Diastereoselective Construction of Tetracyclic Chromanes *via* Triply Annulative Strategy

Zhishun Tang, [a] Linghong Chen, [a] Pengxuan Yin, [a] Lu Yang, [a] Zhichuan Shi, [a] Zhigang Zhao, [a] Ling Ye*[b] and Xuefeng Li *[a]

[a] Key Laboratory of General Chemistry of the National Ethnic Affairs Commission, Key Laboratory of Pollution Control Chemistry and Environmental Functional Materials for Qinghai-Tibet Plateau of the National Ethnic Affairs Commission, School of Chemistry and Environment, Southwest Minzu University, Chengdu 610041, China.

[b] Faculty of Geosciences and Environmental Engineering, Southwest Jiaotong University, Chengdu 610031, China.

E-mail: yeling@swjtu.edu.cn; lixuefeng@swun.edu.cn

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1. General Information

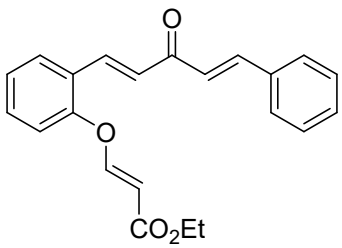
^{1}H and ^{13}C NMR spectra were recorded on Varian 400 MHz spectrometers. Chemical shifts (δ) were reported in ppm downfield from $CDCl_3$ (δ = 7.26 ppm) or DMSO-d6 (δ = 2.50 ppm) for ^{1}H NMR and relative to the central $CDCl_3$ resonance (δ = 77.0 ppm) or DMSO-d6 (δ = 39.5 ppm) for ^{13}C NMR spectroscopy. Coupling constants (J) were given in Hz. An ESI-HRMS spectrometer was measured with a Thermo Scientific LTQ Orbitrap XL mass spectrometer. Commercially available compounds were used without further purification. Solvents were dried according to standard procedures. Column chromatography was performed with silica gel (300-400 mesh).

2. General Procedure for the Synthesis of Enolate-tethered dienones 1

(2-Hydroxyaryl)divinyl ketones were synthesized via condensation reaction reported in the literature.[1]

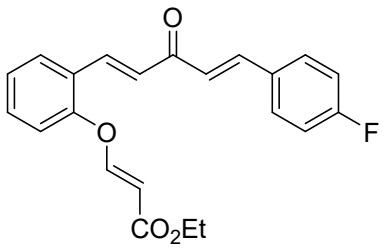
To a solution of (2-hydroxyaryl)divinyl ketone (5 mmol) in anhydrous MeCN (25 mL) was added ethyl propiolate (1.1 equiv) and *N*-methylmorpholine (6 mol%) at 0 °C, and the resulting solution was then allowed to stir at rt for due reaction time (about 24 h). Once divinyl ketone was consumed according to the TLC, the solvent was removed under reduced pressure. Purification of the residue by column chromatography (Petroleum ether/Ethyl acetate = 30:1, v/v) delivered the pure enolate substituted dienone **1**.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-fluorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1a).



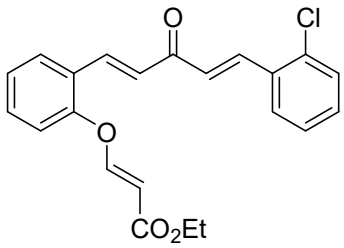
The product **1a** was obtained as a pale yellow oil (1.46 g, 84% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.85 (d, J = 16.0 Hz, 1H), 7.74 (d, J = 12.4 Hz, 1H), 7.68 (d, J = 15.6 Hz, 1H), 7.65 (d, J = 7.2 Hz, 1H), 7.56-7.53 (m, 2H), 7.37-7.34 (m, 4H), 7.18 (t, J = 7.6 Hz, 1H), 7.07 (d, J = 16.0 Hz, 1H), 7.02 (d, J = 8.4 Hz, 1H), 7.01 (d, J = 16.0 Hz, 1H), 5.54 (d, J = 12.4 Hz, 1H), 4.15 (q, J = 7.0 Hz, 2H), 1.24 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 166.7, 158.6, 154.3, 143.5, 136.2, 134.6, 131.8, 130.6, 128.9, 128.5, 128.4, 127.4, 126.0, 125.4, 125.3, 118.6, 103.2, 60.2, 14.3; IR (KBr): 3069, 2996, 1716, 1620, 1492, 1221, 1106, 1043, 988, 853, 755 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{21}O_4$ 349.1434, found 349.1433.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-fluorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1b).



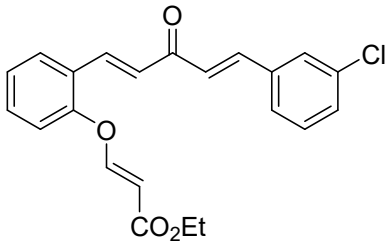
The product **1b** was obtained as a pale yellow oil (1.41 g, 77% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 16.4 Hz, 1H), 7.77 (d, J = 12.0 Hz, 1H), 7.68 (d, J = 7.2 Hz, 1H), 7.67 (d, J = 15.6 Hz, 1H), 7.58 (dd, J = 8.6, 5.4 Hz, 2H), 7.41 (t, J = 8.4 Hz, 1H), 7.23 (t, J = 7.4 Hz, 1H), 7.10-7.06 (m, 4H), 6.97 (d, J = 16.0 Hz, 1H), 5.56 (d, J = 12.0 Hz, 1H), 4.13 (q, J = 7.2 Hz, 2H), 1.30 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.5, 166.7, 164.0 ($^{1}J_{C\text{-}F}$ = 250.5 Hz), 158.6, 154.3, 142.2, 136.3, 131.7, 130.9 ($^{4}J_{C\text{-}F}$ = 3.3 Hz), 130.2 ($^{3}J_{C\text{-}F}$ = 8.5 Hz), 128.5, 127.4, 125.9, 125.4, 124.9, 118.6, 116.0 ($^{2}J_{C\text{-}F}$ = 21.8 Hz), 103.2, 60.2, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -108.9; IR (KBr): 3076, 2997, 1718, 1618, 1516, 1233, 1108, 1046, 986, 855, 753 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}FO_4$ 367.1340, found 367.1339.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(2-chlorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1c).



The product **1c** was obtained as a pale yellow oil (1.53 g, 80% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.10 (d, J = 16.0 Hz, 1H), 7.88 (d, J = 16.0 Hz, 1H), 7.78 (d, J = 12.0 Hz, 1H), 7.71-7.68 (m, 2H), 7.44-7.40 (m, 2H), 7.32-7.29 (m, 2H), 7.24 (t, J = 8.0 Hz, 1H), 7.16 (d, J = 16.4 Hz, 1H), 7.08 (dd, J = 8.4, 0.8 Hz, 1H), 7.00 (d, J = 16.0 Hz, 1H), 5.58 (d, J = 12.4 Hz, 1H), 4.19 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.7, 166.8, 158.6, 154.4, 139.1, 136.8, 135.3, 132.9, 131.8, 131.2, 130.2, 128.7, 128.0, 127.6, 127.1, 126.8, 125.8, 125.4, 118.6, 103.2, 60.2, 14.2; IR (KBr): 3081, 2989, 1720, 1656, 1487, 1230, 1127, 1047, 985, 850, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}ClO_4$ 383.1045, found 383.1039.

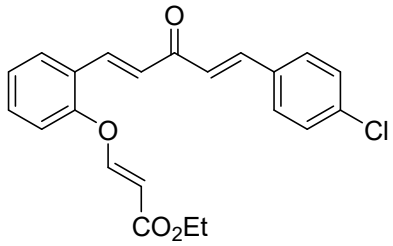
Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(3-chlorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate(1d).



The product **1d** was obtained as a pale yellow oil (1.80 g, 94% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 16.4 Hz, 1H), 7.76 (d, J = 12.4 Hz, 1H), 7.67 (dd, J = 8.0, 1.6 Hz, 1H), 7.61 (d, J = 16.0 Hz, 1H), 7.55 (t, J = 1.6 Hz, 1H), 7.45-7.42 (m, 1H), 7.39 (dd, J = 7.6, 1.2 Hz, 1H), 7.34-

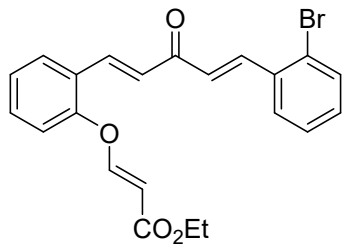
7.28 (m, 2H), 7.22 (t, J = 7.4 Hz, 1H), 7.07 (d, J = 16.0 Hz, 1H), 7.06 (dd, J = 8.0, 0.8 Hz, 1H), 7.02 (d, J = 16.0 Hz, 1H), 5.56 (d, J = 12.4 Hz, 1H), 4.17 (q, J = 7.2 Hz, 2H), 1.26 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.2, 166.6, 158.4, 154.3, 141.7, 136.6, 136.4, 134.8, 131.8, 130.2, 130.0, 128.4, 127.9, 127.2, 126.5, 126.3, 125.7, 125.3, 118.5, 103.2, 60.1, 14.2; IR (KBr): 3080, 2992, 1719, 1655, 1488, 1231, 1126, 1045, 987, 858, 762 cm^{-1}; HRMS (ESI) m/z: [M+H]+ calcd. for $C_{22}H_{20}ClO_4$ 383.1045, found 383.1045.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-chlorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1e).



The product **1e** was obtained as a pale yellow oil (1.34 g, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 16.4 Hz, 1H), 7.77 (d, J = 12.0 Hz, 1H), 7.68 (d, J = 8.8 Hz, 1H), 7.65 (d, J = 16.0 Hz, 1H), 7.51 (d, J = 8.4 Hz, 2H), 7.41 (t, J = 7.8 Hz, 1H), 7.36 (d, J = 8.8 Hz, 2H), 7.23 (t, J = 7.6 Hz, 1H), 7.08 (d, J = 8.0 Hz, 1H), 7.07 (d, J = 16.0 Hz, 1H), 7.01 (d, J = 16.0 Hz, 1H), 5.56 (d, J = 12.0 Hz, 1H), 4.18 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.4, 166.7, 158.5, 154.3, 140.0, 136.4, 136.3, 133.1, 131.8, 129.5, 129.1, 128.5, 127.4, 125.8, 125.5, 125.4, 118.6, 103.2, 60.2, 14.2; IR (KBr): 3096, 2984, 1716, 1663, 1492, 1231, 1124, 1034, 981, 854, 755 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}ClO_4$ 383.1045, found 383.1043.

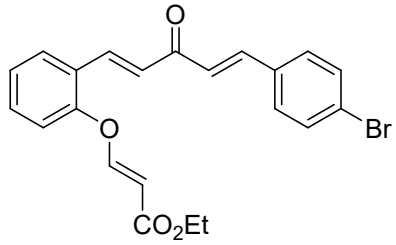
Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(2-bromophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1f).



The product **1f** was obtained as a pale yellow oil (1.49 g, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.06 (d, J = 16.0 Hz, 1H), 7.88 (d, J = 16.4 Hz, 1H), 7.79 (d, J = 12.4 Hz, 1H), 7.68 (dd, J = 7.4, 1.4 Hz, 2H), 7.61 (d, J = 8.0 Hz, 1H), 7.42 (t, J = 7.6 Hz, 1H), 7.34 (t, J = 7.4 Hz, 1H), 7.26-7.21 (m, 2H), 7.18 (d, J = 16.0 Hz, 1H), 7.08 (d, J = 8.4 Hz, 1H), 6.95 (d, J = 16.0 Hz, 1H), 5.59 (d, J = 12.4 Hz, 1H), 4.19 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.7, 166.7, 158.5, 154.4, 141.7, 136.8, 134.6, 133.4, 131.8, 131.3, 128.8, 128.2, 127.74, 127.70, 126.7, 125.82, 125.77, 125.4, 118.6, 103.3, 60.2, 14.2; IR (KBr): 3079, 2994, 1720, 1653, 1482, 1228, 1125, 1039, 986, 849, 760 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}BrO_4$ 427.0539,

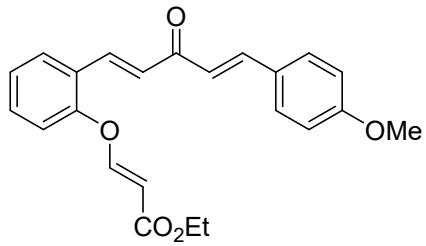
found 427.0538.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-bromophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1g).



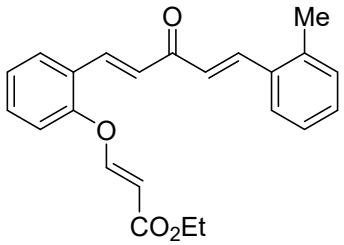
The product **1g** was obtained as a pale yellow oil (1.71 g, 80% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.88 (d, J = 16.4 Hz, 1H), 7.78 (d, J = 12.4 Hz, 1H), 7.69 (dd, J = 7.8, 1.4 Hz, 1H), 7.64 (d, J = 15.6 Hz, 1H), 7.53 (d, J = 8.4 Hz, 2H), 7.46 (d, J = 8.4 Hz, 2H), 7.42 (dd, J = 7.8, 1.0 Hz, 1H), 7.24 (t, J = 7.8 Hz, 1H), 7.09 (dd, J = 8.0, 0.8 Hz, 1H), 7.08 (d, J = 16.0 Hz, 1H), 7.04 (d, J = 16.0 Hz, 1H), 5.57 (d, J = 12.4 Hz, 1H), 4.19 (q, J = 7.0 Hz, 2H), 1.28 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.4, 166.7, 158.6, 154.4, 142.1, 136.5, 133.6, 132.1, 131.8, 129.7, 128.5, 127.4, 125.9, 125.7, 125.4, 124.8, 118.7, 103.2, 60.2, 14.2; IR (KBr): 3084, 2984, 1716, 1660, 1489, 1230, 1120, 984, 810, 756 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}BrO_4$ 427.0539, found 427.0535.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-methoxyphenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1h).



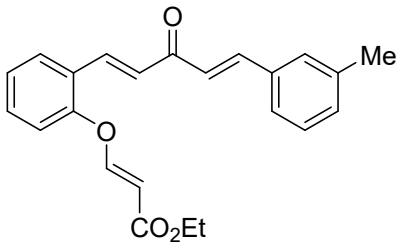
The product **1h** was obtained as a pale yellow oil (1.71 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.86 (d, J = 16.4 Hz, 1H), 7.78 (d, J = 12.4 Hz, 1H), 7.70 (d, J = 15.6 Hz, 1H), 7.69 (dd, J = 7.8, 1.4 Hz, 1H), 7.54 (d, J = 8.8 Hz, 2H), 7.40 (td, J = 7.6, 1.2 Hz, 1H), 7.22 (t, J = 7.4 Hz, 1H), 7.09 (d, J = 16.0 Hz, 1H), 7.07 (dd, J = 8.2, 0.6 Hz, 1H), 6.94-6.90 (m, 3H), 5.56 (d, J = 12.4 Hz, 1H), 4.18 (q, J = 7.2 Hz, 2H), 3.82 (s, 3H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 166.7, 161.6, 158.7, 154.2, 143.4, 135.7, 131.5, 130.1, 128.4, 127.6, 127.3, 126.1, 125.4, 123.1, 118.6, 114.3, 103.1, 60.1, 55.3, 14.2; IR (KBr): 3082, 3002, 1728, 1662, 1621, 1489, 1229, 1108, 987, 815, 753 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_5$ 379.1540, found 379.1537.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-(*o*-tolyl)penta-1,4-dien-1-yl)phenoxy)acrylate (1i). The product **1i** was obtained as a pale yellow oil (1.69 g, 93% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.03 (d, J = 15.6 Hz, 1H), 7.89 (d, J = 16.4 Hz, 1H), 7.79 (d, J = 12.4 Hz, 1H), 7.69 (d, J = 7.6 Hz, 1H), 7.64 (d, J = 7.6 Hz, 1H), 7.42 (t, J = 7.8 Hz, 1H), 7.31-7.20 (m, 4H), 7.10 (d, J = 16.0



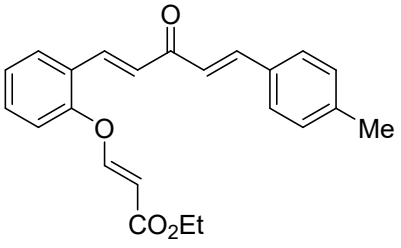
Hz, 1H), 7.08 (d, *J* = 8.0 Hz, 1H), 6.99 (d, *J* = 16.0 Hz, 1H), 5.57 (d, *J* = 12.4 Hz, 1H), 4.19 (q, *J* = 7.2 Hz, 2H), 2.46 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.7, 166.7, 158.6, 154.3, 141.1, 138.1, 136.2, 133.6, 131.7, 130.8, 130.2, 128.5, 127.7, 126.31, 126.28, 126.09, 125.93, 125.4, 118.6, 103.1, 60.1, 19.8, 14.2; IR (KBr): 3078, 2991, 1719, 1654, 1490, 1230, 1046, 986, 849, 762 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1587.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-(*m*-tolyl)penta-1,4-dien-1-yl)phenoxy)acrylate (1j). The



product **1j** was obtained as a pale yellow oil (1.67 g, 92% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.88 (d, *J* = 16.4 Hz, 1H), 7.79 (d, *J* = 12.4 Hz, 1H), 7.70 (d, *J* = 16.0 Hz, 1H), 7.69 (dd, *J* = 7.6, 1.2 Hz, 1H), 7.43-7.39 (m, 3H), 7.29 (t, *J* = 7.8 Hz, 1H), 7.24 (t, *J* = 7.4 Hz, 1H), 7.21 (d, *J* = 7.2 Hz, 1H), 7.11 (d, *J* = 16.0 Hz, 1H), 7.08 (d, *J* = 8.0 Hz, 1H), 7.04 (d, *J* = 16.0 Hz, 1H), 5.57 (d, *J* = 12.0 Hz, 1H), 4.19 (q, *J* = 7.2 Hz, 2H), 2.38 (s, 3H), 1.28 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.7, 166.7, 158.6, 154.3, 143.7, 138.5, 136.1, 134.5, 131.6, 131.4, 129.0, 128.7, 128.4, 127.4, 126.0, 125.5, 125.4, 125.1, 118.6, 103.1, 60.1, 21.2, 14.2; IR (KBr): 3060, 2993, 1719, 1654, 1490, 1232, 1047, 988, 847, 770 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1588.

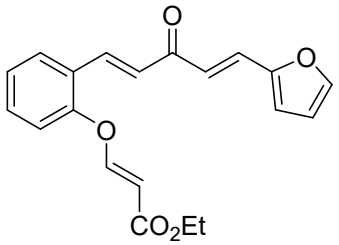
Ethyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-(*p*-tolyl)penta-1,4-dien-1-yl)phenoxy)acrylate(1k). The



product **1k** was obtained as a pale yellow oil (1.36 g, 75% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, *J* = 16.0 Hz, 1H), 7.78 (d, *J* = 12.0 Hz, 1H), 7.70 (d, *J* = 16.0 Hz, 1H), 7.69 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.49 (d, *J* = 8.4 Hz, 2H), 7.40 (td, *J* = 7.6, 1.2 Hz, 1H), 7.22 (t, *J* = 7.4 Hz, 1H), 7.20 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 16.0 Hz, 1H), 7.07 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.00 (d, *J* = 16.0 Hz, 1H), 5.56 (d, *J* = 12.0 Hz, 1H), 4.19 (q, *J* = 7.2 Hz, 2H), 2.36 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.7, 166.7, 158.6, 154.2, 143.6, 141.0, 135.9, 131.8, 131.6, 129.6, 128.4, 128.3, 127.4, 126.0, 125.4, 124.3, 118.6, 103.1, 60.1, 21.4, 14.2; IR (KBr):

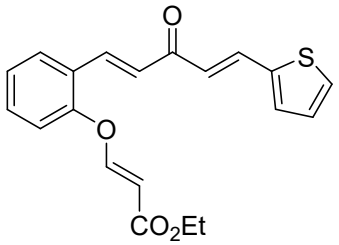
3049, 2993, 1717, 1662, 1489, 1234, 1126, 1040, 989, 850, 754 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1589.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(furan-2-yl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1l). The



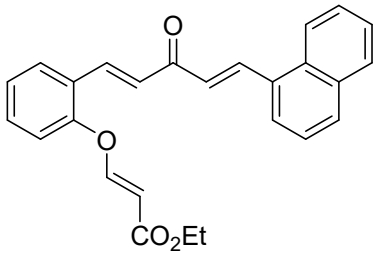
product **1l** was obtained as a pale yellow oil (1.53 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.86 (d, J = 16.4 Hz, 1H), 7.77 (d, J = 12.0 Hz, 1H), 7.67 (d, J = 7.2 Hz, 1H), 7.51 (s, 1H), 7.48 (d, J = 15.6 Hz, 1H), 7.40 (t, J = 7.8 Hz, 1H), 7.22 (t, J = 7.4 Hz, 1H), 7.07 (d, J = 8.0 Hz, 1H), 7.01 (d, J = 16.0 Hz, 1H), 6.96 (d, J = 15.6 Hz, 1H), 6.69 (d, J = 3.2 Hz, 1H), 6.49 (dd, J = 3.2, 2.0 Hz, 1H), 5.55 (d, J = 12.0 Hz, 1H), 4.18 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.3, 166.7, 158.6, 154.3, 151.3, 145.0, 135.9, 131.6, 129.6, 128.4, 128.0, 126.0, 125.4, 122.3, 118.6, 116.1, 112.6, 103.1, 60.1, 14.2; IR (KBr): 3086, 2979, 1720, 1623, 1490, 1228, 1124, 1032, 981, 810, 757 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{19}O_5$ 339.1227, found 339.1226.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-(thiophen-2-yl)penta-1,4-dien-1-yl)phenoxy)acrylate (1m).



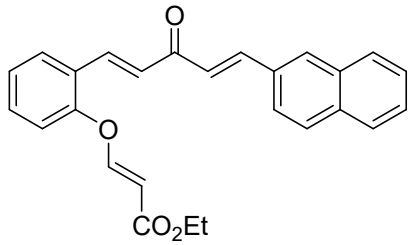
The product **1m** was obtained as a pale yellow oil (1.69 g, 95% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 10.0 Hz, 1H), 7.83 (d, J = 9.6 Hz, 1H), 7.77 (d, J = 12.4 Hz, 1H), 7.68 (dd, J = 8.0, 1.6 Hz, 1H), 7.43-7.38 (m, 2H), 7.32 (d, J = 3.6 Hz, 1H), 7.22 (t, J = 7.4 Hz, 1H), 7.08-7.05 (m, 2H), 7.03 (d, J = 16.0 Hz, 1H), 6.84 (d, J = 15.6 Hz, 1H), 5.56 (d, J = 12.0 Hz, 1H), 4.18 (q, J = 7.2 Hz, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.7, 158.6, 154.3, 140.1, 136.01, 135.97, 131.8, 131.7, 128.9, 128.4, 128.3, 127.5, 126.0, 125.4, 124.1, 118.6, 103.1, 60.1, 14.2; IR (KBr): 3090, 2991, 1718, 1654, 1489, 1230, 1126, 1043, 983, 849, 769 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{20}H_{19}O_4S$ 355.0999, found 355.0998.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(naphthalen-1-yl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1n). The product **1n** was obtained as a pale yellow oil (1.54 g, 77% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.60 (d, J = 15.6 Hz, 1H), 8.25 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 16.0 Hz, 1H), 7.92 (d, J = 8.8 Hz, 1H), 7.88 (t, J = 8.4 Hz, 2H), 7.82 (d, J = 12.0 Hz, 1H), 7.73 (dd, J = 7.6, 1.2 Hz, 1H), 7.62-7.58 (m, 1H), 7.56-7.50 (m, 2H), 7.44 (td, J = 7.6, 1.2 Hz, 1H), 7.26 (t, J = 7.6 Hz, 1H), 7.18



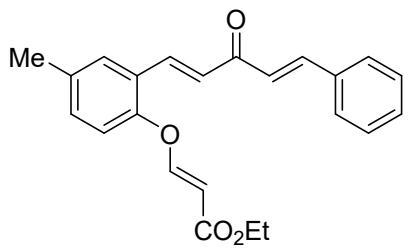
(d, J = 15.6 Hz, 1H), 7.17 (d, J = 16.4 Hz, 1H), 7.11 (d, J = 8.4 Hz, 1H), 5.61 (d, J = 12.4 Hz, 1H), 4.20 (q, J = 7.0 Hz, 2H), 1.29 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 166.8, 158.6, 154.3, 140.4, 136.4, 133.6, 132.0, 131.8, 131.6, 130.8, 128.7, 128.6, 127.8, 127.6, 126.9, 126.2, 125.9, 125.42 125.40, 125.1, 123.3, 118.6, 103.2, 60.2, 14.2; IR (KBr): 3069, 2988, 1718, 1653, 1489, 1231, 1127, 1046, 981, 850, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{26}H_{23}O_4$ 399.1591, found 399.1586.

Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(naphthalen-2-yl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1o).



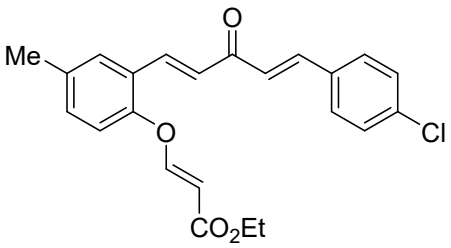
The product **1o** was obtained as a pale yellow oil (1.50 g, 75% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.97 (s, 1H), 7.92 (d, J = 16.0 Hz, 1H), 7.90-7.79 (m, 5H), 7.72 (t, J = 8.8 Hz, 2H), 7.53-7.48 (m, 2H), 7.41 (t, J = 7.6 Hz, 1H), 7.24 (t, J = 7.6 Hz, 1H), 7.15 (d, J = 16.0 Hz, 1H), 7.14 (d, J = 16.0 Hz, 1H), 7.08 (dd, J = 8.0, 0.8 Hz, 1H), 5.60 (d, J = 12.4 Hz, 1H), 4.20 (q, J = 7.2 Hz, 2H), 1.29 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 166.7, 158.6, 154.3, 143.6, 136.2, 134.3, 133.2, 132.1, 131.7, 130.6, 128.6, 128.5, 128.4, 127.7, 127.5, 127.3, 126.7, 126.0, 125.40, 125.37, 123.5, 118.6, 103.2, 60.1, 14.2; IR (KBr): 3070, 2985, 1713, 1652, 1489, 1231, 1129, 1036, 986, 820, 760 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{26}H_{23}O_4$ 399.1591, found 399.1592.

Ethyl (*E*)-3-(4-methyl-2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1p).

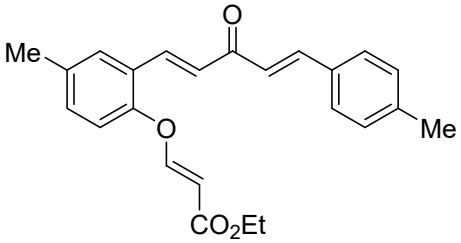


The product **1p** was obtained as a pale yellow oil (1.13 g, 61% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.83 (d, J = 16.0 Hz, 1H), 7.74 (d, J = 12.0 Hz, 1H), 7.70 (d, J = 16.0 Hz, 1H), 7.58-7.56 (m, 2H), 7.47 (d, J = 1.2 Hz, 1H), 7.39-7.35 (m, 3H), 7.18 (dd, J = 8.4, 1.6 Hz, 1H), 7.07 (d, J = 16.0 Hz, 1H), 7.03 (d, J = 16.0 Hz, 1H), 6.93 (d, J = 8.4 Hz, 1H), 5.50 (d, J = 12.4 Hz, 1H), 4.16 (q, J = 7.2 Hz, 2H), 2.34 (s, 3H), 1.25 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 166.7, 159.1, 152.2, 143.3, 136.2, 135.0, 134.5, 132.3, 130.4, 128.8, 128.6, 128.2,

127.0, 125.5, 125.2, 118.6, 102.5, 60.0, 20.6, 14.1; IR (KBr): 3048, 2993, 1719, 1652, 1496, 1234, 1130, 1046, 988, 836, 762 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1591.

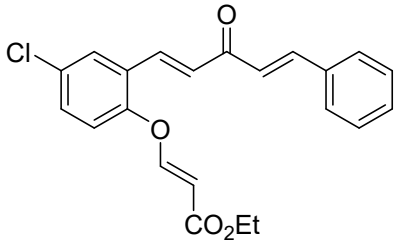
Ethyl (*E*)-3-(2-((1*E*,4*E*)-5-(4-chlorophenyl)-3-oxopenta-1,4-dien-1-yl)-4-methylphenoxy)acrylate (1q). 

The product **1q** was obtained as a pale yellow oil (1.79 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.81 (d, J = 16.0 Hz, 1H), 7.73 (d, J = 12.4 Hz, 1H), 7.61 (d, J = 16.0 Hz, 1H), 7.47 (d, J = 8.4 Hz, 2H), 7.44 (s, 1H), 7.31 (d, J = 8.4 Hz, 2H), 7.17 (d, J = 8.4 Hz, 1H), 7.04 (d, J = 16.4 Hz, 1H), 6.98 (d, J = 16.0 Hz, 1H), 6.92 (d, J = 8.0 Hz, 1H), 5.50 (d, J = 12.4 Hz, 1H), 4.16 (q, J = 7.0 Hz, 2H), 2.33 (s, 3H), 1.25 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.6, 158.8, 152.1, 141.6, 136.3, 136.0, 134.9, 132.9, 132.3, 129.3, 128.9, 128.5, 126.7, 125.4, 125.2, 118.3, 102.4, 59.9, 20.5, 14.1; IR (KBr): 3057, 2993, 1713, 1657, 1496, 1233, 1139, 1099, 982, 820, 708 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{22}ClO_4$ 397.1201, found 397.1200.

Ethyl (*E*)-3-(4-methyl-2-((1*E*,4*E*)-3-oxo-5-(*p*-tolyl)penta-1,4-dien-1-yl)phenoxy)acrylate (1r). 

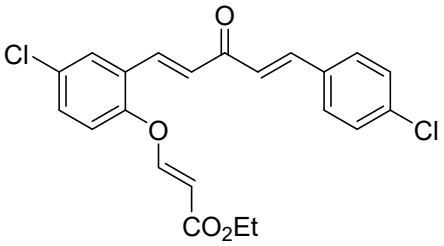
The product **1r** was obtained as a pale yellow oil (1.74 g, 92% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.73 (d, J = 16.0 Hz, 1H), 7.65 (d, J = 12.4 Hz, 1H), 7.58 (d, J = 16.0 Hz, 1H), 7.37 (s, 1H), 7.36 (d, J = 8.0 Hz, 2H), 7.06 (d, J = 8.0 Hz, 3H), 6.99 (d, J = 16.0 Hz, 1H), 6.88 (d, J = 16.0 Hz, 1H), 6.81 (d, J = 8.4 Hz, 1H), 5.43 (d, J = 12.0 Hz, 1H), 4.09 (q, J = 7.2 Hz, 2H), 2.24 (s, 6H), 1.18 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.3, 158.7, 151.9, 143.0, 140.5, 135.5, 134.6, 131.9, 131.5, 129.2, 128.2, 128.0, 126.6, 125.1, 124.1, 118.1, 102.2, 59.6, 21.0, 20.3, 13.9; IR (KBr): 3058, 2993, 1709, 1634, 1496, 1217, 1057, 986, 804 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{25}ClO_4$ 377.1747, found 377.1745.

Ethyl (*E*)-3-(4-chloro-2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1s). The product **1s** was obtained as a pale yellow oil (1.40 g, 73% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.77 (d, J = 16.0 Hz, 1H), 7.71 (d, J = 16.4 Hz, 1H), 7.70 (d, J = 12.0 Hz, 1H), 7.64 (d, J



= 2.4 Hz, 1H), 7.59-7.56 (m, 2H), 7.39-7.37 (m, 3H), 7.33 (dd, *J* = 8.6, 2.6 Hz, 1H), 7.08 (d, *J* = 16.0 Hz, 1H), 7.00 (d, *J* = 16.4 Hz, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 5.55 (d, *J* = 12.0 Hz, 1H), 4.17 (q, *J* = 7.2 Hz, 2H), 1.26 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.4, 158.0, 152.6, 143.8, 134.5, 134.4, 131.2, 130.7, 130.6, 128.8, 128.3, 127.9, 127.8, 127.5, 125.2, 119.8, 103.6, 60.2, 14.1; IR (KBr): 3079, 2992, 1717, 1657, 1488, 1245, 1138, 984, 812, 757 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}ClO_4$ 383.1045, found 383.1041.

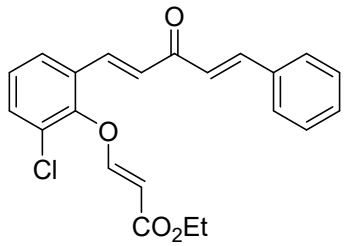
Ethyl (*E*)-3-(4-chloro-2-((1*E*,4*E*)-5-(4-chlorophenyl)-3-oxopenta-1,4-dien-1-yl)phenoxy)acrylate (1t). The product **1t** was obtained as a pale yellow oil (1.08 g, 52% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.77 (d, *J* = 16.4 Hz, 1H), 7.70 (d, *J* = 12.4 Hz, 1H), 7.64 (d, *J* = 16.0 Hz, 1H), 7.63 (d, *J* = 2.8 Hz, 1H), 7.50 (d, *J* = 8.4 Hz, 2H), 7.36-7.33 (m, 3H), 7.05 (d, *J* = 16.0 Hz, 1H), 7.00 (d, *J* = 8.8 Hz, 1H), 6.97 (d, *J* = 16.0 Hz, 1H), 5.55 (d, *J* = 12.4 Hz, 1H), 4.17 (q, *J* = 7.0 Hz, 2H), 1.26 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 187.9, 166.4, 158.0, 152.6, 142.3, 136.5, 134.8, 132.9, 131.3, 130.7, 129.5, 129.1, 127.93, 127.85, 127.4, 125.6, 119.9, 103.7, 60.3, 14.2; IR (KBr): 3098, 2993, 1716, 1658, 1488, 1235, 1136, 981, 819, 739 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{19}Cl_2O_4$ 417.0655, found 417.0651.



Ethyl (*E*)-3-(4-chloro-2-((1*E*,4*E*)-3-oxo-5-(*p*-tolyl)penta-1,4-dien-1-yl)phenoxy)acrylate (1u). The product **1u** was obtained as a pale yellow oil (1.25 g, 63% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.76 (d, *J* = 16.0 Hz, 1H), 7.71 (d, *J* = 12.0 Hz, 1H), 7.69 (d, *J* = 16.0 Hz, 1H), 7.64 (d, *J* = 2.0 Hz, 1H), 7.48 (d, *J* = 7.6 Hz, 2H), 7.33 (dd, *J* = 8.6, 1.8 Hz, 1H), 7.19 (d, *J* = 7.6 Hz, 2H), 7.08 (d, *J* = 16.0 Hz, 1H), 7.00 (d, *J* = 8.8 Hz, 1H), 6.96 (d, *J* = 16.0 Hz, 1H), 5.55 (d, *J* = 12.4 Hz, 1H), 4.18 (q, *J* = 7.2 Hz, 2H), 2.36 (s, 3H), 1.27 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.2, 166.4, 158.1, 152.6, 144.0, 141.2, 134.3, 131.7,

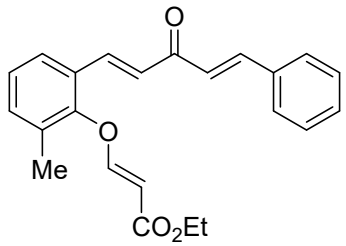
131.1, 130.7, 129.6, 128.4, 128.1, 127.8, 127.6, 124.4, 119.8, 103.6, 60.2, 21.4, 14.2; IR (KBr): 3063, 2991, 1710, 1638, 1482, 1233, 1157, 980, 803, 732 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{22}ClO_4$ 397.1201, found 397.1200.

Ethyl (*E*)-3-(2-chloro-6-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1v).



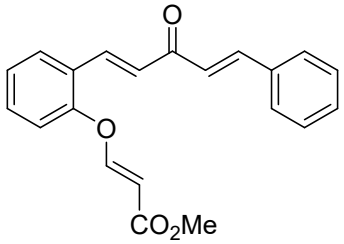
The product **1v** was obtained as a pale yellow oil (1.38 g, 72% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.71 (d, J = 12.4 Hz, 1H), 7.70 (d, J = 16.0 Hz, 1H), 7.69 (d, J = 16.0 Hz, 1H), 7.61 (dd, J = 7.8, 1.4 Hz, 1H), 7.58-7.56 (m, 2H), 7.46 (dd, J = 8.0, 1.2 Hz, 1H), 7.39-7.37 (m, 3H), 7.22 (t, J = 8.0 Hz, 1H), 7.09 (d, J = 16.0 Hz, 1H), 7.00 (d, J = 16.0 Hz, 1H), 5.13 (d, J = 12.4 Hz, 1H), 4.13 (q, J = 7.2 Hz, 2H), 1.23 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.2, 166.3, 159.6, 148.9, 143.9, 135.0, 134.3, 132.1, 130.6, 129.7, 128.8, 128.4, 128.3, 127.7, 127.0, 126.4, 125.1, 101.2, 60.1, 14.1; IR (KBr): 3082, 2995, 1719, 1635, 1451, 1226, 1046, 986, 845, 784 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{22}H_{20}ClO_4$ 383.1045, found 383.1041.

Ethyl (*E*)-3-(2-methyl-6-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1w).



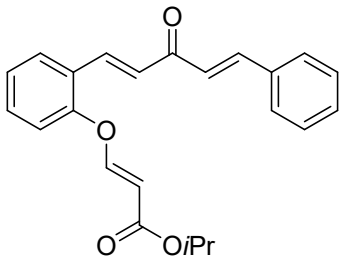
The product **1w** was obtained as a pale yellow oil (1.47 g, 81% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.71 (d, J = 12.4 Hz, 1H), 7.68 (d, J = 16.0 Hz, 1H), 7.62 (d, J = 16.0 Hz, 1H), 7.49-7.47 (m, 3H), 7.29-7.27 (m, 3H), 7.16 (d, J = 7.2 Hz, 1H), 7.09 (t, J = 7.6 Hz, 1H), 7.00 (d, J = 16.0 Hz, 1H), 6.93 (d, J = 16.0 Hz, 1H), 4.96 (d, J = 12.4 Hz, 1H), 4.04 (q, J = 7.0 Hz, 2H), 2.10 (s, 3H), 1.13 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.4, 160.2, 151.0, 143.1, 135.8, 134.2, 133.2, 130.6, 130.1, 128.5, 123.0, 127.04, 126.99, 126.0, 125.3, 125.0, 99.9, 59.7, 15.6, 13.8; IR (KBr): 3080, 2992, 1721, 1651, 1459, 1252, 1186, 1041, 989, 841, 780 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1586.

Methyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1x). The product **1x** was obtained as a pale yellow oil (1.02 g, 61% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.84 (d, J = 16.0 Hz, 1H), 7.73 (d, J = 12.0 Hz, 1H), 7.67 (d, J = 15.6 Hz, 1H), 7.64 (d, J = 7.6 Hz, 1H), 7.54-7.52 (m, 2H), 7.35-7.32 (m, 4H), 7.17 (t, J = 7.4 Hz, 1H), 7.06 (d, J = 16.0 Hz,



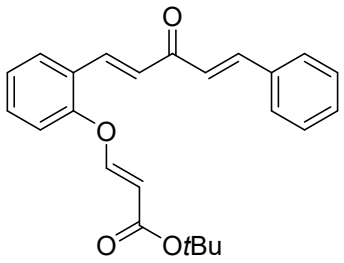
1H), 7.00 (d, J = 16.0 Hz, 2H), 6.99 (d, J = 8.8 Hz, 2H), 5.54 (d, J = 12.4 Hz, 1H), 3.67 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.3, 166.8, 158.4, 154.1, 143.2, 135.8, 134.4, 131.5, 130.3, 128.7, 128.2, 128.1, 127.1, 125.6, 125.2, 125.1, 118.2, 102.6, 51.1; IR (KBr): 3080, 2962, 1723, 1655, 1452, 1231, 1049, 988, 848, 763 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{19}O_4$ 335.1278, found 335.1281.

Isopropyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1y). The



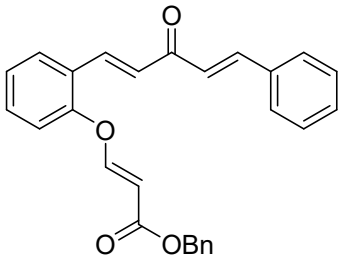
product **1y** was obtained as a pale yellow oil (1.63 g, 90% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.82 (d, J = 16.0 Hz, 1H), 7.68 (d, J = 12.4 Hz, 1H), 7.64 (d, J = 16.4 Hz, 1H), 7.61 (d, J = 8.8 Hz, 1H), 7.50-7.48 (m, 2H), 7.32-7.26 (m, 4H), 7.13 (t, J = 7.4 Hz, 1H), 7.04 (d, J = 16.0 Hz, 1H), 6.97 (d, J = 14.0 Hz, 1H), 6.96 (d, J = 8.8 Hz, 1H), 5.48 (d, J = 12.4 Hz, 1H), 5.04-4.98 (m, 1H), 1.19 (d, J = 6.4 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.2, 165.9, 158.1, 154.0, 143.1, 135.7, 134.3, 131.4, 130.2, 128.6, 128.1, 128.09, 128.04, 127.0, 125.6, 125.0, 118.2, 103.2, 67.1, 21.6; IR (KBr): 3077, 2993, 1716, 1653, 1459, 1232, 1104, 992, 847, 762 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}O_4$ 363.1591, found 363.1593.

***Tert*-butyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1z).** The



product **1z** was obtained as a pale yellow oil (1.58 g, 84% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 16.4 Hz, 1H), 7.70 (d, J = 15.6 Hz, 3H), 7.67 (d, J = 10.8 Hz, 2H), 7.40-7.37 (m, 4H), 7.20 (t, J = 7.4 Hz, 1H), 7.09 (d, J = 16.0 Hz, 1H), 7.06-7.02 (m, 2H), 5.49 (d, J = 12.4 Hz, 1H), 1.47 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.6, 165.9, 157.8, 154.3, 143.4, 136.2, 134.5, 131.6, 130.4, 128.8, 128.4, 128.3, 127.3, 125.8, 125.2, 125.1, 118.5, 104.7, 80.3, 28.1; IR (KBr): 3080, 2988, 1715, 1653, 1458, 1230, 1121, 989, 849, 762 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{24}H_{24}NaO_4$ 399.1567, found 399.1570.

Benzyl (*E*)-3-(2-((1*E*,4*E*)-3-oxo-5-phenylpenta-1,4-dien-1-yl)phenoxy)acrylate (1aa). The product **1aa** was obtained as a pale yellow oil (1.83 g, 89% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ

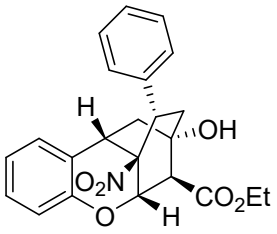


(ppm): 7.90 (d, J = 16.0 Hz, 1H), 7.80 (d, J = 12.4 Hz, 1H), 7.72 (d, J = 16.0 Hz, 1H), 7.66 (d, J = 7.6 Hz, 1H), 7.56-7.55 (m, 2H), 7.36-7.26 (m, 9H), 7.19 (t, J = 7.4 Hz, 1H), 7.11 (d, J = 16.0 Hz, 1H), 7.04 (d, J = 16.0 Hz, 1H), 6.99 (d, J = 8.0 Hz, 1H), 5.63 (d, J = 12.4 Hz, 1H), 5.18 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 188.1, 166.1, 158.7, 153.9, 143.1, 135.64, 135.63, 134.2, 131.4, 130.2, 128.6, 128.2, 128.08, 128.05, 127.8, 127.0, 125.5, 125.1, 125.0, 118.1, 102.5, 77.2, 65.6; IR (KBr): 3047, 2960, 1721, 1653, 1456, 1229, 1122, 988, 846, 759 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{27}H_{23}O_4$ 411.1591, found 411.1596.

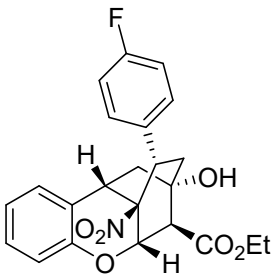
3. General Procedure for the triple Michael/aldol Cascade Reaction

Enolate substituted dienone **1** (0.1 mmol), nitromethane **2** (54 μL, 1.0 mmol) and TMG (12.5 μL, 0.1 mmol) were stirred in redistilled acetonitrile (1 mL) at rt. Once the TLC analysis showed complete consumption of **1**, the reaction mixture was concentrated in *vacu*o to give the crude residue. The resulting residue was subsequently purified by flash chromatography on silica gel (CH_2Cl_2/Petroleum ether = 3:2, v/v) to afford the desired tetracyclic chromane **3**.

Ethyl 3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 9:1 mixture of diastereomers) (3a). The product **3a** was obtained as a white solid (31.1 mg, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.40-7.32 (m, 3H), 7.29-7.26 (m, 2H), 7.12 (t, J = 7.8 Hz, 1H), 7.07 (d, J = 7.6 Hz, 1H), 6.93 (t, J = 7.4 Hz, 1H), 6.83 (d, J = 8.0 Hz, 1H), 5.64 (t, J = 3.4 Hz, 1H), 4.36 (q, J = 7.2 Hz, 2H), 3.84 (d, J = 11.6 Hz, 1H), 3.79 (dd, J = 12.2, 5.4 Hz, 1H), 3.28 (br s, 1H), 2.99 (t, J = 2.8 Hz, 1H), 2.80 (t, J = 12.4 Hz, 1H), 2.59 (td, J = 13.0, 3.4 Hz, 1H), 2.05-1.96 (m, 2H), 1.38 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 148.2, 137.0, 129.1, 128.52, 128.47, 128.3, 128.1, 126.4, 122.5, 117.6, 87.0, 75.5, 67.9, 62.3, 55.2, 45.4, 45.3, 37.3, 31.3, 14.2; IR (KBr): 3095, 2983, 1708, 1553, 1462, 1351, 1214, 1034, 839, 761 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{23}H_{23}NNaO_6$ 432.1418, found 432.1421.

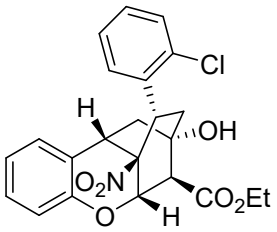


Ethyl 1-(4-fluorophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-



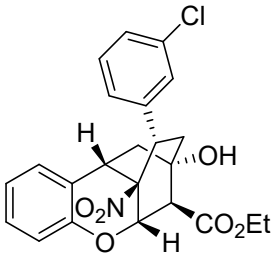
thene-4-carboxylate (a 9:1 mixture of diastereomers) (3b). The product **3b** was obtained as a white solid (32.5 mg, 76% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.24 (dd, J = 7.8, 5.4 Hz, 2H), 7.13 (t, J = 7.8 Hz, 1H), 7.08-7.04 (m, 3H), 6.94 (t, J = 7.4 Hz, 1H), 6.82 (d, J = 8.0 Hz, 1H), 5.62 (t, J = 3.0 Hz, 1H), 4.35 (q, J = 7.2 Hz, 2H), 3.81-3.76 (m, 2H), 3.24 (br s, 1H), 2.98 (t, J = 2.2 Hz, 1H), 2.75 (t, J = 12.4 Hz, 1H), 2.60 (td, J = 13.0, 3.4 Hz, 1H), 1.98-1.94 (m, 2H), 1.38 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 162.5 ($^1J_{C\text{-}F}$ = 246.7 Hz), 148.1, 132.7 ($^4J_{C\text{-}F}$ = 3.3 Hz), 129.8 ($^3J_{C\text{-}F}$ = 8.1 Hz), 128.6, 128.5, 126.3, 122.6, 117.7, 116.1 ($^2J_{C\text{-}F}$ = 21.5 Hz), 87.0, 75.4, 67.9, 62.3, 55.2, 45.3, 44.8, 37.6, 31.3, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ (ppm): -113.6; IR (KBr): 3476, 2982, 1731, 1555, 1464, 1347, 1234, 1033, 841, 757 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}FNO_6$ 428.1504, found 428.1504.

Ethyl 1-(2-chlorophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-



thene-4-carboxylate (a 8:1 mixture of diastereomers) (3c). The product **3c** was obtained as a white solid (30.6 mg, 69% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.57 (d, J = 7.6 Hz, 1H), 7.38-7.33 (m, 2H), 7.22 (t, J = 7.6 Hz, 1H), 7.13 (t, J = 7.8 Hz, 1H), 7.10 (d, J = 8.4 Hz, 1H), 6.93 (t, J = 7.6 Hz, 1H), 6.83 (d, J = 8.0 Hz, 1H), 5.68 (t, J = 3.4 Hz, 1H), 4.59 (dd, J = 12.2, 6.2 Hz, 1H), 4.36 (q, J = 7.2 Hz, 2H), 4.14 (d, J = 11.6 Hz, 1H), 3.35 (br s, 1H), 3.00 (dd, J = 3.2, 2.4 Hz, 1H), 2.77 (t, J = 12.6 Hz, 1H), 2.65 (td, J = 12.8, 3.6 Hz, 1H), 2.00 (d, J = 13.2 Hz, 1H), 1.79 (dd, J = 13.0, 5.0 Hz, 1H), 1.39 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 148.2, 135.7, 134.8, 130.4, 129.1, 128.9, 128.53, 128.49, 127.6, 125.8, 122.4, 117.6, 85.1, 75.3, 67.7, 62.3, 55.5, 45.5, 40.1, 39.0, 32.4, 14.1; IR (KBr): 3456, 2937, 1730, 1556, 1484, 1348, 1202, 1037, 821, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}ClNO_6$ 444.1208, found 444.1207.

Ethyl 1-(3-chlorophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-thene-4-carboxylate (a 12:1 mixture of diastereomers) (3d). The product **3d** was obtained as a white solid (32.4 mg, 73% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.29 (d, J = 6.0 Hz, 3H), 7.15-7.09 (m, 3H), 6.95 (t, J = 7.4 Hz, 1H), 6.82 (d, J = 8.0 Hz, 1H), 5.60 (t, J = 3.2 Hz, 1H), 4.35



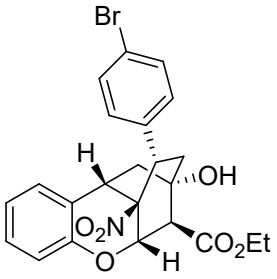
(q, *J* = 7.2 Hz, 2H), 3.83 (d, *J* = 11.6 Hz, 1H), 3.76 (dd, *J* = 12.0, 5.2 Hz, 1H), 3.23 (br s, 1H), 2.98 (t, *J* = 2.4 Hz, 1H), 2.77 (t, *J* = 12.4 Hz, 1H), 2.60 (td, *J* = 13.0, 3.4 Hz, 1H), 2.00-1.93 (m, 2H), 1.38 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 148.1, 139.1, 134.9, 130.4, 128.60, 128.58, 128.5, 128.2, 126.7, 126.2, 122.7, 117.7, 86.8, 75.4, 67.8, 62.3, 55.1, 45.3, 45.1, 37.3, 31.3, 14.2; IR (KBr): 3434, 2985, 1732, 1551, 1468, 1337, 1194, 1034, 852, 756 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}ClNO_6$ 444.1208, found 444.1207.

Ethyl 1-(4-chlorophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 11:1 mixture of diastereomers) (3e). The product **3e** was obtained as a white solid (31.0 mg, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.34 (d, *J* = 8.0 Hz, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 7.13 (t, *J* = 7.8 Hz, 1H), 7.07 (d, *J* = 7.2 Hz, 1H), 6.94 (t, *J* = 7.4 Hz, 1H), 6.82 (d, *J* = 8.4 Hz, 1H), 5.61 (t, *J* = 3.2 Hz, 1H), 4.35 (q, *J* = 7.2 Hz, 2H), 3.79 (d, *J* = 12.0 Hz, 1H), 3.76 (dd, *J* = 12.0, 5.2 Hz, 1H), 3.26 (br s, 1H), 2.98 (t, *J* = 2.6 Hz, 1H), 2.75 (t, *J* = 12.4 Hz, 1H), 2.60 (td, *J* = 13.2, 3.6 Hz, 1H), 1.99-1.93 (m, 2H), 1.38 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 148.1, 135.5, 134.4, 129.5, 129.3, 128.6, 128.5, 126.2, 122.7, 117.7, 86.9, 75.4, 67.8, 62.4, 55.2, 45.3, 44.9, 37.4, 31.3, 14.2; IR (KBr): 3466, 2984, 1731, 1554, 1495, 1346, 1201, 1030, 835, 759 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}ClNO_6$ 444.1208, found 444.1208.

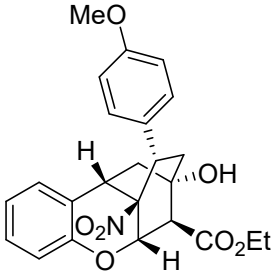
Ethyl 1-(2-bromophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 11:1 mixture of diastereomers) (3f). The product **3f** was obtained as a white solid (34.7 mg, 71% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.57-7.55 (m, 2H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.16-7.10 (m, 3H), 6.94 (t, *J* = 7.4 Hz, 1H), 6.84 (d, *J* = 8.0 Hz, 1H), 5.68 (s, 1H), 4.57 (dd, *J* = 11.6, 6.4 Hz, 1H), 4.38 (q, *J* = 7.0 Hz, 2H), 4.19 (d, *J* = 11.2 Hz, 1H), 3.29 (br s, 1H), 3.00 (s, 1H), 2.77 (t, *J* = 12.4 Hz, 1H), 2.65 (td, *J* = 12.8, 2.4 Hz, 1H), 2.01 (d, *J* = 12. 8 Hz, 1H), 1.76 (dd, *J* = 12.8, 6.0 Hz, 1H), 1.40 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 148.2, 137.6, 133.9, 129.4, 128.7, 128.5, 128.4, 128.3, 125.8, 125.6,

122.4, 117.6, 85.0, 75.3, 67.8, 62.4, 55.6, 45.6, 43.0, 39.4, 32.5, 14.2; IR (KBr): 3405, 2987, 1718, 1551, 1481, 1300, 1216, 1036, 858, 760 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}BrNO_6$ 488.0703, found 488.0707.

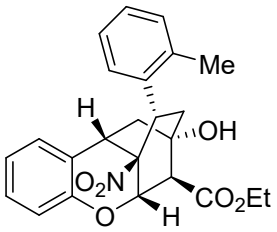
Ethyl 1-(4-bromophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (3g). The product **3g** was obtained as a white solid (35.2 mg, 72% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.49 (d, J = 8.8 Hz, 2H), 7.16-7.11 (m, 3H), 7.06 (dd, J = 7.6, 1.2 Hz, 1H), 6.94 (td, J = 7.4, 1.0 Hz, 1H), 6.82 (d, J = 8.0 Hz, 1H), 5.60 (dd, J = 4.0, 3.2 Hz, 1H), 4.35 (q, J = 7.2 Hz, 2H), 3.79 (d, J = 11.6 Hz, 1H), 3.75 (dd, J = 12.0, 5.2 Hz, 1H), 3.24 (br s, 1H), 2.97 (dd, J = 4.0, 2.4 Hz, 1H), 2.74 (t, J = 12.4 Hz, 1H), 2.60 (td, J = 13.4, 3.8 Hz, 1H), 1.99-1.92 (m, 2H), 1.38 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 148.1, 136.0, 132.3, 129.8, 128.6, 128.5, 126.2, 122.7, 122.5, 117.7, 86.8, 75.4, 67.8, 62.3, 55.2, 45.3, 44.9, 37.3, 31.3, 14.2; IR (KBr): 3471, 2939, 1732, 1554, 1492, 1347, 1201, 1031, 833, 759 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}BrNO_6$ 488.0703, found 488.0698.



Ethyl 3-hydroxy-1-(4-methoxyphenyl)-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 8:1 mixture of diastereomers) (3h). The product **3h** was obtained as a white solid (33.0 mg, 75% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.19 (d, J = 8.4 Hz, 2H), 7.12 (t, J = 8.0 Hz, 1H), 7.07 (d, J = 7.2 Hz, 1H), 6.93 (t, J = 8.0 Hz, 1H), 6.89 (d, J = 8.8 Hz, 2H), 6.82 (d, J = 8.0 Hz, 1H), 5.62 (t, J = 3.2 Hz, 1H), 4.35 (q, J = 7.0 Hz, 2H), 3.81 (d, J = 15.6 Hz, 1H), 3.79 (s, 3H), 3.74 (dd, J = 12.4, 5.2 Hz, 1H), 3.26 (br s, 1H), 2.97 (t, J = 2.8 Hz, 1H), 2.77 (t, J = 12.4 Hz, 1H), 2.58 (td, J = 13.0, 3.0 Hz, 1H), 2.00-1.94 (m, 2H), 1.38 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 159.4, 148.2, 129.2, 128.8, 128.5, 128.4, 126.5, 122.5, 117.6, 114.5, 87.1, 75.5, 67.9, 62.3, 55.22, 55.21, 45.3, 44.8, 37.6, 31.3, 14.2; IR (KBr): 3496, 2973, 1731, 1555, 1463, 1347, 1193, 1034, 836, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_7$ 440.1704, found 440.1705.



Ethyl 3-hydroxy-9a-nitro-1-(*o*-tolyl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-car-boxylate (a 9:1 mixture of diastereomers) (3i). The product **3i** was obtained as a white solid



(29.6 mg, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.47 (d, J = 7.6 Hz, 1H), 7.31 (t, J = 7.4 Hz, 1H), 7.18 (t, J = 7.6 Hz, 1H), 7.15-7.11 (m, 3H), 6.95 (t, J = 7.4 Hz, 1H), 6.83 (d, J = 7.6 Hz, 1H), 5.65 (s, 1H), 4.37 (q, J = 7.0 Hz, 2H), 4.23-4.17 (m, 2H), 3.07 (br s, 1H), 3.01 (s, 1H) 2.82 (t, J = 12.6 Hz, 1H), 2.60 (td, J = 12.6, 3.0 Hz, 1H), 2.31 (s, 3H), 2.00 (d, J = 13.2 Hz, 1H), 1.84 (dd, J = 13.0, 6.2 Hz, 1H), 1.39 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.8, 148.2, 137.2, 136.4, 131.3, 128.5, 127.7, 127.2, 126.8, 126.2, 122.4, 117.5, 85.5, 75.7, 68.1, 62.3, 55.8, 45.8, 39.9, 39.6, 32.3, 19.7, 14.2; IR (KBr): 3474, 2971, 1713, 1551, 1465, 1350, 1218, 1034, 844, 756 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_6$ 424.1755, found 424.1751.

Ethyl 3-hydroxy-9a-nitro-1-(*m*-tolyl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 11:1 mixture of diastereomers) (3j). The product **3j** was obtained as a white solid (28.4 mg, 67% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.26 (t, J = 7.6 Hz, 1H), 7.14-7.05 (m, 5H), 6.94 (t, J = 7.4 Hz, 1H), 6.82 (d, J = 8.0 Hz, 1H), 5.63 (t, J = 3.0 Hz, 1H), 4.36 (q, J = 7.0 Hz, 2H), 3.84 (d, J = 11.6 Hz, 1H), 3.74 (dd, J = 12.0, 5.2 Hz, 1H), 3.26 (br s, 1H), 2.98 (t, J = 2.8 Hz, 1H), 2.81 (t, J = 12.4 Hz, 1H), 2.58 (td, J = 13.0, 3.4 Hz, 1H), 2.36 (s, 3H), 2.04-1.95 (m, 2H), 1.39 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 148.2, 138.7, 136.9, 129.1, 129.00, 128.96, 128.5, 128.4, 126.5, 125.1, 122.5, 117.6, 87.0, 75.5, 67.9, 62.3, 55.2, 45.4, 45.3, 37.4, 31.4, 21.6, 14.2; IR (KBr): 3526, 2986, 1731, 1549, 1463, 1337, 1195, 1035, 839, 758 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_6$ 424.1755, found 424.1756.

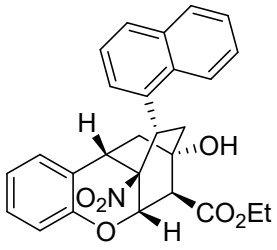
Ethyl 3-hydroxy-9a-nitro-1-(*p*-tolyl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-car-boxylate (a 8:1 mixture of diastereomers) (3k). The product **3k** was obtained as a white solid (33.0 mg, 78% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.21-7.15 (m, 4H), 7.11 (d, J = 8.0 Hz, 1H), 7.07 (d, J = 7.2 Hz, 1H), 6.93 (t, J = 7.4 Hz, 1H), 6.82 (d, J = 8.4 Hz, 1H), 5.63 (t, J = 3.2 Hz, 1H), 4.35 (q, J = 7.0 Hz, 2H), 3.83 (d, J = 11.6 Hz, 1H), 3.75 (dd, J = 12.0, 5.2 Hz, 1H), 3.26 (br s, 1H), 2.98 (t, J = 2.8 Hz, 1H), 2.79 (t, J =

12.4 Hz, 1H), 2.58 (td, *J* = 13.0, 3.0 Hz, 1H), 2.34 (s, 3H), 2.03-1.94 (m, 2H), 1.38 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 148.2, 138.1, 133.9, 129.8, 128.5, 128.4, 128.0, 126.5, 122.5, 117.6, 87.1, 75.5, 67.9, 62.2, 55.2, 45.3, 45.1, 37.4, 31.3, 21.0, 14.2; IR (KBr): 3504, 2982, 1732, 1555, 1463, 1347, 1201, 1034, 829, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_6$ 424.1755, found 424.1755.

Ethyl 1-(furan-2-yl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 8:1 mixture of diastereomers) (3l). The product **3l** was obtained as a white solid (26.4 mg, 66% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.44 (s, 1H), 7.14 (t, *J* = 7.6 Hz, 1H), 7.10 (d, *J* = 6.8 Hz, 1H), 6.96 (t, *J* = 7.4 Hz, 1H), 6.82 (d, *J* = 8.4 Hz, 1H), 6.34-6.32 (m, 1H), 6.19 (d, *J* = 3.2 Hz, 1H), 5.52 (t, *J* = 3.0 Hz, 1H), 4.33 (q, *J* = 7.2 Hz, 2H), 3.95 (dd, *J* = 12.2, 4.2 Hz, 1H), 3.81 (d, *J* = 11.6 Hz, 1H), 3.17 (br s, 1H), 2.97 (t, *J* = 2.8 Hz, 1H), 2.86 (t, *J* = 12.0 Hz, 1H), 2.51 (td, *J* = 12.4, 3.2 Hz, 1H), 2.06 (d, *J* = 13.2 Hz, 1H), 1.89 (dd, *J* = 12.8, 3.2 Hz, 1H), 1.36 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 150.2, 148.2, 143.3, 128.7, 128.4, 126.7, 122.7, 117.7, 110.6, 109.0, 86.6, 74.9, 68.0, 62.2, 54.3, 44.4, 38.9, 34.5, 32.2, 14.2; IR (KBr): 3476, 2938, 1718, 1558, 1462, 1349, 1206, 1034, 838, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{22}NO_7$ 440.1391, found 440.1390.

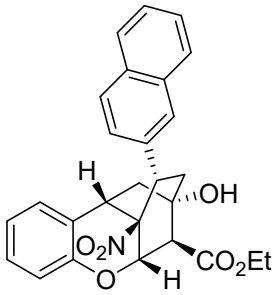
Ethyl 3-hydroxy-9a-nitro-1-(thiophen-2-yl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (3m). The product **3m** was obtained as a white solid (24.9 mg, 60% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.30 (d, *J* = 5.2 Hz, 1H), 7.14 (t, *J* = 7.2 Hz, 1H), 7.11 (d, *J* = 7.2 Hz, 1H), 6.96 (t, *J* = 6.8 Hz, 2H), 6.86 (d, *J* = 2.8 Hz, 1H), 6.83 (d, *J* = 8.0 Hz, 1H), 5.56 (t, *J* = 3.4 Hz, 1H), 4.34 (q, *J* = 7.2 Hz, 2H), 4.18 (dd, *J* = 12.0, 4.4 Hz, 1H), 3.93 (d, *J* = 11.2 Hz, 1H), 3.21 (br s, 1H), 2.98 (t, *J* = 2.8 Hz, 1H), 2.82 (t, *J* = 12.4 Hz, 1H), 2.74 (td, *J* = 13.4, 3.0 Hz, 1H), 2.02-1.94 (m, 2H), 1.37 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.6, 148.2, 140.2, 128.7, 128.5, 127.5, 127.4, 126.6, 125.7, 122.7, 117.7, 87.3, 75.2, 67.9, 62.3, 54.4, 44.7, 40.9, 39.7, 31.5, 14.2; IR (KBr): 3473, 2968, 1731, 1555, 1461, 1346, 1200, 1033, 848, 761 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{22}NO_6S$ 416.1162, found 416.1159.

Ethyl 3-hydroxy-1-(naphthalen-1-yl)-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-



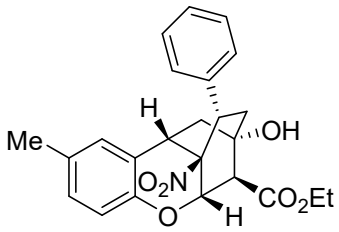
thene-4-carboxylate (a 8:1 mixture of diastereomers) (3n). The product **3n** was obtained as a white solid (28.0 mg, 61% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 8.10 (d, J = 8.4 Hz, 1H), 7.83 (t, J = 7.0 Hz, 2H), 7.72 (d, J = 7.2 Hz, 1H), 7.57 (t, J = 7.6 Hz, 1H), 7.53 (d, J = 8.0 Hz, 1H), 7.48 (t, J = 7.4 Hz, 1H), 7.13 (d, J = 6.4 Hz, 2H), 6.95 (t, J = 7.4 Hz, 1H), 6.84 (d, J = 8.4 Hz, 1H), 5.82 (t, J = 3.2 Hz, 1H), 4.89 (dd, J = 11.8, 5.8 Hz, 1H), 4.41 (q, J = 7.0 Hz, 2H), 4.21 (d, J = 11.6 Hz, 1H), 3.09 (br s, 1H), 2.92 (t, J = 12.4 Hz, 1H), 2.76 (td, J = 12.8, 2.4 Hz, 1H), 2.06 (d, J = 14.8 Hz, 2H), 2.01 (dd, J = 13.2, 4.8 Hz, 1H), 1.42 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.9, 148.3, 134.5, 133.9, 132.0, 128.9, 128.8, 128.6, 126.7, 126.3, 126.1, 125.2, 125.1, 122.5, 122.3, 117.6, 85.7, 75.9, 68.1, 62.4, 55.7, 45.7, 40.2, 38.2, 32.4, 14.3; IR (KBr): 3457, 2938, 1706, 1550, 1463, 1346, 1216, 1033, 794, 752 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{27}H_{26}NO_6$ 460.1755, found 460.1750.

Ethyl 3-hydroxy-1-(naphthalen-2-yl)-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-



thene-4-carboxylate (a 10:1 mixture of diastereomers) (3o). The product **3o** was obtained as a white solid (32.2 mg, 70% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.87 (d, J = 8.8 Hz, 1H), 7.84-7.81 (m, 2H), 7.73 (s, 1H), 7.53-7.48 (m, 2H), 7.41 (d, J = 8.8 Hz, 1H), 7.13 (t, J = 7.8 Hz, 1H), 7.09 (d, J = 7.6 Hz, 1H), 6.93 (t, J = 7.2 Hz, 1H), 6.84 (d, J = 8.4 Hz, 1H), 5.71 (t, J = 3.4 Hz, 1H), 4.38 (q, J = 7.2 Hz, 2H), 3.98 (dd, J = 12.0, 5.2 Hz, 1H), 3.92 (d, J = 12.0 Hz, 1H), 3.31 (br s, 1H), 3.03 (dd, J = 3.6, 2.4 Hz, 1H), 2.93 (t, J = 12.4 Hz, 1H), 2.68 (td, J = 13.0, 3.0 Hz, 1H), 2.16 (ddd, J = 13.6, 4.8, 2.0 Hz, 1H), 2.03 (d, J = 13.2 Hz, 1H), 1.40 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 148.2, 134.3, 133.2, 132.9, 129.0, 128.54, 128.48, 128.0, 127.7, 127.6, 126.53, 126.48, 126.47, 125.4, 122.6, 117.6, 87.1, 75.6, 68.0, 62.3, 55.3, 45.6, 45.4, 37.4, 31.5, 14.2; IR (KBr): 3577, 2983, 1740, 1550, 1462, 1347, 1198, 1032, 819, 758 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{27}H_{26}NO_6$ 460.1755, found 460.1756.

Ethyl 3-hydroxy-7-methyl-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxan-thene-4-carboxylate (a 7:1 mixture of diastereomers) (3p). The product **3p** was obtained as a white solid (28.8 mg, 68% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.39-7.32 (m, 3H), 7.27



(d, *J* = 8.0 Hz, 2H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.87 (s, 1H), 6.72 (d, *J* = 8.4 Hz, 1H), 5.61 (t, *J* = 2.8 Hz, 1H), 4.35 (q, *J* = 7.0 Hz, 2H), 3.78 (d, *J* = 12.0 Hz, 2H), 3.26 (br s, 1H), 2.98 (s, 1H), 2.79 (t, *J* = 12.4 Hz, 1H), 2.60 (td, *J* = 13.0, 3.0 Hz, 1H), 2.24 (s, 3H), 2.04-1.95 (m, 2H), 1.38 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.8, 145.9, 137.0, 131.9, 129.2, 129.1, 128.7, 128.3, 128.2, 126.1, 117.4, 87.1, 75.5, 68.0, 62.2, 55.1, 45.5, 45.3, 37.3, 31.3, 20.5, 14.2; IR (KBr): 3493, 2939, 1731, 1555, 1465, 1348, 1208, 1034, 818, 733 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_6$ 424.1755, found 424.1750.

Ethyl 1-(4-chlorophenyl)-3-hydroxy-7-methyl-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 14:1 mixture of diastereomers) (3q). The product **3q** was obtained as a white solid (31.1 mg, 68% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.34 (d, *J* = 8.0 Hz, 2H), 7.20 (d, *J* = 8.0 Hz, 2H), 6.93 (d, *J* = 8.4 Hz, 1H), 6.88 (s, 1H), 6.71 (d, *J* = 8.0 Hz, 1H), 5.58 (s, 1H), 4.34 (q, *J* = 7.2 Hz, 2H), 3.78-3.72 (m, 2H), 3.24 (br s, 1H), 2.97 (s, 1H), 2.73 (t, *J* = 12.4 Hz, 1H), 2.60 (t, *J* = 12.8 Hz, 1H), 2.24 (s, 3H), 1.98-1.92 (m, 2H), 1.37 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.7, 145.8, 135.5, 134.3, 132.0, 129.5, 129.31, 129.29, 128.7, 125.9, 117.4, 87.0, 75.4, 67.9, 62.3, 55.1, 45.3, 44.9, 37.3, 31.2, 20.5, 14.2; IR (KBr): 3493, 2939, 1731, 1555, 1465, 1348, 1208, 1034, 818, 733 cm^{-1}; IR (KBr): 3492, 2974, 1731, 1555, 1467, 1349, 1210, 1031, 826, 734 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{25}ClNO_6$ 458.1365, found 458.1361.

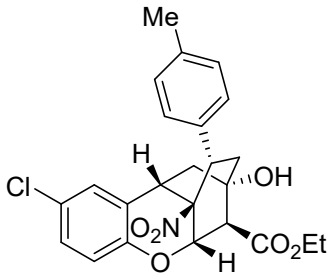
Ethyl 3-hydroxy-7-methyl-9a-nitro-1-(*p*-tolyl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 7:1 mixture of diastereomers) (3r). The product **3r** was obtained as a white solid (22.3 mg, 51% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.20-7.14 (m, 4H), 6.92 (d, *J* = 8.4 Hz, 1H), 6.88 (s, 1H), 6.71 (d, *J* = 8.0 Hz, 1H), 5.60 (t, *J* = 2.8 Hz, 1H), 4.35 (q, *J* = 7.2 Hz, 2H), 3.79-3.72 (m, 2H), 3.27 (br s, 1H), 2.97 (s, 1H), 2.78 (t, *J* = 12.2 Hz, 1H), 2.58 (td, *J* = 13.0, 2.6 Hz, 1H), 2.33 (s, 3H), 2.24 (s, 3H), 2.02-1.94 (m, 2H), 1.38 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ

(ppm): 171.8, 145.9, 138.0, 133.9, 131.8, 129.8, 129.2, 128.8, 128.0, 126.2, 117.3, 87.2, 75.5, 68.0, 62.2, 55.1, 45.3, 45.1, 37.4, 31.3, 21.0, 20.5, 14.2; IR (KBr): 3502, 2941, 1734, 1556, 1465, 1349, 1208, 1034, 822, 769 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{25}H_{28}NO_6$ 438.1911, found 438.1906.

Ethyl 7-chloro-3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 5:1 mixture of diastereomers) (3s). The product **3s** was obtained as a White solid (22.2 mg, 50% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.39-7.31 (m, 4H), 7.24 (s, 1H), 7.12-7.07 (m, 2H), 6.77 (d, J = 9.2 Hz, 1H), 5.63 (t, J = 2.8 Hz, 1H), 4.36 (q, J = 7.2 Hz, 2H), 3.80-3.76 (m, 2H), 3.26 (br s, 1H), 2.93 (s, 1H), 2.80 (t, J = 12.6 Hz, 1H), 2.59 (td, J = 13.2, 3.2 Hz, 1H), 2.03 (dd, J = 13.4, 3.4 Hz, 1H), 1.95 (d, J = 13.2 Hz, 1H), 1.39 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.5, 146.8, 136.6, 129.2, 129.0, 128.6, 128.4, 128.1, 128.0, 127.2, 119.7, 86.7, 75.7, 67.8, 62.4, 55.2, 45.2, 45.0, 37.3, 31.3, 14.2; IR (KBr): 3494, 2940, 1729, 1555, 1486, 1350, 1199, 1032, 820, 705 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}ClNO_6$ 444.1208, found 444.1206.

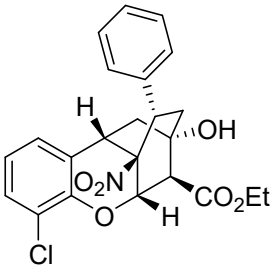
Ethyl 7-chloro-1-(4-chlorophenyl)-3-hydroxy-9a-nitro-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 10:1 mixture of diastereomers) (3t). The product **3t** was obtained as a white solid (29.2 mg, 61% yield). ^1H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.34 (d, J = 8.0 Hz, 2H), 7.18 (d, J = 8.4 Hz, 2H), 7.10-7.08 (m, 2H), 6.77 (d, J = 9.2 Hz, 1H), 5.61 (t, J = 2.8 Hz, 1H), 4.35 (q, J = 7.2 Hz, 2H), 3.78-3.74 (m, 2H), 3.24 (br s, 1H), 2.93 (s, 1H), 2.74 (t, J = 12.4 Hz, 1H), 2.58 (td, J = 13.2, 3.2 Hz, 1H), 1.97-1.93 (m, 2H), 1.38 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.4, 146.7, 135.1, 134.5, 129.45, 129.40, 128.7, 128.1, 127.7, 127.3, 119.1, 86.5, 75.6, 67.7, 62.5, 55.2, 45.0, 44.7, 37.2, 31.2, 14.2; IR (KBr): 3491, 2978, 1731, 1555, 1489, 1350, 1199, 1029, 827, 734 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{22}Cl_2NO_6$ 478.0819, found 478.0819.

Ethyl 7-chloro-3-hydroxy-9a-nitro-1-(*p*-tolyl)-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 5:1 mixture of diastereomers) (3u). The product **3u** was obtained as a

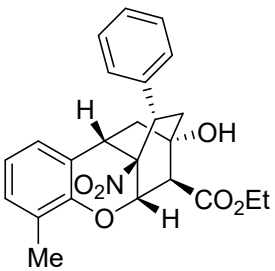


white solid (26.1 mg, 57% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.22-7.12 (m, 4H), 7.08-7.06 (m, 2H), 6.76 (d, J = 9.2 Hz, 1H), 5.63 (t, J = 3.2 Hz, 1H), 4.35 (q, J = 7.0 Hz, 1H), 3.80-3.73 (m, 2H), 3.30 (br s, 1H), 2.93 (t, J = 2.8 Hz, 1H), 2.78 (t, J = 12.4 Hz, 1H), 2.57 (td, J = 13.0, 3.0 Hz, 1H), 2.33 (s, 3H), 2.00 (dd, J = 13.4, 3.0 Hz, 1H), 1.93 (d, J = 13.2 Hz, 1H), 1.38 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.5, 146.8, 138.2, 133.5, 129.8, 128.5, 128.1, 128.0, 127.9, 127.1, 119.0, 86.7, 75.7, 67.8, 62.3, 55.3, 45.0, 44.8, 37.2, 31.2, 21.0, 14.2; IR (KBr): 3509, 2983, 1732, 1555, 1484, 1350, 1197, 1032, 823, 734 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{25}ClNO_6$ 458.1365, found 458.1367.

Ethyl 5-chloro-3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 13:1 mixture of diastereomers) (3v). The product **3v** was obtained as a white solid (32.4 mg, 73% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.39-7.32 (m, 3H), 7.27 (d, J = 6.4 Hz, 2H), 7.20 (dd, J = 8.0, 1.2 Hz, 1H), 6.99 (d, J = 7.6 Hz, 1H), 6.87 (t, J = 7.8 Hz, 1H), 5.80 (t, J = 3.4 Hz, 1H), 4.36 (q, J = 7.2 Hz, 2H), 3.86 (d, J = 11.6 Hz, 1H), 3.81 (dd, J = 12.0, 5.6 Hz, 1H), 3.25 (br s, 1H), 2.95 (dd, J = 3.4, 2.6 Hz, 1H), 2.81 (t, J = 12.4 Hz, 1H), 2.57 (td, J = 13.0, 3.0 Hz, 1H), 2.03 (ddd, J = 13.6, 5.4, 2.2 Hz, 1H), 1.93 (d, J = 12.0 Hz, 1H), 1.38 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.3, 144.3, 136.7, 129.2, 129.1, 128.4, 128.3, 126.8, 122.7, 122.4, 86.7, 76.0, 67.7, 62.4, 55.7, 45.2, 37.3, 31.4, 14.2; IR (KBr): 3441, 2936, 1744, 1555, 1462, 1324, 1194, 1033, 785, 738 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{23}ClNO_6$ 444.1208, found 444.1205.

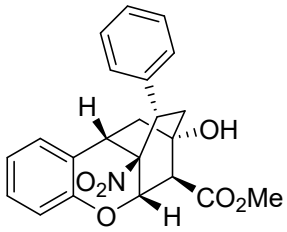


Ethyl 3-hydroxy-5-methyl-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 13:1 mixture of diastereomers) (3w). The product **3w** was obtained as a white solid (22.9 mg, 54%). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.40-7.32 (m, 3H), 7.28 (d, J = 7.2 Hz, 2H), 6.97 (d, J = 7.2 Hz, 1H), 6.91 (d, J = 7.2 Hz, 1H), 6.83 (t, J = 7.4 Hz, 1H), 5.67 (t, J = 3.4 Hz, 1H), 4.39-4.33 (m, 2H), 3.84-3.77 (m, 2H), 3.20 (br s, 1H), 2.95 (dd, J = 3.6, 2.4 Hz, 1H), 2.80 (t, J = 12.4 Hz, 1H), 2.61 (td, J = 12.8,

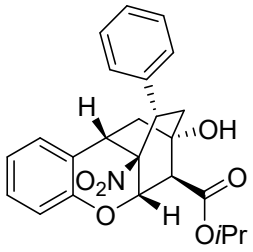


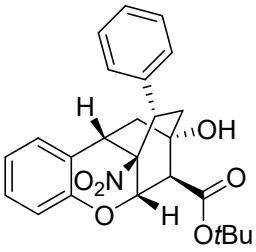
3.2 Hz, 1H), 2.14 (s, 3H), 2.03 (ddd, *J* = 13.6, 5.0, 2.2 Hz, 1H), 1.96 (dd, *J* = 13.4, 1.8 Hz, 1H), 1.39 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.8, 146.3, 137.1, 129.6, 129.1, 128.3, 128.2, 126.9, 126.03, 125.99, 122.0, 87.1, 75.5, 67.9, 62.2, 55.4, 45.5, 45.4, 37.4, 31.4, 15.8, 14.2; IR (KBr): 3517, 2986, 1733, 1552, 1469, 1337, 1196, 1038, 785, 738 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{24}H_{26}NO_6$ 424.1755, found 424.1751.

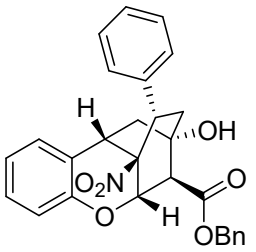
Methyl 3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-car-boxylate (a 8:1 mixture of diastereomers) (3x). The product **3x** was obtained as a white solid (23.7 mg, 60% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.39-7.32 (m, 3H), 7.27 (d, *J* = 9.6 Hz, 2H), 7.12 (t, *J* = 7.8 Hz, 1H), 7.07 (d, *J* = 7.2 Hz, 1H), 6.94 (t, *J* = 7.4 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 1H), 5.63 (t, *J* = 3.0 Hz, 1H), 3.88-3.78 (m, 5H), 3.30 (br s, 1H), 3.01 (s, 1H), 2.79 (t, *J* = 12.4 Hz, 1H), 2.62 (td, *J* = 12.8, 2.8 Hz, 1H), 2.05-1.96 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 172.2, 148.0, 136.9, 129.1, 128.5, 128.4, 128.3, 128.1, 126.4, 122.5, 117.6, 86.9, 75.5, 67.9, 55.1, 52.9, 45.4, 45.2, 37.2, 31.3; IR (KBr): 3508, 2970, 1735, 1554, 1454, 1350, 1216, 1032, 847, 764 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{22}H_{21}NNaO_6$ 418.1261, found 418.1266.



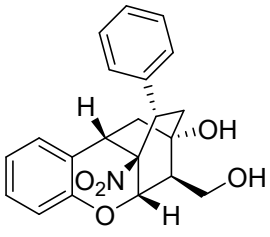
Isopropyl 3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (a 17:1 mixture of diastereomers) (3y). The product **3y** was obtained as a white solid (27 mg, 64% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.40-7.33 (m, 3H), 7.28 (d, *J* = 7.2 Hz, 2H), 7.12 (t, *J* = 7.8 Hz, 1H), 7.07 (d, *J* = 7.6 Hz, 1H), 6.93 (t, *J* = 7.2 Hz, 1H), 6.83 (d, *J* = 8.0 Hz, 1H), 5.65 (t, *J* = 3.2 Hz, 1H), 5.24-5.18 (m, 1H), 3.84 (d, *J* = 11.6 Hz, 1H), 3.77 (dd, *J* = 12.2, 5.4 Hz, 1H), 3.27 (br s, 1H), 2.95 (s, 1H), 2.80 (t, *J* = 12.4 Hz, 1H), 2.57 (td, *J* = 13.2, 3.2 Hz, 1H), 2.02 (dd, *J* = 15.2, 4.8 Hz, 1H), 1.96 (d, *J* = 13.2 Hz, 1H), 1.38 (d, *J* = 6.4 Hz, 3H), 1.35 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 171.1, 148.2, 137.0, 129.1, 128.5, 128.4, 128.2, 128.1, 126.4, 122.4, 117.6, 87.0, 75.4, 70.3, 67.9, 55.4, 45.41, 45.36, 37.3, 31.3, 21.78, 21.76; IR (KBr): 3472, 2939, 1727, 1555, 1463, 1382, 1215, 1033, 814, 762 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{24}H_{25}NNaO_6$ 446.1574, found 446.1579.



***Tert*-butyl 3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-carboxylate (3z).**  The product **3z** was obtained as a white solid (24.2 mg, 55% yield). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.38-7.31 (m, 3H), 7.26 (d, J = 7.2 Hz, 2H), 7.10 (t, J = 7.4 Hz, 1H), 7.05 (d, J = 7.2 Hz, 1H), 6.91 (t, J = 7.0 Hz, 1H), 6.81 (d, J = 8.0 Hz, 1H), 5.63 (s, 1H), 3.81 (d, J = 11.2 Hz, 1H), 3.75 (dd, J = 11.6, 4.4 Hz, 1H), 3.34 (br s, 1H), 2.88 (s, 1H), 2.78 (t, J = 12.4 Hz, 1H), 2.54 (t, J = 12.4 Hz, 1H), 2.00 (d, J = 13.2 Hz, 1H), 1.93 (d, J = 12.8 Hz, 1H), 1.57 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 170.7, 148.3, 137.0, 129.1, 128.5, 128.4, 128.23, 128.17, 126.5, 122.4, 117.5, 87.0, 83.8, 75.5, 67.9, 56.0, 45.5, 45.4, 37.5, 31.3, 28.1; IR (KBr): 3549, 2977, 1708, 1553, 1463, 1384, 1234, 1033, 831, 767 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{25}H_{27}NNaO_6$ 460.1731, found 460.1735.

Benzyl 3-hydroxy-9a-nitro-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-car-boxylate (3aa).  The product **3aa** was obtained as a white solid (32 mg, 68% yield). ^{1}H NMR (400 MHz, DMSO-d6) δ (ppm): 7.45 (d, J = 6.8 Hz, 2H), 7.40-7.32 (m, 8H), 7.25 (d, J = 7.2 Hz, 1H), 7.13 (t, J = 7.4 Hz, 1H), 6.97 (t, J = 7.4 Hz, 1H), 6.83 (d, J = 8.0 Hz, 1H), 5.53 (br s, 1H), 5.42 (s, 1H), 5.31-5.24 (m, 2H), 3.90 (d, J = 11.2 Hz, 1H), 3.80 (dd, J = 11.6, 4.8 Hz, 1H), 2.96 (s, 1H), 2.85 (t, J = 12.2 Hz, 1H), 2.68 (t, J = 12.0 Hz, 1H), 1.92-1.84 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d6) δ (ppm): 171.6, 147.9, 137.6, 135.7, 128.94, 128.85, 128.5, 128.4, 128.3, 128.1, 128.00, 128.97, 127.3, 122.5, 116.9, 87.3, 76.1, 67.5, 66.7, 56.3, 45.6, 45.3, 36.6, 31.3; IR (KBr): 3632, 3518, 3348, 3034, 2961, 1719, 1551, 1459, 1351, 1213, 1033, 844, 743 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ calcd. for $C_{28}H_{25}NNaO_6$ 494.1574, found 494.1578.

4. Reduction of ester group of 3a

4-(hydroxymethyl)-9a-nitro-1-phenyl-1,2,4,4a,9,9a-hexahydro-3*H*-3,9-methanoxanthen-3-ol (a 12:1 mixture of diastereomers) (4).  Lithium triethylborohydride (0.01 mmol, 1M in THF) was added dropwise to a solution of **3a** (41 mg, 0.1 mmol) and lithium borohydride (0.1 mmol, 2M in THF) in THF (1 mL). The solution was then stirred at rt for 1 h until the

completion of reaction, as monitored by TLC. The reaction mixture was diluted with THF (1 mL), washed with aqueous NaOH (3M; 2 x 3 mL), brine and water (2 x 3 mL). The organic phase was dried over Na_2SO_4 and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel, eluting with (Petroleum ether/Ethyl acetate = 2/1, v/v) to give **4** as a pale yellow oil (36.4 mg, 99% yield, 12:1 dr).

^{1}H NMR (400 MHz, DMSO-d6) δ (ppm): 7.39-7.36 (m, 2H), 7.32-7.29 (m, 3H), 7.18 (d, J = 7.6 Hz, 1H), 7.09 (t, J = 7.2 Hz, 1H), 6.90 (t, J = 7.4 Hz, 1H), 6.77 (d, J = 8.0 Hz, 1H), 5.21 (t, J = 3.2 Hz, 1H), 5.03 (t, J = 4.8 Hz, 1H), 4.98 (br s, 1H), 3.86-3.82 (m, 3H), 3.71 (dd, J = 12.0, 5.6 Hz, 1H), 2.73 (t, J = 12.2 Hz, 1H), 2.59 (td, J = 12.6, 3.0 Hz, 1H), 1.84 (d, J = 3.2 Hz, 1H), 1.73-1.67 (m, 2H); ^{13}C NMR (100 MHz, DMSO-d6) δ (ppm): 148.6, 138.3, 128.8, 128.6, 128.5, 127.91, 127.87, 127.8, 121.7, 116.8, 88.1, 76.7, 66.4, 59.1, 51.7, 47.2, 45.5, 37.8, 31.5; IR (KBr): 3572, 3336, 2963, 1553, 1462, 1363, 1225, 1017, 809, 766 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{21}H_{22}NO_5$ 368.1492, found 368.1489.

5. Reduction of 3a to primary amine 5

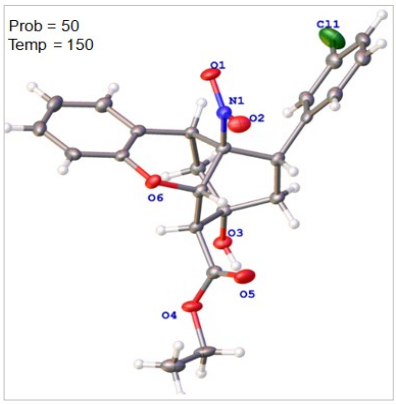
Ethyl 9a-amino-3-hydroxy-1-phenyl-2,3,4,4a,9,9a-hexahydro-1*H*-3,9-methanoxanthene-4-car-boxylate (a 15:1 mixture of diastereomers) (5). Zinc dust (260 mg, 4 mmol) was added portionwise to a solution of **3a** (41 mg, 0.1 mmol) and concentrated HCl (150 μL, 1.2 mmol) in ethanol (1 mL) at 0 °C. The suspension was stirred at 0 °C for 30 min. After completion of the reaction, a saturated aqueous $NaHCO_3$ solution was added dropwise to around pH 9. The resulting mixture was filtered through a pad of Celite, and the filter cake was rinsed with EtOAc. Subsequently, the filtrate was dried over Na_2SO_4, filtered, and concentrated in vacuum to give pure primary amine **5** (37.6 mg, 99% yield, 15:1 dr).

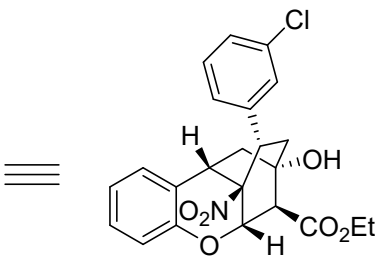
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 7.43-7.37 (m, 4H), 7.30 (t, J = 6.6 Hz, 1H), 7.13 (t, J = 7.6 Hz, 1H), 6.98 (d, J = 7.2 Hz, 1H), 6.88 (t, J = 8.6 Hz, 2H), 4.66 (s, 1H), 4.28 (q, J = 7.0 Hz, 2H), 3.12 (dd, J = 11.8, 5.4 Hz, 1H), 2.84 (s, 2H), 2.63 (t, J = 12.2 Hz, 1H), 2.48 (td, J = 12.8, 2.4 Hz, 1H), 2.00 (br s, 2H), 1.92 (dd, J = 13.6, 3.6 Hz, 1H), 1.83 (d, J = 12.8 Hz, 1H), 1.33 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm): 172.7, 149.2, 140.2, 129.8, 129.3, 128.6, 128.1, 127.6, 127.2, 121.7, 117.3, 79.2, 67.3, 61.6, 55.8, 48.3, 46.4, 45.7, 38.3, 37.1, 14.1; IR (KBr): 3450, 2966,

1731, 1596, 1494, 1461, 1340, 1228, 1196, 1023, 758, 704 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ calcd. for $C_{23}H_{26}NO_4$ 380.1856, found 380.1855.

6. X-ray crystallographic analysis of 3d (CCDC 2131464)

Single crystals of $C_{23}H_{22}ClNO_6$ were obtained via slow volatilization in a mixed solution of dichloromethane/petroleum ether. A suitable crystal was selected and measured on a New Gemini Dual-sourced diffractometer (Mo K_α λ = 0.71073 Å). The crystal was kept at 150 K during data collection. Using Olex2, the structure was solved with the ShelXT structure solution program using Direct Methods and refined with the ShelXL refinement package using Least Squares minimisation. The ellipsoid contour percent probability level of **3d** is 50%.





3d

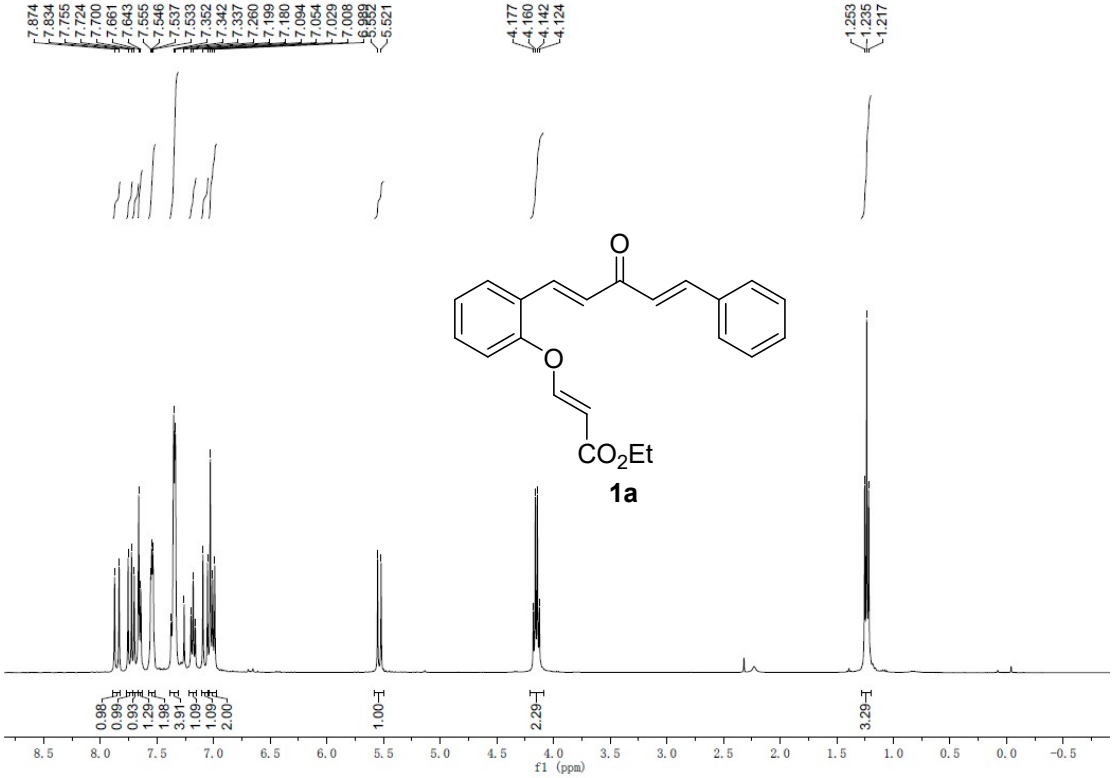
Empirical formula	$C_{23}H_{22}ClNO_6$
Formula weight	443.86
Temperature/K	150.00(10)
Crystal system	orthorhombic
Space group	Pbca
a/Å	14.9980(6)
b/Å	12.8933(5)
c/Å	21.1475(11)
α/°	90
β/°	90
γ/°	90
Volume/$Å^3$	4089.4(3)

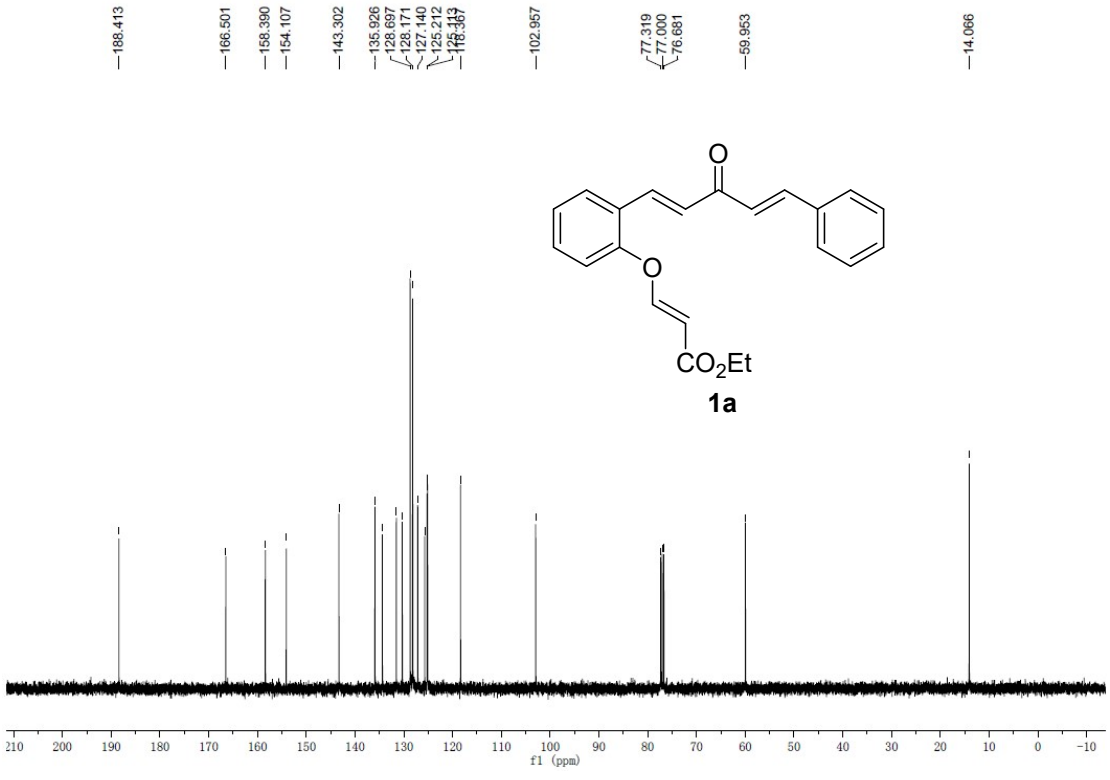
Z	8
ρ_{calc}g/cm^3	1.442
μ/mm^{-1}	0.229
F(000)	1856.0
Crystal size/mm^3	0.14 × 0.13 × 0.12
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection/°	4.59 to 49.996
Index ranges	-17 ≤ h ≤ 16, -15 ≤ k ≤ 15, -25 ≤ l ≤ 18
Reflections collected	11972
Independent reflections	3607 [R_{int} = 0.0330, R_{sigma} = 0.0348]
Data/restraints/parameters	3607/0/282
Goodness-of-fit on F^2	1.057
Final R indexes [I>=2σ (I)]	R_1 = 0.0389, wR_2 = 0.0830
Final R indexes [all data]	R_1 = 0.0502, wR_2 = 0.0903
Largest diff. peak/hole / e Å^{-3}	0.27/-0.30

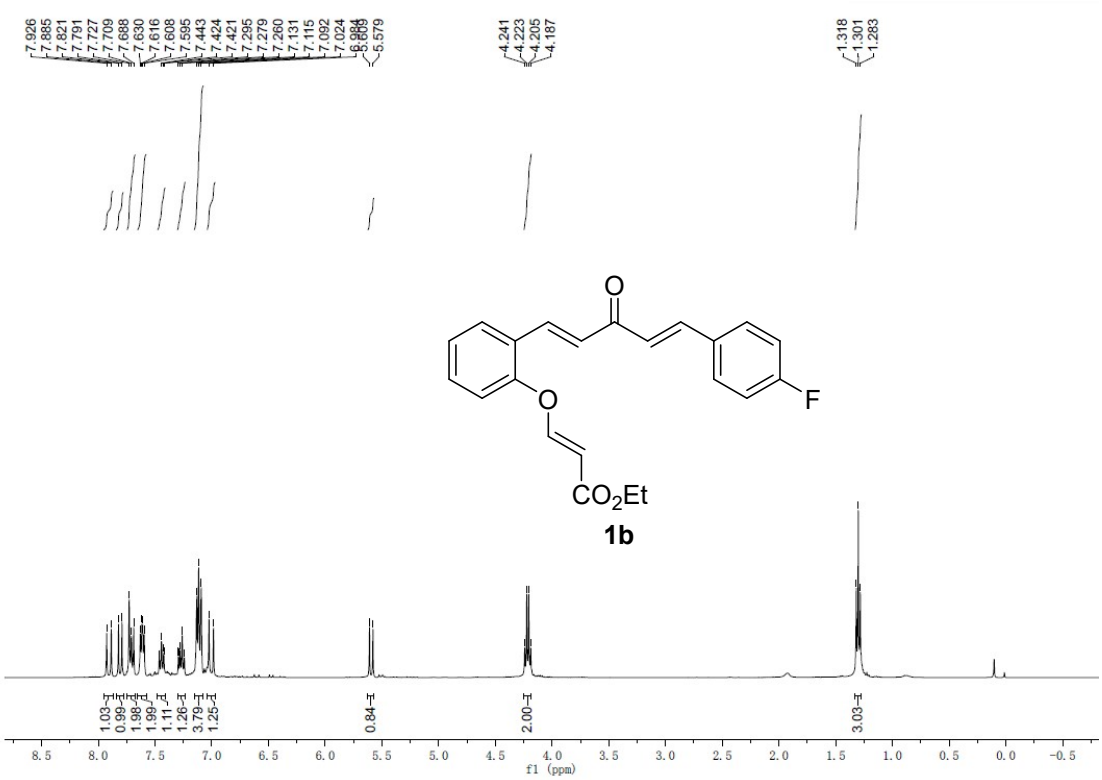
7. Reference

1. L. Chen, T. Guo, R. Xia, X. Tang, Y. Chen, C. Zhang and W. Xue, *Molecules*, 2019, **24**, 925.

8. NMR spectra of products



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7.791
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7.709
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7.608
7.595
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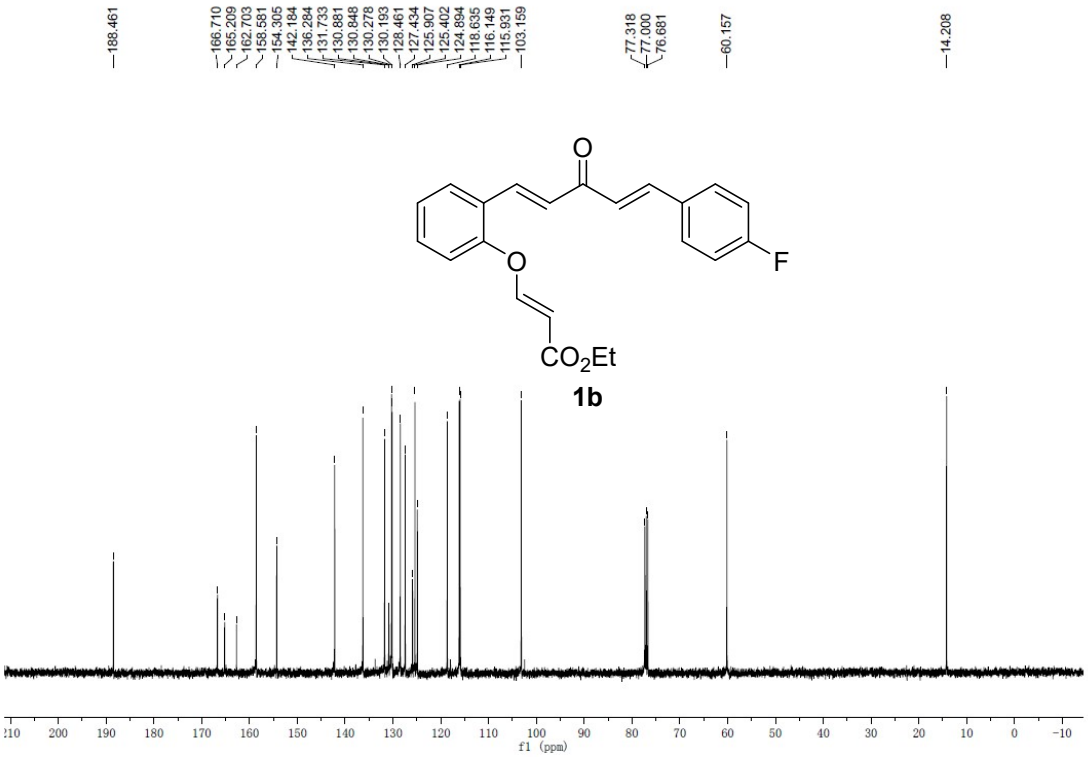
7.421
7.295
7.279
7.260
7.131
7.115
7.092
7.024
5.579
4.241
4.223
4.205
4.187
1.318
1.301
1.283
O
O
F
CO2Et
1b
1.03
0.99
1.98
1.99
1.11
1.26
3.79
1.25
0.84
2.00
3.03
f1 (ppm)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142.184
136.284
131.733
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130.848
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130.193
128.461
127.434
125.907
125.402
124.894
118.635
116.149
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103.159
77.318
77.000
76.681
60.157
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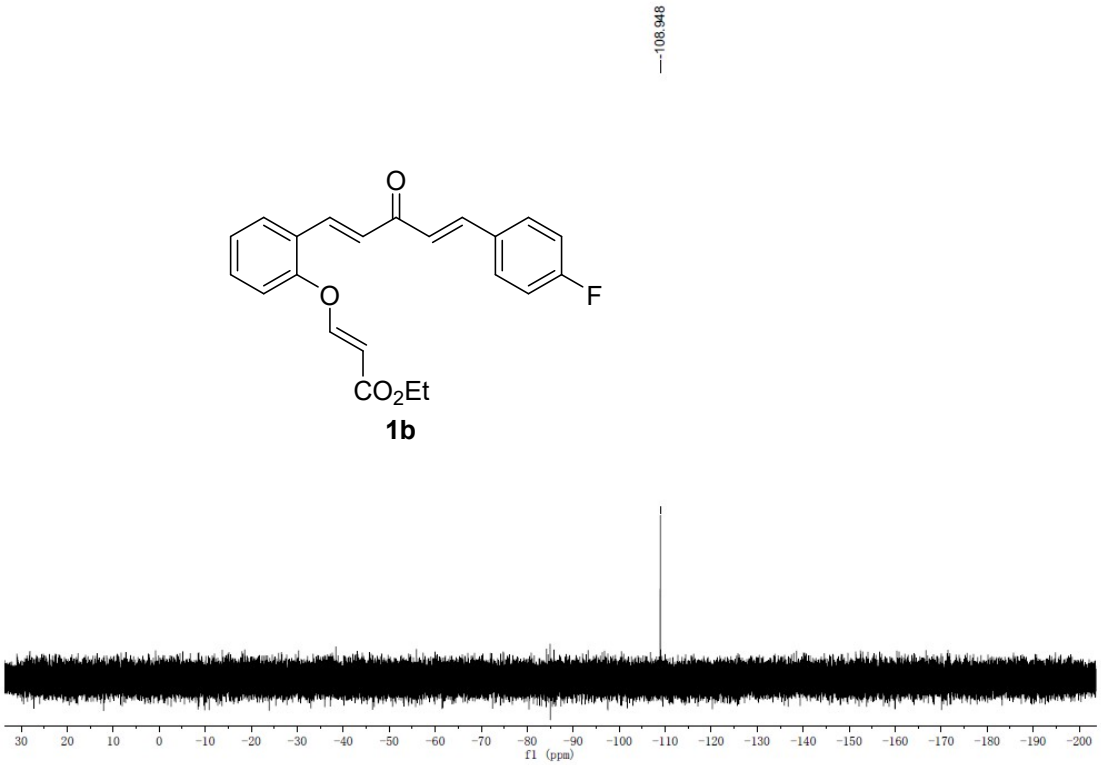
O
O
F
CO2Et
1b
f1 (ppm)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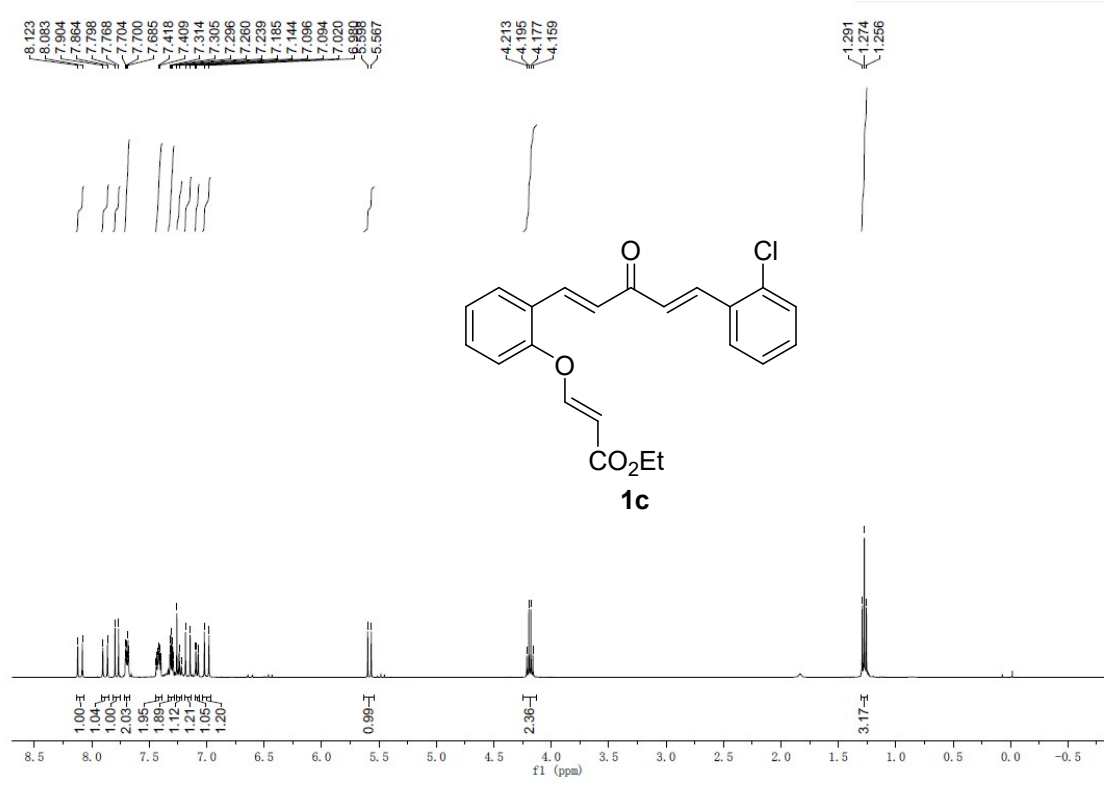
1b
f1 (ppm)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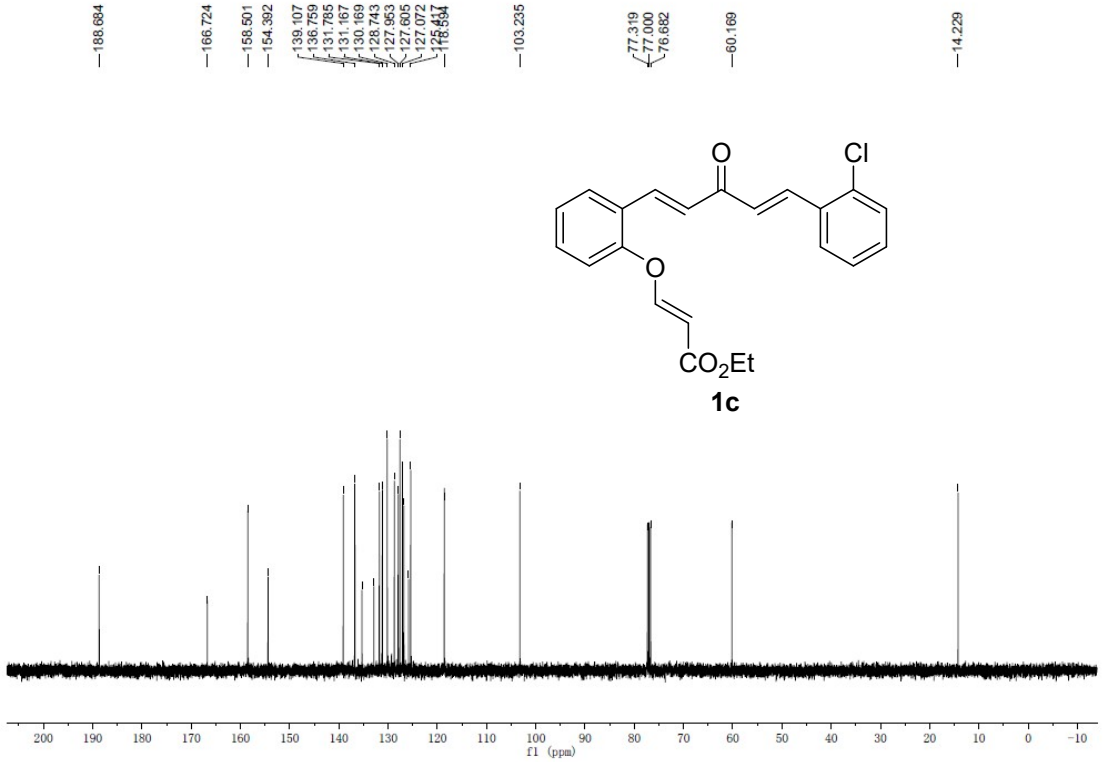
7.864
7.798
7.768
7.704
7.700
7.685
7.418
7.409
7.314
7.305
7.296
7.260
7.239
7.185
7.144
7.096
7.094
7.020
6.980
5.598
5.567
4.213
4.195
4.177
4.159
1.291
1.274
1.256
O
Cl
O
CO2Et
1c
1.00
1.04
1.00
2.03
1.95
1.89
1.12
1.21
1.05
1.20
0.99
2.36
3.17
f1 (ppm)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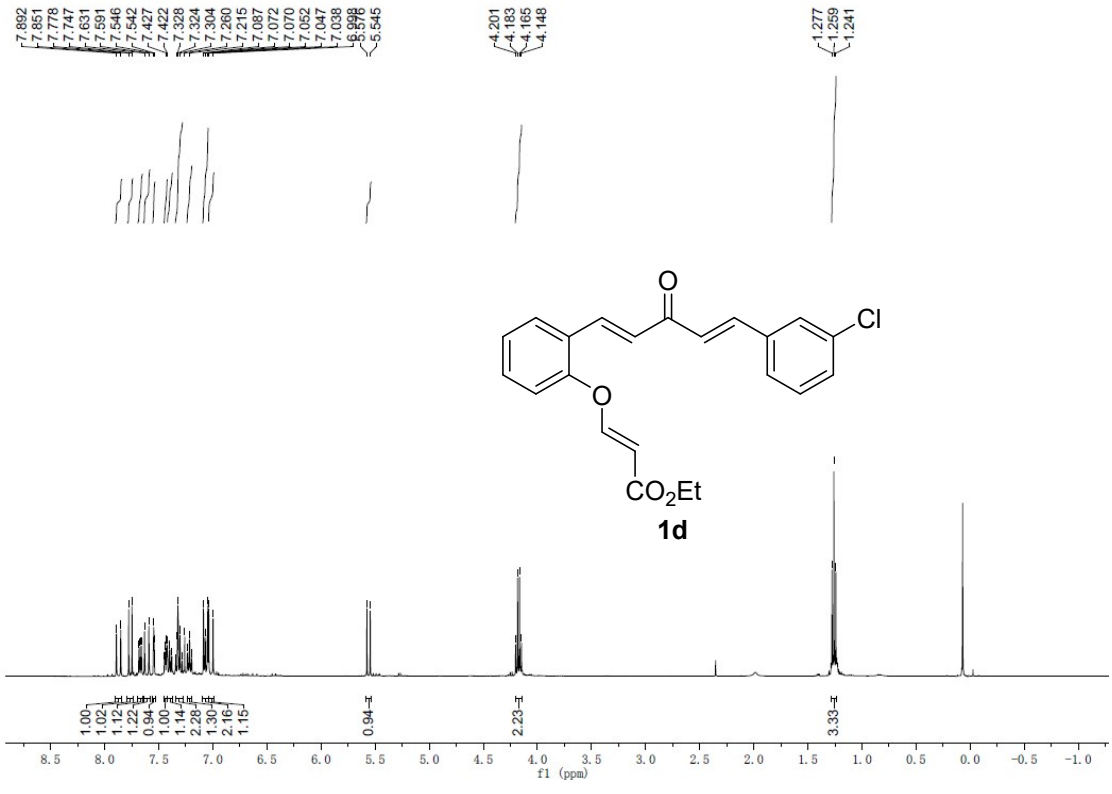
158.501
154.392
139.107
136.759
131.785
131.167
130.169
128.743
127.953
127.605
127.072
125.417
118.594
103.235
77.319
77.000
76.682
60.169
14.229
O
Cl
O
CO2Et
1c
f1 (ppm)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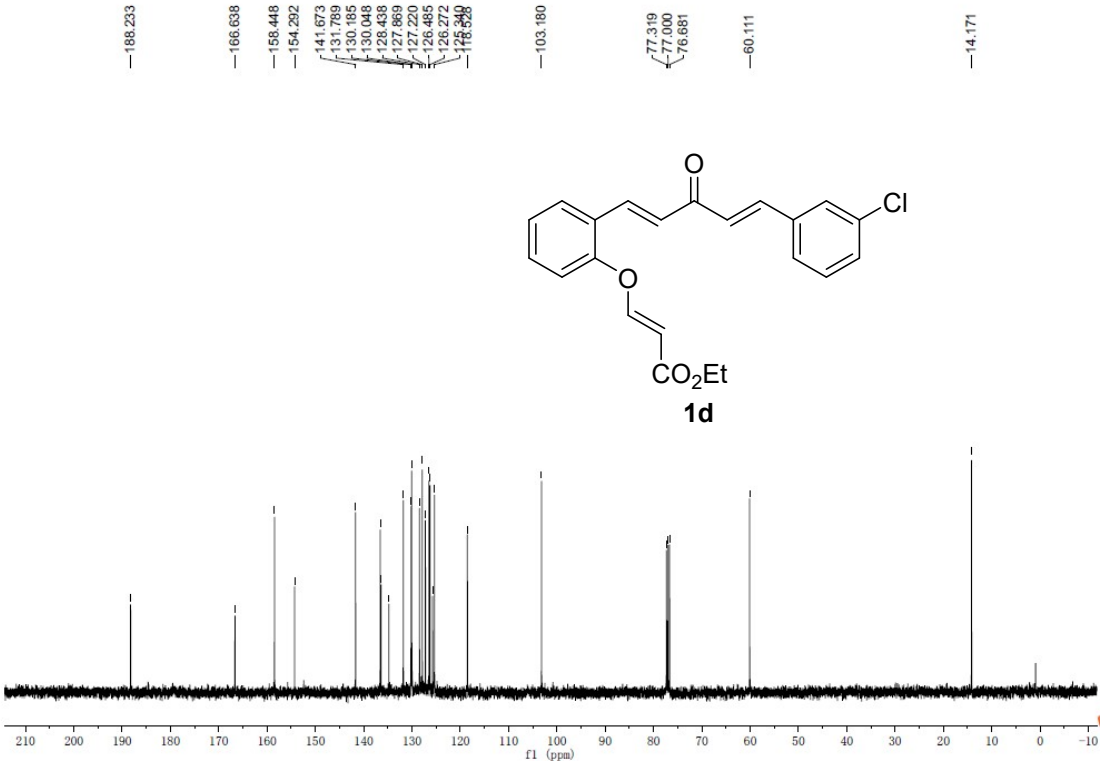
7.546
7.542
7.427
7.422
7.328
7.324
7.304
7.260
7.215
7.087
7.072
7.070
7.052
7.047
7.038
5.545
4.201
4.183
4.165
4.148
1.277
1.259
1.241
O
Cl
O
CO2Et
1d
1.00
1.02
1.12
1.22
0.94
1.00
1.14
2.28
1.30
2.16
1.15
0.94
2.23
3.33
f1 (ppm)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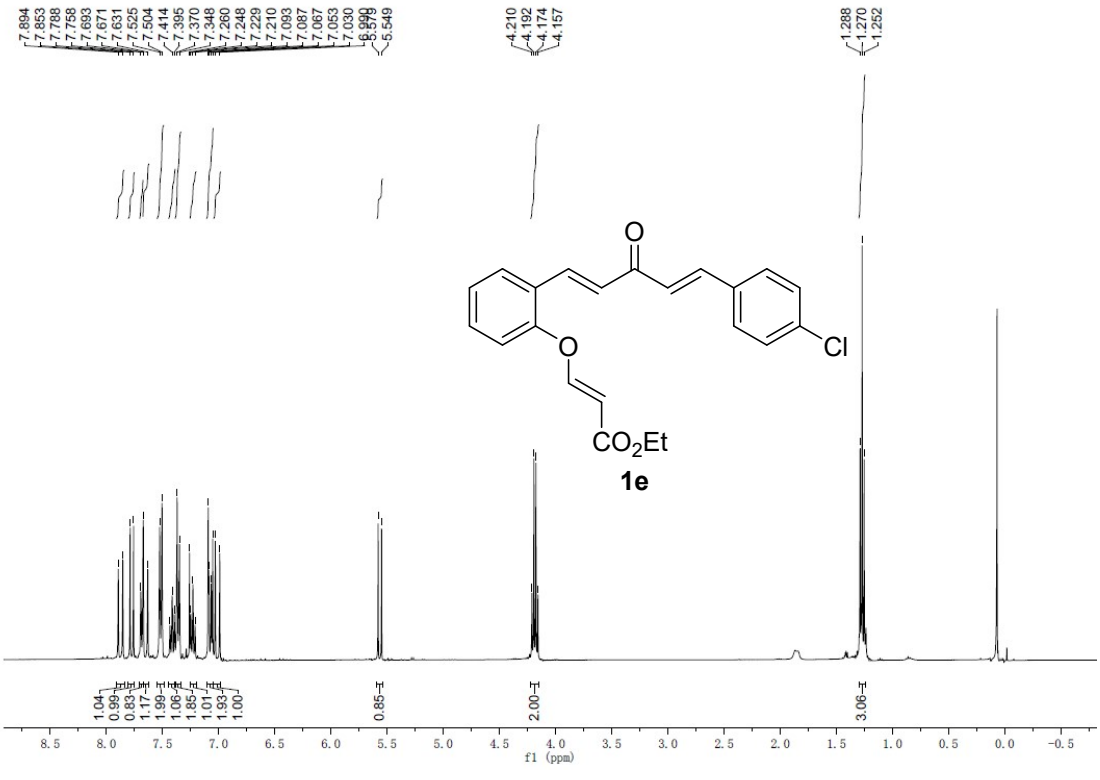
154.292
141.673
131.789
130.185
130.048
128.438
127.869
127.220
126.485
126.272
125.340
118.528
103.180
77.319
77.000
76.681
60.111
14.171
O
Cl
O
CO2Et
1d
f1 (ppm)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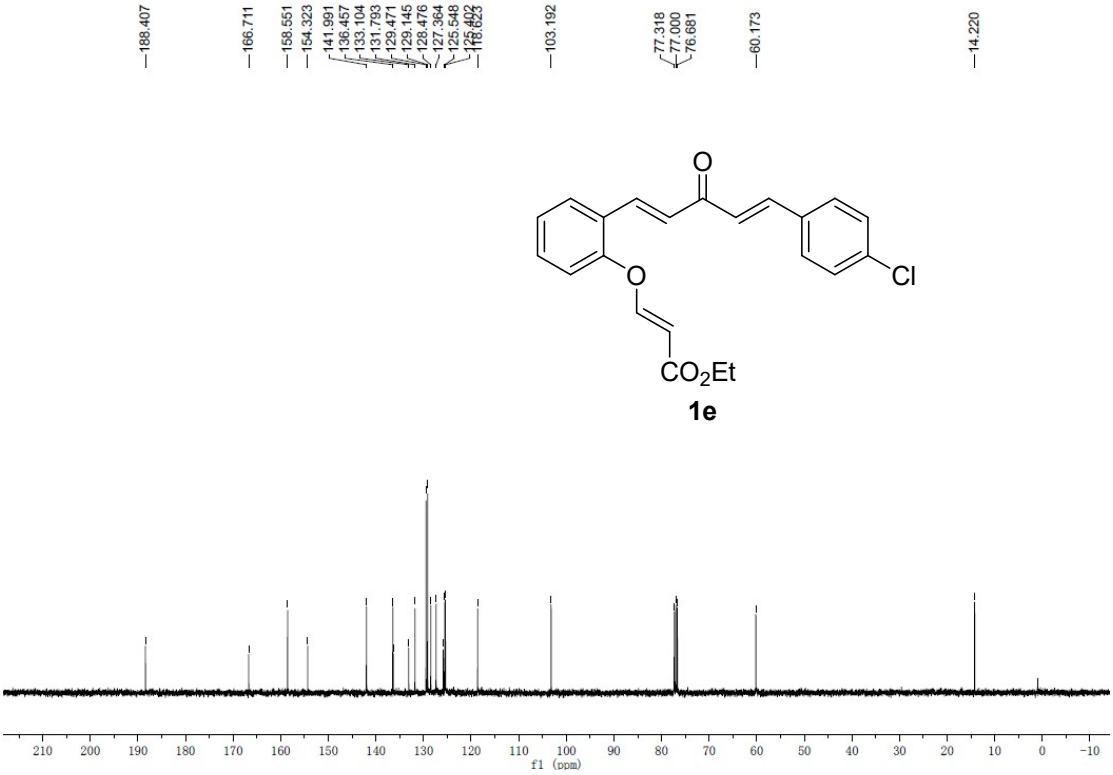
7.788
7.758
7.693
7.671
7.631
7.525
7.504
7.414
7.395
7.370
7.348
7.260
7.248
7.229
7.210
7.093
7.087
7.067
7.053
7.030
6.990
5.579
5.549
4.210
4.192
4.174
4.157
1.288
1.270
1.252
O
Cl
O
CO2Et
1e
1.04
0.99
0.83
1.17
1.99
1.06
1.85
1.01
1.93
1.00
0.85
2.00
3.06
f1 (ppm)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158.551
154.323
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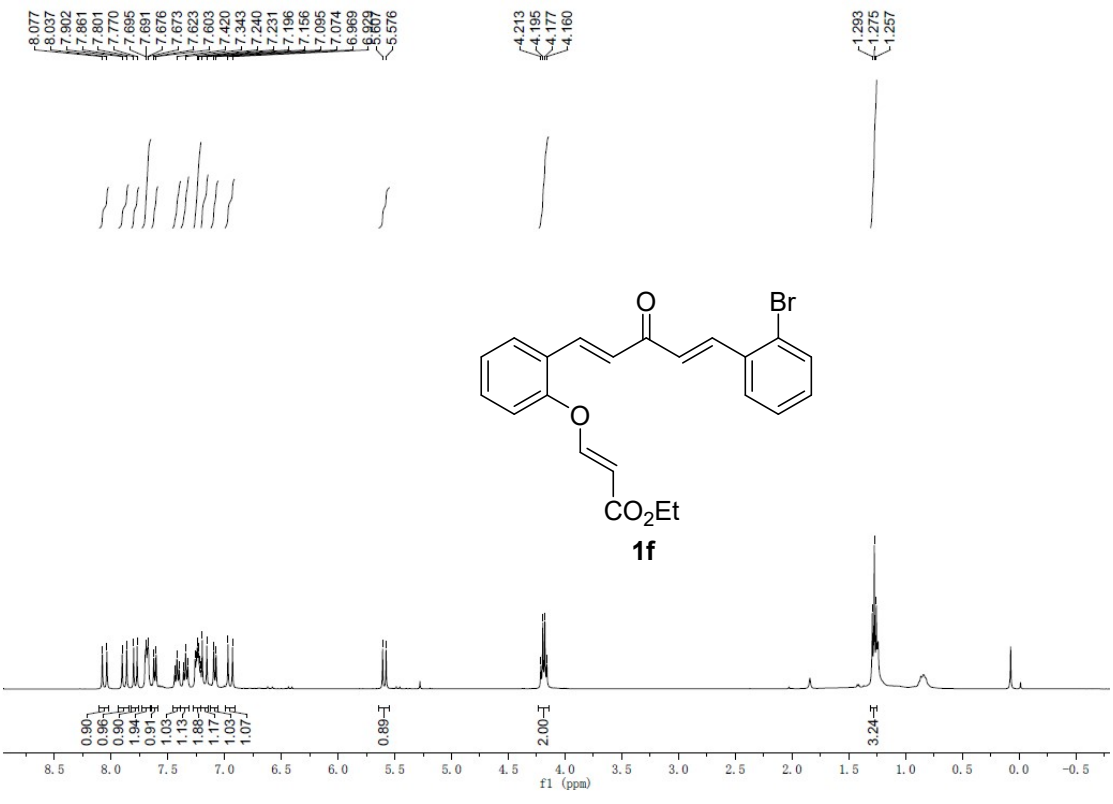
133.104
131.793
129.471
129.145
128.476
127.364
125.548
103.192
77.318
77.000
76.681
60.173
14.220
O
O
Cl
CO2Et
1e
f1 (ppm)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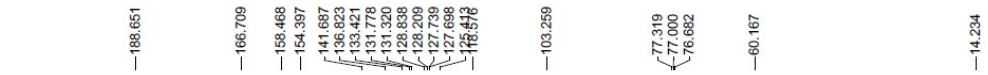
7.861
7.801
7.770
7.695
7.691
7.676
7.673
7.623
7.603
7.420
7.343
7.240
7.231
7.196
7.156
7.095
7.074
6.969
5.576
4.213
4.195
4.177
4.160
1.293
1.275
1.257
O
Br
O
CO2Et
1f
0.90
0.96
0.90
1.94
0.91
1.03
1.13
1.88
1.17
1.03
1.07
0.89
2.00
3.24
f1 (ppm)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136.623
133.421
131.778
131.320
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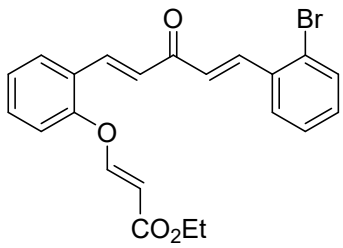
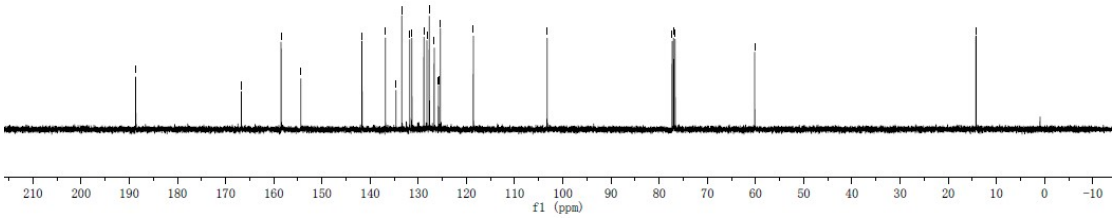
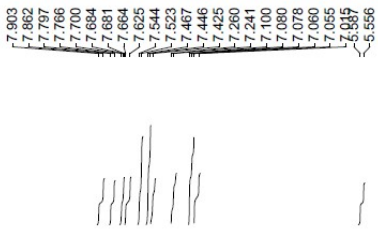
128.209
127.739
127.698
103.259
77.319
77.000
76.682
60.167
14.234


O
Br
O
CO2Et

1f


f1 (ppm)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7.700
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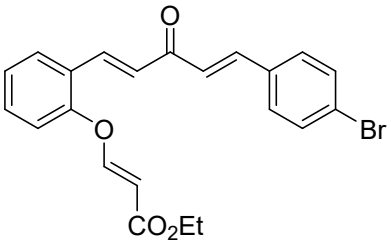
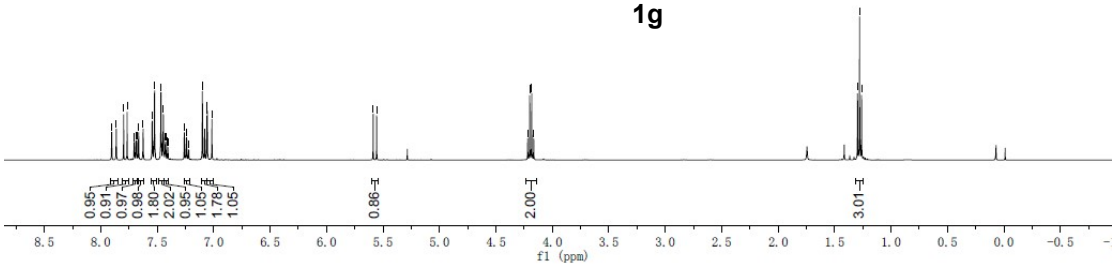
7.681
7.664
7.625
7.544
7.523
7.467
7.446
7.425
7.260
7.241
7.100
7.080
7.078
7.060
7.055
5.587
5.556

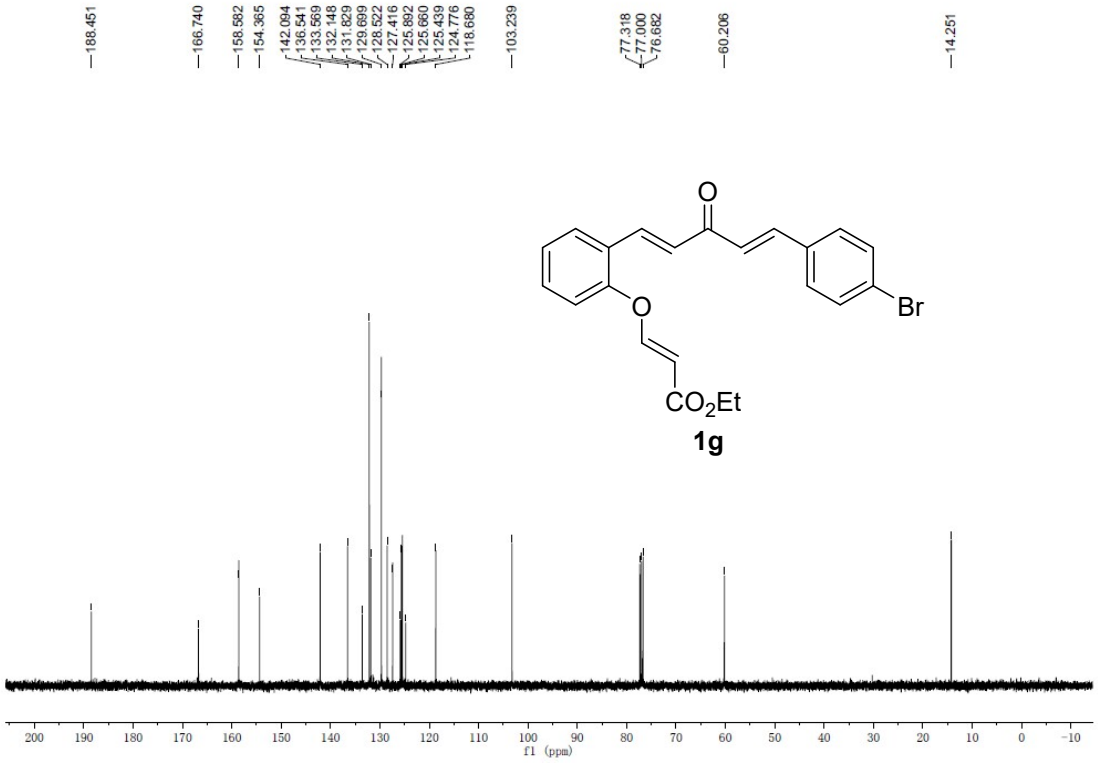

4.218
4.200
4.183
4.165


1.296
1.279
1.261


O
O
Br
CO2Et

1g


0.95
0.91
0.97
0.98
1.80
2.02
0.95
1.05
1.78
1.05
0.86
2.00
3.01
f1 (ppm)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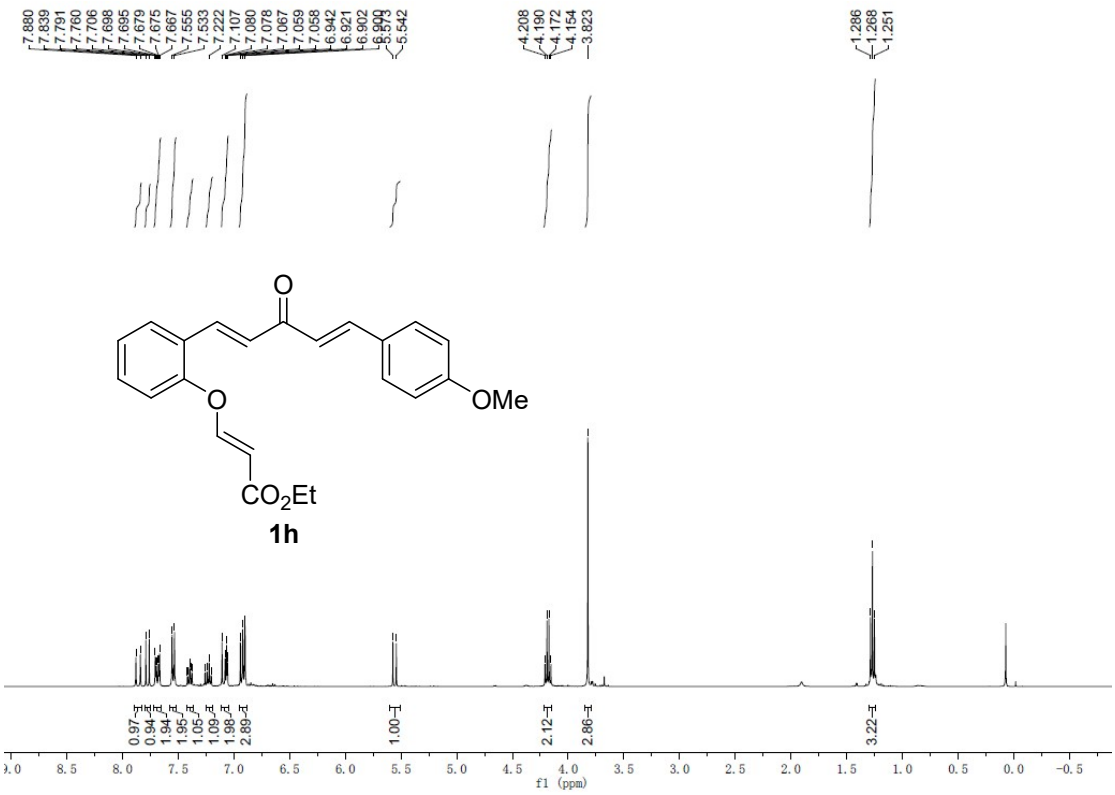
154.365
142.094
136.541
133.569
132.148
131.829
129.699
128.522
127.416
125.892
125.660
125.439
124.776
118.680
103.239
77.318
77.000
76.682
60.206
14.251
O
O
Br
CO2Et
1g
f1 (ppm)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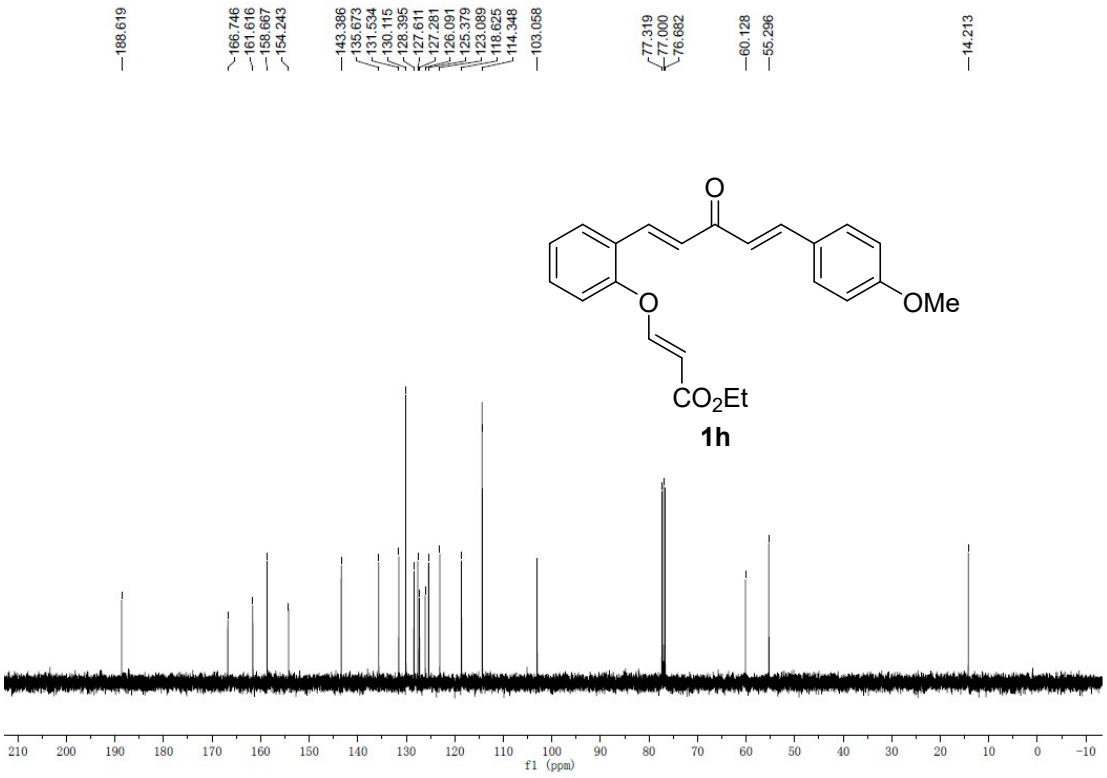
7.791
7.760
7.706
7.698
7.695
7.679
7.675
7.667
7.555
7.533
7.222
7.107
7.080
7.078
7.067
7.059
7.058
6.942
6.921
6.902
6.900
5.573
5.542
4.208
4.190
4.172
4.154
3.823
1.286
1.268
1.251
O
O
OMe
CO2Et
1h
0.97
0.94
1.94
1.95
1.05
1.09
1.98
2.89
1.00
2.12
2.86
3.22
f1 (ppm)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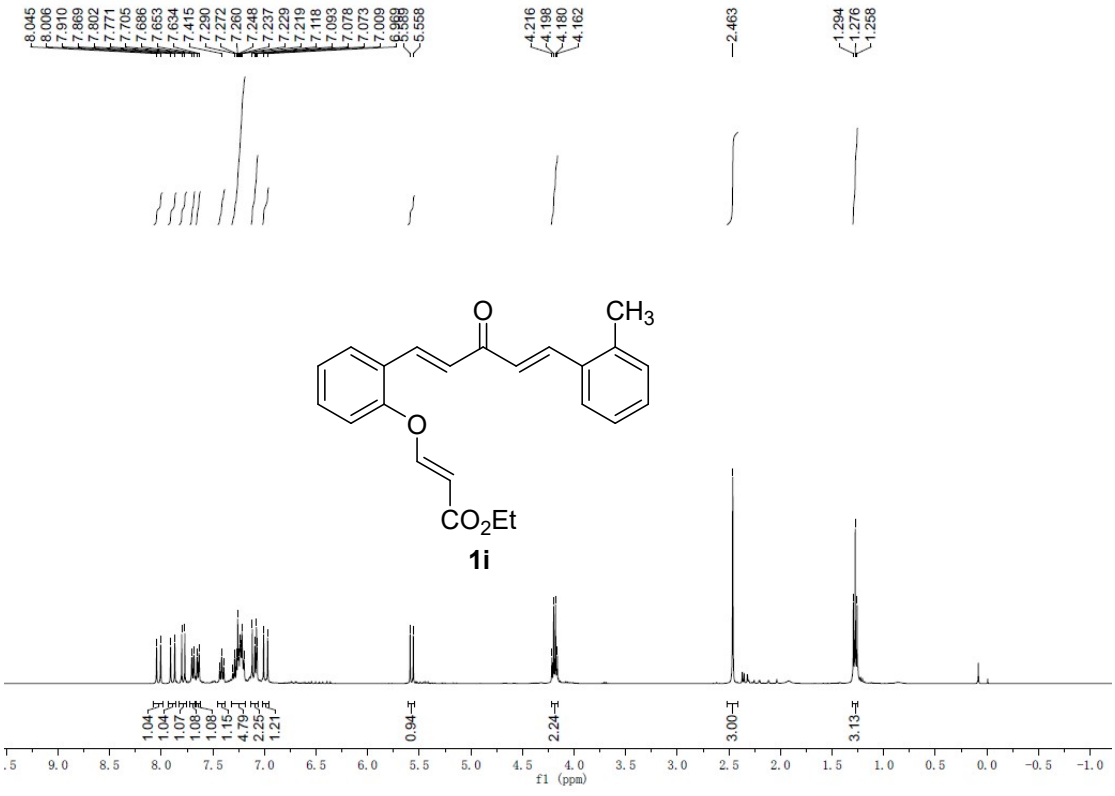
135.673
131.534
130.115
128.395
127.611
127.281
126.091
125.379
123.089
118.625
114.348
103.058
77.319
77.000
76.682
60.128
55.296
14.213
O
OMe
O
CO2Et
1h
f1 (ppm)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7.771
7.705
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7.653
7.634
7.415
7.290
7.272
7.260
7.248
7.237
7.229
7.219
7.118
7.093
7.078
7.073
7.009
5.588
5.558
4.216
4.198
4.180
4.162
2.463
1.294
1.276
1.258
O
CH3
O
CO2Et
1i
1.04
1.04
1.07
1.08
1.08
1.15
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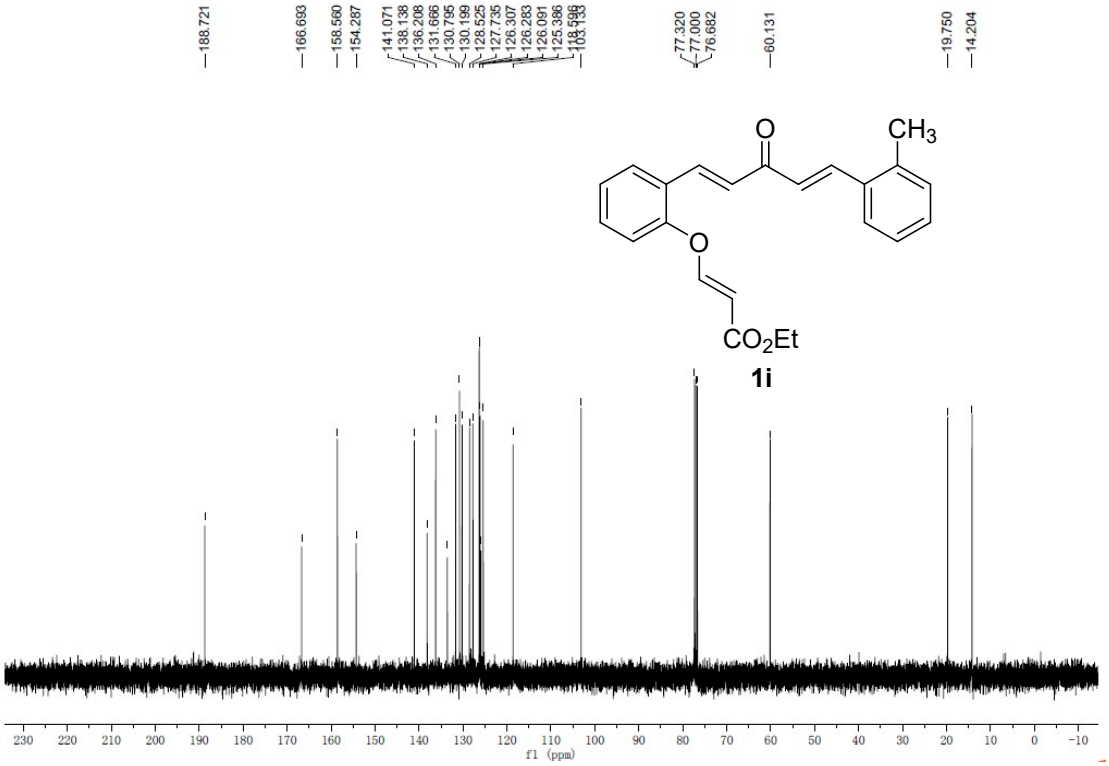
2.24
3.00
3.13
f1 (ppm)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136.208
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126.307
126.283
126.091
125.386
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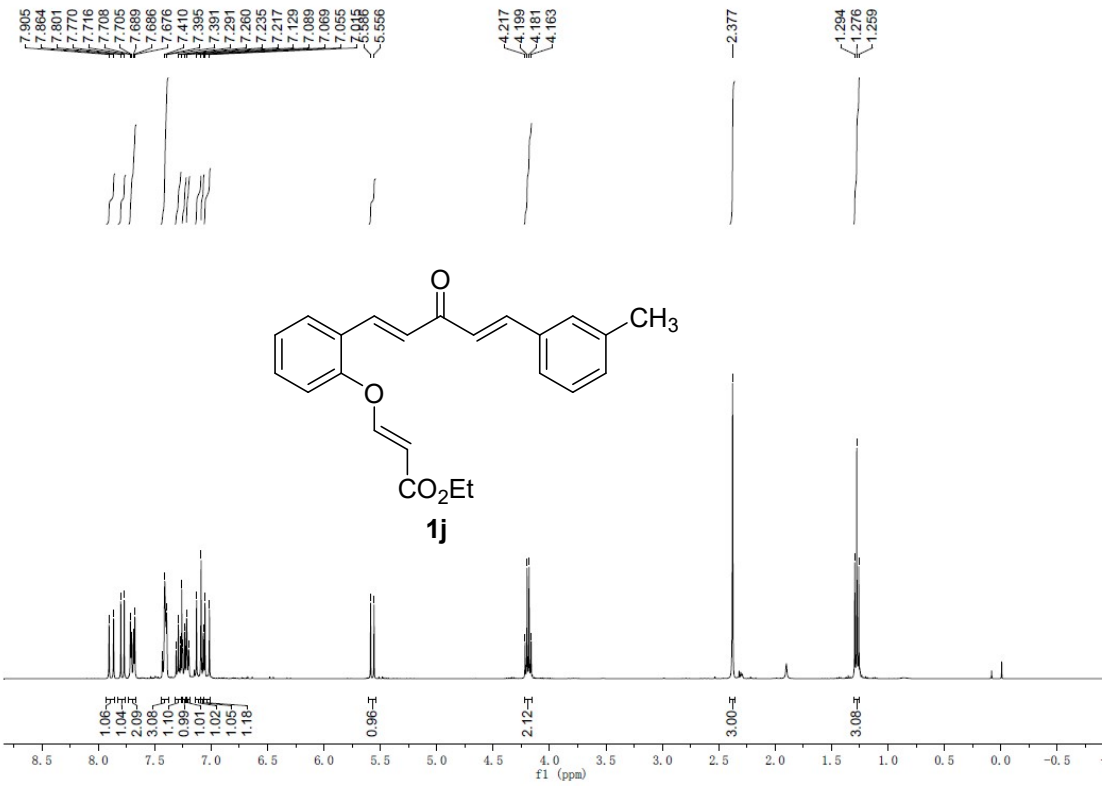
60.131
19.750
14.204
O
CH3
O
CO2Et
1i
f1 (ppm)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7.689
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7.676
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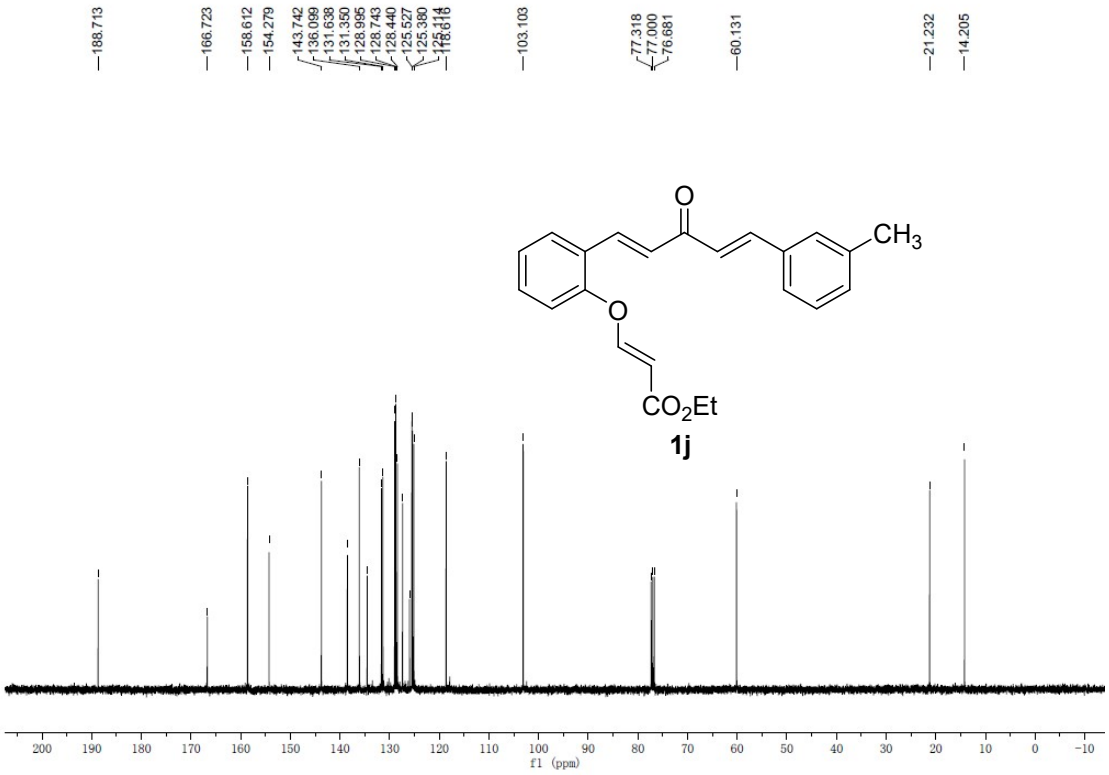
7.395
7.391
7.291
7.260
7.235
7.217
7.129
7.089
7.069
7.055
5.566
4.217
4.199
4.181
4.163
2.377
1.294
1.276
1.259
O
CH3
O
CO2Et
1j
1.06
1.04
2.09
3.08
1.10
0.99
1.01
1.02
1.05
1.18
0.96
2.12
3.00
3.08
f1 (ppm)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131.350
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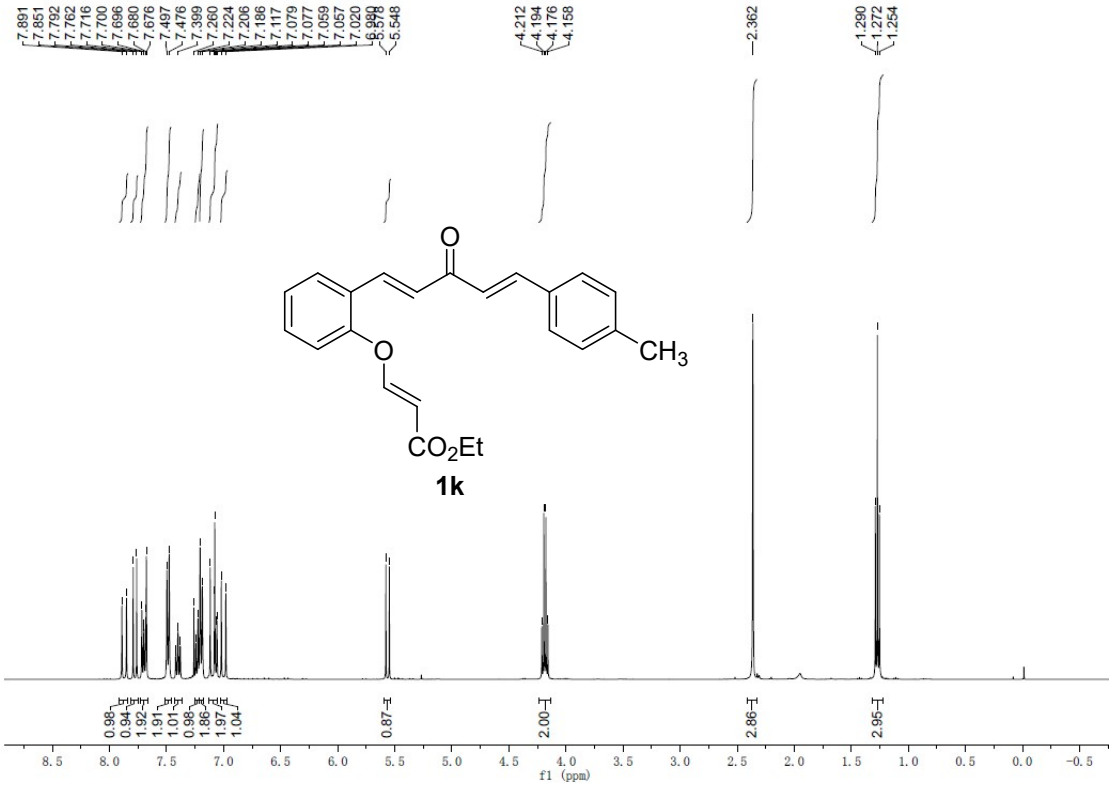
128.440
125.527
125.380
103.103
77.318
77.000
76.681
60.131
21.232
14.205
O
CH3
O
CO2Et
1j
f1 (ppm)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7.762
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7.700
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7.680
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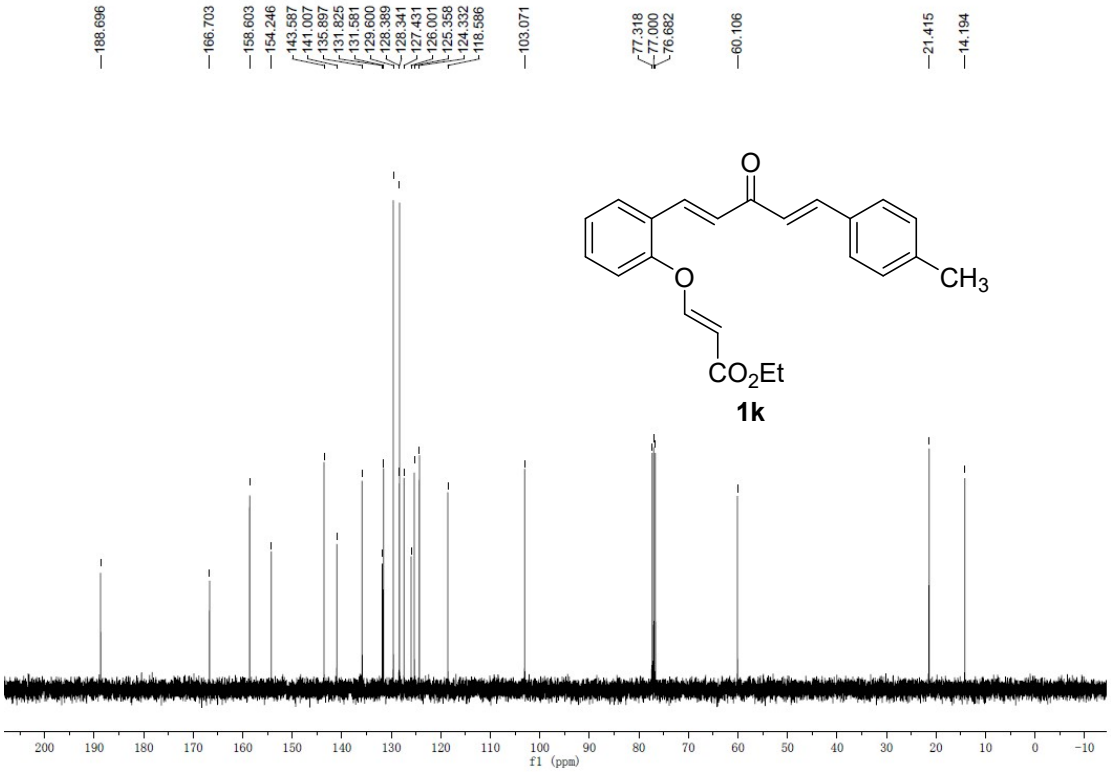
7.497
7.476
7.399
7.260
7.224
7.206
7.186
7.117
7.079
7.077
7.059
7.057
7.020
6.980
5.578
5.548
4.212
4.194
4.176
4.158
2.362
1.290
1.272
1.254
O
CH3
O
CO2Et
1k
0.98
0.94
1.92
1.91
1.01
0.98
1.86
1.97
1.04
0.87
2.00
2.86
2.95
f1 (ppm)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129.600
128.389
128.341
127.431
126.001
125.358
124.332
118.386
103.071
77.318
77.000
76.682
60.106
21.415
14.194
O
O
CH3
CO2Et
1k
f1 (ppm)


7.878
7.837
7.786
7.756
7.665
7.511
7.502
7.463
7.260
7.219
7.078
7.058
7.031
6.991
6.980
6.941
6.695
6.687
6.495
6.490
6.487
5.566
5.539
4.206
4.188
4.170
4.152
1.284
1.267
1.249
O
O
O
CO2Et
1l
0.92
0.89
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0.86
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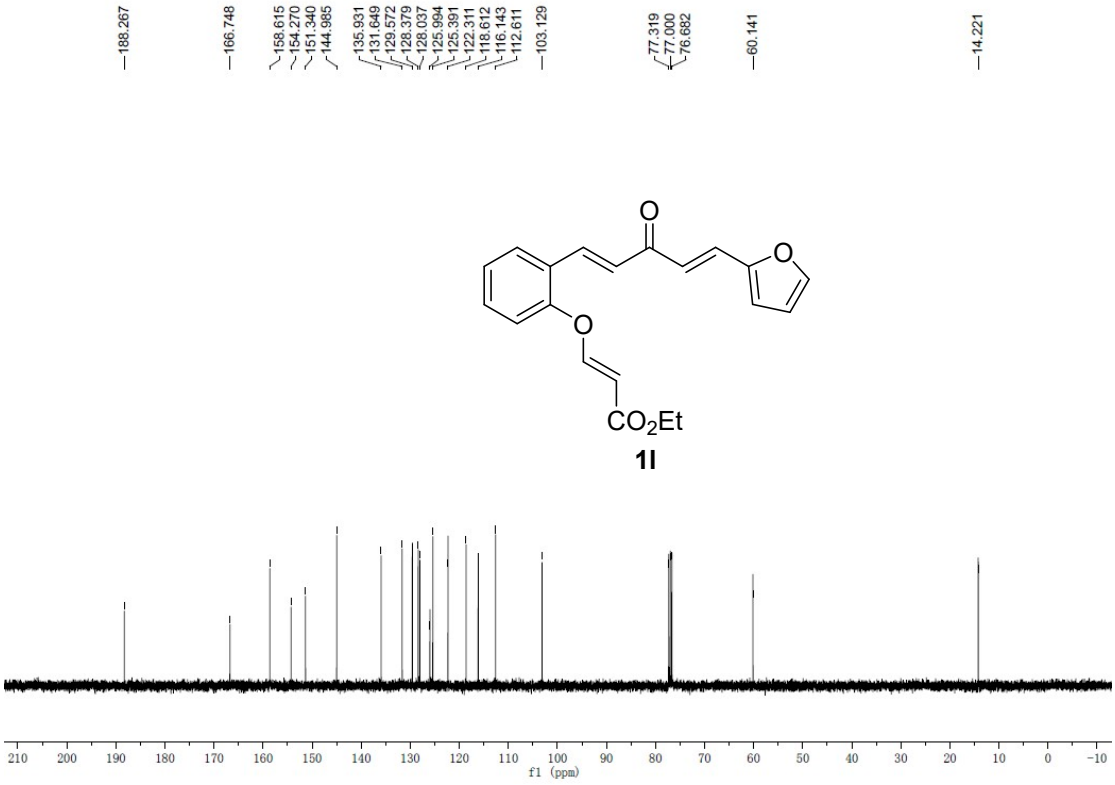
3.00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128.037
125.994
125.391
122.311
118.612
116.143
112.611
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77.000
76.682
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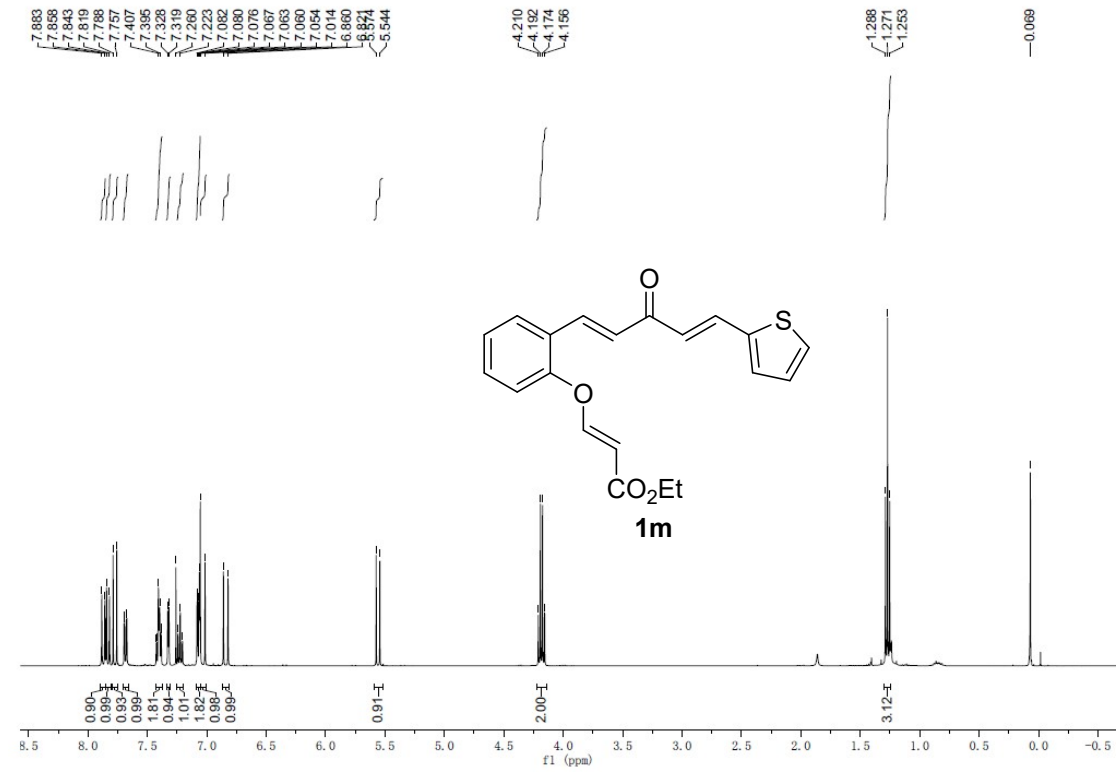
14.221
O
O
O
CO2Et
f1 (ppm)

1l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7.395
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7.319
7.260
7.223
7.082
7.080
7.076
7.067
7.063
7.060
7.054
7.014
6.860
6.821
5.574
5.544
4.210
4.192
4.174
4.156
1.288
1.271
1.253
0.069
O
S
O
CO2Et
0.90
0.99
0.93
0.99
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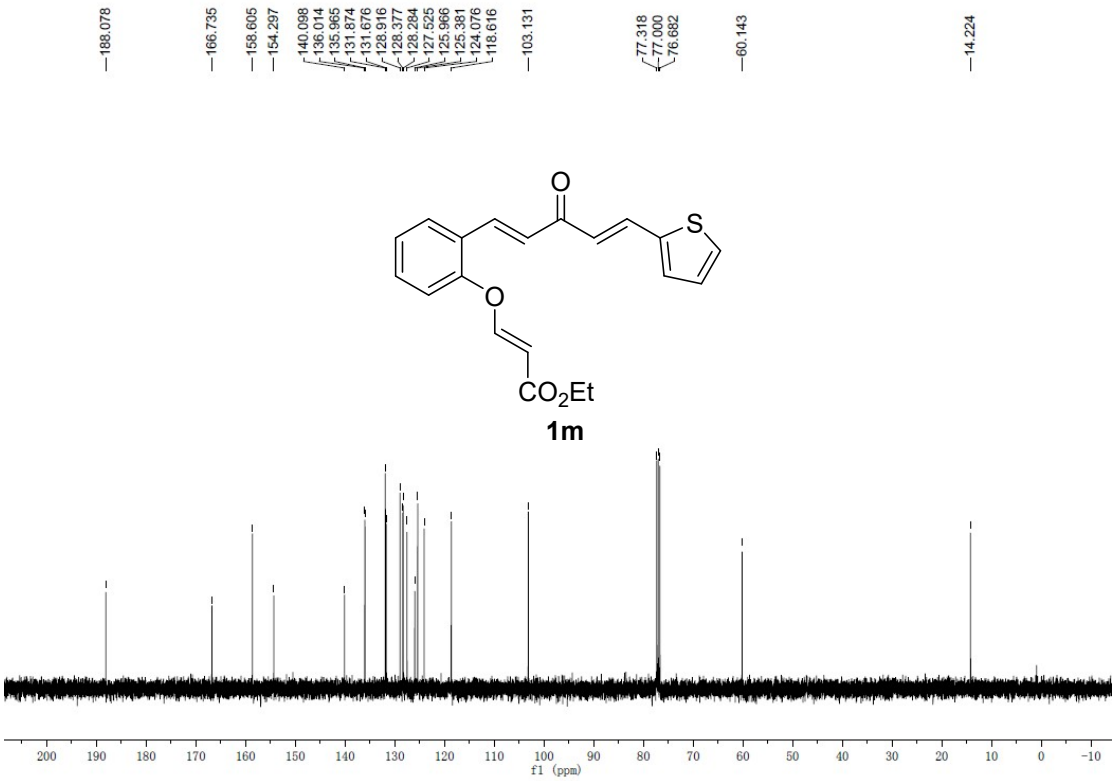
1.82
0.98
0.99
0.91
2.00
3.12
f1 (ppm)

1m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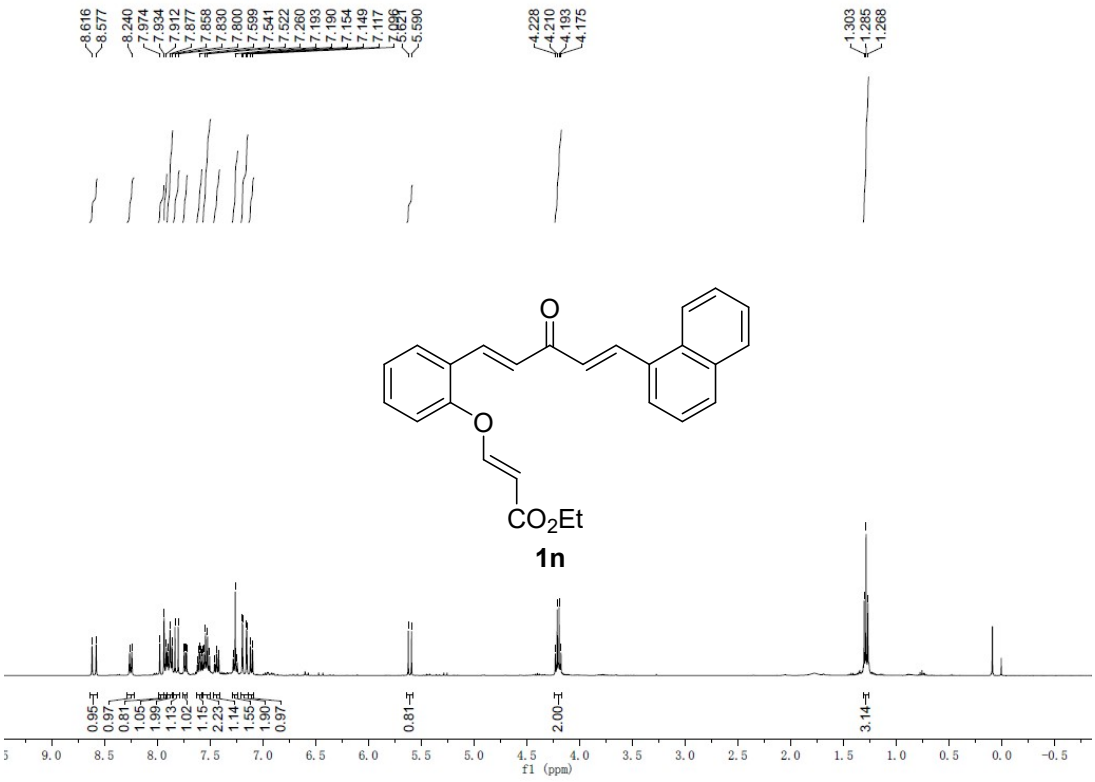
128.377
128.284
127.525
125.966
125.381
124.076
118.616
103.131
77.318
77.000
76.682
60.143
14.224
O
S
O
CO2Et
1m
f1 (ppm)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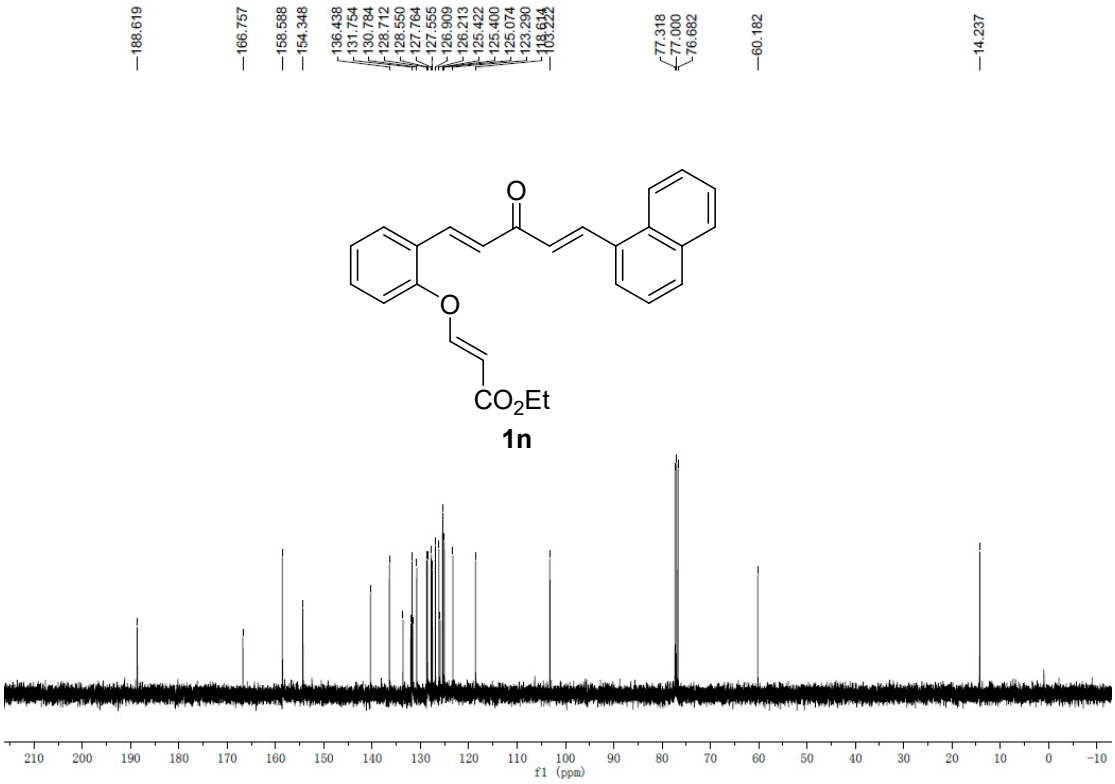
7.934
7.912
7.877
7.858
7.830
7.800
7.599
7.541
7.522
7.260
7.193
7.190
7.154
7.149
7.117
7.096
5.621
5.590
4.228
4.210
4.193
4.175
1.303
1.285
1.268
O
O
CO2Et
1n
0.95
0.97
0.81
1.05
1.99
1.13
1.02
1.15
2.23
1.14
1.55
1.90
0.97
0.81
2.00
3.14
f1 (ppm)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128.712
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127.555
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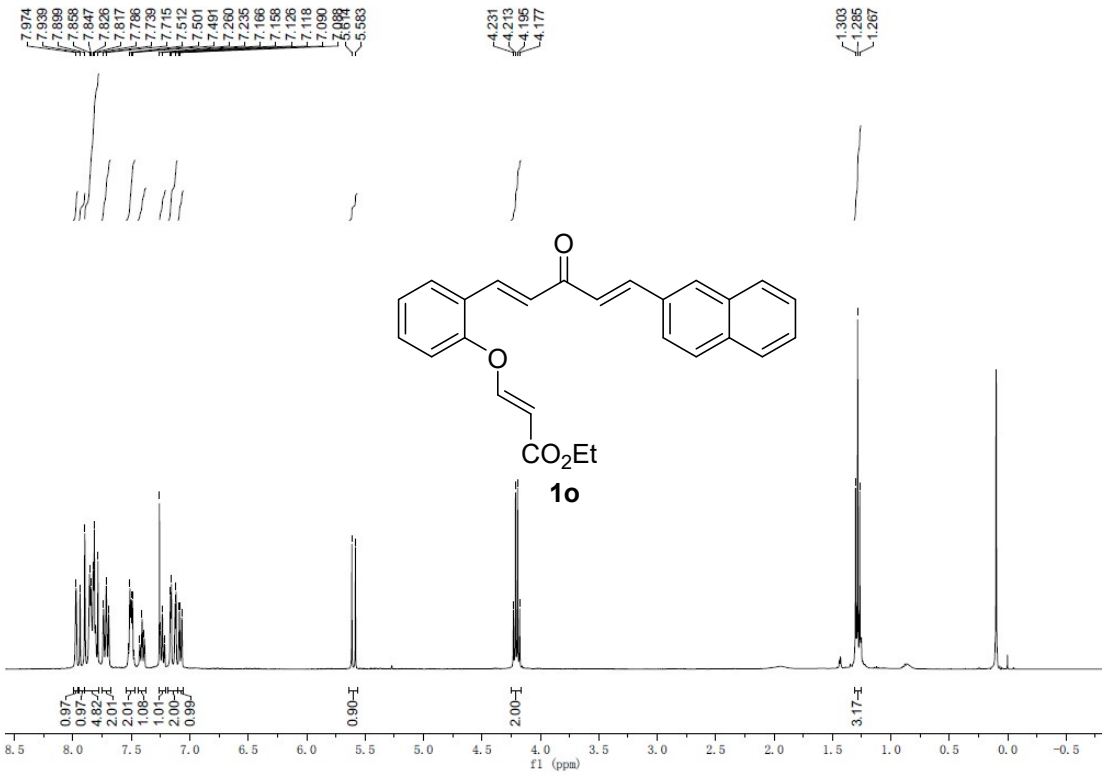
126.213
125.422
125.400
125.074
123.290
118.614
103.222
77.318
77.000
76.882
60.182
14.237
O
O
CO2Et
1n
f1 (ppm)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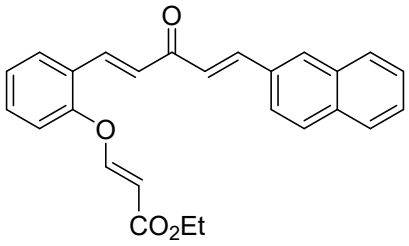
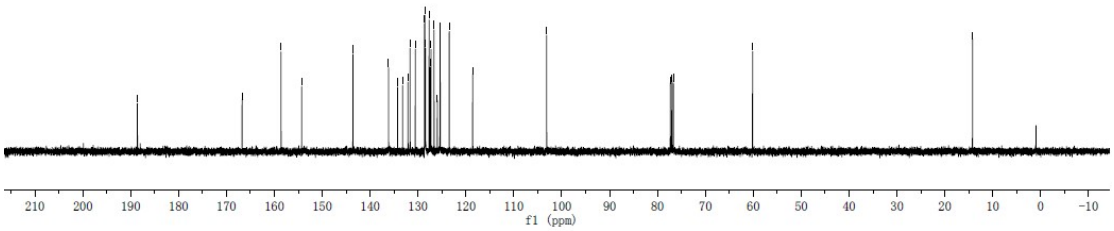
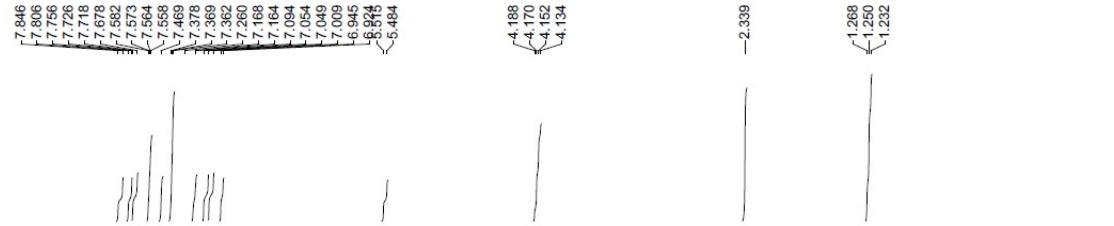
7.939
7.899
7.858
7.847
7.826
7.817
7.786
7.739
7.715
7.512
7.501
7.491
7.260
7.235
7.166
7.158
7.126
7.118
7.090
5.583
4.231
4.213
4.195
4.177
1.303
1.285
1.267
O
O
CO2Et
1o
0.97
0.97
4.82
2.01
2.01
1.08
1.01
2.00
0.99
0.90
2.00
3.17
f1 (ppm)


188.601
166.737
158.601
154.303
143.588
131.661
130.572
128.645
128.535
128.448
127.694
127.295
126.653
125.403
125.374
77.319
77.000
76.684
60.147
14.221


O
O
CO2Et

1o


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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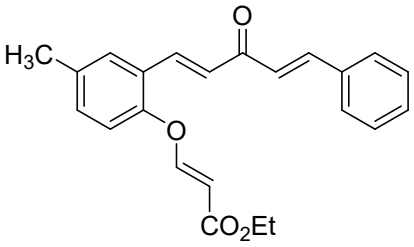
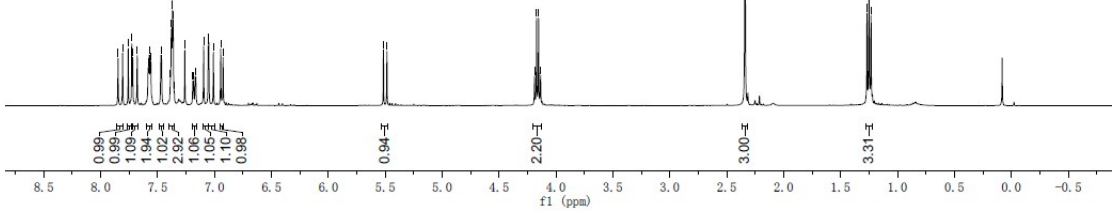
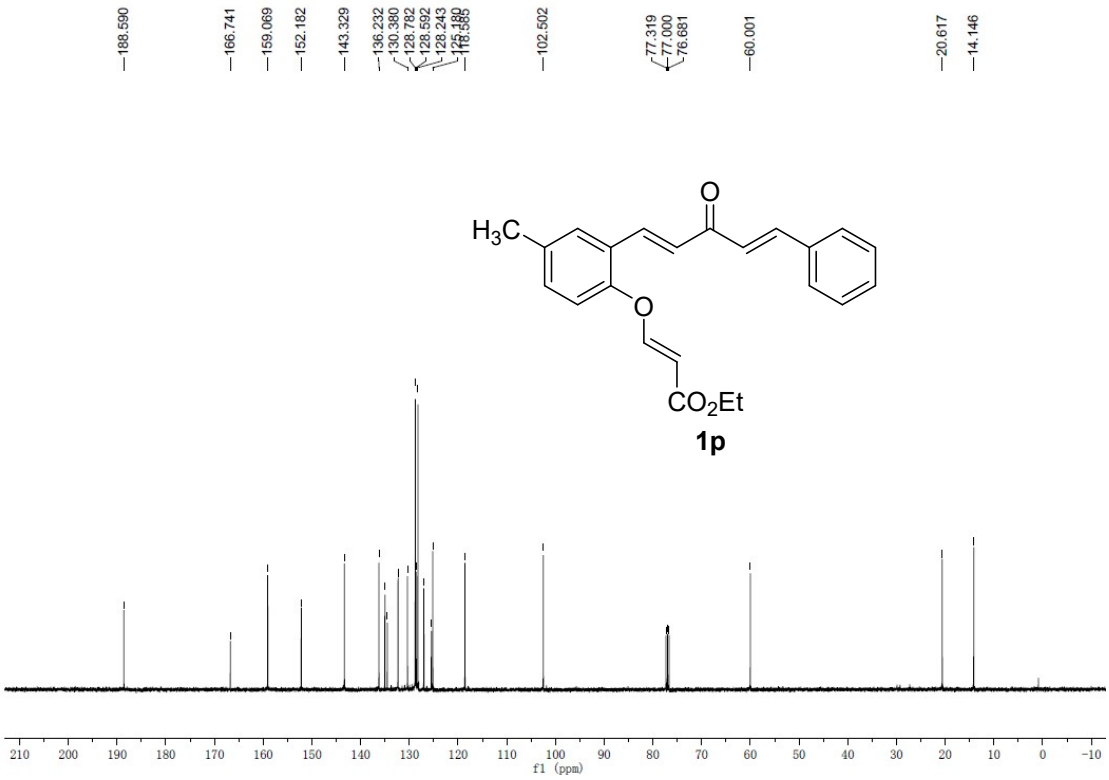
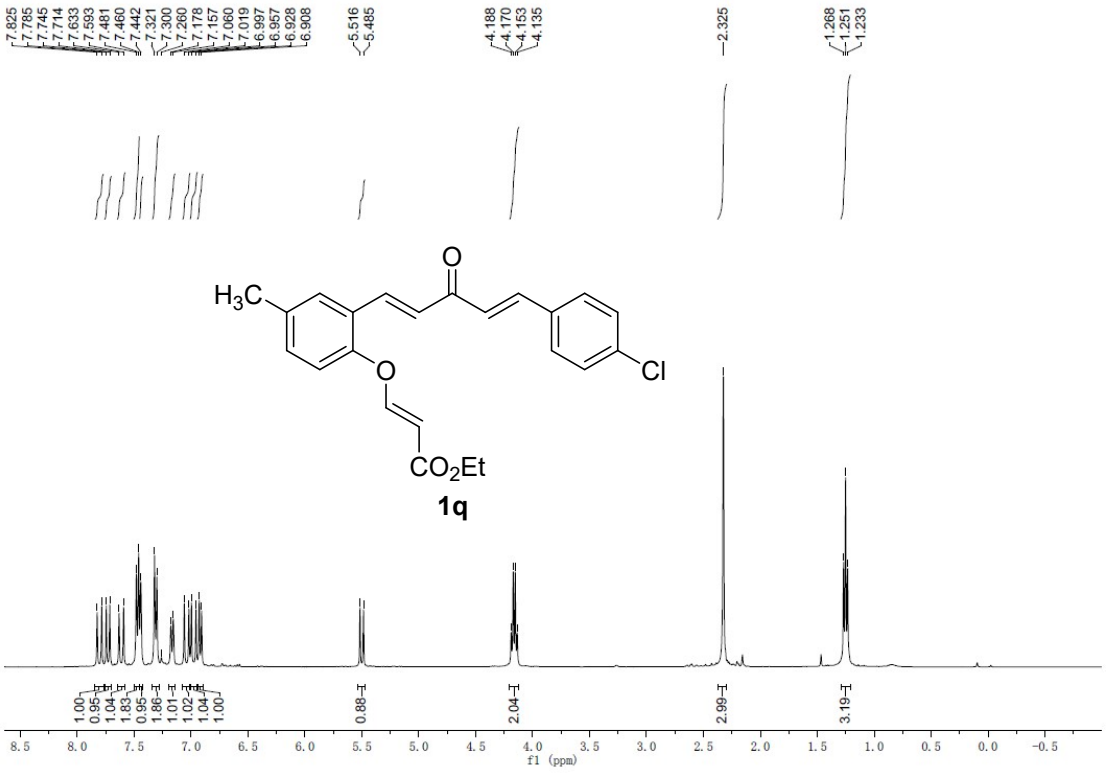
7.756
7.726
7.718
7.678
7.582
7.573
7.564
7.558
7.469
7.378
7.369
7.362
7.260
7.168
7.164
7.094
7.054
7.049
7.009
6.945
5.484
4.188
4.170
4.152
4.134
2.339
1.268
1.250
1.232


O
H3C
O
CO2Et

1p


0.99
0.99
1.09
1.94
1.02
2.92
1.06
1.05
1.10
0.98
0.94
2.20
3.00
3.31
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


188.590
166.741
159.069
152.182
143.329
136.232
130.380
128.782
128.592
128.243
125.180
118.585
102.502
77.319
77.000
76.681
60.001
20.617
14.146
O
H3C
O
CO2Et
1p
f1 (ppm)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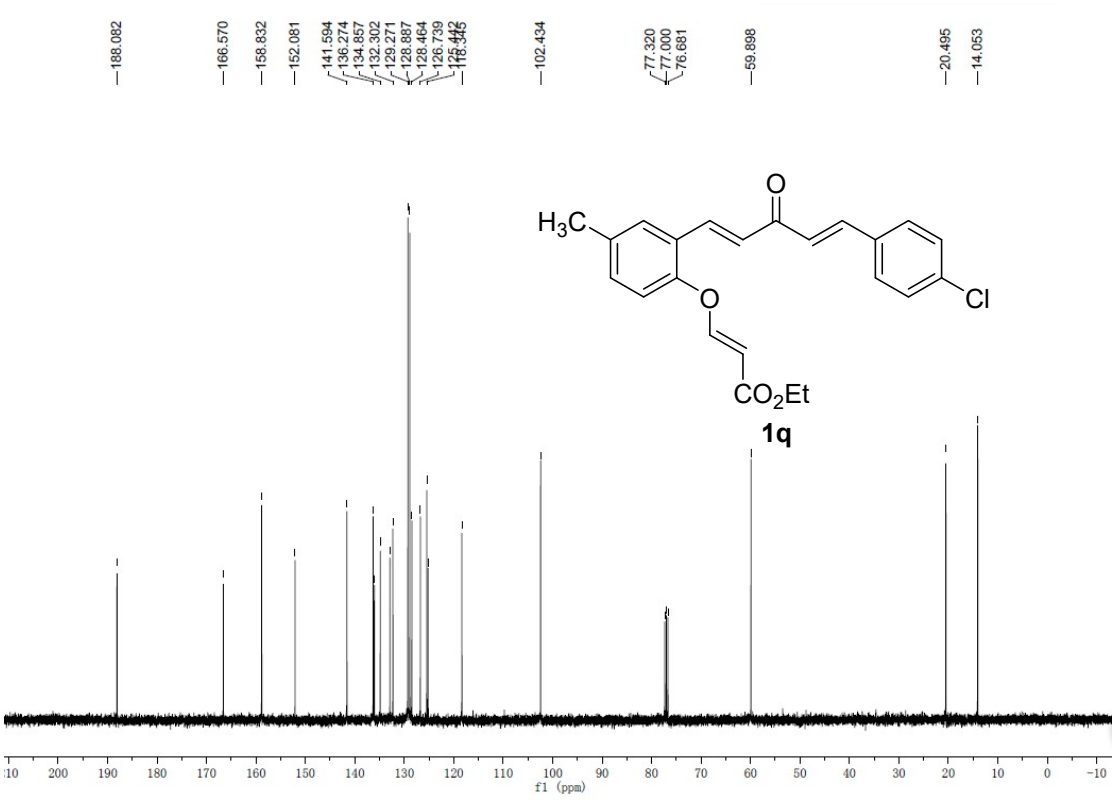
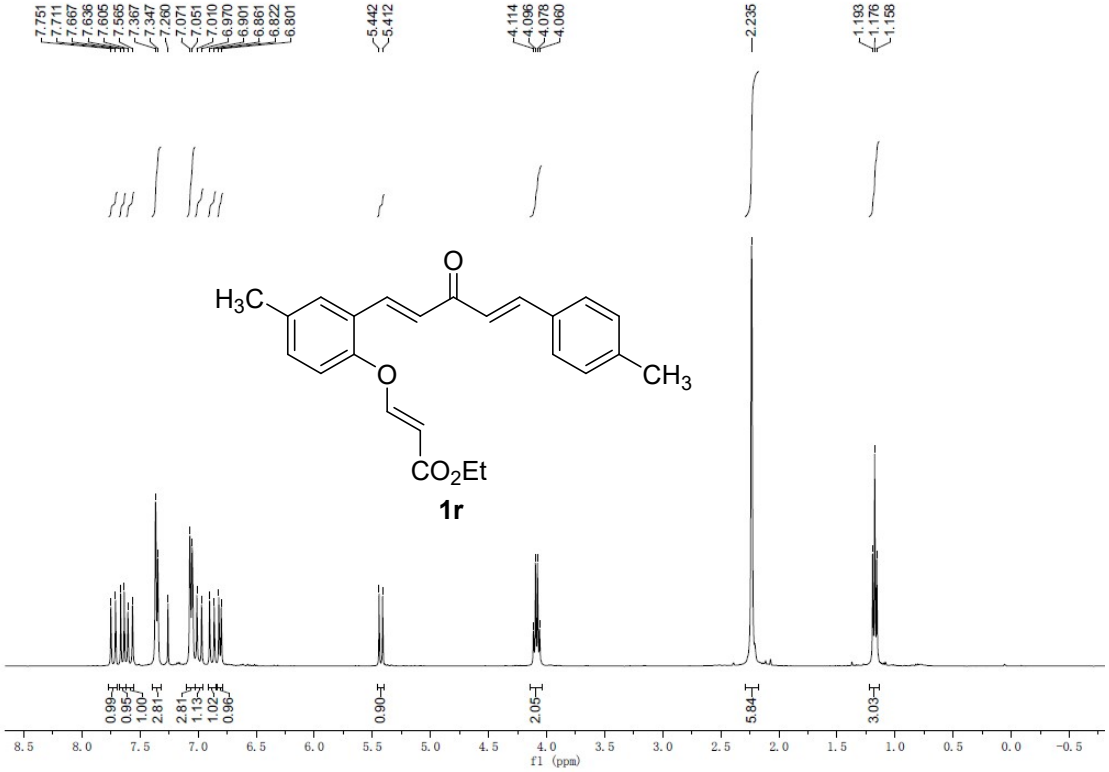
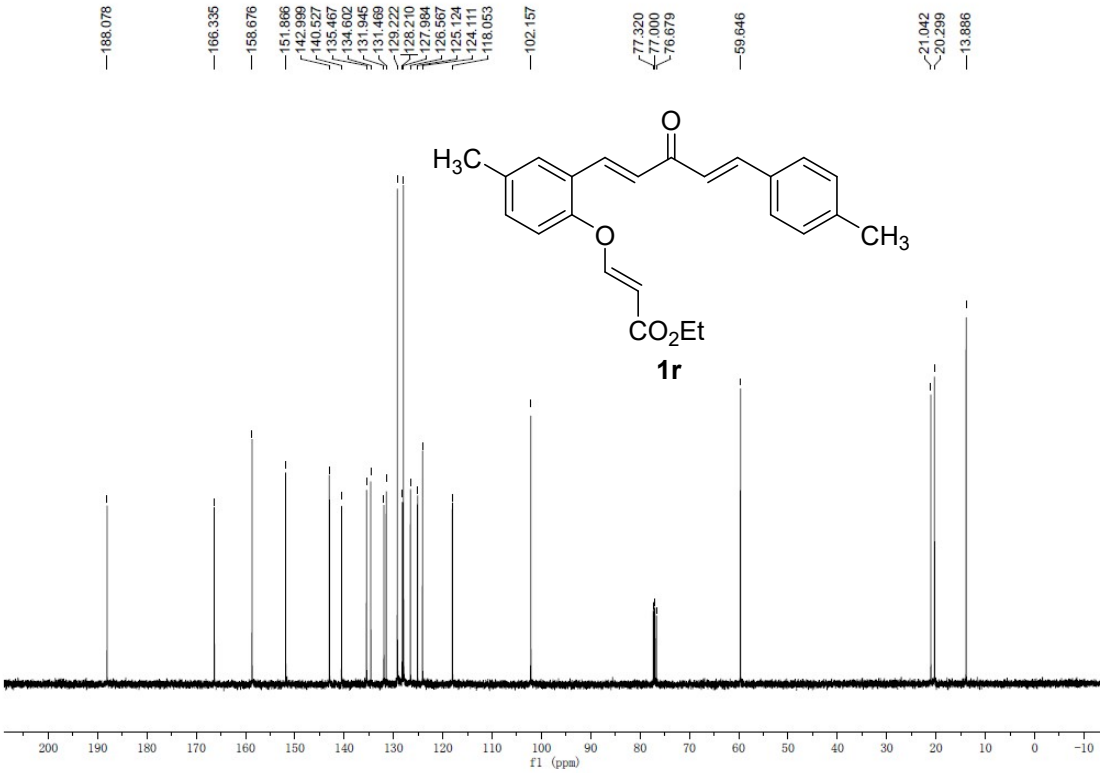
7.785
7.745
7.714
7.633
7.593
7.481
7.460
7.442
7.321
7.300
7.260
7.178
7.157
7.060
7.019
6.997
6.957
6.928
6.908
5.516
5.485
4.188
4.170
4.153
4.135
2.325
1.268
1.251
1.233
O
H3C
O
Cl
CO2Et
1q
1.00
0.95
1.04
1.83
0.95
1.86
1.01
1.02
1.04
1.00
0.88
2.04
2.99
3.19
f1 (ppm)


188.082
166.570
158.832
152.081
141.594
136.274
134.857
132.302
129.271
128.887
128.464
126.739
102.434
77.320
77.000
76.681
59.898
20.495
14.053
H3C
O
O
Cl
CO2Et
1q
f1 (ppm)


7.751
7.711
7.667
7.636
7.606
7.565
7.367
7.347
7.260
7.071
7.051
7.010
6.970
6.901
6.861
6.822
6.801
5.442
5.412
4.114
4.096
4.078
4.060
2.235
1.193
1.176
1.158
H3C
O
O
CH3
CO2Et
1r
0.99
0.95
1.00
2.81
2.81
1.13
1.02
0.96
0.90
2.05
5.84
3.03
f1 (ppm)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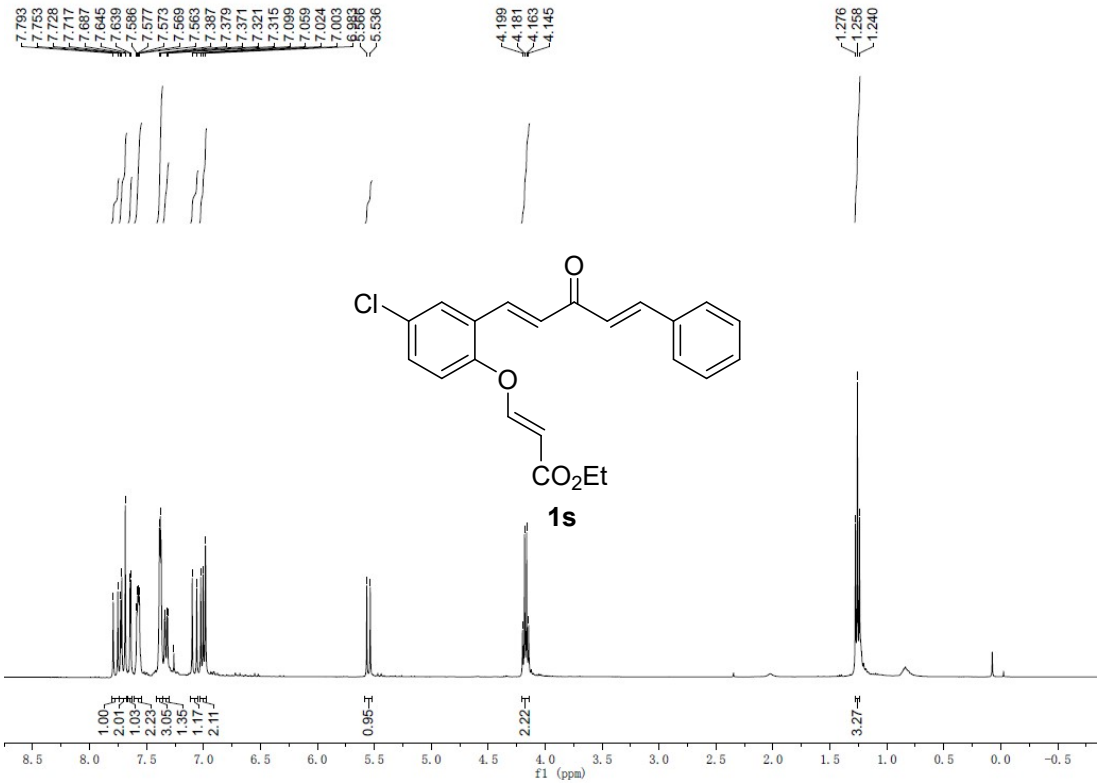
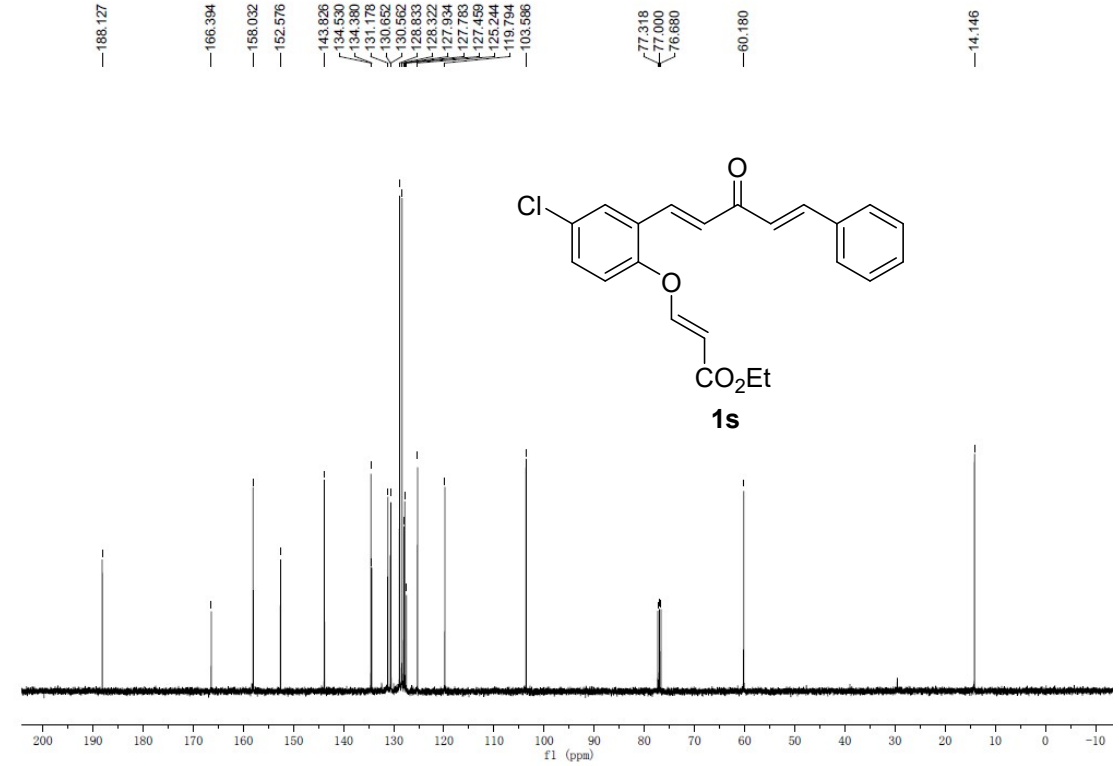
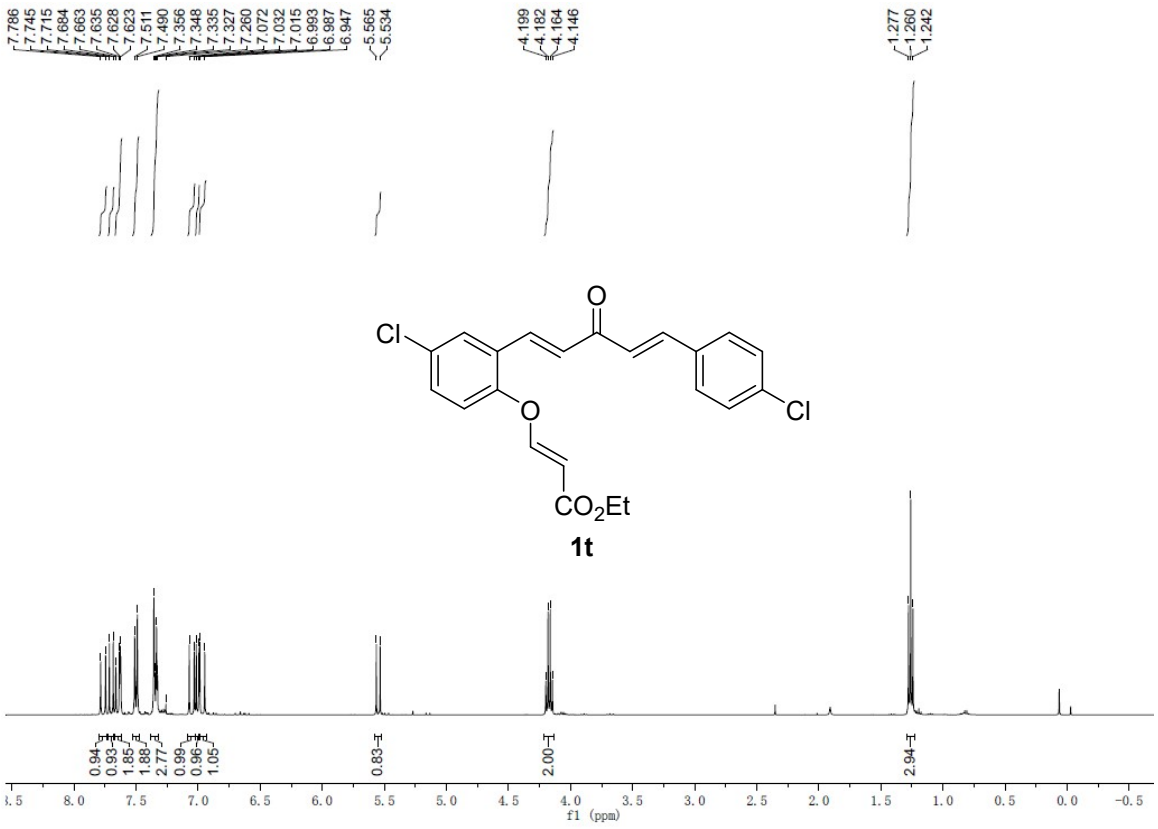
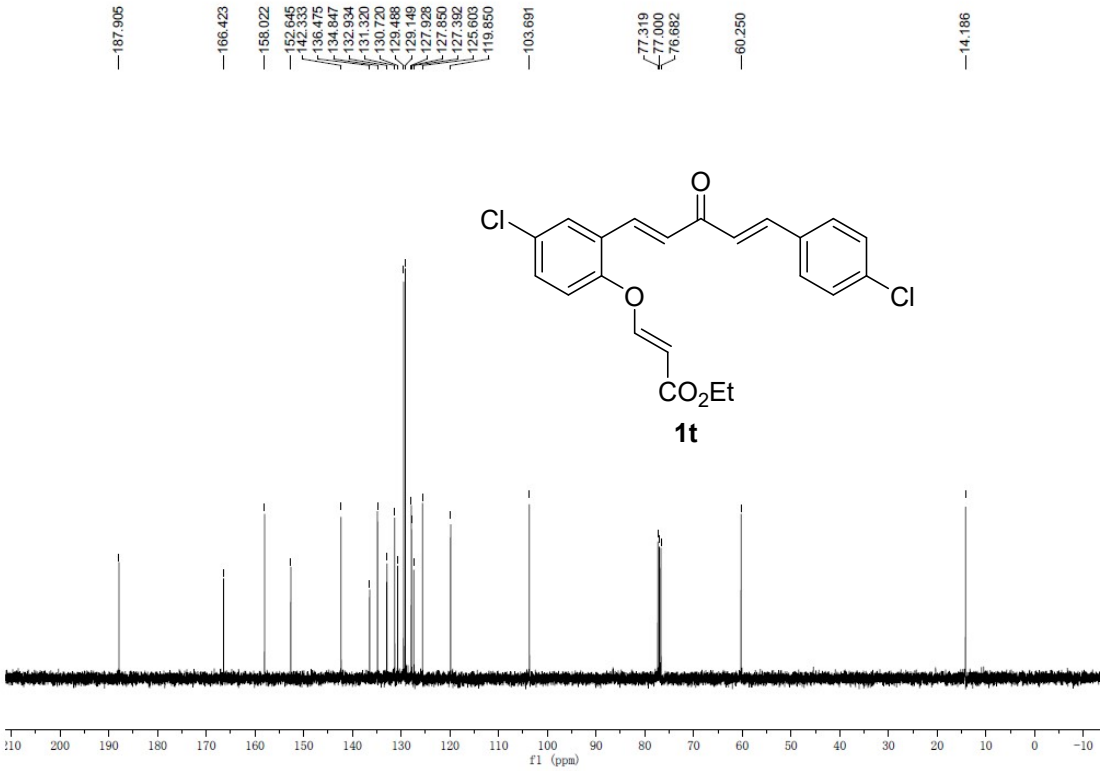
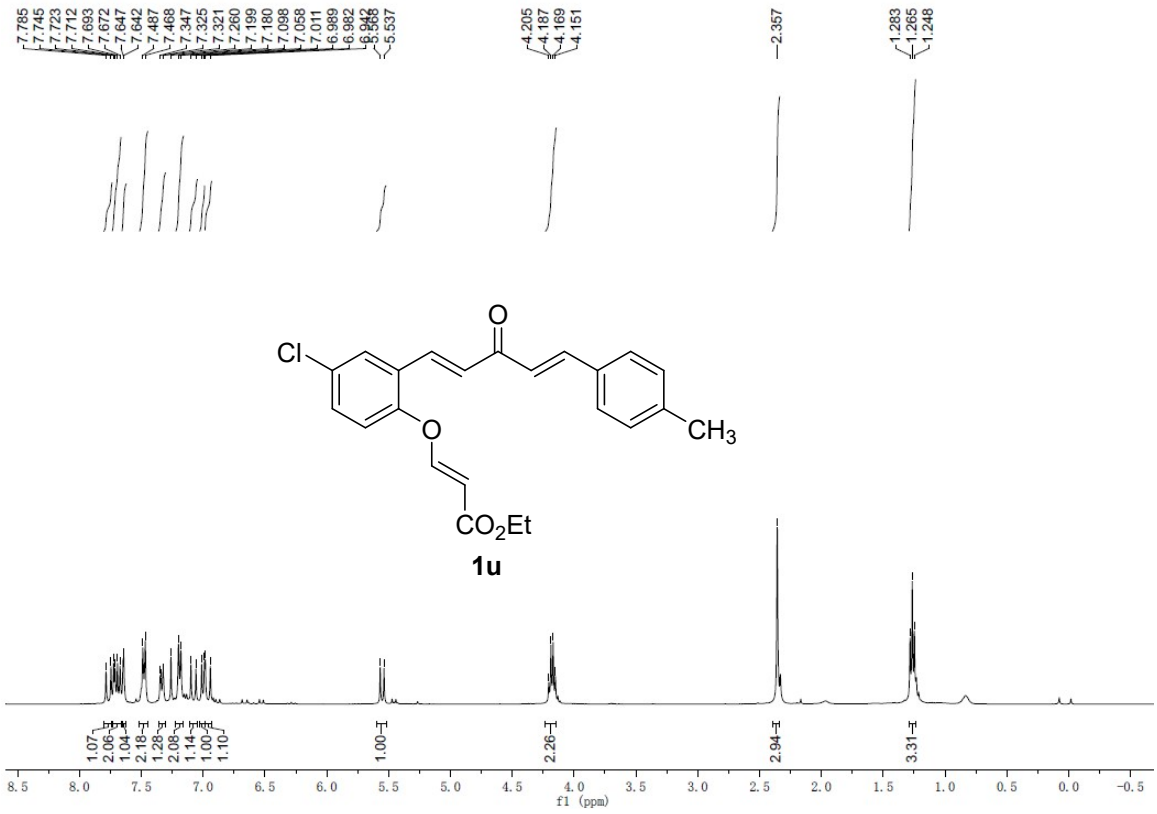
166.335
158.676
151.866
142.999
140.527
135.467
134.602
131.945
131.469
129.222
128.210
127.984
126.567
125.124
124.111
118.053
102.157
77.320
77.000
76.679
59.646
21.042
20.299
13.886
O
H3C
O
CH3
CO2Et
1r
f1 (ppm)


7.793
7.753
7.728
7.717
7.687
7.645
7.639
7.586
7.577
7.573
7.569
7.563
7.387
7.379
7.371
7.321
7.315
7.099
7.059
7.024
7.003
5.536
4.199
4.181
4.163
4.145
1.276
1.258
1.240
O
Cl
O
CO2Et
1s
1.00
2.01
1.03
2.23
3.05
1.35
1.17
2.11
0.95
2.22
3.27
f1 (ppm)


188.127
166.394
158.032
152.576
143.826
134.530
134.380
131.178
130.652
130.562
128.833
128.322
127.934
127.783
127.459
125.244
119.794
103.586
77.318
77.000
76.680
60.180
14.146
Cl
O
O
CO2Et
1s
f1 (ppm)


7.786
7.745
7.715
7.684
7.663
7.635
7.628
7.623
7.511
7.490
7.356
7.348
7.335
7.327
7.260
7.072
7.032
7.015
6.993
6.987
6.947
5.565
5.534
4.199
4.182
4.164
4.146
1.277
1.260
1.242
Cl
O
O
Cl
CO2Et
1t
0.94
0.93
1.85
1.88
2.77
0.99
0.96
1.05
0.83
2.00
2.94
f1 (ppm)


187.905
166.423
158.022
152.645
142.333
136.475
134.847
132.934
131.320
130.720
129.488
129.149
127.928
127.850
127.392
125.603
119.850
103.691
77.319
77.000
76.682
60.250
14.186
Cl
O
O
Cl
CO2Et
1t
f1 (ppm)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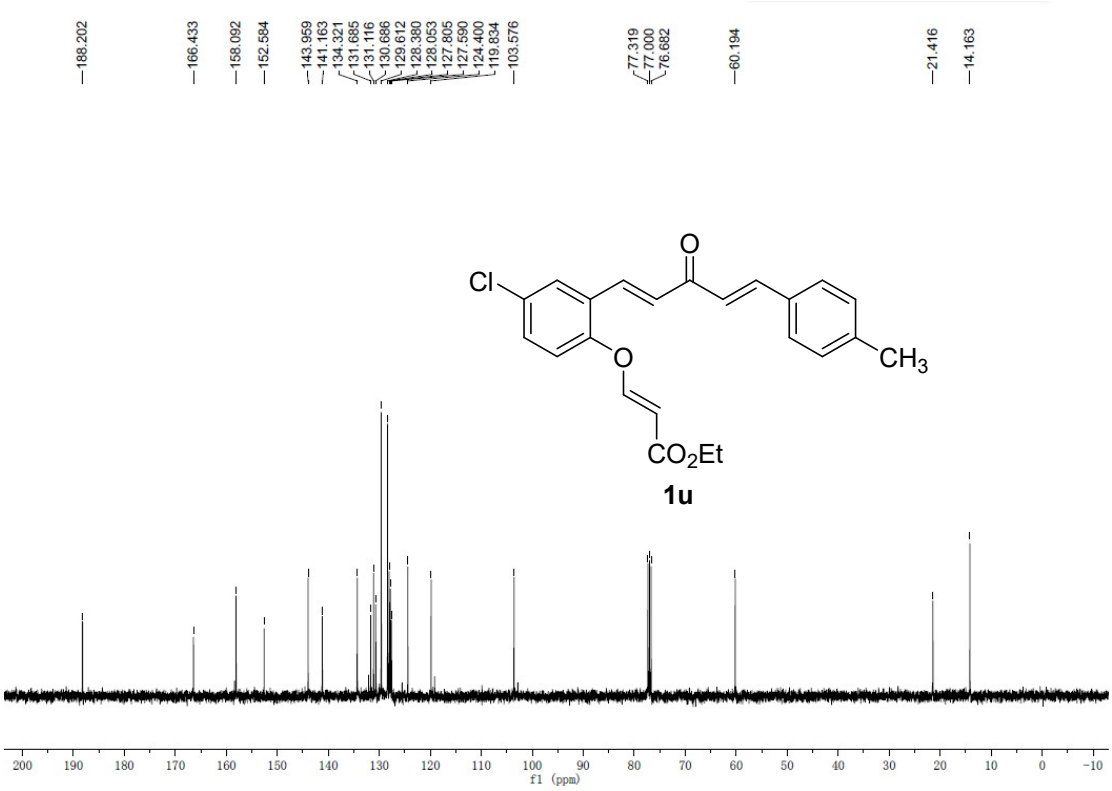
7.723
7.712
7.693
7.672
7.647
7.642
7.487
7.468
7.347
7.325
7.321
7.260
7.199
7.180
7.098
7.058
7.011
6.989
6.982
5.537
4.205
4.187
4.169
4.151
2.357
1.283
1.265
1.248
Cl
O
O
CH3
CO2Et
1u
1.07
2.06
1.04
2.18
1.28
2.08
1.14
1.00
1.10
1.00
2.26
2.94
3.31
f1 (ppm)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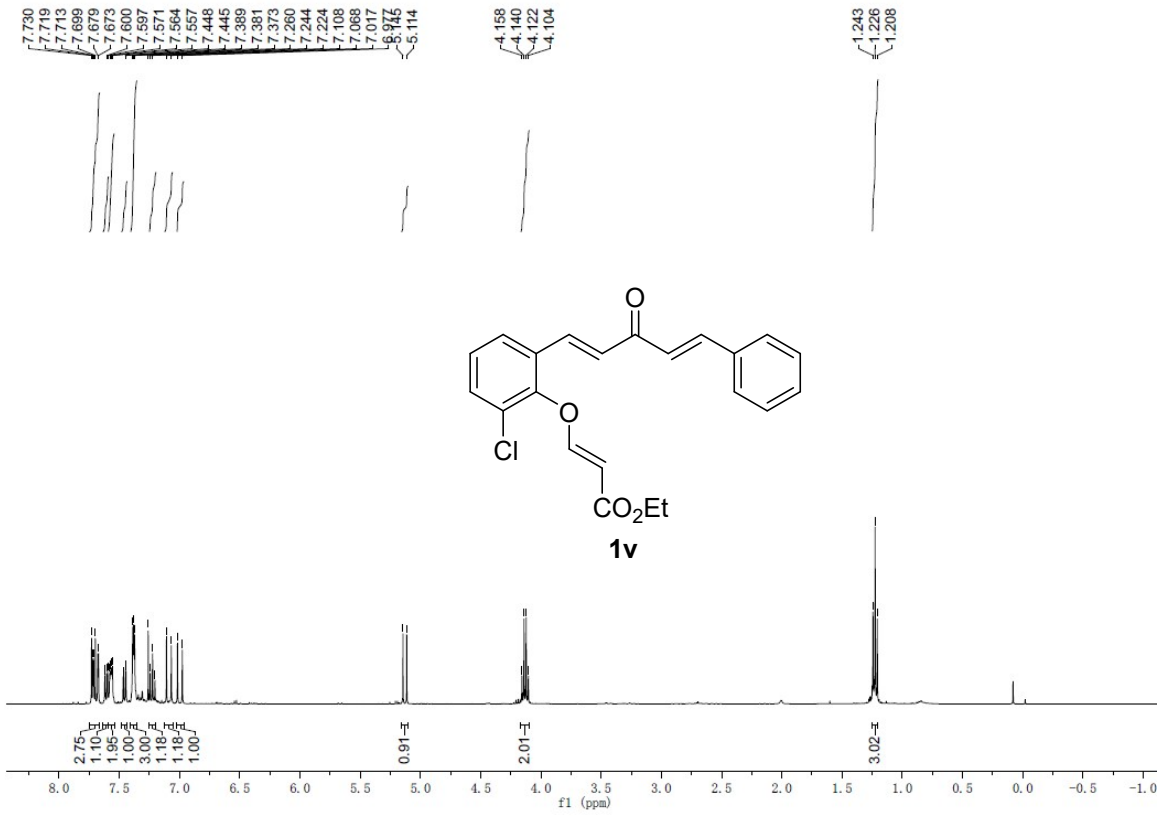
158.092
152.584
143.959
141.163
134.321
131.685
131.116
130.686
129.612
128.380
128.053
127.805
127.590
124.400
119.834
103.576
77.319
77.000
76.682
60.194
21.416
14.163
Cl
O
O
CH3
CO2Et
1u
f1 (ppm)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7.713
7.699
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7.673
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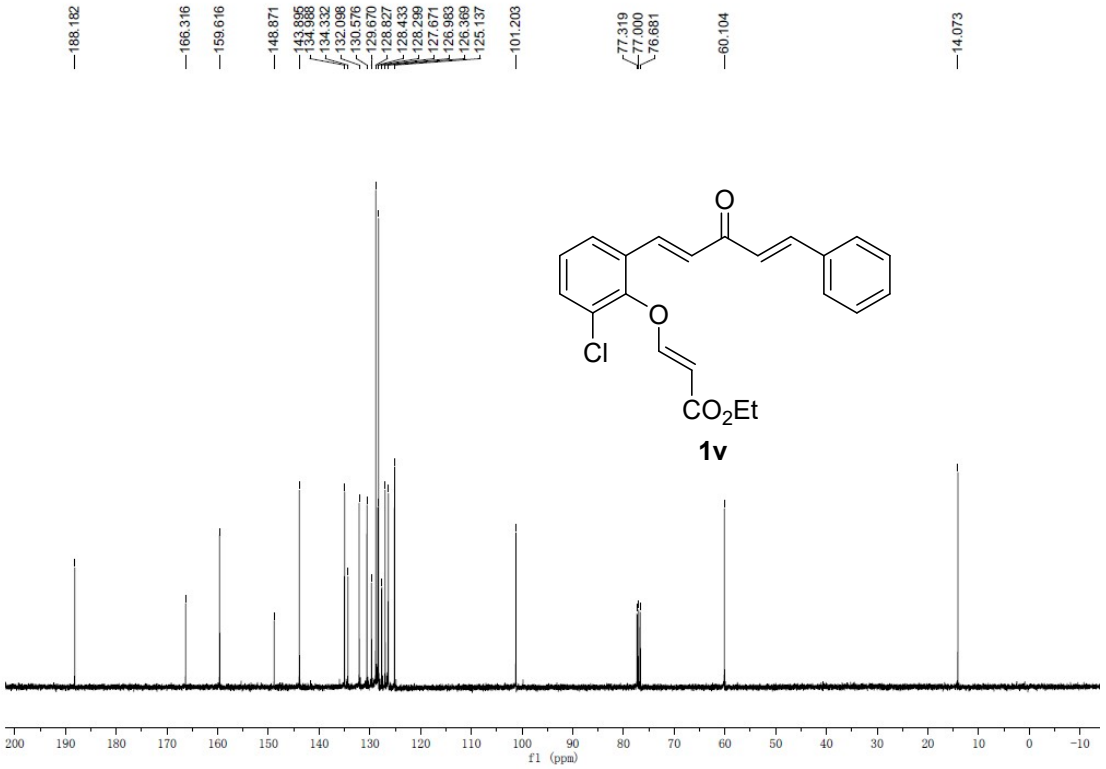
7.597
7.571
7.564
7.557
7.448
7.445
7.389
7.381
7.373
7.260
7.244
7.224
7.108
7.088
7.017
6.977
5.145
5.114
4.158
4.140
4.122
4.104
1.243
1.226
1.208
O
O
Cl
CO2Et
1v
2.75
1.10
1.95
1.00
3.00
1.18
1.18
1.00
0.91
2.01
3.02
f1 (ppm)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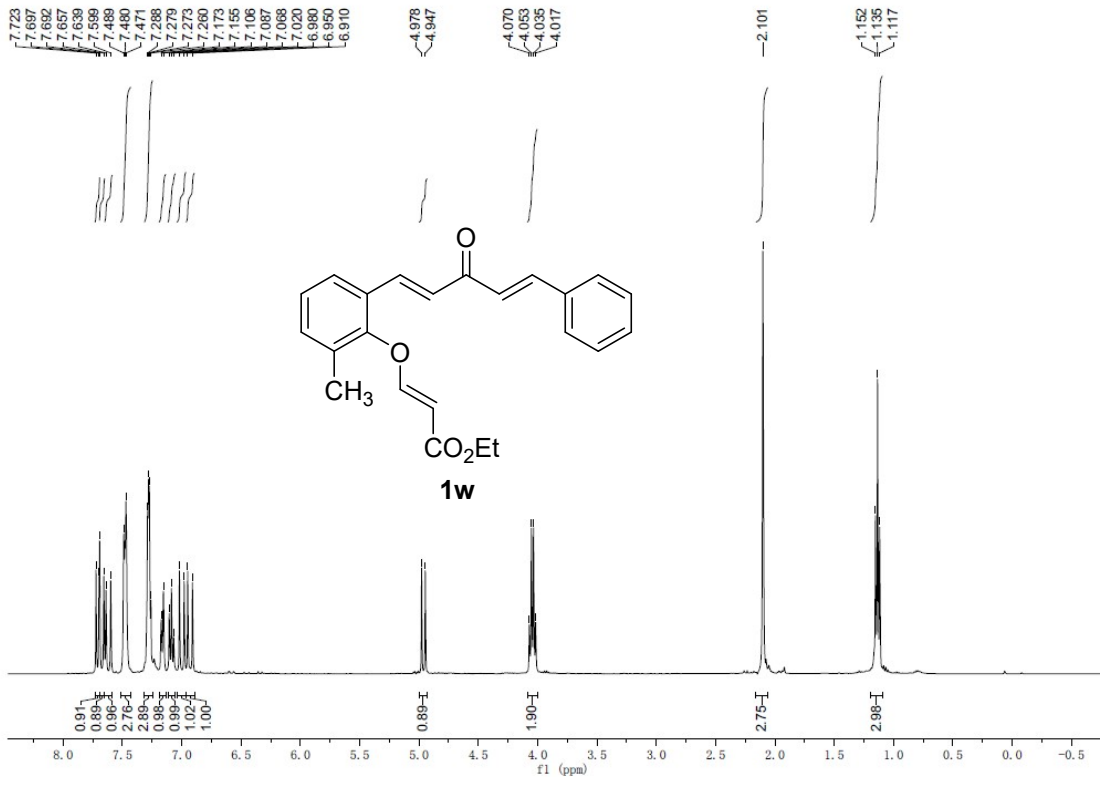
159.616
148.871
143.895
134.988
134.332
132.098
130.576
129.670
128.827
128.433
128.299
127.671
126.983
126.369
125.137
101.203
77.319
77.000
76.681
60.104
14.073
O
O
Cl
CO2Et
1v
f1 (ppm)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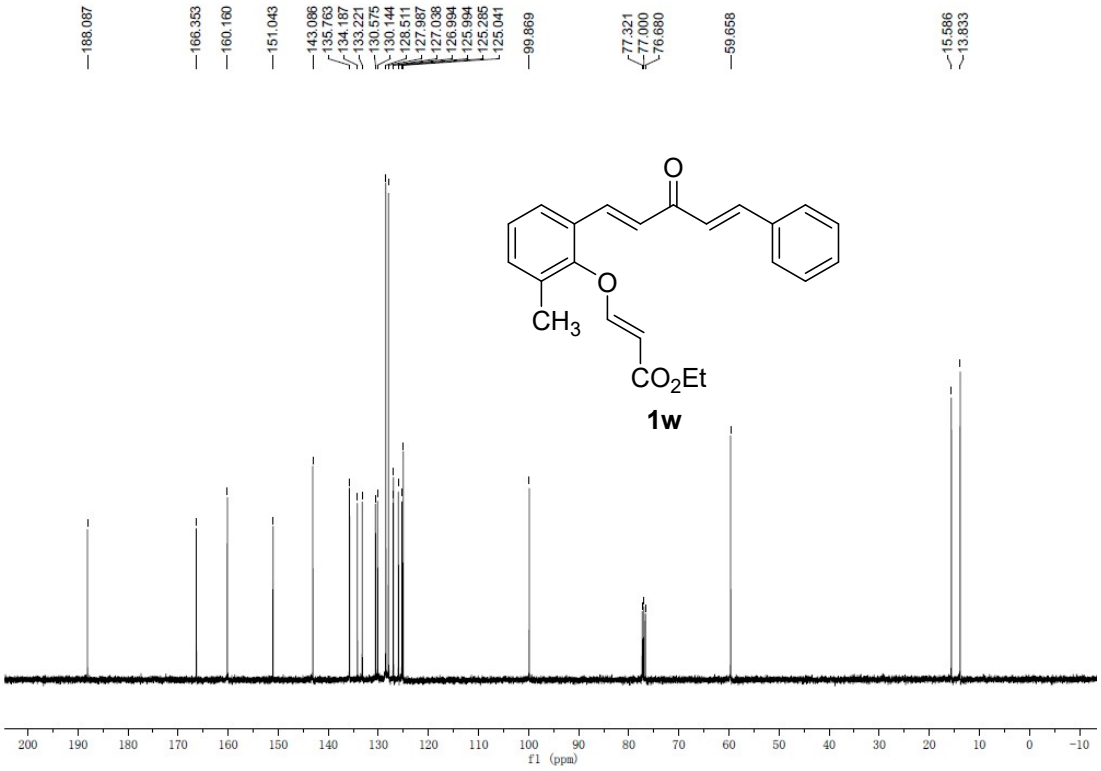
7.692
7.657
7.639
7.599
7.489
7.480
7.471
7.288
7.279
7.273
7.260
7.173
7.155
7.106
7.087
7.068
7.020
6.980
6.950
6.910
4.978
4.947
4.070
4.053
4.035
4.017
2.101
1.152
1.135
1.117
O
O
CH3
CO2Et
1w
0.91
0.89
0.96
2.76
2.89
0.98
0.99
1.02
1.00
0.89
1.90
2.75
2.98
f1 (ppm)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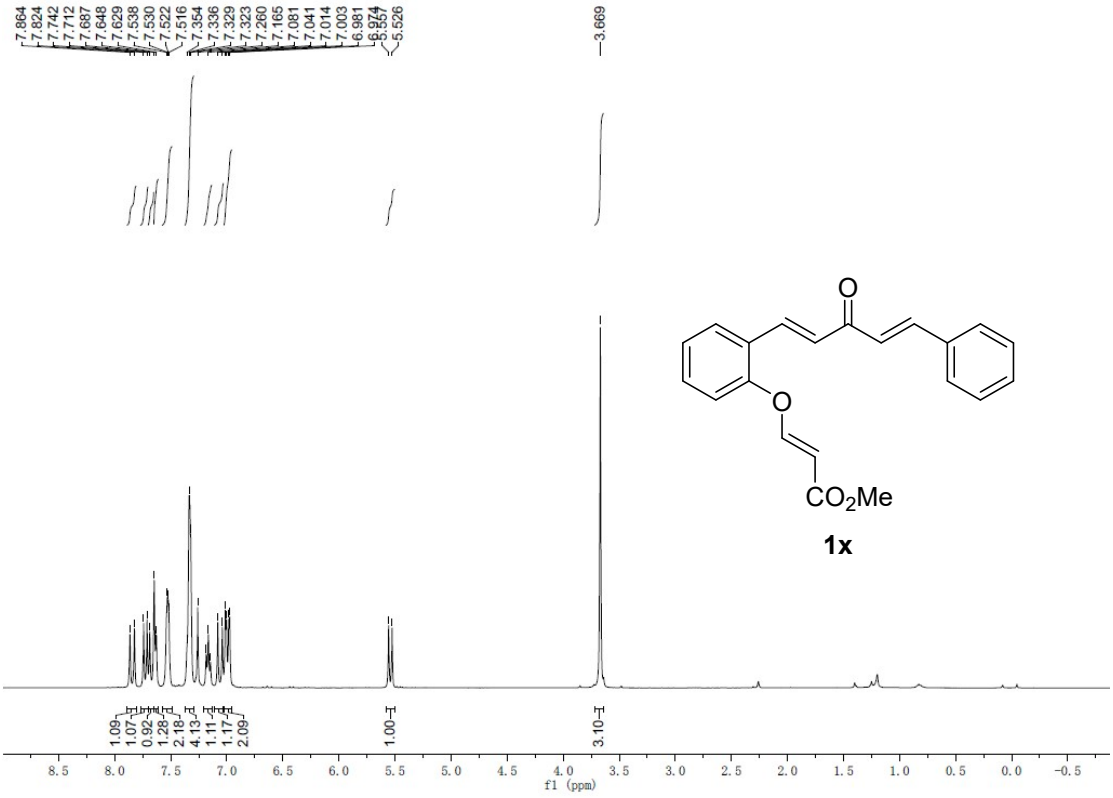
134.187
133.221
130.575
130.144
128.511
127.987
127.038
126.994
125.994
125.285
125.041
99.869
77.321
77.000
76.680
59.658
15.586
13.833
O
O
CH3
CO2Et
1w
f1 (ppm)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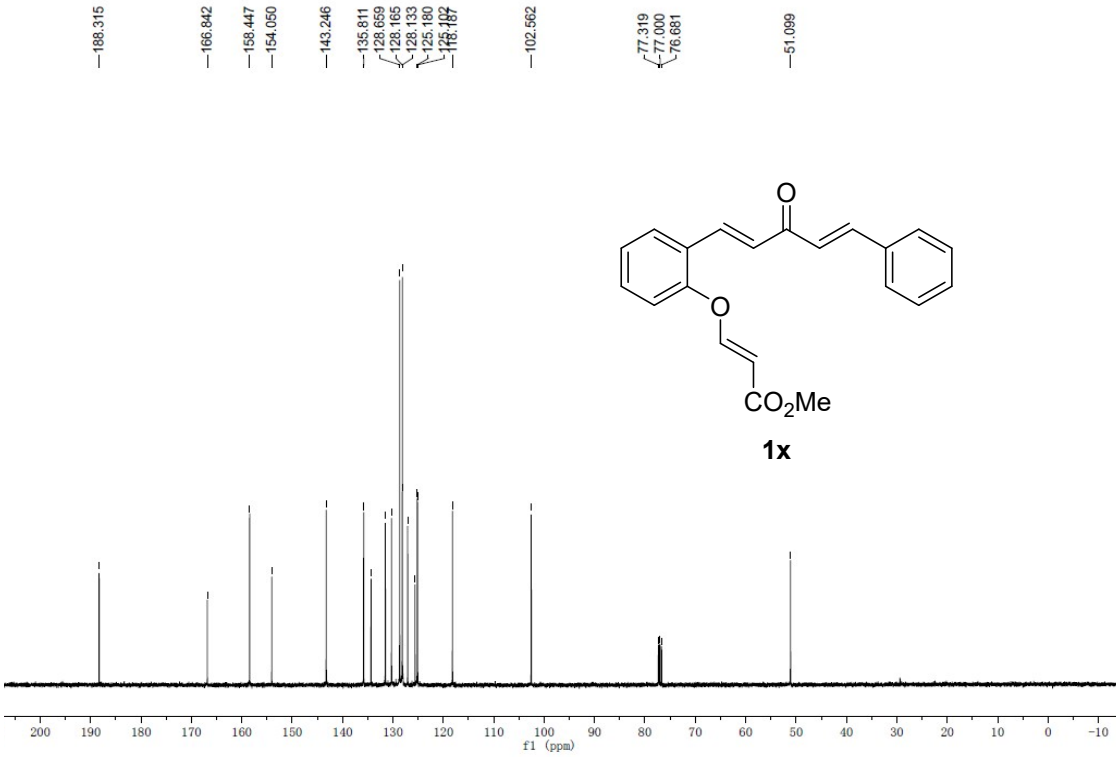
7.538
7.530
7.522
7.516
7.354
7.336
7.329
7.323
7.260
7.165
7.081
7.041
7.014
7.003
6.981
6.974
5.557
5.526
3.669
O
O
CO2Me
1x
1.09
1.07
0.92
1.28
2.18
4.13
1.11
1.17
2.09
1.00
3.10
f1 (ppm)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158.447
154.050
143.246
135.811
128.659
128.165
128.133
125.180
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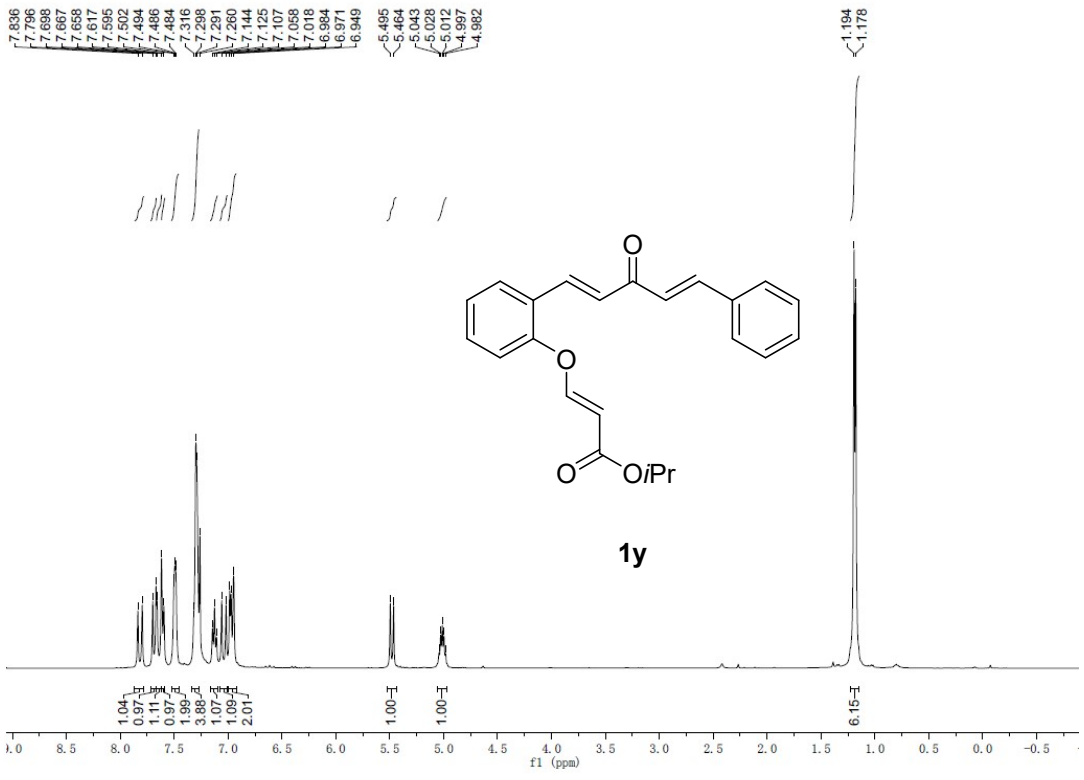
102.562
77.319
77.000
76.681
51.099
O
O
CO2Me
1x
f1 (ppm)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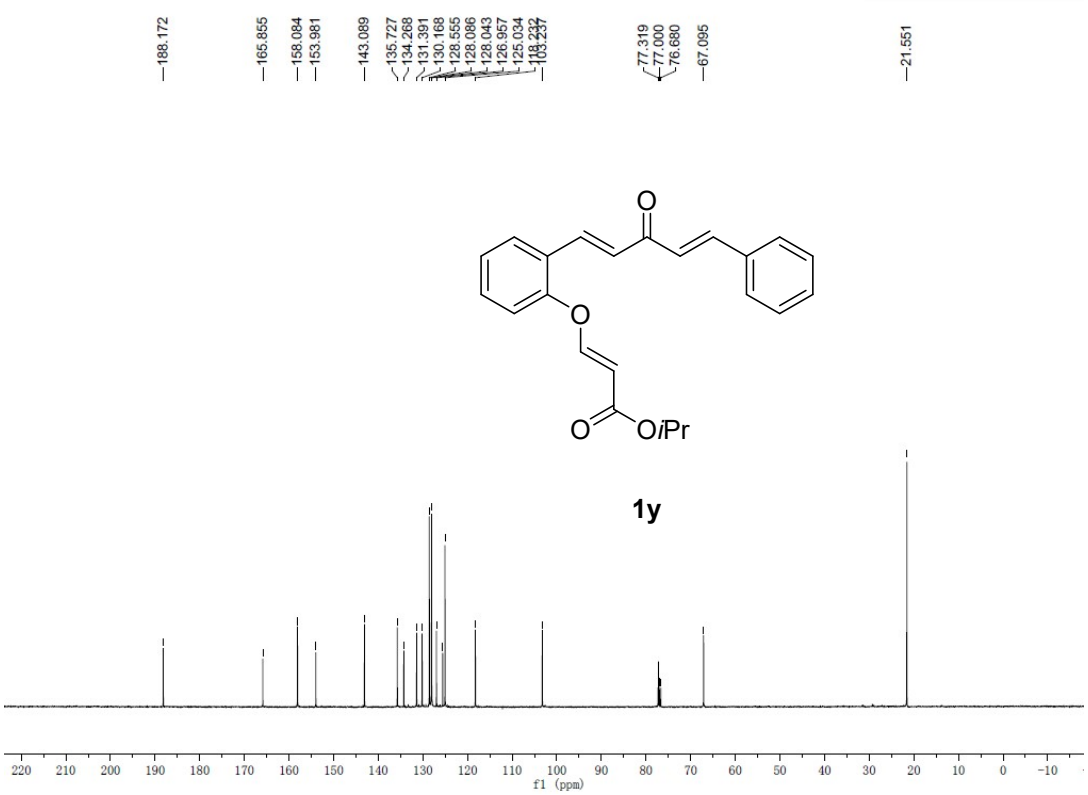
7.698
7.667
7.658
7.617
7.595
7.502
7.494
7.486
7.484
7.316
7.298
7.291
7.260
7.144
7.125
7.107
7.058
7.018
6.984
6.971
6.949
5.496
5.464
5.043
5.028
5.012
4.997
4.982
1.194
1.178
O
O
O
OiPr
1y
1.04
0.97
1.11
0.97
1.99
3.88
1.07
1.09
2.01
1.00
1.00
6.15
f1 (ppm)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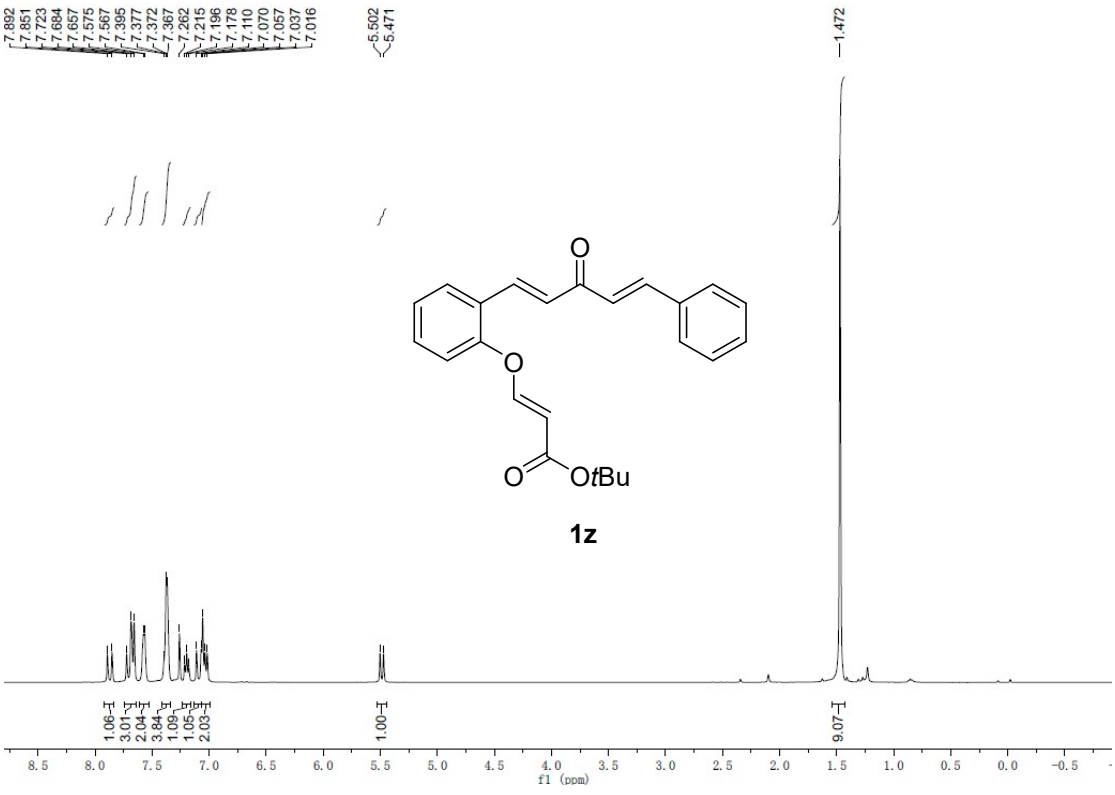
153.981
143.089
135.727
134.268
131.391
130.168
128.555
128.086
128.043
126.957
125.034
118.232
103.237
77.319
77.000
76.680
67.095
21.551
O
O
O
OiPr
1y
f1 (ppm)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7.723
7.684
7.657
7.575
7.567
7.395
7.377
7.372
7.367
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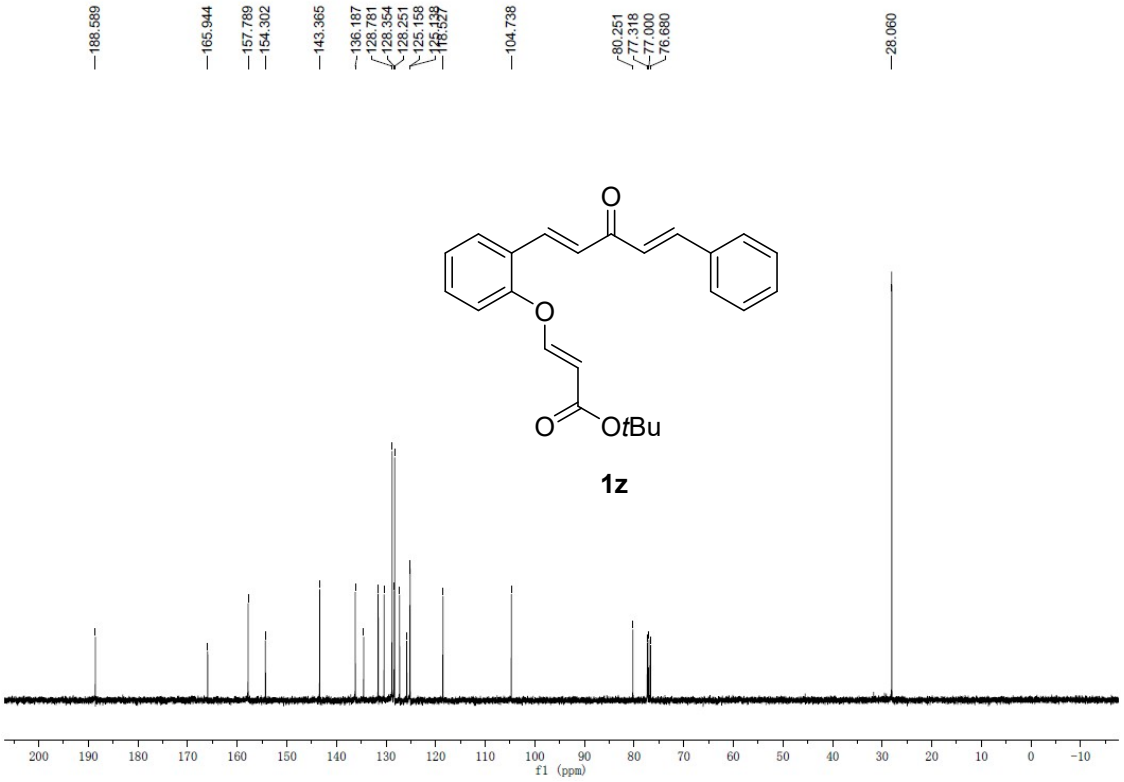
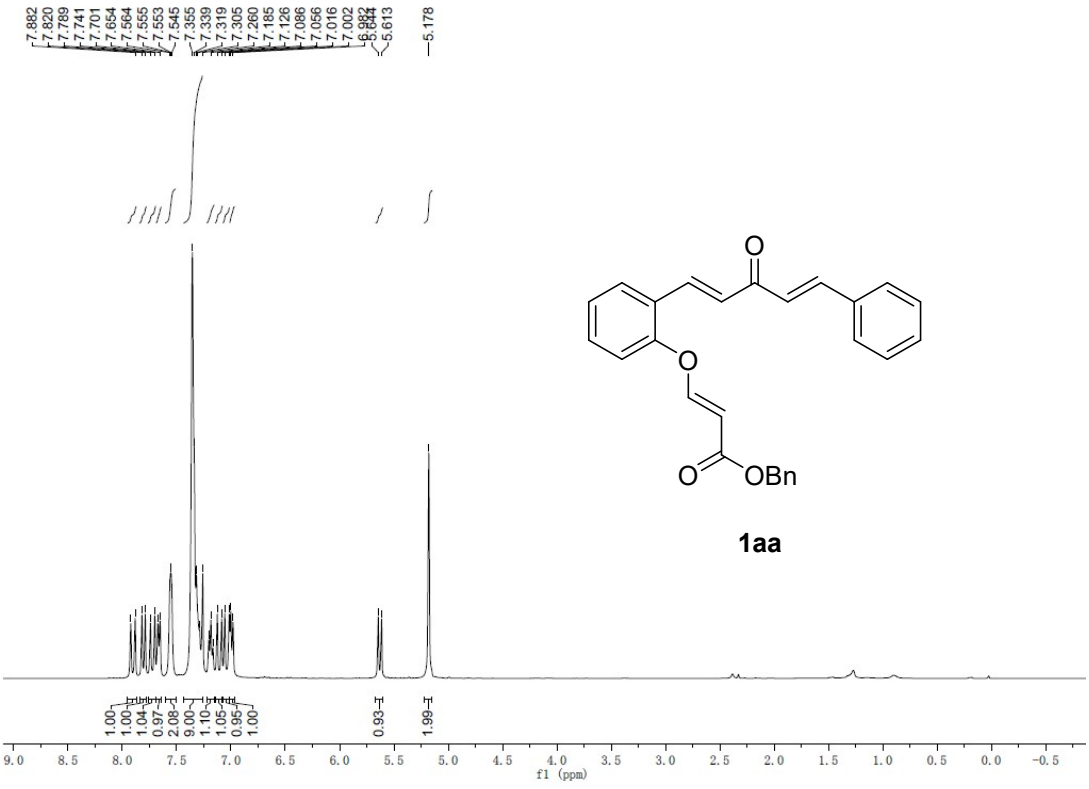
7.215
7.196
7.178
7.110
7.070
7.057
7.037
7.016
5.502
5.471
1.472
O
O
O
OtBu
1z
1.06
3.01
2.04
3.84
1.09
1.05
2.03
1.00
9.07
f1 (ppm)


188.589
165.944
157.789
154.302
143.365
136.187
128.781
128.354
128.251
125.158
104.738
80.251
77.318
77.000
76.680
28.060
O
O
O
OtBu
1z
f1 (ppm)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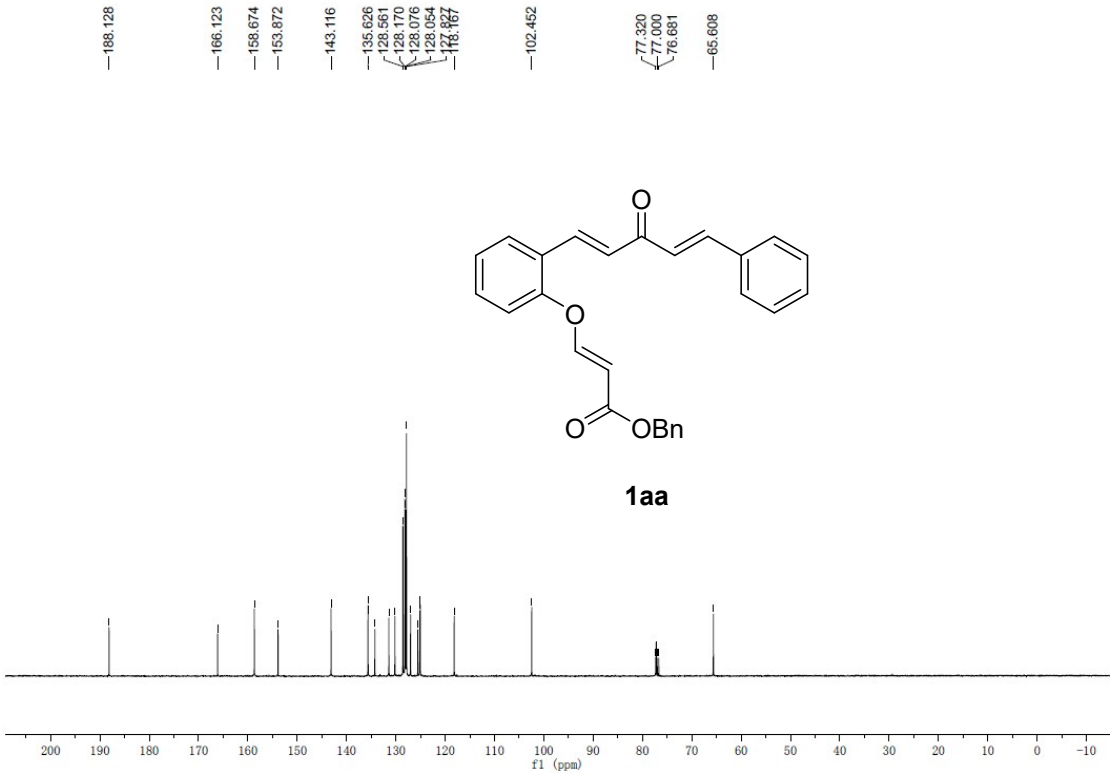
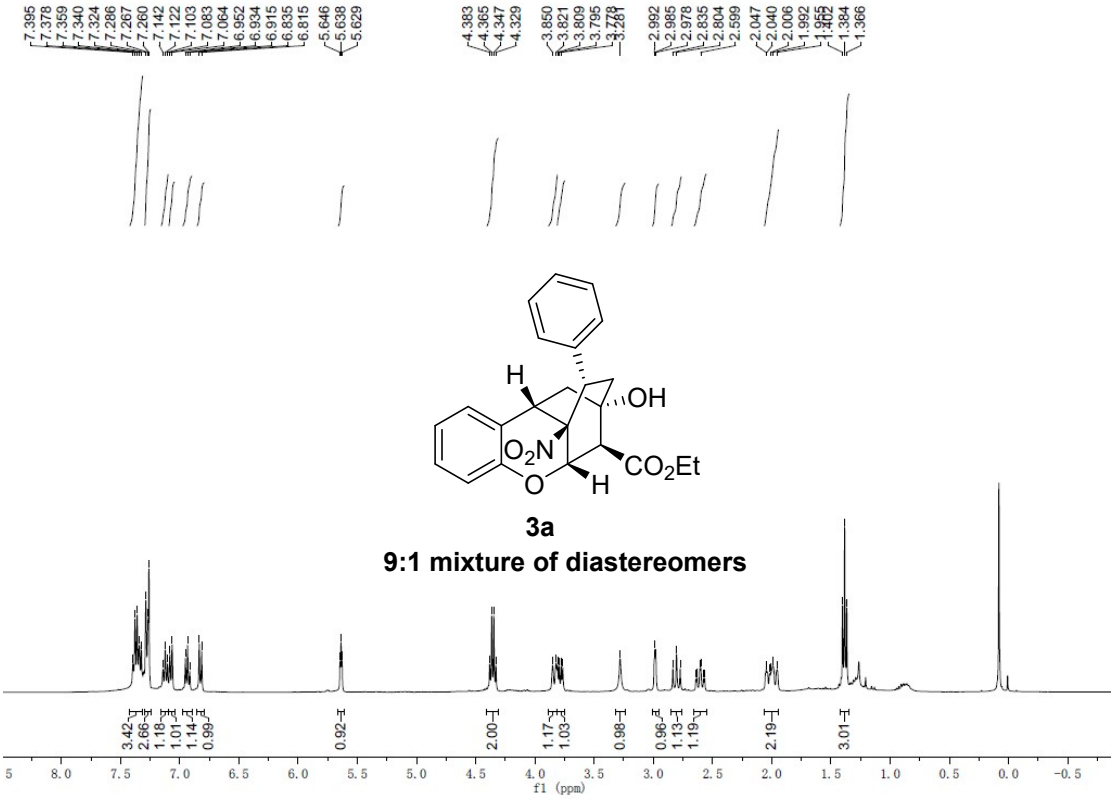
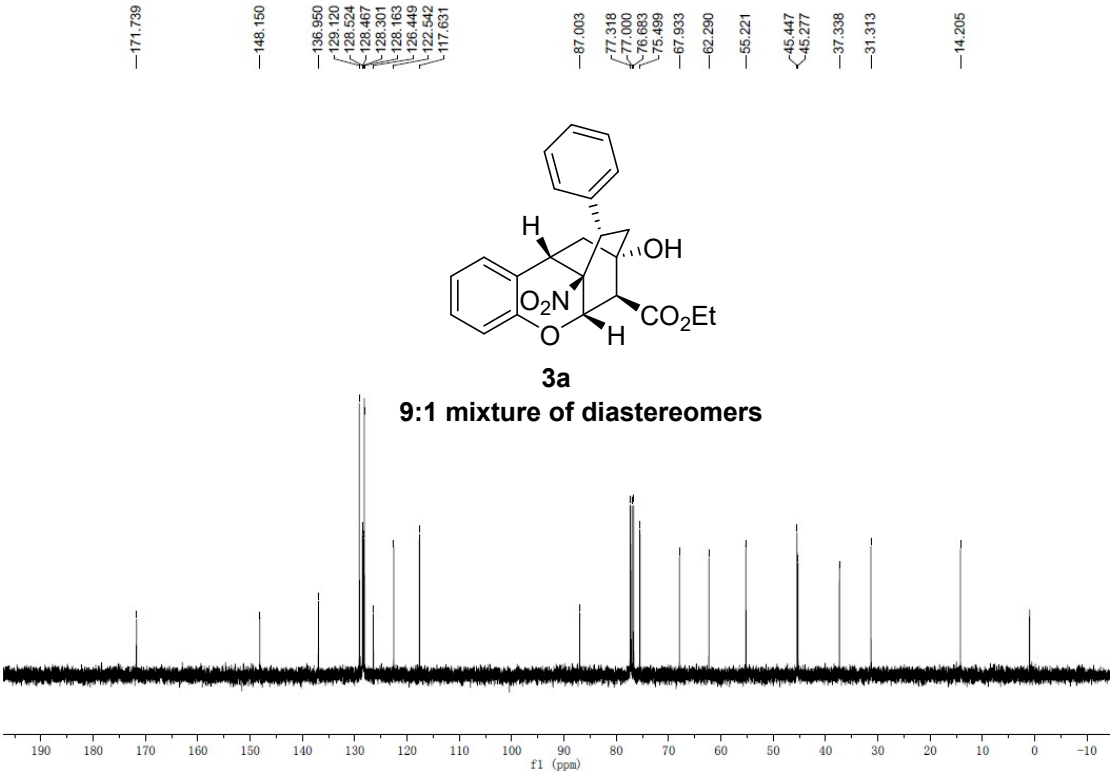
7.789
7.741
7.701
7.654
7.564
7.555
7.553
7.545
7.355
7.339
7.319
7.305
7.260
7.185
7.126
7.086
7.056
7.016
7.002
6.982
6.844
5.613
5.178
O
O
O
OBn
1aa
1.00
1.00
1.04
0.97
2.08
9.00
1.10
1.05
0.95
1.00
0.93
1.99
f1 (ppm)

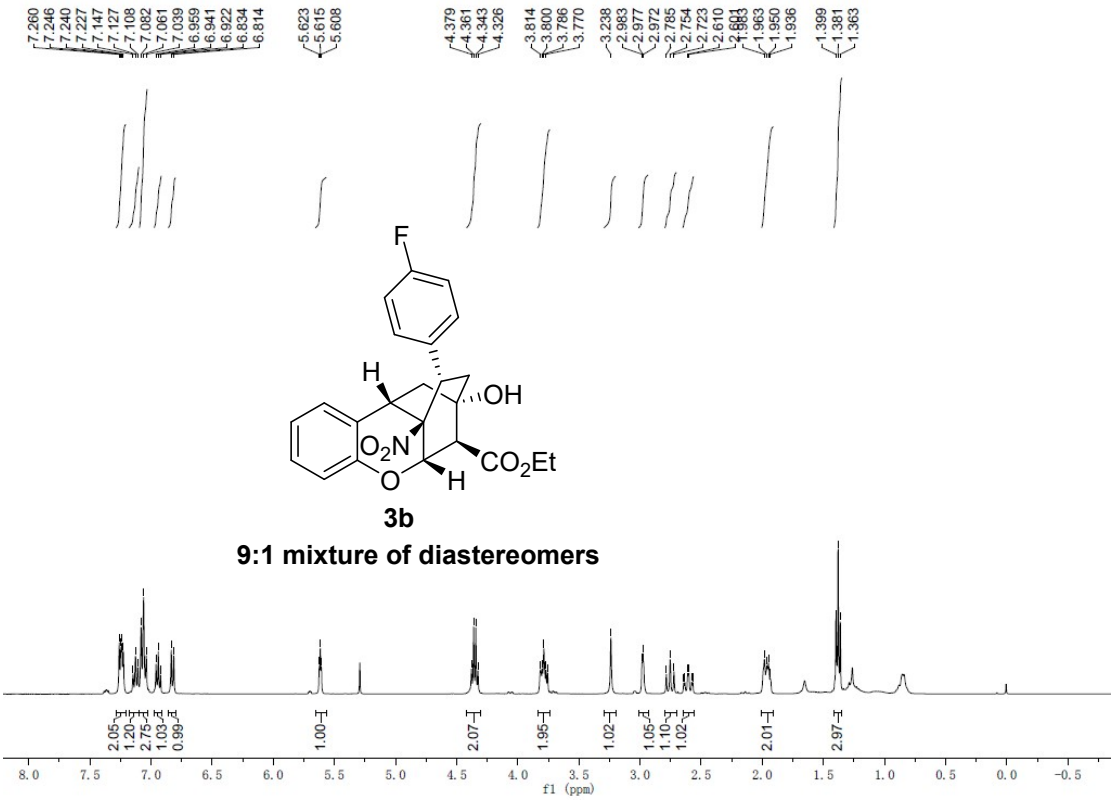

188.128
166.123
158.674
153.872
143.116
135.626
128.561
128.170
128.076
128.054
127.827
118.167
102.452
77.320
77.000
76.681
65.608
O
O
O
OBn
1aa
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.395
7.378
7.359
7.340
7.324
7.286
7.267
7.260
7.142
7.122
7.103
7.083
7.064
6.952
6.934
6.915
6.835
6.815
5.646
5.638
5.629
4.383
4.365
4.347
4.329
3.850
3.821
3.809
3.795
3.778
3.281
2.992
2.985
2.978
2.835
2.804
2.599
2.047
2.040
2.006
1.992
1.384
1.366
H
OH
O2N
CO2Et
O
H
3a
9:1 mixture of diastereomers
3.42
2.66
1.18
1.01
1.14
0.99
0.92
2.00
1.17
1.03
0.98
0.96
1.13
1.19
2.19
3.01
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)



3a

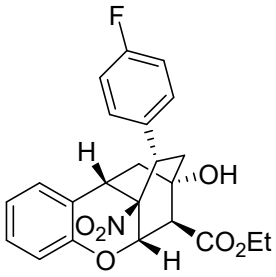
9:1 mixture of diastereomers



3b

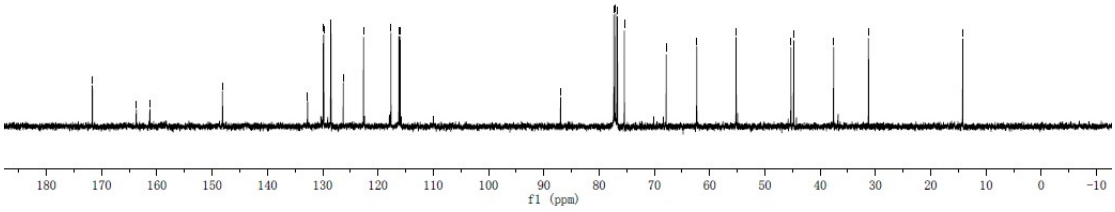
9:1 mixture of diastereomers

171.679
163.738
161.271
148.126
132.765
132.732
129.880
129.799
128.558
128.495
126.290
122.617
117.661
116.212
115.998
86.963
77.318
77.000
76.682
75.430
67.855
62.327
55.207
45.291
44.776
37.570
31.254
14.205

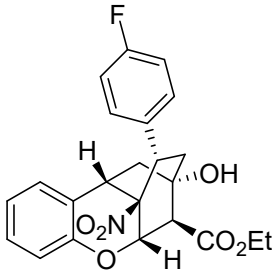


3b

9:1 mixture of diastereomers

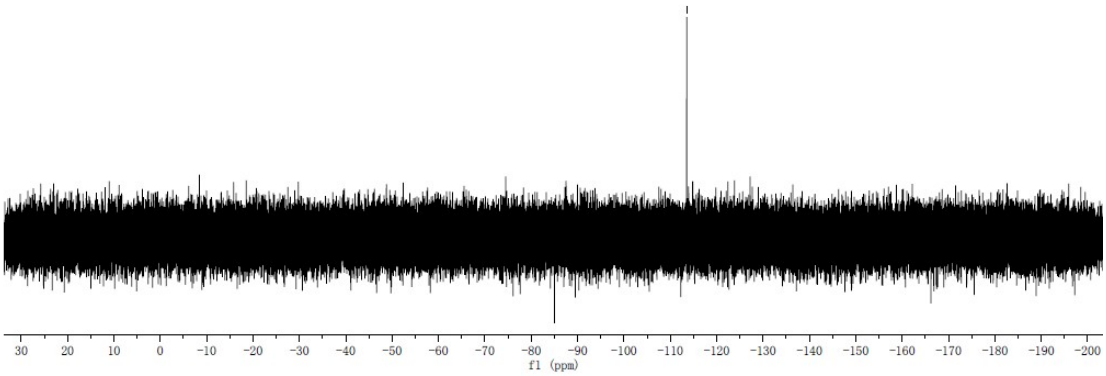


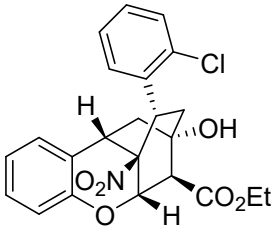
113.552



3b

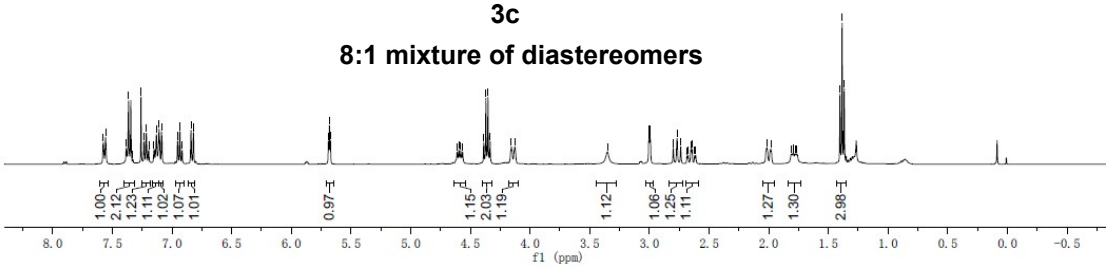
9:1 mixture of diastereomers

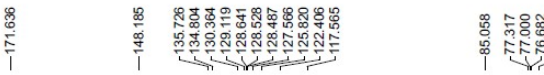


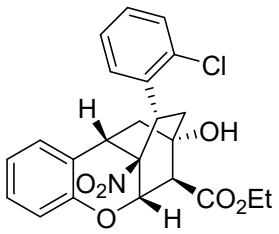


3c

8:1 mixture of diastereomers

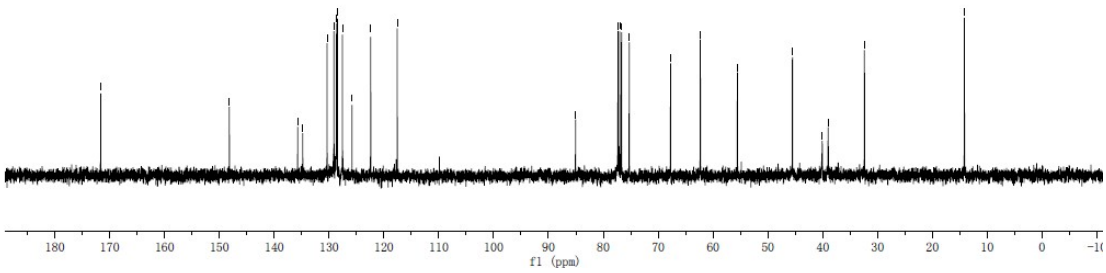


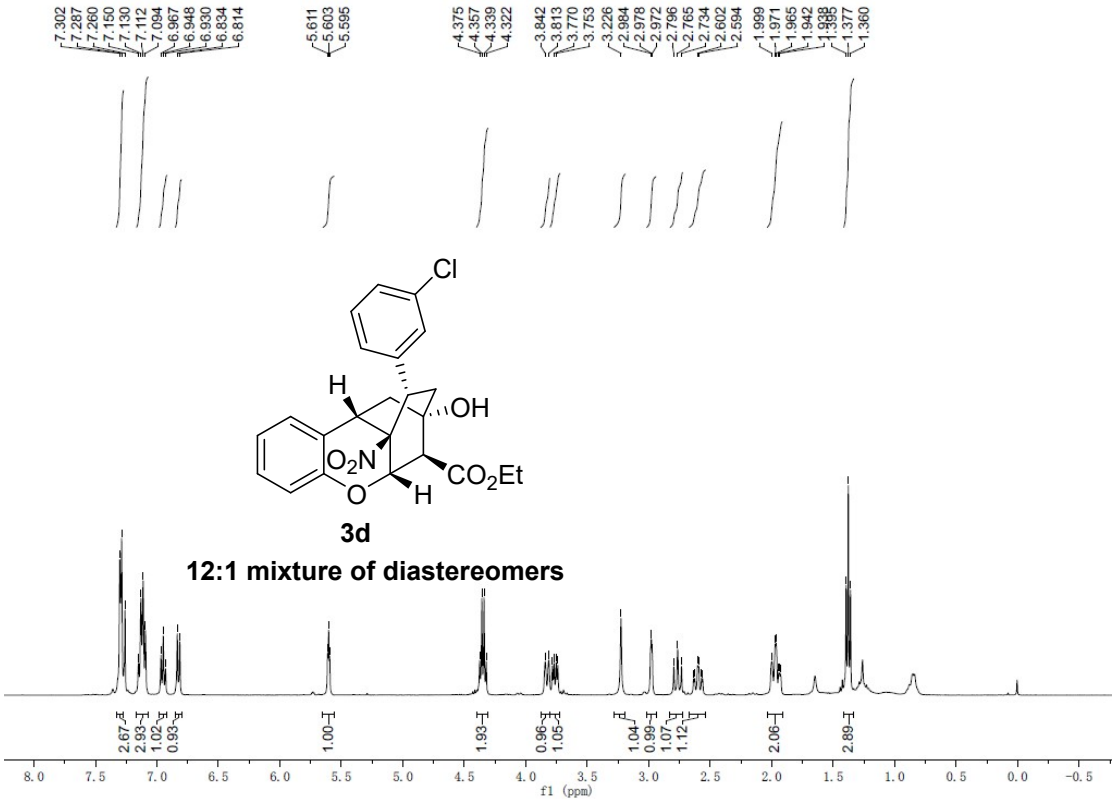




3c

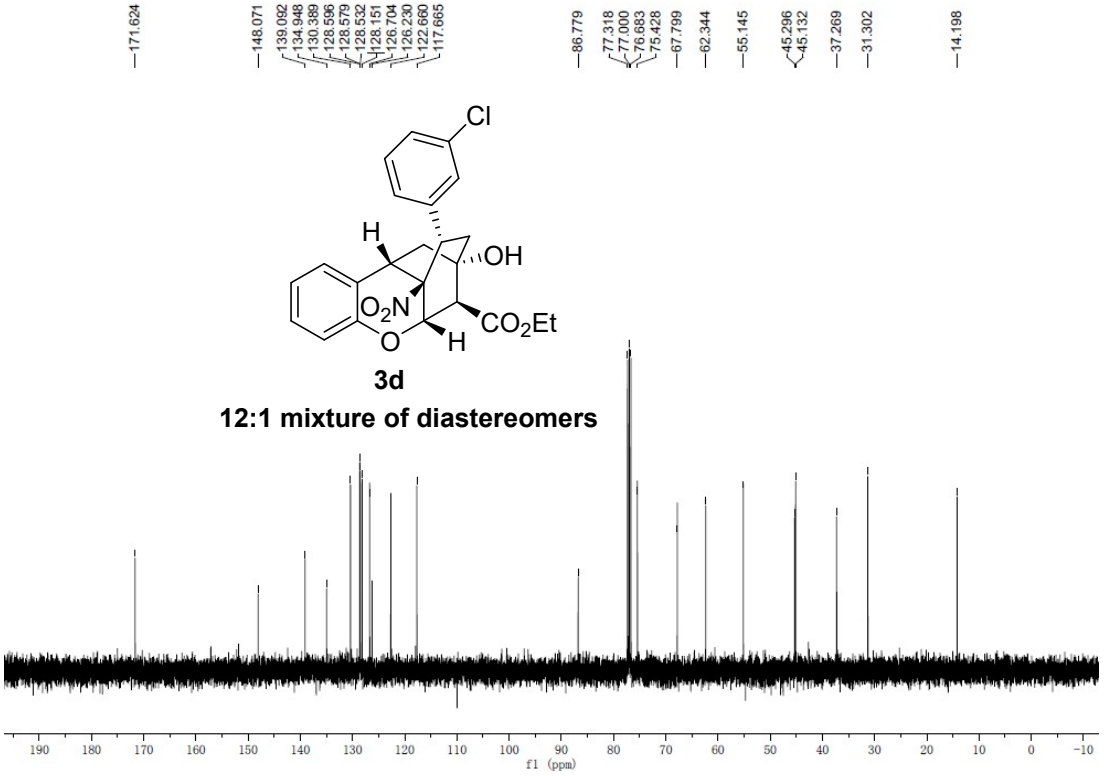
8:1 mixture of diastereomers





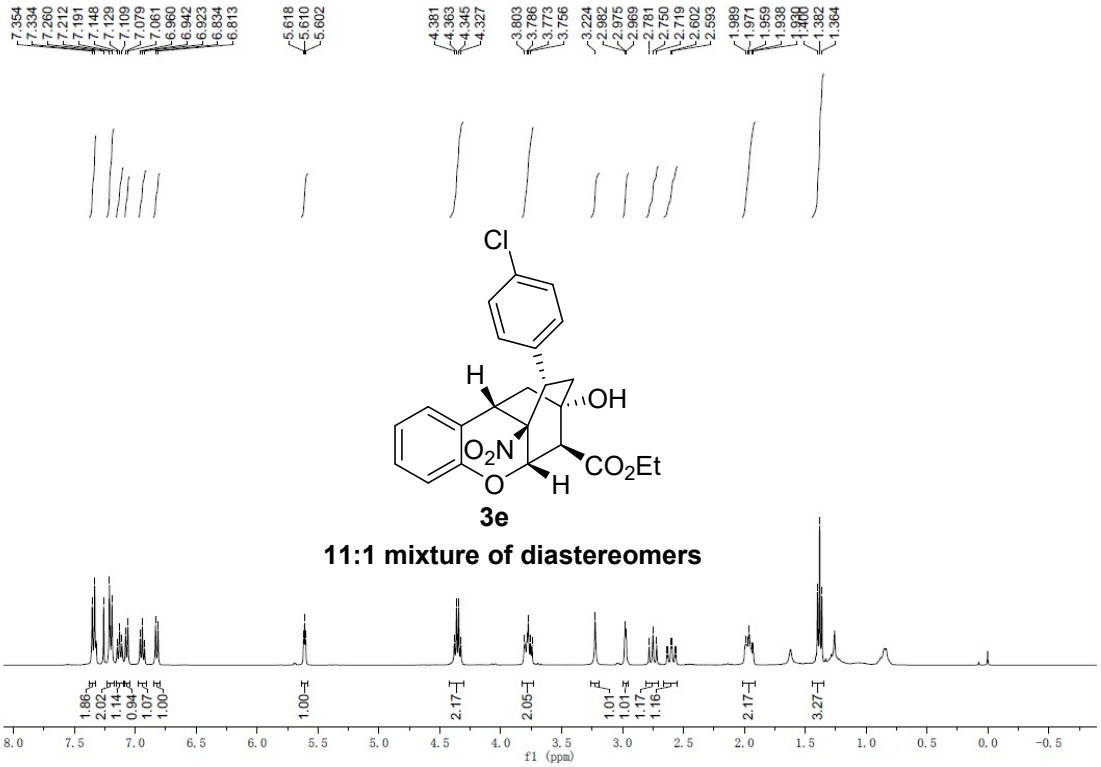
3d

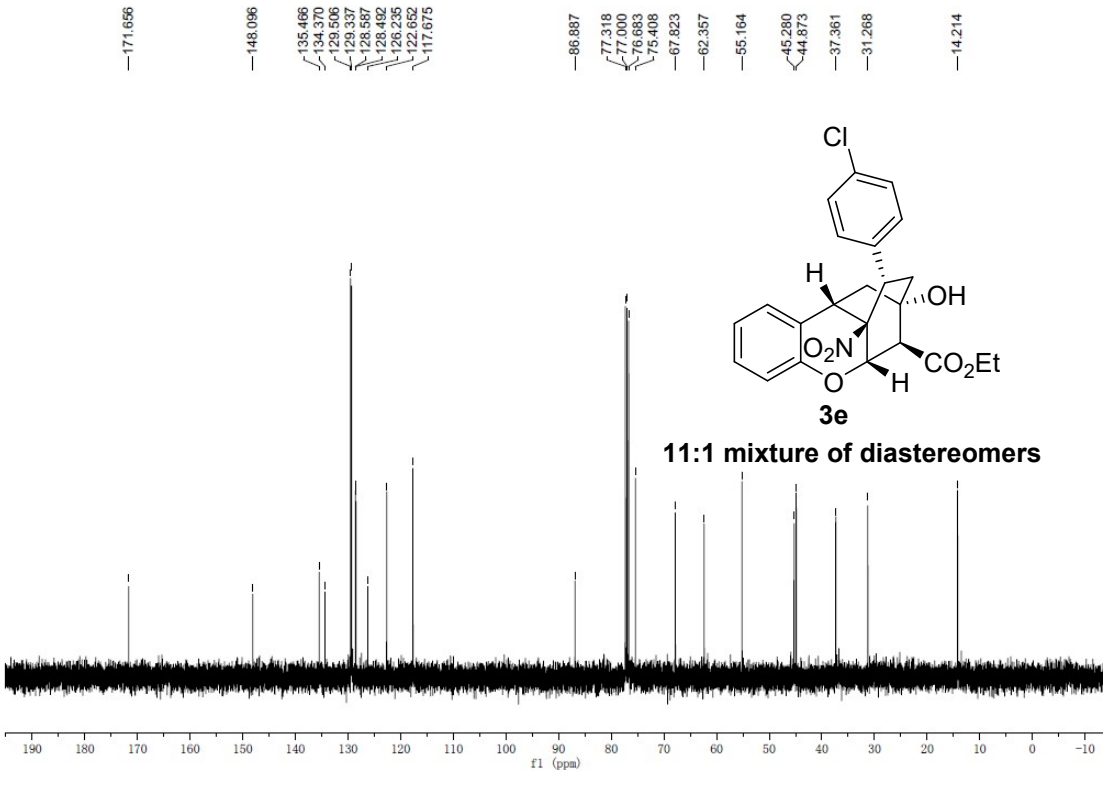
12:1 mixture of diastereomers

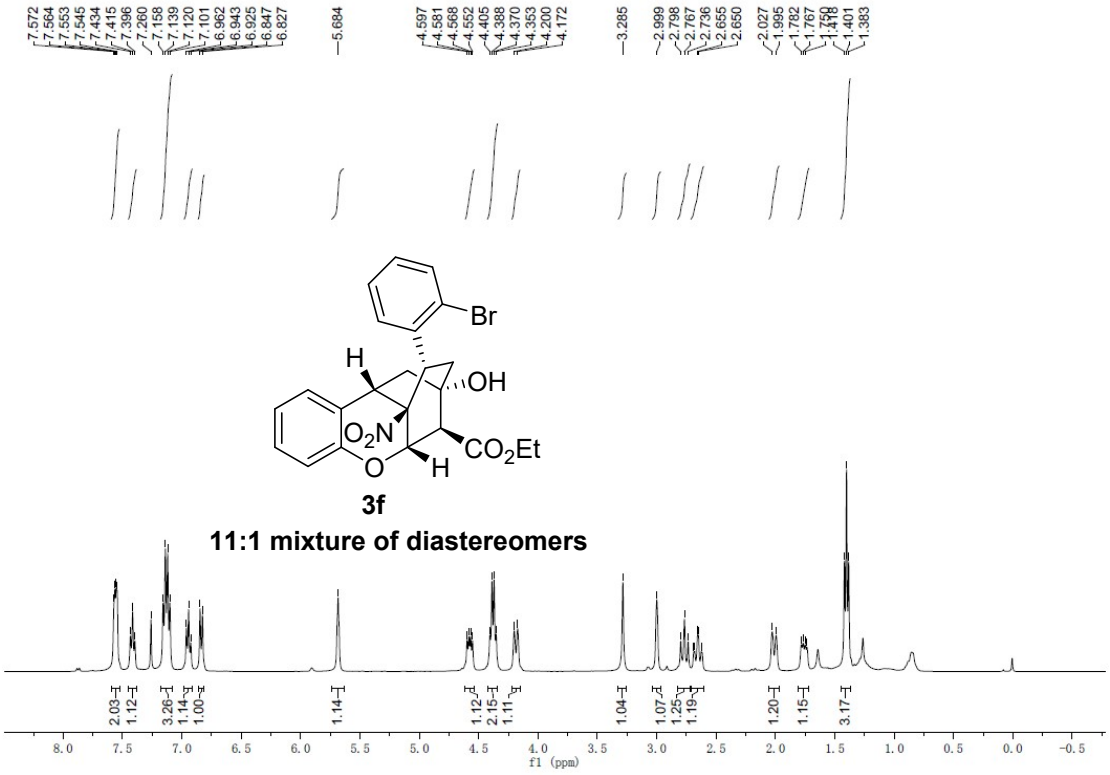


3d

12:1 mixture of diastereomers

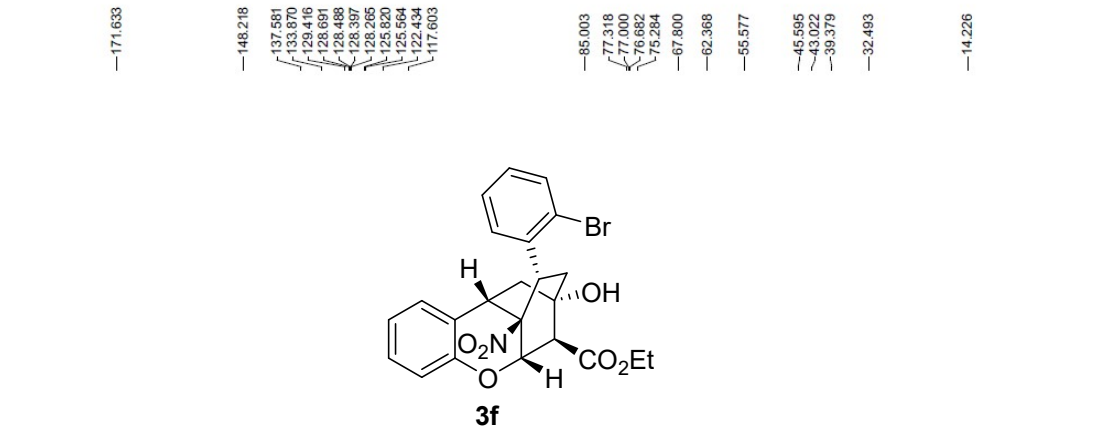

7.354
7.334
7.260
7.212
7.191
7.148
7.129
7.109
7.079
7.061
6.960
6.942
6.923
6.834
6.813
5.618
5.610
5.602
4.381
4.363
4.345
4.327
3.803
3.786
3.773
3.756
3.224
2.982
2.975
2.969
2.781
2.750
2.719
2.602
2.593
1.989
1.971
1.959
1.938
1.382
1.364
Cl
H
OH
O2N
CO2Et
O
H
3e
11:1 mixture of diastereomers
1.86
2.02
1.14
0.94
1.07
1.00
1.00
2.17
2.05
1.01
1.01
1.17
1.16
2.17
3.27
f1 (ppm)


171.656
148.096
135.466
134.370
129.506
129.337
128.587
128.492
126.235
122.652
117.675
86.887
77.318
77.000
76.683
75.408
67.823
62.357
55.164
45.280
44.873
37.361
31.268
14.214
Cl
H
OH
O2N
CO2Et
O
H
3e
11:1 mixture of diastereomers
f1 (ppm)



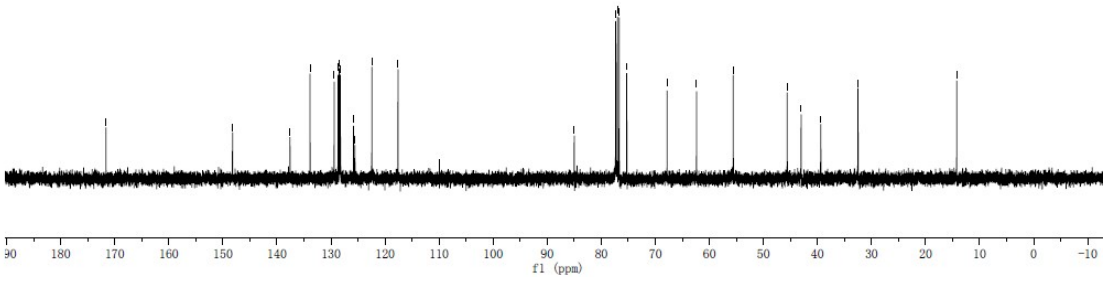
3f

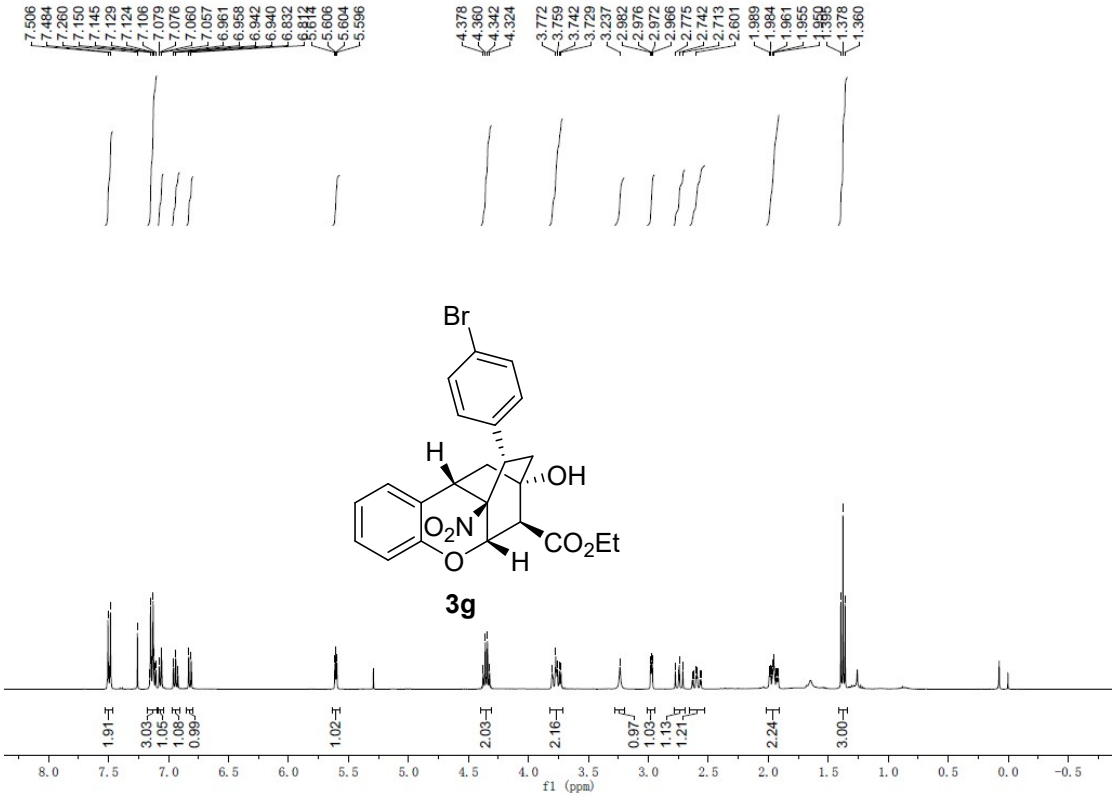
11:1 mixture of diastereomers

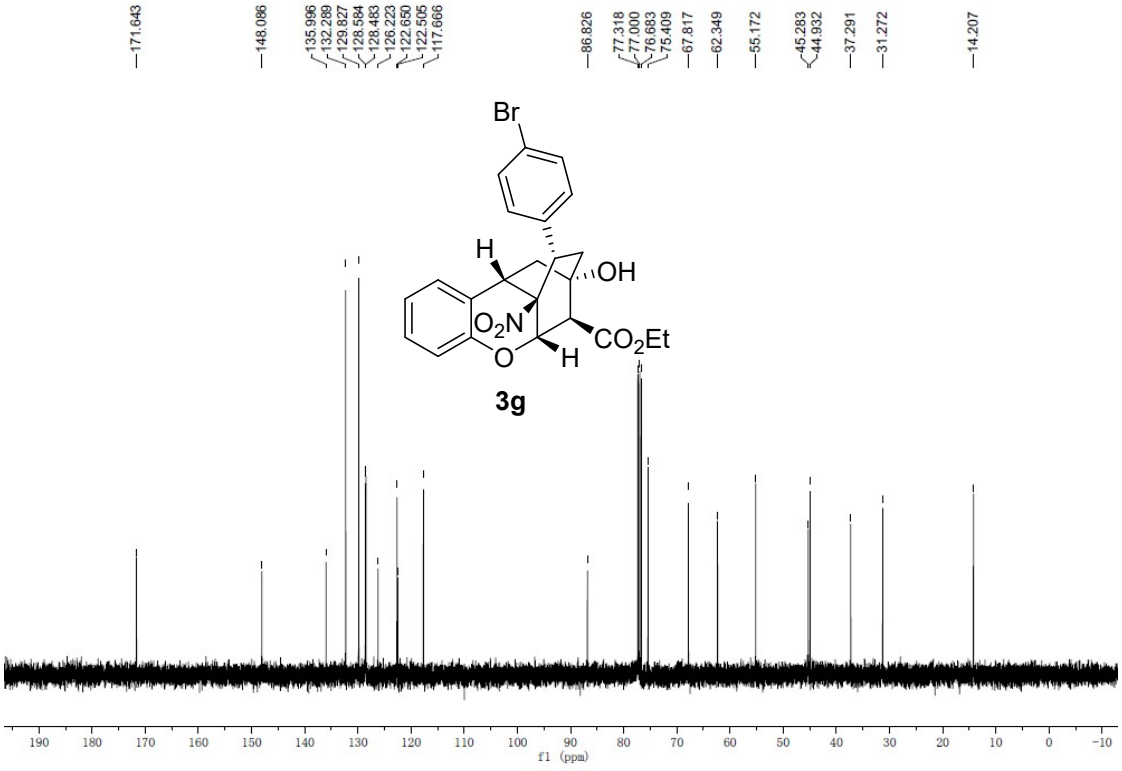


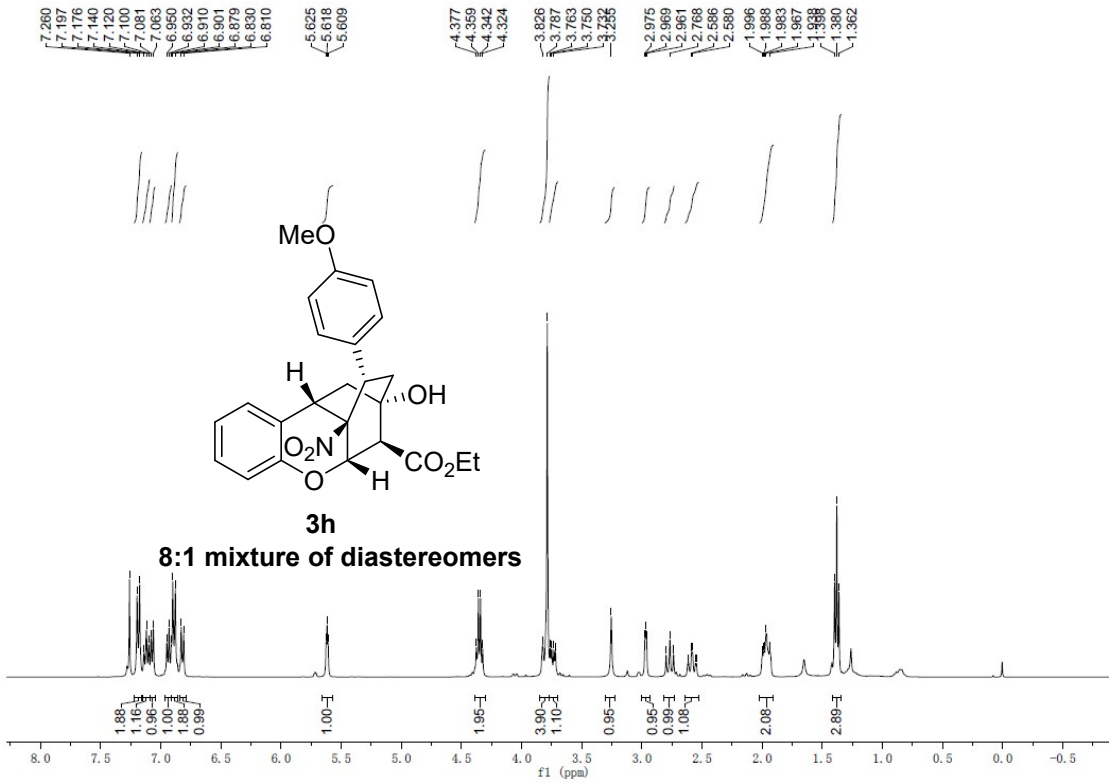
3f

11:1 mixture of diastereomers



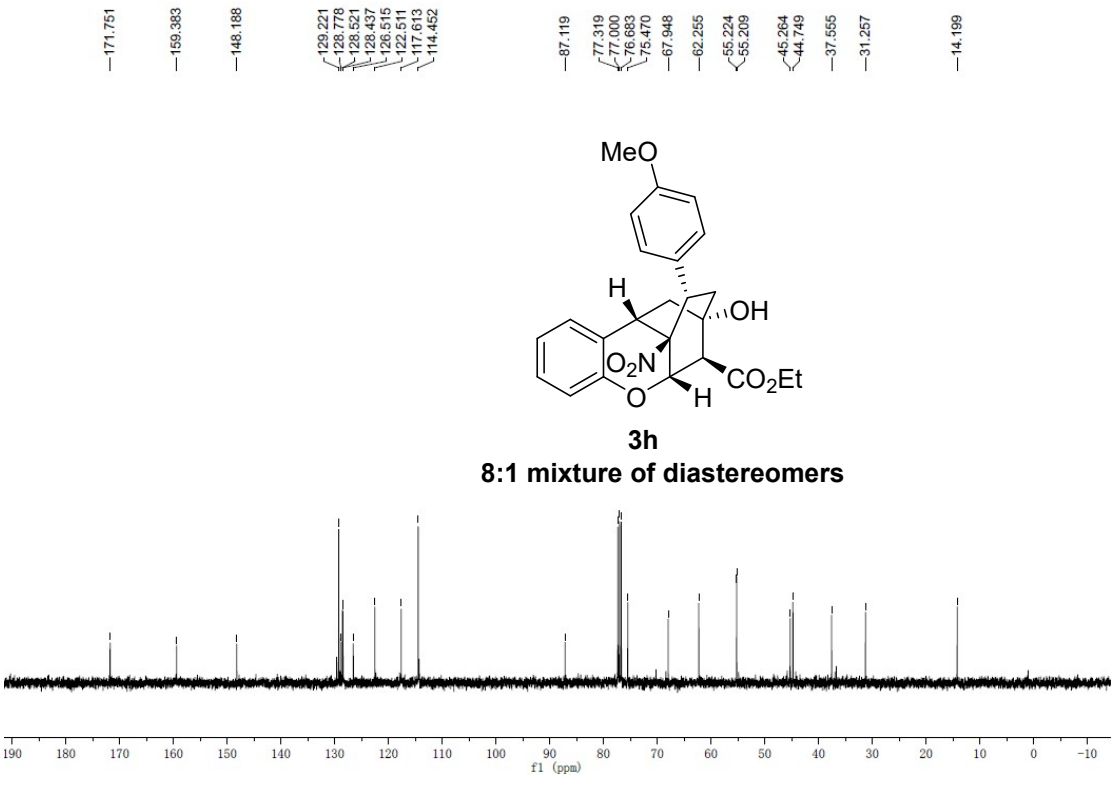

7.506
7.484
7.260
7.150
7.145
7.129
7.124
7.106
7.079
7.076
7.060
7.057
6.961
6.958
6.942
6.940
6.832
5.606
5.604
5.596
4.378
4.360
4.342
4.324
3.772
3.759
3.742
3.729
3.237
2.982
2.976
2.972
2.966
2.775
2.742
2.713
2.601
1.989
1.984
1.961
1.955
1.378
1.360
Br
H
OH
O2N
O
CO2Et
H
3g
1.91
3.03
1.05
1.08
0.99
1.02
2.03
2.16
0.97
1.03
1.13
1.21
2.24
3.00
f1 (ppm)


171.643
148.086
135.996
132.289
129.827
128.584
128.483
126.223
122.650
122.505
117.666
86.826
77.318
77.000
76.683
75.409
67.817
62.349
55.172
45.283
44.932
37.291
31.272
14.207
Br
H
OH
O2N
O
CO2Et
H
3g
f1 (ppm)



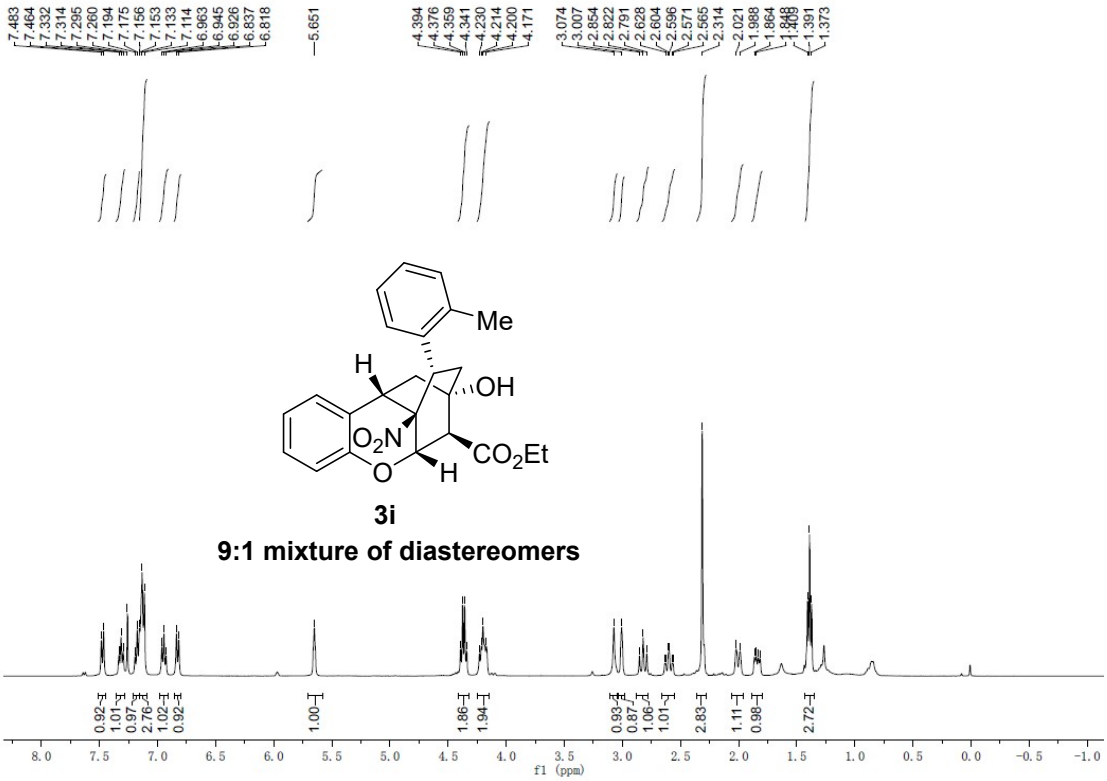
3h

8:1 mixture of diastereomers



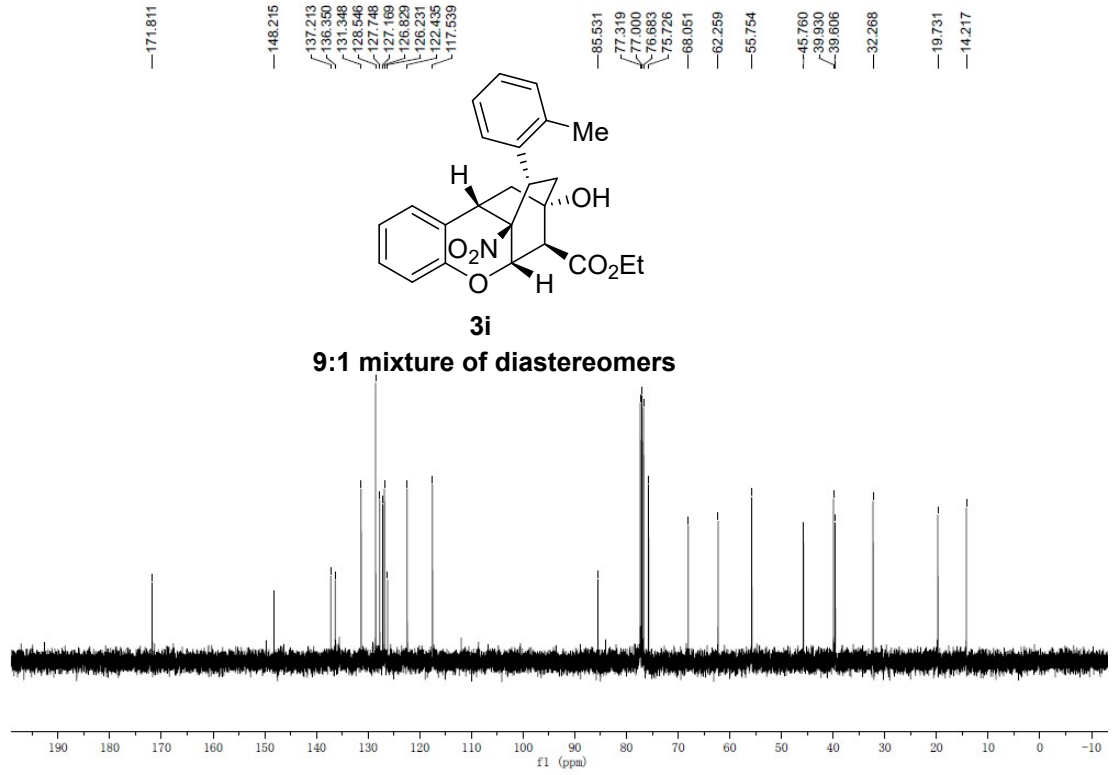
3h

8:1 mixture of diastereomers



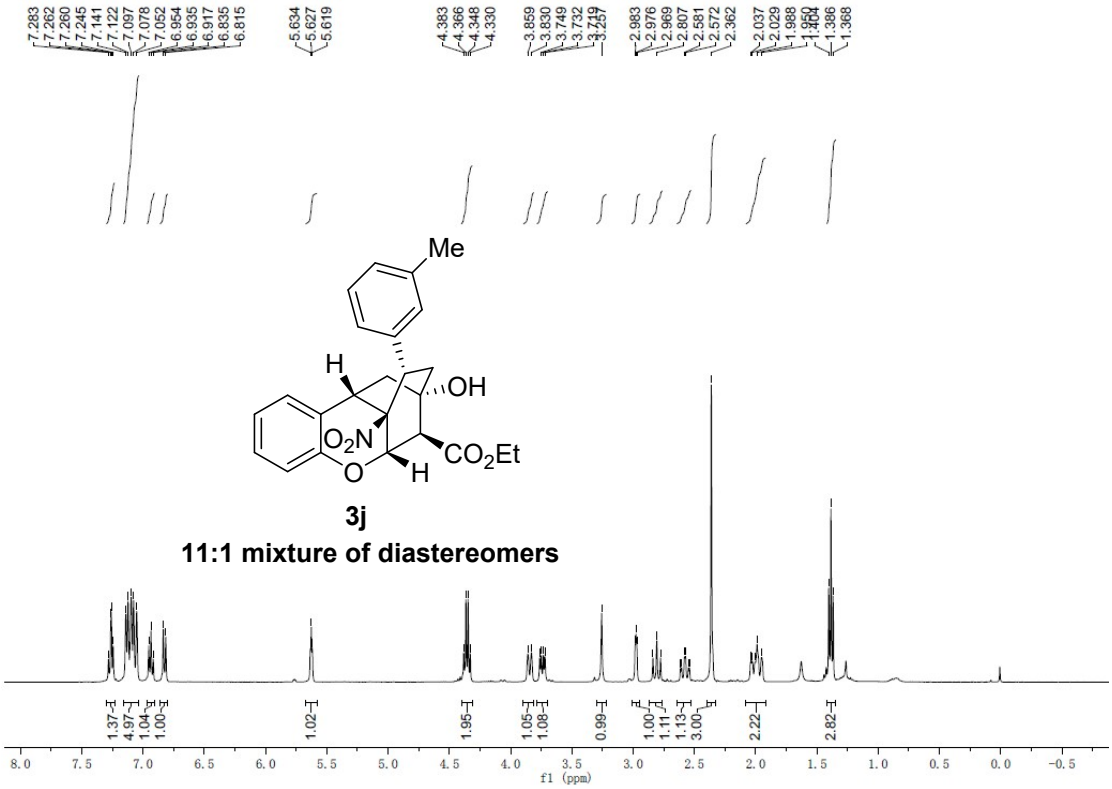
3i

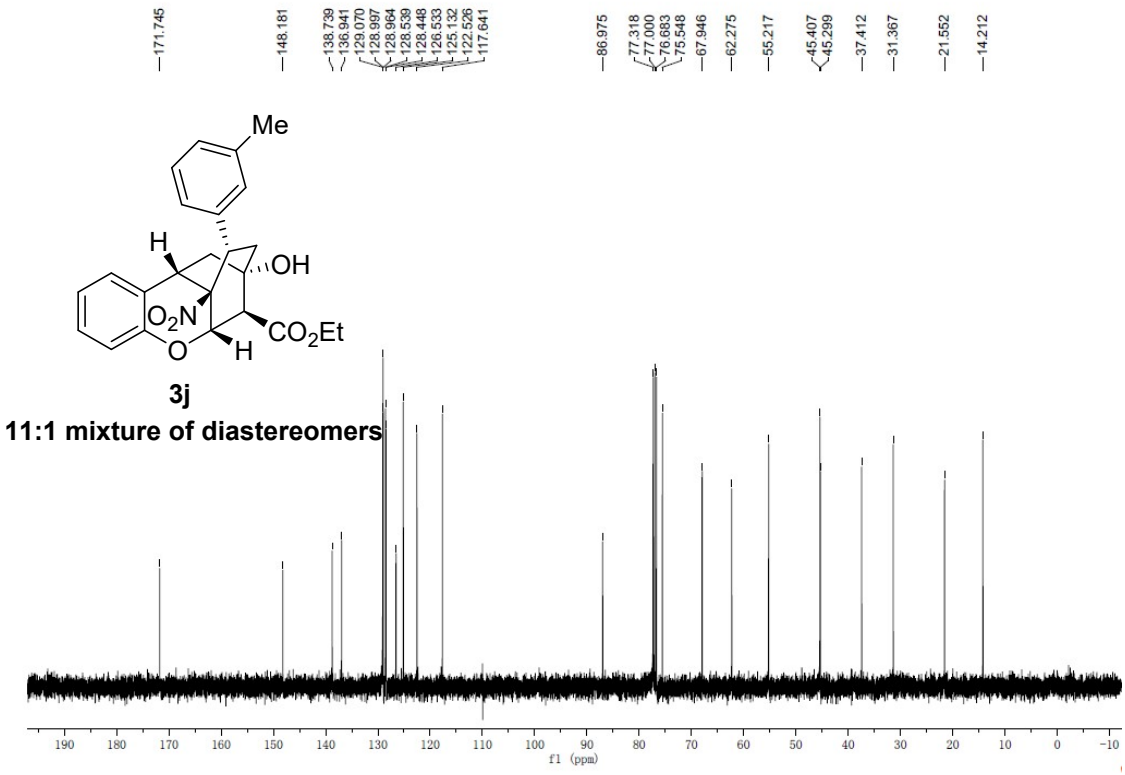
9:1 mixture of diastereomers

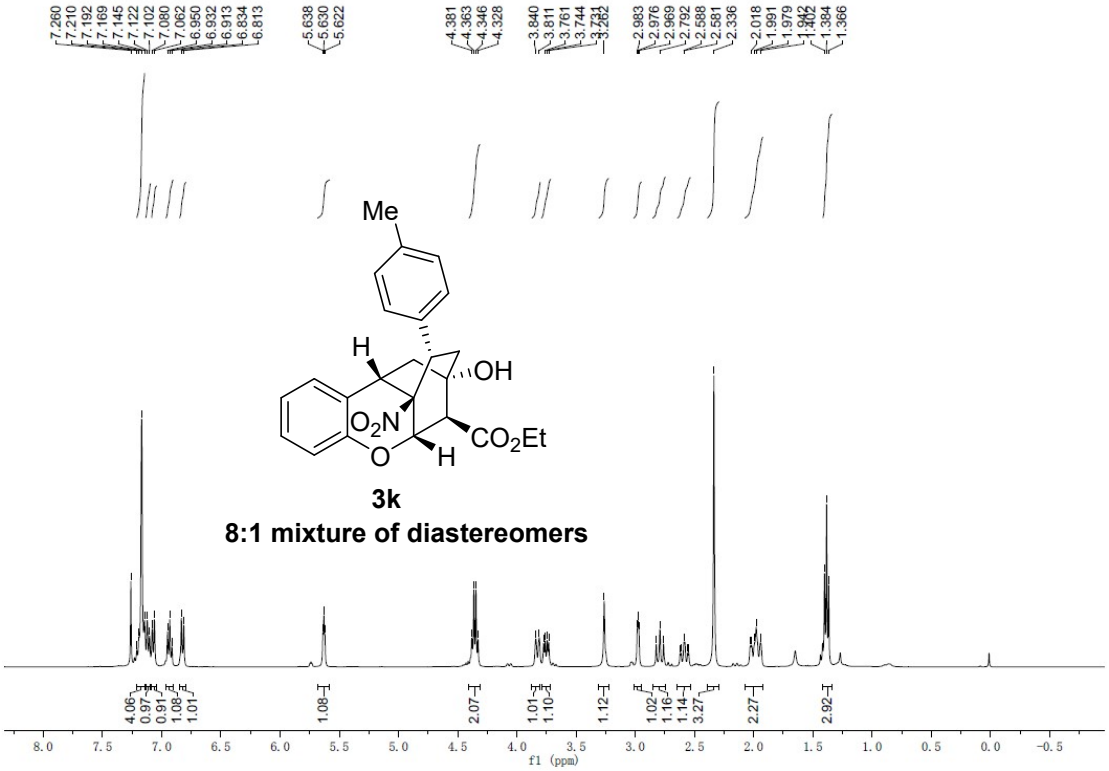


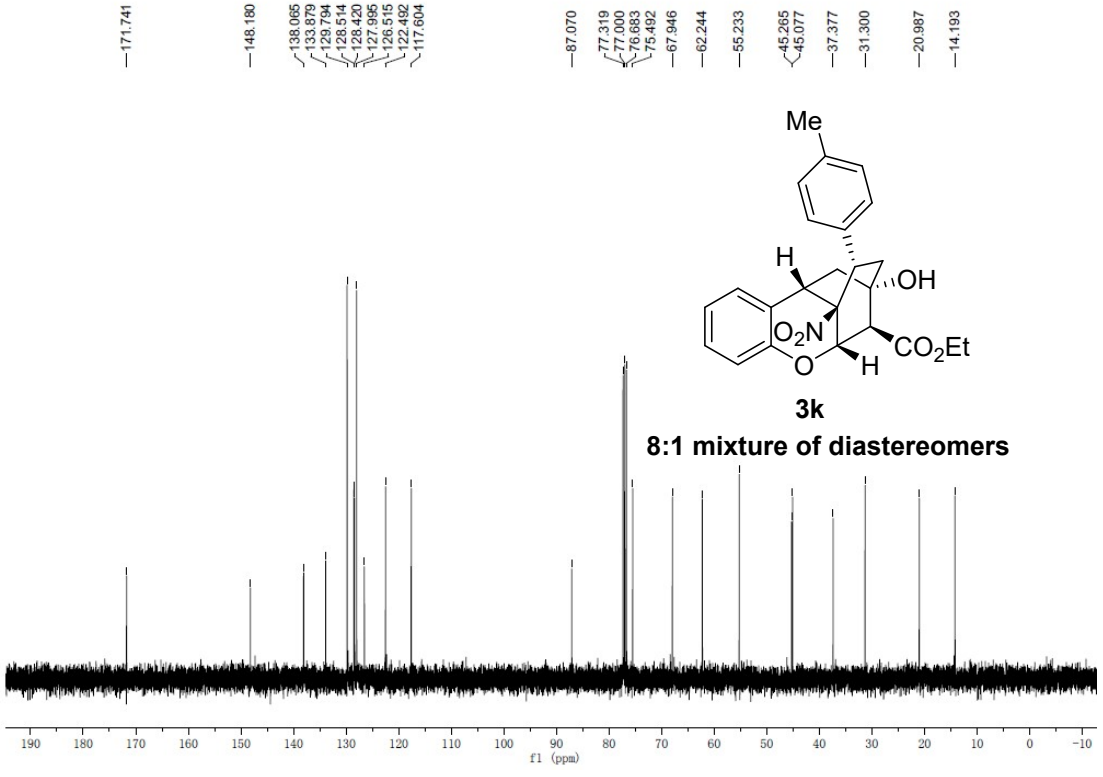
3i

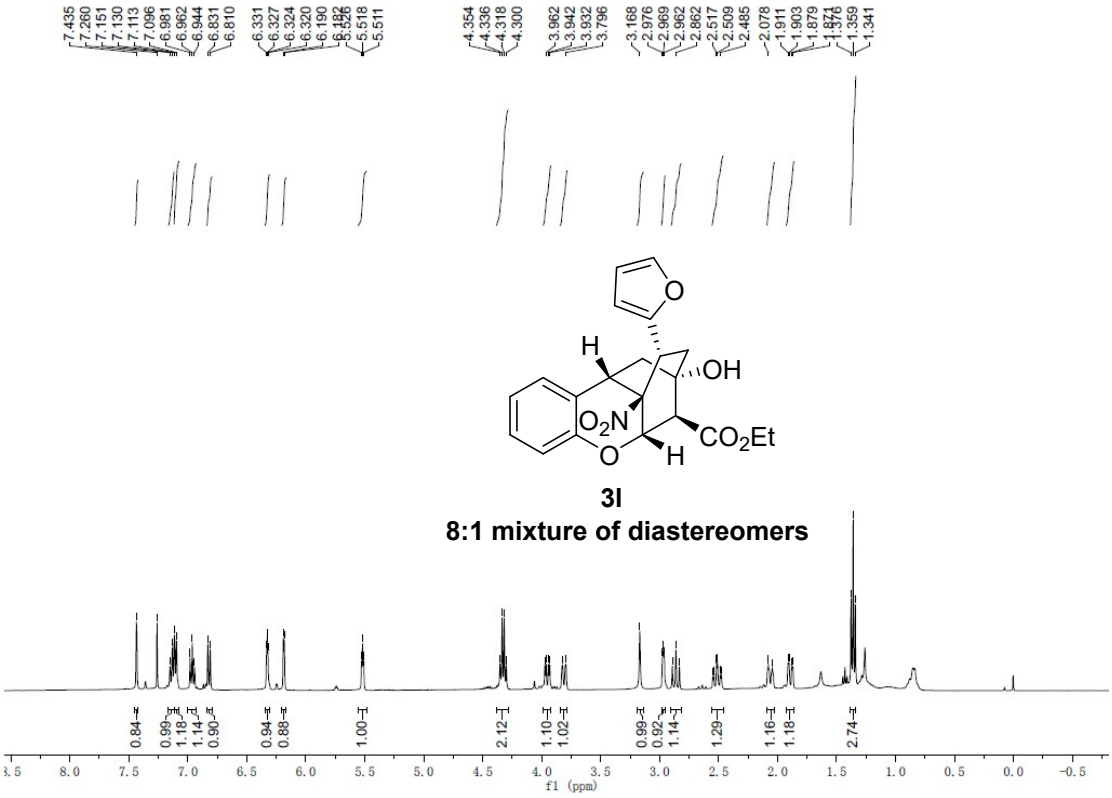
9:1 mixture of diastereomers


Me
H
OH
O2N
CO2Et
O
H
3j
11:1 mixture of diastereomers
f1 (ppm)


Me
H
OH
O2N
CO2Et
O
H
3j
11:1 mixture of diastereomers
f1 (ppm)

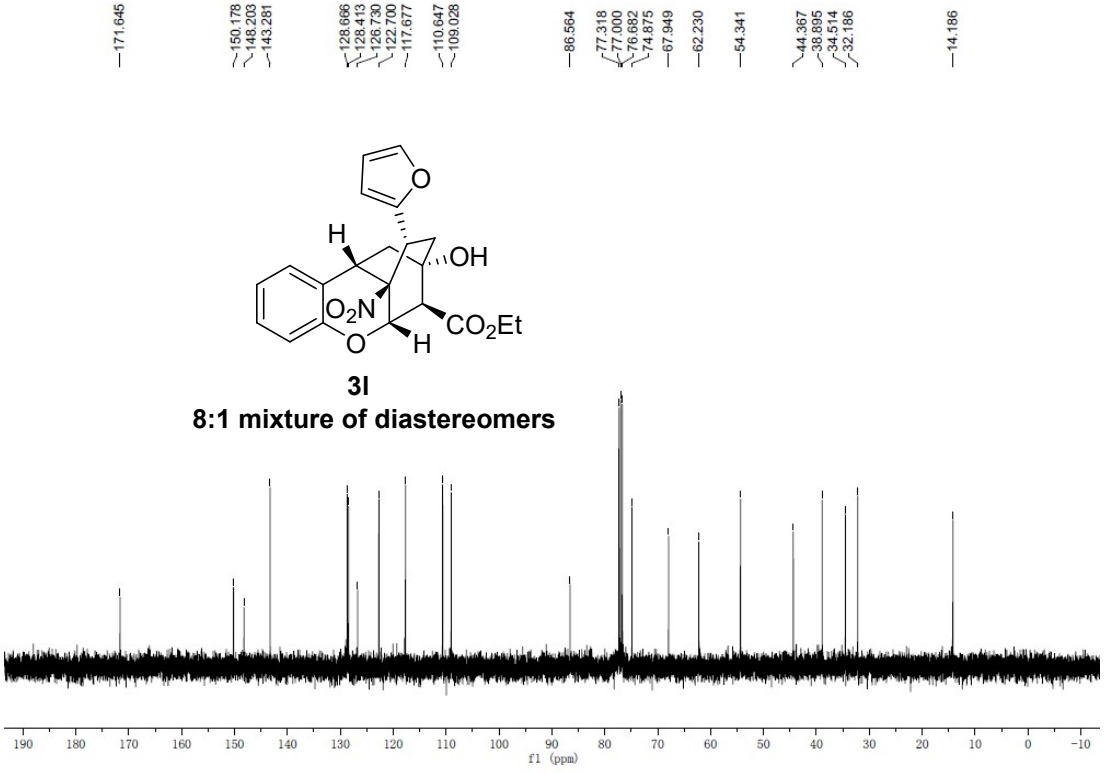

Me
H
OH
O2N
CO2Et
O
H
3k
8:1 mixture of diastereomers
f1 (ppm)


Me
H
OH
O2N
CO2Et
O
H
3k
8:1 mixture of diastereomers
f1 (ppm)



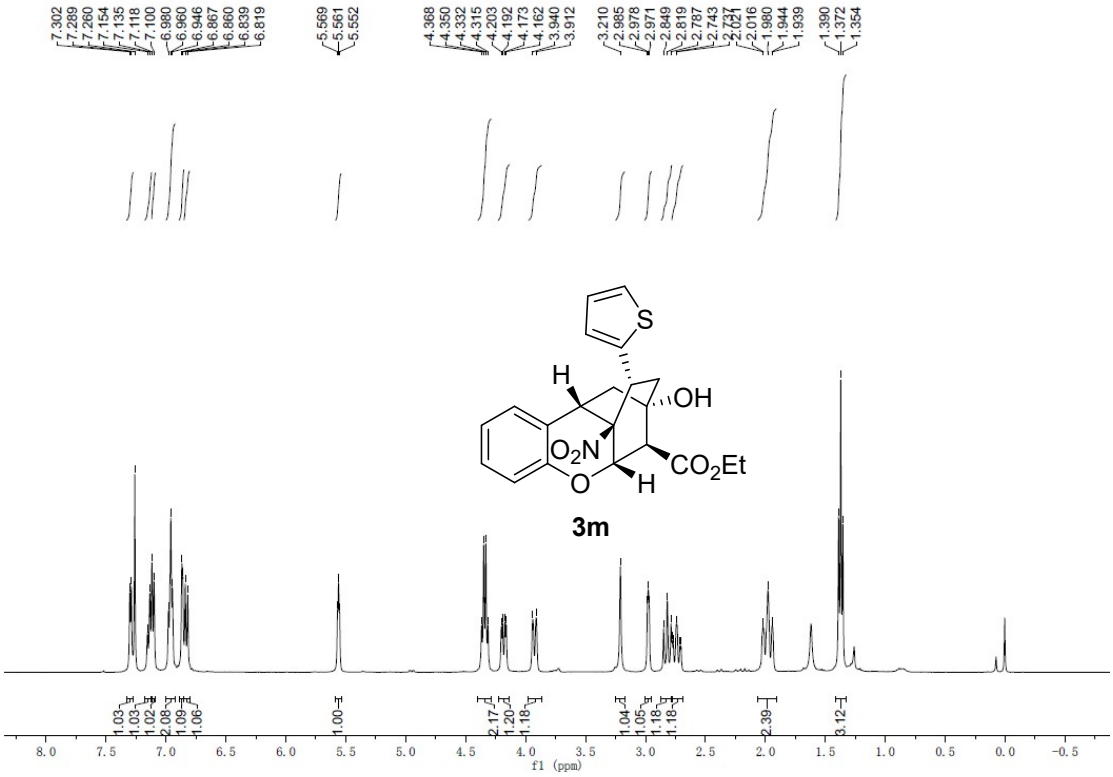
3l

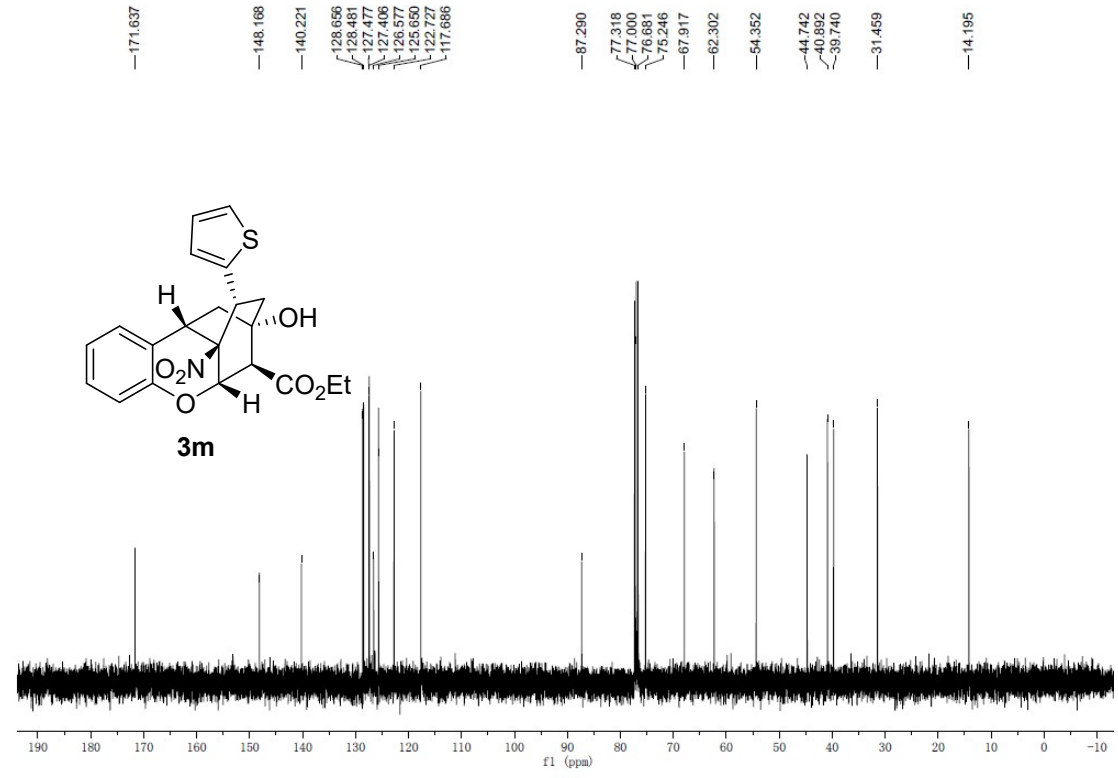
8:1 mixture of diastereomers

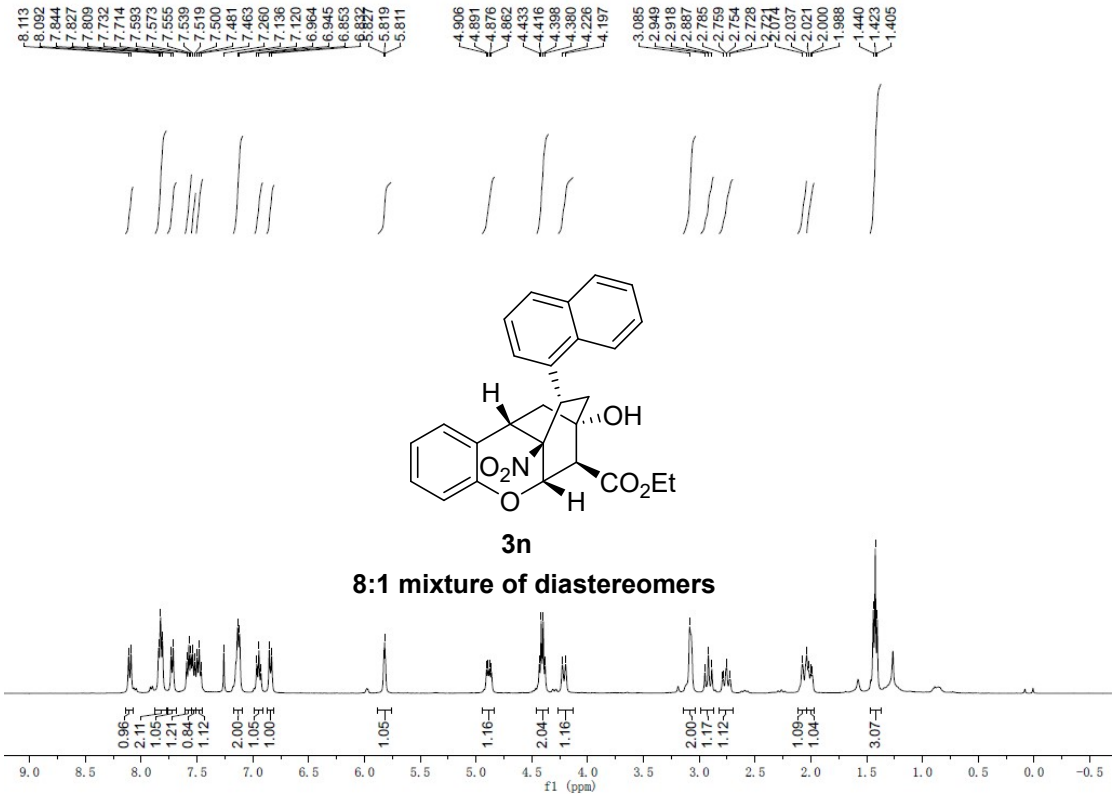


3l

8:1 mixture of diastereomers

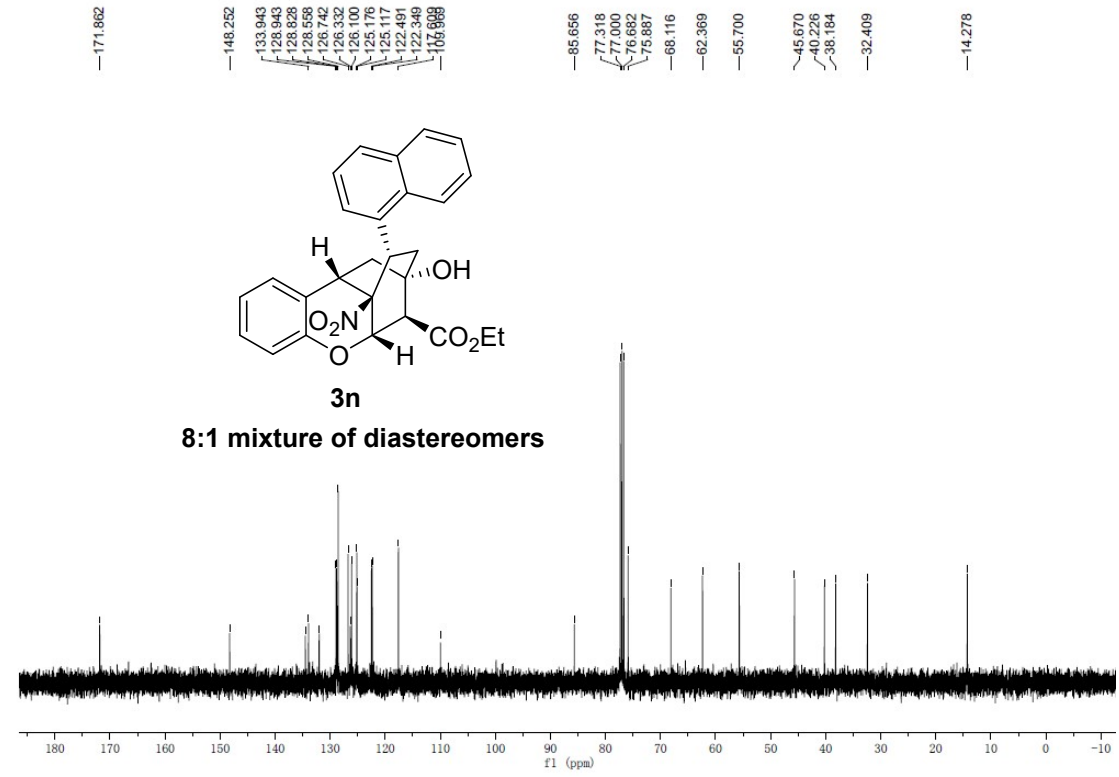

7.302
7.289
7.260
7.154
7.135
7.118
7.100
6.980
6.960
6.946
6.867
6.860
6.839
6.819
5.569
5.561
5.552
4.368
4.350
4.332
4.315
4.203
4.192
4.173
4.162
3.940
3.912
3.210
2.985
2.978
2.971
2.849
2.819
2.787
2.743
2.731
2.021
2.016
1.980
1.944
1.939
1.390
1.372
1.354
S
H
OH
O2N
O
H
CO2Et
3m
1.03
1.03
1.02
2.08
1.09
1.06
1.00
2.17
1.20
1.18
1.04
1.05
1.18
1.18
2.39
3.12
f1 (ppm)


171.637
148.168
140.221
128.656
128.481
127.477
127.406
126.577
125.650
122.727
117.686
87.290
77.318
77.000
76.681
75.246
67.917
62.302
54.352
44.742
40.892
39.740
31.459
14.195
S
H
OH
O2N
O
H
CO2Et
3m
f1 (ppm)



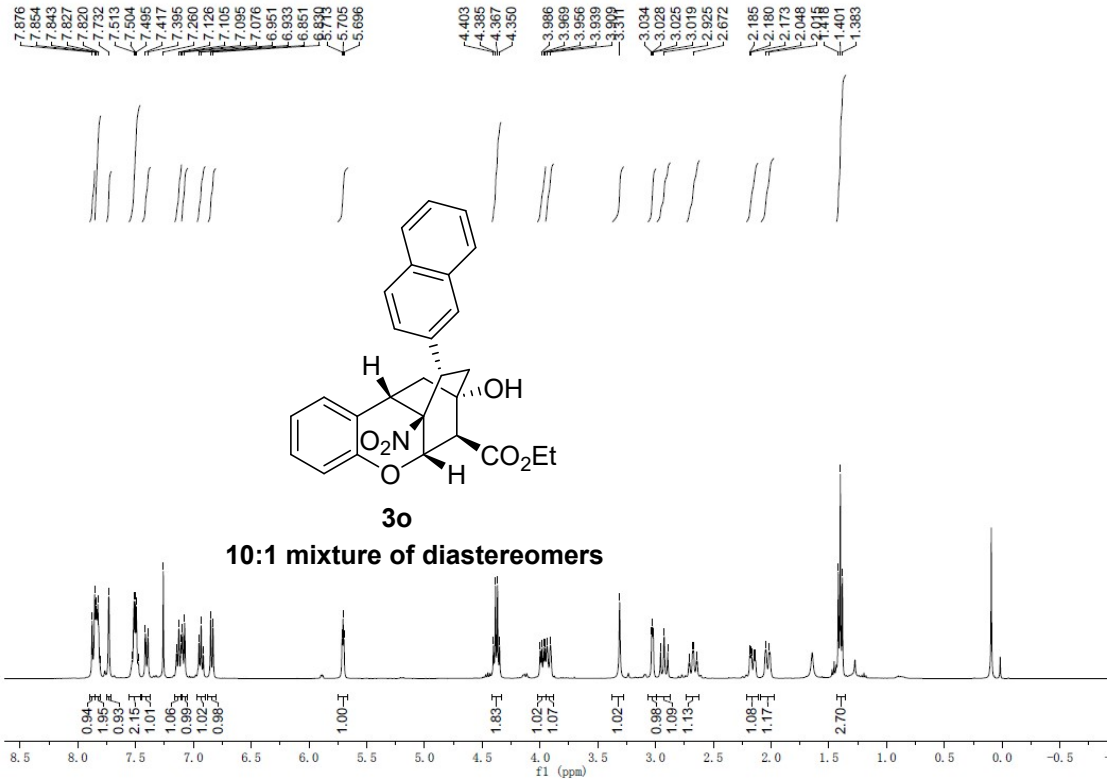
3n

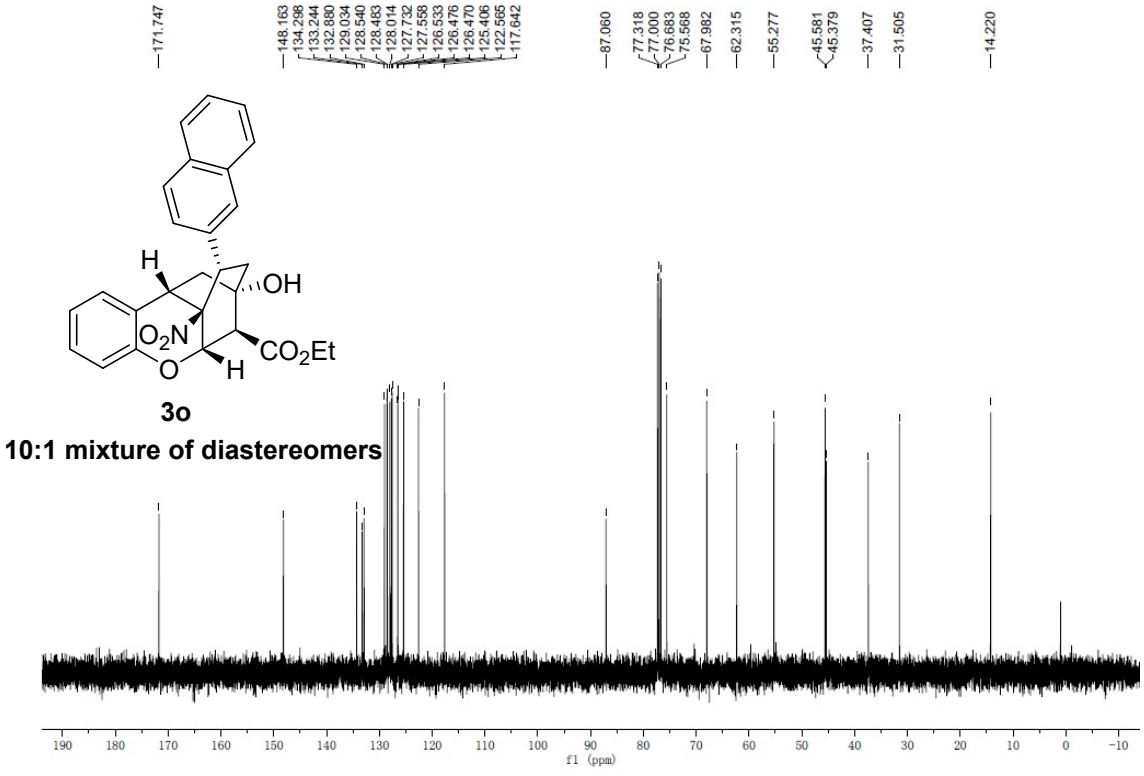
8:1 mixture of diastereomers

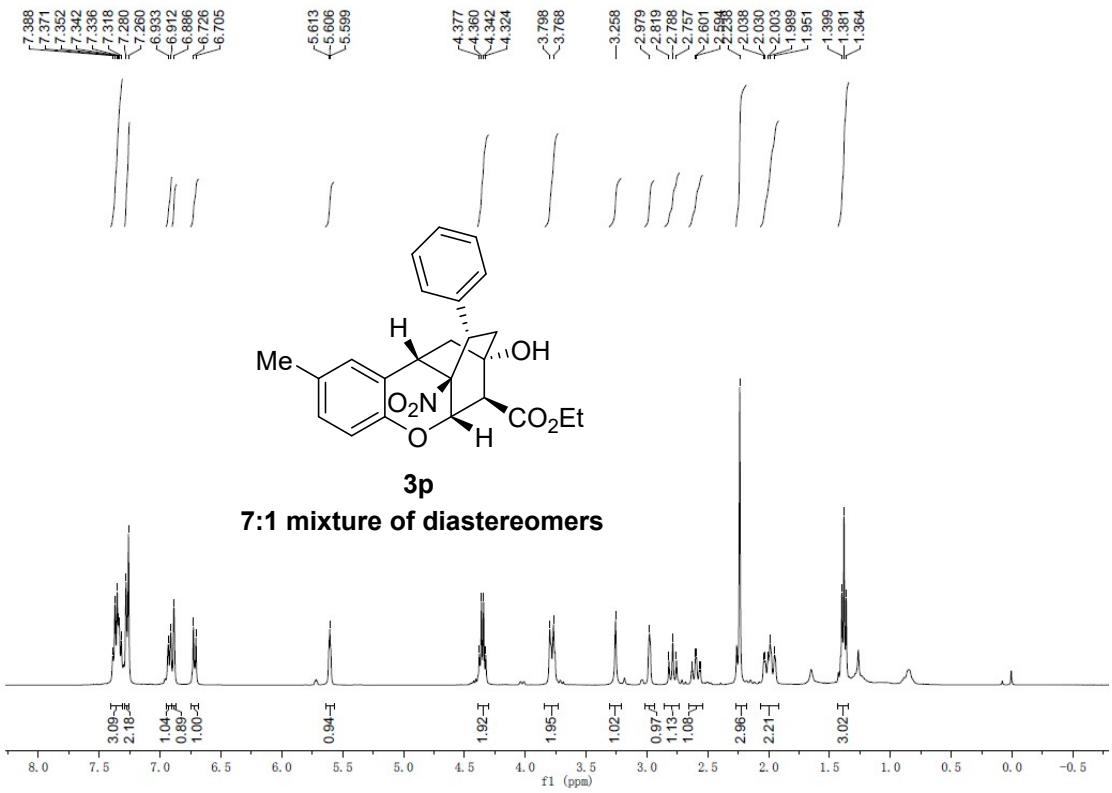


3n

8:1 mixture of diastereomers

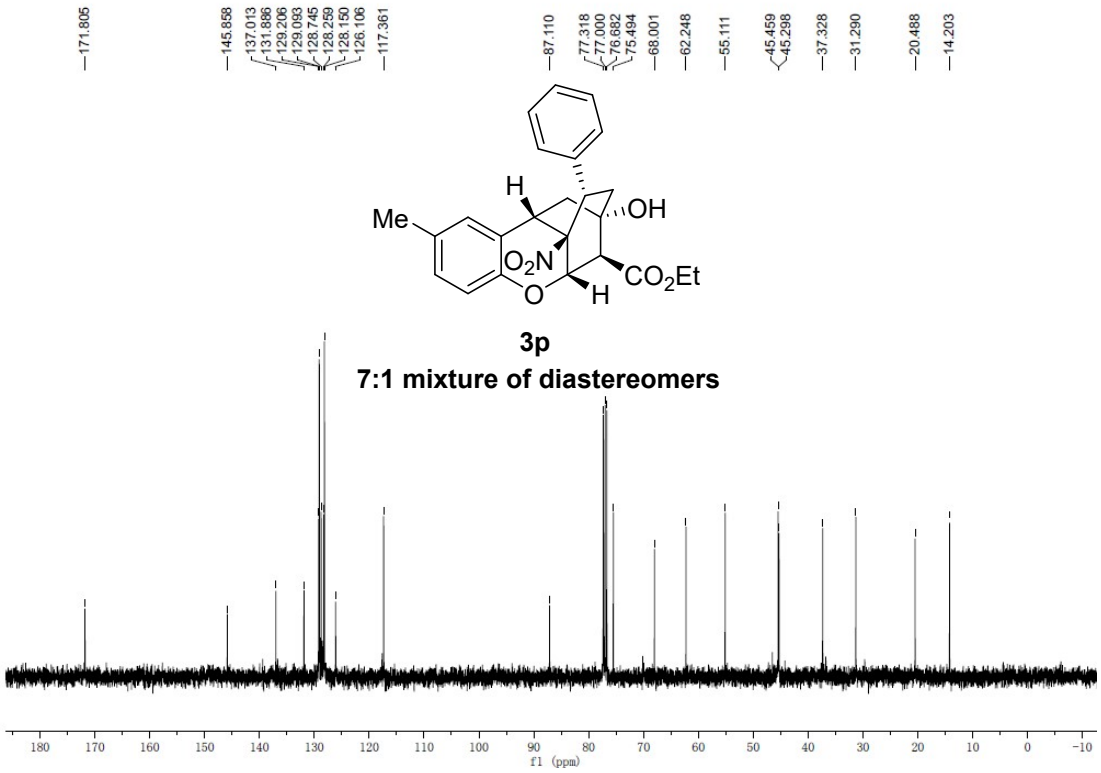

H
OH
O2N
CO2Et
O
H
3o
10:1 mixture of diastereomers
f1 (ppm)


H
OH
O2N
CO2Et
O
H
3o
10:1 mixture of diastereomers
f1 (ppm)



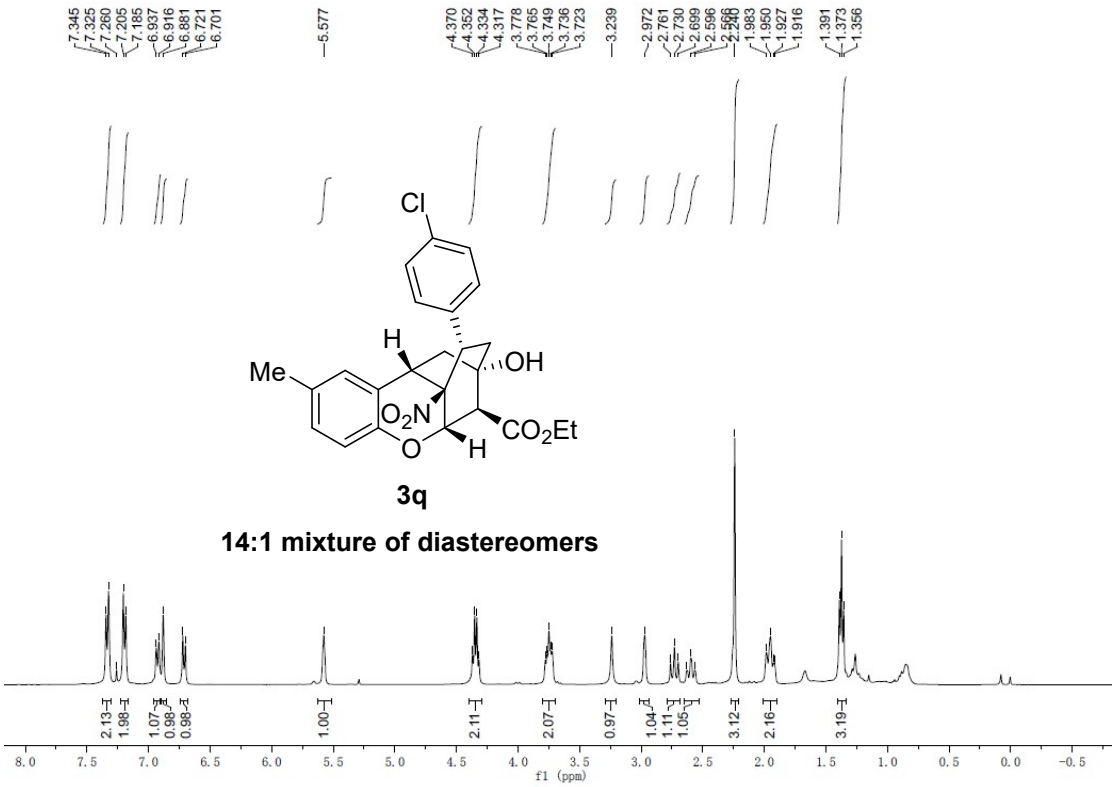
3p

7:1 mixture of diastereomers



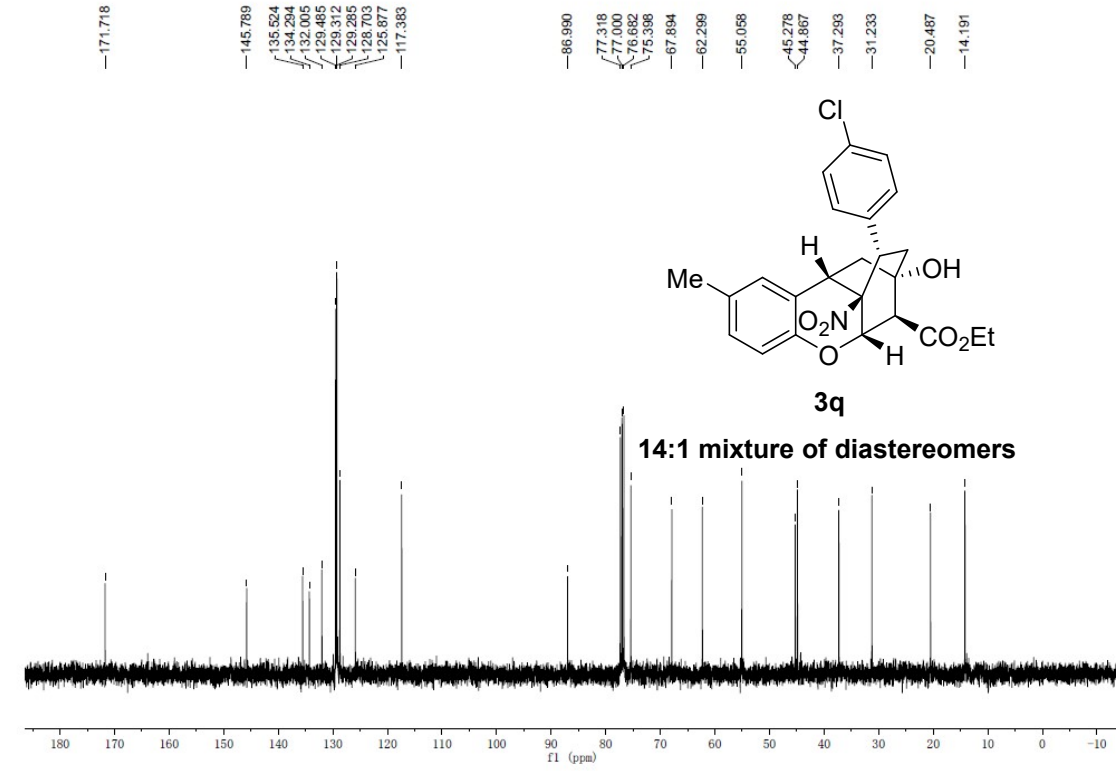
3p

7:1 mixture of diastereomers



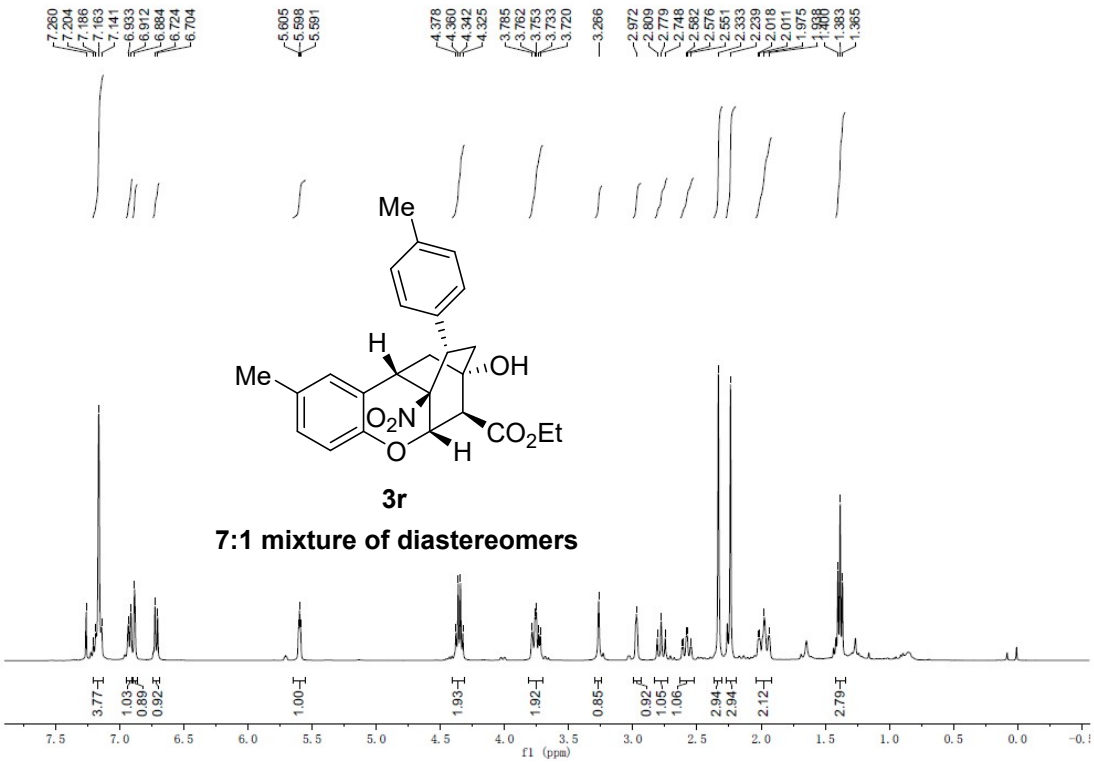
3q

14:1 mixture of diastereomers



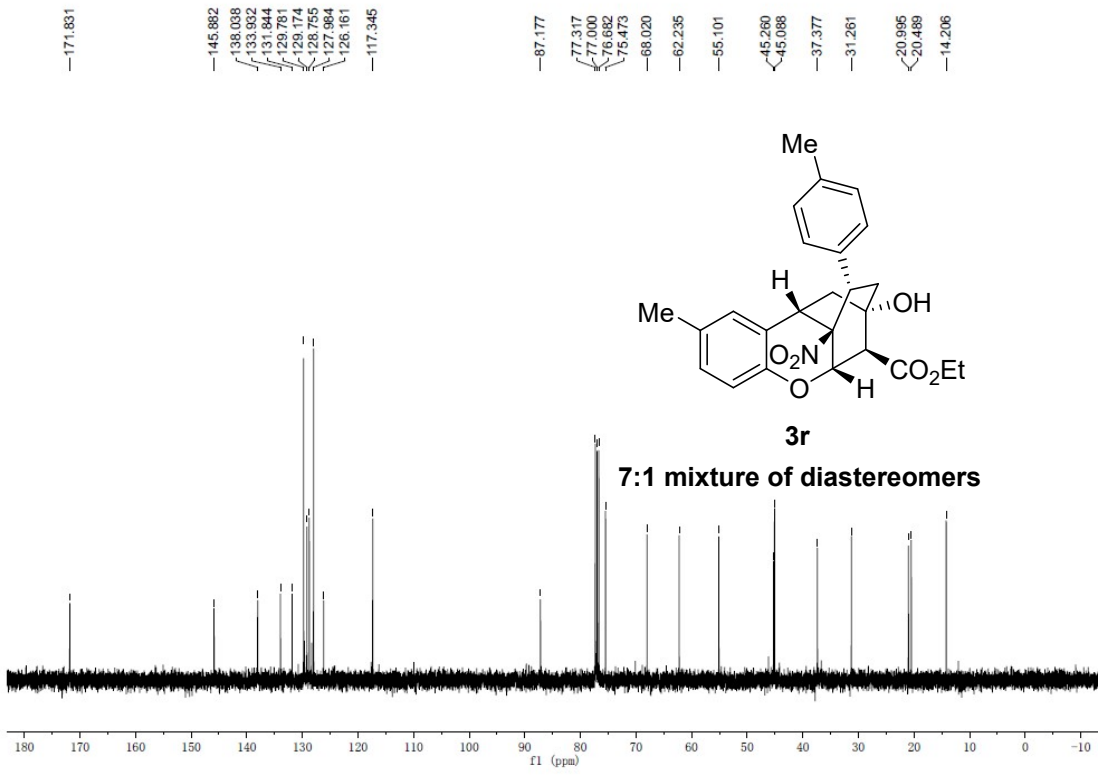
3q

14:1 mixture of diastereomers



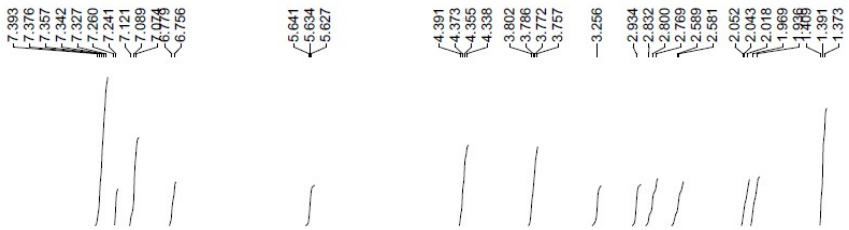
3r

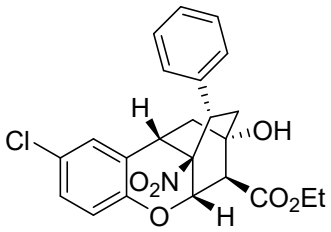
7:1 mixture of diastereomers



3r

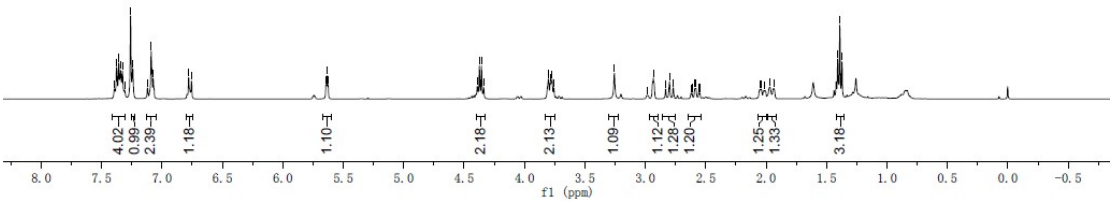
7:1 mixture of diastereomers

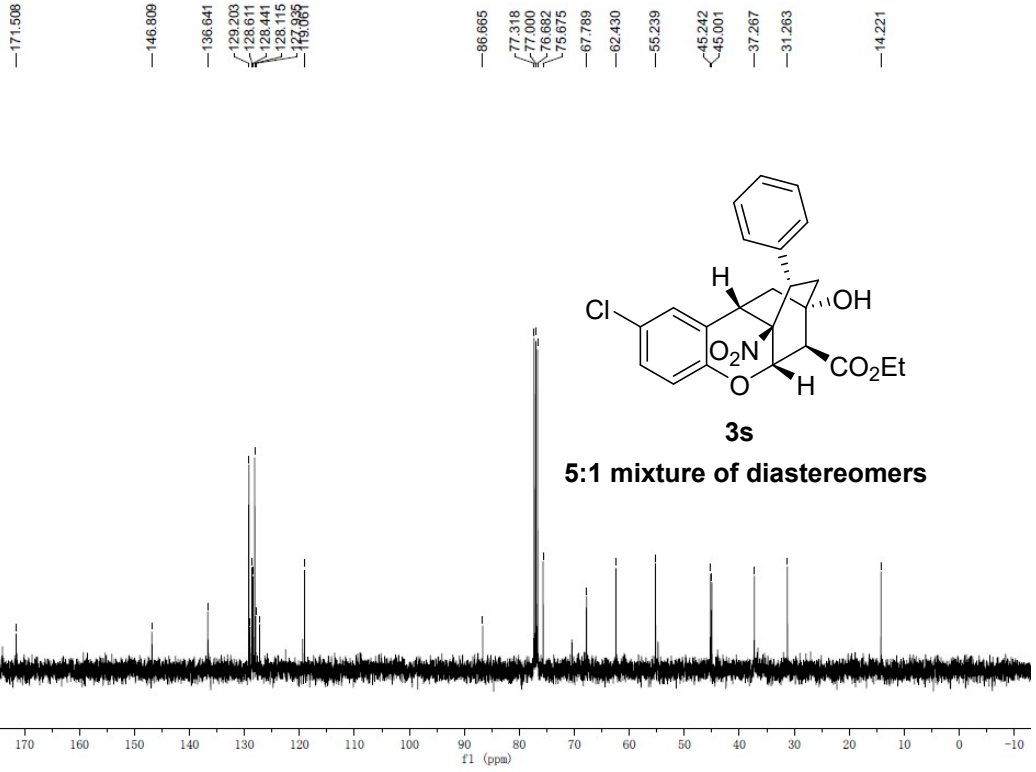




3s

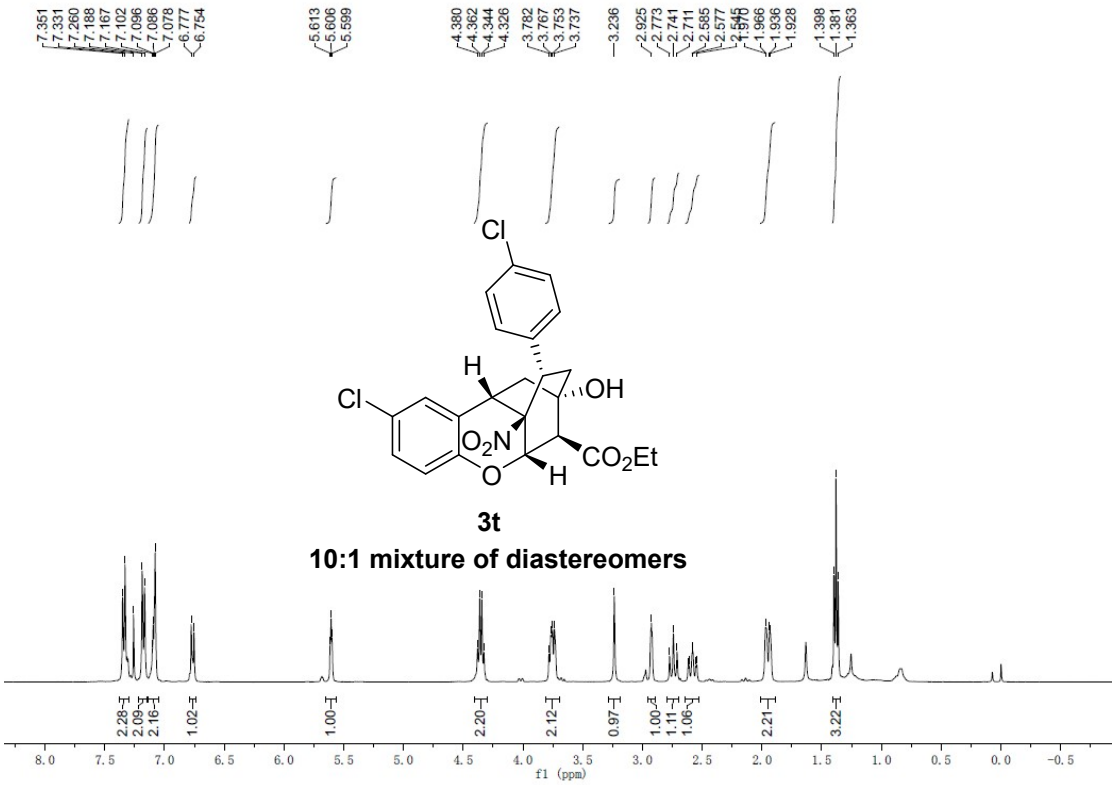
5:1 mixture of diastereomers





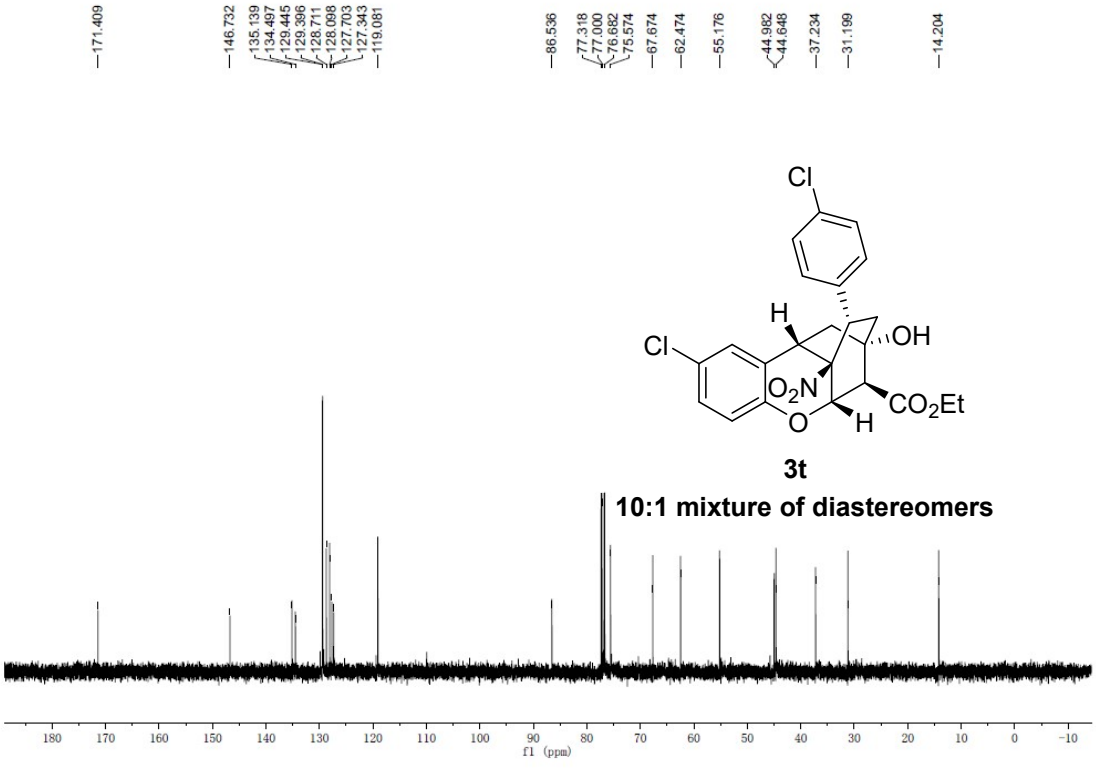
3s

5:1 mixture of diastereomers



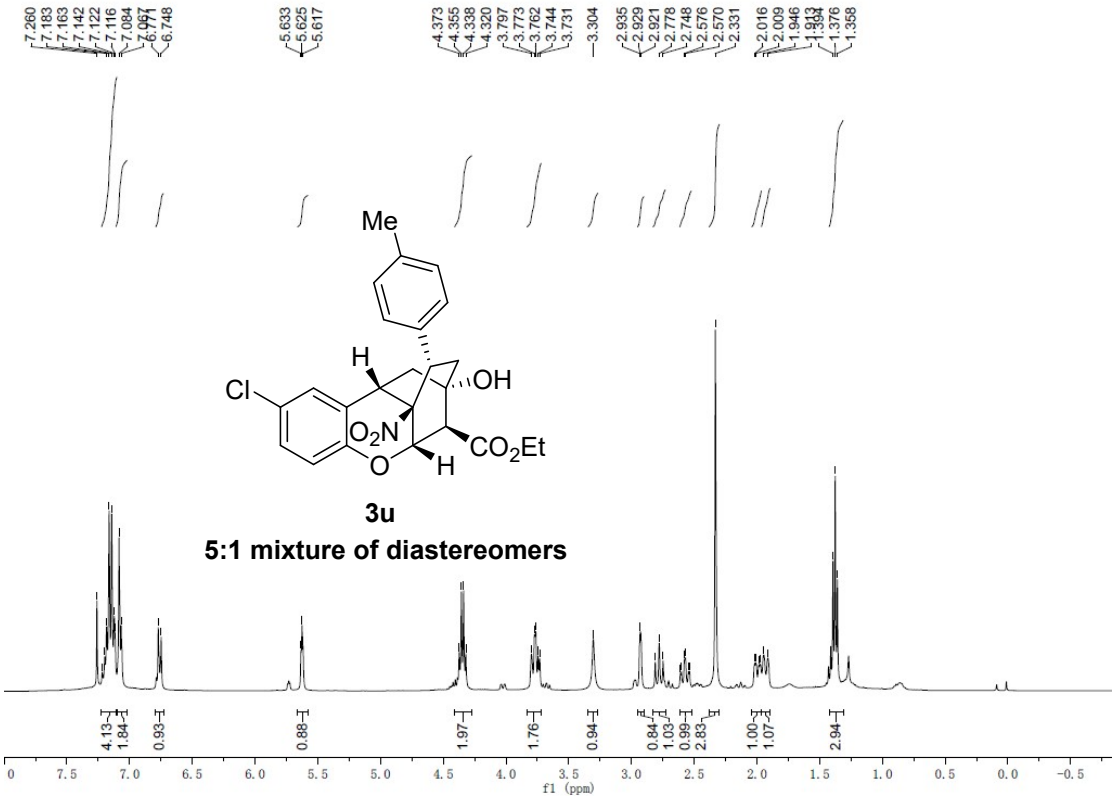
3t

10:1 mixture of diastereomers



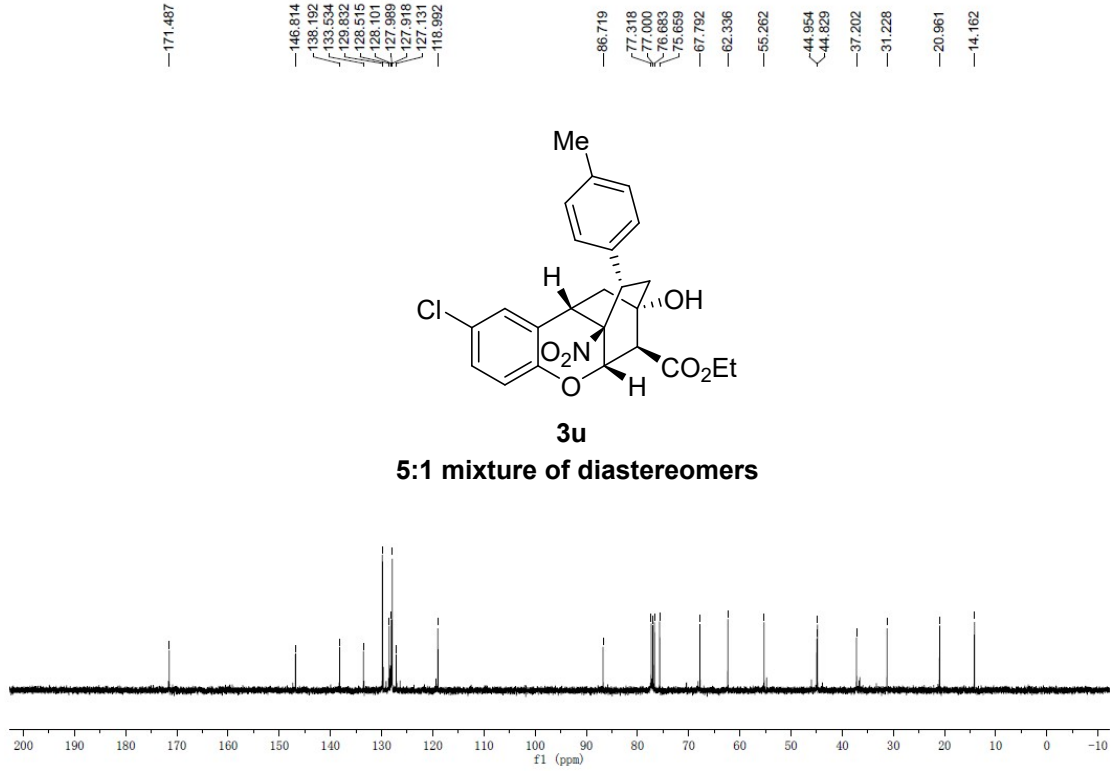
3t

10:1 mixture of diastereomers



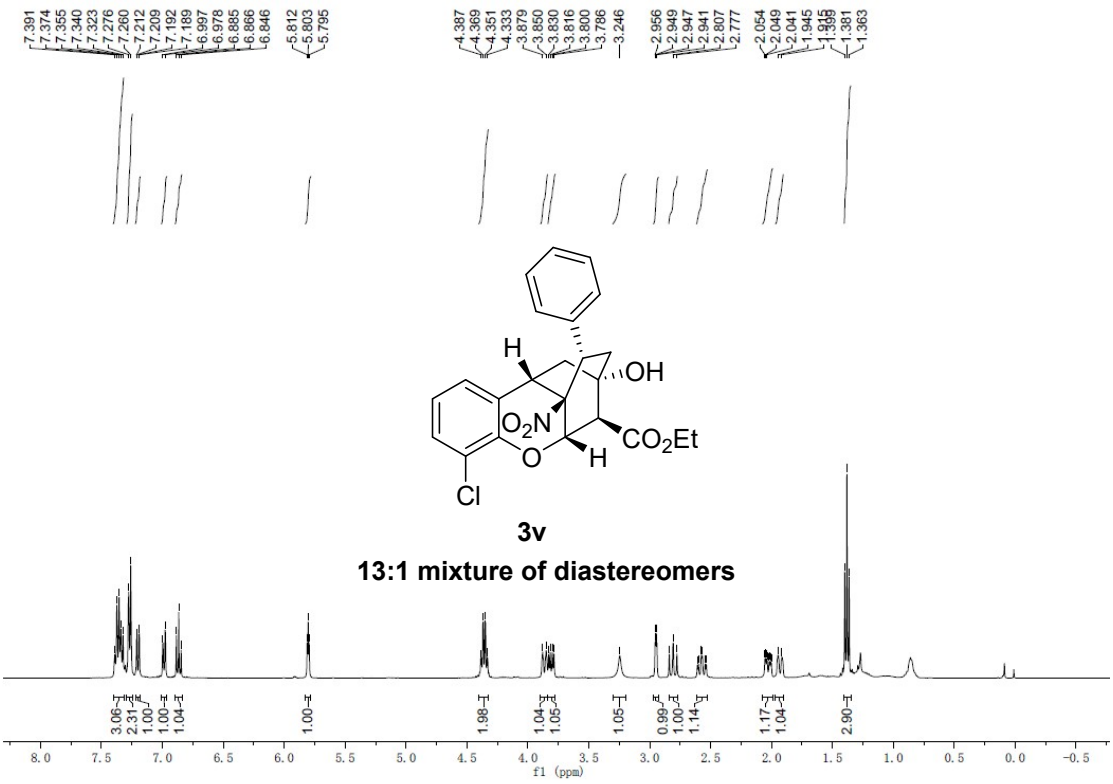
3u

5:1 mixture of diastereomers



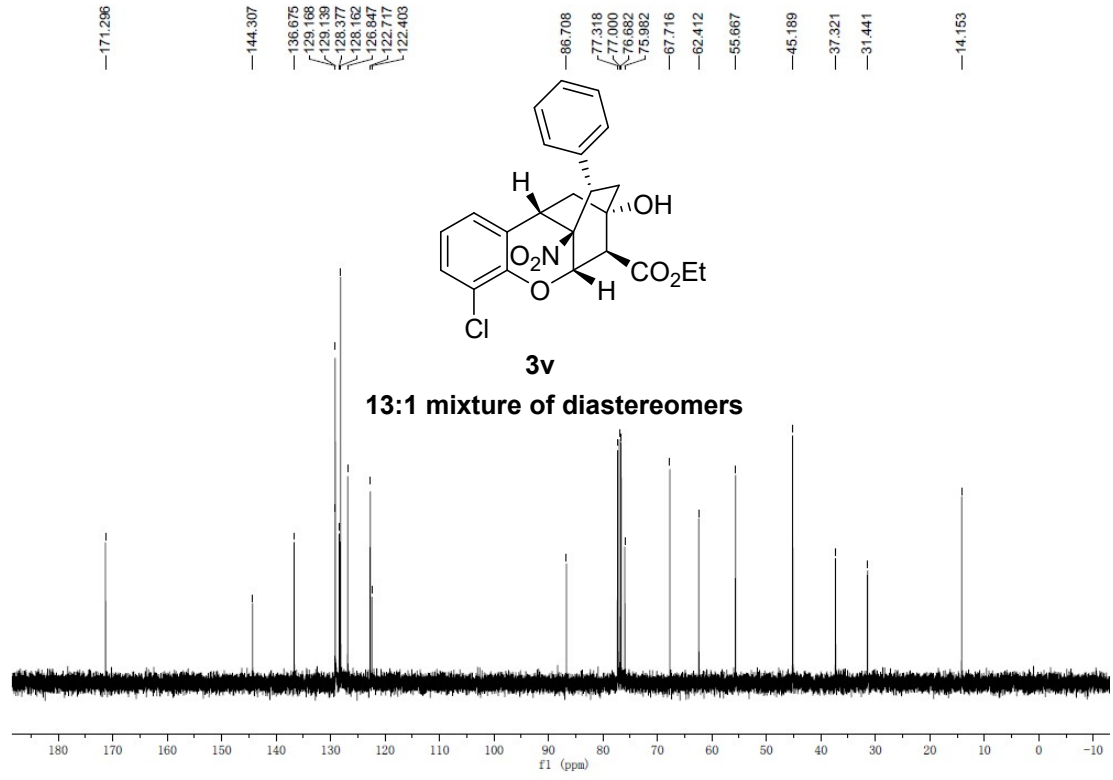
3u

5:1 mixture of diastereomers



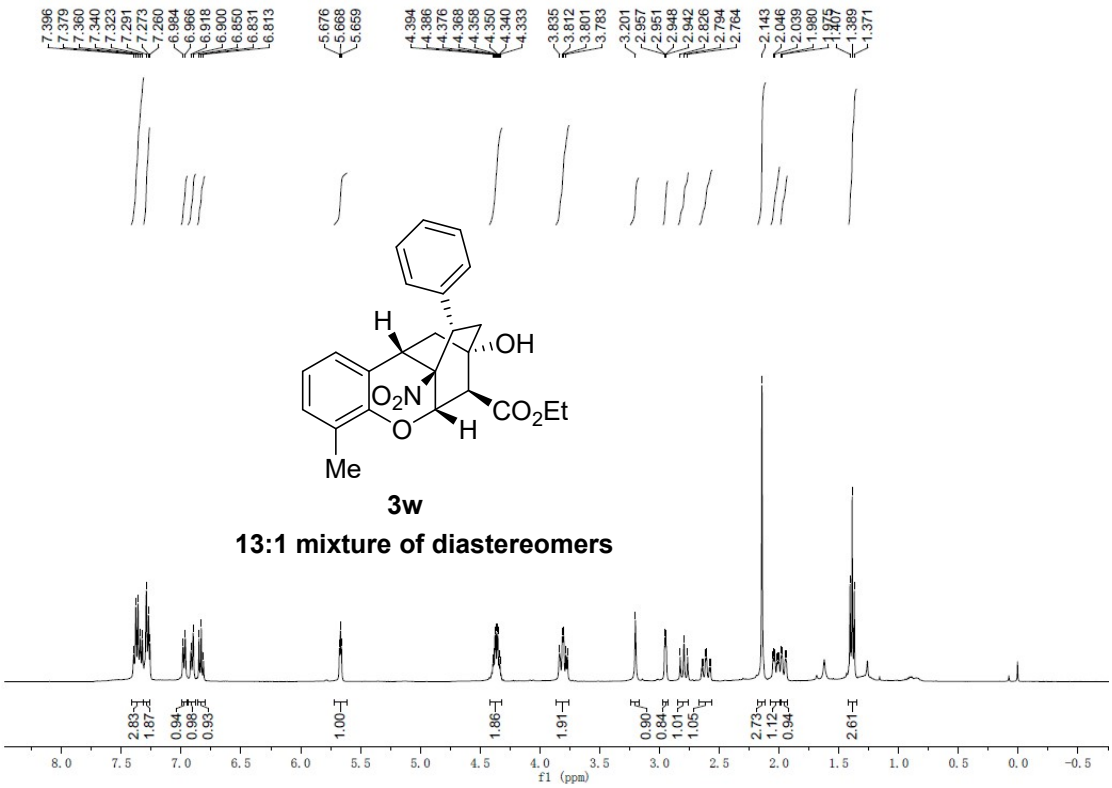
3v

13:1 mixture of diastereomers



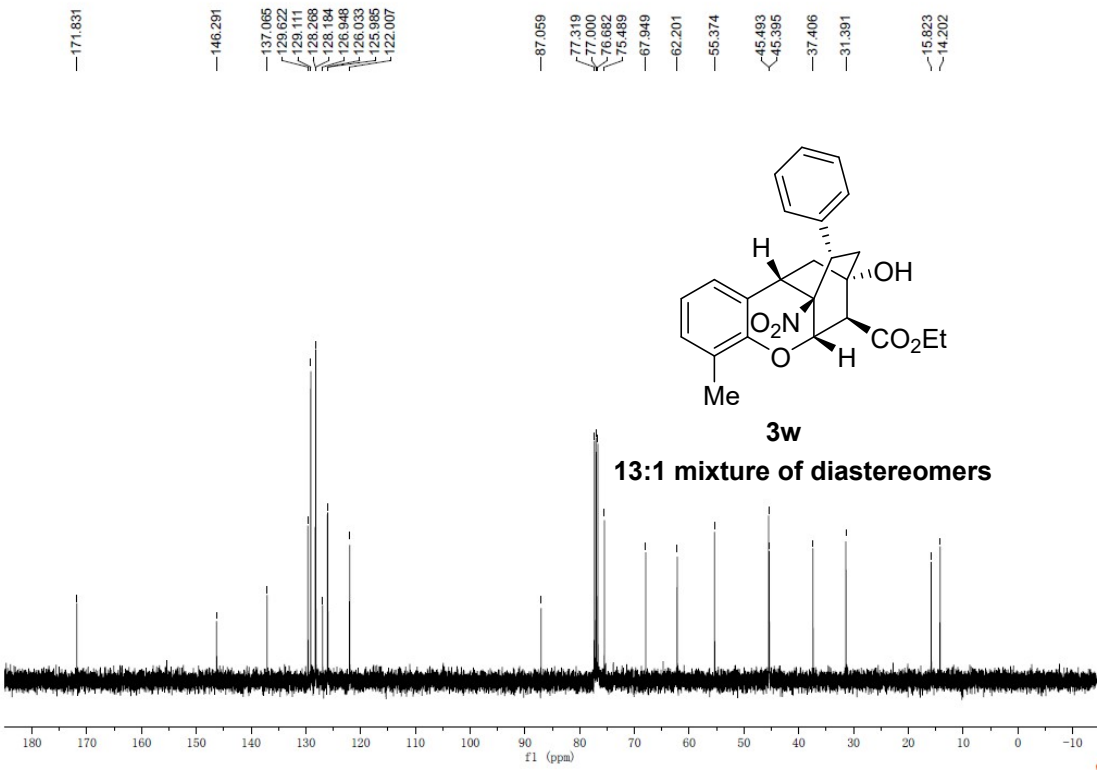
3v

13:1 mixture of diastereomers



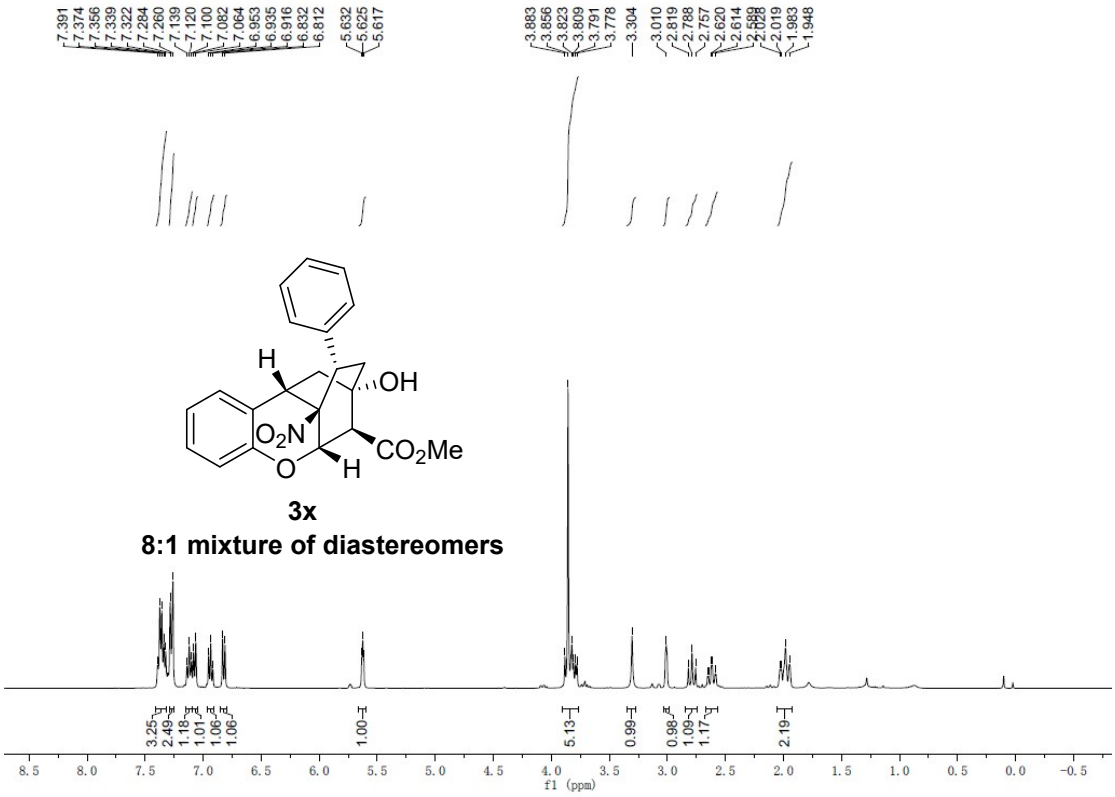
3w

13:1 mixture of diastereomers



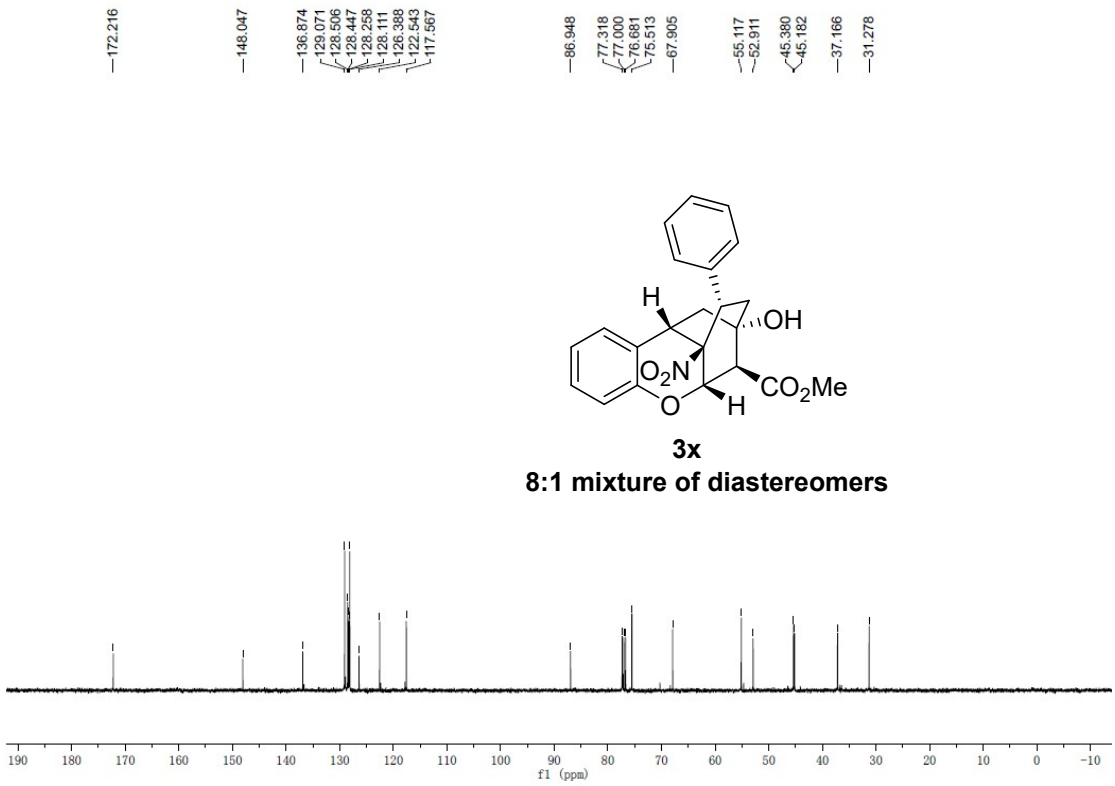
3w

13:1 mixture of diastereomers



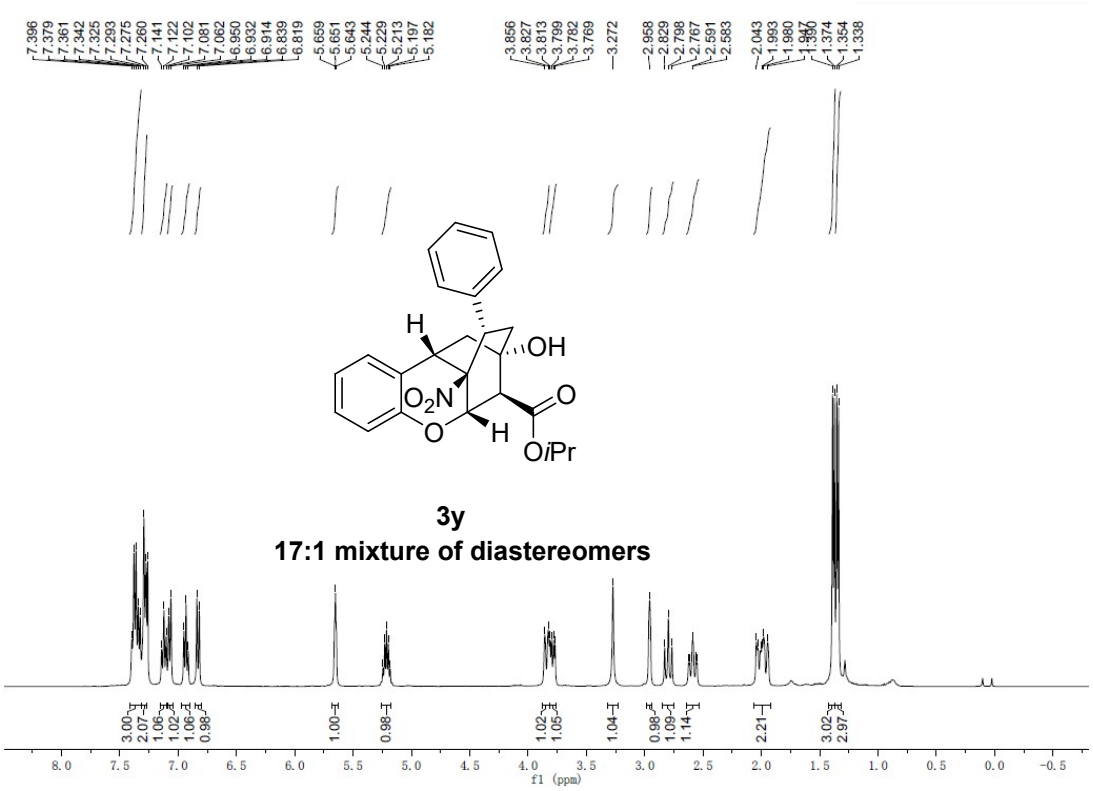
3x

8:1 mixture of diastereomers

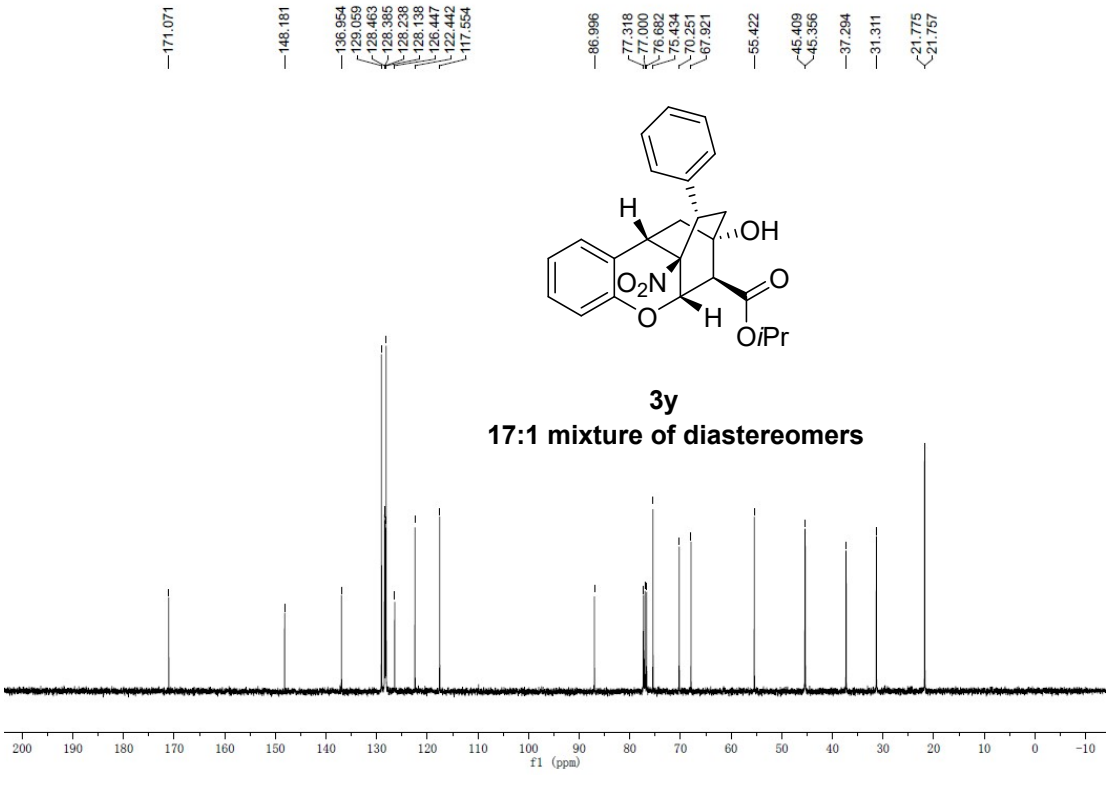


3x

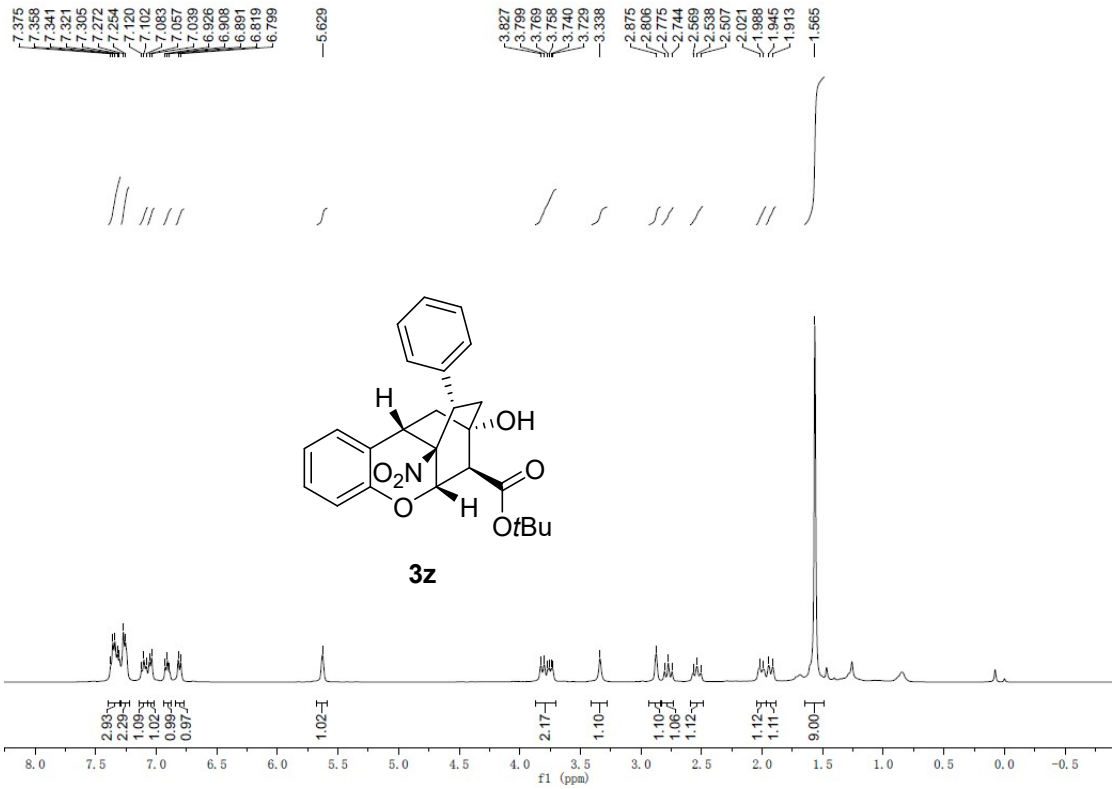
8:1 mixture of diastereomers

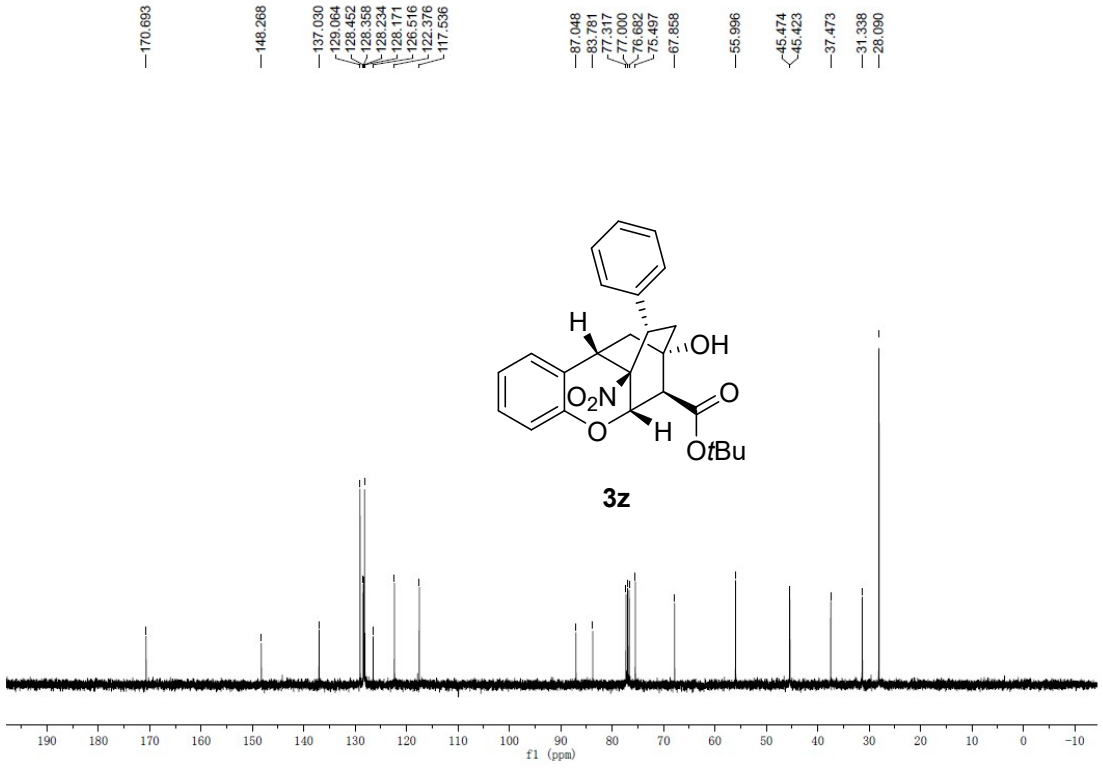


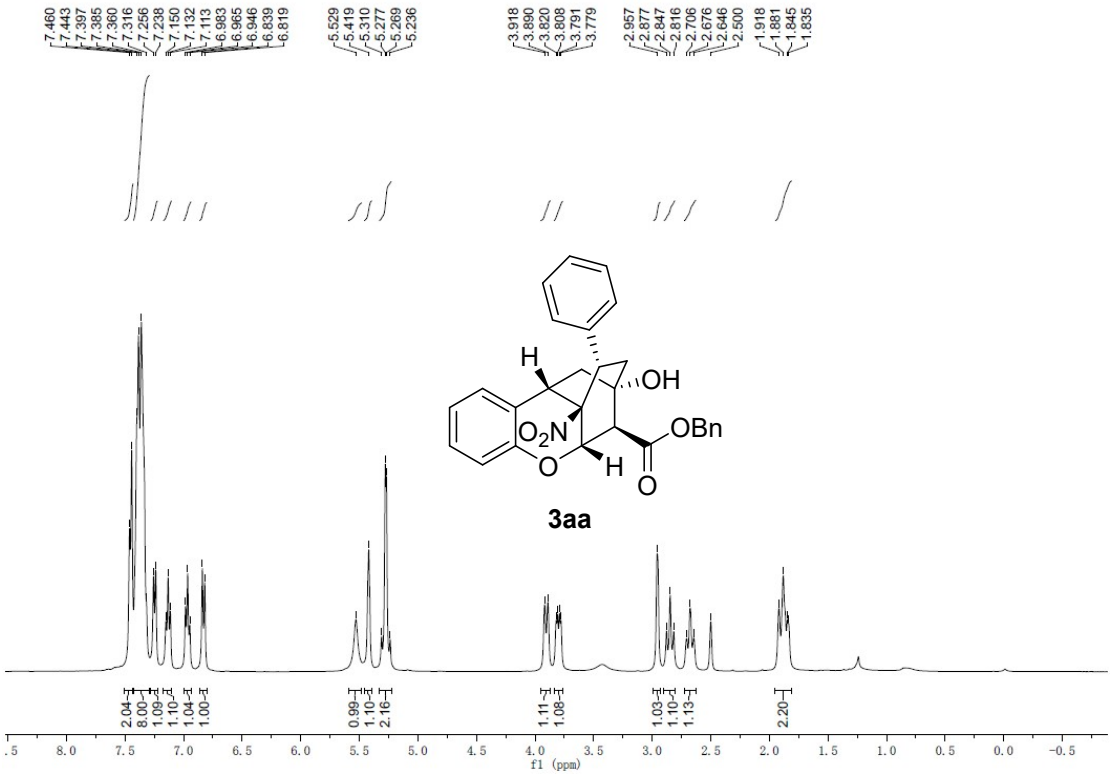
3y
17:1 mixture of diastereomers



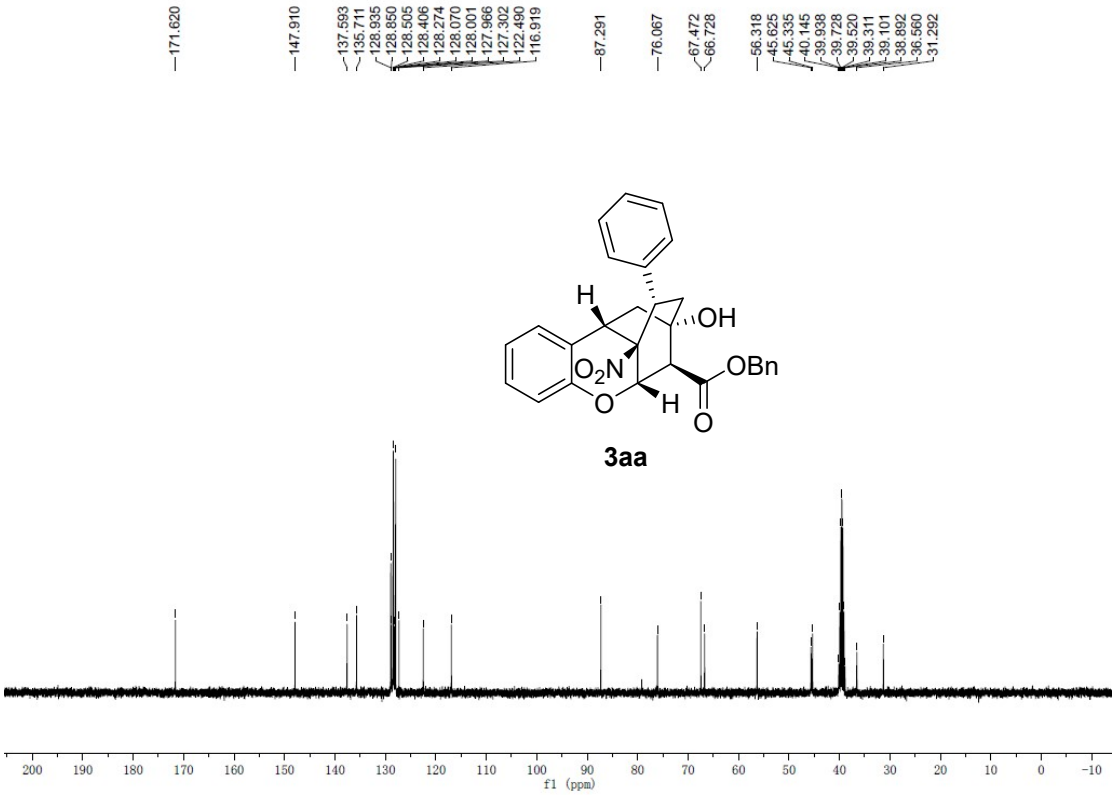
3y
17:1 mixture of diastereomers


7.375
7.358
7.341
7.321
7.305
7.272
7.254
7.120
7.102
7.083
7.057
7.039
6.926
6.908
6.891
6.819
6.799
5.629
3.827
3.799
3.769
3.758
3.740
3.729
3.338
2.875
2.806
2.775
2.744
2.569
2.538
2.507
2.021
1.988
1.945
1.913
1.565
H
OH
O2N
O
H
O
OtBu
3z
2.93
2.29
1.09
1.02
0.99
0.97
1.02
2.17
1.10
1.10
1.06
1.12
1.12
1.11
9.00
f1 (ppm)

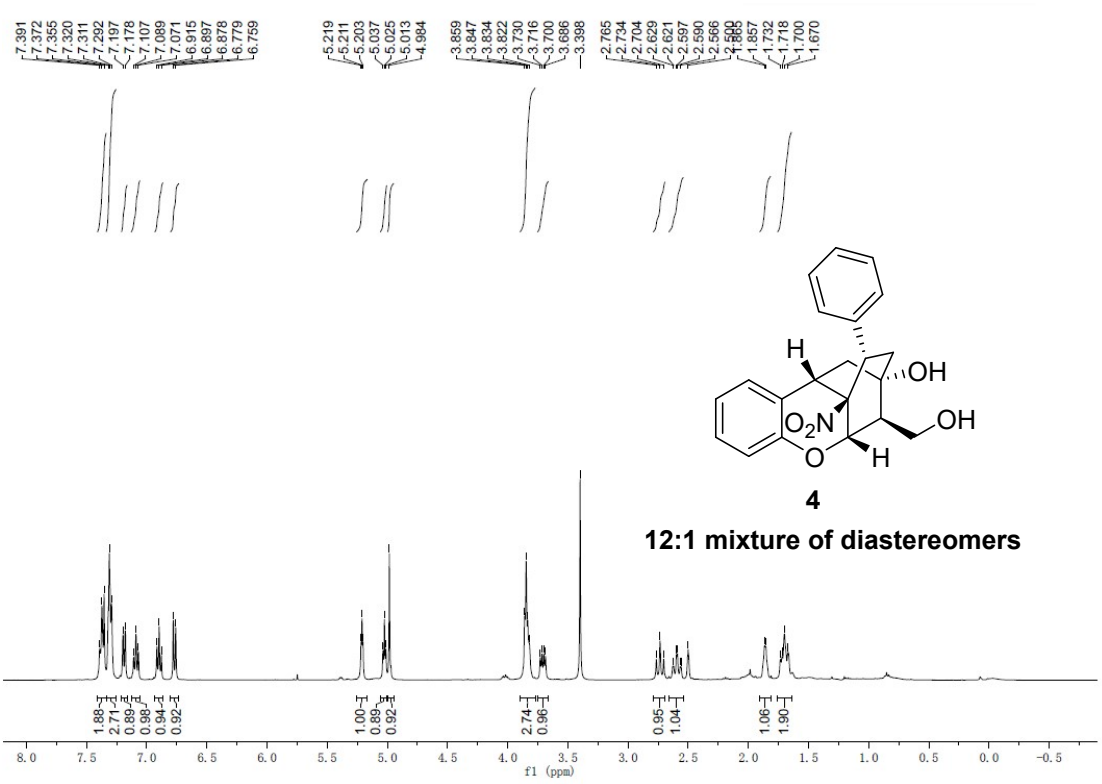

170.693
148.268
137.030
129.064
128.452
128.358
128.234
128.171
126.516
122.376
117.536
87.048
83.781
77.317
77.000
76.682
75.497
67.858
55.996
45.474
45.423
37.473
31.338
28.090
H
OH
O2N
O
H
O
OtBu
3z
f1 (ppm)

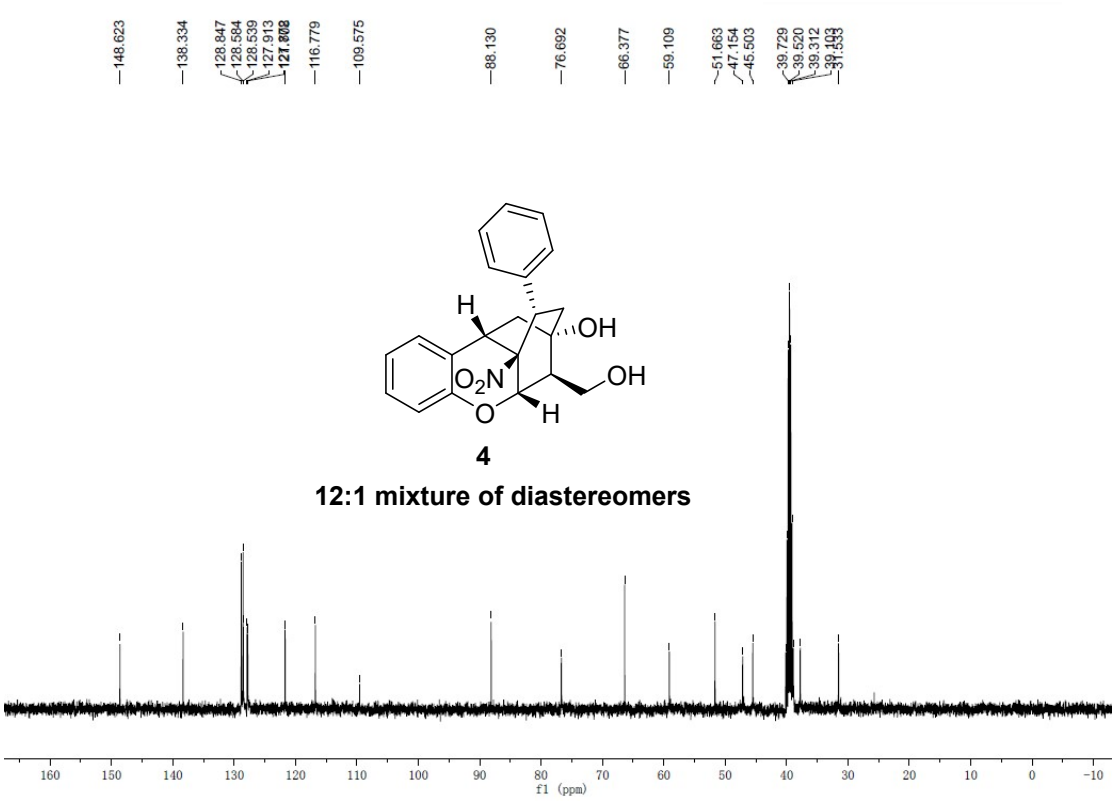

7.460
7.443
7.397
7.385
7.360
7.316
7.256
7.238
7.150
7.132
7.113
6.983
6.965
6.946
6.839
6.819
5.529
5.419
5.310
5.277
5.269
5.236
3.918
3.890
3.820
3.808
3.791
3.779
2.957
2.877
2.847
2.816
2.706
2.676
2.646
2.500
1.918
1.881
1.845
1.835
H
OH
O2N
O
H
OBn
O
2.04
8.00
1.09
1.10
1.04
1.00
0.99
1.10
2.16
1.11
1.08
1.03
1.10
1.13
2.20
f1 (ppm)

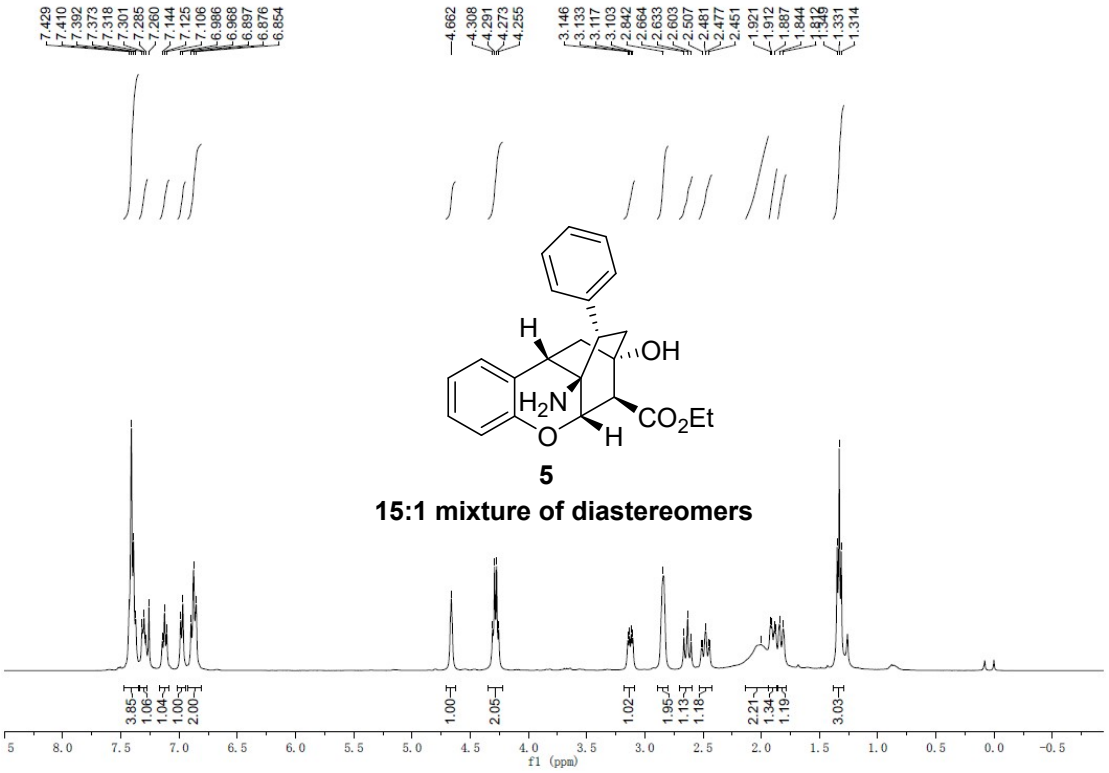
3aa


171.620
147.910
137.593
135.711
128.935
128.850
128.505
128.406
128.274
128.070
128.001
127.966
127.302
122.490
116.919
87.291
76.067
67.472
66.728
56.318
45.625
45.335
40.145
39.938
39.728
39.520
39.311
39.101
38.892
36.560
31.292
H
OH
O2N
O
H
OBn
O
f1 (ppm)

3aa

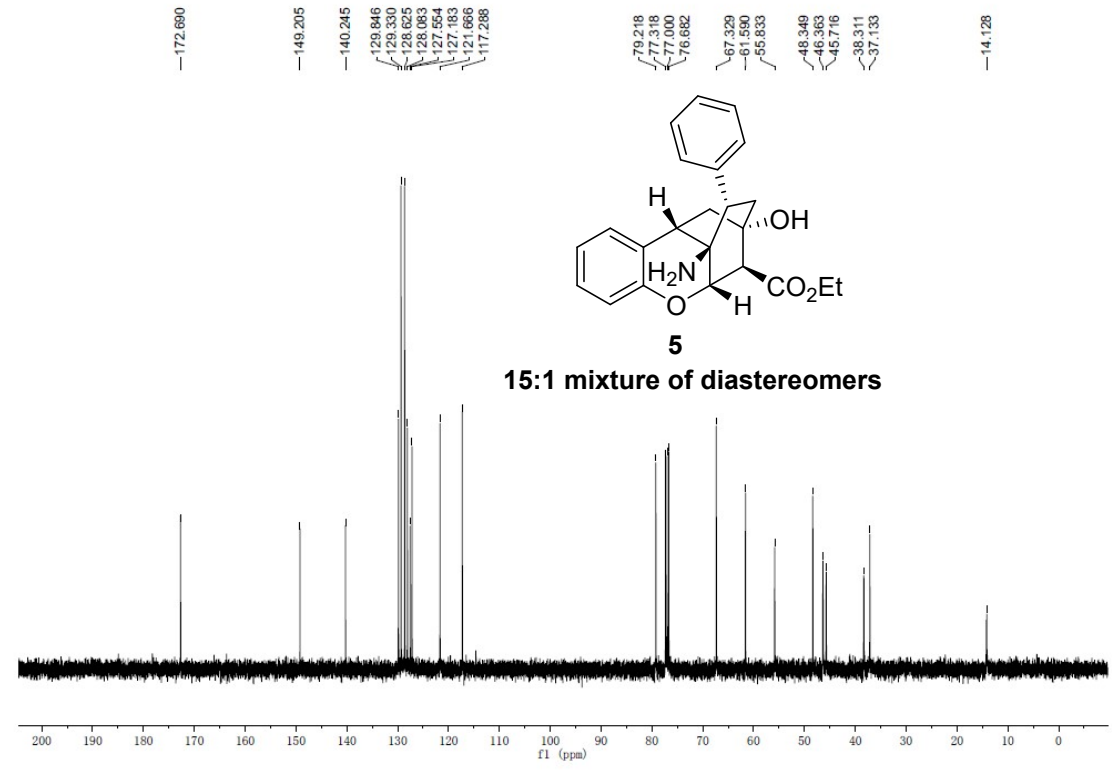

H
OH
O2N
OH
O
H
4
12:1 mixture of diastereomers
f1 (ppm)


H
OH
O2N
OH
O
H
4
12:1 mixture of diastereomers
f1 (ppm)



5

15:1 mixture of diastereomers



5

15:1 mixture of diastereomers