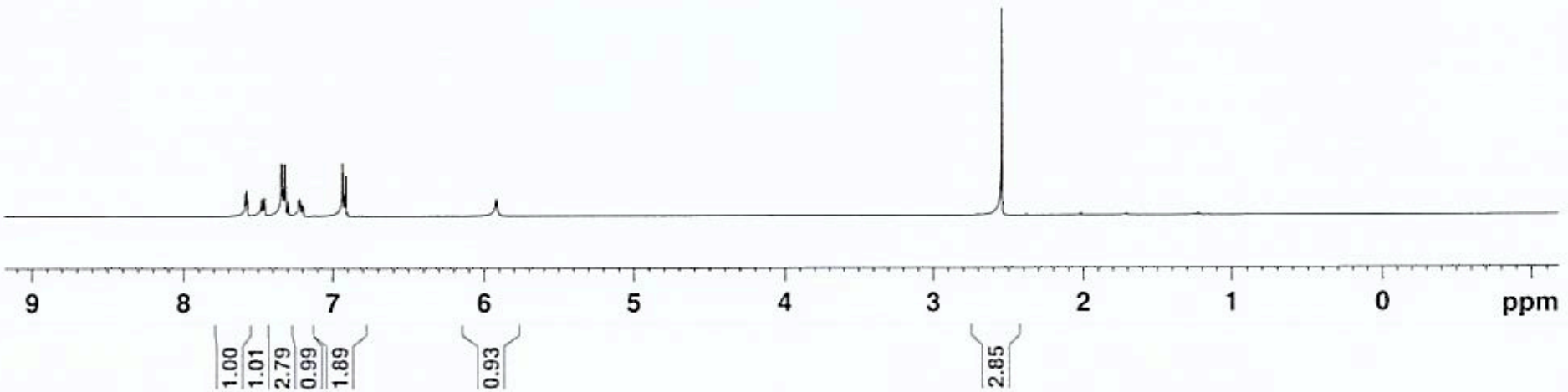


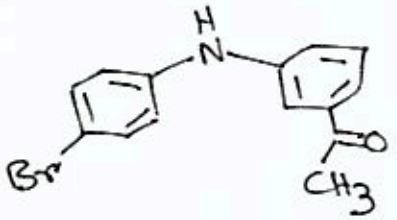


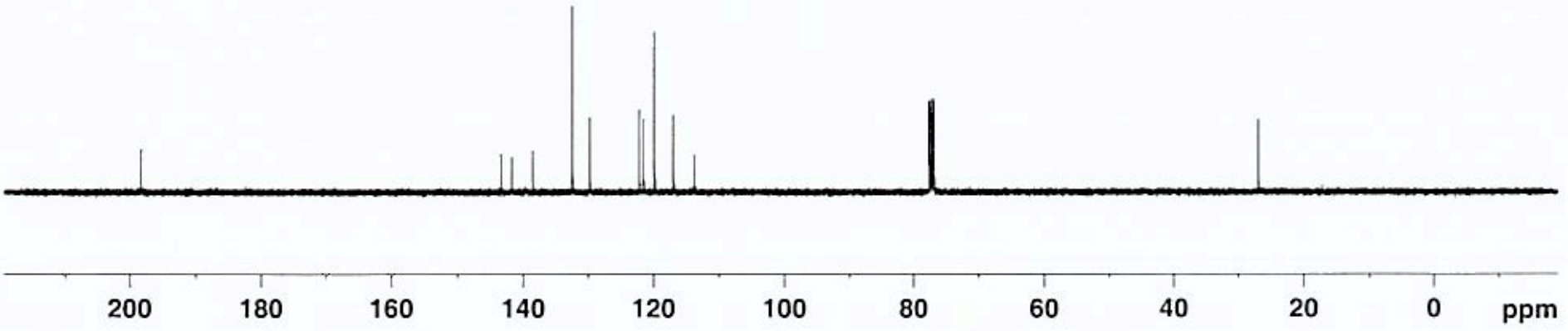

H
N
OH
HO
d6-DMSO
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


H
N
OH
HO
CD3CN
200
180
160
140
120
100
80
60
40
20
0
ppm


H
N
O
Br
CH3

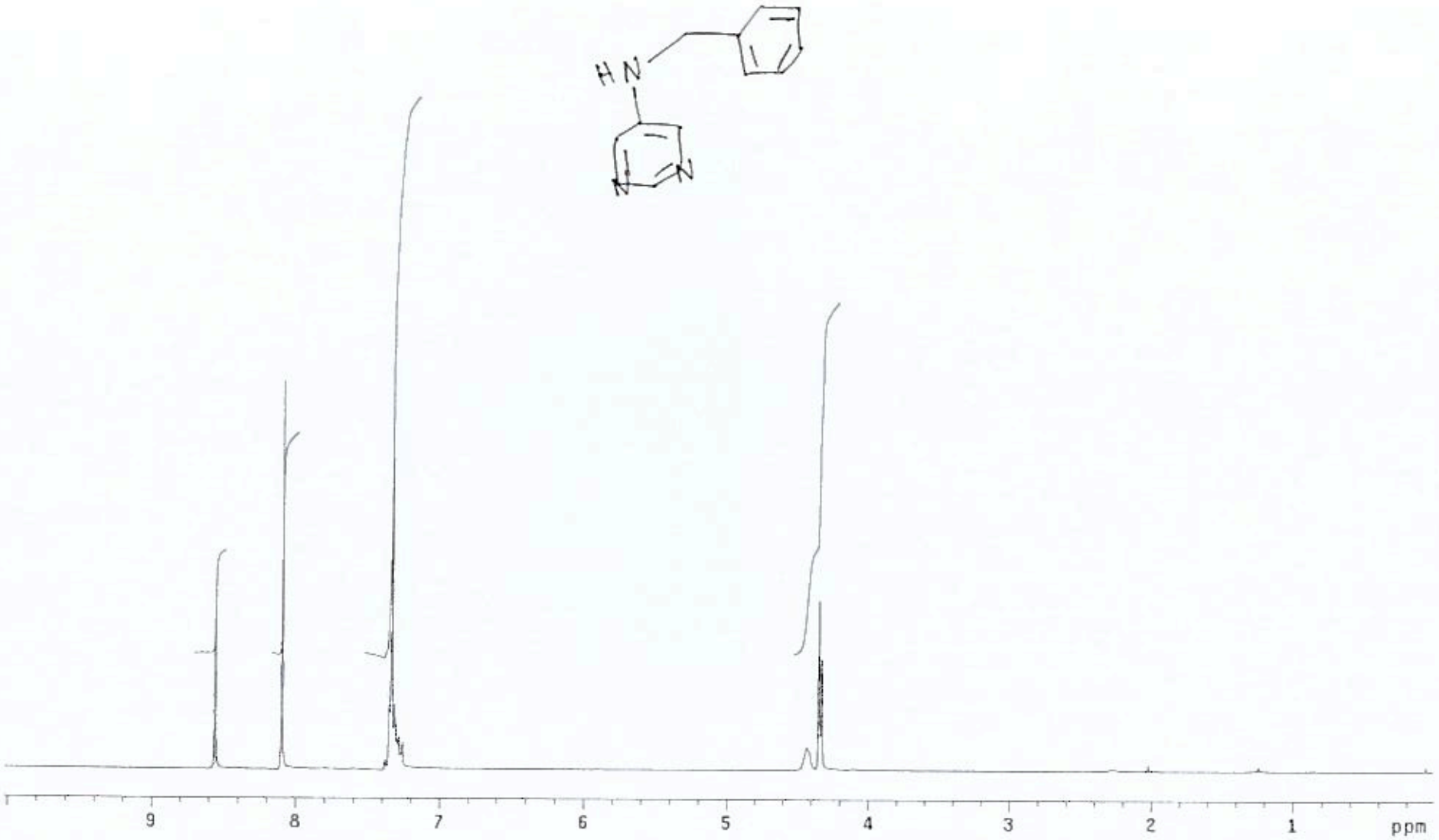

9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.01
2.79
0.99
1.89
0.93
2.85


H
N
Br
O
CH3


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

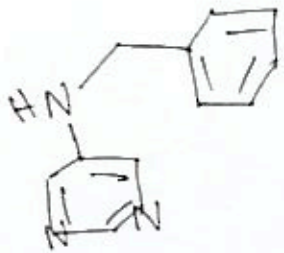
BF-III-226

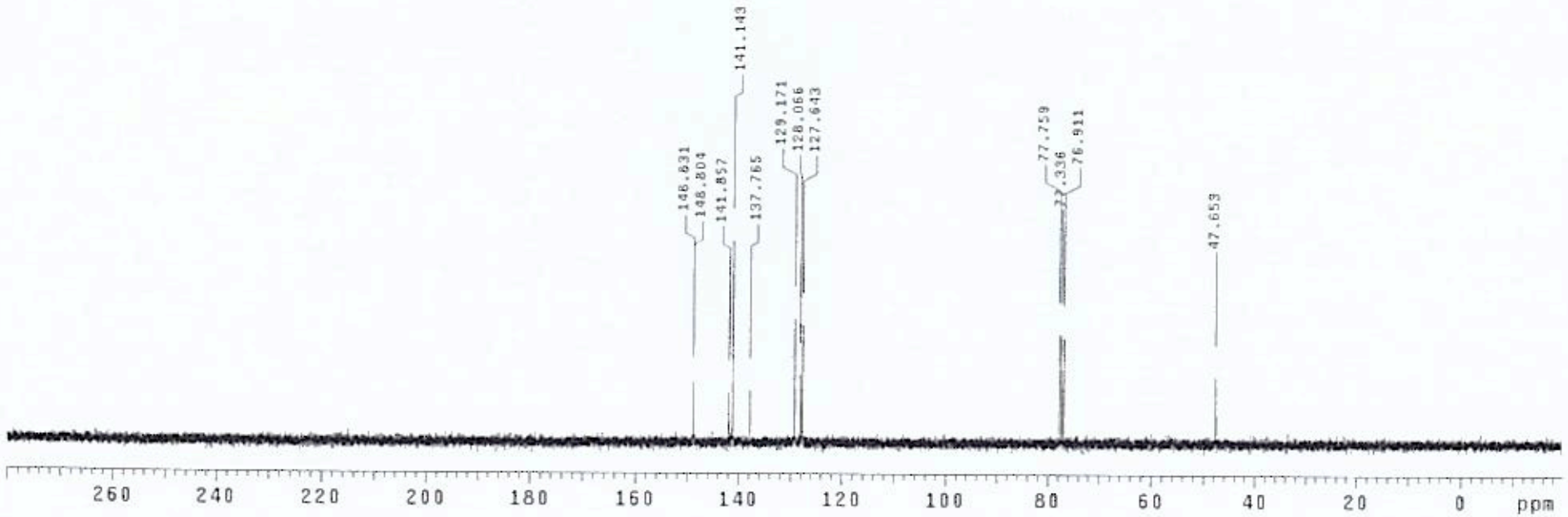
Pulse Sequence: s2pul



BF-III-226-13C

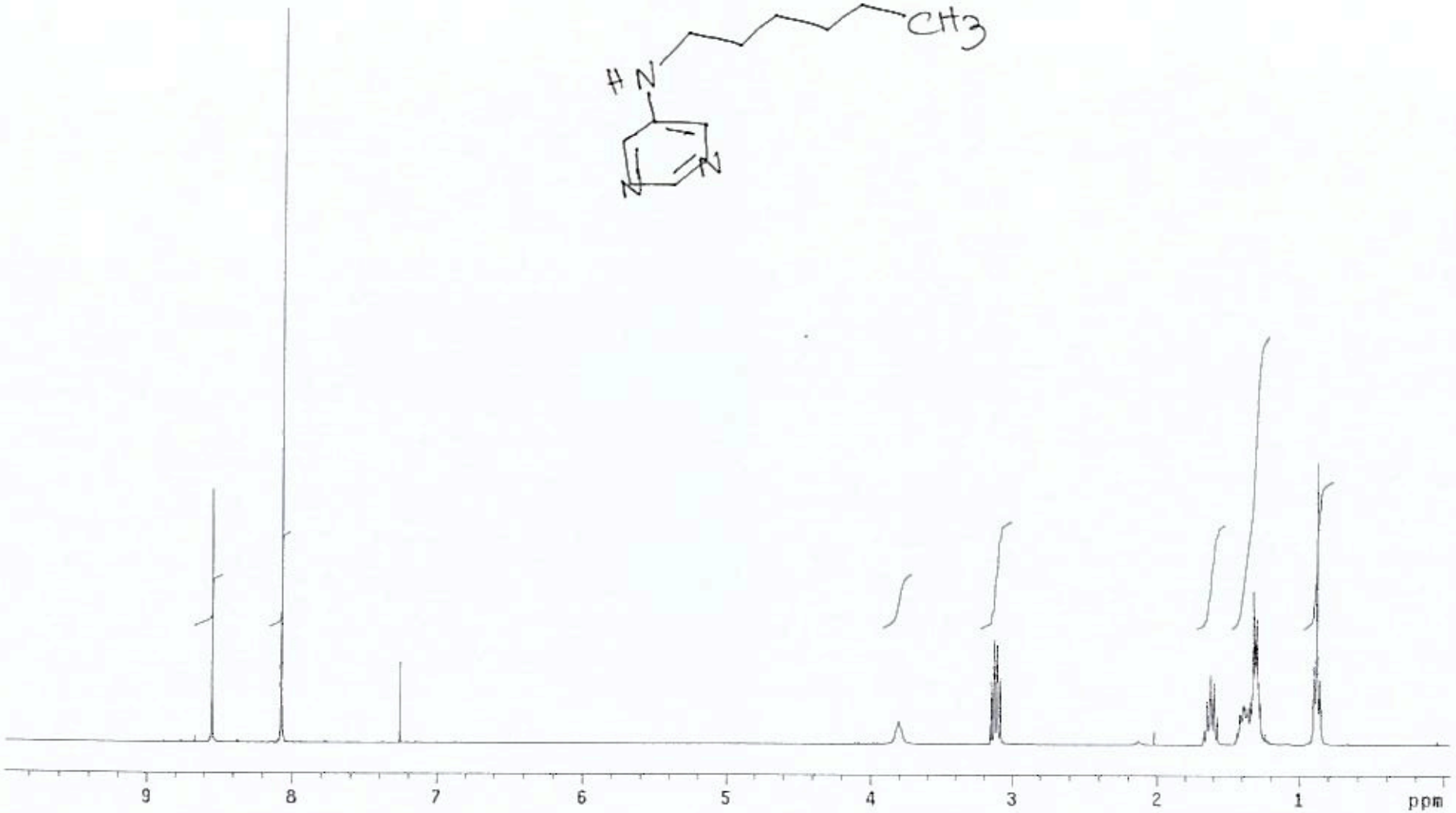
Pulse Sequence: s2pul





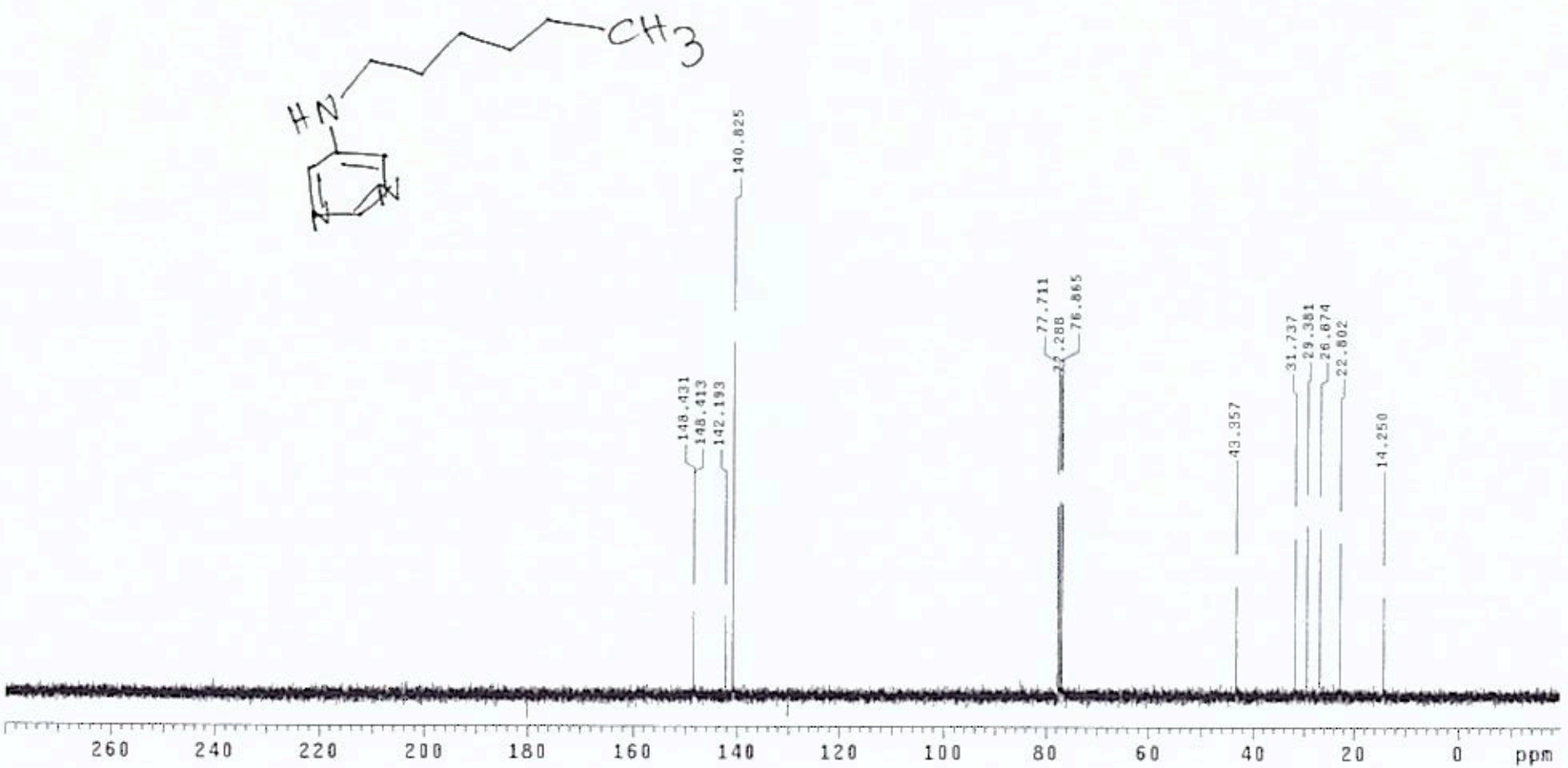
BF-III-132

Pulse Sequence: s2pul



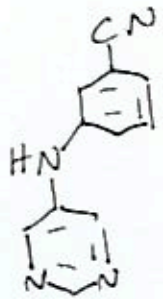
BF-III-132-13C

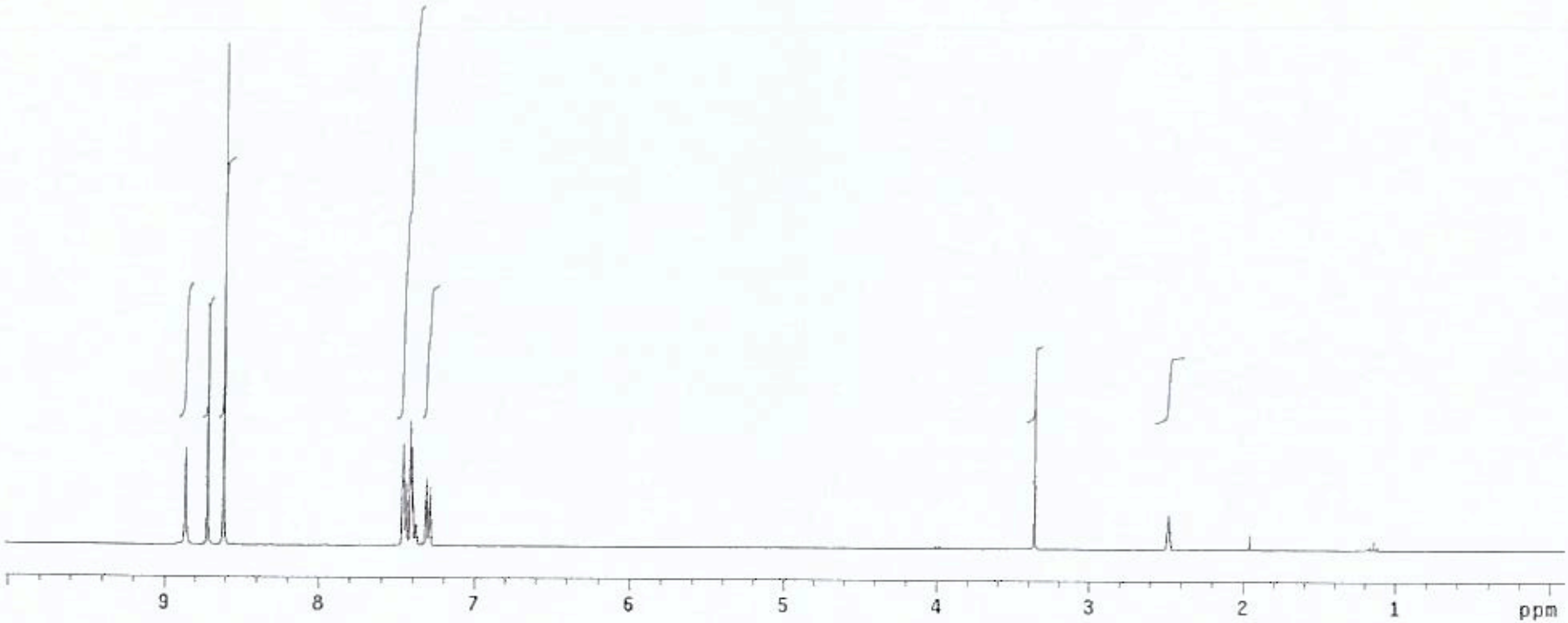
Pulse Sequence: s2pul



BF-III-119

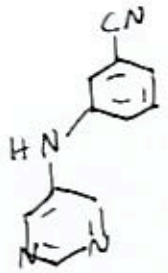
Pulse Sequence: s2pul

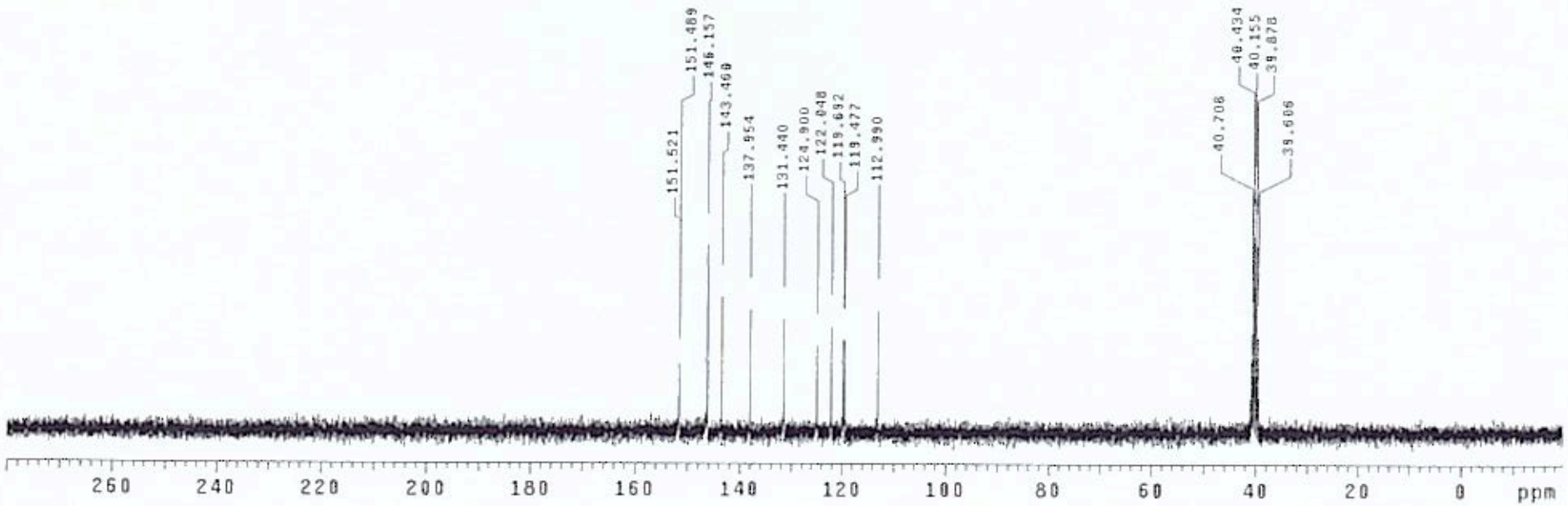




BF-IV-59-13C

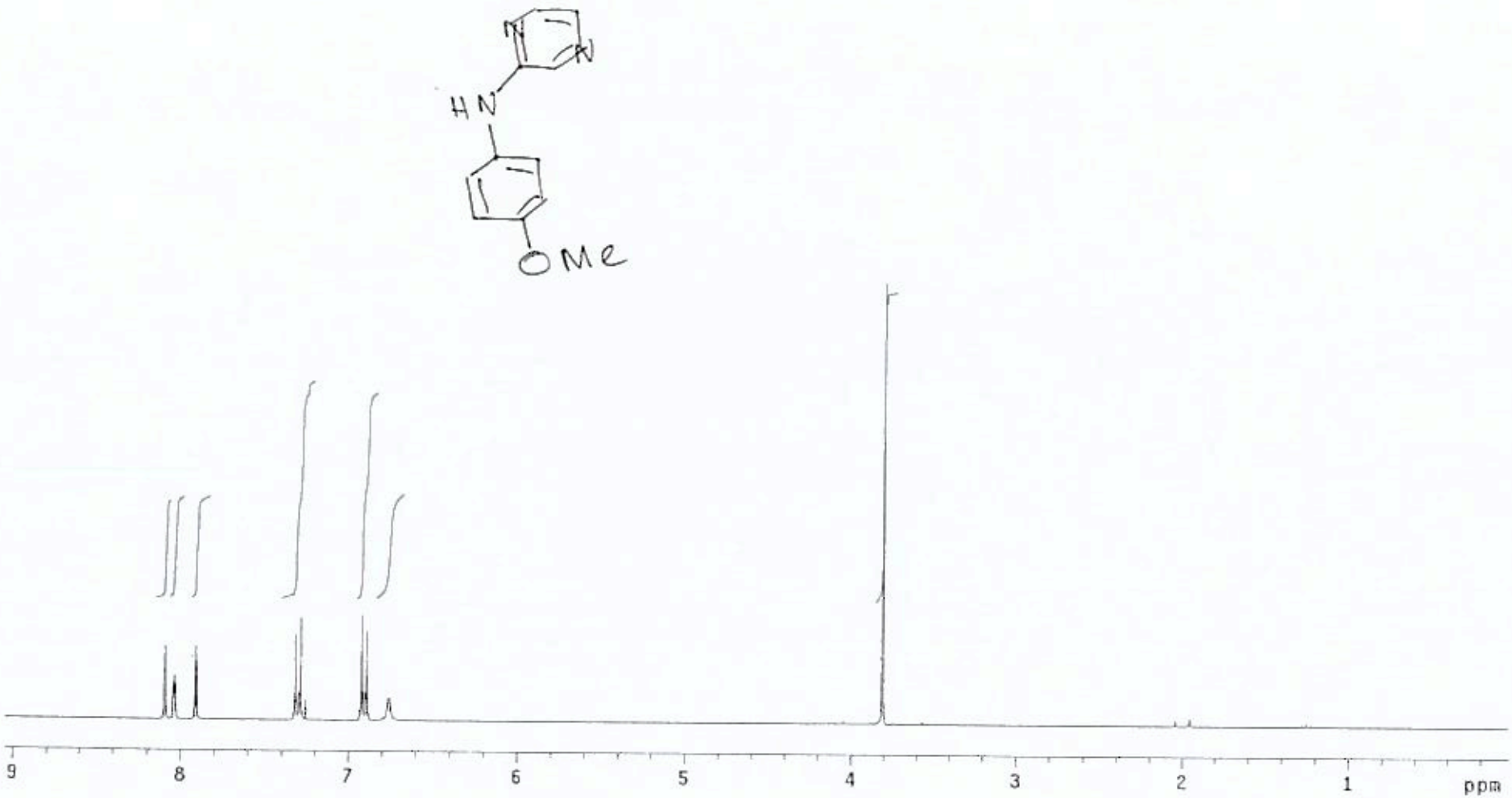
Pulse Sequence: s2pul





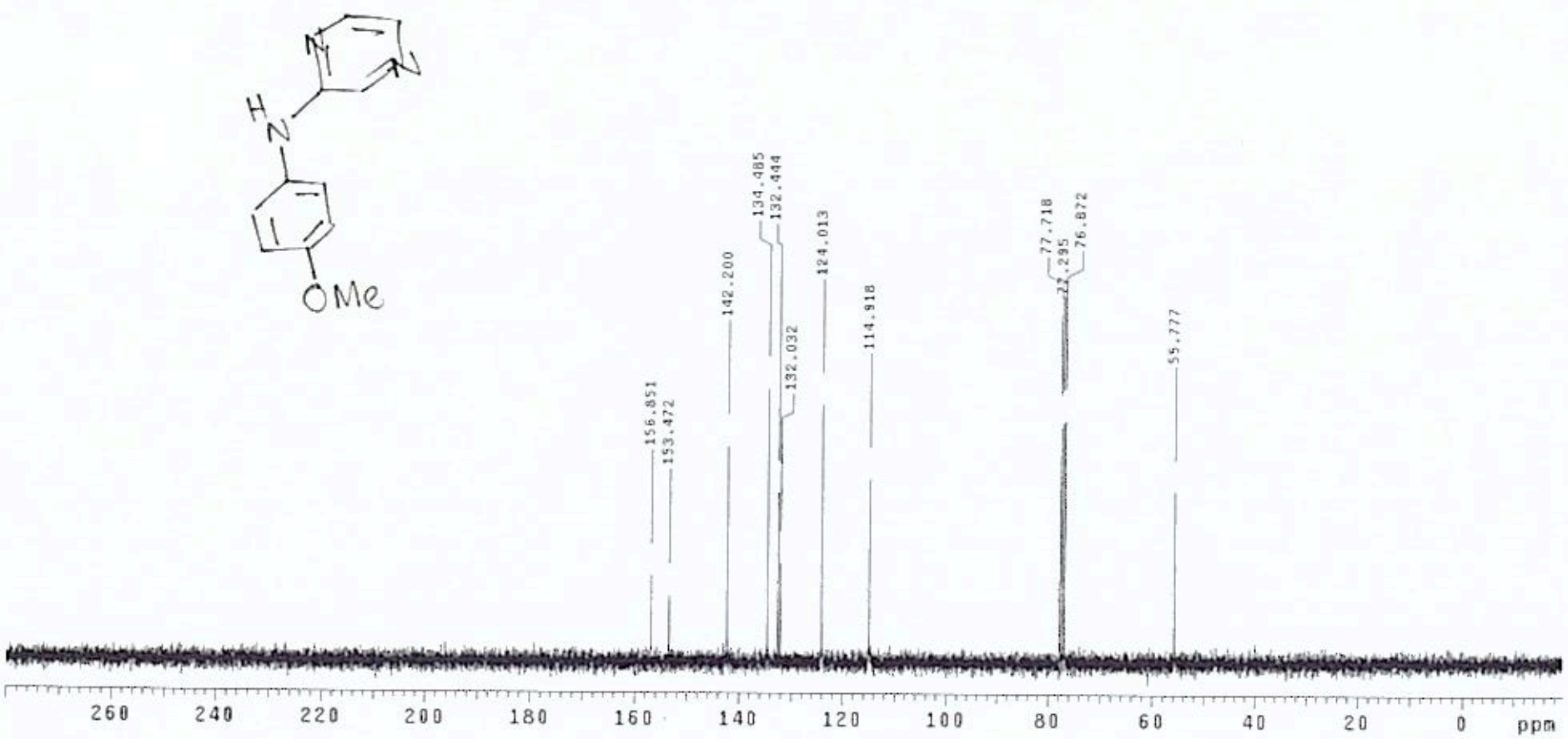
BF-III-135

Pulse Sequence: s2pul



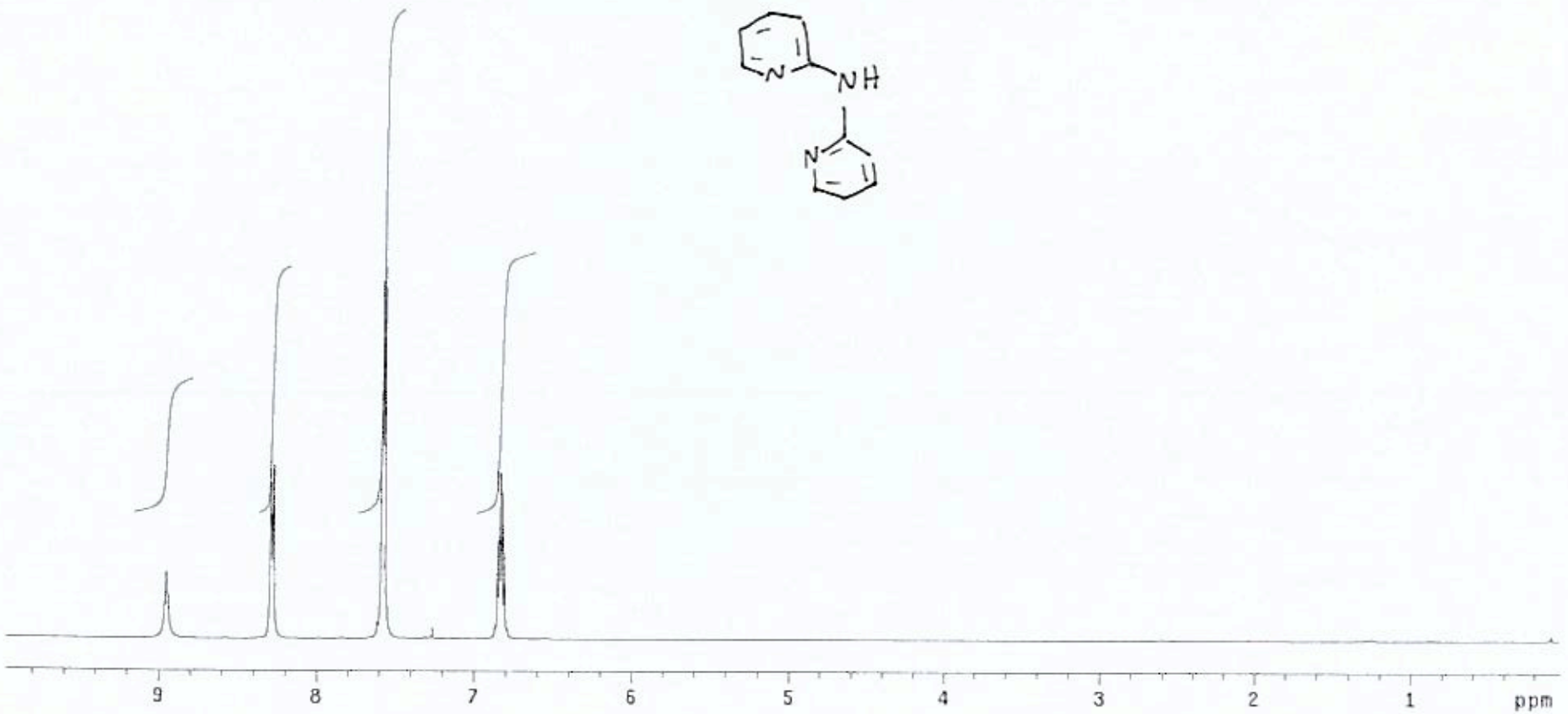
BF-III-135-13C

Pulse Sequence: s2pul



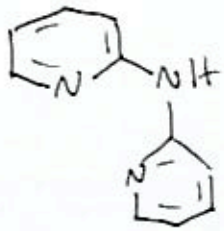
BF-III-265

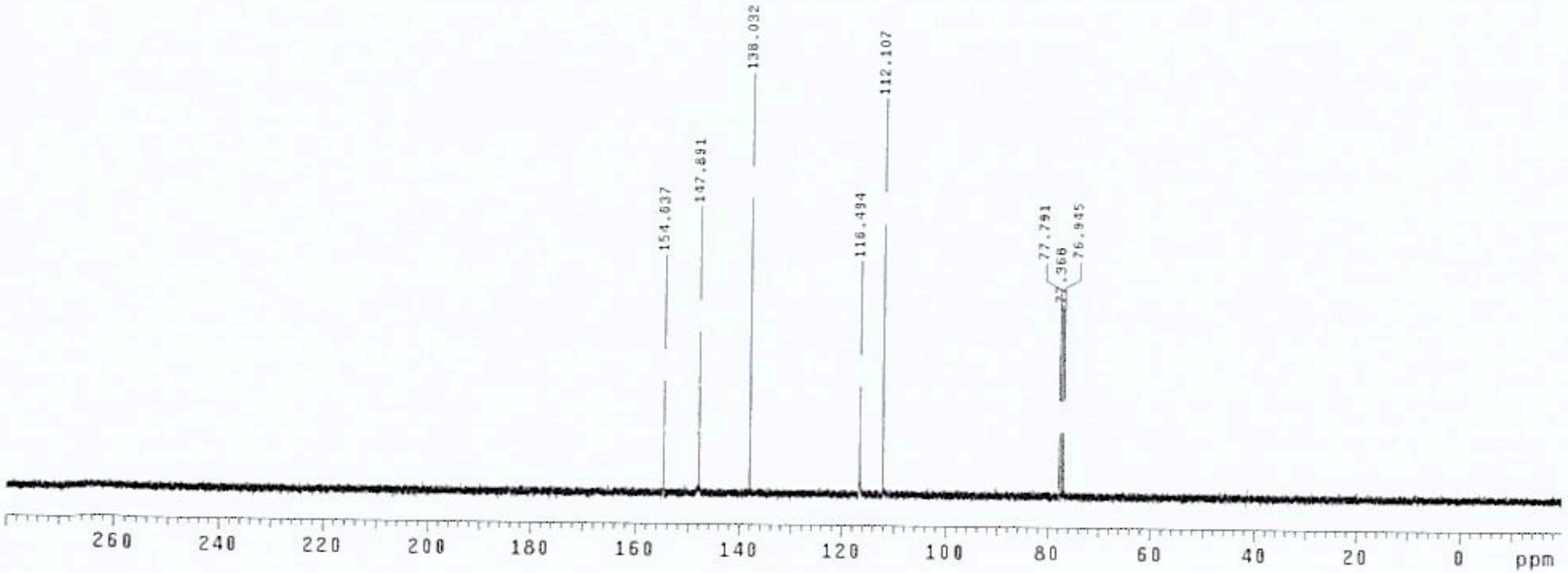
Pulse Sequence: s2pul

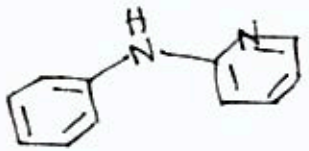


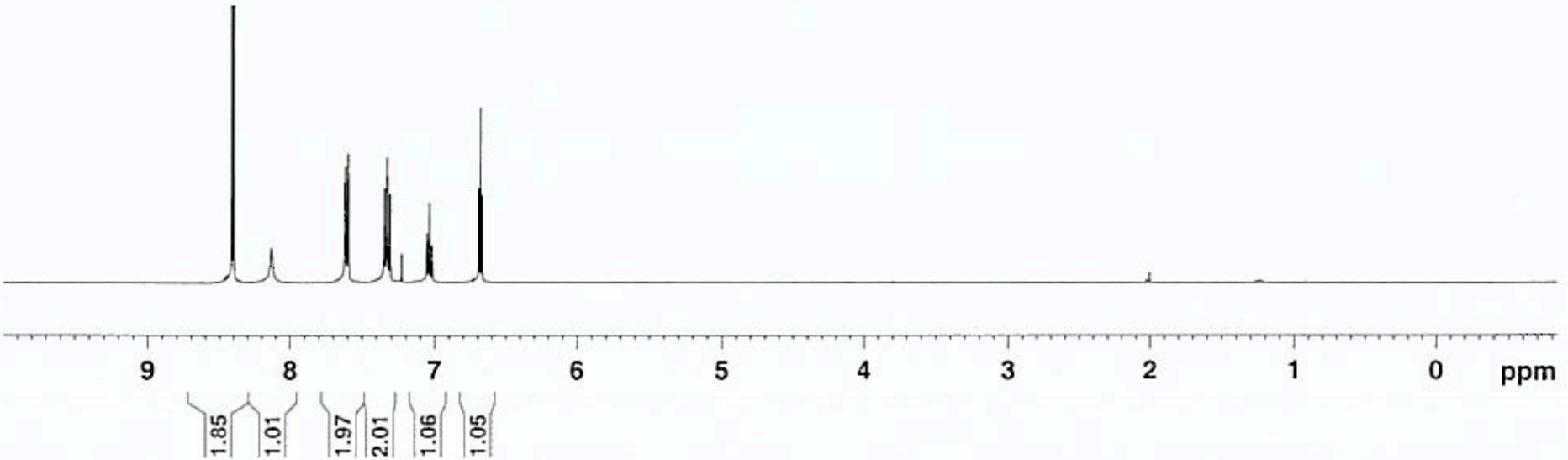
BF—III-265-13C

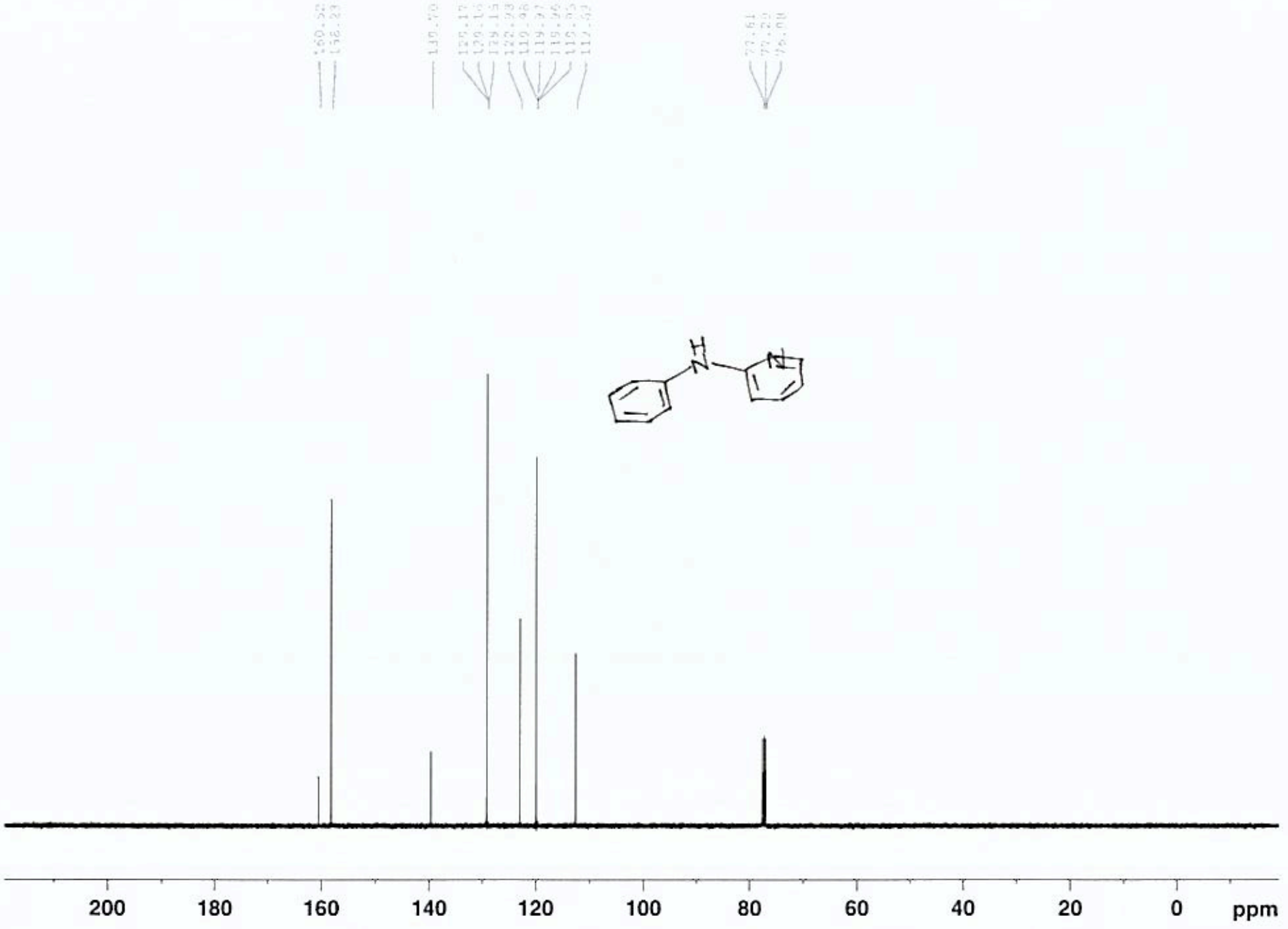
Pulse Sequence: s2pul





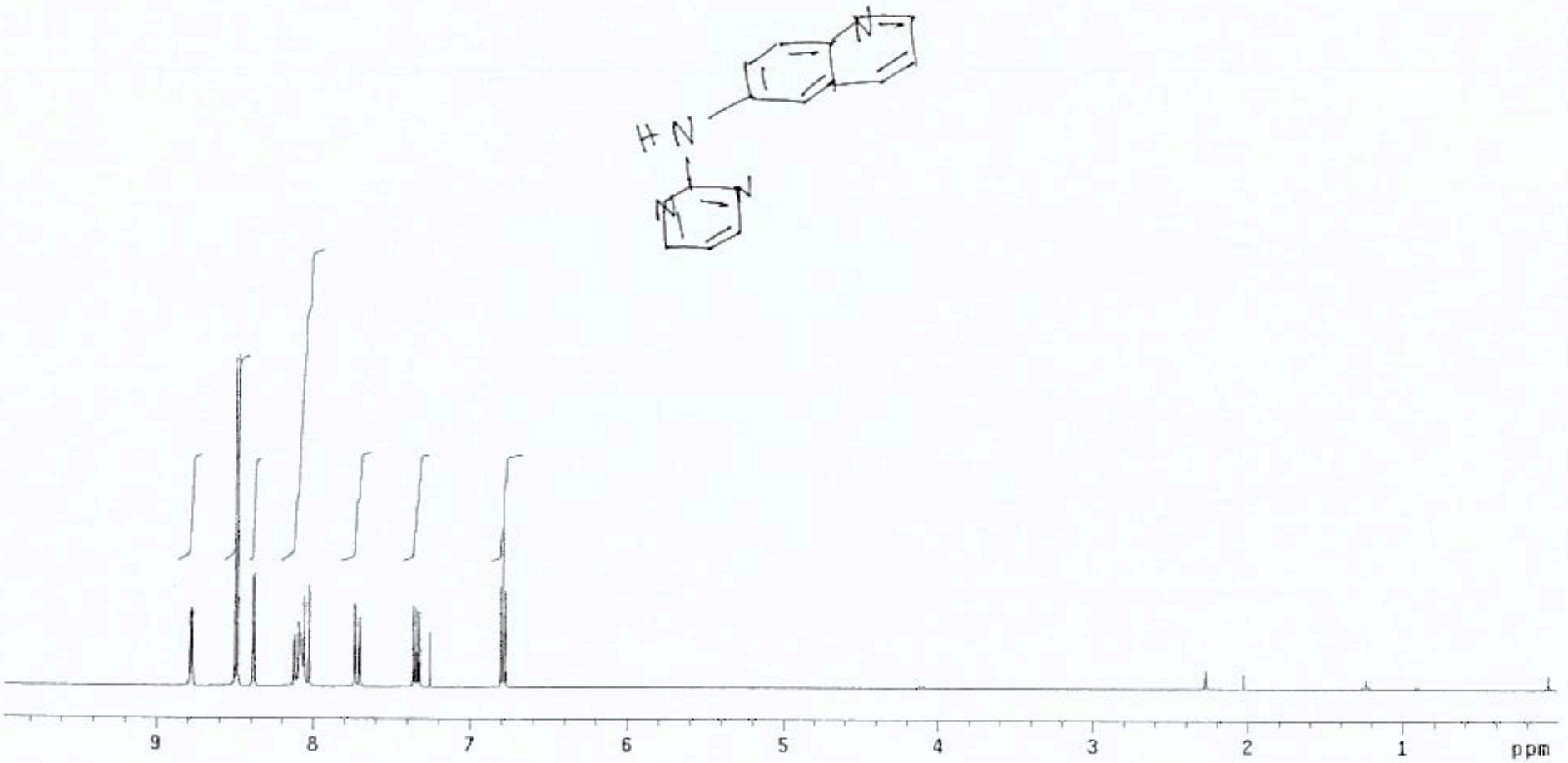



9
8
7
6
5
4
3
2
1
0
ppm
1.85
1.01
1.97
2.01
1.06
1.05


160.22
158.23
140.70
129.15
122.93
110.96
119.97
115.05
112.53
77.61
77.29
76.98
200
180
160
140
120
100
80
60
40
20
0
ppm

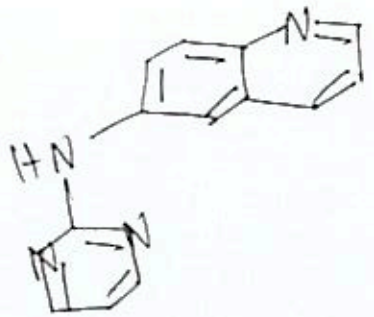
BF-III-133

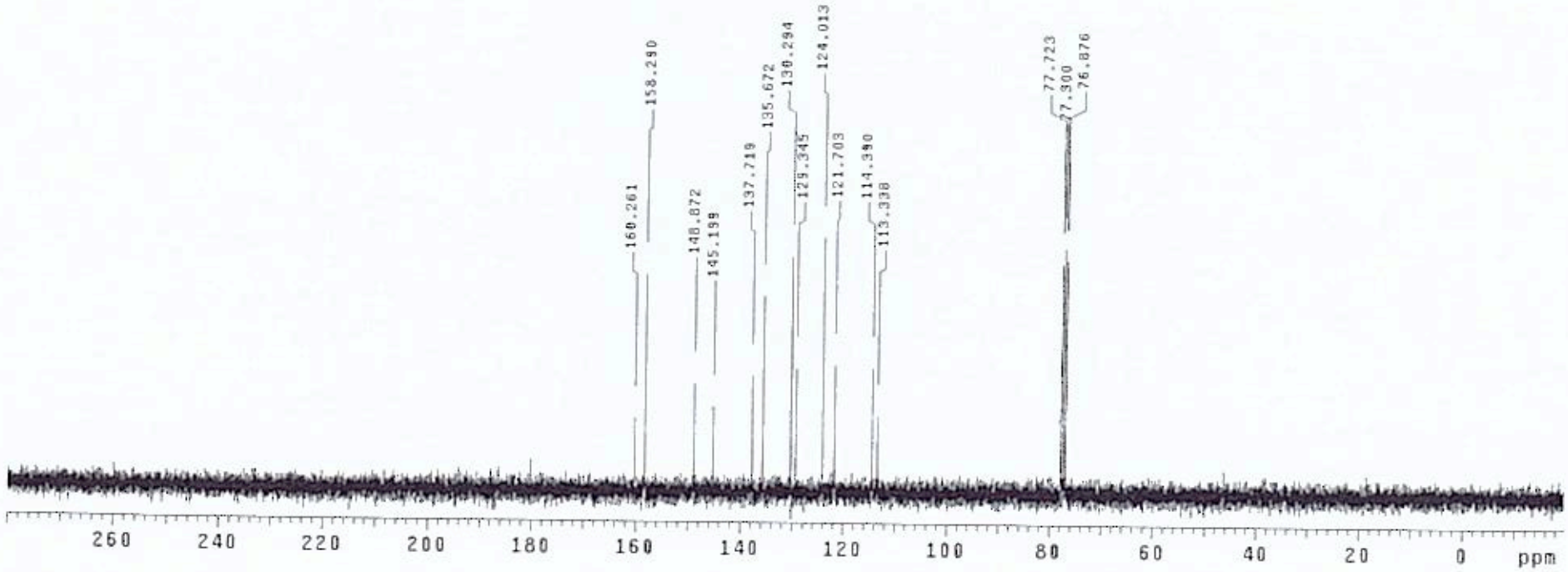
Pulse Sequence: s2pul

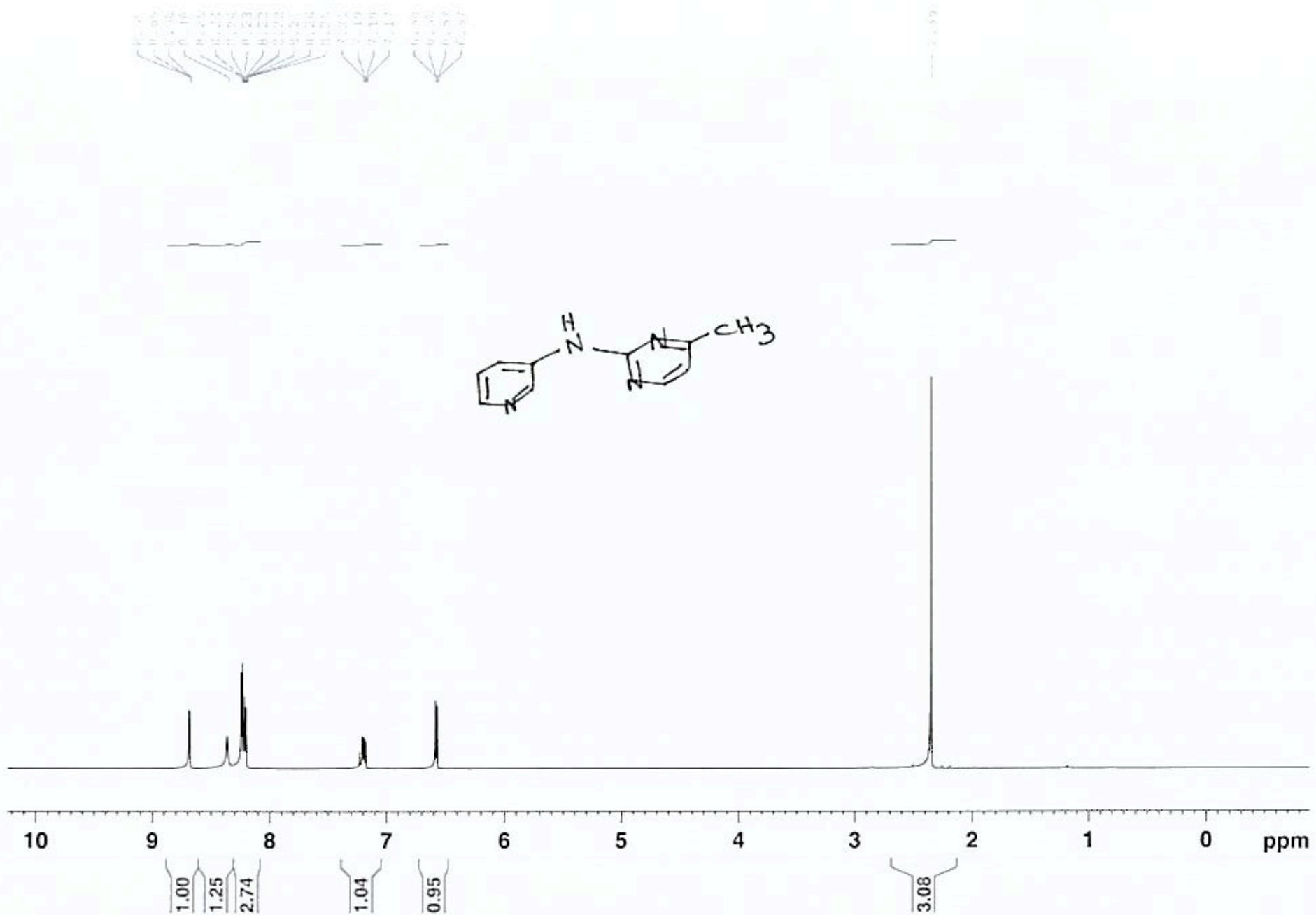


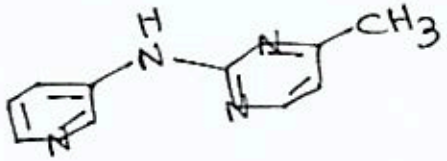
Bf-III-133-13C

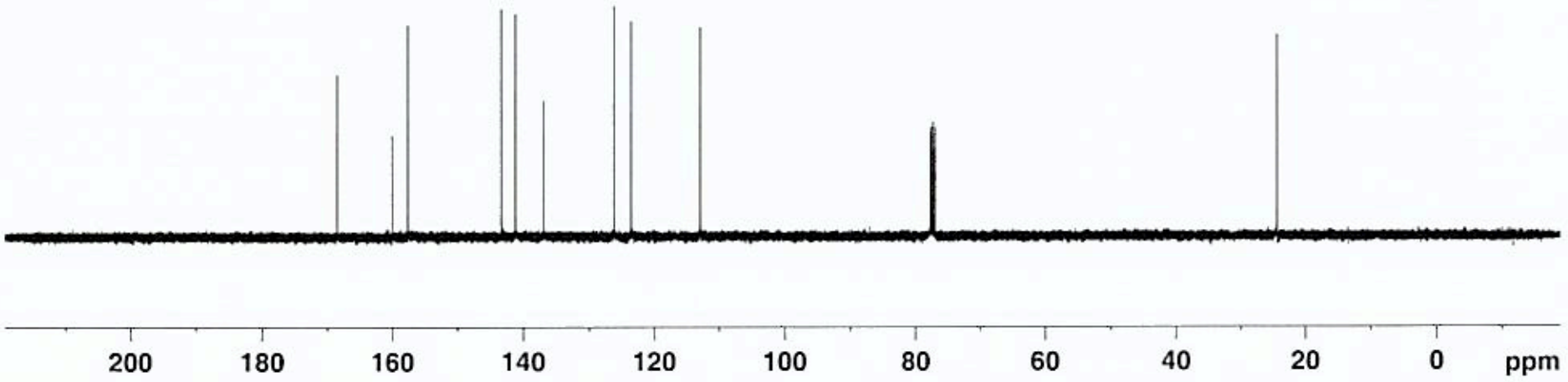
Pulse Sequence: s2pul

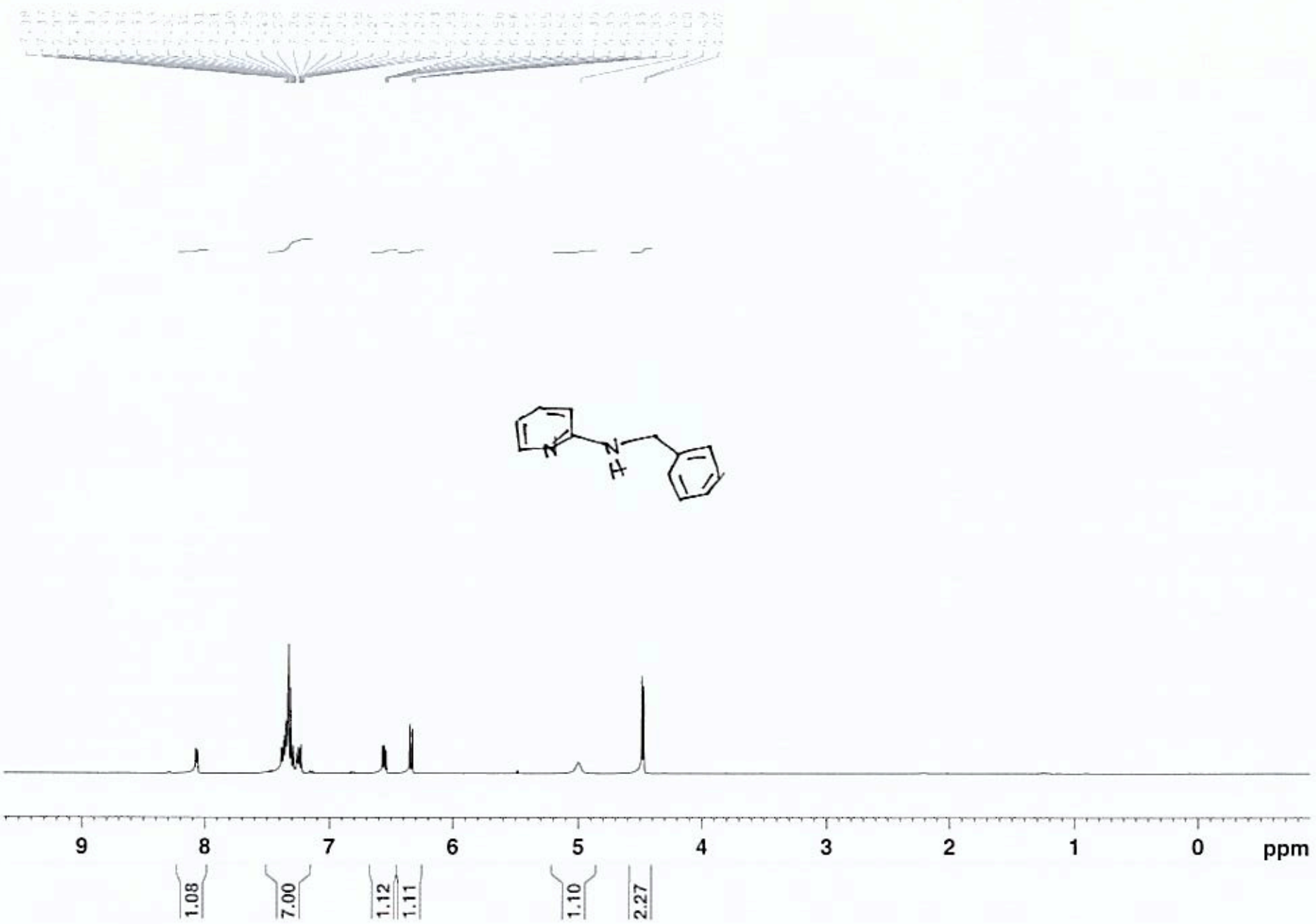


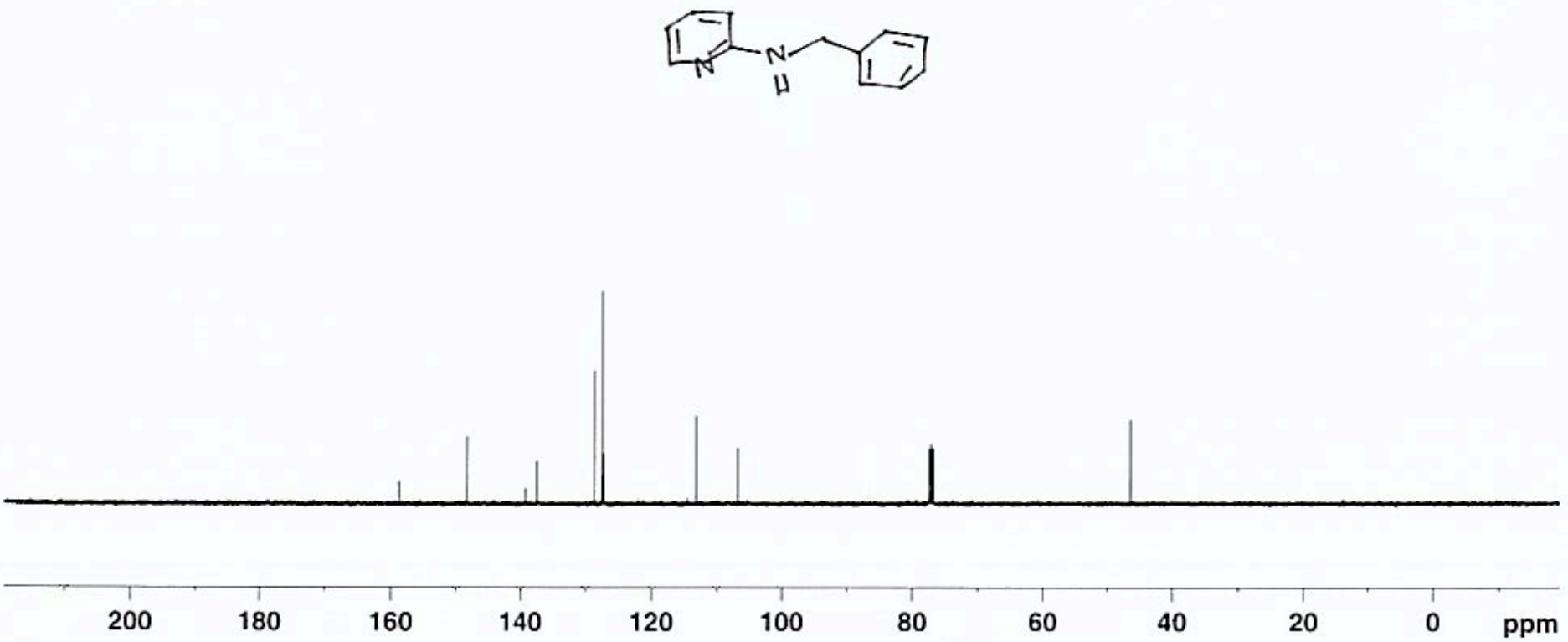


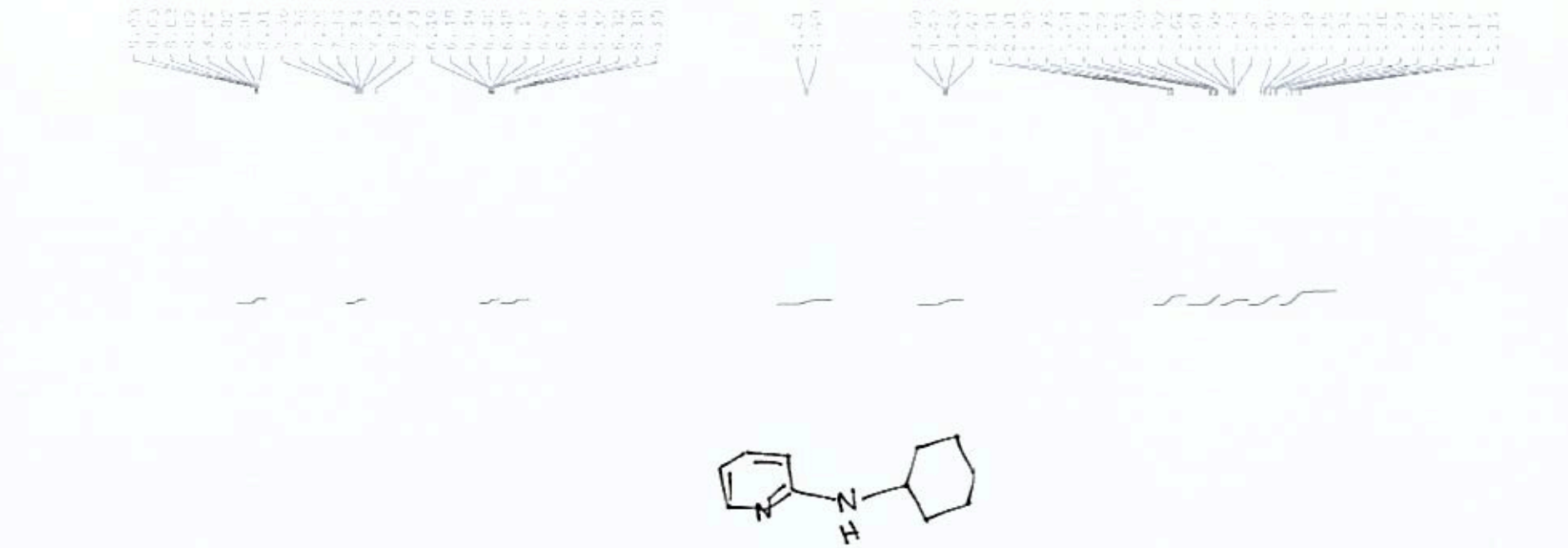

H
N
CH3
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.25
2.74
1.04
0.95
3.08

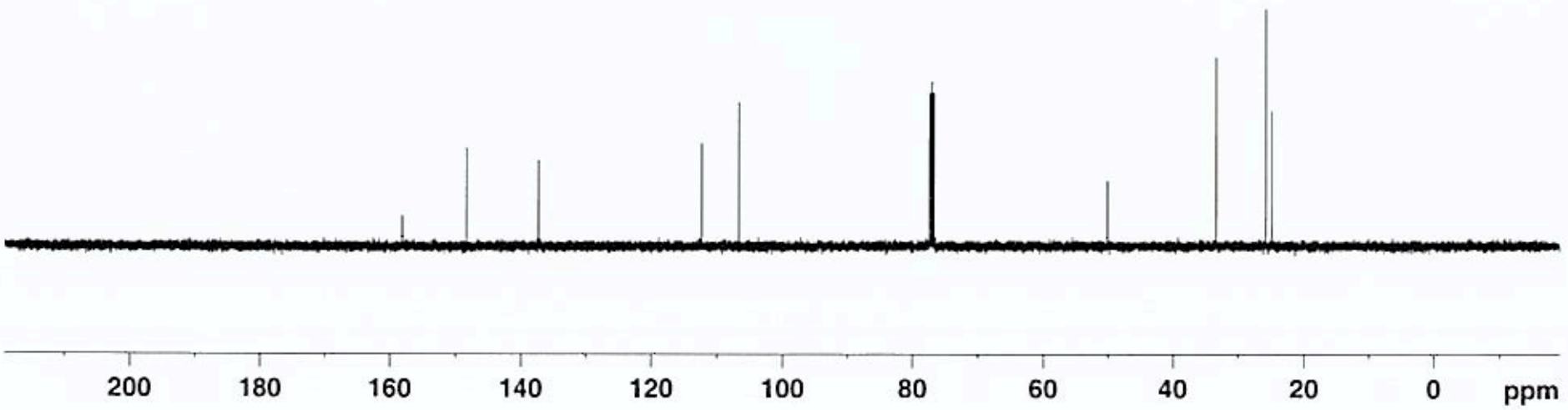

H
N
N
N
N
CH3

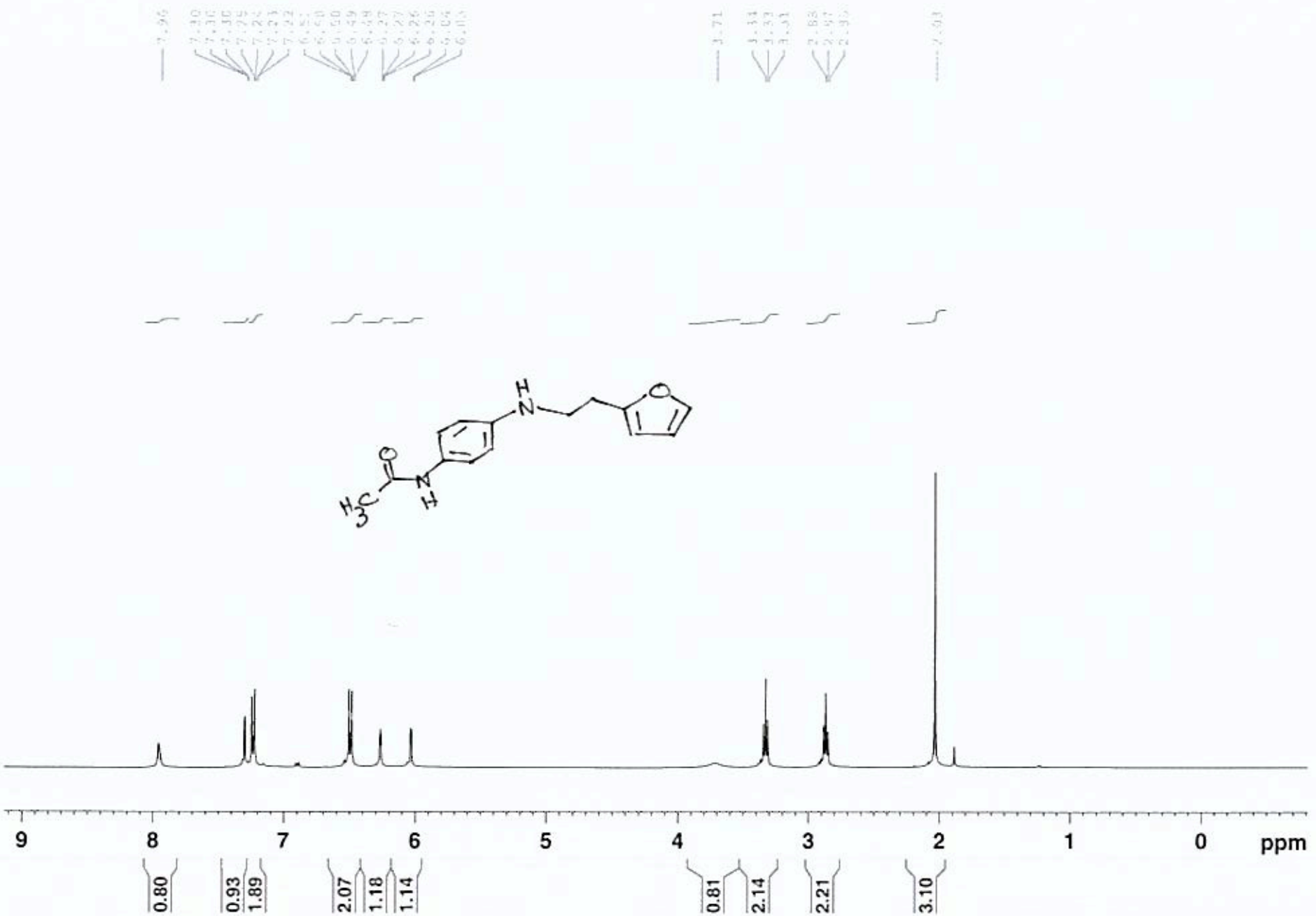

200
180
160
140
120
100
80
60
40
20
0
ppm

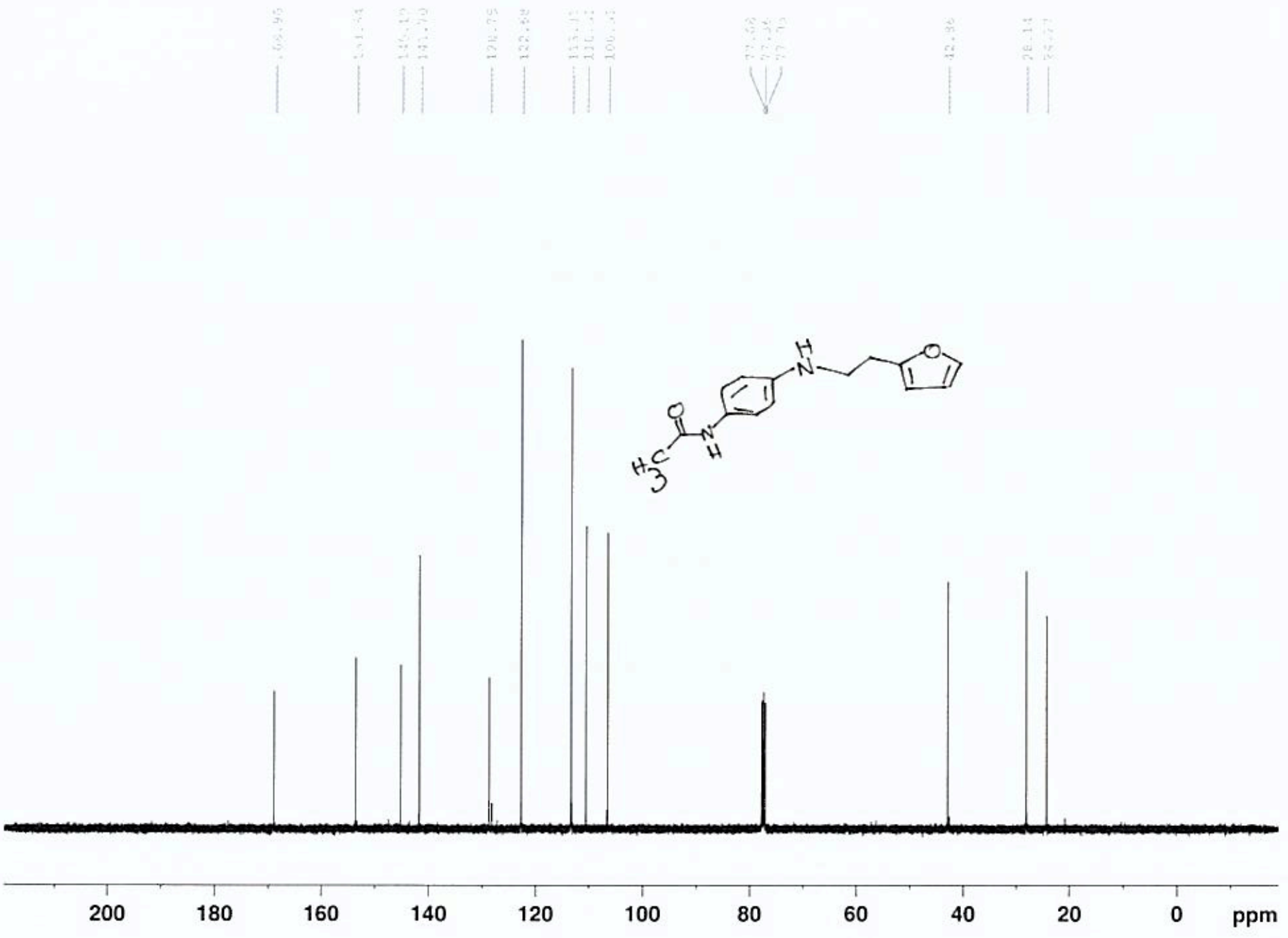

9
8
7
6
5
4
3
2
1
0
ppm
1.08
7.00
1.12
1.11
1.10
2.27

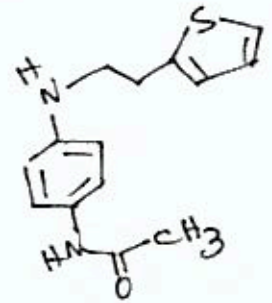

200
180
160
140
120
100
80
60
40
20
0
ppm

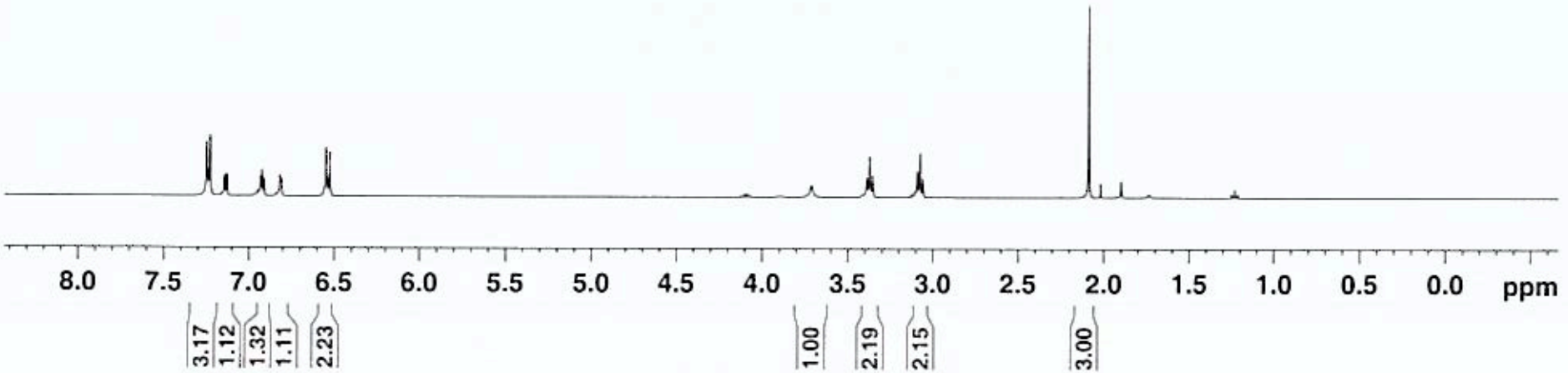

N
N
H
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.03
1.03
1.05
1.01
1.06
2.25
2.30
1.19
2.33
3.52

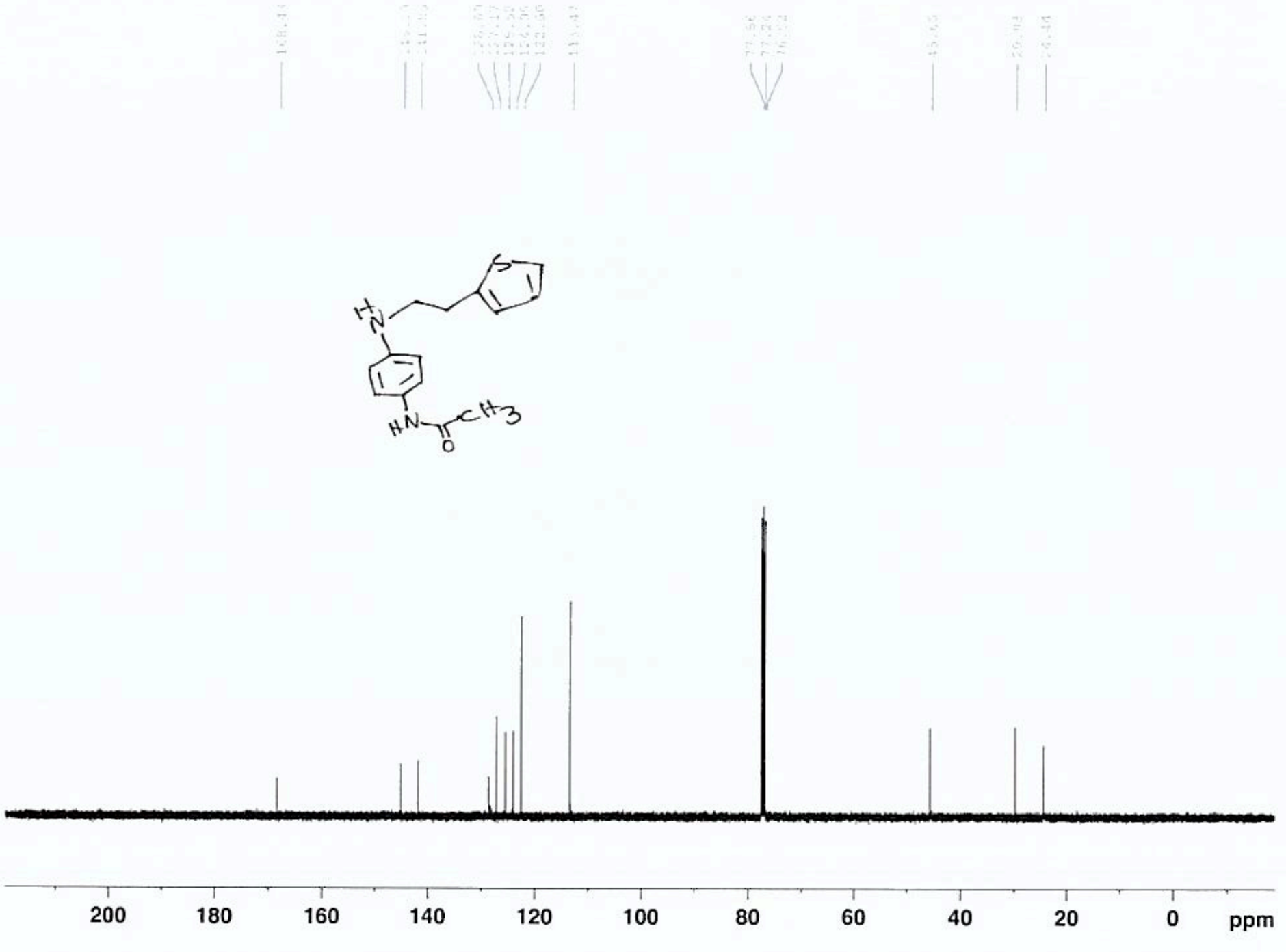


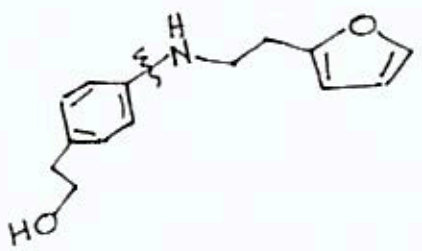

9
8
7
6
5
4
3
2
1
0
ppm
0.80
0.93
1.89
2.07
1.18
1.14
0.81
2.14
2.21
3.10

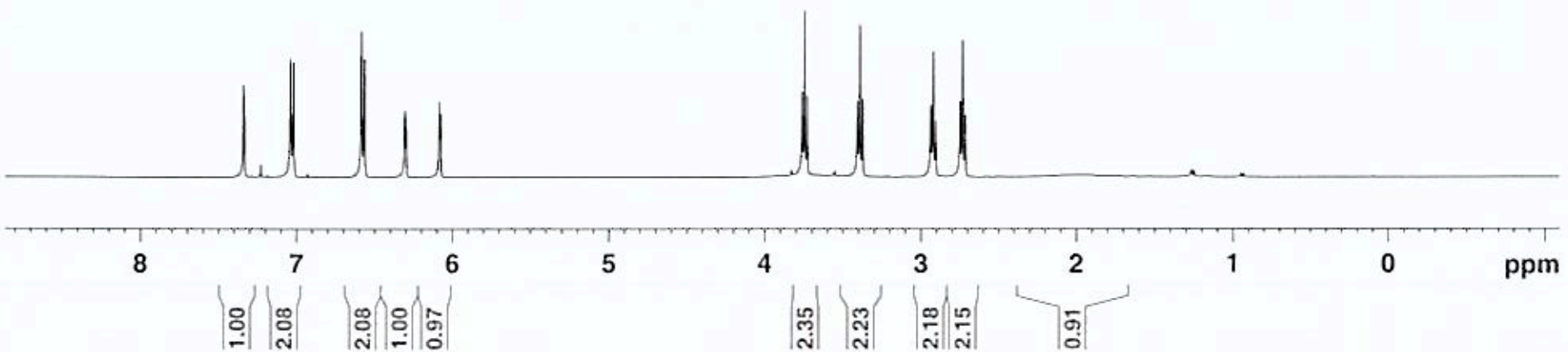

168.95
141.79
122.48
42.36
26.14
200
180
160
140
120
100
80
60
40
20
0
ppm

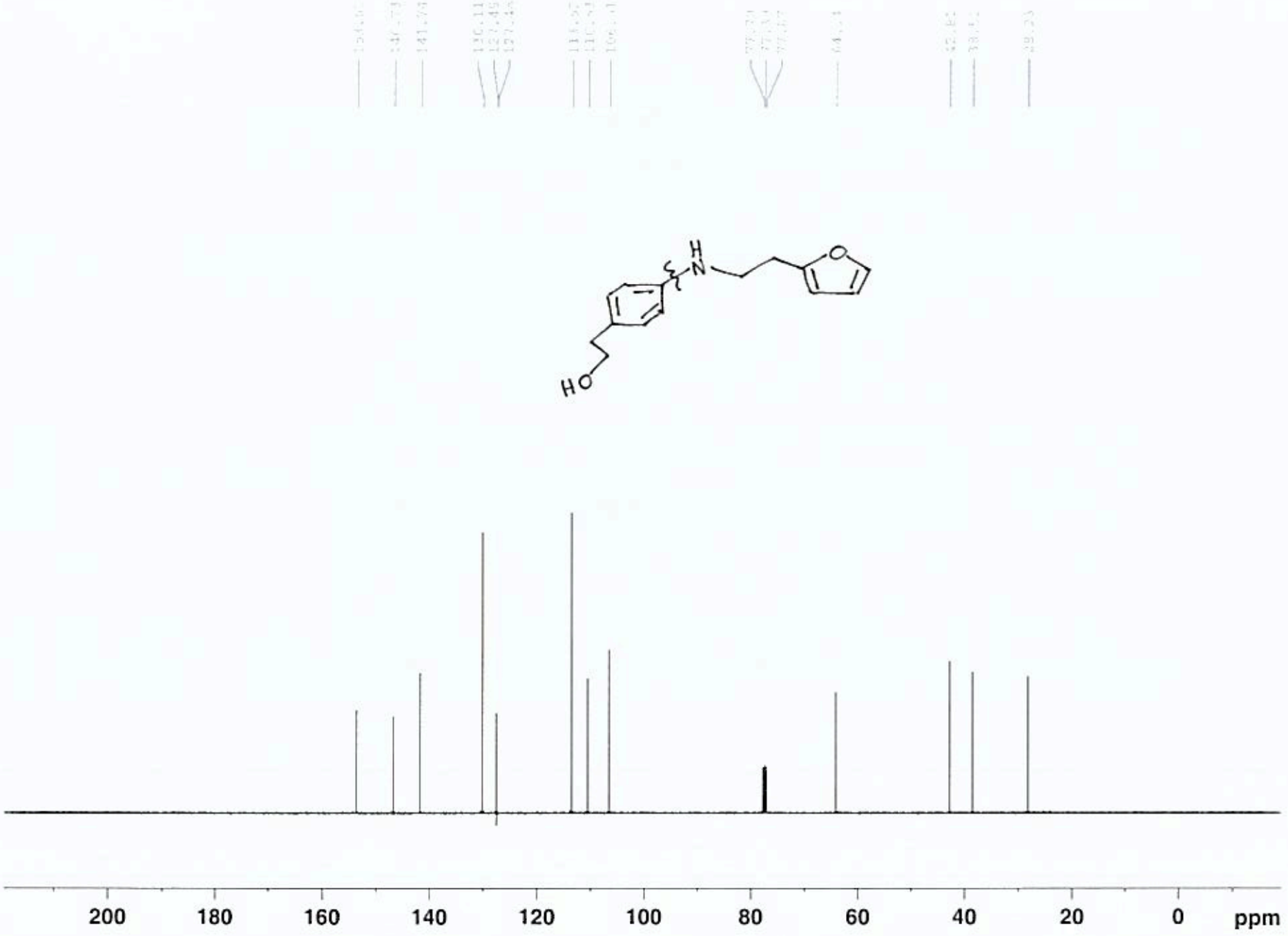

S
H
N
HN
CH3
O

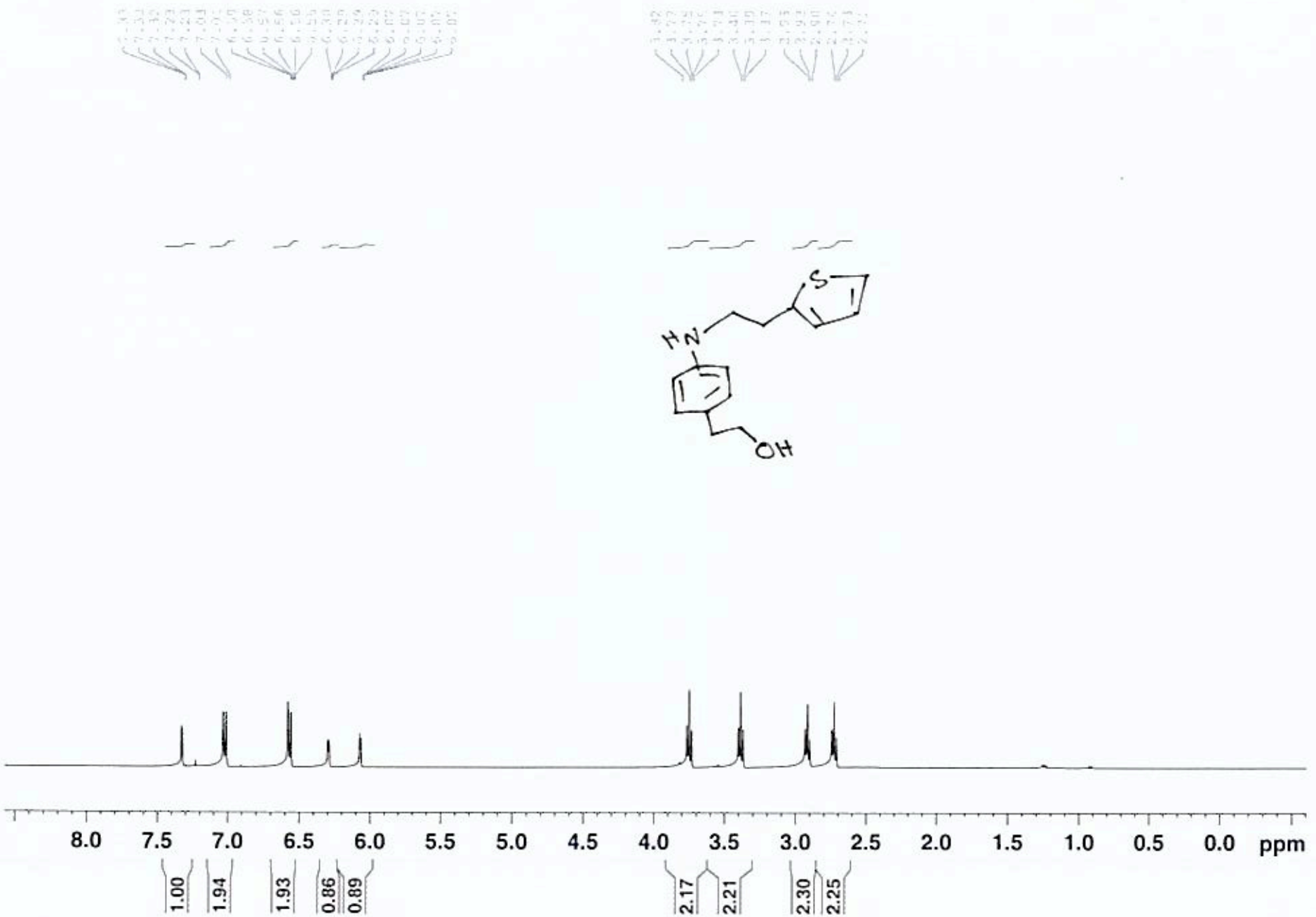

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
3.17
1.12
1.32
1.11
2.23
1.00
2.19
2.15
3.00

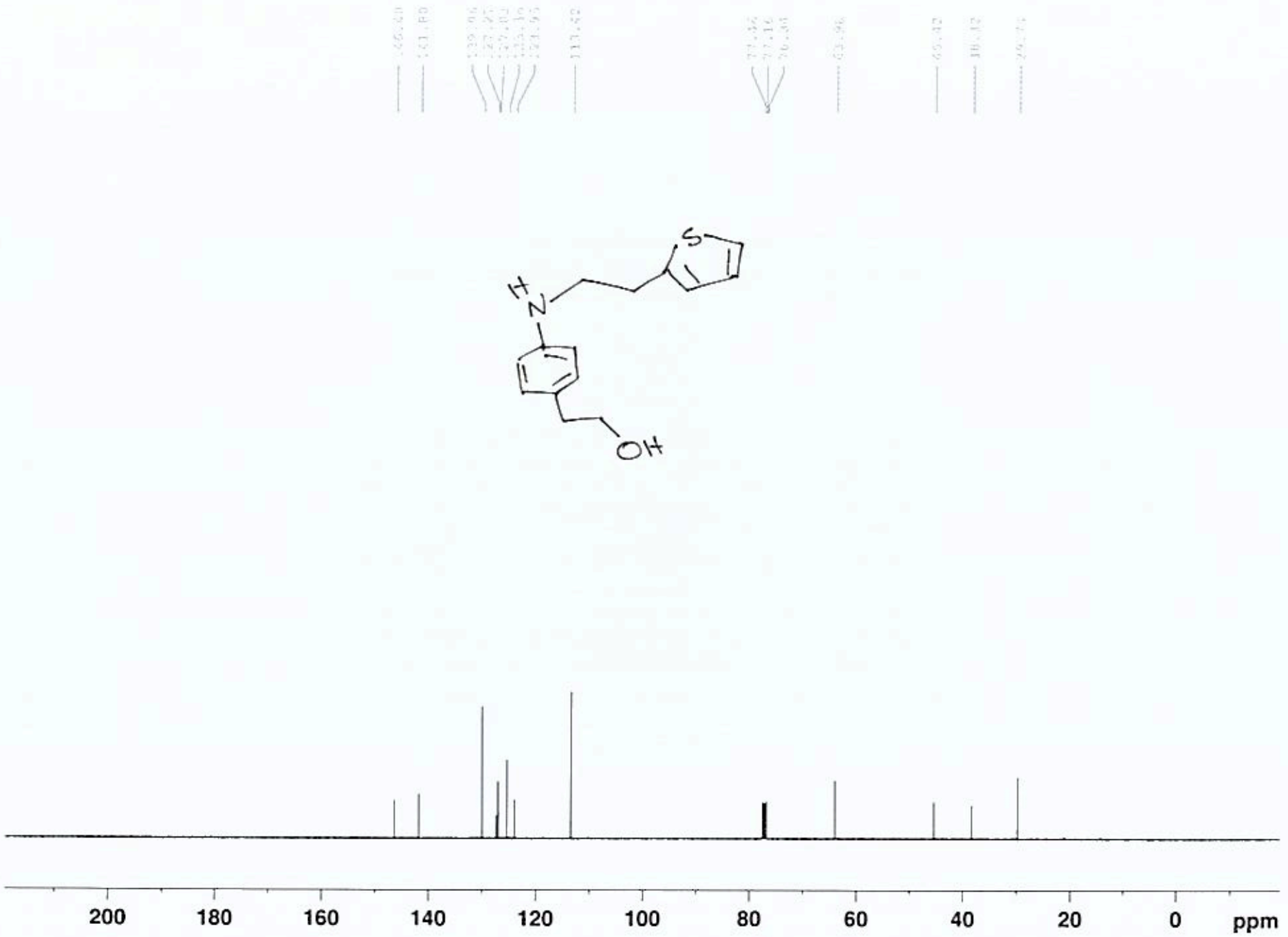

200
180
160
140
120
100
80
60
40
20
0
ppm

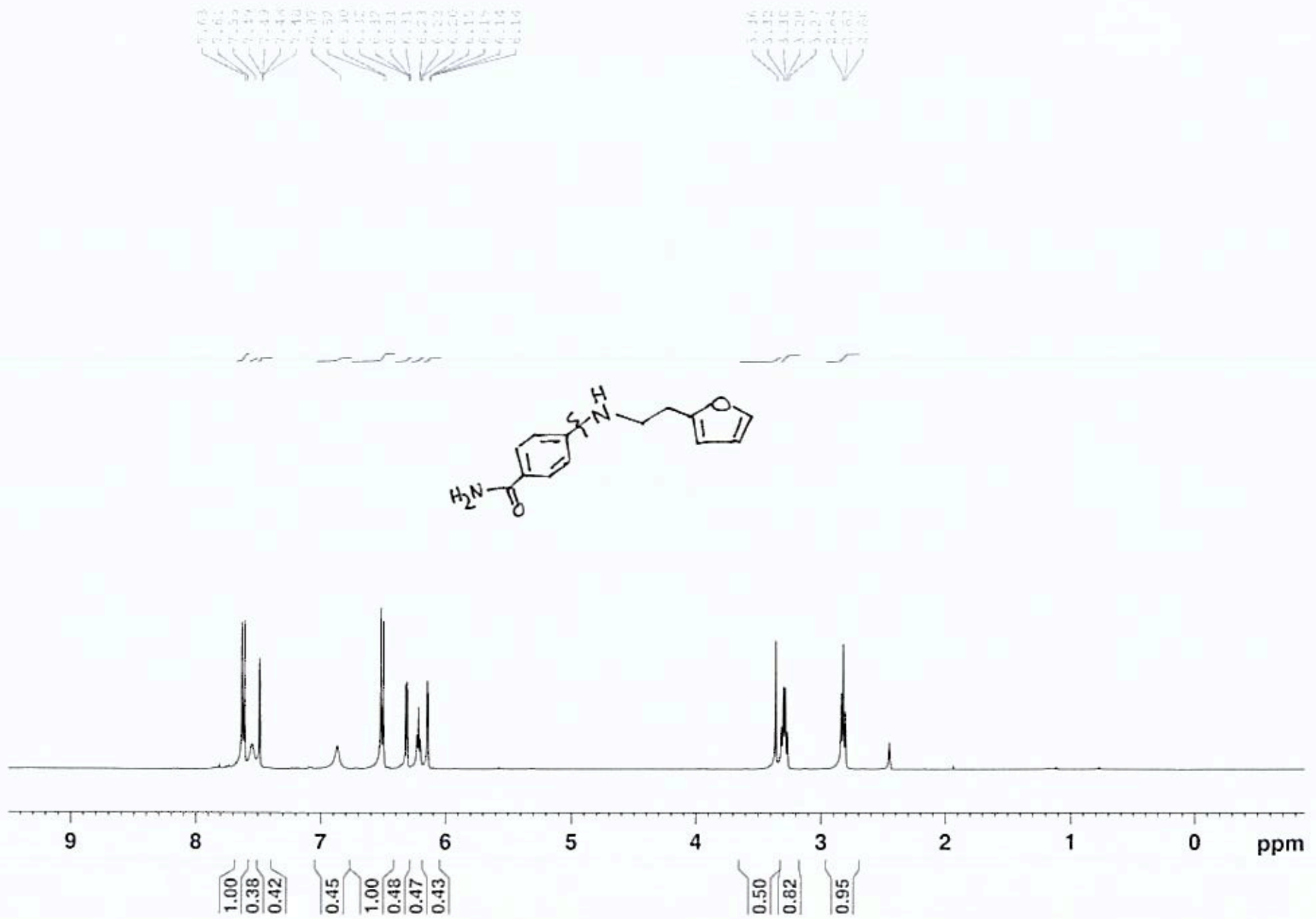

H
N
O
HO

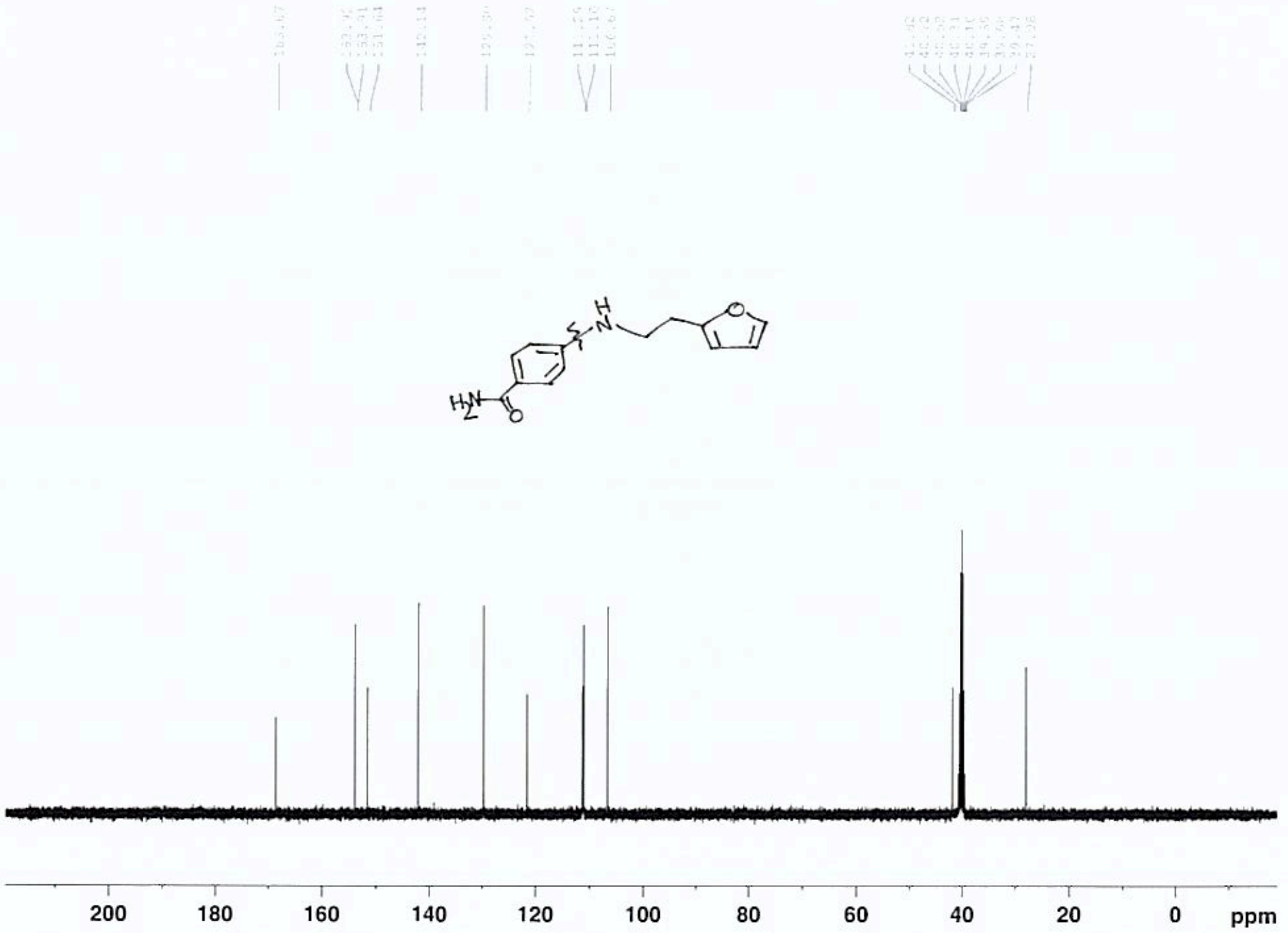

8
7
6
5
4
3
2
1
0
ppm
1.00
2.08
2.08
1.00
0.97
2.35
2.23
2.18
2.15
0.91

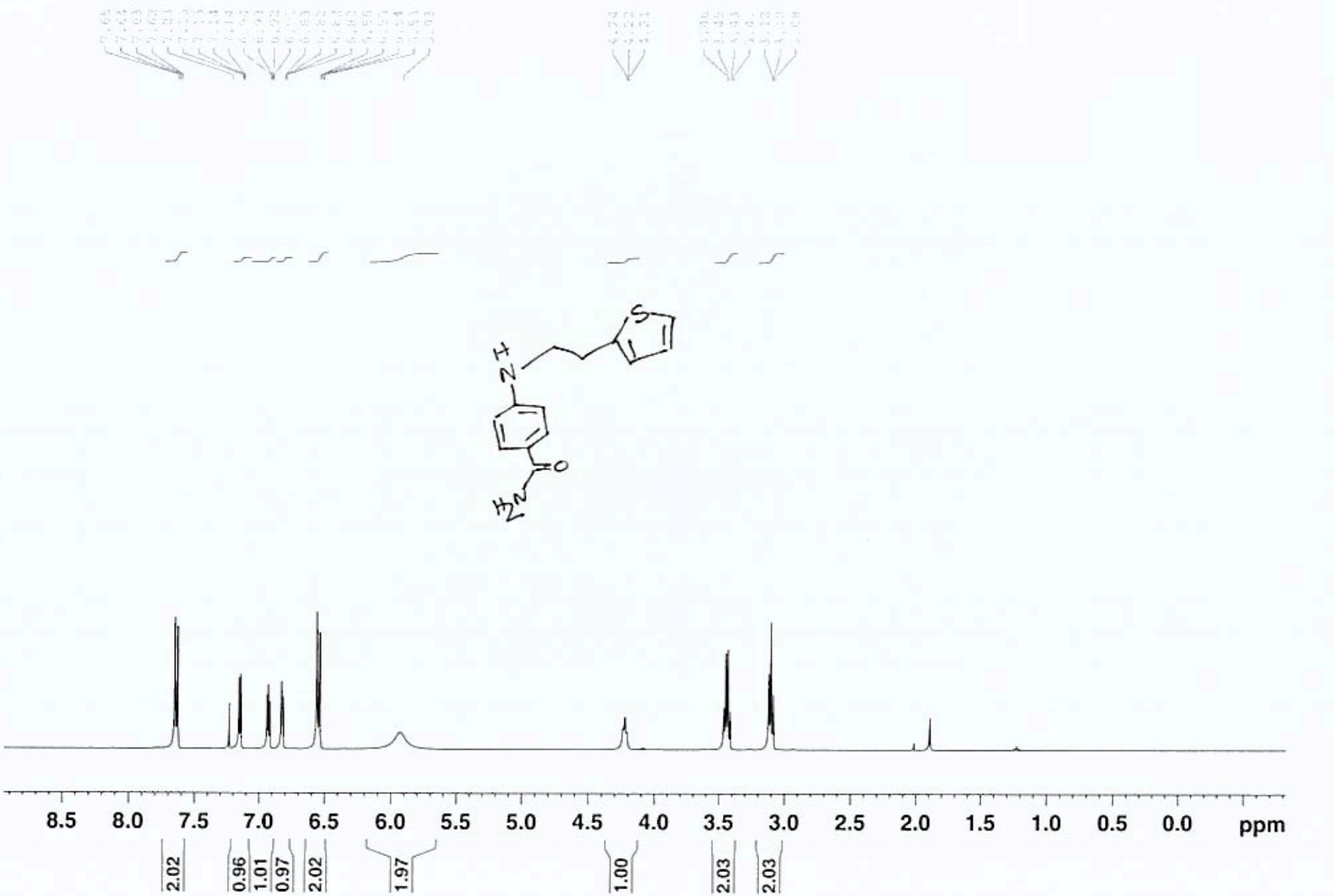

HO
H
N
O
200
180
160
140
120
100
80
60
40
20
0
ppm

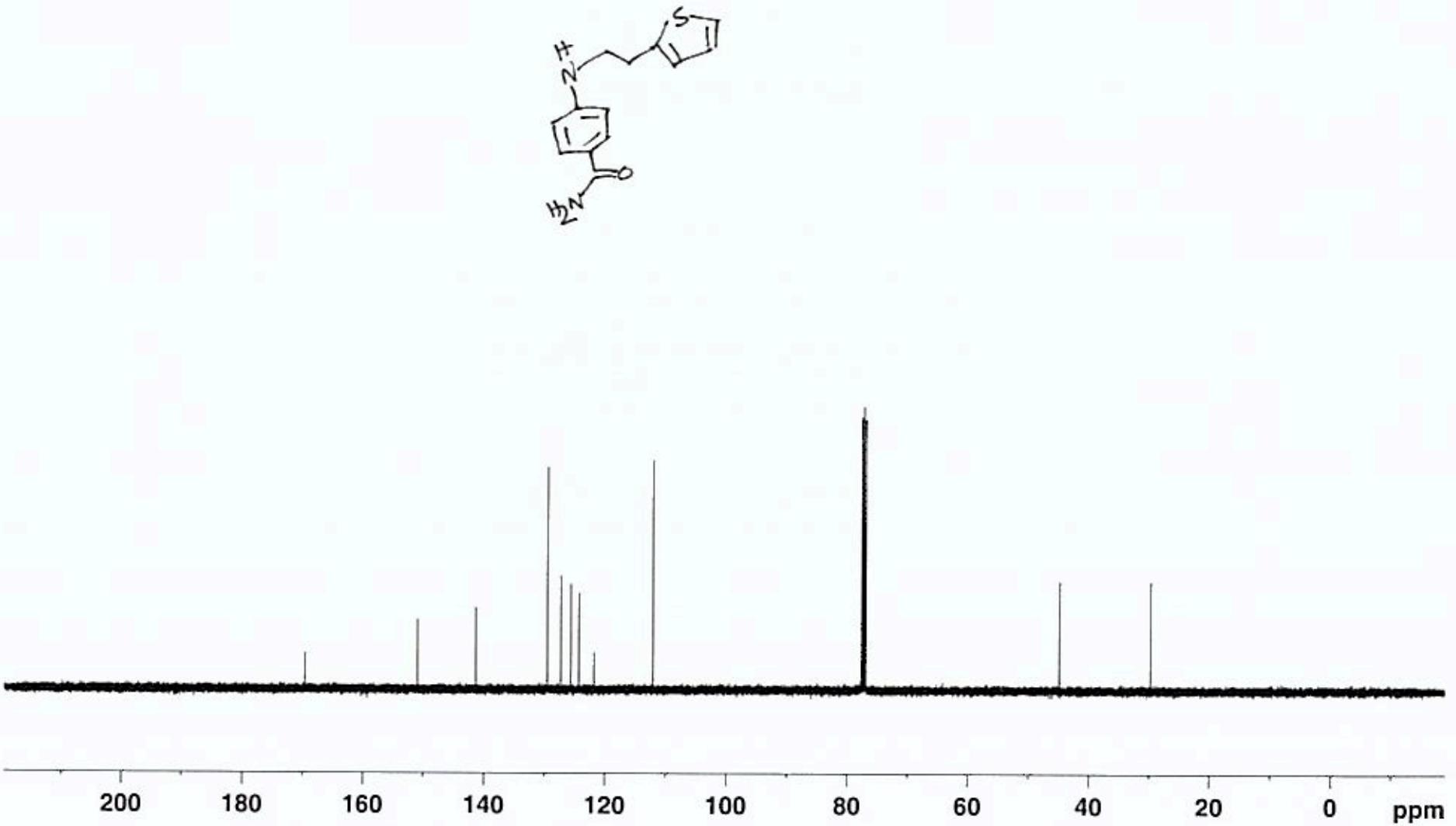

S
H2N
OH
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.00
1.94
1.93
0.86
0.89
2.17
2.21
2.30
2.25

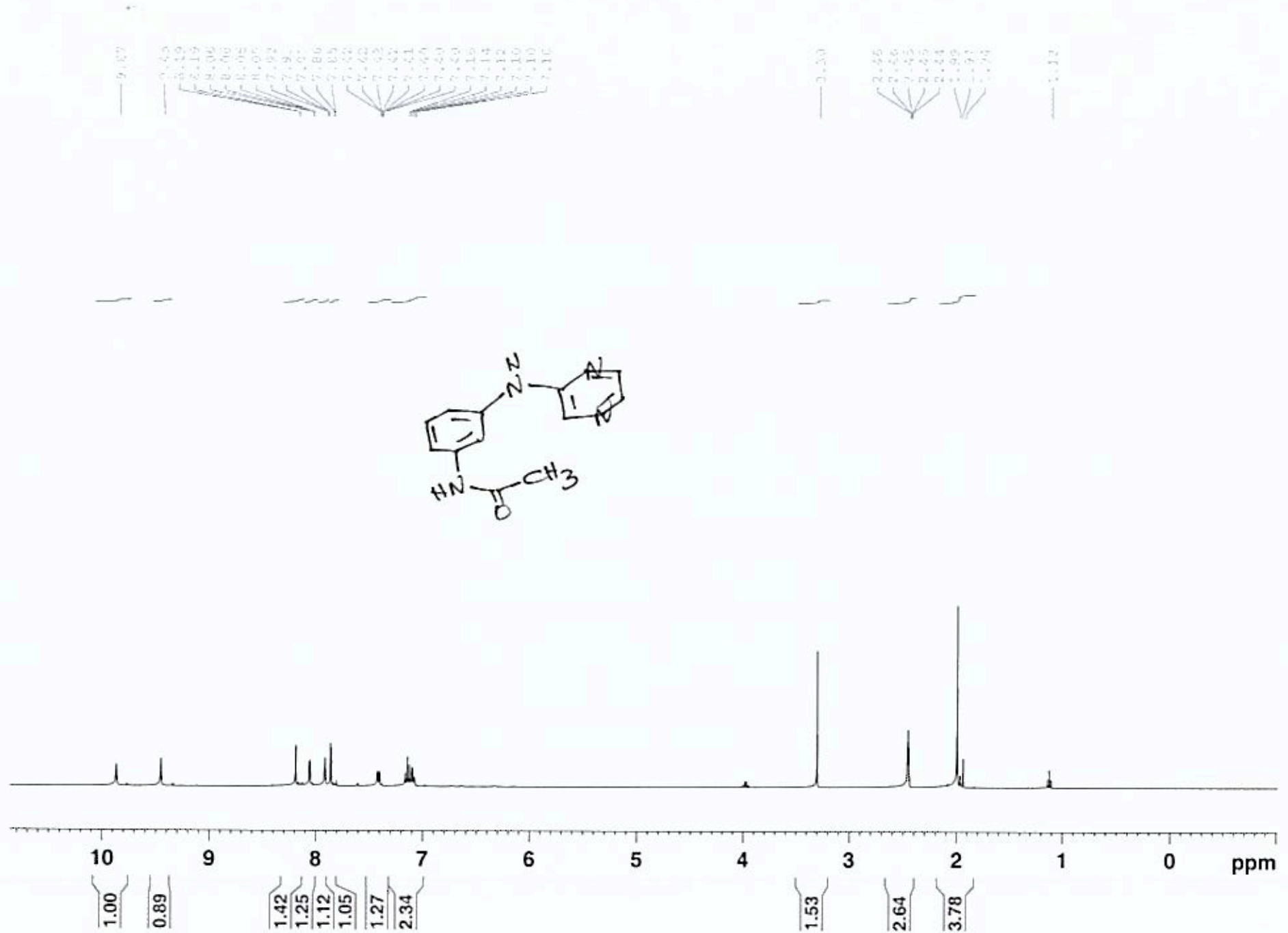

S
H
N
OH
200
180
160
140
120
100
80
60
40
20
0
ppm

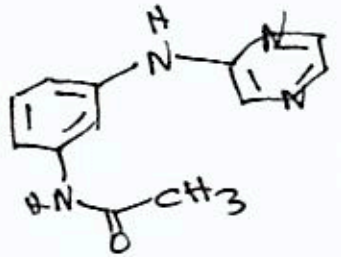

9
8
7
6
5
4
3
2
1
0
ppm
1.00
0.38
0.42
0.45
1.00
0.48
0.47
0.43
0.50
0.82
0.95

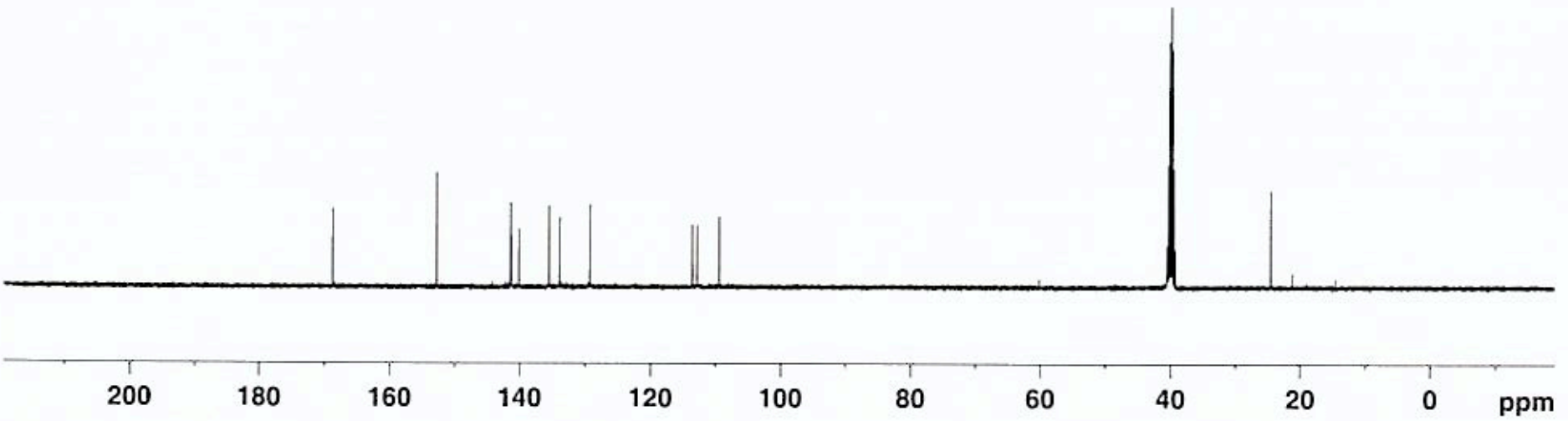

200
180
160
140
120
100
80
60
40
20
0
ppm

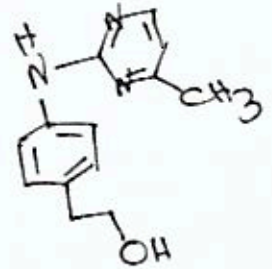


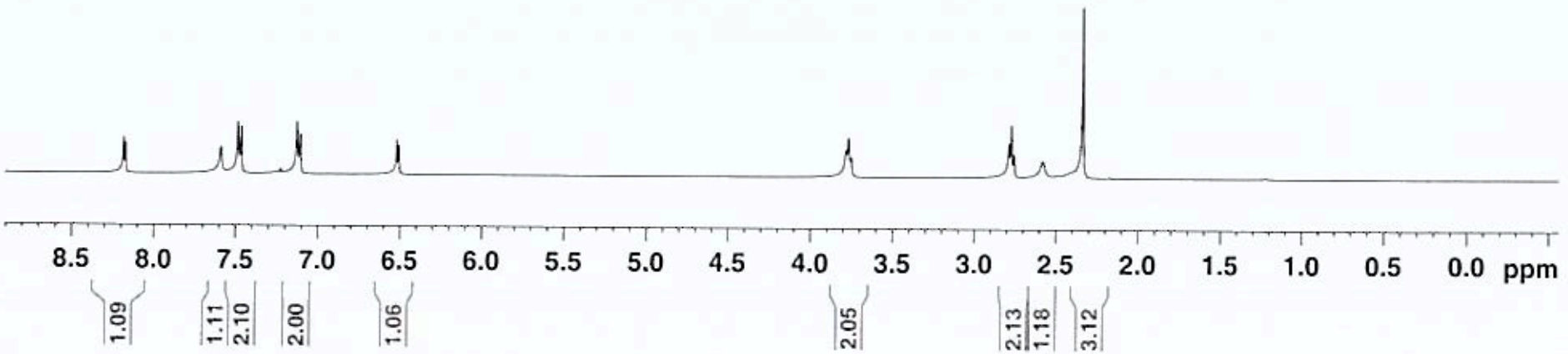

S
H
N
O
H2N
200
180
160
140
120
100
80
60
40
20
0
ppm

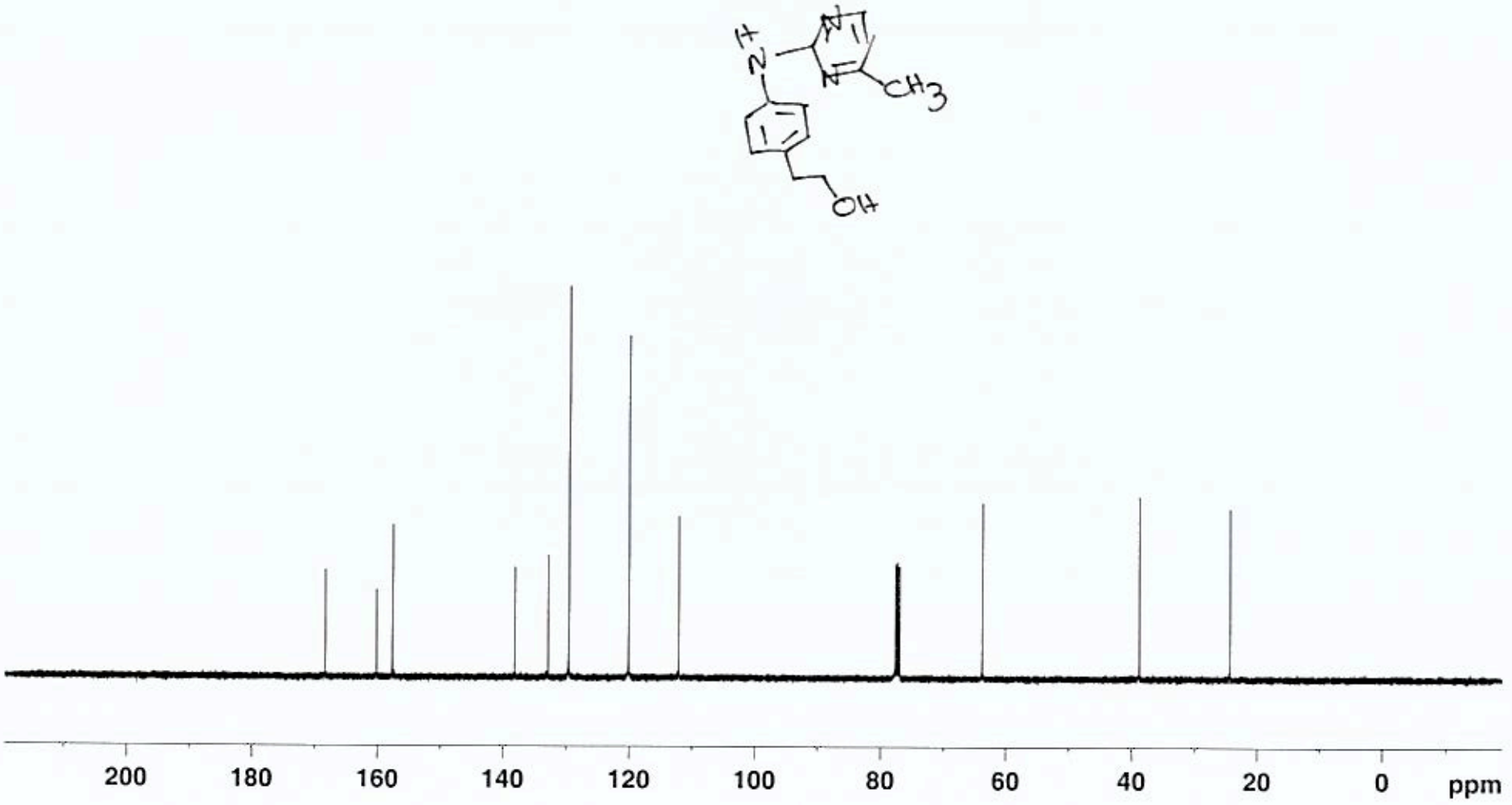

HN
CH3
O
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
0.89
1.42
1.25
1.12
1.05
1.27
2.34
1.53
2.64
3.78

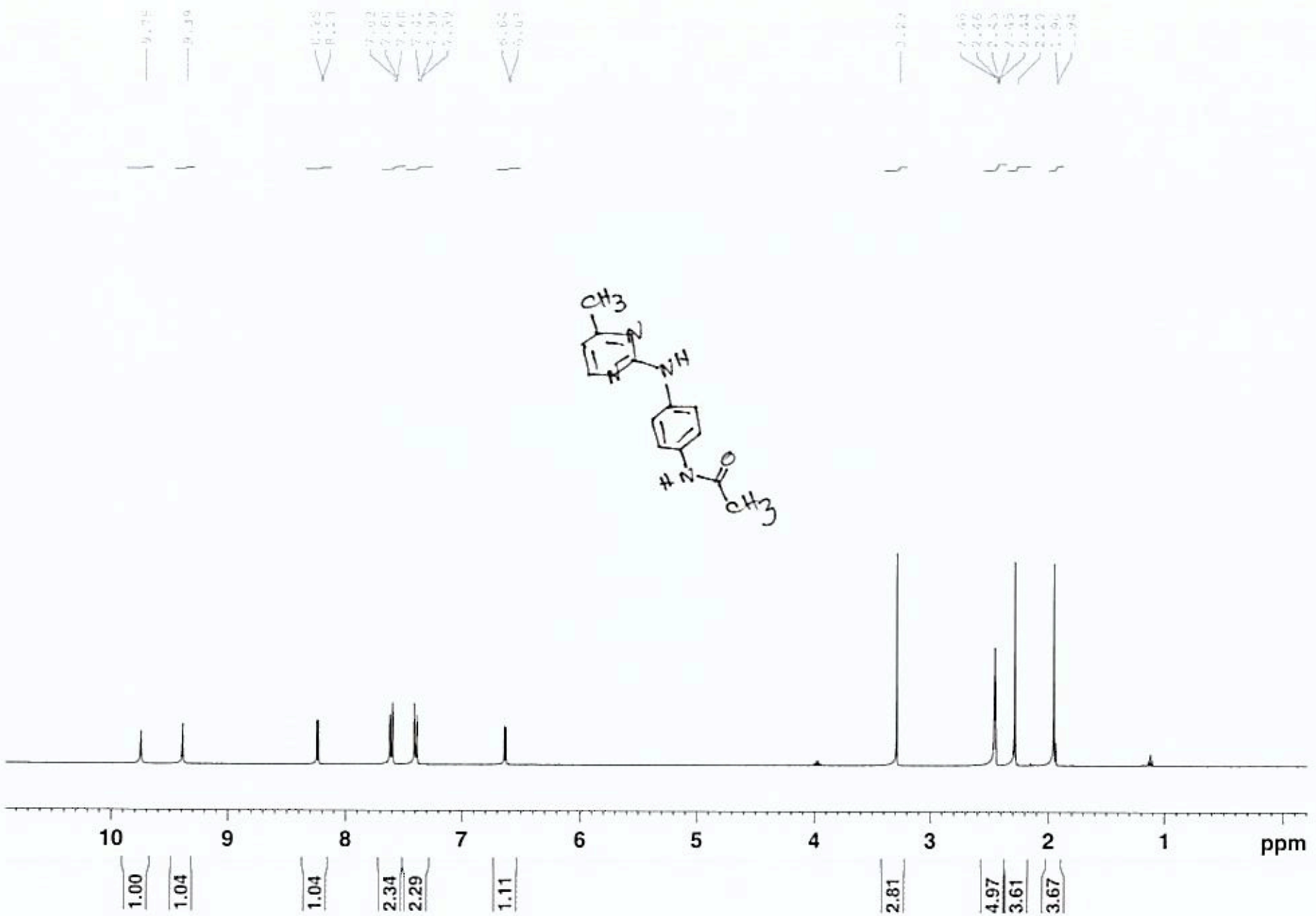

H
N
N
N
H-N
CH3
O

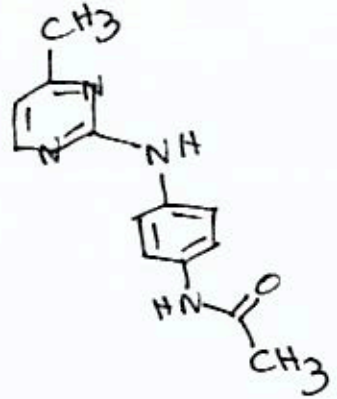

200
180
160
140
120
100
80
60
40
20
0
ppm

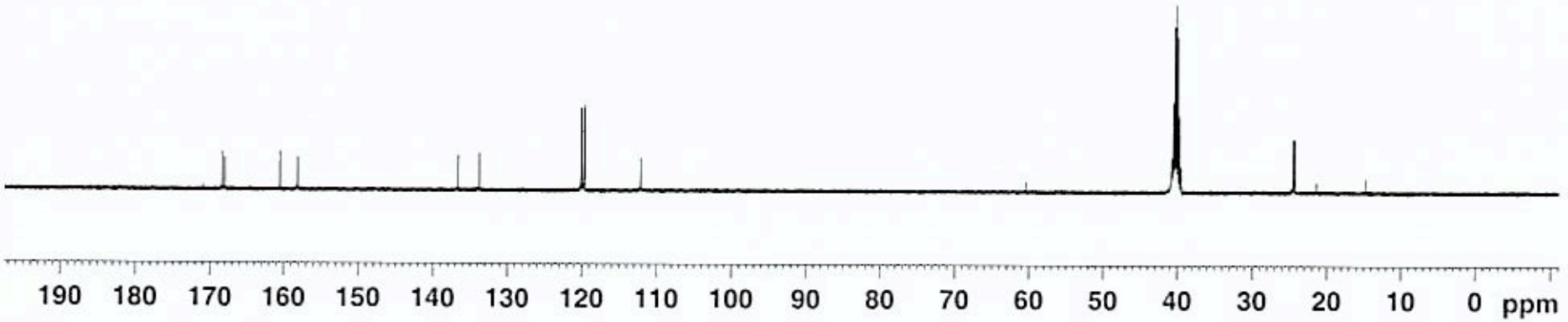


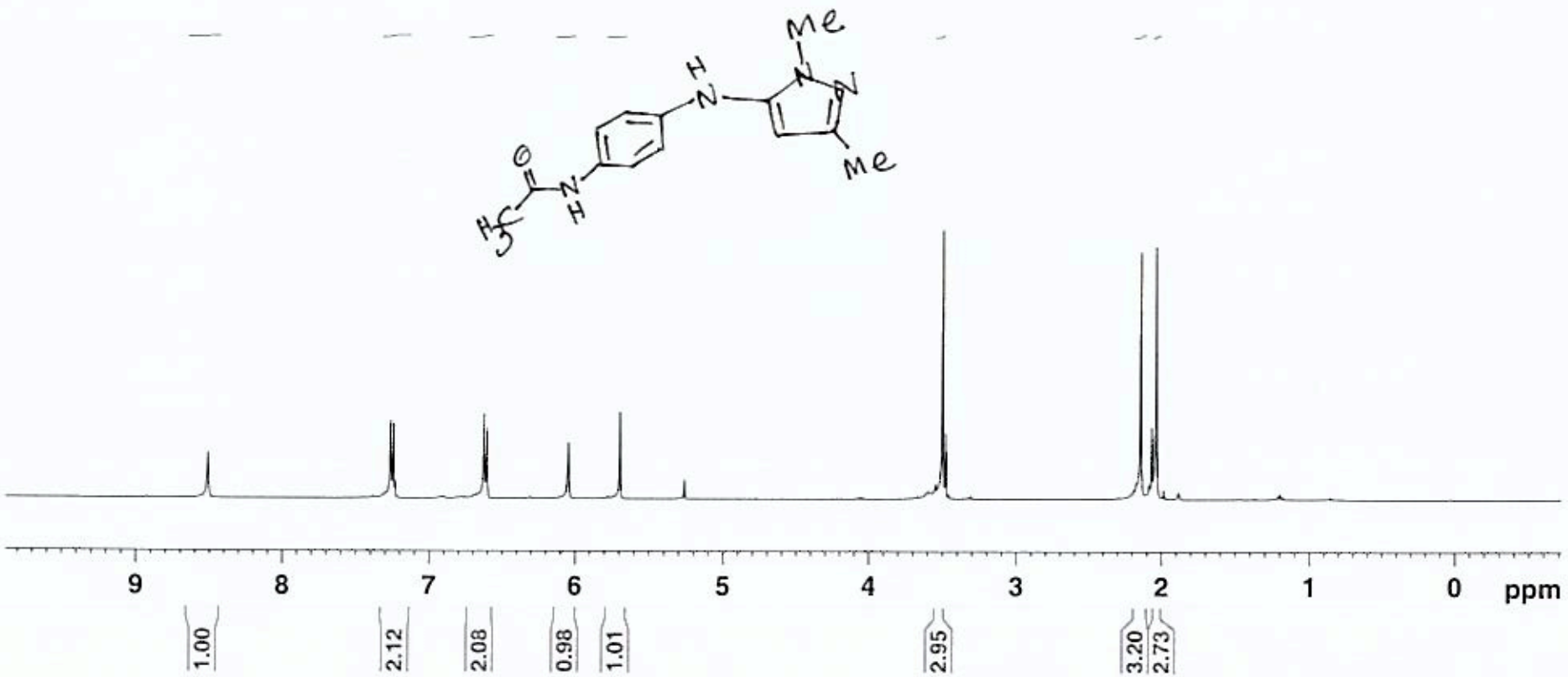


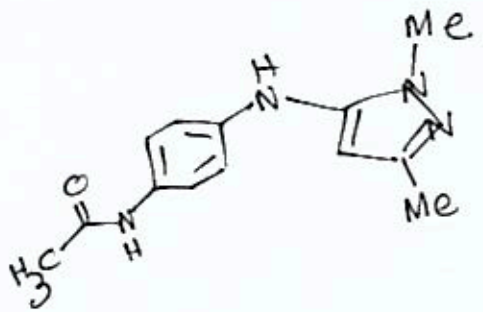

H
N
N
N
CH3
OH
200
180
160
140
120
100
80
60
40
20
0
ppm

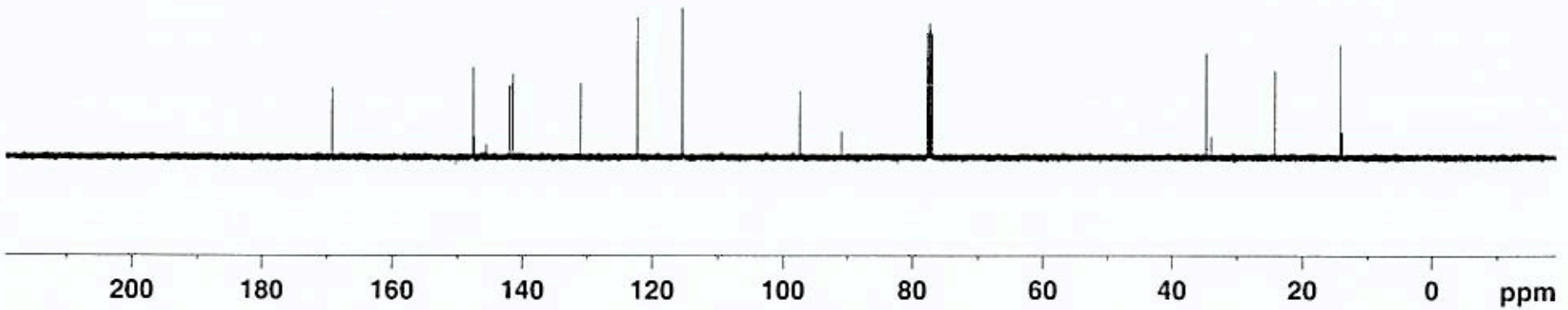

CH3
N
NH
N
H
N
O
CH3
10
9
8
7
6
5
4
3
2
1
ppm
1.00
1.04
1.04
2.34
2.29
1.11
2.81
4.97
3.61
3.67

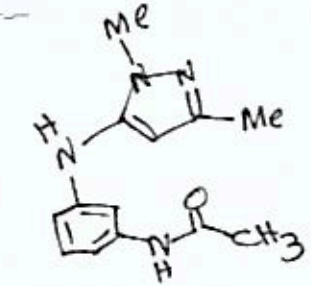


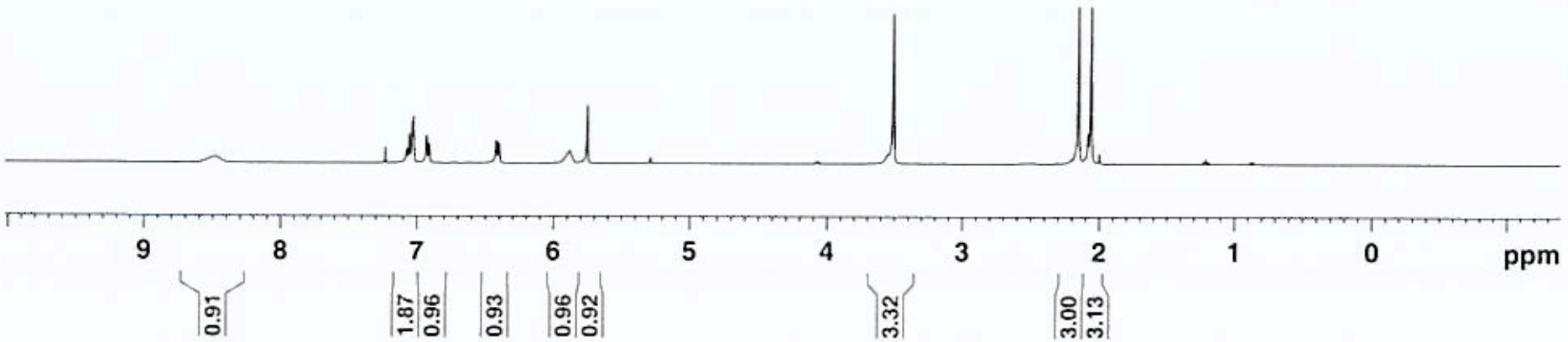


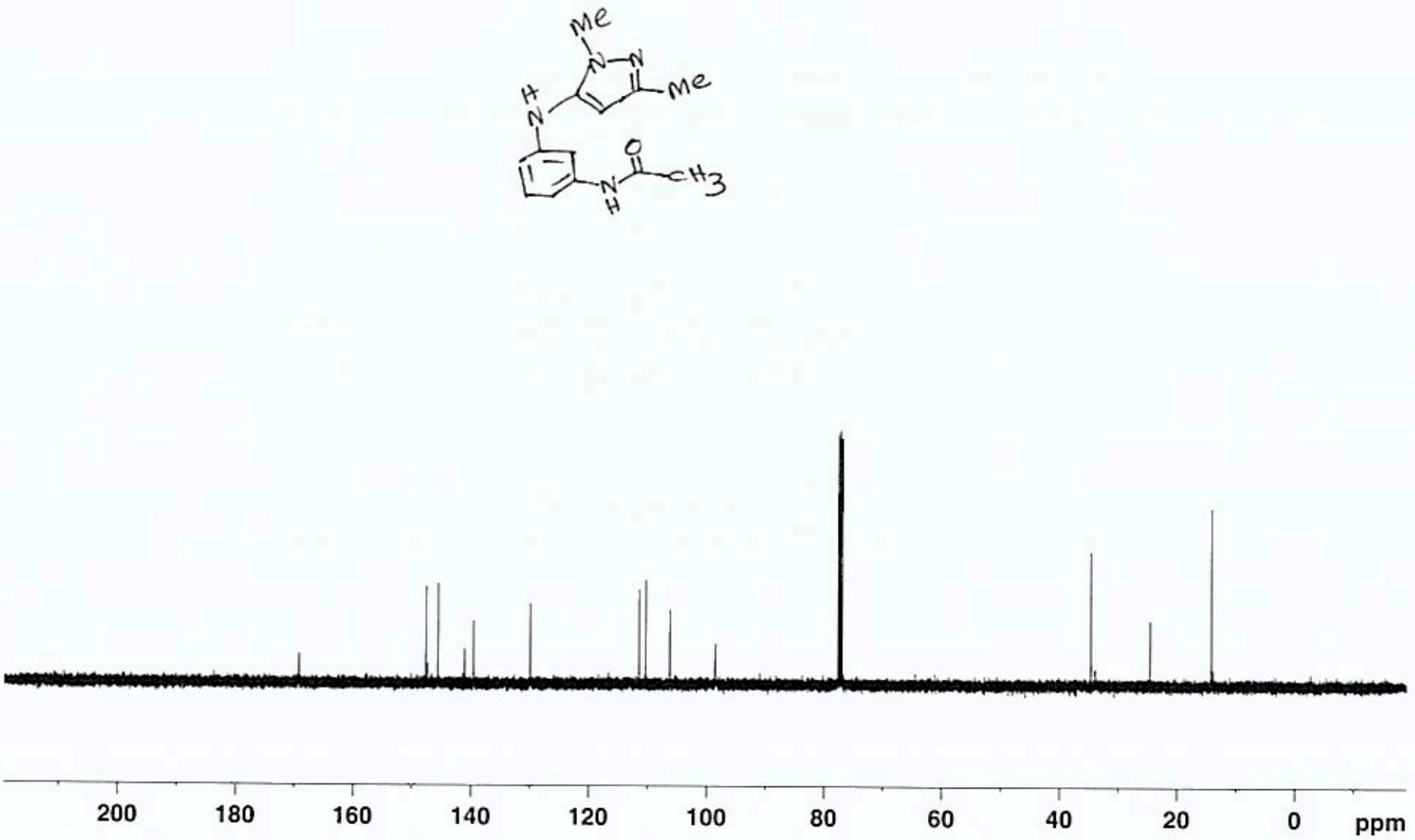

Me
H
N
N
N
Me
O
N
H
H3C
9
8
7
6
5
4
3
2
1
0
ppm
1.00
2.12
2.08
0.98
1.01
2.95
3.20
2.73

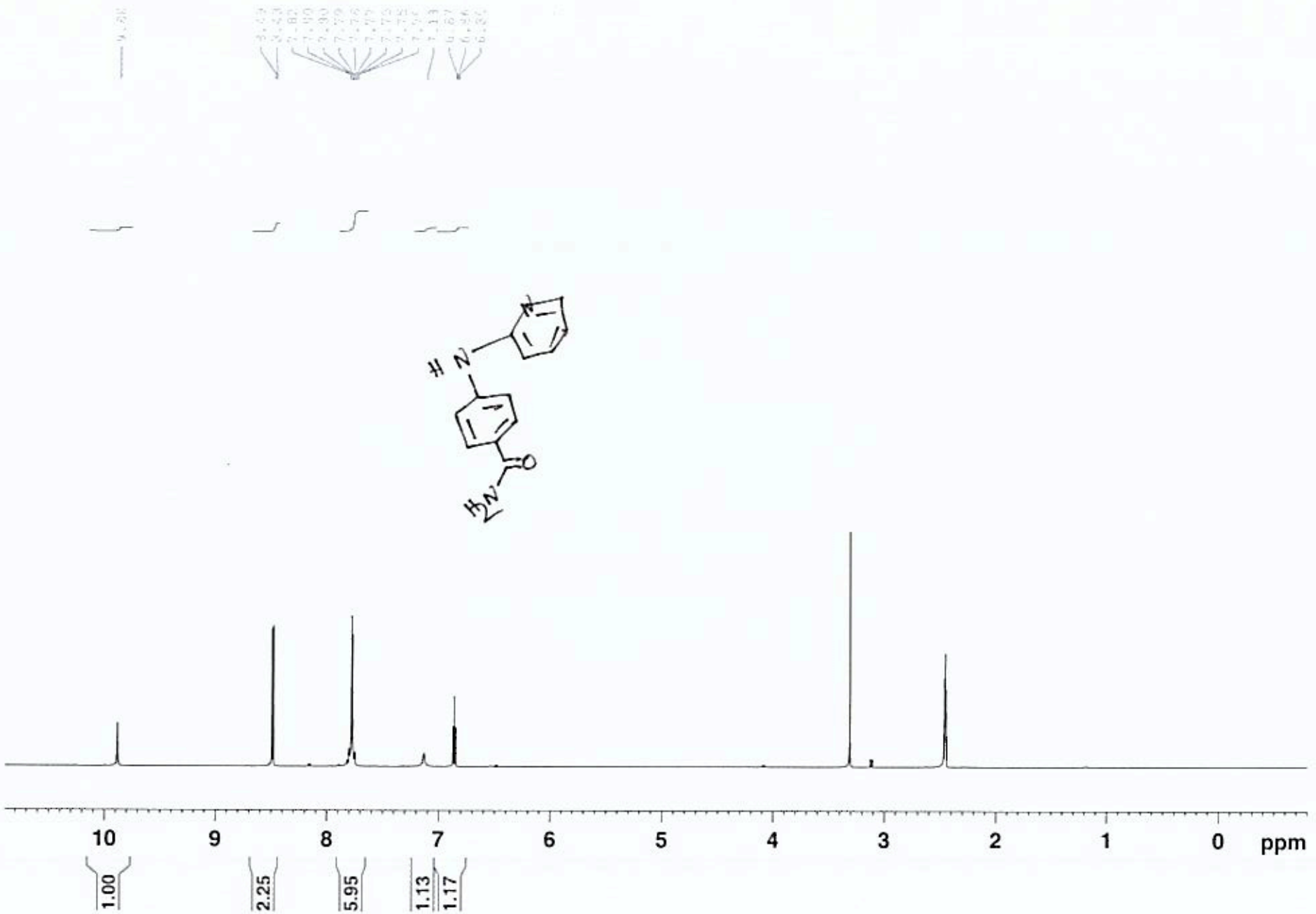

Me
H
N
N
N
Me
O
N
H
H3C

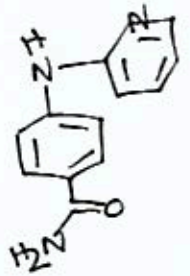

200
180
160
140
120
100
80
60
40
20
0
ppm

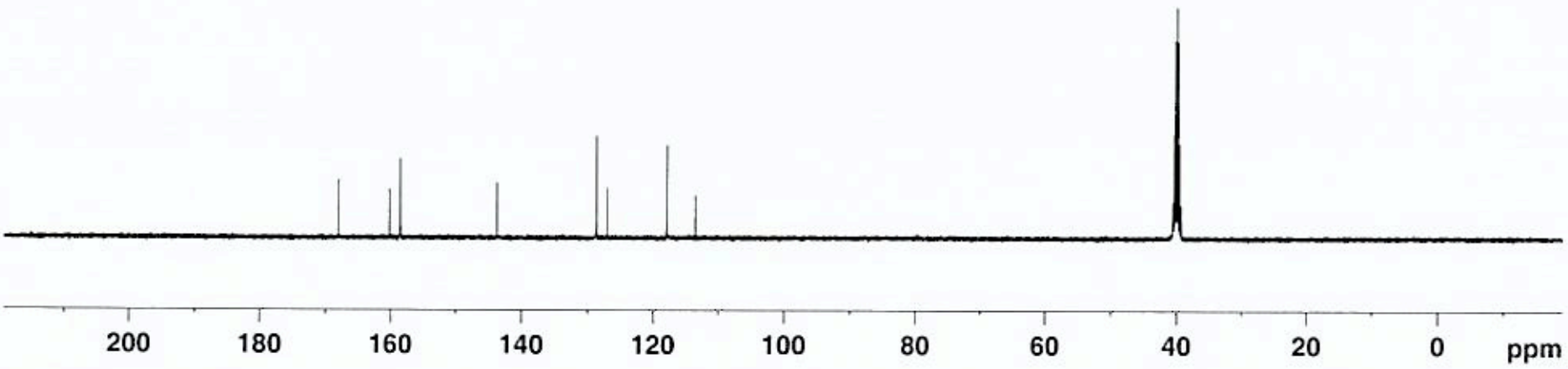

Me
Me
H
N
N
N
H
CH3

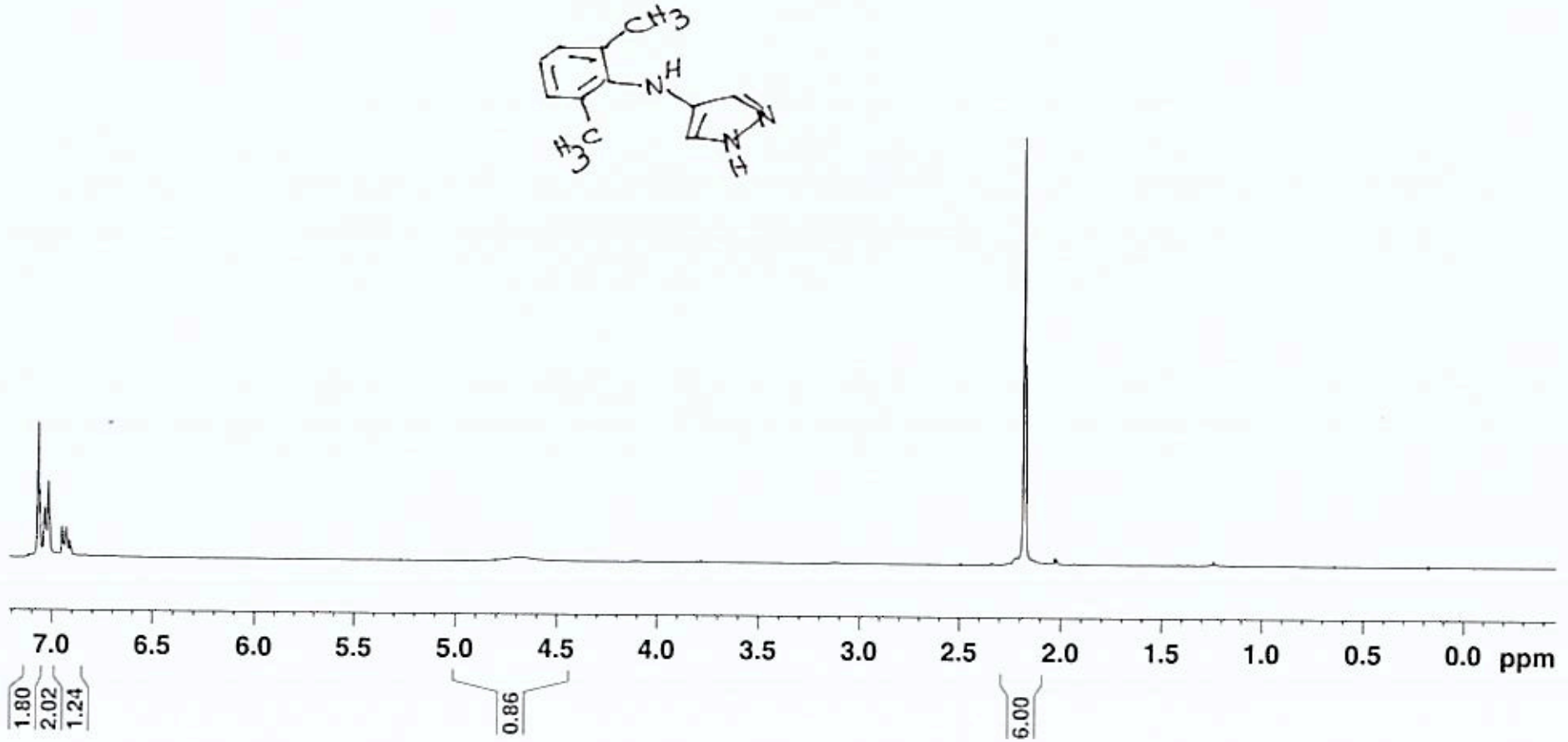

9
8
7
6
5
4
3
2
1
0
ppm
0.91
1.87
0.96
0.93
0.96
0.92
3.32
3.00
3.13

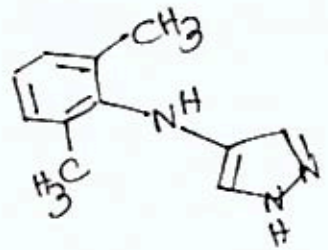

Me
N
N
Me
H
N
O
CH3
N
H
200
180
160
140
120
100
80
60
40
20
0
ppm

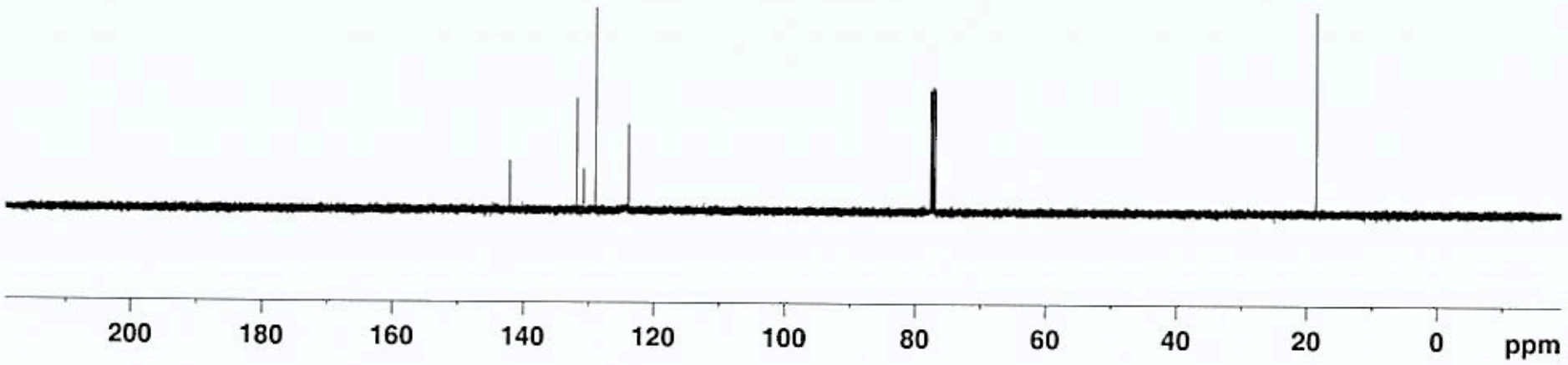

10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
2.25
5.95
1.13
1.17




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




CH3
NH
H3C
N
N
H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180
160
140
120
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60
40
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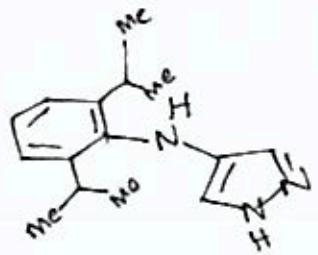
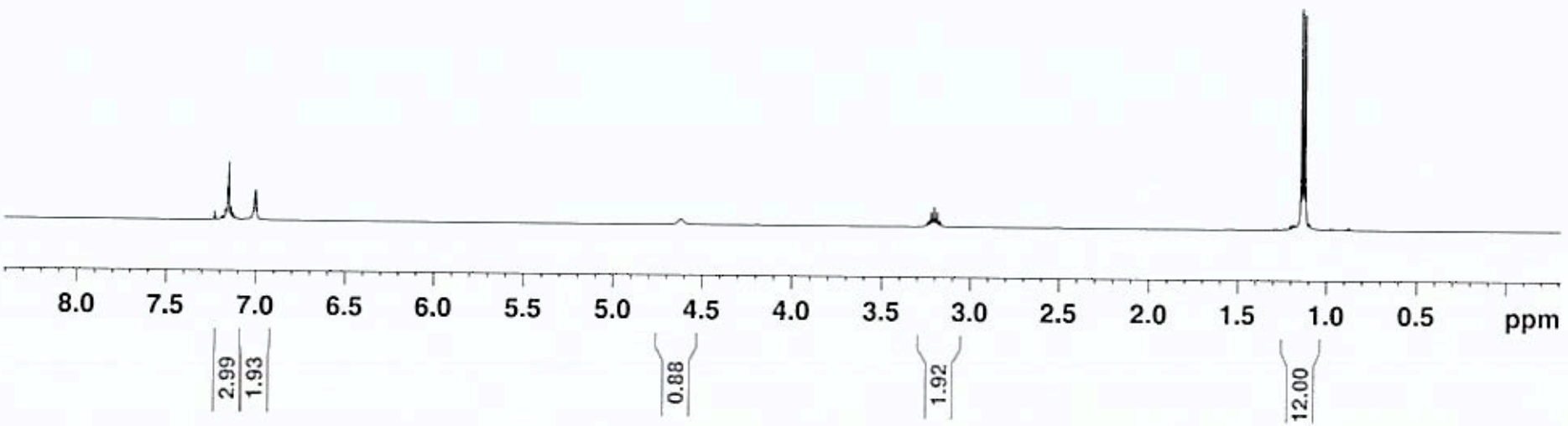
ppm


Me
Me
H
N
Me
Me
N
H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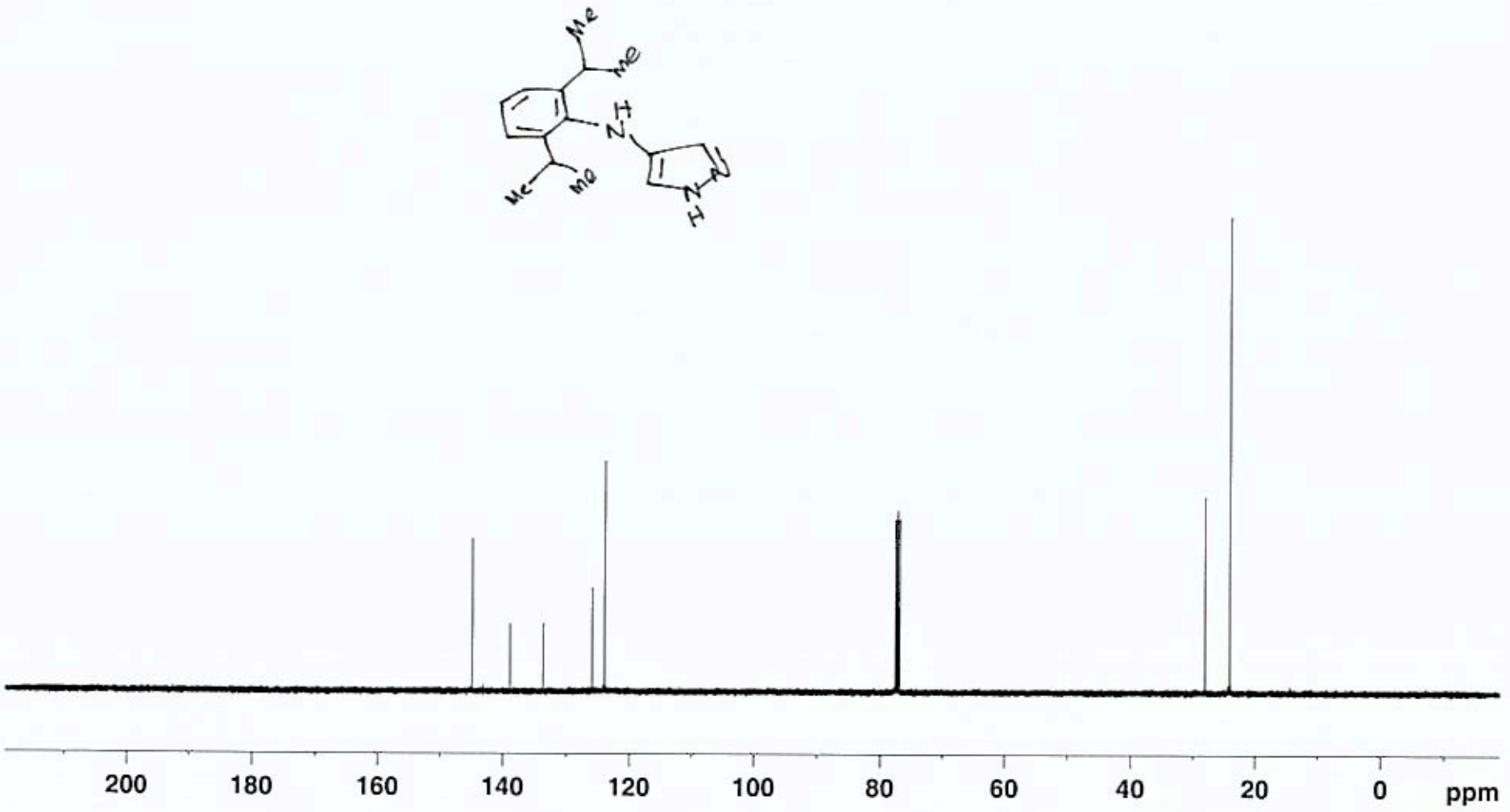
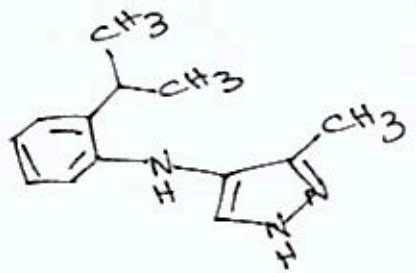
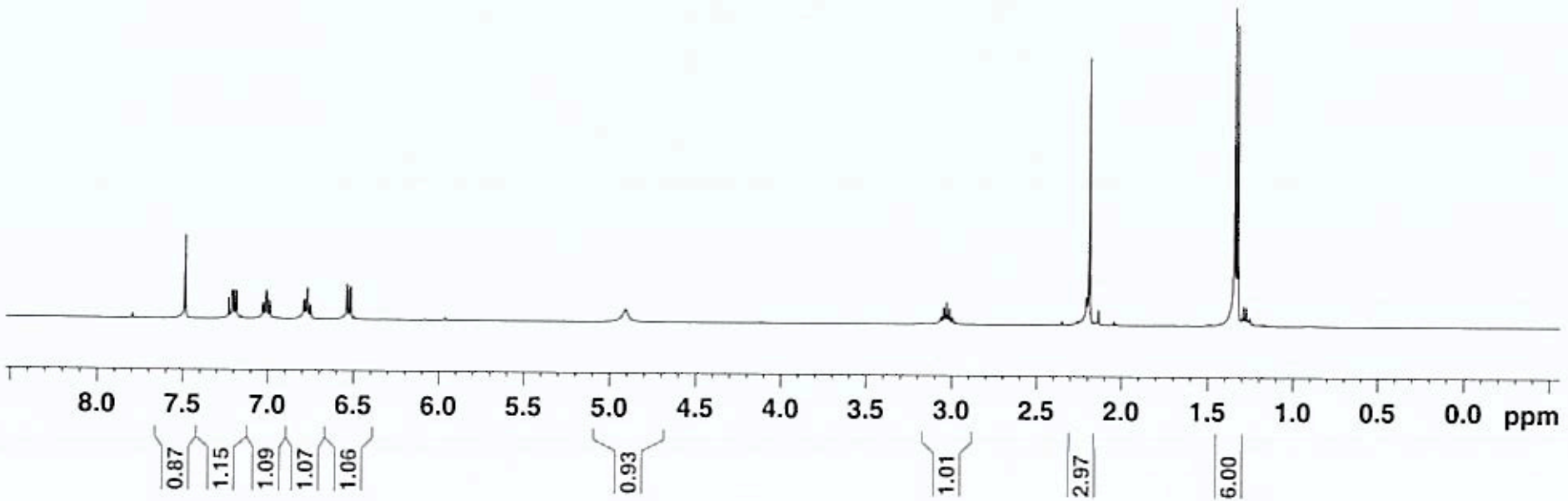
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.99
1.93
0.88
1.92
12.00


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


CH3
CH3
CH3
N
H
N
H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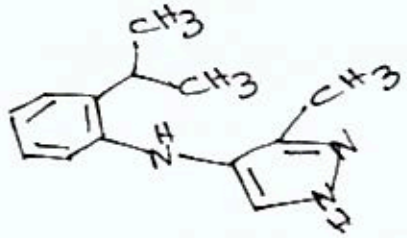
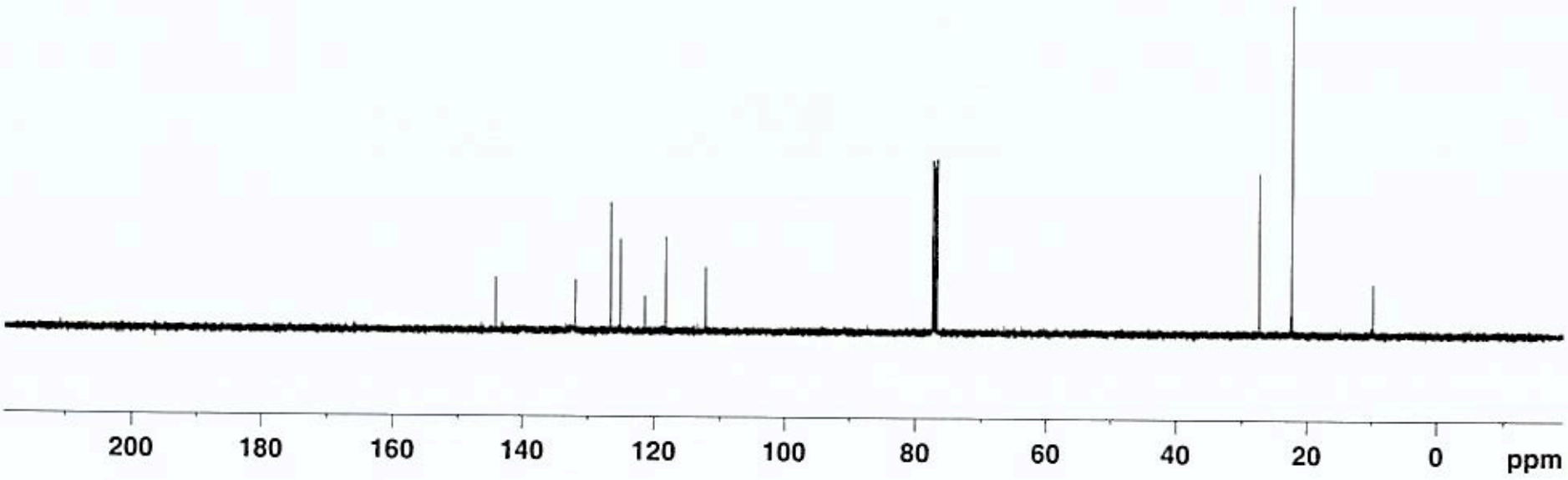
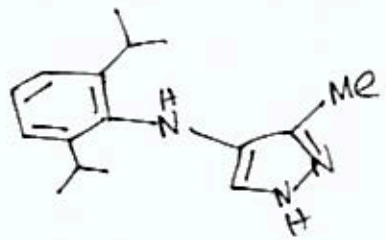
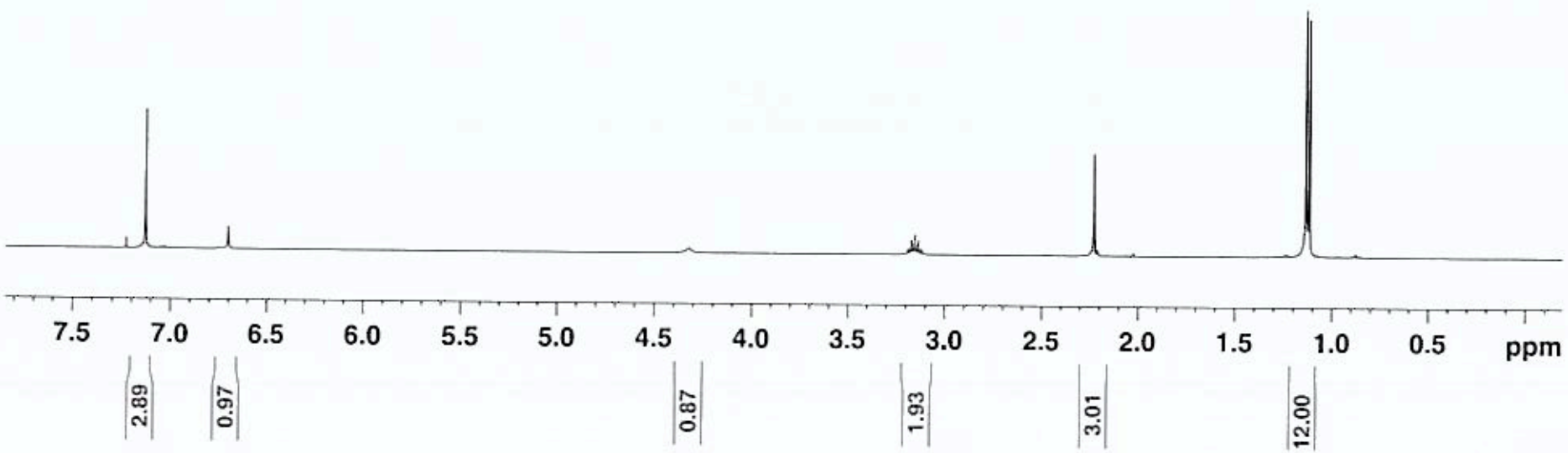
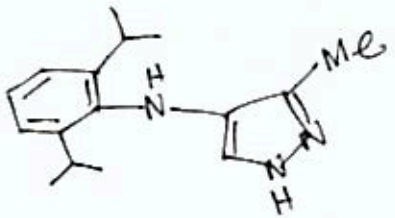
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
0.87
1.15
1.09
1.07
1.06
0.93
1.01
2.97
6.00

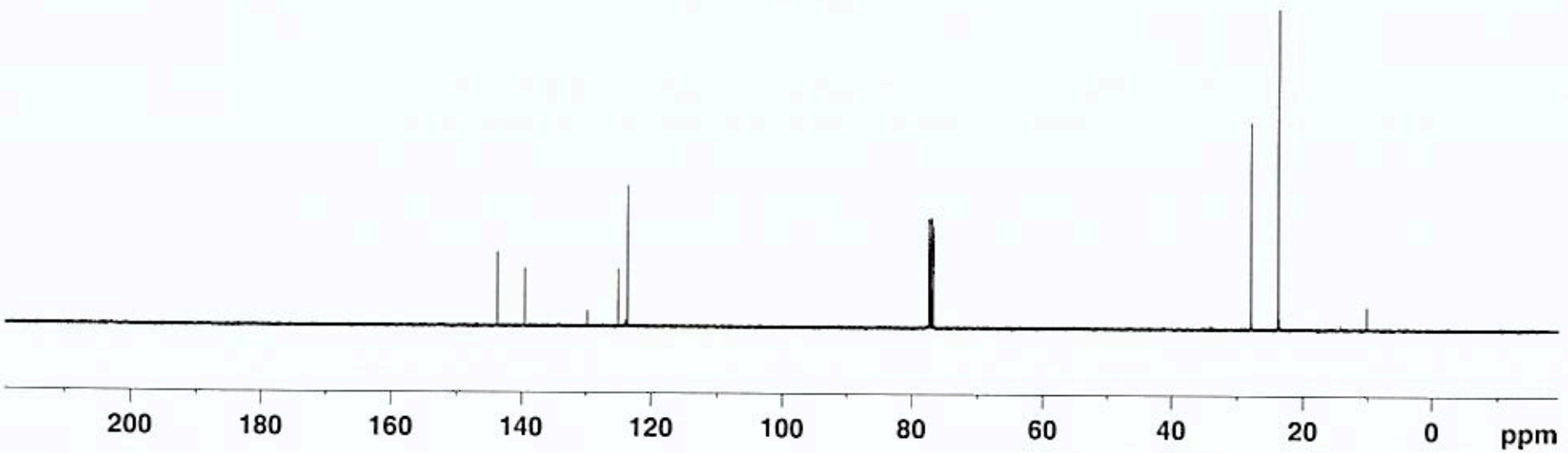

CH3
CH3
CH3
N
H
N
N
H

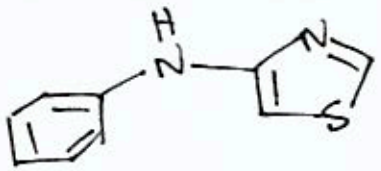

200
180
160
140
120
100
80
60
40
20
0
ppm

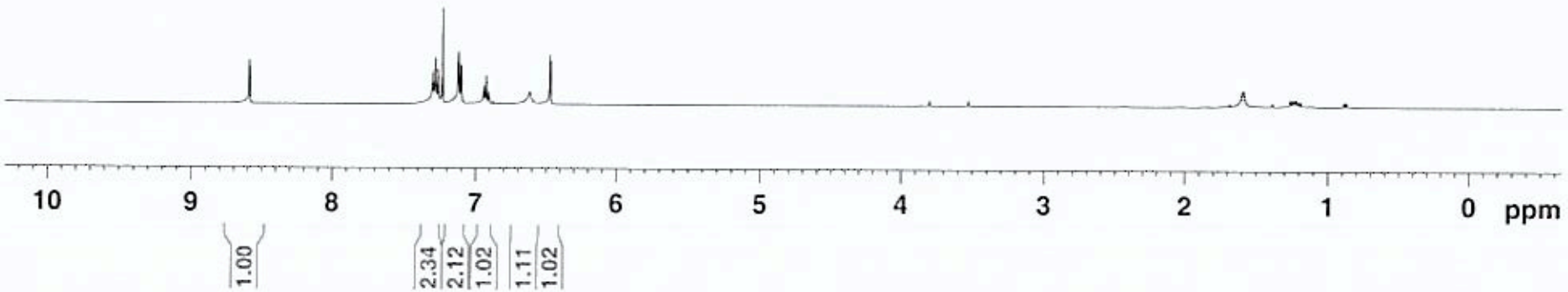

Me
H
N
N
H

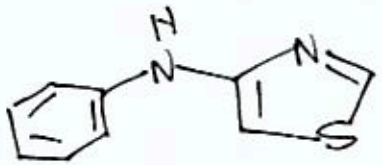

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.89
0.97
0.87
1.93
3.01
12.00

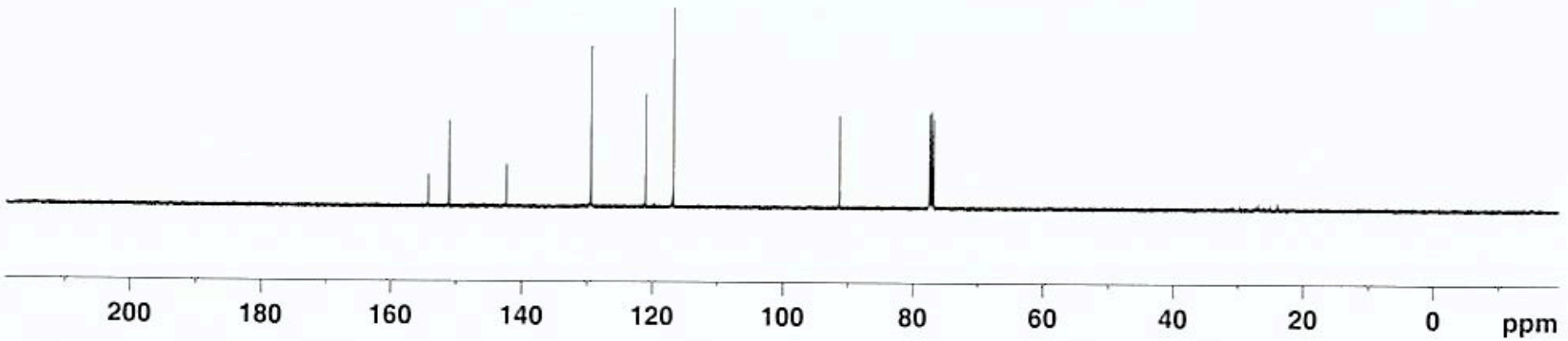

Me
H
N
N
N
H

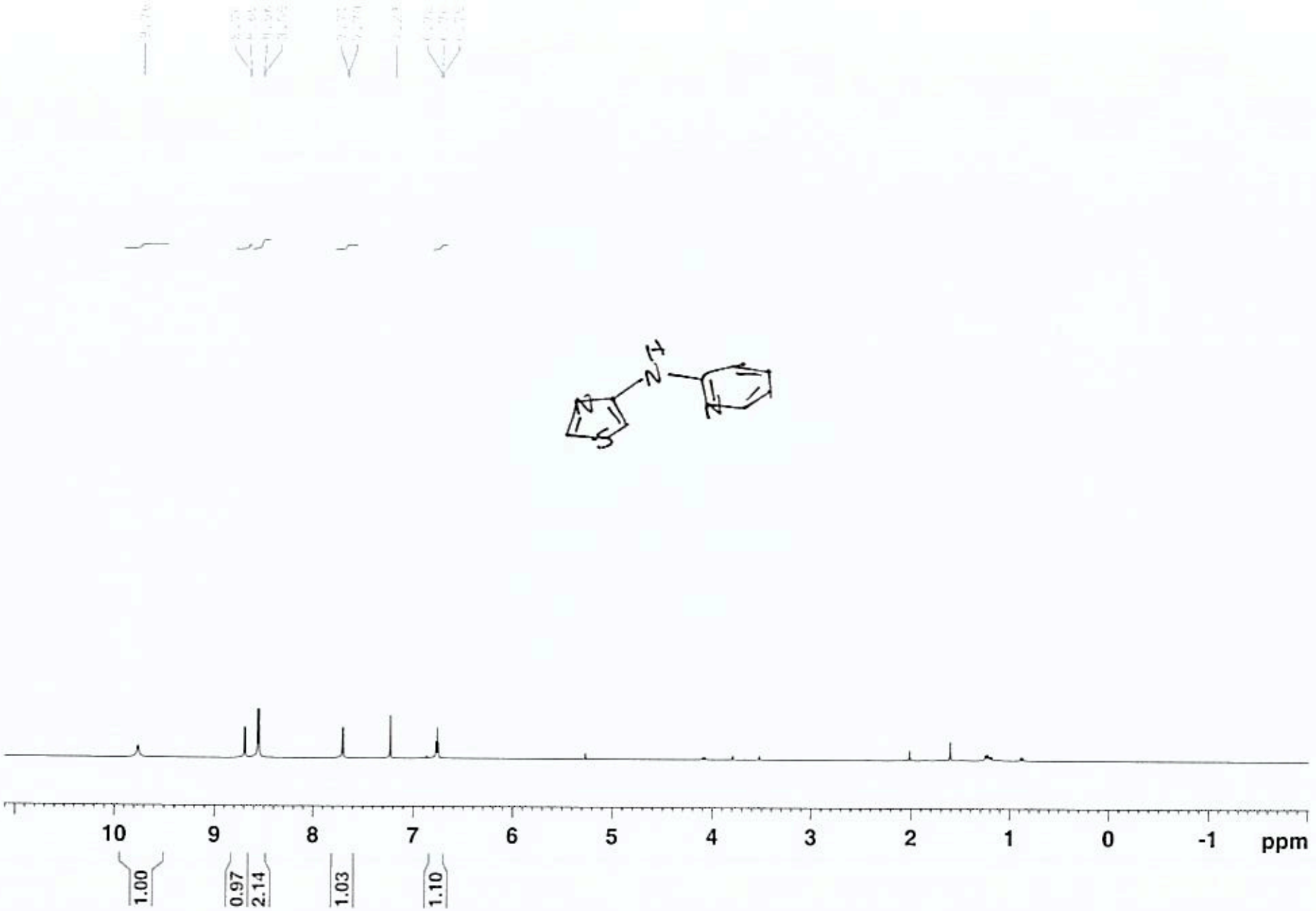

200
180
160
140
120
100
80
60
40
20
0
ppm

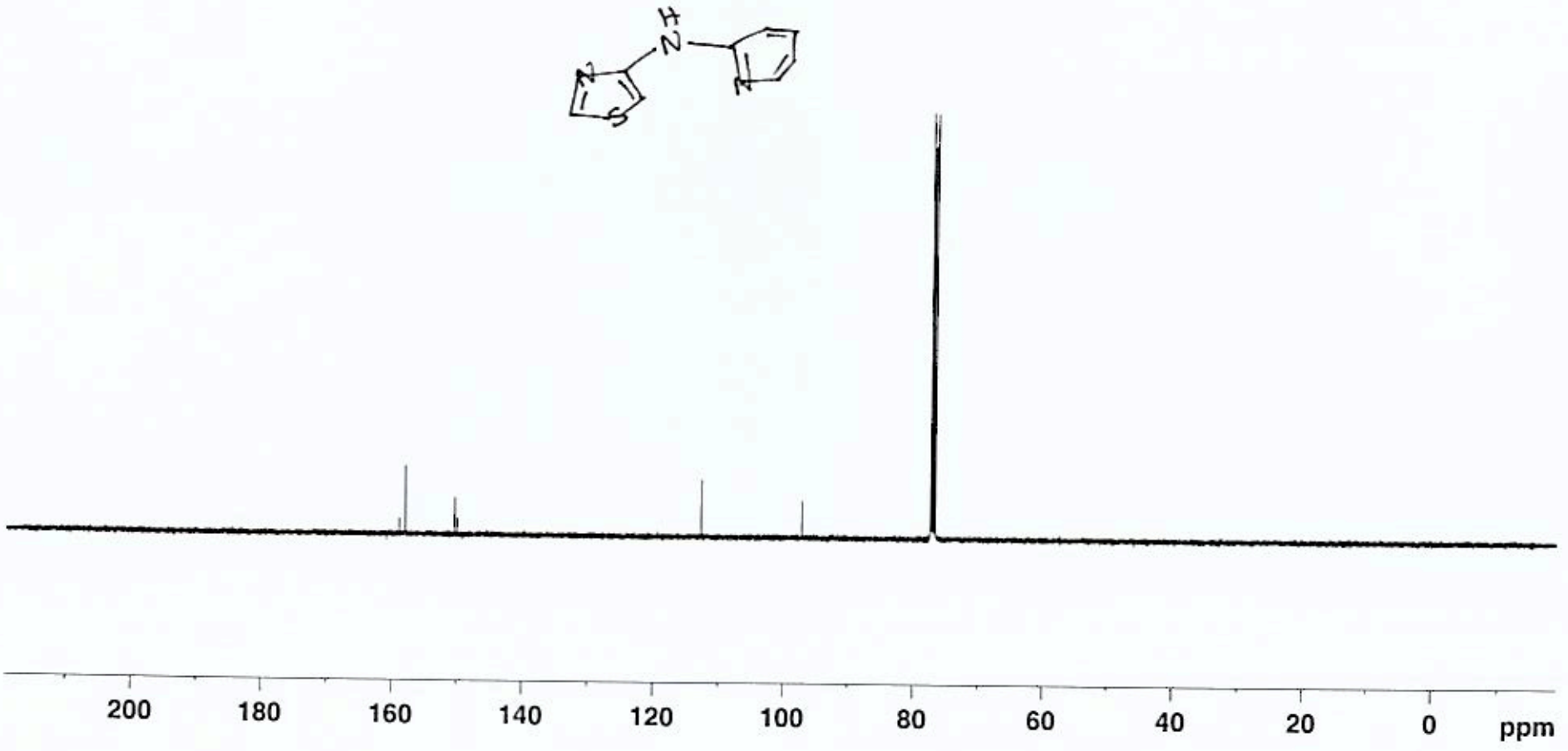

H
N
N
S

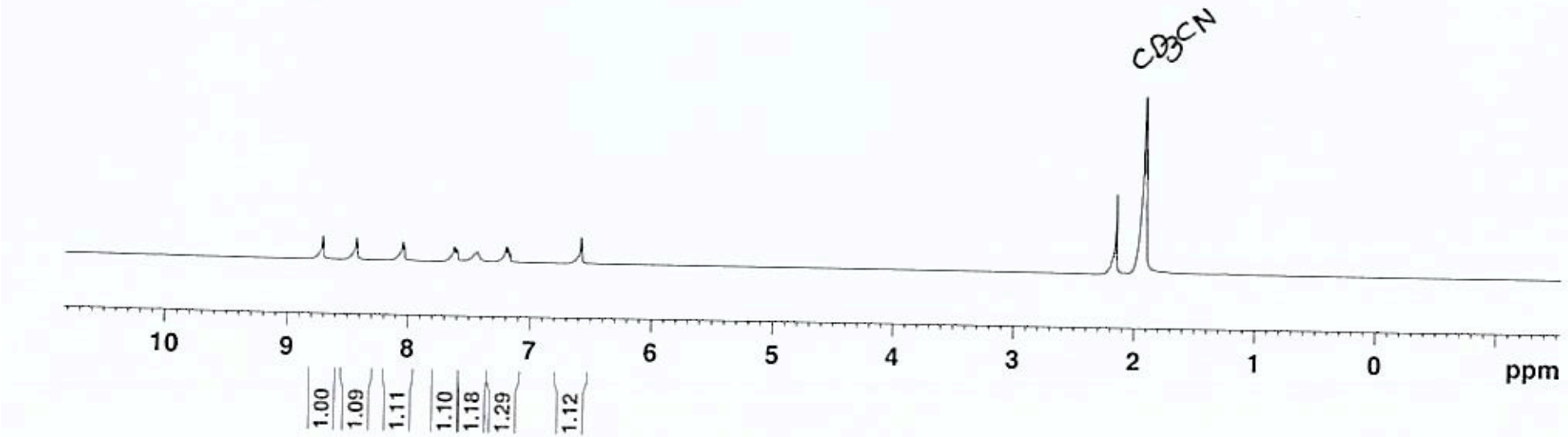

10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
2.34
2.12
1.02
1.11
1.02

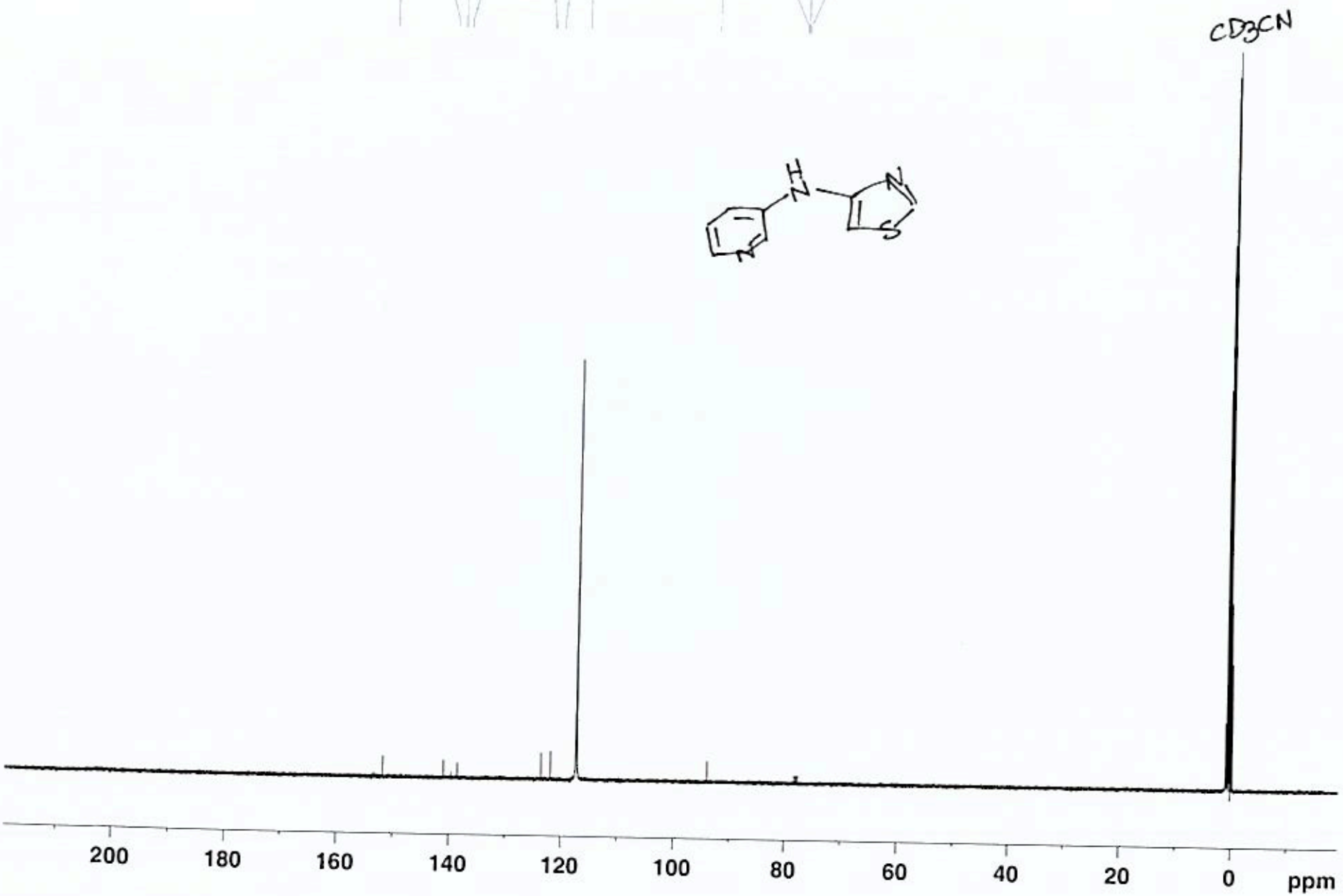

H
N
N
S

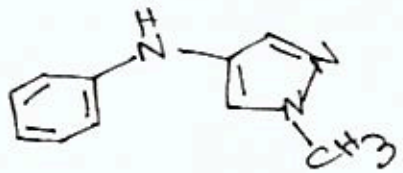

200
180
160
140
120
100
80
60
40
20
0
ppm

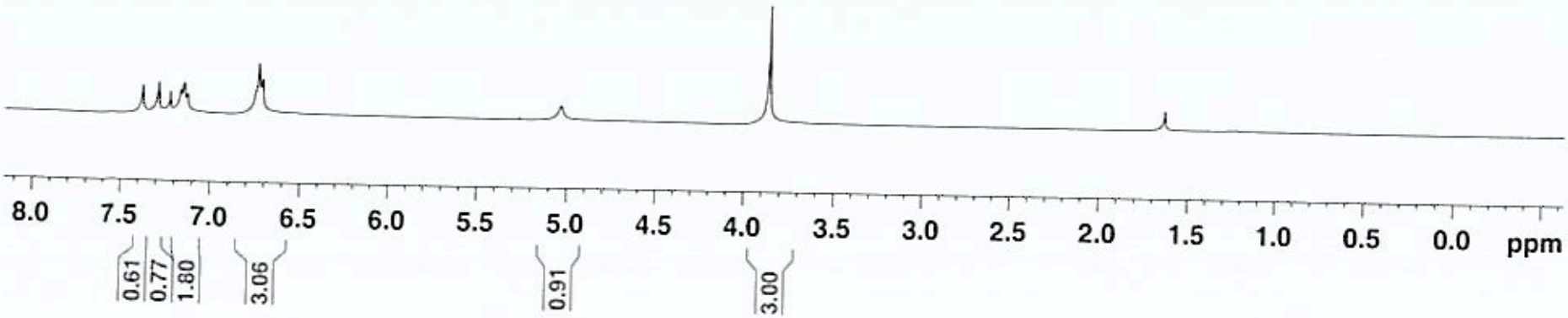

10
9
8
7
6
5
4
3
2
1
0
-1
ppm
1.00
0.97
2.14
1.03
1.10

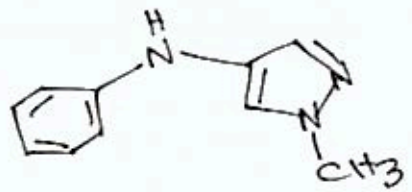

200
180
160
140
120
100
80
60
40
20
0
ppm

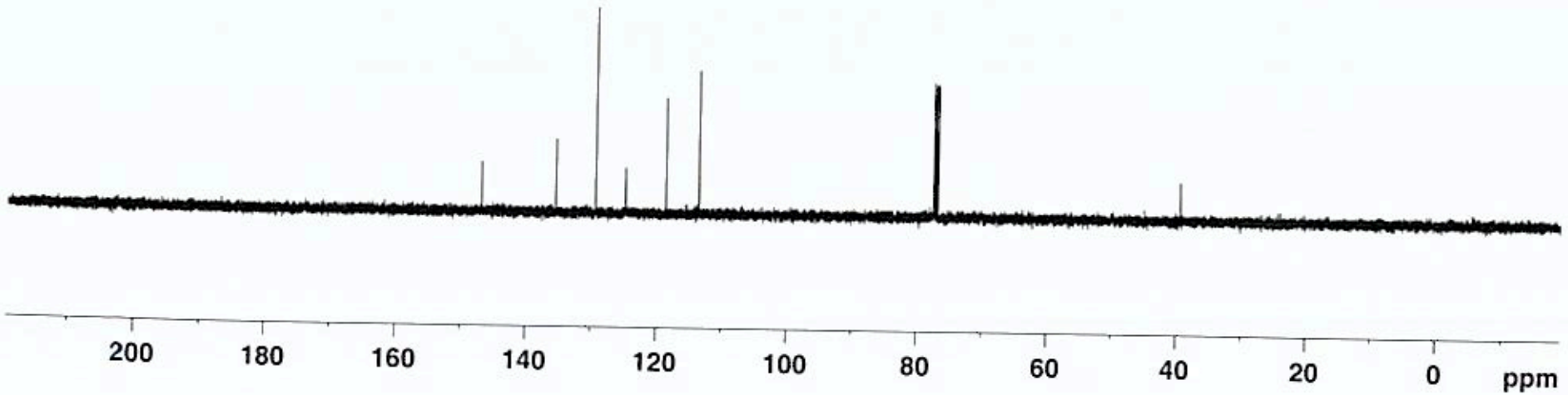

CD3CN
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.09
1.11
1.10
1.18
1.29
1.12

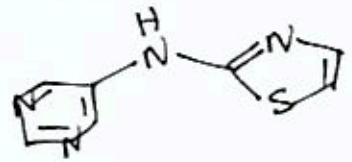

CD3CN
200
180
160
140
120
100
80
60
40
20
0
ppm

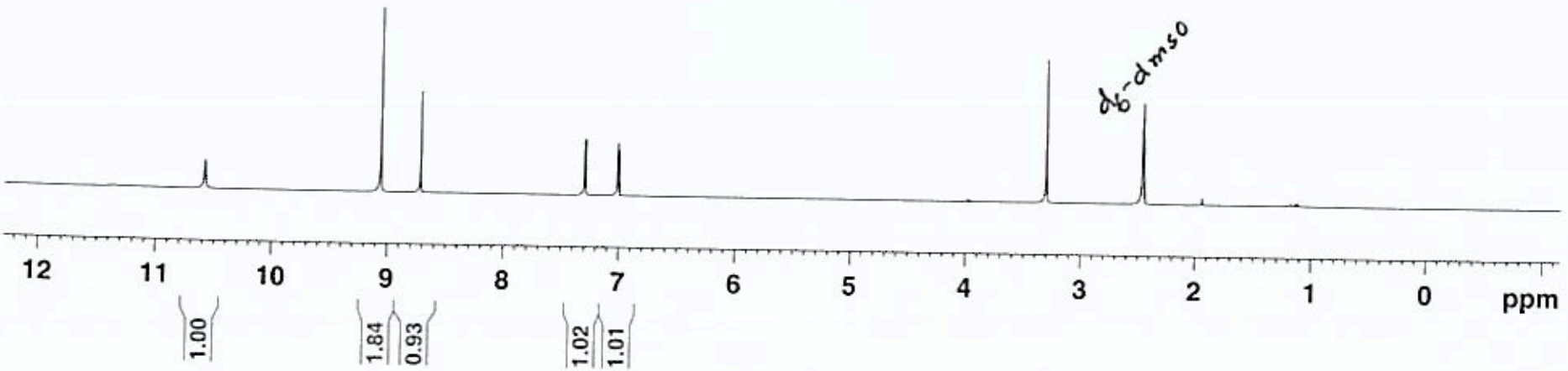

H
N
N
CH3

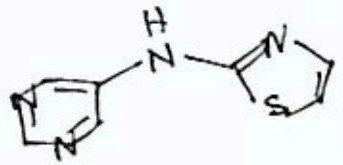

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
0.61
0.77
1.80
3.06
0.91
3.00

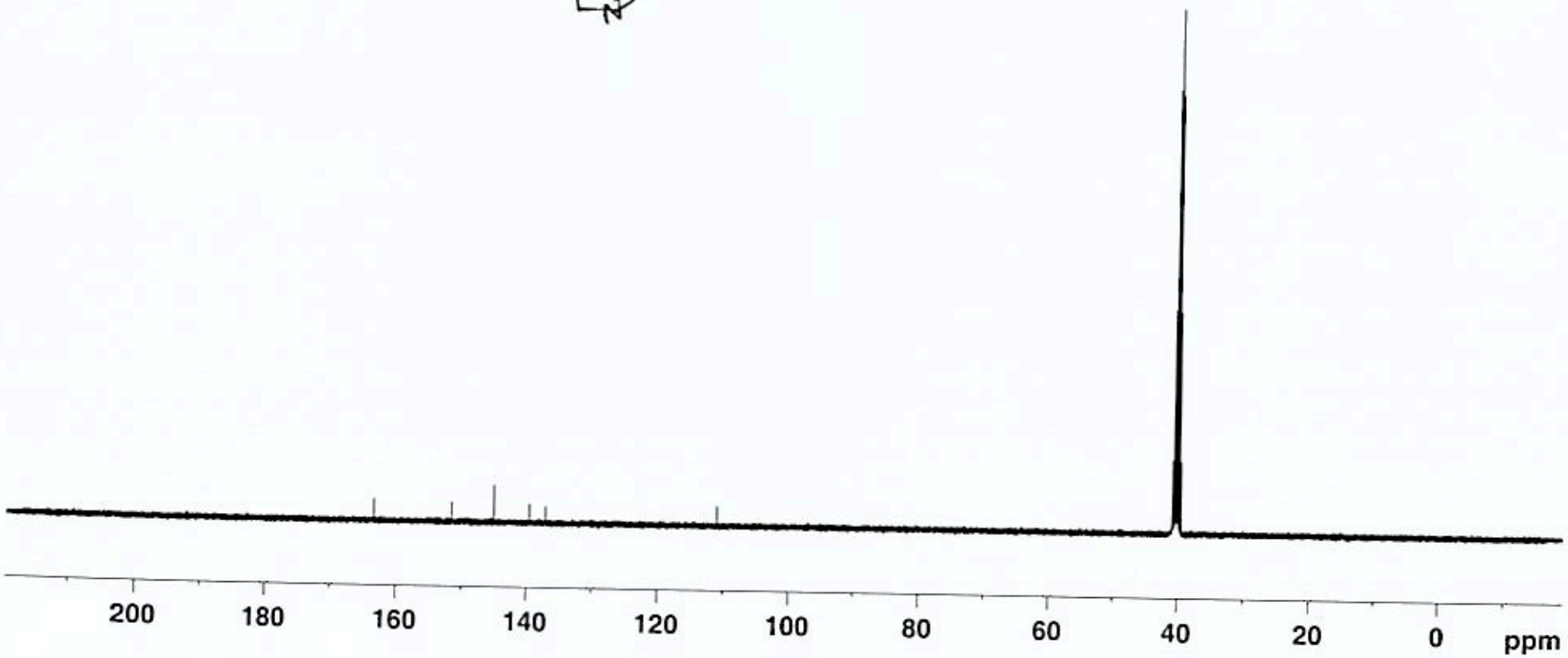

H
N
N
CH3

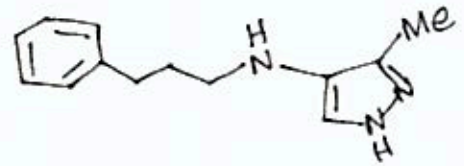

200
180
160
140
120
100
80
60
40
20
0
ppm

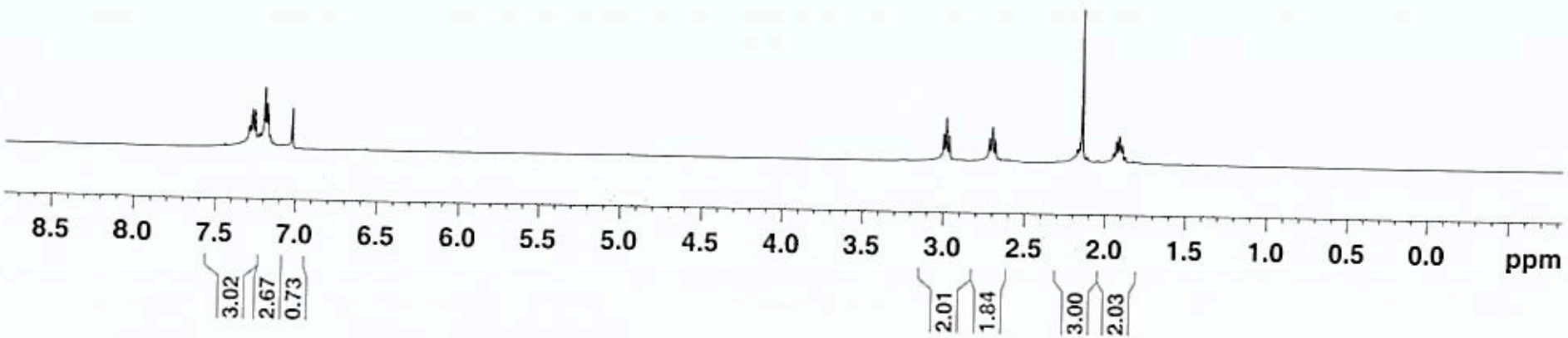


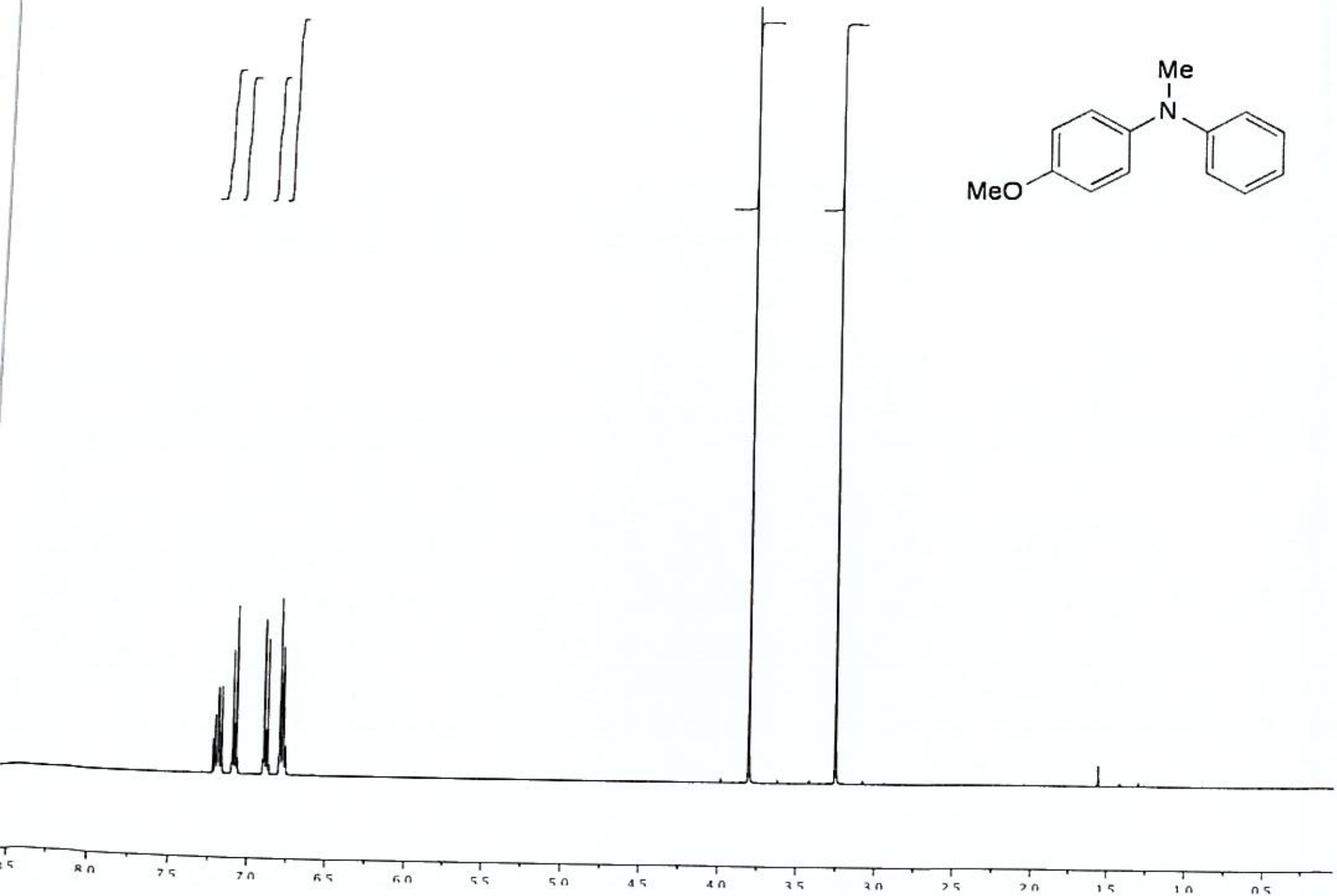

d6-dmso
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.84
0.93
1.02
1.01

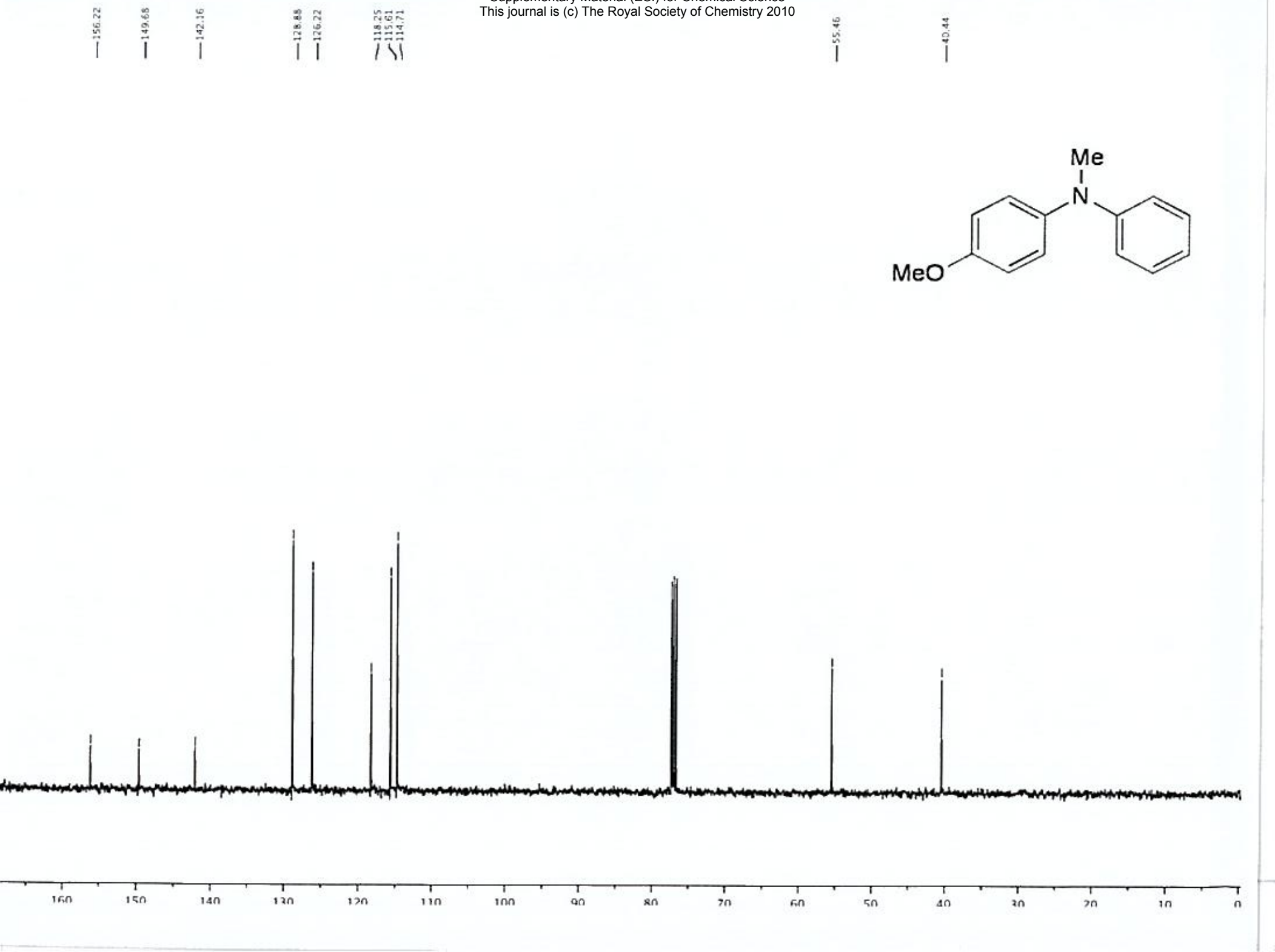


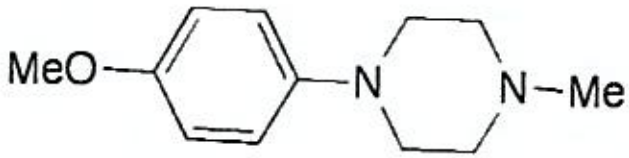


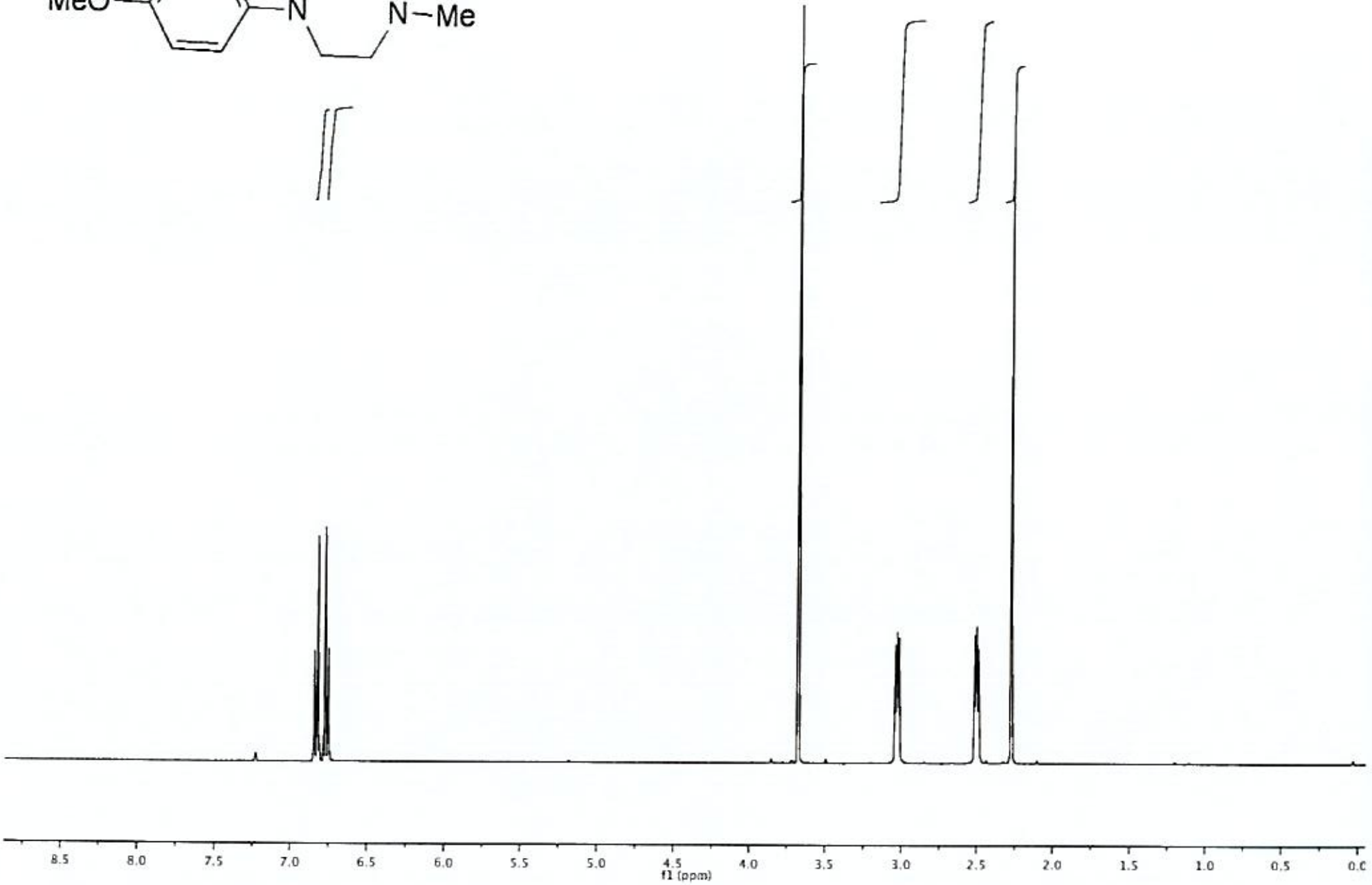

Me
H
N
N
H

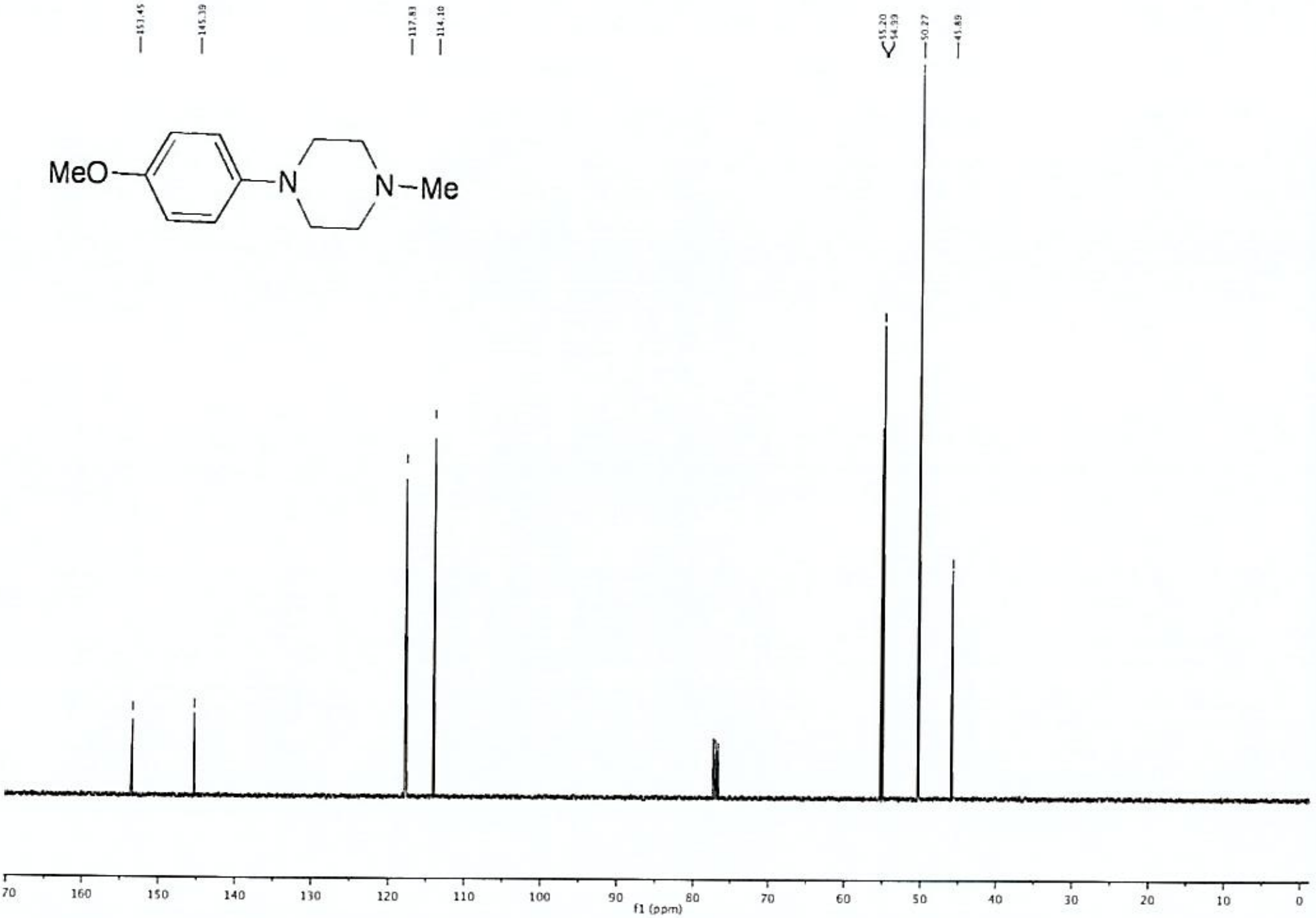

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
3.02
2.67
0.73
2.01
1.84
3.00
2.03

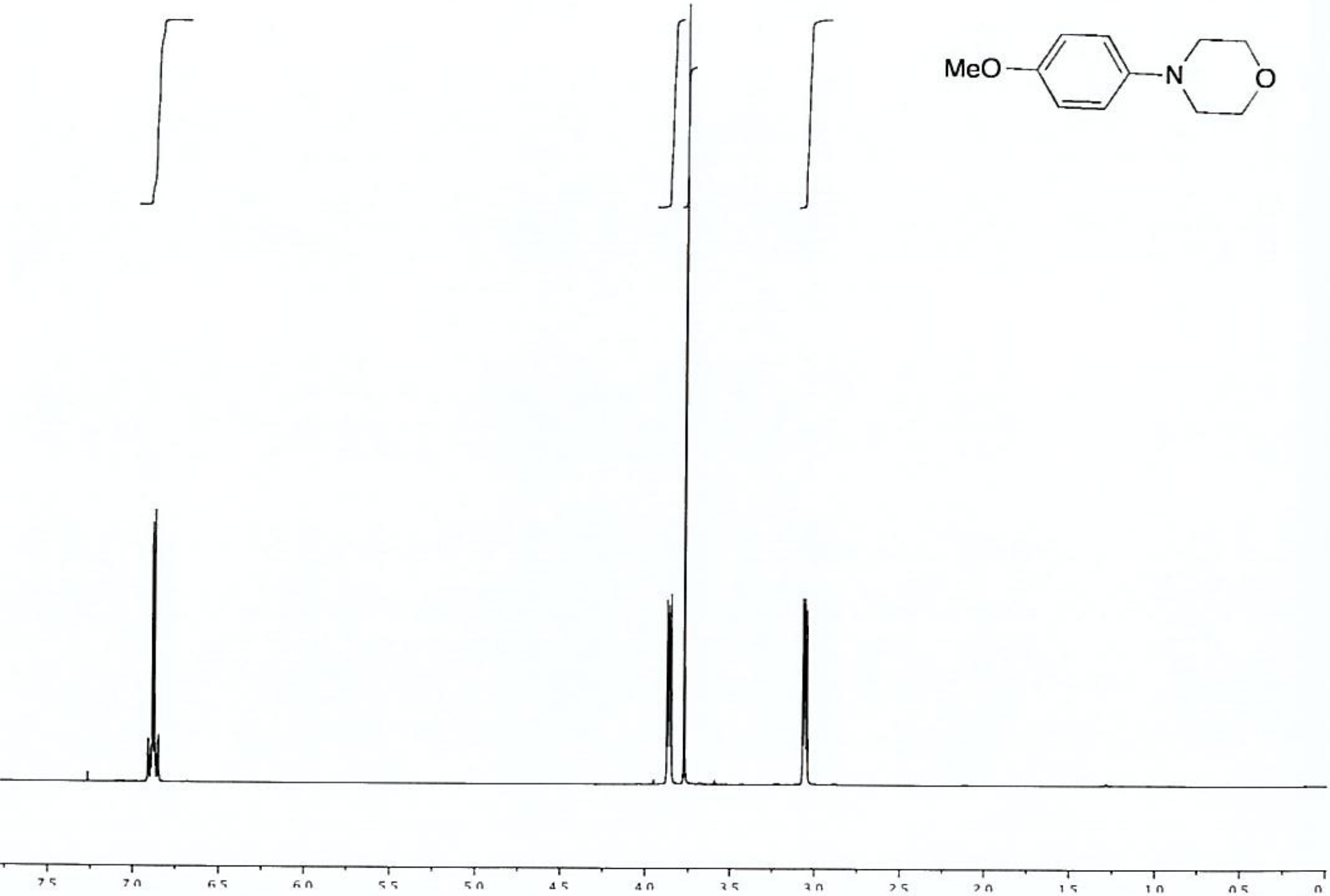

Me
N
MeO
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

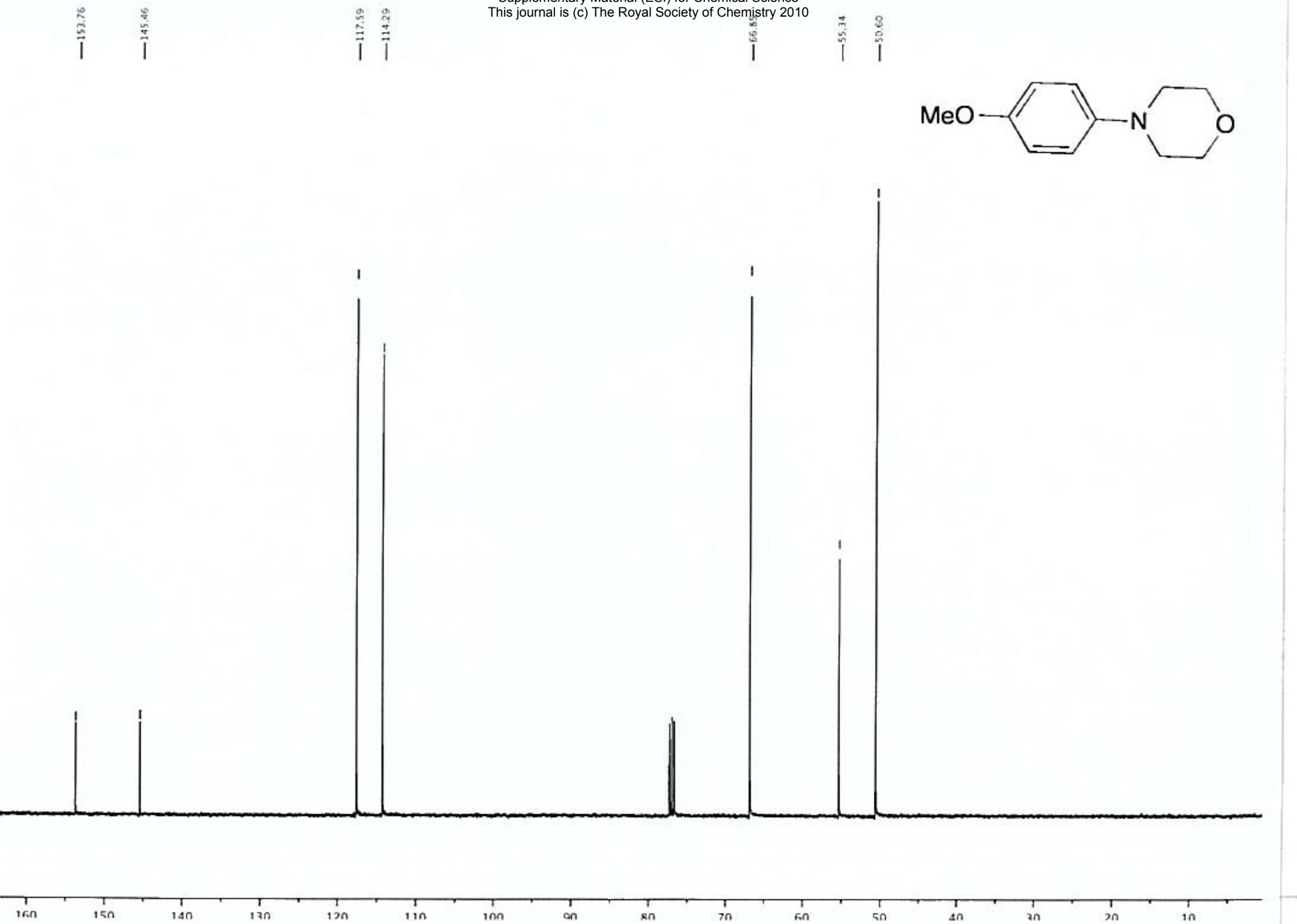

156.22
149.68
142.16
128.88
126.22
118.25
115.61
114.71
55.46
40.44
Me
N
MeO
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

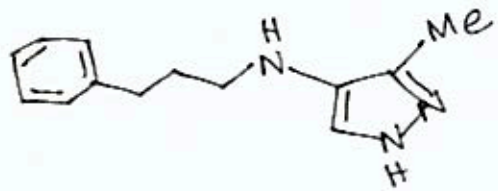

MeO
N
N
Me

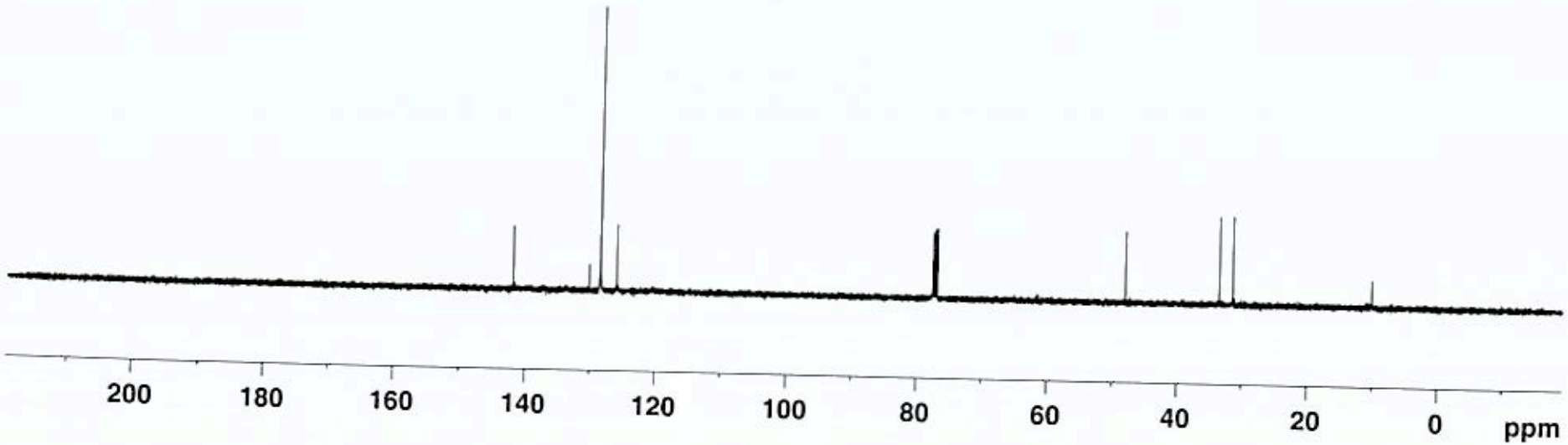

8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
f1 (ppm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

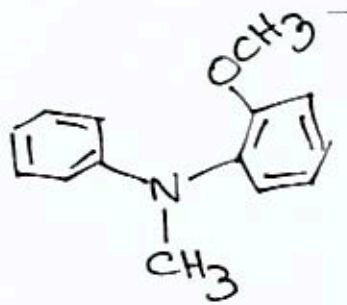

153.45
145.39
117.83
114.10
55.20
54.99
50.27
45.89
MeO
N
N–Me
f1 (ppm)

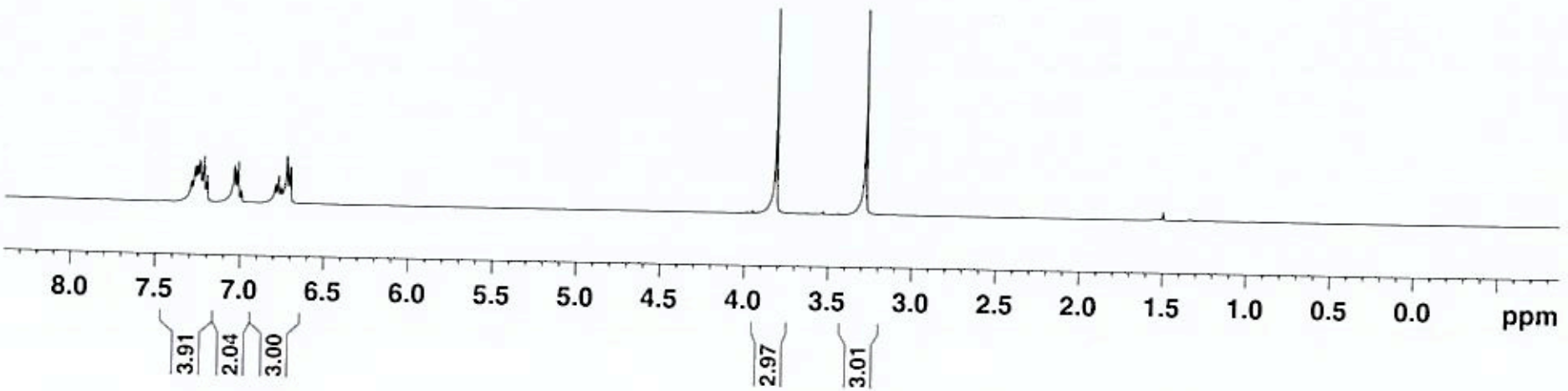

MeO
N
O
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0

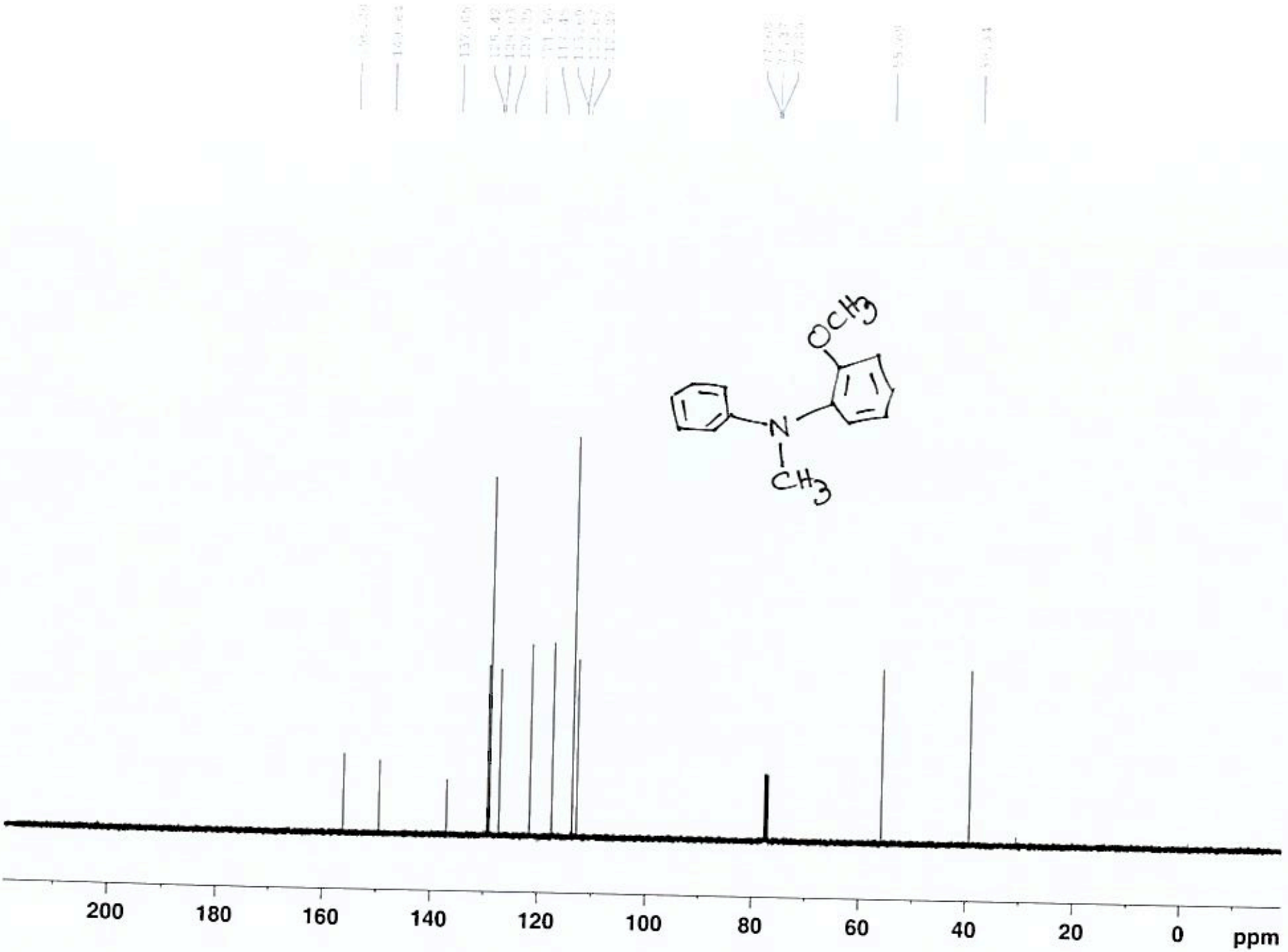

153.76
145.46
117.59
114.29
66.85
55.34
50.60
MeO
N
O
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

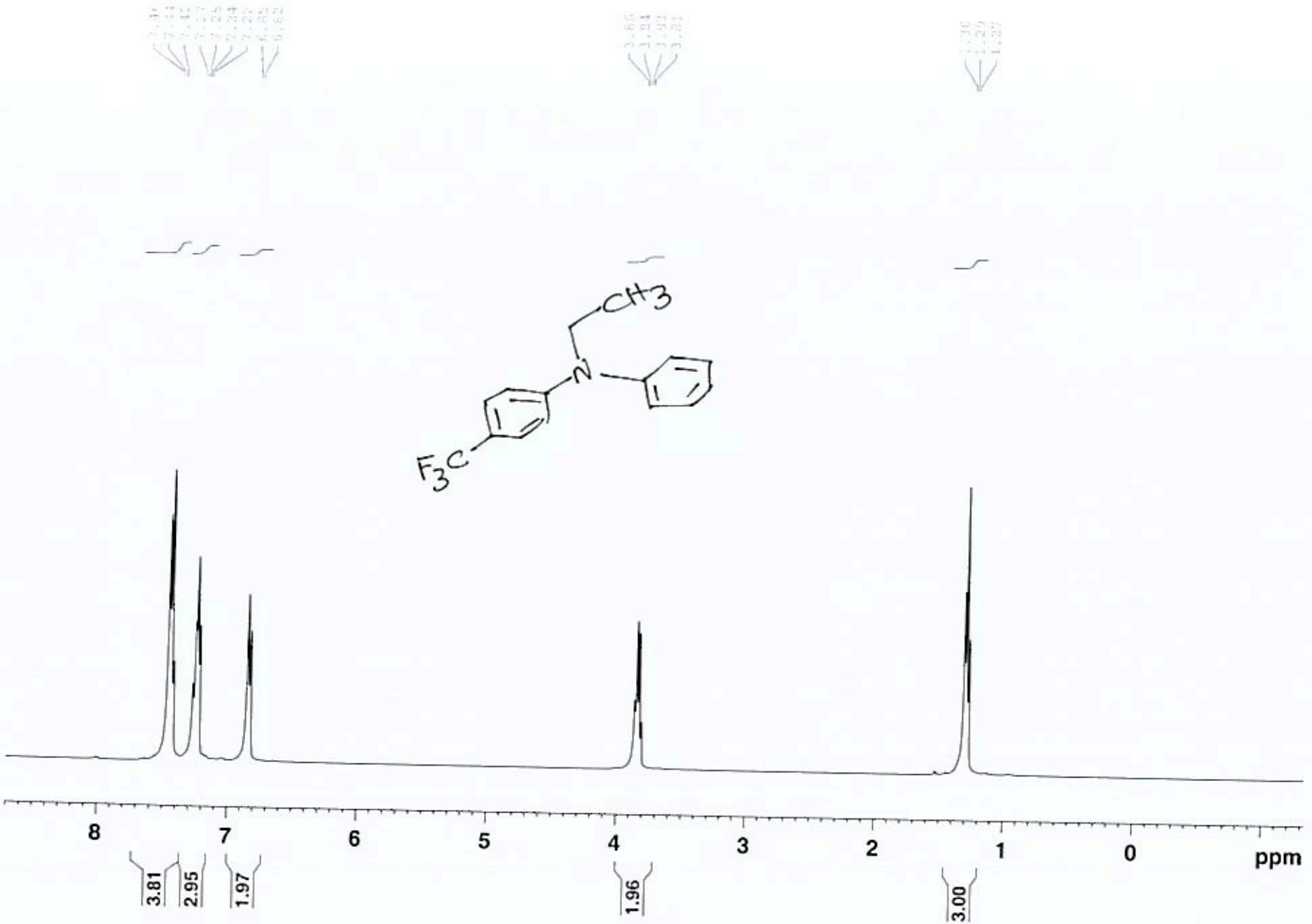


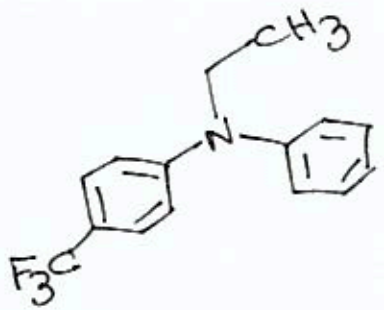


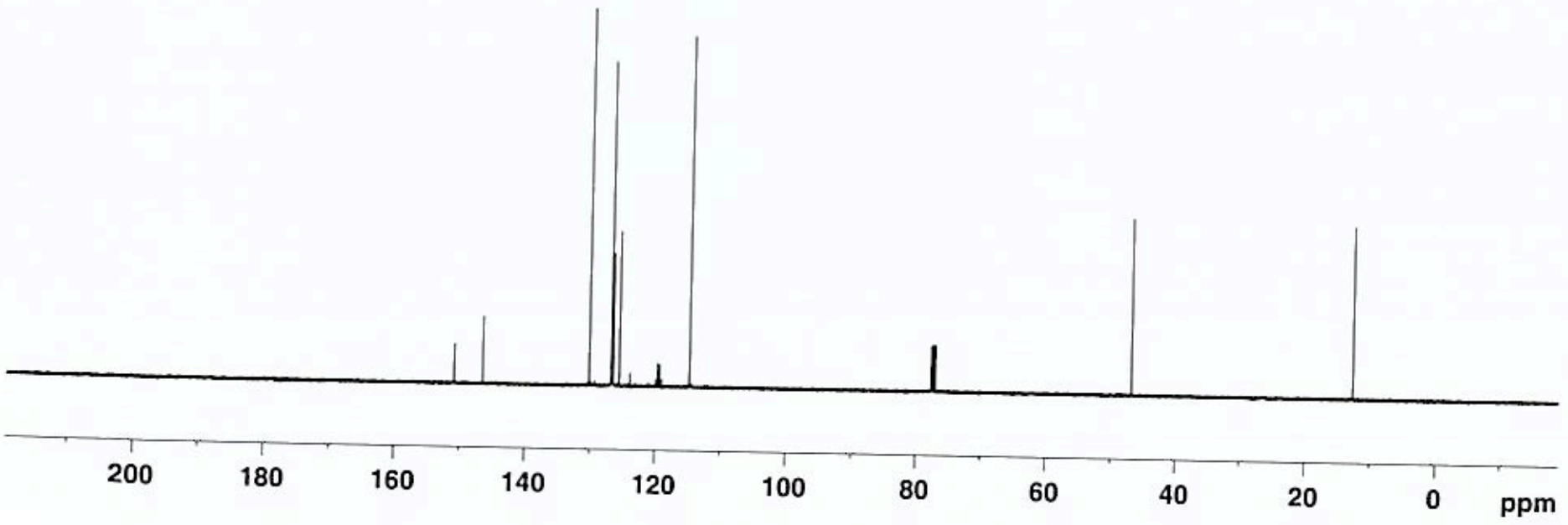


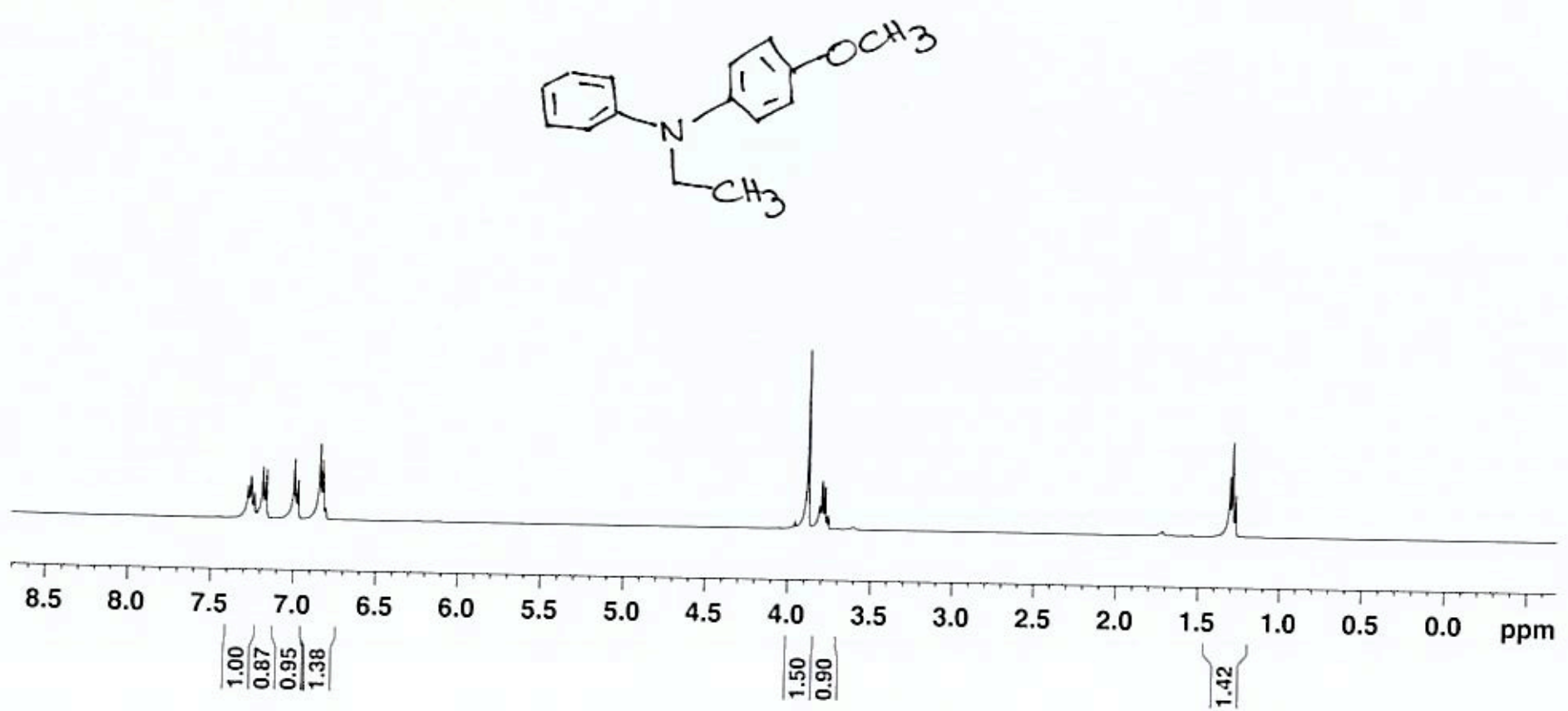


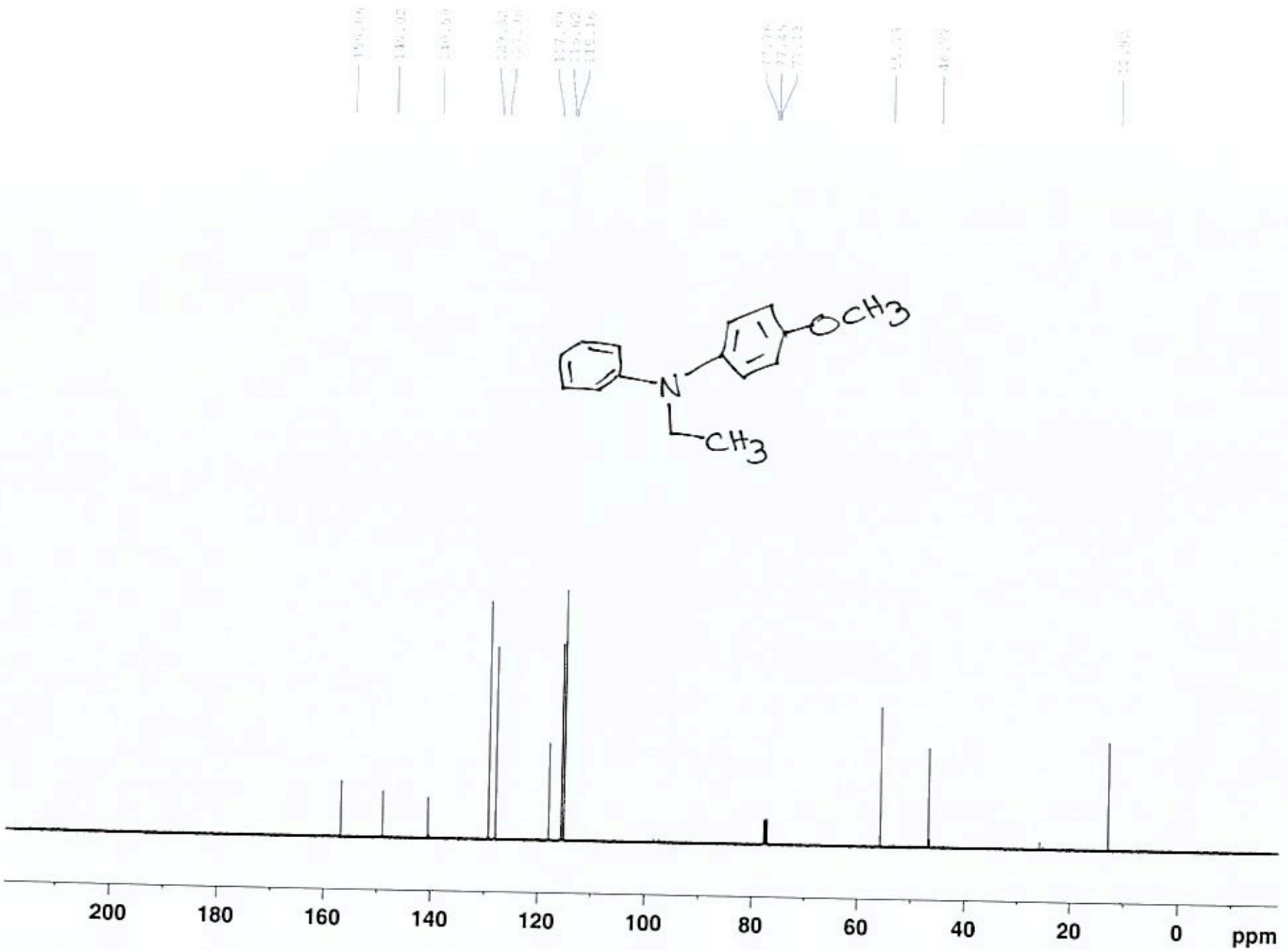


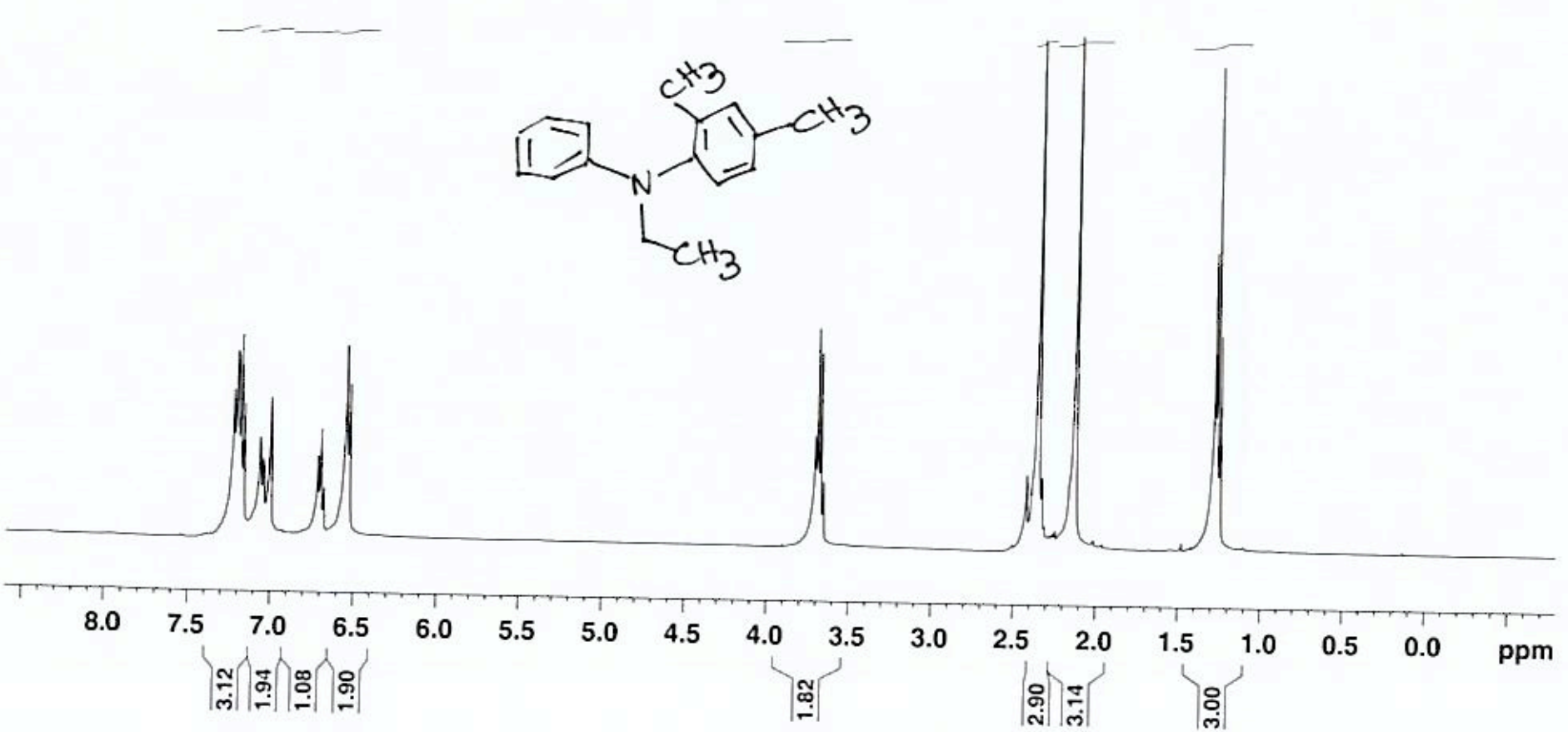

CH3
N
F3C
8
7
6
5
4
3
2
1
0
ppm
3.81
2.95
1.97
1.96
3.00


CH3
N
F3C


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


OCH3
N
CH3
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
1.00
0.87
0.95
1.38
1.50
0.90
1.42

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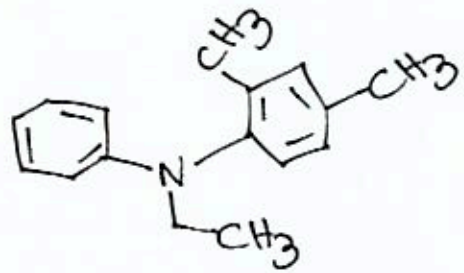
3.00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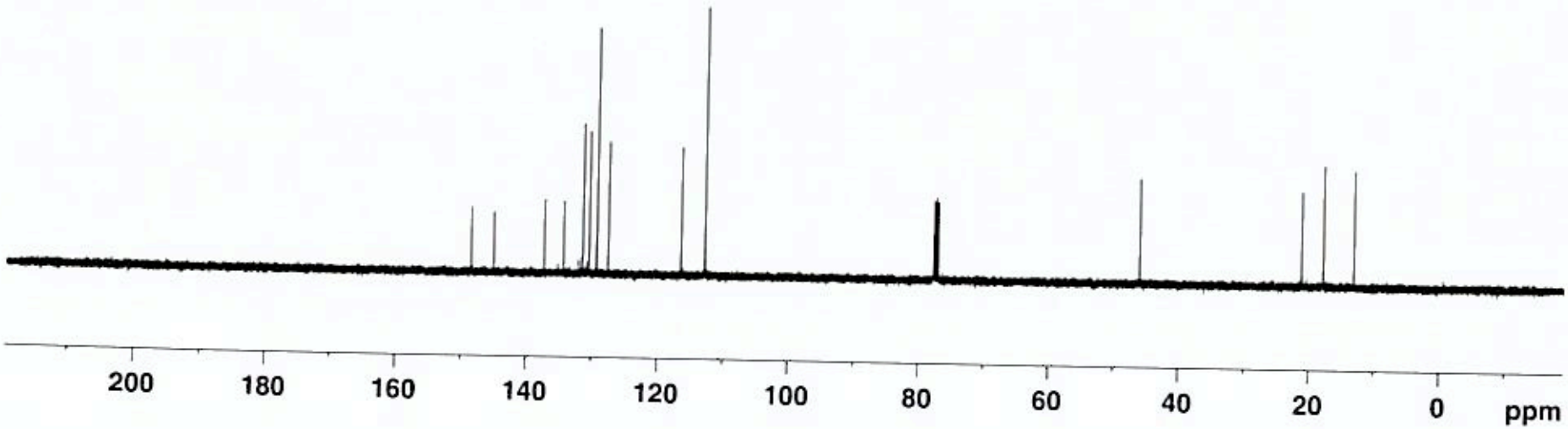
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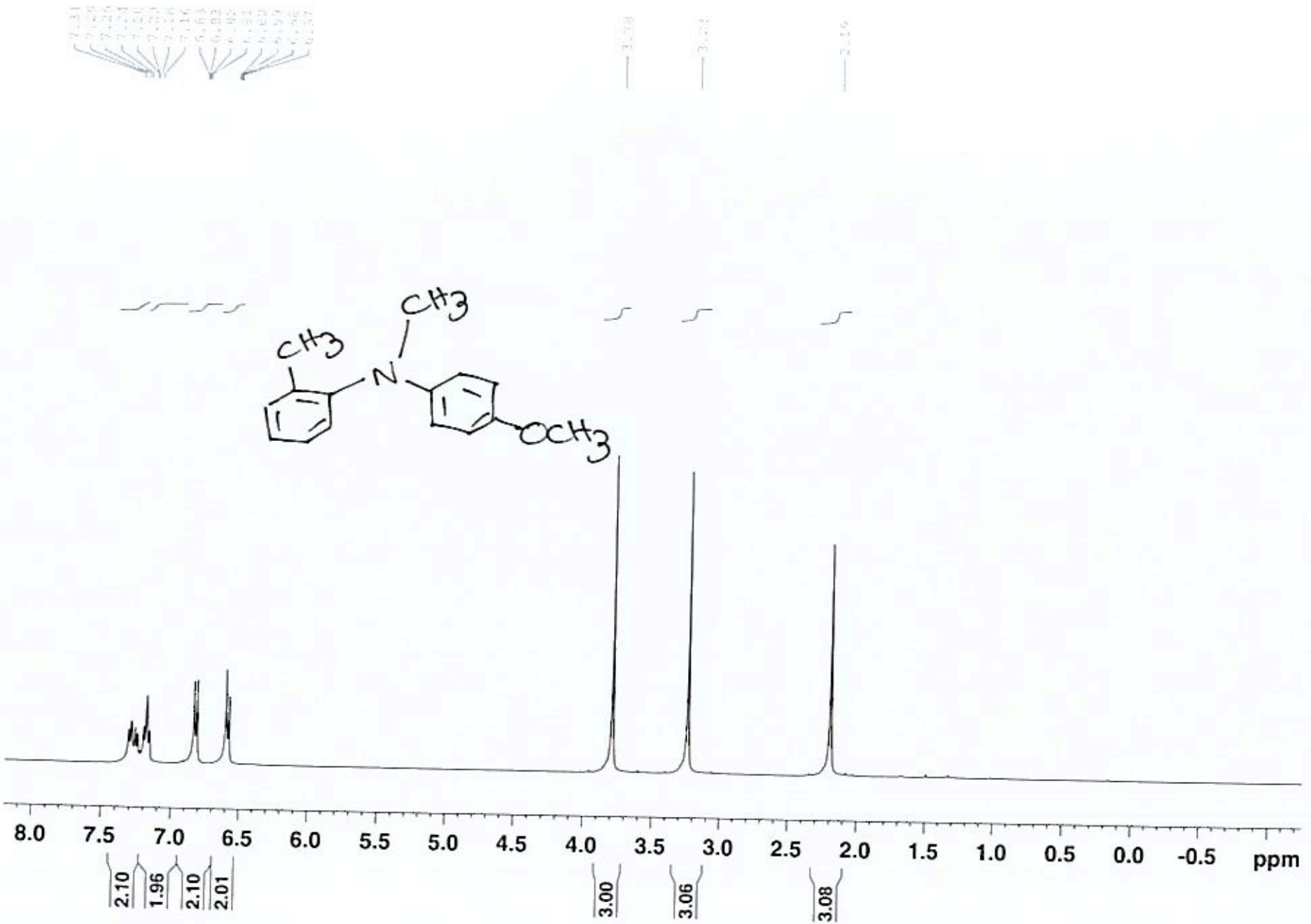

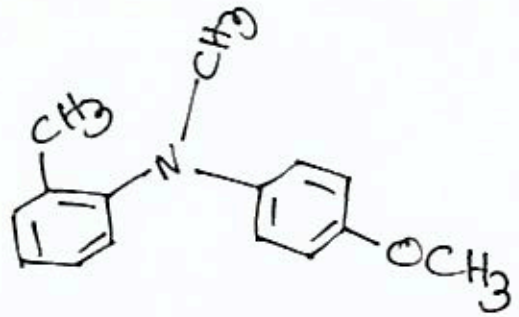
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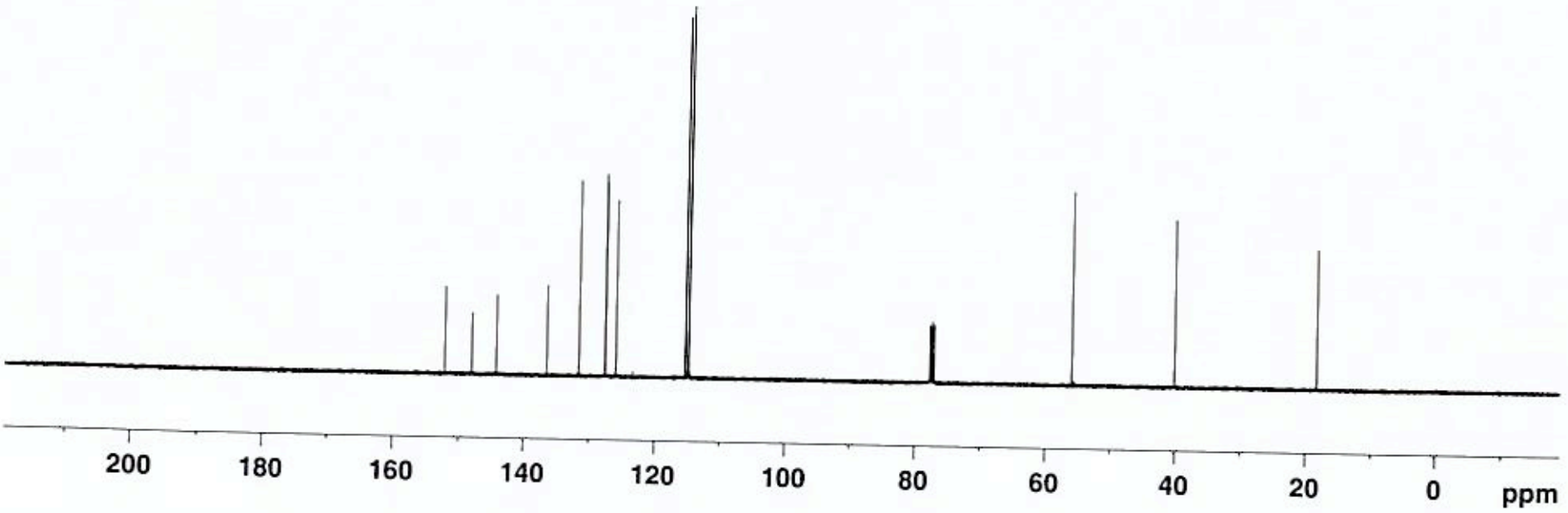
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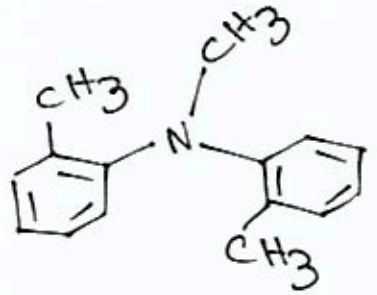

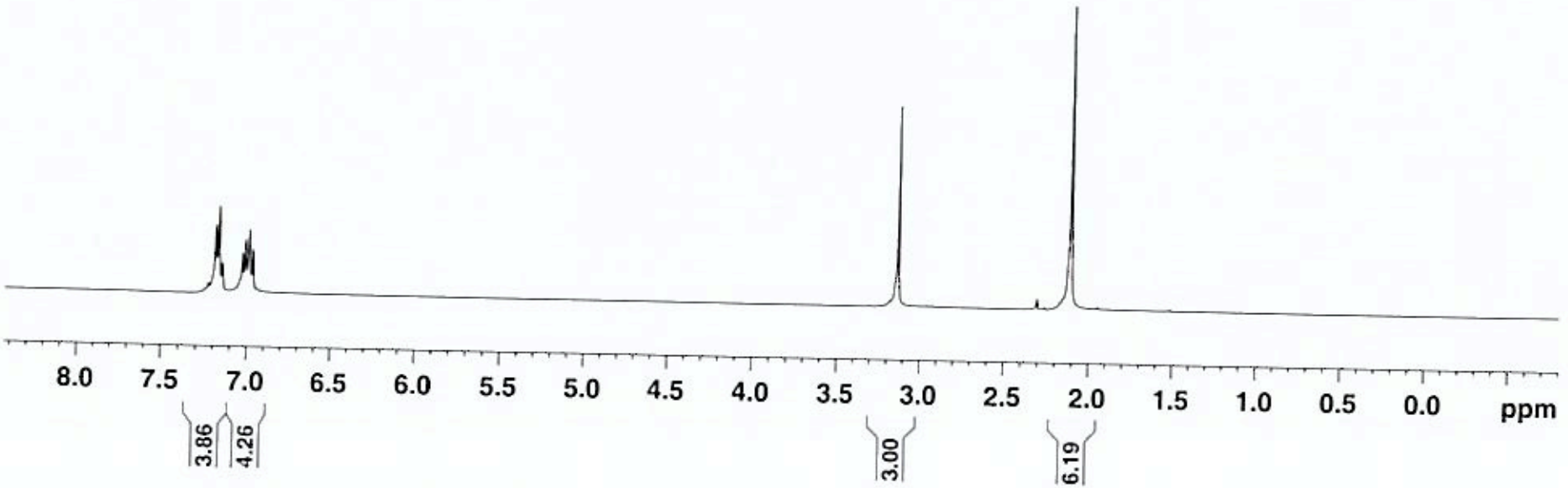

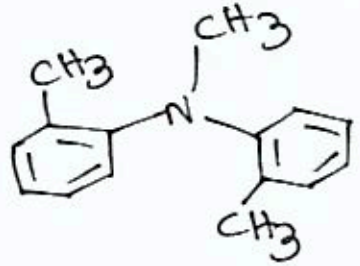
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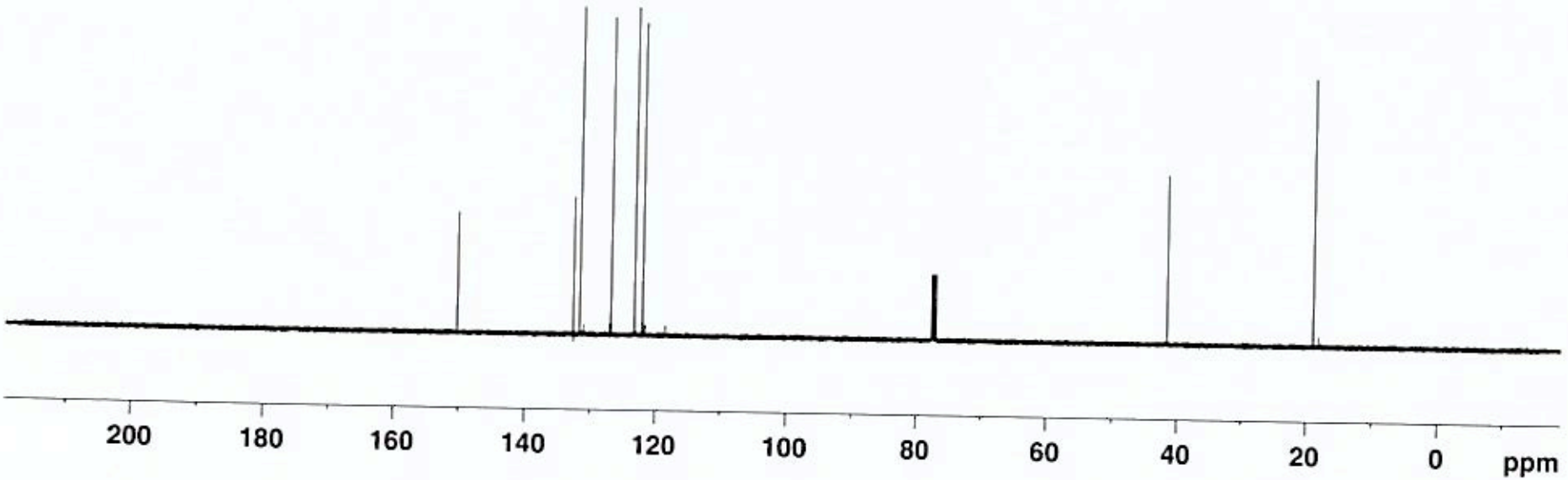
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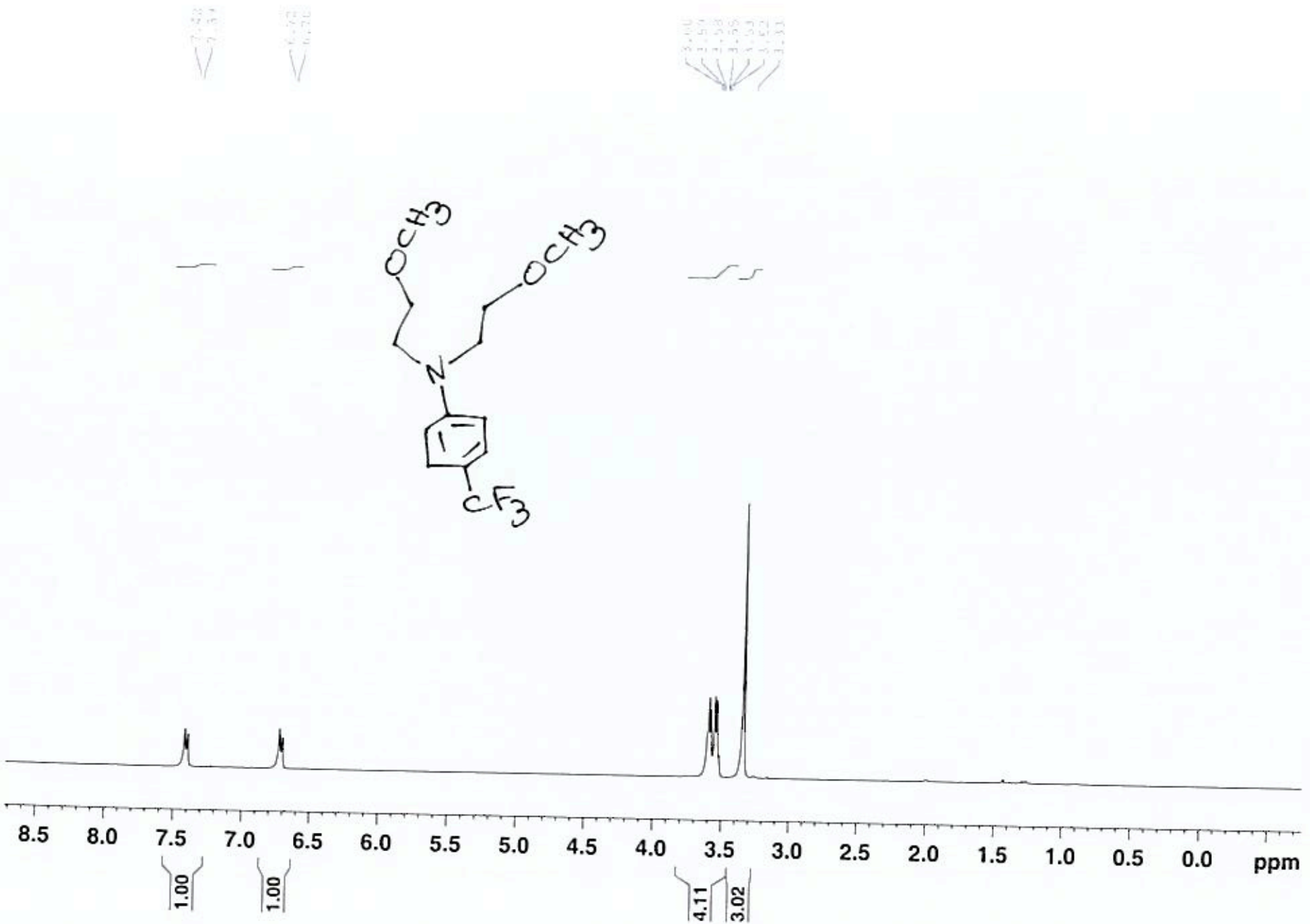

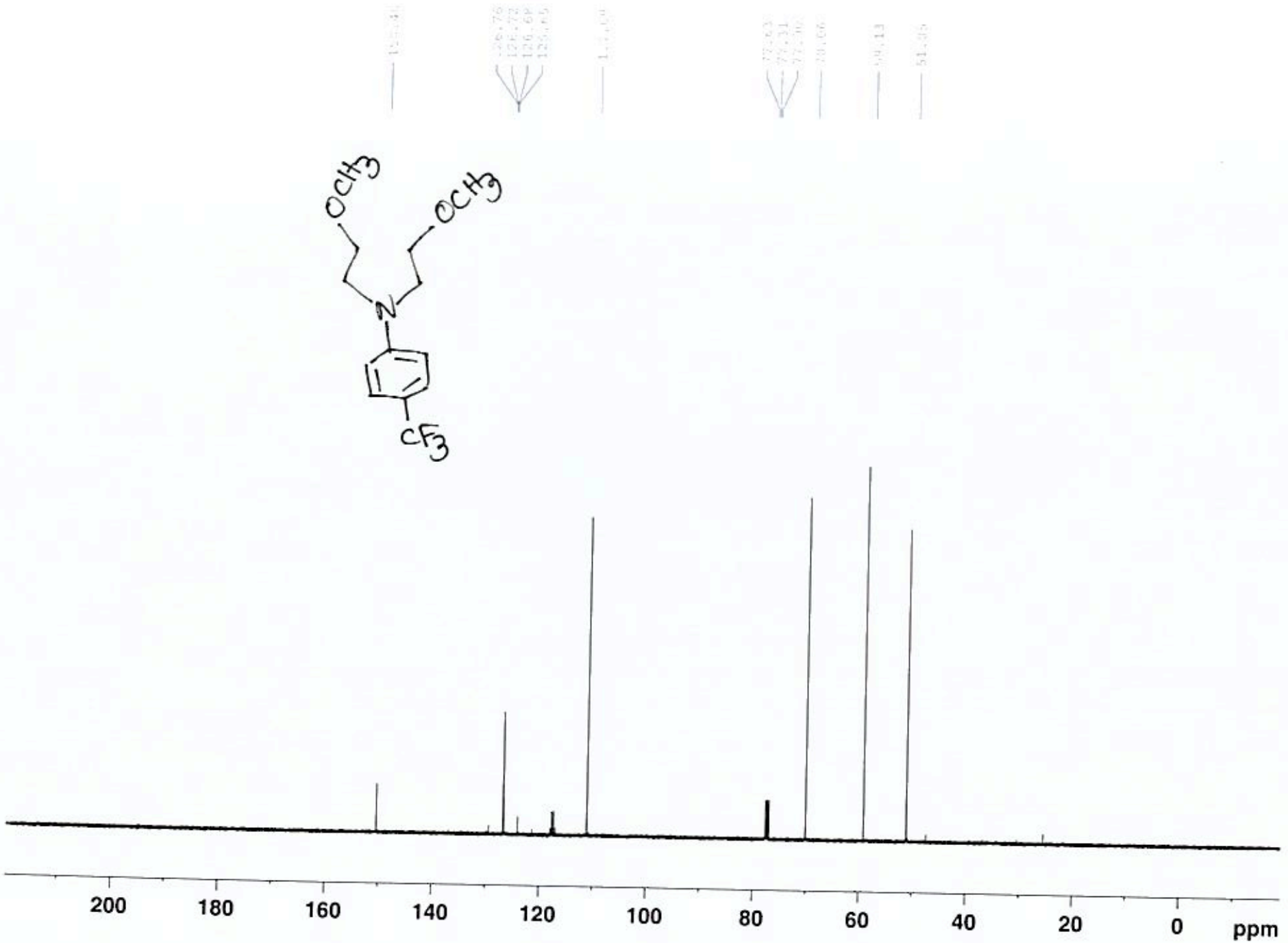
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OCH3
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CF3
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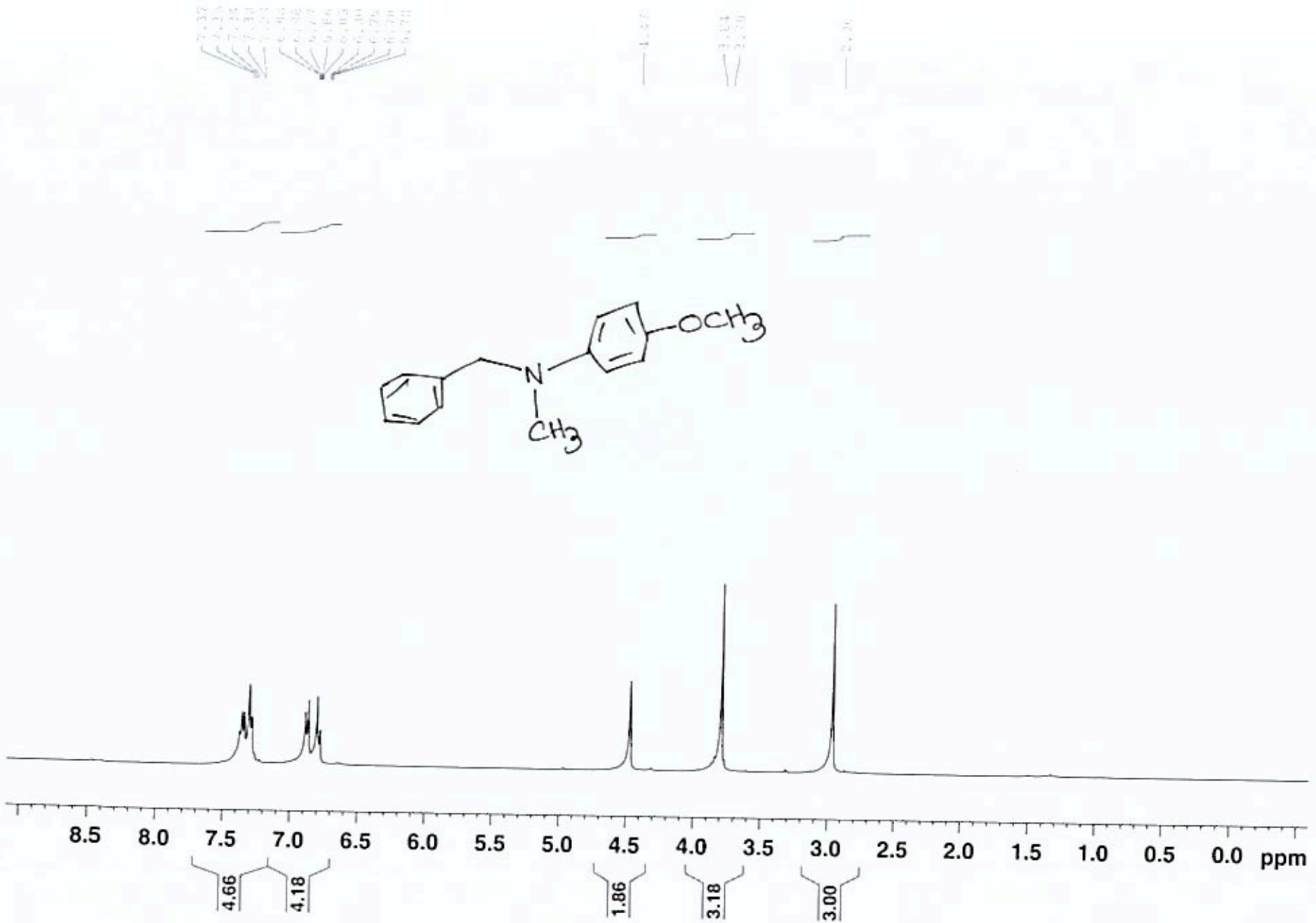
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CH3
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6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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1.0
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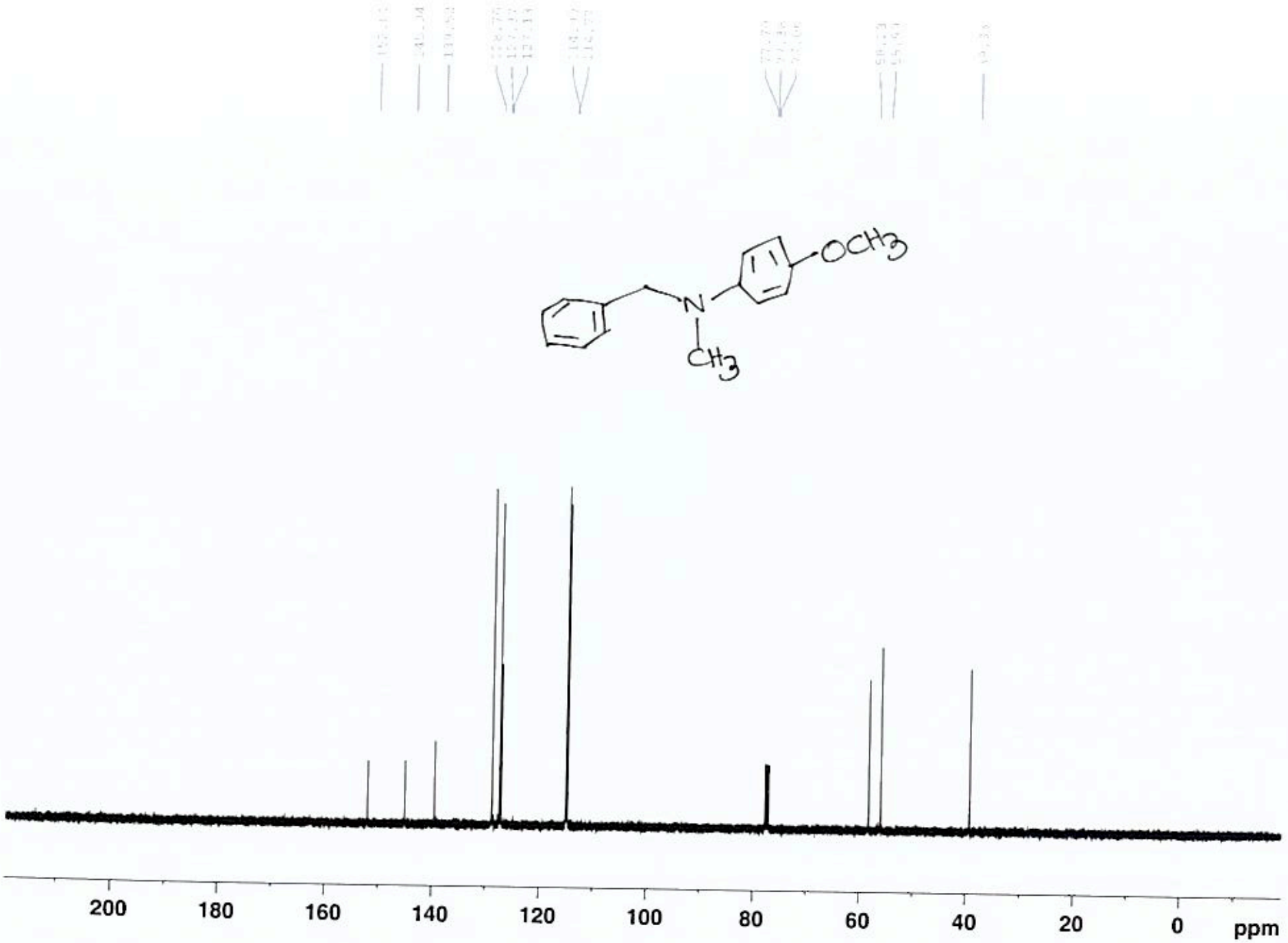
3.18
3.00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140
120
100
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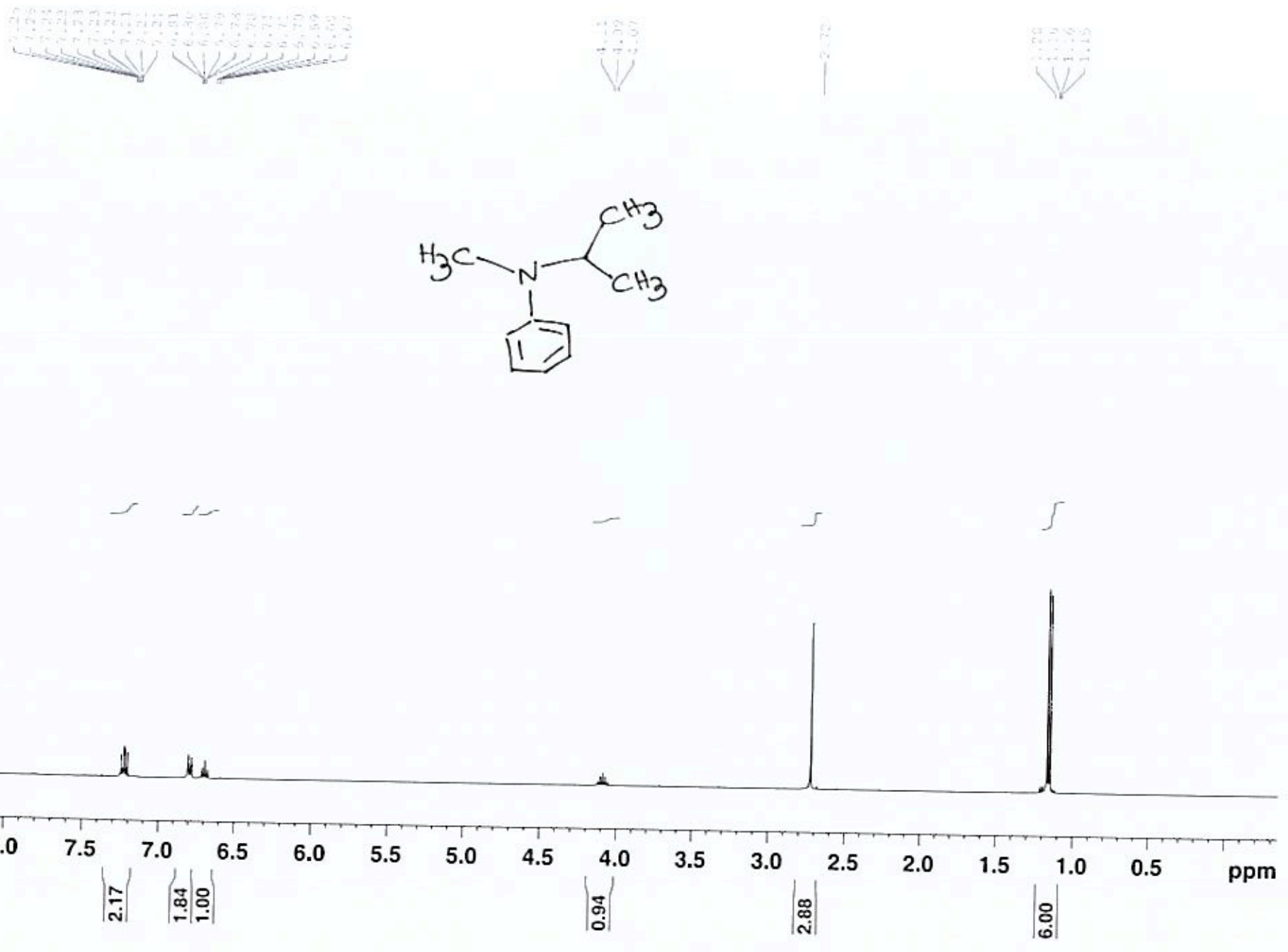
60
40
20
0
ppm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CH3
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7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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ppm
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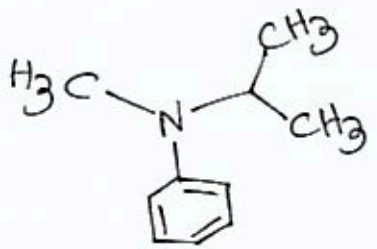
2.88
6.00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H3C
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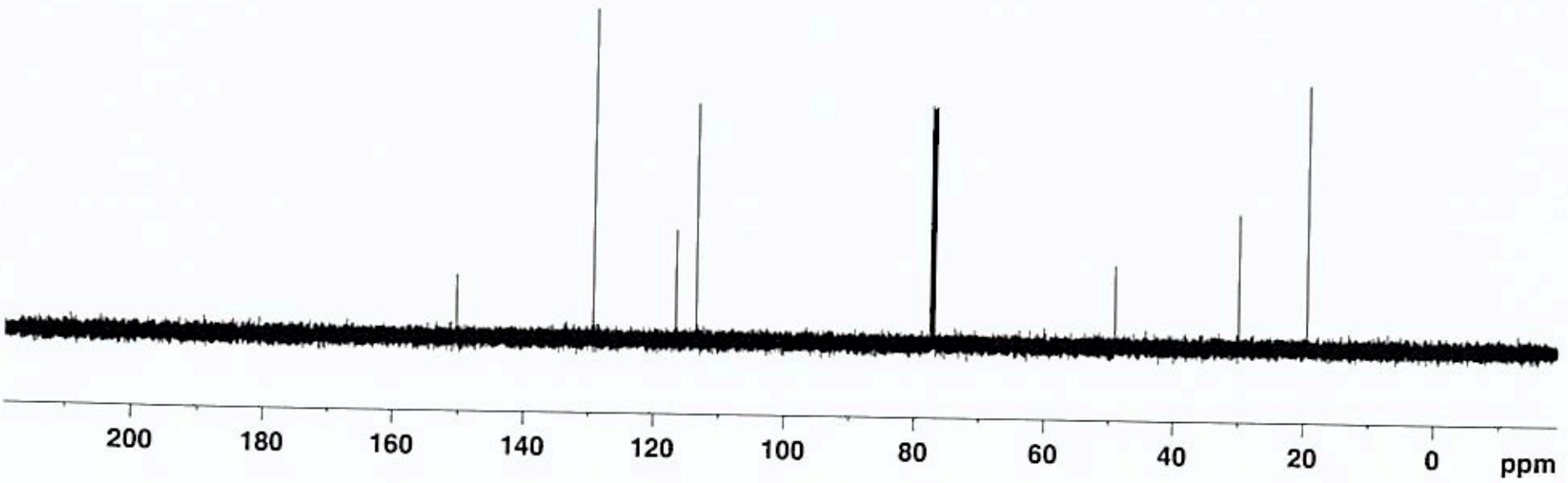
CH3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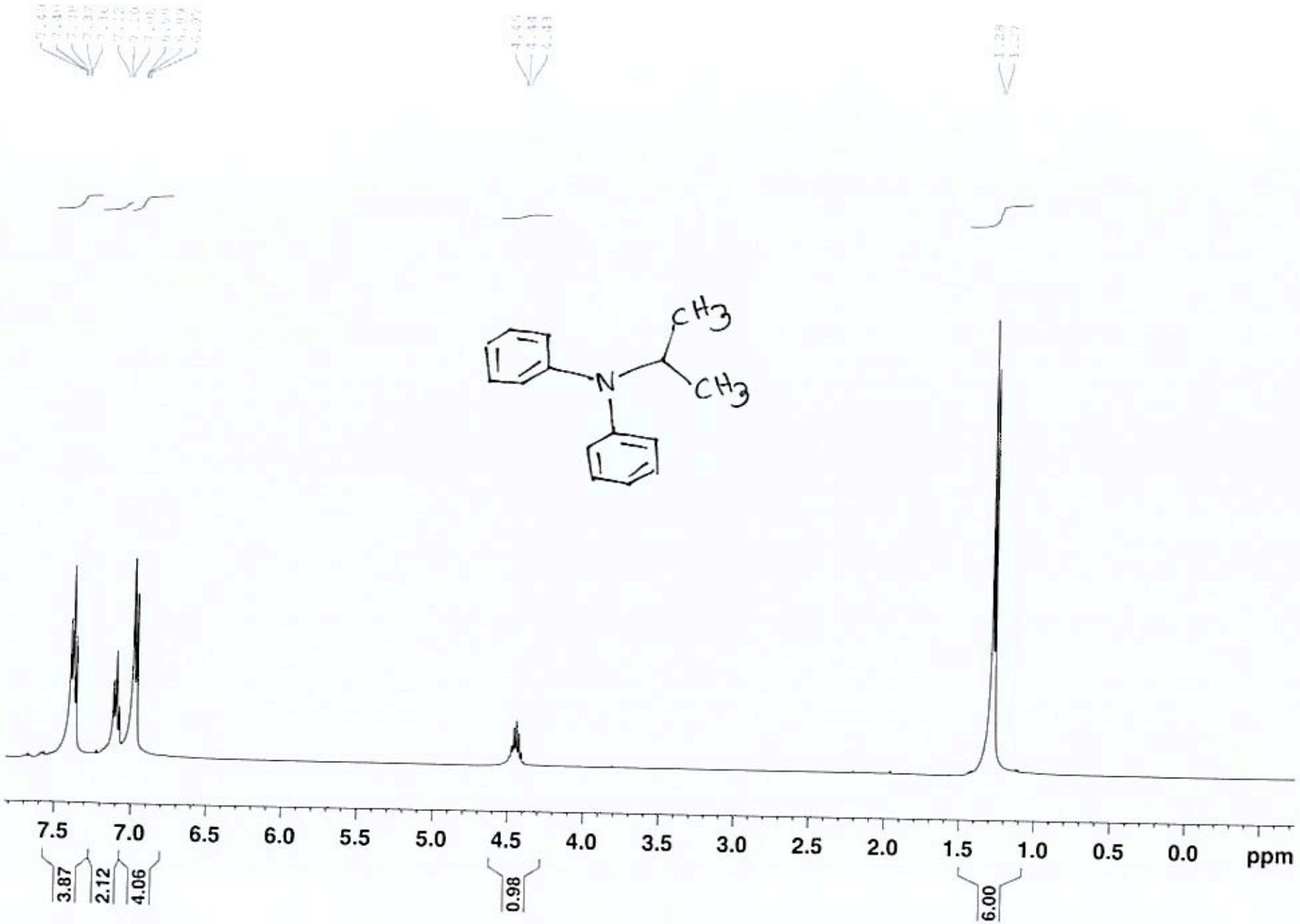
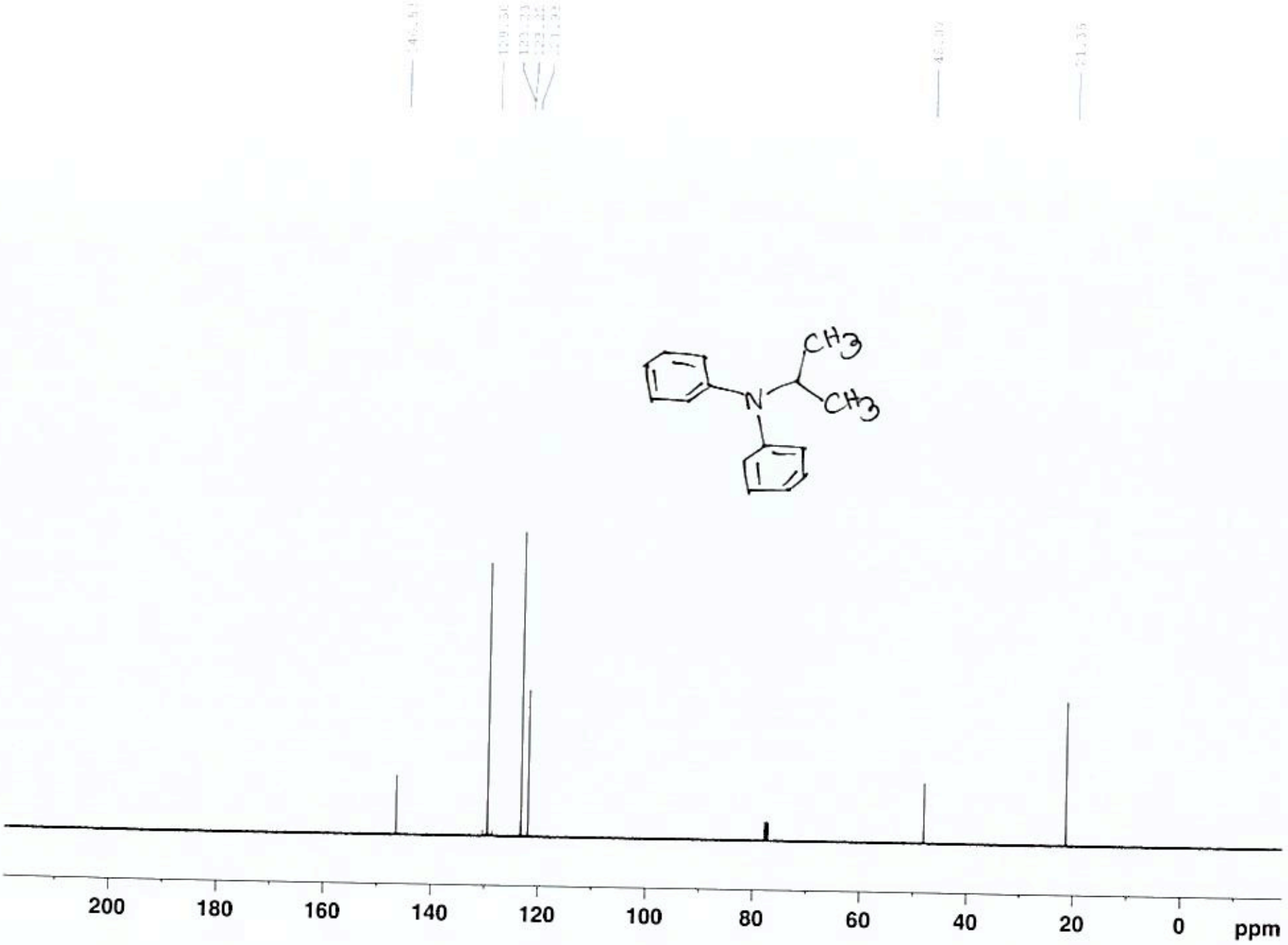
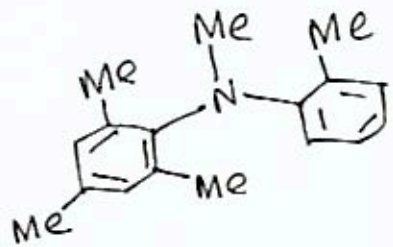
120
100
80
60
40
20
0
ppm



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Me
Me
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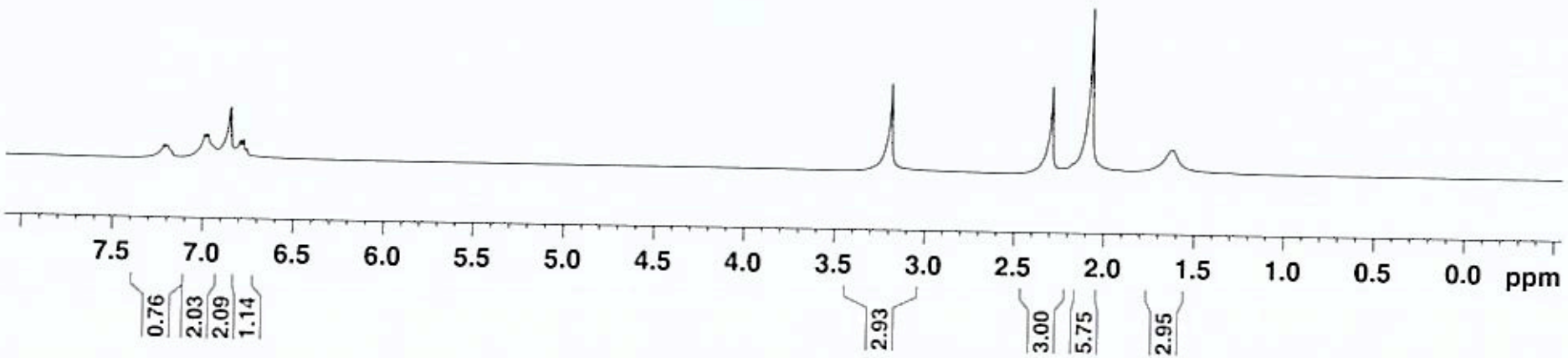
Me
Me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7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
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0.0
ppm
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2.09
1.14
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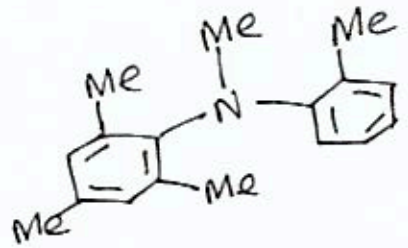
2.95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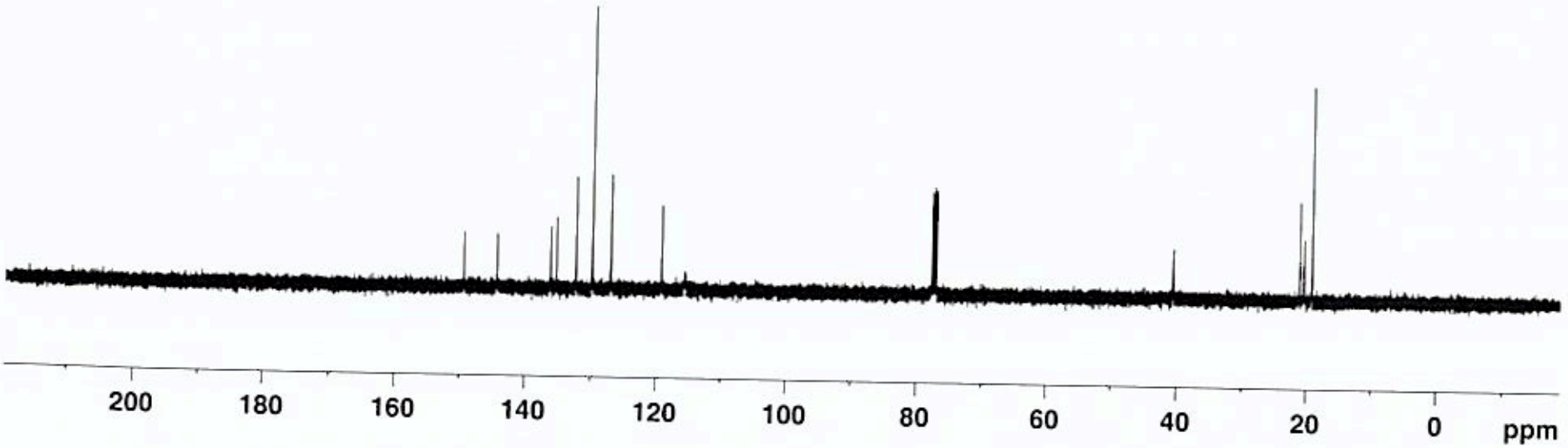
Me
Me
N
Me
Me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120
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40
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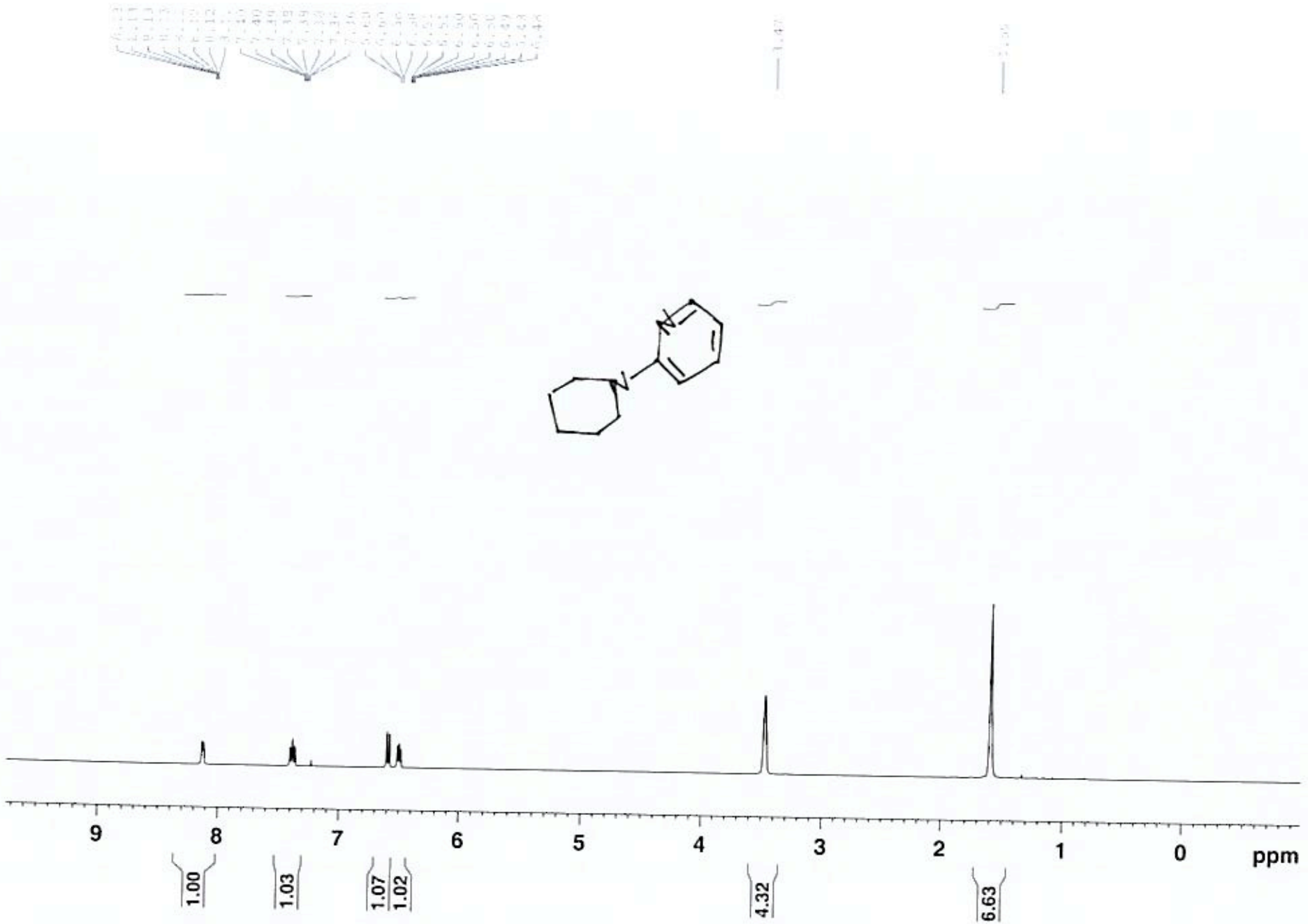
0
ppm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8
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4
3
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ppm
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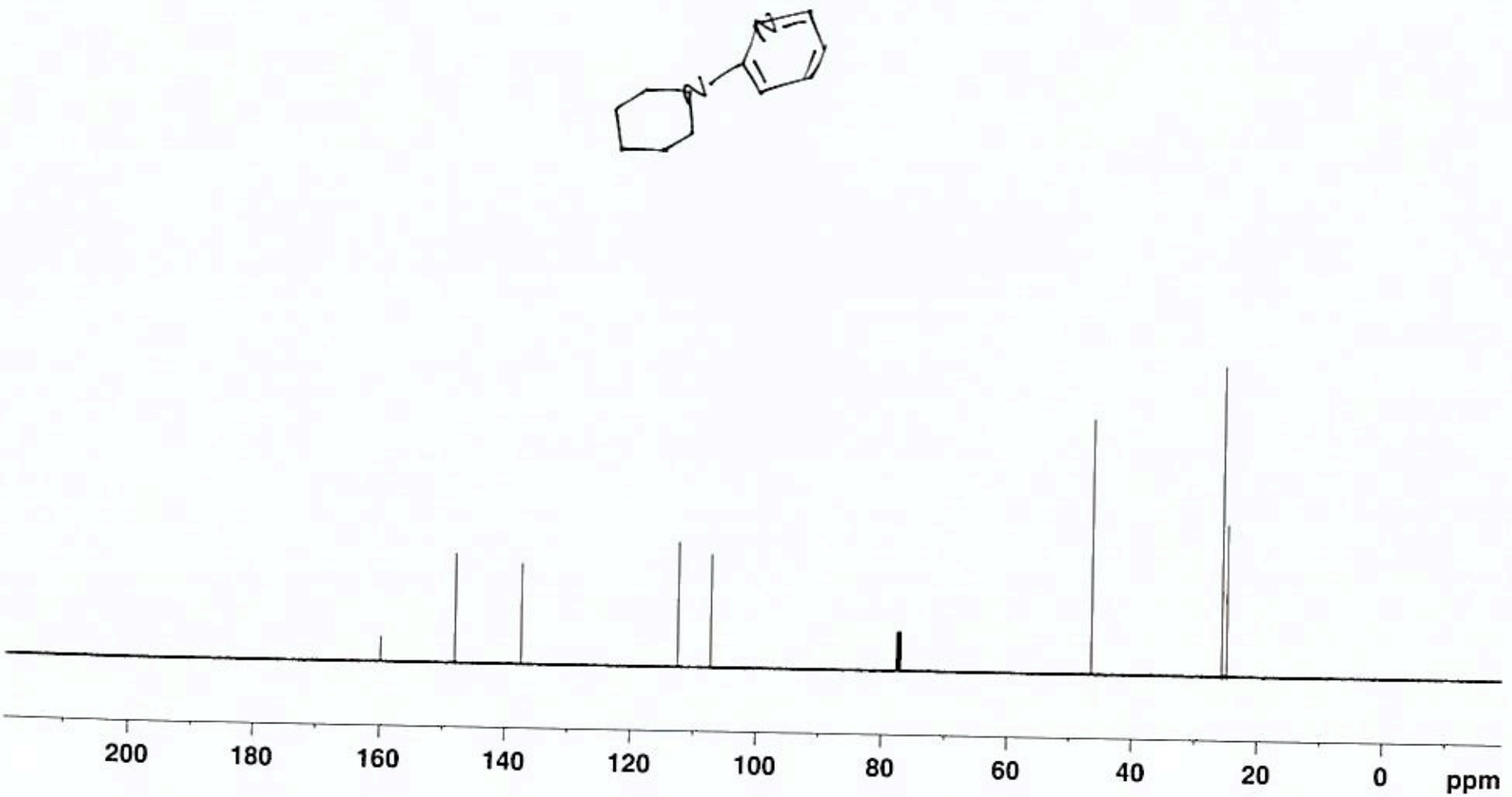
1.02
4.32
6.63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100
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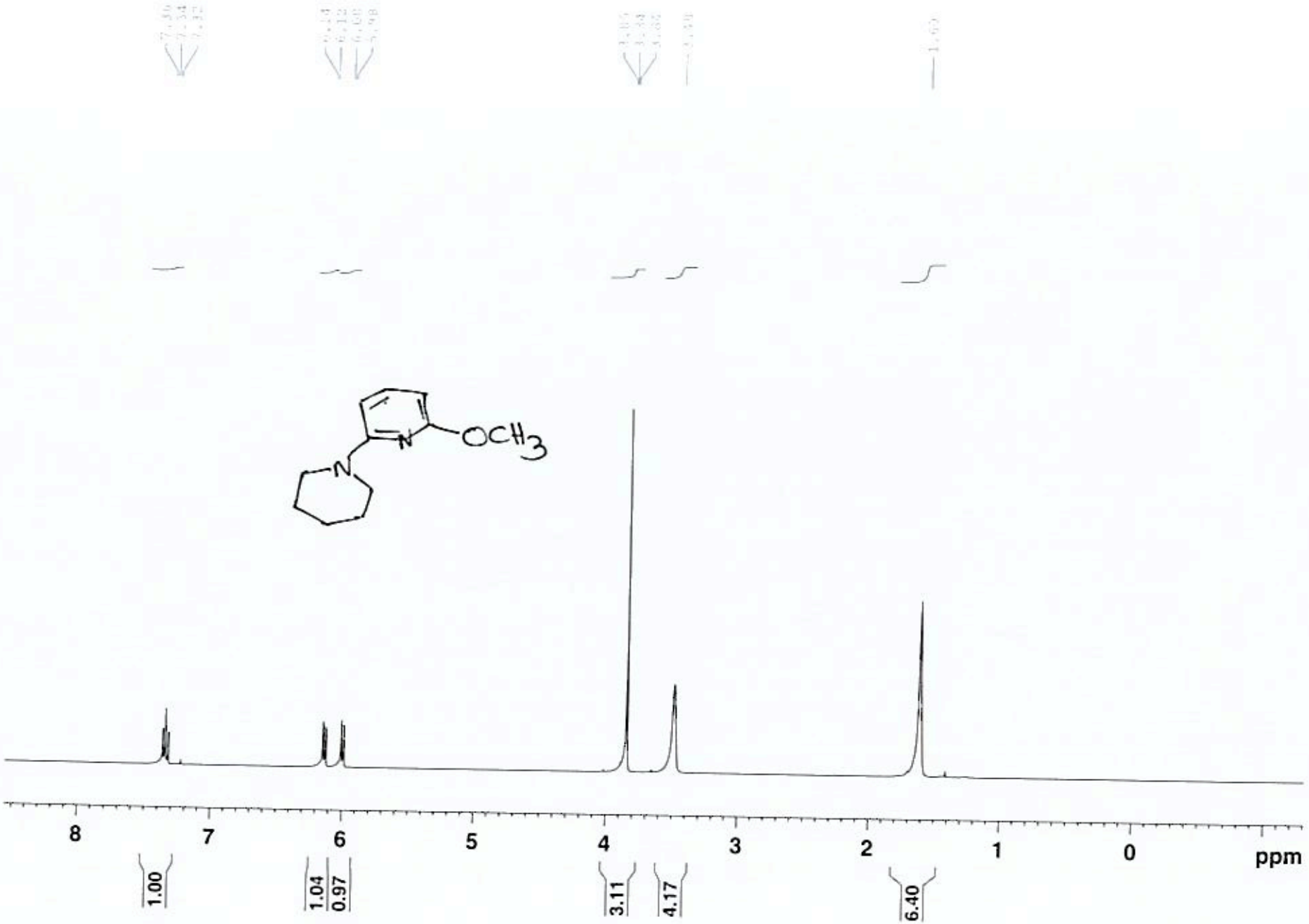
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4
3
2
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ppm
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1.04
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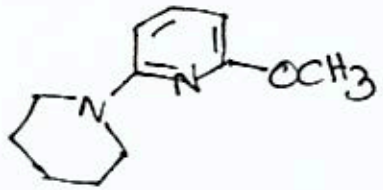
4.17
6.40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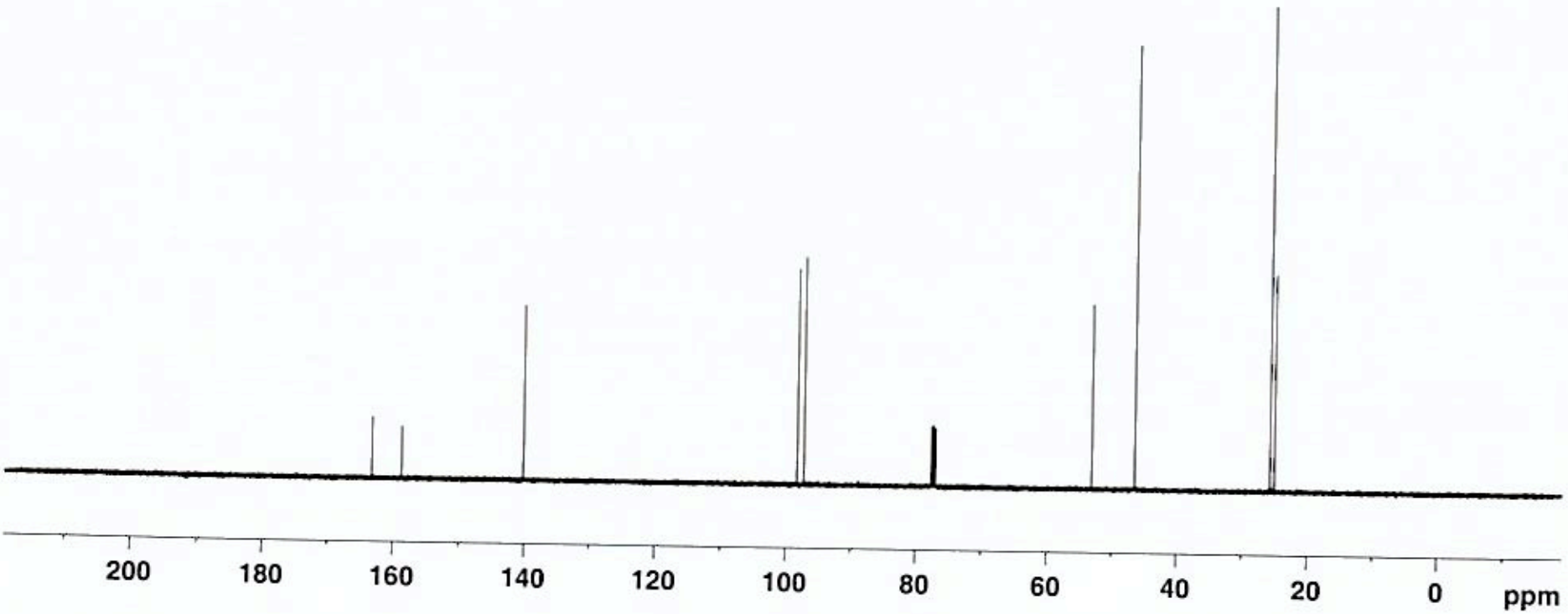
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0
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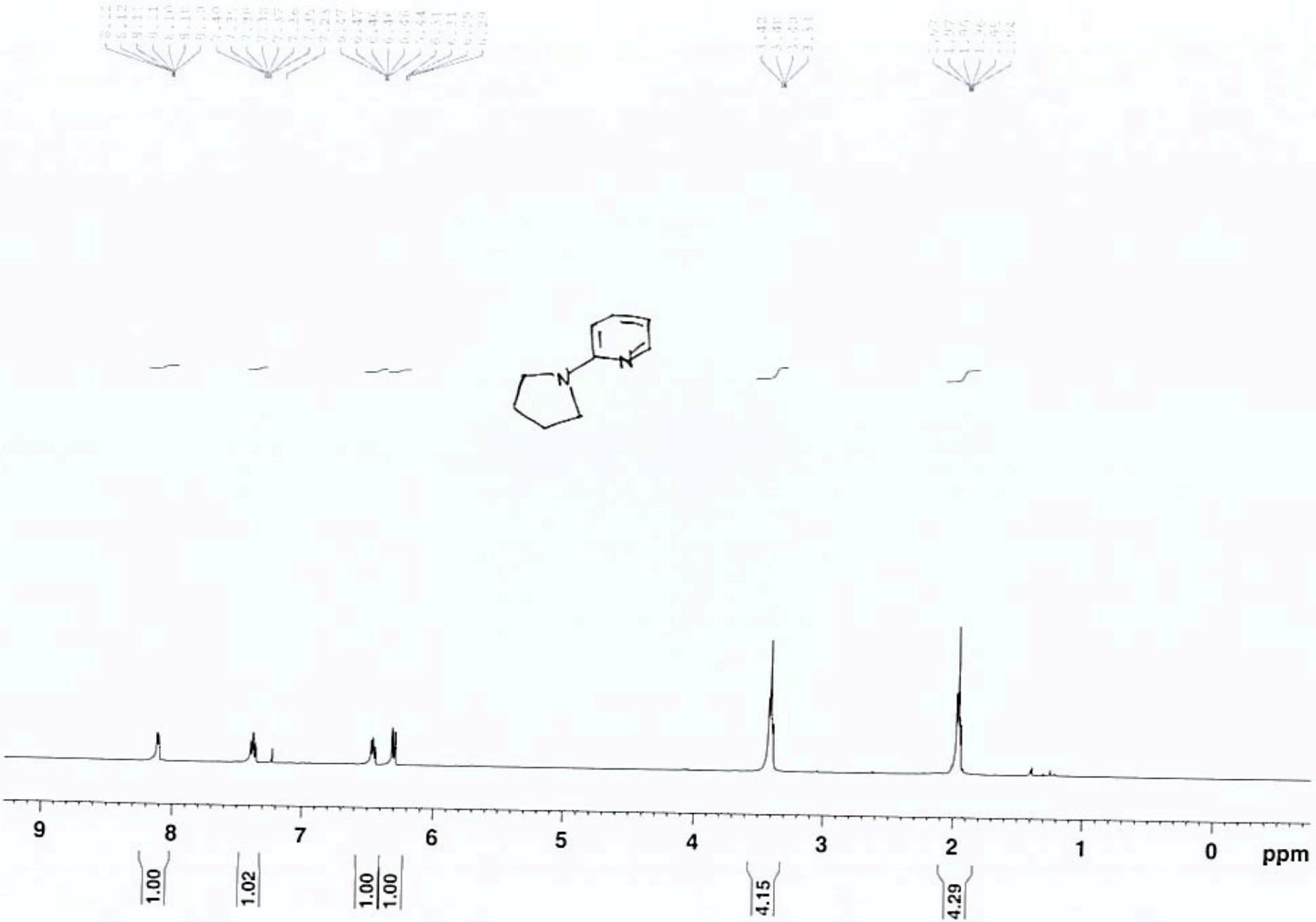
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N
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8
7
6
5
4
3
2
1
0
ppm
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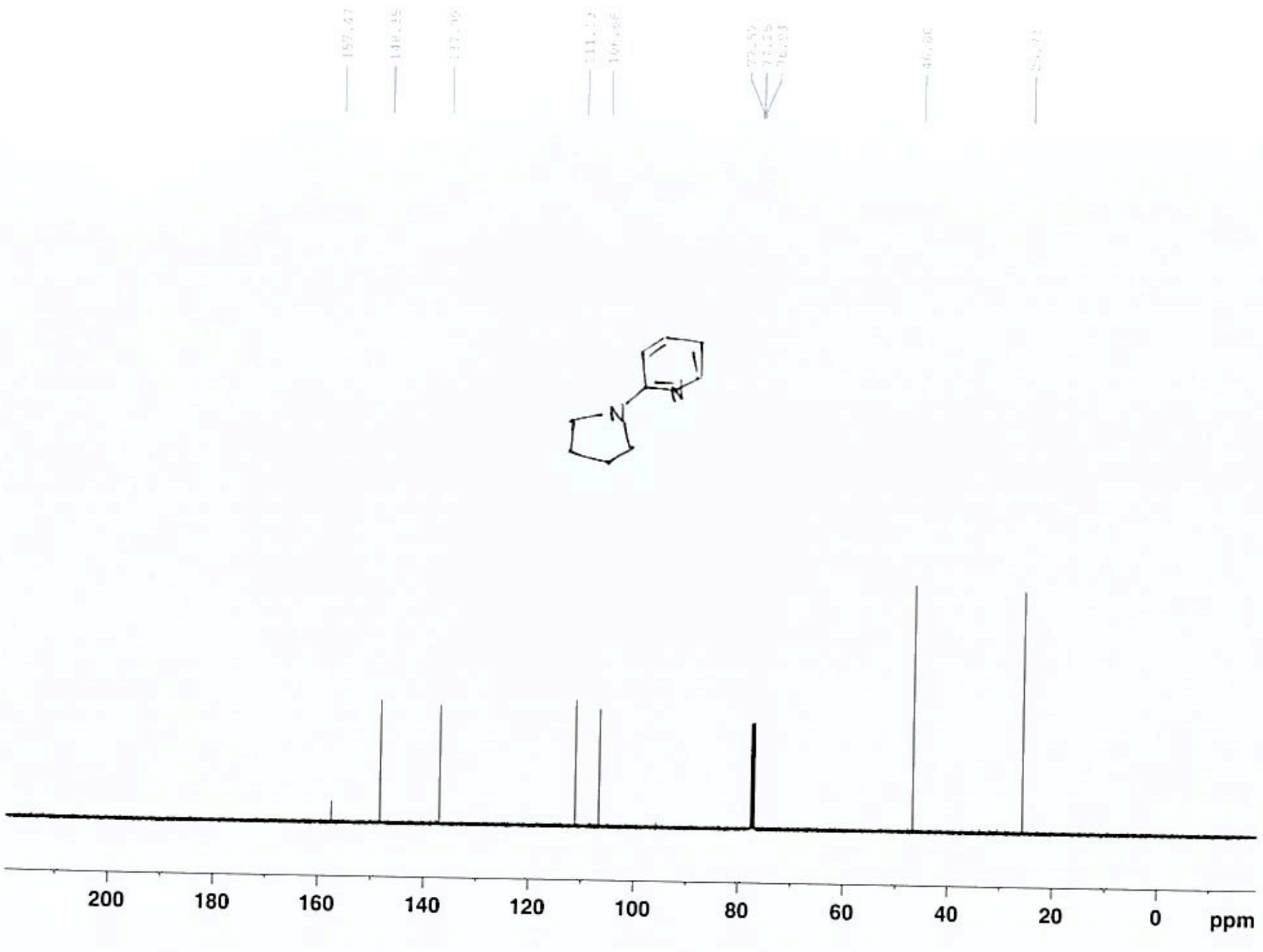
1.02
1.00
1.00
4.15
4.29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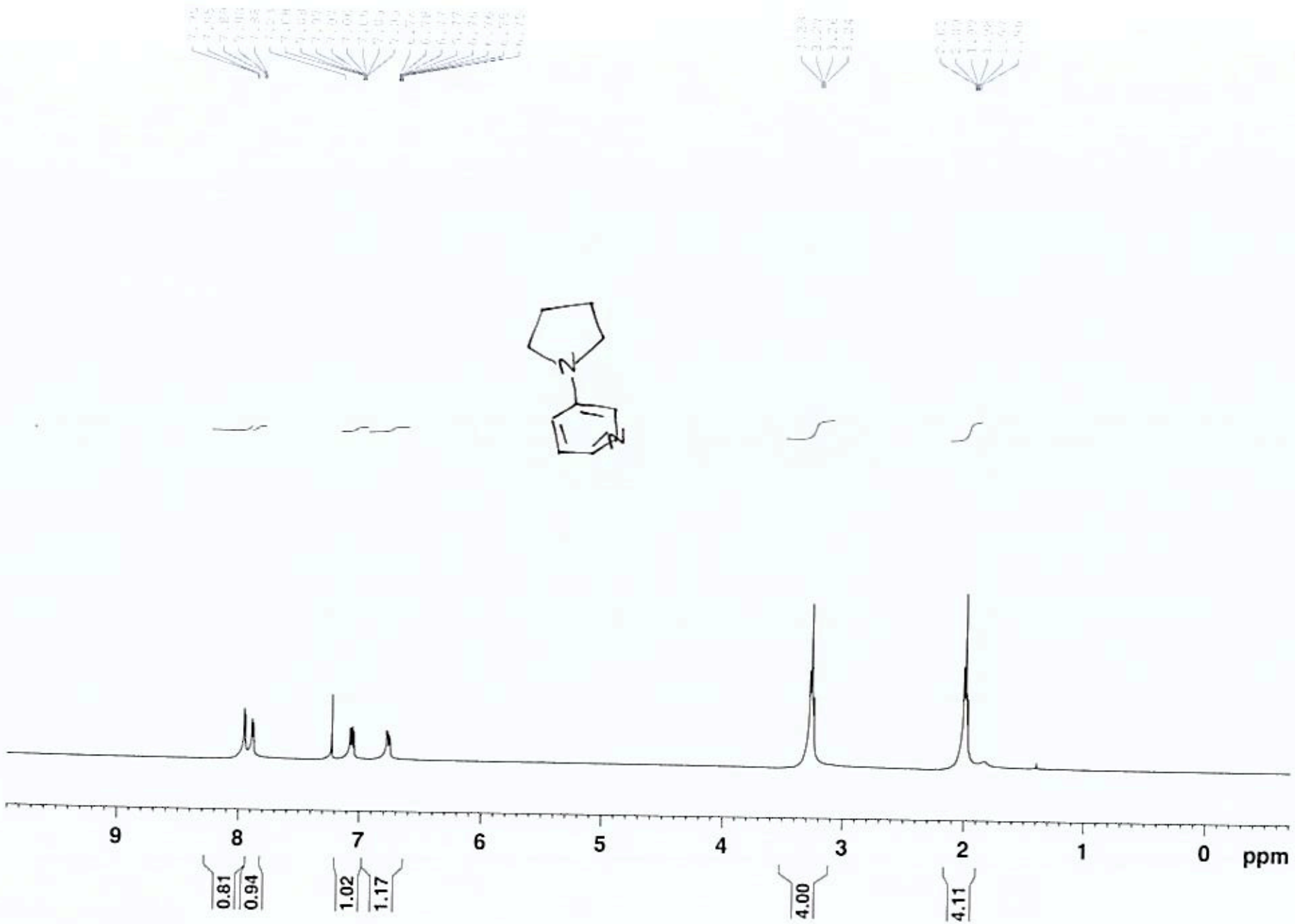
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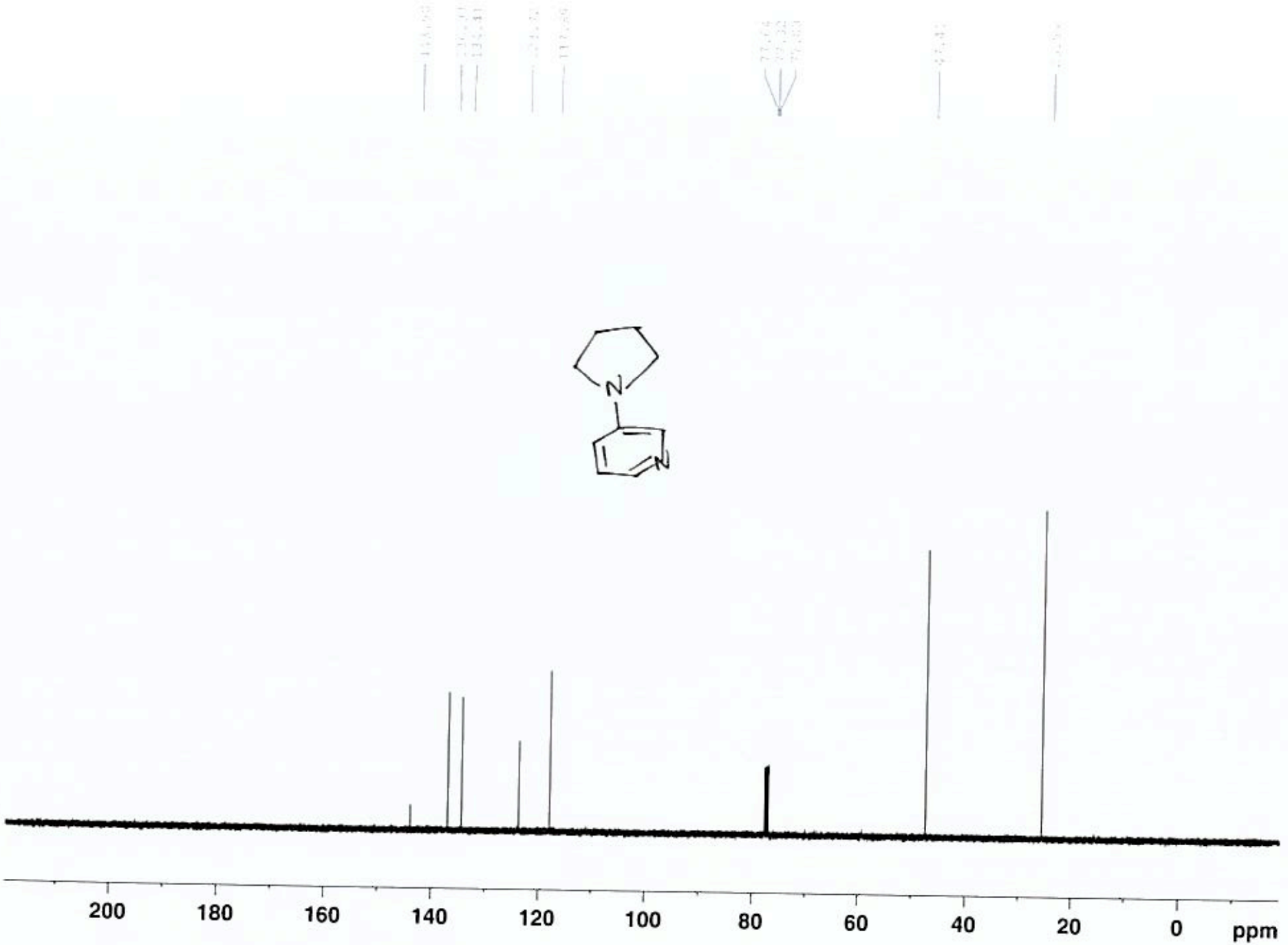
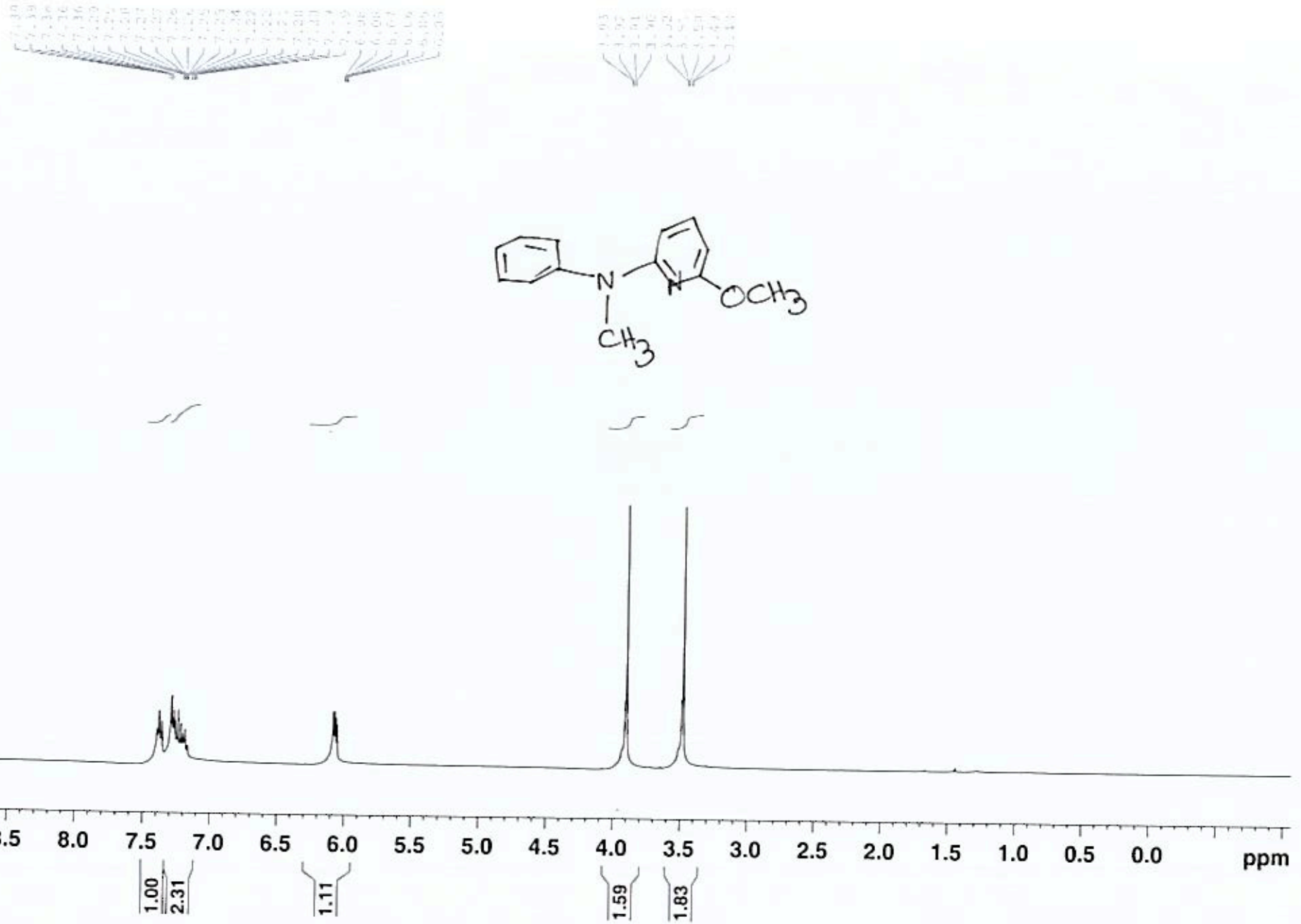
4.11

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N
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CH3
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7.5
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5.5
5.0
4.5
4.0
3.5
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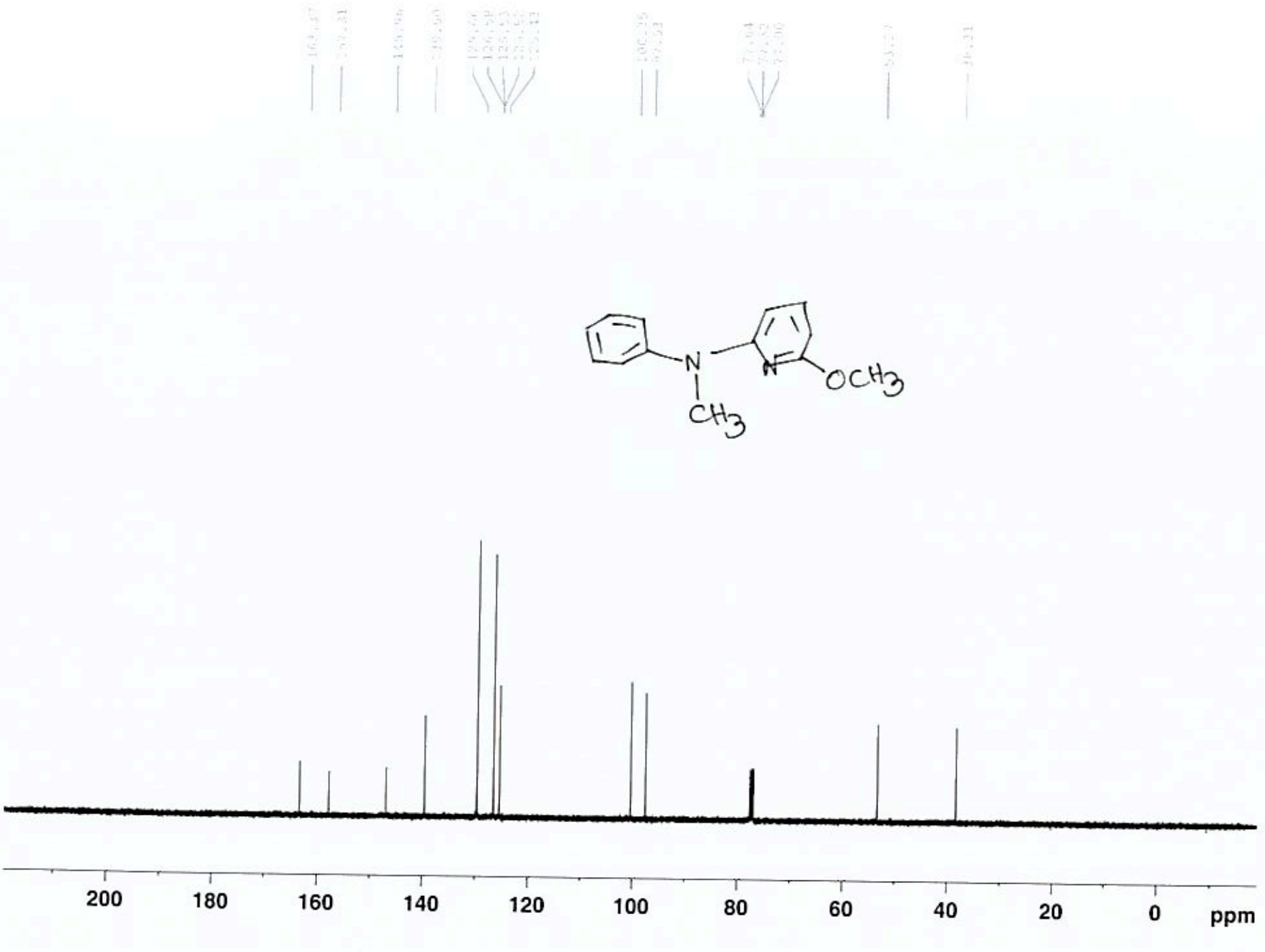
1.83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N
OCH3
CH3
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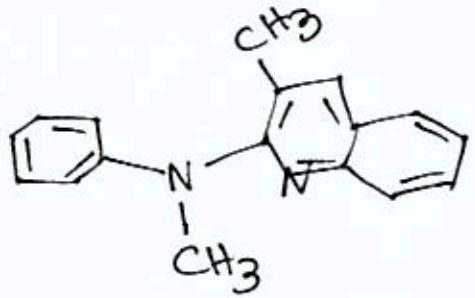
140
120
100
80
60
40
20
0
ppm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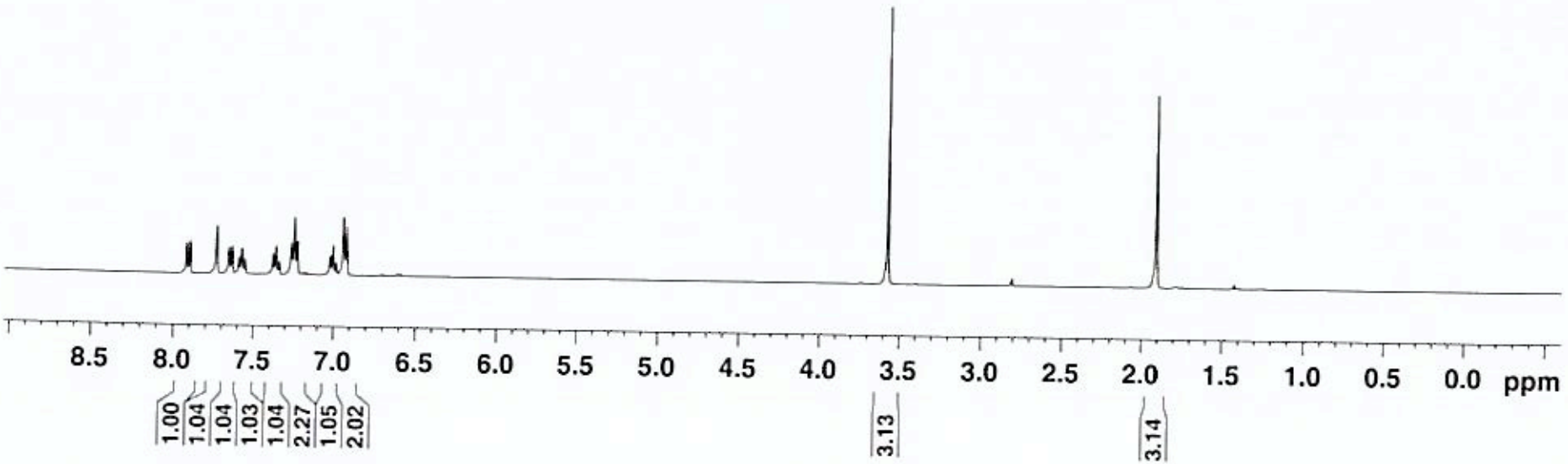
CH3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4.0
3.5
3.0
2.5
2.0
1.5
1.0
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1.03
1.04
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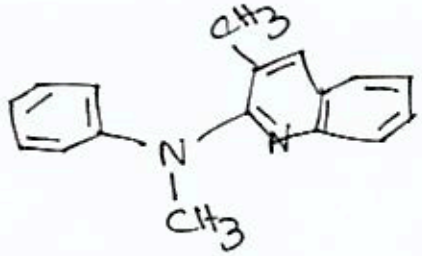
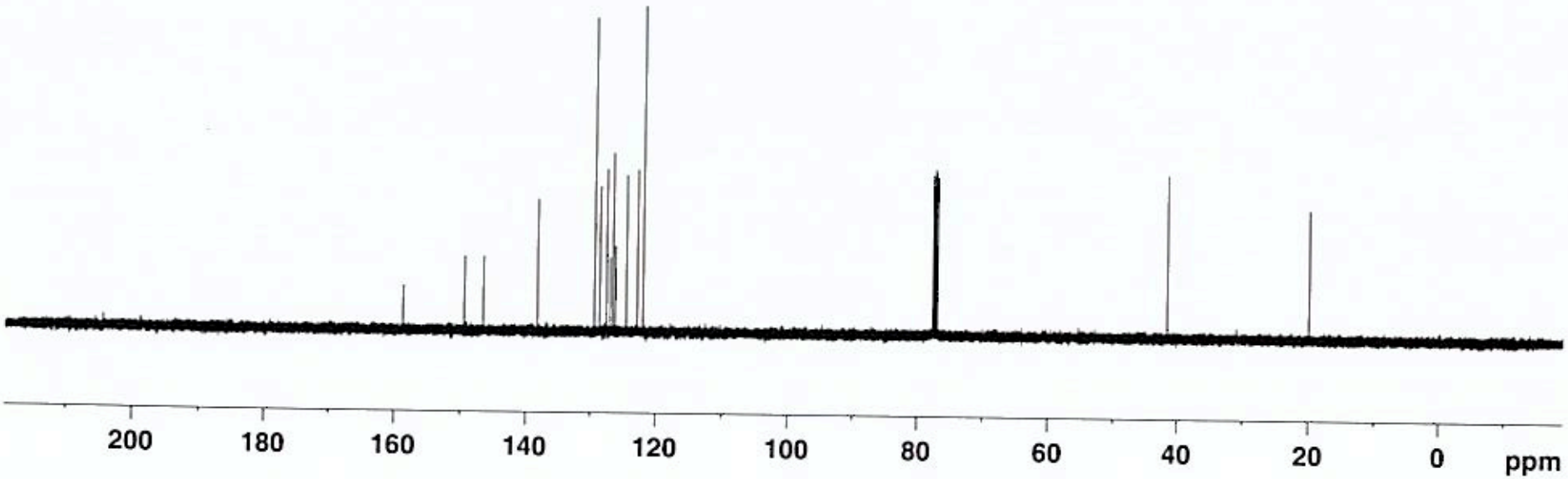
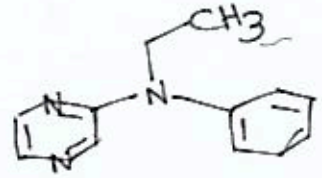
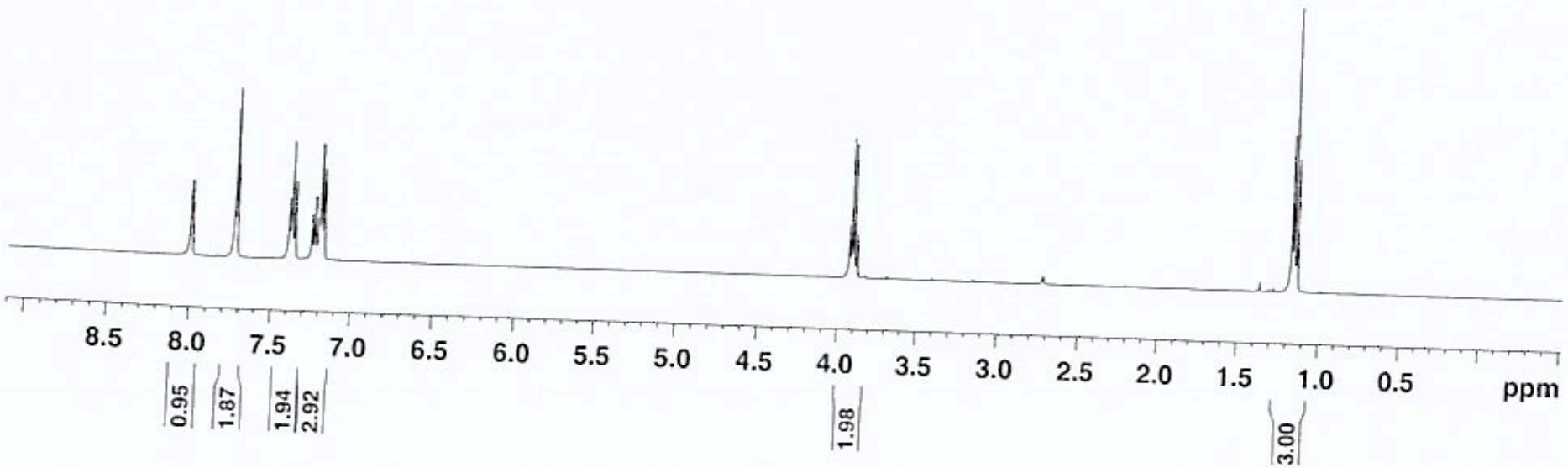
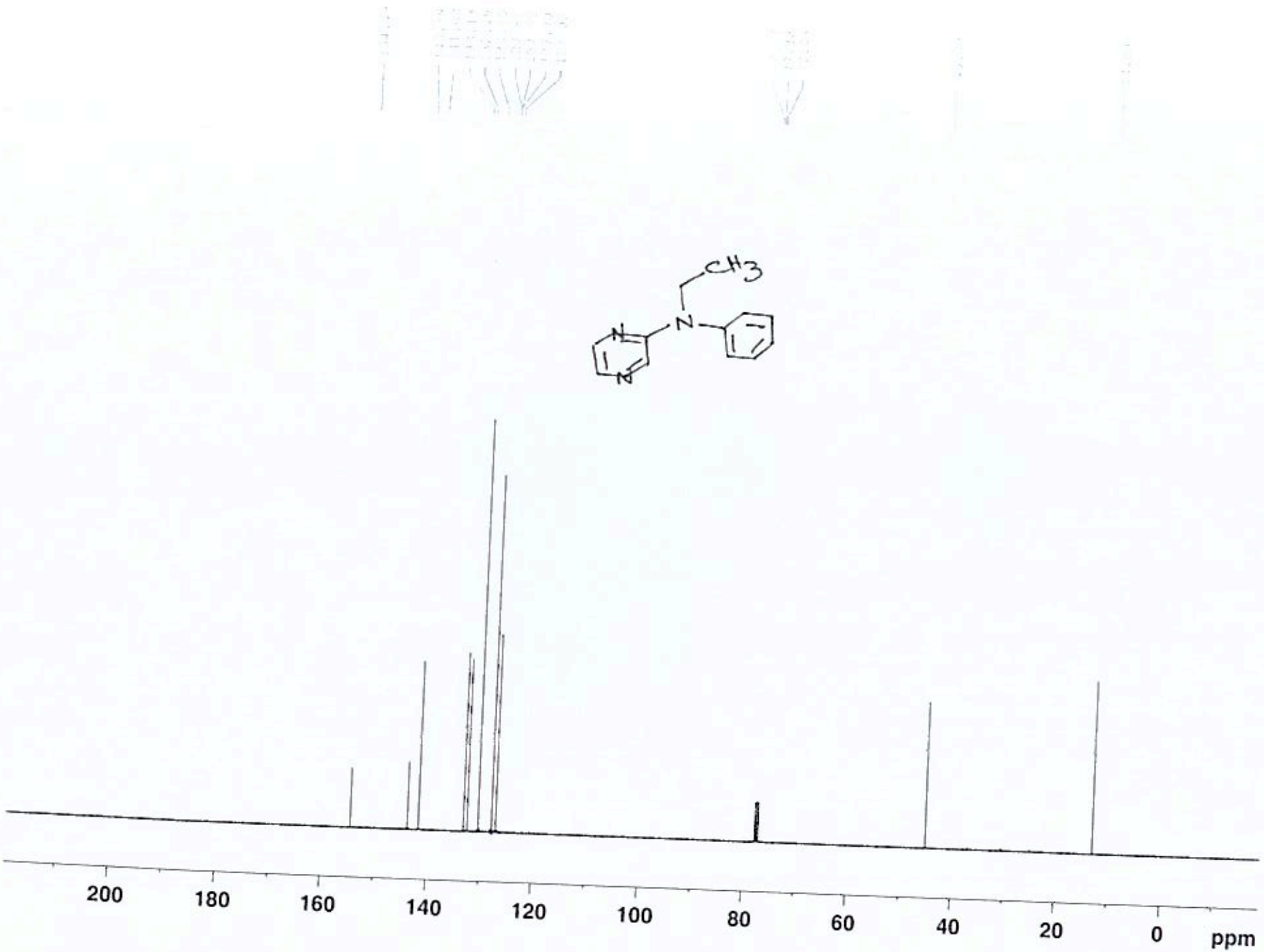
2.02
3.13
3.14

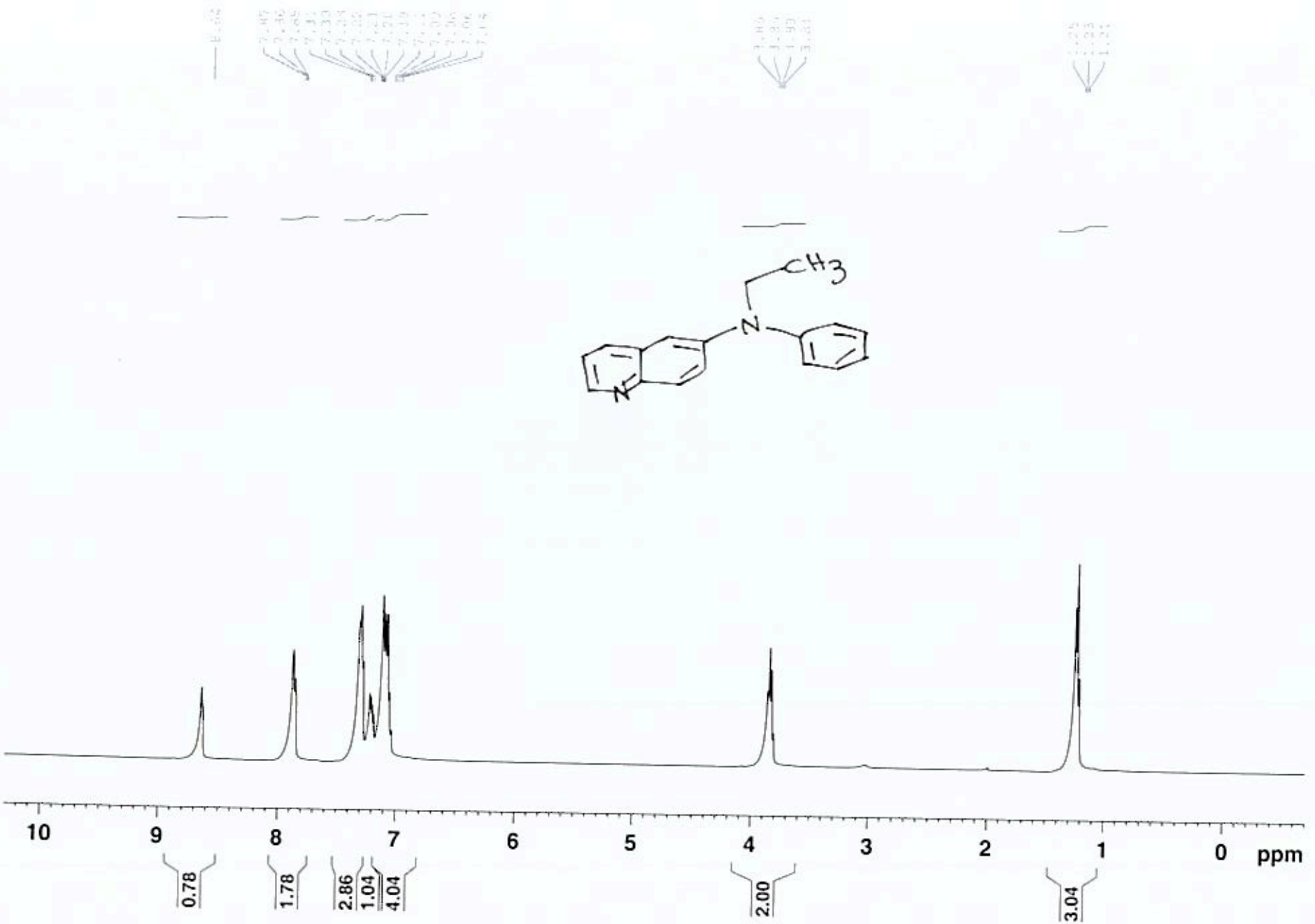











CH3
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N
10
9
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5
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3
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1
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ppm
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2.86
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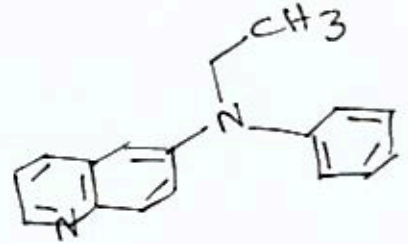
2.00
3.04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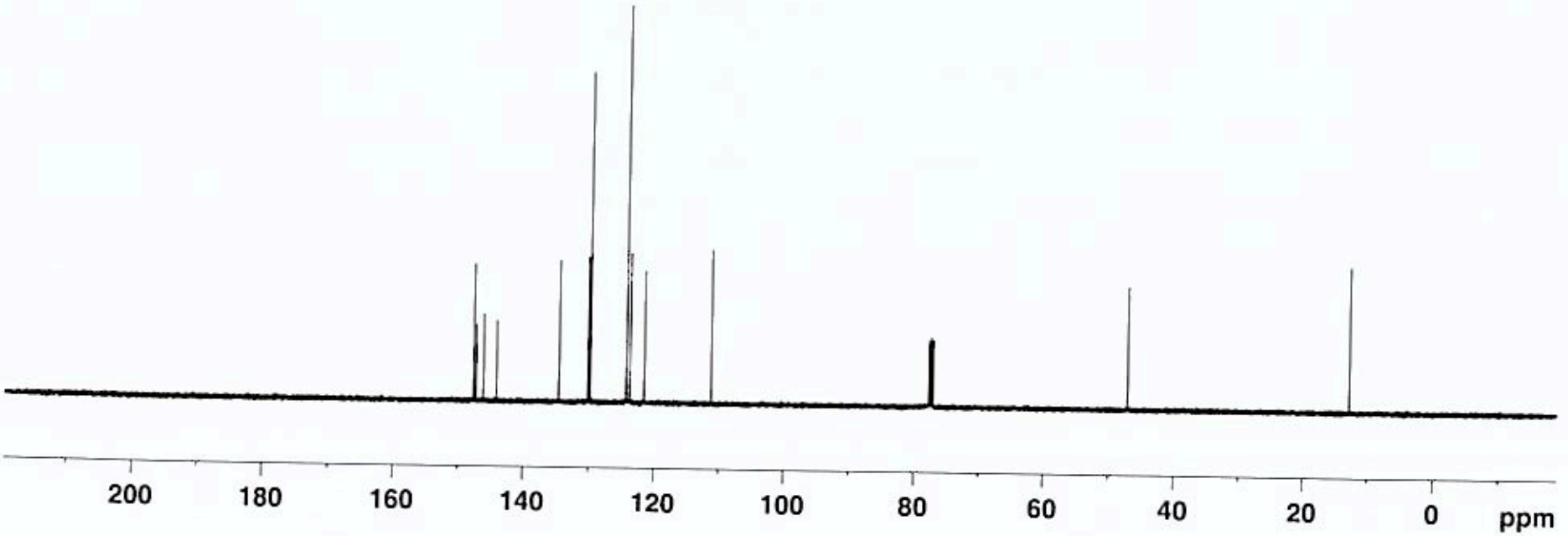
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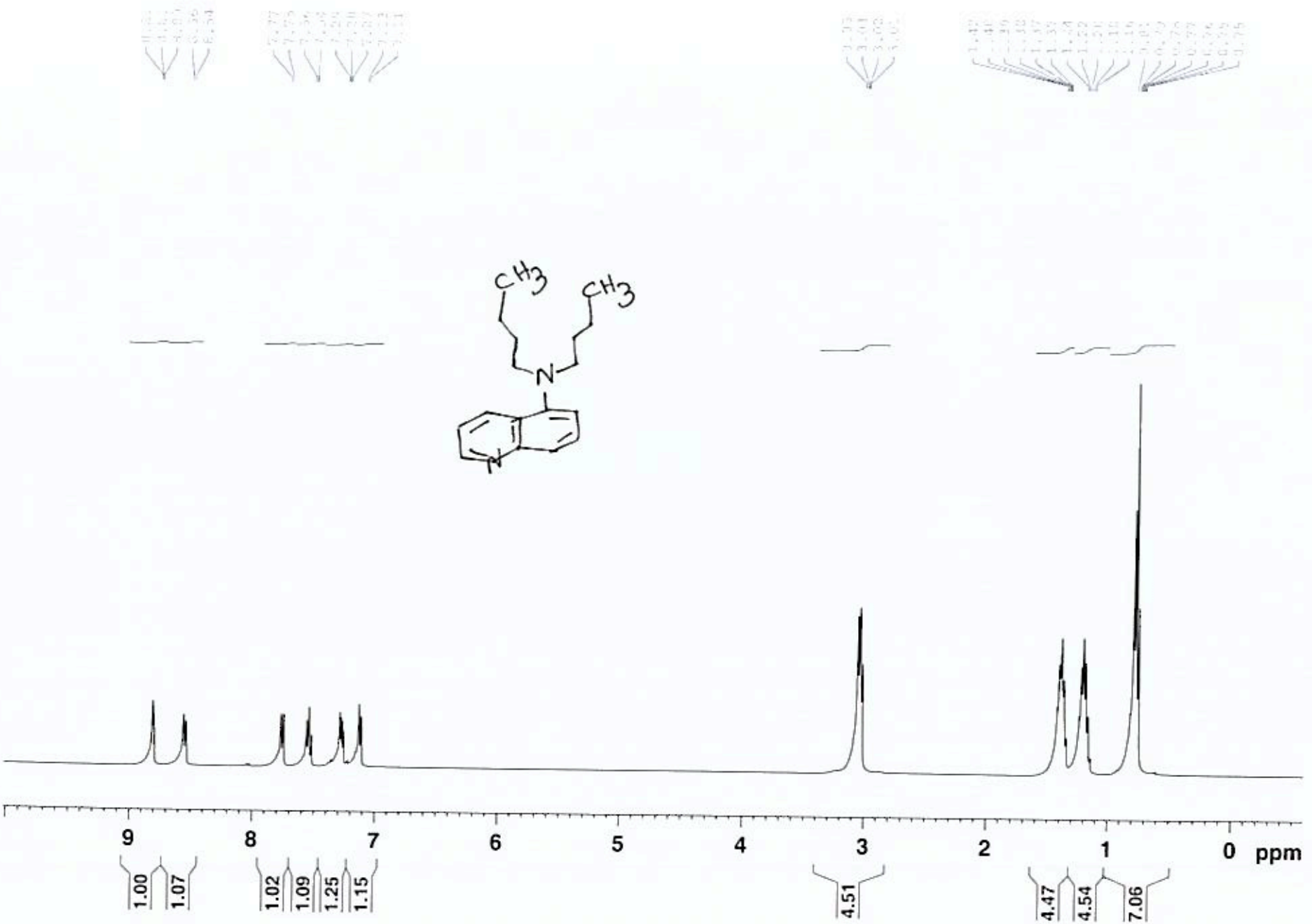
120
100
80
60
40
20
0
ppm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CH3
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N
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5
4
3
2
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1.07
1.02
1.09
1.25
1.15
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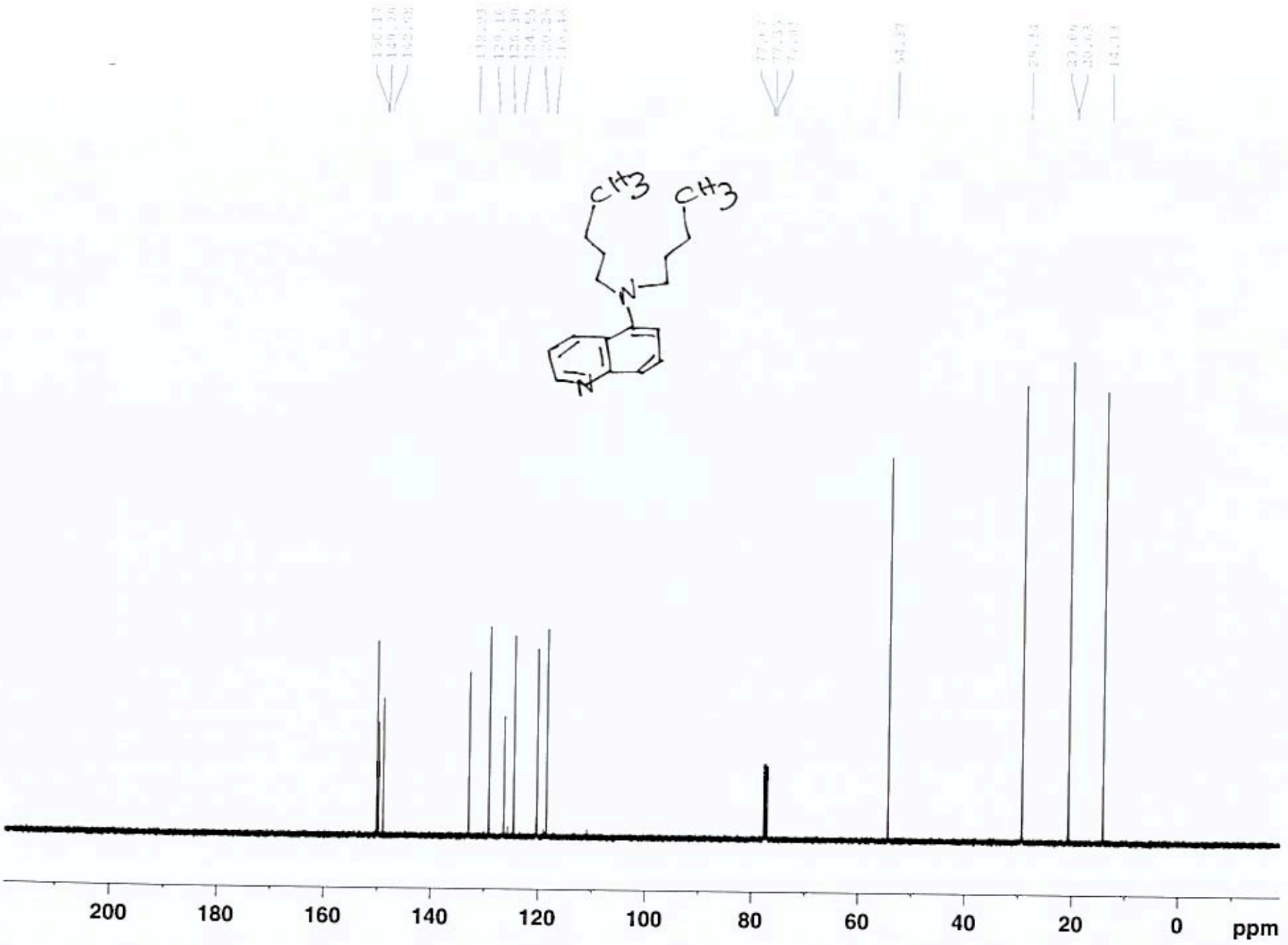
4.47
4.54
7.06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CH3
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120
100
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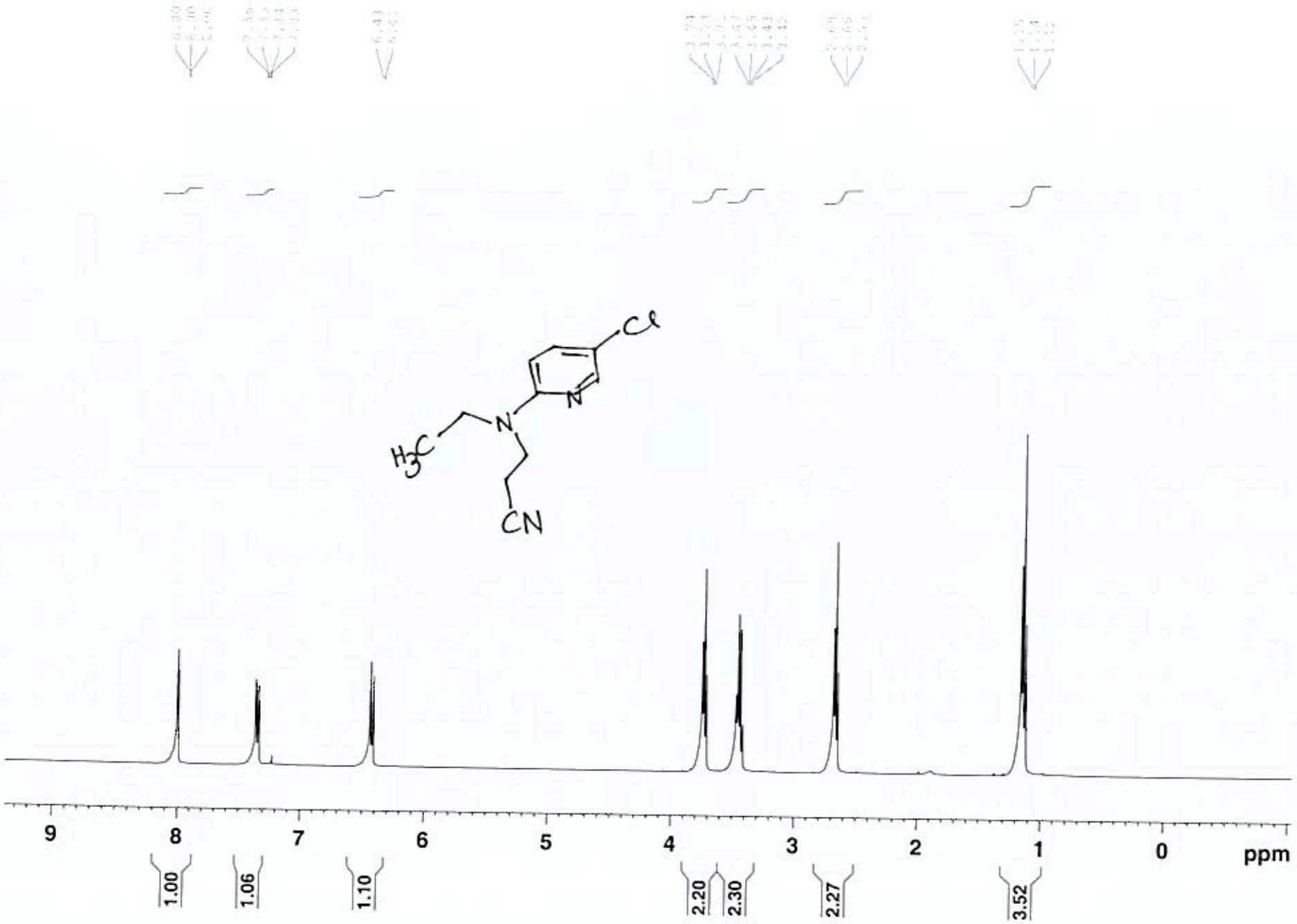
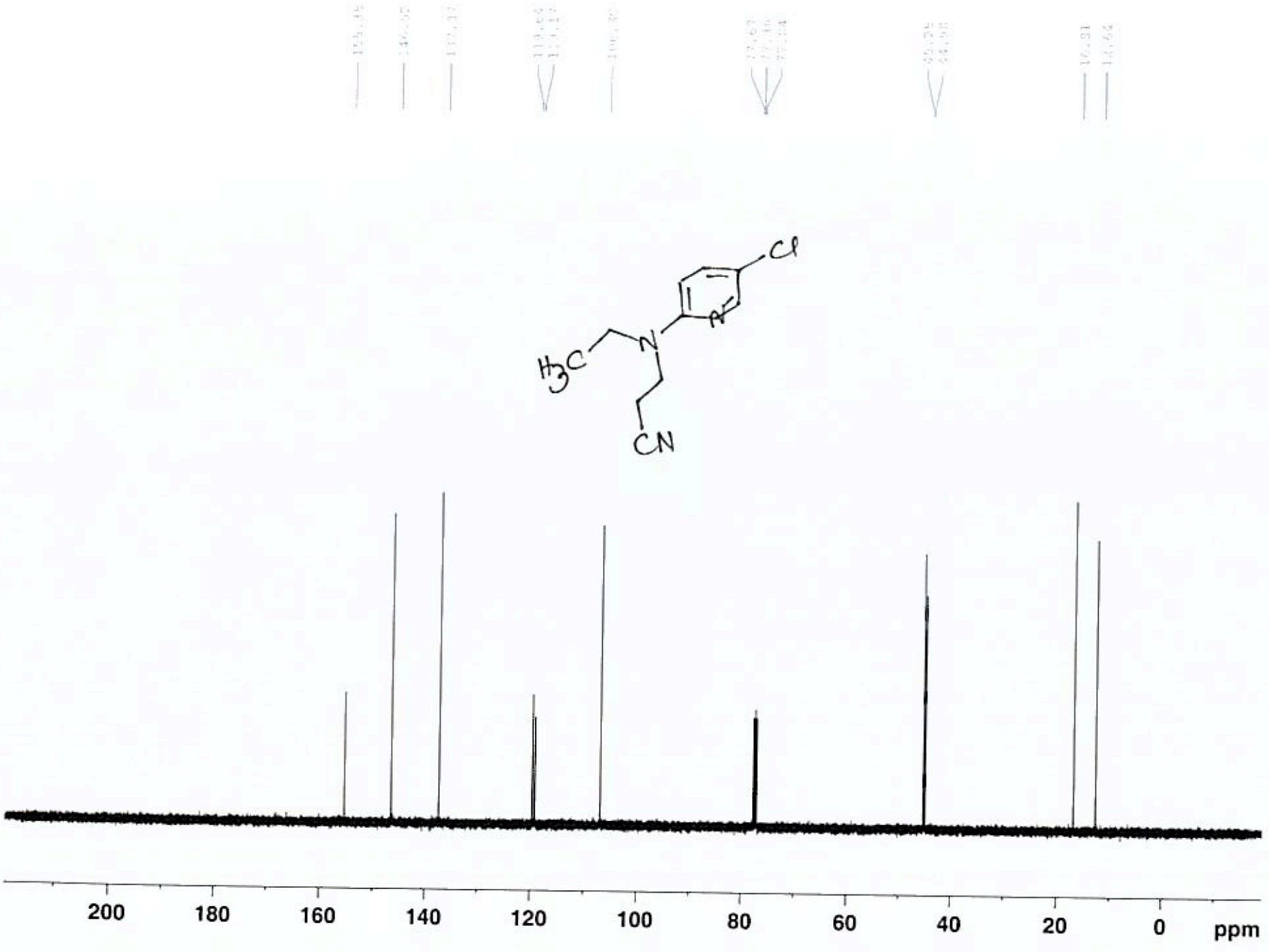
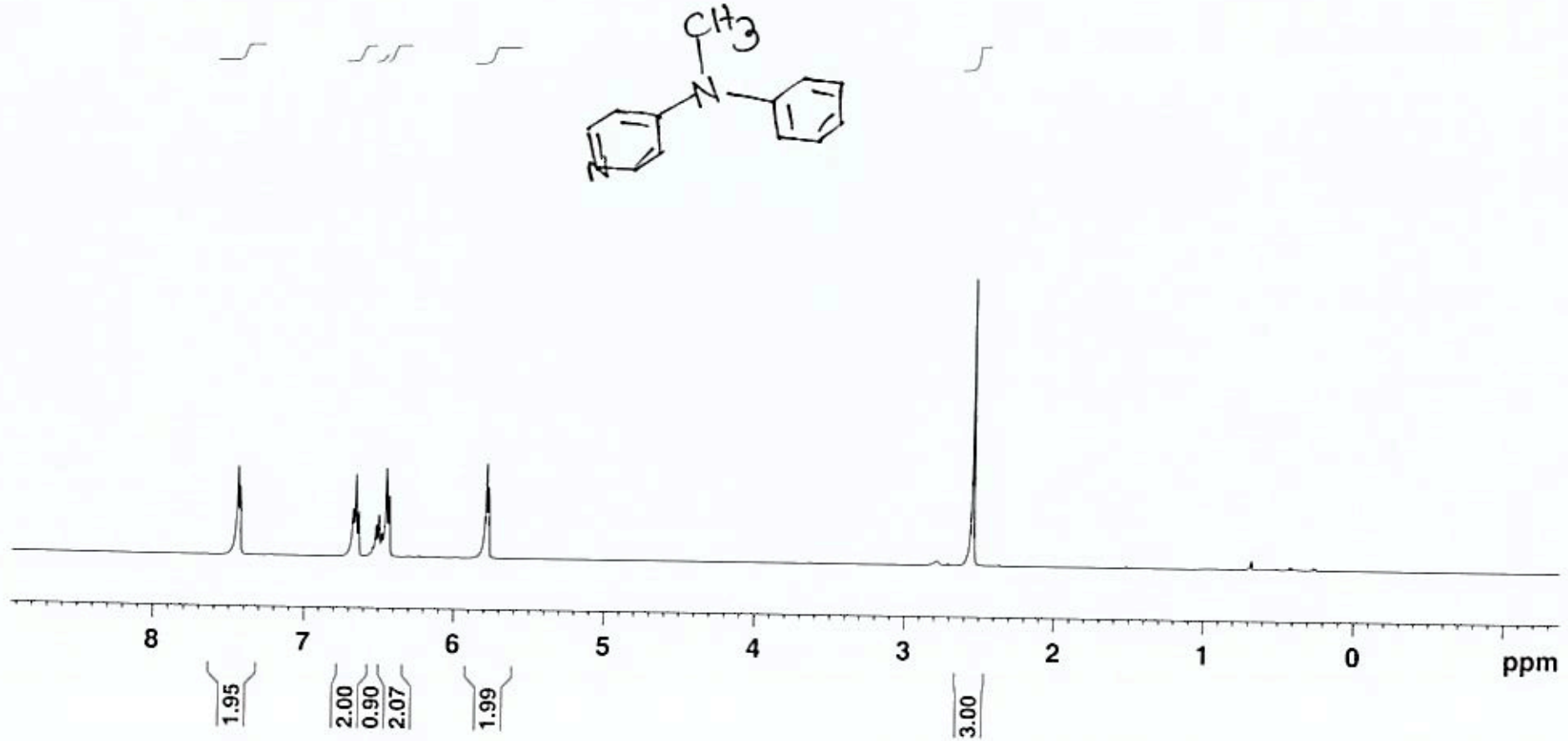
40
20
0
ppm


Cl
N
N
H3C
CN
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.06
1.10
2.20
2.30
2.27
3.52


Cl
N
H3C
CN
200
180
160
140
120
100
80
60
40
20
0
ppm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7
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4
3
2
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0
ppm
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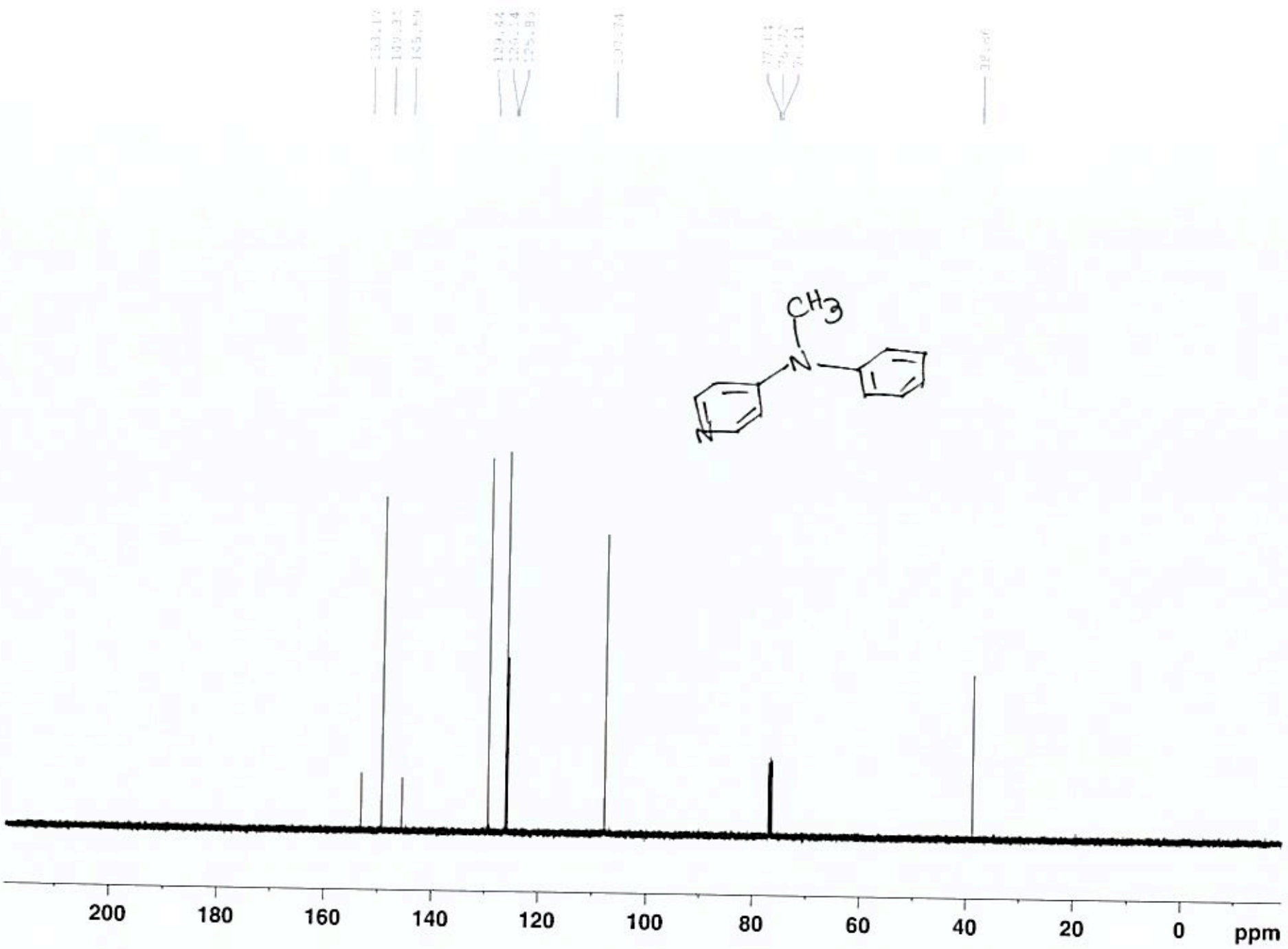
2.00
0.90
2.07
1.99
3.00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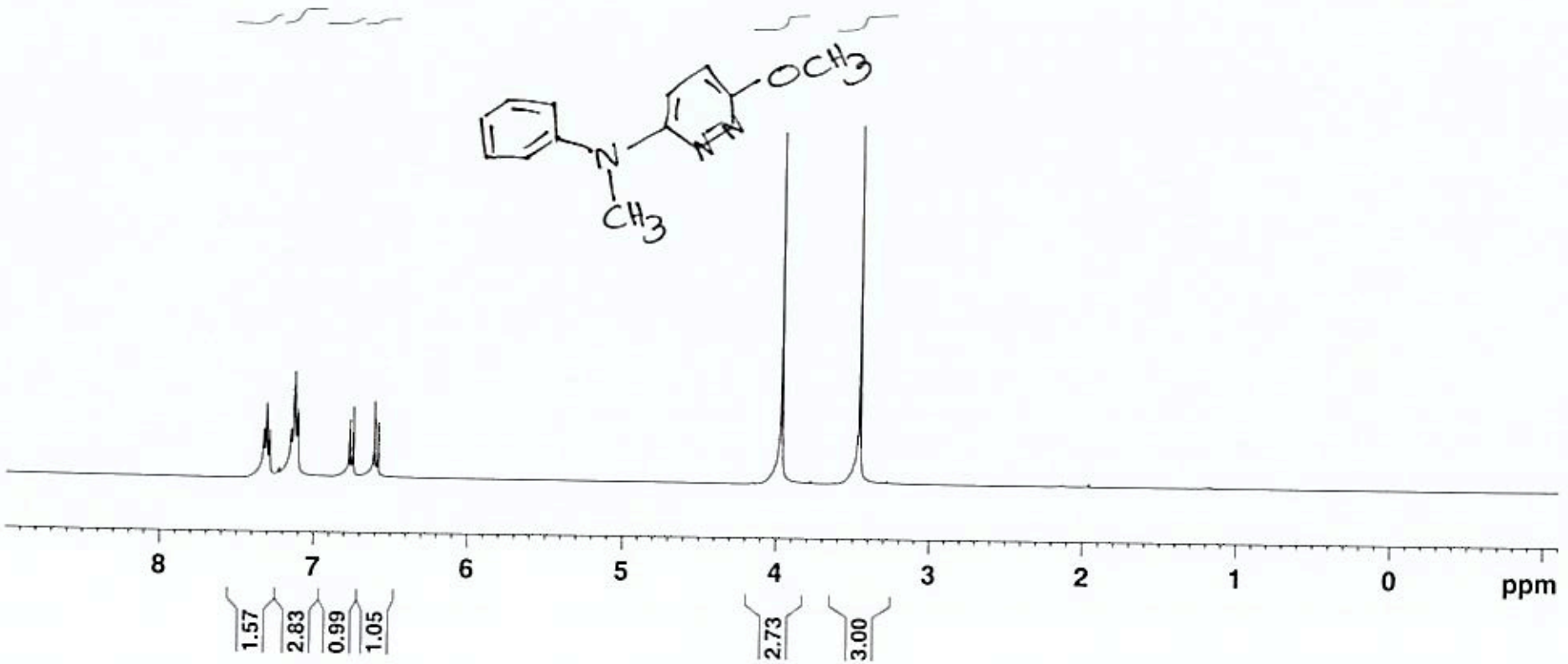

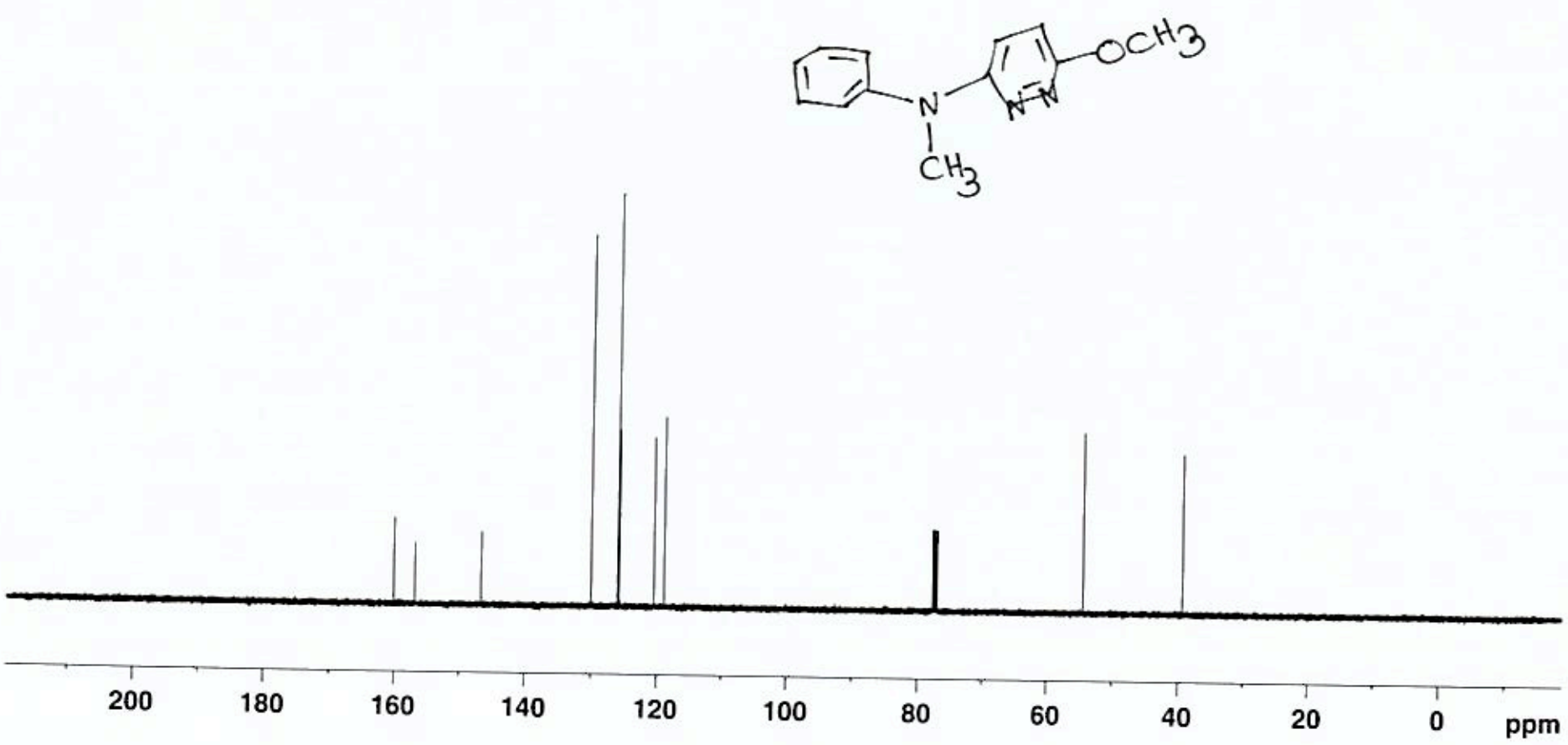

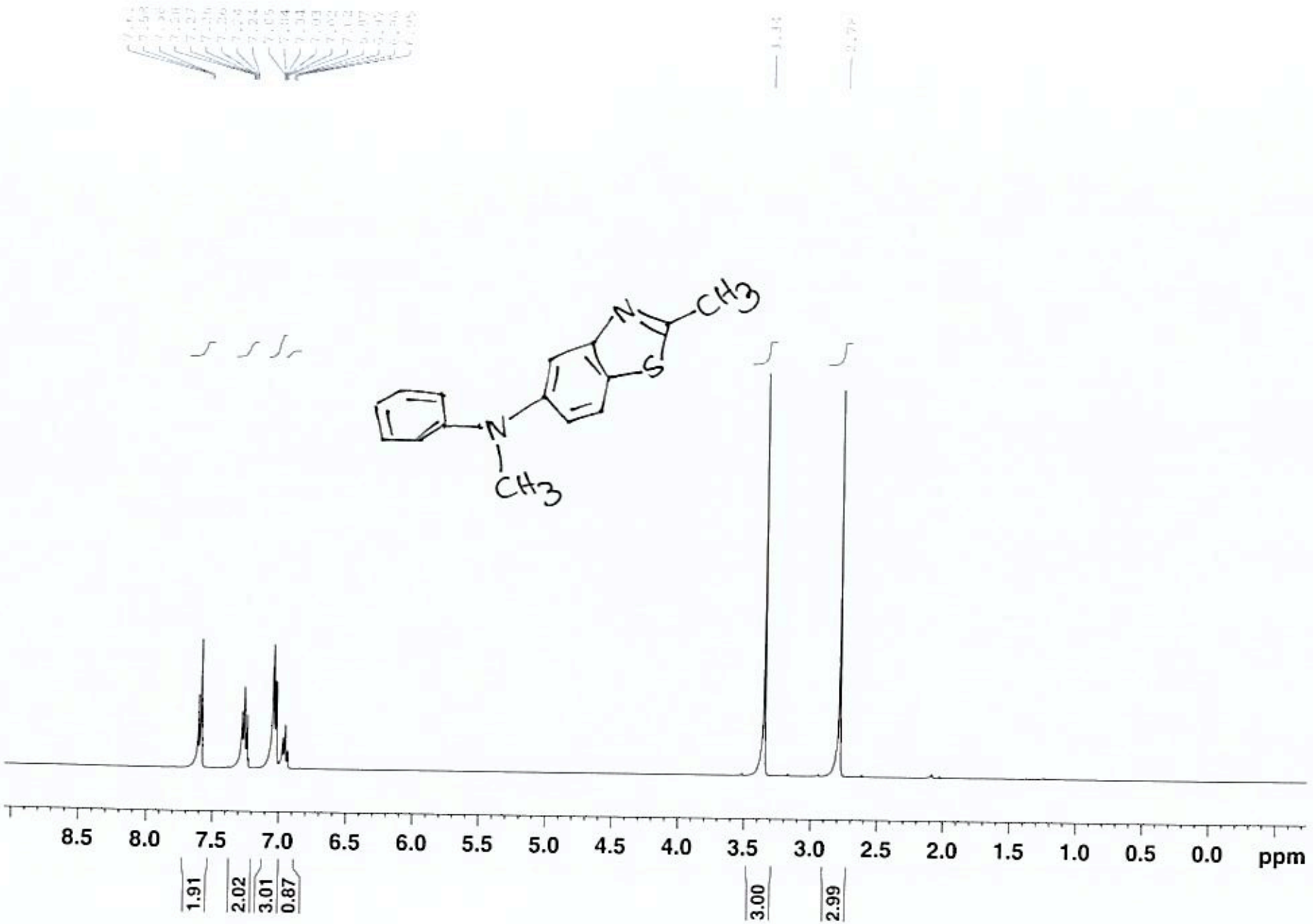
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CH3
S
N
CH3
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
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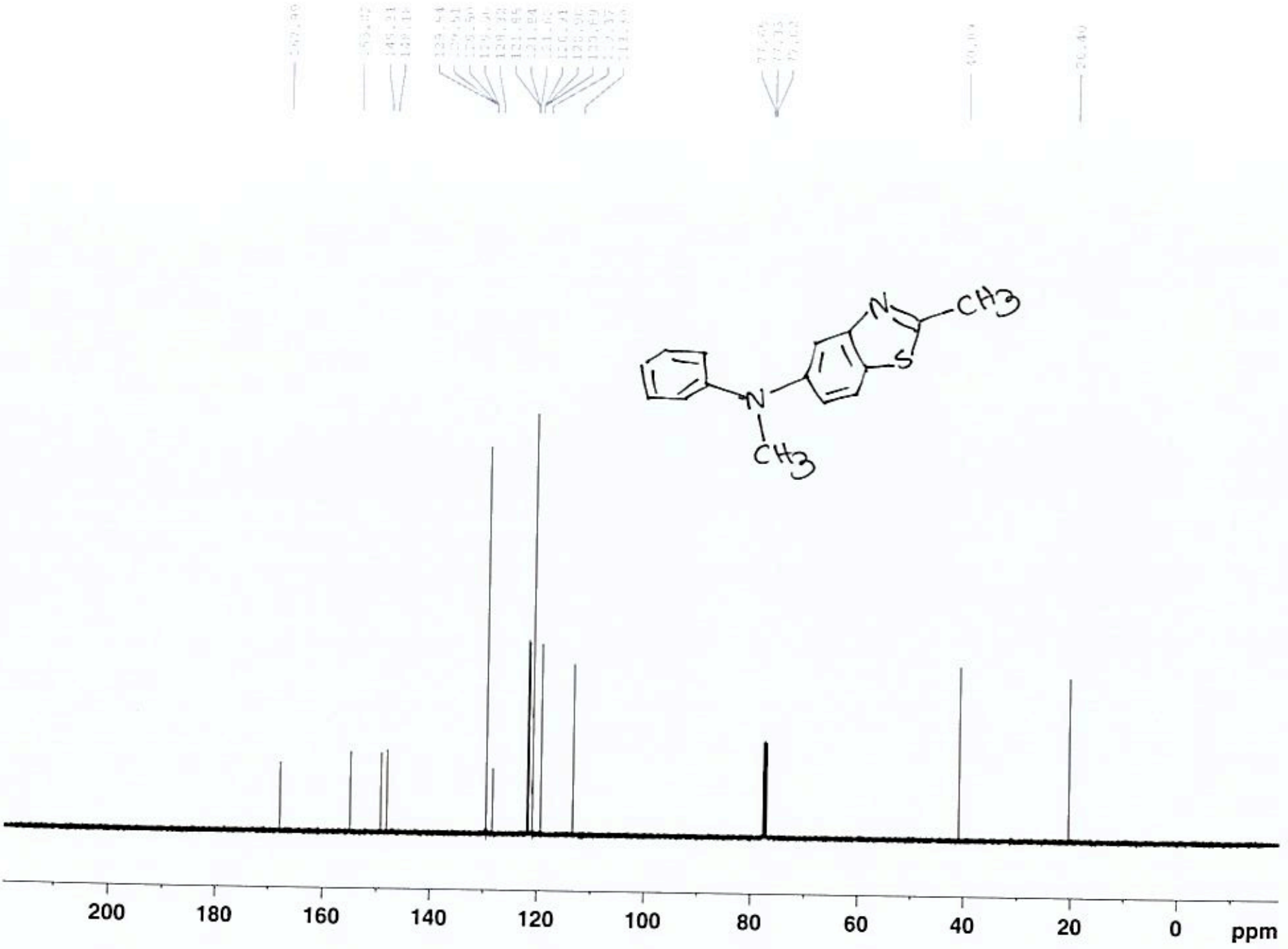
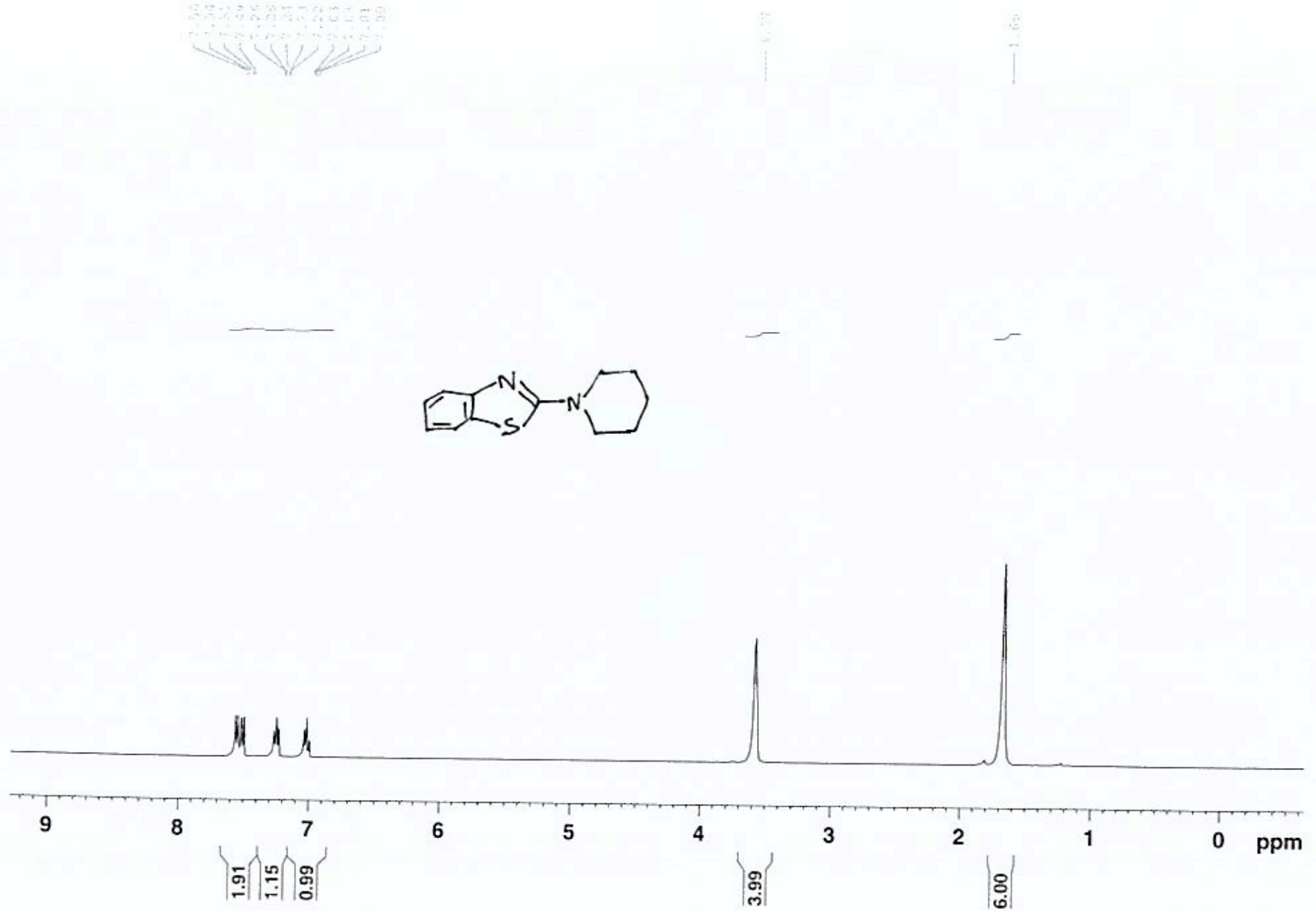
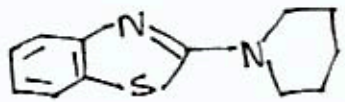
1.0
0.5
0.0
ppm
1.91
2.02
3.01
0.87
3.00
2.99


N
CH3
S
N
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

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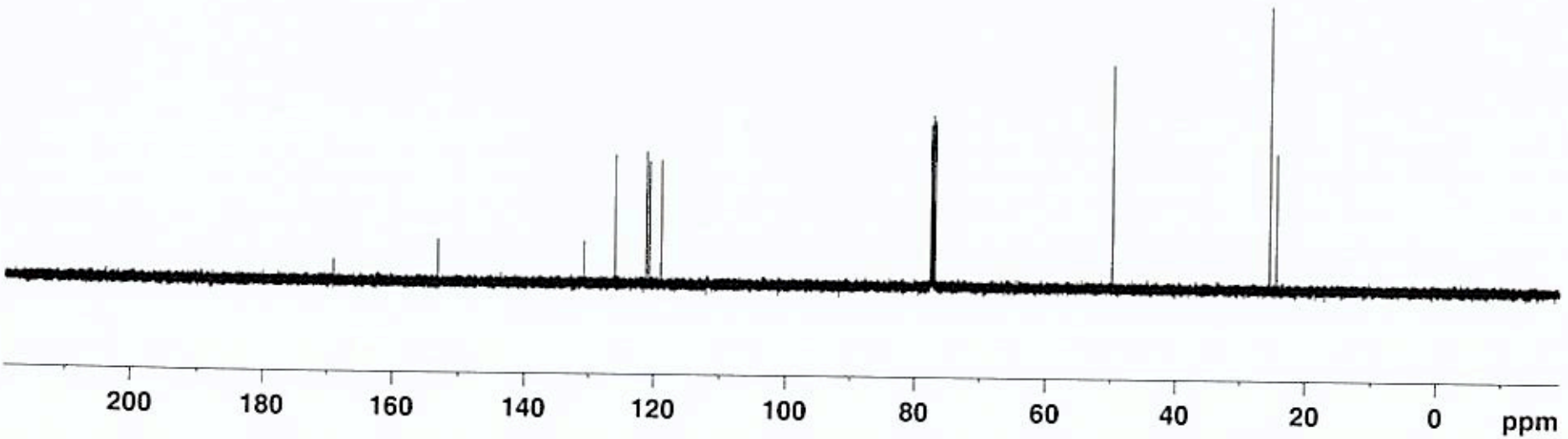
S
N


200
180
160
140
120
100
80
60
40
20
0
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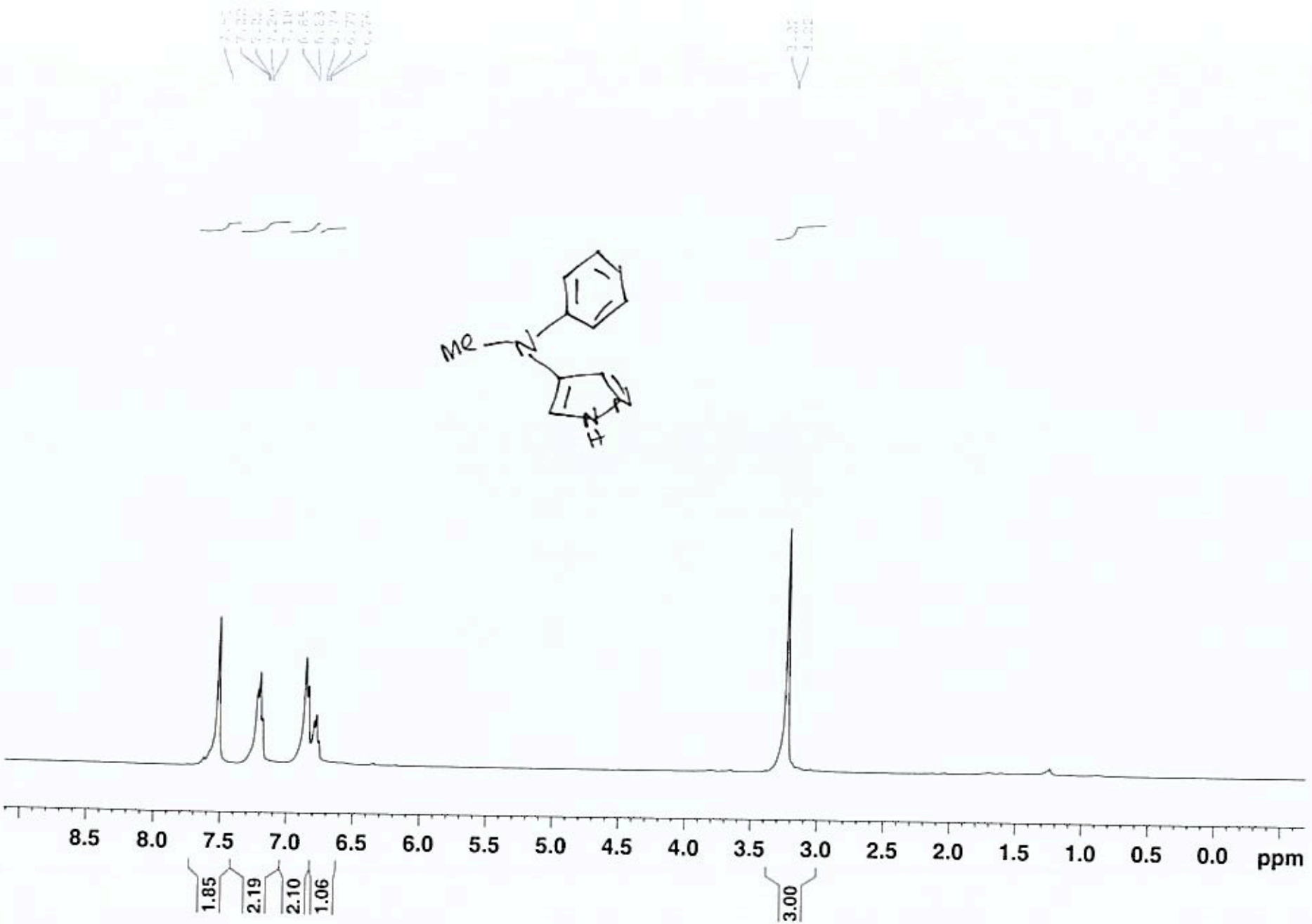
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N
N
H
8.5
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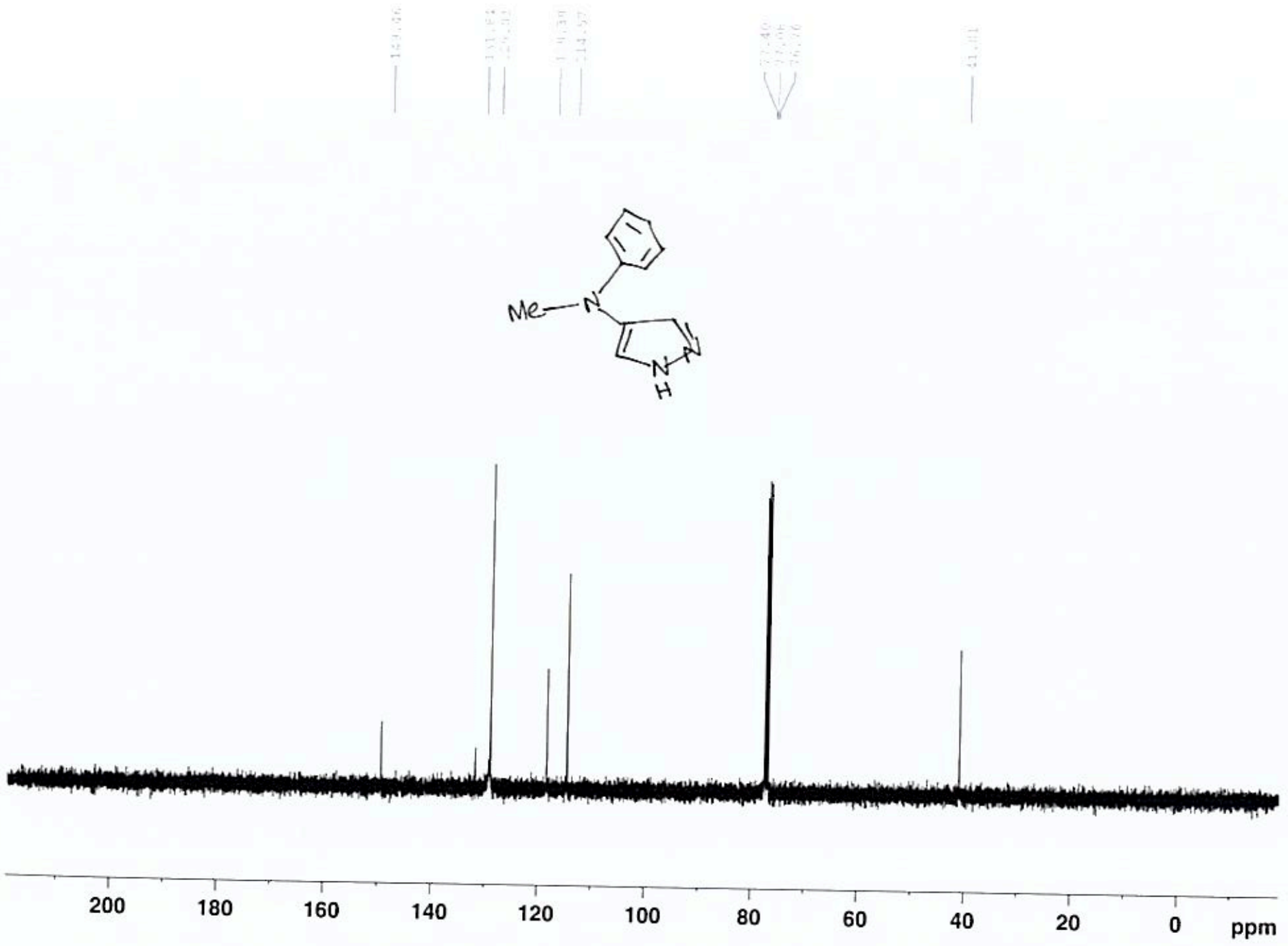
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
1.85
2.19
2.10
1.06
3.00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N
N
H
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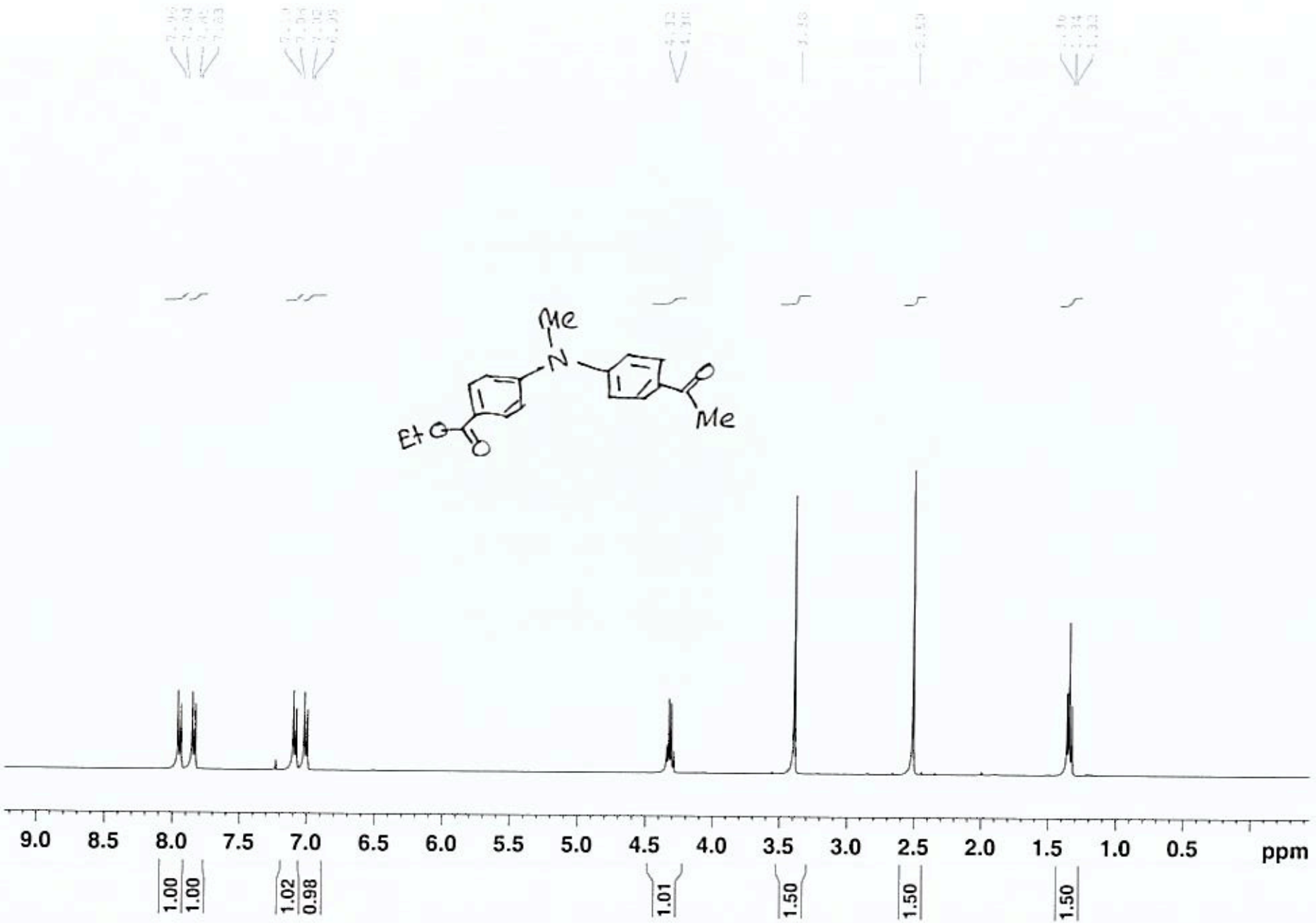
180
160
140
120
100
80
60
40
20
0
ppm


Me
N
Et O
O
Me
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
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0.5
ppm
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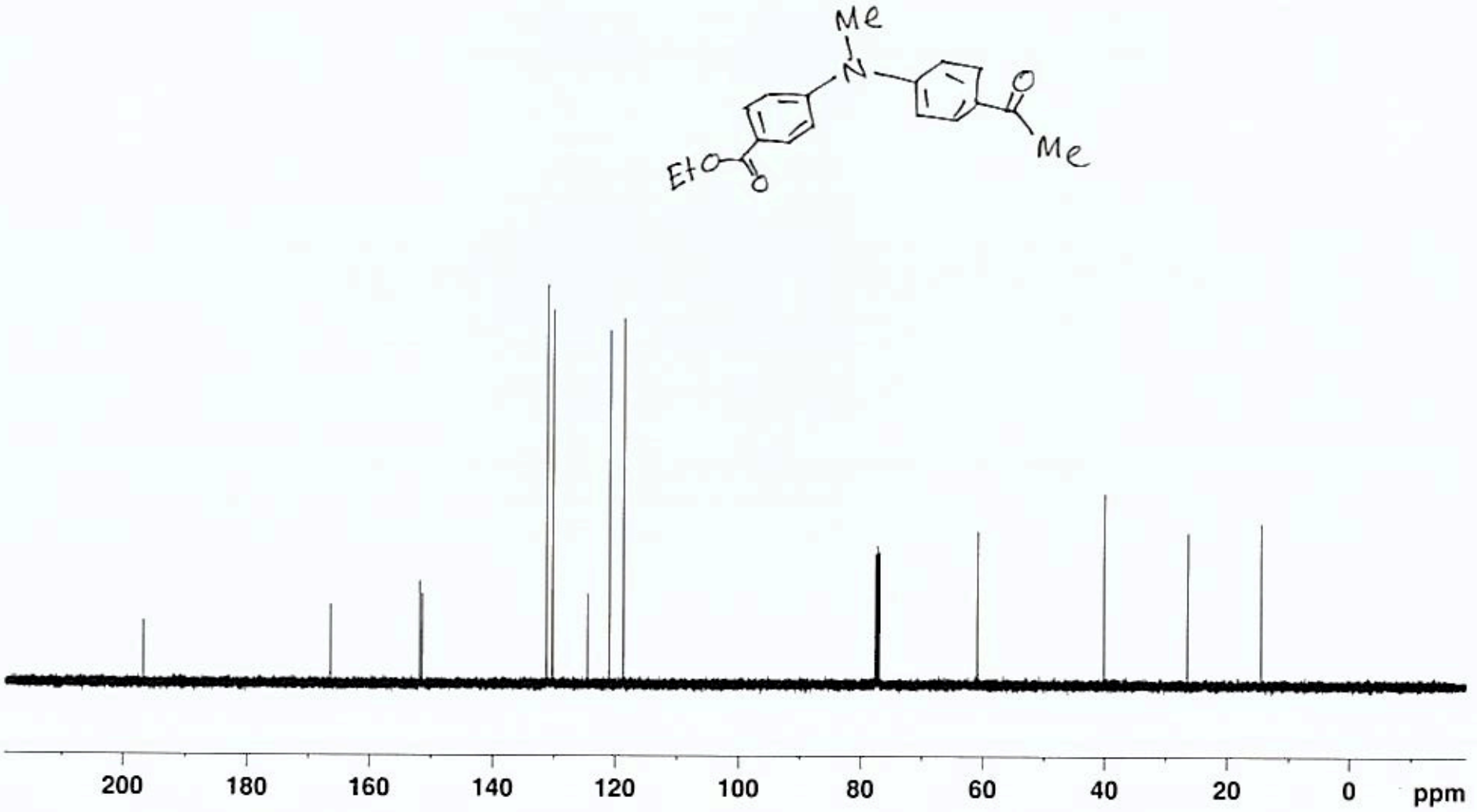
1.00
1.02
0.98
1.01
1.50
1.50
1.50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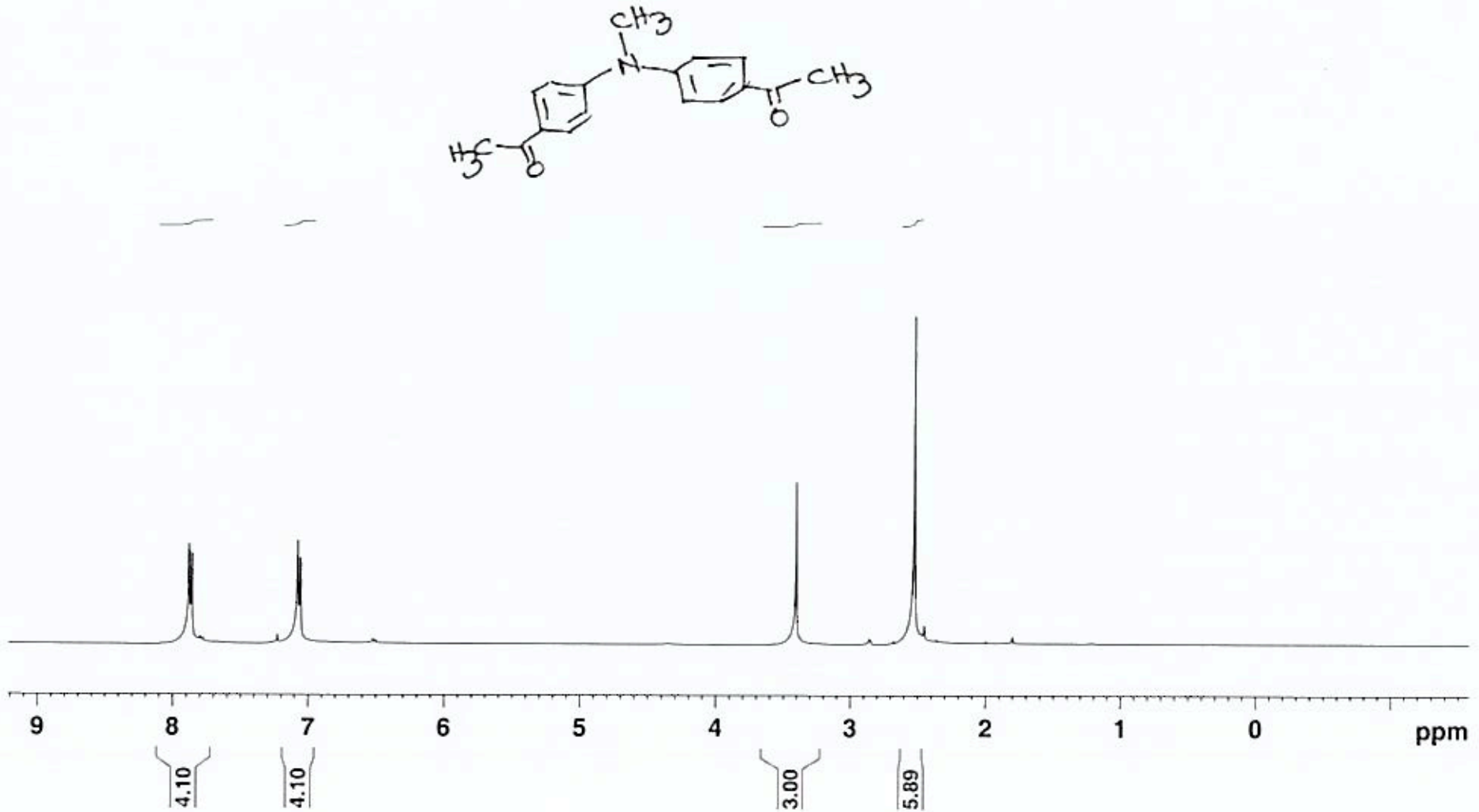
EtO
O
O
Me
200
180
160
140
120
100
80
60
40
20
0
ppm


CH3
N
CH3
O
H3C
O
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8
7
6
5
4
3
2
1
0
ppm
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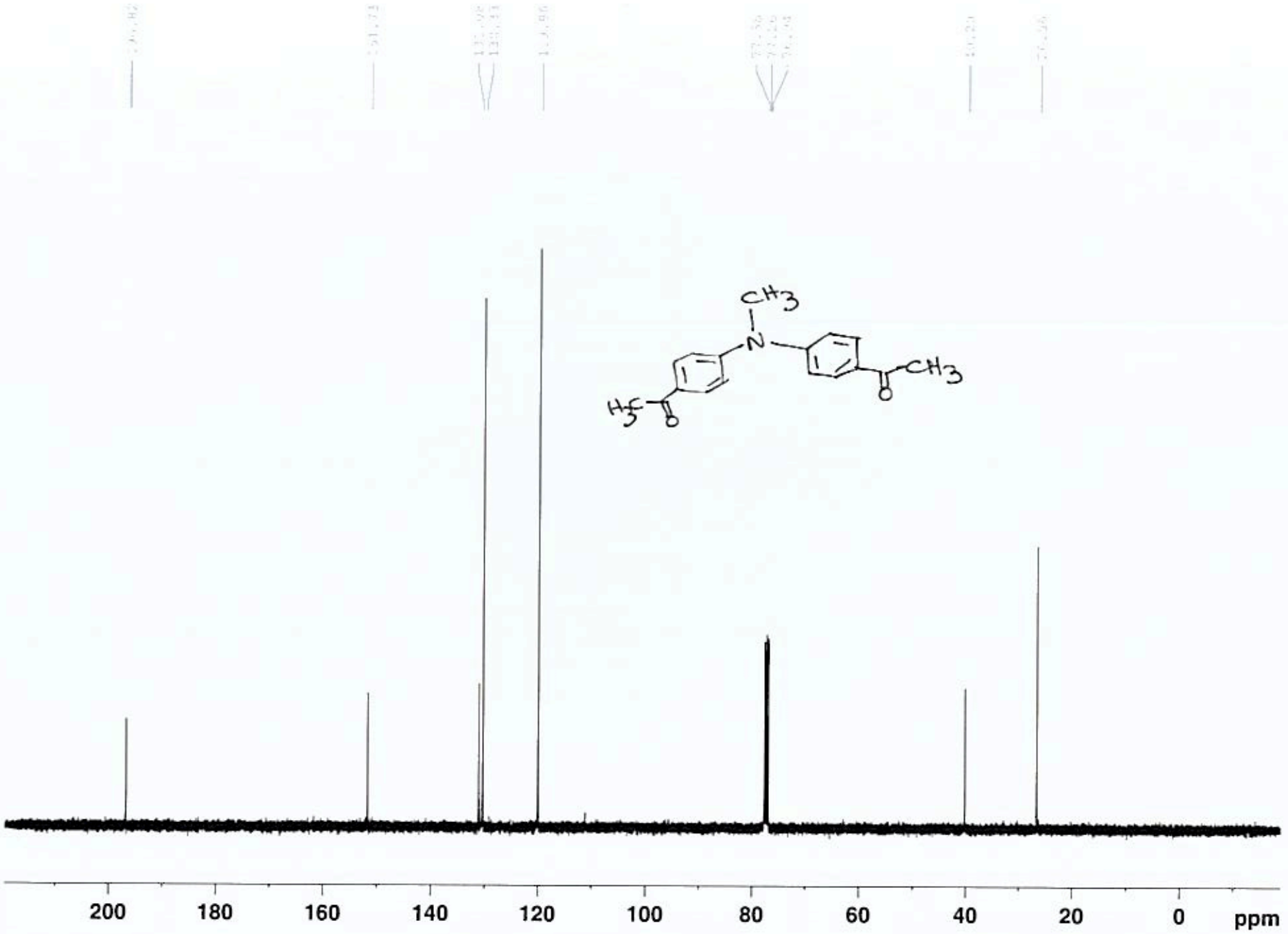
4.10
3.00
5.89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CH3
H3C
O
O
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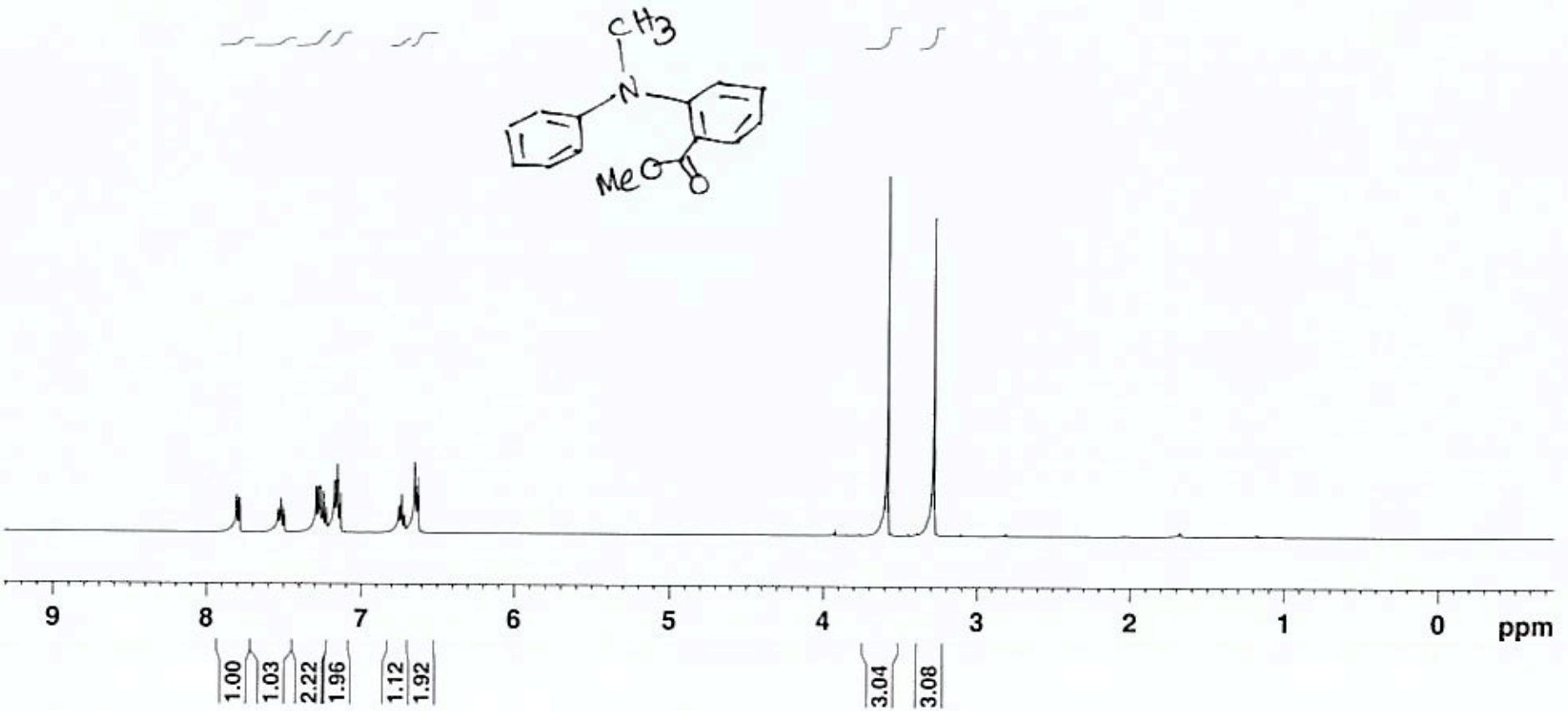
160
140
120
100
80
60
40
20
0
ppm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MeO
O
9
8
7
6
5
4
3
2
1
0
ppm
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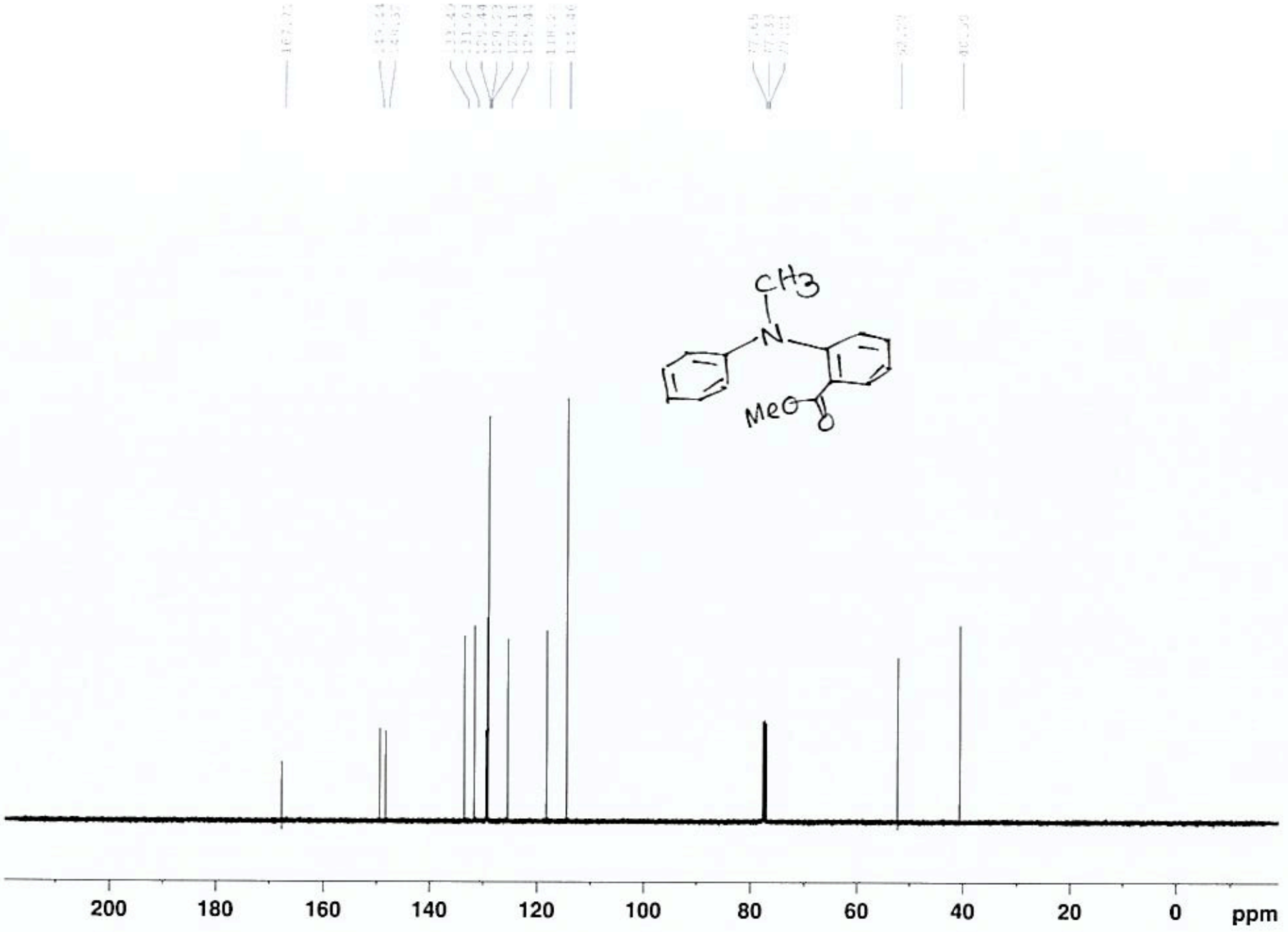
1.03
2.22
1.96
1.12
1.92
3.04
3.08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MeO
O
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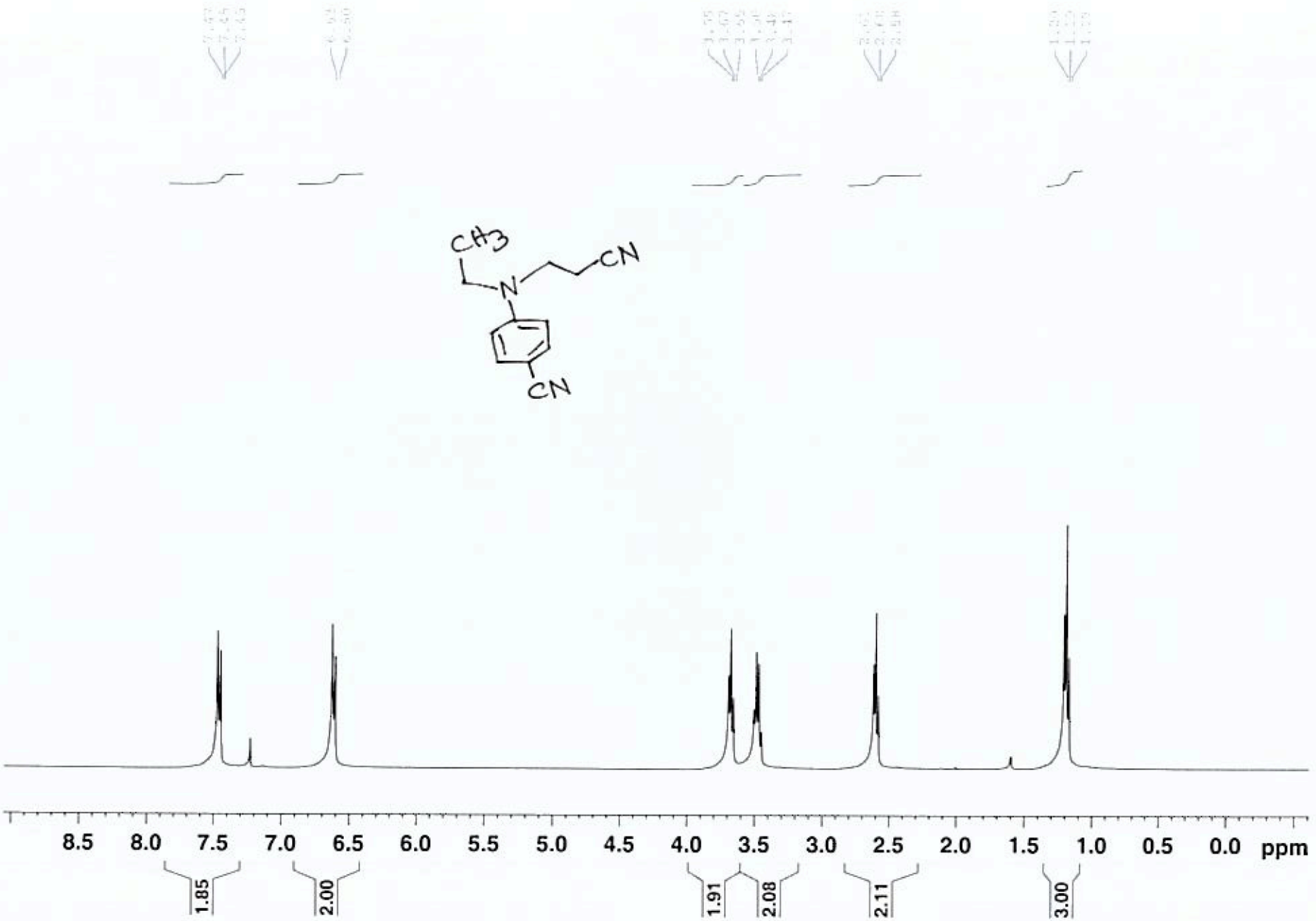
180
160
140
120
100
80
60
40
20
0
ppm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CN
CN
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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
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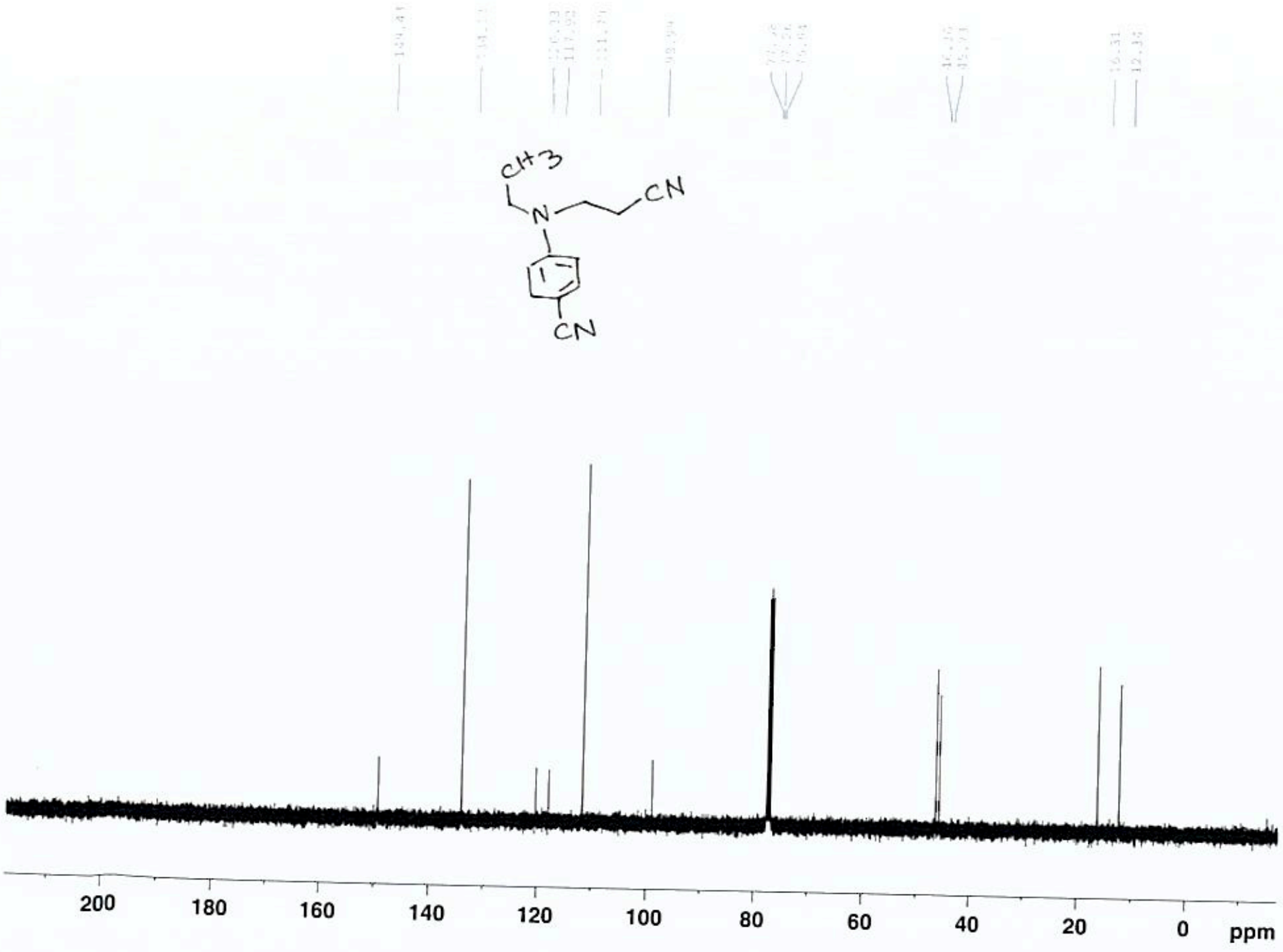
2.00
1.91
2.08
2.11
3.00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CN
CN
200
180
160
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120
100
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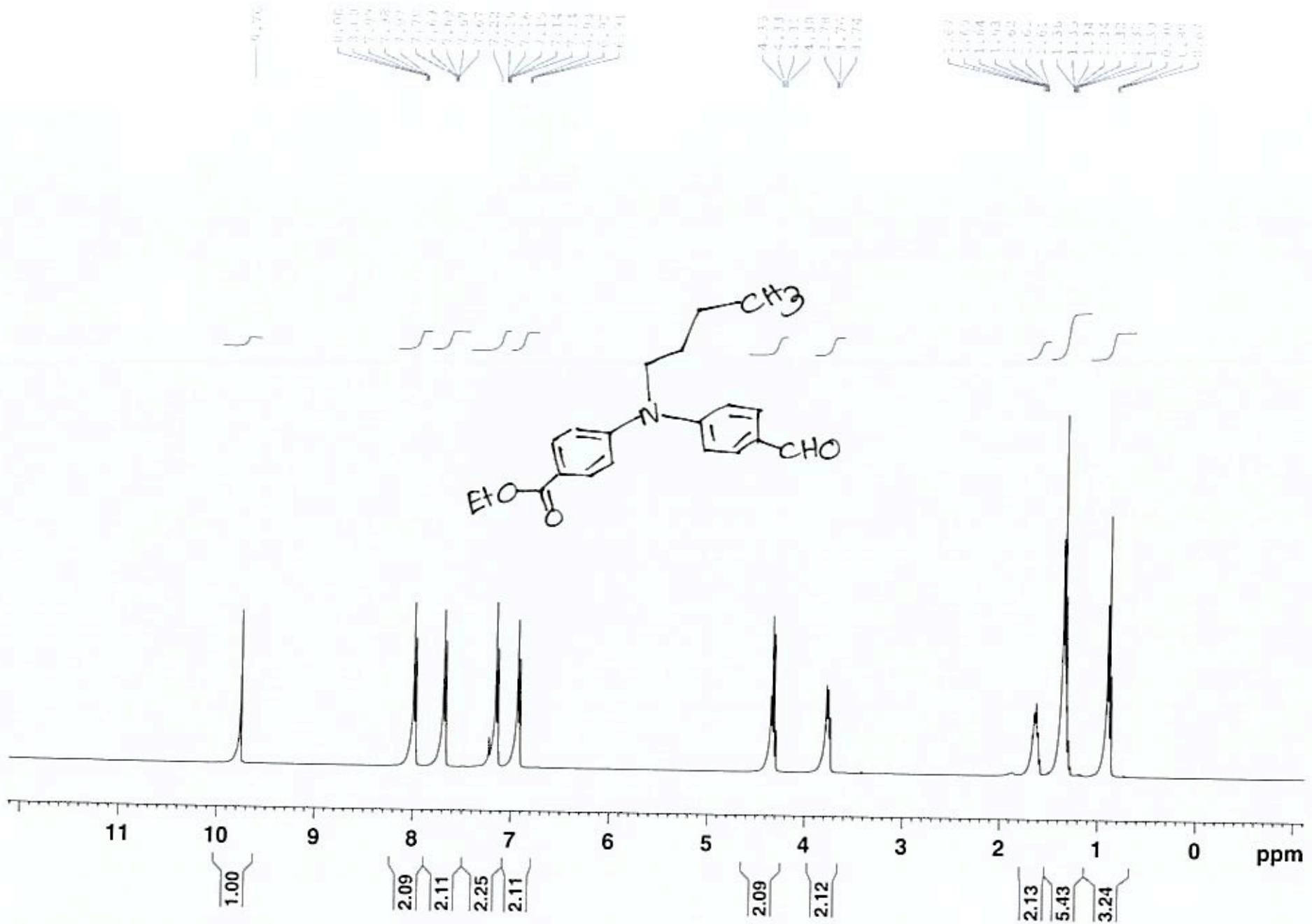
40
20
0
ppm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CHO
EtO
O
11
10
9
8
7
6
5
4
3
2
1
0
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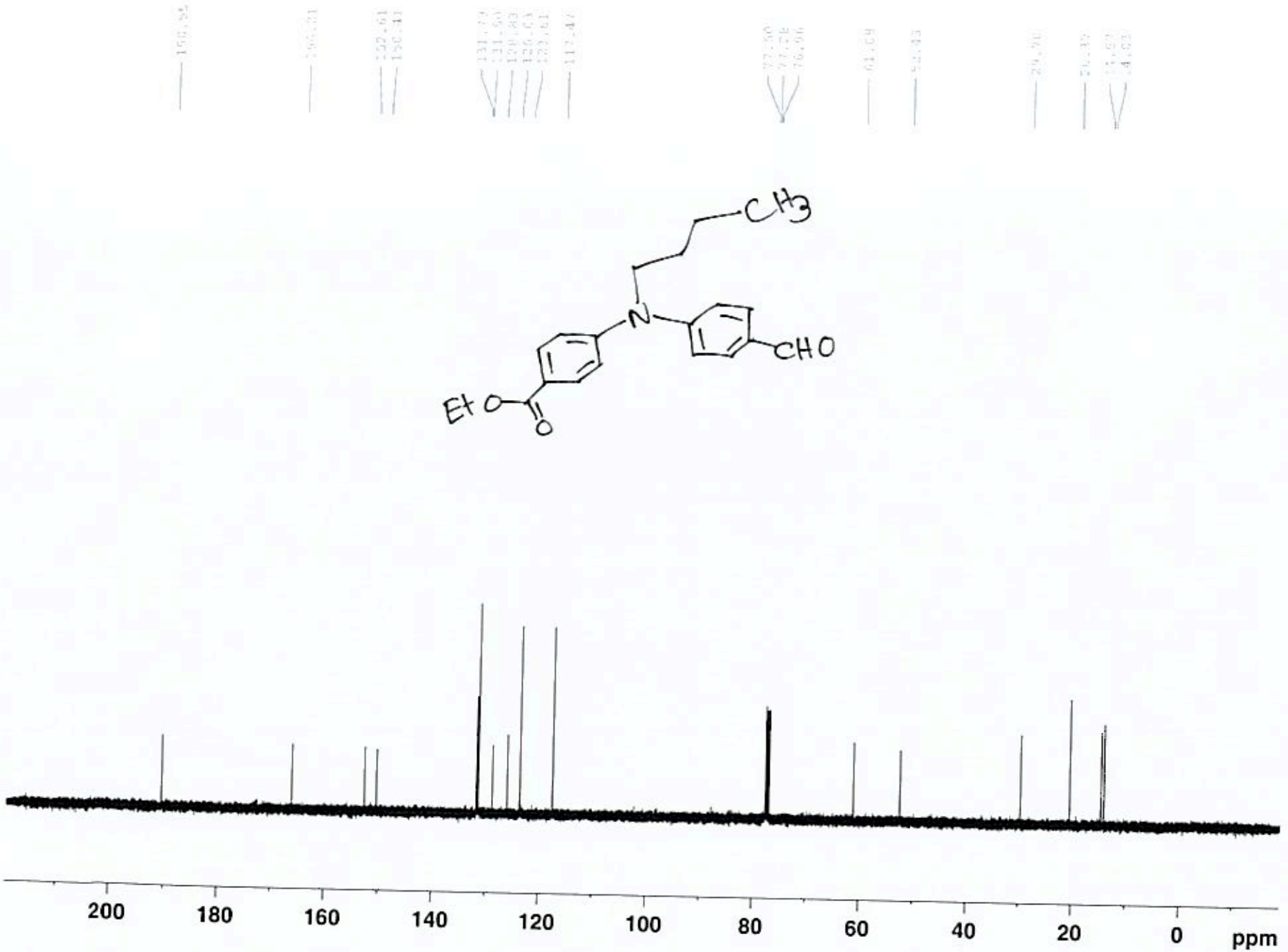
2.09
2.11
2.25
2.11
2.09
2.12
2.13
5.43
3.24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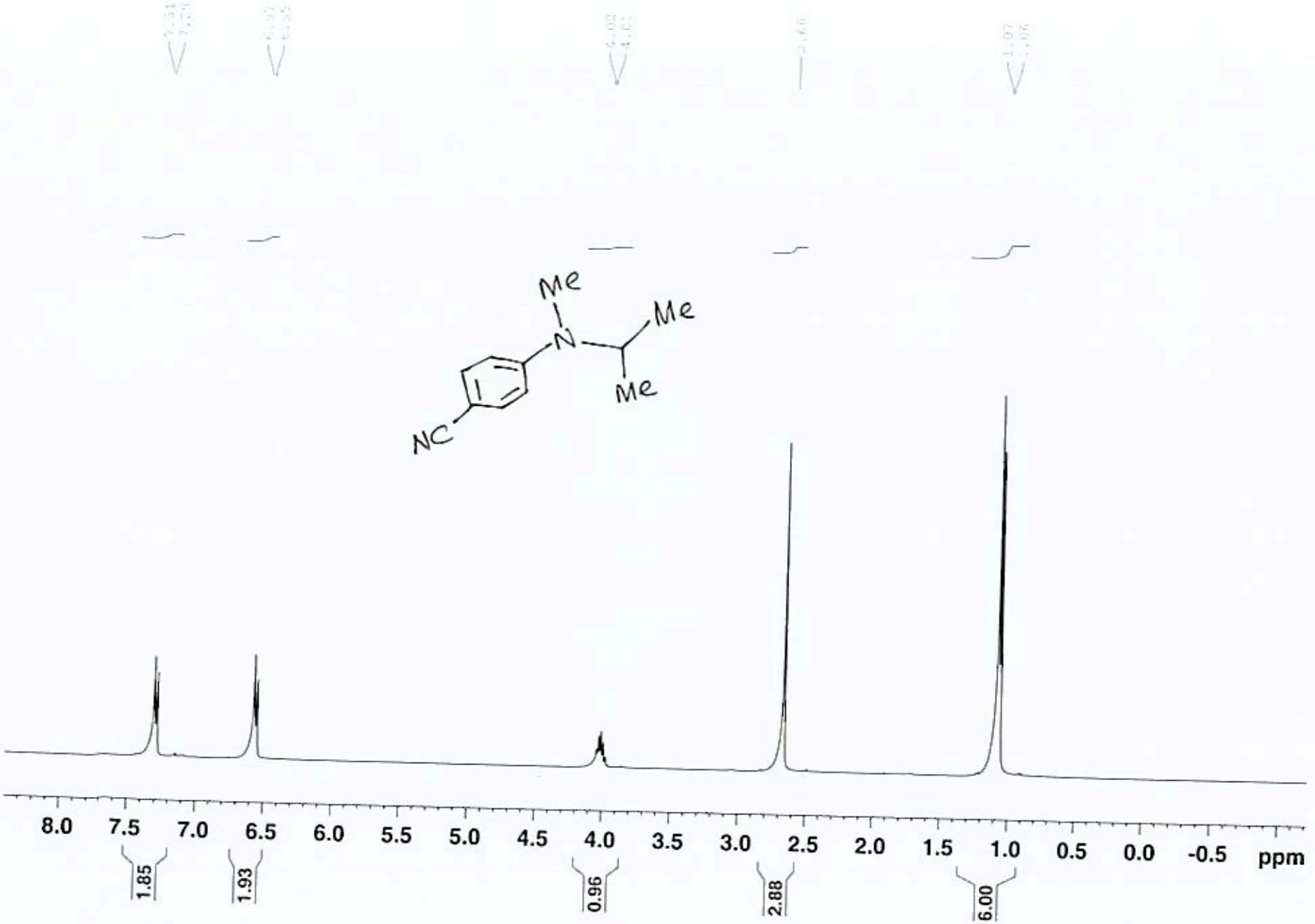
N
CHO
Et O
O
200
180
160
140
120
100
80
60
40
20
0
ppm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Me
Me
NC
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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
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1.0
0.5
0.0
-0.5
ppm
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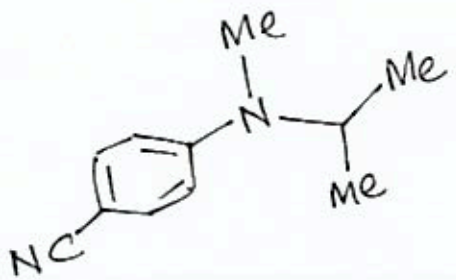
0.96
2.88
6.00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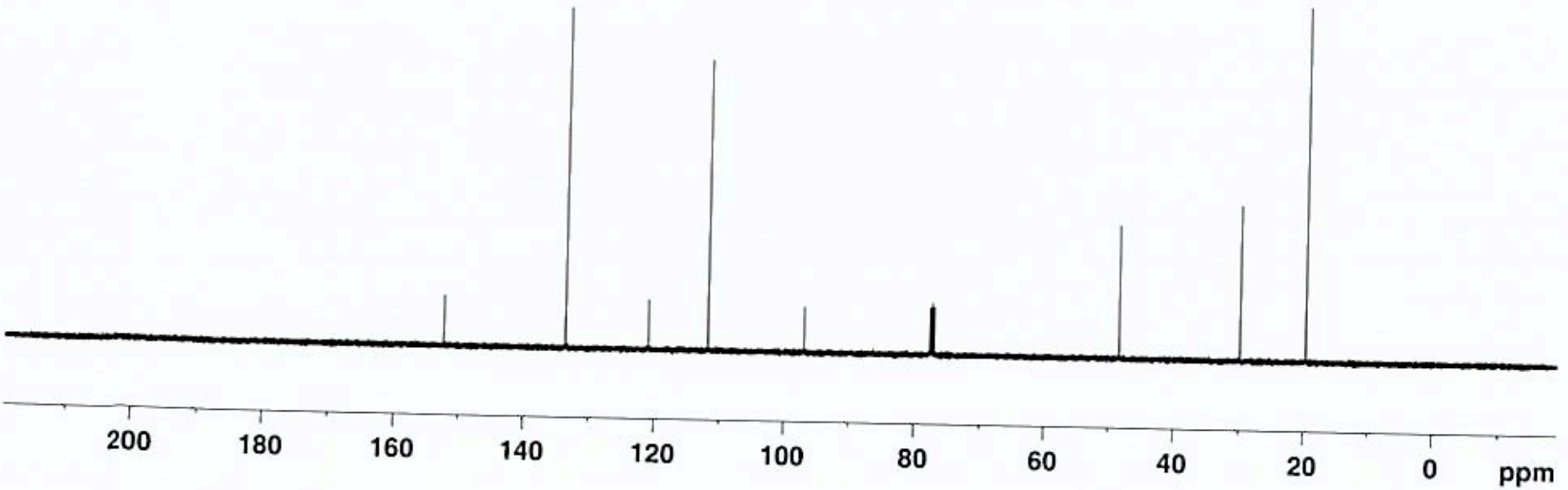
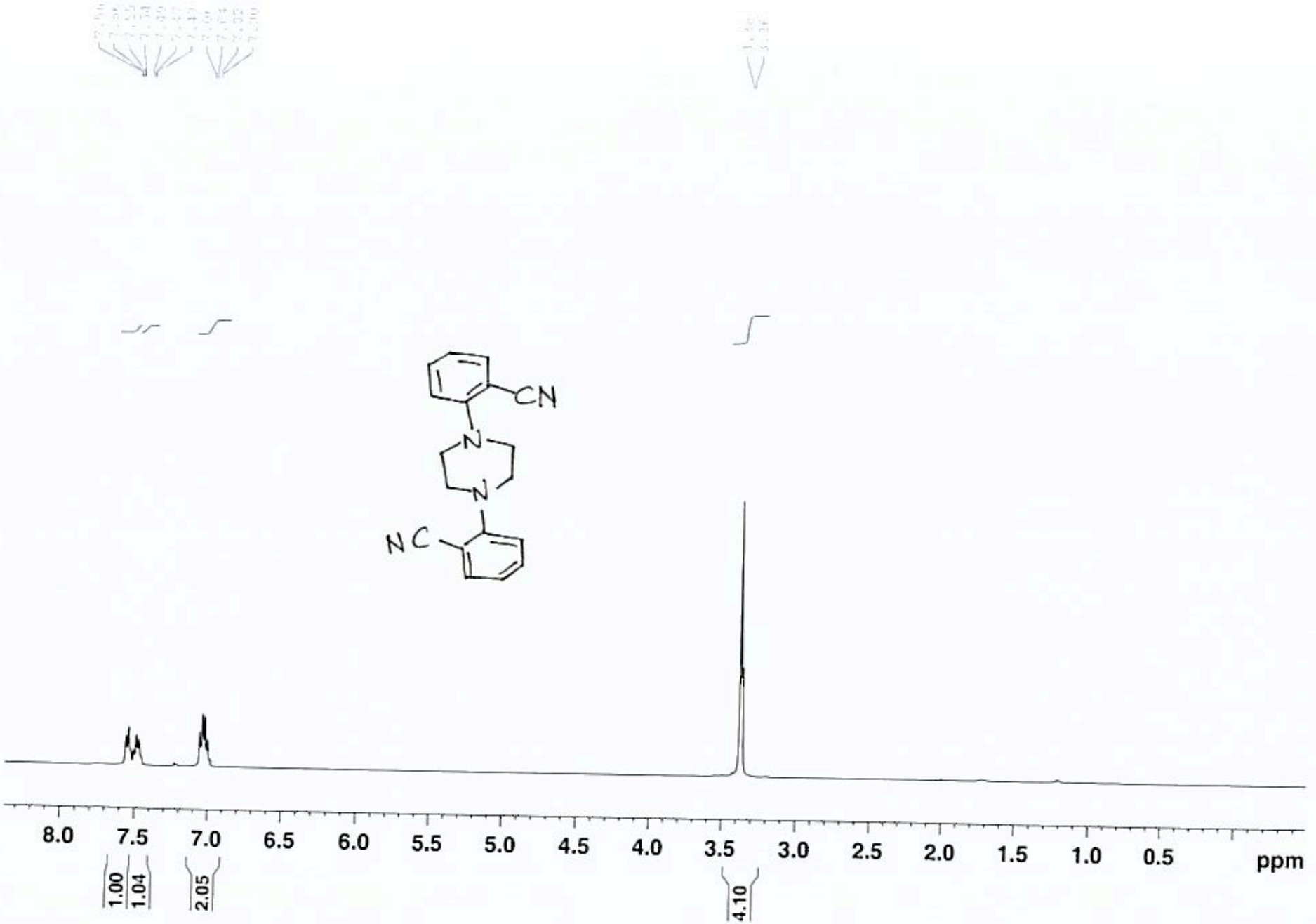
N
Me
Me
NC


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


CN
N
N
NC
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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
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2.5
2.0
1.5
1.0
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ppm
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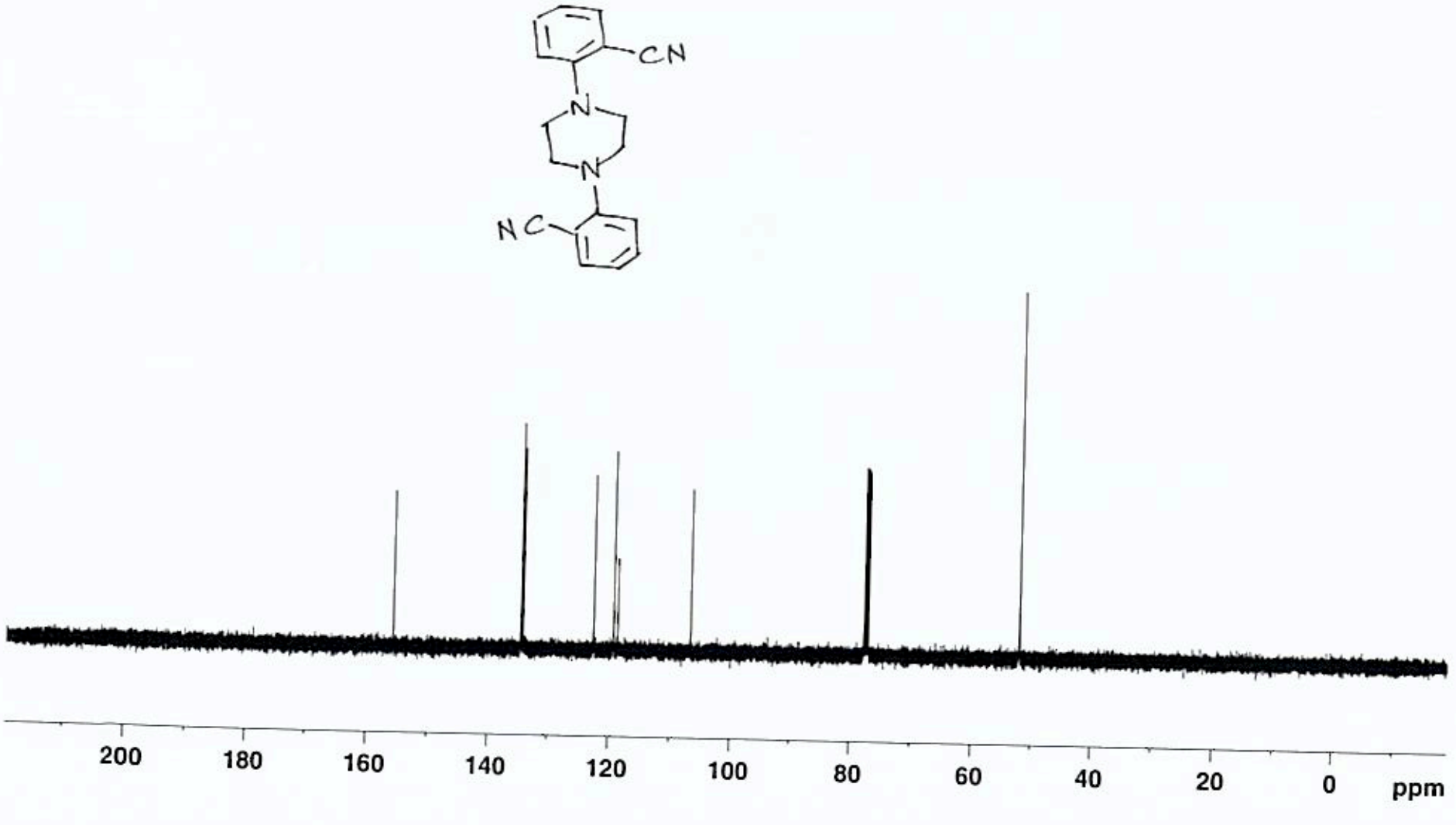
2.05
4.10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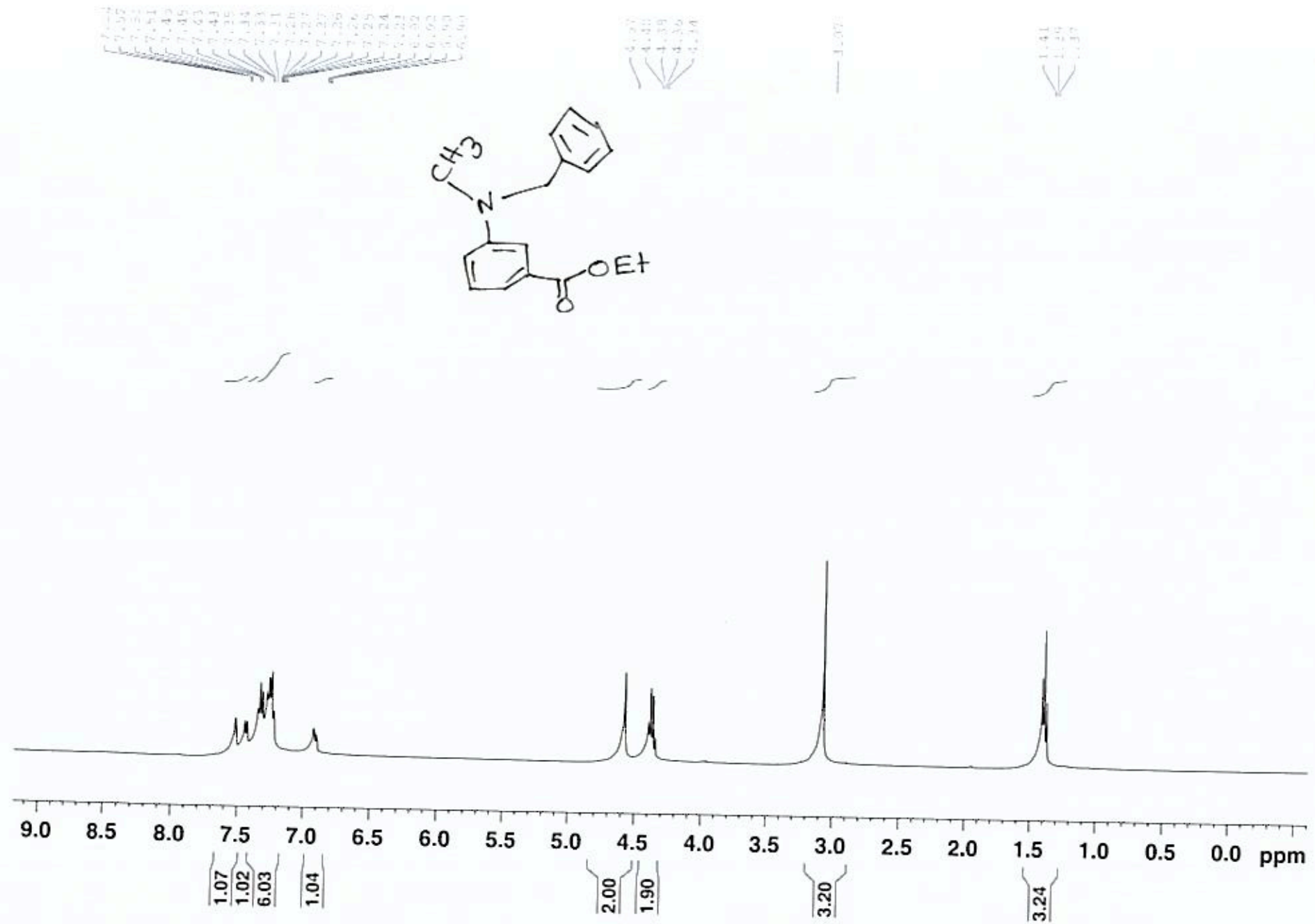
N
NC
200
180
160
140
120
100
80
60
40
20
0
ppm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N
OEt
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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
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0.0
ppm
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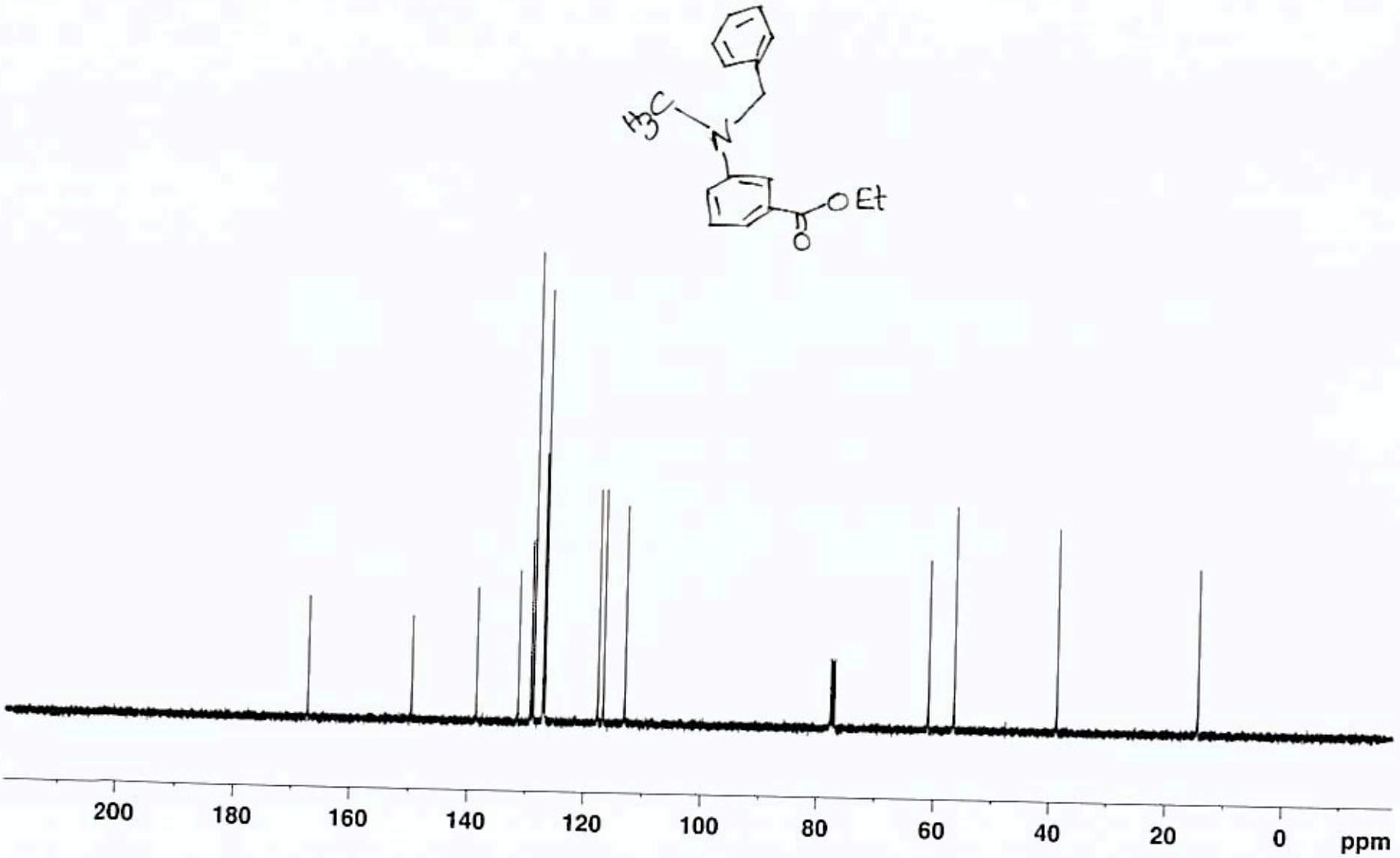
1.02
6.03
1.04
2.00
1.90
3.20
3.24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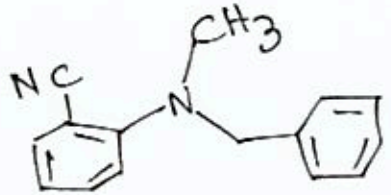
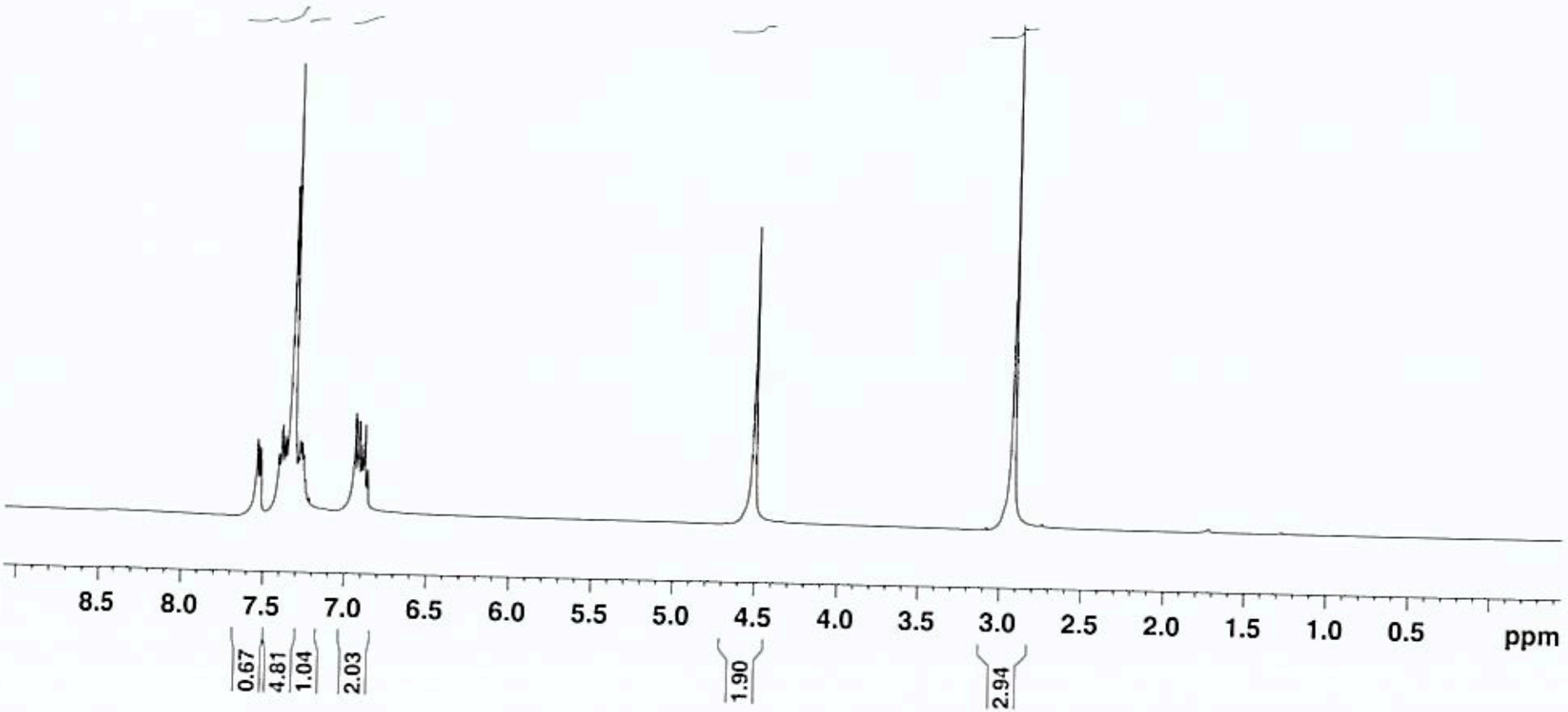
N
O
Et
O
200
180
160
140
120
100
80
60
40
20
0
ppm


CH3
NC
N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7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
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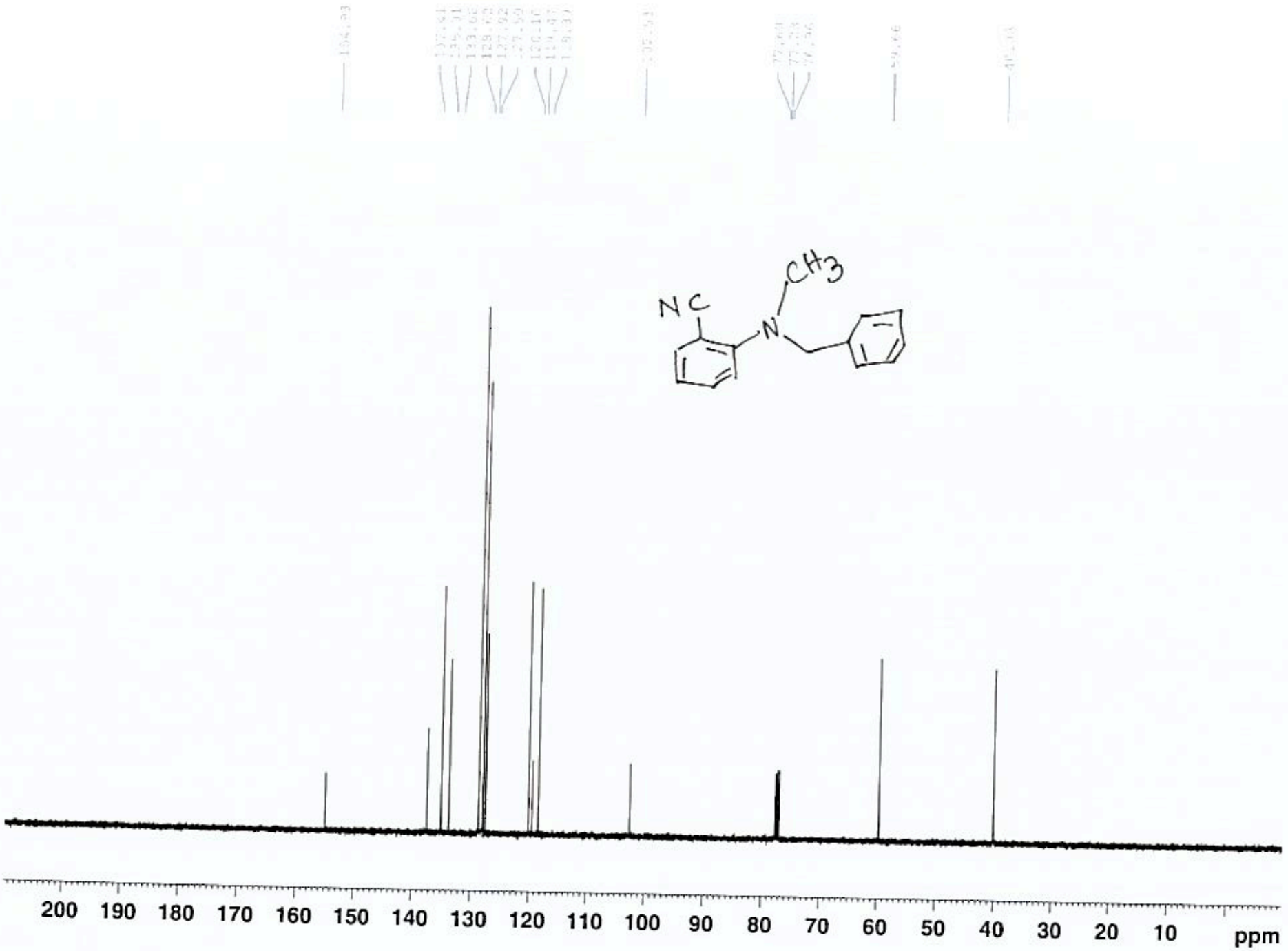
2.94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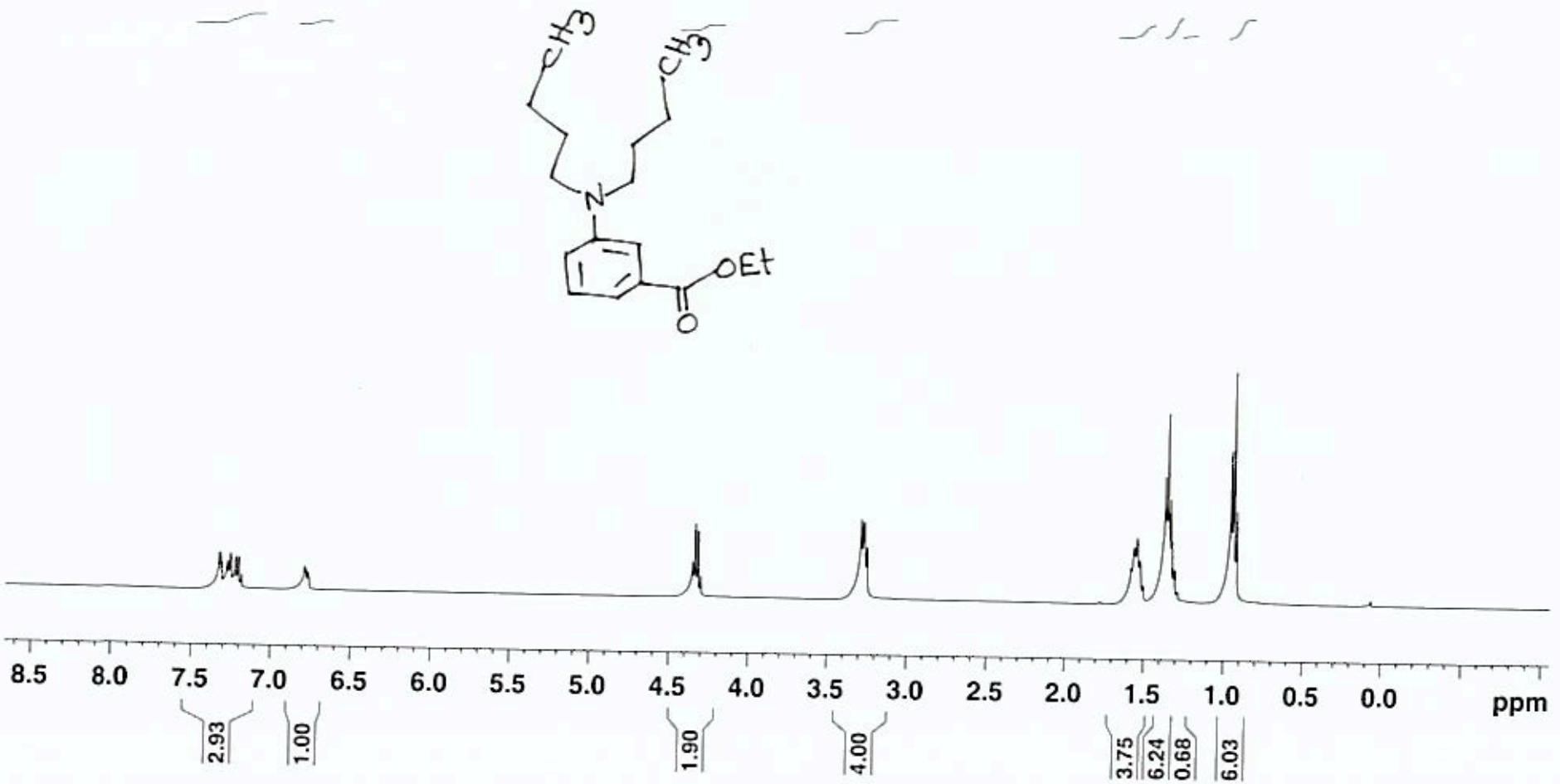
NC
N
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
ppm


CH3
CH3
N
OEt
O
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
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0.0
ppm
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1.90
4.00
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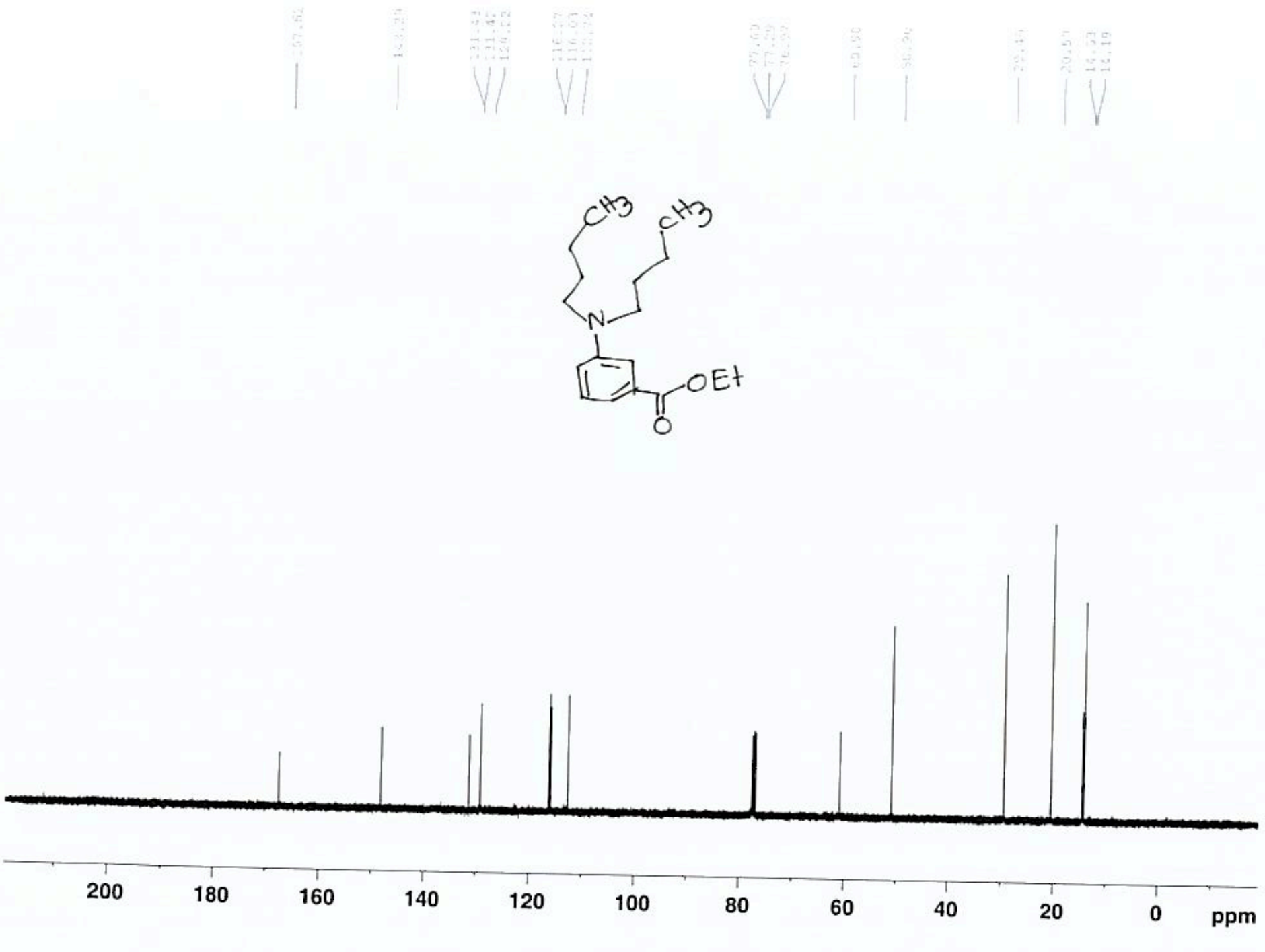
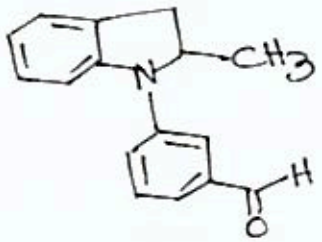
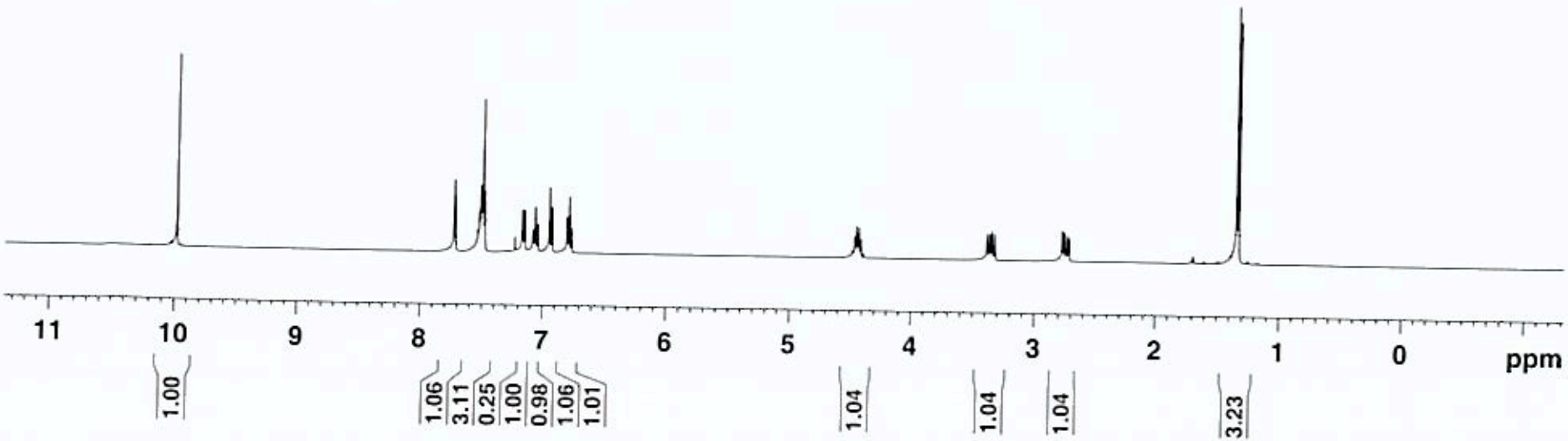
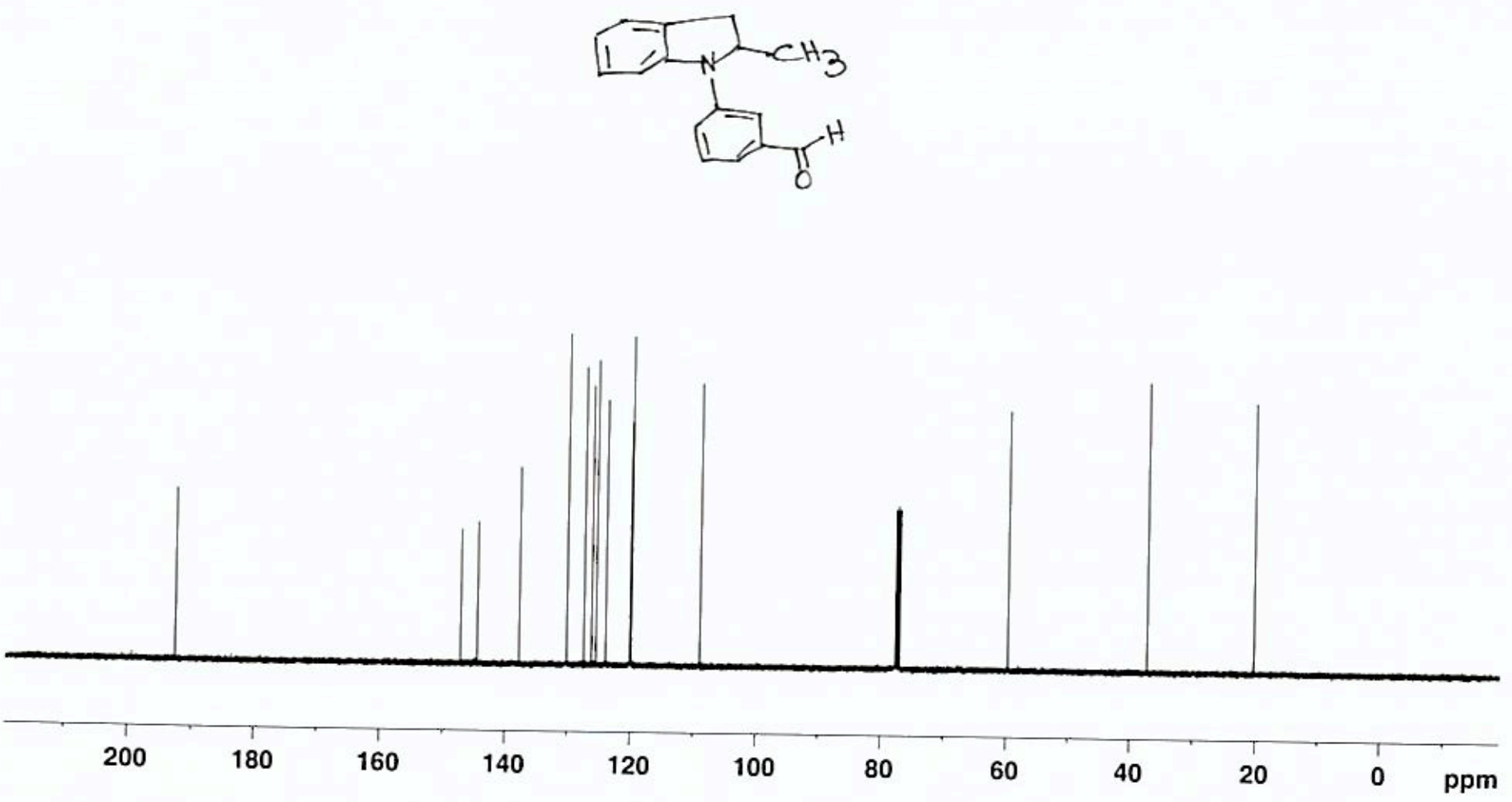
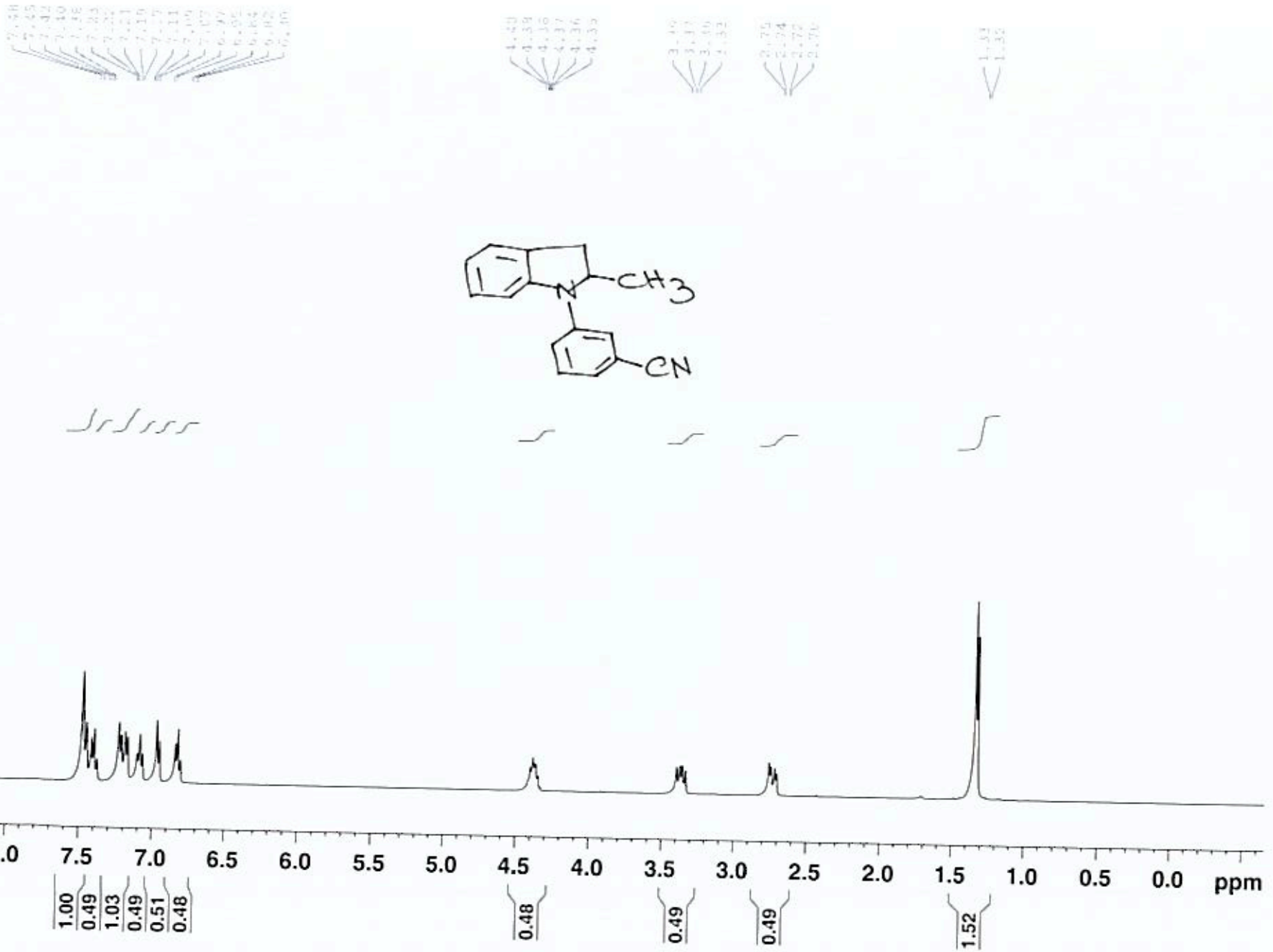
0.68
6.03


CH3
CH3
N
OEt
O
200
180
160
140
120
100
80
60
40
20
0
ppm


CH3
N
H
O


11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.06
3.11
0.25
1.00
0.98
1.06
1.01
1.04
1.04
1.04
3.23


CH3
N
H
O
200
180
160
140
120
100
80
60
40
20
0
ppm


CH3
N
CN
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
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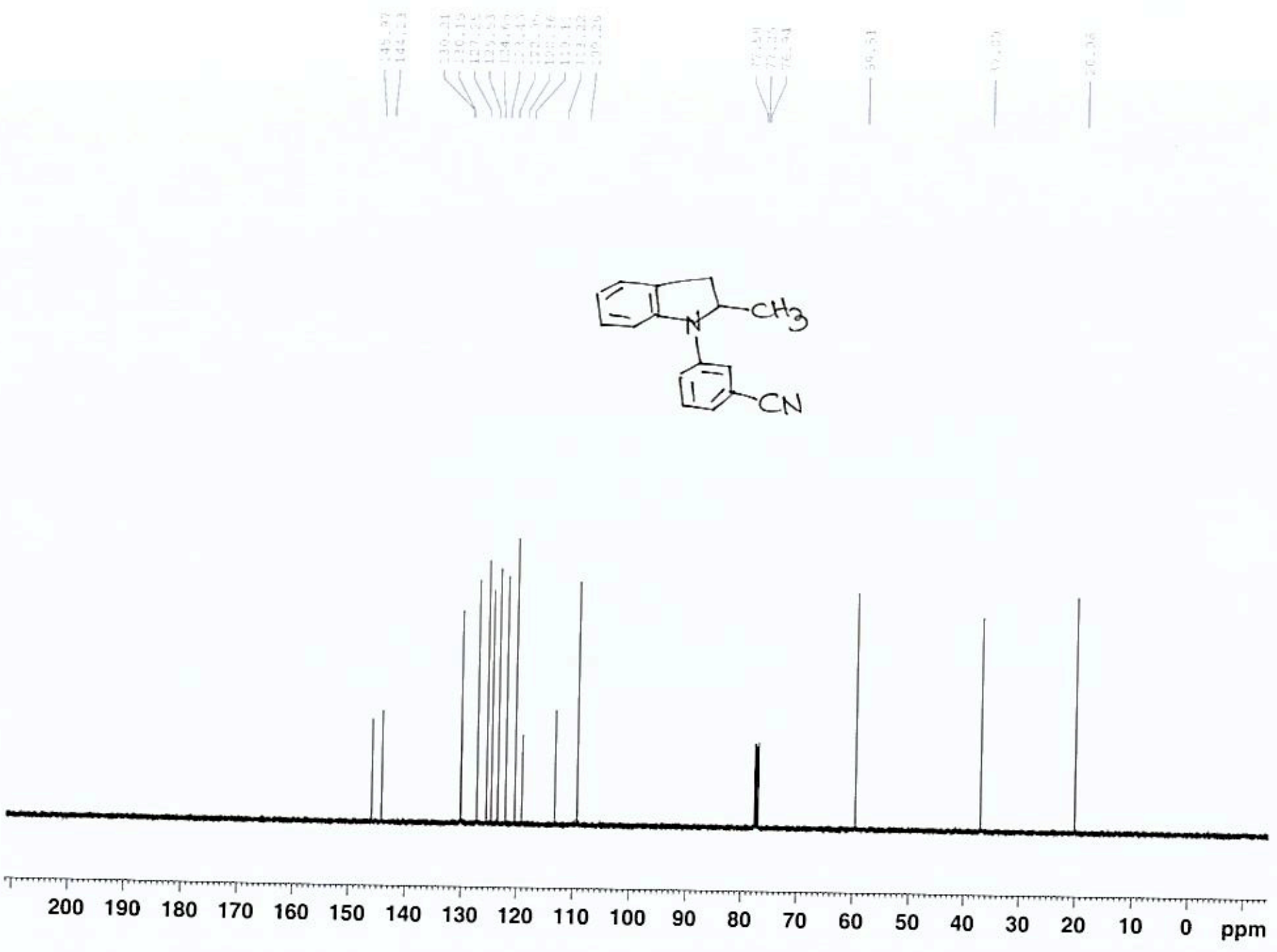
0.49
0.51
0.48
0.48
0.49
0.49
1.52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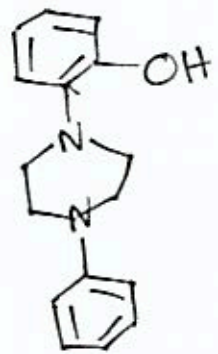
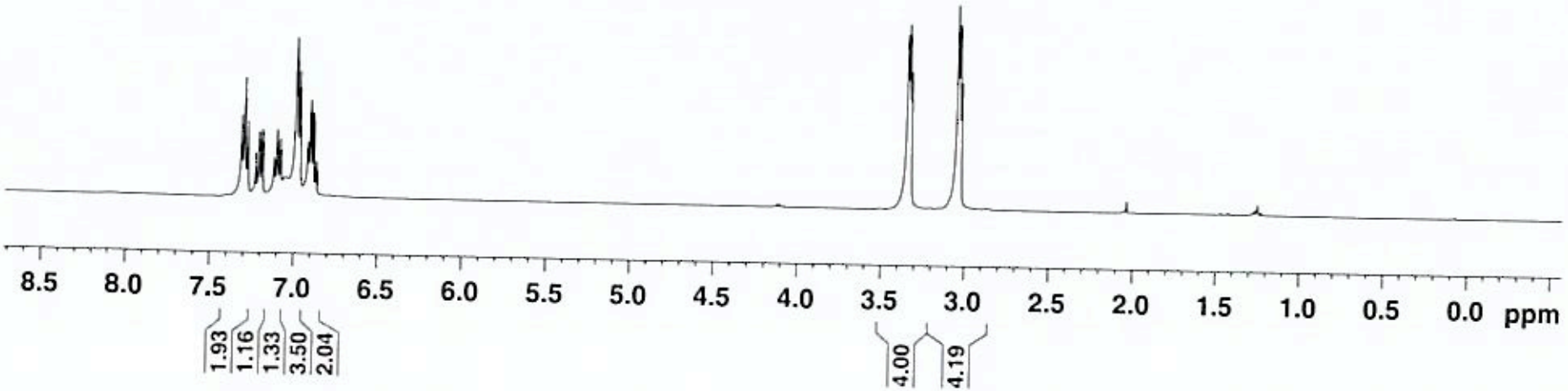
N
CN
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm


OH
N
N


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
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0.5
0.0
ppm
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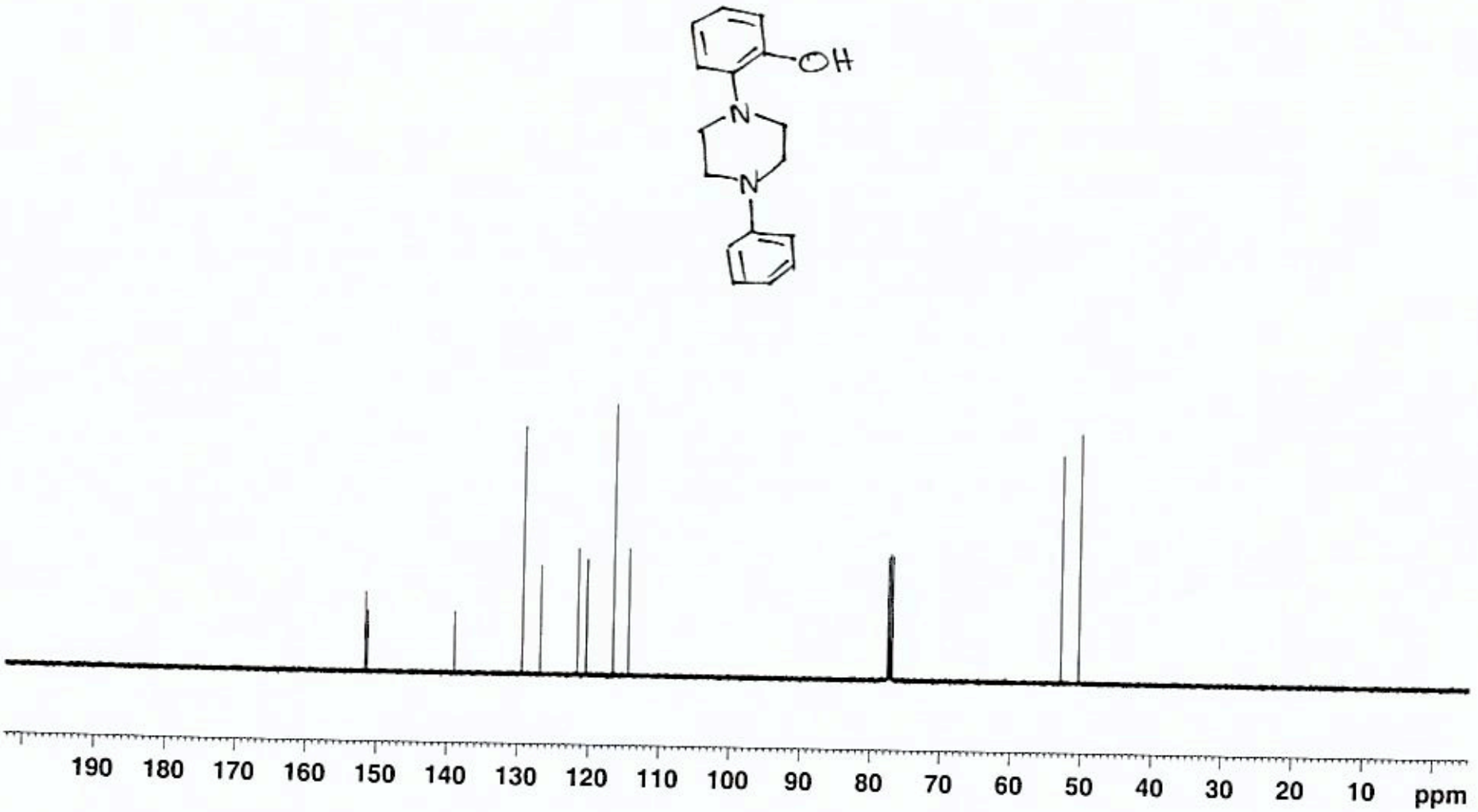
1.16
1.33
3.50
2.04
4.00
4.19


OH
N
N
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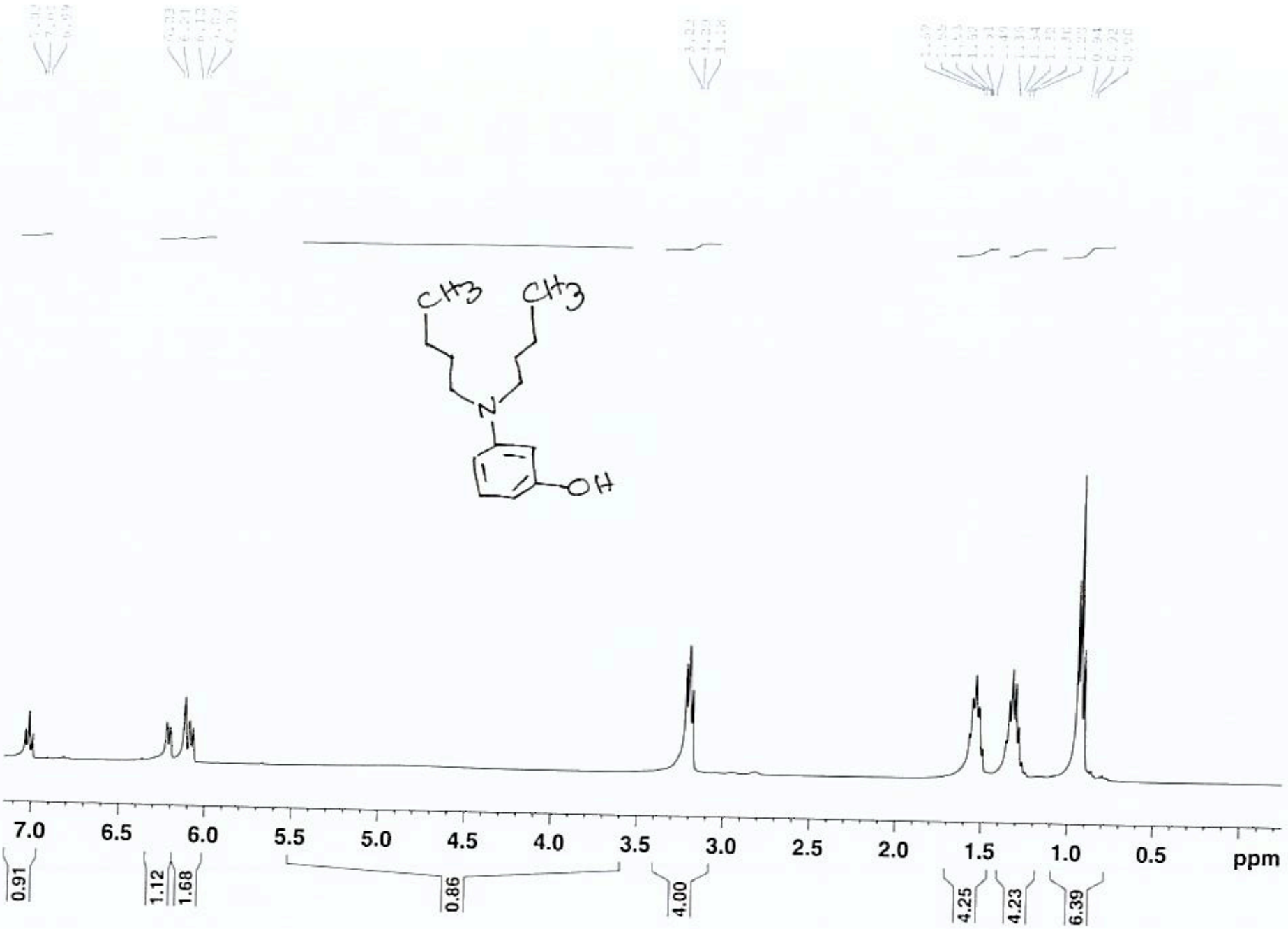
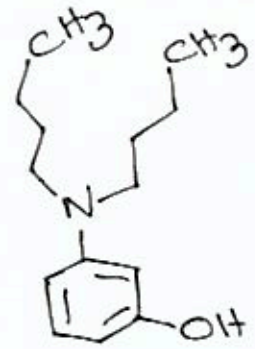
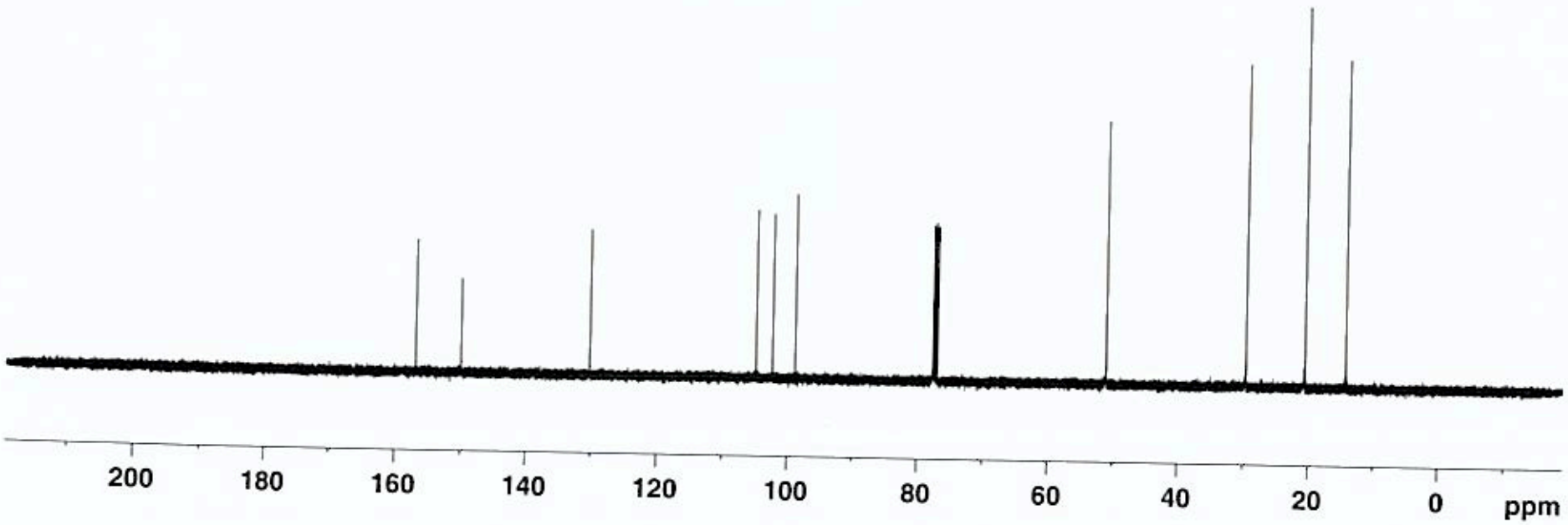
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm




CH3
CH3
N
OH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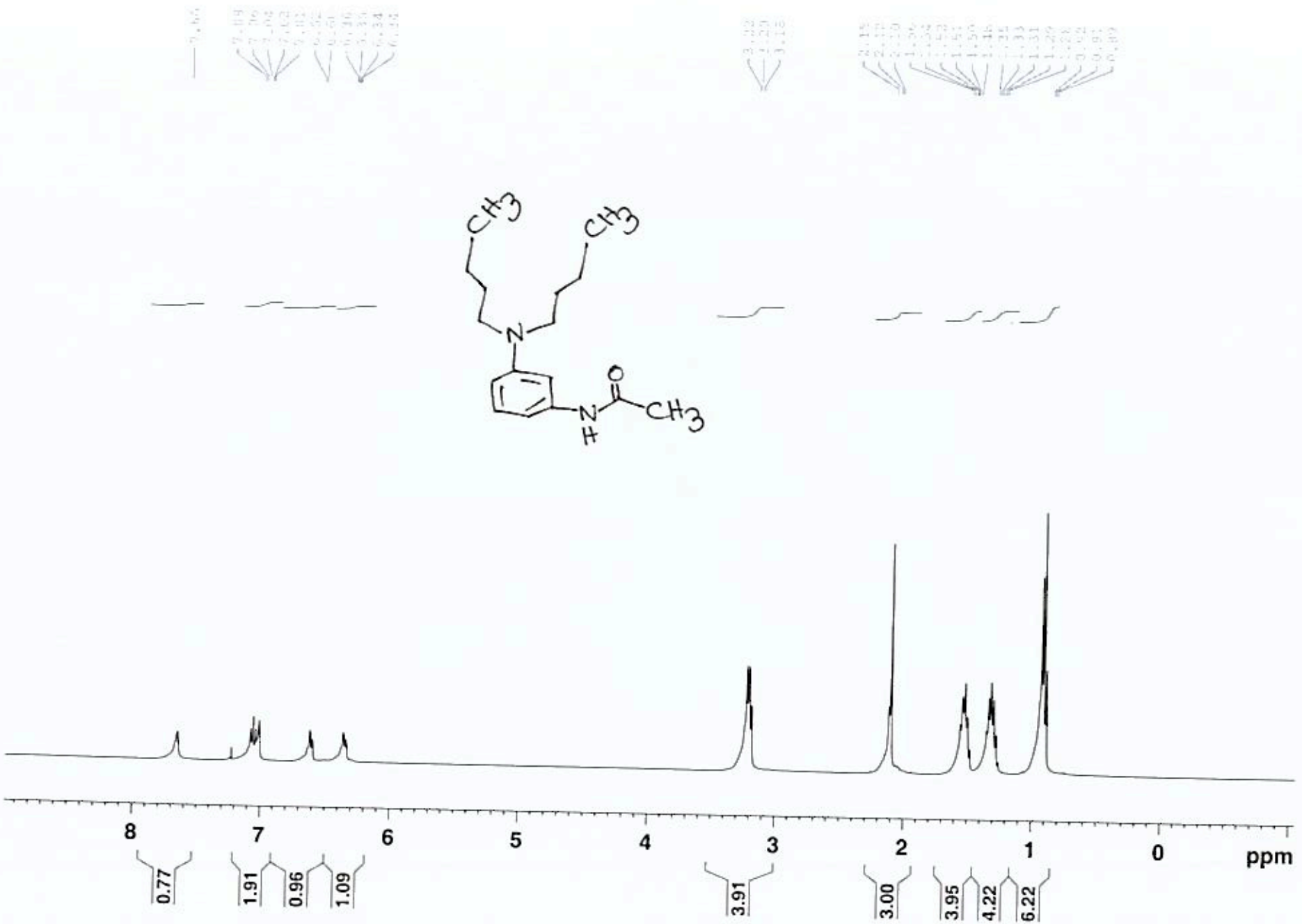
180
160
140
120
100
80
60
40
20
0
ppm


CH3
CH3
N
O
N
H
CH3
8
7
6
5
4
3
2
1
0
ppm
0.77
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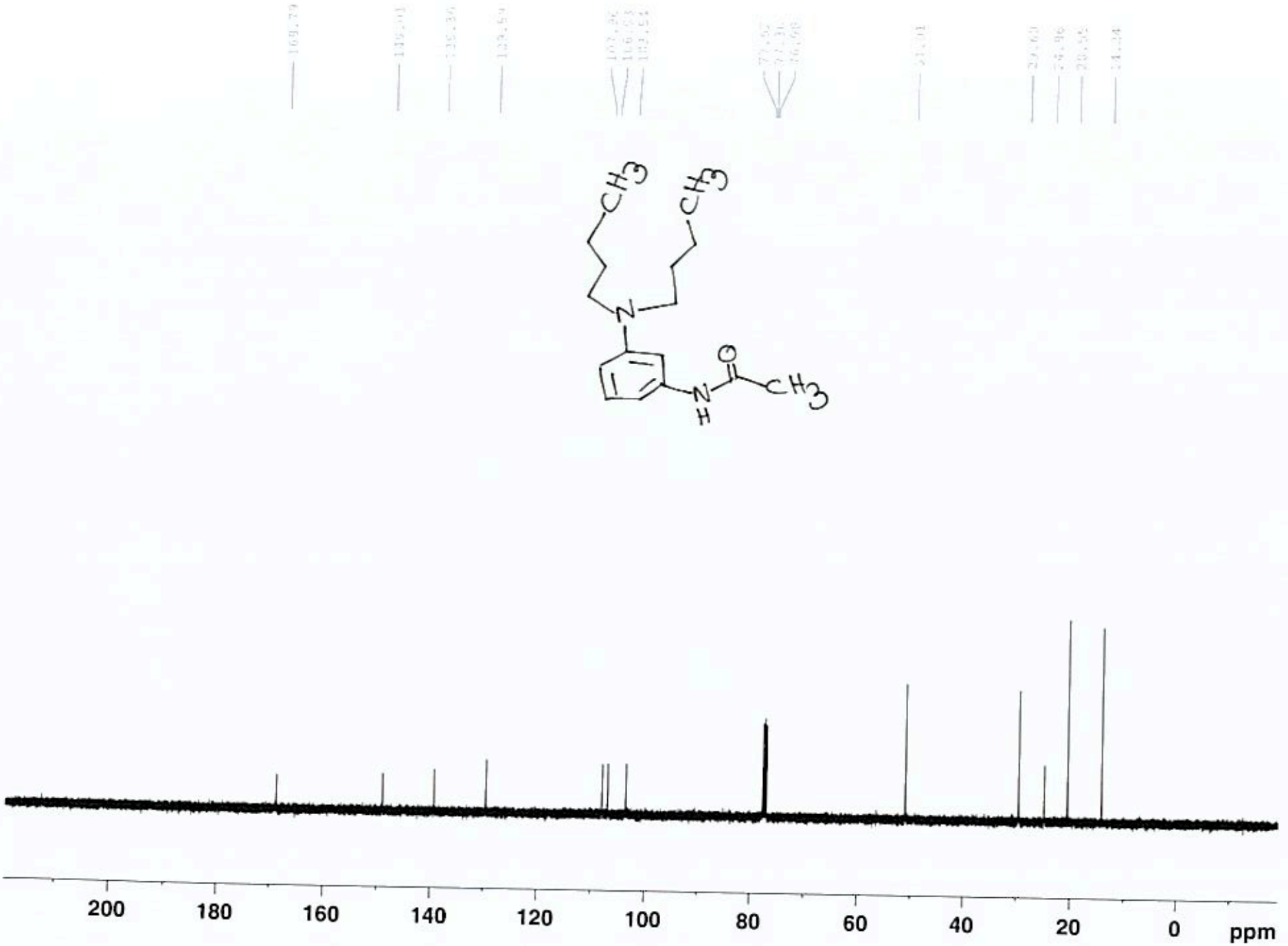
0.96
1.09
3.91
3.00
3.95
4.22
6.22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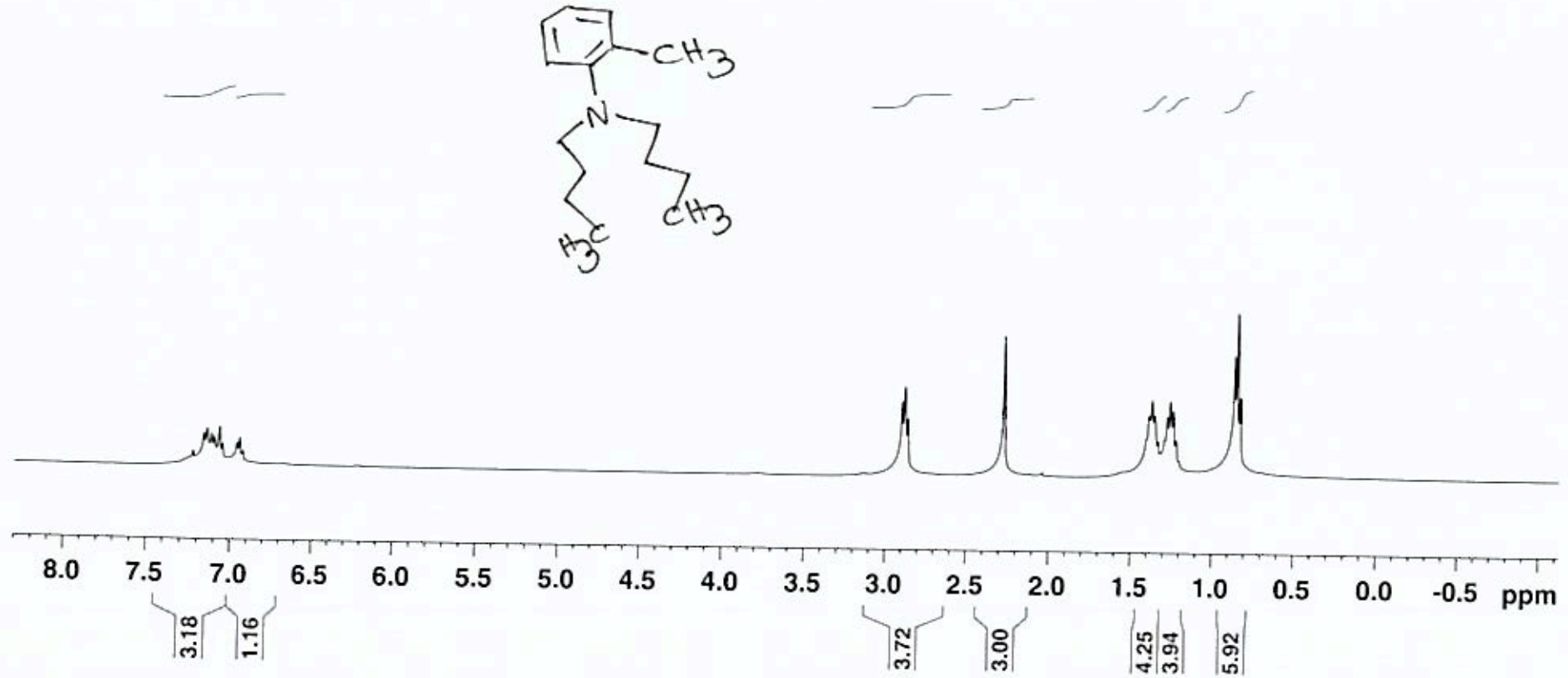
180
160
140
120
100
80
60
40
20
0
ppm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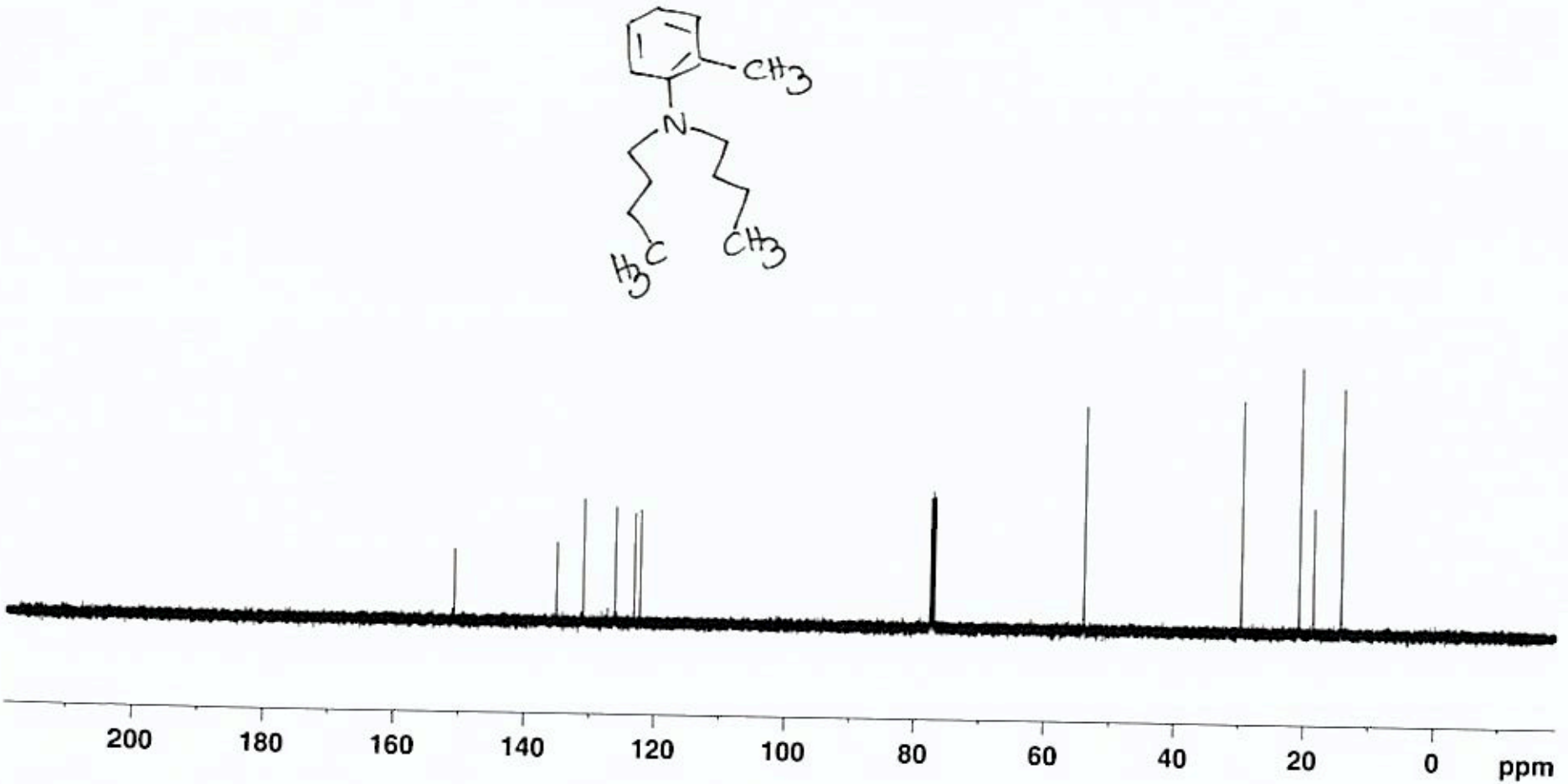
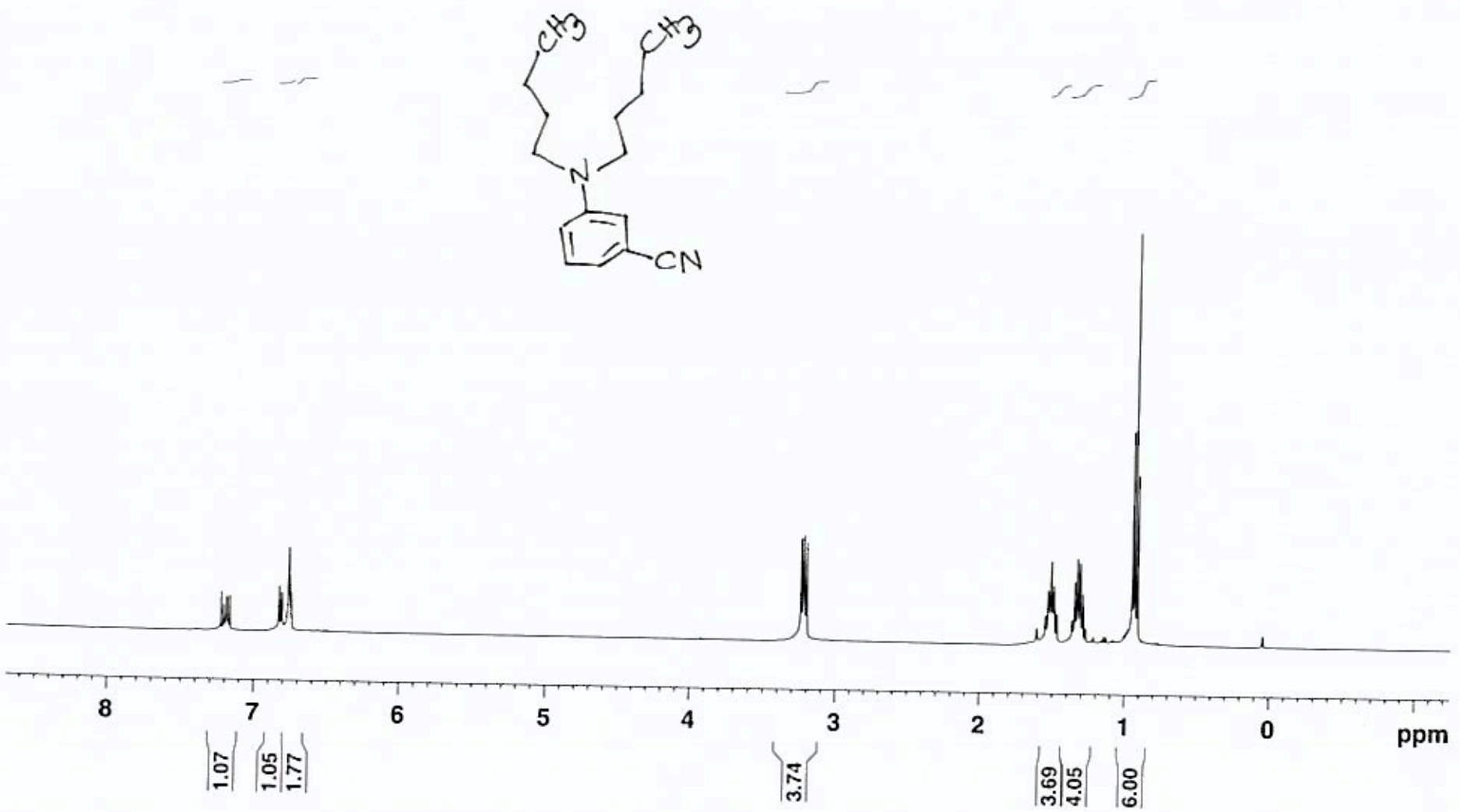
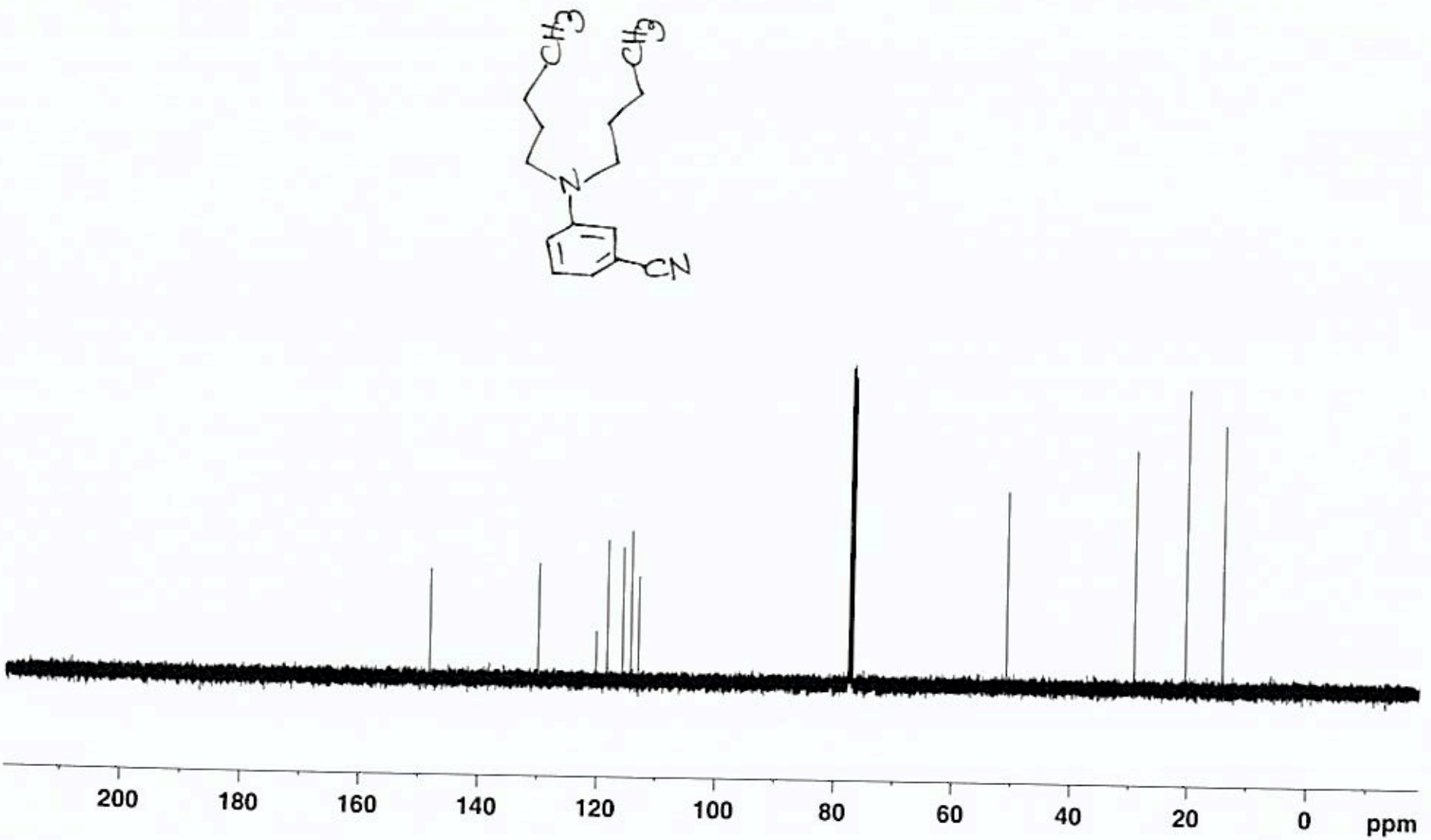
N
H3C
CH3
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
ppm
3.18
1.16
3.72
3.00
4.25
3.94
5.92


CH3
N
H3C
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm


CH3
CH3
N
CN
8
7
6
5
4
3
2
1
0
ppm
1.07
1.05
1.77
3.74
3.69
4.05
6.00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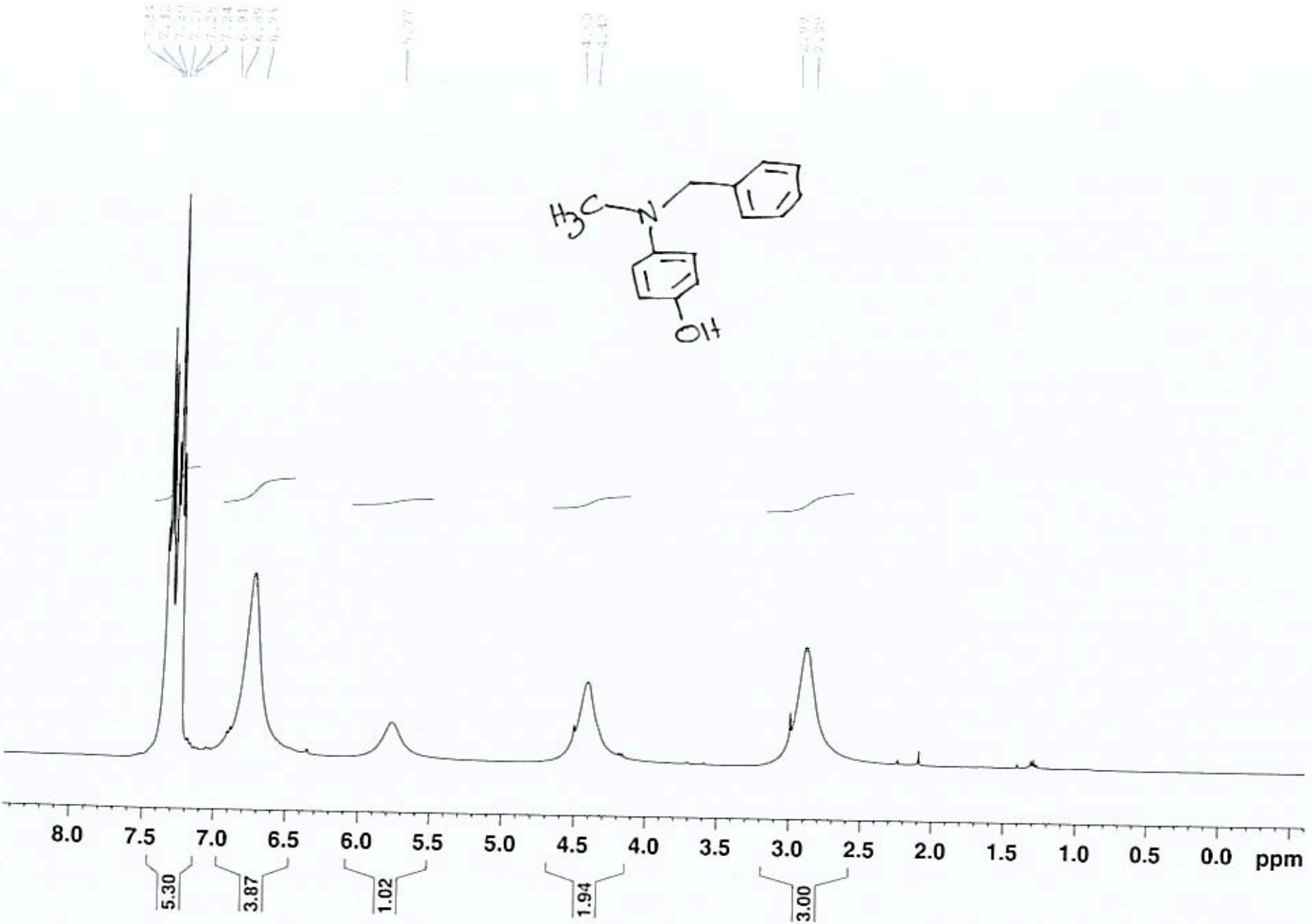
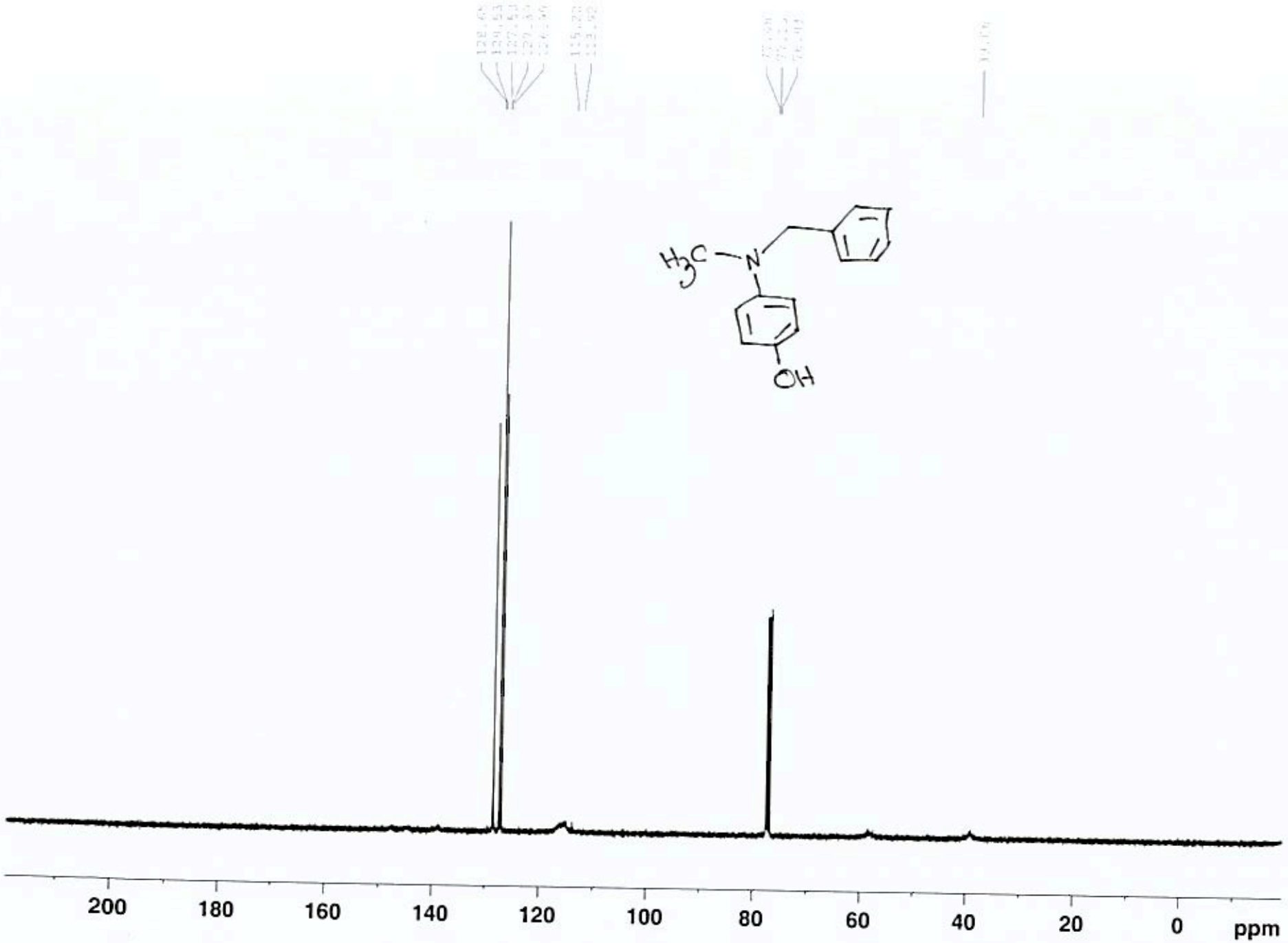
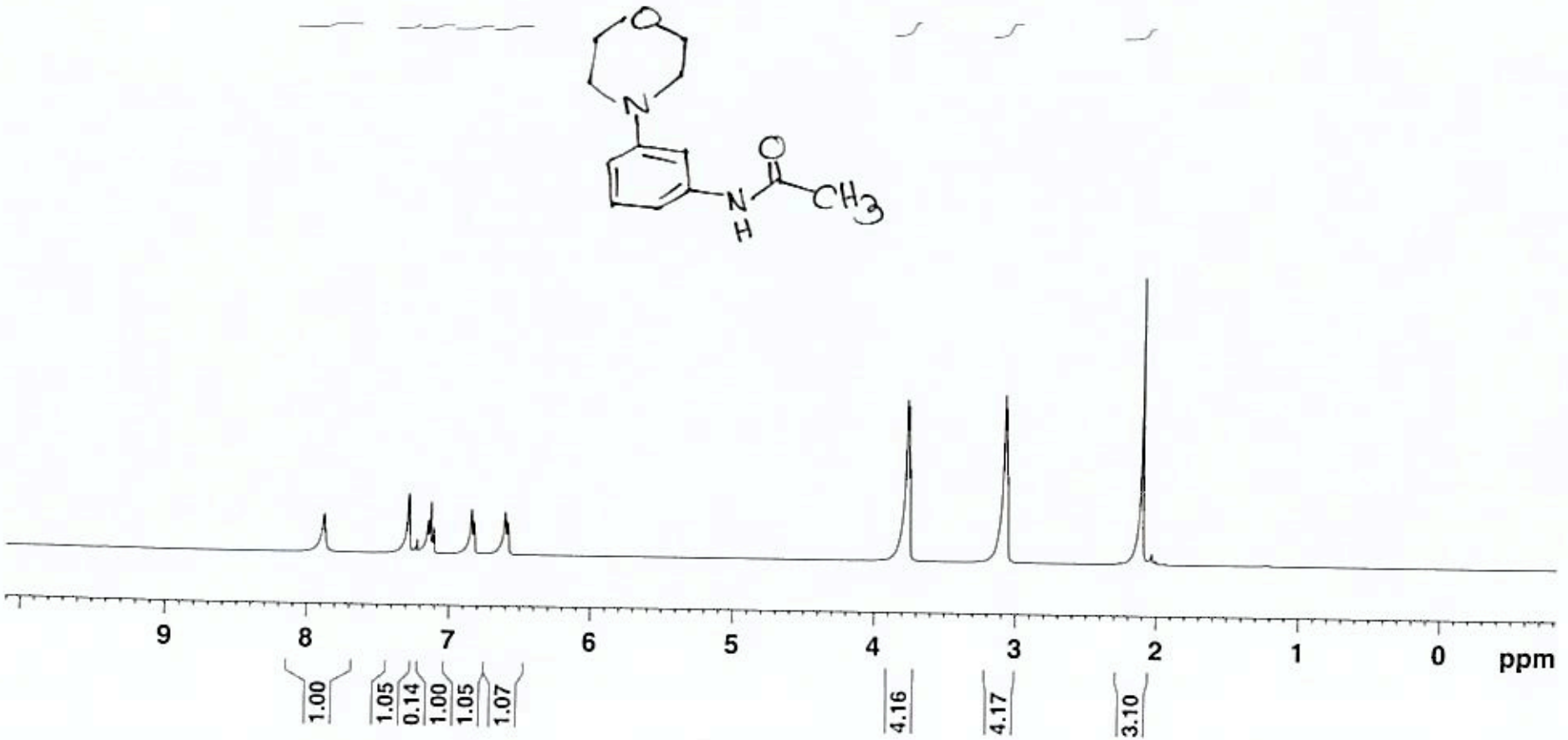
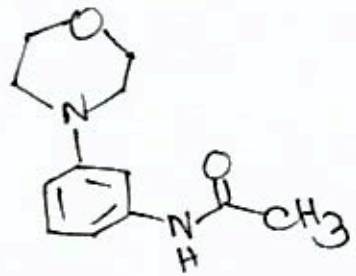
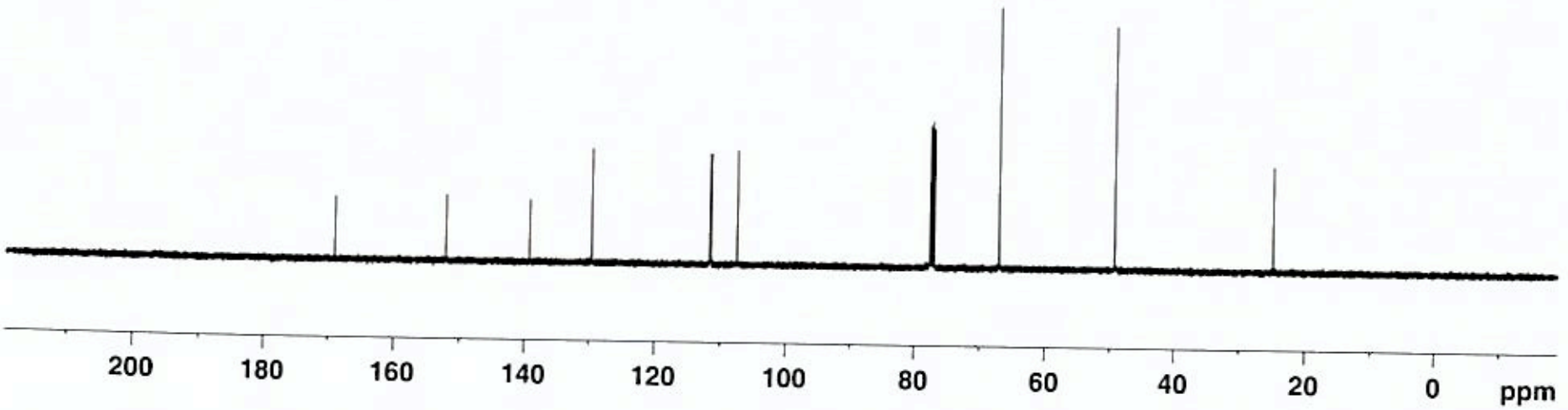
CH3
N
CN
200
180
160
140
120
100
80
60
40
20
0
ppm

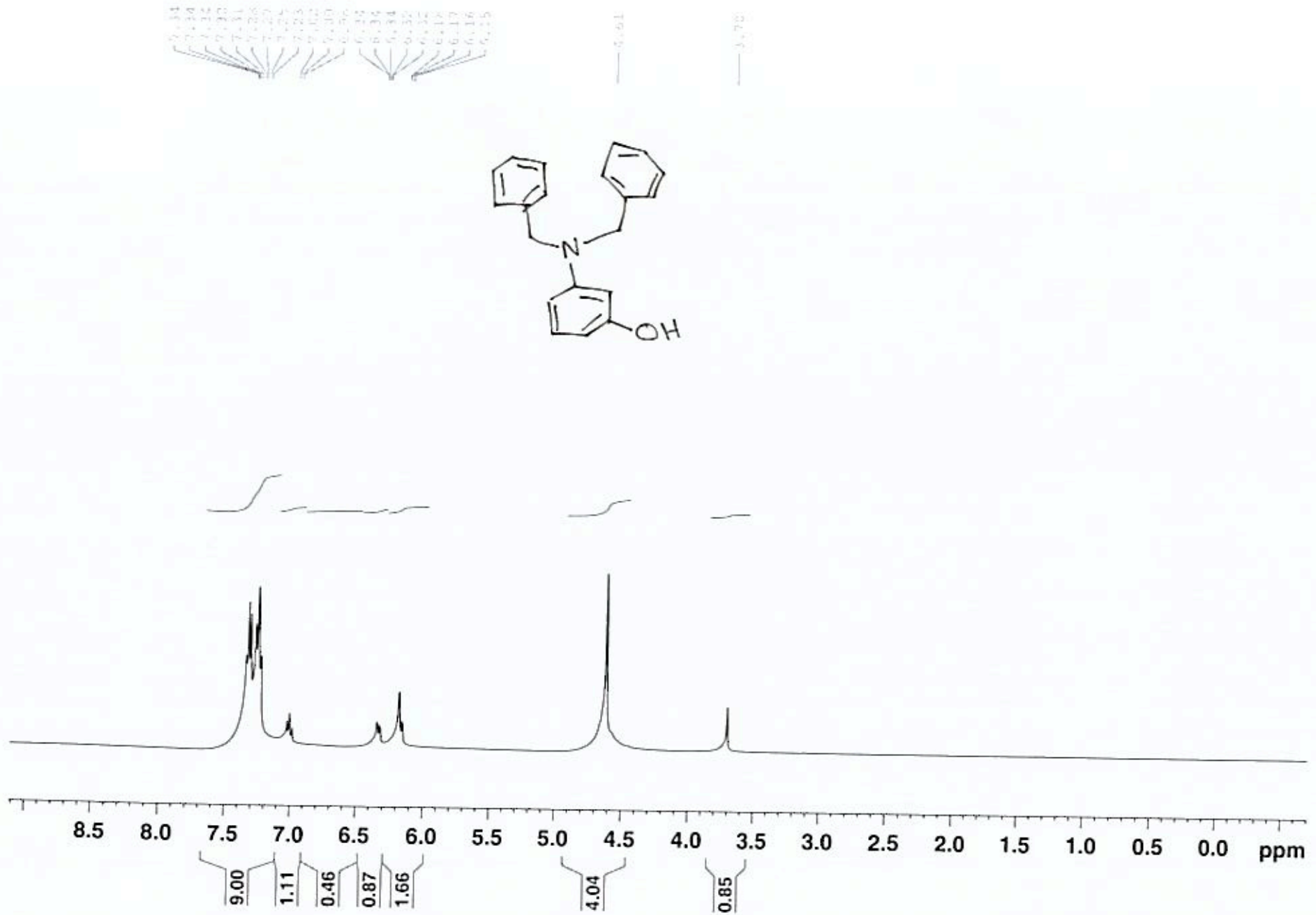

H3C
N
OH
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
5.30
3.87
1.02
1.94
3.00

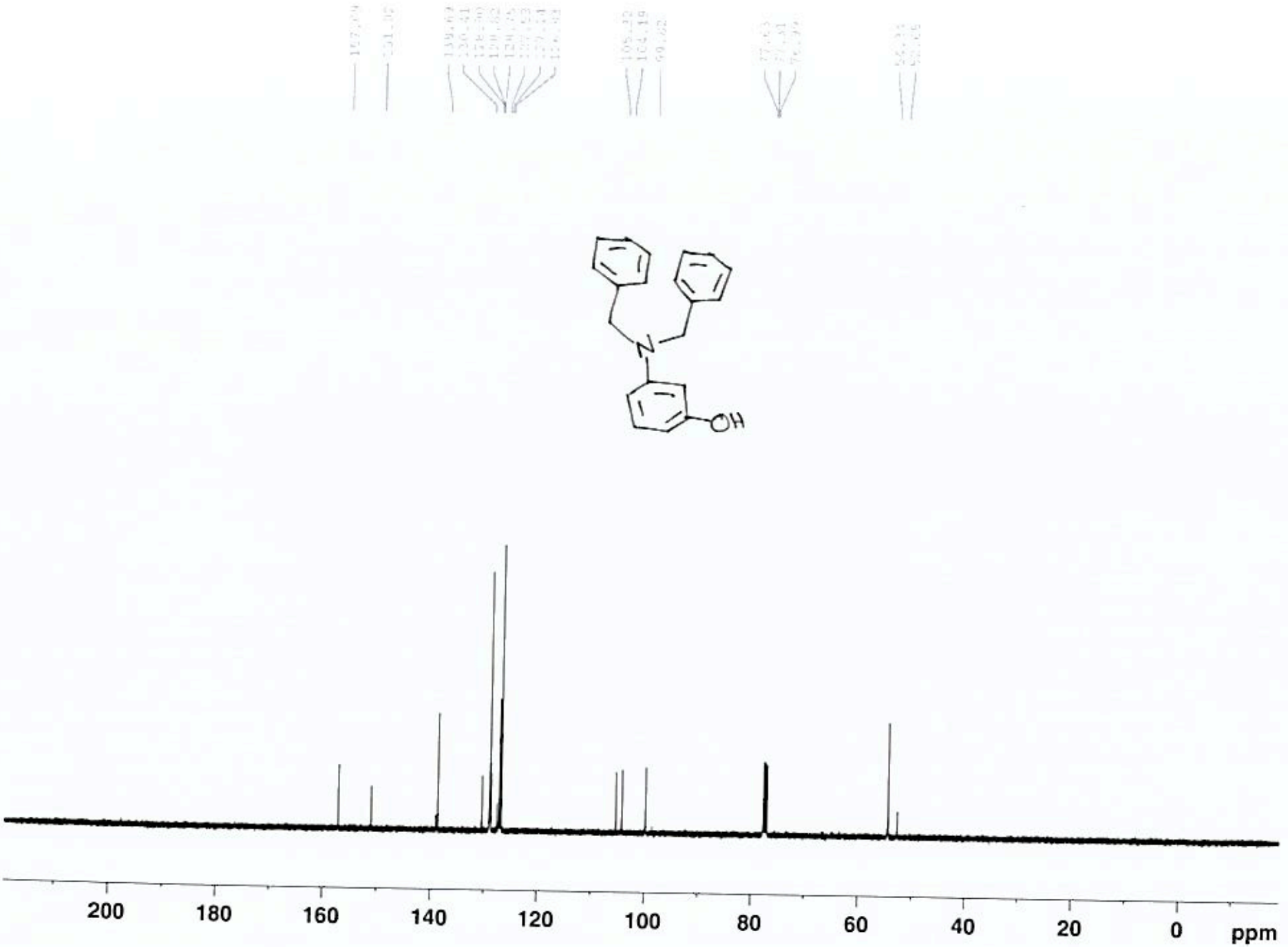

H3C
N
OH
200
180
160
140
120
100
80
60
40
20
0
ppm

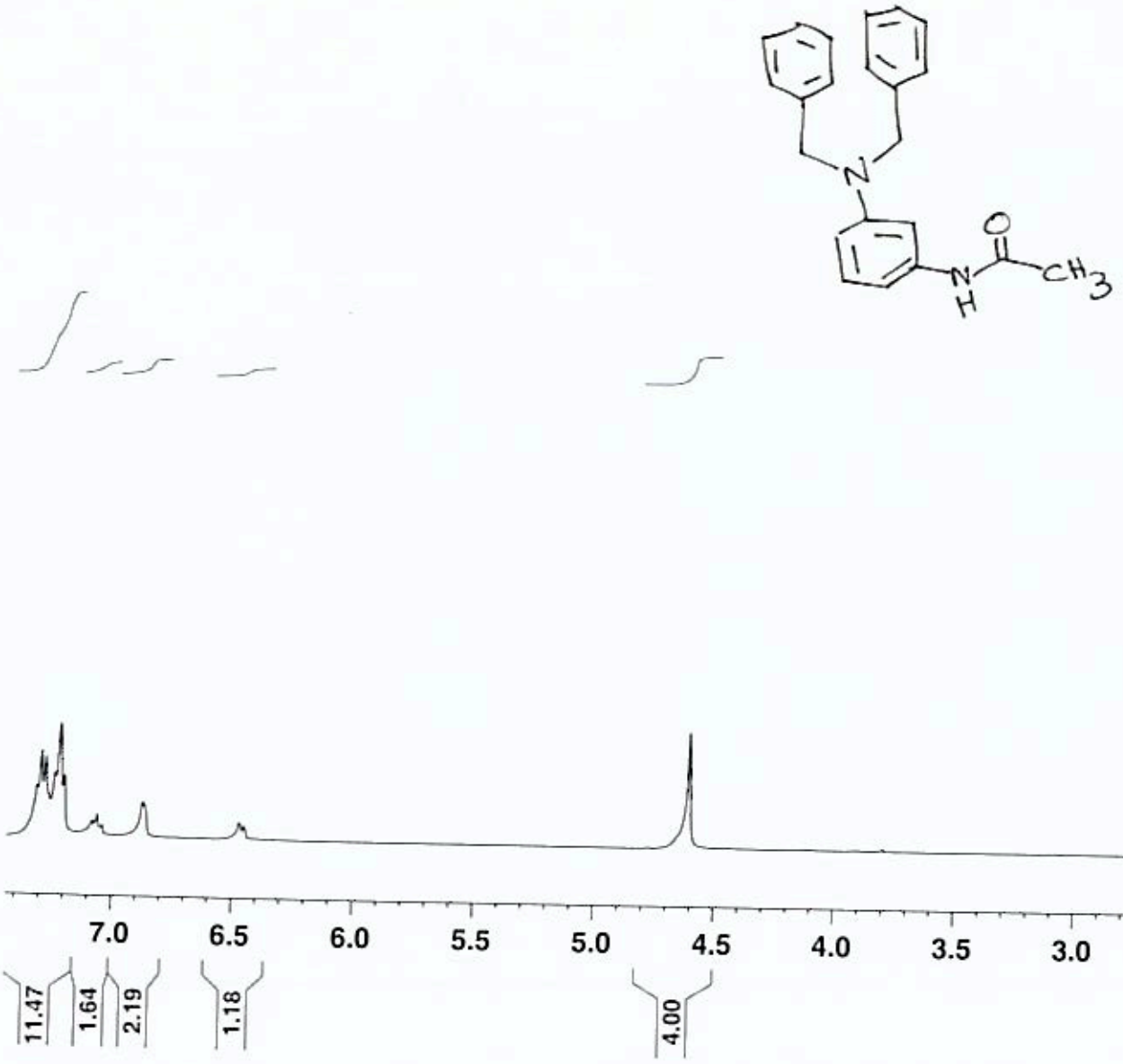

O
N
N
H
O
CH3
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.05
0.14
1.00
1.05
1.07
4.16
4.17
3.10

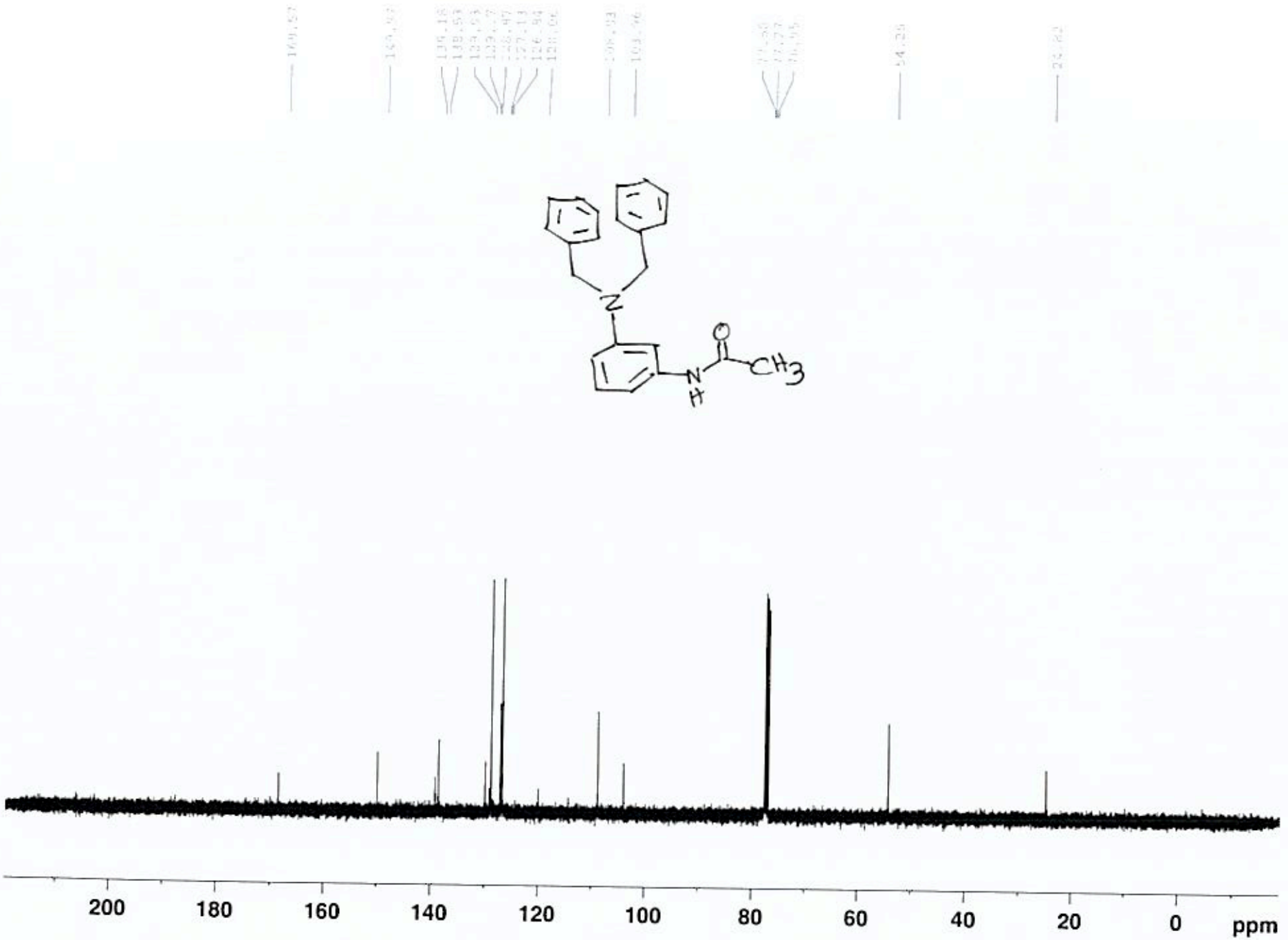

O
N
N
H
CH3

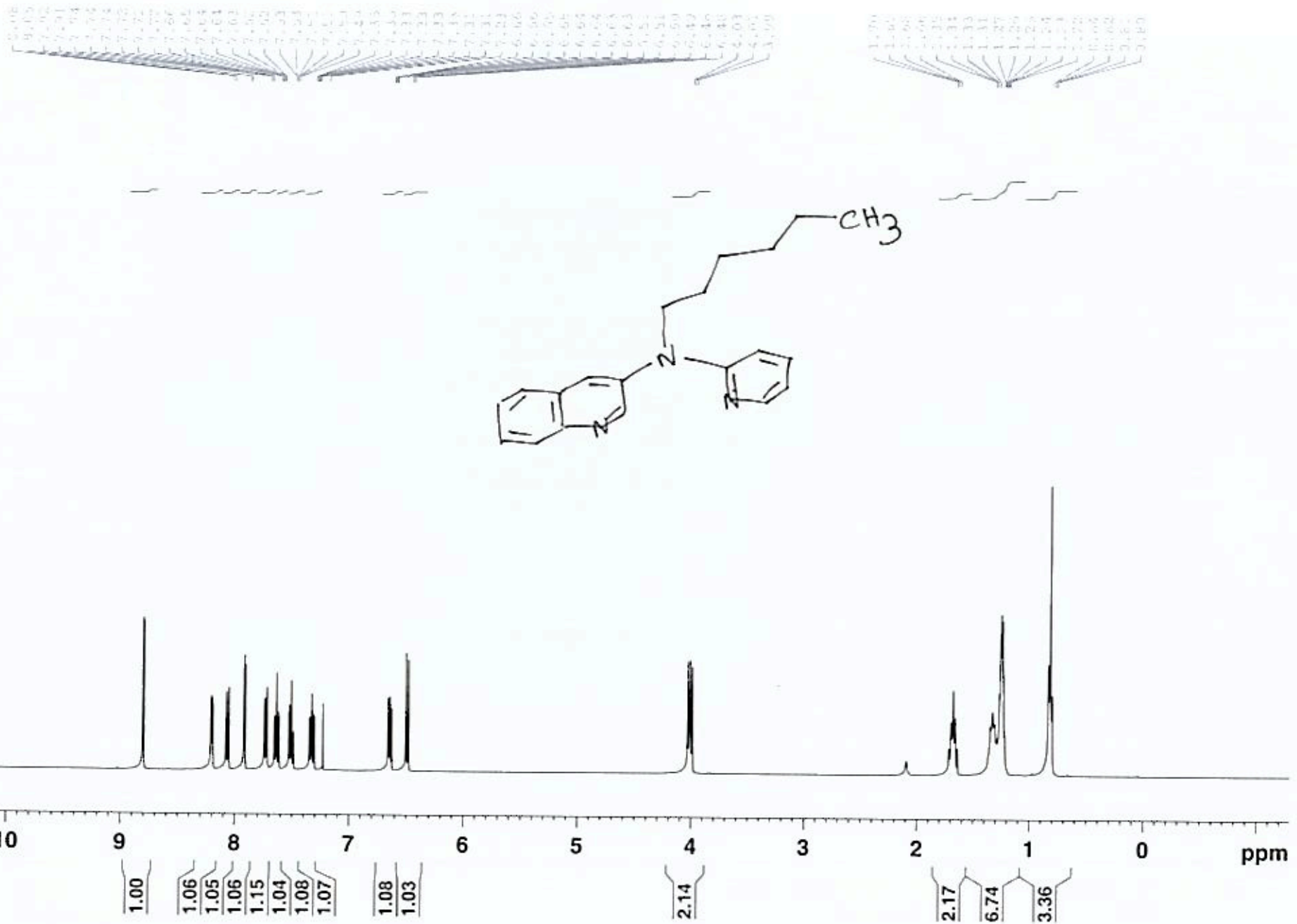

200
180
160
140
120
100
80
60
40
20
0
ppm

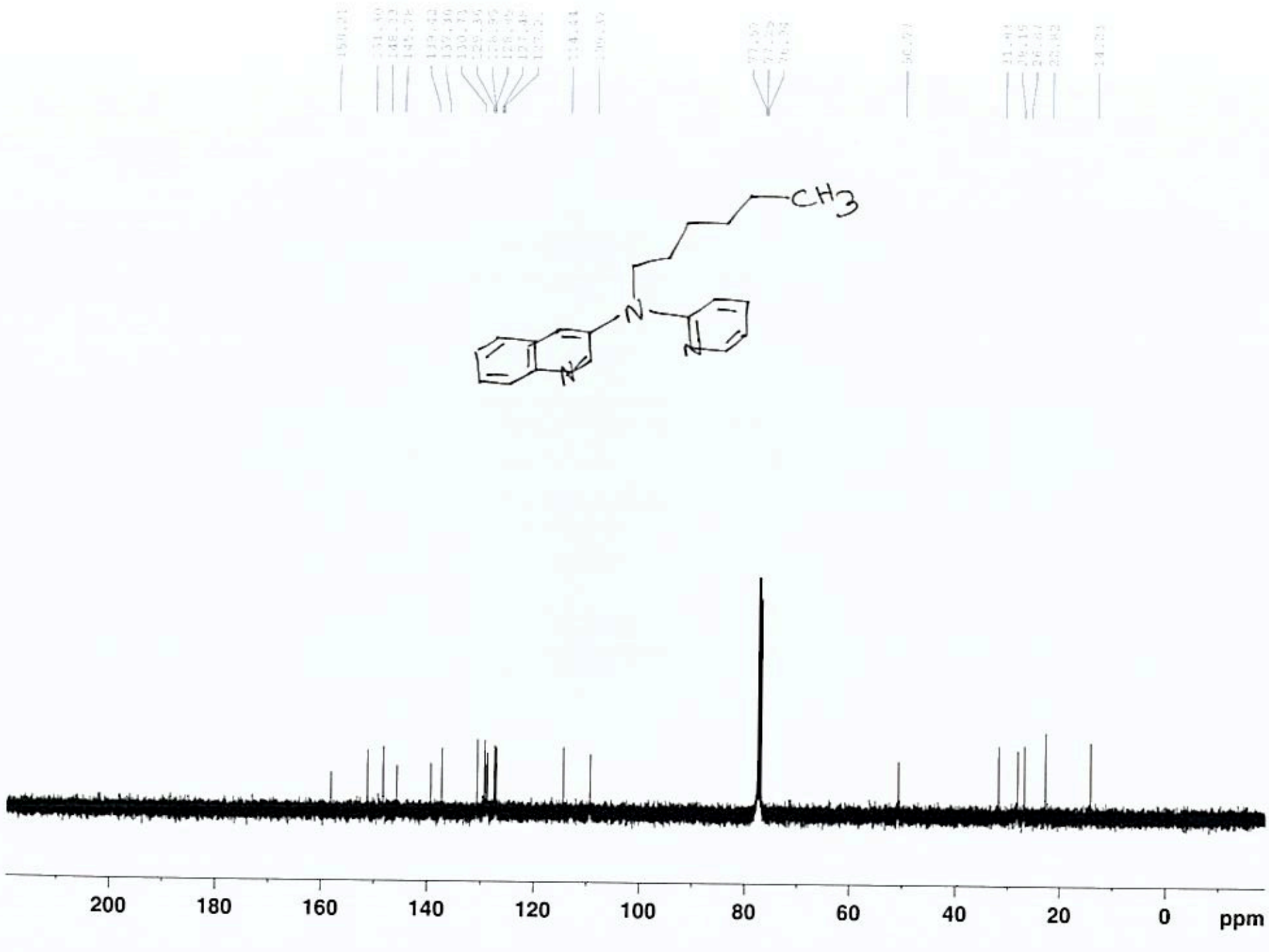

N
OH
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
9.00
1.11
0.46
0.87
1.66
4.04
0.85

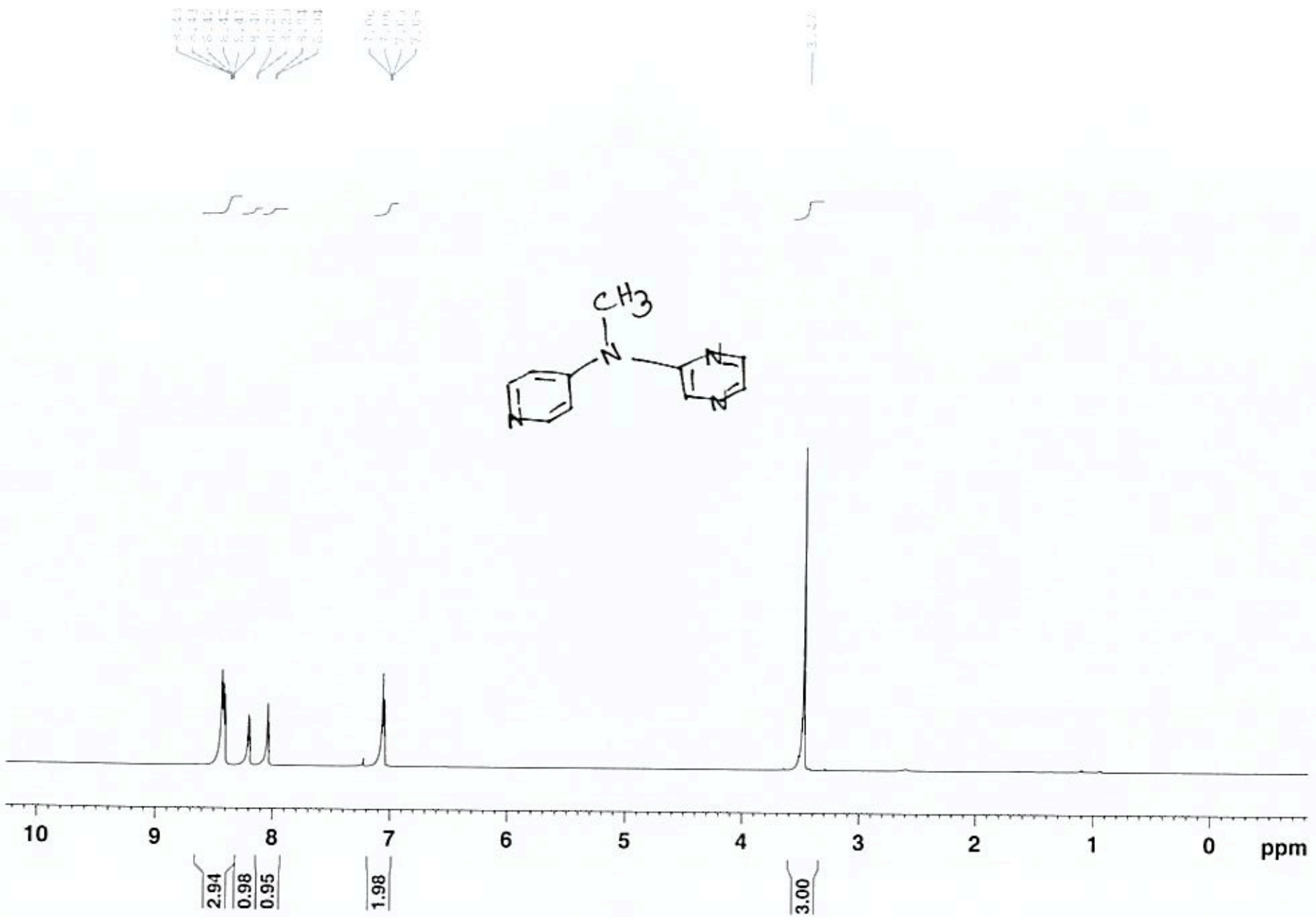

OH
200
180
160
140
120
100
80
60
40
20
0
ppm

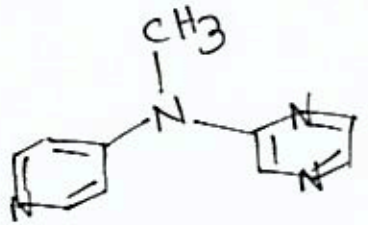


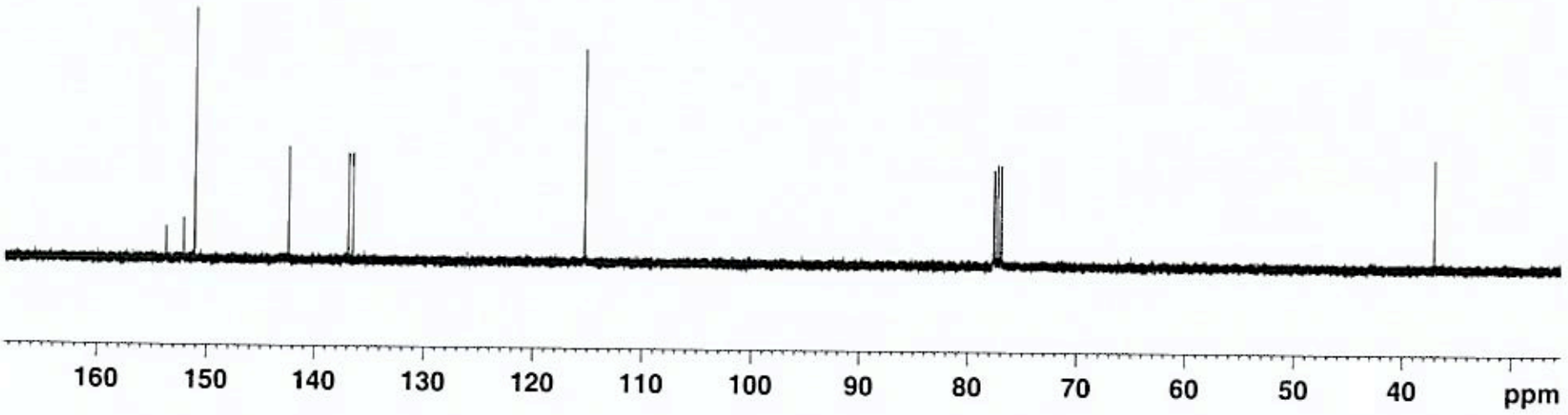

169.57
139.53
129.53
127.13
124.94
118.06
54.29
23.82
N
H
O
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

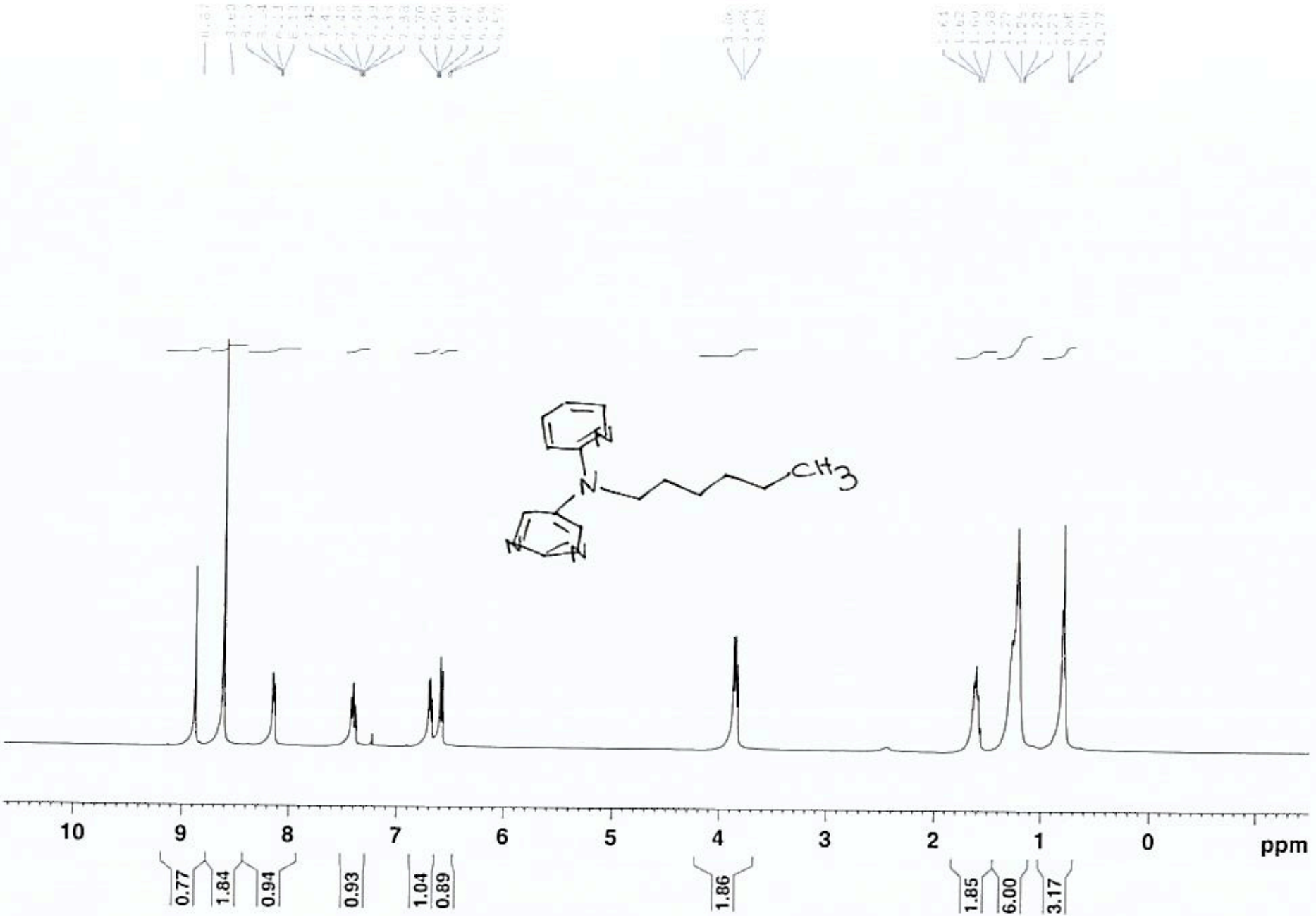

CH3
2
10
9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.06
1.05
1.06
1.15
1.04
1.08
1.07
1.08
1.03
2.14
2.17
6.74
3.36

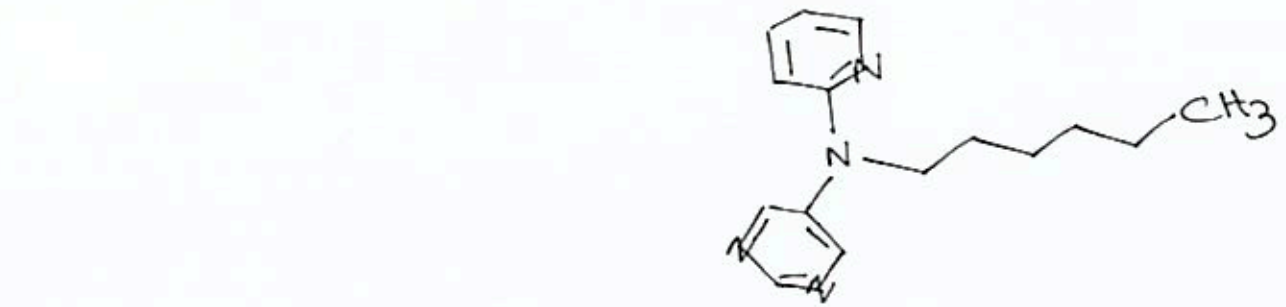

CH3
N
200
180
160
140
120
100
80
60
40
20
0
ppm

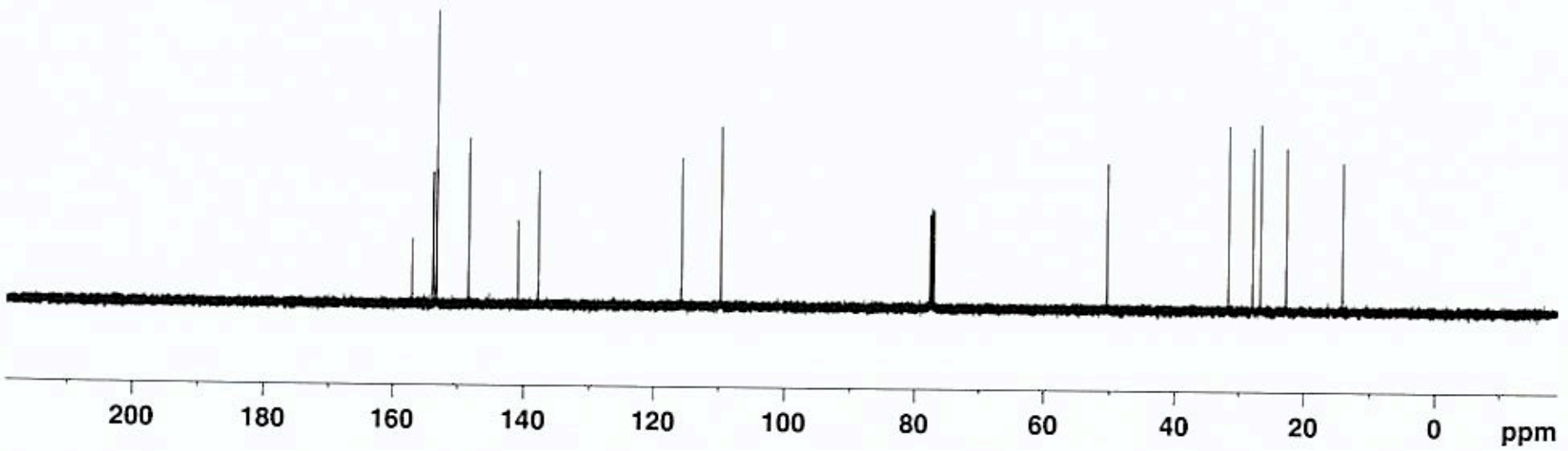

CH3
N
10
9
8
7
6
5
4
3
2
1
0
ppm
2.94
0.98
0.95
1.98
3.00

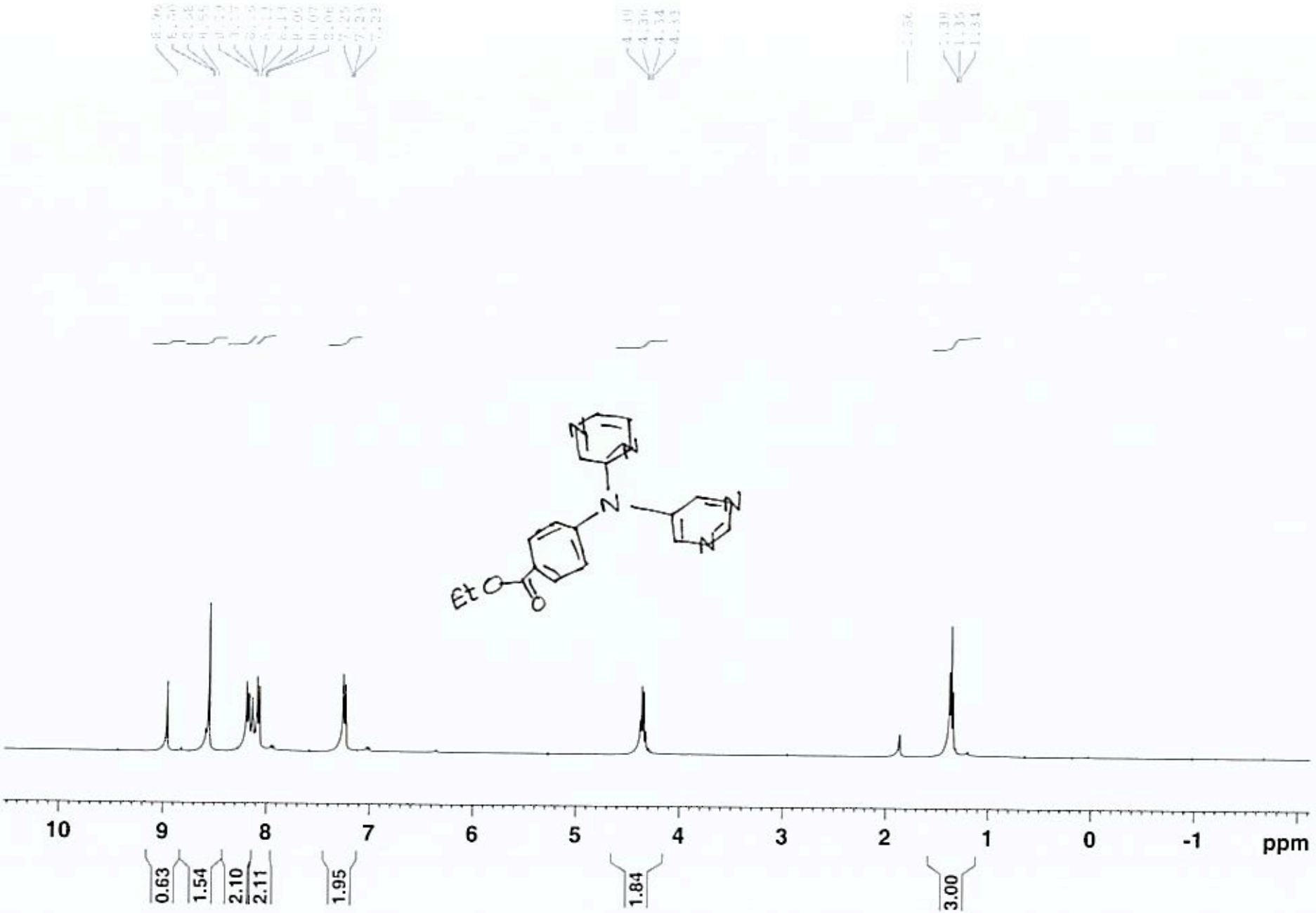

CH3
N
N
N
N

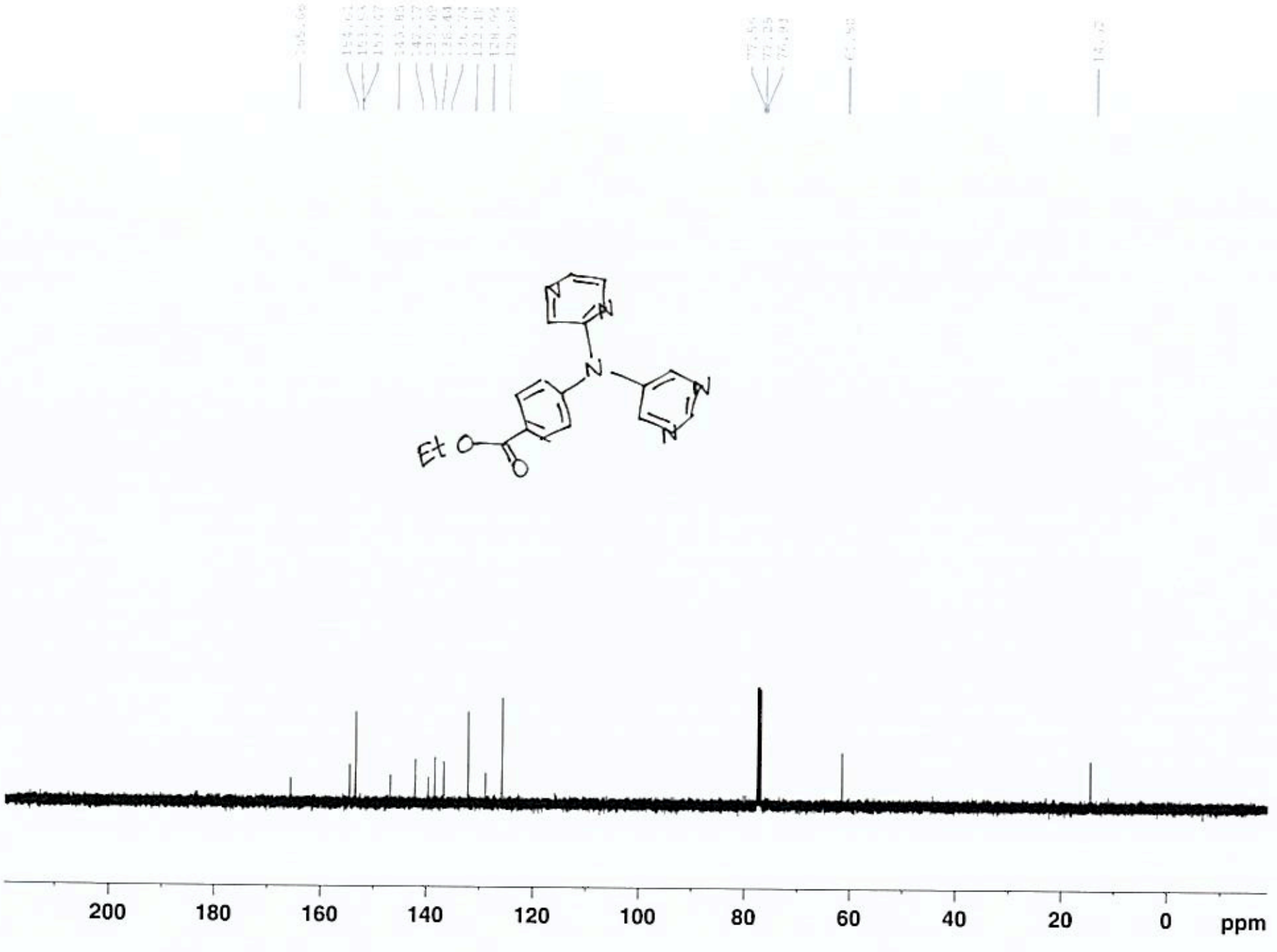

160
150
140
130
120
110
100
90
80
70
60
50
40
ppm

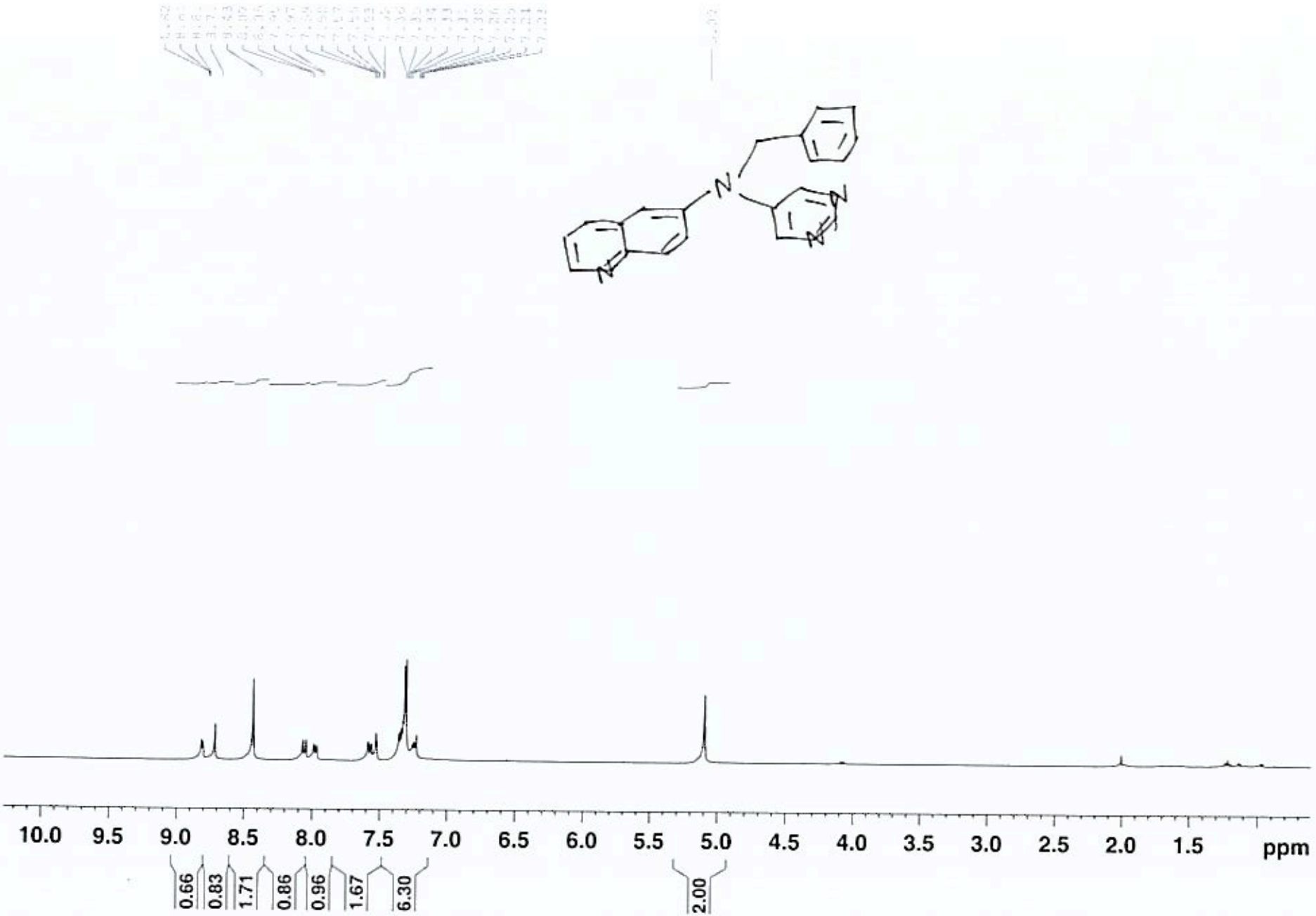

N
CH3
10
9
8
7
6
5
4
3
2
1
0
ppm
0.77
1.84
0.94
0.93
1.04
0.89
1.86
1.85
6.00
3.17

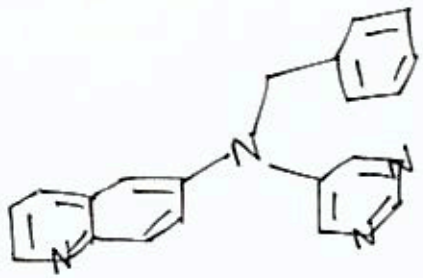

N
N
CH3

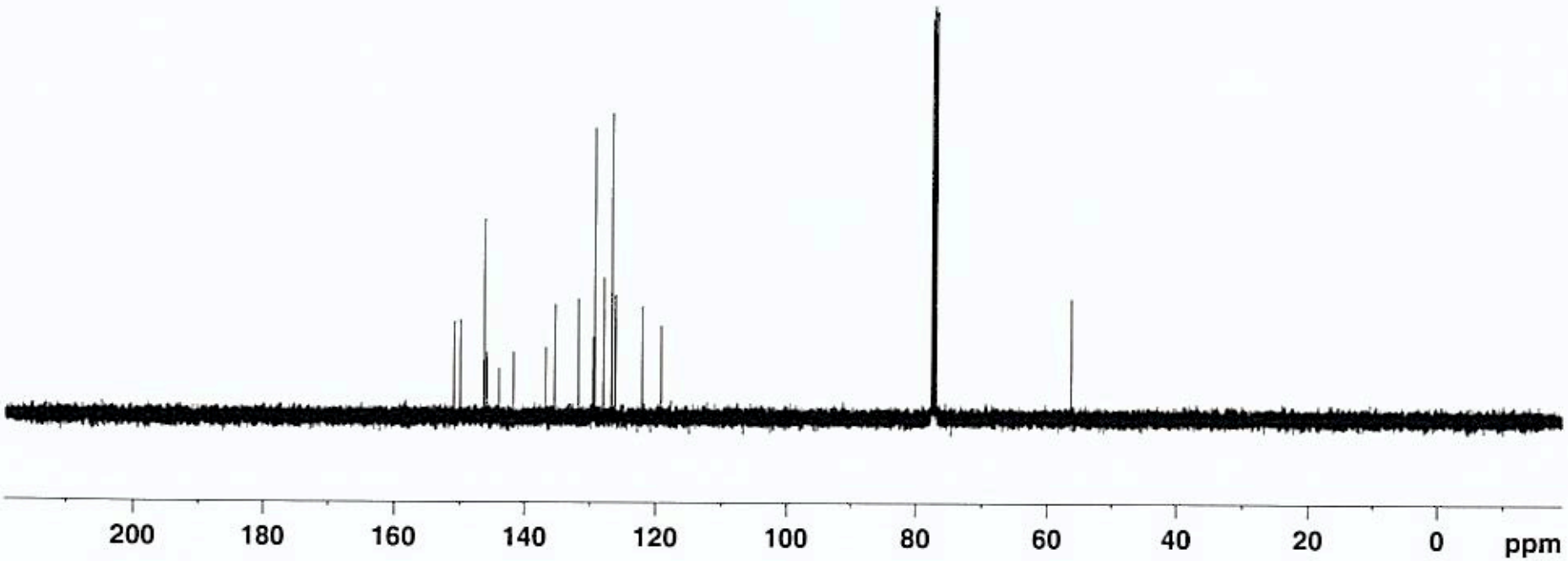

200
180
160
140
120
100
80
60
40
20
0
ppm

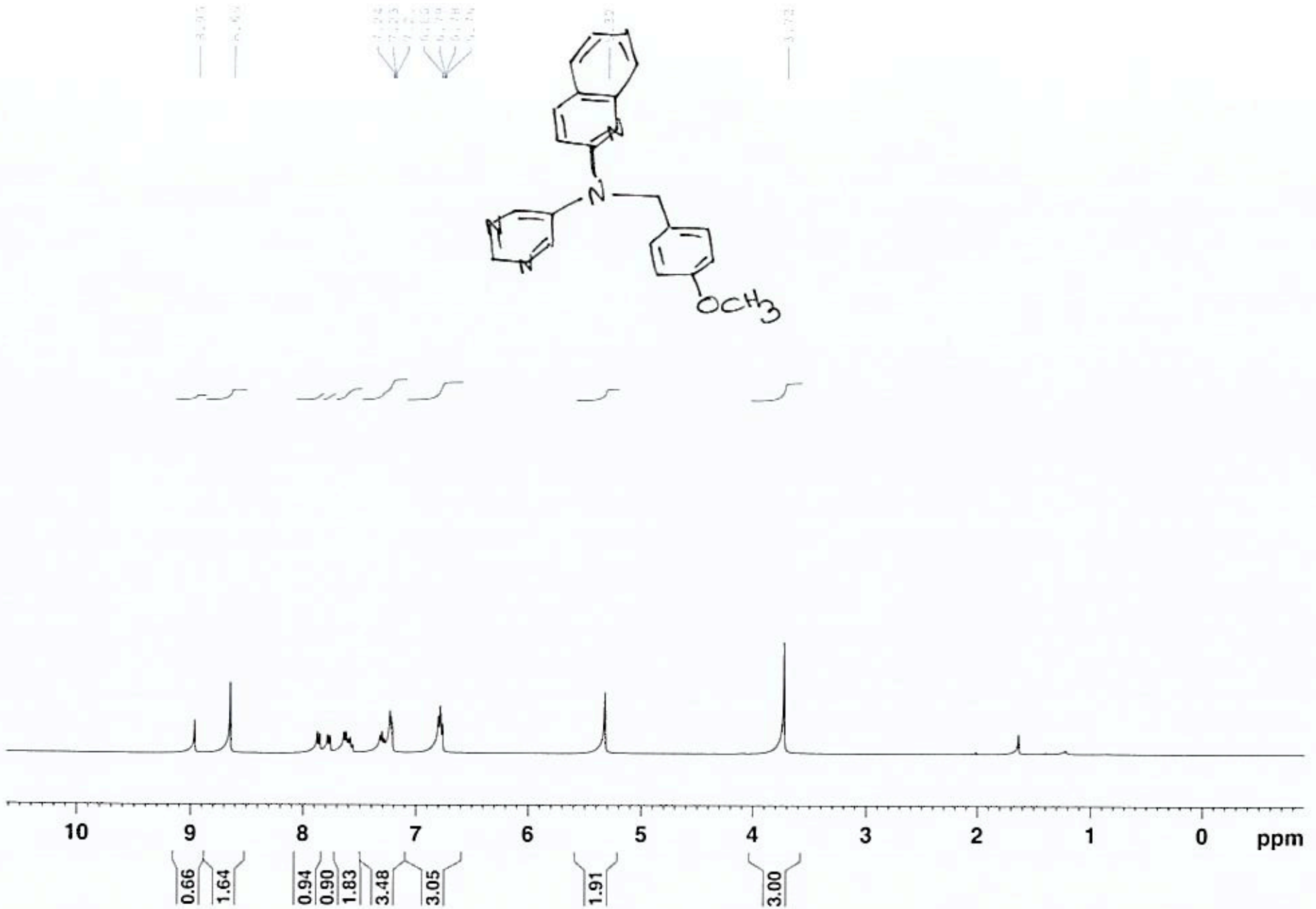

N
N
N
N
Et
O
O
10
9
8
7
6
5
4
3
2
1
0
-1
ppm
0.63
1.54
2.10
2.11
1.95
1.84
3.00

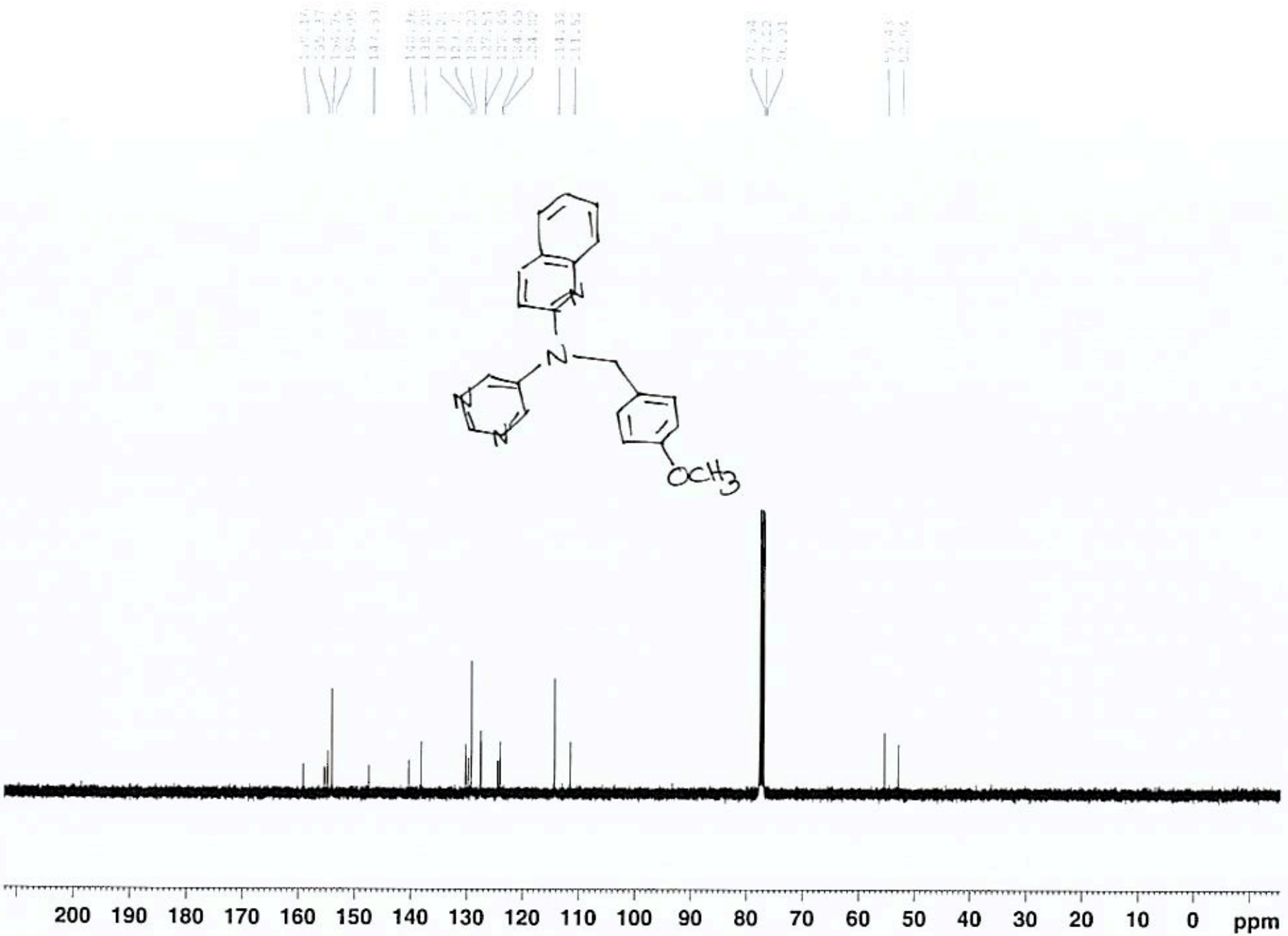

Et
O
O
N
N
N
N
200
180
160
140
120
100
80
60
40
20
0
ppm

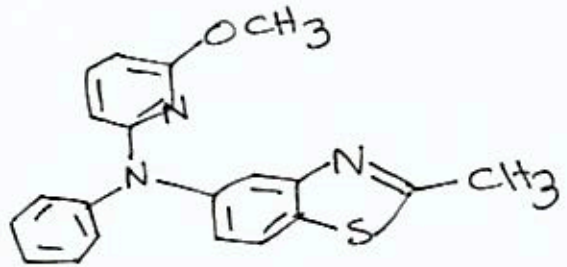

N
N
N
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
0.66
0.83
1.71
0.86
0.96
1.67
6.30
2.00

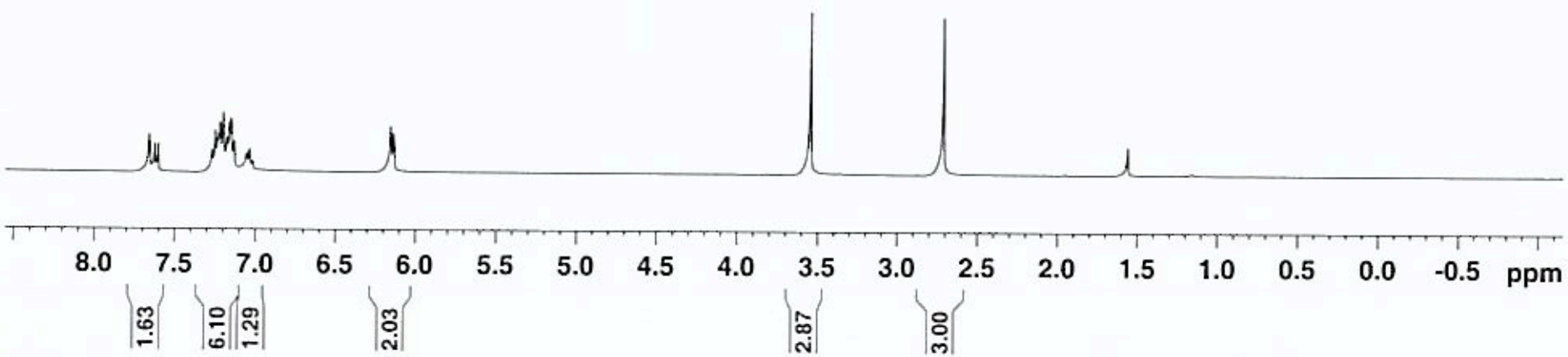


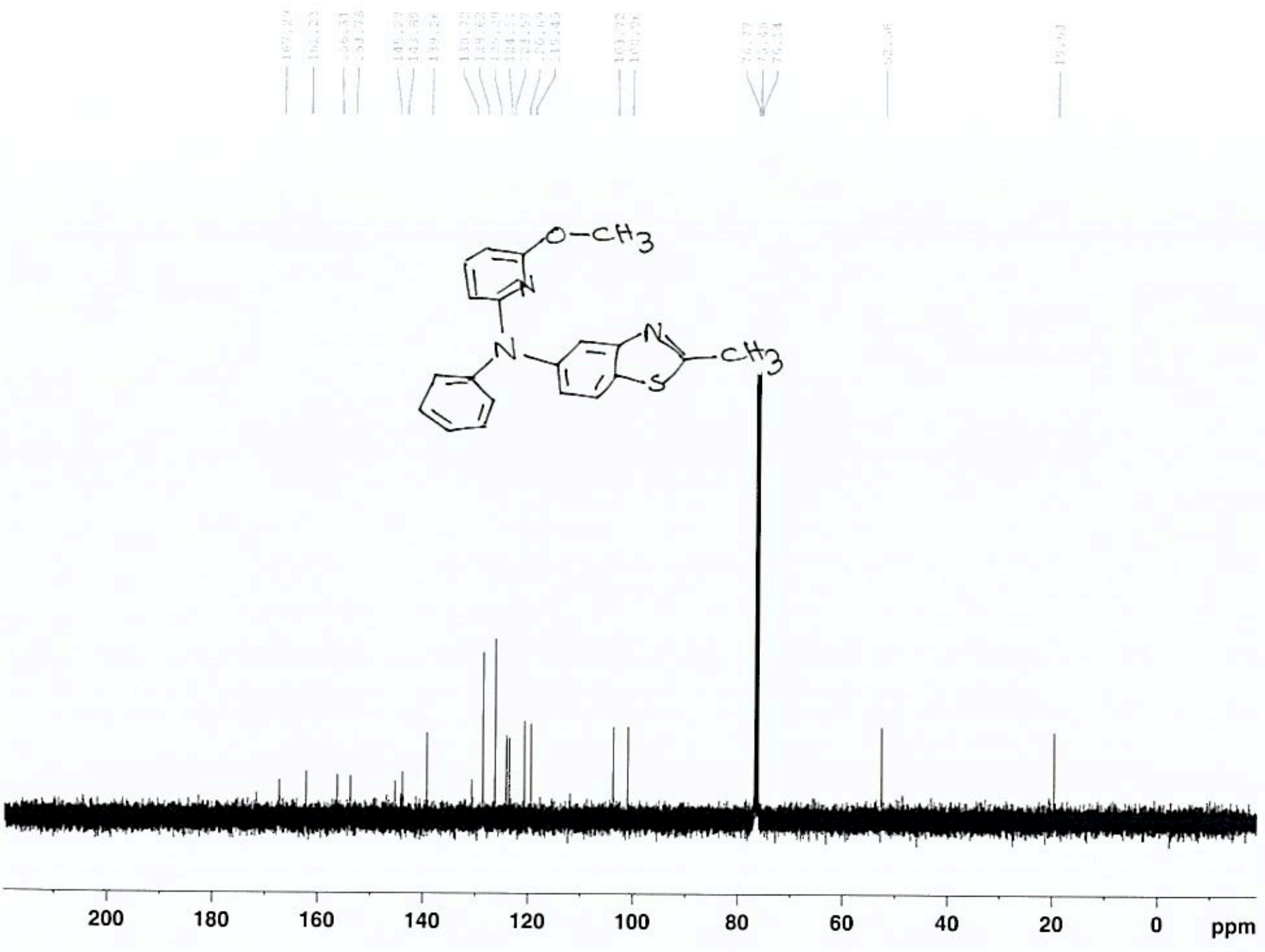

200
180
160
140
120
100
80
60
40
20
0
ppm

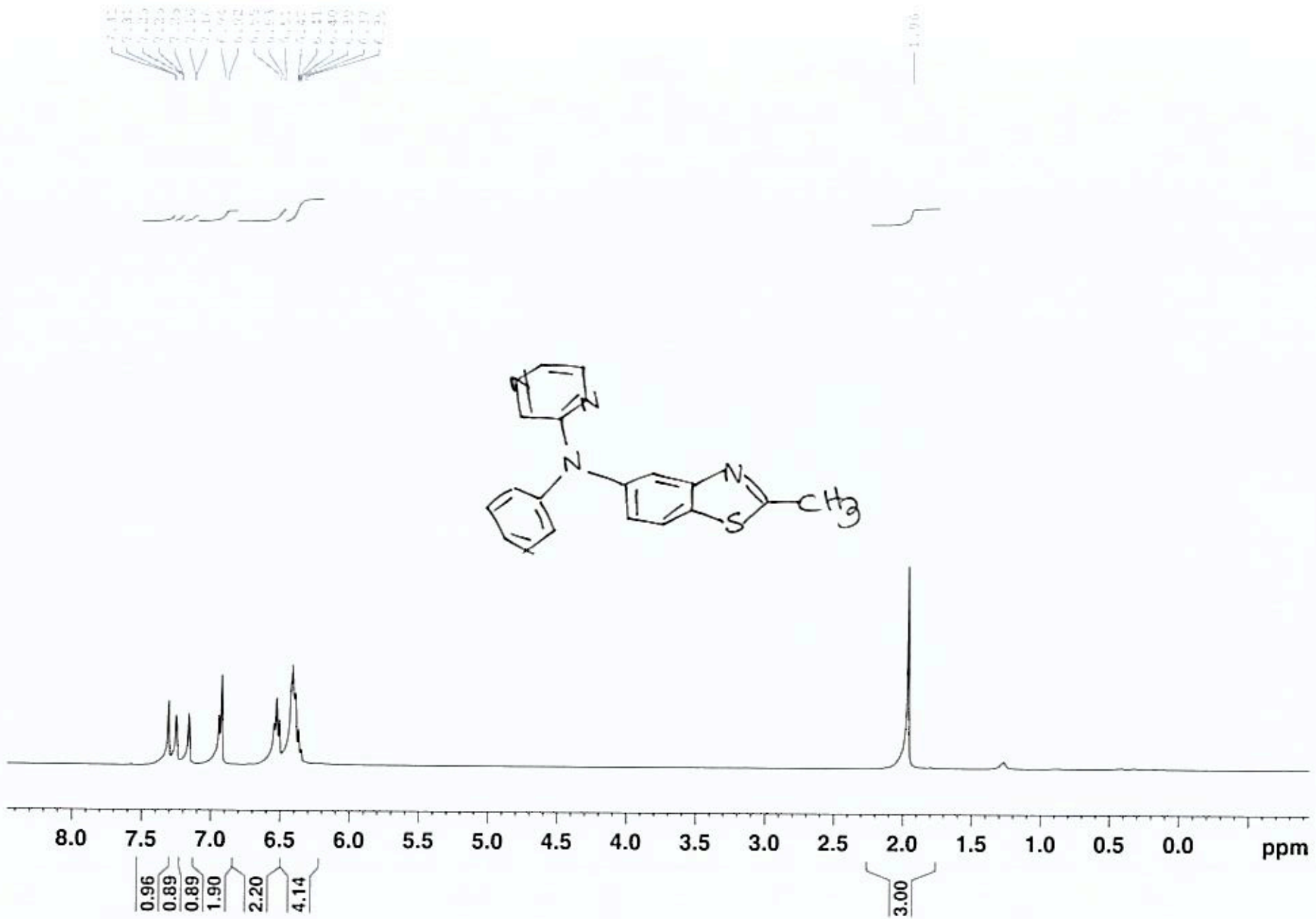

OCH3
10
9
8
7
6
5
4
3
2
1
0
ppm
0.66
1.64
0.94
0.90
1.83
3.48
3.05
1.91
3.00

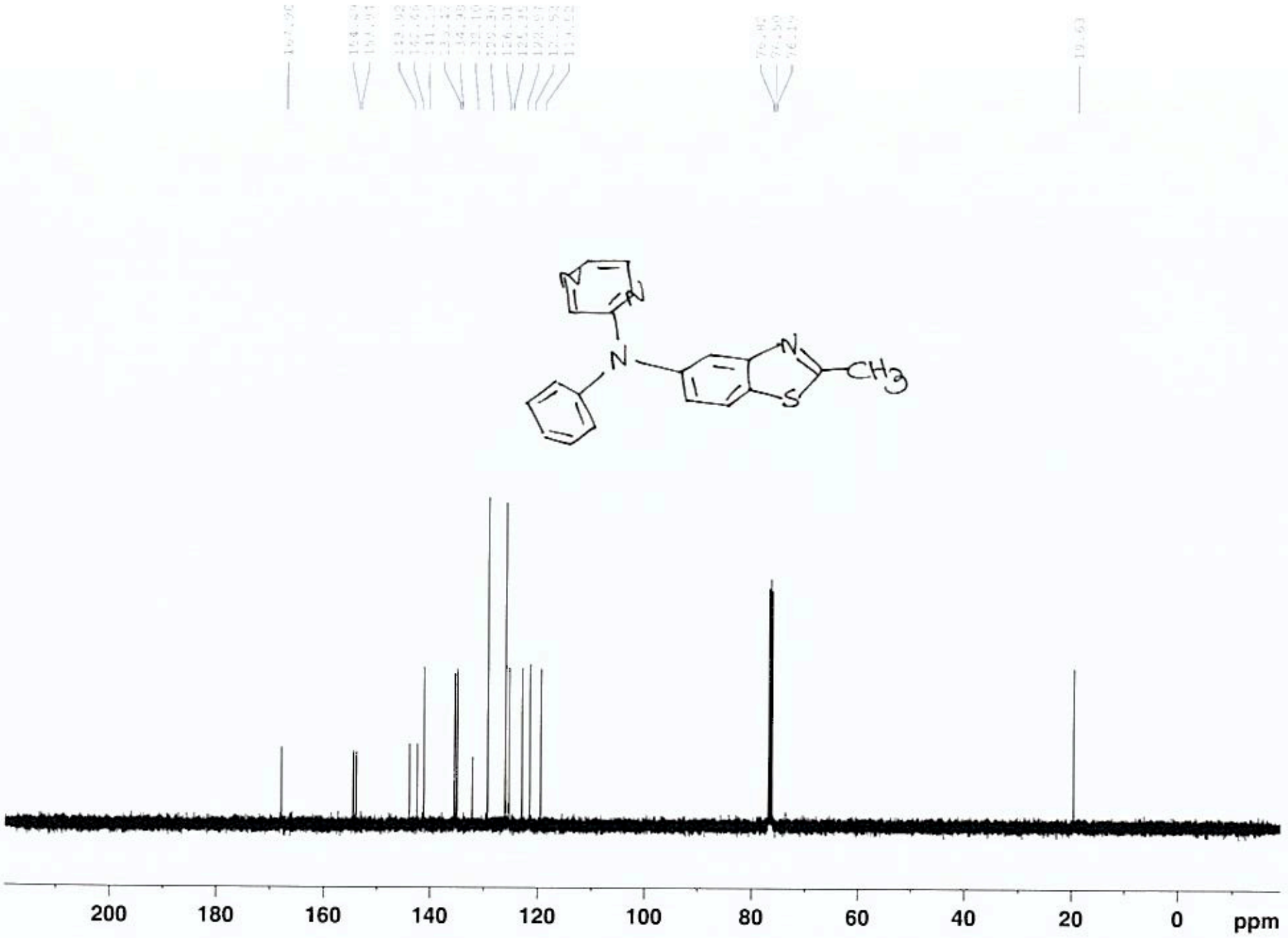


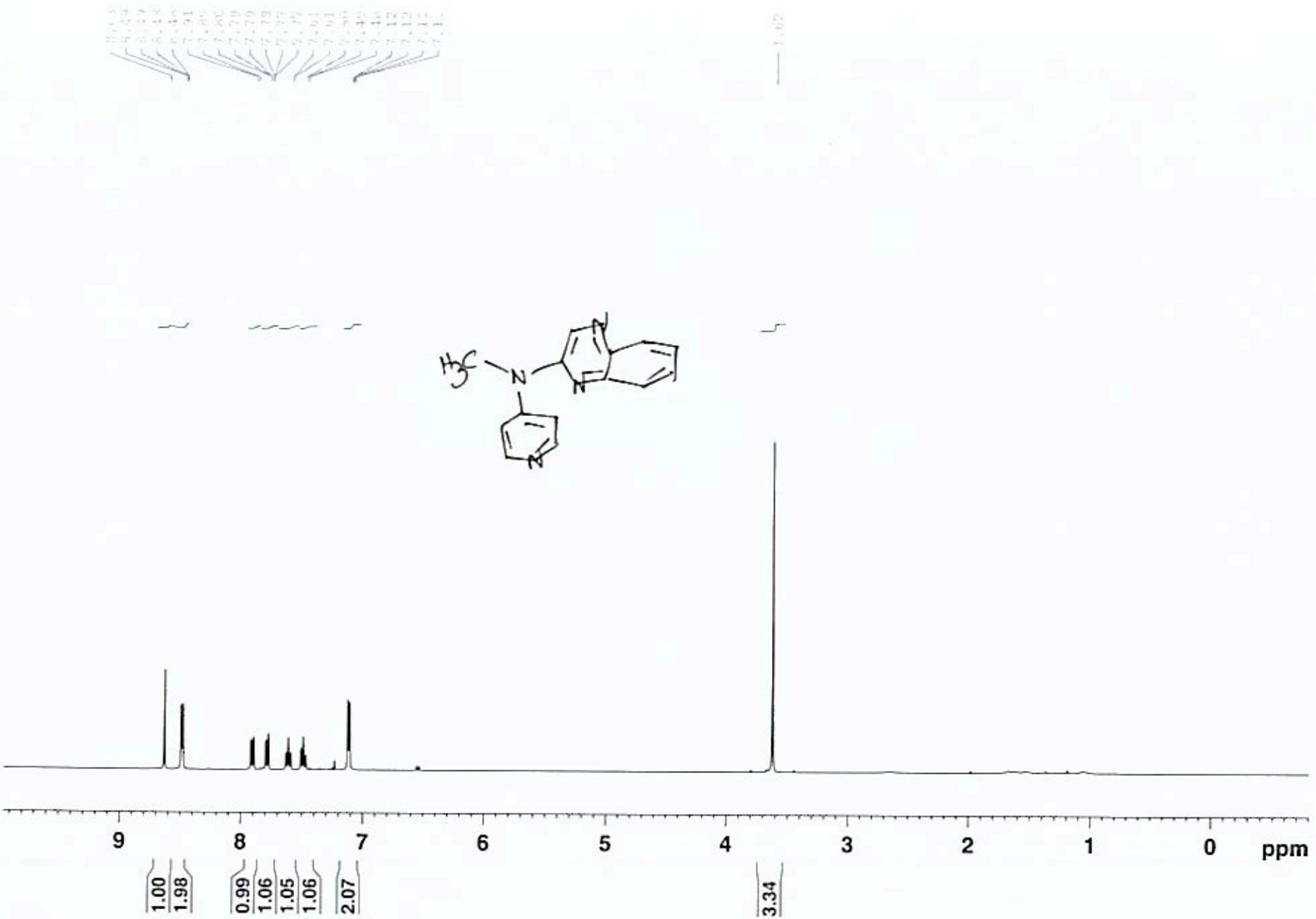

OCH3
N
N
N
S
CH3

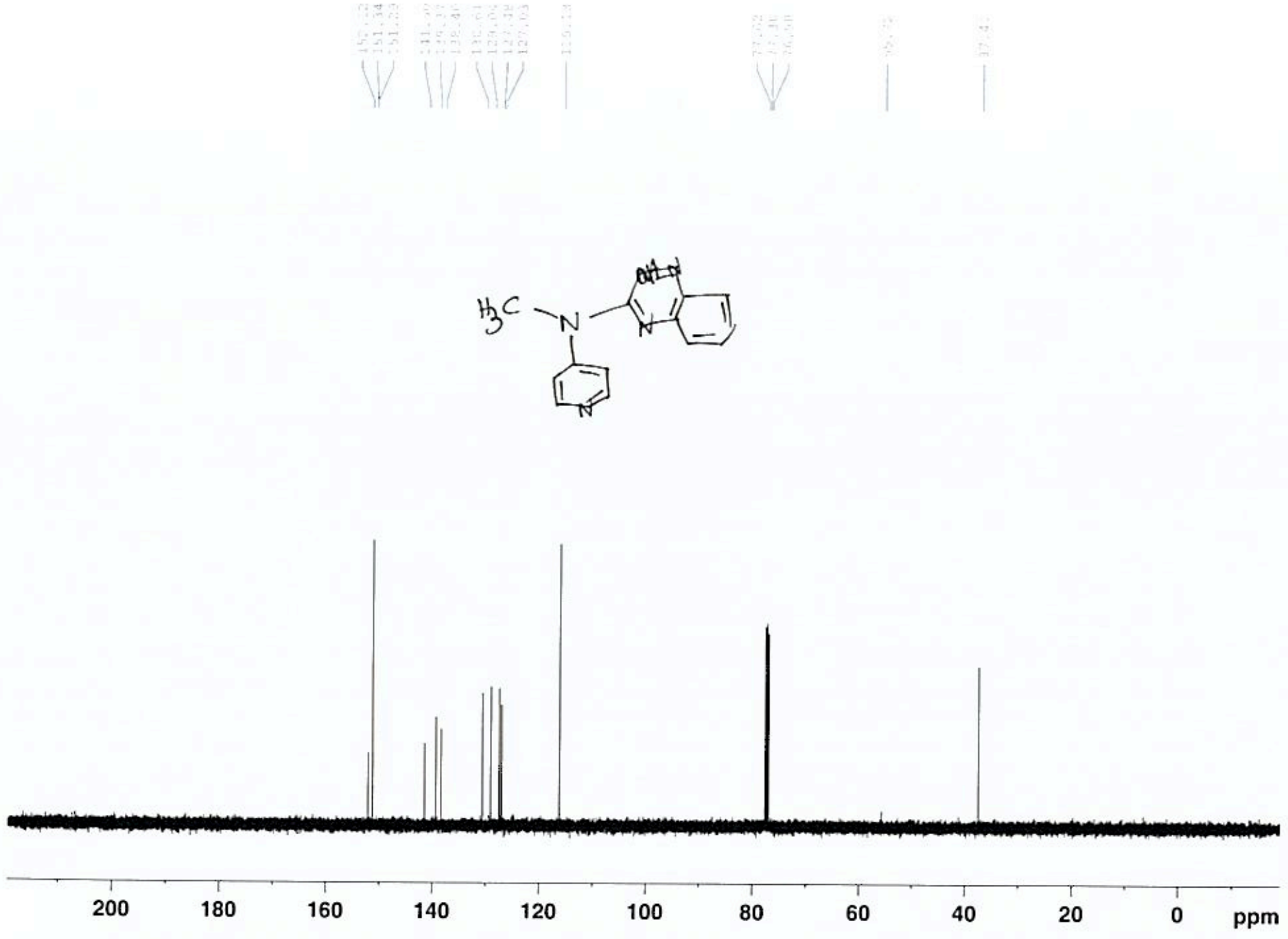

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
ppm
1.63
6.10
1.29
2.03
2.87
3.00

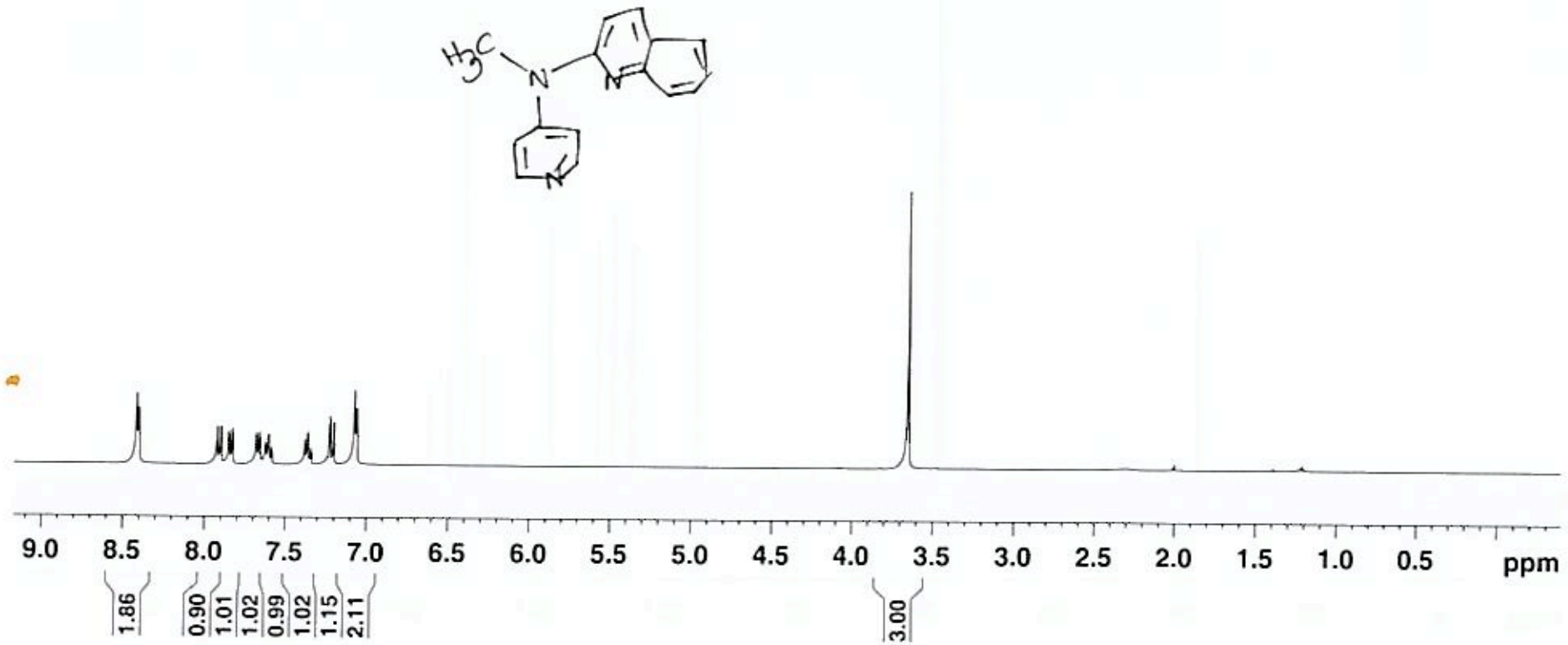

O–CH3
N
N
N
S
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

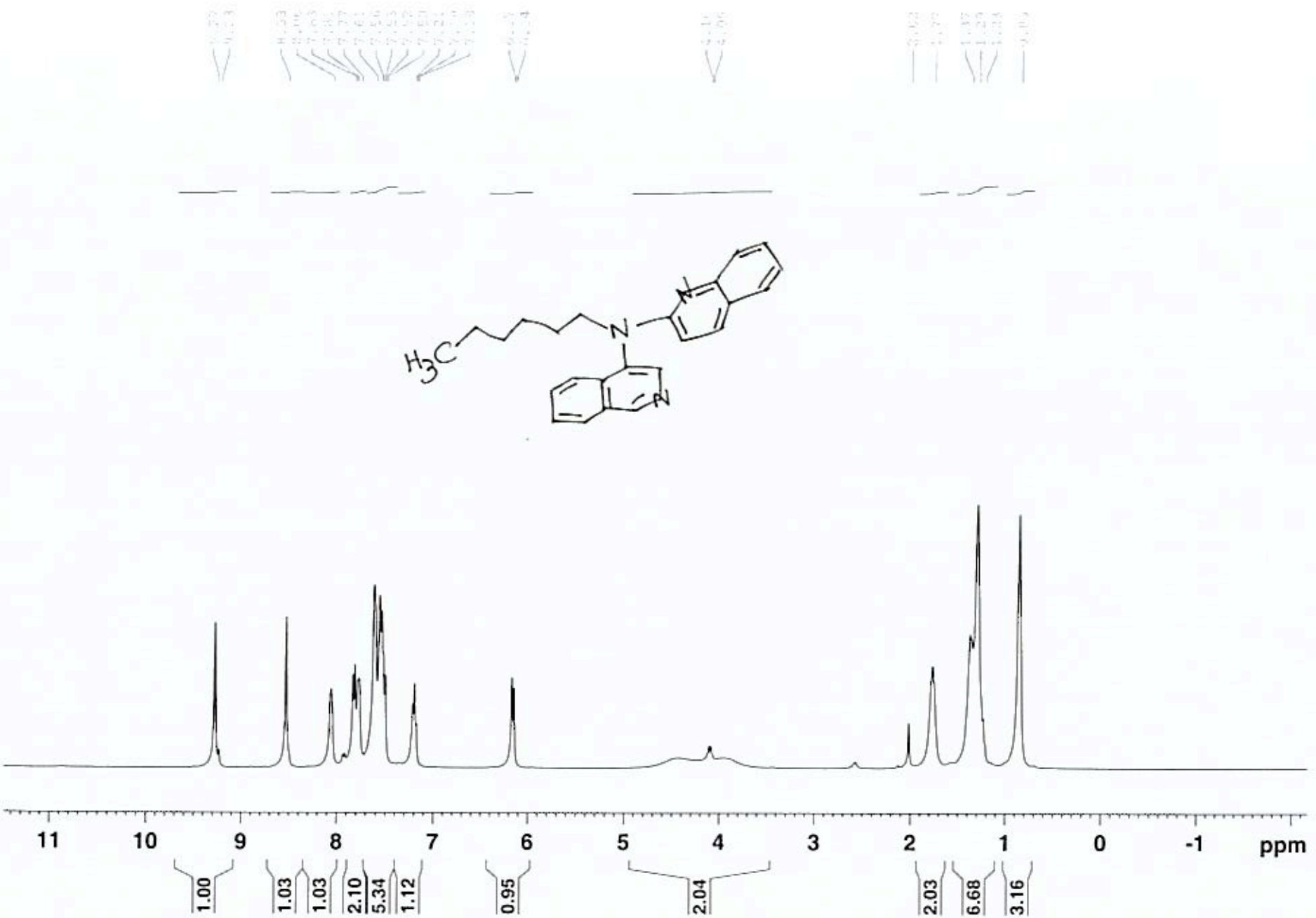

N
N
N
S
CH3
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
0.96
0.89
0.89
1.90
2.20
4.14
3.00

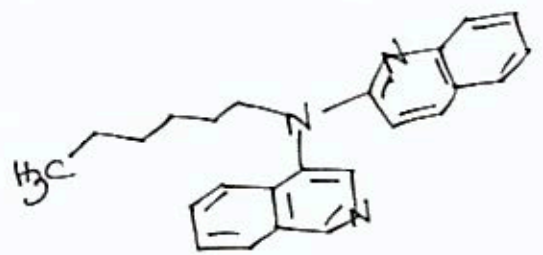

N
N
N
S
CH3
200
180
160
140
120
100
80
60
40
20
0
ppm

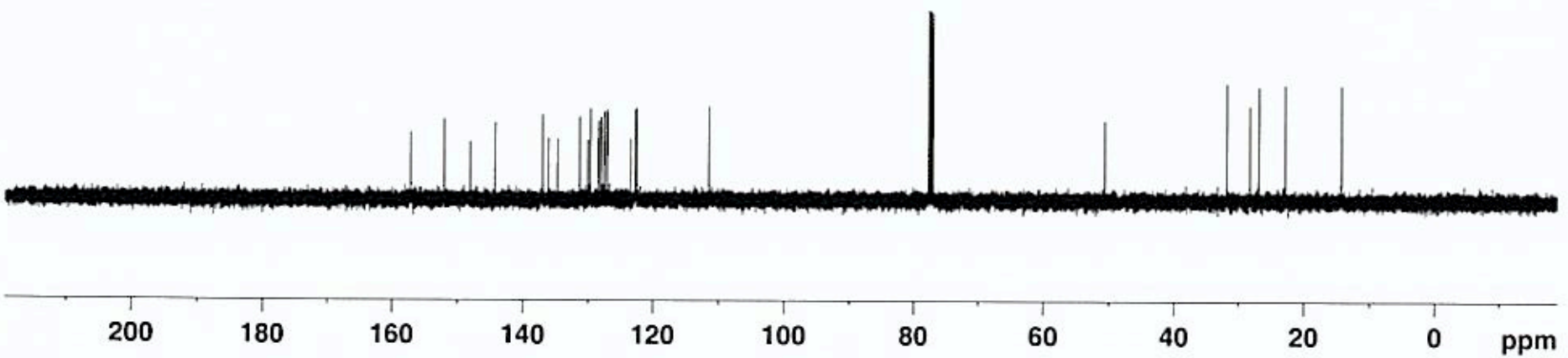

9
8
7
6
5
4
3
2
1
0
ppm
1.00
1.98
0.99
1.06
1.05
1.06
2.07
3.34

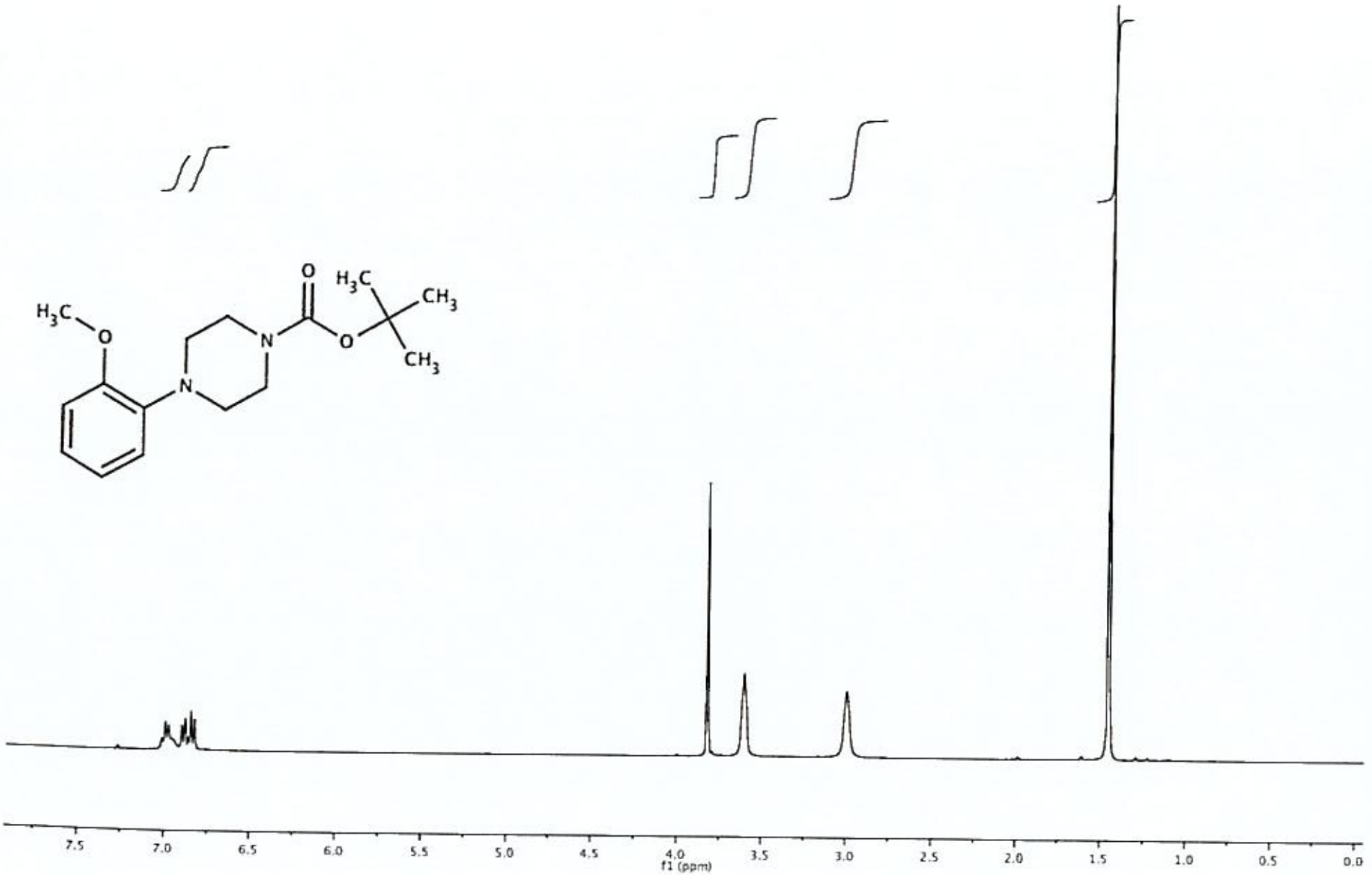

200
180
160
140
120
100
80
60
40
20
0
ppm

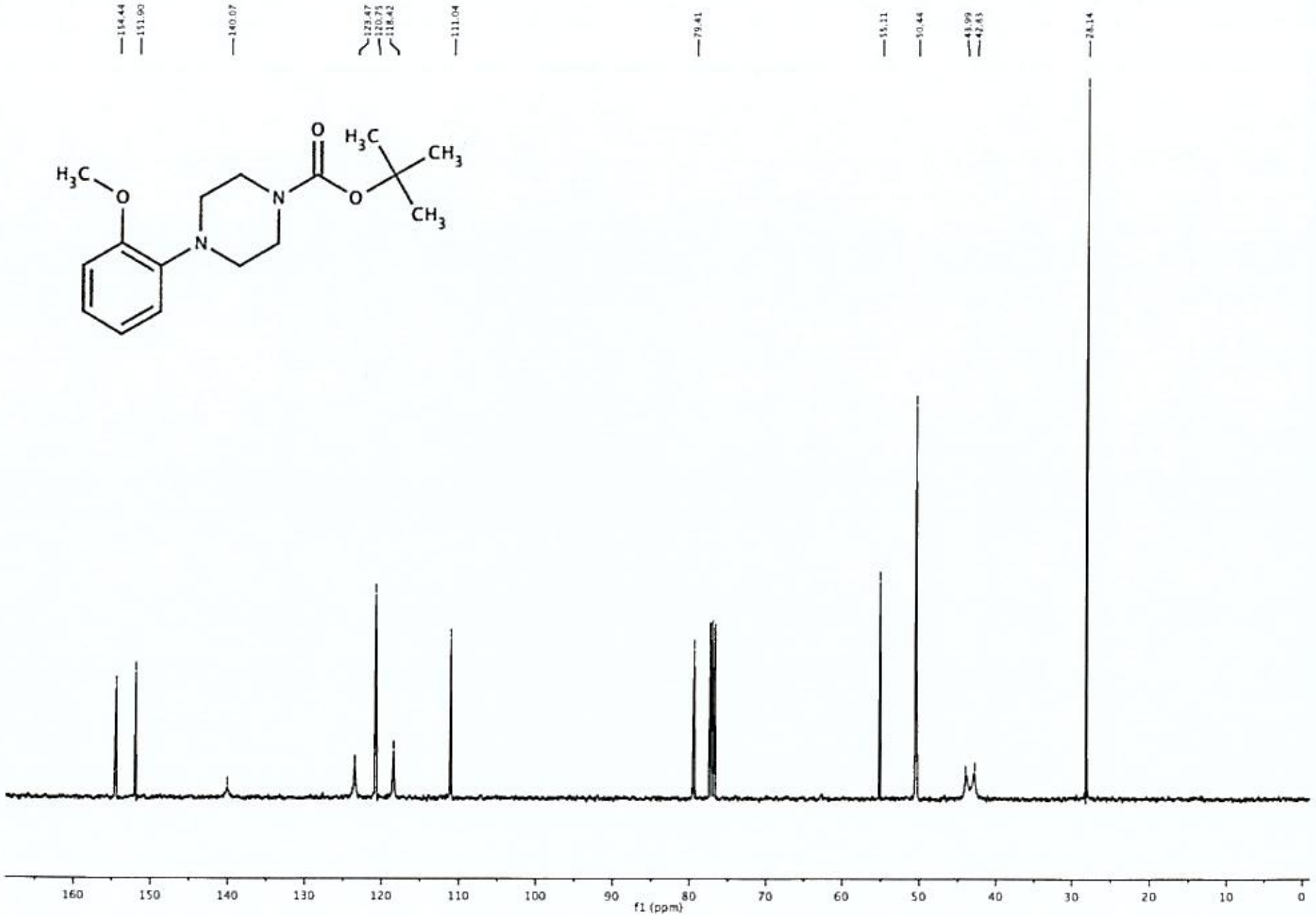

9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.86
0.90
1.01
1.02
0.99
1.02
1.15
2.11
3.00

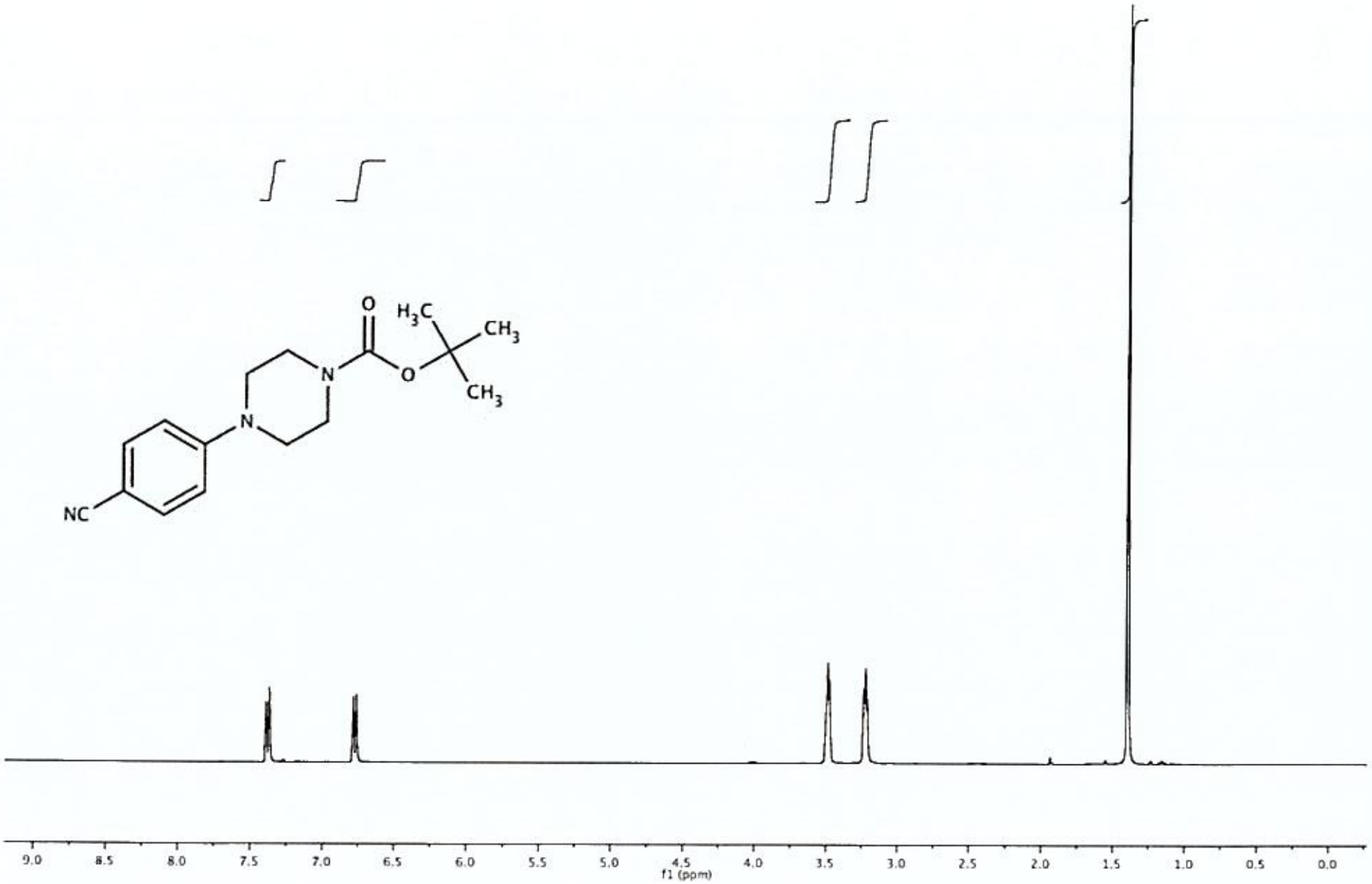

H3C
N
N
N
11
10
9
8
7
6
5
4
3
2
1
0
-1
ppm
1.00
1.03
1.03
2.10
5.34
1.12
0.95
2.04
2.03
6.68
3.16

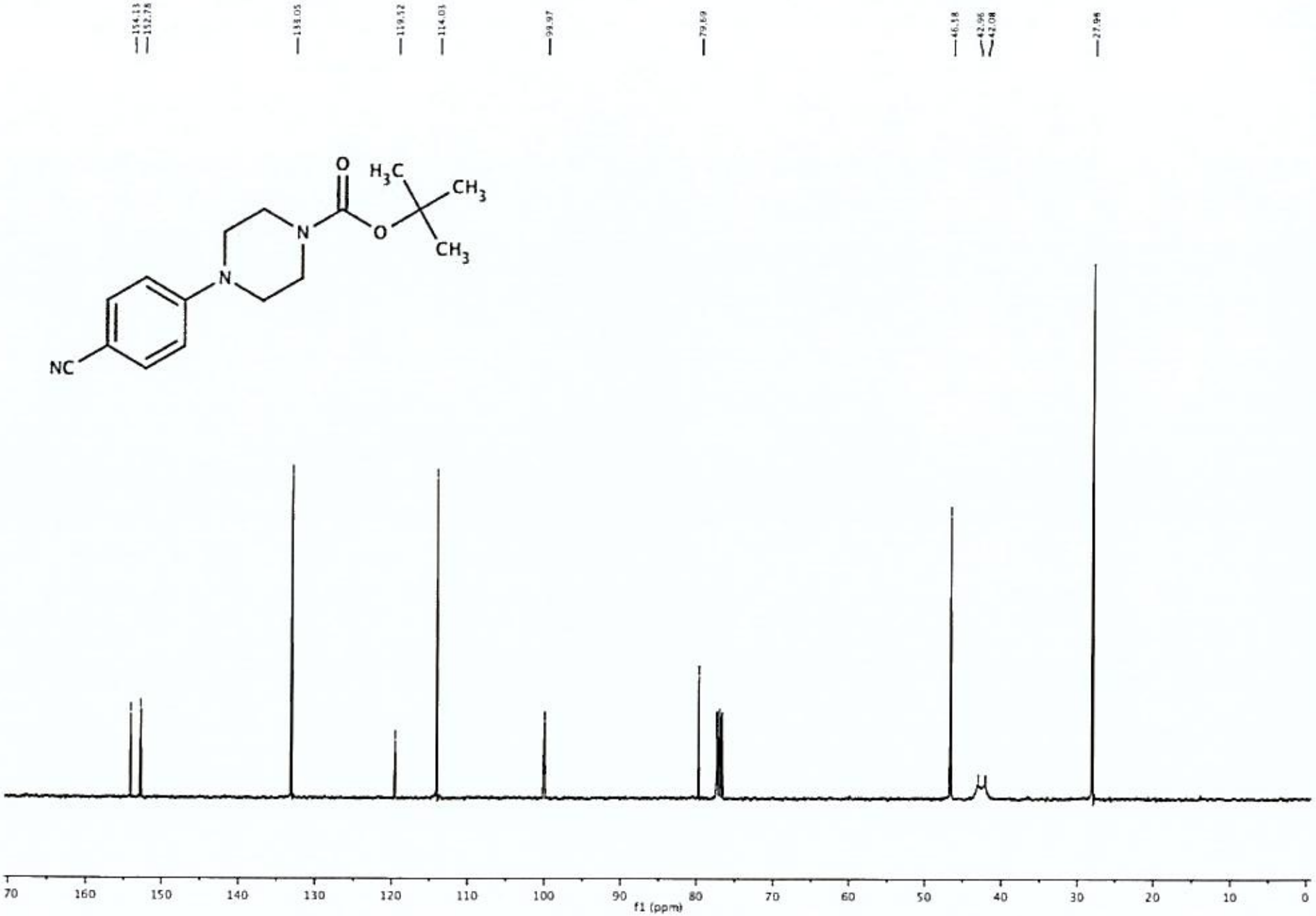


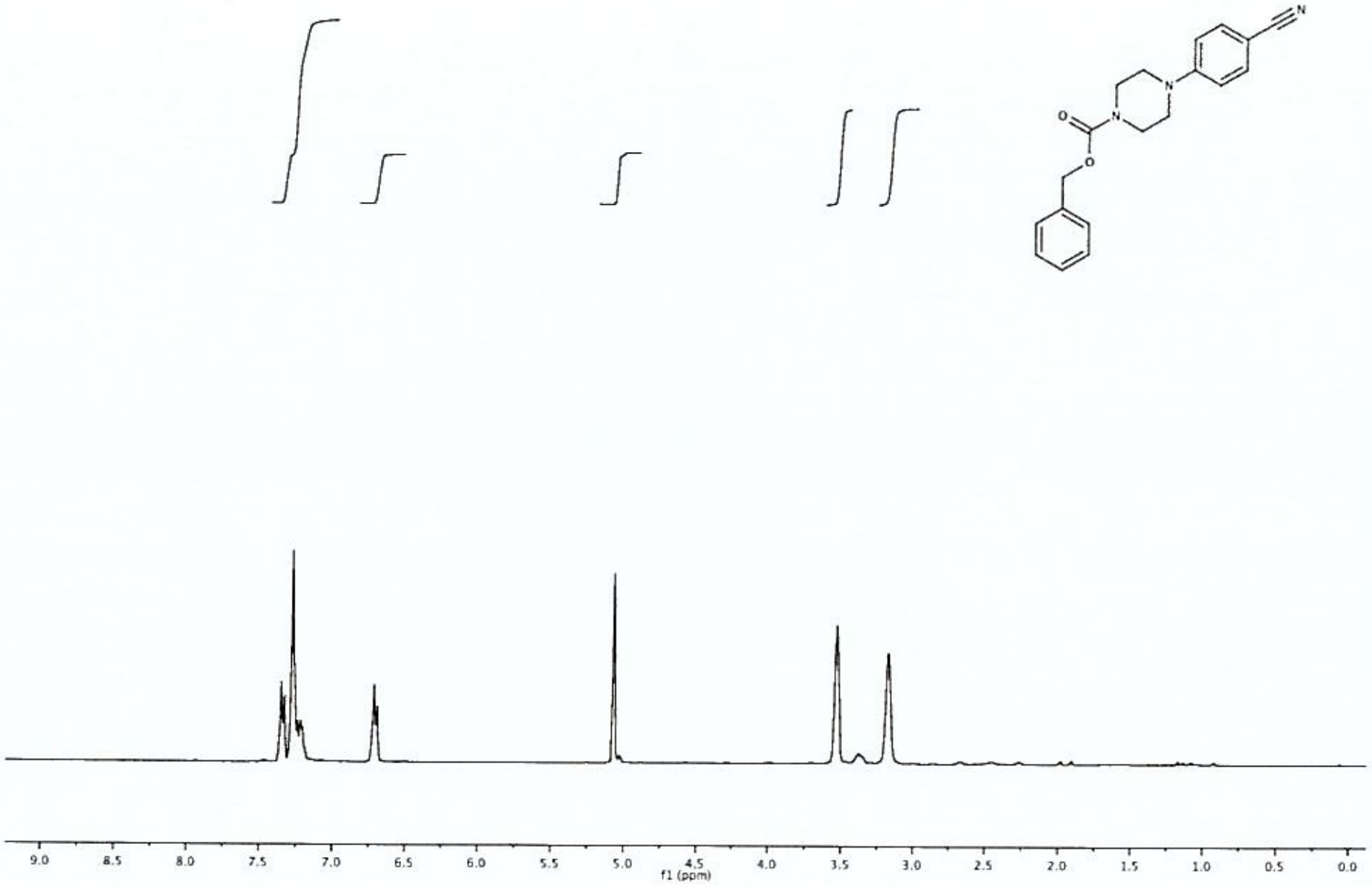

200
180
160
140
120
100
80
60
40
20
0
ppm

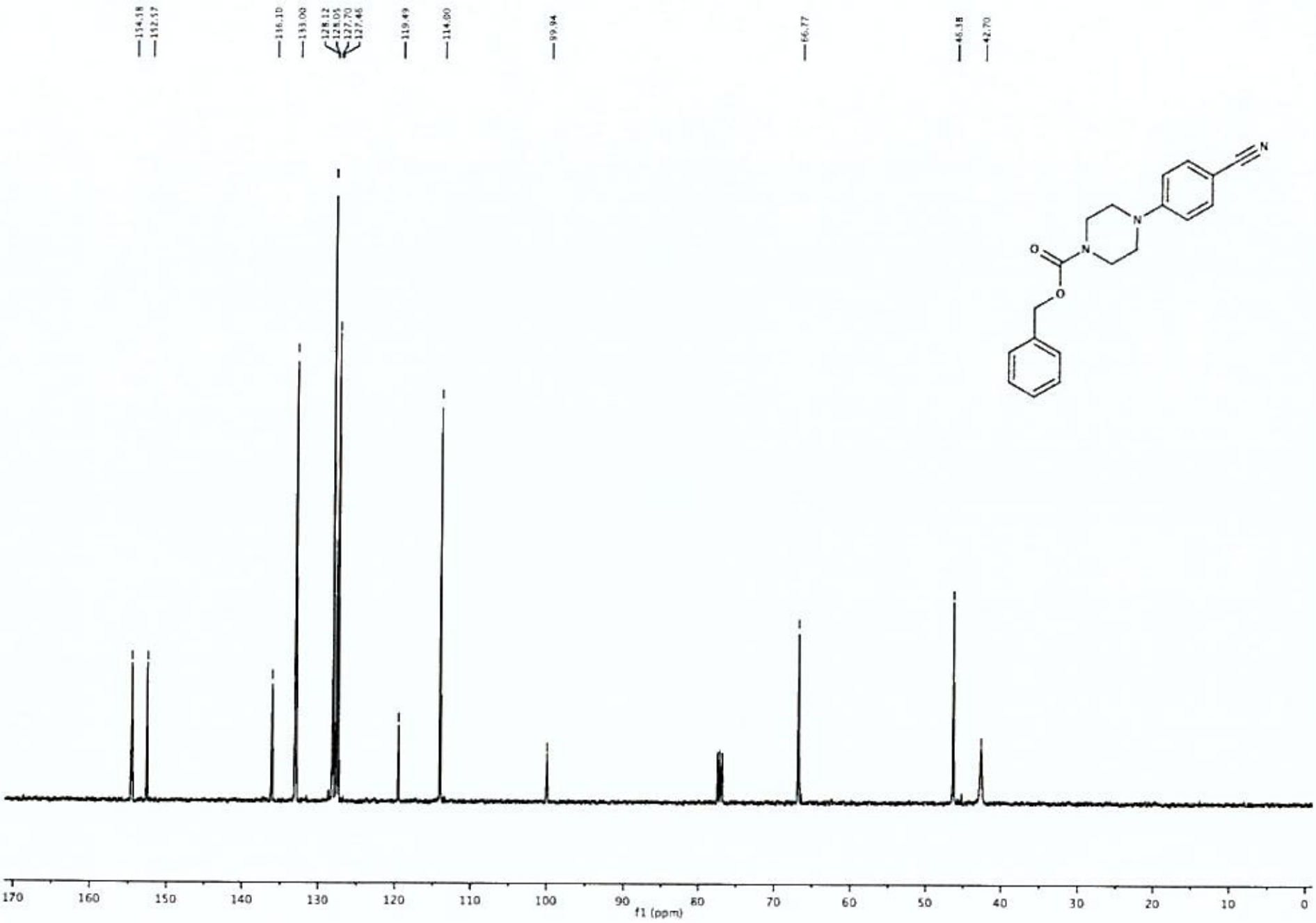

O
H3C
CH3
H3C
O
N
O
N
CH3
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
f1 (ppm)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

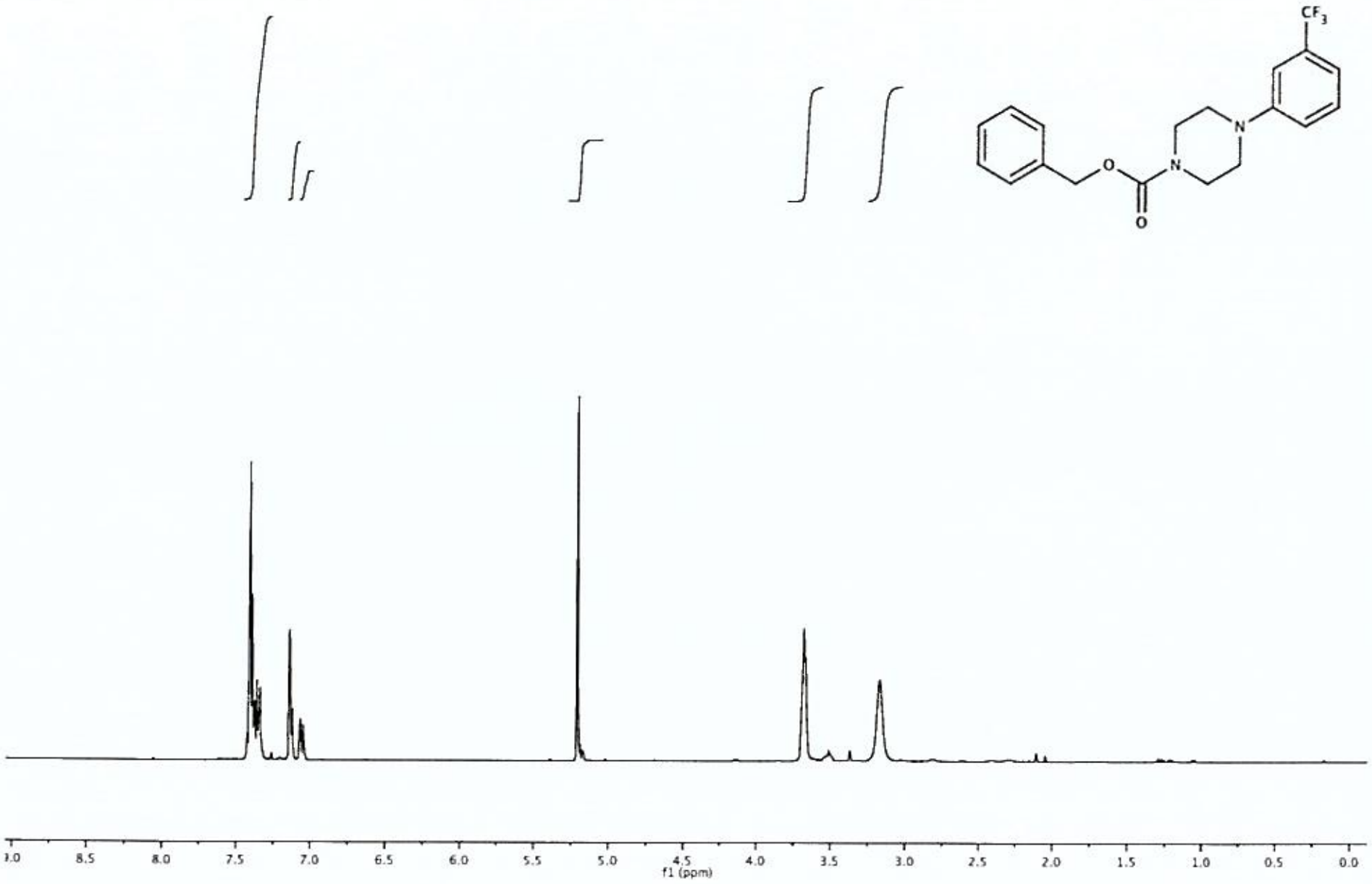

154.44
151.90
140.07
123.47
120.75
118.42
111.04
79.41
55.11
50.44
43.99
42.83
28.14
O
H3C
CH3
H3C
O
N
O
CH3
N
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

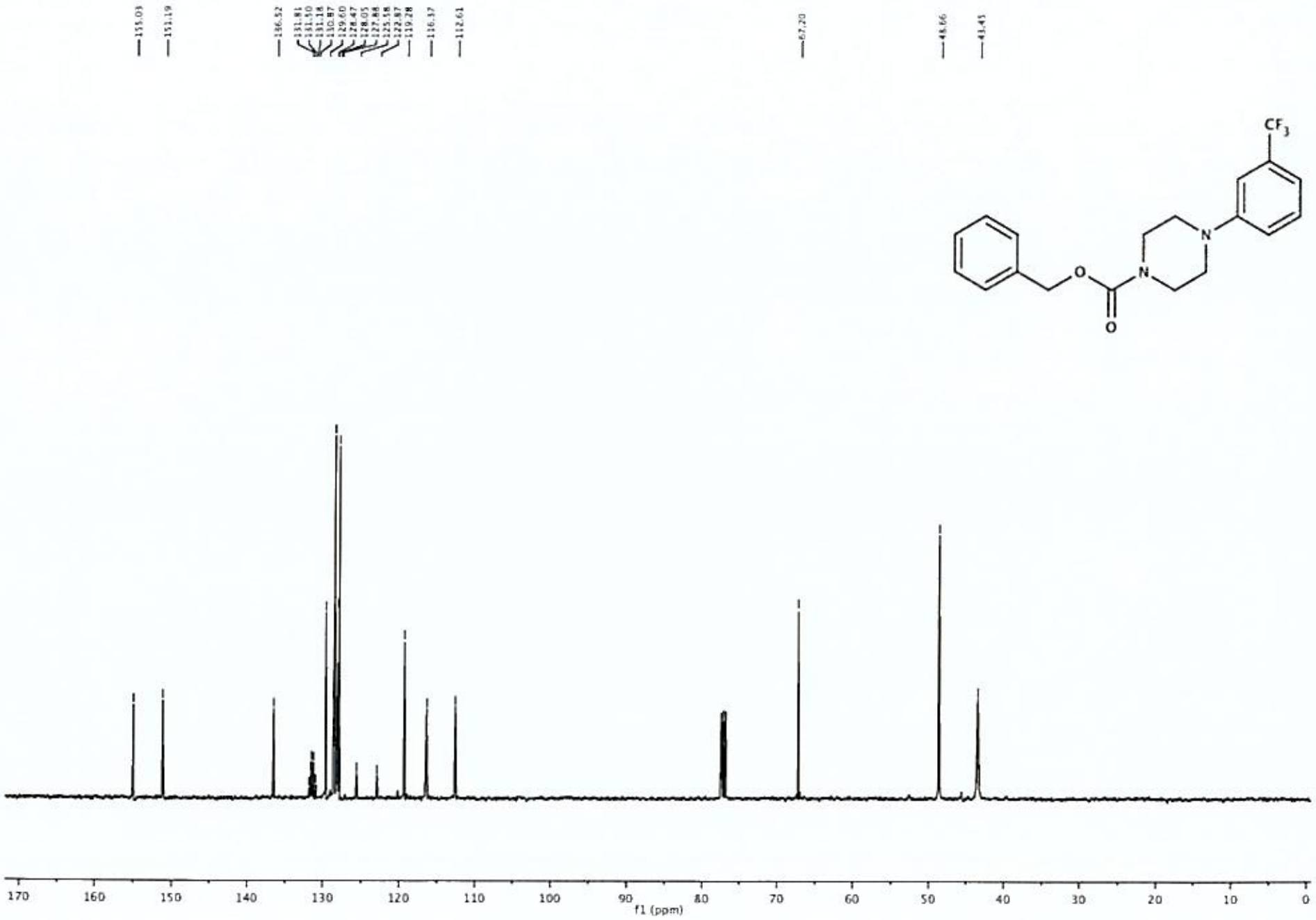

O
H3C
CH3
CH3
N
O
N
NC
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

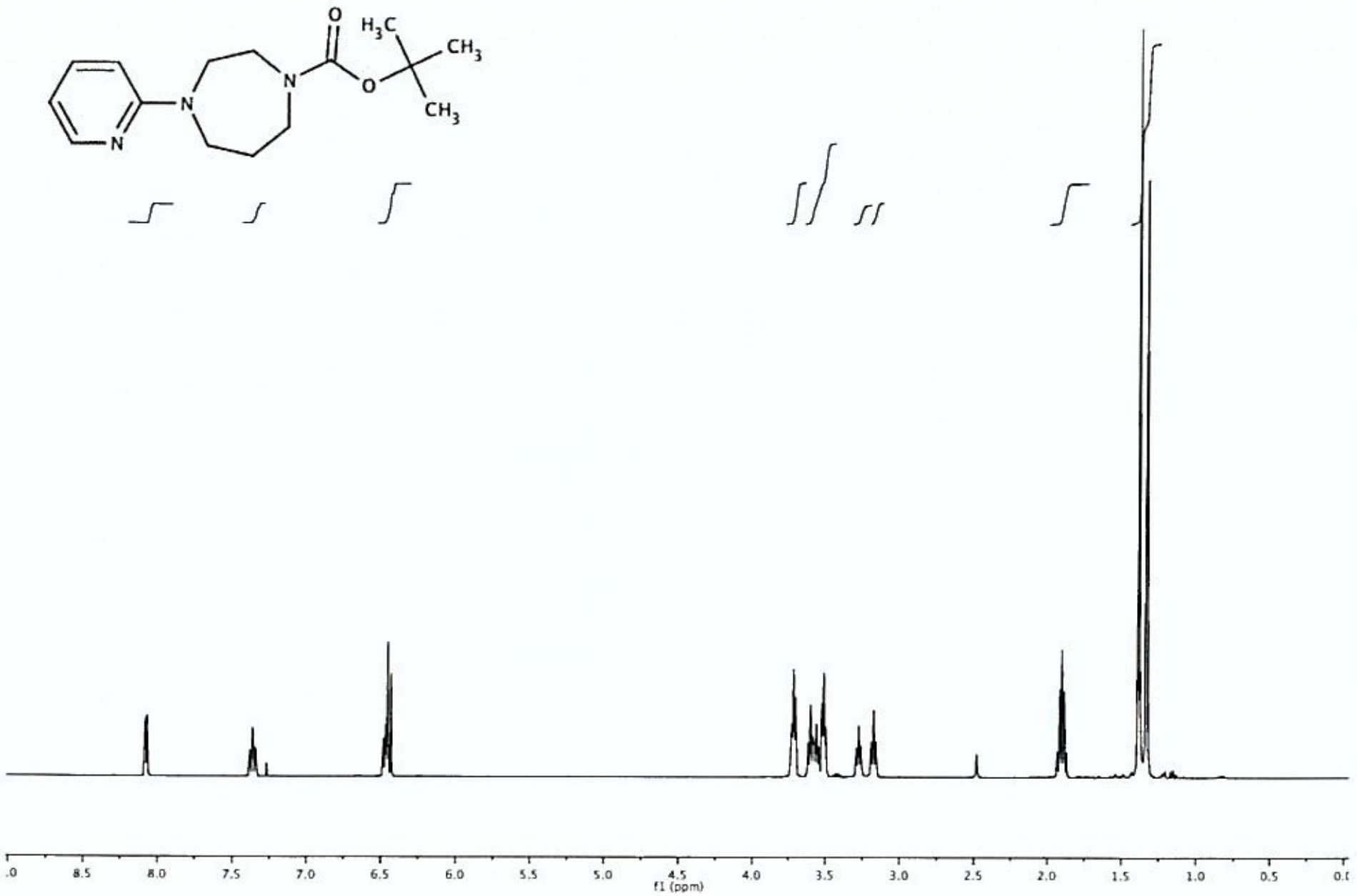

154.13
152.78
133.05
119.52
114.03
99.97
79.89
46.38
42.96
42.08
27.94
O
H3C
CH3
CH3
O
N
N
NC
70
160
150
140
130
120
110
100
90
f1 (ppm)
80
70
60
50
40
30
20
10
0

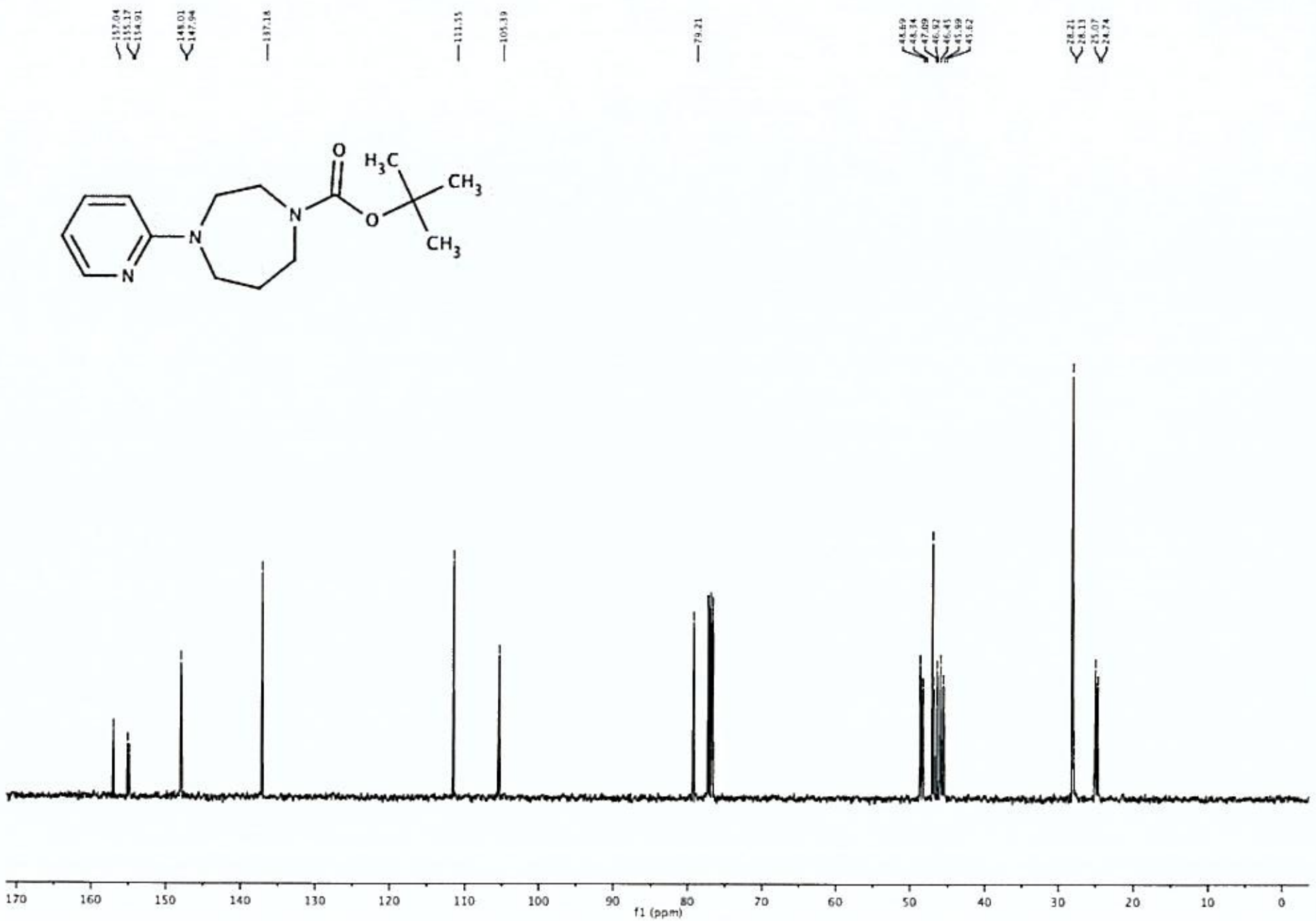

N
N
O
O
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
f1 (ppm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

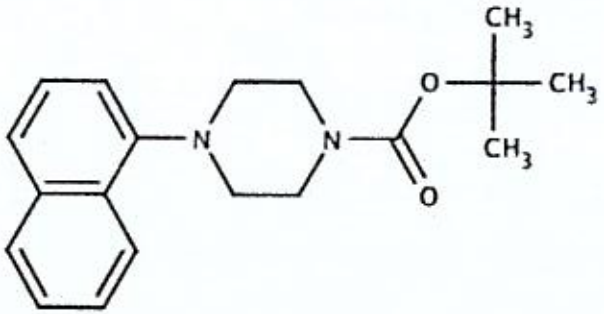

154.58
152.57
116.10
133.08
128.12
128.05
127.70
127.46
119.49
114.80
99.94
66.77
46.38
42.70
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
N
O
N
O
O
N

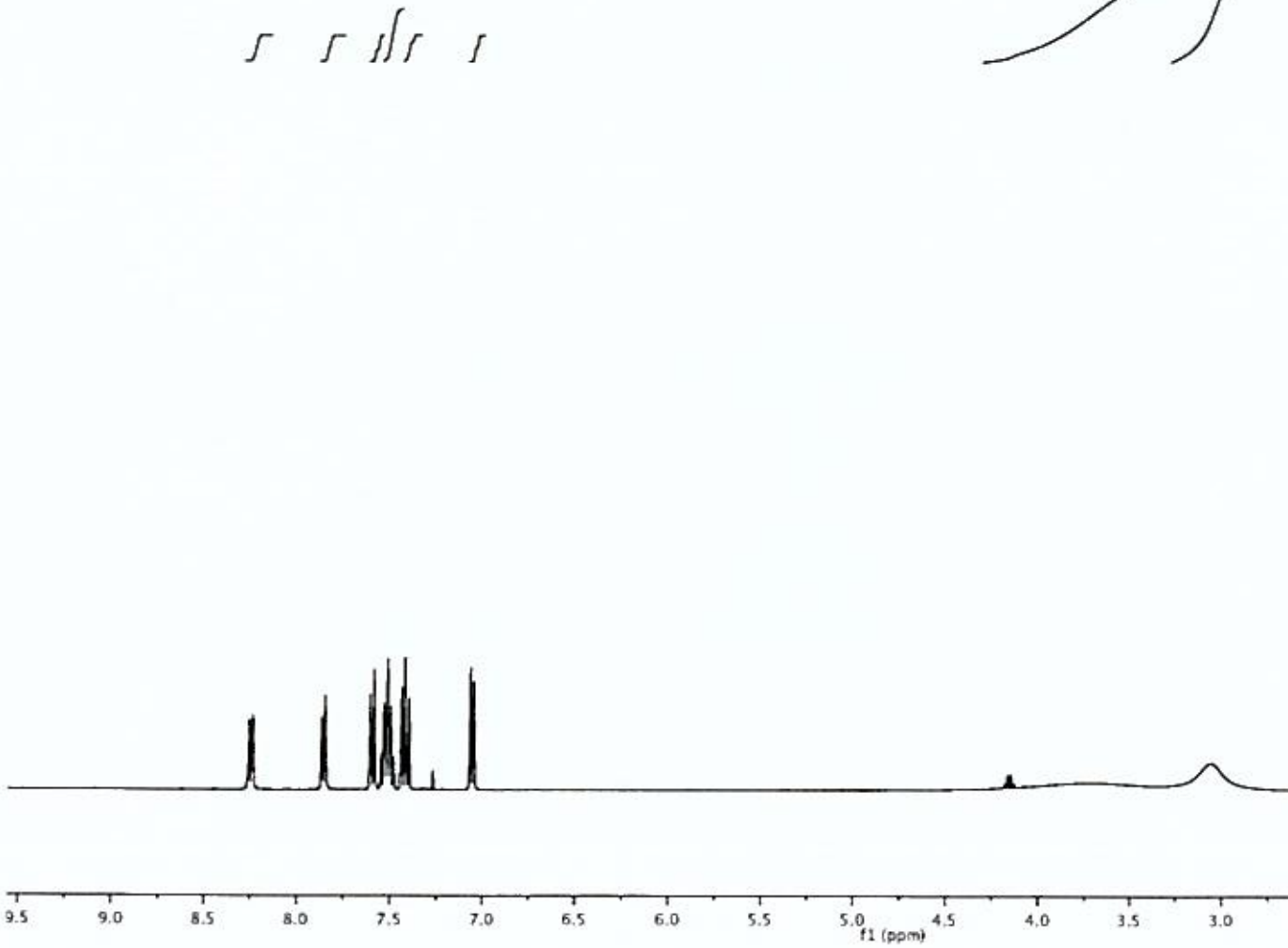

CF3
O
N
N
O
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

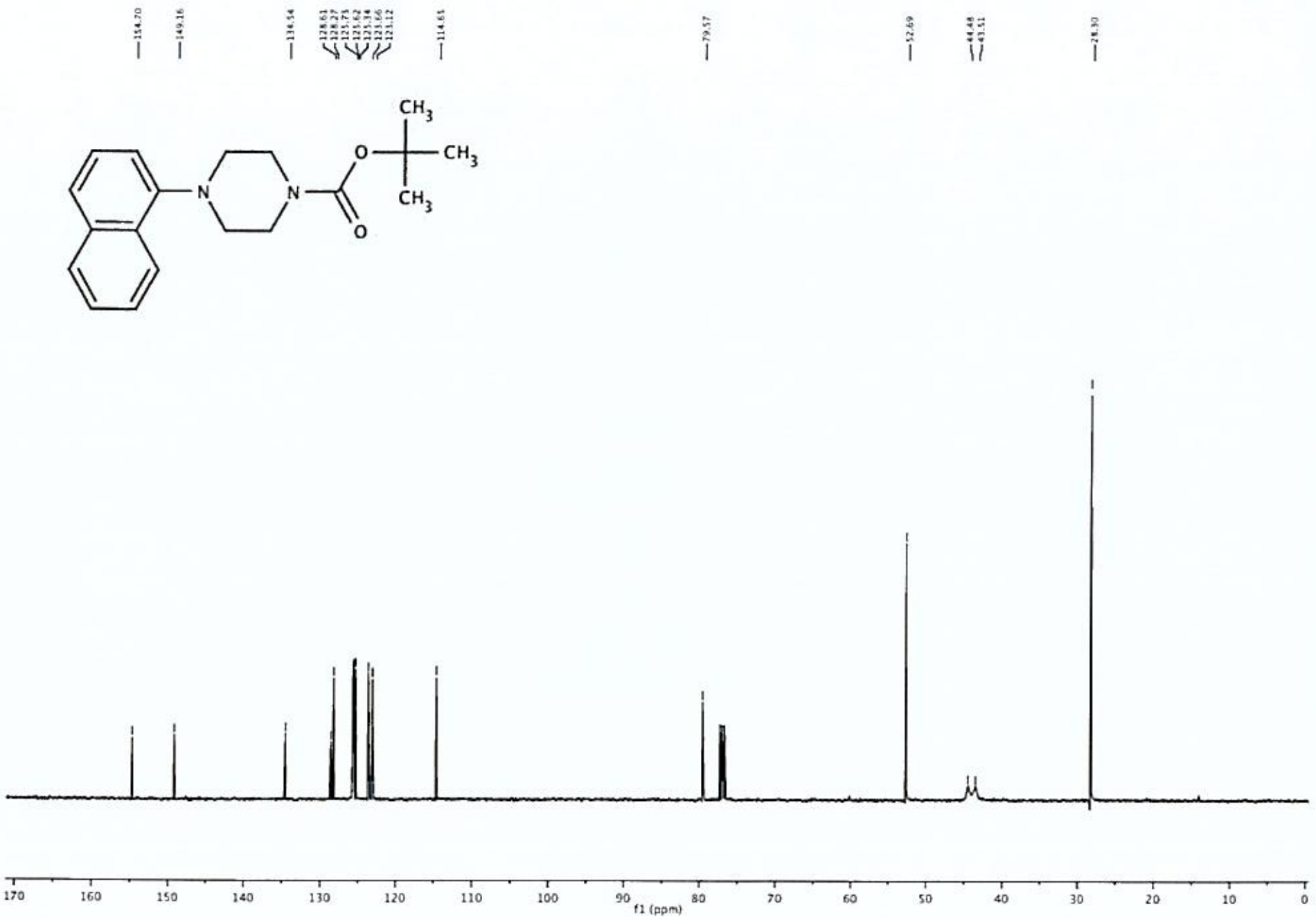

155.03
151.19
136.52
131.81
131.50
131.18
130.87
129.60
128.47
128.05
127.88
125.58
122.87
119.28
116.37
112.61
67.20
48.66
43.45
CF3
O
O
N
N
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

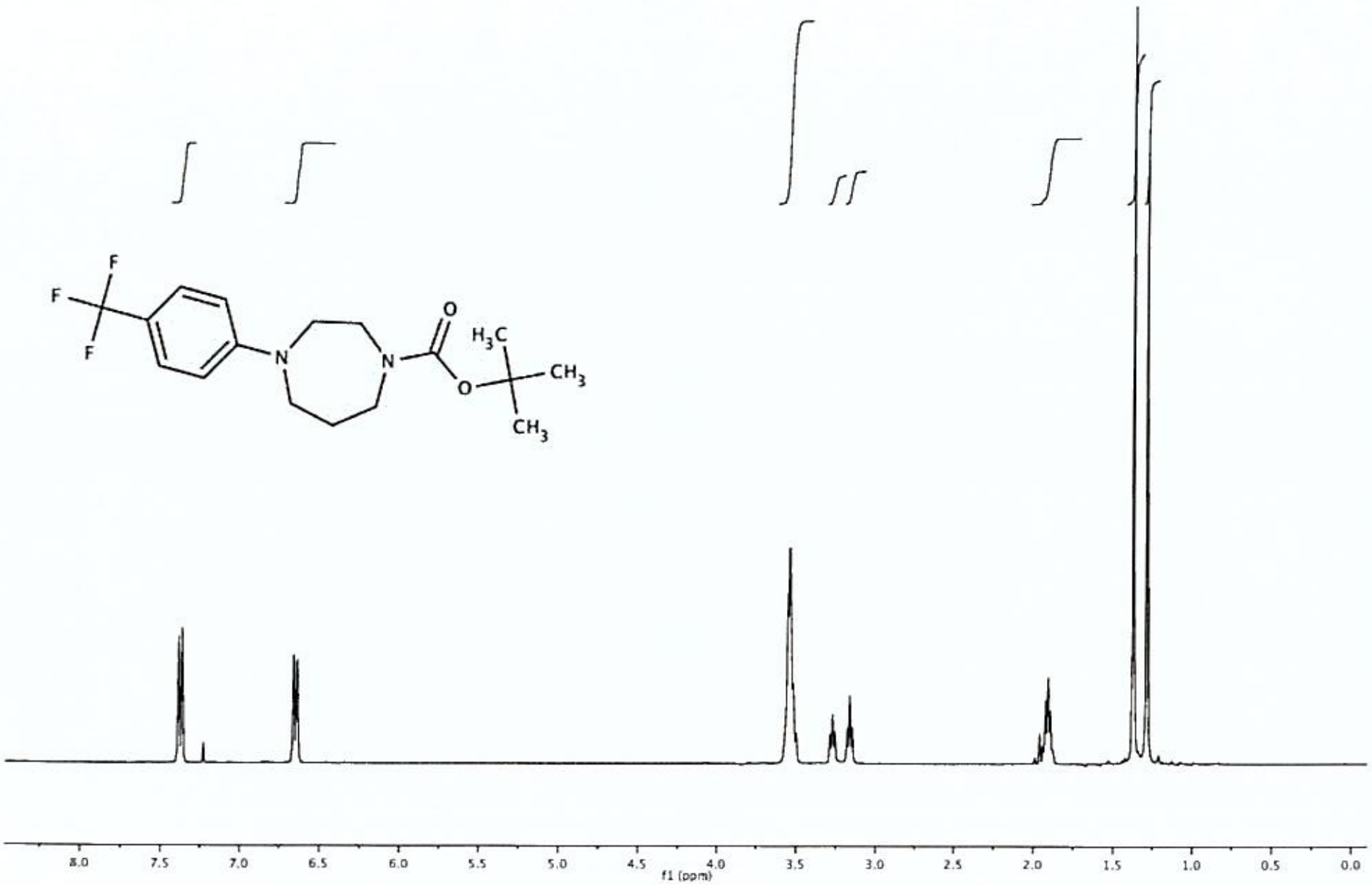

O
H3C
CH3
CH3
N
N
N
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
f1 (ppm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5

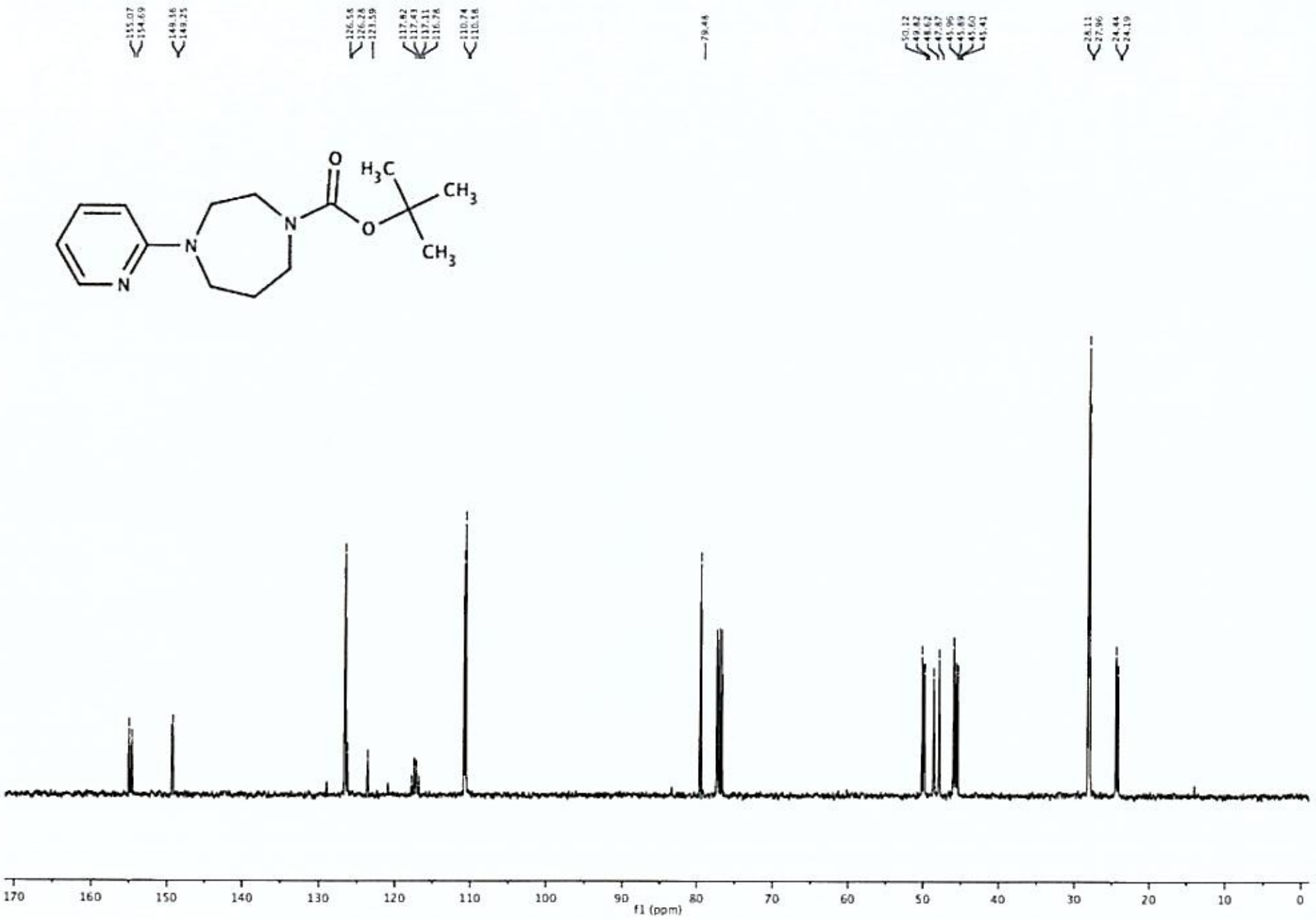

157.64
155.17
154.91
148.01
147.94
137.18
111.55
105.39
79.21
48.69
48.34
47.89
46.92
46.45
45.99
45.62
28.21
28.13
25.07
24.74
O
H3C
CH3
CH3
O
N
N
N
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


CH3
CH3
CH3
O
N
N
O


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
f1 (ppm)

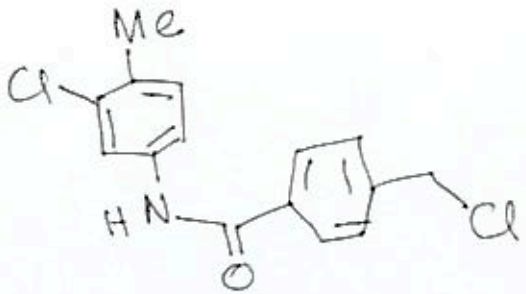

154.70
149.16
134.54
128.61
128.27
125.71
125.62
125.34
123.66
123.12
114.61
79.57
52.69
44.48
43.51
28.30
CH3
CH3
CH3
O
O
N
N
O
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

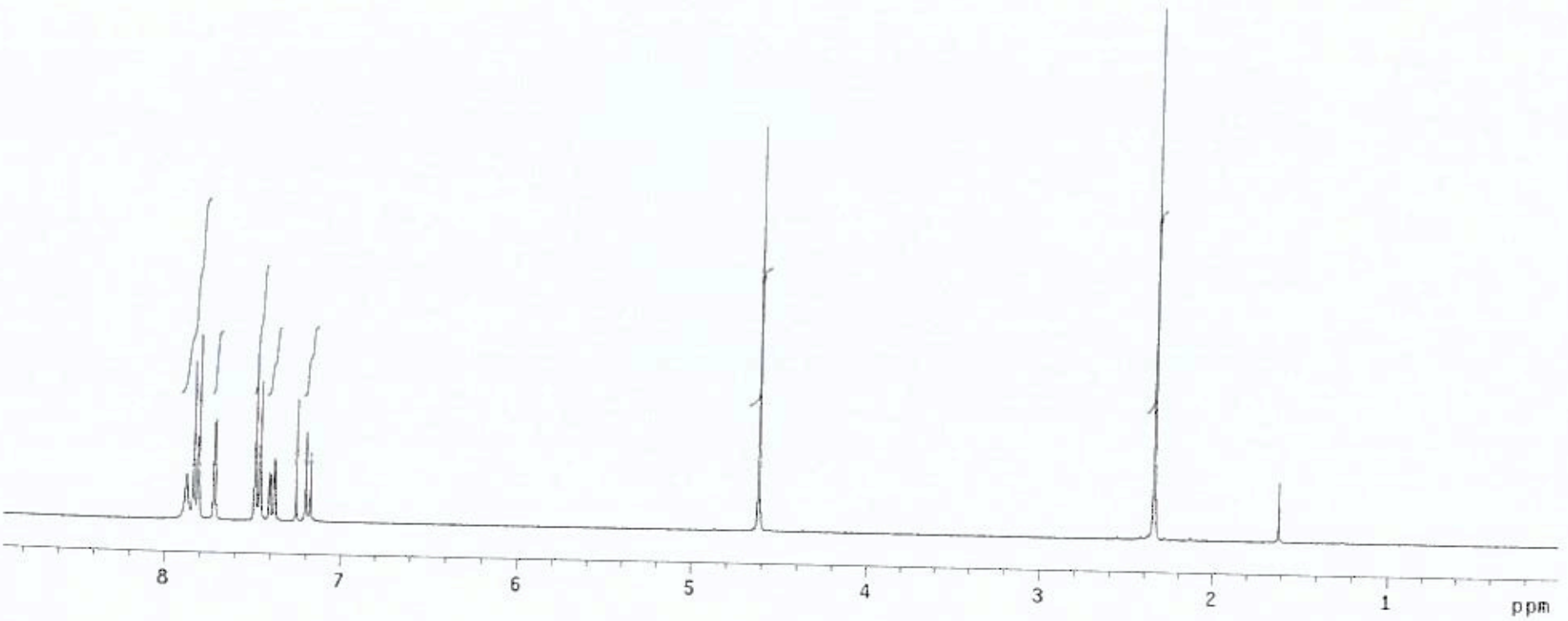



155.07
154.69
149.16
149.25
126.58
126.28
123.59
117.82
117.43
117.11
116.78
110.74
110.58
79.44
50.12
49.82
48.62
47.87
45.96
45.89
45.60
45.41
28.11
27.96
24.44
24.19
O
H3C
CH3
CH3
N
N
N
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

BF-III-214

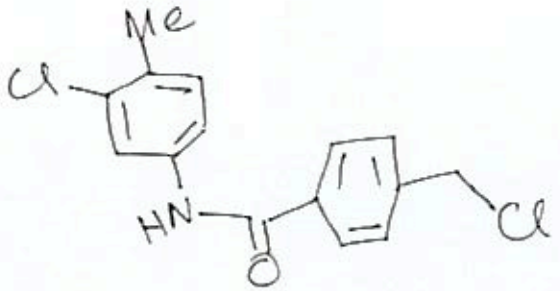
Pulse Sequence: s2pul

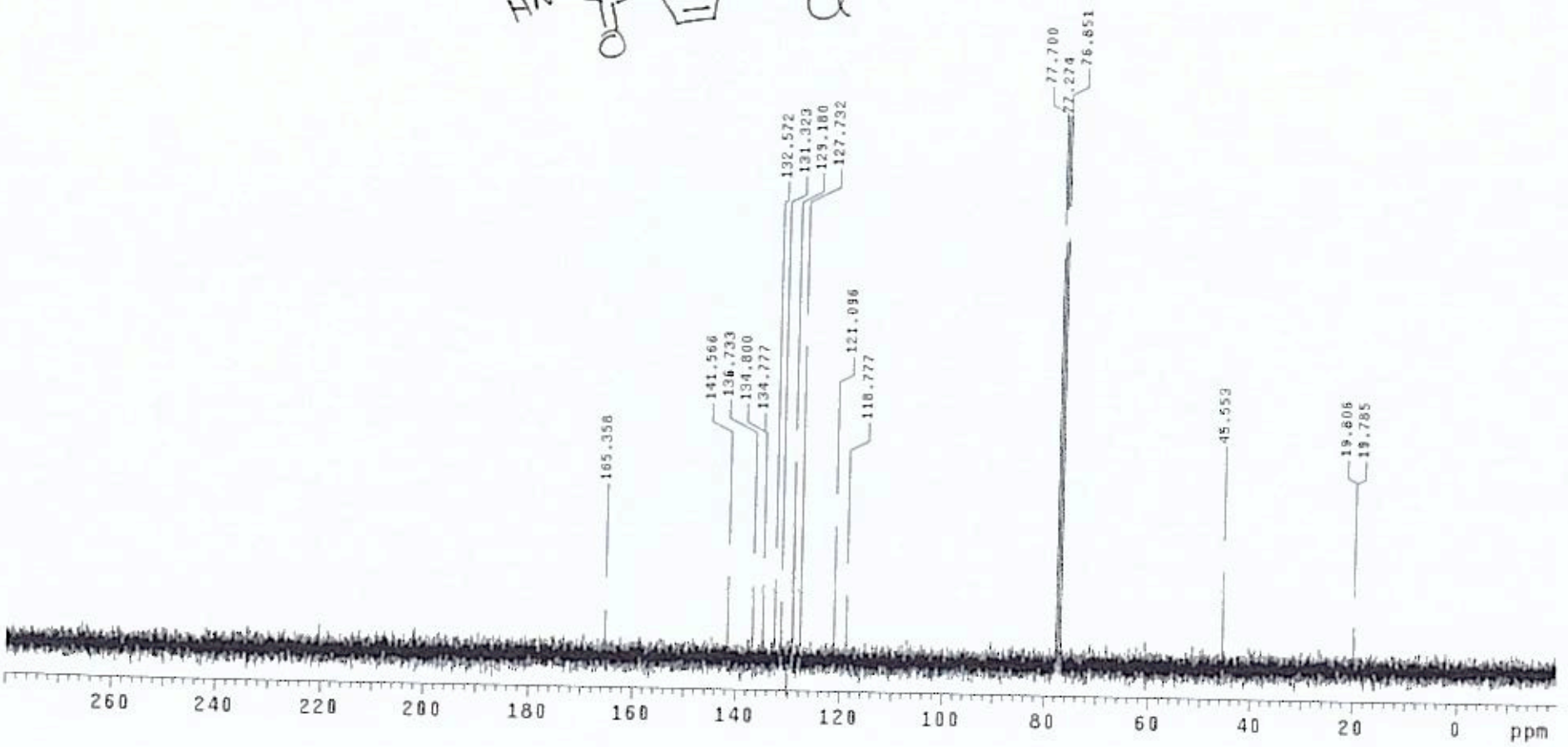




8F-III-214-13C

Pulse Sequence: s2pul



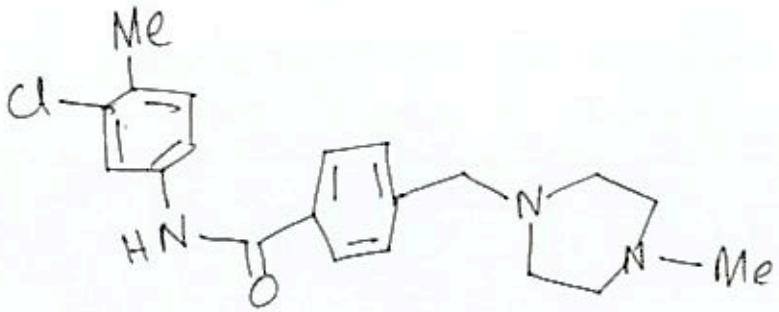


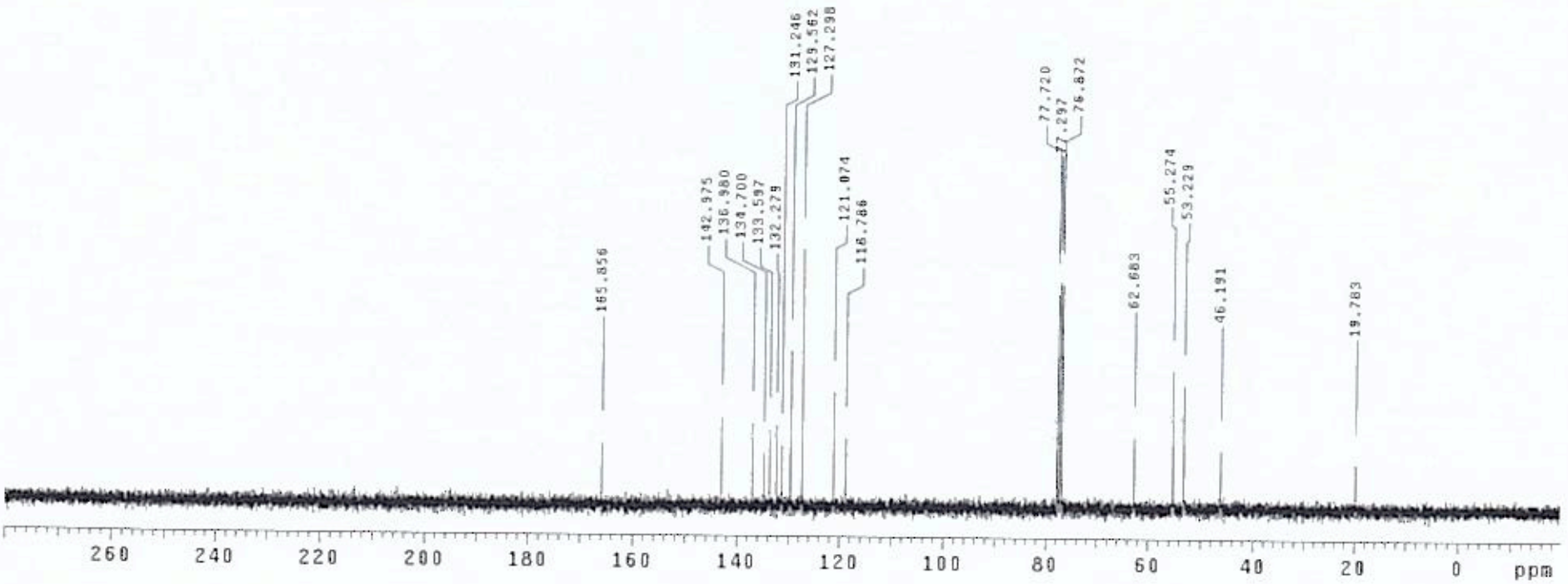
8F-III-215

Pulse Sequence: s2pul

BF-III-215-13C

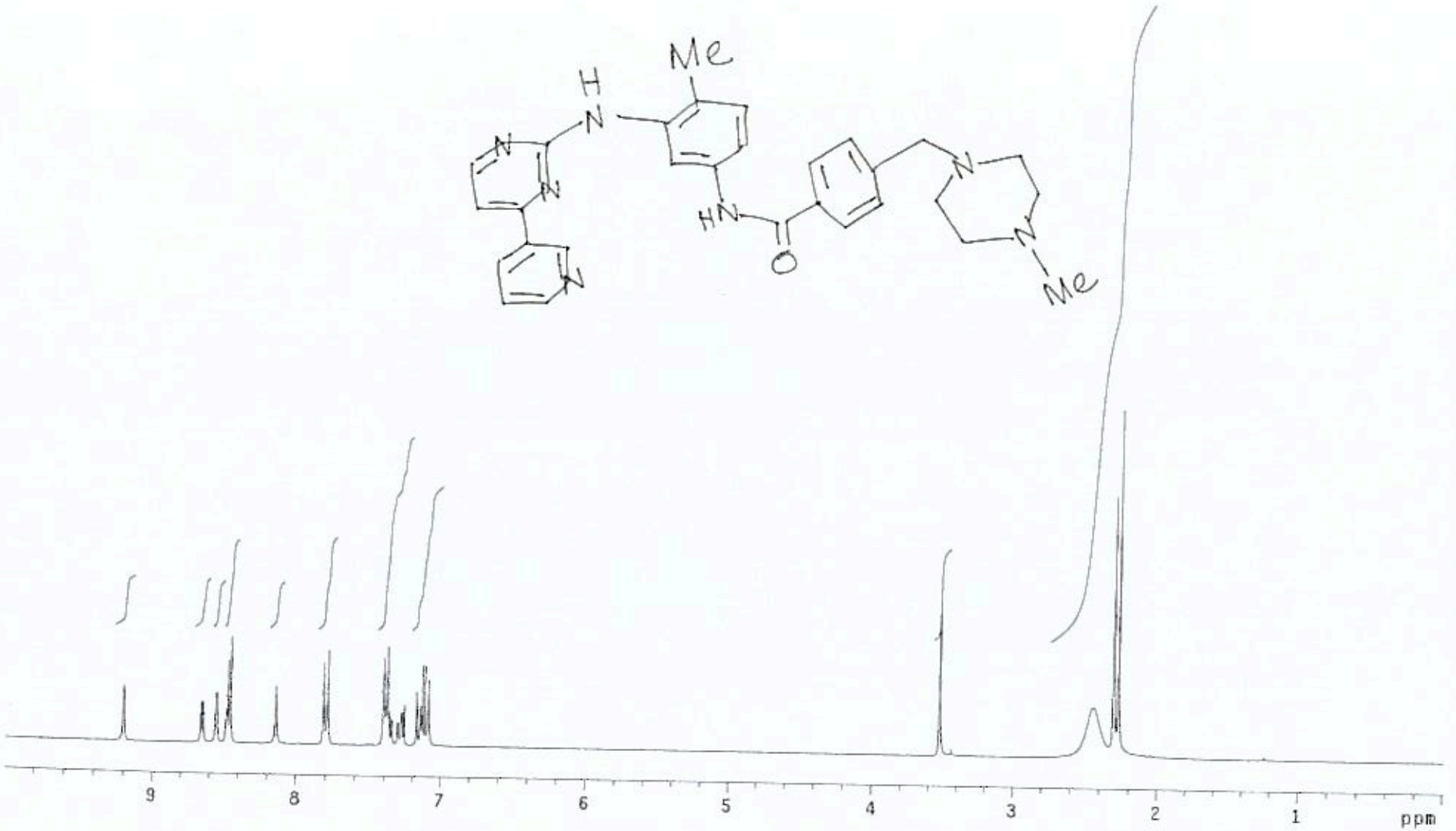
Pulse Sequence: s2pul





BF-III-224

Pulse Sequence: s2pul



BF-III-Gle-13C

Pulse Sequence: s2pul