An Efficient Synthesis of Enamides from Ketones

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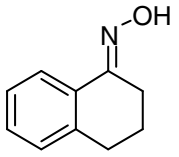
Supporting Information

General. All reagents were obtained from commercial suppliers and were used without further purification. Only anhydrous solvents were used for the reactions and these were equally purchased from commercial suppliers. Triethylphosphine (*caution: extremely pyrophoric and has a strong odor*) was purchased from Cytec as 50 wt% solution in toluene. All the reactions were performed under nitrogen atmosphere. ^{1}H NMR and ^{13}C NMR were obtained from a Varian Mercury 400 spectrometer in deuterio-solvents with TMS as an internal standard at room temperature. Chemical shifts are reported in ppm from an internal standard on the δ scale. A Waters 2690 HPLC system equipped with Waters 2487 UV detector was used for in-process as well as chiral assays. The HPLC data were reported in area % and were not adjusted to weight %. High resolution mass spectra were acquired on a Waters QTOF microsystem and externally by and M-Scan Inc. Elemental analyses were conducted by Galbraith Laboratories, Inc.

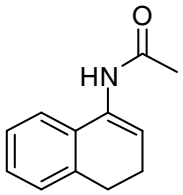
3,4-Dihydronaphthalen-1(2H)-one oxime (Table 1, compound 4)



The mixture of α-Tetralone (4.0 g, 26.8 mmol), sodium acetate (2.64 g, 32.2 mmol, 1.2 equiv) and hydroxylamine hydrochloride (2.42 g, 32.2 mmol, 1.2 equiv) in MeOH (12 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature before diluting with ethyl acetate (50 mL). 2 N sodium hydroxide (13 mL) was added

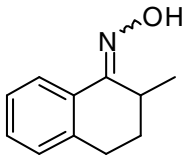
prior to removal of solvent *in vacuo*. The residue was re-dissolved in DI H_2O (40 mL) and EtOAc (80 mL). The aqueous layer was extracted with additional EtOAc (50 mL). The combined organic layers were washed with brine (50 mL) and concentrated to give a crude brown solid (4.4 g, 100% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.87 (br, 1H), 7.91 (dd, 1H, *J* = 8.0, 1.2 Hz), 7.27 (m, 2H), 7.18 (dd, 1H, *J* = 7.6, 0.8 Hz), 2.88 (t, 2H, *J* = 6.8 Hz), 2.79 (t, 2H, *J* = 6.0 Hz), 1.91 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 139.8, 130.3, 129.2, 128.6, 126.4, 124.0, 29.7, 23.9, 21.2. HRMS (*m/z*) [M+H$^+$] calcd for $C_{10}H_{12}NO$ 162.0919; found, 162.0907.

_N_-(3,4-Dihydronaphthalen-1-yl)acetamide (Table 1, compound 5)



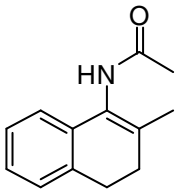
The solution of the above crude oxime (1.0 g, 6.1 mmol) in toluene (9.0 mL) was purged with N_2 for 30 min. Neat Et_3P (0.86 g, 1.1 mL, 7.3 mmol, 1.2 equiv) was charged at room temperature. After stirring for 10 min, acetic anhydride (0.75 g, 0.69 mL, 7.3 mmol, 1.2 equiv) was added and the reaction heated to reflux. After 16 h, the reaction mixture was cooled to room temperature and concentrated *in vacuo*. The residue was mixed with methanol (15 mL) and excess K_2CO_3 (1.3 g). After 1 h, methanol was removed *in vacuo*. The residue was dissolved in EtOAc (100 mL) and DI water (50 mL). The organic layer was separated, washed with DI water (2 × 50 mL), concentrated and purified with flash column to give an off-white solid (1.0 g, 89% yield). ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 7.11 – 7.21 (m, 4H), 6.90 (br, 1H), 6.36 (t, 0.75H, *J* = 4.8 Hz), 5.94 (br, 0.25H), 2.82 and 2.74 (t, 0.5H and 1.5H, *J* = 8.0 Hz), 2.40 and 2.34 (m, 0.5H and 1.5H), 2.11 and 1.93 (s, 2.25H and 0.75H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.4, 136.7, 131.5, 131.5, 128.1, 127.7, 127.4, 126.8, 126.3, 125.9, 122.0, 120.7, 119.7, 27.5, 27.2, 24.0, 22.5, 22.1, 20.2. HRMS (*m/z*) [M+H$^+$] calcd for $C_{12}H_{14}NO$ 188.1075; found, 188.1069.

2-Methyl-1-tetralone oxime (Table 2, entry 1, oxime)



The ketone (10.0 g, 62.4 mmol) was dissolved in dry methanol (45 mL). Sodium acetate (6.1 g, 74.9 mmol, 1.2 equiv) and hydroxylamine hydrochloride (5.2 g, 74.9 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 1.7 h, the reaction was allowed to cool to ambient temperature and concentrated to dryness *in vacuo*. To the residue was added EtOAc (100 mL) and washed with DI water (2 × 50 mL). The organic layer was dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the crude product as an off-white solid (100%), which was used in the next reaction without further purification: mp 89-91 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.12 (br s, 1H), 7.85 (d, 1H, *J* = 7.8 Hz), 7.29 – 7.13 (m, 3H), 3.73 – 3.63 (m, 1H), 3.02 – 2.91 (m, 1H), 2.70 – 2.62 (m, 1H), 2.04 – 1.93 (m, 1H), 1.78 – 1.69 (m, 1H), 1.23 (d, 3H, *J* = 6.9 Hz). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.0, 139.1, 129.9, 129.4, 129.0, 126.6, 124.6, 28.5, 27.1, 25.4, 15.4. HRMS (*m/*z) $[M+H]^+$: calcd for $C_{11}H_{13}NO$: 176.1075; found, 176.1071.

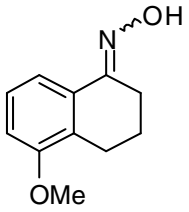
***N*-(2-Methyl-3,4-dihydronapthalen-1-yl)acetamide (Table 2, entry 1, enamide)**



The oxime (2.0 g, 11.4 mmol) was dissolved in toluene (15 mL). A 50% (w/w) Et_3P solution in toluene (4.0 mL, 13.7 mmol, 1.2 equiv) was added and the solution was allowed to stir 10 minutes at ambient temperature under nitrogen. Acetic anhydride (1.3 mL, 13.7 mmol, 1.2 equiv) was added and the solution heated to reflux to form a yellow solution. After refluxing 22 h, the solution treated with 1% (by wt) aq $CuSO_4$ (30 mL), and extracted with EtOAc (2 × 50 mL). The combined organic layers were concentrated *in vacuo*, the residue dissolved in MeOH (40 mL) and the imide byproduct hydrolyzed with 2 N NaOH (5 mL). The mixture was stirred for 1 h at ambient temperature, concentrated *in vacuo*, the residue diluted with DI water (50 mL) and extracted twice with EtOAc. The combined organic layers were dried (Na_2SO_4), filtered and concentrated

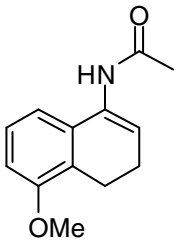
in vacuo to afford the crude product. Column chromatography of the crude material (silica, 1:1:0.1% Hex/EtOAc/NEt_3; R_f = 0.21) yielded a white solid (1.7 g, 74%): mp 152-154 °C. ^{1}H NMR (400 MHz, CD_3OD) δ 7.14 – 7.05 (m, 4H), 2.80 (t, 2H, *J* = 8.4, 7.6 Hz), 2.36 (t, 2H, *J* = 8.0, 7.6 Hz), 2.15 (s, 3H,), 1.83 (s, 3H). ^{13}C NMR (100 MHz, CD_3OD) δ 172.9, 136.7, 135.2, 134.4, 128.4, 127.8, 127.4, 122.8, 30.7, 28.6, 22.5, 19.4. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{13}H_{15}NO$: 202.1232; found, 202.1227.

5-Methoxy-1-tetralone oxime (Table 2, entry 2, oxime)



The ketone (10.0 g, 56.7 mmol) was suspended in dry methanol (41 mL). Sodium acetate (5.6 g, 68.2 mmol, 1.2 equiv) and hydroxylamine hydrochloride (4.7 g, 68.2 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 1 h, the reaction was allowed to cool to room temperature and concentrated *in vacuo* to dryness. The resulting solid was slurried in DI water (70 mL), filtered and the cake washed with (70 mL) DI water and (40 mL) toluene to yield a tan solid (10.5 g. 97%): mp 158-160 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.52 (br s, 1H), 7.51 (d, 1H, *J* = 8.0 Hz), 7.17 (t, 1H, *J* = 8.0, 8.0 Hz), 6.83 (d, 1H, *J* = 8.0 Hz), 3.83 (s, 3H), 2.83 – 2.72 (m, 4H), 1.89 – 1.82 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.9, 155.7, 131.7, 129.1, 126.8, 116.3, 110.5, 55.7, 23.5, 22.4, 21.0. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{11}H_{13}NO_2$: 192.1025; found, 192.1017.

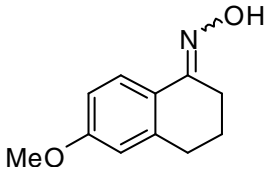
***N*-(5-Methoxy-2-methyl-3,4-dihydronapthalen-1-yl)acetamide (Table 2, entry 2, enamide)**



To the oxime (3.0 g, 15.7 mmol) was added toluene (21 mL). A 50% Et_3P solution in toluene (5.4 mL, 18.9 mmol, 1.2 equiv) was added and the solution was allowed to stir 10

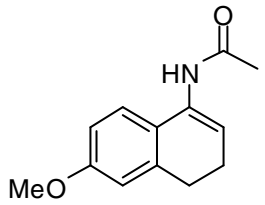
minutes at ambient temperature under nitrogen. Acetic anhydride (1.8 mL, 18.9 mmol, 1.2 equiv) was added and the solution heated to reflux to form a brown solution. After refluxing 23 h, the solution was treated with 1% (by wt) aq $CuSO_4$ (45 mL) and EtOAc (150 mL), resulting in a slurry. The solids (product) were filtered and combined with the organic layer (also product) from the mother liquors and concentrated to dryness *in vacuo*. The solid residue was suspended in MeOH (60 mL) and the imide byproduct was hydrolyzed with 2 N NaOH (5 mL). The mixture was stirred for 1 h at ambient temperature, then filtered. The solids were washed with 1:1 (*v/v*) MeOH : water which yielded a tan solid (2.6 g, 77%): mp 183-185 °C. ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.07 (s, 1H), 7.16 (t, 1H, *J* = 8.0, 7.6 Hz), 6.91 (d, 1H, *J* = 8.4 Hz), 6.86 (d, 1H, *J* = 8.0 Hz), 6.15 (s, 1H), 3.78 (s, 3H), 2.64 (t, 2H, *J* = 8.0, 8.0 Hz), 2.25 – 2.22 (m, 2H), 2.01 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 168.8, 155.5, 132.8, 132.3, 126.3, 123.3, 119.2, 115.0, 110.3, 55.5, 23.3, 21.3, 19.2. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{13}H_{15}NO_2$: 218.1181; found, 218.1176.

6-Methoxy-1-tetralone oxime (Table 2, entry 3, oxime)



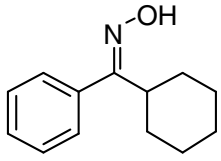
The ketone (10.0 g, 56.8 mmol) was suspended in dry methanol (41 mL). Sodium acetate (5.6 g, 68.2 mmol, 1.2 equiv) and hydroxylamine hydrochloride (4.7 g, 68.2 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 1.5 h, the reaction was allowed to cool to room temperature and concentrated to dryness *in vacuo*. The resulting solid was slurried in DI water (70 mL), filtered and the cake washed with (70 mL) DI water and (40 mL) toluene to yield a white crystalline solid (10.4 g. 96%): mp 135-137 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.46 (br s, 1H), 7.82 (d, 1H, *J* = 8.8 Hz), 6.77 (dd, 1H, *J* = 8.8, 2.4 Hz), 6.66 (d, 1H, *J* = 2.4 Hz), 3.81 (s, 3H), 2.83 – 2.72 (m, 4H), 1.90 – 1.84 (M, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.5, 155.2, 141.7, 125.8, 123.4, 113.2, 113.1, 55.4, 30.3, 24.0, 21.6. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{11}H_{13}NO_2$: 192.1025; found, 192.1026.

***N*-(6-Methoxy-2-methyl-3,4-dihydronapthalen-1-yl)acetamide (Table 2, entry 3, enamide)**



The oxime (3.0 g, 15.7 mmol) was suspended in toluene (21 mL). A 50% Et_3P solution in toluene (5.4 mL, 18.9 mmol, 1.2 equiv) was added and the solution allowed to stir 10 minutes at ambient temperature under nitrogen. Acetic anhydride (1.8 mL, 18.9 mmol, 1.2 equiv) was added and the solution heated to reflux to form a pale yellow solution. After refluxing 19 h, the mixture was cooled to ambient temperature and treated with 1% (by wt) aq $CuSO_4$ (45 mL) MeOH (90 mL) and 2 N NaOH (10 mL). The mixture was stirred for 1 h at ambient temperature to hydrolyze the imide byproduct. The mixture was concentrated to near dryness *in vacuo*, the residue dissolved in DI water (50 mL) and extracted with EtOAc (2 × 100 mL). The combined organic layers were dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford a pink solid. Column chromatography of the crude material (silica, 1:1:0.1% Hex/EtOAc/NEt_3; R_f = 0.23) yielded a white solid (2.4 g, 71%): mp 128-130 °C. ^{1}H NMR (400 MHz, $CD_3OD/CDCl_3$) δ 7.09 (d, 1H, *J* = 8.0 Hz), 6.71 – 6.69 (m, 2H), 5.99 (t, 1H, *J* = 4.8, 4.8 Hz), 3.78 (s, 3H), 2.76 (t, 2H, *J* = 8.4, 7.6 Hz), 2.37 – 2.32 (m, 2H), 1.92 (s, 3H). ^{13}C NMR (100 MHz, $CD_3OD/CDCl_3$) δ 172.5, 160.0, 139.3, 132.9, 125.7, 123.9, 120.2, 114.5, 111.7, 55.7, 28.8, 23.3, 23.1. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{13}H_{15}NO_2$: 218.1181; found, 218.1166.

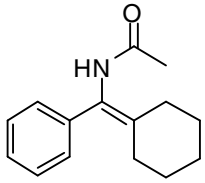
Cyclohexyl(phenyl)methanone oxime (Table 2, entry 4, oxime)



A mixture of ketone (4.0 g, 20.8 mmol), sodium acetate (2.05 g, 25.0 mmol, 1.2 equiv) and hydroxylamine hydrochloride (1.74 g, 25.0 mmol, 1.2 equiv) in MeOH (62 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature. The solvent was removed *in vacuo*. The residue was redissolved in DI H_2O (40 mL) and

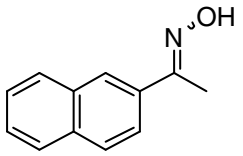
ethyl acetate (150 mL). The organic layer was separated, washed with brine (50 mL) and concentrated to give a crude light yellow solid (4.3 g, 100% yield). ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 9.68 (br, 1H), 7.30 – 7.46 (m, 5H), 3.35 and 2.49 (m, 0.54H and 0.46H), 1.15 – 1.90 (m, 10H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 162.5, 136.0, 133.9, 128.3, 128.2, 128.2, 128.2, 128.1, 128.0, 127.9, 127.4, 44.2, 38.1, 30.4, 29.2, 26.2, 26.1, 26.0, 26.0, 25.9. The rotamers exist. HRMS (*m/z*) [M+H$^+$] calcd for $C_{13}H_{18}NO$ 204.1388; found, 204.1367.

_N_-(cyclohexylidene(phenyl)methyl)acetamide (Table 2, entry 4, enamide)



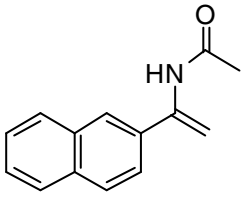
The solution of the crude oxime (from cyclohexyl phenyl ketone) (1.0 g, 4.8 mmol) in toluene (6.5 mL) was purged with N_2 for 30 min. Neat Et_3P (0.69 g, 0.86 mL, 5.8 mmol, 1.2 equiv) was charged at room temperature. After stirring for 10 min, acetic anhydride (0.59 g, 0.55 mL, 5.8 mmol, 1.2 equiv) was added. The reaction mixture was heated to reflux. After 24 h, the reaction mixture was cooled to room temperature and concentrated *in vacuo*. The residue was mixed with methanol (20 mL) and excess K_2CO_3 (1.0 g). After 2h, methanol was removed *in vacuo*. The residue was dissolved in EtOAc (100 mL) and DI water (50 mL). The organic layer was separated, washed with DI water (2 × 50 mL), concentrated and purified with flash chromatography to give a white solid (1.0 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ (ppm) 7.22 - 7.36 (m, 5H), 6.70 and 6.58 (br, 0.33H and 67H), 2.20 – 2.35 (m, 4H), 2.03 and 1.79 (s, 2H and 1H), 1.56 – 1.65 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 173.4, 168.3, 138.7, 138.5, 138.0, 137.4, 129.0, 129.0, 128.1, 127.9, 127.5, 127.1, 124.9, 31.0, 30.8, 30.7, 30.5, 28.0, 27.5, 27.3, 26.4, 26.3, 23.3, 20.6. HRMS (*m/z*) [M+H$^+$] calcd for $C_{15}H_{20}NO$ 230.1545; found, 230.1541.

1-(Naphthalen-2-yl)ethanone oxime (Table 2, entry 5, oxime)



The ketone (4.56 g, 26.8 mmol) was slurried in dry methanol (25 mL). Sodium acetate (2.64 g, 32.2 mmol, 1.2 equiv) and hydroxylamine hydrochloride (2.23 g, 32.2 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 2 h, the reaction was allowed to cool to room temperature before diluting with toluene (50 mL). 2 N NaOH (13 mL) was added prior to removal of solvent *in vacuo*. The crude product was extracted from DI H_2O (40 mL) and EtOAc (80 mL), and again with EtOAc (50 mL). The combined organic layers were washed with brine (50 mL). Filtration through cotton, followed by concentration *in vacuo* furnished an off-white solid (5.0 g, 100% yield), which was used for further processing without purification: mp 146-147 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.00 (br s, 1H), 8.04 (s, 1H), 7.87 (m, 4H), 7.52 (m, 2H), 2.44 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 156.2, 134.0, 133.9, 133.3, 128.7, 128.4, 127.9, 126.9, 126.6, 126.2, 123.5, 12.3. HRMS (*m/*z) $[M+H]^+$: calcd for $C_{12}H_{12}NO$: 186.0919; found, 186.0912.

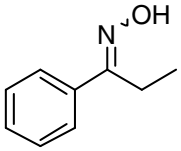
***N*-(1-(Naphthalen-2-yl)vinylacetamide (Table 2, entry 5, enamide)**



The oxime (1.15 g, 6.20 mmol) was slurried in toluene (9 mL). A 50% Et_3P solution in toluene (2.15 mL, 7.44 mmol, 1.20 equiv) was added and the white slurry was allowed to stir 10 minutes under nitrogen. During acetic anhydride addition (0.71 mL, 7.51 mmol, 1.21 equiv), the mixture formed a solution before returning to a slurry. This slurry was heated to reflux to form a yellow solution, which darkened over time to assume an orange color. After determining reaction completion at 10 h, the mixture was cooled and treated with 1% (by wt) aq $CuSO_4$, causing a change in color and consistency to a green-brown slurry. Dilution with EtOAc (20 mL) and separation of the layers was followed by

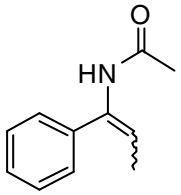
extraction with EtOAc (20 mL). The combined organic layers were treated with 6 N NaOH (4 mL) and 1 N *n*-Bu_4NOH in MeOH (0.03 mL) to hydrolyze the byproduct imide. After stirring for several hours, the layers were separated and the organic layer was washed with water (2 × 15 mL), dried over Na_2SO_4, filtered and concentrated to give the crude solid (1.40 g). Column chromatography (gradient to 70:30 Hex/EtOAc; R_f = 0.22, 2:1 Hex/EtOAc/1% NEt_3) yielded an off-white solid (1.00 g, 76%): mp 124-125 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.80 (m, 4H), 7.49 (m, 3H), 7.38 (br s, 1H), 5.85 (s, 1H), 5.20 (s, 1H), 2.05 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.7, 140.8, 135.7, 133.3, 128.6, 128.4, 127.9, 126.8, 126.7, 125.1, 124.4, 103.8, 24.6. HRMS (*m/*z) $[M+H]^+$: calcd for $C_{14}H_{14}NO$: 212.1075; found, 212.1062.

Propiophenone oxime (Table 2, entry 6, oxime)



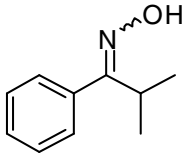
The ketone (3.60 g, 26.83 mmol) was slurried in dry methanol (12 mL). Sodium acetate (2.64 g, 32.2 mmol, 1.2 equiv) and hydroxylamine hydrochloride (2.24 g, 32.2 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 2 h, the reaction was allowed to cool to room temperature before diluting with toluene (50 mL). 2 N NaOH (13 mL) was added prior to removal of solvent *in vacuo*. The crude product was extracted from DI H_2O (40 mL) and EtOAc (80 mL), and again with EtOAc (50 mL). The combined organic layers were washed with brine (50 mL). Filtration through cotton followed by concentration *in vacuo* furnished a white solid (4.1 g, 99% yield), which was used as such for further processing: mp 49-50 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 9.25 (br s, 1H), 7.62 (m, 2H), 7.41 (m, 3H), 2.86 (q, 2H, *J* = 7.7 Hz), 1.20 (t, 3H, *J* = 7.7 Hz). ^{13}C NMR (100 MHz, $CDCl_3$): δ 161.1, 135.7, 129.4, 128.8, 128.5, 127.9, 126.5, 19.9, 11.1. HRMS (*m/*z) $[M+H]^+$: calcd for $C_9H_{12}NO$: 150.0919; found, 150.0921.

***N*-(1-Phenylprop-1-enyl)acetamide (Table 2, entry 6, enamide)**



The oxime (0.93 g, 6.20 mmol) was dissolved in toluene (9 mL). A 50% Et_3P solution in toluene (2.15 mL, 7.44 mmol, 1.20 equiv) was added and the colorless solution was allowed to stir 10 minutes under nitrogen. Acetic anhydride (0.71 mL, 7.51 mmol, 1.21 equiv) was added and the solution heated to reflux to form a light yellow solution. After determining reaction completion at 10 h, the mixture was cooled and treated with 1% (by wt) aq $CuSO_4$, causing a change to a green slurry. Dilution with EtOAc (20 mL) and separation of the layers was followed by extraction with EtOAc (20 mL). The combined organic layers were treated with 6 N NaOH (4 mL) and 1 N *n*-Bu_4NOH in MeOH (0.03 mL) to hydrolyze the byproduct imide. After stirring for several hours, the layers were separated and the organic layer was washed with water (2 × 15 mL), dried over Na_2SO_4, filtered and concentrated to give the crude solid (1.40 g). Column chromatography (gradient to 70:30 Hex/EtOAc; R_f = 0.22, 2:1 Hex/EtOAc/1% NEt_3) yielded a white solid (0.63 g, 58%): mp 125-126 °C, ^{1}H NMR (400 MHz, $CDCl_3$) (~2:1 mixture of geometric isomers) δ 7.30 (m, 5H), 6.65/6.59 (br s, 1H), 6.04/5.96 (q, 1H, *J* = 7.0 Hz), 2.17 (s, 3H), 1.85/1.76 (d, 3H, *J* = 7.0 Hz). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.1, 137.0, 134.3, 129.0, 128.6, 128.2, 121.9, 115.4, 24.4, 14.1. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{11}H_{14}NO$: 176.1075; found, 176.1066.

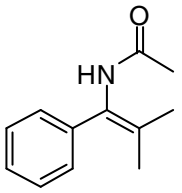
2-Methyl-1-phenylpropan-1-one oxime (Table 2, entry 7, oxime)



The ketone (4.0 g, 27.0 mmol) was dissolved in dry methanol (12 mL). Sodium acetate (2.7 g, 32.9 mmol, 1.2 equiv) and hydroxylamine hydrochloride (2.3 g, 33.1 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 1.5 h, the reaction was allowed to cool to room temperature and added toluene (50 mL) and 2 N NaOH (13 mL). The phases were allowed to settle, and the aqueous phase was separated and discarded.

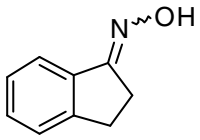
The organic phase was washed with brine (2 × 50 mL) and concentrated *in vacuo* to afford a colorless oil (4.3 g, 99% yield): ^{1}H NMR (400 MHz, $CDCl_3$) (~1:1 mixture of geometric isomers) δ 9.80 (br s, 1H), 7.43 – 7.26 (m, 10H), 3.67 – 3.53 (m, 1H), 2.90 – 2.76 (m, 1H), 1.21 (dd, 3H, *J* = 7.2, 0.6 Hz), 1.12 (dd, 3H, *J* = 7.2, 0.6 Hz). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.9, 163.3, 135.9, 133.9, 128.7, 128.6, 128.32, 128.29, 127.9, 127.7, 34.7, 27.9, 20.3, 19.5. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{10}H_{13}NO$: 164.1075; found, 164.1046.

_N_-(2-Methyl-1-phenylprop-1-enyl)acetamide (Table 2, entry 7, enamide)



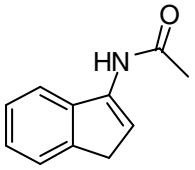
The oxime (1.0 g, 6.1 mmol) was dissolved in toluene (8 mL). A 50% Et_3P solution in toluene (2.1 mL, 7.4 mmol, 1.2 equiv) was added and the solution was allowed to stir 10 minutes at ambient temperature under nitrogen. Acetic anhydride (0.7 mL, 7.4 mmol, 1.2 equiv) was added and the solution heated to reflux to form a pale yellow solution. After refluxing 23 h, the mixture was cooled to ambient temperature and concentrated *in vacuo*. The residue was treated with 20 mL of 1% (by wt) aq $CuSO_4$, followed by MeOH (8 mL) and K_2CO_3 (1.0 g). The mixture was stirred for 1 h at ambient temperature then concentrated *in vacuo*. The residue was dissolved in EtOAc (75 mL) and washed with DI water (2 × 25 mL). The organic layer was dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford the crude product as a tan oil. Column chromatography of the crude material (silica, 1:1:0.1% Hex/EtOAc/NEt_3; R_f = 0.18) yielded a white solid (670 mg, 58%): mp 100-102 °C. ^{1}H NMR (400 MHz, CD_3OD) δ 7.34 – 7.19 (m, 5H), 2.00 (s, 3H), 1.77 (s, 6H). ^{13}C NMR (100 MHz, CD_3OD) δ 171.9, 140.2, 131.1, 130.3, 129.7, 129.4, 129.0, 128.3, 22.7, 21.3, 20.9. HRMS (*m/z*) $[M+H]^+$: calcd for $C_{12}H_{15}NO$: 190.1232; found, 190.1223.

1-Indanone oxime (Table 2, entry 8, oxime)



The ketone (14.6 g, 110.5 mmol) was dissolved in dry methanol (80 mL). Sodium acetate (10.9 g, 132.9 mmol, 1.2 equiv) and hydroxylamine hydrochloride (9.2 g, 132.4 mmol, 1.2 equiv) were added before heating the mixture to reflux. After 3 h, the reaction was cooled to room temperature and concentrated *in vacuo*. The solid residue was suspended in DI water (100 mL), stirred for 1 h, and filtered. The solids were washed with DI water (97 mL) and MtBE (22 g) to afford a white crystalline solid (15.1 g, 93% yield): mp 146–148 °C. ^{1}H NMR (400 MHz, CD_3OD) δ 7.63 (d, 1H, J = 8.0 Hz), 7.32 (d, 2H, J = 4.0 Hz), 7.25 - 7.20 (m, 1H), 3.04 – 3.01 (m, 2H), 2.91 – 2.88 (m, 2H). ^{13}C NMR (100 MHz, CD_3OD) δ 164.8, 149.8, 137.5, 131.4, 128.0, 126.8, 122.3, 29.4, 26.9. HRMS (*m/*z) $[M+H]^+$: calcd for C_9H_9NO: 148.0762; found, 148.0759.

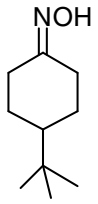
***N*-(1*H*-Inden-3-yl)acetamide (Table 2, entry 8, enamide)**



The oxime (7.5 g, 51.0 mmol) was dissolved in toluene (68 mL). A 50% Et_3P solution in toluene (17.6 mL, 61.2 mmol, 1.2 equiv) was added and the solution was allowed to stir 10 minutes at ambient temperature under nitrogen. Acetic anhydride (5.8 mL, 61.2 mmol, 1.2 equiv) was added and the solution heated to reflux to form a red solution. After refluxing 5 h, the mixture was cooled to ambient temperature and treated with 150 mL of 1% (by wt) aq $CuSO_4$. The aqueous layer was extracted with EtOAc (200 mL), separated and the organic layer was concentrated to dryness. The solid residue was dissolved in 150 mL of MeOH and the imide byproduct was hydrolyzed with 2 N NaOH (10 mL). The solution was concentrated *in vacuo* and the solid residue was dissolved in EtOAc (200 mL), washed with DI water (2 × 50 mL), dried (Na_2SO_4), filtered and concentrated to give the crude solid product (7.8 g). Column chromatography on 1.3 g sample of the crude material (silica, 1:1:0.1% Hex/EtOAc/NEt_3; R_f = 0.44) yielded a yellow solid (1.29 g, 78%): mp 132-134 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (br s,

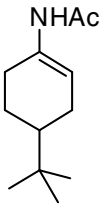
1H), 7.51 – 7.47 (m, 1H), 7.23 – 7.22 (m, 3H), 6.88 (br t, 1H), 3.43 (m, 2H), 2.24 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.3, 142.9, 139.9, 135.7, 126.1, 125.5, 124.3, 116.6, 116.0, 36.7, 24.2. HRMS (*m/*z) $[M+H]^+$: calcd for $C_{11}H_{11}NO$: 174.0919; found, 174.0904.

4-*tert*-Butylcyclohexanone oxime (Table 3, entry 1, oxime)



A mixture of ketone (8.40 g, 54.4 mmol), sodium acetate (4.92 g, 60.0 mmol, 1.1 equiv) and hydroxylamine hydrochloride (4.16 g, 60.0 mmol, 1.1 equiv) in MeOH (24 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature and concentrated *in vacuo*. The residue was redissolved with EtOAc (150 mL) and 2 N NaOH (50 mL). The organic layer was separated, washed with brine (50 mL) and concentrated to give a crude white solid (9.2 g, 100% yield). ^1H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 9.51 (br, 1H), 3.36 (m, 1H), 2.43 (m, 1H), 2.05 (m, 1H), 1.92 (m, 2H), 1.68 (m, 1H), 1.19 (m, 3H), 0.85 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8, 47.4, 32.4, 31.9, 27.6, 27.5, 26.3, 24.3.

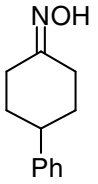
***N*-(4-*tert*-Butylcyclohex-1-enyl)acetamide (Table 3, entry 1, enamide)**



The solution of the crude oxime (1.0 g, 6.5 mmol) in toluene (6.0 mL) was purged with N_2 for 1 h. 50 wt% Et_3P in toluene (1.8 g, 2.2 mL, 7.8 mmol, 1.2 equiv) was charged at room temperature. After stirring for 10 min, acetic anhydride (0.99 g, 0.92 mL, 9.7 mmol, 1.5 equiv) was added, and the mixture heated to reflux. After 22 h, the reaction was cooled to room temperature and concentrated *in vacuo*. The residue was mixed with methanol (50 mL) and excess K_2CO_3. After 15 min, methanol was removed *in vacuo*.

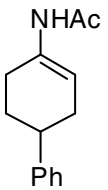
The residue was dissolved in EtOAc (100 mL) and DI water (50 mL). The organic layer was separated, washed with brine (50 mL), concentrated and purified by flash chromatography to give a semi-solid (0.86 g, 71% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.71 (br, 1H), 6.01 (m, 1H), 2.21 (m, 1H), 2.12 (m, 1H), 2.08 (br, 1H), 1.99 (s, 3H), 1.81 (m, 2H), 1.23 (m, 2H), 0.84 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 132.5, 113.2, 43.6, 32.1, 29.3, 27.1, 25.4, 24.3, 23.7. HRMS (*m/z*) [M+H$^+$] calcd for $C_{12}H_{22}NO$ 196.1701; found, 196.1702.

4-Phenylcyclohexanone oxime (Table 3, entry 2, oxime)



A mixture of ketone (5.00 g, 28.7 mmol), sodium acetate (2.59 g, 31.6 mmol, 1.1 equiv) and hydroxylamine hydrochloride (2.19 g, 31.6 mmol, 1.1 equiv) in MeOH (12 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature and concentrated *in vacuo*. The residue was redissolved with EtOAc (150 mL) and 2 N NaOH (50 mL). The organic layer was separated, washed with brine (50 mL) and concentrated to give a crude white solid (5.4 g, 99% yield). ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 9.03 (br, 1H), 7.31 (m, 2H), 7.23 (m, 3H), 3.50 (m, 1H), 2.79 (m, 1H), 2.57 (m, 1H), 2.29 (m, 1H), 2.08 (m, 2H), 1.91 (m, 1H), 1.71 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.7, 145.7, 128.5, 128.3, 126.8, 126.7, 126.3, 126.0, 43.7, 34.0, 32.8, 32.6, 32.0, 30.4, 24.2.

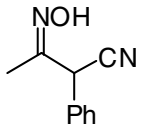
***N*-(4-Phenylcyclohex-1-enyl)acetamide (Table 3, entry 2, enamide)**



The solution of the crude oxime (1.0 g, 5.3 mmol) in toluene (6.0 mL) was purged with N_2 for 1 h. 50 wt% Et_3P in toluene (1.5 g, 1.8 mL, 6.3 mmol, 1.2 equiv) was charged at room temperature. After stirring for 10 min, acetic anhydride (0.81 g, 0.75 mL, 7.9 mmol,

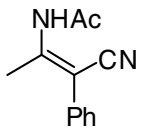
1.5 equiv) was added. The reaction mixture was heated to reflux. After 22 h, the reaction was cooled to room temperature and concentrated *in vacuo*. The residue was mixed with methanol (50 mL) and excess K_2CO_3. After 30 min, methanol was removed *in vacuo*. The residue was dissolved in EtOAc (100 mL) and DI water (30 mL). The organic layer was separated, washed with brine (30 mL) and concentrated to give the crude product (1.1 g). A white solid (0.53 g, 47% yield) was obtained by crystallization from MeOH. The mother liquor was purified by column to give additional white solid (0.20 g), bringing the total isolated yield to 64%. ^{1}H NMR (400 MHz, CD_3OD) δ 7.24 (m, 4H), 7.15 (m, 1H), 6.06 (t, 1H, J = 2.8 Hz), 2.77 (m, 1H), 2.34 (m, 2H), 2.26 (m, 1H), 2.22 (m, 1H), 1.98 (s, 3H), 1.93 (m, 1H), 1.85 (m, 1H). ^{13}C NMR (100 MHz, CD_3OD) δ 171.67, 147.85, 134.41, 129.43, 127.87, 127.15, 114.27, 41.09, 33.40, 30.87, 29.11, 23.61. HRMS (*m/z*) [M+H$^+$] calcd for $C_{14}H_{18}NO$ 216.1388; found, 216.1381.

3-(Hydroxyimino)-2-phenylbutanenitrile (Table 3, entry 3, oxime)



The mixture of ketone (4.00 g, 24.6 mmol), sodium acetate (2.22 g, 27.1 mmol, 1.1 equiv) and hydroxylamine hydrochloride (1.88 g, 27.1 mmol, 1.1 equiv) in MeOH (12 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature and concentrated *in vacuo*. The residue was redissolved with EtOAc (150 mL) and 2 N NaOH (20 mL). The organic layer was separated, washed with DI H_2O (20 mL) and concentrated to give a crude yellow oil (4.2 g, 98% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (m, 2H), 7.30 (m, 3H), 4.53 (br, 2H), 2.24 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.8, 159.5, 130.7, 128.8, 127.9, 126.4, 94.7, 10.9.

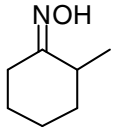
(*Z*)-*N*-(1-Cyano-1-phenylprop-1-en-2-yl)acetamide (Table 3, entry 3, enamide)



The solution of the crude oxime (1.0 g, 5.7 mmol) in toluene (6.5 mL) was purged with N_2 for 1 h. 50 wt% Et_3P in toluene (1.60 g, 2.0 mL, 6.9 mmol, 1.2 equiv) was charged at

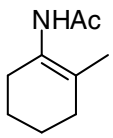
room temperature. After stirring for 10 min, acetic anhydride (0.70 g, 0.65 mL, 6.9 mmol, 1.2 equiv) was added and the reaction mixture heated to reflux. After 28 h, the reaction was cooled to room temperature and quenched with 30% aq $CuSO_4$ (1 mL) solution. After stirring for 10 min, EtOAc (50 mL) and DI water (2 mL) were charged. The organic layer was separated, washed with 2 mL 2 N NaOH (aq) and 20 mL brine and concentrated to give the crude product (1.2 g). A green solid (0.57 g, 50%) was obtained by crystallization from EtOAc. The mother liquor was purified on column to give an additional yellow solid (0.05 g), bringing the total isolated yield to 54%. ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.40 (br, 1H), 7.20 - 7.38 (m, 5H), 2.25 (s, 3H), 2.01 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.5, 159.7, 156.5, 134.4, 130.0, 127.8, 127.0, 122.3, 22.3, 20.8. HRMS (*m/z*) [M+H$^+$] calcd for $C_{12}H_{13}N_2O$ 201.1028; found, 201.1019.

2-Methylcyclohexanone oxime (Table 3, entry 4, oxime)



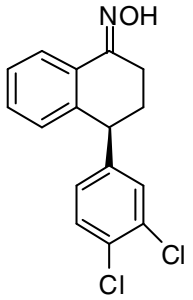
The mixture of ketone (10.0 g, 89.2 mmol), sodium acetate (8.04 g, 98.1 mmol, 1.1 equiv) and hydroxylamine hydrochloride (6.81 g, 98.1 mmol, 1.1 equiv) in MeOH (30 mL) was heated to reflux. After 1 h, the reaction was allowed to cool to room temperature and concentrated *in vacuo*. The residue was redissolved with EtOAc (150 mL), DI water (50 mL) and 2 N NaOH (20 mL). The organic layer was separated, washed with DI water (50 mL) and concentrated to give a crude yellow oil (11.4 g, 100% yield). ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 9.92 (br, 1H), 3.10 (m, 1H), 2.28 (m, 1H), 1.68 – 1.92 (m, 4H), 1.42 – 1.52 (m, 2H), 1.29 (m, 1H), 1.09 and 1.07 (s, 2H and 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.6, 163.0, 37.1, 35.5, 31.5, 28.2, 26.3, 26.6, 25.9, 24.6, 23.9, 20.3, 16.7, 16.1.

***N*-(2-Methylcyclohex-1-enyl)acetamide (Table 3, entry 4, enamide)**



The solution of the crude oxime (1.0 g, 7.9 mmol) in toluene (6.0 mL) was purged with N_2 for 1 h. 50 wt% Et_3P in toluene (2.2 g, 2.7 mL, 9.4 mmol, 1.2 equiv) was charged at room temperature. After stirring for 10 min, acetic anhydride (1.6 g, 1.5 mL, 15.7 mmol, 2.0 equiv) was added and the reaction mixture heated to reflux. After 22 h, the reaction was cooled to room temperature and concentrated *in vacuo*. The residue was mixed with methanol (50 mL) and excess K_2CO_3. After 1 h, methanol was removed *in vacuo*. The residue was dissolved in EtOAc (150 mL) and DI water (100 mL). The organic layer was separated, washed with brine (50 mL), dried over Na_2SO_4, filtered and concentrated to give 0.90 g crude brown solid (5:1 regioisomeric ratio by ^{1}H NMR). A solid (0.34 g, 28%) was obtained by crystallization from heptanes. The mother liquor was purified on neutral Al_2O_3 to give additional yellow solid (0.30 g), bringing the yield of the major regioisomer to 54% yield. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.72 (br, 1H), 2.10 (m, 2H), 1.98 (m, 5H), 1.59 (m, 7H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.1, 168.3, 131.8, 126.8, 126.6, 30.7, 30.6, 28.6, 23.4, 23.0, 22.9, 22.4, 22.3, 19.5, 18.3. Anal. calcd for $C_9H_{15}NO$: C, 70.55; H, 9.87; N, 9.14; found: C, 70.17; H, 10.16; N, 9.09.

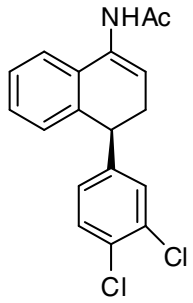
(*S*)-1-(3,4-Dichlorophenyl)-1,2-dihydronaphthalen-1(2H)-one oxime (Scheme 2, compound 7)



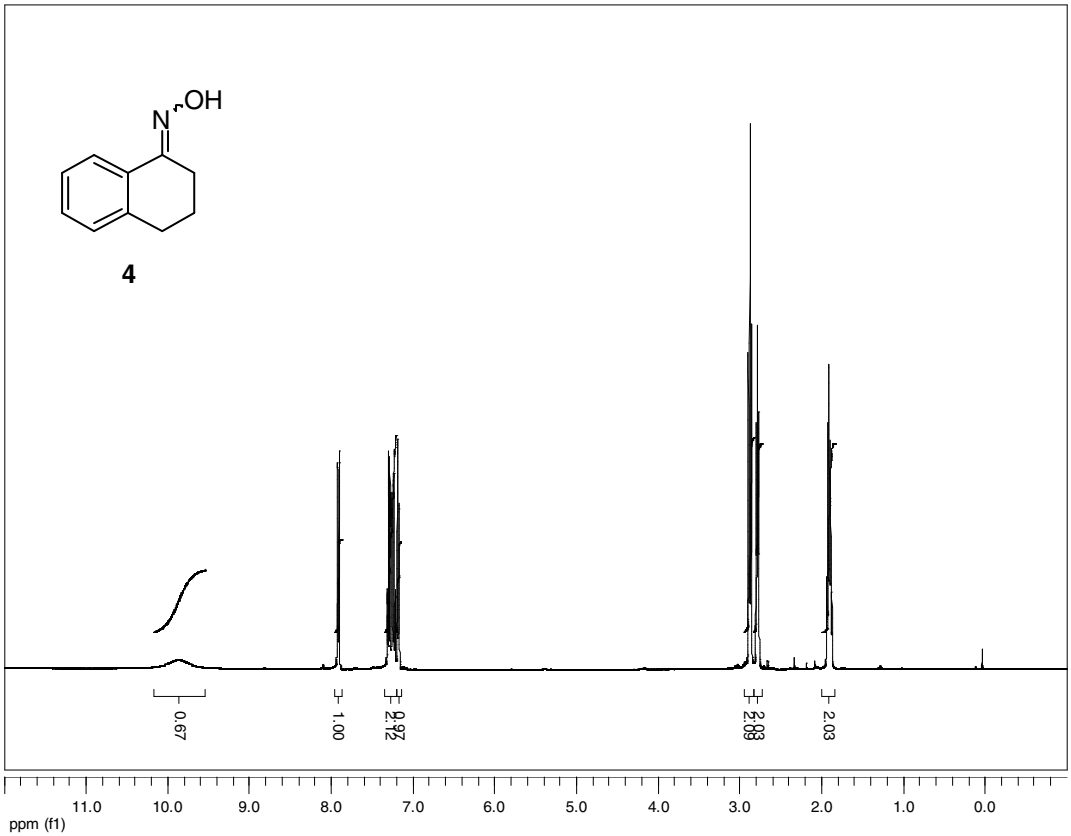
The suspension of a solution of (*S*)-tetralone (56.0 g, 0.192 mol), hydroxylamine hydrochloride (14.7 g, 0.212 mol), and sodium acetate (17.4 g, 0.212 mol) in methanol (168 mL) was heated to reflux for 2 h under N_2 atmosphere. After the reaction was deemed complete by HPLC, the mixture was concentrated *in vacuo*. The residue was diluted with toluene (400 mL) and 200 mL water. The organic layer was separated and washed with additional 200 mL water before concentration and drying to give crude solid oxime (58.9 g, 100%), mp 117-120 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.40 (br, 1H), 7.99 (m, 1H), 7.38 (d, 1H, J = 8.0 Hz), 7.28 (m, 2H), 7.19 (d, 1H, J = 2.4 Hz), 6.91 (m,

2H), 4.11 (dd, 1H, J = 7.2, 4.4 Hz), 2.82 (m, 2H), 2.22 (m, 1H), 2.05 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.6, 144.1, 140.1, 132.5, 130.6, 130.5, 130.4, 130.3, 129.7, 129.1, 127.8, 127.4, 124.2, 44.2, 29.2, 21.0.

_N_-((_S_)-1-(3,4-dichlorophenyl)-1,2-dihydronaphthalen-4-yl)acetamide (Scheme 2, compound 9)



A solution of the crude oxime (59 g, 0.193 mol) in toluene (500 mL) was purged with N_2 for 30 min. Neat Et_3P (25 g, 0.212 mol) was charged. After stirring for 10 min, acetic anhydride (21.6 g, 20 mL, 0.212 mol) was added. The reaction mixture was refluxed for 12 h, monitored by HPLC. The reaction mixture was cooled to room temperature and 6 N aq NaOH (86 mL, 0.516 mol) and 1.0 N (n-Bu)$_4$NOH in methanol (1.0 mL) were charged. The hydrolysis of imide to enamide took about 3 h. The organic layer was separated and diluted with EtOAc (300 mL) and 30 mL 2-BuOH. The diluted organic solution was washed with 1% aq AcOH solution (300 mL) and 3 × 300 mL DI water, and concentrated to about 350 mL slurry *in vacuo*. The slurry was diluted with heptane (100 mL) and 2-BuOH (4 mL) and heated to reflux to form a clear solution. Heptane (100 mL) was slowly added until cloudy solution formed. The suspension was slowly cooled to room temperature. The product was filtered off, washed with 3 × 100 mL (30% toluene in heptane) and dried under vacuum at 60 °C to give 56.9 g of white solid (89% yield), mp 167-168 °C. ^{1}H NMR (400 MHz, $CDCl_3$, mixture of rotamers) δ 7.35 (d, 1H, J = 8.4 Hz), 7.26 (m, 3H), 7.18 (m, 1H), 7.05 (d, 1H, J = 8.4 Hz), 6.90 (br, 1H), 6.88 and 6.73 (m, 0.85H and 0.15H), 6.33 and 5.91 (br, 0.85H and 0.15H), 4.12 and 4.04 (m, 0.15H and 0.85H), 2.72 (m, 1H), 2.61 (m, 1H), 2.18 and 1.95 (s, 2.6H and 0.4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.2, 143.8, 137.7, 131.8, 131.4, 130.5, 130.4, 130.3, 130.2, 128.2, 127.8, 127.2, 121.2, 117.4, 42.6, 30.4, 24.1. HRMS (*m/z*) [M+H$^+$] calcd for $C_{18}H_{15}Cl_2NO$ 332.0609; found, 332.0624.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2.03
11.0
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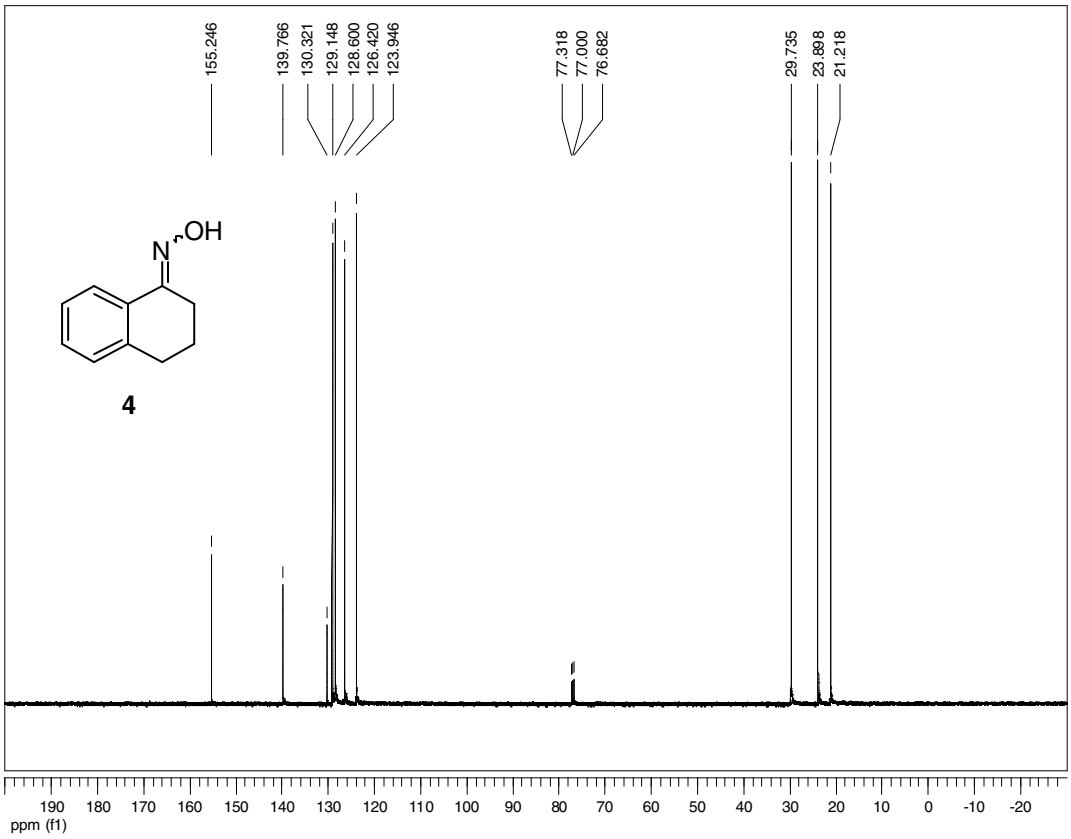
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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130.321
129.148
128.600
126.420
123.946
77.318
77.000
76.682
29.735
23.898
21.218
N
OH
4
190
180
170
160
150
140
130
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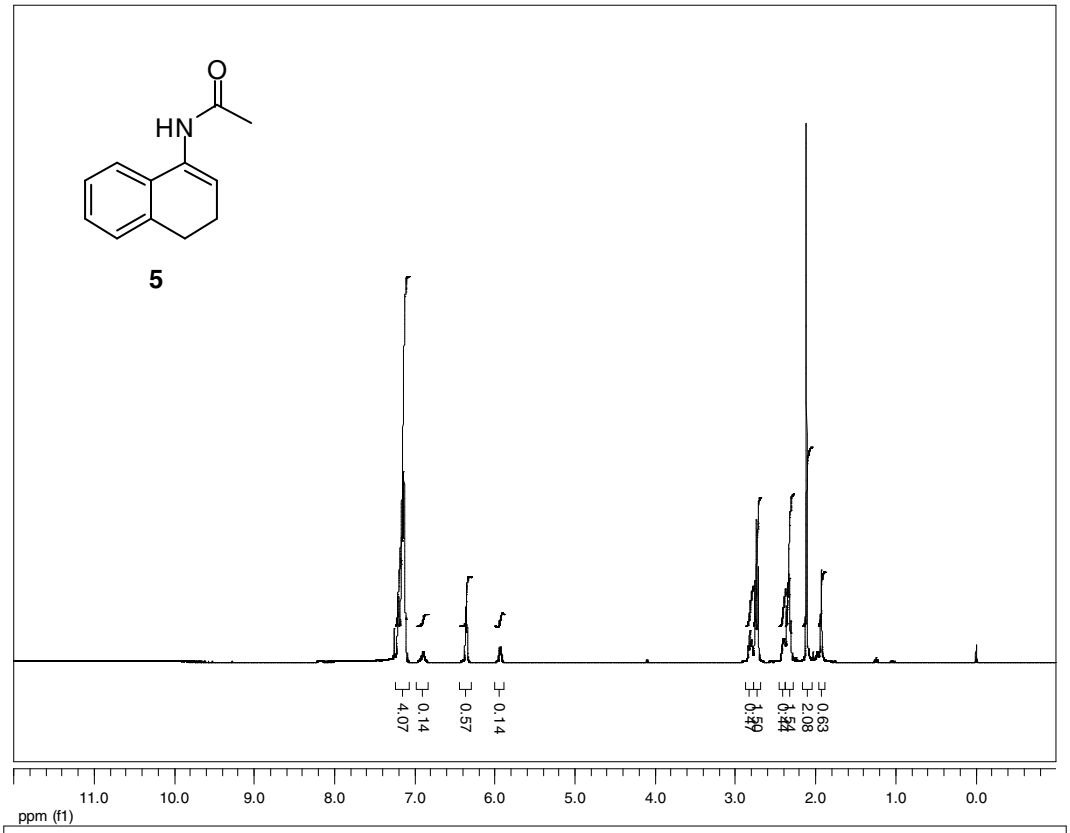
100
90
80
70
60
50
40
30
20
10
0
-10
-20
ppm (f1)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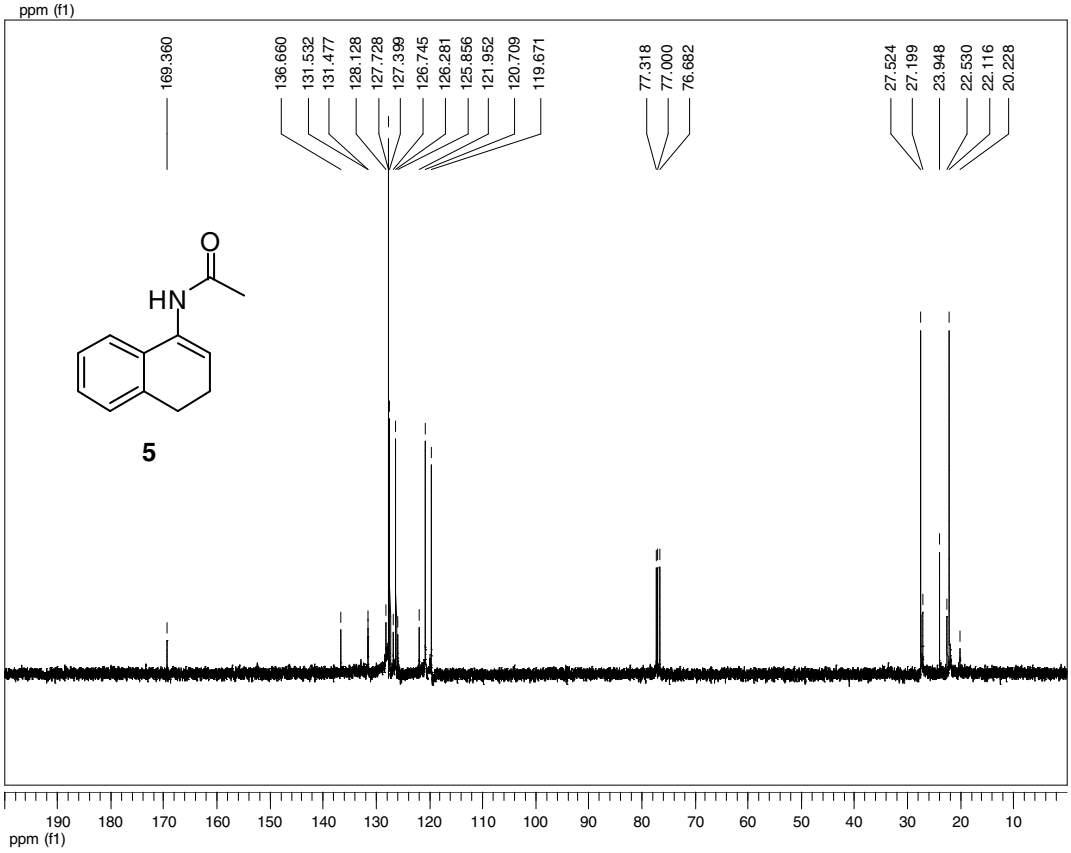
0.57
0.14
0.59
0.54
2.80
0.93
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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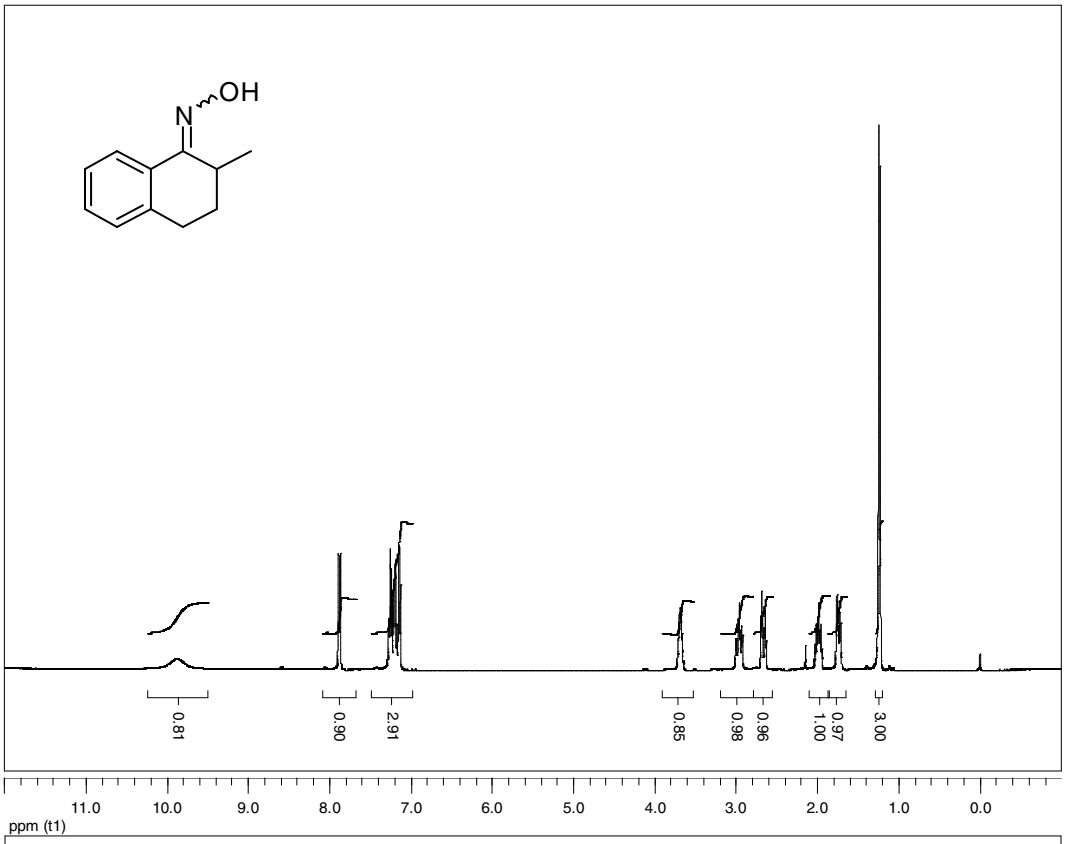
131.532
131.477
128.128
127.728
127.399
126.745
126.281
125.856
121.952
120.709
119.671
77.318
77.000
76.682
27.524
27.199
23.948
22.530
22.116
20.228
O
HN
5
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)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9.0
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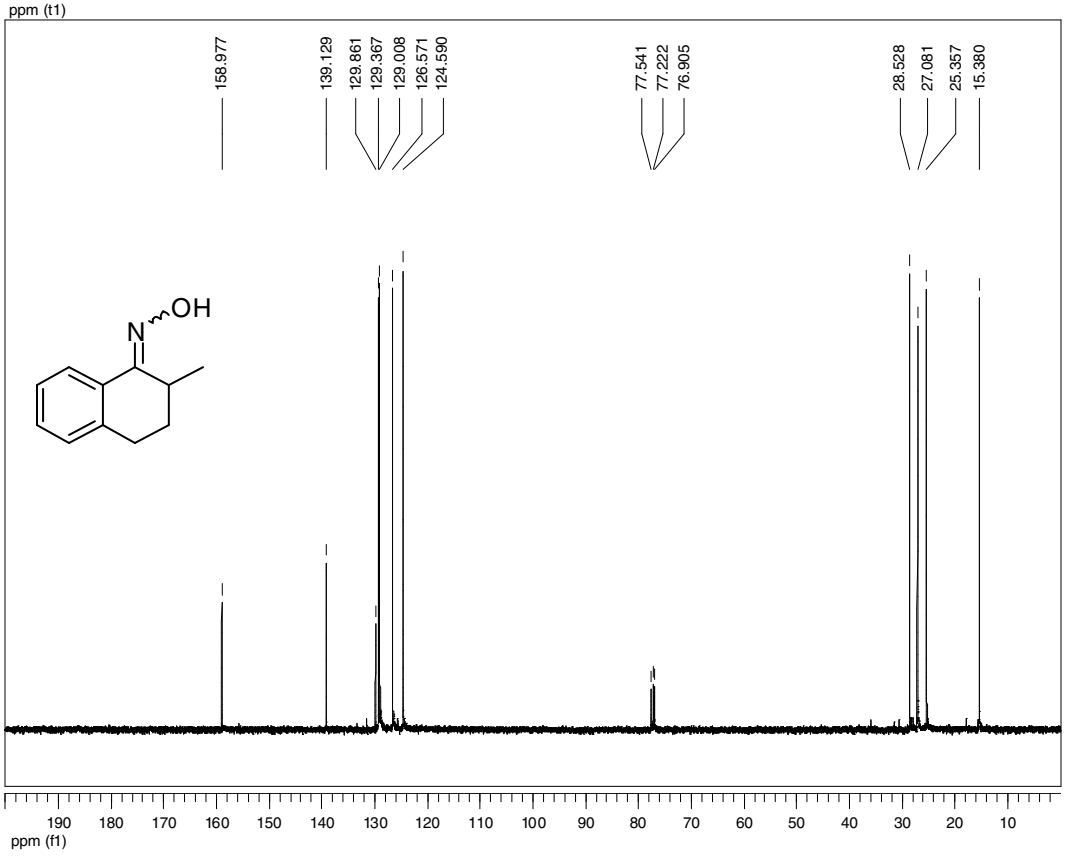
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)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129.861
129.367
129.008
126.571
124.590
77.541
77.222
76.905
28.528
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25.357
15.380
N
OH
190
180
170
160
150
140
130
120
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100
90
80
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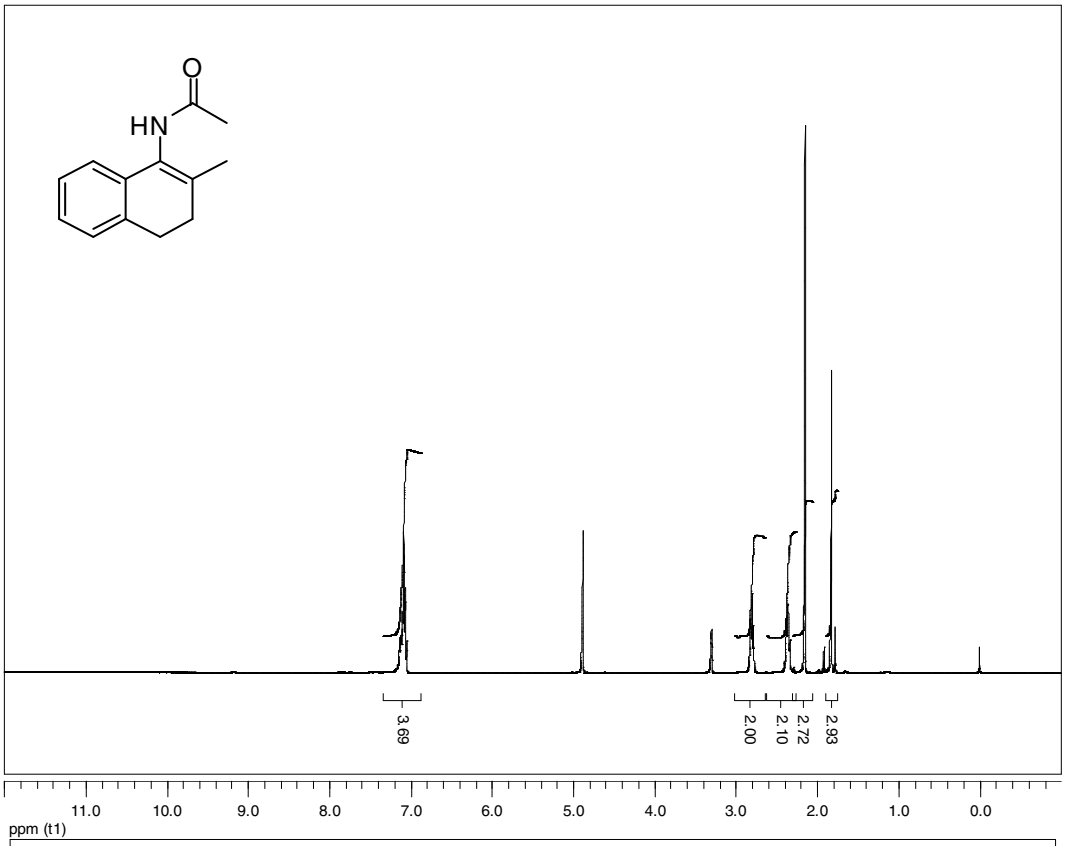
60
50
40
30
20
10
ppm (f1)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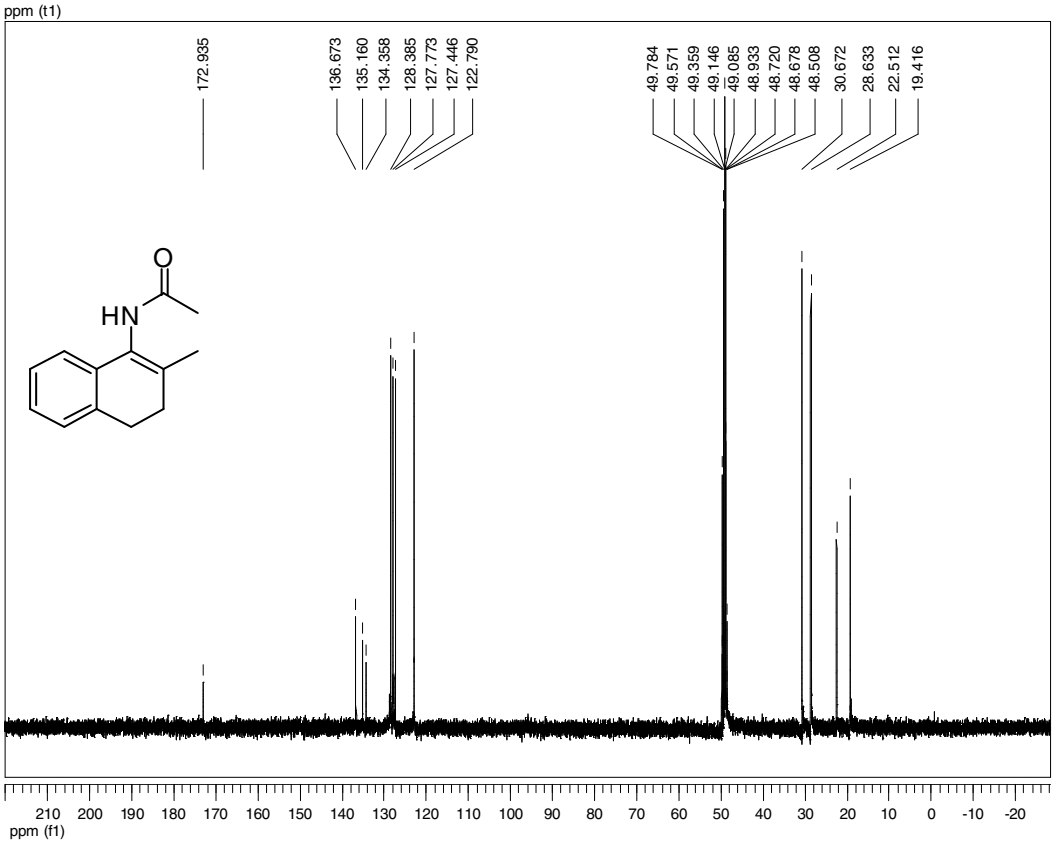
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


172.935
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134.358
128.385
127.773
127.446
122.790
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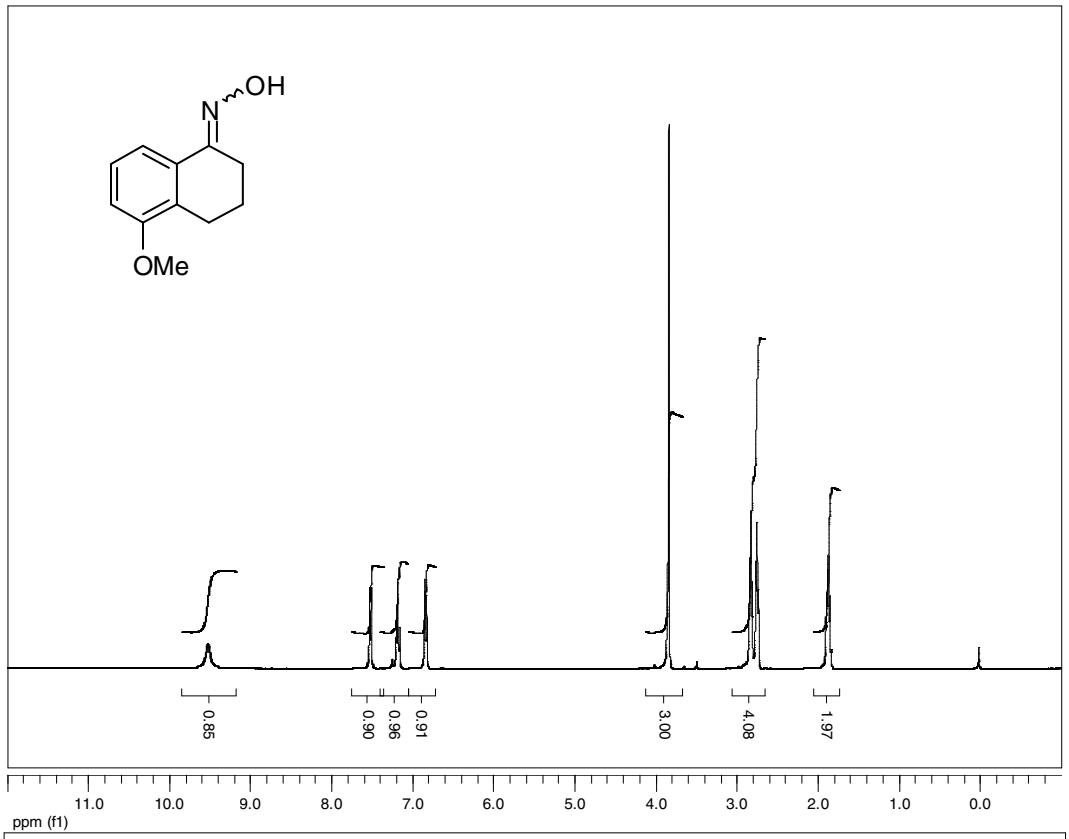
49.571
49.359
49.146
49.085
48.933
48.720
48.678
48.508
30.672
28.633
22.512
19.416
O
HN
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
ppm (f1)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0.91
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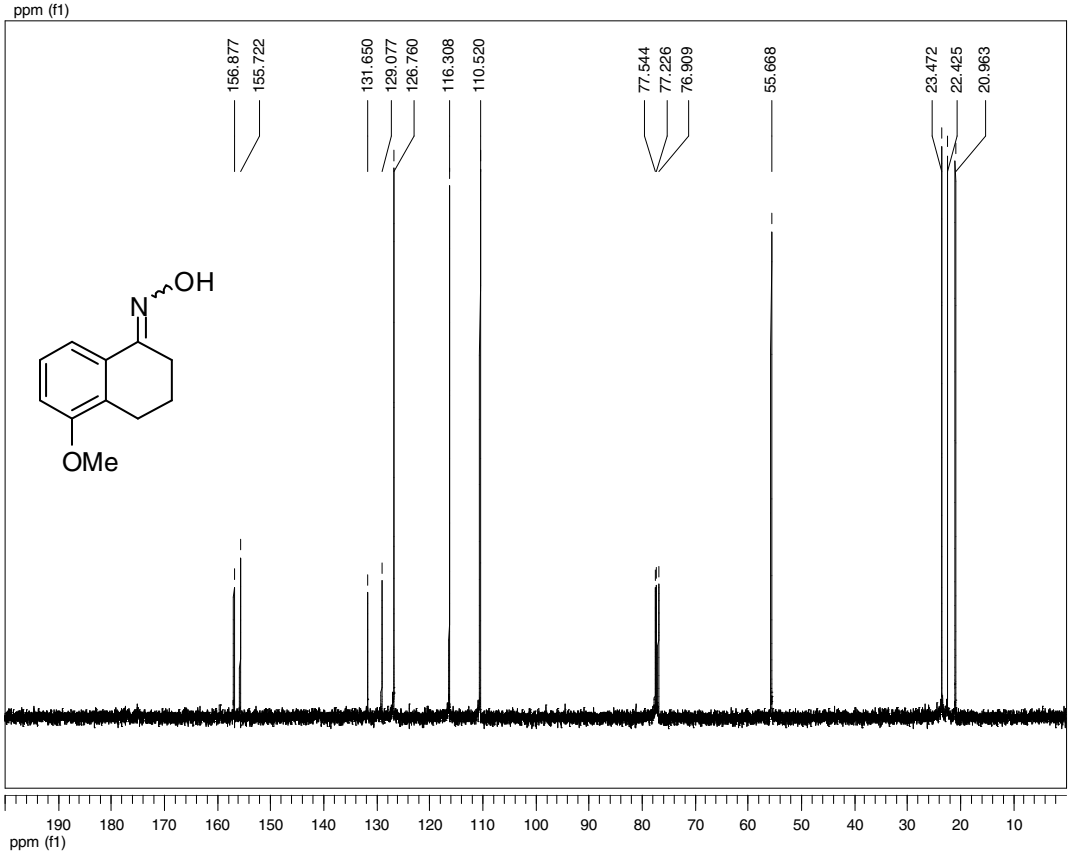
4.08
1.97
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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116.308
110.520
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55.668
23.472
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20.963
OH
N
OMe
190
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140
130
120
110
100
90
80
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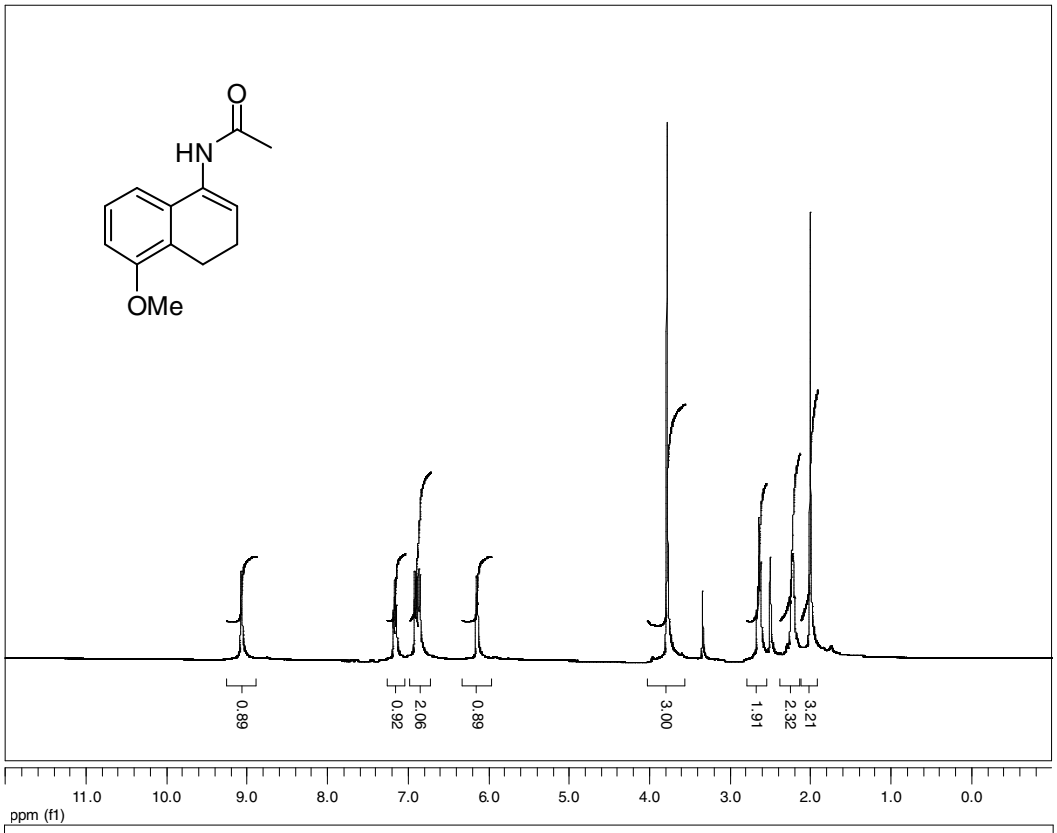
60
50
40
30
20
10
ppm (f1)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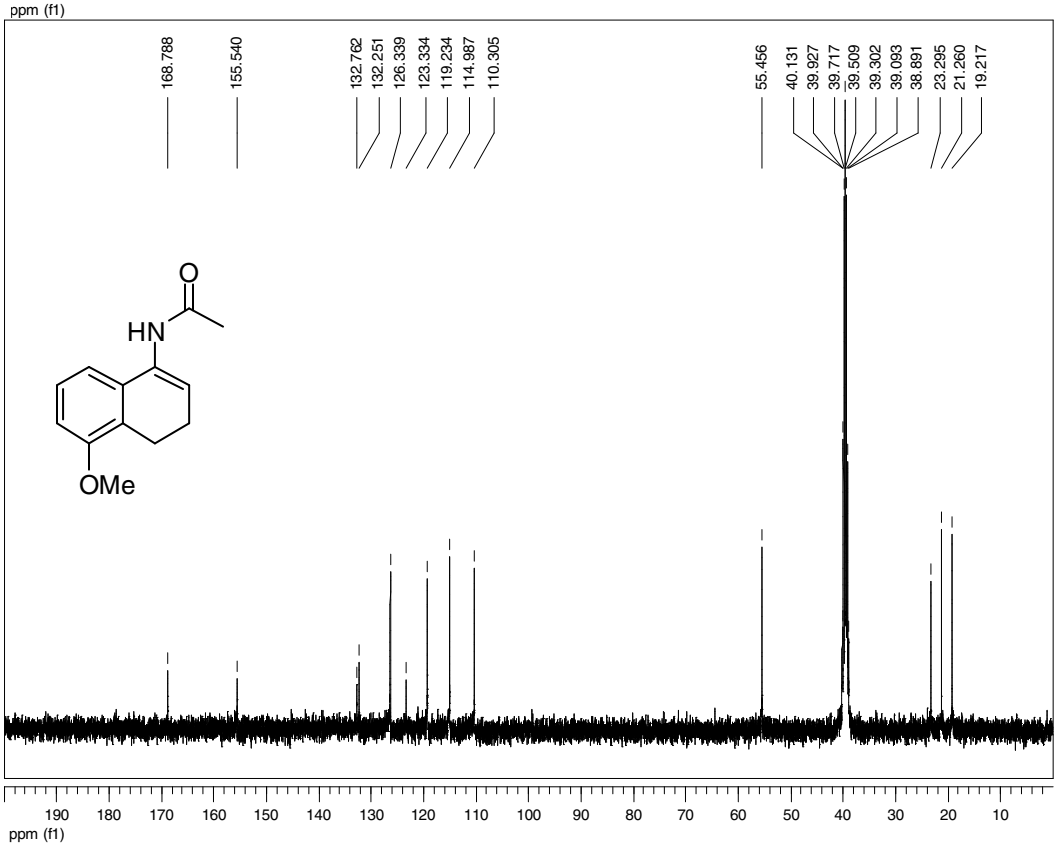
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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39.927
39.717
39.509
39.302
39.093
38.891
23.295
21.260
19.217
O
HN
OMe
190
180
170
160
150
140
130
120
110
100
90
80
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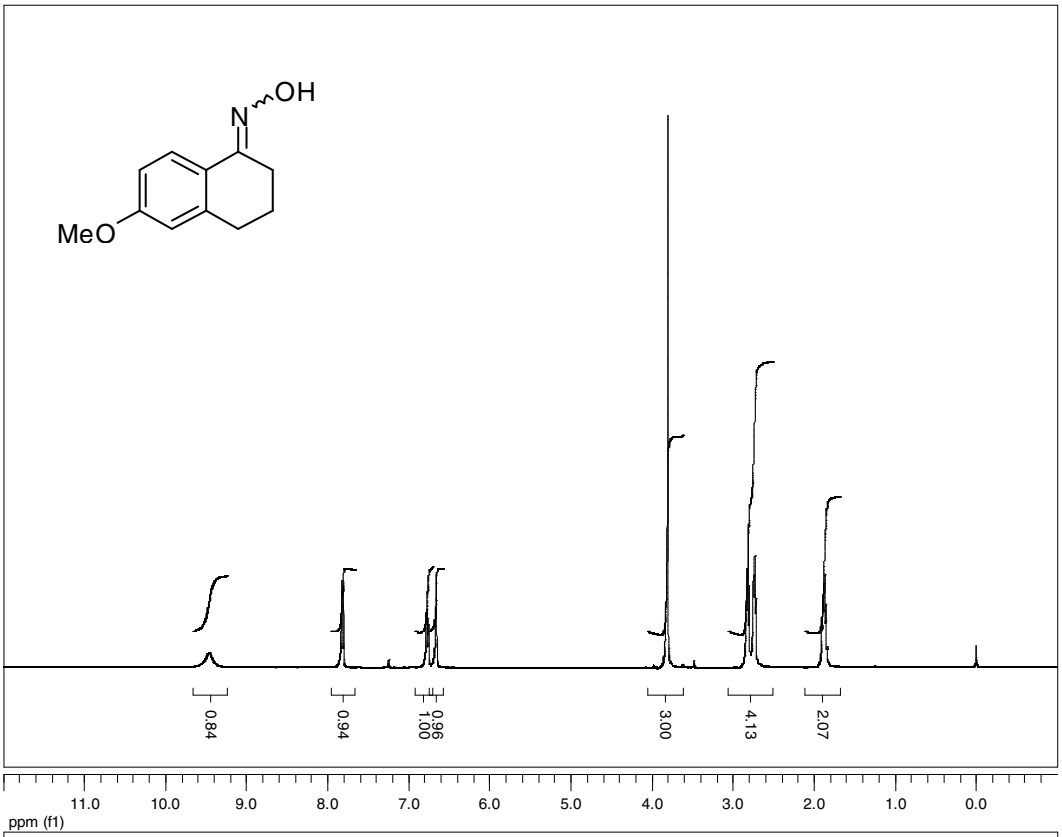
60
50
40
30
20
10
ppm (f1)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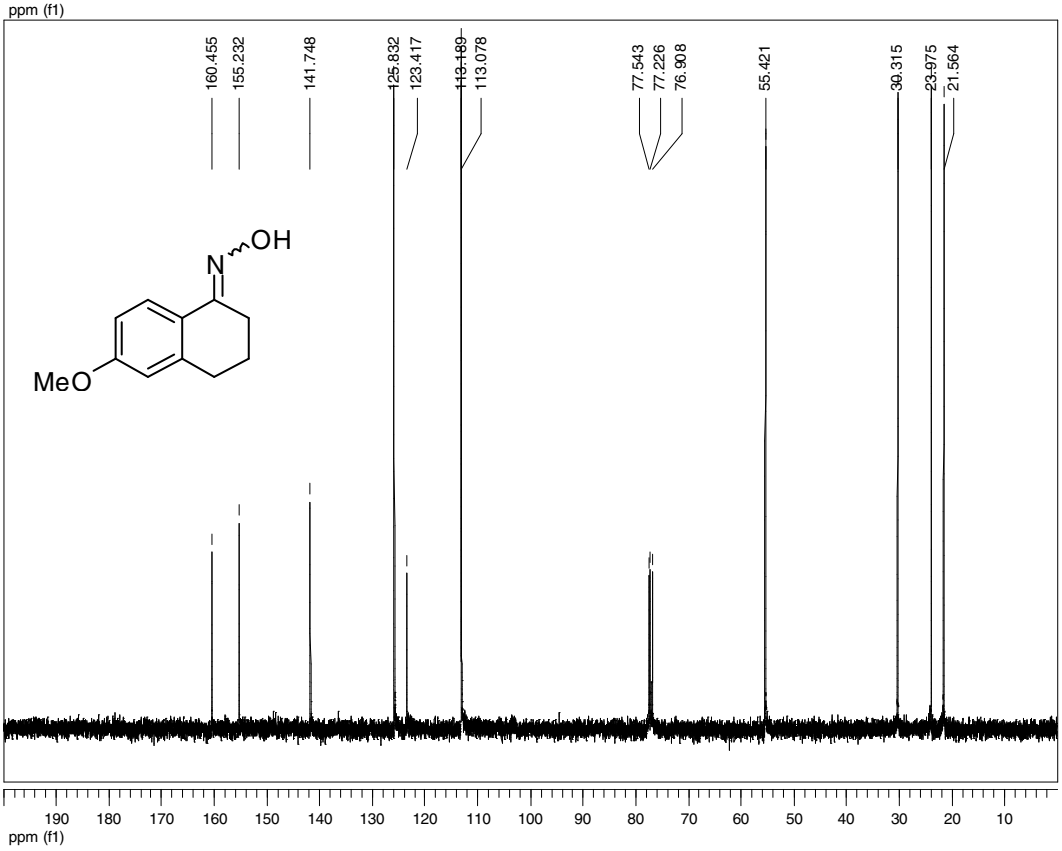
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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141.748
125.832
123.417
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113.078
77.543
77.226
76.908
55.421
30.315
23.975
21.564
N
OH
MeO
190
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170
160
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140
130
120
110
100
90
80
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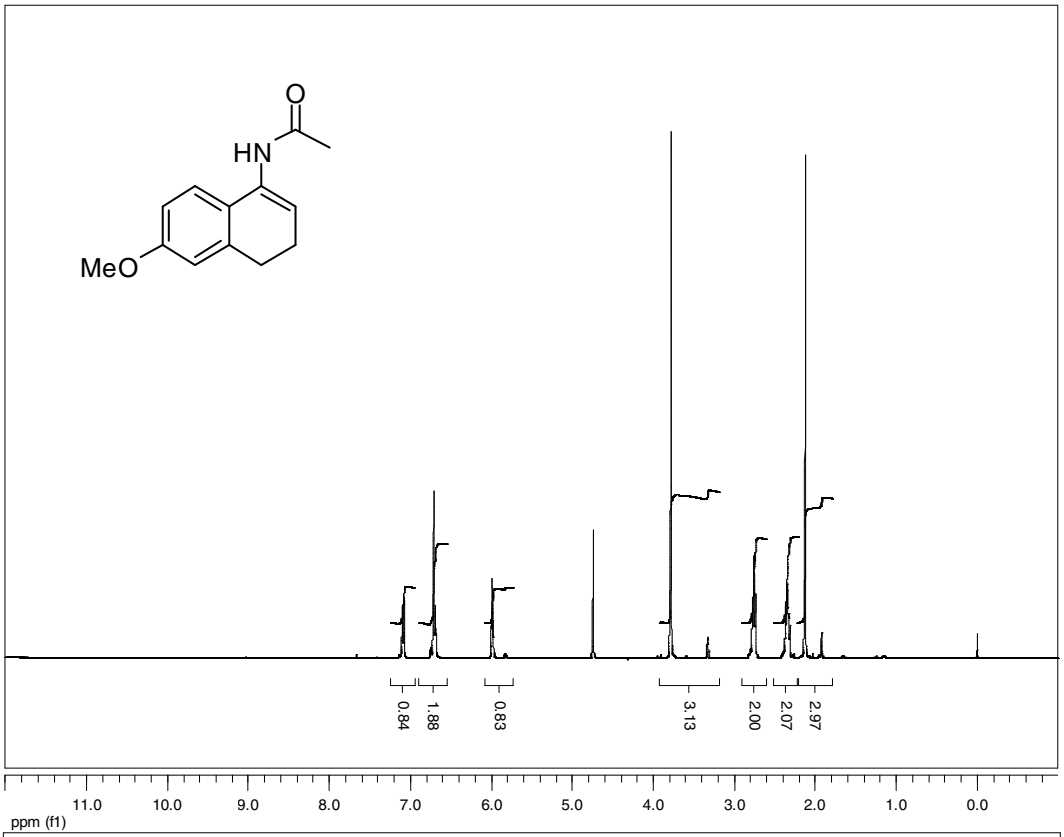
60
50
40
30
20
10
ppm (f1)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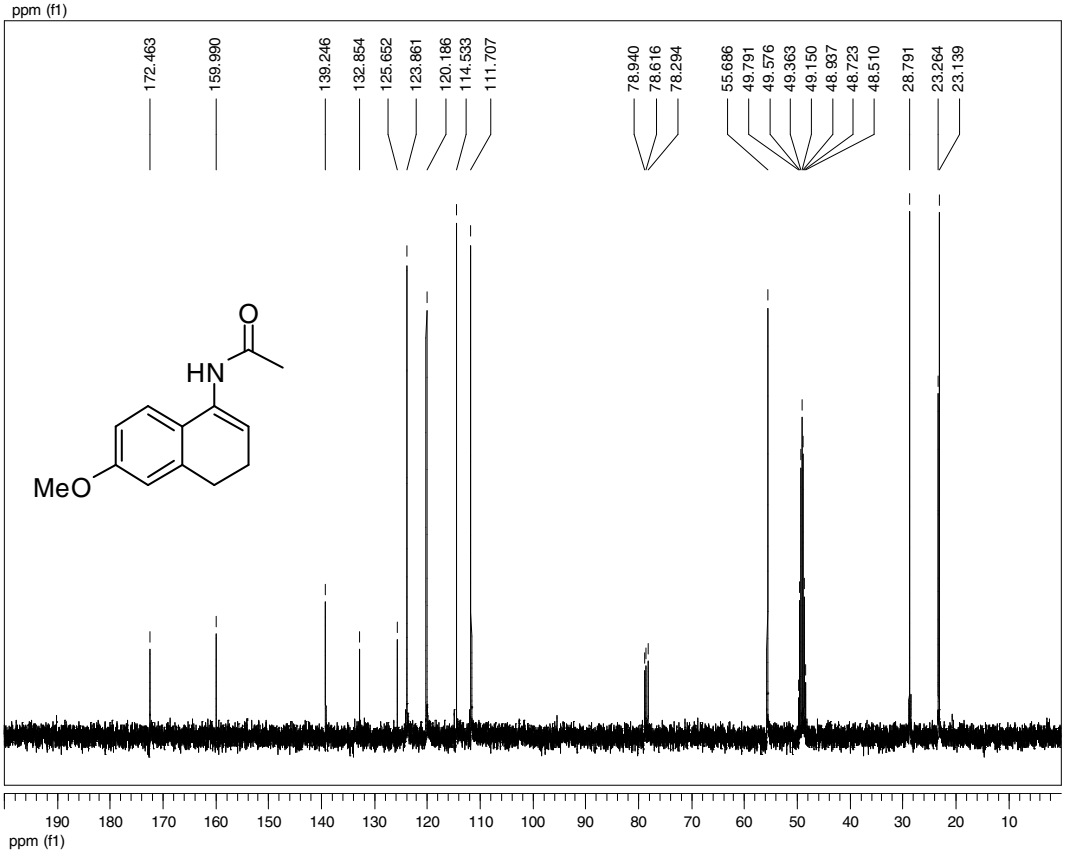
2.0
1.0
0.0
ppm (f1)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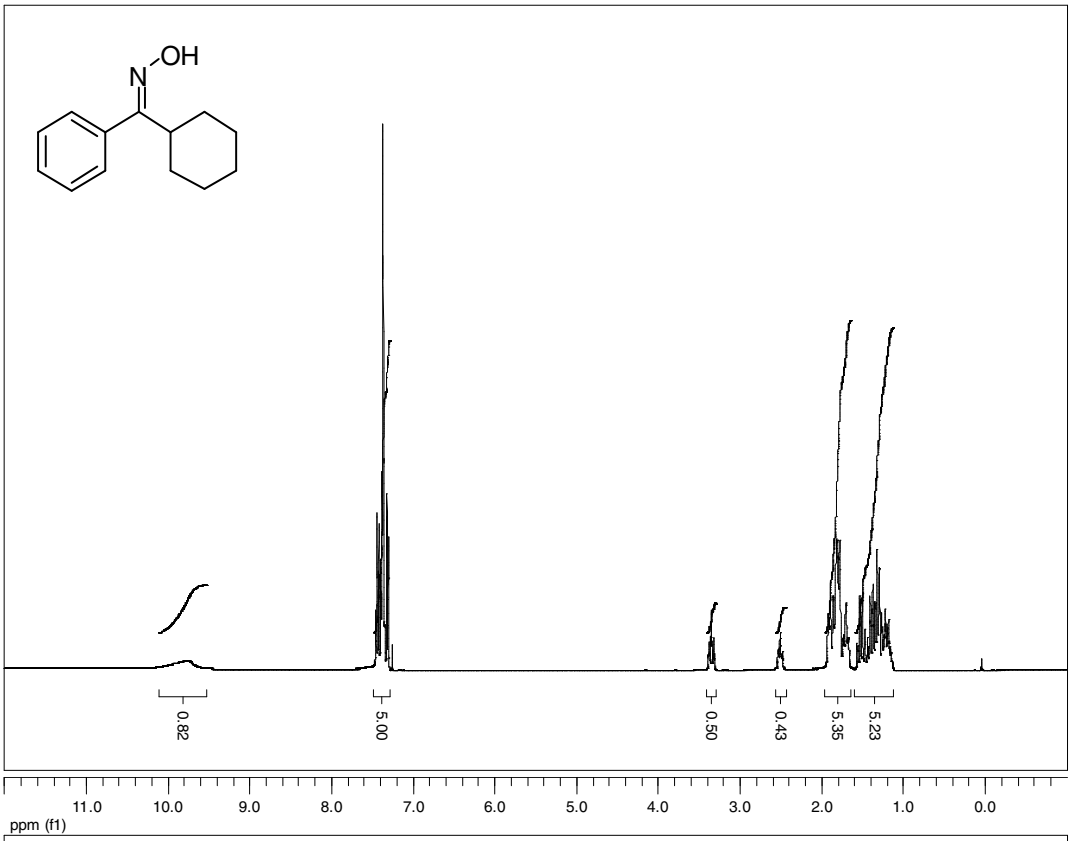
55.686
49.791
49.576
49.363
49.150
48.937
48.723
48.510
28.791
23.264
23.139
O
HN
MeO
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)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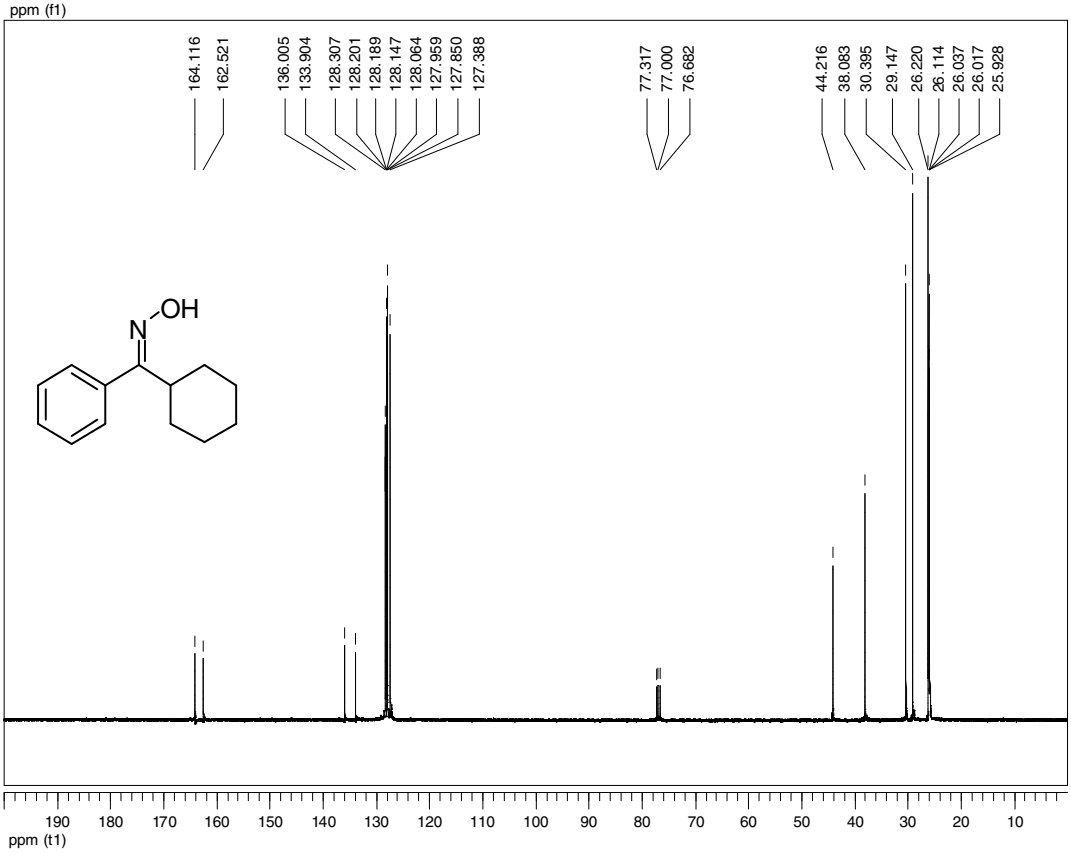
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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77.000
76.682
44.216
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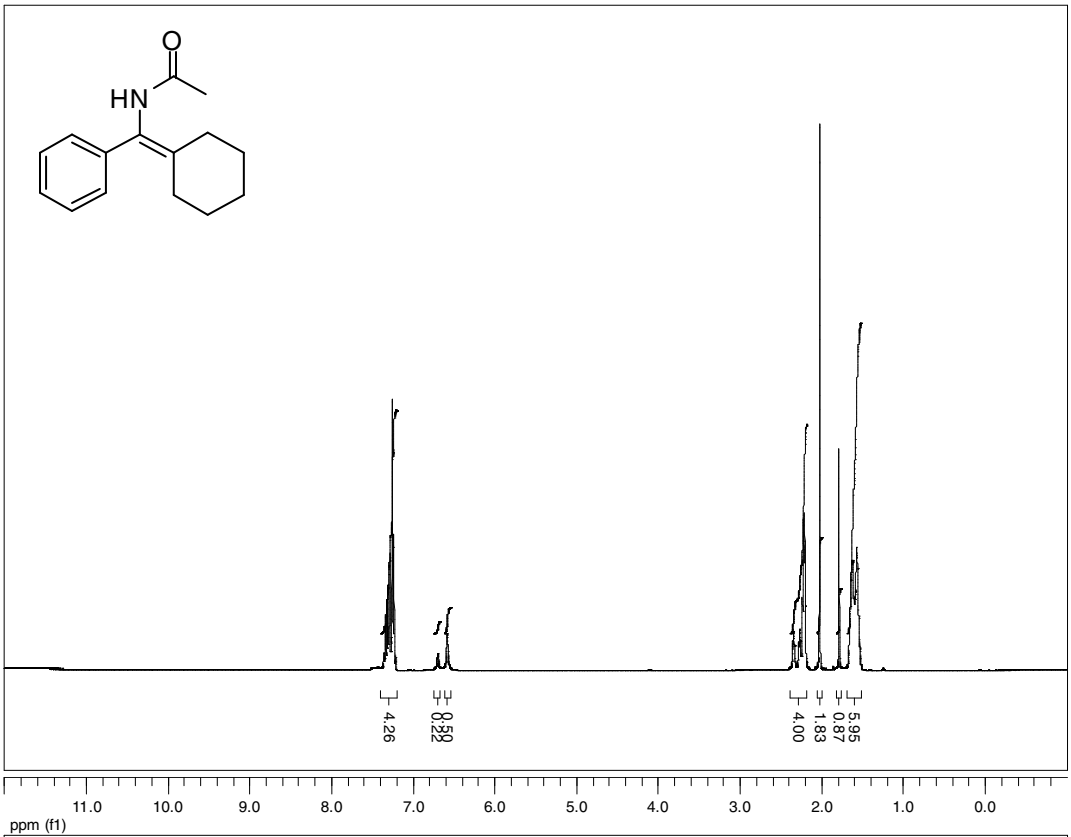
30.395
29.147
26.220
26.114
26.037
26.017
25.928
OH
N
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)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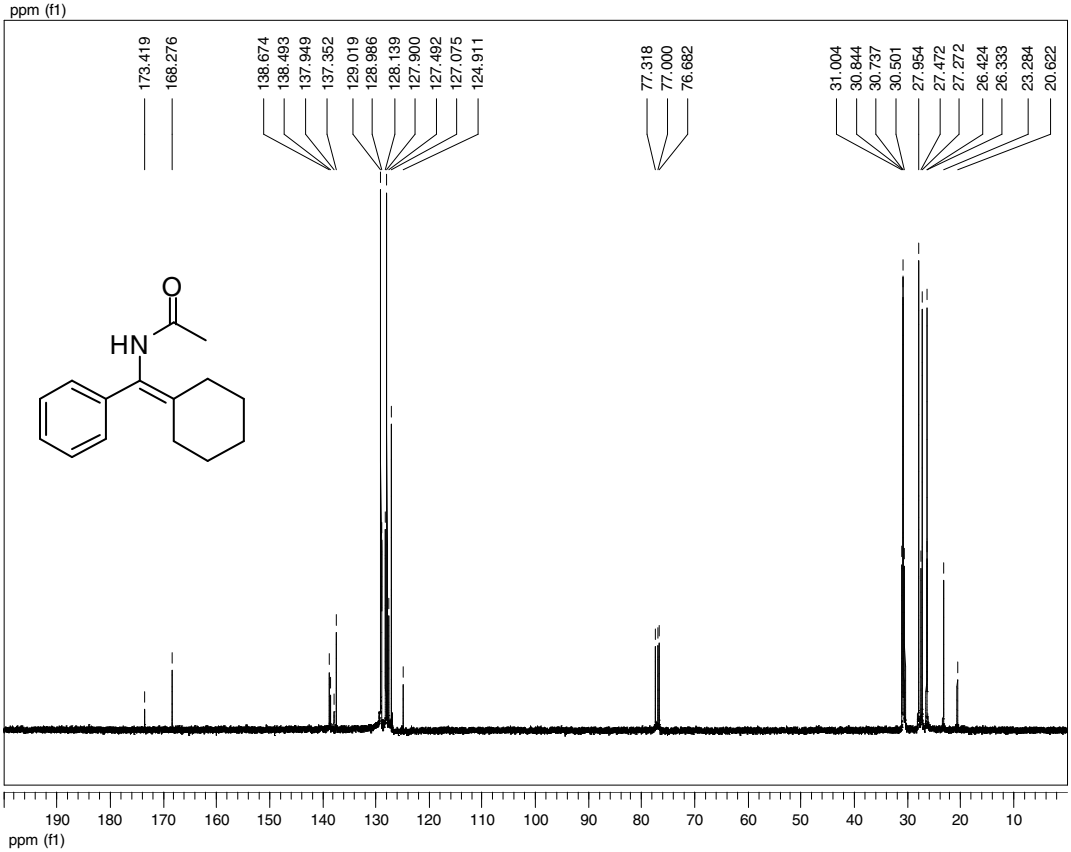
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)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137.352
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128.986
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127.900
127.492
127.075
124.911
77.318
77.000
76.682
31.004
30.844
30.737
30.501
27.954
27.472
27.272
26.424
26.333
23.284
20.622
O
HN
190
180
170
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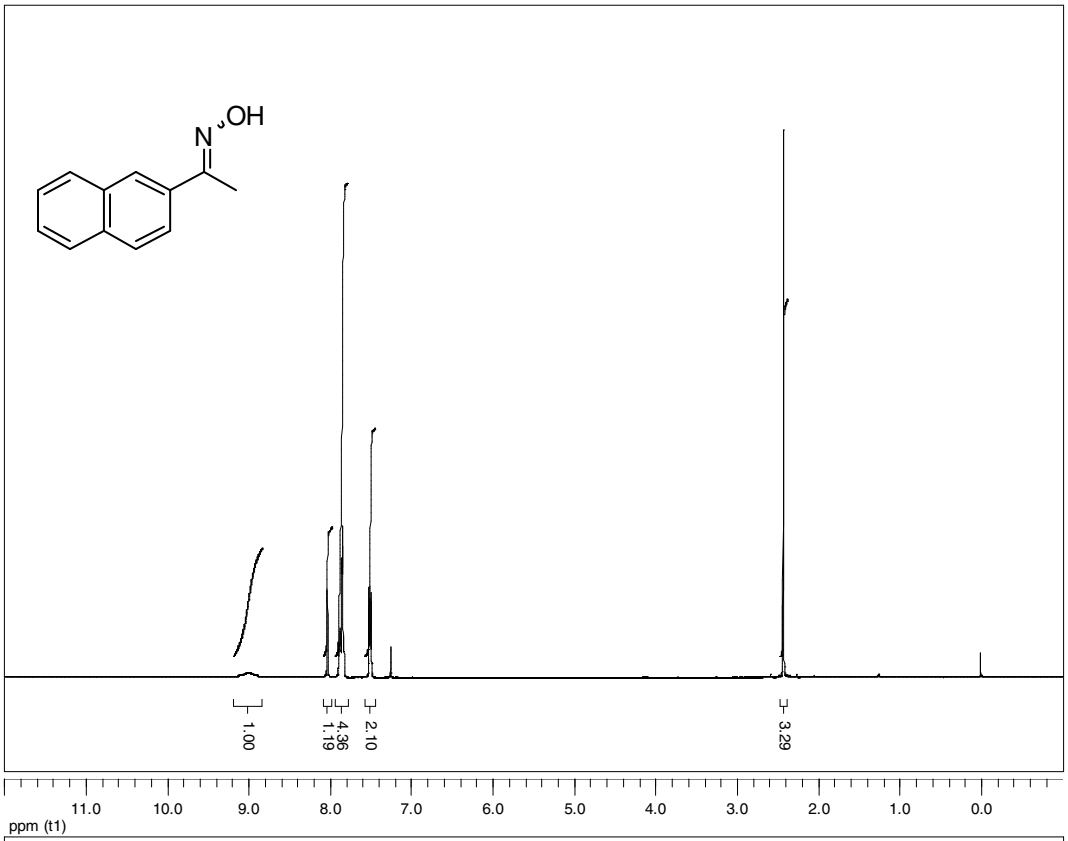
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)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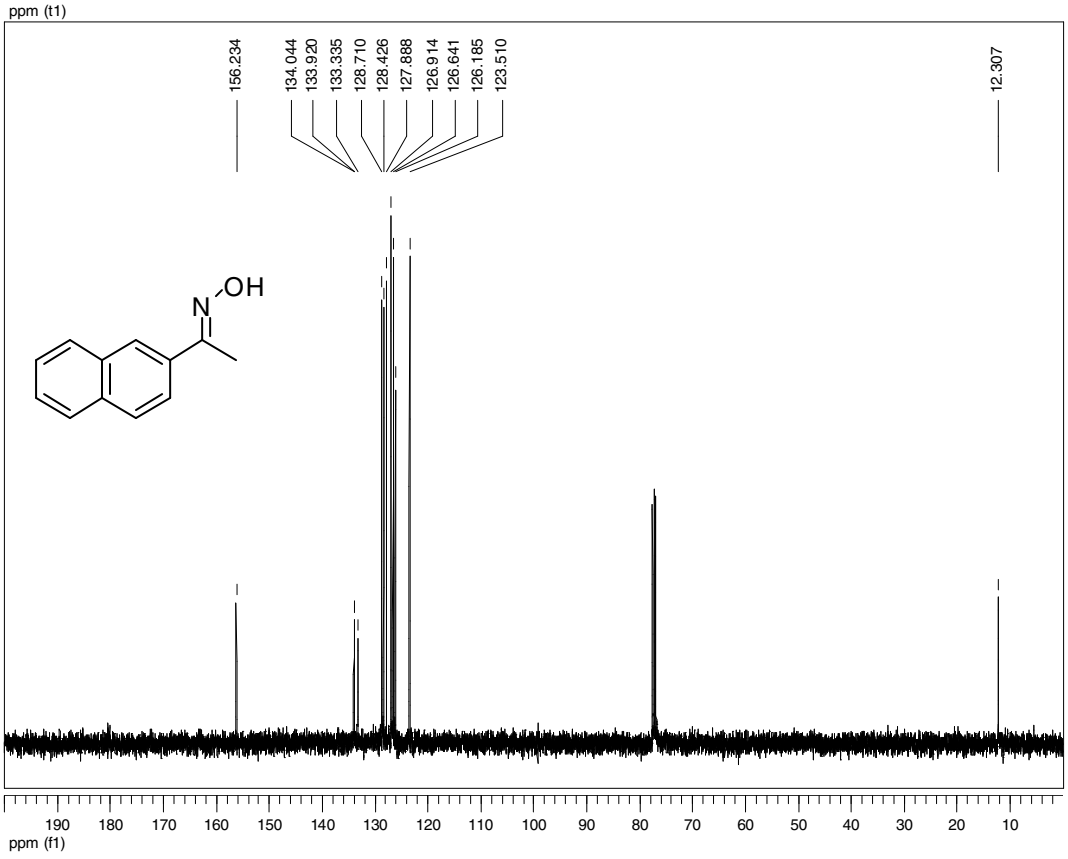
3.29
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)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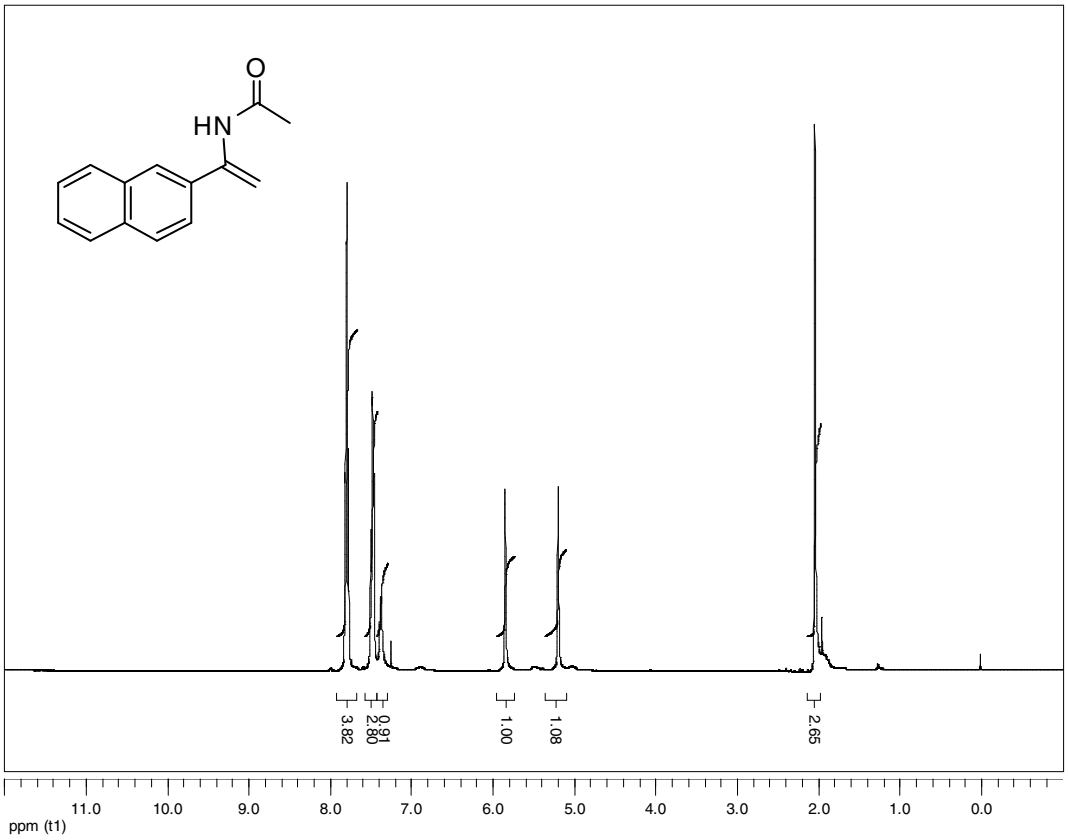
128.710
128.426
127.888
126.914
126.641
126.185
123.510
12.307
N
OH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)


O
HN
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1.08
2.95
11.0
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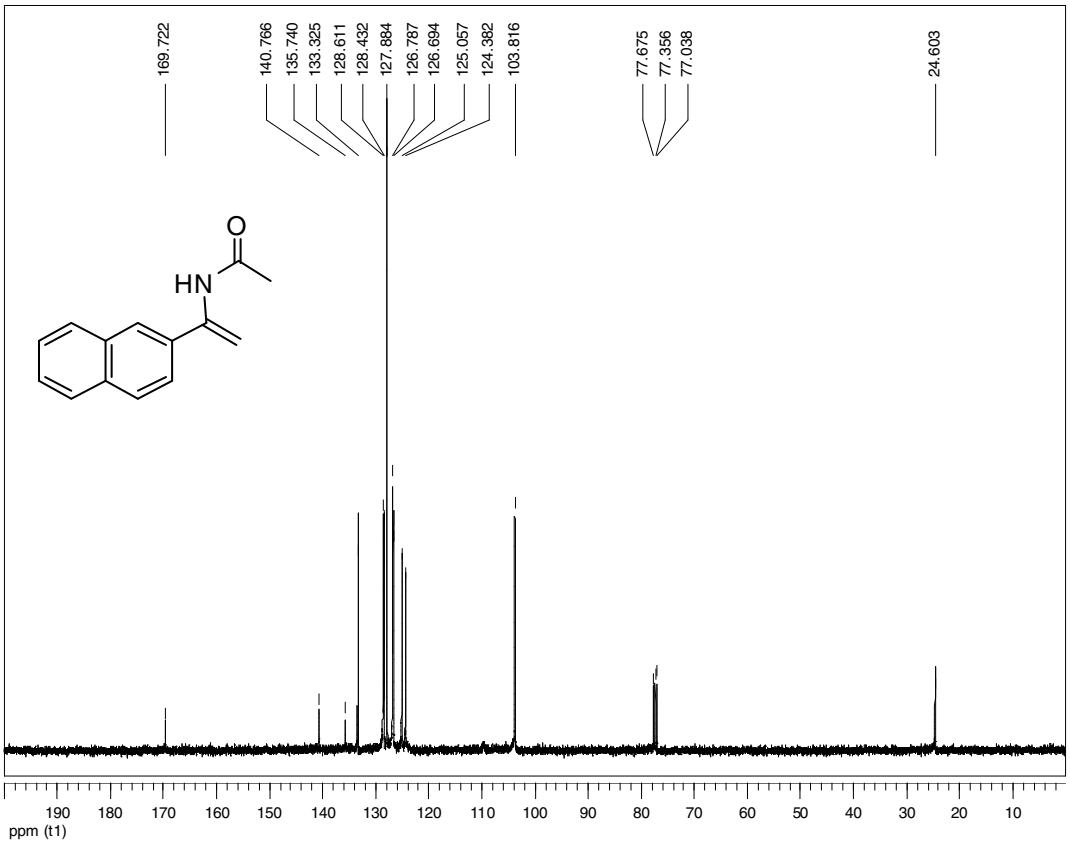
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)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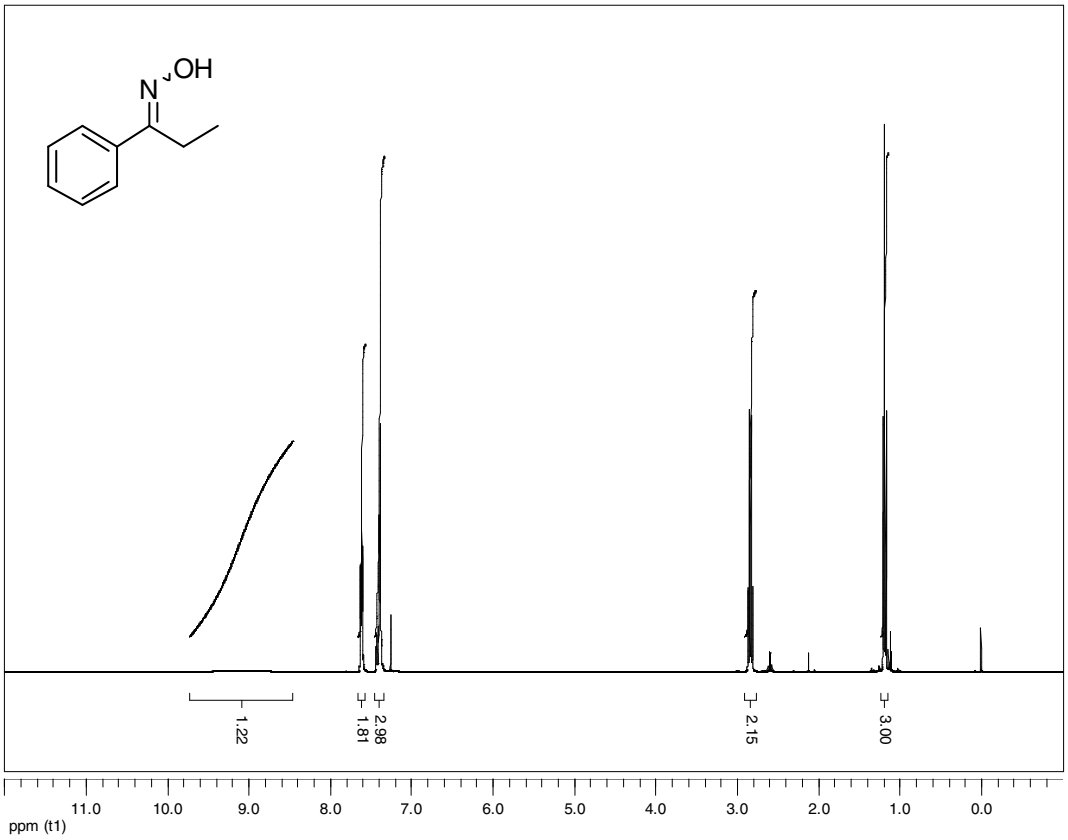
128.611
128.432
127.884
126.787
126.694
125.057
124.382
103.816
77.675
77.356
77.038
24.603
O
HN
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)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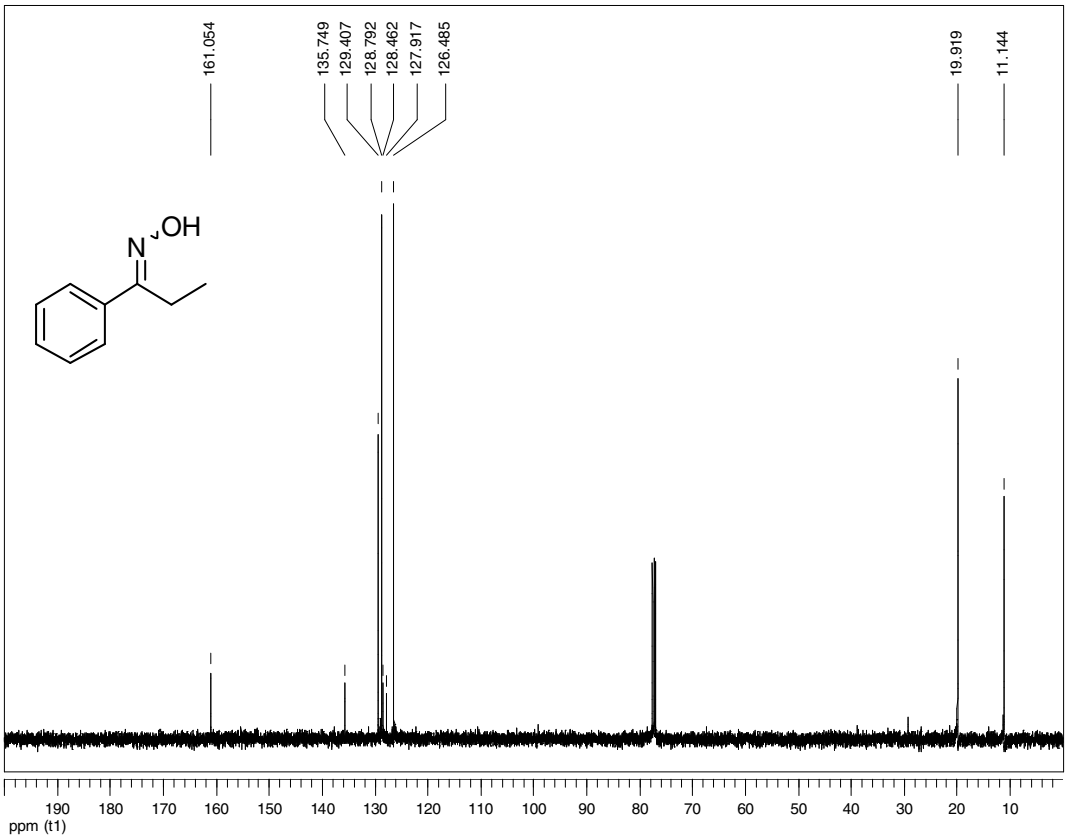
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)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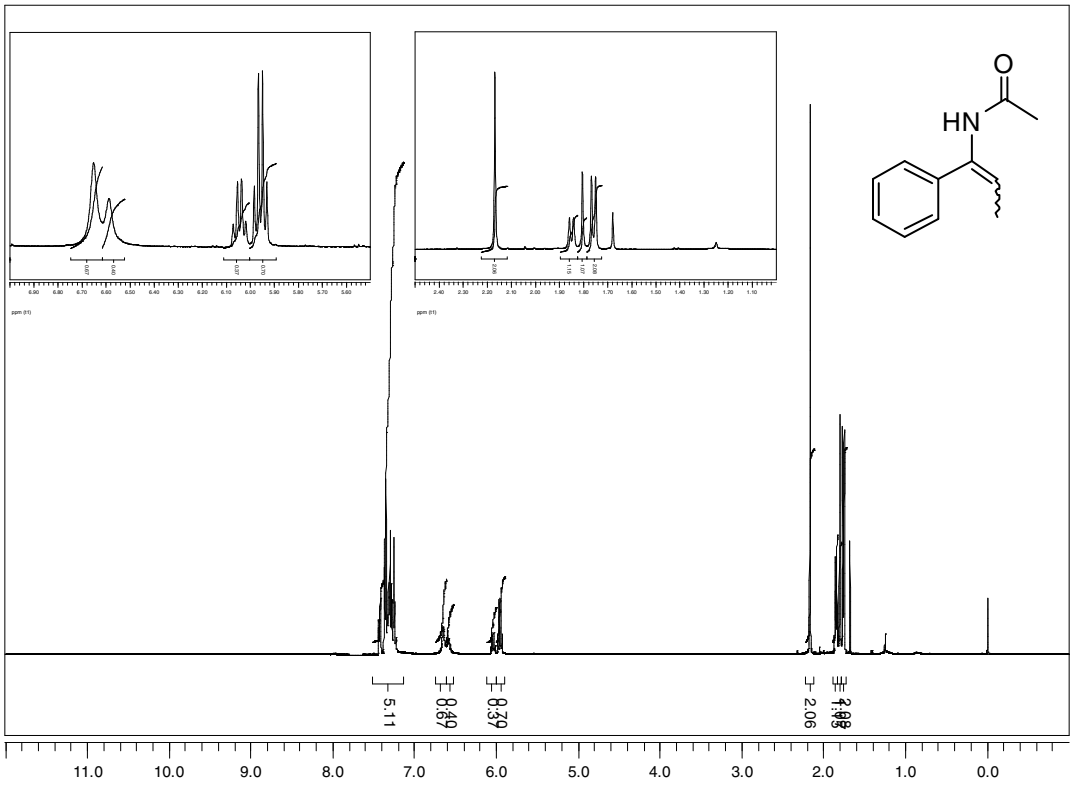
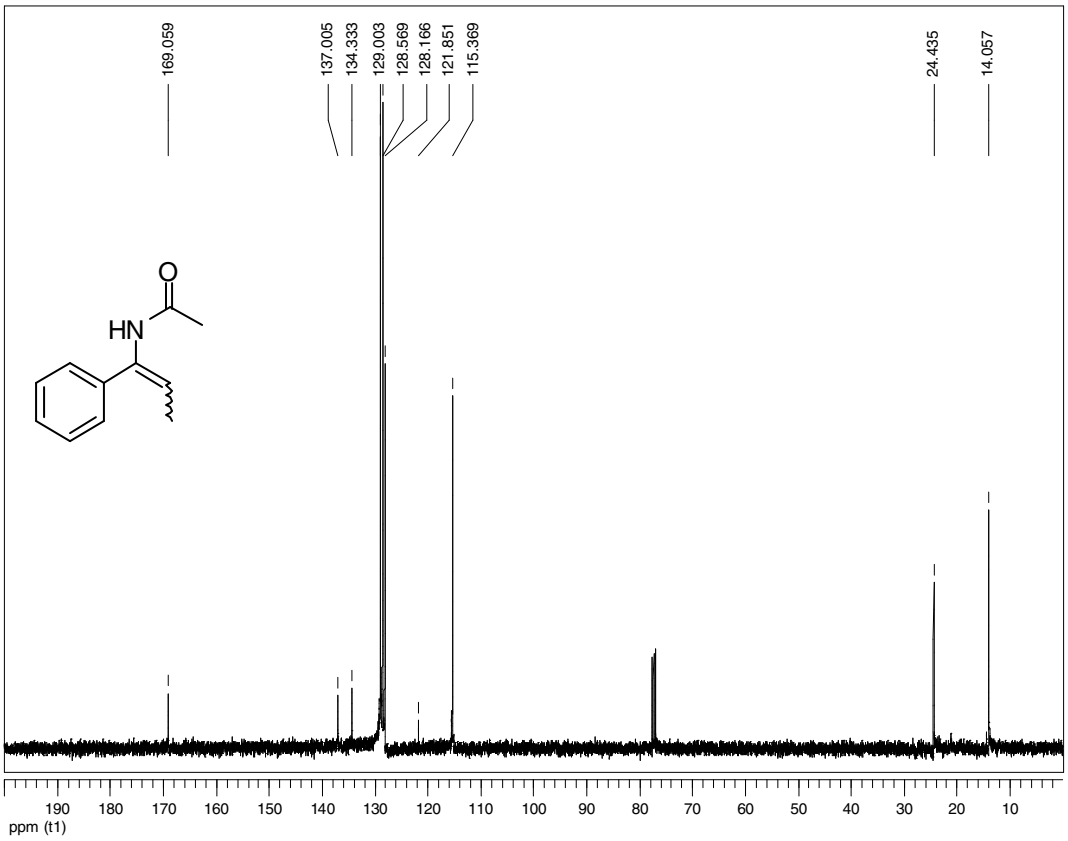
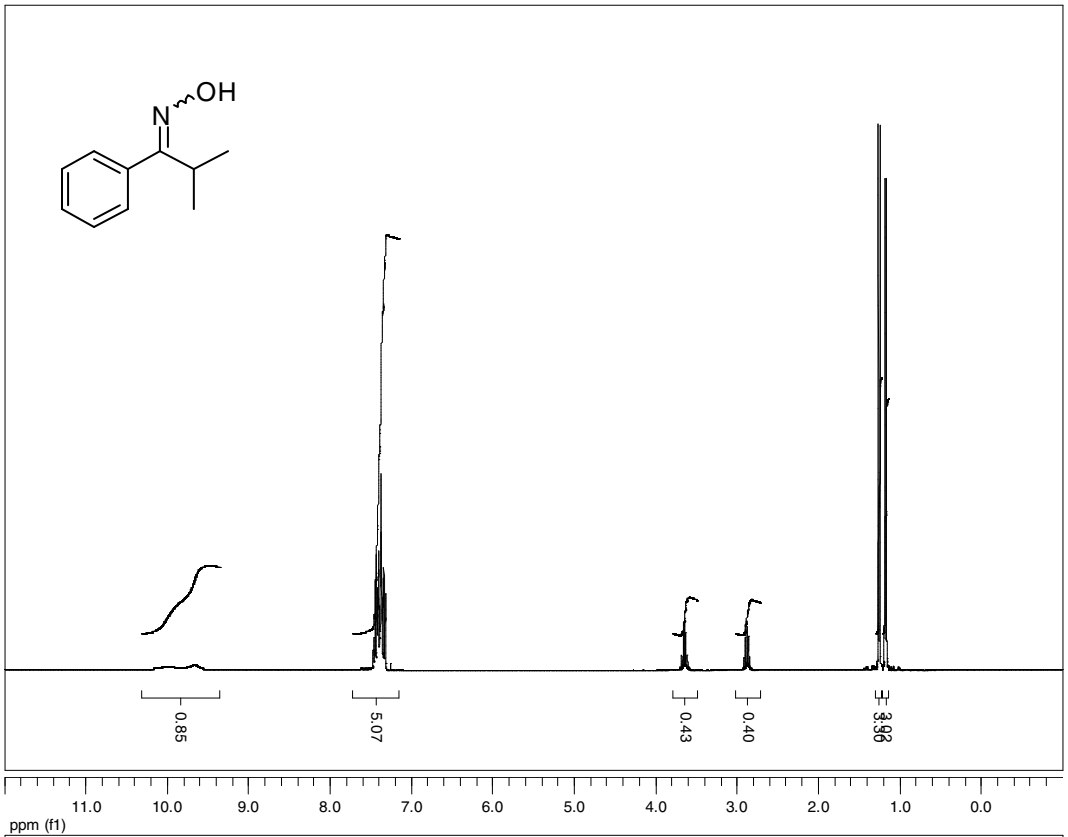
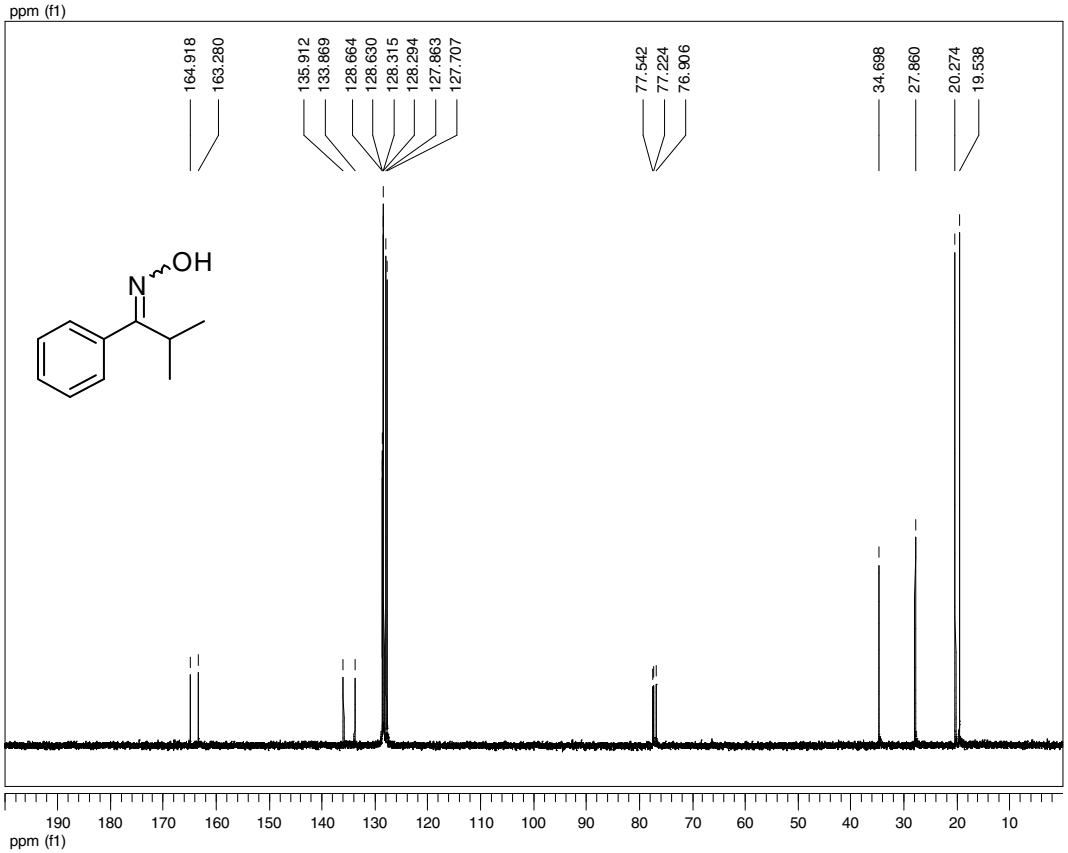
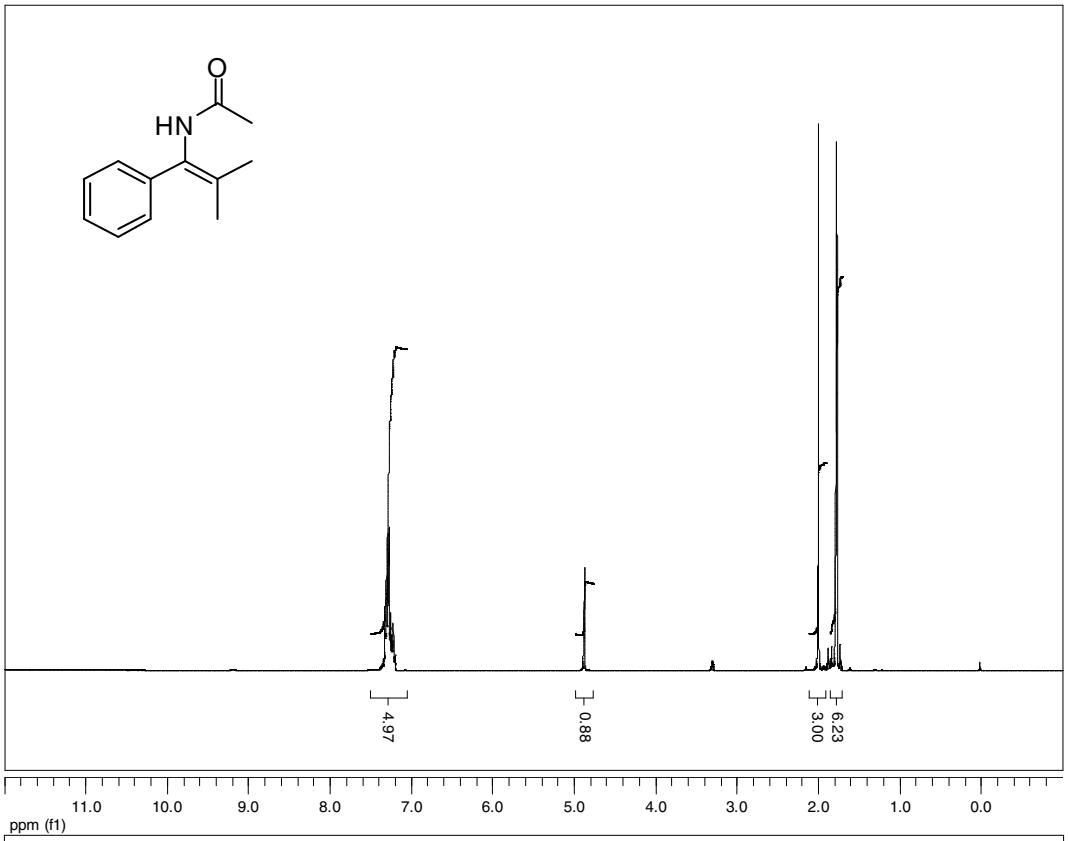
129.407
128.792
128.462
127.917
126.485
19.919
11.144
N
OH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)

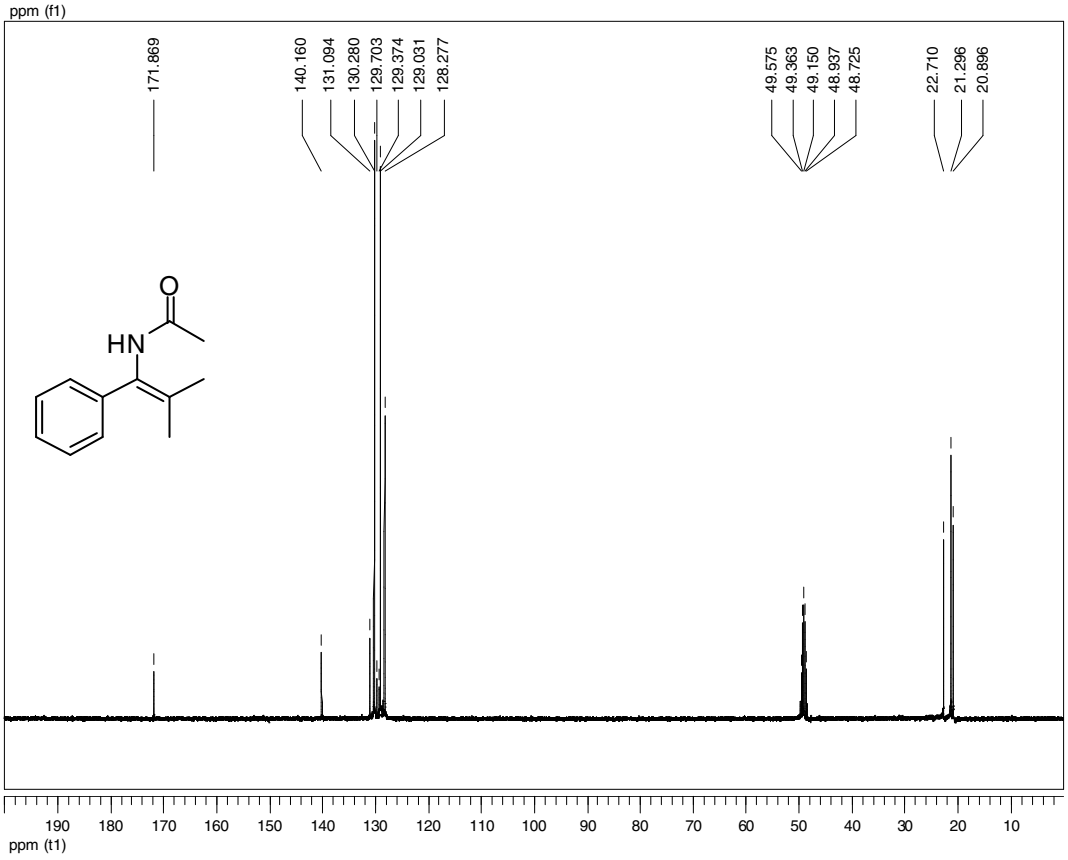

O
HN
5.11
0.49
0.79
2.06
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

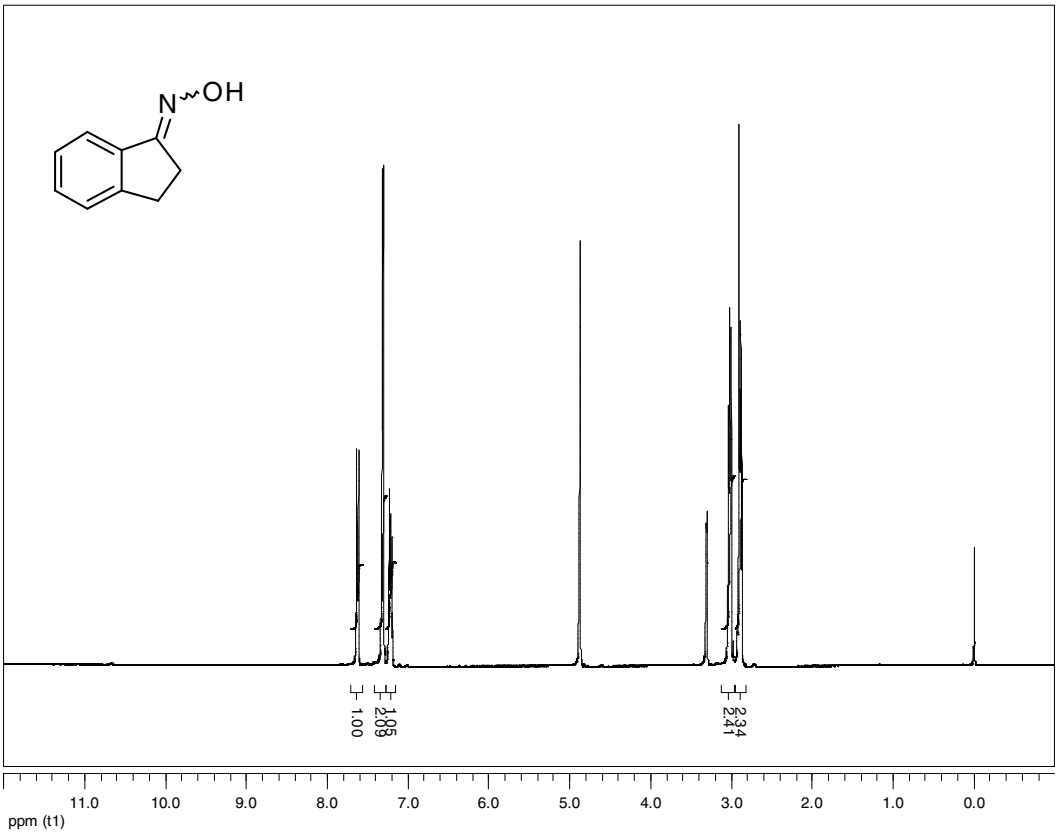

169.059
137.005
134.333
129.003
128.569
128.166
121.851
115.369
24.435
14.057
O
HN
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)

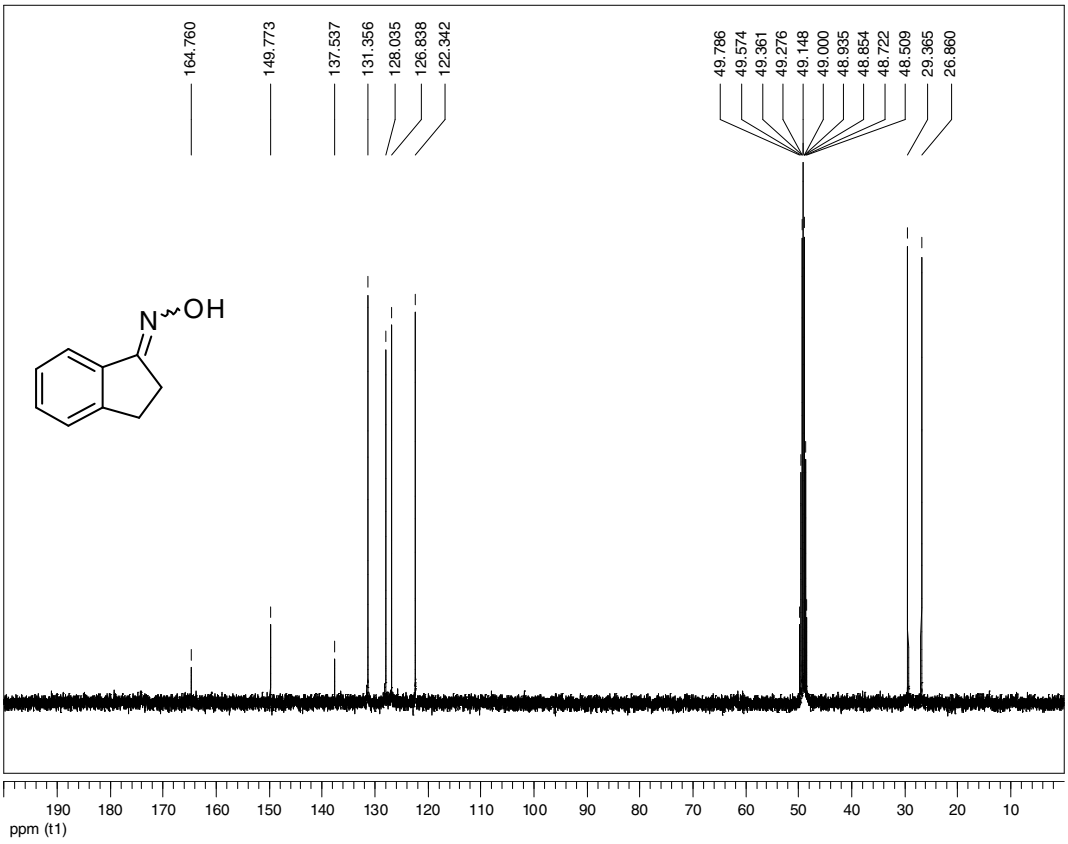

N
OH
0.85
5.07
0.43
0.40
3.00
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

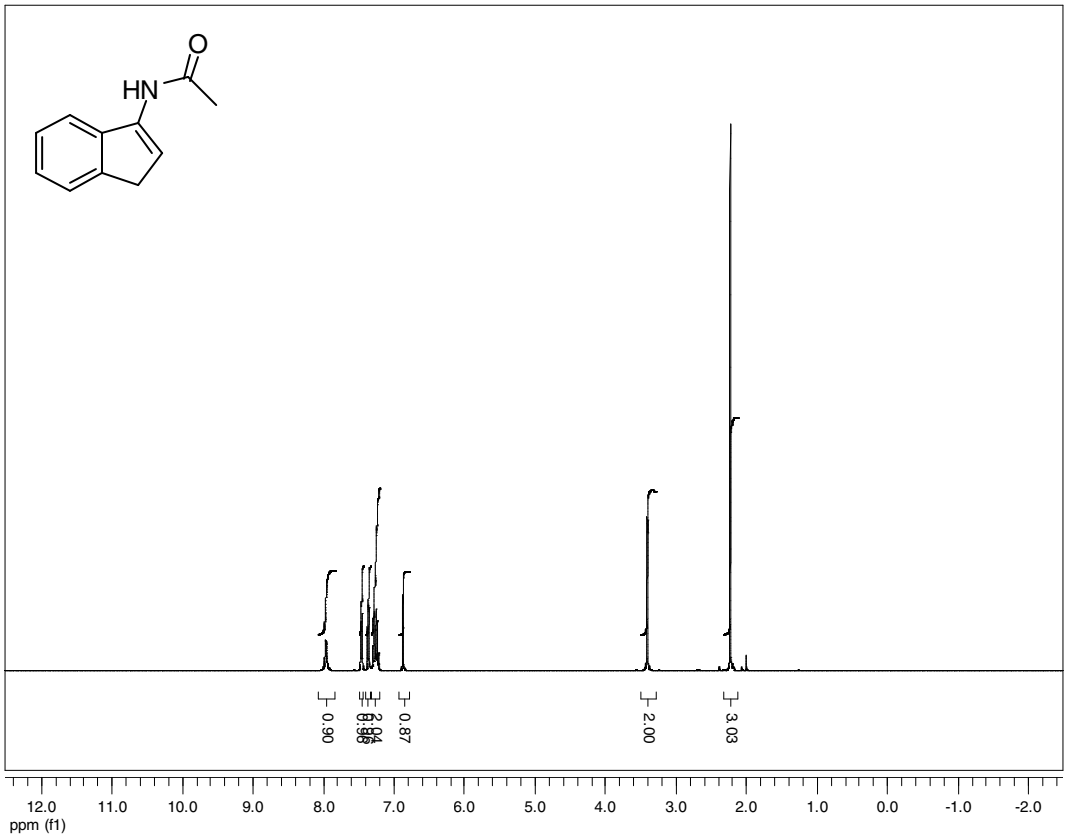

164.918
163.280
135.912
133.869
128.664
128.630
128.315
128.294
127.863
127.707
77.542
77.224
76.906
34.698
27.860
20.274
19.538
N
OH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

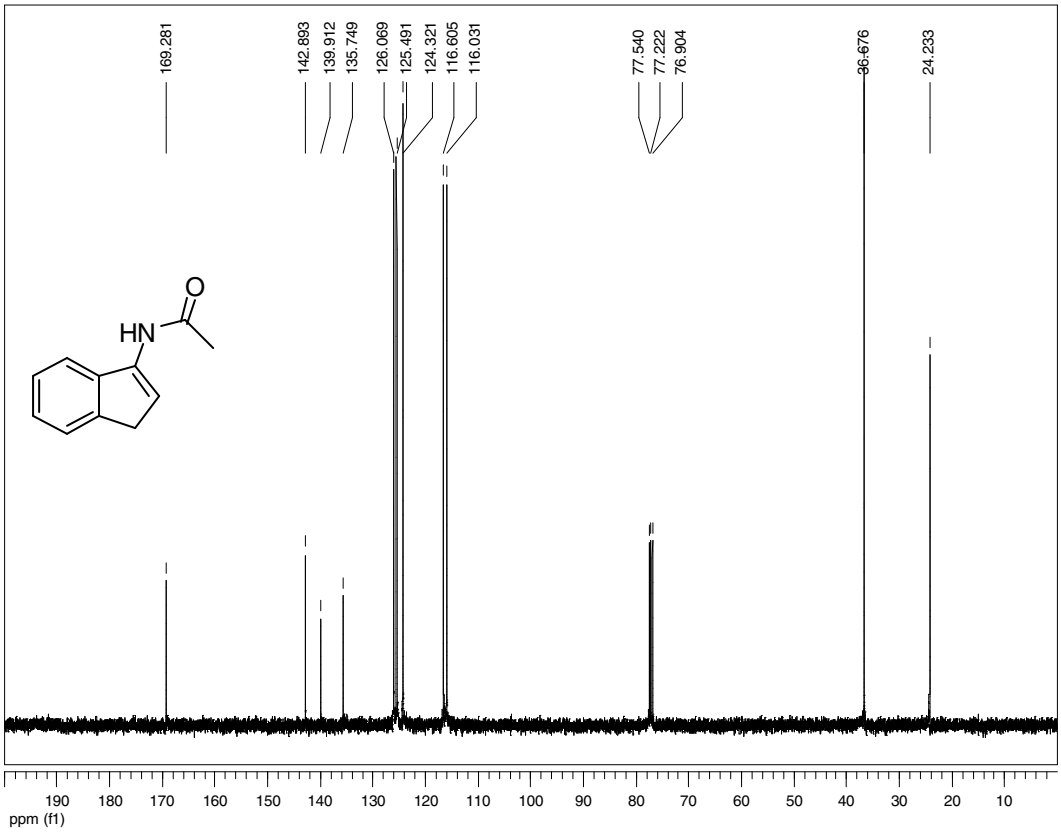

O
HN
4.97
0.88
3.00
6.23
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

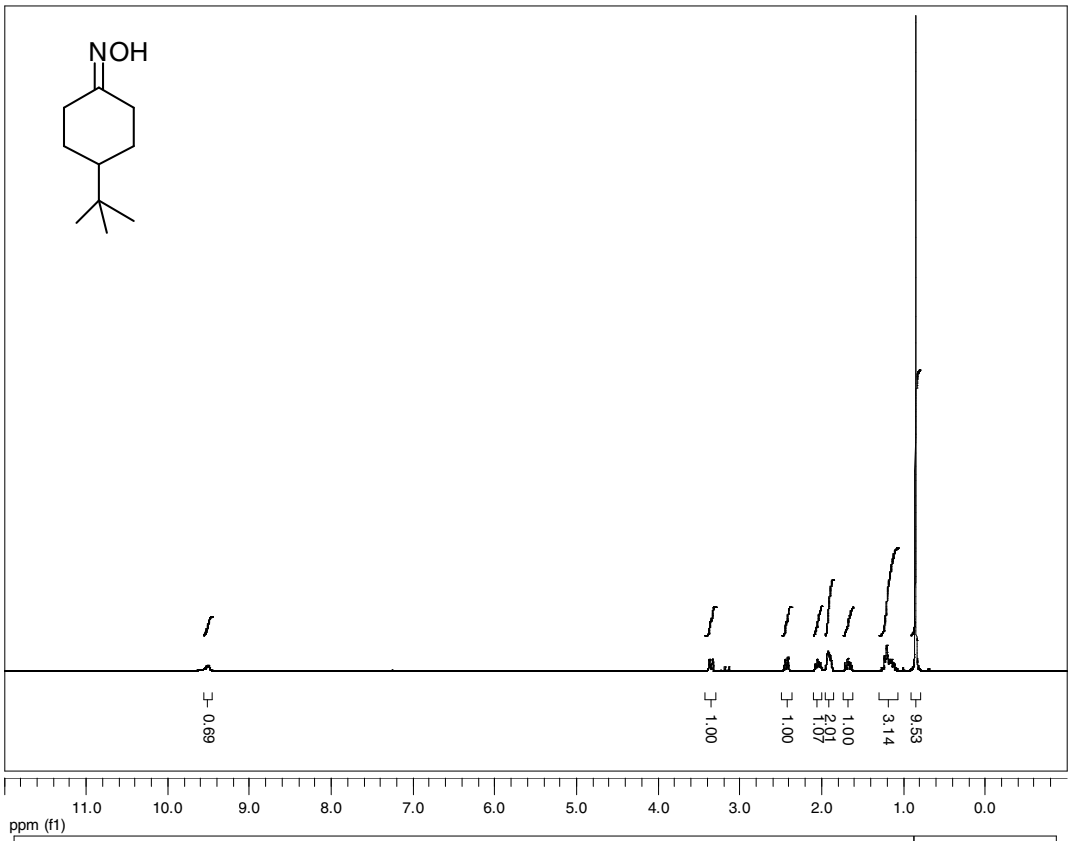

171.869
140.160
131.094
130.280
129.703
129.374
129.031
128.277
49.575
49.363
49.150
48.937
48.725
22.710
21.296
20.896
O
HN
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)

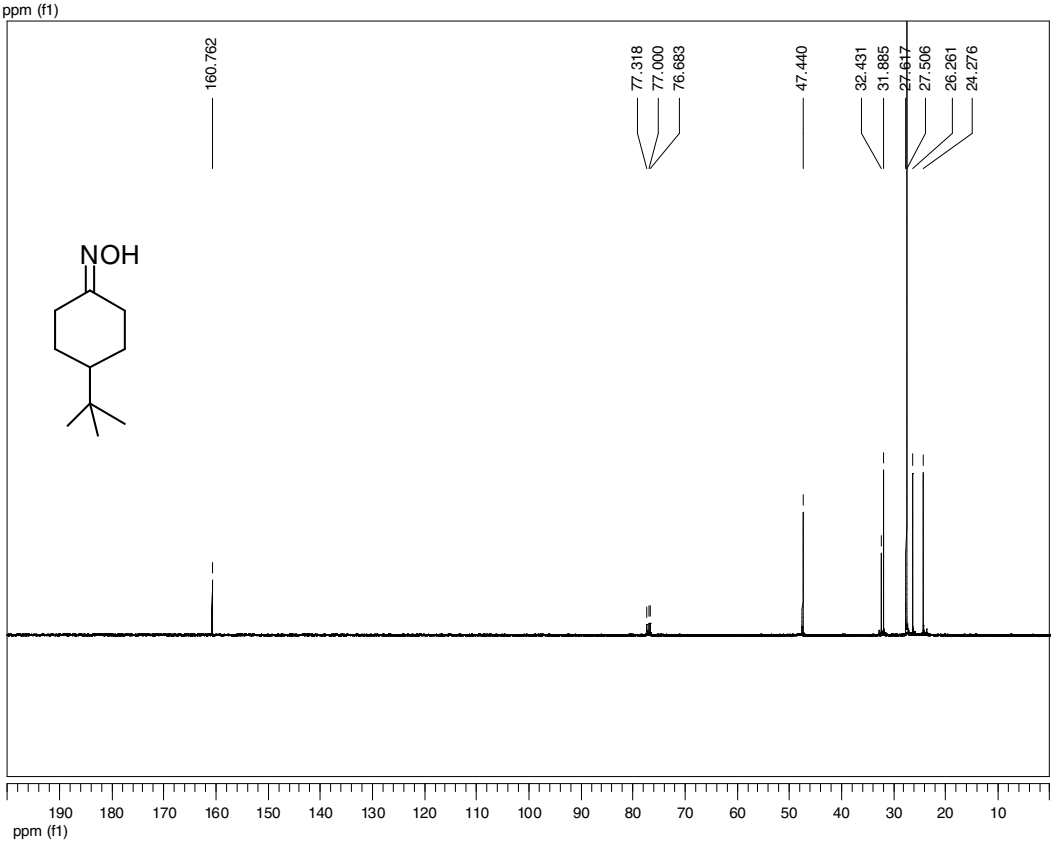

N
OH
1.00
2.09
1.05
2.34
2.41
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

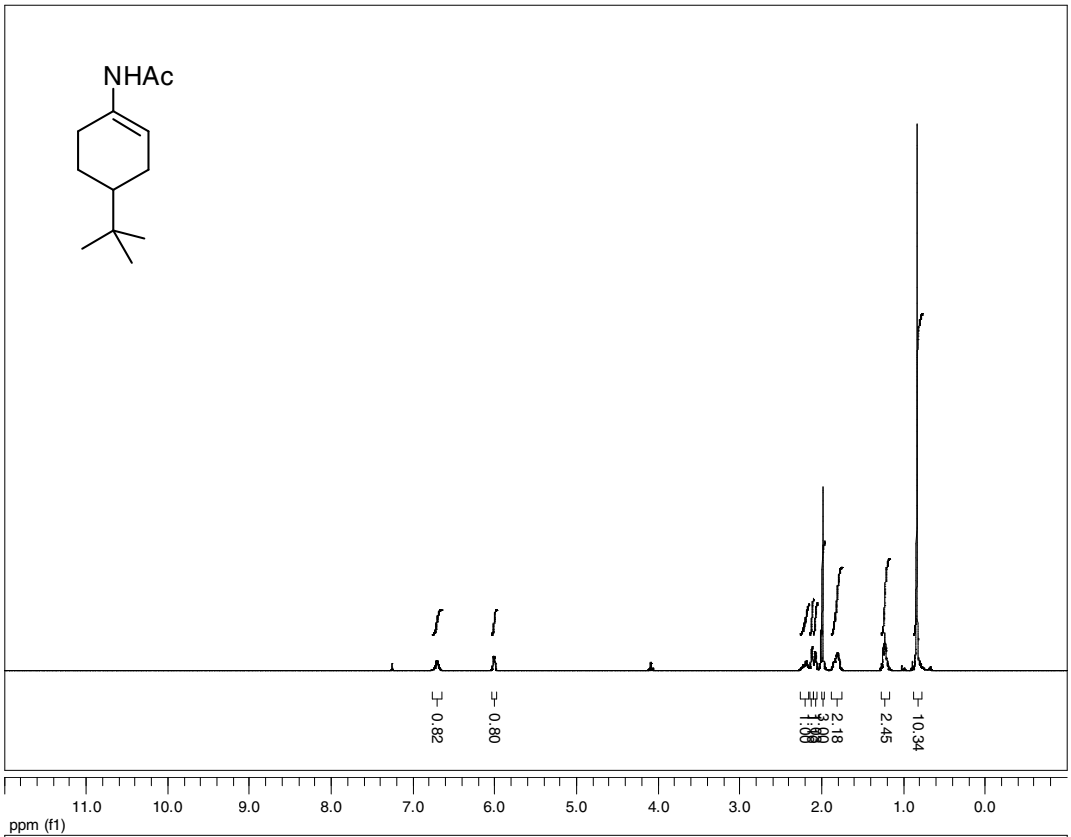

164.760
149.773
137.537
131.356
128.035
126.838
122.342
49.786
49.574
49.361
49.276
49.148
49.000
48.935
48.854
48.722
48.509
29.365
26.860
N
OH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)

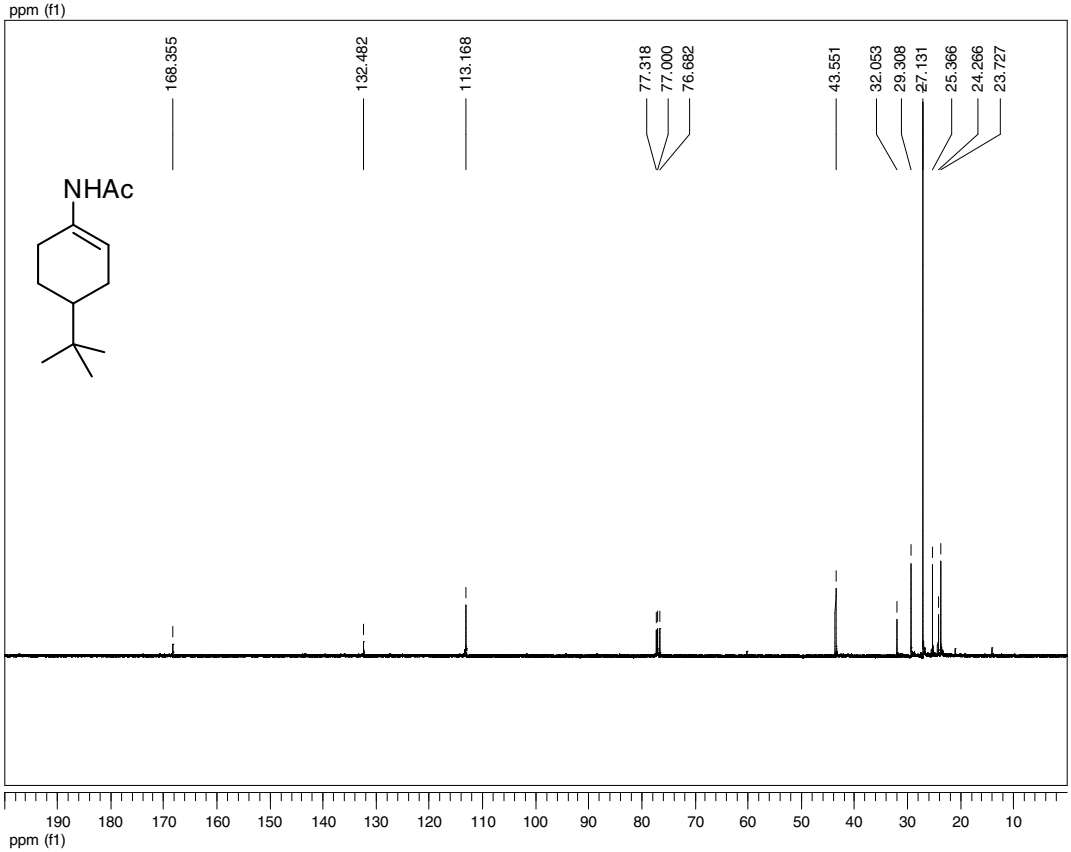

O
HN
0.90
2.04
0.87
2.00
3.03
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
ppm (f1)

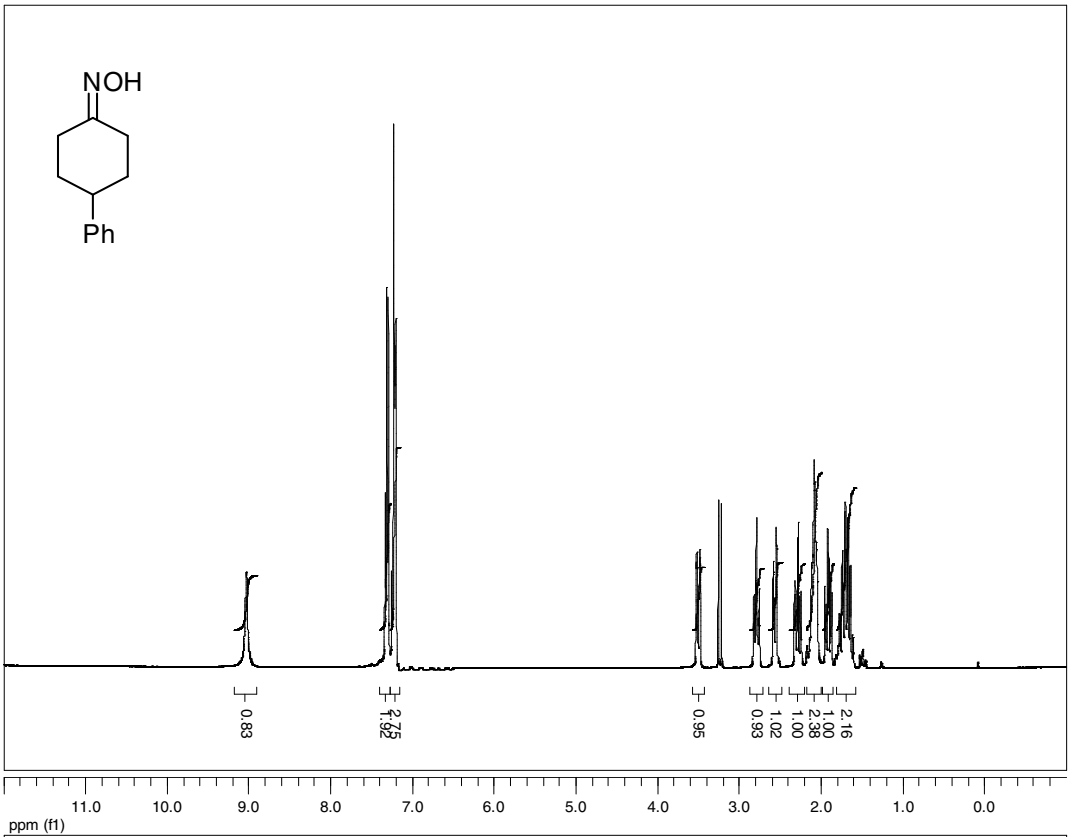

169.281
142.893
139.912
135.749
126.069
125.491
124.321
116.605
116.031
77.540
77.222
76.904
36.676
24.233
O
HN
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

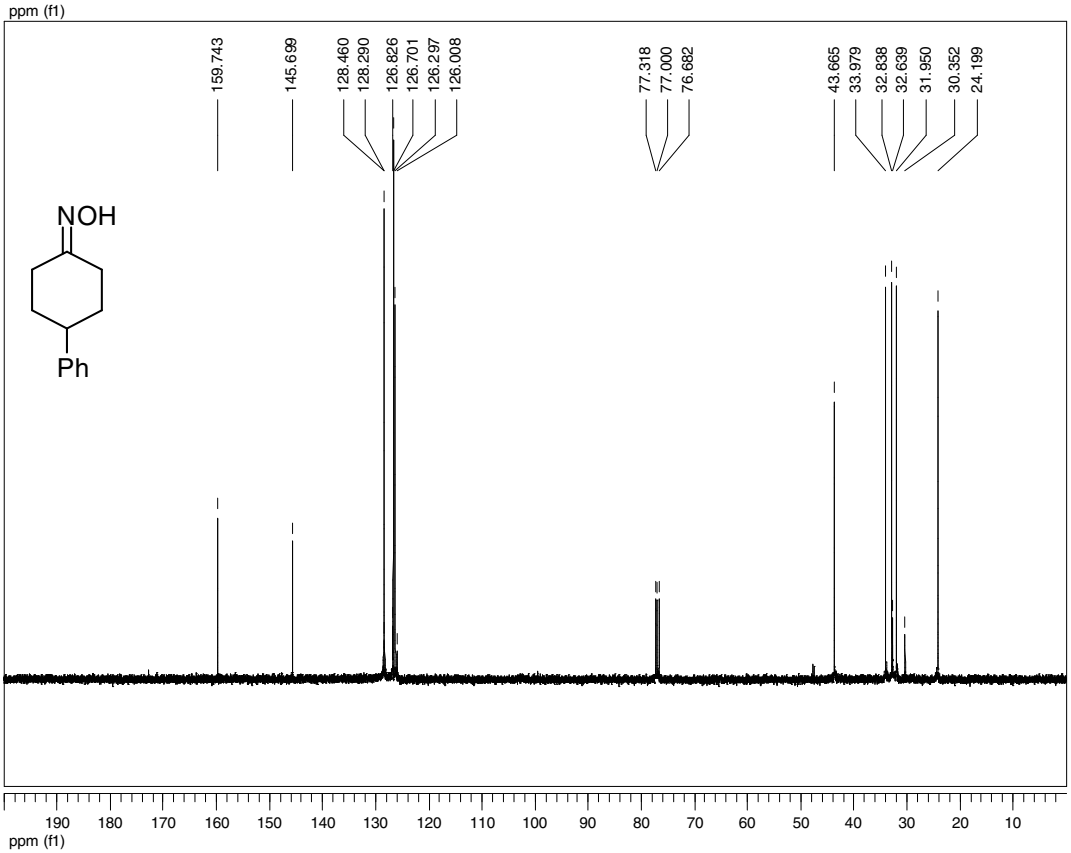

NOH
0.69
1.00
1.00
2.01
1.07
1.00
3.14
9.53
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

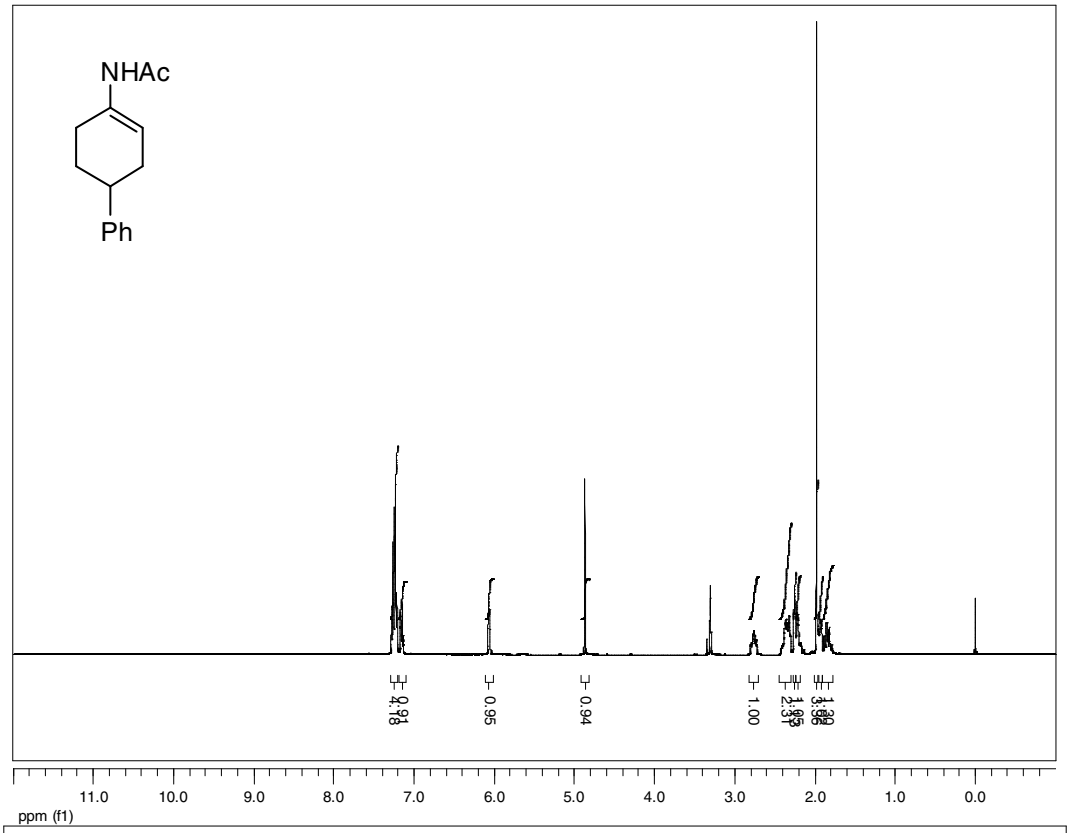

160.762
77.318
77.000
76.683
47.440
32.431
31.885
27.617
27.506
26.261
24.276
NOH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

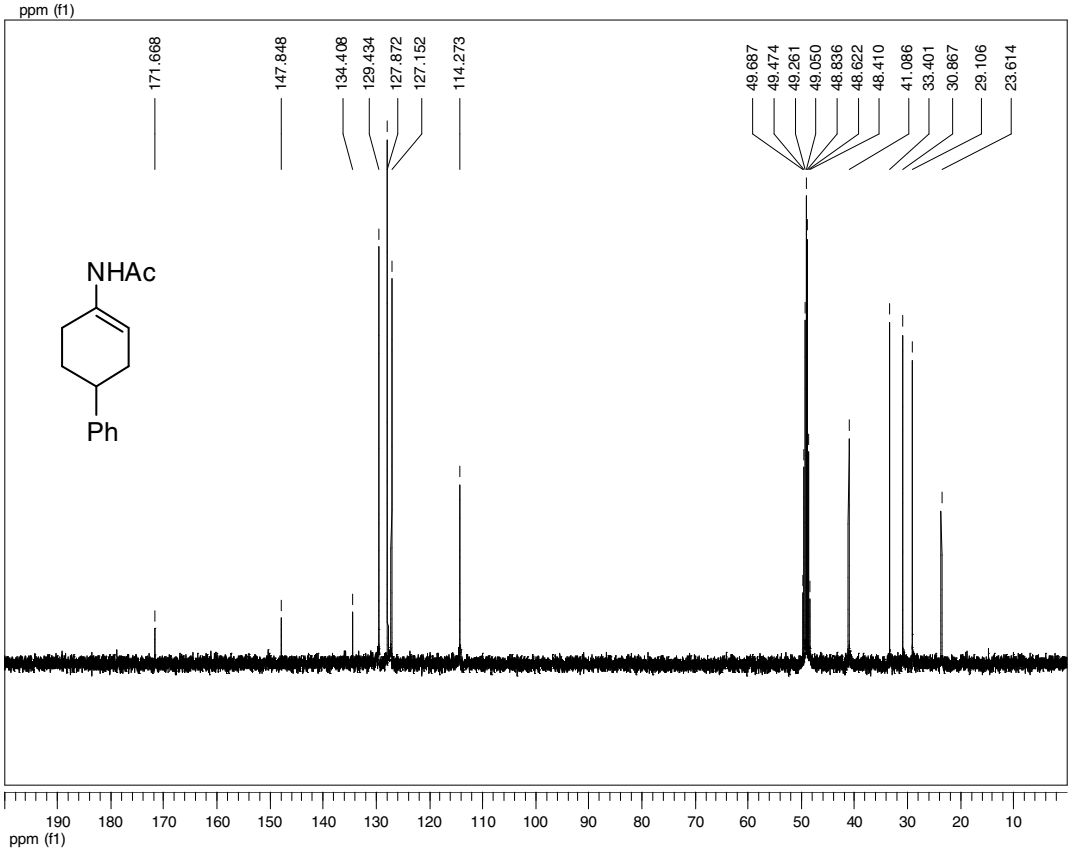

NHAc
0.82
0.80
2.18
1.00
2.45
10.34
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

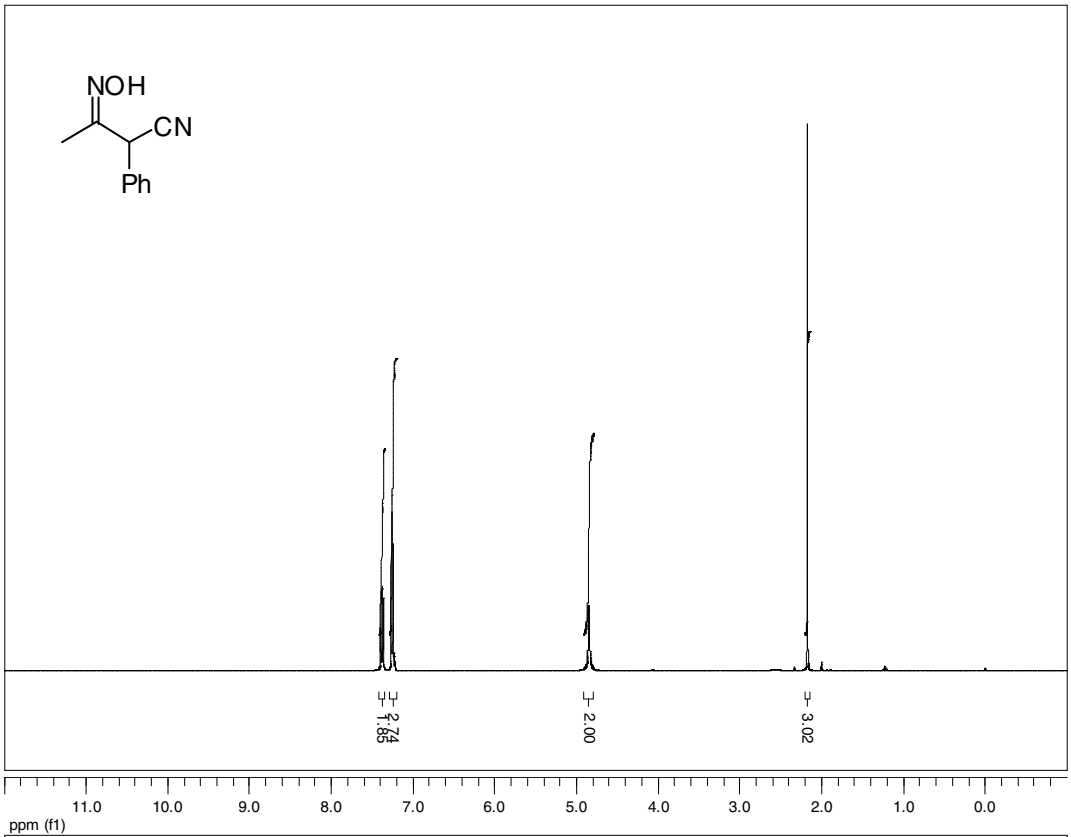

168.355
132.482
113.168
77.318
77.000
76.682
43.551
32.053
29.308
27.131
25.366
24.266
23.727
NHAc
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

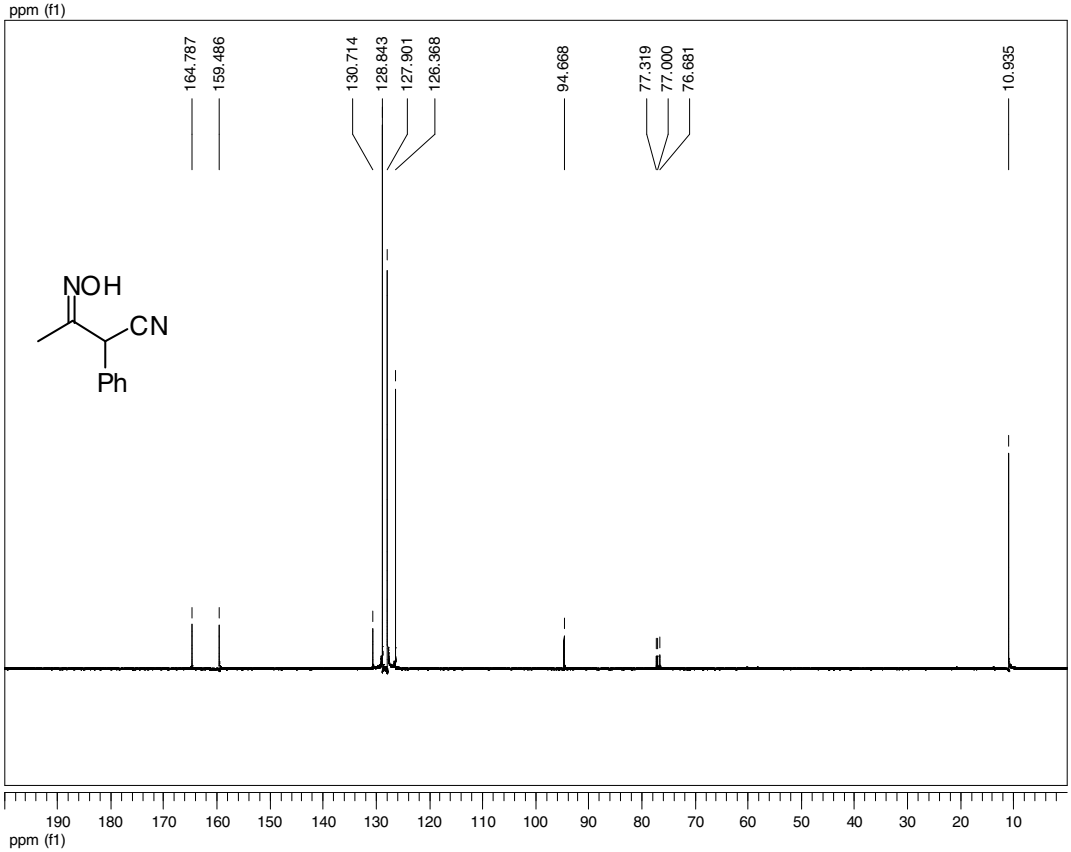

NOH
Ph
0.83
2.75
1.62
0.95
0.93
1.02
1.00
2.38
1.00
2.16
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

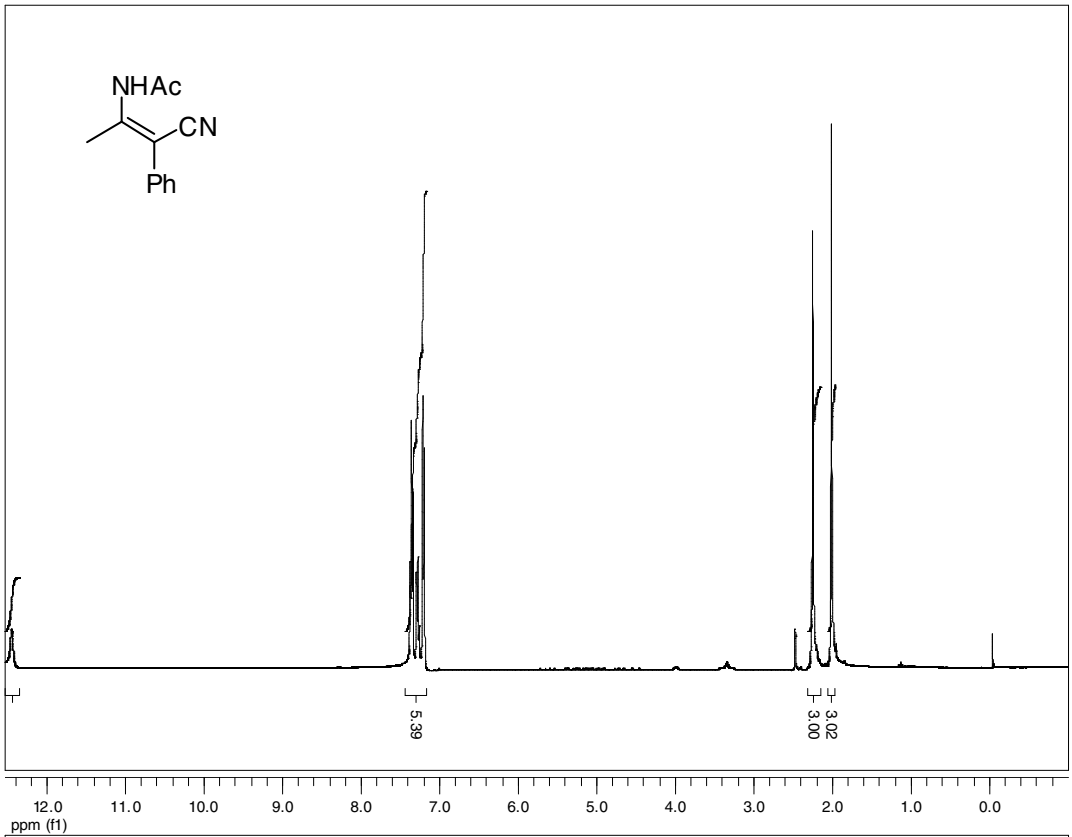

159.743
145.699
128.460
128.290
126.826
126.701
126.297
126.008
77.318
77.000
76.682
43.665
33.979
32.838
32.639
31.950
30.352
24.199
NOH
Ph
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

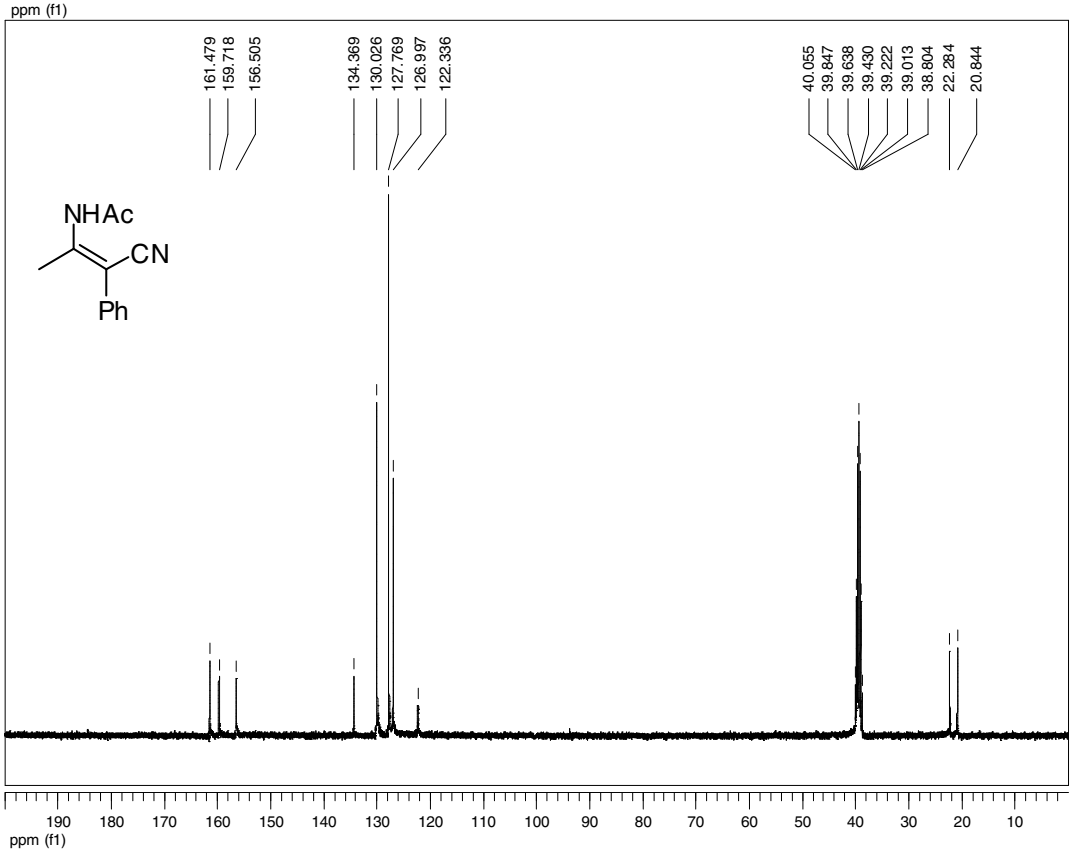

NHAc
Ph
0.81
0.95
0.94
1.00
2.37
ppm (f1)

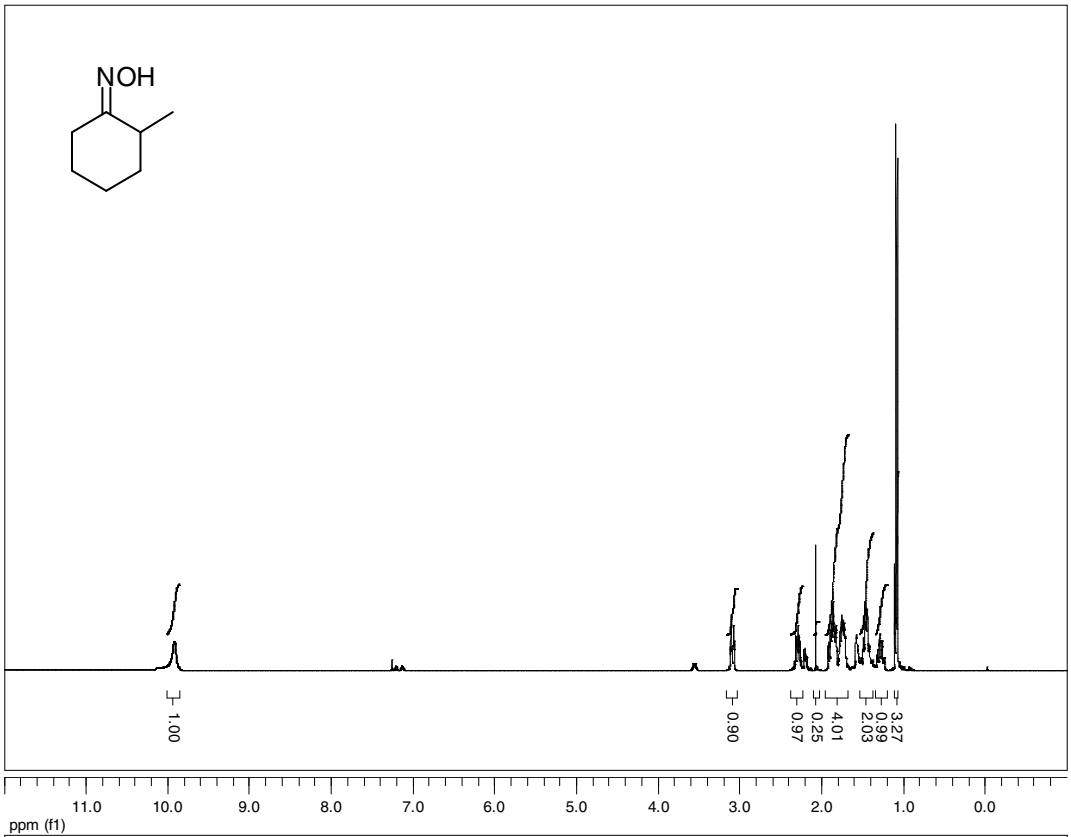

171.668
147.848
134.408
129.434
127.872
127.152
114.273
49.687
49.474
49.261
49.050
48.836
48.622
48.410
41.086
33.401
30.867
29.106
23.614
NHAc
Ph
ppm (f1)

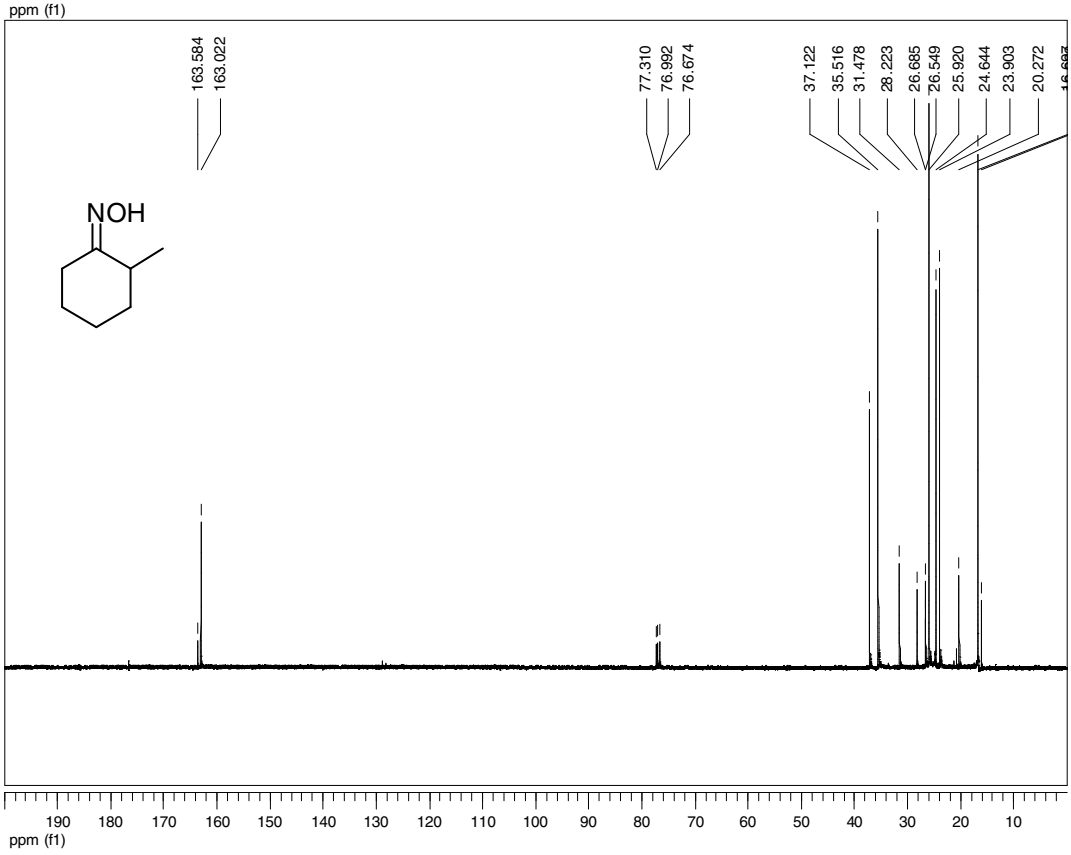

NOH
CN
Ph
1.85
2.74
2.00
3.02
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

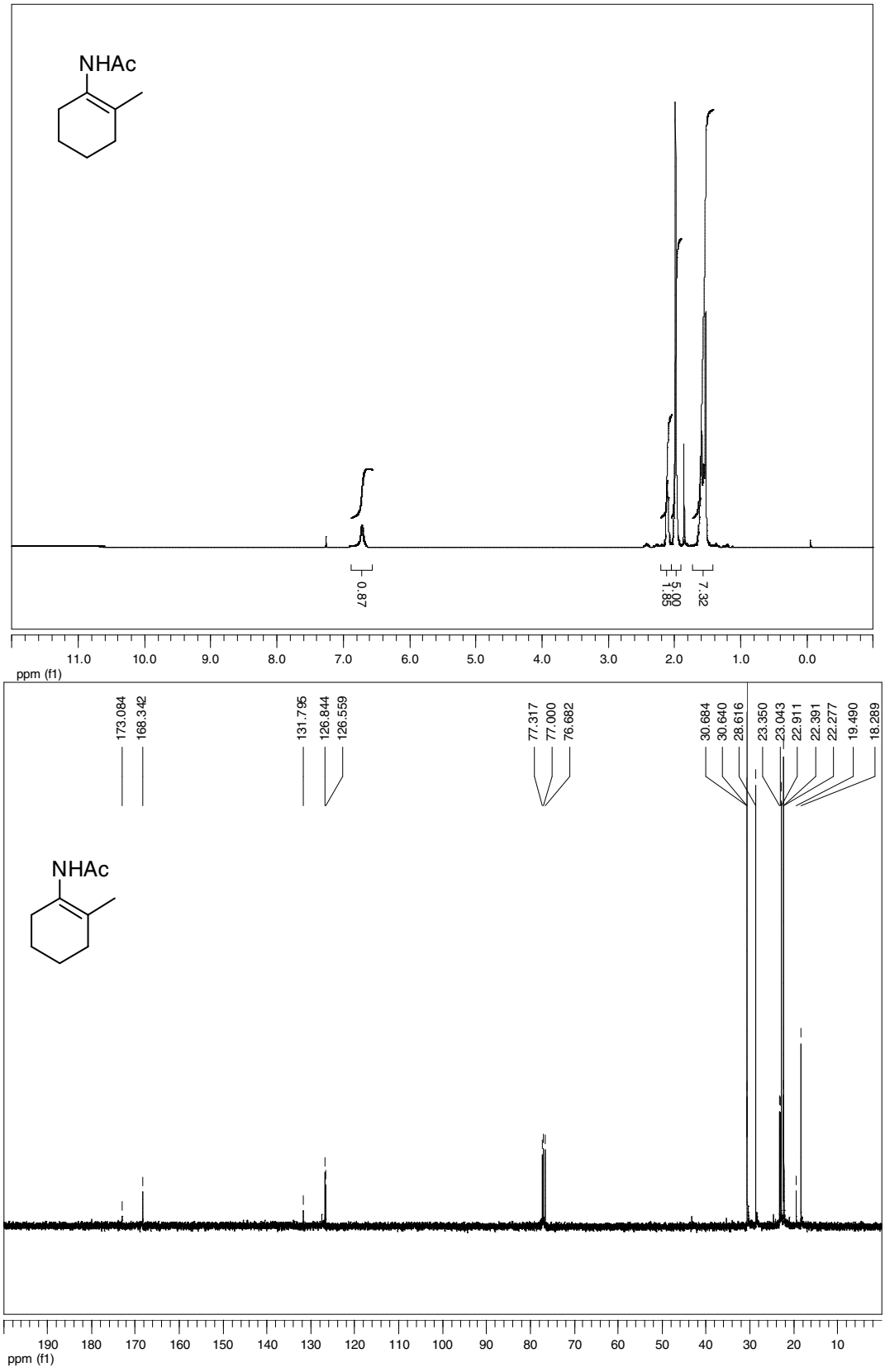

164.787
159.486
130.714
128.843
127.901
126.368
94.668
77.319
77.000
76.681
10.935
NOH
CN
Ph
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

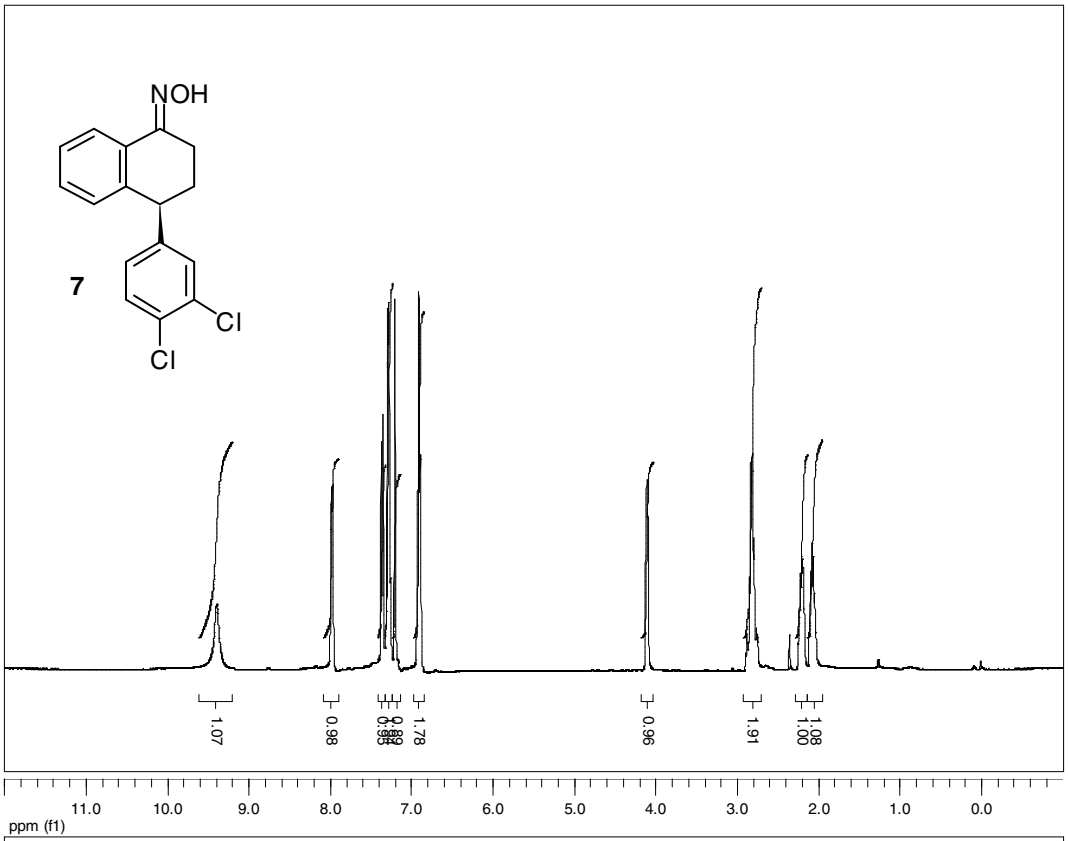

NHAc
CN
Ph
5.39
3.00
3.02
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)

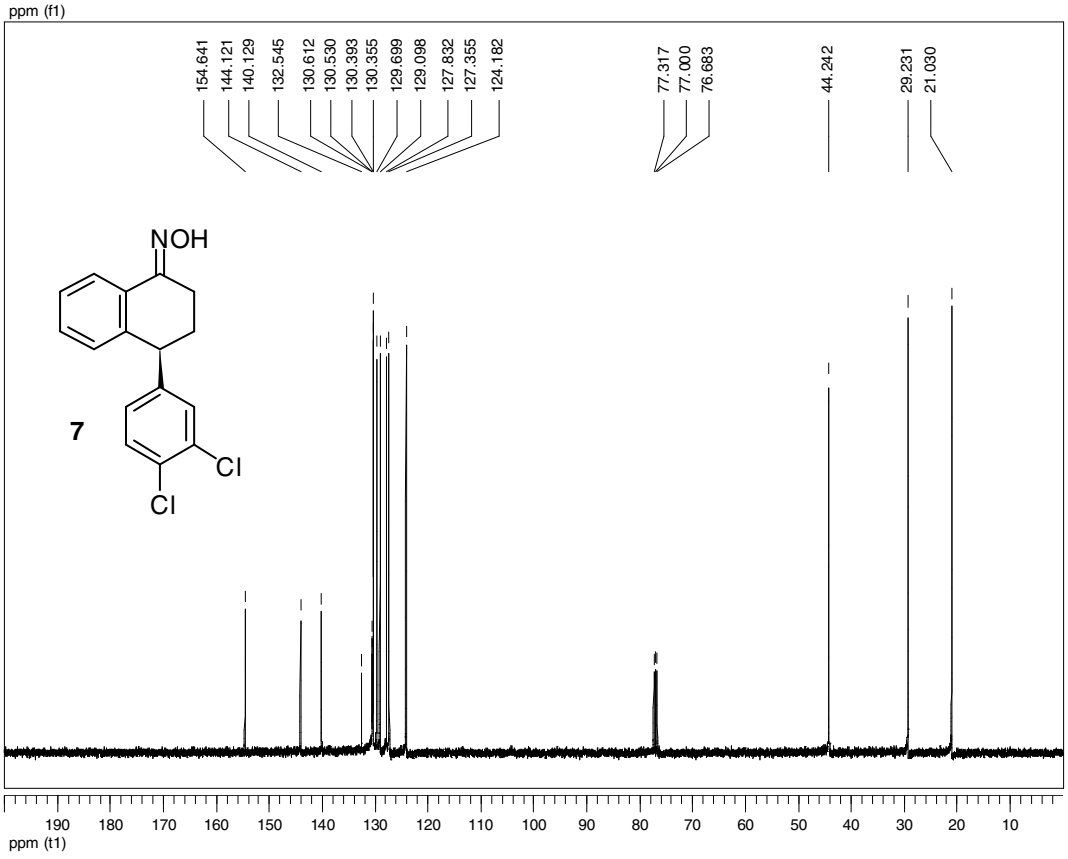

161.479
159.718
156.505
134.369
130.026
127.769
126.997
122.336
40.055
39.847
39.638
39.430
39.222
39.013
38.804
22.284
20.844
NHAc
CN
Ph
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)

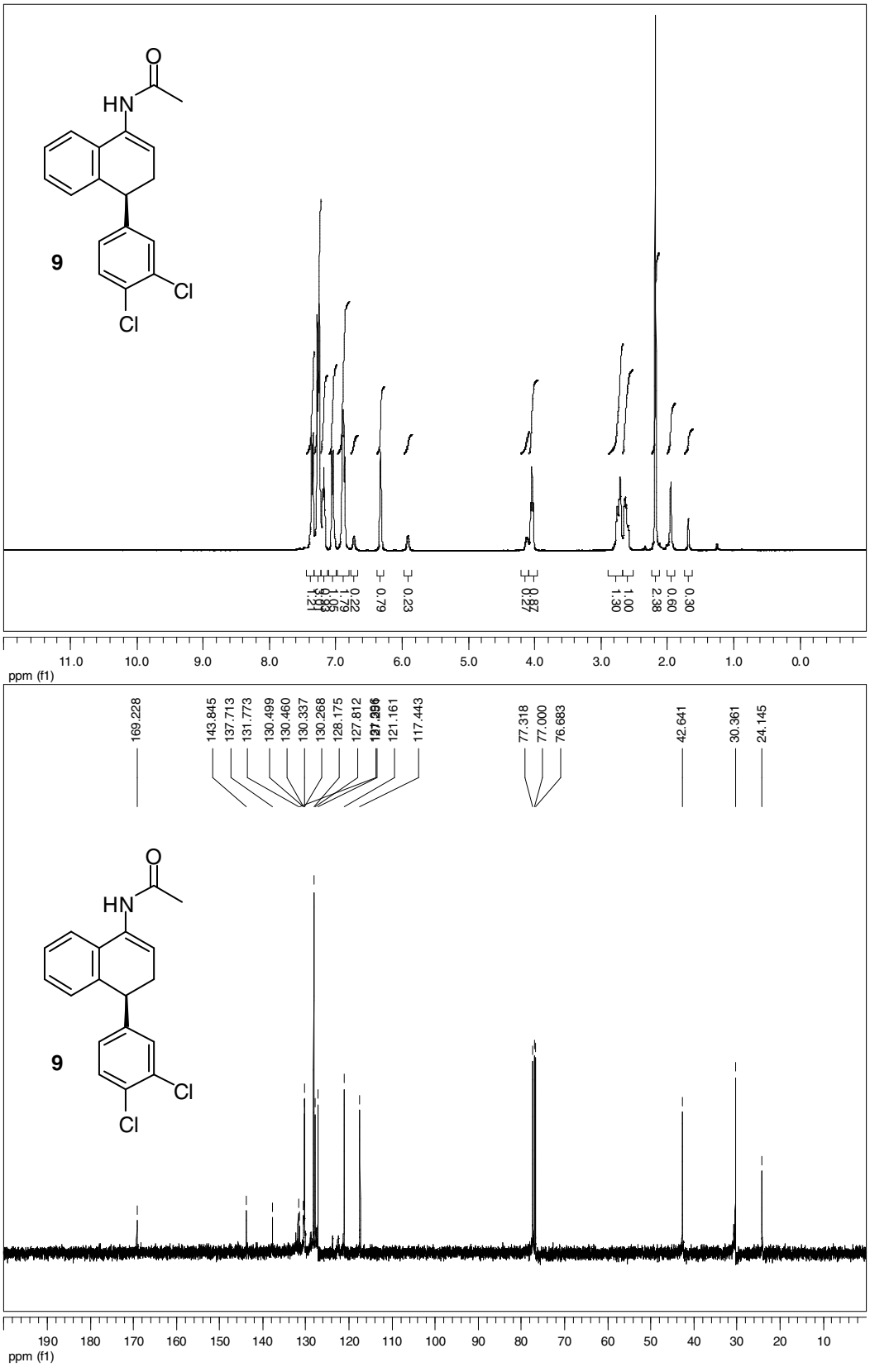

NOH
1.00
0.90
0.97
0.25
4.01
2.03
0.99
3.27
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)


163.584
163.022
77.310
76.992
76.674
37.122
35.516
31.478
28.223
26.685
26.549
25.920
24.644
23.903
20.272
NOH
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)


NHAc
0.87
1.00
5.85
7.32
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)
173.084
168.342
131.795
126.844
126.559
77.317
77.000
76.682
30.684
30.640
28.616
23.350
23.043
22.911
22.391
22.277
19.490
18.289
NHAc
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)


NOH
7
Cl
Cl
1.07
0.98
1.78
0.96
1.91
1.00
1.08
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)


154.641
144.121
140.129
132.545
130.612
130.530
130.393
130.355
129.699
129.098
127.832
127.355
124.182
77.317
77.000
76.683
44.242
29.231
21.030
NOH
7
Cl
Cl
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (t1)


O
HN
9
Cl
Cl
1.21
1.05
1.05
1.19
1.22
0.79
0.23
0.87
1.00
1.30
2.38
0.90
0.30
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (f1)
169.228
143.845
137.713
131.773
130.499
130.460
130.337
130.268
128.175
127.812
121.161
117.443
77.318
77.000
76.683
42.641
30.361
24.145
O
HN
9
Cl
Cl
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm (f1)