

Supporting Information

A Concise Formal Synthesis of Platencin

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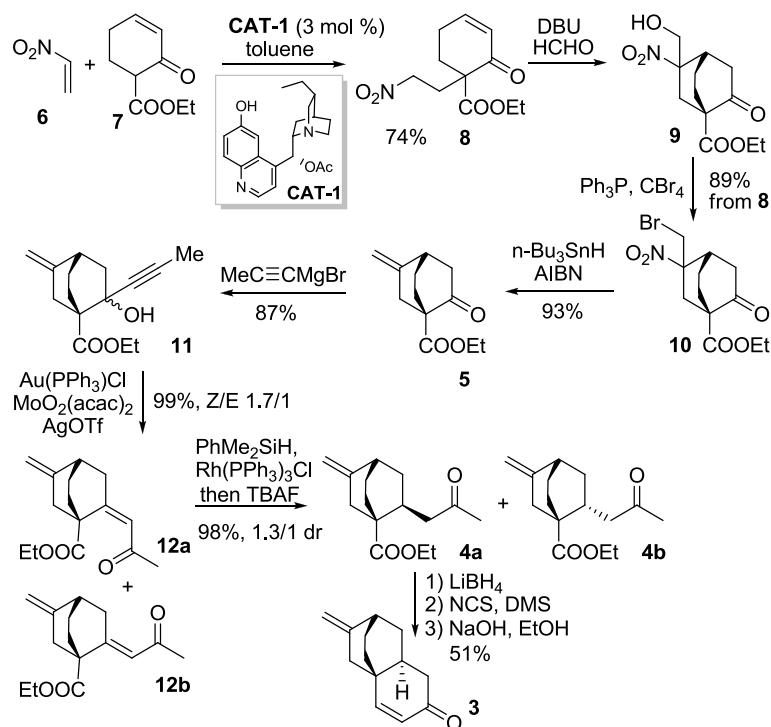
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General Information

All non-aqueous reactions were run under a positive pressure of nitrogen. Anhydrous solvents were obtained using standard drying techniques. Commercial grade reagents were used without further purification unless stated otherwise. Flash chromatography was performed on 300-400 mesh silica gel with the indicated solvent systems. ¹H NMR were recorded on a Bruker 400 (400 MHz) spectrometer and chemical shifts are reported in ppm down field from TMS, using TMS (0.00 ppm) or residual chloroform (7.26 ppm) as an internal standard. Data are reported as: (s = singlet, br = broad, d = doublet, t = triplet, q = quartet, quint = quintuplet, hept = heptalet, m = multiplet; *J* = coupling constant in Hz, integration.). ¹³C NMR spectra were recorded on a Bruker 400 (100 MHz) spectrometer, using proton decoupling unless otherwise noted. Chemical shifts are reported in ppm down field

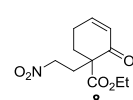
from TMS, using the central resonance of CDCl₃ (77.00 ppm) as the internal standard. [α]_D values were given in 10⁻¹ deg cm² g⁻¹. HRMS were recorded by using either FTMS-7 or IonSpec 4.7 spectrometers.

Formal Synthesis of Platencin



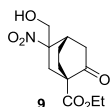
Compound 8

Ethyl 1-(2-nitroethyl)-2-oxocyclohex-3-enecarboxylate

 To a solution of 7 (1.32 g, 7.8 mmol) in PhMe (35 mL) was added CAT-1 (83 mg, 3 mol%) and the resulting suspension was allowed to stir vigorously at room temperature for 15 min. Nitroethylene 6 (2.0 M in PhMe, 7.8 mL, 2.0 equiv) dissolved in PhMe (10 mL) was added to the mixture at a rate of 4 mL/h by using a syringe pump. The resulting mixture was stirred at that temperature until 7 is consumed as indicated by TLC. Then, the reaction mixture was filtered through a pad of celite, evaporated in *vacuo* and purified by flash chromatography on silica gel (5:1 hexane/EtOAc) to give 8 (1.40 g, 74% yield). ¹H NMR (CDCl₃, 400 MHz) δ 6.96-6.93 (m, 1H), 6.08 (d, *J* = 10.2 Hz, 1H), 4.66 (ddd, *J* = 15.6, 8.9, 6.4 Hz, 1H), 4.52 (ddd, *J* = 14.6, 9.0, 6.0 Hz, 1H), 4.25-4.14 (m, 2H); 2.59-2.37 (m, 5H), 2.01-1.93 (m, 1H), 1.25 (t, *J* = 7.1 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 195.3, 170.6, 149.7, 128.9, 71.8, 62.0, 55.2, 31.5, 30.9, 23.5, 14.0; LRMS (ESI): 264.1 (M+Na)⁺; HRMS (ESI) calcd. for C₁₁H₁₅NO₅Na (M+Na)⁺: 264.0842, found: 264.0845; IR (KBr film): ν 2983, 2937, 1730, 1684, 1556, 1386, 1245, 1096, 1018 cm⁻¹.

Compound 9

Ethyl 5-(hydroxymethyl)-5-nitro-2-oxobicyclo[2.2.2]octane-1-carboxylate



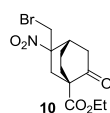
To a solution of **8** (1.06 g, 4.39 mmol) in CH₂Cl₂ (60 mL) was added DBU (33 μ L, 5 mol %) and the resulting mixture was allowed to stir at ambient temperature until completion of **8** as indicated by TLC (typically 3-5 hours). HCHO (33% aq., 1.3 mL, 3.0 equiv) was then added and the mixture was stirred for another 1 hour. The reaction was quenched by adding brine (20 mL) and HCl (1 M, 1.0 mL). The organic layer was separated and the aqueous layer was extracted with CH₂Cl₂ (10 mL $\times$ 3). The combined organic layers were dried over Na₂SO₄ and concentrated to give **9** as 1:1 mixture of two diastereoisomers, which was used directly in the next step without further purification. A small portion of **9** was purified by flash chromatography on silica gel (2:1 hexane/EtOAc) for analysis.

For diastereoisomer **9a**: ¹H NMR (CDCl₃, 400 MHz) δ 4.23 (q, J = 7.2 Hz, 2H), 4.00-3.92 (m, 2H), 3.23 (d, J = 16.0 Hz, 1H), 3.01-2.95 (m, 2H), 2.59 (dt, J = 19.5, 2.8 Hz, 1H), 2.43-2.35 (m, 2H), 2.33-2.25 (m, 1H), 2.06-1.99 (m, 1H), 1.80-1.65 (m, 2H), 1.29 (t, J = 7.1 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 207.2, 170.1, 93.5, 67.5, 61.7, 53.8, 40.1, 34.4, 32.2, 23.7, 21.1, 14.1; LRMS (ESI): 294.0 (M+Na)⁺; HRMS (ESI) calcd. for C₁₂H₁₈O₆Br (M+H)⁺: 272.1129, found: 272.1126; IR (KBr film): ν 3504, 2960, 1736, 1544, 1458, 1344, 1262, 1059 cm⁻¹.

For diastereoisomer **9b**: ¹H NMR (CDCl₃, 400 MHz) δ 4.24 (q, J = 7.2 Hz, 2H), 4.06-4.04 (m, 2H), 3.37 (dd, J = 16.0, 2.8 Hz, 1H), 3.00-2.99 (m, 1H), 2.93-2.90 (m, 1H), 2.40-2.26 (m, 3H), 2.07-1.99 (m, 2H), 1.90-1.78 (m, 2H), 1.30 (t, J = 7.0 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 206.6, 170.0, 93.3, 67.8, 61.7, 54.2, 40.6, 33.9, 33.2, 24.1, 21.0, 14.1; LRMS (ESI): 272.2 (M+H)⁺; HRMS (ESI) calcd. for C₁₂H₁₈O₆Br (M+H)⁺: 272.1129, found: 272.1126; IR (KBr film): ν 3501, 2963, 1739, 1543, 1346, 1263, 1072, 854 cm⁻¹.

Compound 10

Ethyl 5-(bromomethyl)-5-nitro-2-oxobicyclo[2.2.2]octane-1-carboxylate



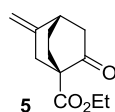
To a solution of crude **9** and PPh₃ (1.15 g, 1.0 equiv) in THF (15 mL) was added CBr₄ (1.45 g, 1.0 equiv) and the resulting mixture was allowed to stir at 60 °C for 1 hour. More PPh₃ (1.50 g, 1.3 equiv) and CBr₄ (1.89 g, 1.3 equiv) was added to the mixture in two portions with an interval of 1 hour. After completion of **9** as indicated by TLC, the reaction mixture was diluted with THF (50 mL), filtered through celite, concentrated in *vacuo* and purified by flash chromatography on silica gel (6:1 ~ 3:1 hexane/EtOAc) to give **10** (1.31 g, 89% yield from **8**) as 1:1 mixture of two diastereoisomers.

For diastereoisomer **10a**: ^1H NMR (CDCl_3 , 400 MHz) δ 4.23 (q, J = 7.2 Hz, 2H), 4.04 (d, J = 11.4 Hz, 1H), 3.71-3.67 (m, 1H), 3.36 (d, J = 16.4 Hz, 1H), 2.85-2.84 (m, 1H), 2.56-2.49 (m, 1H), 2.45-2.37 (m, 2H), 2.30-2.22 (m, 1H), 2.05-1.97 (m, 1H), 1.80-1.65 (m, 2H), 1.28 (t, J = 7.2 Hz, 3H); ^{13}C NMR (CDCl_3 , 100 MHz) δ 205.8, 169.4, 92.5, 61.7, 54.2, 40.0, 38.0, 37.5, 33.9, 22.9, 22.1, 14.1; LRMS (ESI): 334.0 ($\text{M}+\text{H}$) $^+$; HRMS (ESI) calcd. for $\text{C}_{12}\text{H}_{17}\text{O}_5\text{NBr}$ ($\text{M}+\text{H}$) $^+$: 334.0285, found: 334.0281; IR (KBr film): ν 2980, 1742, 1722, 1550, 1421, 1264, 1069, 1031, 851 cm^{-1} .

For diastereoisomer **10b**: ^1H NMR (CDCl_3 , 400 MHz) δ 4.25 (q, J = 7.2 Hz, 2H), 4.07 (AB, J_{AB} = 11.4 Hz, 1H), 3.84 (BA, J_{BA} = 11.3 Hz, 1H), 3.54 (dd, J = 16.0, 2.7 Hz, 1H), 2.91-2.88 (m, 1H), 2.43-2.26 (m, 3H), 2.16 (d, J = 16.4 Hz, 1H), 2.04-1.81 (m, 3H), 1.30 (t, J = 7.3 Hz, 3H); ^{13}C NMR (CDCl_3 , 100 MHz) δ 205.0, 169.4, 92.1, 61.8, 54.3, 40.6, 37.4, 37.1, 35.4, 24.1, 20.8, 14.1; LRMS (ESI): 356.0 ($\text{M}+\text{Na}$) $^+$; HRMS (ESI) calcd. for $\text{C}_{12}\text{H}_{17}\text{O}_5\text{NBr}$ ($\text{M}+\text{H}$) $^+$: 334.0285, found: 334.0281; IR (KBr film): ν 1717, 1549, 1418, 1348, 1259, 1119, 1074 cm^{-1} .

Compound 5

Ethyl 5-methylene-2-oxobicyclo[2.2.2]octane-1-carboxylate

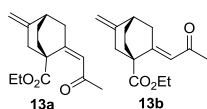


To a solution of **10** (990 mg, 2.96 mmol) and AIBN (97 mg, 20 mol %) in PhMe (15 mL) was added $n\text{-Bu}_3\text{SnH}$ (1.43 mL, 1.8 equiv). The resulting mixture was heated to 90 $^\circ\text{C}$ for 1 hour. After concentration in *vacuo*, the residue was purified by flash chromatography on silica gel (20:1 hexane/EtOAc) to give **5** (574 mg, 93% yield) as a white solid. m.p.: 49-50 $^\circ\text{C}$; ^1H NMR (CDCl_3 , 400 MHz) δ 4.89 (s, 1H), 4.74 (s, 1H), 4.15 (q, J = 7.2 Hz, 2H), 2.96-2.93 (m, 1H), 2.67-2.66 (m, 1H), 2.61-2.56 (m, 1H), 2.34-2.33 (m, 2H), 2.31-2.23 (m, 1H), 1.91-1.69 (m, 3H), 1.21 (t, J = 7.0 Hz, 3H); ^{13}C NMR (CDCl_3 , 100 MHz) δ 209.5, 171.0, 145.7, 108.3, 61.1, 56.1, 44.3, 38.3, 34.5, 25.6, 25.4, 14.1; LRMS (ESI): 231.0 ($\text{M}+\text{Na}$) $^+$; HRMS (ESI) calcd. for $\text{C}_{12}\text{H}_{17}\text{O}_3$ ($\text{M}+\text{H}$) $^+$: 209.1172, found: 209.1171; IR (KBr film): ν 2940, 1740, 1719, 1296, 1247, 1062, 1046 cm^{-1} .

Compound 12

(Z)-ethyl 5-methylene-2-(2-oxopropylidene)bicyclo[2.2.2]octane-1-carboxylate (**12a**);

(E)-ethyl 5-methylene-2-(2-oxopropylidene)bicyclo[2.2.2]octane-1-carboxylate (**12b**)



To a solution of **5** (144 mg, 0.69 mmol) in THF (5 mL) at -78 $^\circ\text{C}$ was added $\text{CH}_3\text{C}\equiv\text{CMgBr}$ (0.5 M in THF, 1.66 mL, 1.2 equiv) dropwise. The resulting mixture was allowed to stir for 5 hour at -30 $^\circ\text{C}$ before being quenched with saturated aqueous NH_4Cl . The organic layer was separated and the aqueous layer was extracted with CH_2Cl_2 (10 mL $\times$ 3). The combined organic layers were dried over Na_2SO_4 ,

concentrated, and purified by flash chromatography on silica gel (20:1 hexane/EtOAc) to give the corresponding propargyl alcohol **11** (150 mg, 87% yield) as 3/2 mixture of two diastereoisomers. To a solution of **11** (420 mg, 1.69 mmol) in CH₂Cl₂ (20 mL) at room temperature was added MoO₂(acac)₂ (11.0 mg, 2 mol%), Au(PPh₃)Cl (16.7 mg, 2 mol%) and AgOTf (8.7 mg, 2 mol%) successively. The resulting mixture was allowed to stir at ambient temperature until completion as indicated by TLC. Saturated aqueous NH₄Cl was added to quench the reaction. The organic layer was separated and the aqueous layer was extracted with CH₂Cl₂ (15 mL × 3). The combined organic layers were dried over Na₂SO₄, concentrated, and purified by flash chromatography on silica gel (20:1~10:1 hexane/EtOAc) to give **12a** (262 mg, 62% yield) and **12b** (156 mg, 37% yield). The configuration of **12a/12b** was confirmed by 2D NOE spectra.

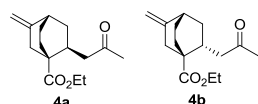
Note: This reaction could also be conducted in PhMe with 1 mol % catalyst and gave quantitative combined yields with 2~3:1 ratio of **12b/12a**.

For **12a**: ¹H NMR (CDCl₃, 400 MHz) δ 6.07 (br s, 1H), 4.82 (br s, 1H), 4.69 (br s, 1H), 4.07 (q, *J* = 7.1 Hz, 2H), 2.75-2.71 (m, 1H), 2.56-2.52 (m, 1H), 2.49-2.45 (m, 3H), 2.13 (s, 3H), 2.10-2.02 (m, 1H), 1.87-1.80 (m, 1H), 1.74-1.65 (m, 2H), 1.23 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 198.7, 173.4, 154.6, 147.8, 124.3, 106.8, 60.2, 47.8, 38.4, 37.6, 36.6, 30.6, 28.5, 25.9, 14.1; LRMS (ESI): 271.1 (M+Na)⁺; HRMS (ESI) calcd. for C₁₅H₂₀NaO₃ (M+Na)⁺: 271.1305, found: 271.1307; IR (KBr film): ν 2939, 1733, 1693, 1623, 1242, 1192, 1070, 1044 cm⁻¹.

For **12b**: ¹H NMR (CDCl₃, 400 MHz) δ 5.88 (br t, *J* = 2.3 Hz, 1H), 4.85 (m, 1H), 4.69 (m, 1H), 4.25 (q, *J* = 7.1 Hz, 2H), 2.98-2.91 (m, 1H), 2.88-2.77 (m, 2H), 2.59-2.55 (m, 1H), 2.51-2.50 (m, 1H), 2.17 (s, 3H), 2.15-2.09 (m, 1H), 1.86-1.78 (m, 1H), 1.76-1.66 (m, 2H), 1.32 (t, *J* = 7.2 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 198.1, 173.6, 162.3, 147.7, 119.1, 106.7, 60.9, 49.9, 37.2, 37.0, 36.4, 31.8, 28.1, 25.7, 14.2; LRMS (ESI): 271.0 (M+Na)⁺; HRMS (ESI) calcd. for C₁₅H₂₀NaO₃ (M+Na)⁺: 271.1305, found: 271.1307; IR (KBr film): ν 2936, 1731, 1689, 1607, 1245, 1192, 1066, 1046 cm⁻¹.

Compound 4

Ethyl 5-methylene-2-(2-oxopropyl)bicyclo[2.2.2]octane-1-carboxylate



To a solution of **12a** (138 mg, 0.56 mmol) and Rh(PPh₃)₃Cl (10.3 mg, 2 mol %) in PhMe (8 mL) was added PhMe₂SiH (101 μL, 1.2 equiv) and the resulting mixture was allowed to stir at 60 °C for 30 min. More PhMe₂SiH (50 μL, 0.6 equiv) was added and the mixture was stirred for another 1.5 hours before being cooled to room temperature. The reaction mixture was filtered through a pad of silica gel and washed with EtOAc to remove the rhodium catalyst. The filtrate was evaporated *in vacuo* and taken up in THF (5 mL) before being treated with TBAF (1.0 M in THF, 1.0

mL). After been stirred at room temperature for 1 hour, the reaction mixture was evaporated in *vacuo* and purified by flash chromatography on silica gel (20:1 hexane/EtOAc) to give a 1.3/1 mixture of **4a** and **4b** (136 mg, 98% combined yield) as colorless oil. The two diastereoisomers can be separated by careful chromatography on silica gel (35:1 hexane/EtOAc).

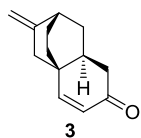
Note: The other substrate **12b** could also undergo conjugate reduction with the same reagents but at an elevated temperature of 115 °C to give ~70% combined yield of **4a/4b** along with ~20% yield of 1,2-reduction products, which could be reused after DMP oxidation to give **12b**.

For **4a**: ^1H NMR (CDCl_3 , 400 MHz) δ 4.79 (m, 1H), 4.67-4.66 (m, 1H), 4.10 (q, $J = 7.1$ Hz, 2H), 2.68-2.62 (m, 1H), 2.54-2.37 (m, 4H), 2.25-2.22 (m, 1H), 2.13 (s, 3H), 2.05-1.99 (m, 1H), 1.95-1.87 (m, 1H), 1.71-1.59 (m, 3H), 1.24 (t, $J = 7.0$ Hz, 3H), 1.13 (ddd, $J = 8.1, 5.6, 2.6$ Hz, 1H); ^{13}C NMR (CDCl_3 , 100 MHz) δ 207.6, 176.0, 148.9, 106.2, 60.5, 48.1, 44.2, 39.5, 35.7, 34.3, 33.8, 30.1, 26.0, 22.4, 14.2; LRMS (ESI): 273.1 ($\text{M}+\text{Na}$) $^+$; HRMS (ESI) calcd. for $\text{C}_{15}\text{H}_{22}\text{NaO}_3$ ($\text{M}+\text{Na}$) $^+$: 273.1461, found: 273.1457; IR (KBr film): ν 2928, 1721, 1368, 1239, 1158, 1059, 879 cm^{-1} .

For **4b**: ^1H NMR (CDCl_3 , 400 MHz) δ 4.77 (s, 1H), 4.67 (s, 1H), 4.11 (q, $J = 7.1$ Hz, 2H), 2.66-2.54 (m, 2H), 2.45-2.36 (m, 3H), 2.24 (m, 1H), 2.13-2.03 (m, 1H), 2.11 (s, 3H), 1.97-1.91 (m, 1H), 1.74-1.61 (m, 3H), 1.24 (t, $J = 7.2$ Hz, 3H), 1.13-1.10 (m, 1H); ^{13}C NMR (CDCl_3 , 100 MHz) δ 207.6, 176.2, 149.4, 106.0, 60.4, 47.8, 43.9, 35.6, 34.5, 33.3, 32.1, 30.5, 30.3, 25.3, 14.2; LRMS (ESI): 273.2 ($\text{M}+\text{Na}$) $^+$; HRMS (ESI) calcd. for $\text{C}_{15}\text{H}_{22}\text{NaO}_3$ ($\text{M}+\text{Na}$) $^+$: 273.1461, found: 273.1466; IR (KBr film): ν 2931, 1722, 1365, 1242, 1068, 1039, 876 cm^{-1} .

Compound 3

(1R,2R,4R,6S)-3-methylene-6-(2-oxopropyl)-2-phenylbicyclo[2.2.2]octane-1-carbaldehyde



To a solution of **4a** (56 mg, 0.22 mmol) in THF (5 mL) at 0 °C was added LiAlH_4 (21 mg, 2.5 equiv) in one portion. The resulting suspension was allowed to stir at that temperature for 30 min before being quenched with saturated aqueous NaHCO_3 . After filtration, the organic layer was separated and the aqueous layer was extracted with CH_2Cl_2 (15 mL $\times$ 3). The combined organic layers were dried over Na_2SO_4 , concentrated and purified by flash chromatography on silica gel (1:1 hexane/EtOAc) to give the corresponding diol (41 mg, 87% yield) as viscous oil.

To a solution of NCS (254 mg, 10.0 equiv) in CH_2Cl_2 (8 mL) at -20 °C was added Me_2S (0.14 mL, 10.0 eq) dropwise. After 30 min, a solution of the diol (40 mg, 0.19 mmol) in CH_2Cl_2 (3 mL) was added in. The mixture was kept stirring at -20 °C for 2 hours before Et_3N (0.40 mL, 15.0 equiv) was added. The mixture was allowed to warm up to room temperature and stir for

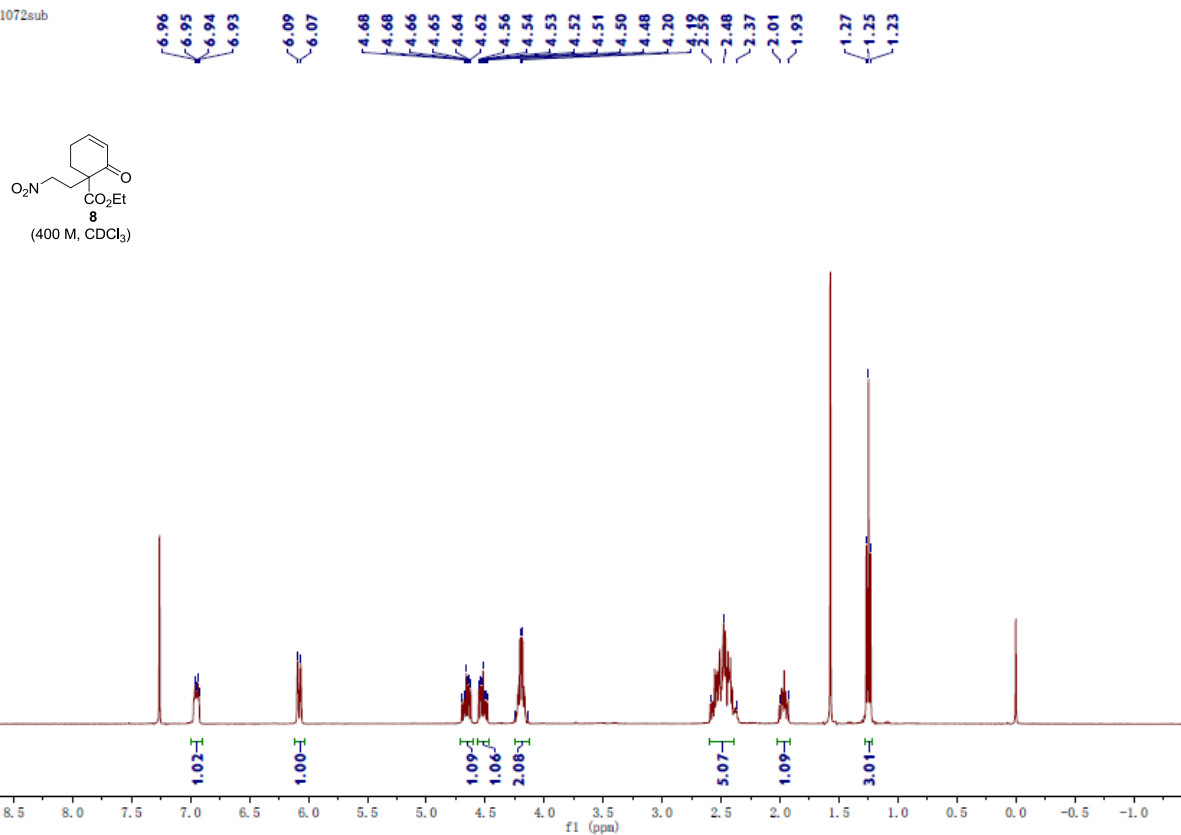
another 30 min before being quenched with brine. The organic layer was separated and the aqueous layer was extracted with CH₂Cl₂ (10 mL × 3). The combined organic layers were dried over Na₂SO₄, concentrated and purified by flash chromatography on silica gel (15:1 hexane/EtOAc) to give the corresponding ketoaldehyde (24 mg, 61% yield).

To a solution of the ketoaldehyde (8.0 mg, 39 μmol) in EtOH (4 mL) was added NaOH (20 mg in 1 mL EtOH) at room temperature. The resulting solution was allowed to stir overnight before being quenched with saturated NH₄Cl (20 mL). The organic layer was separated and the aqueous layer was extracted with CH₂Cl₂ (15 mL × 3). The combined organic layers were dried over Na₂SO₄, concentrated, and purified by flash chromatography on silica gel (25:1 hexane/EtOAc) to give **3** (7.0 mg, 96% yield). ¹H NMR (CDCl₃, 400 MHz) δ 6.56 (d, *J* = 10.0 Hz, 1H), 5.87 (d, *J* = 10.0 Hz, 1H), 4.83 (s, 1H), 4.69 (s, 1H), 2.49–2.40 (m, 2H), 2.36–2.29 (m, 2H), 2.19–2.08 (m, 2H), 2.03–1.97 (m, 1H), 1.82–1.70 (m, 3H), 1.53–1.48 (m, 1H), 1.21 (dd, *J* = 12.4, 7.6 Hz, 1H); ¹³C NMR (CDCl₃, 100 MHz) δ 200.0, 156.6, 148.9, 127.8, 106.9, 41.7, 41.0, 36.1, 35.61, 35.56, 35.0, 26.5, 24.6.

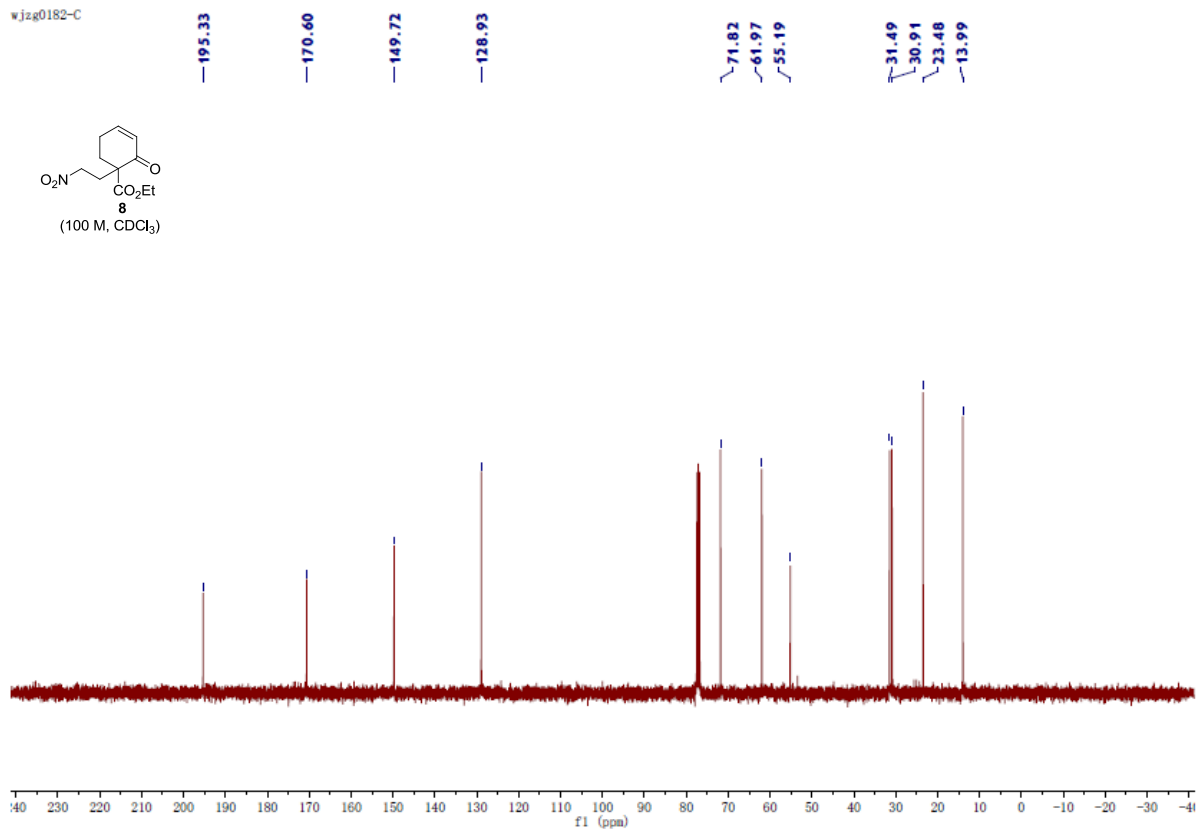
Spectral Data

Compound 8

1072sub

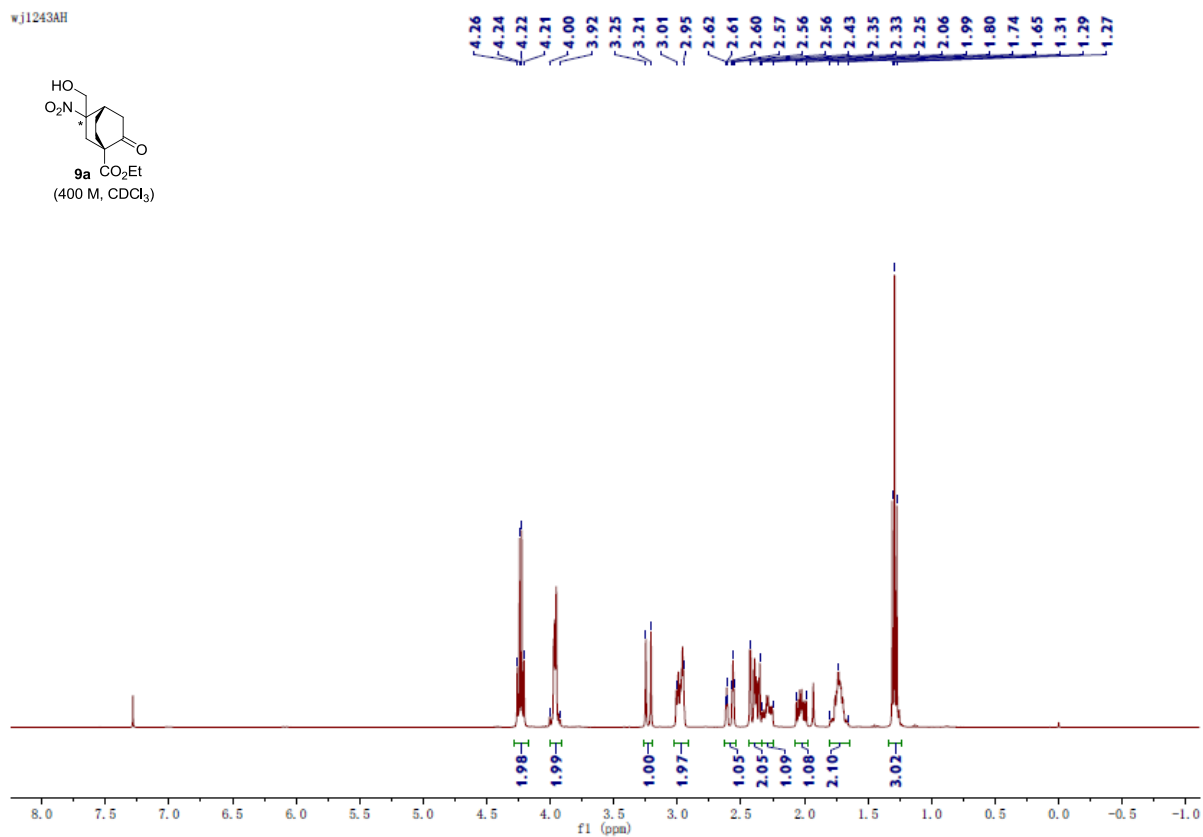
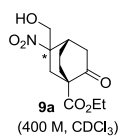


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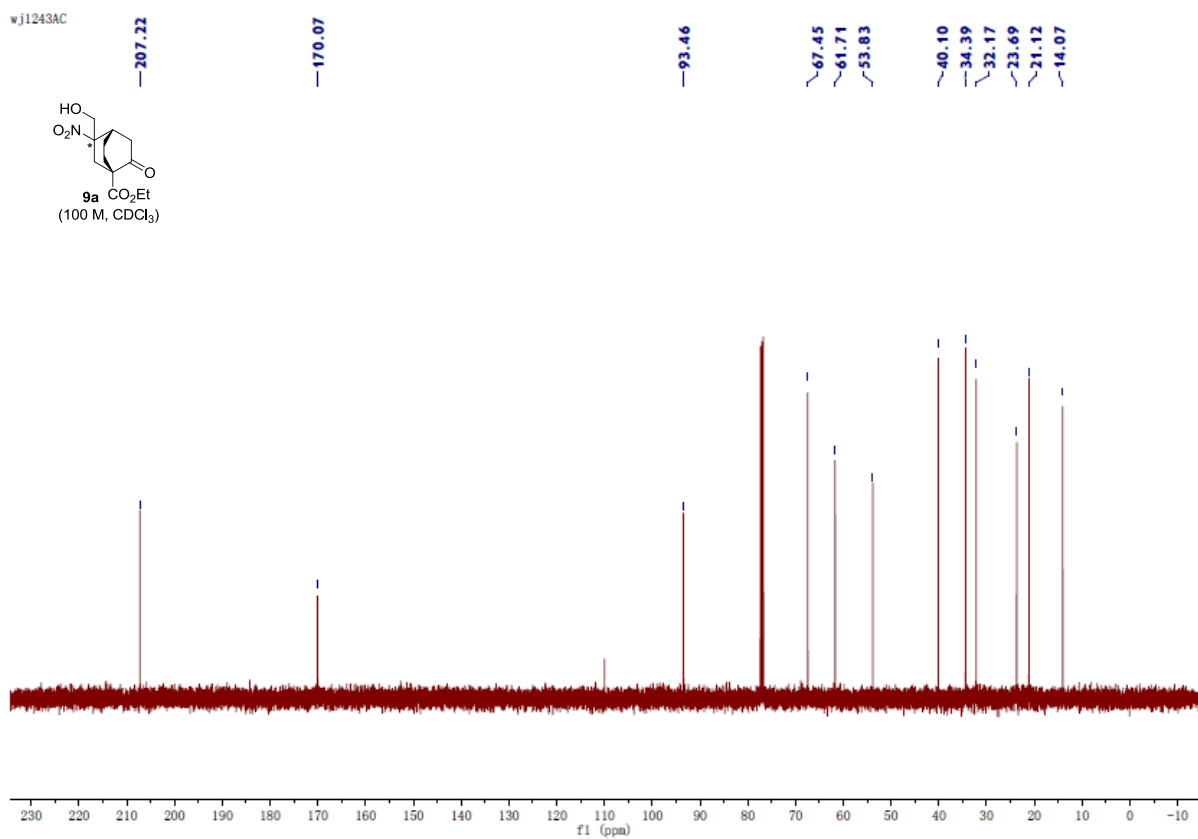
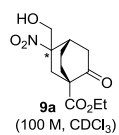


Compound 9a

wj1243AH

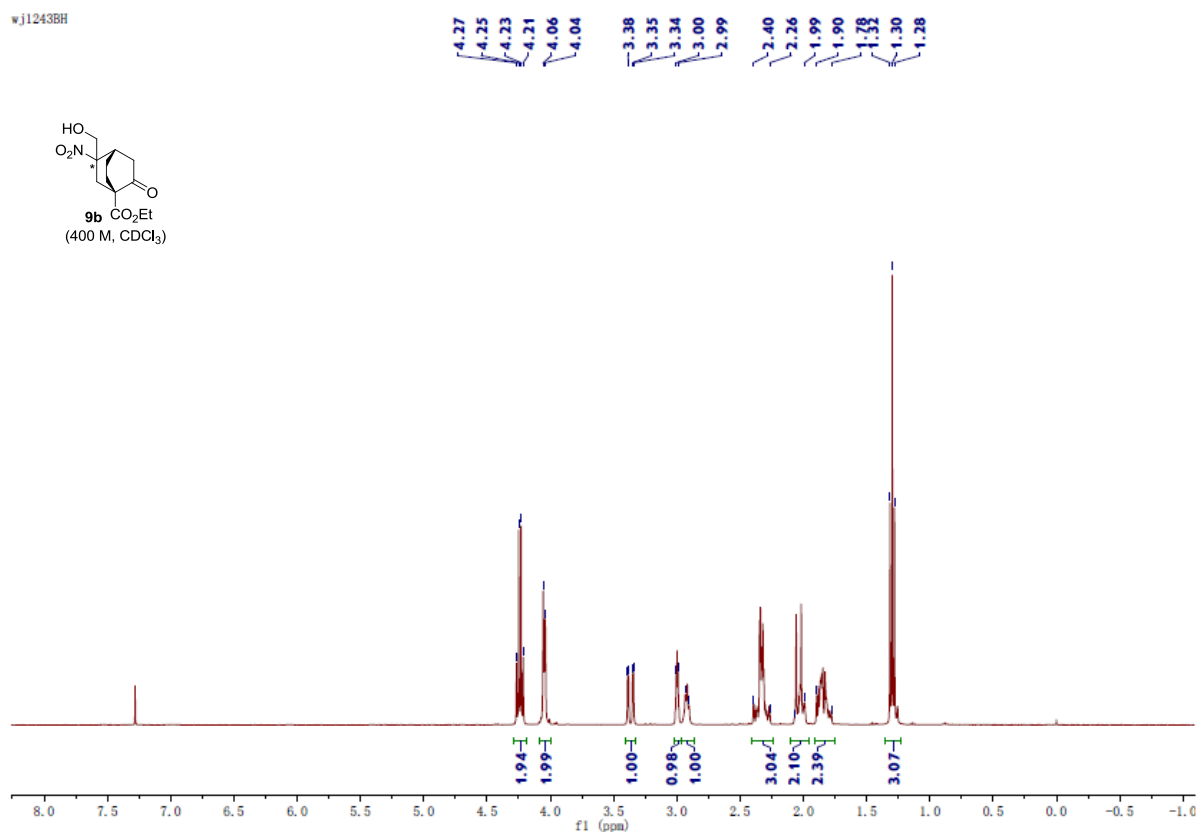
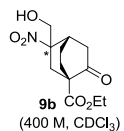


wj1243AC

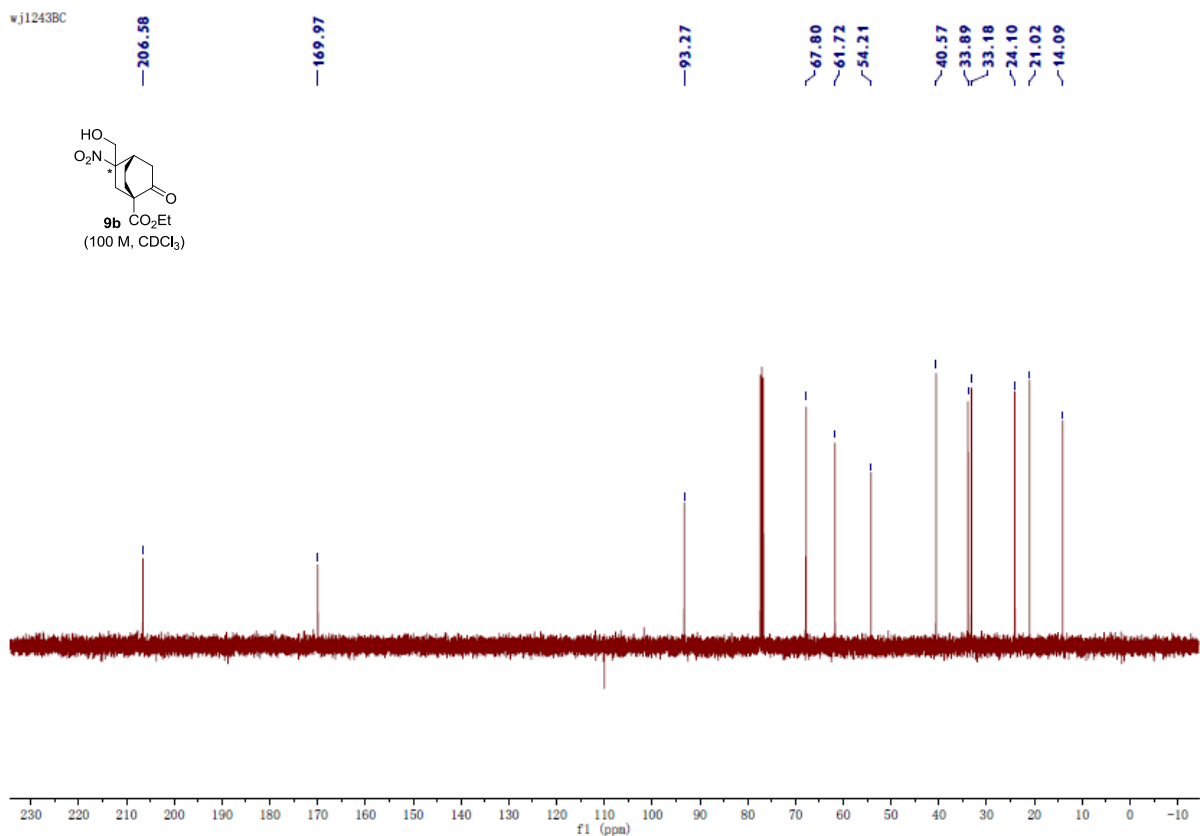
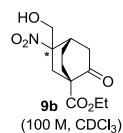


Compound 9b

wj1243BH

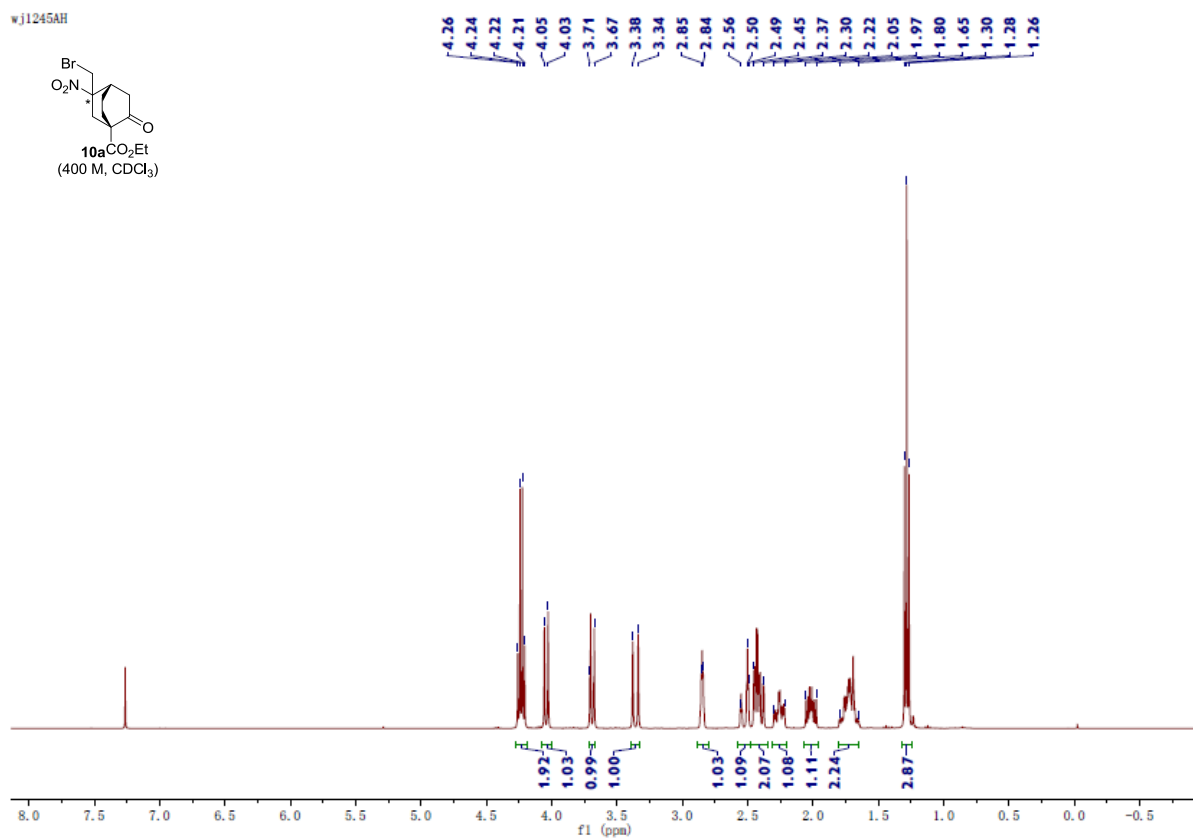
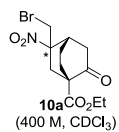


wj1243BC

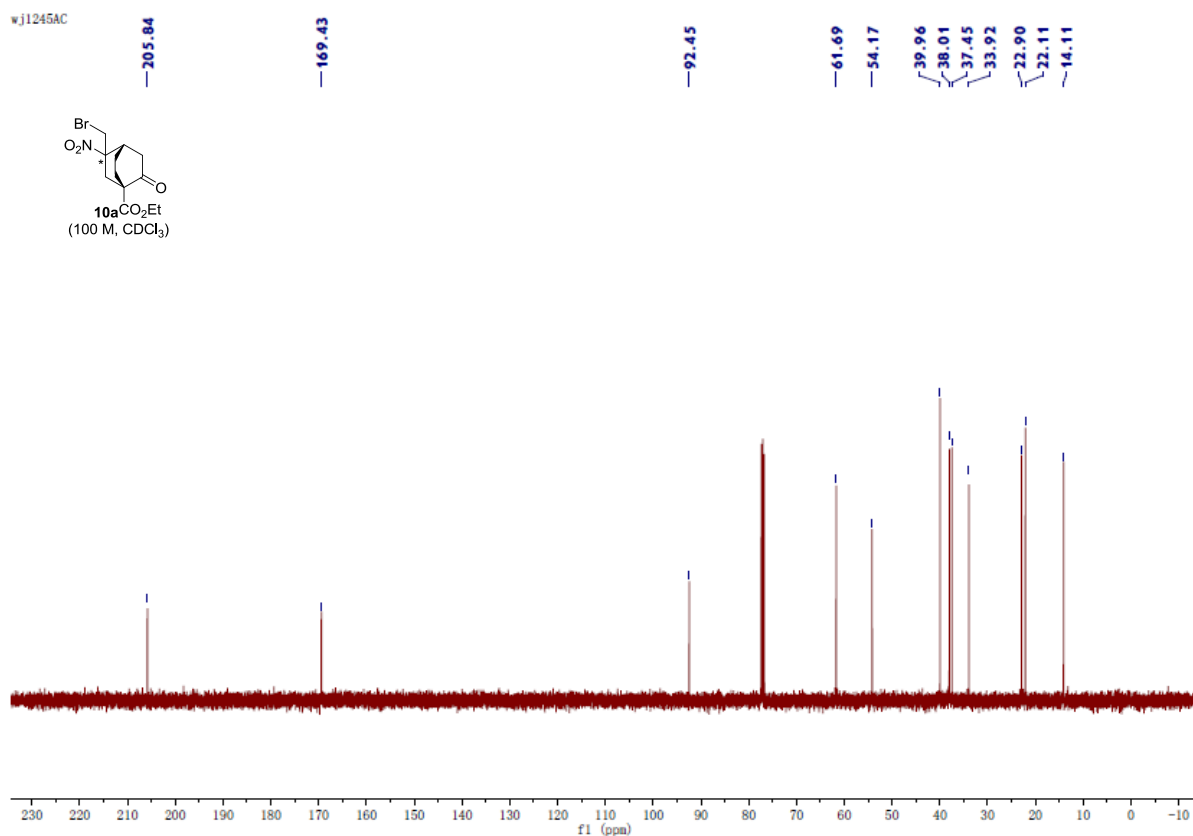
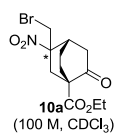


Compound 10a

wj1245AH

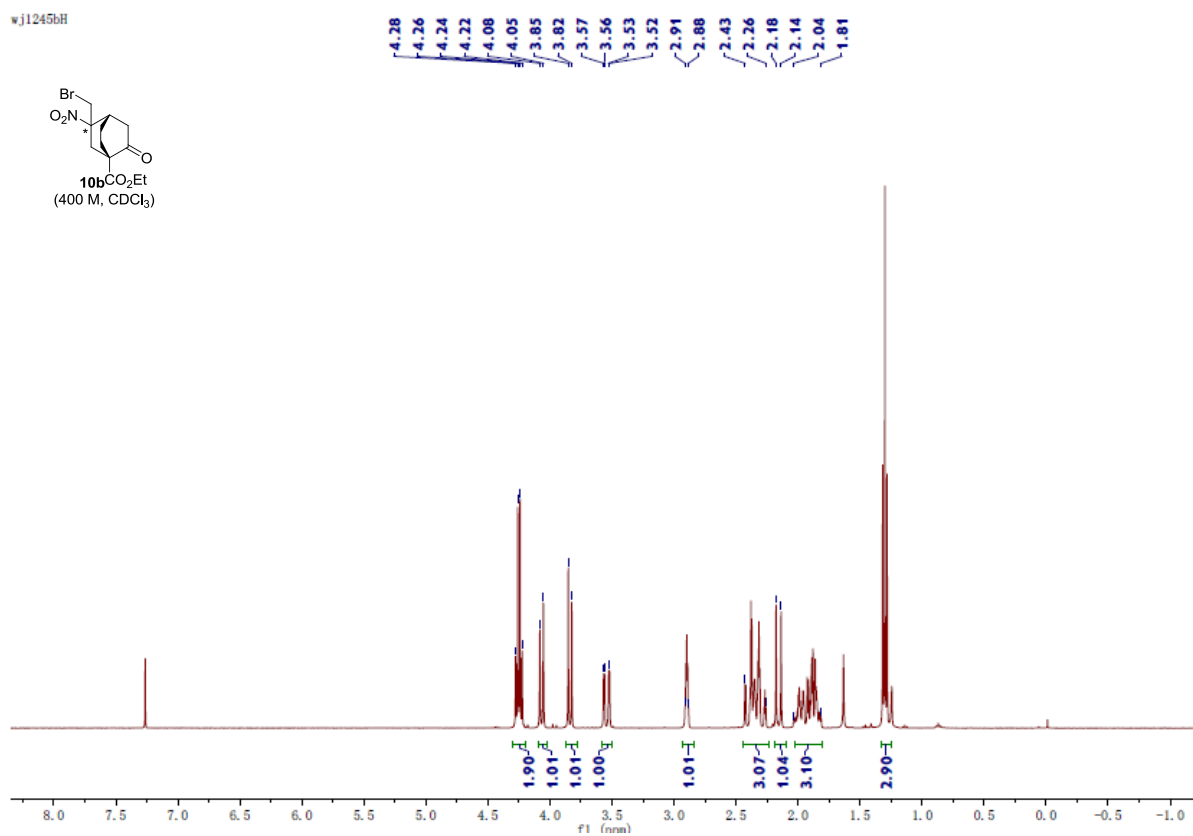
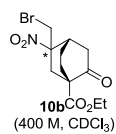


wj1245AC

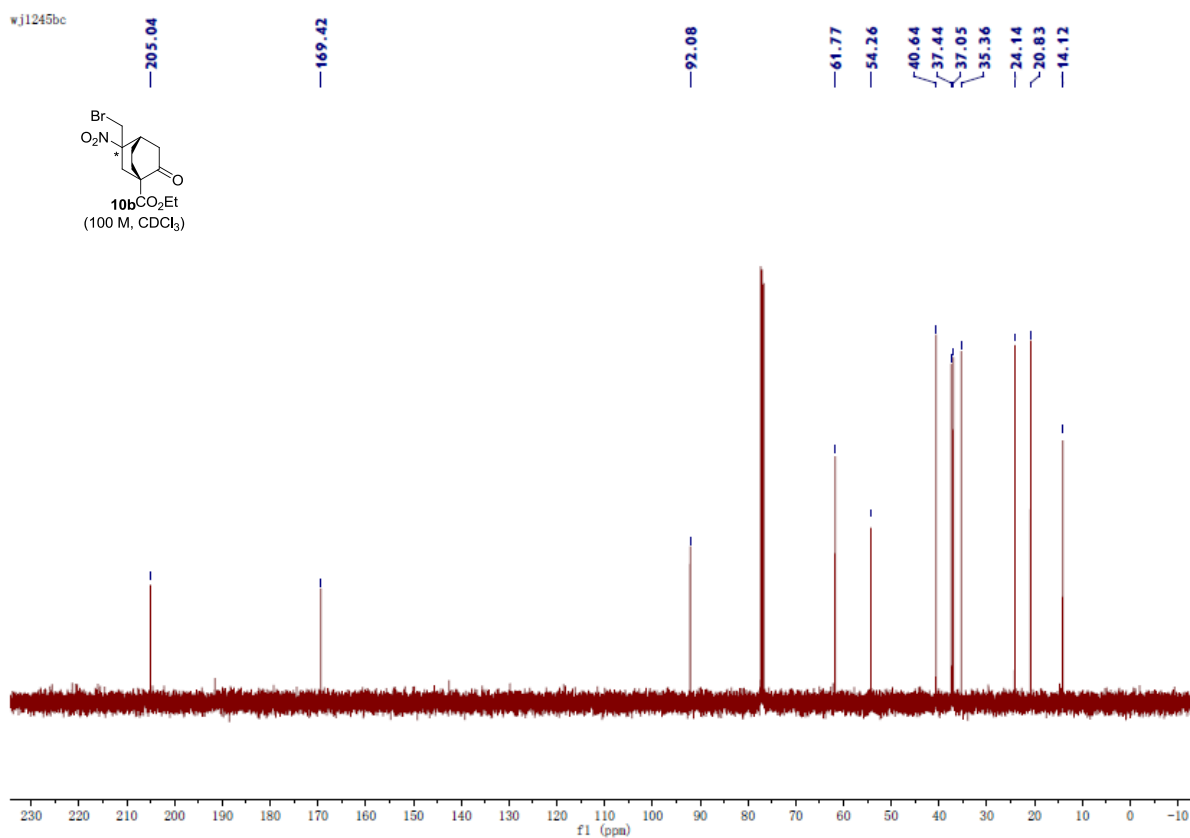
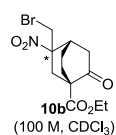


Compound 10b

wj1245bH

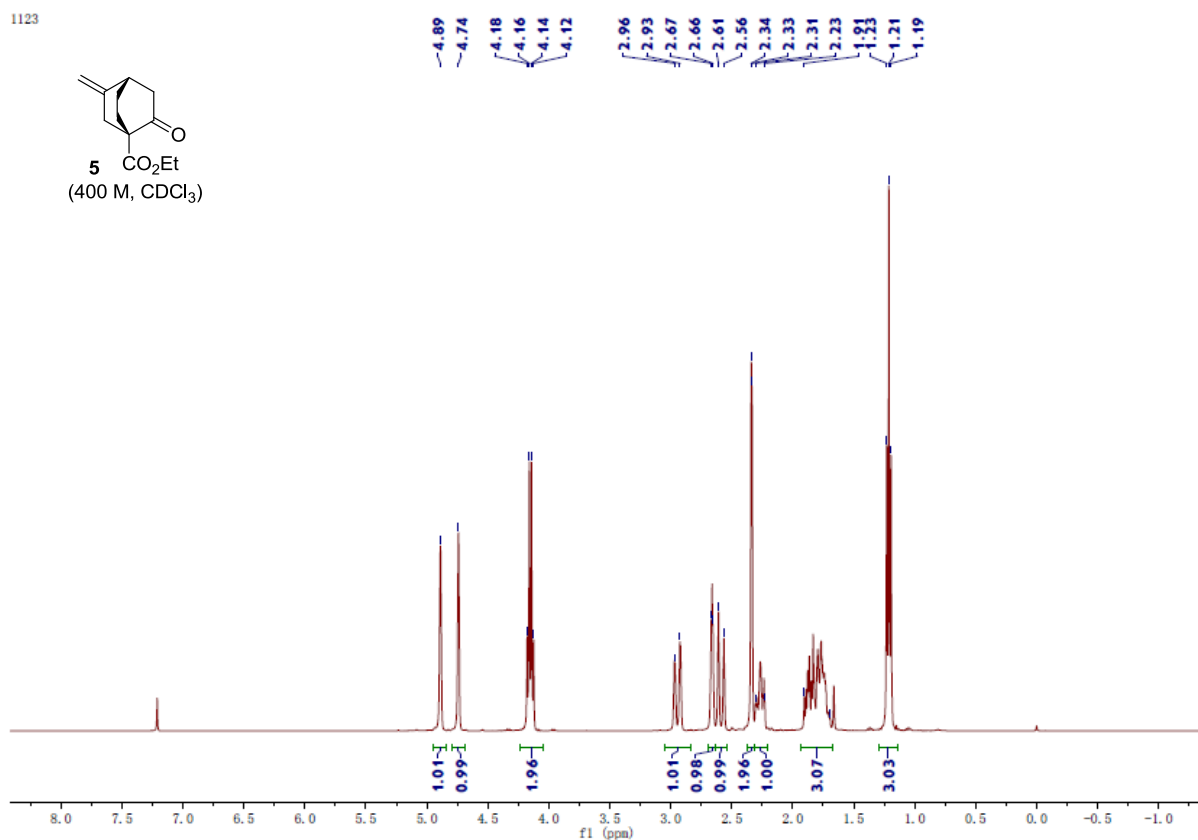
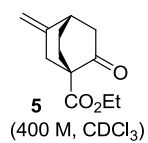


wj1245bc

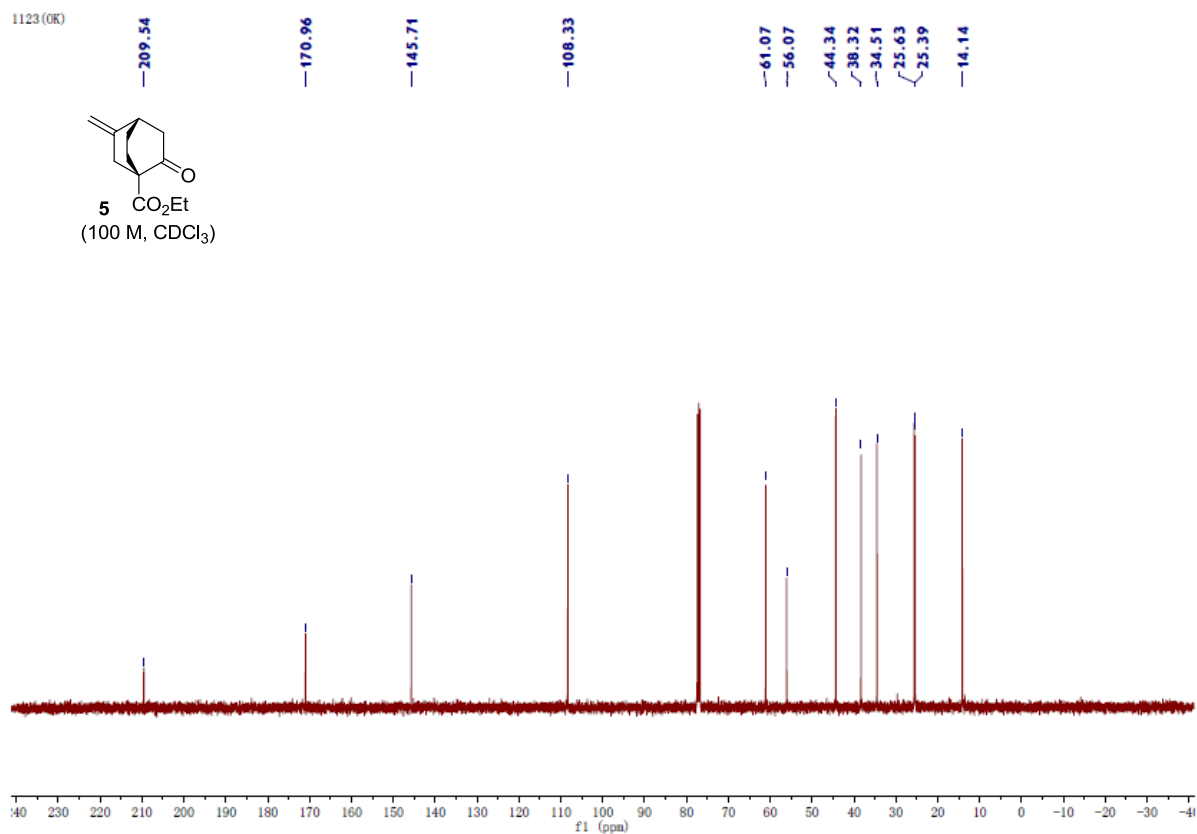
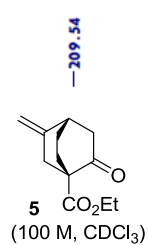


Compound 5

1123

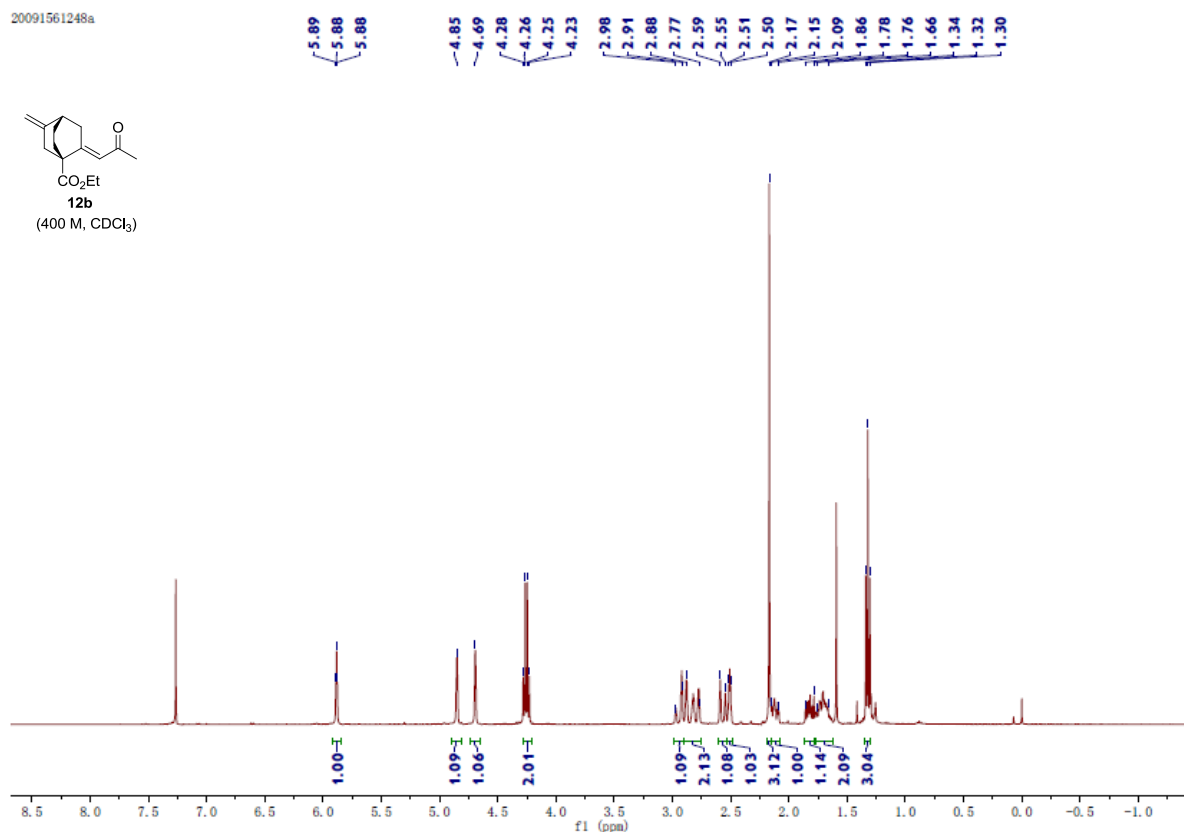
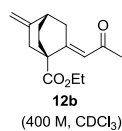


1123 (OK)

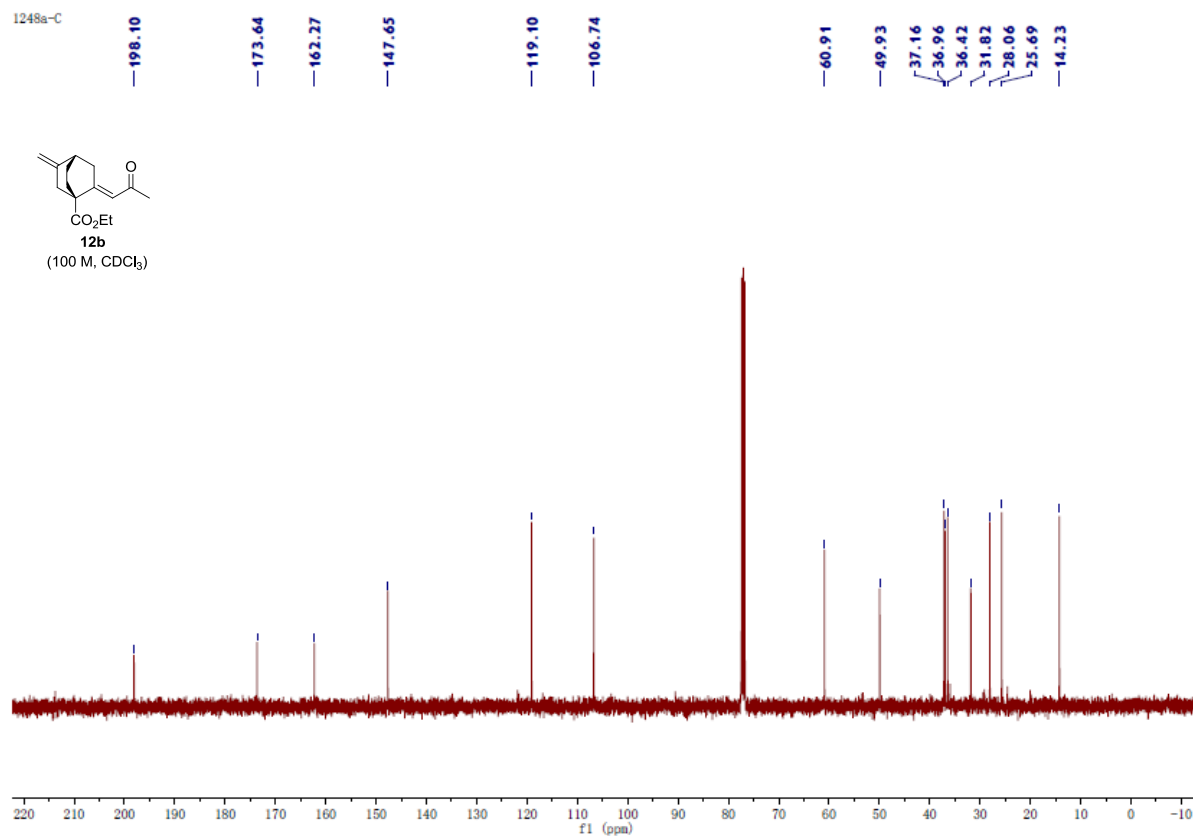
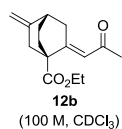


Compound 12b

20091561248a

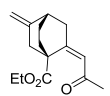


1248a-C

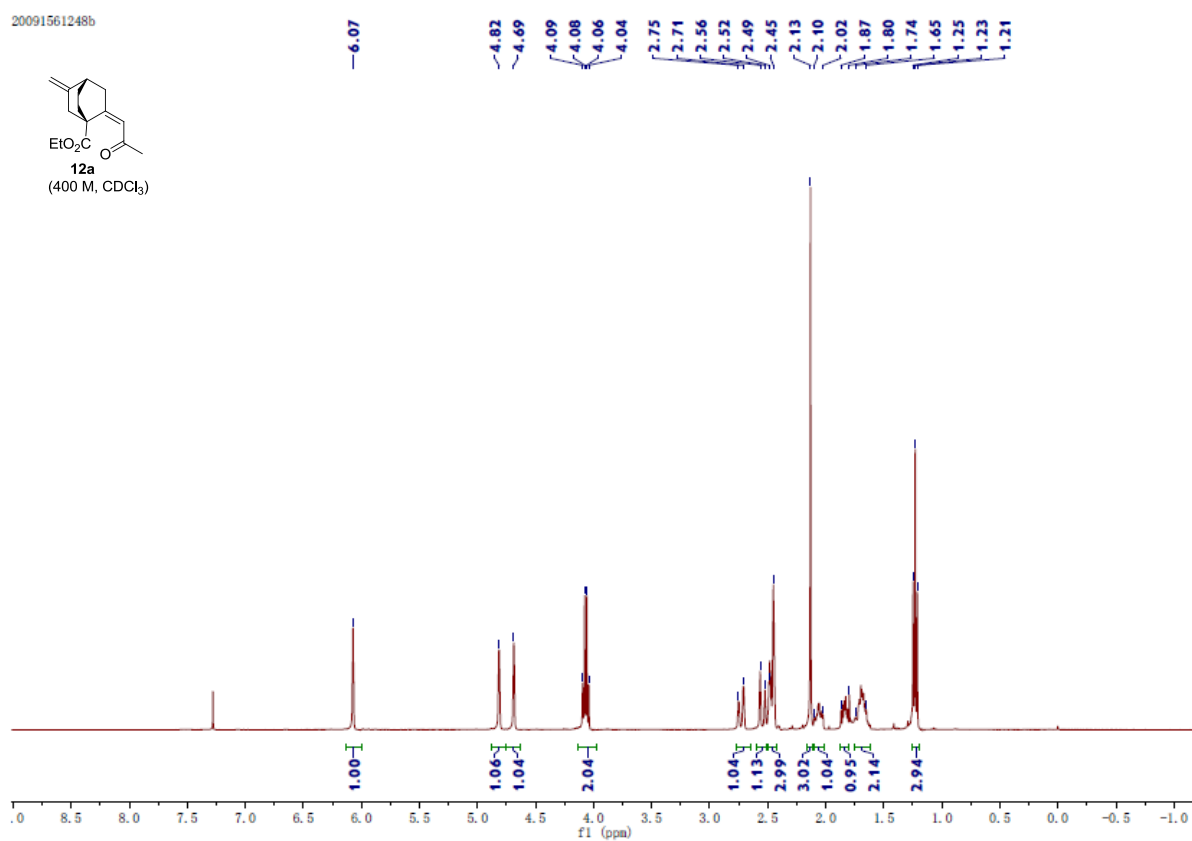


Compound 12a

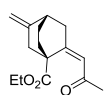
20091561248b



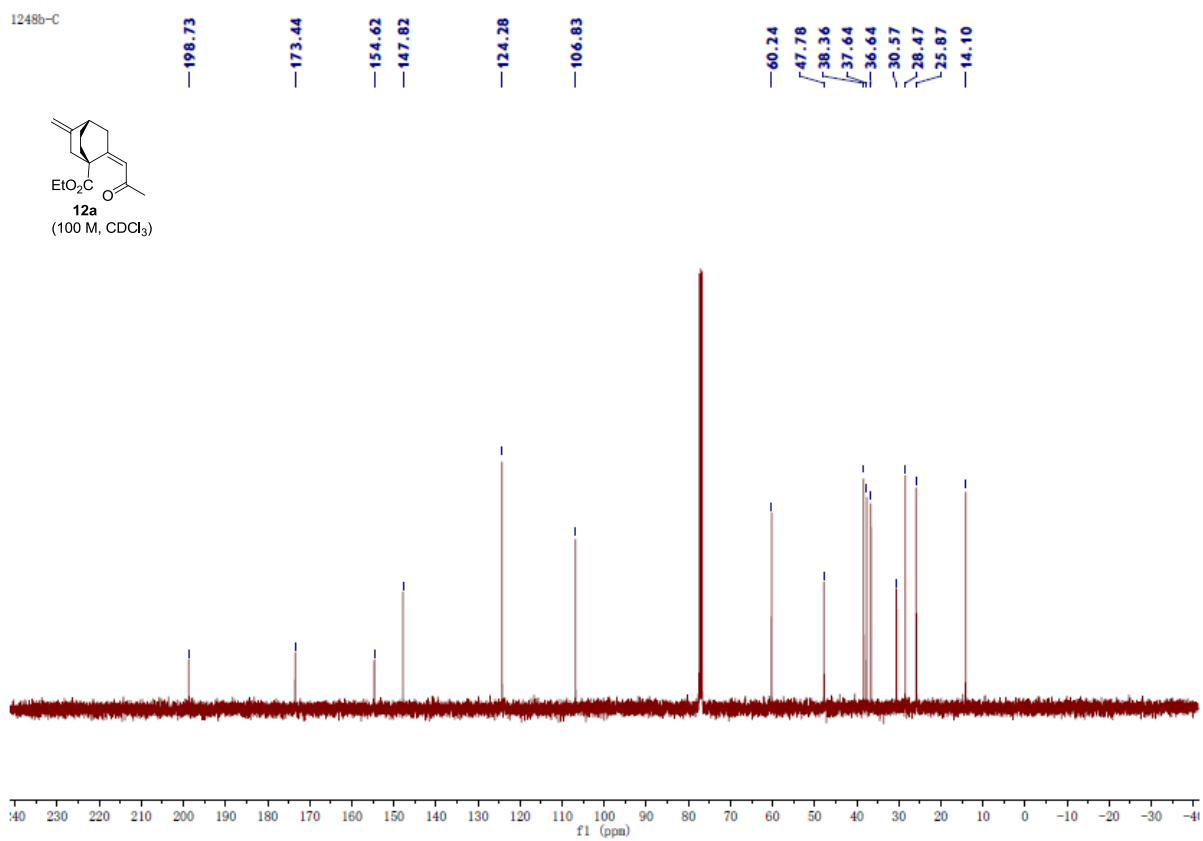
12a
(400 M, CDCl₃)



1248b-C

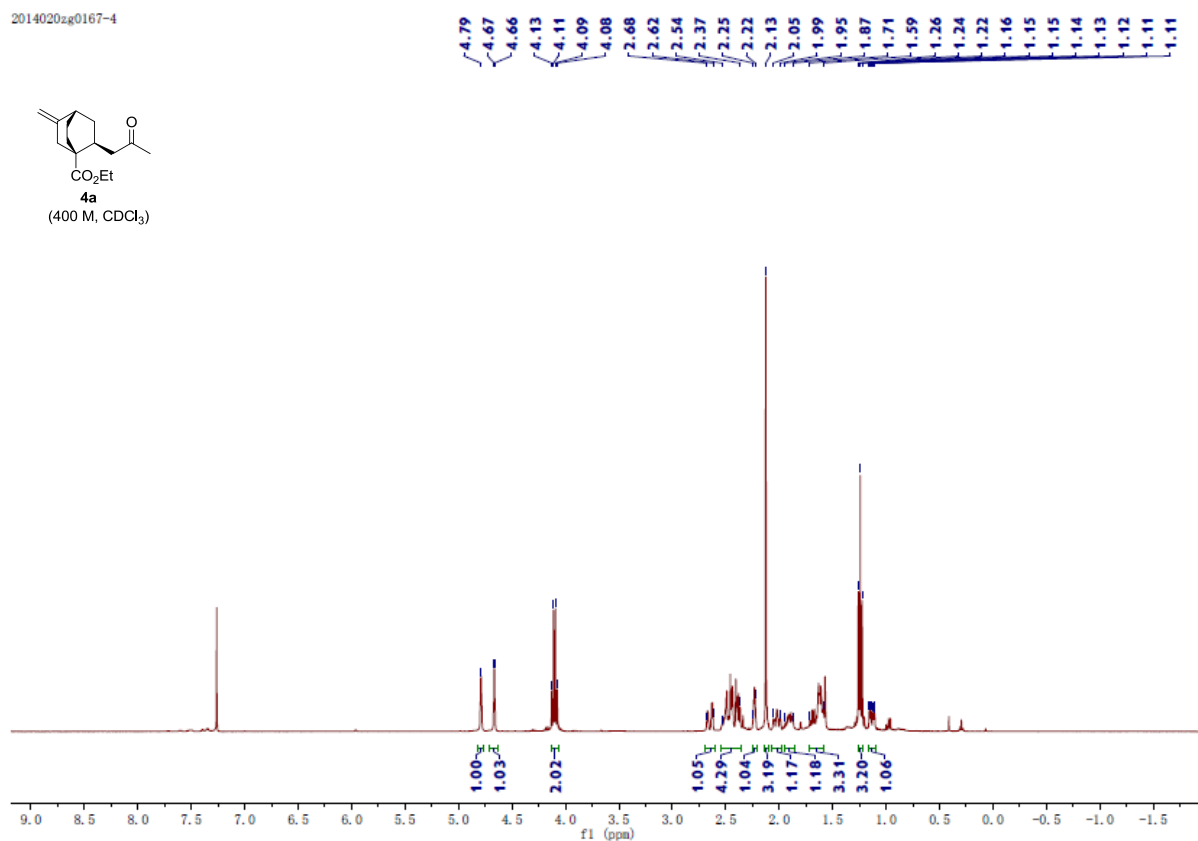
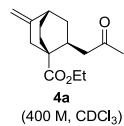


12a
(100 M, CDCl₃)

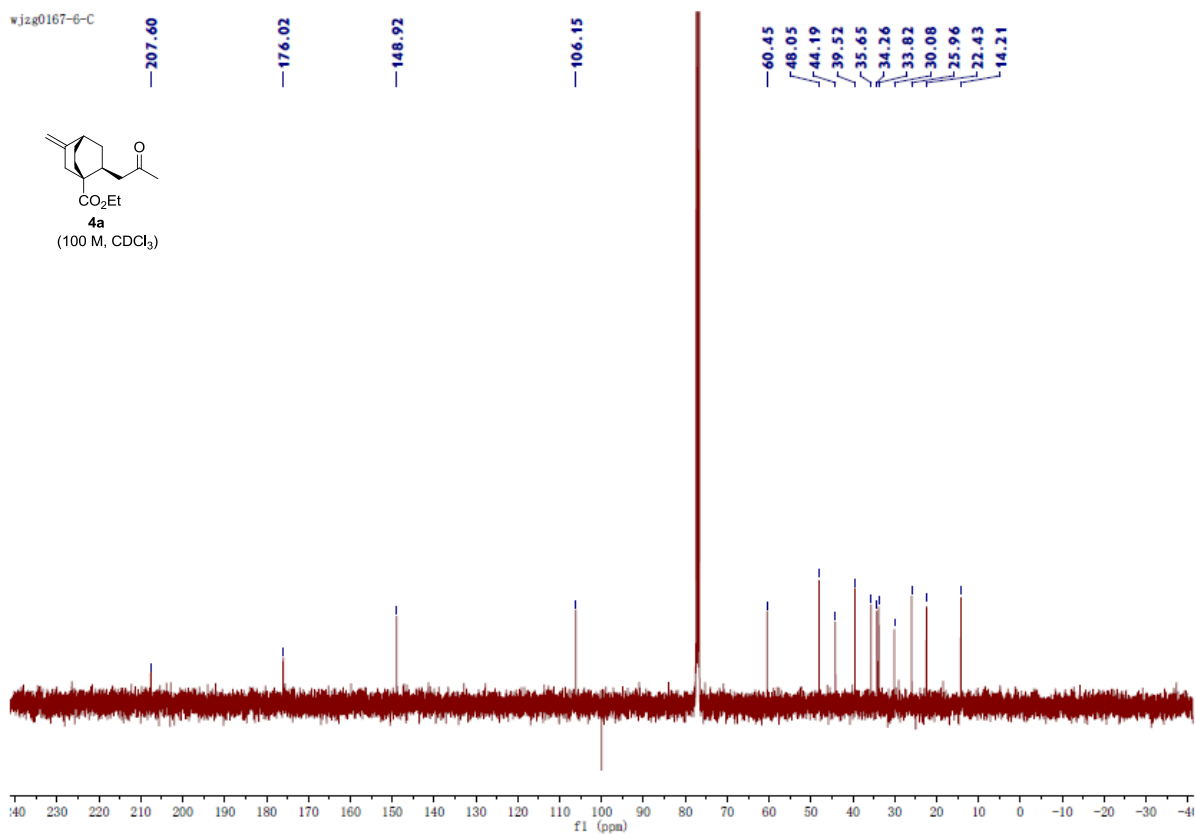
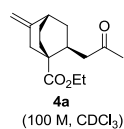


Compound 4a

2014020zg0167-4

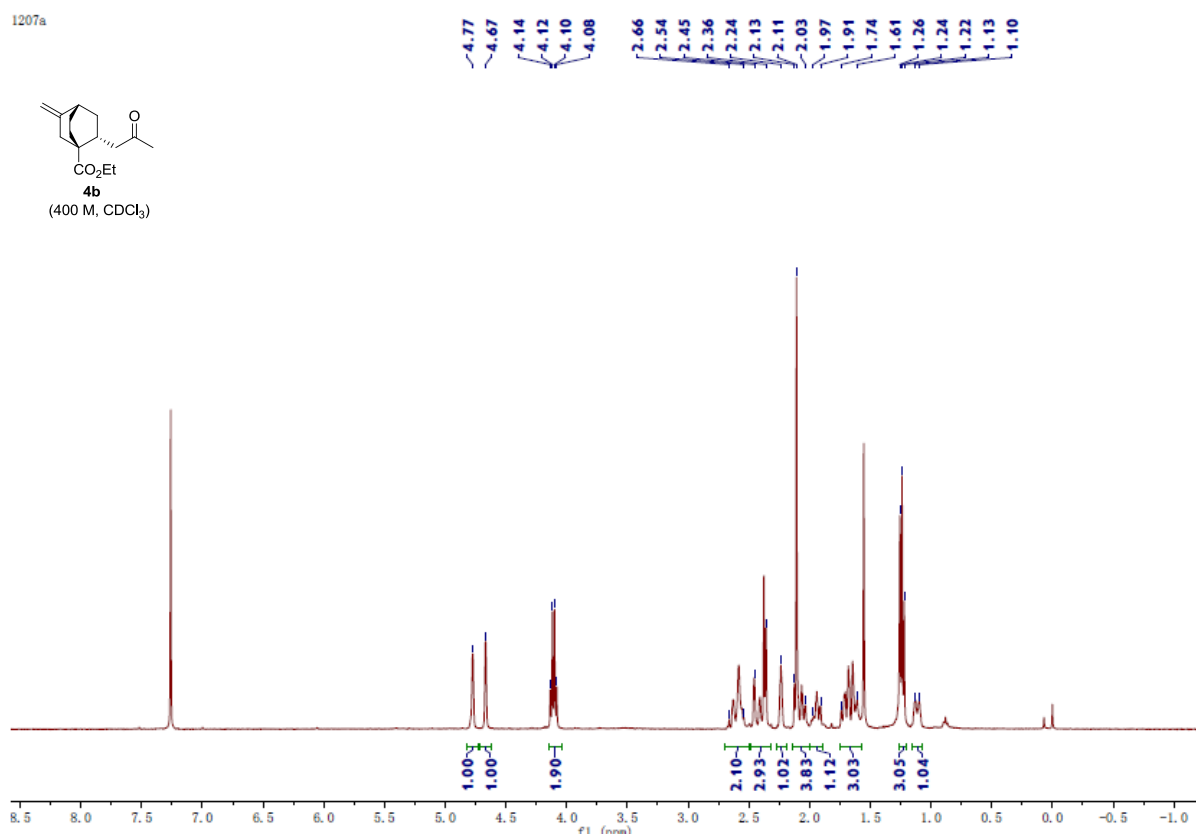
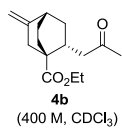


wjzg0167-6-C

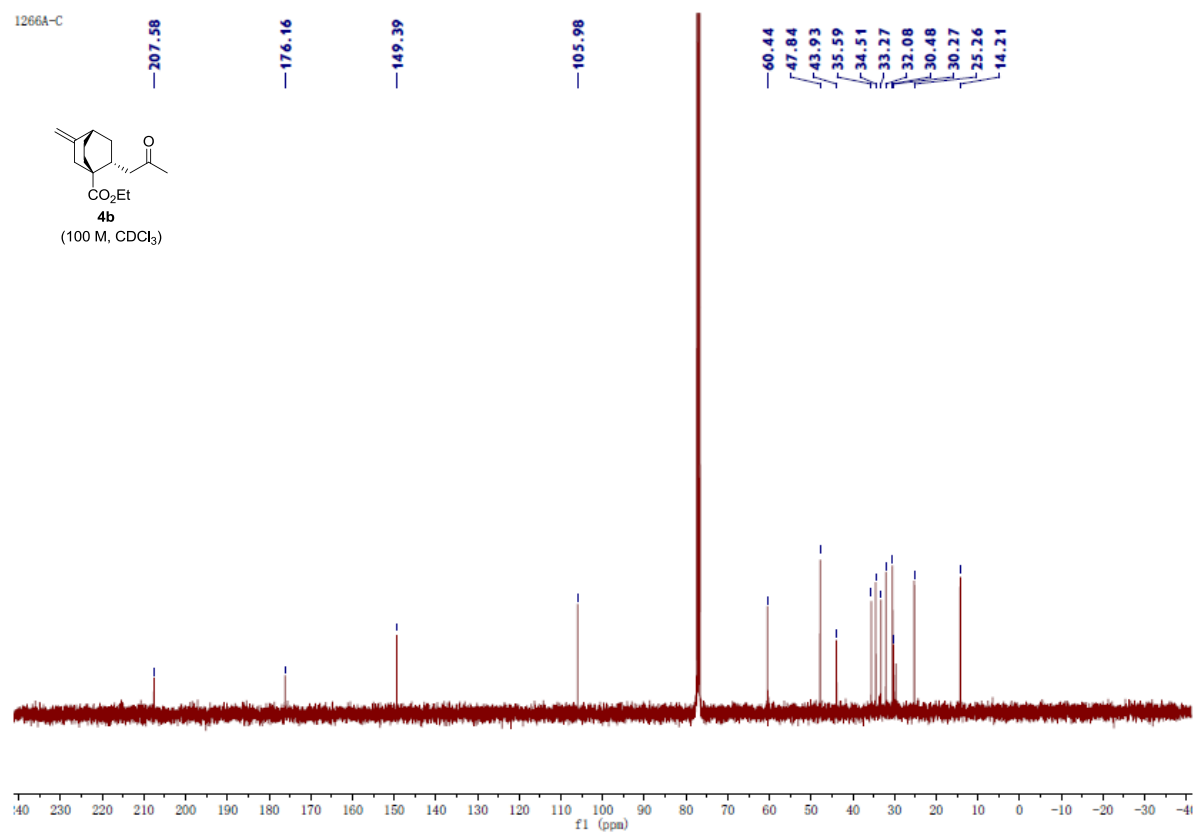
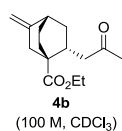


Compound 4b

1207a

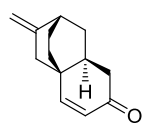


1266A-C

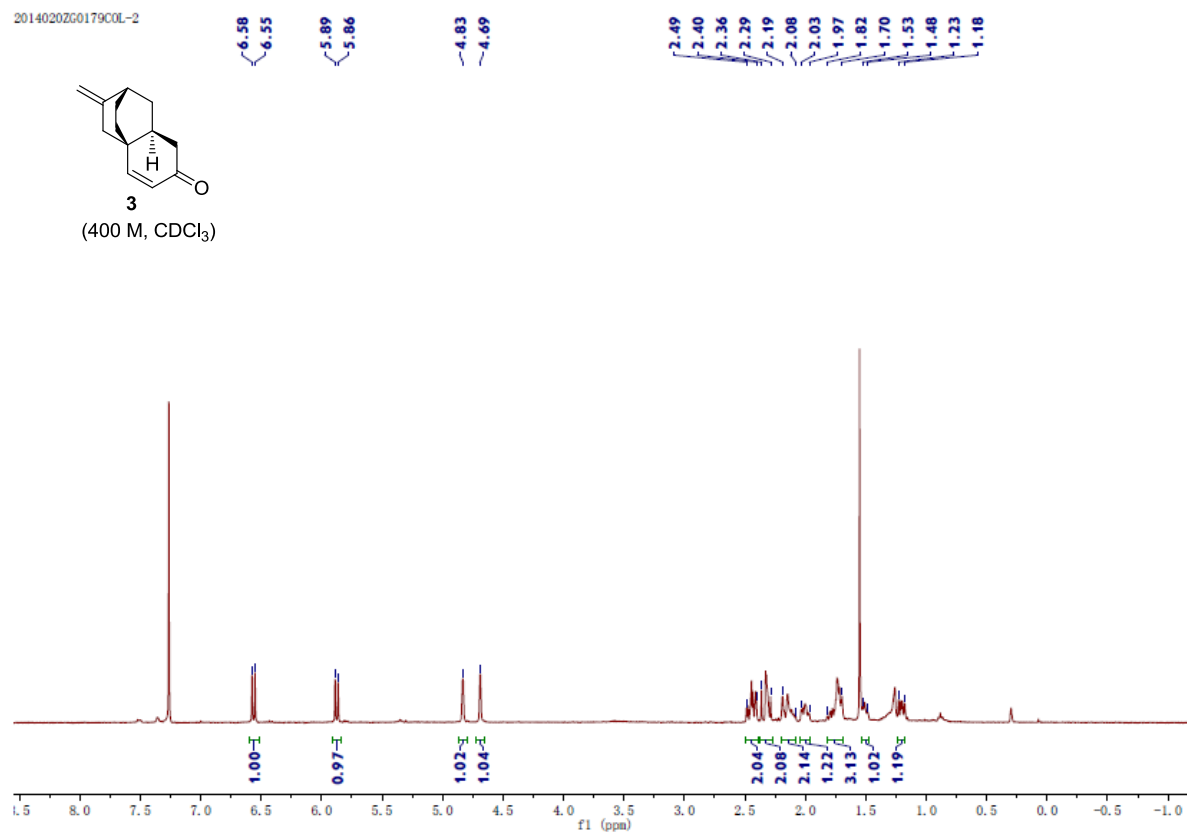


Compound 3

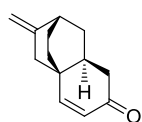
20140202G0179COL-2



3
(400 M, CDCl₃)



1219 (OK)



3
(100 M, CDCl₃)

