Supporting Information For: A General and Efficient Catalyst System for the Wacker Oxidation Using TBHP as the Terminal Oxidant

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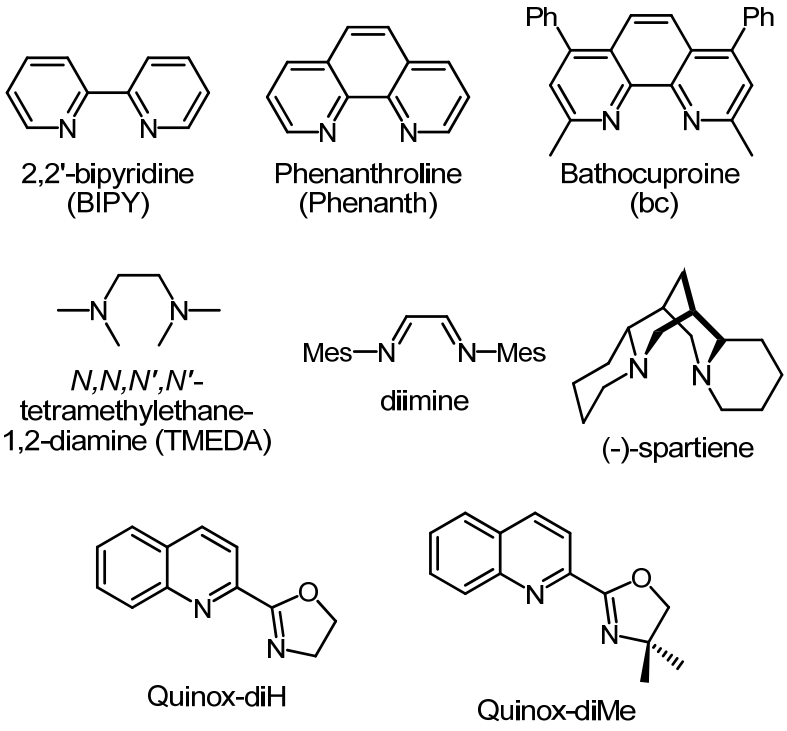
Table of Contents

General Considerations:

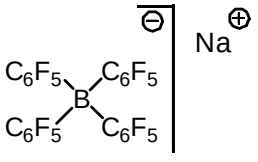
Dichloromethane (DCM), 1,2-dichloroethane (DCE), and triethylamine (TEA) were distilled from CaH_2 for ligand and substrate synthesis. Unless otherwise noted all chemicals were purchased from Aldrich or Acros and used without further purification. Acetic anhydride was purchased from Malincrodt and used without further purification. *All silver salts were stored in a nitrogen filled glove box and protected from light*. (S)-1-octen-3-ol was purchased from Fluka and used without further purification. Quinaldic Acid was purchased from AK scientific and used without further purification. 4-N,N-dimethylaminopyridine (DMAP) was recrystallized from toluene[1] and Tosylchloride (TsCl) was recrystallized from chloroform and petroleum ether prior to use.[2] Ethanolamine was fractionally distilled immediately prior to use. 4-Methyl styrene and *m*-Nitro styrene were passed through a plug of activated alumina immediately prior to use. Analytical thin layer chromatography was performed with Whatman K6F Silica 60 Å plates. Flash Chromatography was performed using Dynamic Adsorbents Inc. flash silica gel 32-63u. All NMR were taken on one of the following instruments: Inova 500 MHz (TRIAX probe), Varian 500 MHz, or Unity 300 MHz and referenced to the residual solvent peak from $CHCl_3$ at 7.27 ppm. All melting points are uncorrected and recorded on Thomas Hoover Unimelt capillary melting point apparatus. Elemental Analysis obtained through Columbia Analytical Services. FT-IR spectra were obtained on a Thermo Nicolet 380 FT-IR. HRMS were obtained with either an ESI or APCI source on a Waters LCT Premier XE. GC conversions were determined relative to an internal standard. ALTHOUGH NO PROBLEMS OCCURRED DURING THESE STUDIES, HIGHLY CONCENTRATED SOLUTIONS OF TBHP IN THE PRESENCE OF TRANSITION METALS CAN BE DANGEROUS.

Procedure for evaluation of solvent and bidentate ligands (Figure 2): The full range of ligands evaluated is shown below, along with their abbreviations as they may appear in figure 2. Standard solutions of 1-octen-3-yl acetate were made so that 240 μL of the respective solvent (DCE, DCM, Methanol, or DMA) would deliver 0.1 mmol along with ~10 wt% of dodecane as an internal standard. Standard solutions were also made of ligands which were viscous or that 0.006 mmol would be too small to accurately weigh. A standard solution of $Pd(CH_3CN)_2Cl_2$ was made so that 0.005 mmol would be added to each vial. To each 2 mL brown glass reaction vial was weighed $AgBF_4$ (2.3 mg, 0.012 mmol) in the dark and ligand (0.006 mmol, if standard solution then added as a specific volume). To vials with ligand weighed directly into them was added solvent of the same amount as was used for ligand standard solutions. A micro stir bar was added to each vial and the mixture was stirred. A specified amount of the $Pd(CH_3CN)_2Cl_2$ standard solution was added to each vial. The mixture was stirred for ~10 min before 70 wt% $TBHP_{(aq)}$ (1.5 mmol, 215 μL) was added to each vial. Finally the substrate was added to the vials as a specified volume, which brought the reaction mixtures to 0.1M. Aliquots (~50 μL) of the reaction mixture were taken periodically, passed through a small silica pipette with ethyl acetate, and analyzed for conversion and product formation by gas chromatography. The conversions and products were calculated relative to the dodecane internal standard. Pyridine was also evaluated as a ligand in DCM at 12 mol% relative to $Pd(CH_3CN)_2Cl_2$.



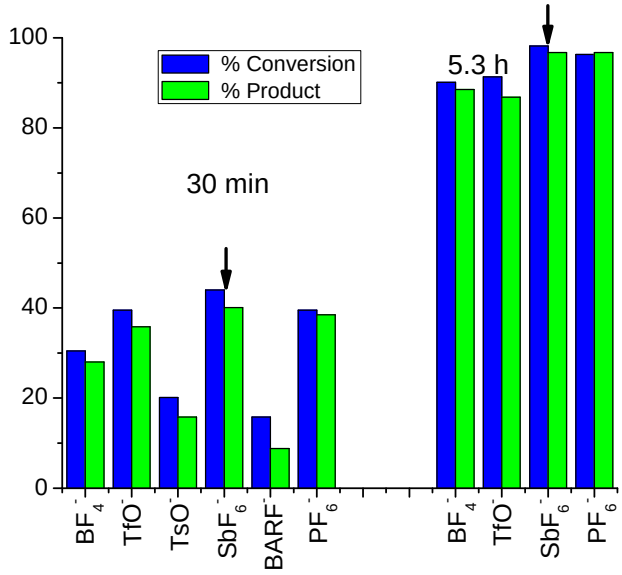
Counter ion screen:

The silver salts of the counter ions evaluated, of the form $Ag^+ X^-$ (0.012 mmol) (except $BARF^-$ which was in the form of the sodium salt) were weighed into 2 mL brown vials followed by a standard solution made so that quinox ligand (0.001 mmol) and Pd(quinox)Cl_2 (0.005 mmol) were added in a specified volume of solution. The mixtures were stirred for ~10 min, before 70 wt% $TBHP_{(aq)}$ (1.3



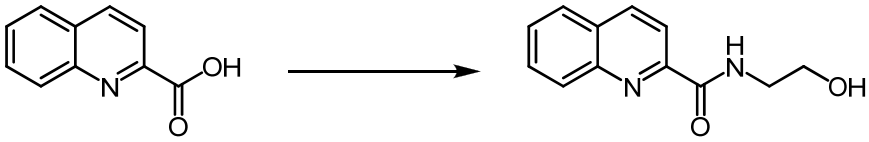
NaBARF

mmol, 186 μL) was added to the vials. A standard solution was made so a specified volume would add substrate (0.1 mmol) and ~10 wt% dodecane as an internal standard to the vials and bring the reaction mixture to 0.1M. Alliquots (~50 μL) of the reaction mixture were taken periodically, run through a small silica pipette with ethyl acetate, and analyzed for conversion and product formation by gas chromatography.



Note: It was found that the less coordinating SbF_6^- counterion led to the most rapid and selective conversion of olefin. PF_6^- was nearly as good, however had slightly less selectivity for methyl ketone formation and is more expensive than SbF_6^-. OTf^- and BF_4^- counterions led to a slower reaction, although good selectivity was still observed. Selectivity was measured as % product/ % conversion.

Synthesis of Quinox (Quinox-diH) and Quinox-diMe ligands:
N-(2-hydroxyethyl)quinoline-2-carboxamide



To an oven dried 250 mL round bottomed flask was weighed quinaldic acid (1.734g, 10.0 mmol). A magnetic stir bar was added and the flask was put under N_2 atmosphere. The flask was charged with DCM (100 mL) and cooled to 0 °C in an ice bath. The flask was then charged with N-methyl morpholine (1.44 mL, 15.0 mmol) and *iso*butylchloroformate (1.51 mL, 11.5 mmol) via syringe addition. The reaction was allowed to stir at 0 °C for 20 min until the solution became cloudy. At which point freshly distilled ethanolamine (695 uL, 11.5 mmol) was added slowly to the flask via syringe. The reaction mixture was allowed to slowly warm to room temperature. The reaction mixture was quenched, after stirring for 2 h at room temperature, with saturated sodium bicarbonate solution (80 mL) and transferred to a separatory funnel with DCM (2 × 15 mL). The layers were separated, and the aqueous layer was back extracted with DCM (2 × 30 mL). The combined organic phases were washed with water (1 × 70 mL), which was back extracted with DCM (2 × 25 mL). The combined organic phases were washed with brine (1 × 100 mL), which was back extracted with DCM (1 ×25 mL). Combined organic phases were

dried over sodium sulfate, filtered and concentrated under reduced pressure. The resulting mixture was purified by flash chromatography using a mixed solvent system: 70 % EtOAc, 19 % DCM, 10 % Hexanes, and 1 % MeOH. The product was isolated (1.95 g, 90% yield) as a colorless solid by recrystallizing by slow evaporation of DCM.

R_f = 0.21 in above solvent system, UV.

M.P = 107 – 109 °C.

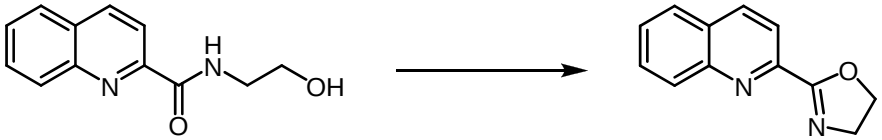
^{1}H NMR (500 MHz (VXR), $CDCl_3$): δ 3.04 (br s, 1H), 3.73 (dd, *J* = 5.4 , 10.4 Hz, 2H), 3.92 (dd, *J* = 5.4, 10.4 Hz, 2H), 7.61 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.76 (dd, *J* = 7.3, 8.1 Hz, 1H), 7.86 (d, *J* = 8.1 Hz, 1H), 8.08 (d, *J* = 8.1 Hz, 1H), 8.28 (s, 2H), 8.65 (br s, 1H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$): δ 42.9, 62.8, 119.0, 127.9, 128.2, 129.5, 129.9, 130.4, 137.8, 146.7, 149.6, 165.9.

IR: 3364 (s, br), 3336 (s, br), 3060 (w), 2944 (m), 2923 (m), 2871 (m), 1640 (s), 1589 (m), 1520 (s), 1498 (s), 1423 (s), 1070 (m), 1055 (m), 850 (s), 776 (s) cm^{-1}.

HRMS: m/z (ESI/APCI) calculated [MH^+] 217.0977, observed 217.0982.

Quinoline-2-oxazoline



N-(2-hydroxyethyl)quinoline-2-carboxamide was dissolved in DCE (40 mL) in an oven dried 100 mL pear bottomed flask. To a 250 mL 3 necked round bottomed flask was fitted a water condenser, and a magnetic stir bar was added. *p*-Toluene sulfonyl chloride (2.2288 g, 11.65 mmol) and N, N-dimethylaminopyridine (95.4 mg, 0.78 mmol) were added to the reaction flask. The flask was placed under N_2 atmosphere. DCE (30 mL) was added to the reaction flask and cooled to -5 °C. The reaction flask was charged with triethylamine (5.50 mL, 39 mmol). The reaction mixture was stirred for 10 min. The solution of amide in DCE was slowly cannulated into the reaction vessel over the course of 20 min. The pear bottomed flask was rinsed with DCE (15 mL), which was also cannulated to the reaction mixture. The reaction mixture was stirred at -5 °C for 5 min and then allowed to slowly warm to room temperature. The reaction was monitored by TLC until all of the amide had been consumed, which took ~2 h. The reaction mixture was then heated to reflux in an 85 °C oil bath for 3 h. The reaction mixture was then cooled to room temperature and quenched with saturated sodium bicarbonate solution (80 mL). The mixture was transferred to a separatory funnel, diluted with DCM (120 mL) and saturated sodium bicarbonate (70 mL). The layers were separated and the aqueous layer was back extracted with DCM (50 mL). The combined organic phases were washed with water (2 × 100 mL), which were each back extracted with DCM (50 mL). The combined organic phases were washed with brine (1 × 150 mL), and then dried over sodium sulfate, filtered and concentrated under reduced pressure. The resulting mixture

was purified by flash chromatography using 2% methanol in DCM. The product was isolated as a white solid (1.10 g, 71% yield).

R_f : 0.17 (70 % EtOAc, 19 % DCM, 10 % hexanes, 1 % MeOH), UV.

M.P. = 109 – 110 °C

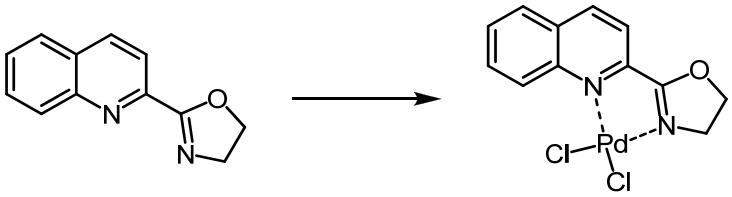
^{1}H NMR (300 MHz (Unity), $CDCl_3$): δ 4.21 (ddd, *J* = 0.5, 9.4, 9.7 Hz, 2H), 4.63 (ddd, *J* = 0.8, 9.6, 9.9 Hz, 2H), 7.62 (ddd, *J* = 1.3, 7.0, 8.2 Hz, 1H), 7.77 (ddd, *J* = 1.5, 6.9, 8.4 Hz, 1H), 7.87 (dd, *J* = 1.5, 8.2 Hz, 1H), 8.18 (d, *J* = 8.6 Hz, 1H), 8.26 (dd, *J* = 0.9, 7.9 Hz, 1H), 8.28 (ddm, *J* = 0.7, 8.4 Hz, 1H).

^{13}C NMR: (75 MHz (Unity), $CDCl_3$): δ 55.4, 68.7, 120.9, 127.8, 128.2, 129.0, 130.3, 130.6, 137.0, 147.0, 147.8, 164.4 ppm.

IR: 2980 (w), 2952 (w), 2937 (w), 2909 (w), 2882 (w), 1632 (m), 1593 (m), 1556 (m), 1370 (m), 1120 (m), 1080 (s), 837 (s), 736 (s) cm^{-1}.

HRMS: m/z (ESI/APCI) calculated [MH^+] 199.0871, observed 199.0871.

Pd(quinox)Cl_2:



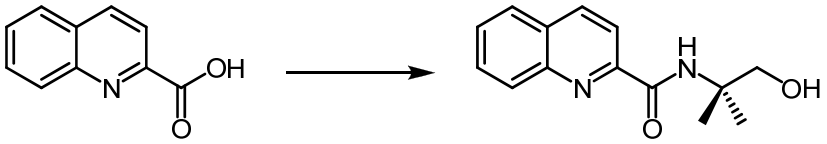
Quinoline-2-oxazoline (695.6 mg, 3.51 mmol) was weighed into an oven dried 100 mL round bottomed flask. A magnetic stir bar was added and the reaction was placed under N_2 atmosphere. DCE (30 mL) was added to the reaction flask and stirred until quinox was completely dissolved. $Pd(CH_3CN)_2Cl_2$ (880.3 mg, 3.39 mmol) was added to the reaction flask. The reaction mixture was allowed to stir for 16 h. A precipitate formed and was filtered off using a Buchner funnel. The Pd(quinox)Cl_2 complex was isolated (1.24 g, 99% yield) as an orange powder. *Pd(Quinox)Cl_2 is completely insoluble in ALL common NMR solvents and the reaction becomes homogeneously upon treatment with aqueous TBHP.*

M.P. = 285 °C (decomposition temp).

IR: 3076 (w), 3024 (w), 3020 (w), 2974 (w), 2944 (w), 1674 (m), 1619 (w), 1593 (m), 1529 (m), 1483 (m), 1464 (w), 1275 (m), 1182 (m), 1122 (m), 926 (m), 851 (m), 759 (s), 755 (s) cm^{-1}.

Elemental Analysis: Predicted: C, 38.38; H, 2.68; N, 7.46; Found: C, 38.62; H, 2.84; N, 7.40.

***N*-(1-hydroxy-2-methylpropan-2-yl)quinoline-2-carboxamide**



To an oven dried 250 mL round bottomed flask was weighed quinaldic acid (866 mg, 5.0 mmol). A magnetic stir bar was added and the flask was put under N_2 atmosphere. The flask was charged with DCM (50 mL) and cooled to 0 °C in an ice bath. The flask was charged with N-methyl morpholine (720 µL, 7.5 mmol) and *iso*butlychloroformate (752 µL, 5.75 mmol) via syringe addition. The reaction was allowed to stir at 0 °C for 10 min until the solution became cloudy. At which point 2-methyl-2-aminopropanol (550 uL, 5.75 mmol) was added slowly to the flask via syringe. The reaction mixture was allowed to slowly warm to room temperature. The reaction was quenched after 2 h with 1M HCl solution (30 mL) and transferred to a separatory funnel with DCM (50 mL). The layers were partitioned and the organic phase was washed with H_2O (2 × 30 mL) and brine (1 × 40 mL). After drying over Na_2SO_4 and filtration, the mixture was concentrated under reduced pressure. The crude mixture was purified by flash chromatography eluting with a 1:1 mixture of EtOAc and hexanes to afford *N*-(1-hydroxy-2-methylpropan-2-yl)quinoline-2-carboxamide as a colorless oil in 91% yield (1.112 g, 4.55 mmol);

R_f = 0.20 (50% EtOAc in Hexanes), UV.

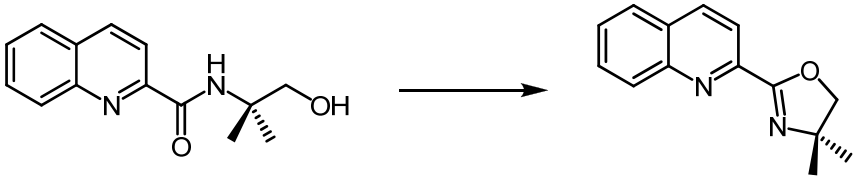
IR(neat): 3357 (br), 3061 (w), 2970 (m), 2929 (m), 2872 (w), 1657 (s), 1526 (s), 1499 (s), 1059 (s), 845 (m), 771 (s) cm^{-1}.

^1H NMR (500 MHz (VXR), $CDCl_3$) δ 1.51 (s, 6H), 3.79 (d, *J* = 5.5 Hz, 2H), 5.00 (t, *J* = 5.9 Hz, 1H), 7.64 (dd, *J* = 6.8, 7.8 Hz, 1H), 7.79 (dd, *J* = 6.8, 8.8 Hz, 1H), 7.89 (d, *J* = 7.8 Hz,1H), 8.13 (d, *J* = 7.8 Hz, 1H), 8.30 (dd, *J* = 8.8, 11.7 Hz, 1H), 8.33 (dd, *J* = 7.8, 11.7 Hz, 1H), 8.44 (s, 1H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 25.2, 56.4, 71.0, 118.7, 127.9, 128.2, 129.5, 129.8, 130.4, 137.9, 146.5, 149.7, 165.0.

HRMS: m/z (ESI/APCI) calculated [MH^+] 245.1290, observed 245.1295.

4,4-dimethyl-2-(quinoline-2-yl)-oxazoline



To an oven dried 250 mL round bottomed flask was weighed *p*-Toluene sulfonyl chloride (1.049 g, 5.5 mmol) and N, N-dimethylaminopyridine (39.1 mg, 0.32 mmol). A magnetic stirbar was added and the flask was placed under N_2 atmosphere. The flask was charged with DCE (20 mL) and triethylamine (3.2 mL, 23 mmol). The *N*-(1-hydroxy-2-methylpropan-2-yl)quinoline-2-carboxamide (1.112 g, 4.55 mmol) was dissolved in DCE (15 mL) and added to the flask dropwise via syringe. The reaction mixture was stirred at 0 °C for 15 min, before a reflux condenser was fitted to the flask and heated to reflux for 16 h. The reaction mixture was cooled to room temperature, transferred to a separatory funnel and diluted with DCM (70 mL). The organic phase was washed with saturated $NaHCO_3$ solution (2 × 70 mL), H_2O

(2 × 70 mL), and Brine (1 × 70 mL). Dried over Na_2SO_4, filtered and concentrated under reduced pressure. The crude mixture was purified by flash chromatography eluting with 20% → 30% acetone in hexanes to afford 4,4-dimethyl-2-(quinoline-2-yl)-oxazoline in 47% yield (484 mg, 2.14 mmol).

R_f = 0.13 (50% EtOAc in Hexanes), UV.

IR(neat): 3060 (w), 2965 (m), 2927 (w), 2892 (w), 1638 (s), 1361 (s), 1077 (s), 971 (s), 838 (s), 762 (s) cm^{-1}.

^1H NMR (500 MHz (VXR), $CDCl_3$) δ 1.47 (s, 6H), 4.30 (s, 2H), 7.62 (dd, *J* = 6.8, 6.8 Hz, 1H), 7.77 (ddd, *J* = 2.0, 6.8, 8.8 Hz, 1H), 7.86 (d, *J* = 7.8 Hz, 1H), 8.19 (d, *J* = 8.8 Hz, 1H), 8.25 (d, *J* = 7.8 Hz, 1H), 8.29 (d, *J* = 8.8 Hz, 1H).

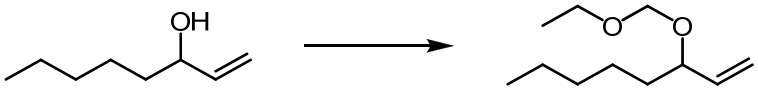
^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 28.7, 68.4, 80.1, 121.0, 127.7, 128.1, 128.9, 130.2, 130.6, 136.9, 147.3, 147.8, 161.7.

HRMS: m/z (ESI/APCI) calculated [MH^+] 227.1184, observed 227.1189.

Preparation of Substrates:

Oct-1-en-3-yl acetate,[3] *tert*-butyldimethyl(oct-1-en-3-yloxy)silane,[3] 4-(*tert*-butyldimethylsiloxy)-4-phenylbutan-2-one,[4] 10-undecenoic acid methyl ester,[5] 4-hex-5-enyl-2,2-dimethyl-[1,3]dioxolane,[6] 11-choroundec-1-ene,[7] and *tert*-butyl 4-vinylphenylcarbamate[8] were prepared following literature procedures and purity confirmed via ^1H NMR. Adamantyl ethylene was prepared following the literature procedure and purity was confirmed by ^1H NMR.[9] Enantiomerically enriched oct-1-en-3-yl acetate was prepared from the purchased enantiomerically enriched alcohol and was protected by the same procedure as the racemate. Retention of enantiomeric excess was confirmed by chiral phase column gas chromatography. Enantiomerically enriched 1-phenylbut-3-en-1-ol was synthesized using the literature method and enantiomeric excess was confirmed using the HPLC method from the same report.[10]

3-(ethoxymethoxy)oct-1-ene:



To a flame dried 250 mL round bottomed flask containing a stirbar and under N_2 atmosphere, was combined 1-octen-3-ol (3.08 mL, 20 mmol), DIPEA (84 mL, 40 mmol), and DCM (40 mL). Next (chloromethoxy)ethane (2.23 mL, 24 mmol) was added via syringe. The reaction mixture was heated to reflux for 12 h and then cooled to room temperature. TLC indicated complete consumption of the starting material, and the reaction was quenched with saturated aqueous Na_2SO_4 solution (50 mL). The reaction mixture was transferred to a separatory funnel with ether. The phases were partitioned and the organic layer was washed with brine. The aqueous layer was back-extracted with DCM. The combined organic layers were dried over Na_2SO_4, filtered and concentrated under reduced pressure. The resulting mixture was purified by flash chromatography using 2.5% ether in hexanes to give 3-(ethoxymethoxy)oct-1-ene as a colorless oil (3.5 g, 95% yield).

R_f = 0.55 (25% ether in hexanes), $KMnO_4$ stain.

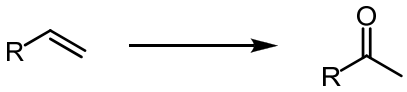
IR(neat): 3079 (w), 2956 (m), 2931 (s), 2874 (m), 1467 (w), 1390 (w), 1096 (s), 1032(s), 992 (s), 924 (s)

^{1}H NMR (500 MHz (VXR), $CDCl_3$) δ 0.83 (t, *J* = 6.8 Hz, 3H), 1.22 (t, *J* = 6.8 Hz, 3H), 1.26-1.64 (m, 6H), 3.49-3.55 (m, 1H), 3.68-3.75 (m, 1H), 4.00 (q, *J* = 6.9 Hz, 1H), 4.63 (d, *J* = 6.8 Hz, 1H), 4.72 (d, *J* = 6.8 Hz, 1H), 5.18 (dd, *J* = 9.8, 15.6 Hz, 2H), 5.63-5.70 (m, 1H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 14.3, 15.3, 22.9, 25.3, 32.0, 35.6, 63.5, 77.7, 92.5, 117.1, 138.8.

HRMS: m/z (ESI/APCI) calculated [MNa^+] 209.1517, observed 209.1524.

General TBHP mediated Wacker reaction (Table 1):



In the dark, $AgSbF_6$ (51.5 mg, 0.15 mmol), Pd(quinox)Cl_2 complex (22.5 mg, 0.06 mmol), and a magnetic stir bar were added to a 100 mL round bottomed flask. DCM (4.8 mL) was added to the flask and the mixture was stirred for 15 min. The mixture was then diluted with DCM (20 mL) and 70 wt% $TBHP_{(aq)}$ (5.2 mL, 36 mmol) was added. The resulting mixture was stirred for an additional 10 min, before being cooled in an ice bath. Once the solution had cooled, the substrate (3.0 mmol) was added with stirring. After 5 min, the ice bath was removed and the reaction mixture was allowed to slowly warm to room temperature. Once TLC indicated complete consumption of starting material, the reaction was quenched with a saturated aqueous solution of Na_2SO_3 (50 mL) to consume excess TBHP. The mixture was transferred to a separatory funnel and diluted with hexanes (50 mL). The aqueous layer was separated and back extracted with hexanes (25 mL). The combined organics were washed with water (4 × 25 mL) and brine (50 mL). The combined organic phases were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude material was purified by silica gel flash chromatography if necessary; the product containing fractions were combined and concentrated under reduced pressure.

Modifications:

- Table 1, entry 1, reaction started at room temperature.
- Table 1, entry 2, 15 mol% $AgSbF_6$ used.
- Table 1, entry 3, 1 mmol scale in a 25 mL round bottomed flask.
- Table 1, entry 4, reaction started at room temperature.
- Table 1, entry 5, 1 mmol scale in a 25 mL round bottomed flask.
- Table 1, entry 7, 4 equivalents of TBHP used.
- Table 1, entry 9, 20 mmol scale in a 250 mL round bottomed flask, 1% catalyst and 0.2 M.
- Table 1, entry 12, 1 mmol scale in a 25 mL round bottomed flask.
- Table 1, entry 14, 1 mmol scale in a 25 mL round bottomed flask.
- Table 1, entry 15, 1 mmol scale in a 25 mL round bottomed flask.

Product Purification/Characterization data:

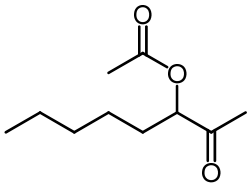


Table 1, entry 1 (2-oxooctan-3-yl acetate). The general procedure was used for 1-octen-3-yl acetate, with the modification that the substrate was added to the reaction vessel at room temperature. The reactions were performed with 513 mg (3.01 mmol) and 510 mg (3.00 mmol) of 1-octen-3-yl acetate respectively. Purified by flash chromatography eluting with 20% Et_2O in hexanes to afford 2-oxooctan-3-yl acetate as a colorless oil in 89% yield (506 mg and 483 mg). The ^1H and ^{13}C spectra, see below, were compared with previously reported spectra.[11]

R_f = 0.24 (20% Et_2O in hexanes), $KMnO_4$ stain.

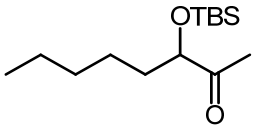


Table 1, entry 2 (3-(*tert*-butyldimethylsiloxy)octan-2-one). The general procedure was used for *tert*-butyldimethyl(oct-1-en-3-yloxy)silane, with the modification that 15 mol% $AgSbF_6$ was used. The reactions were performed with 722 mg (2.98 mmol) and 724 mg (2.99 mmol) of *tert*-butyldimethyl(oct-1-en-3-yloxy)silane respectively. Purified by flash chromatography eluting with 3% Et_2O in hexanes to afford 3-(*tert*-butyldimethylsiloxy)octan-2-one as a colorless oil in 77% yield (608 mg and 576 mg). The ^1H and ^{13}C spectra, see below, were compared with previously reported spectra.[12]

R_f = 0.52 (10% Et_2O in hexanes), $KMnO_4$ stain.

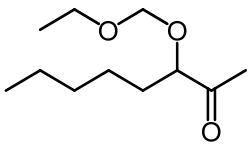


Table 1, entry 3 (3-(ethoxymethoxy)octan-2-one). The general procedure was used for 3-(ethoxymethoxy)-oct-1-ene, with the modification that the reaction was performed on ~1 mmol scale in a 25 mL round bottomed flask. The reactions were performed with 195 mg (1.05 mmol) and 187 mg (1.00 mmol) of 3-(ethoxymethoxy)-oct-1-ene respectively. Purified by flash chromatography eluting with 15% Et_2O in hexanes to afford 3-(ethoxymethoxy)octan-2-one as a colorless oil in 81% yield (162 mg and 172 mg).

R_f = 0.27 (25% Et_2O in hexanes), $KMnO_4$ stain.

IR(neat): 2955 (m), 2931 (m), 2873 (m), 1715 (s), 1352 (m), 1097 (m), 1027 (s), 846 (w) cm^{-1}.

^1H NMR (500 MHz (VXR), $CDCl_3$) δ 0.88 (t, J = 6.8 Hz, 3H), 1.19 (t, J = 7.8 Hz, 3H), 1.23-1.43 (m, 6H), 1.61-1.70 (m, 2H), 2.17 (s, 3H), 3.56-3.66 (m, 2H), 3.99 (dd, J = 5.9, 7.8 Hz, 1H), 4.69 (dd, J = 6.8, 7.8 Hz, 2H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 14.2, 15.2, 22.7, 25.0, 26.2, 31.8, 32.1, 64.2, 82.9, 95.1, 210.3.

HRMS: m/z (ESI/APCI) calculated [MNa^+] 225.1467, observed 225.1468.

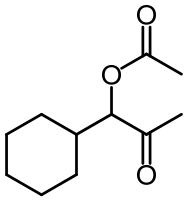


Table 1, entry 4 (1-cyclohexyl-2-oxopropyl acetate). The general procedure was used for 1-cyclohexylallyl acetate, with the modification that the substrate was added to the reaction vessel at room temperature. The reactions were performed with 553 mg (3.04 mmol) and 544 mg (2.98 mmol) of 1-cyclohexylallyl acetae respectively. Purified by flash chromatography eluting with 15% Et_2O in hexanes to afford 1-cyclohexyl-2-oxopropyl acetate as a colorless oil in 89% yield (563 mg and 501 mg);

R_f = 0.21 (20% Et_2O in hexanes), $KMnO_4$ stain.

IR(neat): 2928 (m), 2854 (m), 1741 (s), 1725 (s), 1370 (m), 1233 (s), 1102 (m) cm^{-1}.

^{1}H NMR (500 MHz (VXR), $CDCl_3$) δ 1.09-1.32 (m, 5H), 1.56-1.90 (m, 6H), 2.14 (s, 3H), 4.83 (d, J = 4.9 Hz, 1H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 20.9, 26.1, 26.1, 26.3, 27.4, 27.5, 29.6, 39.3, 82.8, 170.9, 205.7.

HRMS: m/z (ESI/APCI) calculated [MNa^+] 221.1154, observed 221.1026.

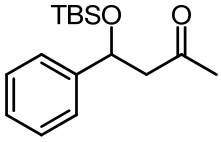


Table 1, entry 5 (4-(*tert*-butyldimethylsolxy)-4-phenylbutan-2-one). The general procedure was used for *tert*-butyldimethyl(1-phenylbut-3-enyloxy)silane, with the modification that the reaction was performed on ~1 mmol scale in a 25 mL round bottomed flask. The reactions were performed with 253 mg (0.96 mmol) and 261 mg (0.99 mmol) of *tert tert*-butyldimethyl(1-phenylbut-3-enyloxy)silane respectively. Purified by flash chromatography eluting with 5% Et_2O in hexanes to afford 4-(*tert*-butyldimethylsolxy)-4-phenylbutan-2-one as a colorless oil in 92% yield (243 mg and 254 mg). The ^{1}H and ^{13}C spectra, see below, were compared with previously reported spectra.[13]

R_f = 0.20 (5% Et_2O in hexanes), UV and $KMnO_4$ stain.

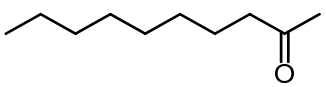


Table 1, entry 6 (2-decanone). The general procedure was used for decene. The reactions were performed with 431 mg (3.08 mmol) and 418 mg (2.98 mmol) of decene respectively. Purified by flash chromatography eluting with 4% Et_2O in hexanes to afford 2-decanone as a colorless oil in 86% yield (416 mg and 390 mg). The ^1H spectrum, see below, was compared with the previously reported spectra.[14]

R_f = 0.23 (5% Et_2O in hexanes), $KMnO_4$ stain.

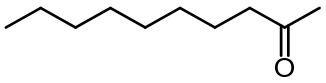


Table 1, entry 7 (2-decanone). The general procedure was used for decene, with the modification that 4 equivilents (1.7 mL, 12 mmol) of TBHP was used. The reactions were performed with 431 mg (3.07 mmol) and 410 mg (2.92 mmol) of decene respectively. Purified by flash chromatography eluting with 4% Et_2O in hexanes to afford 2-decanone as a colorless oil in 75% yield (370 mg and 334 mg). The ^1H spectrum, see below, was compared with the previously reported spectrum.[14]

R_f = 0.23 (5% Et_2O in hexanes), $KMnO_4$ stain.

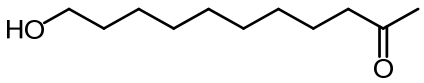


Table 1, entry 8 (11-hydroxyundecan-2-one). The general procedure was used for ω-undecenol. The reactions were performed with 512 mg (3.01 mmol) and 537 mg (3.16 mmol) ω-undecenol respectively. 11-hydroxyundecan-2-one was isolated pure after work up as a white solid in 98% yield (593 mg and 566 mg). The ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[15]

R_f = 0.07 (25% EtOAc in hexanes), $KMnO_4$ stain

MP = 39-40 °C

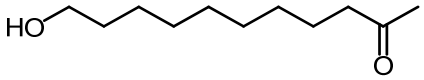


Table 1, entry 9 (11-hydroxyundecan-2-one). The general procedure was used for ω-undecenol, with the modification that the reaction was performed on 20 mmol scale, with 1 mol% catalyst, in a 250 mL round bottomed flask. The reaction was performed with 3.406 g (20 mmol) of ω-undecenol. 11-hydroxyundecan-2-one was isolated pure after work up as a white solid in 91% yield (3.40 g). The ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[15]

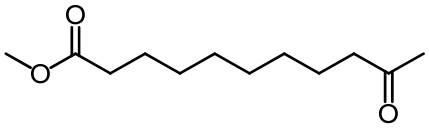


Table 1, entry 11 (methyl 10-oxoundecanoate). The general procedure was used for methyl undec-10-enoate. The reactions were performed with 599 mg (3.02 mmol) and 603 mg (3.04 mmol) methyl undec-10-enoate respectively. The reaction mixture was purified by flash chromatography eluting with 25% Et_2O in hexanes to afford methyl 10-oxoundecanoate as a colorless oil in 87% yield (580 mg and 555 mg). The ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[16]

R_f = 0.16 (25% Et_2O in hexanes), $KMnO_4$ stain.

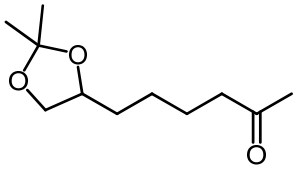


Table 1, entry 12 (6-(2,2-dimethyl-1,3-dioxolan-4-yl)hexan-2-one). The general procedure was used for 4-(hex-5-enyl)-2,2-dimethyl-1,3-dioxolane. The reactions were performed with 547 mg (2.97 mmol) and 550 mg (2.99 mmol) 4-(hex-5-enyl)-2,2-dimethyl-1,3-dioxolane respectively. The reaction mixture was purified by flash chromatography eluting with 25% Et_2O in hexanes to afford 6-(2,2-dimethyl-1,3-dioxolan-4-yl)hexan-2-one as a colorless oil in 95% yield (560 mg and 566 mg). The ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[13]

R_f = 0.13 (20% Et_2O in hexanes), $KMnO_4$ stain.

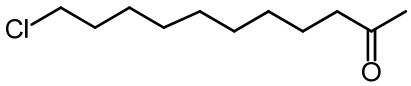


Table 1, entry 13 (11-chloroundecan-2-one). The general procedure was used for 11-chloroundec-1-ene, with the modification that the reaction was performed on ~1 mmol scale in 25 mL round bottomed flask. The reactions were performed with 171 mg (0.90 mmol) and 175 mg (0.93 mmol) 11-chloroundec-1-ene respectively. The reaction mixture was purified by flash chromatography eluting with 8% Et_2O in hexanes to afford 11-chloroundecan-2-one as a colorless oil in 89% yield (170 mg and 163 mg).

R_f = 0.18 (5% Et_2O in hexanes), $KMnO_4$ stain.

IR(neat): 2927 (s), 2854 (m), 1714 (s), 1357 (m), 720 (m), 650 (m) cm^{-1}.

^1H NMR (500 MHz (VXR), $CDCl_3$) δ 1.29-1.32 (m, 8H), 1.38-1.44 (m, 2H), 1.53-1.59 (m, 2H), 1.76 (tt, app. quint, *J* = 6.8, 7.8 Hz, 2H), 2.13 (s, 3H), 2.42 (t, *J* = 7.8 Hz, 2H), 3.53 (t, *J* = 5.9 Hz, 2H).

^{13}C NMR (125 MHz (VXR), $CDCl_3$) δ 24.0, 27.1, 29.0, 29.3, 29.5, 29.5, 30.1, 32.8, 44.0, 45.4, 209.4.

HRMS: m/z (ESI/APCI) calculated [MNa^+] 227.1179, observed 227.1177.

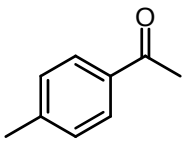


Table 1, entry 14 (1-*p*-tolyethanone). The general procedure was used for 1-methyl-4-vinylbenzene. The reactions were performed with 359 mg (3.04 mmol) and 350 mg (2.96 mmol) 1-methyl-4-vinylbenzene respectively. The reaction mixture was purified by flash chromatography eluting with 20% Et_2O in hexanes to afford 1-*p*-tolyethanone as a colorless oil in 88% yield (356 mg and 349 mg). ^1H NMR spectrum, see below, was compared with the previously reported spectrum.[17]

R_f = 0.40 (5% Et_2O in hexanes), UV and $KMnO_4$ stain.

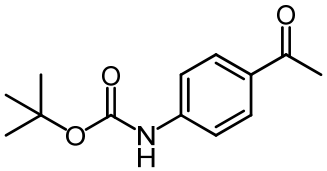


Table 1, entry 15 (*tert*-butyl 4-acetylphenylcarbamate). The general procedure was used for *tert*-butyl 4-vinylphenylcarbamate, with the modification that the reaction was performed on ~1 mmol scale in a 25 mL round bottomed flask. The reactions were performed with 205 mg (0.93 mmol) and 222 mg (1.01 mmol) *tert*-butyl 4-vinylphenylcarbamate respectively. The reaction mixture was purified by flash chromatography eluting with 30% EtOAc in hexanes to afford *tert*-butyl 4-acetylphenylcarbamate as a white solid in 83% yield (188 mg and 191 mg). ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[18]

R_f = 0.29 (30% EtOAc in hexanes), UV and $KMnO_4$ stain.

MP = 113-114 °C

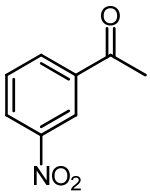


Table 1, entry 16 (1-(3-nitro)ethanone). The general procedure was used for 1-(3-nitro)ethanone, with the modification that the reaction was performed on ~1 mmol scale in a 25 mL round bottomed flask. The reactions were performed with 160 mg (1.07 mmol) and 149 mg (1.00 mmol) 1-(3-nitro)ethanone respectively. The reaction mixture was purified by flash chromatography eluting with 25% EtOAc in hexanes to afford 1-(3-nitro)ethanone as a white solid in 60% yield (103 mg and 100 mg). ^1H and ^{13}C NMR spectra, see below, were compared with the previously reported spectra.[19] It should be noted that a small amount c.a. <5% of inseparable aldehyde was detected in the ^1H NMR spectrum.

R_f = 0.17 (20% EtOAc in hexanes), UV and $KMnO_4$ stain.

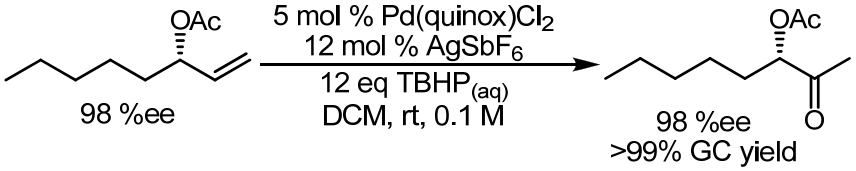
MP = 68-70 °C

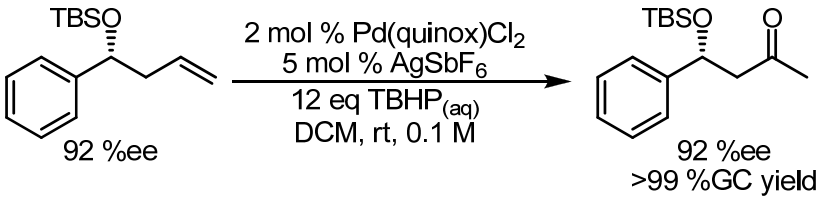
***Footnote 11*: Evaluation of 1-ethenyladamantane:**

To a small 1.5 mL vial was weighed $AgSbF_6$ (3.9 mg, 0.01 mmol) and Pd(Quinox)Cl_2 (1.1 mg, 0.003 mmol). CH_2Cl_2 (64 μL) and a stirbar were added to the vial and the mixture was stirred for 10 min. TBHP (86 μL) was added to the flask and stirred for an additional 10 min. A solution of 1-ethenyladamantane (9.7 mg, 0.05 mmol) and dodecane (~1 mg as an internal standard for GC analysis) was made in CH_2Cl_2 (380 μL). 350 μL of the standard solution was used to add substrate to the reaction mixture while the remaining solution was used as a initial timepoint. A timepoint taken after 15 min

indicated complete consumption of the starting material and a GC yield of 94% (measured relative to the internal standard and corrected for response factor). After 1 h the reaction mixture was worked up in the standard way and the product was isolated to confirm that the product was indeed the methyl ketone. ^{1}H NMR, ^{13}C NMR, and GC-MS analysis all indicate exclusive formation of the methyl ketone in accordance with the published NMR data,[9] with no aldehyde product observed. *Note: Dodecane is observed in the NMR spectra*.

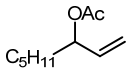
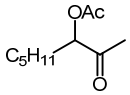
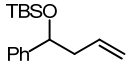
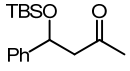
Evaluation of enantiomeric excess retention:





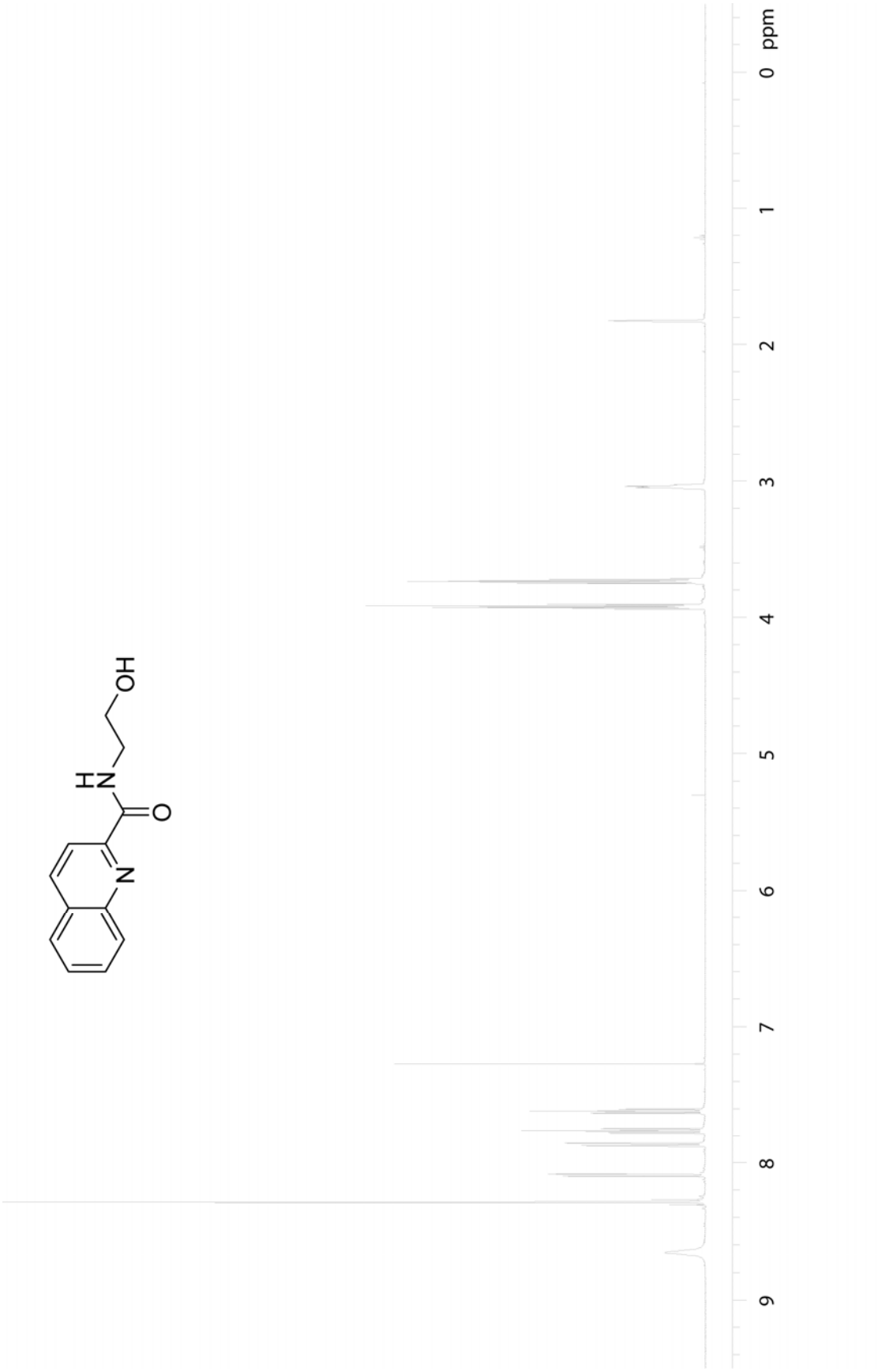
To 2 mL brown screw cap vials was weighed $AgSbF_6$ (0.012 mmol and 0.006 mmol respectively) followed by a specified volume of a $Pd(quinox)Cl_2$ (0.005 mmol and 0.002 mmol respectively) standard solution and the mixtures were stirred for ~15 min. 70 wt% $TBHP_{(aq)}$ (1.2 mmol, 172 μL) was added to the vials and stirred for an additional 10 min, at which time the enantiomerically enriched substrates (0.1 mmol, 98% ee and 92% ee respectively) were added as standard solutions so that the concentration of the reaction would be 0.1 M. Alliquots (~50 μL) of the reaction mixture were taken periodically, run through a small silica pipet with ethyl acetate, and analyzed for conversion, product formation, and enantiomeric excess by chiral phase gas chromatography (see methods below).

Chiral separations:

compound	method	retention times (min)
	hold 100 °C 25 min	6.5 / 6.9
	hold 100 °C 25 min	19.9 / 20.8
	hold 80 °C 150 min	45.1 / 45 .8
	hold 100 °C 150 min	135.2 / 143.0

GC column: HP-Chiral 20% permethylated β-cyclodextrin

^{1}H-, and ^{13}C-NMR spectra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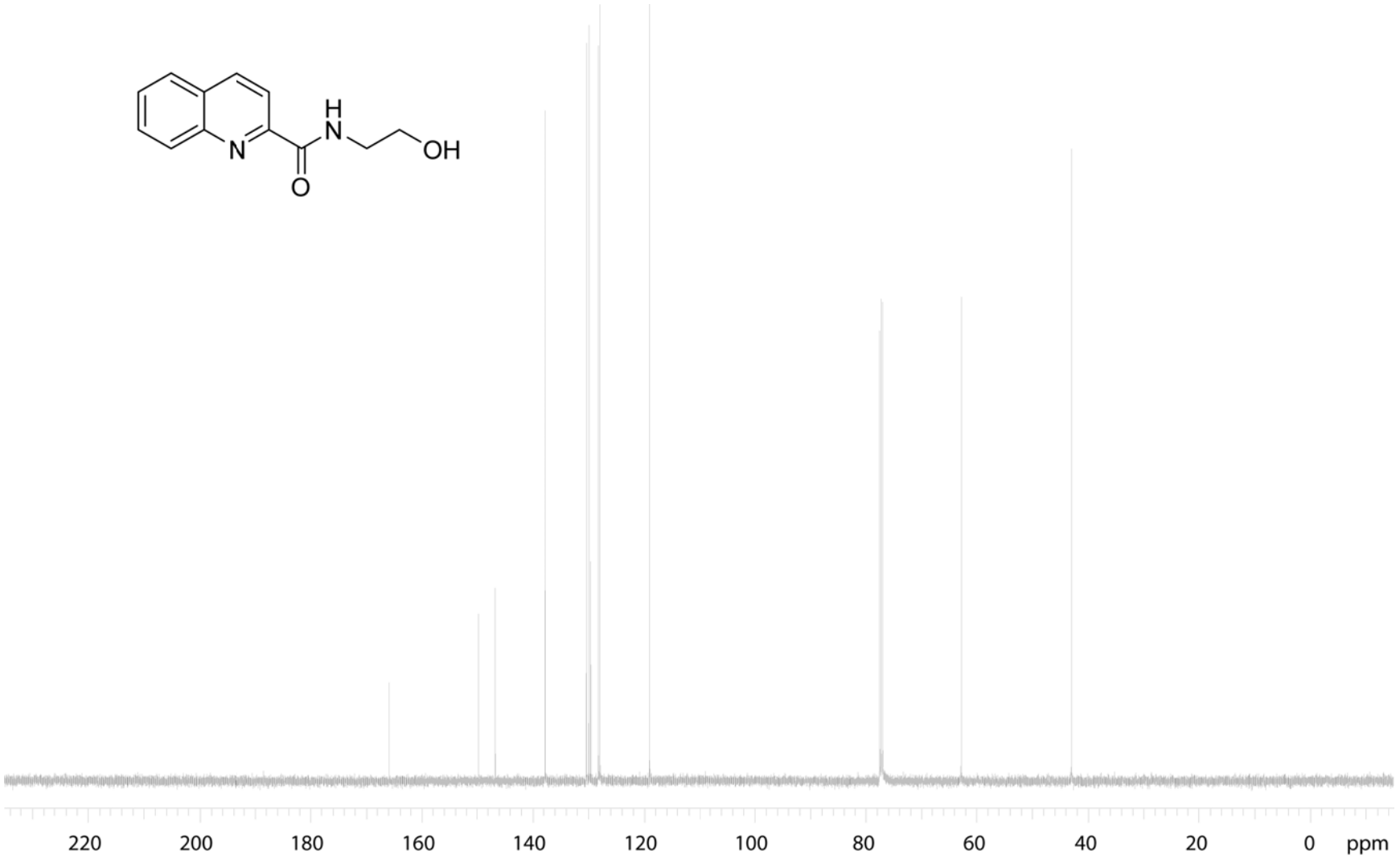
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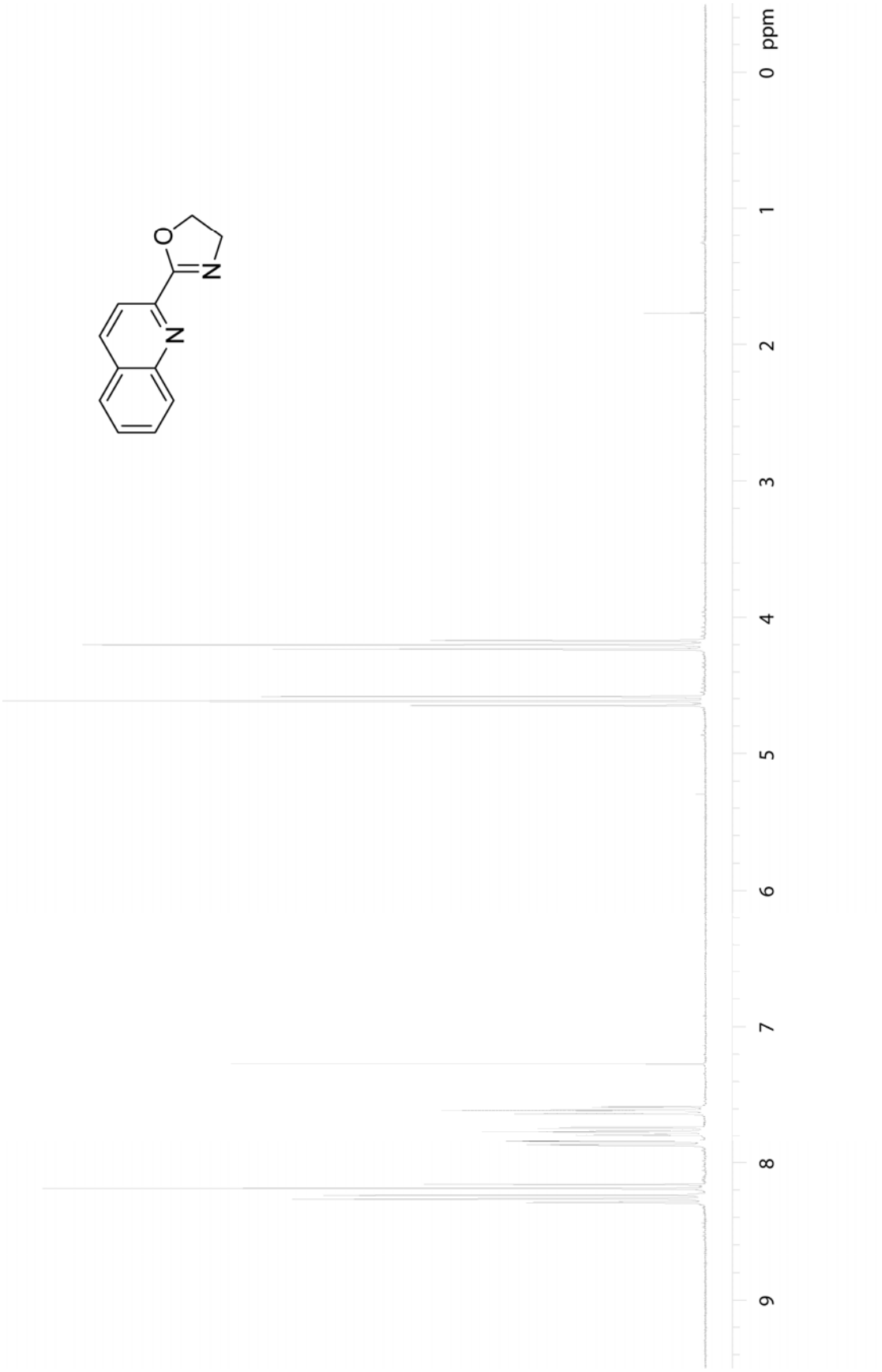
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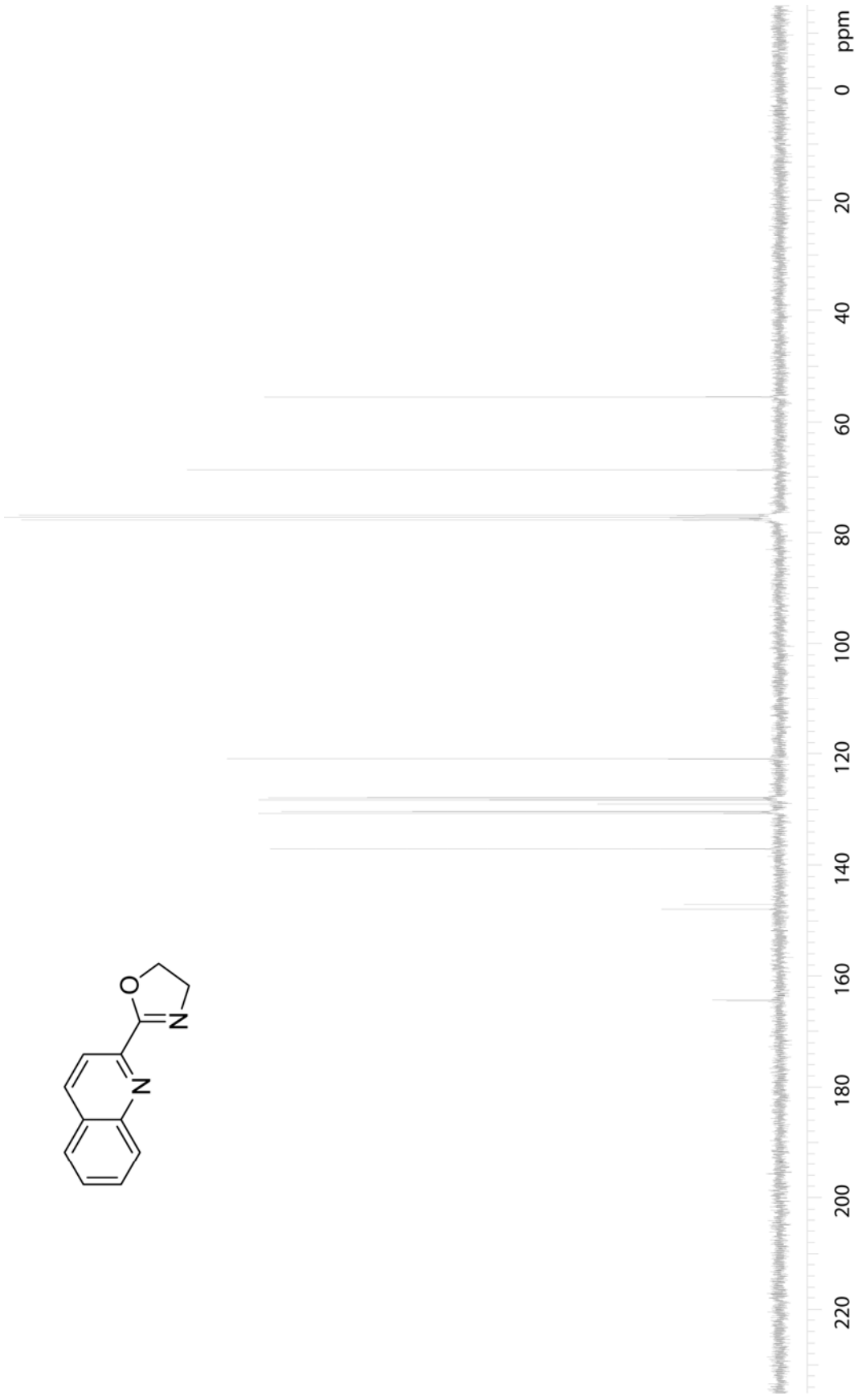
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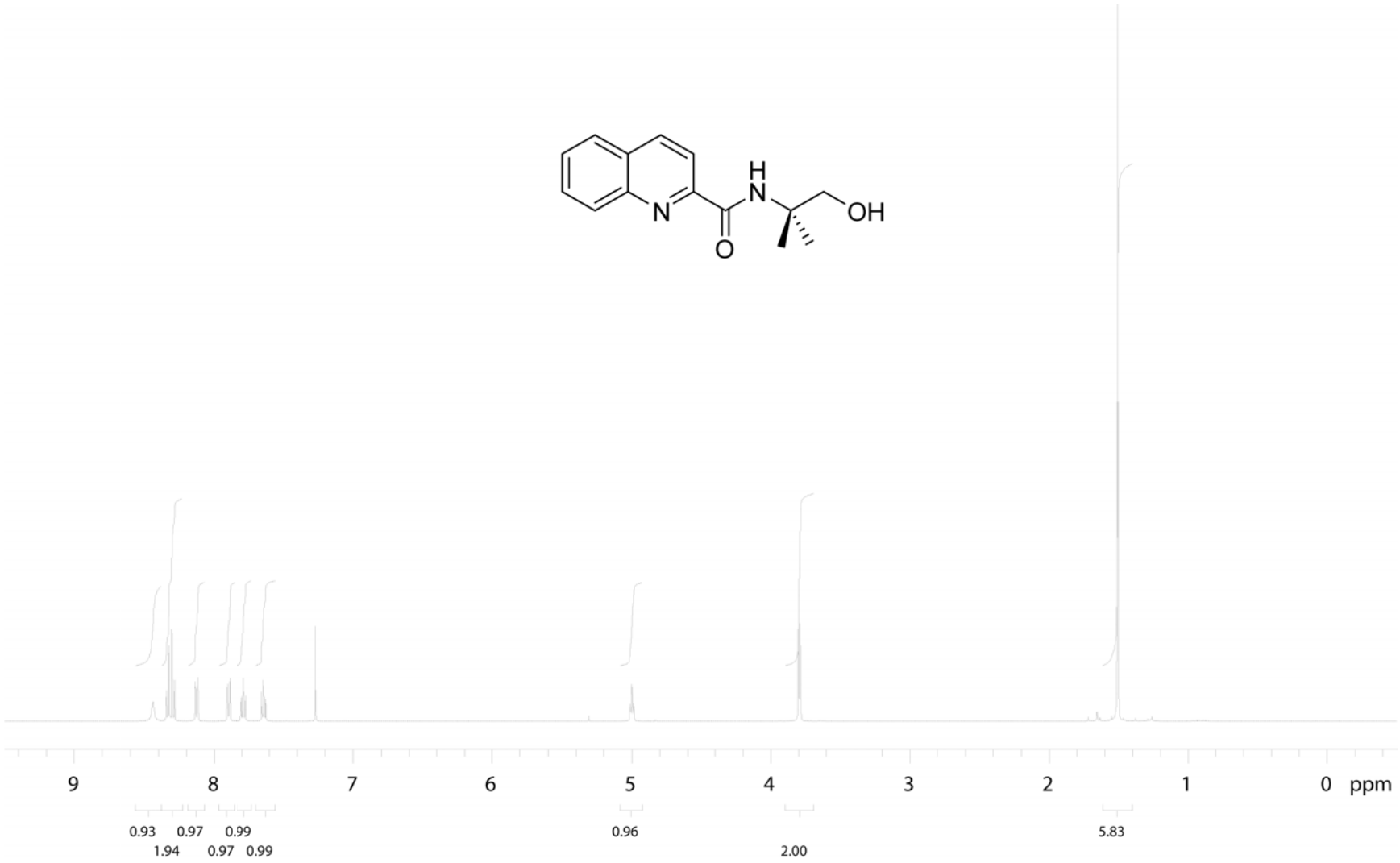
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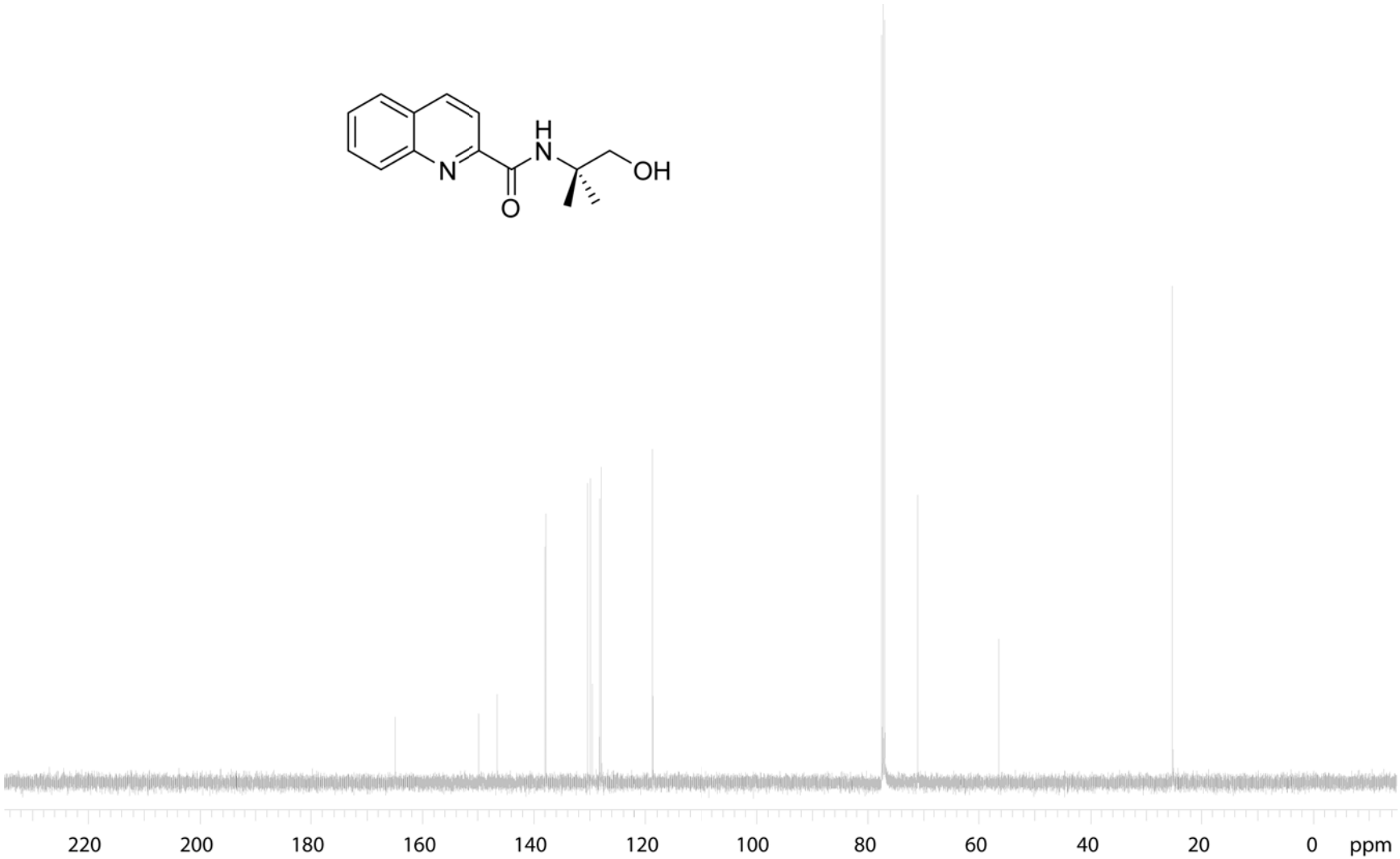
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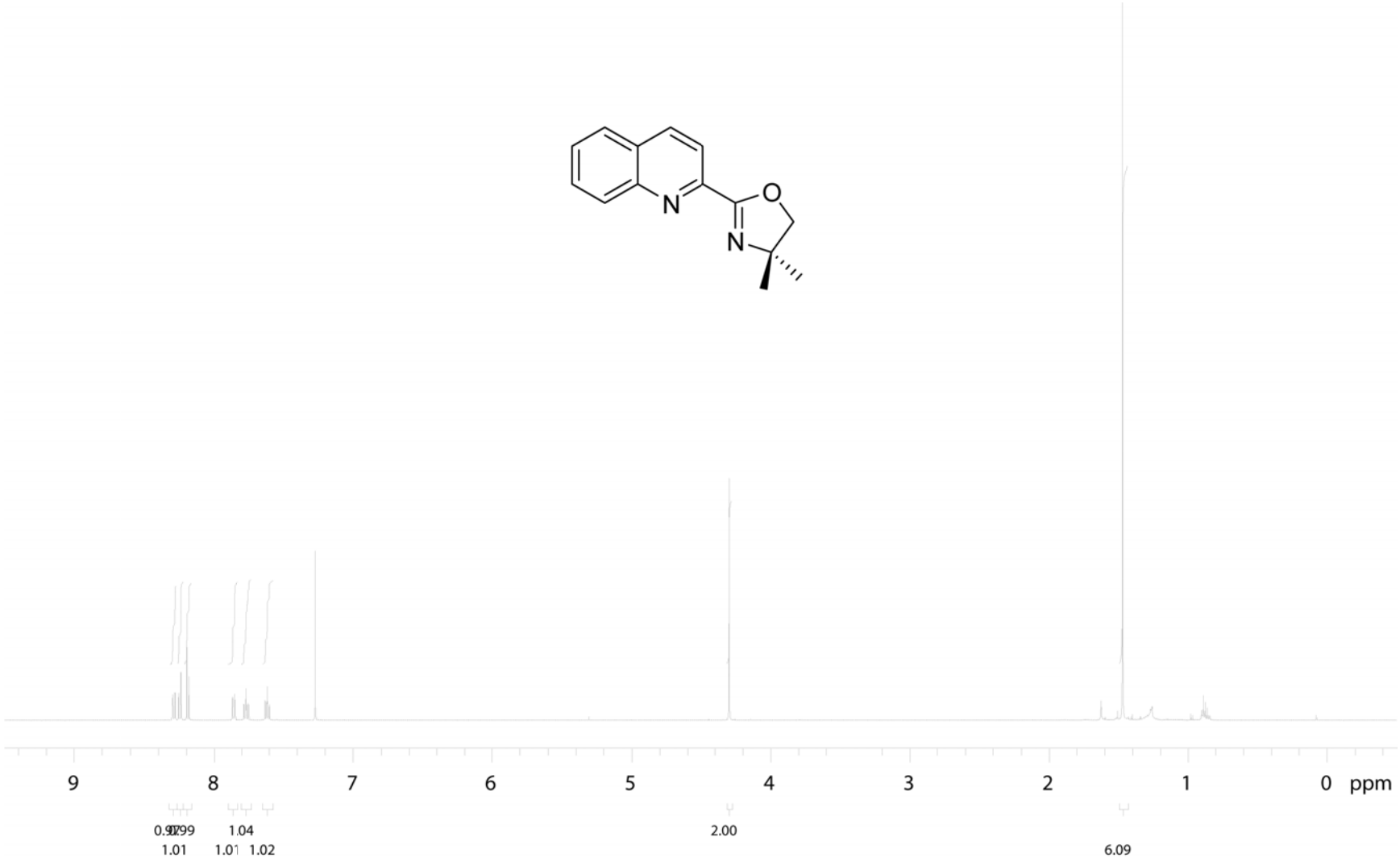
ppm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O
N
9
8
7
6
5
4
3
2
1
0
ppm
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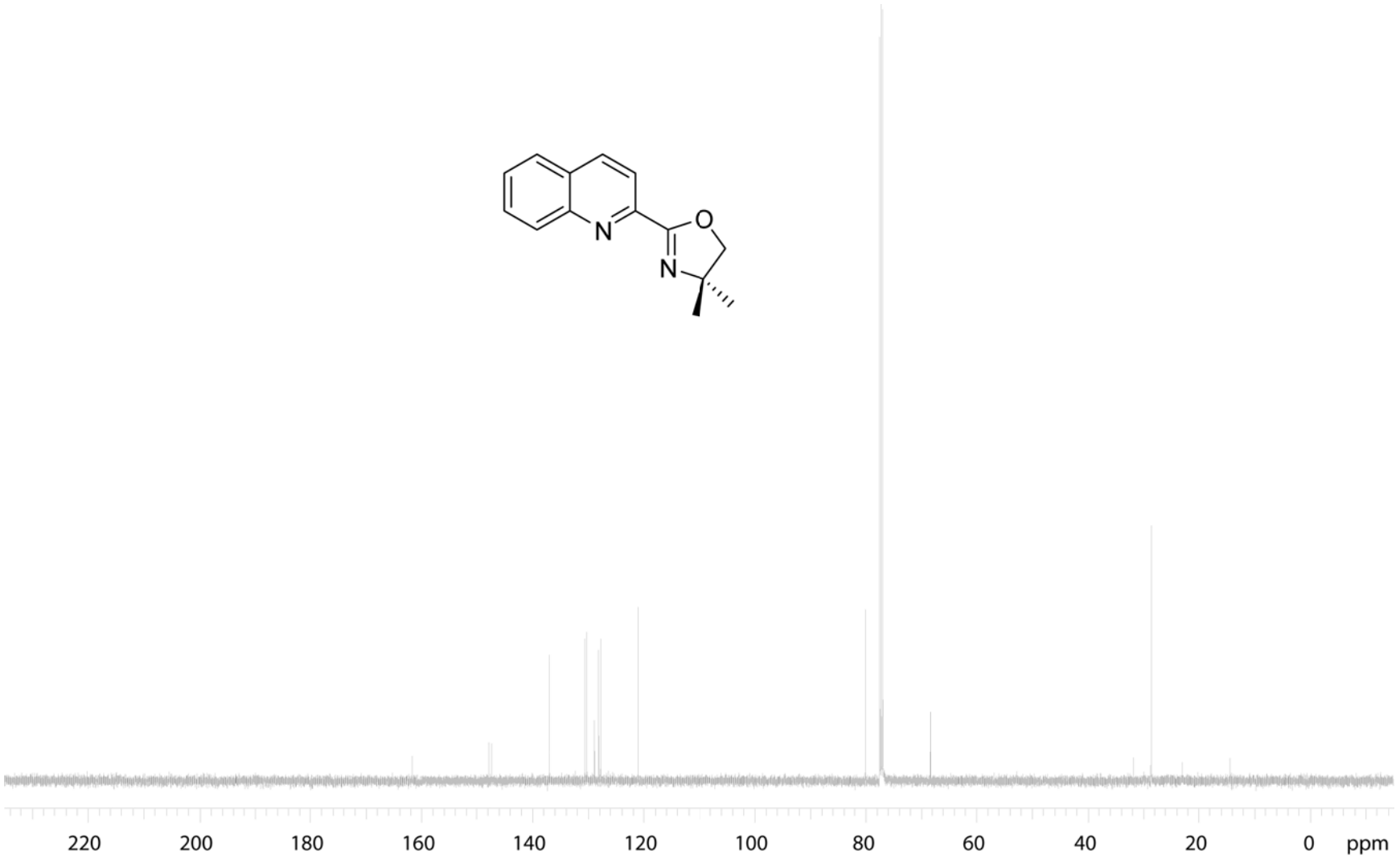
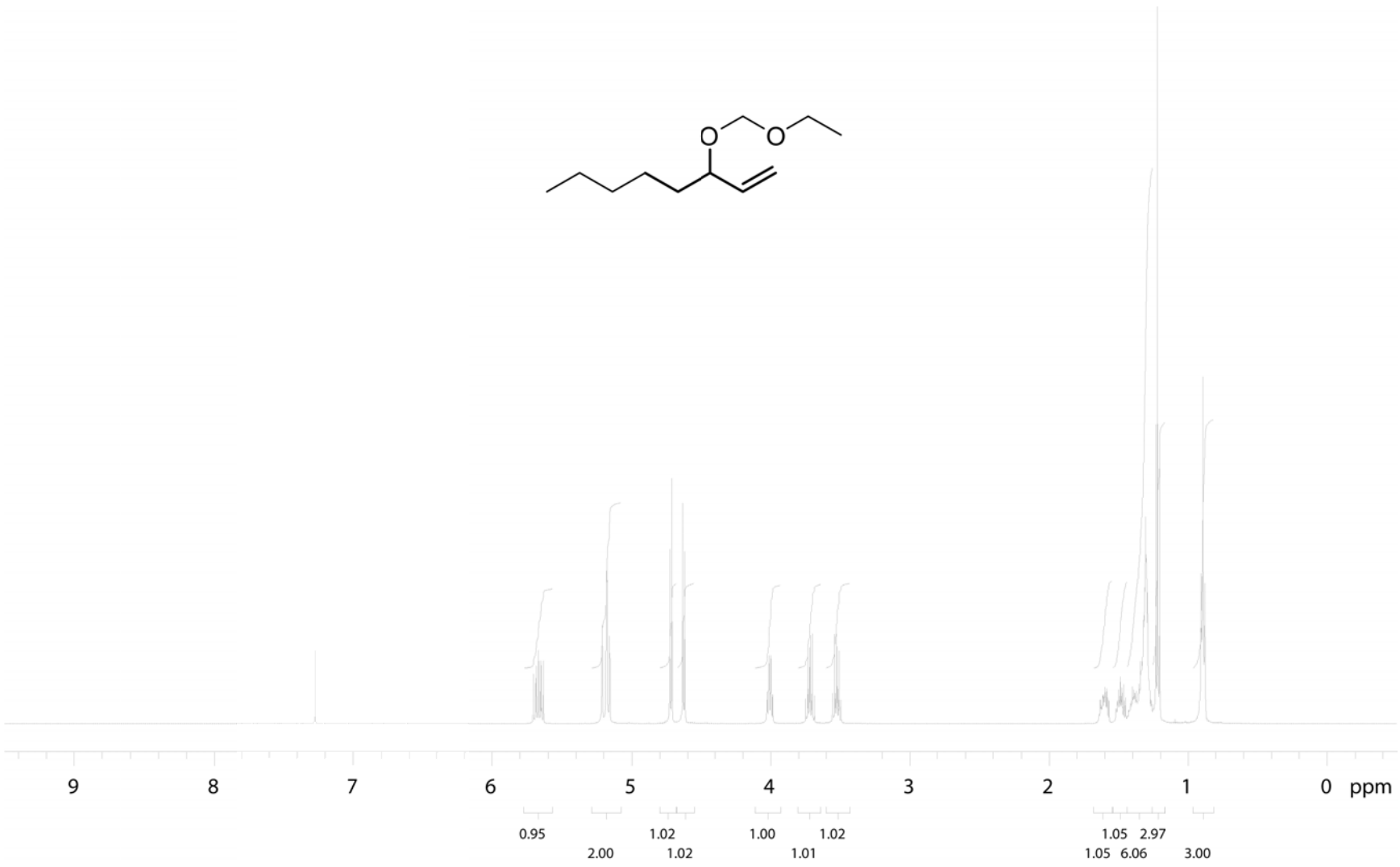
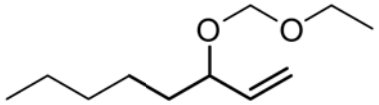
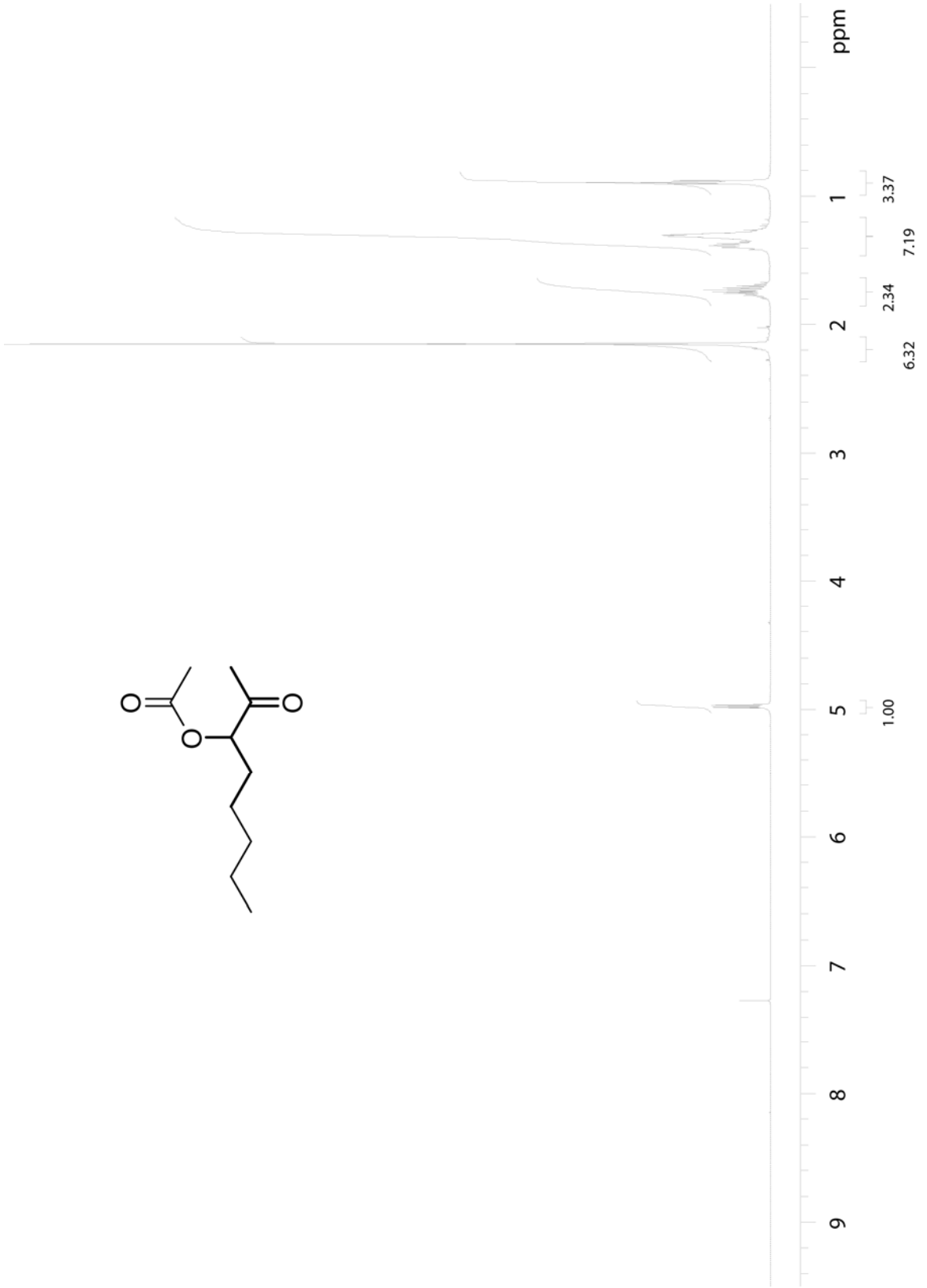
1.01
1.04
1.02
2.00
6.09


N
O
N
220
200
180
160
140
120
100
80
60
40
20
0
ppm


O
O
9
8
7
6
5
4
3
2
1
0 ppm
0.95
2.00
1.02
1.02
1.00
1.01
1.02
1.05
1.05
2.97
6.06
3.00


O
O

220
200
180
160
140
120
100
80
60
40
20
0
ppm


ppm
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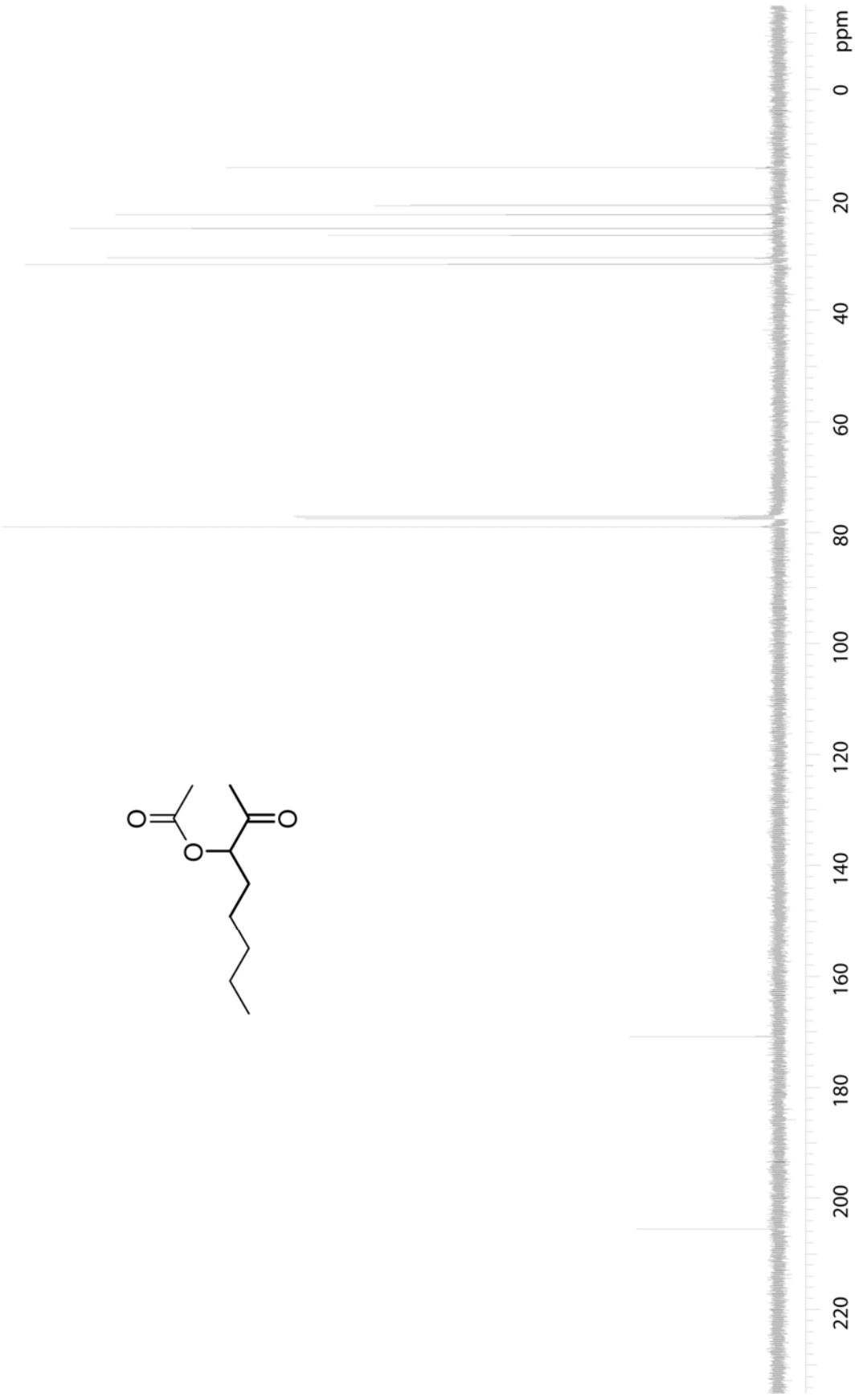
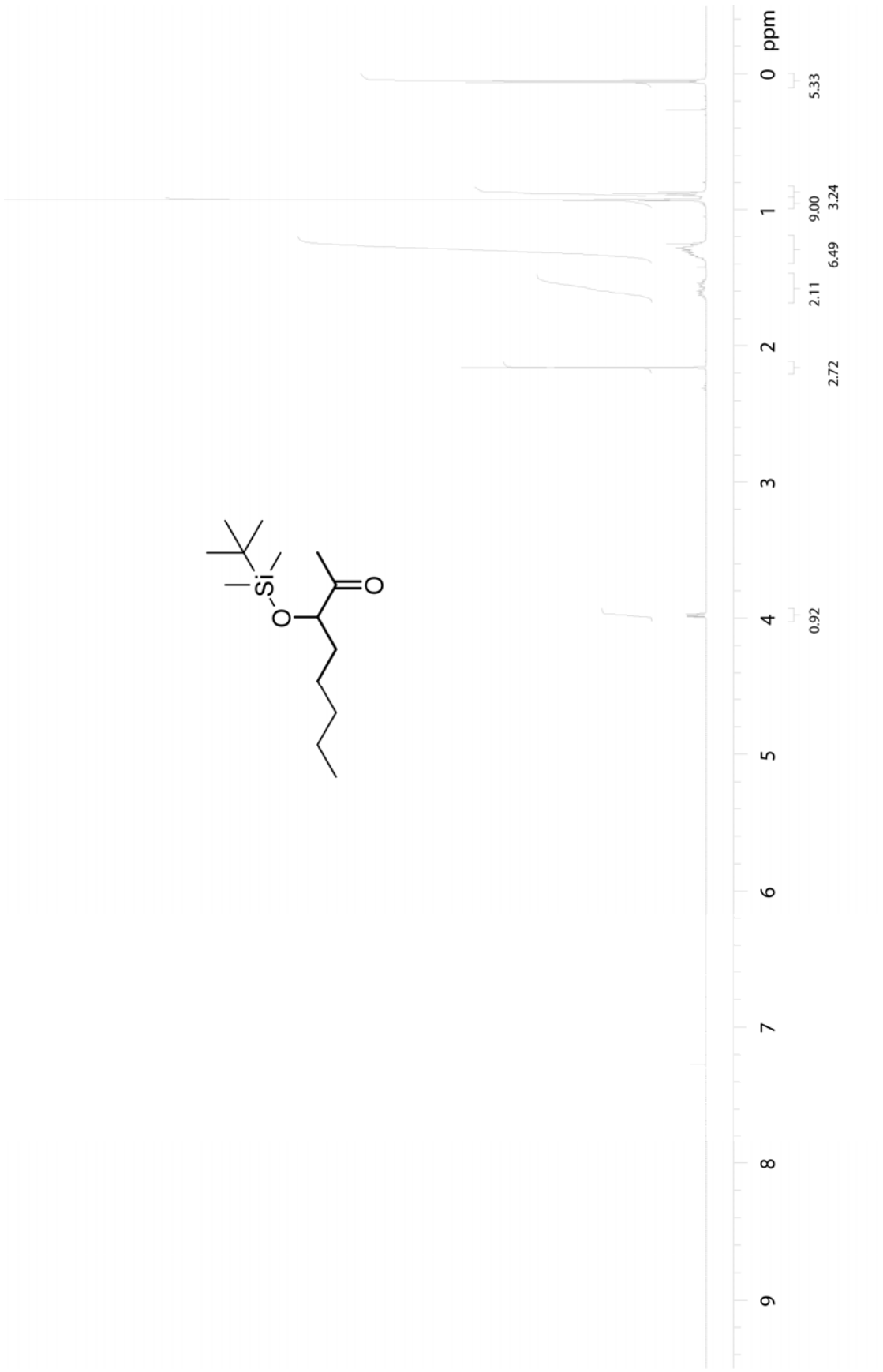
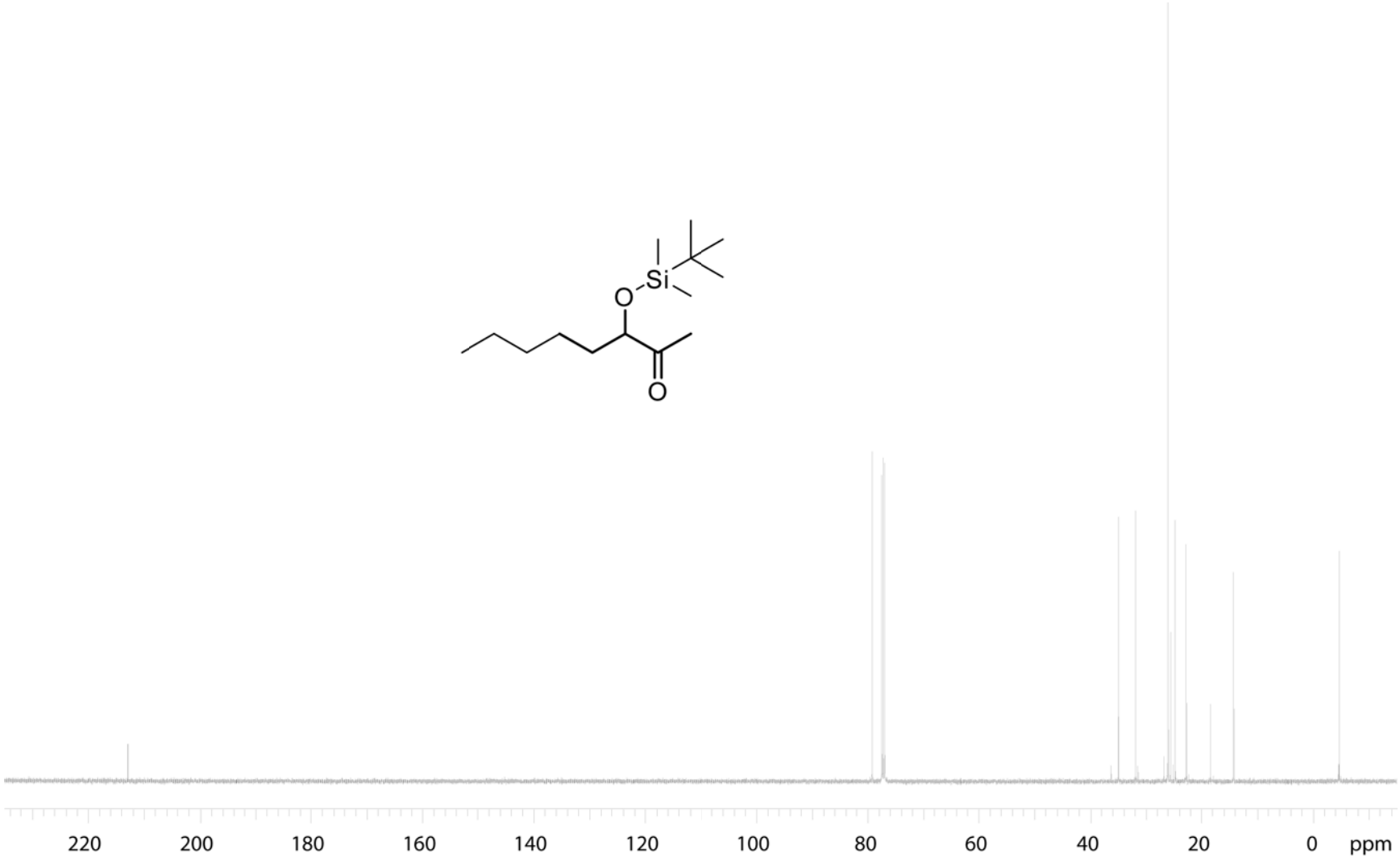
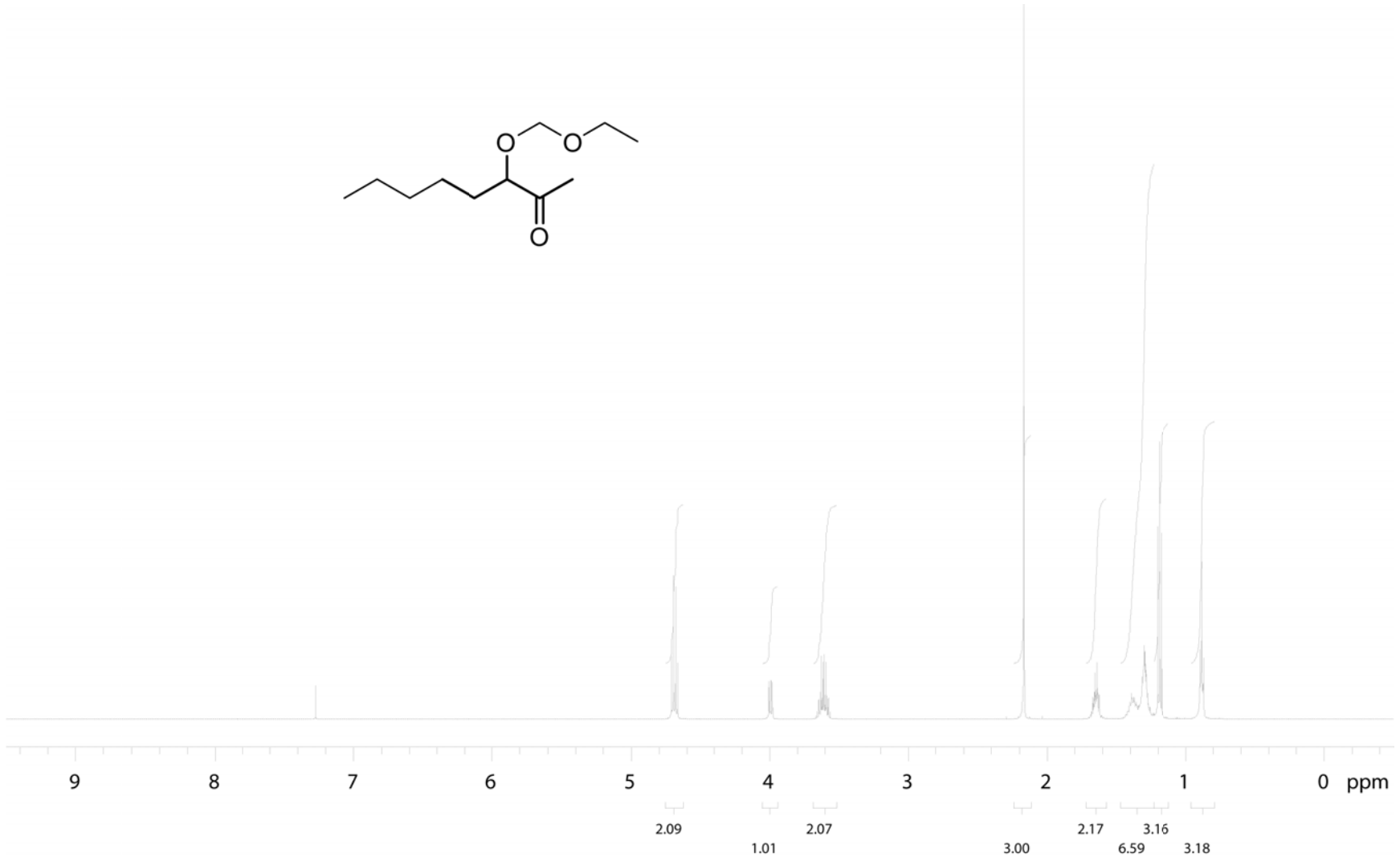
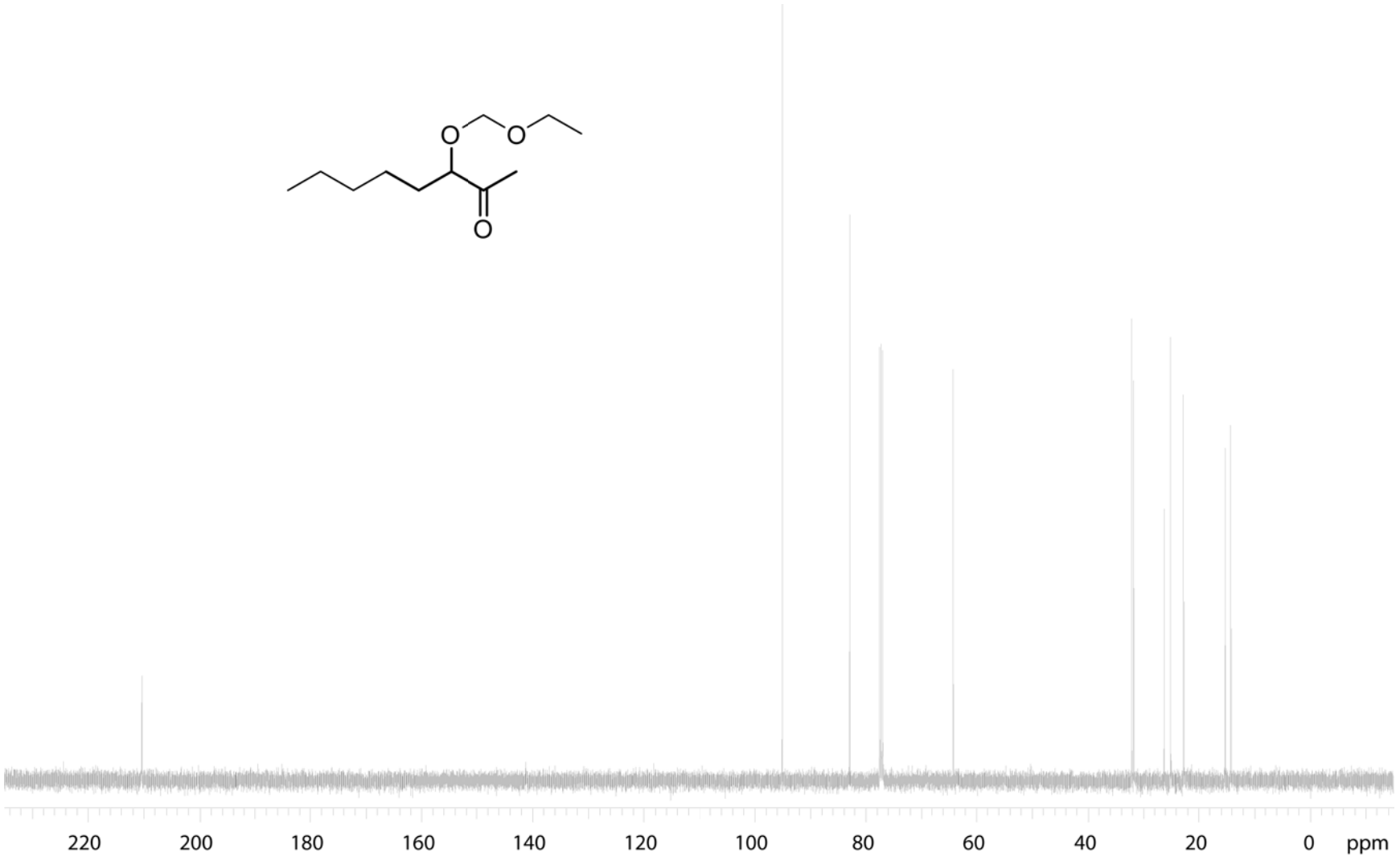
2
3
4
5
6
7
8
9
3.37
7.19
2.34
6.32
1.00

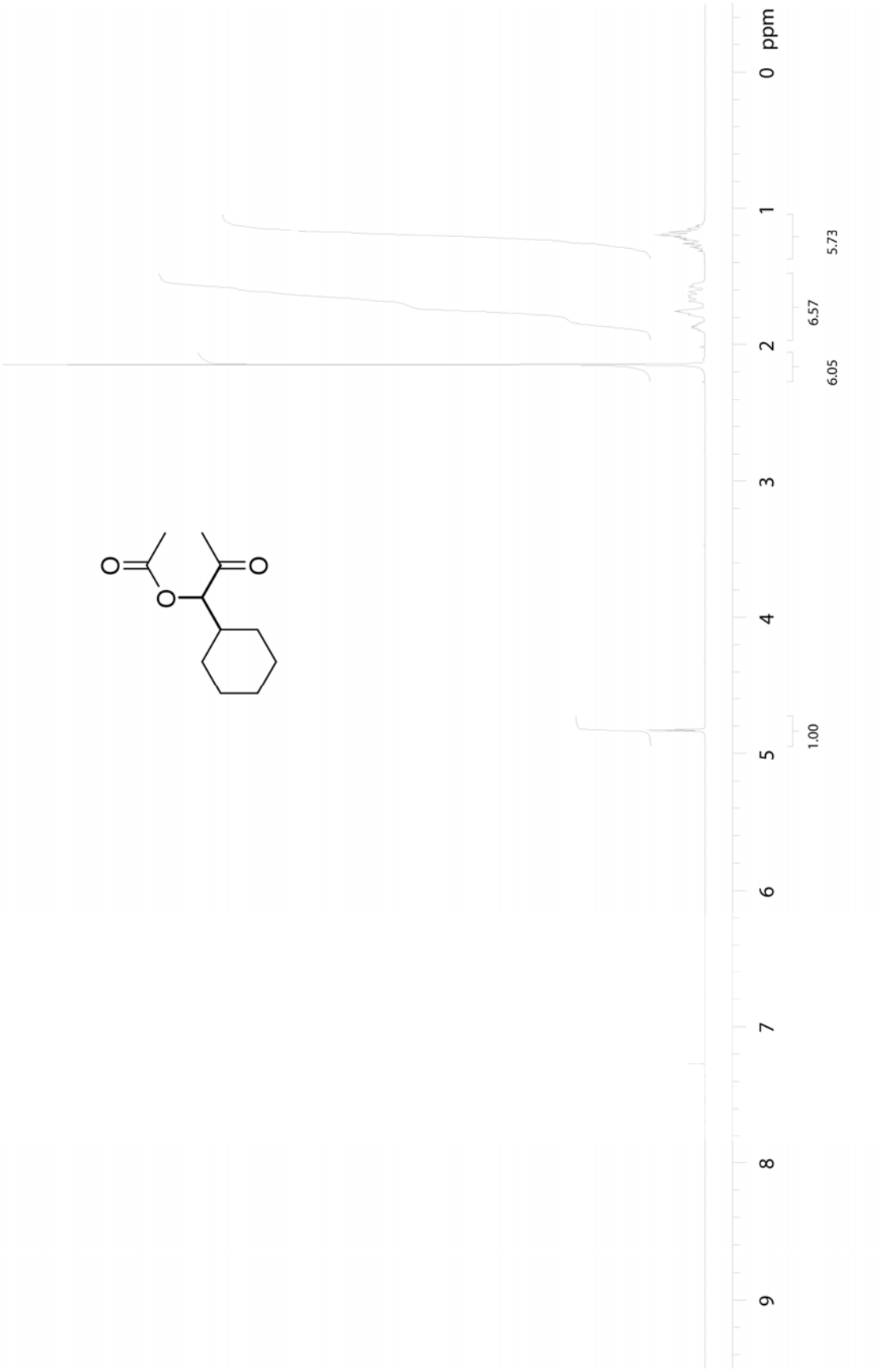

O
O
O
ppm
0
20
40
60
80
100
120
140
160
180
200
220

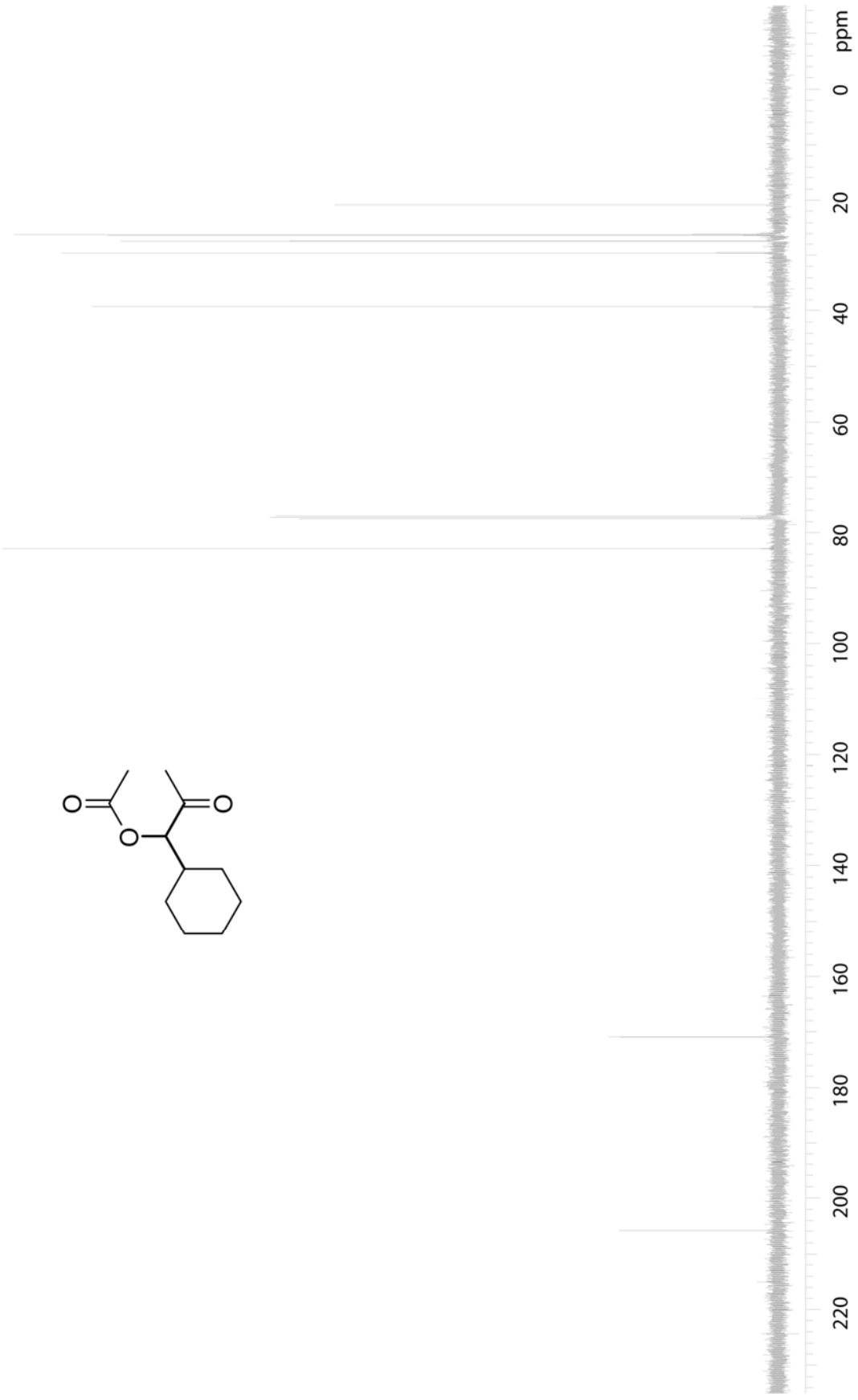

Si
O
O
9
8
7
6
5
4
3
2
1
0 ppm
0.92
2.72
2.11
6.49
9.00
3.24
5.33

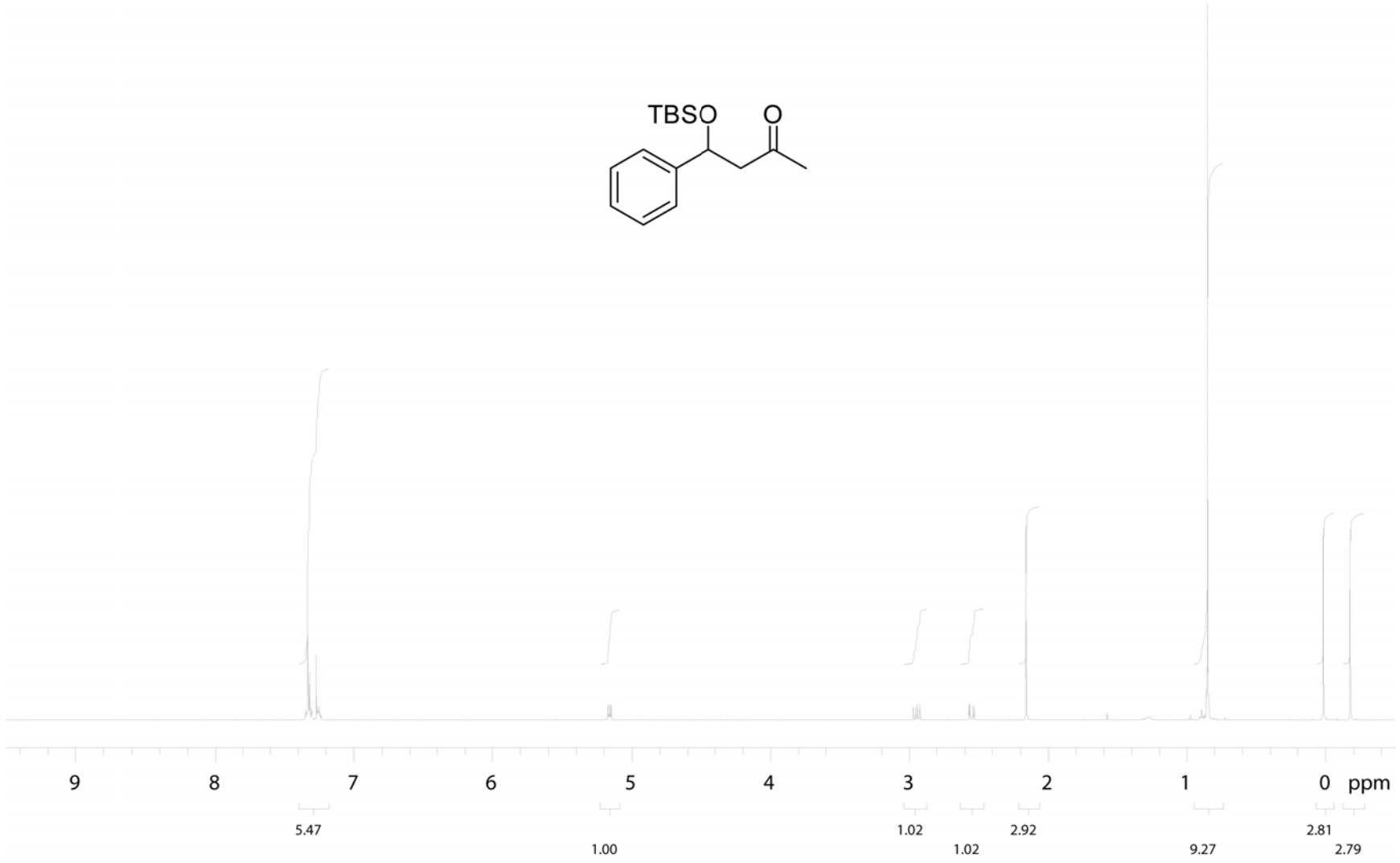

Si
O
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm

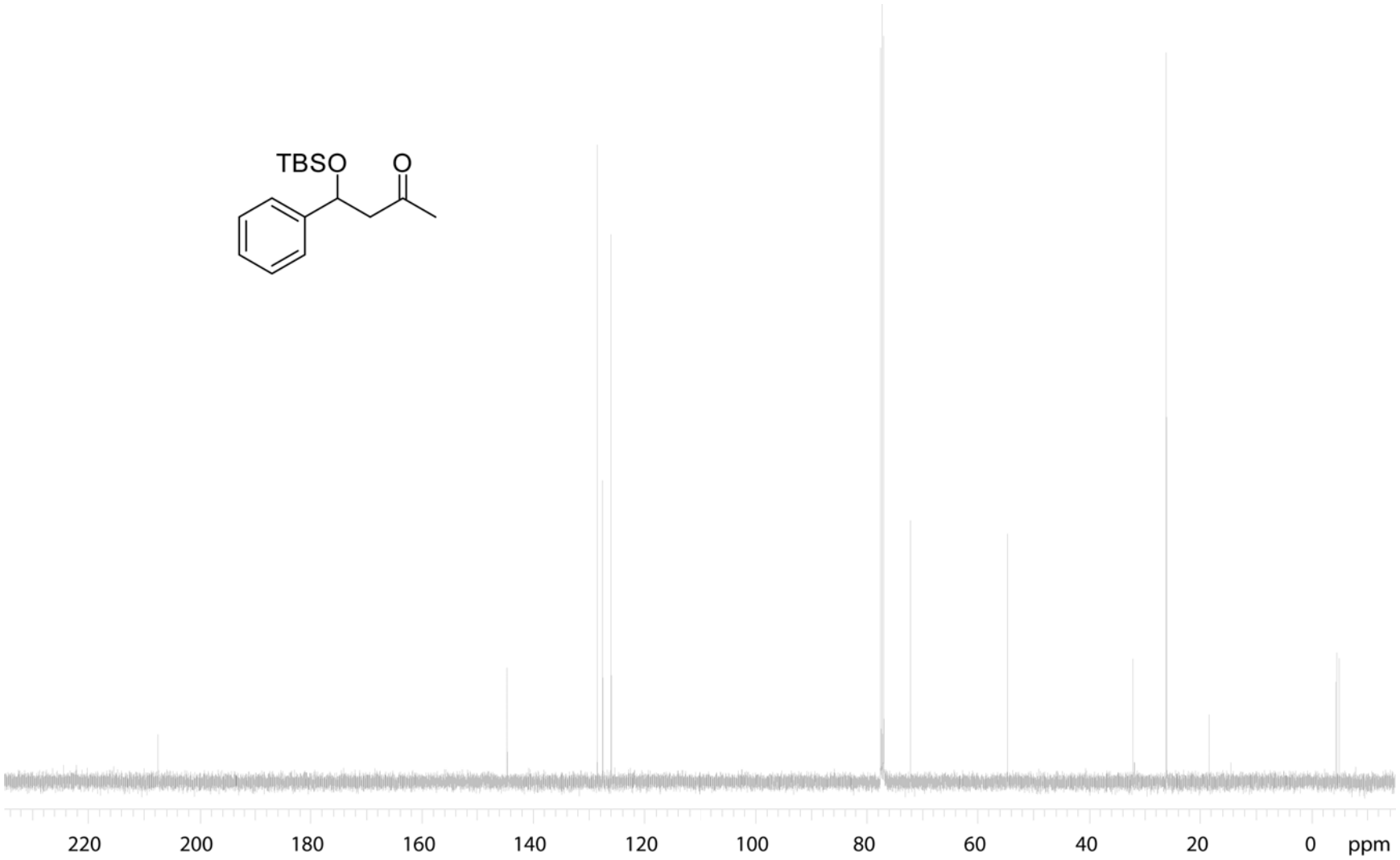

O
O
O
9
8
7
6
5
4
3
2
1
0 ppm
2.09
1.01
2.07
3.00
2.17
6.59
3.16
3.18

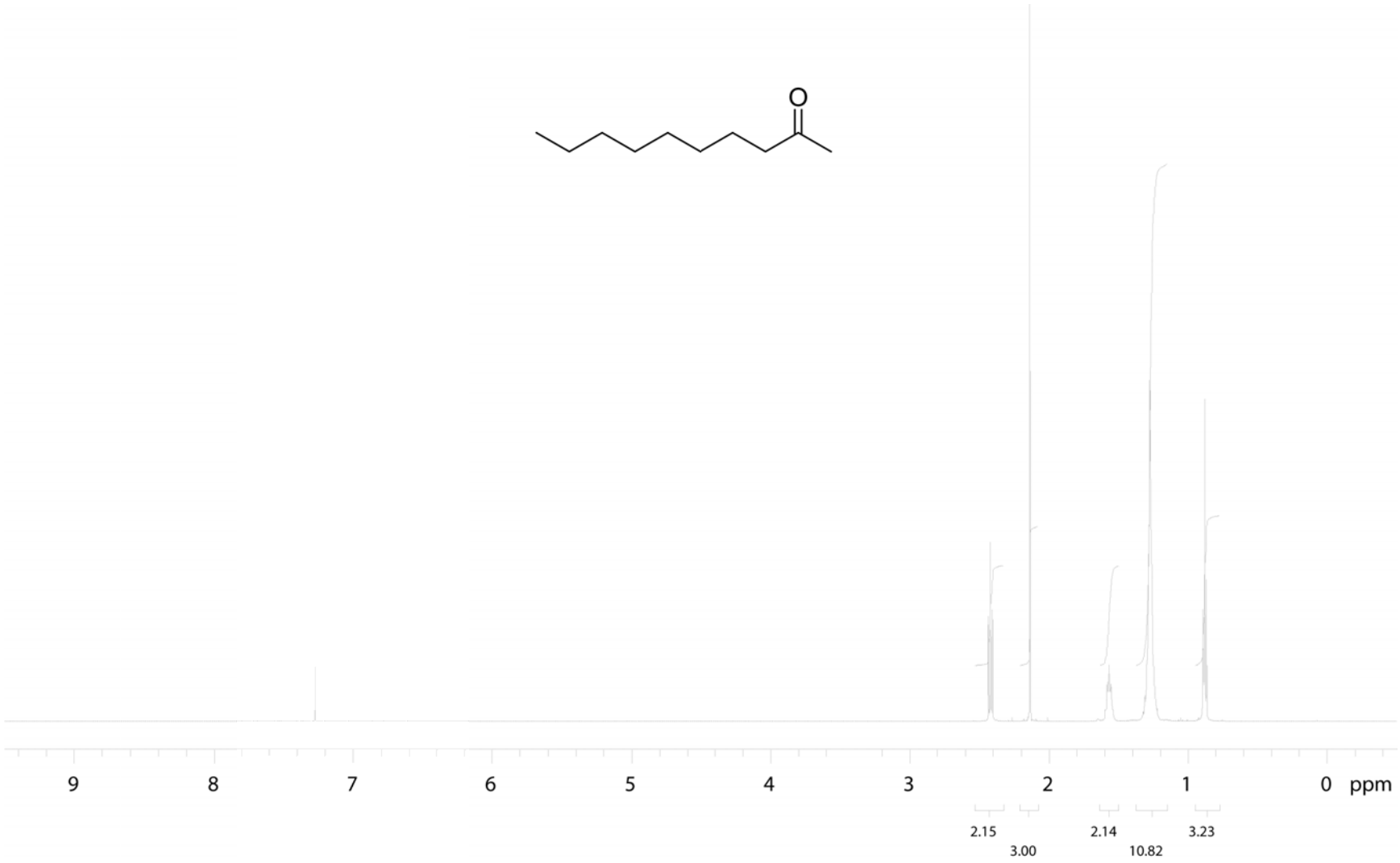

O
O
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm

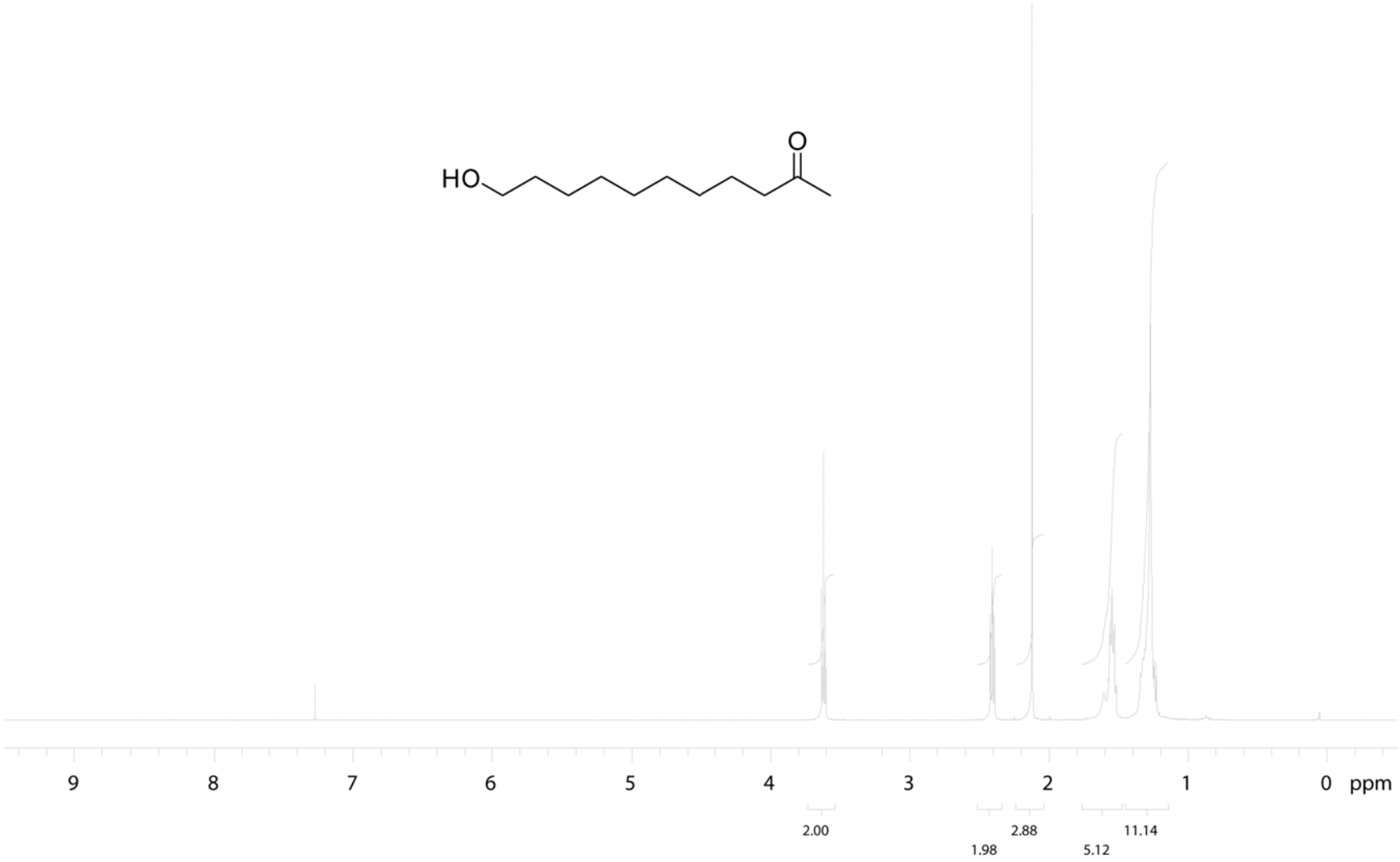

O
O
O
9
8
7
6
5
4
3
2
1
0 ppm
1.00
6.05
6.57
5.73

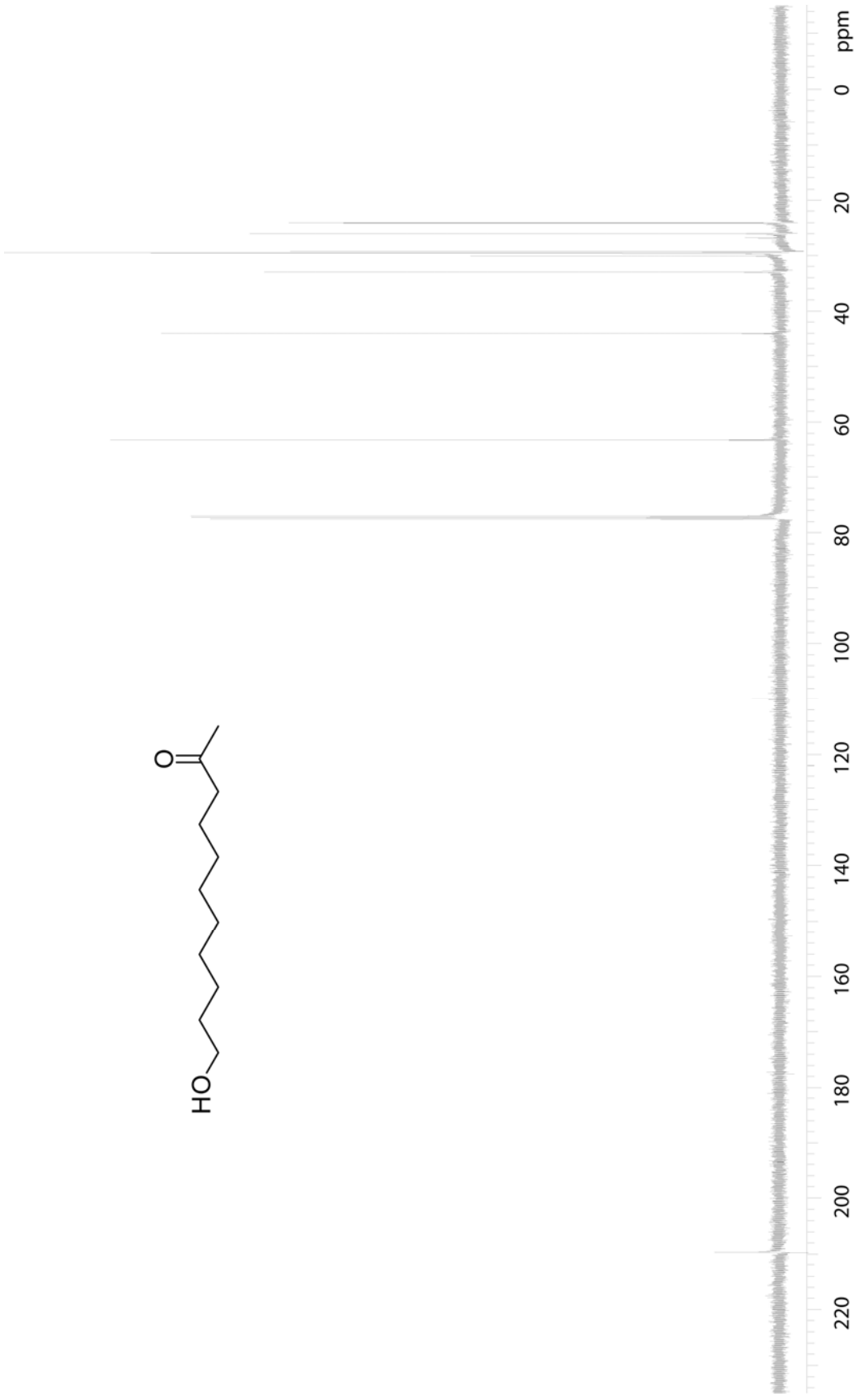

O
O
O
ppm
0
20
40
60
80
100
120
140
160
180
200
220

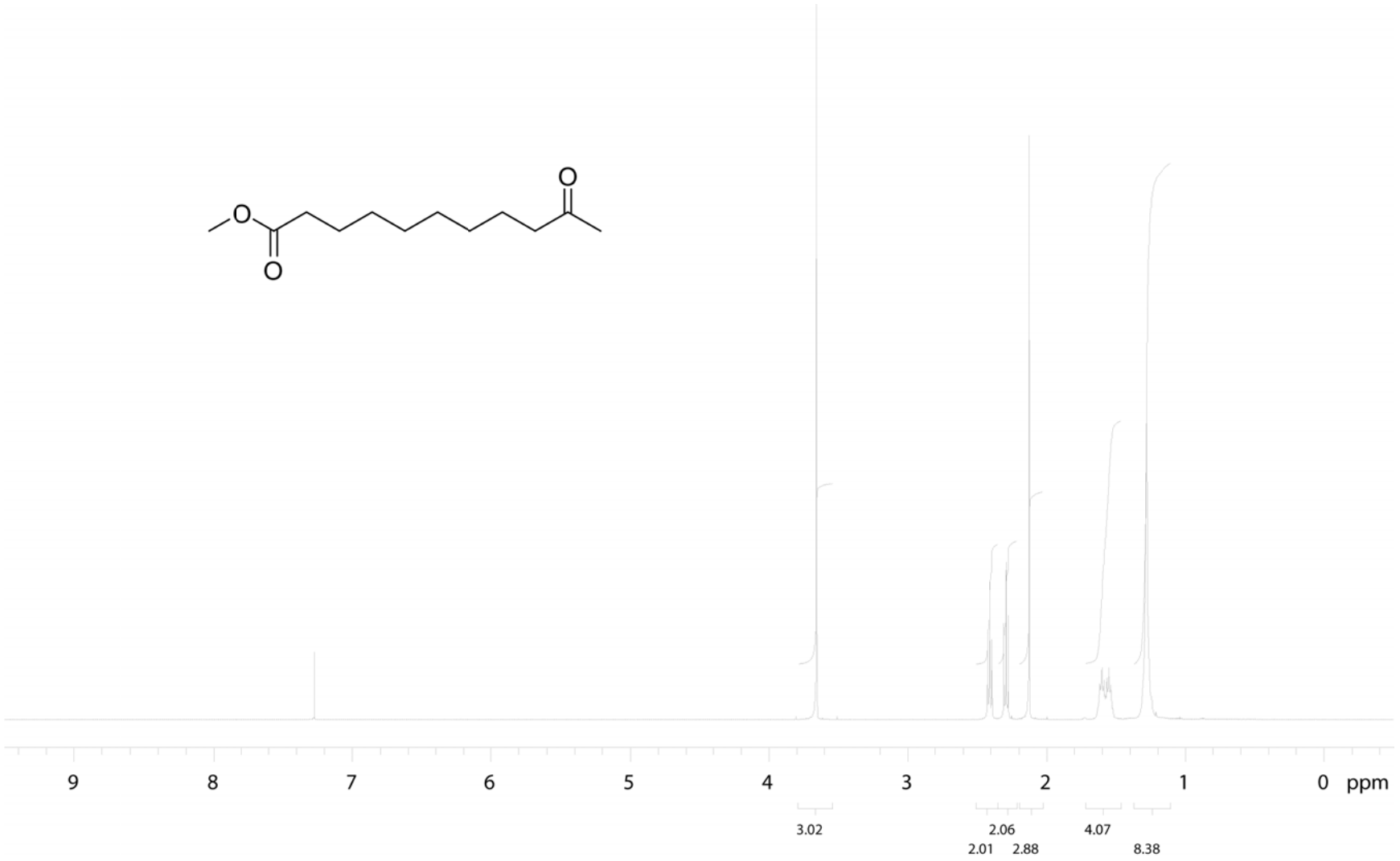

TBSO
O
9
8
7
6
5
4
3
2
1
0
ppm
5.47
1.00
1.02
1.02
2.92
9.27
2.81
2.79

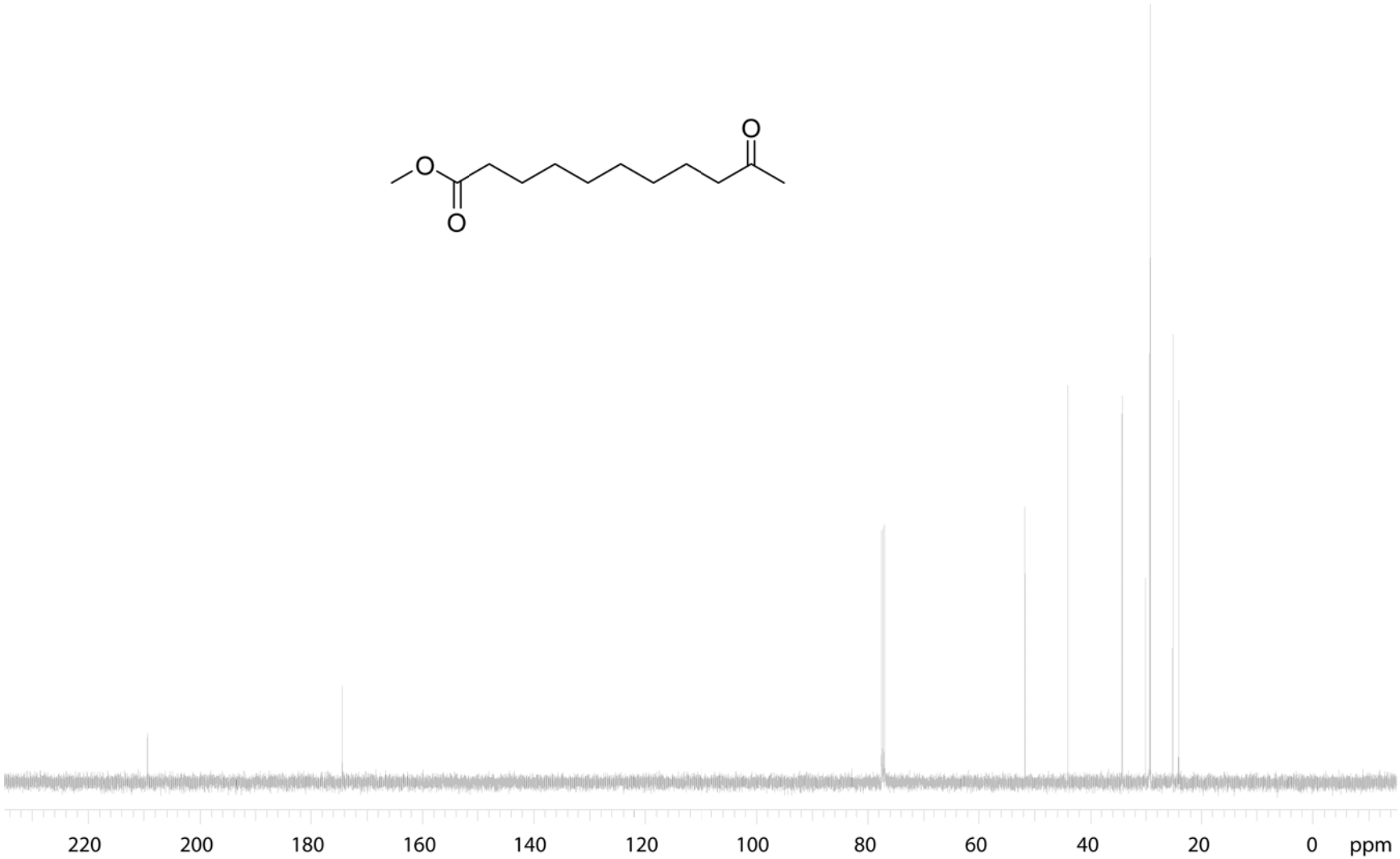

TBSO
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm

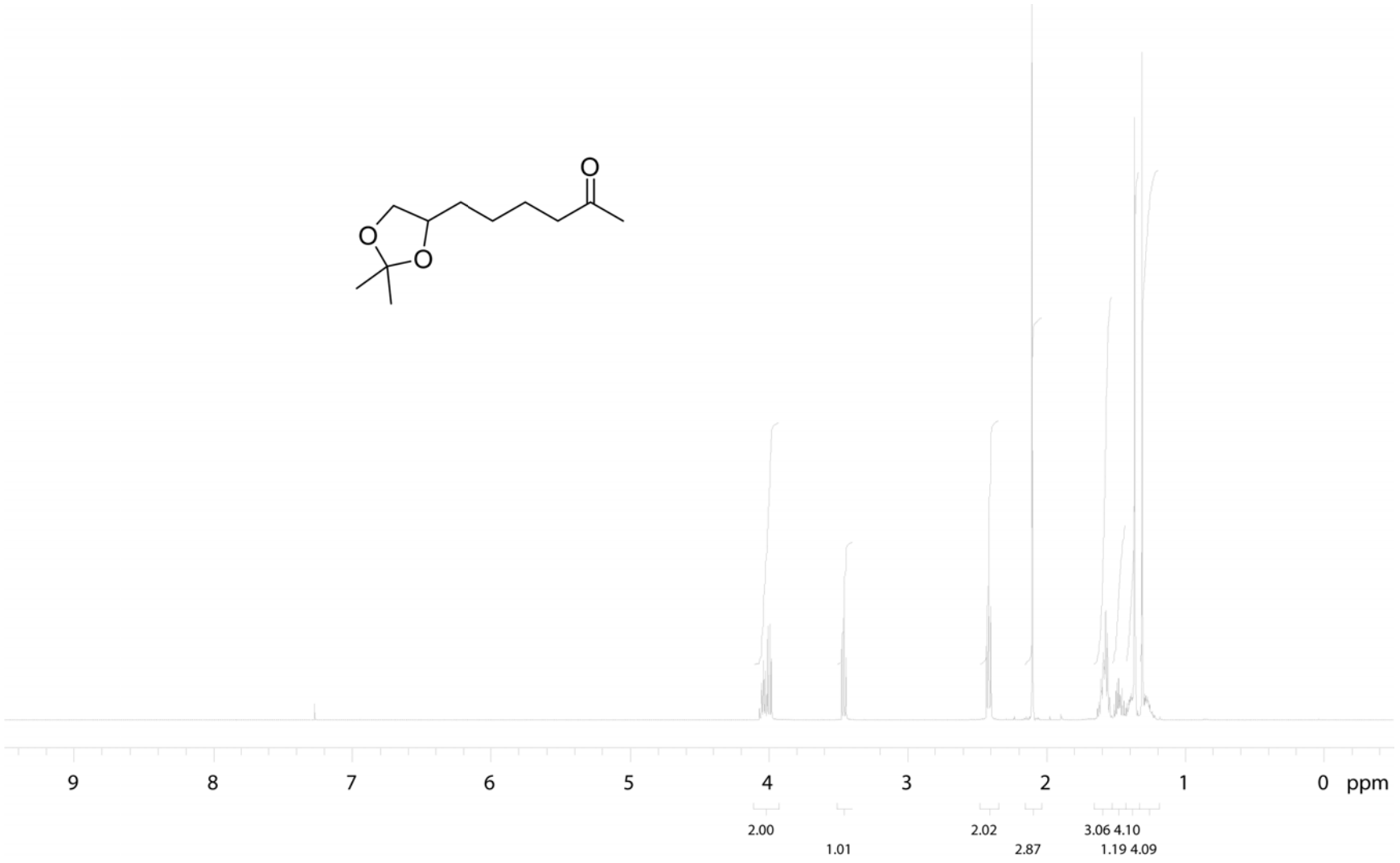

O
9
8
7
6
5
4
3
2
1
0
ppm
2.15
3.00
2.14
10.82
3.23


HO
O
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.98
2.88
5.12
11.14


HO
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm


O
O
O
9
8
7
6
5
4
3
2
1
0 ppm
3.02
2.06
2.01
2.88
4.07
8.38

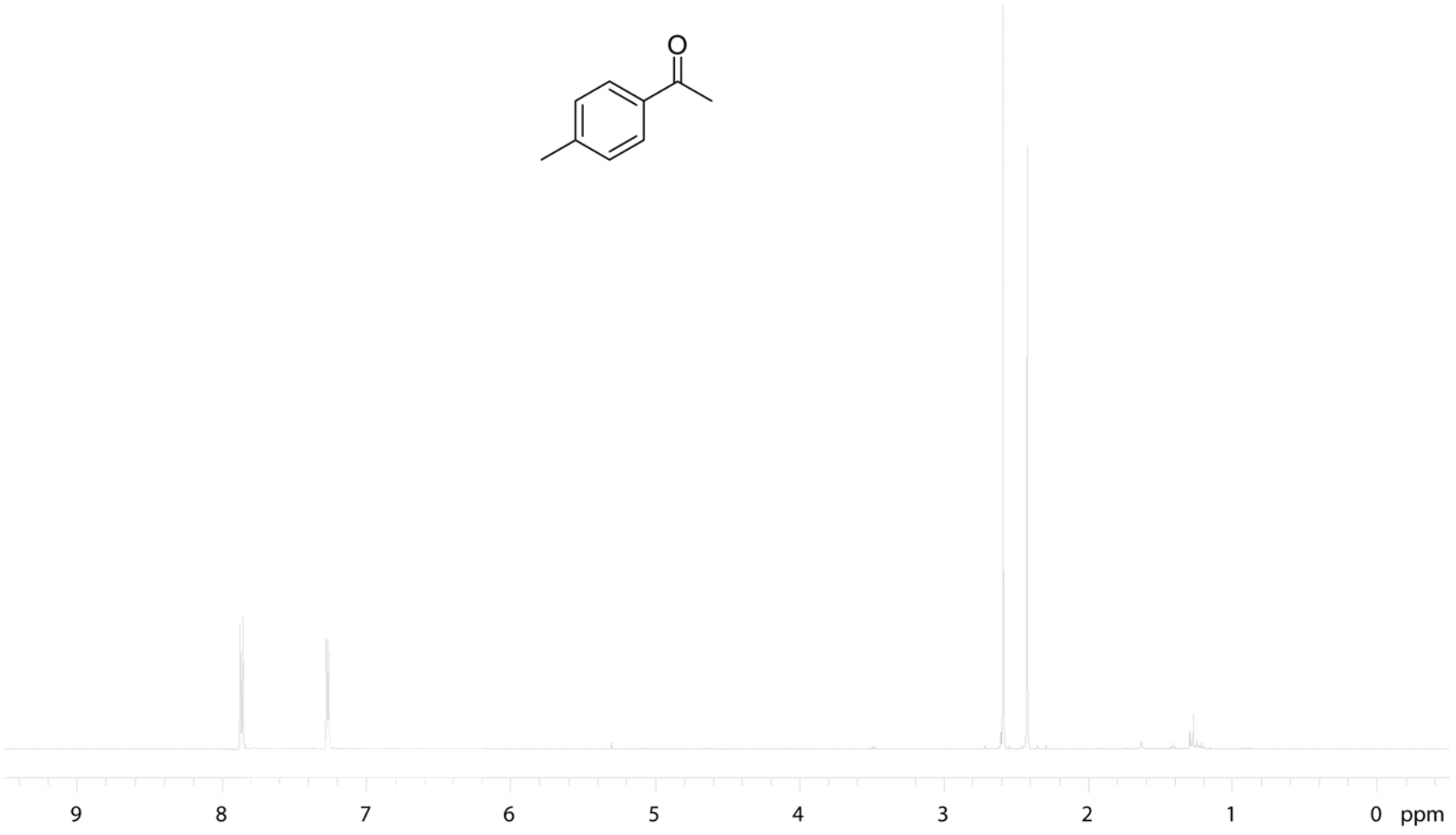

O
O
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm

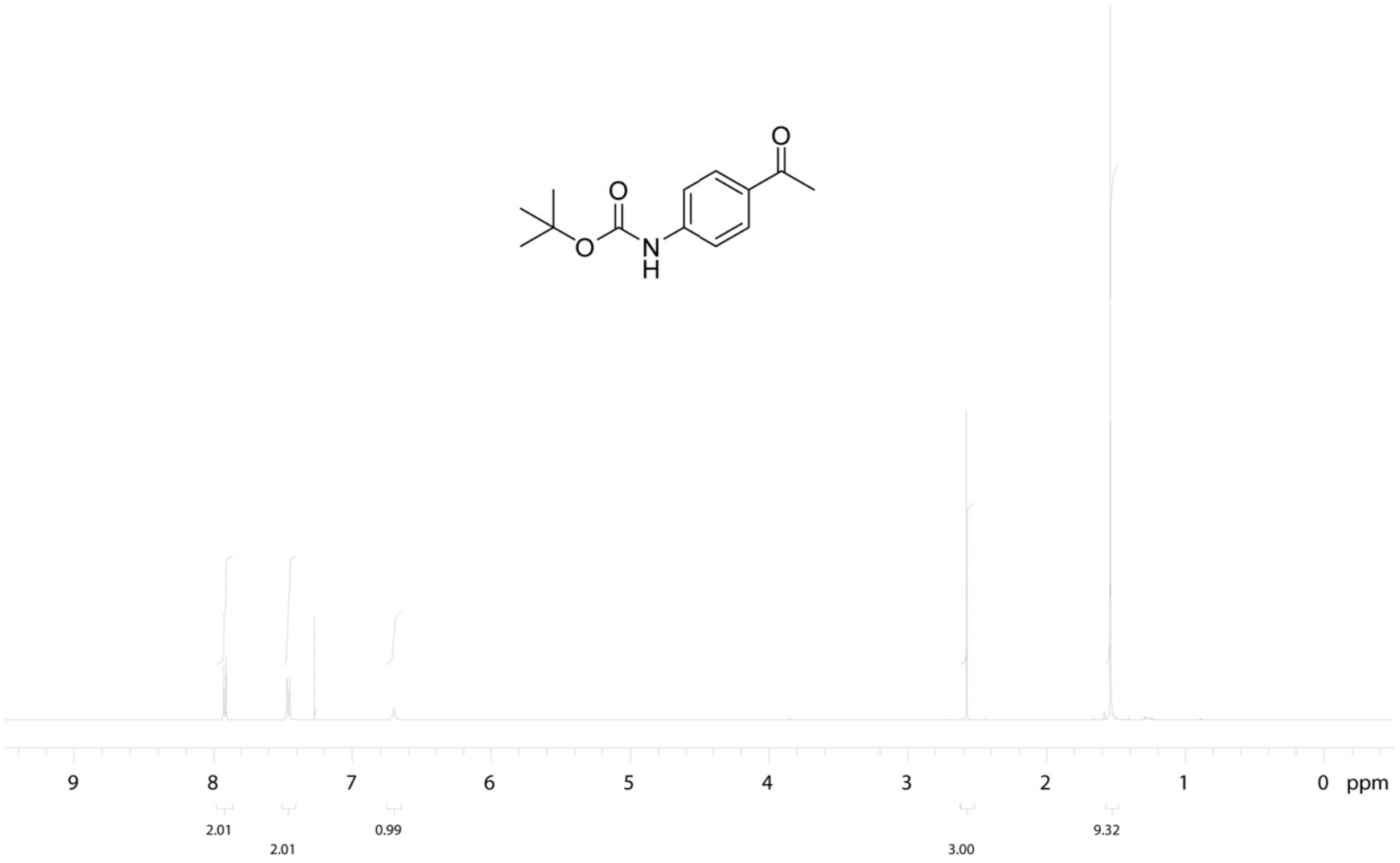

O
O
O
9
8
7
6
5
4
3
2
1
0
ppm
2.00
1.01
2.02
2.87
3.06
4.10
1.19
4.09


O
O
O
ppm
0
20
40
60
80
100
120
140
160
180
200
220


Cl
O
9
8
7
6
5
4
3
2
1
0
ppm
2.09
2.10
3.00
2.14
2.17
2.24
8.61


Cl
O
220
200
180
160
140
120
100
80
60
40
20
0
ppm


O
9
8
7
6
5
4
3
2
1
0
ppm


O
O
O
N
H
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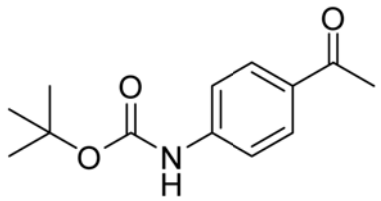
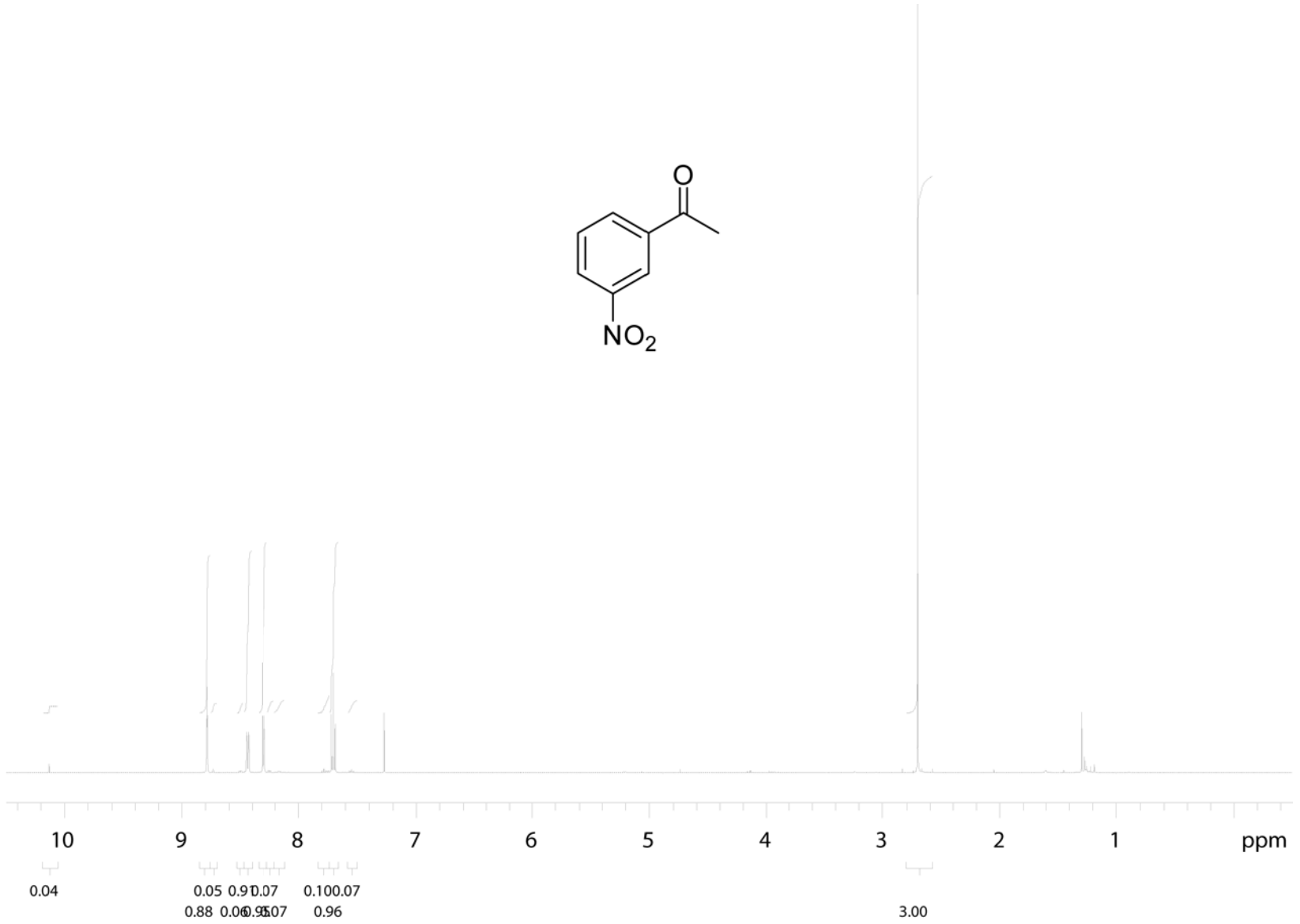
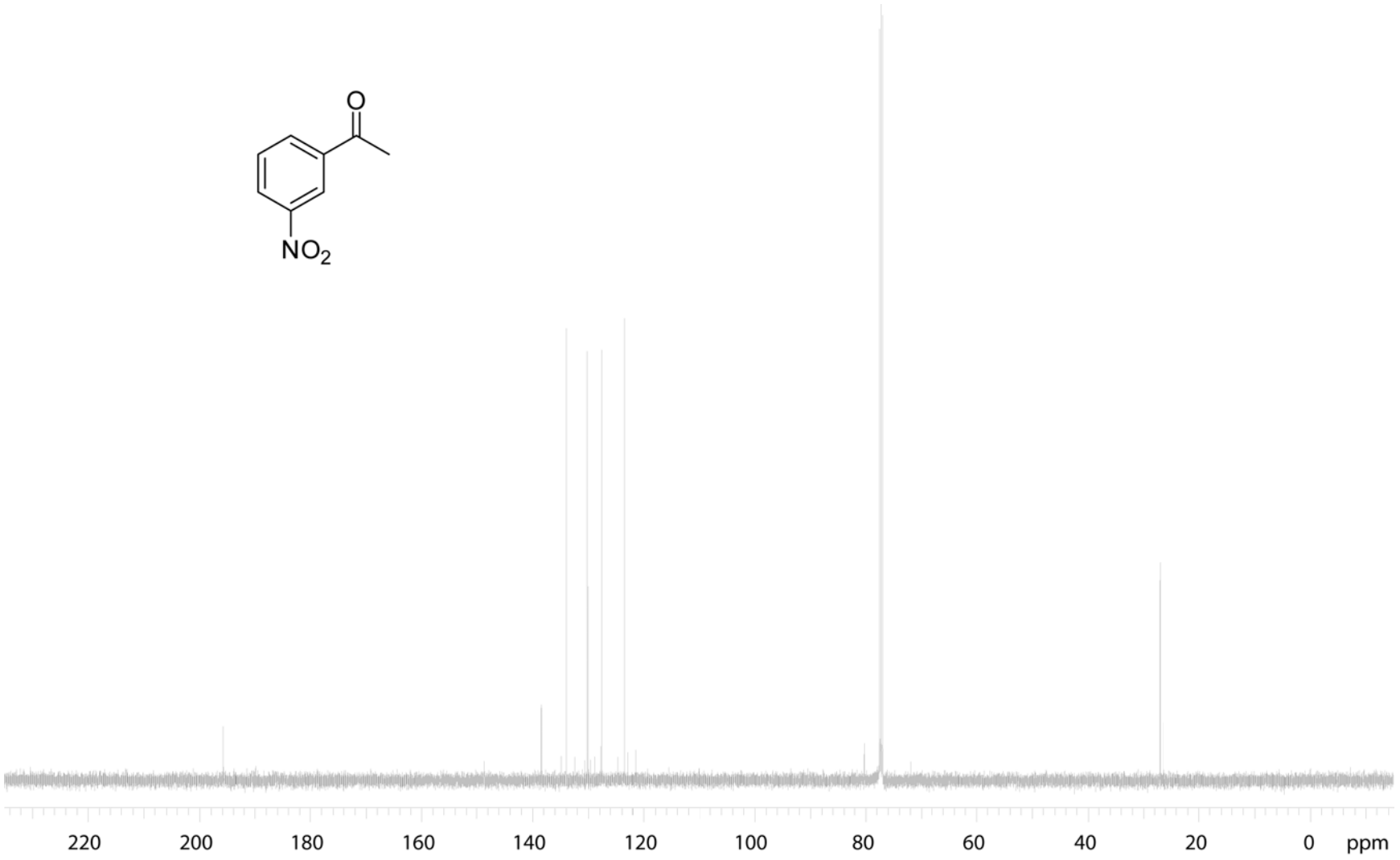
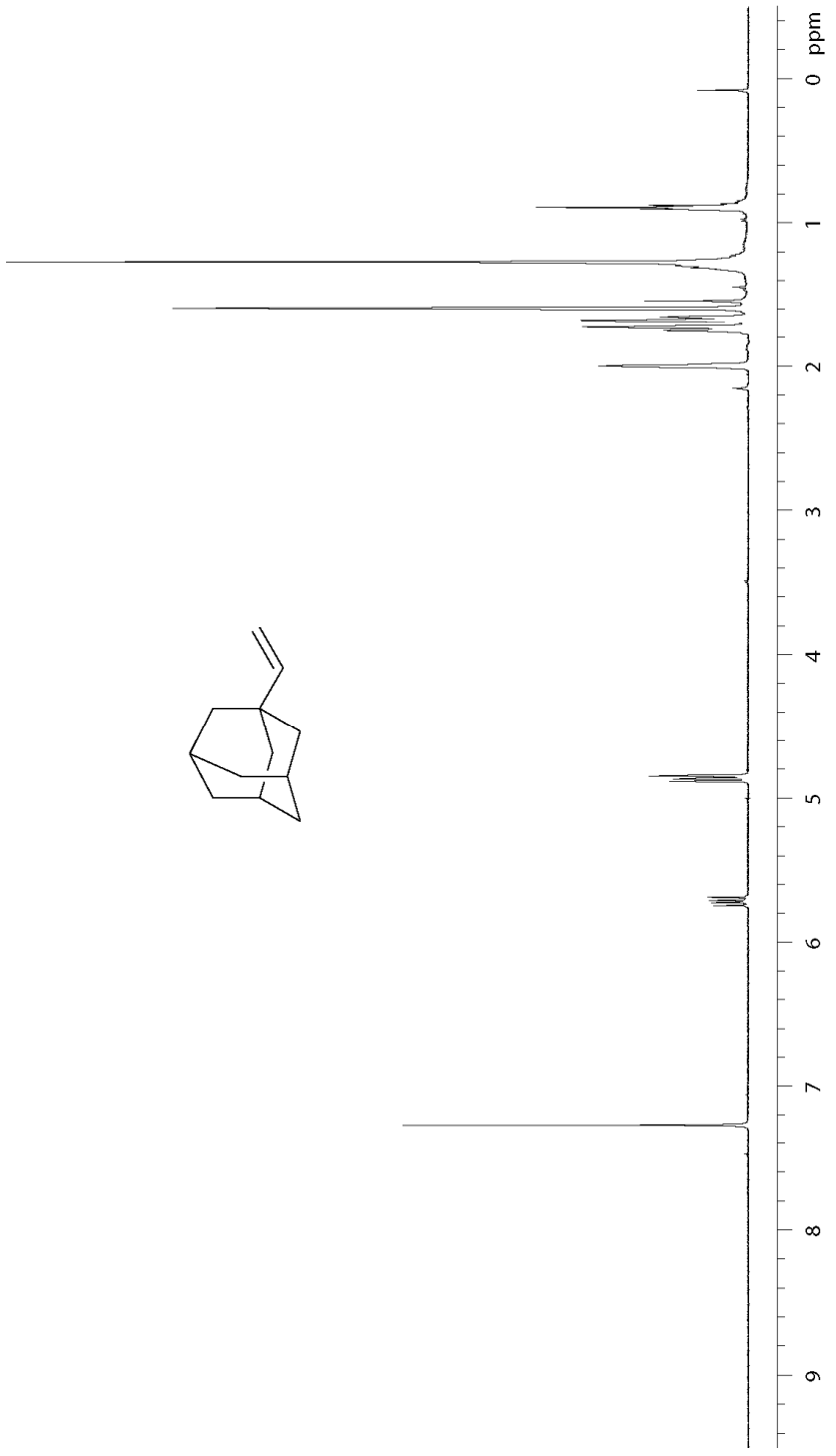
8
7
6
5
4
3
2
1
0
ppm
2.01
2.01
0.99
3.00
9.32

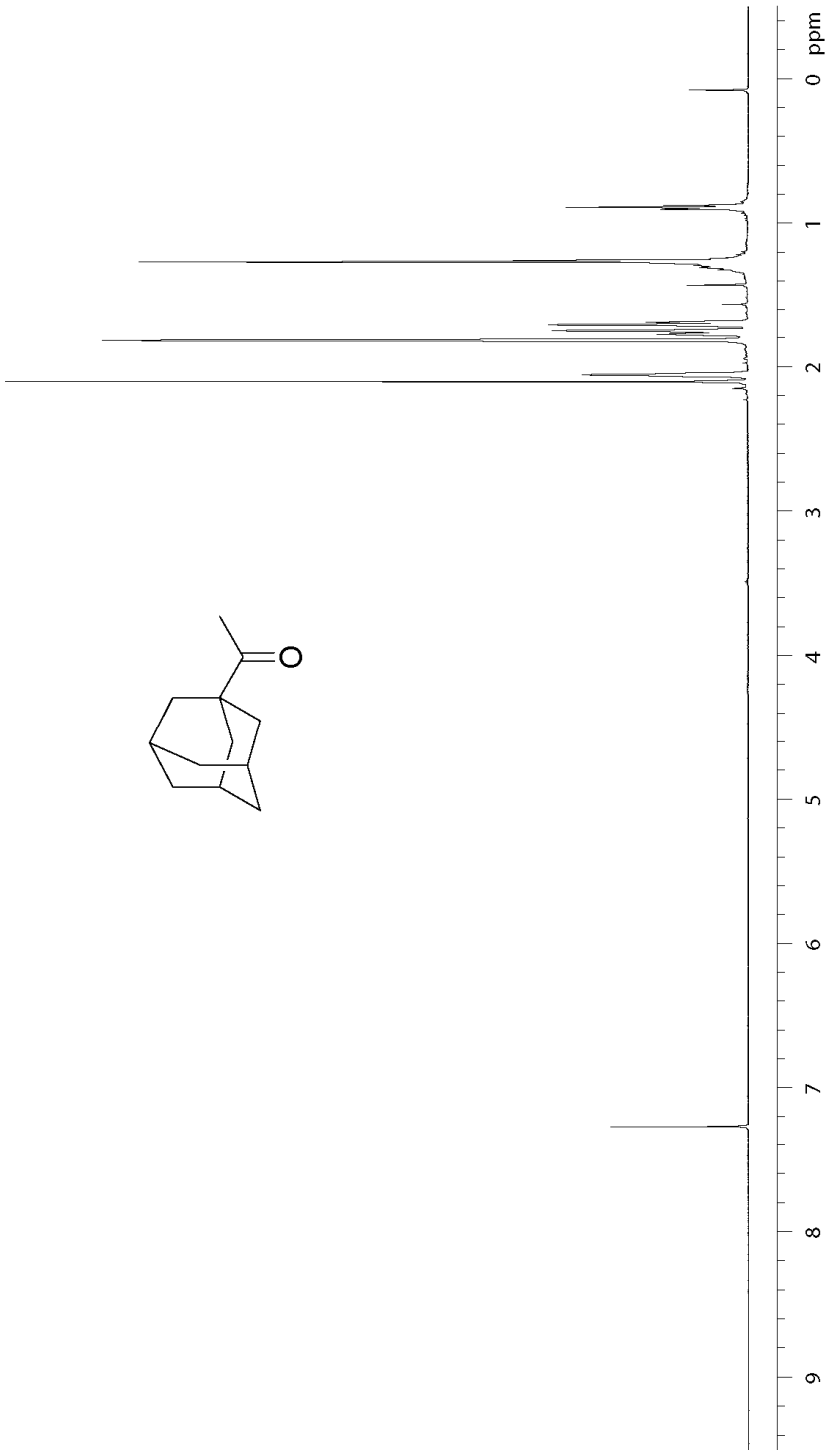

O
O
O
N
H

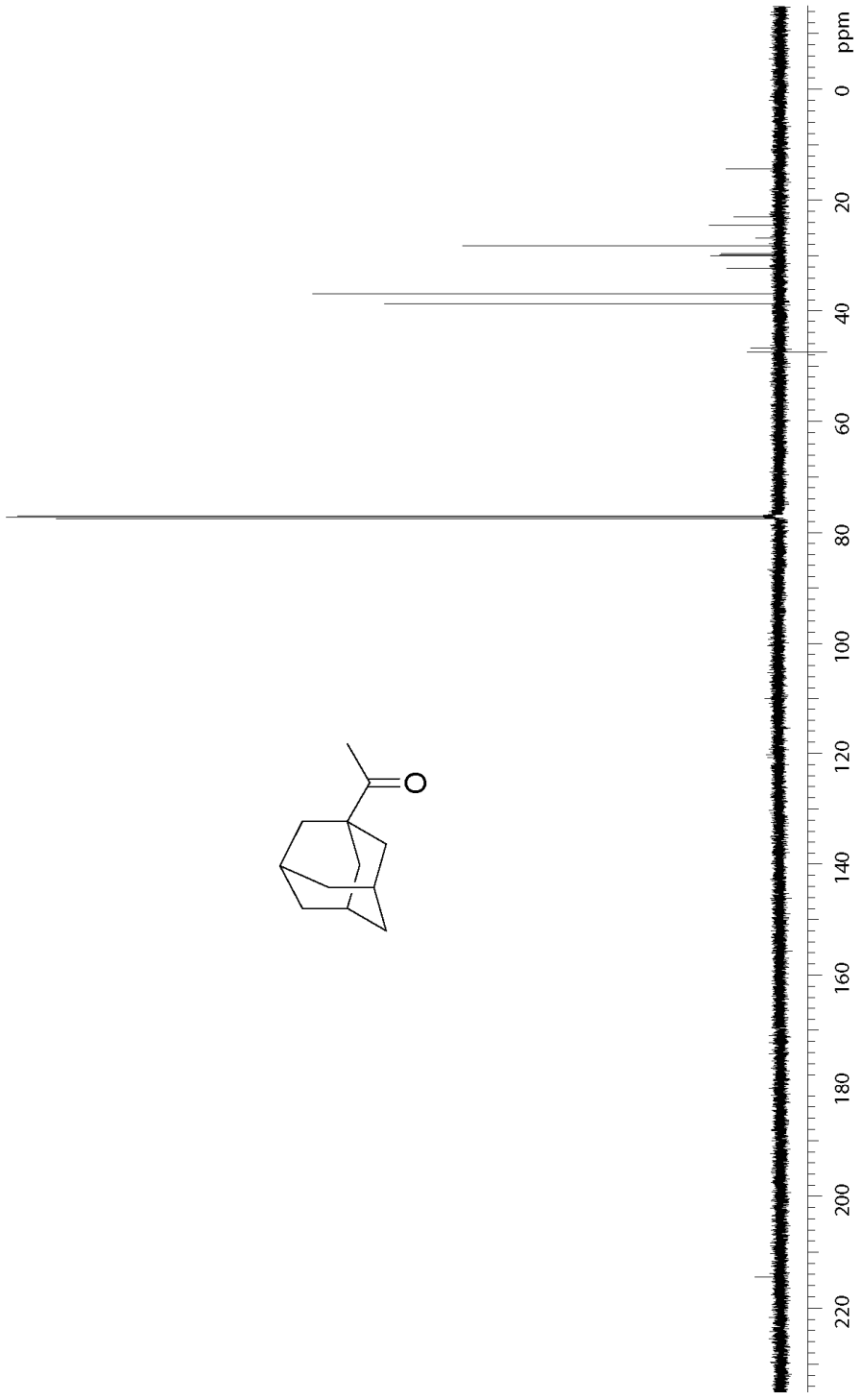
220
200
180
160
140
120
100
80
60
40
20
0
ppm


O
NO2
10
9
8
7
6
5
4
3
2
1
ppm
0.04
0.05
0.88
0.06
0.07
0.96
0.10
0.07
3.00


O
NO2
220
200
180
160
140
120
100
80
60
40
20
0
ppm


9
8
7
6
5
4
3
2
1
0
ppm


O
9
8
7
6
5
4
3
2
1
0
ppm


O
ppm
0
20
40
60
80
100
120
140
160
180
200
220

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