**Electronic Supplementary Information**

# Asymmetric Direct Vinylogous Michael Addition of 3-Alkylidene Oxindoles to Chalcones Catalyzed by a Chiral Ytterbium(III)-*N,N′*-Dioxide Complex

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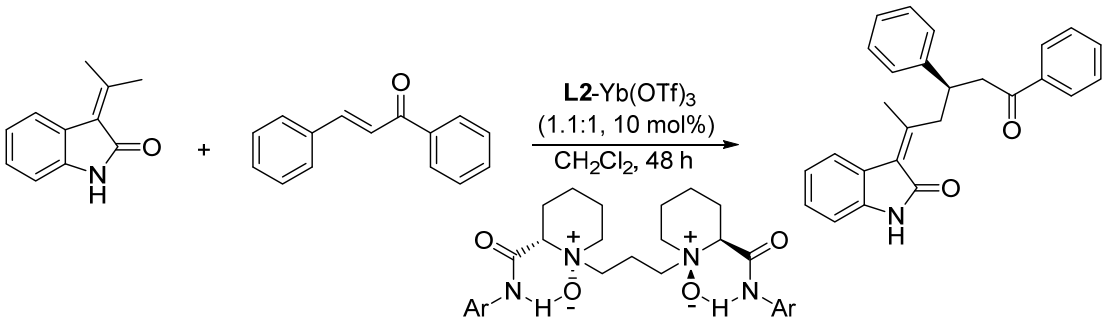
**Contents:**

## 1. General remarks

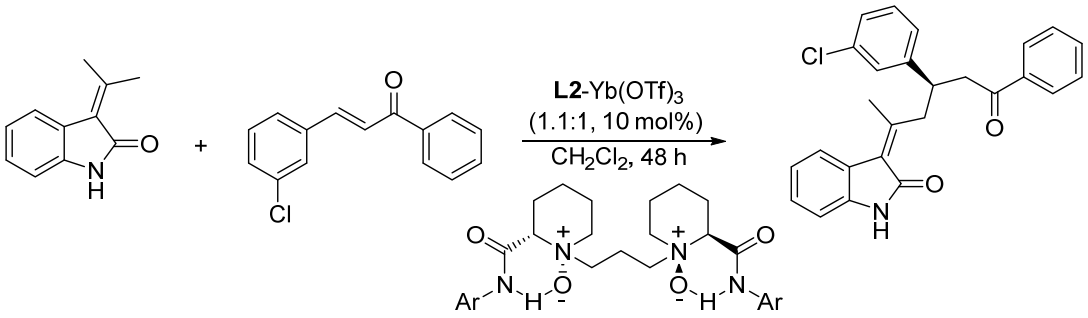
$^1$H NMR spectra were recorded on commercial instruments (400 MHz). Chemical shifts were reported in ppm from tetramethylsilane with the solvent resonance as the internal standard ($CDCl_3$, δ = 7.26). Spectra are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz), integration, and assignment. $^{13}$C NMR spectra were collected on commercial instruments (100 MHz) with complete proton decoupling. Chemical shifts are reported in ppm from the tetramethylsilane with the solvent resonance as internal standard ($CDCl_3$, δ = 77.16). The enantiomeric excess was determined by HPLC analysis on commercial chiral columns. Optical rotations were measured on a commercial polarimeter and reported as follows: $[\alpha]^T_D$ (c = g/100 mL, solvent). HR-ESIMS spectra were recorded using a commercial apparatus and methanol or acetonitrile was used to dissolve the sample. Unless otherwise indicated, reagents obtained from commercial sources were used without further purification. Solvents were dried and distilled prior to use according to the standard methods. 4 Å MS was powdered <50 μm, which was activated at 400 ºC for 3 hours and stored under nitrogen. Unless noted, commercial reagents were used without further purification. 3-alkylidene oxindoles were prepared according to the literature and references therein.[1] Chalcones were prepared according to the literature.[2] The *N*,*N*'-dioxdes were prepared according to the methods reported in the literature.[3] The racemic products of the catalytic asymmetric direct vinylogous Michael reactions were prepared with the $Yb(OTf)_3$-racemic ligand-DMAP complex.

## 2. Typical experimental procedure for the catalytic asymmetric direct vinylogous Michael reaction



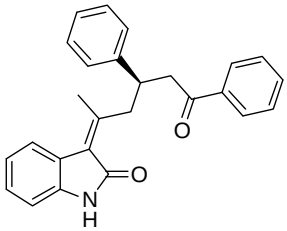

*N*,*N*'-dioxide **L2** (7.2 mg, 0.011 mmol, 11 mol%), ytterbium triflate (6.2 mg, 0.010 mmol, 10 mol%), 4 Åmolecular sieves (20 mg), and chalcone **2a** (0.1 mmol, 20.8 mg) were stirred in a dry reaction tube under nitrogen, then $CH_2Cl_2$ (0.5 mL) was added, and the reaction was stirred at 30 ºC under nitrogen. After 0.5 h, 3-alkylidene oxindole **1a** (0.12 mmol, 20.7 mg), and DMAP (7.32 mg, 0.6 mmol) were added and the mixture was stirred at 0 ºC for 48 h. The *Z*/*E* ratio was determined by $^1$HNMR analysis. Separation by column chromatography on silica gel with petroleum ether/ethyl acetate (5:1-3:1) afforded the desired product *Z*/*E*-**3a**, the pure *Z*-isomer could be separated. The enantiomeric excess (*ee*) of product *Z*-**3a** was determined by high-performance liquid chromatography (HPLC).

**3. Typical procedure for the scale-up reaction with 10 mol% catalyst loading:**

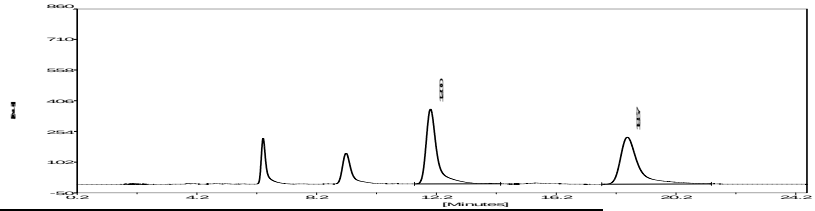



*N*,*N*'-dioxide **L2** (218.0 mg, 0.33 mmol, 11mol%), ytterbium triflate (186.0 mg, 0.30 mmol, 10 mol%), 4 Å molecular sieves (600 mg), and chalcone **2h** (3.0 mmol, 726.0 mg) were stirred in a dry reaction boiling flask under nitrogen, then $CH_2Cl_2$ (15.0 mL) was added, and the reaction was stirred at 0 ºC under nitrogen. After 0.5 h, 3-alkylidene oxindole **1a** (3.6 mmol, 623.0 mg), and DMAP (2196.0 mg, 18.0 mmol) were added and the mixture was stirred at 0 ºC for 48 h. The *Z/E* ratio was determined by $^1$HNMR analysis. Separation by column chromatography on silica gel with petroleum ether/ethyl acetate (5:1-3:1) afforded the desired product *Z/E*-**3h**, the pure *Z*-isomer could be separated. The enantiomeric excess (*ee*) of product *Z*-**3h** was determined by high-performance liquid chromatography (HPLC).

**4. Characterization of the product 3**

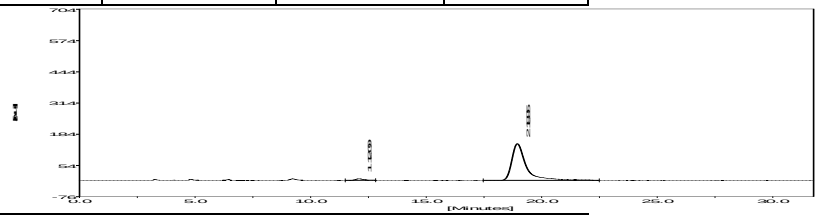


**(*R*, *Z*)-3a (Table 1, entry 1):** A yellow solid, 88% isolated yield of *Z*/*E* products. The *ee* was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 18.95 min, $t_r$ (minor) = 12.09 min]. $[\alpha]_D^{25}$ = −3.846 (c = 0.31 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 3.14 - 3.18 (dd, *J* = 12.0, 7.2 Hz, 1H ), 3.28 - 3.34 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.50 - 3.56 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.84 - 3.92 (m, 1H), 4.01 - 4.07(m, 1H), 6.76 - 6.78 (d, *J* = 7.6, 1H), 6.95 - 6.99 (t, *J* = 7.6, 1H), 7.12 - 7.18 (dd, *J* = 16.0, 7.6 Hz, 2H), 7.25 - 7.31 (m, 4H), 7.39 - 7.45 (m, 4H), 7.79 - 7.81 (d, *J* = 7.2, 2H), 8.27 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.1, 169.5, 157.6, 144.6, 139.4, 137.1, 132.9, 128.4, 128.1, 128.0, 127.7, 126.7, 124.7, 124.3, 121.8, 109.3, 44.4, 41.6, 40.8, 23.6 ppm. ESI-HRMS: calcd for $C_{26}H_{23}NO_2Na^+$, ([M + Na] $^+$ ) 404.1621, found 404.1628.

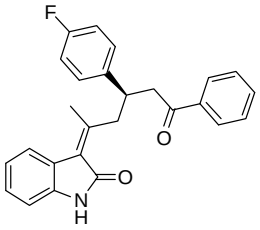



| Peak | Retention Time | Area | % Area |
|---|---|---|---|

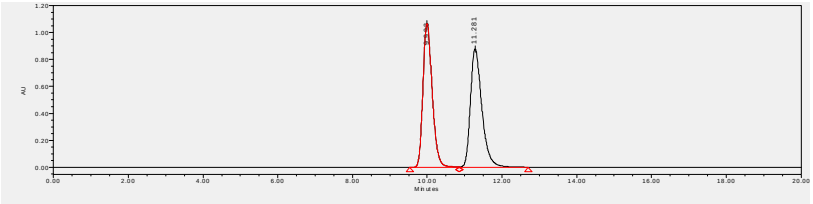
| | | | |
|---|---|---|---|
| 1 | 12.00 | 9589.02 | 49.7646 |
| 2 | 18.57 | 9679.74 | 50.2354 |



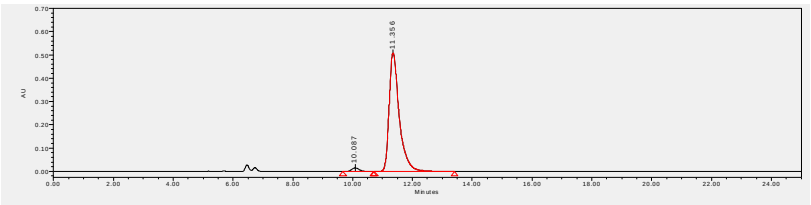
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 12.09 | 144.47 | 2.1497 |
| 2 | 18.95 | 6576.03 | 97.8503 |



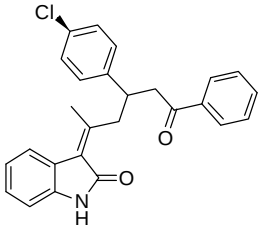
**(*R*, *Z*)-3b (Table 1, entry 2):** A yellow solid, 83% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IE, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 11.35 min, $t_r$ (minor) = 10.08 min]. $[\alpha]_D^{25} = -3.883$ (c = 0.41 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 3.22 - 3.33 (m, 2H), 3.46 - 3.52 (dd, *J* = 16.8, 6.0 Hz, 1H), 3.84 - 3.93 (m, 2H), 6.75 - 6.77 (d, *J* = 7.6, 1H), 6.92 - 7.00 (m, 3H), 7.14 - 7.17 (t, *J* = 7.6, 1H), 7.30 - 7.36 (m, 4H), 7.41 - 7.48 (m, 2H), 7.80 - 7.82 (d, *J* = 7.6, 2H), 7.93 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.9, 169.2, 162.8, 160.4, 157.1, 140.1, 139.3, 137.1, 133.0, 129.2, 129.1, 128.5, 128.1, 124.7, 124.4, 124.2, 121.9, 115.5, 115.2, 109.2, 44.6, 41.5, 40.0, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_5FNa^+$, ([M + Na] $^+$ ) 422.1527, found 422.1533.



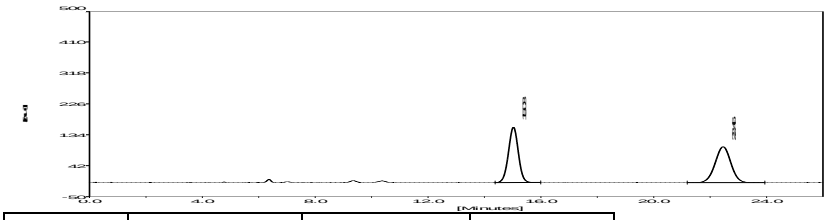
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.993 | 18444018 | 49.62 |
| 2 | 11.281 | 18724117 | 50.38 |



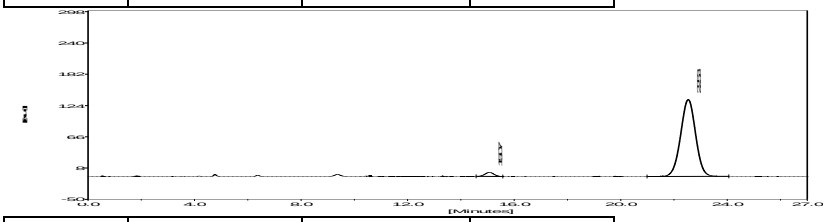
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.087 | 278832 | 2.28 |
| 2 | 11.356 | 11971286 | 97.72 |



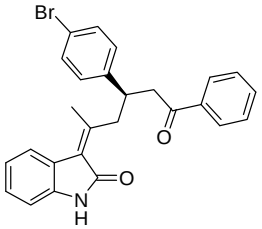
**(*R, Z*)-3c (Table 1, entry 3):** A yellow solid, 81% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 22.53 min, $t_r$ (minor) = 15.07 min]. $[\alpha]_D^{25} = -3.755$ (c = 0.36 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.28 (s, 3H), 3.21 - 3.33 (m, 2H), 3.46 - 3.52 (dd, *J* = 16.8, 6.0 Hz, 1H), 3.82 - 3.94 (m, 2H), 6.76- 6.78 (d, *J* = 8.0 Hz, 1H), 6.96 - 7.00 (t, *J* = 7.6Hz, 1H), 7.14 - 7.17 (t, *J* = 7.6 Hz, 1H), 7.21 - 7.23 (m, 2H), 7.30 - 7.34 (m, 4H), 7.41 - 7.47 (m, 2H), 7.80 – 7.82 (d, *J* = 8.0 Hz, 2H), 8.12 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.7, 169.4, 156.8, 143.0, 139.4, 137.0, 133.1, 132.3, 129.2, 128.5, 1281, 124.6, 124.4, 124.2, 121.9, 109.3, 44.4, 41.4, 40.2, 23.7 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_5{}^{34.9689}ClNa^+$, ([M + Na] $^+$ ) 438.1231, found 438.1237, $C_{26}H_{22}NO_2{}^{36.9659}ClNaS^+$, ([M + Na] $^+$ ) 440.1202, found 440.1207 .



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.03 | 4006.89 | 49.2522 |
| 2 | 22.46 | 4128.57 | 50.7478 |

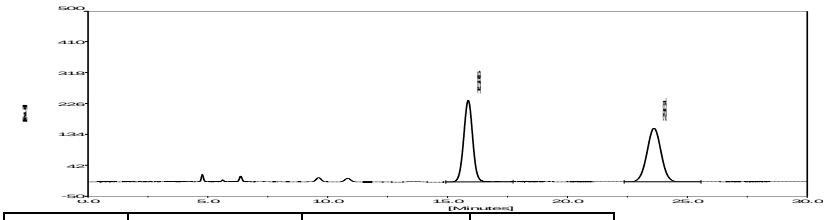


| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.07 | 174.87 | 3.0486 |
| 2 | 22.53 | 5561.20 | 96.9514 |

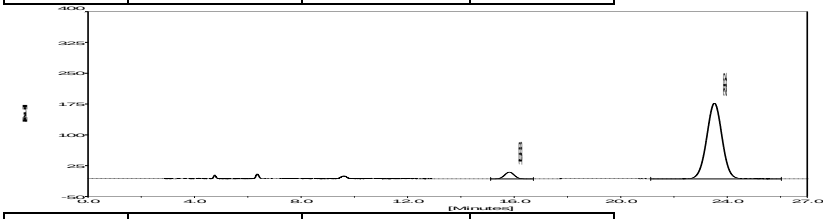


**(*R, Z*)-3d (Table 1, entry4):** A yellow solid, 82% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 23.52 min, $t_r$ (minor) = 15.83 min]. $[\alpha]_D^{25} = -2.564$ (c = 0.31 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 3.21 - 3.32 (m, 2H), 3.46 - 3.51(dd, *J* = 17.2, 6.0 Hz, 1H), 3.82 - 3.92 (m, 2H), 6.75- 6.77 (d, *J* = 7.6, 1H), 6.97 - 7.00 (t, *J* = 8.0, 1H), 7.14 - 7.18 (t, *J* = 7.6, 1H), 7.26 - 7.33 (m,4H), 7.36 - 7.39 (m, 2H), 7.41 - 7.49 (m, 2H), 7.71 (s, 1H), 7.80 - 7.82 (d, *J* = 7.6, 2H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.7, 169.1, 156.9, 143.6, 139.2, 137.0, 133.1, 131.7, 129.7, 128.5, 128.1, 124.7, 124.4, 124.2, 121.9, 120.4, 109.2, 100.1, 44.4, 41.2 40.1, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_5{}^{78.9183}BrNa^+$, ([M + Na] $^+$ ) 482.0726, found 482.0732,

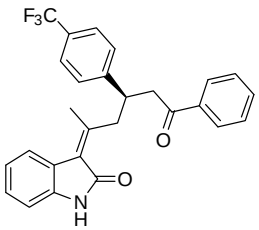
$C_{26}H_{22}NO_5{}^{80.9163}BrNa^+$, ([M + Na] $^+$ ) 484.0706, found 484.0724.



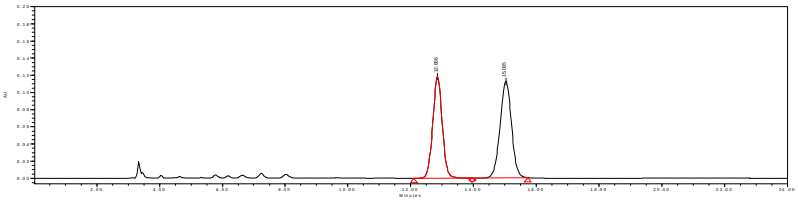
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.86 | 6302.48 | 49.0509 |
| 2 | 23.61 | 6546.37 | 50.9491 |



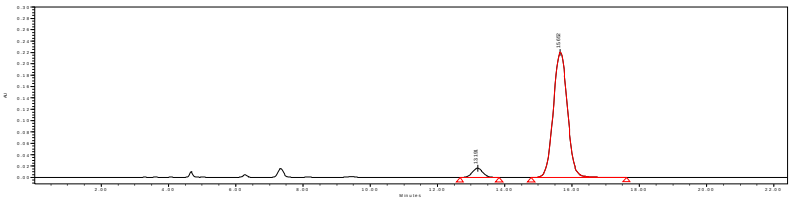
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.83 | 382.46 | 4.8930 |
| 2 | 23.52 | 7434.08 | 95.1070 |



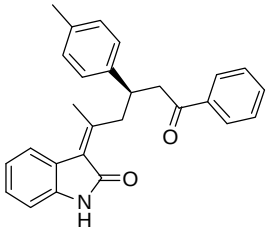
**(*R*, *Z*)-3e (Table 1, entry 5):** A yellow solid, 88% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 15.65 min, $t_r$ (minor) = 13.19 min]. $[\alpha]_D^{25} = -8.163$ (c = 0.29 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.30 (s, 3H), 3.20 - 3.24 (dd, *J* = 10.6, 5.6 Hz, 1H), 3.32 - 3.38 (m, 1H), 3.51 - 3.57 (m, 1H), 3.91 - 4.01 (m, 2H), 6.76 - 6.78 (d, *J* = 8.0, 1H), 6.97 - 7.01 (t, *J* = 7.6, 1H), 7.14 - 7.18 (t, *J* = 7.6, 1H), 7.42 - 7.46 (m, 2H), 7.53 (s, 4H), 7.80 - 7.82 (d, *J* = 7.6, 2H), 8.03 - 8.15 (m, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.5, 169.3, 156.4, 148.7, 139.4, 136.9, 133.1, 129.1, 128.7, 128.6, 128.2, 128.1, 128.0, 125.6, 124.9, 124.4, 124.1, 123.0, 121.9, 109.3, 44.1, 41.2, 40.4, 23.6 ppm. ESI-HRMS: calcd for $C_{27}H_{22}NO_2F_3Na^+$, ([M + Na] $^+$ ) 472.1495, found 472.1498.



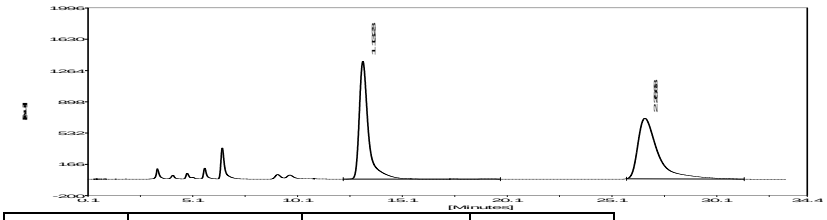
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 12.856 | 2501879 | 48.38 |
| 2 | 15.035 | 2668964 | 51.62 |



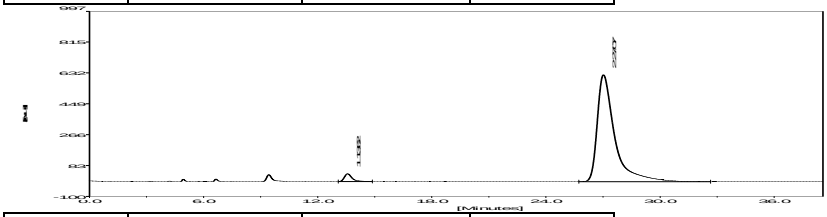
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.191 | 358534 | 5.25 |
| 2 | 15.652 | 6464706 | 94.75 |



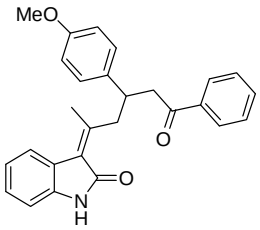
**(*R*, *Z*)-3f (Table 1, entry 6):** A yellow solid, 91% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 27.07 min, $t_r$ (minor) = 13.62 min]. $[\alpha]_D^{25}$ = −7.865 (c = 0.18 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.28 (s, 3H), 2.29 (s, 3H), 3.12 - 3.16 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.25 - 3.31 (dd, *J* = 16.8, 7.6 Hz, 1H), 3.48 - 3.54 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.81 - 3.85 (m, 1H), 4.00 - 4.05 (m, 1H), 6.75-6.77 (d, *J* = 7.6, 1H), 6.95 – 6.99 (t, *J* = 7.6, 1H), 7.07 - 7.09 (d, *J* = 7.6, 2H), 7.12 - 7.16 (t, *J* = 7.6, 1H), 7.26 - 7.30 (m, 4H), 7.41 - 7.43 (m, 2H), 7.79 - 7.80 (d, *J* = 12.0, 7.2 Hz, 2H), 8.21 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.1, 169.5, 157.9, 164.3, 157.6, 141.6, 139.4, 137.2, 136.1, 132.8, 129.3, 128.4, 128.1, 127.9, 127.6, 124.6, 124.3, 121.8, 115.3, 109.2, 44.6, 41.7, 40.4, 23.6, 21.2 ppm. ESI-HRMS: calcd for $C_{27}H_{25}NO_2Na^+$, ($[M + Na]^+$) 418.1778, found 418.1786.



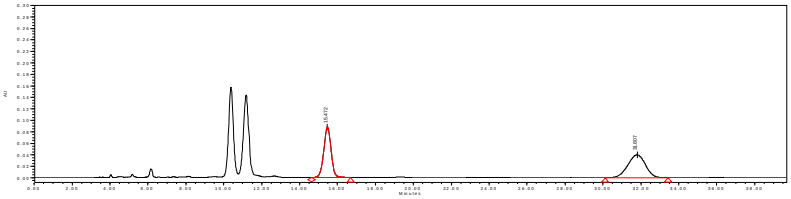
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.23 | 41928.07 | 46.9522 |
| 2 | 26.68 | 47371.44 | 53.0478 |



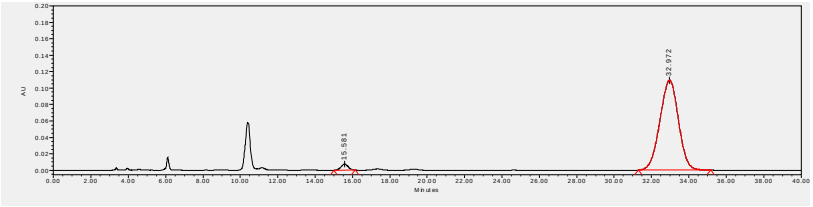
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.62 | 1289.03 | 3.0842 |
| 2 | 27.07 | 40505.64 | 96.9158 |



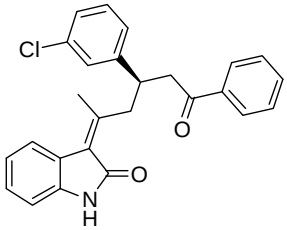
**(*Z*)-3g (Table 1, entry 7):** A yellow solid, 86% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 32.97 min, $t_r$ (minor) = 15.83 min]. $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.28 (s, 3H), 3.17 - 3.30 (m, 2H), 3.44 - 3.51 (m, 1H), 3.75 (s, 3H), 3.79 - 3.84 (m, 1H), 3.92 - 3.97 (m, 1H), 6.74 - 6.81 (m, 3H), 6.95 - 7.00 (m, 1H), 7.13 - 7.19 (m, 1H), 7.26 - 7.33 (m, 4H), 7.41 - 7.47 (m, 2H), 7.66 (s, 1H), 7.80 - 7.82 (d, 2H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.2, 169.1, 158.3, 157.9, 139.2, 137.2, 136.6, 132.9, 128.7, 128.5, 128.1, 127.9, 124.4, 121.8, 113.9, 109.1, 100.0, 55.3, 44.8, 41.7, 40.0, 23.6 ppm. ESI-HRMS: calcd for $C_{27}H_{25}NO_3Na^+$, ($[M + Na]^+$) 434.1727, found 434.1737.



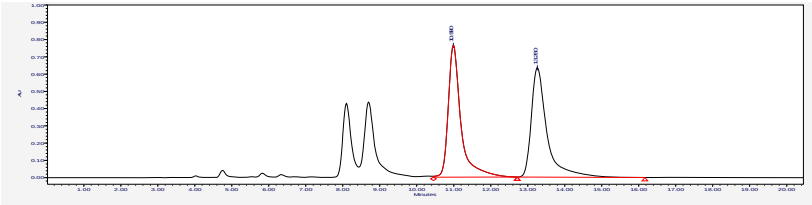
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.472 | 2360673 | 48.05 |
| 2 | 31.807 | 2551932 | 51.95 |



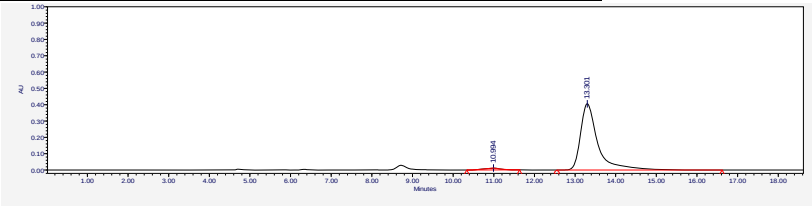
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 15.581 | 196066 | 2.53 |
| 2 | 32.972 | 7545259 | 97.47 |



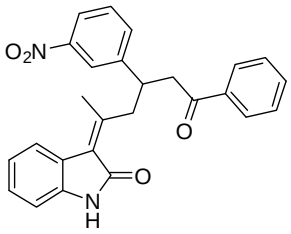
**(*R*, *Z*)-3h (Table 1, entry 8):** A yellow solid, 96% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 13.30 min, $t_r$ (minor) = 10.99 min]. $[\alpha]_D^{25}$ = −1.596 (c = 0.37 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.30 (s, 3H), 3.12 - 3.17 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.26 - 3.32 (dd, *J* = 17.2, 7.2 Hz, 1H), 3.49 - 3.55 (dd, *J* = 17.2, 7.2 Hz, 1H), 3.83 - 3.88 (m, 1H), 3.98 - 4.03 (m, 1H), 6.77 - 6.79 (d, *J* = 7.6, 1H), 6.96 - 7.00 (t, *J* = 7.6, 1H), 7.13 - 7.20 (m, 3H), 7.29 - 7.33 (m, 3H), 7.42 - 7.46 (m, 3H), 7.79 - 7.81 (d, *J* = 7.6, 2H), 8.26 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.9, 169.2, 162.8, 160.4, 157.1, 140.1, 139.3, 137.1, 133.0, 129.2, 129.1, 128.5, 128.1, 124.6, 124.4, 124.2, 121.9, 115.5, 115.2, 109.2, 44.6, 41.5, 40.0, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_5{}^{34.9689}ClNa^+$, ($[M + Na]^+$) 438.1231, found 438.1243, $C_{26}H_{22}NO_2{}^{36.9659}ClNaS^+$, ($[M + Na]^+$) 440.1202, found 440.1224 .



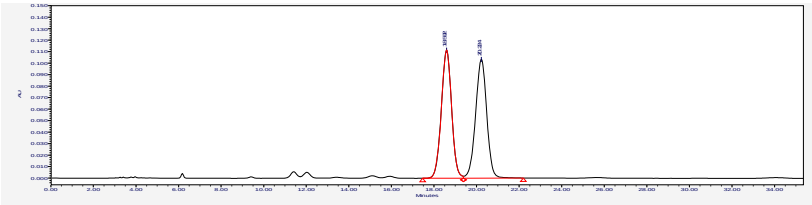
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.990 | 18208126 | 49.45 |
| 2 | 13.260 | 18612084 | 50.55 |



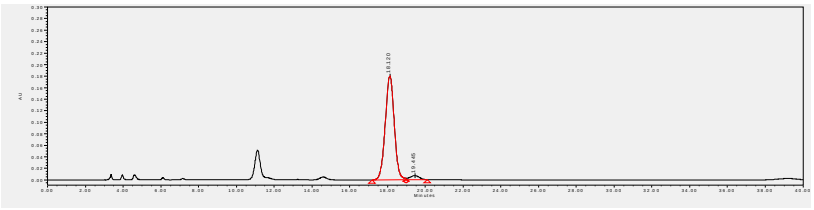
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.994 | 326238 | 2.64 |
| 2 | 13.301 | 12012001 | 97.36 |



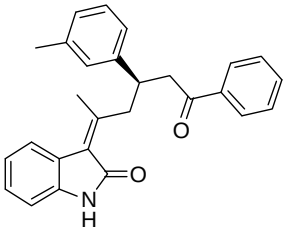
**(*Z*)-3i (Table 1, entry 9):** A yellow solid, 81% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 18.12 min, $t_r$ (minor) = 19.44 min]. $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.32 (s, 3H), 3.34 - 3.43 (m, 2H), 3.54 - 3.60 (m, 1H), 3.85 - 3.90 (m, 1H), 4.00 - 4.04 (m, 1H), 6.76 - 6.78 (m, 1H), 6.97 - 7.00 (m, 1H), 7.12 - 7.19 (m, 1H), 7.33 - 7.37 (t, 2H), 7.41 - 7.48 (m, 3H), 7.72 - 7.77 (m, 2H), 7.82 - 7.84 (m, 2H), 8.02 - 8.04 (d, 1H), 8.29 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.2, 169.0, 155.6, 148.4, 146.6, 139.3, 136.8, 134.3, 133.3, 129.5, 128.9, 128.6, 128.4, 128.1, 125.1, 124.5, 124.0, 122.8, 122.0, 121.9, 109.3, 44.0, 41.1, 40.3, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{22}N_2O_4Na^+$, ([M + Na] $^+$ ) 449.1472, found 449.1476.



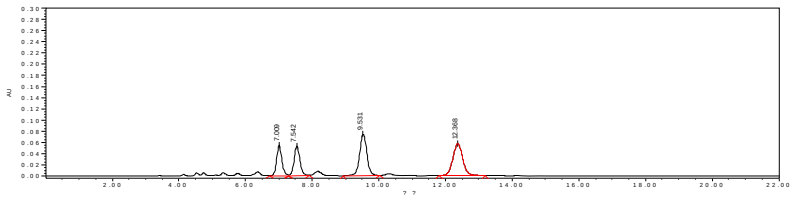
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 18.592 | 3761555 | 49.92 |
| 2 | 20.224 | 3773316 | 50.08 |



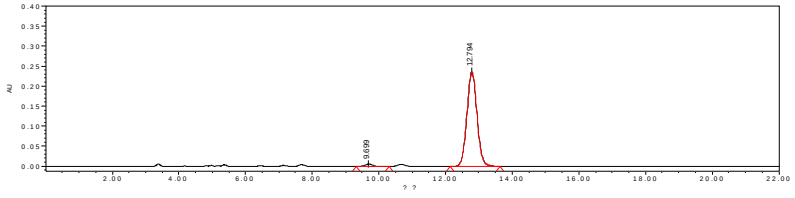
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 18.120 | 5983152 | 95.99 |
| 2 | 19.445 | 250237 | 4.01 |



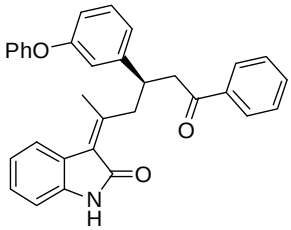
**(*R*, *Z*)-3j (Table 1, entry 10):** A yellow solid, 91% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 12.79 min, $t_r$ (minor) = 9.69 min]. $[\alpha]_D^{25}$ = −3.755 (c = 0.51 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.30 (s, 3H), 2.31 (s, 3H), 3.04 - 3.08 (dd, *J* = 12.0, 6.8 Hz, 1H), 3.24 - 3.30 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.50 - 3.56 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.82 - 3.89 (m, 1H), 4.08 - 4.13 (dd, *J* = 12.0, 8.8 Hz, 1H), 6.74-6.76 (d, *J* = 7.6, 1H), 6.95 – 6.99 (t, *J* = 7.6, 2H), 7.12 - 7.21 (m, 4H), 7.26 - 7.30 (m, 2H), 7.40 - 7.44 (t, *J* = 7.2, 2H), 7.78 - 7.80 (d, *J* = 7.6, 2H), 8.09 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.3, 169.5, 157.6, 144.6, 143.6, 139.3, 138.1, 137.2, 128.5, 128.5, 128.4, 128.1, 127.9, 127.4, 124.7, 124.6, 124.4, 124.3, 121.8, 109.4, 44.4, 41.7, 40.7, 23.6, 21.7 ppm. ESI-HRMS: calcd for $C_{27}H_{25}NO_2Na^+$, ($[M + Na]^+$) 418.1778, found 418.1788.



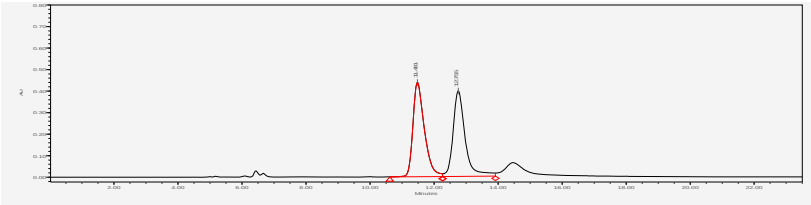
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.531 | 1136003 | 49.20 |
| 2 | 12.368 | 1172869 | 50.80 |



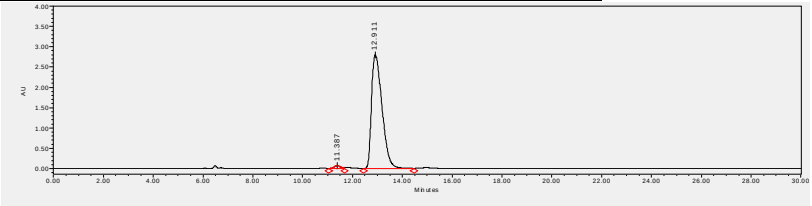
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.699 | 93511 | 1.83 |
| 2 | 12.794 | 5010399 | 98.17 |



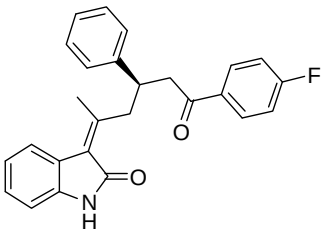

**(*R*, *Z*)-3k (Table 1, entry 11):** A yellow solid, 88% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 12.91 min, $t_r$ (minor) = 11.38 min]. $[\alpha]_D^{25}$ = −17.018 (c = 0.47 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 3.26 - 3.36 (m, 2H), 3.47 - 3.53 (dd, *J* = 16.8, 6.0 Hz, 1H), 3.81 - 3.92 (m, 2H), 6.76 - 6.80 (t, *J* = 16.8, 2H), 6.85-6.87 (d, *J* = 8.0, 2H), 6.96 - 7.04 (m, 2H), 7.07 (s, 1H), 7.12 - 7.25 (m, 5H), 7.29 - 7.33 (m, 2H), 7.41 - 7.46 (m, 2H), 7.80 - 7.82 (m, 2H), 8.42 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.9, 169.5, 157.6, 157.1, 157.0, 146.6, 143.6, 139.5, 137.1, 133.0, 129.9, 129.7, 128.0, 124.8, 124.3, 124.2, 122.9, 121.8, 118.7, 118.5, 117.4, 109.4, 44.4, 41.4, 40.7, 23.6 ppm. ESI-HRMS: calcd for $C_{32}H_{27}NO_3Na^+$, ($[M + Na]^+$) 496.1883, found 496.1885.



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.481 | 10870509 | 51.05 |
| 2 | 12.755 | 10423169 | 48.95 |



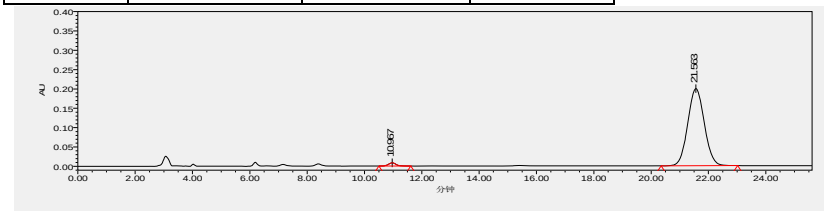

| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.387 | 1374684 | 1.64 |
| 2 | 12.911 | 82304860 | 98.36 |



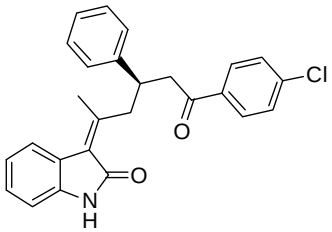

**(*R*, *Z*)-3l (Table 1, entry 12):** A yellow solid, 96% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 21.56 min, $t_r$ (minor) = 10.96 min]. $[\alpha]_D^{25}$ = −3.883 (c = 0.41 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.28 (s, 3H), 3.05 - 3.10 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.21 - 3.26 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.49 - 3.55 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.83 - 3.91 (m, 1H), 4.09 - 4.14 (m, 1H), 6.76 - 6.78 (d, *J* = 7.6 Hz, 1H), 6.91 – 6.99 (m, 2H), 7.13 - 7.19 (dd, *J* = 16.4, 7.6 Hz, 2H), 7.26 - 7.30 (m, 2H), 7.38 - 7.42 (m, 3H), 7.78 - 7.82 (m, 2H), 8.37 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 197.4, 169.6, 166.9, 164.3, 157.6, 144.6, 139.4, 130.7, 124.7, 121.8, 115.3, 109.2, 44.2, 41.7, 41.0,

23.7 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_2FNa^+$, ([M + Na] $^+$ ) 422.1527, found 422.1539.

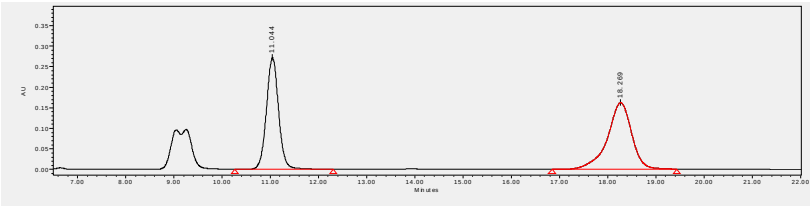
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.888 | 6416106 | 48.79 |
| 2 | 21.146 | 6734385 | 51.21 |



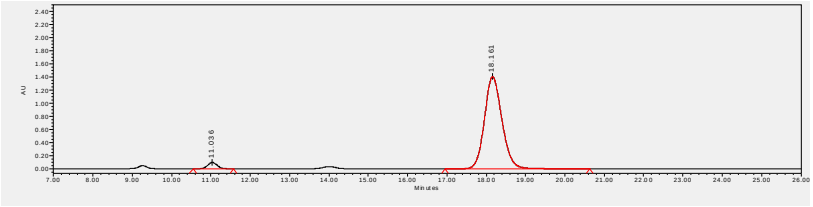

| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.967 | 148488 | 1.83 |
| 2 | 21.563 | 7984898 | 98.17 |



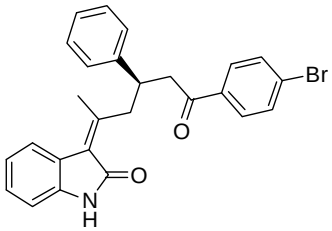

**(*R*, *Z*)-3m (Table 1, entry 13):** A yellow solid, 83% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 18.16 min, $t_r$ (minor) = 11.03 min]. $[\alpha]_D^{25}$ = −1.750 (c = 0.40 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.27 (s, 3H), 3.00 - 3.21 (dd, *J* = 12.0, 6.8 Hz, 1H), 3.17 - 3.23 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.51 - 3.57 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.82 - 3.90 (m, 1H), 4.11 - 4.16 (dd, *J* = 12.0, 8.8 Hz, 1H), 6.75 - 6.77 (d, *J* = 7.6, 1H ), 6.96 - 7.00 (t, *J* = 7.6, 1H), 7.14 - 7.20 (dd, *J* = 16.0, 7.6, 2H), 7.22 - 7.30 (m, 4H), 7.38 - 7.42 (m, 3H), 7.69 - 7.71 (d, *J* = 8.4, 2H), 7.97 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 197.8, 169.3, 157.6, 144.5, 139.2, 135.4, 129.5, 128.7, 127.3, 126.8, 124.7, 124.4, 124.2, 121.9, 109.2, 44.2, 41.7, 41.0, 23.7 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_2{}^{34.9689}ClNaS^+$, ([M + Na] $^+$ ) 438.1231, found 438.1238, $C_{26}H_{22}NO_2{}^{36.9659}ClNaS^+$, ([M + Na] $^+$ ) 4440.1202, found 440.1218.



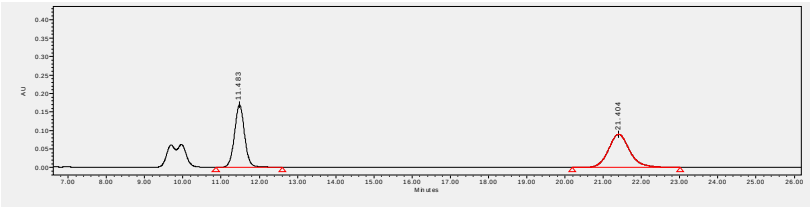

| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.044 | 4779938 | 47.16 |
| 2 | 18.269 | 5355852 | 52.84 |



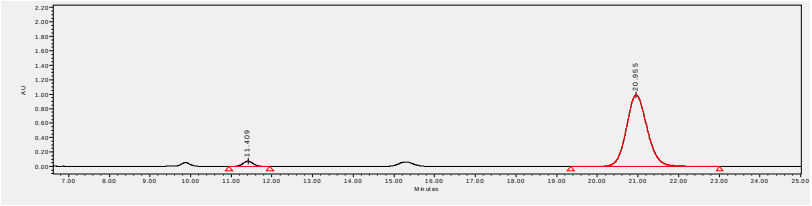
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.036 | 1613336 | 3.59 |
| 2 | 18.161 | 43309887 | 96.41 |



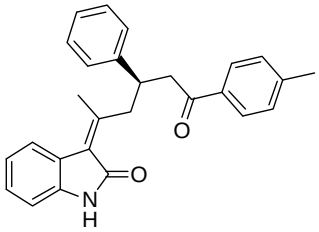
**(*R*, *Z*)-3n (Table 1, entry 14):** A yellow solid, 73% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 20.95 min, $t_r$ (minor) = 11.40 min]. $[\alpha]_D^{25}$ = −2.222 (c = 0.27 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.27 (s, 3H), 2.98 - 3.03 (dd, *J* = 12.4 , 6.8 Hz , 1H), 3.15 - 3.21 (dd, *J* = 16.4 , 6.4 Hz , 1H), 3.51 - 3.57 (dd, *J* = 16.4 , 7.2 Hz , 1H), 3.82 - 3.90 (m, 1H), 4.11 - 4.16 (dd, *J* = 12.0 , 8.8 Hz , 1H), 6.74 - 6.76 (d, *J* = 8.0 Hz, 1H ), 6.96 - 7.00 (t, *J* = 7.6 Hz ,1H), 7.14 - 7.20 (dd, *J* = 15.6 , 7.6 Hz , 2H), 7.26 - 7.30 (m, 2H), 7.38 - 7.41 (m, 5H), 7.61 - 7.63 (d, *J* = 8.8 Hz , 2H), 7.84 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.0, 169.2, 157.6, 144.5, 139.2, 135.8, 131.6, 129.6, 128.7, 127.7, 126.8, 124.7, 124.4, 124.2, 121.9, 109.2, 44.2, 41.8, 41.0, 23.7 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_2{}^{78.9183}BrNa^+$, ([M + Na] $^+$ ) 482.0726, found 482.0737, $C_{26}H_{22}NO_5{}^{80.9163}BrNa^+$, ([M + Na] $^+$ ) 484.0706, found 484.0725.



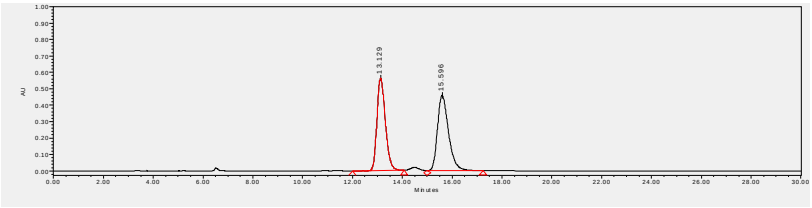
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.483 | 3128504 | 47.48 |
| 2 | 21.404 | 3460021 | 52.52 |



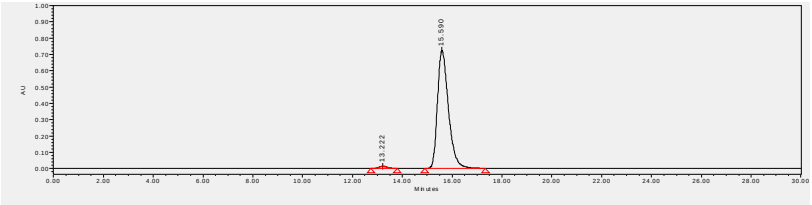
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 11.409 | 1257735 | 3.48 |
| 2 | 20.955 | 34836487 | 96.52 |



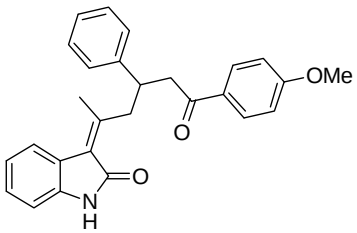
**(*R*, *Z*)-3o (Table 1, entry 15):** A yellow solid, 67% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IE, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 15.59 min, $t_r$ (minor) = 13.22 min]. $[\alpha]_D^{25} = -2.837$ (c = 0.28 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 2.32 (s, 3H), 3.19 - 3.31 (m, 2H), 3.46 - 3.52 (dd, *J* = 16.8, 6.7 Hz, 1H), 3.83 - 3.91 (m, 1H), 3.96 - 4.01 (dd, *J* = 12.4, 6.8 Hz, 1H), 6.75-6.77 (d, *J* = 7.6, 1H), 6.95 – 6.98 (t, *J* = 7.6, 1H), 7.08 - 7.18 (m, 4H), 7.24 - 7.28 (m, 2H),7.38 - 7.42 (m, 3H), 7.70 - 7.72 (d, *J* = 8.0, 2H), 8.02 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.7, 169.3, 157.6, 144.7, 143.6, 139.3, 134.7, 129.1, 128.6, 128.2, 127.9, 127.7, 126.3, 124.6, 124.4, 124.3, 121.8, 109.1, 44.4, 41.5, 40.8, 23.6, 21.7 ppm. ESI-HRMS: calcd for $C_{27}H_{25}NO_2Na^+$, ($[M + Na]^+$) 418.1778, found 418.1788.




| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.129 | 13192082 | 48.10 |
| 2 | 15.596 | 14234631 | 51.90 |

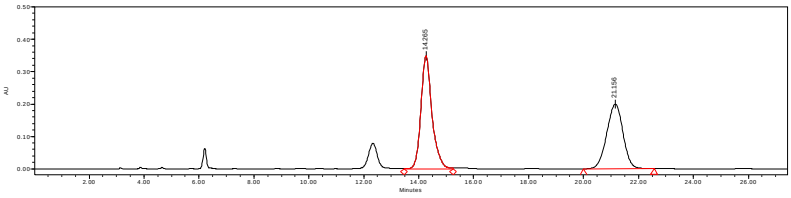



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.222 | 312151 | 1.39 |
| 2 | 15.590 | 22166699 | 98.61 |

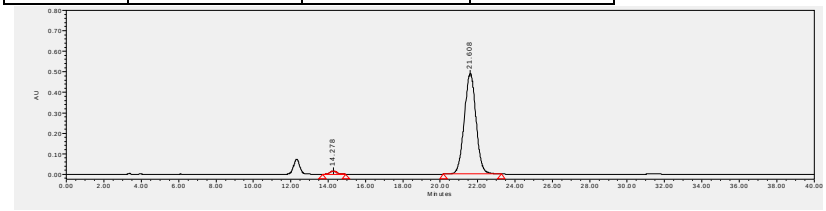


**(*Z*)-3p (Table 1, entry 16):** A yellow solid, 66% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 21.60 min, $t_r$ (minor) = 14.27 min]. $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.29 (s, 3H), 3.14 - 3.26 (m, 2H), 3.45 - 3.51 (m, 1H), 3.77 (s, 3H), 3.83 - 3.91 (m, 1H), 4.01 - 4.06 (m, 1H), 6.73 - 6.78 (m, 3H), 6.94 - 7.00 (m, 1H), 7.12 - 7.17 (m, 2H), 7.24 - 7.28 (m, 3H), 7.39 - 7.42 (m, 2H), 7.77 - 7.79 (d, 2H), 8.47 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 197.6, 169.6, 163.3, 157.7, 144.7, 139.5, 130.5, 130.3, 127.9, 127.6, 126.6, 124.7, 124.3, 121.7, 113.8, 113.5, 109.3, 55.5, 44.1, 41.6, 40.9, 23.6 ppm. ESI-HRMS: calcd for $C_{27}H_{25}NO_3Na^+$,

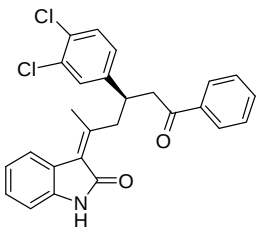
([M + Na] $^{+}$ ) 434.1727, found 434.1726.



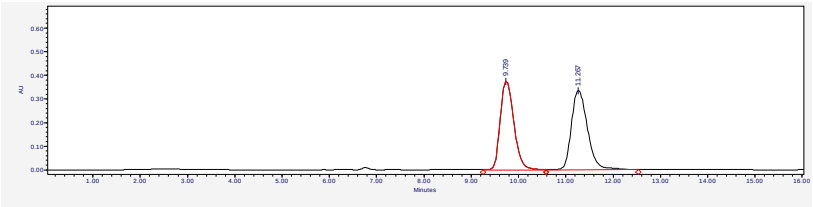
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 14.265 | 8964696 | 51.89 |
| 2 | 21.156 | 8311059 | 48.11 |



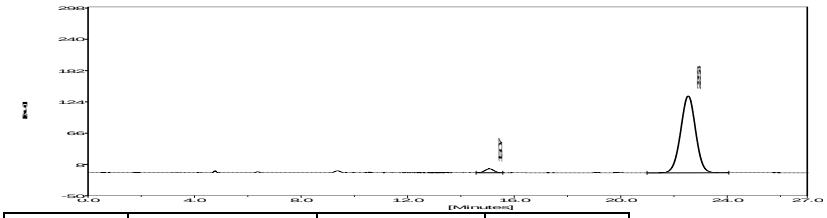
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 14.278 | 406744 | 1.85 |
| 2 | 21.608 | 21533119 | 98.15 |



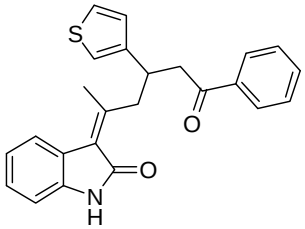
**(*R*, *Z*)-3q (Table 1, entry 17):** A yellow solid, 81% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 11.15 min, $t_r$ (minor) = 9.68 min]. $[\alpha]_D^{25} = -32.022$ (c = 0.20 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.30 (s, 3H), 3.20 - 3.33 (m, 2H), 3.47 - 3.52 (dd, *J* = 17.2, 6.0 Hz, 1H), 3.83 - 3.93 (m, 2H), 6.78 - 6.80 (d, *J* = 7.6, 1H ), 6.96 - 7.01 (t, *J* = 7.6, 1H), 7.14 - 7.18 (t, *J* = 7.6, 1H), 7.24 - 7.27 (m, 1H), 7.30 - 7.34 (m, 3H), 7.42 - 7.48 (m, 2H), 7.51 - 7.52 (m, 1H), 7.80 - 7.82 (m, 2H), 8.39 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.3, 169.5, 156.1, 144.9, 139.5, 136.8, 133.2, 132.5, 130.5, 129.8, 128.0, 127.3, 125.1, 124.4, 124.1, 121.9, 109.4, 44.1, 41.1, 39.9, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{21}NO_2{}^{34.9689}Cl_2Na^+$, ([M + Na] $^{+}$ ) 472.0842, found 472.0845, $C_{26}H_{21}NO_2{}^{36.9659}Cl_2Na^+$, ([M + Na] $^{+}$ ) 476.0783, found 476.0812 .



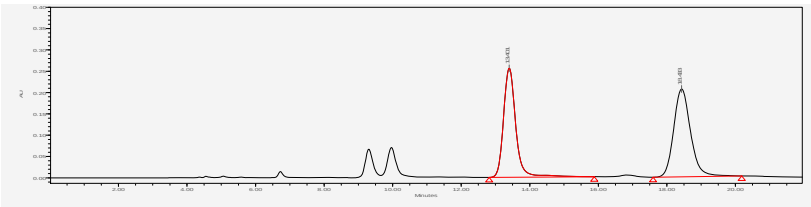
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.739 | 7522802 | 48.56 |
| 2 | 11.267 | 7970374 | 51.44 |



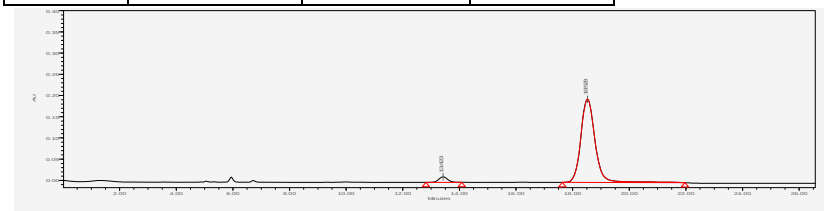
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.685 | 773491 | 8.16 |
| 2 | 11.150 | 8709973 | 91.84 |



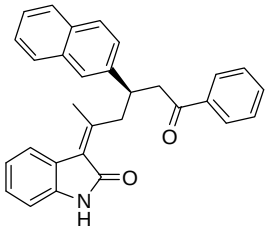
**(*Z*)-3r (Table 1, entry 18):** A yellow solid, 77% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 18.52 min, $t_r$ (minor) = 13.42 min]. $[\alpha]_D^{25} = -20.805$ (c = 0.60 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.32 (s, 3H), 3.23 - 3.28 (m, 1H), 3.35 - 3.41 (m, 1H), 3.50 - 3.56 (m, 1H), 4.01 - 4.06 (m, 1H), 4.19 - 4.22 (m, 1H), 6.77 - 6.79 (d, *J* = 7.6 Hz, 1H), 6.86 - 6.89 (m, 1H), 6.95 - 7.00 (m, 2H), 7.09 - 7.11 (m, 1H), 7.13 - 7.17 (t, *J* = 8.0 Hz, 1H), 7.29 - 7.33 (t, *J* = 7.6 Hz, 2H), 7.43 - 7.47 (m, 2H), 7.82 - 7.84 (m, 2H), 8.36 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.5, 169.4, 156.7, 148.2, 139.6, 137.0, 133.0, 128.5, 128.5, 128.1, 126.8, 124.9, 124.4, 124.2, 124.1, 123.3, 121.8, 109.4, 45.6, 42.5, 37.0, 23.5 ppm. ESI-HRMS: calcd for $C_{24}H_{21}NO_2SNa^+$, ([M + Na] $^+$ ) 410.1185, found 410.1190.



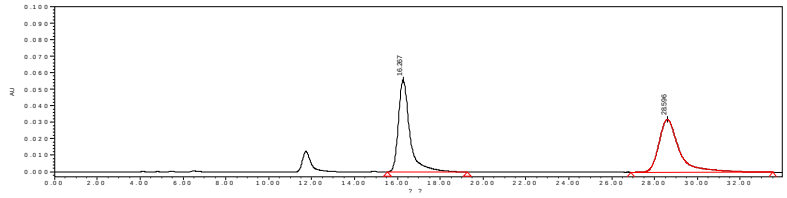
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.401 | 6342157 | 47.41 |
| 2 | 18.433 | 7034758 | 52.59 |



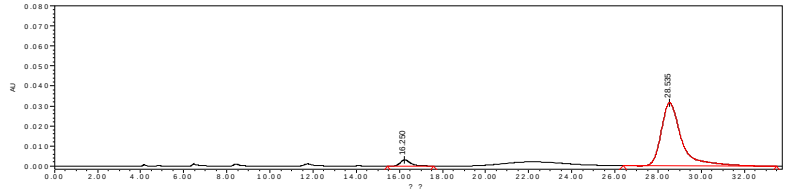
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 13.423 | 280923 | 3.90 |
| 2 | 18.523 | 6918863 | 96.10 |



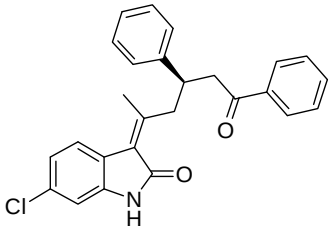
**(*R*, *Z*)-3s (Table 1, entry 19):** A yellow solid, 88% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 28.53 min, $t_r$ (minor) = 16.25 min]. $[\alpha]_D^{25}$ = −14.706 (c = 0.22 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.31 (s, 3H), 3.24 - 3.28 (dd, *J* = 12.0, 6.8 Hz, 1H), 3.37 - 3.43 (dd, *J* = 16.8, 6.8 Hz, 1H), 3.59 - 3.65 (dd, *J* = 16.8, 6.8 Hz, 1H), 4.05 - 4.16 (m, 2H), 6.76 - 6.75 (d, *J* = 7.6, 1H ), 6.94 - 6.97 (t, *J* = 7.6, 1H), 7.11 - 7.15 (t, *J* = 7.6, 1H), 7.27 - 7.31 (t, *J* = 7.6, 2H), 7.40 - 7.44 (m, 4H), 7.58 - 7.61 (dd, *J* = 8.4, 1.8 Hz, 1H), 7.77 - 7.81 (m, 6H), 7.91 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 197.0, 169.3, 157.5, 142.2, 139.3, 137.1, 133.6, 132.9, 132.5, 128.3, 128.0, 127.7, 126.2, 124.3, 121.6, 109.2, 44.5, 41.5, 40.9, 23.7 ppm. ESI-HRMS: calcd for $C_{30}H_{25}NO_2Na^+$, ($[M + Na]^+$) 454.1778, found 454.1781.



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 16.267 | 2070556 | 49.40 |
| 2 | 28.596 | 2121236 | 50.60 |

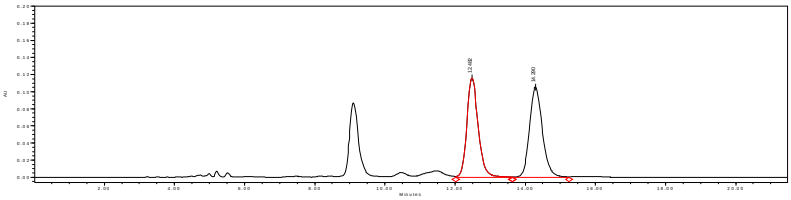


| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 16.250 | 98151 | 4.53 |
| 2 | 28.535 | 2068299 | 95.47 |

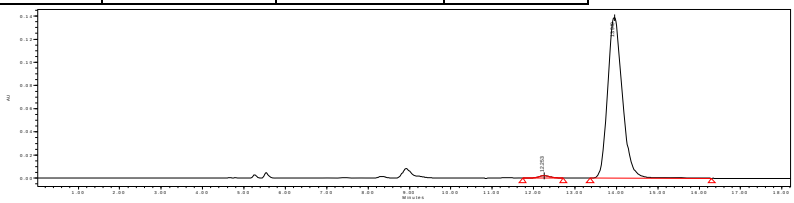


**(*R*, *Z*)-3t (Table 1, entry 20):** A yellow solid, 88% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 13.94 min, $t_r$ (minor) = 12.25 min]. $[\alpha]_D^{25}$ = −4.348 (c = 0.20 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.30 (s, 3H), 3.20 - 3.24 (m, 1H), 3.31 - 3.37(dd, *J* = 17.2, 5.2 Hz, 1H), 3.51 - 3.56 (dd, *J* = 17.2, 5.2 Hz, 1H), 3.91 - 4.01 (m, 2H), 6.76 - 6.78 (d, *J* = 7.6, 1H), 6.97 - 7.01 (t, *J* = 7.6, 1H), 7.14 - 7.18 (t, *J* = 7.6, 1H), 7.31 - 7.34 (t, *J* = 7.6, 2H), 7.42 - 7.48 (m, 2H), 7.52 (s, 4H), 7.80 - 7.82 (d, *J* = 7.6, 2H), 7.98 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.5, 168.9, 156.4, 148.7, 143.0, 139.3, 136.9, 133.1, 128.8, 128.6, 128.2, 128.1, 125.6, 124.9, 124.4, 124.1, 121.9, 109.3, 44.1, 41.2,

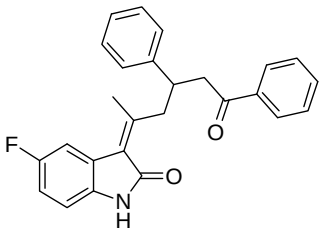
40.4, 23.5 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_2{}^{34.9689}ClNa^+$, ([M + Na] $^+$ ) 438.1231, found 438.1230, $C_{26}H_{22}NO_2{}^{36.9659}ClNa^+$, ([M + Na] $^+$ ) 440.1202, found 440.1227.



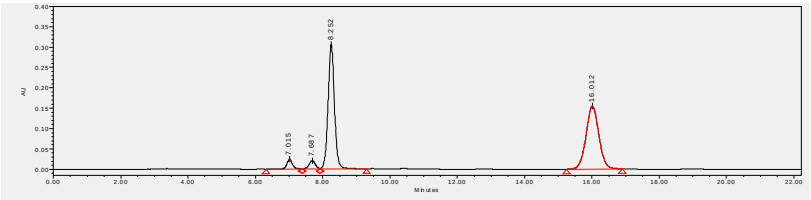
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 12.482 | 2613701 | 49.17 |
| 2 | 14.290 | 2702127 | 50.83 |



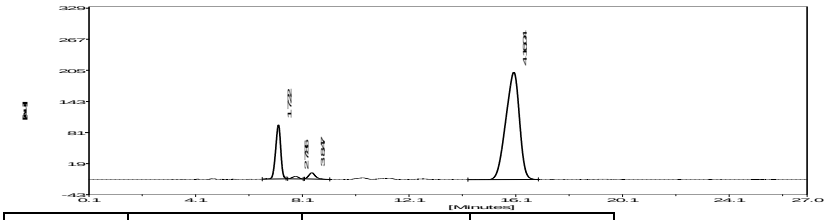
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 12.253 | 42445 | 1.23 |
| 2 | 13.949 | 3420723 | 98.77 |



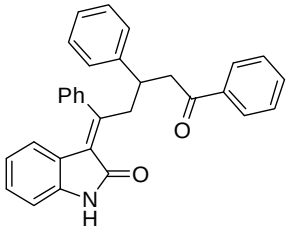
**(*Z*)-3u (Table 1, entry 21):** A yellow solid, 84% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 16.04 min, $t_r$ (minor) = 8.47 min]. $[\alpha]_D^{25} = -1.200$ (c = 0.46 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 2.26 (s, 3H), 3.17 - 3.22 (m, 1H), 3.25 - 3.31 (m, 1H), 3.53 - 3.59 (m, 1H), 3.87 - 3.91 (m, 1H), 3.98 - 4.03 (m, 1H), 6.65 - 6.68 (m, 1H), 6.83 - 6.87 (m, 1H), 7.13 - 7.19 (m, 2H), 7.26 - 7.32 (m, 5H), 7.38 - 7.44 (m, 3H), 7.80 - 7.82 (d, 2H), 8.40 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 198.9, 169.6, 159.7, 159.5, 157.4, 144.5, 137.1, 135.4, 133.0, 128.7, 128.0, 126.8, 125.1, 124.6, 114.2, 114.0, 111.8, 109.5, 109.4, 44.5, 41.7, 40.8, 23.6 ppm. ESI-HRMS: calcd for $C_{26}H_{22}NO_2FNa^+$, ([M + Na] $^+$ ) 422.1527, found 422.1533.



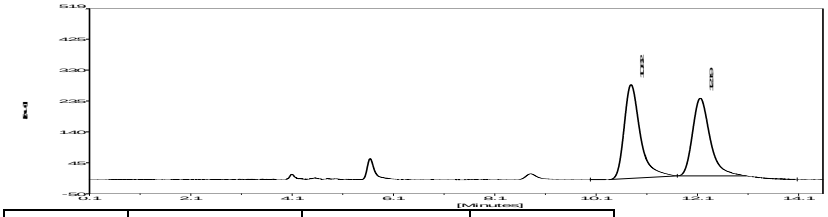
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 7.015 | 289315 | 3.33 |
| 2 | 7.687 | 268782 | 3.09 |
| 3 | 8.252 | 4042197 | 46.50 |
| 4 | 16.012 | 4093498 | 47.09 |



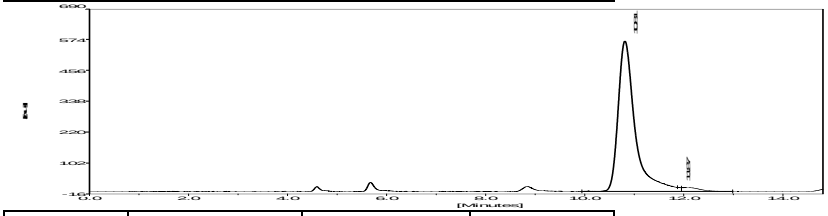
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 7.22 | 1433.99 | 15.3334 |
| 2 | 7.86 | 80.74 | 0.8633 |
| 3 | 8.47 | 216.05 | 2.3102 |
| 4 | 16.04 | 7621.25 | 81.4930 |



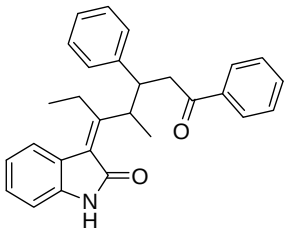
**(*Z*)-3v (Table 1, entry 22):** A yellow solid, 84% isolated yield of *Z*/*E* products. The ee was determined by HPLC analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 11.87 min, $t_r$ (minor) = 10.81 min]. $[\alpha]_D^{25}$ = 48.024 (c = 0.65 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 3.33 - 3.56 (m, 3H), 3.93 - 3.95(m, 2H), 5.99 - 6.01 (d, *J* = 7.6 Hz, 1H), 6.53 - 6.57 (t, *J* = 7.6 Hz, 1H), 6.76 - 6.78 (d, *J* = 7.6 Hz, 1H), 6.96 - 7.04 (m, 2H), 7.09 - 7.13 (m, 1H), 7.18 - 7.21 (m, 2H), 7.24 - 7.27 (m, 2H), 7.32 - 7.34 (m, 2H), 7.40 - 7.48 (m, 4H), 7.81 - 7.83 (d, *J* = 7.6 Hz, 2H), 8.74 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.1, 170.1, 158.0, 144.1, 139.7, 137.2, 133.0, 128.5, 128.1, 128.0, 127.3, 127.2, 126.6, 125.4, 123.5, 121.5, 109.3, 45.3, 39.8, 39.2 ppm. ESI-HRMS: calcd for $C_{31}H_{25}NO_2Na^+$, ($[M + Na]^+$) 466.1778, found 466.1786.



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.82 | 10870509 | 51.05 |
| 2 | 12.19 | 10423169 | 48.95 |

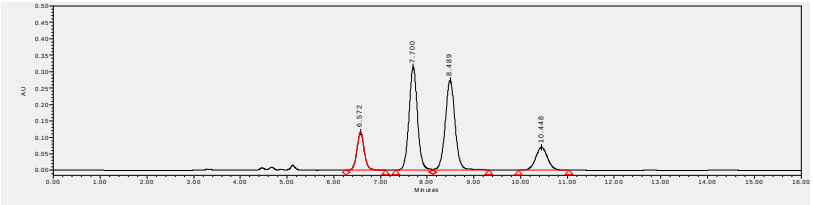


| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 10.81 | 13642.91 | 96.8661 |
| 2 | 11.87 | 441.39 | 3.1339 |

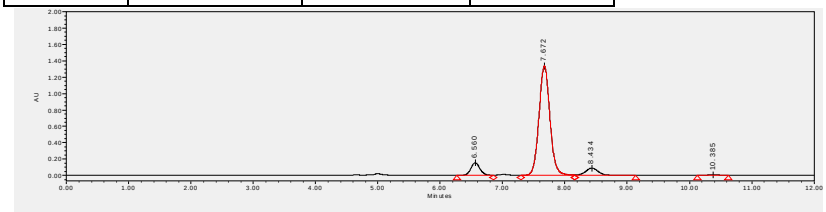


**(*Z*)-3w (Table 1, entry 23):** A yellow solid, 71% isolated yield of *Z*/*E* products. The ee was determined by HPLC

analysis [Chiralpak IA, 70:30 *n*-hexane/*i*PrOH, 1.0 mL/min; $t_r$ (major) = 7.67 min, $t_r$ (minor) = 8.43 min]. $[\alpha]_D^{25}$ = 53.807 (c = 0.40 in $CH_2Cl_2$). $^1$H NMR (400 MHz, $CDCl_3$) δ = 1.13 - 1.17 (t, *J* = 7.6 Hz, 3H), 1.32 - 1.34 (d, *J* = 6.8 Hz 3H), 2.41 - 2.48 (m, 1H), 2.58 - 2.64 (m, 1H), 3.39 - 3.51 (m, 2H), 3.68 - 3.74 (m, 1H), 5.48 - 5.56 (m, 1H), 6.77 - 6.79 (d, *J* = 8.0 Hz, 1H), 6.90 - 6.96 (d, 2H), 7.02 - 7.06 (t, *J* = 7.2 Hz, 2H), 7.10 - 7.13 (t, *J* = 7.2 Hz, 1H), 7.24 - 7.26 (m, 3H), 7.37 - 7.40 (t, *J* = 8.0 Hz, 2H), 7.48 - 7.51 (t, *J* = 7.6 Hz, 1H), 7.84 - 7.86 (d, *J* = 7.2 Hz, 2H), 8.17 (s, 1H) ppm.$^{13}$C NMR (100 MHz, $CDCl_3$) δ = 199.4, 169.8, 168.8, 143.6, 137.4, 133.0, 128.5, 128.2, 128.1, 127.7, 126.4, 124.3, 123.6, 123.3, 121.8, 109.1, 45.4, 44.4, 38.7, 23.8, 17.6, 13.4 ppm. ESI-HRMS: calcd for $C_{28}H_{27}NO_2Na^+$, ([M + Na] $^+$ ) 432.1934, found 432.1940.

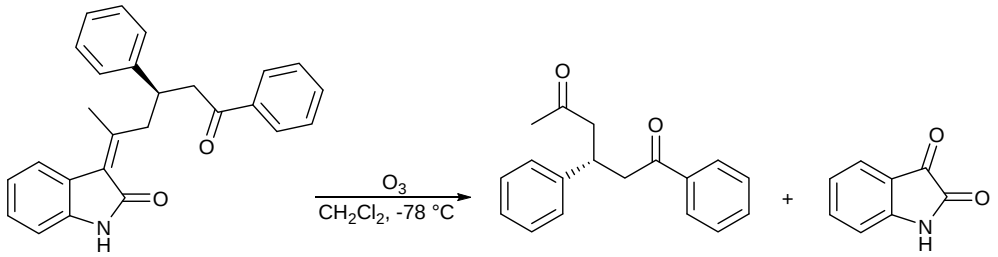



| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 6.572 | 1255275 | 11.99 |
| 2 | 7.700 | 3985548 | 38.08 |
| 3 | 8.489 | 3989355 | 38.12 |
| 4 | 10.448 | 1235879 | 11.81 |




| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 6.560 | 1594200 | 8.30 |
| 2 | 7.672 | 16335267 | 85.00 |
| 3 | 8.434 | 1197072 | 6.23 |
| 4 | 10.385 | 90802 | 0.47 |

## 5. Determination of Absolute Configurations of the Products 3a

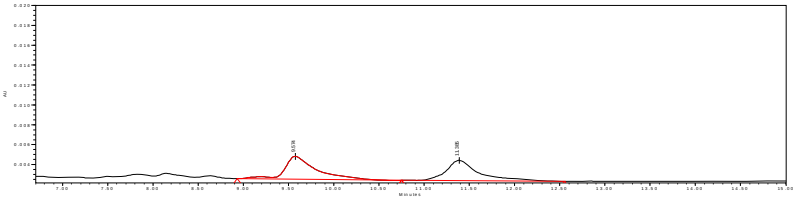



**3a** **4a** **5a**

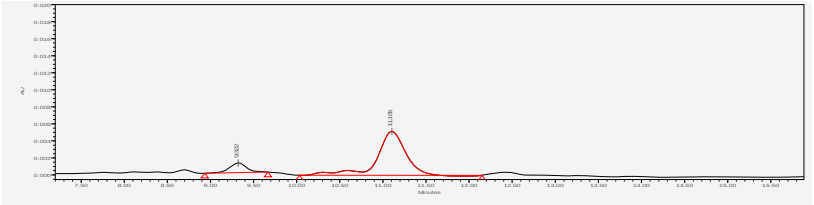
To a stirred solution of **3a** (19.1 mg, 0.05 mmol) in dichloromethane (10 mL) under

ozone atmosphere. The reaction mixture was stirred for indicated time at −78 °C. After completion of the reaction, added $PPh_3$ to quench the reaction, the resulting solution was concentrated in vacuo and the obtained residue was purified by flash chromatography (petroleum ether/ethyl acetate, 8:1) to afford adduct **4a** with 73% yield.

The $^1H$ NMR spectrum of **4a** was consistent with the literature data. [4] The enantiomers of **4a** were analyzed by chiral phase HPLC using IC column at 254 nm (2-propanol : hexane = 20 : 80), flow rate = 1.0 mL/min, $t_r$ (major) = 11.11 min, $t_r$ (minor) = 9.32 min, *ee* = 85%, $[\alpha]_D^{27} = -12.54$ (c = 0.27, in $CHCl_3$). ( literature 4 : IC column at 254 nm (2-propanol : hexane = 20 : 80), 1.0 mL/min, $t_r$ (major) = 12.5 min, $t_r$ (minor) = 11.6 min, *ee* = 95%, $[\alpha]_D^{25} = -10.3$ (c = 1.00, in $CHCl_3$) .

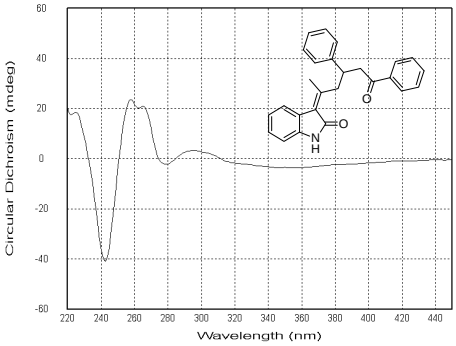


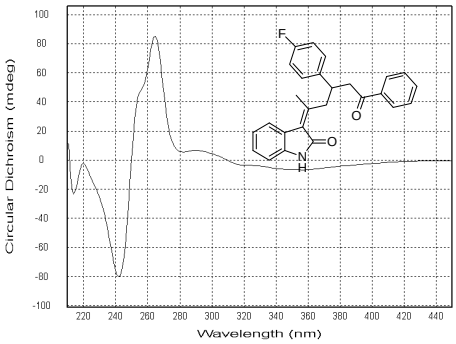
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.574 | 57944 | 53.05 |
| 2 | 11.385 | 51277 | 46.95 |

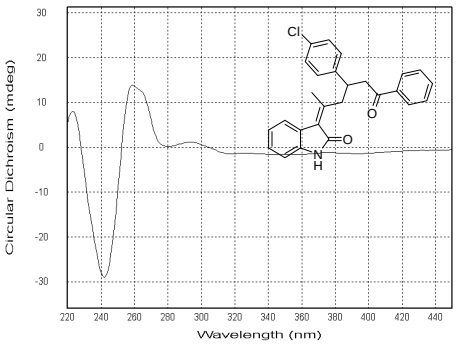


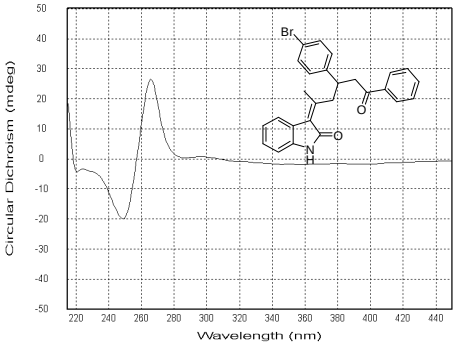
| Peak | Retention Time | Area | % Area |
|---|---|---|---|
| 1 | 9.322 | 9823 | 7.43 |
| 2 | 11.105 | 122375 | 92.57 |

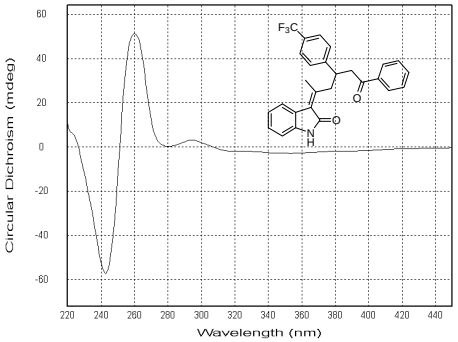
## 6. CD spectra of the products 3

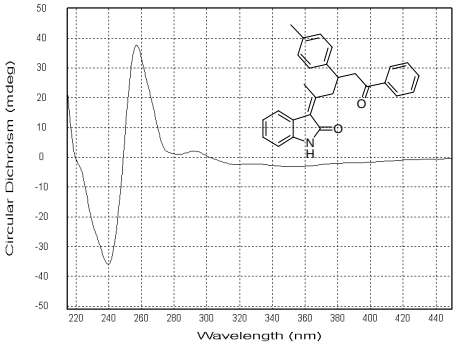


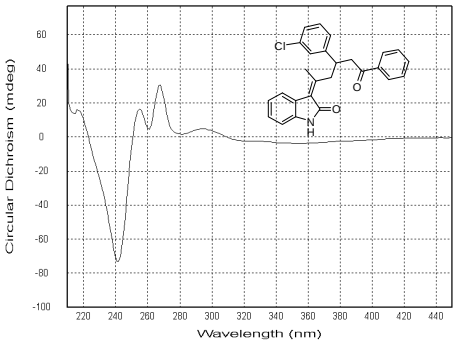



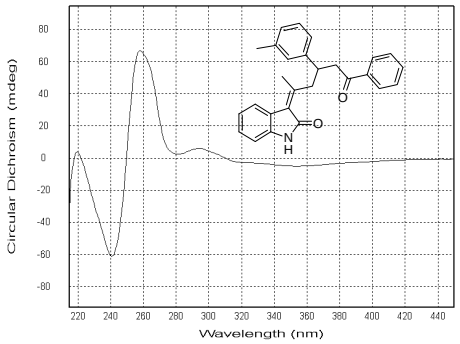

Cl
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

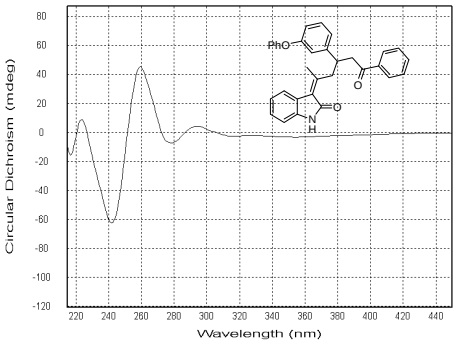

Br
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

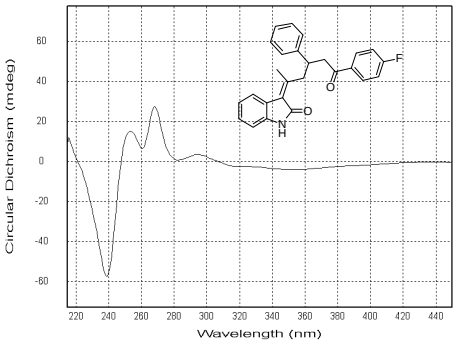

F3C
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

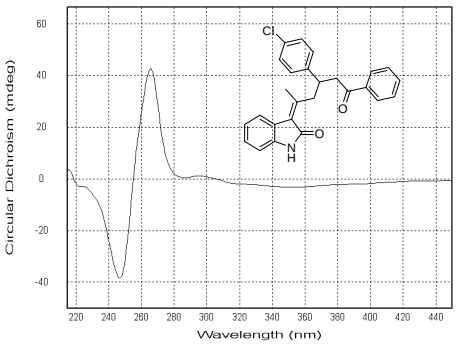

O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

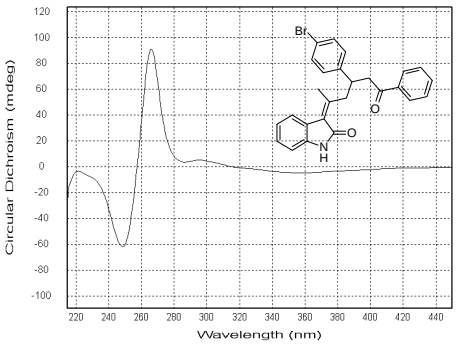

Cl
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

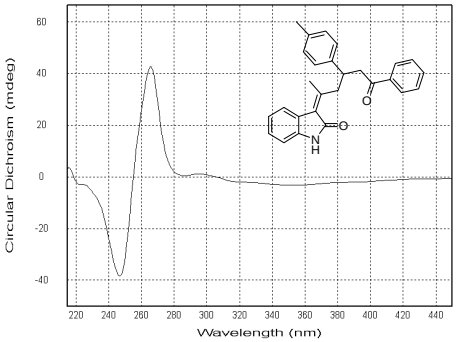

O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

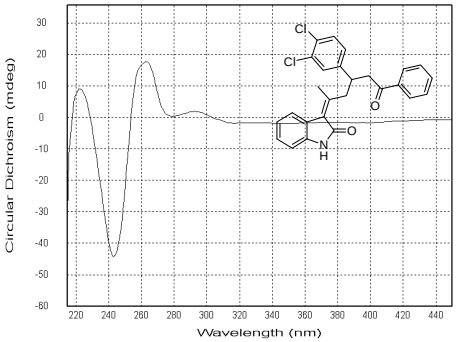

PhO
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

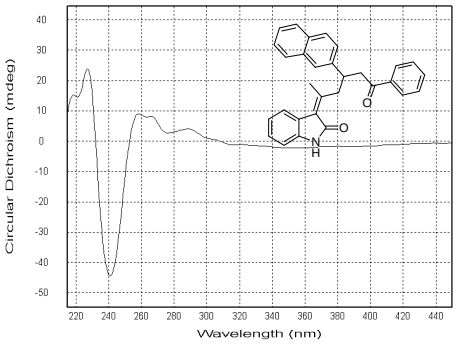

F
O
N
H
O
Circular Dichroism (mdeg)
Wavelength (nm)

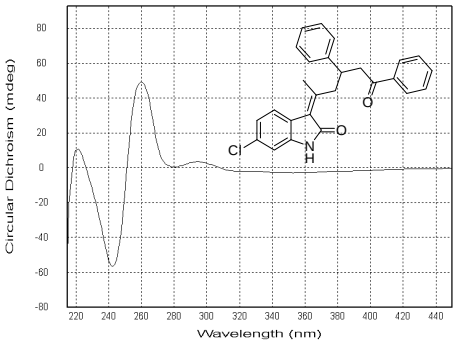


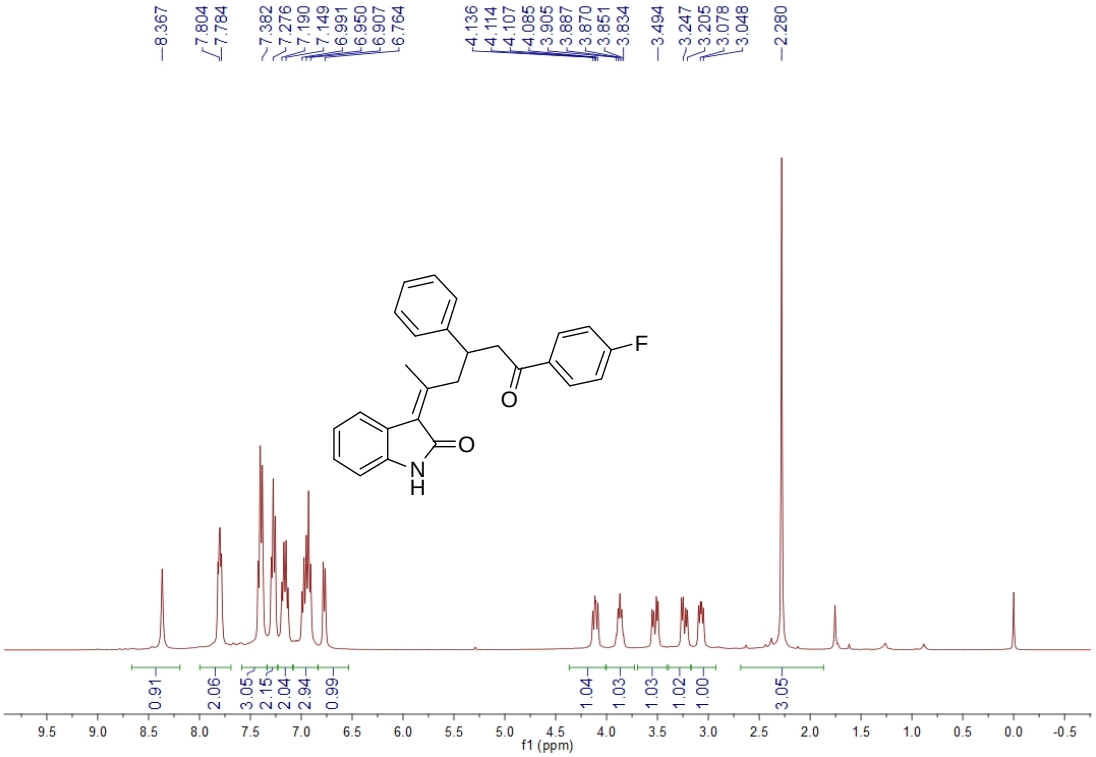



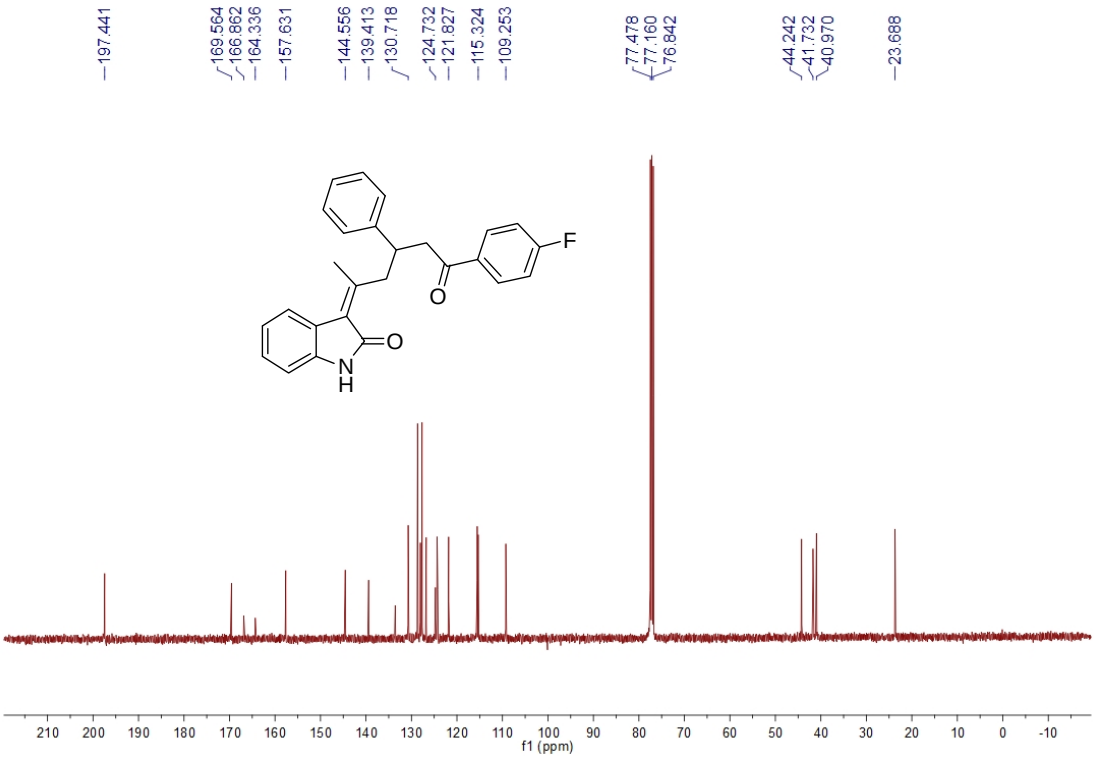



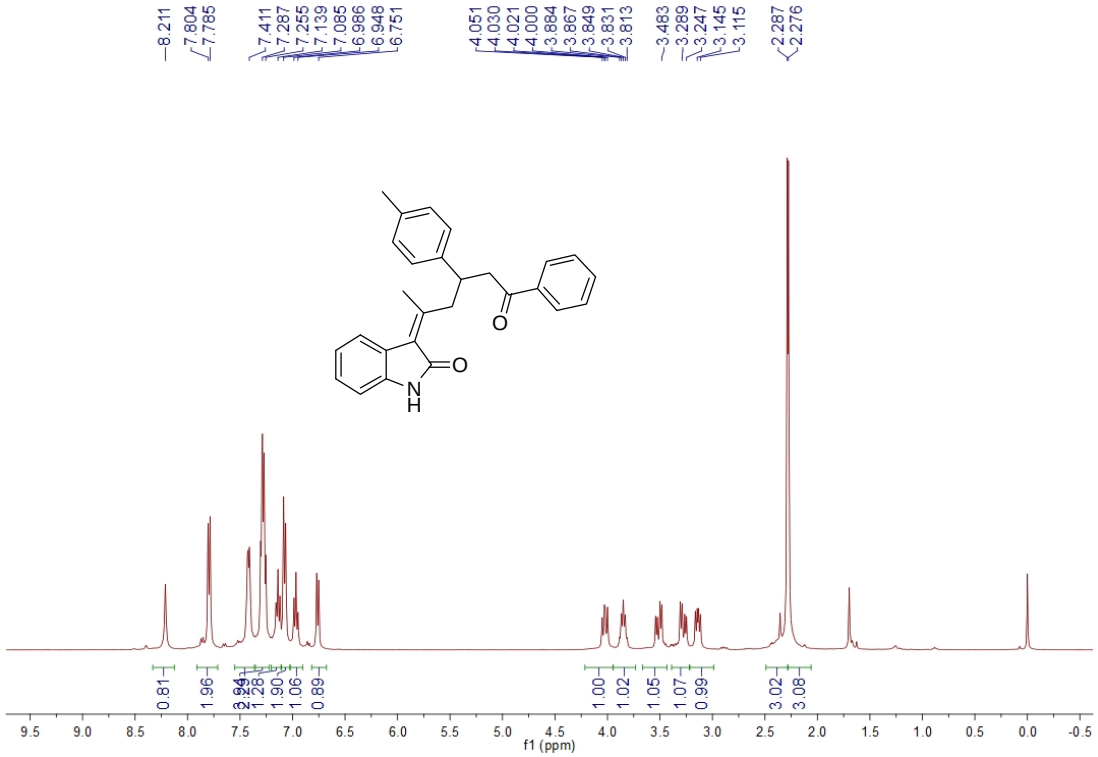

## 6. References:

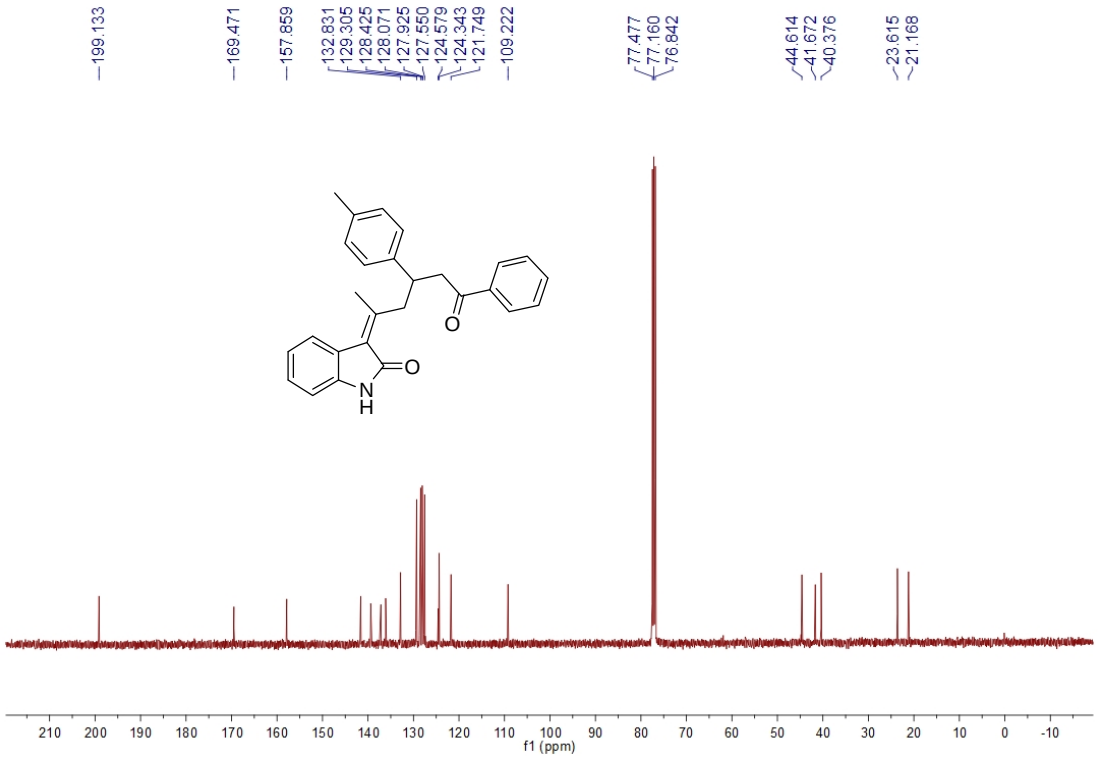

1. C. Curti, G . Rassu, V. Zambrano, L. Pinna, A. Sartori, L. Battistini, F. Zanardi, G. Casiraghi, *Angew. Chem. Int. Ed.* 2012, **51**, 6200-6204.
2. D. H. Chen, Z. L. Chen, X. Xiao, Z. G. Yang, X. H. Liu, L. L. Lin, X. M. Feng, *Chem. Eur. J.* 2009, **12**, 6807-6810.
3. (a) Y. H. Wen, X. Huang, J. L. Huang, Y. Xiong, B. Qin, X. M. Feng, *Synlett* 2005, 2445-2448.
   (b) J. L. Huang, J. Wang, X. H. Chen, Y. H. Wen, X. H. Liu, X. M. Feng, *Adv. Synth. Catal.* 2008, **350**, 287-294.
4. Y. K. Kang, H. J. Lee, H. W. Moon, D. Y. Kim, Y. K. Yang, H. J. Lee, *RSC Adv.* 2013, **3**, 1332–1335.

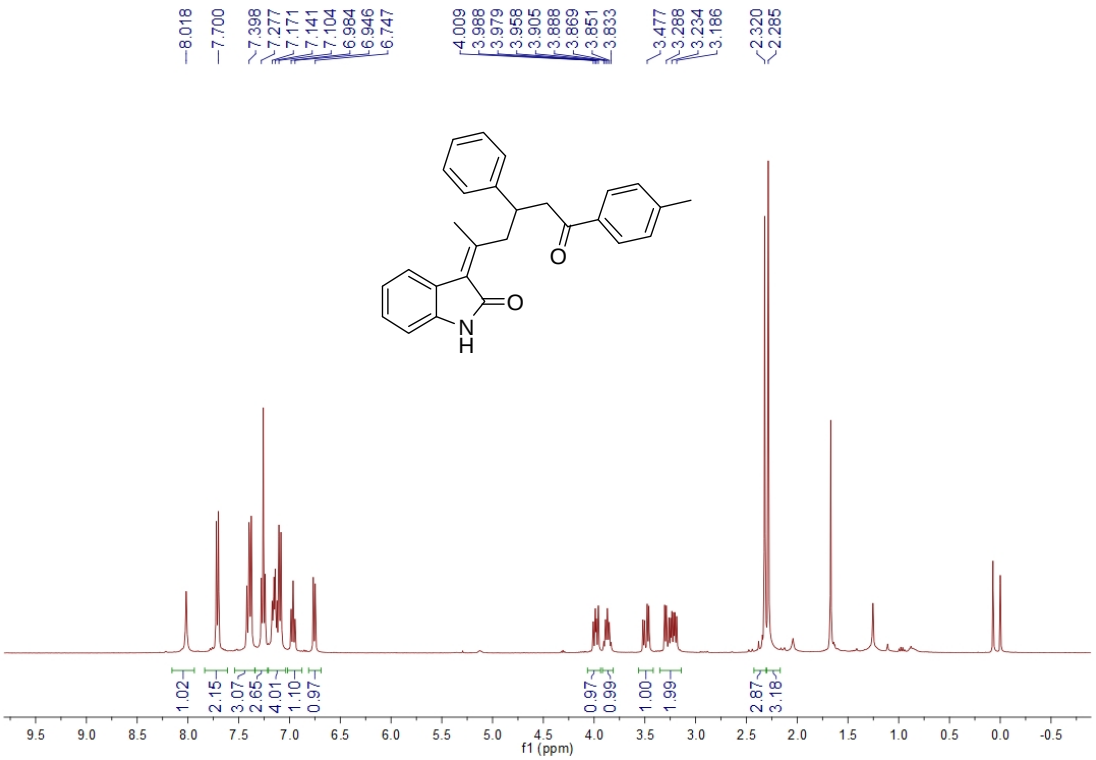

## 7. Copy of $^{1}$H NMR and $^{13}$C NMR spectra for products:

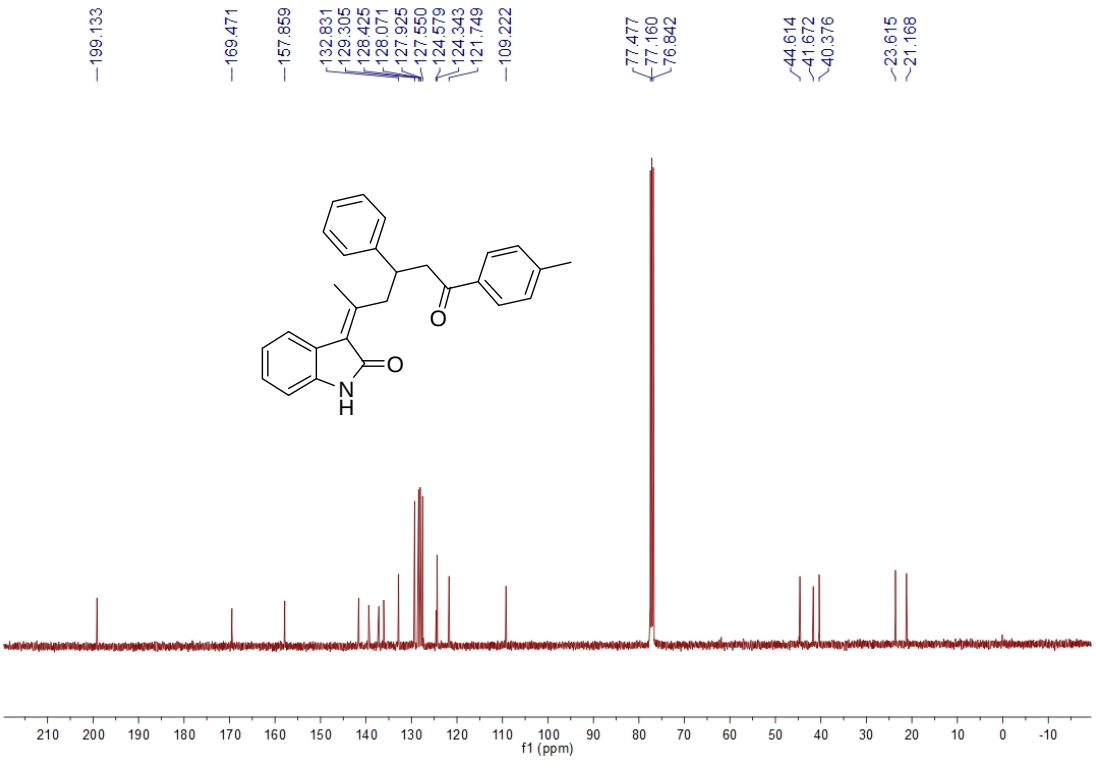

8.367
7.804
7.784
7.382
7.276
7.190
7.149
6.991
6.950
6.907
6.764
4.136
4.114
4.107
4.085
3.905
3.887
3.870
3.851
3.834
3.494
3.247
3.205
3.078
3.048
2.280
F
O
O
N
H
0.91
2.06
3.05
2.15
2.04
2.94
0.99
1.04
1.03
1.03
1.02
1.00
3.05
f1 (ppm)

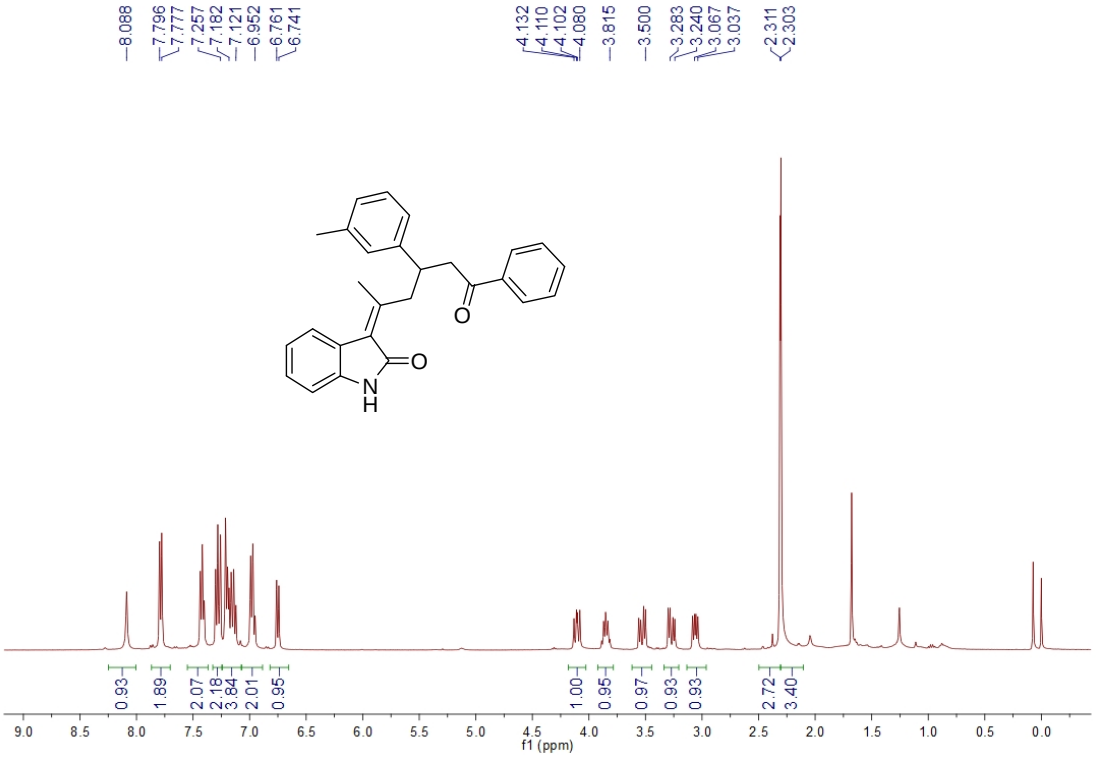

197.441
169.564
166.862
164.336
157.631
144.556
139.413
130.718
124.732
121.827
115.324
109.253
77.478
77.160
76.842
44.242
41.732
40.970
23.688
F
O
O
N
H
f1 (ppm)

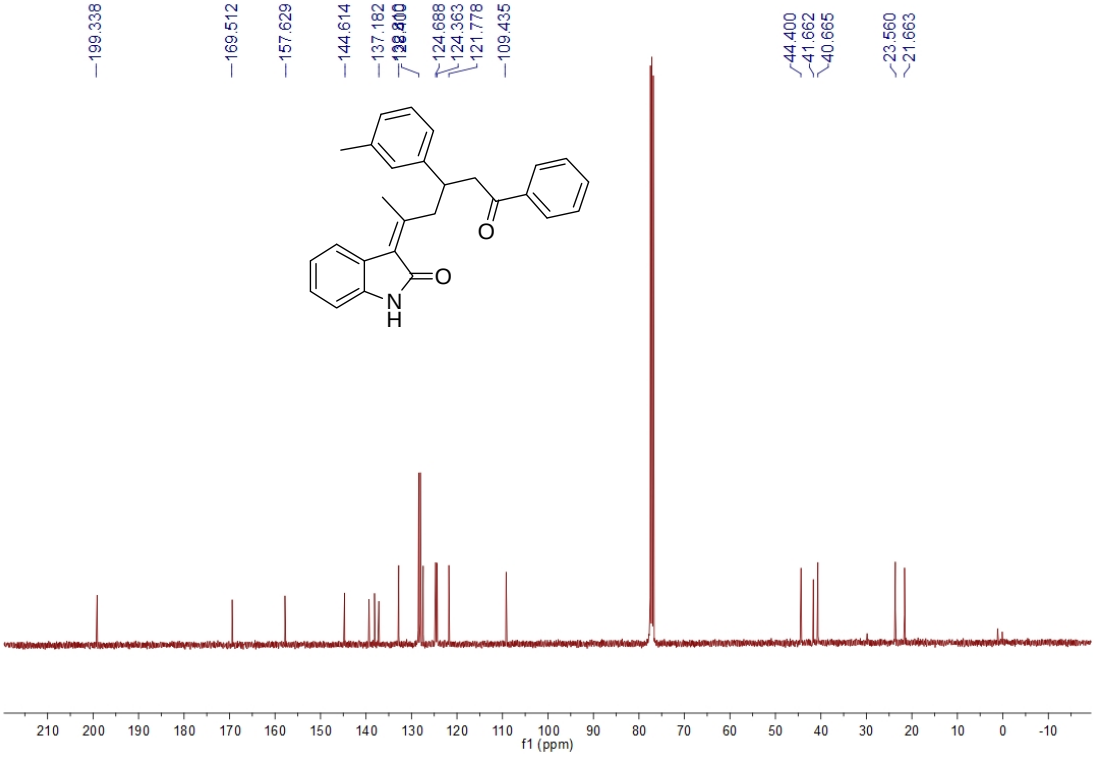

8.211
7.804
7.785
7.411
7.287
7.255
7.139
7.085
6.986
6.948
6.751
4.051
4.030
4.021
4.000
3.884
3.867
3.849
3.831
3.813
3.483
3.289
3.247
3.145
3.115
2.287
2.276
O
O
N
H
0.81
1.96
1.28
1.90
1.06
0.89
1.00
1.02
1.05
1.07
0.99
3.02
3.08
f1 (ppm)

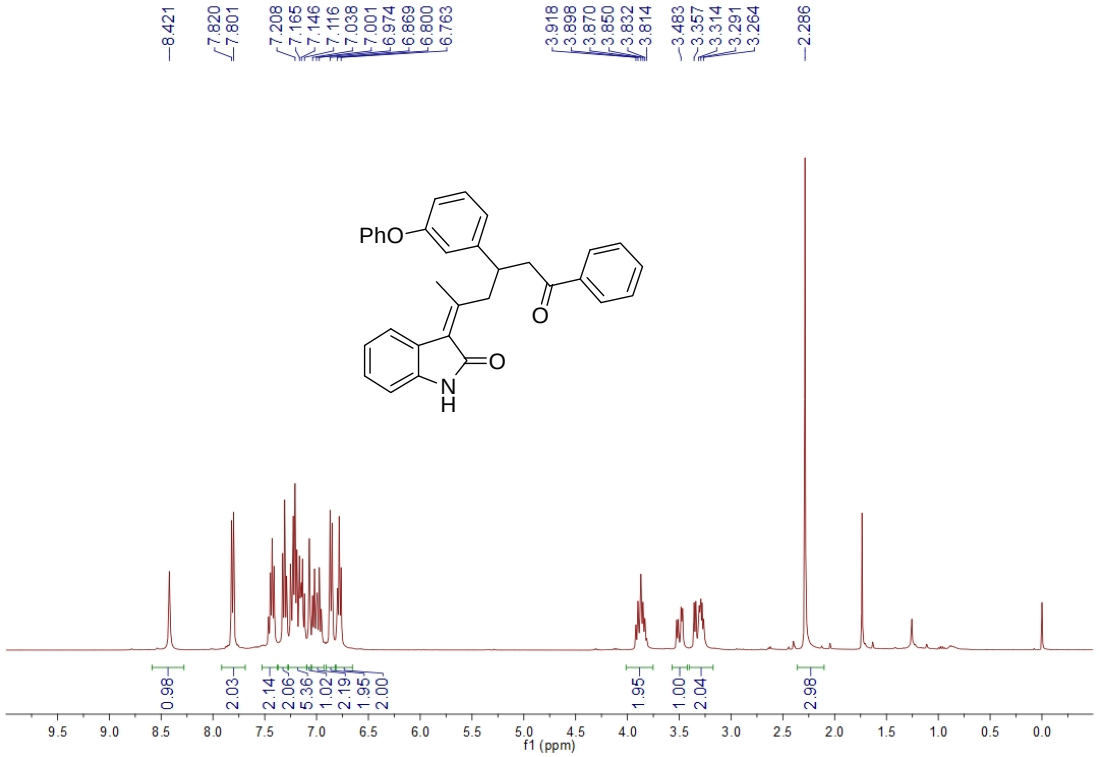

199.133
169.471
157.859
132.831
129.305
128.425
128.071
127.925
127.550
124.579
124.343
121.749
109.222
77.477
77.160
76.842
44.614
41.672
40.376
23.615
21.168
O
O
N
H
f1 (ppm)

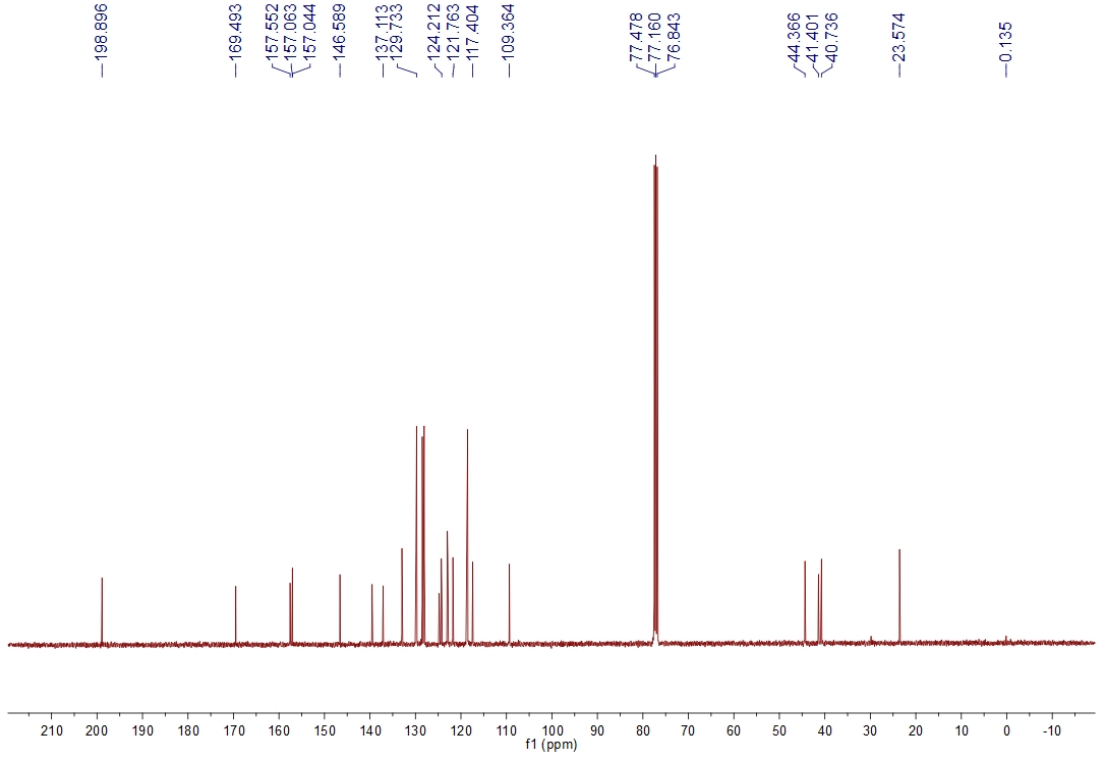

8.018
7.700
7.398
7.277
7.171
7.141
7.104
6.984
6.946
6.747
4.009
3.988
3.979
3.958
3.905
3.888
3.869
3.851
3.833
3.477
3.288
3.234
3.186
2.320
2.285
O
O
N
H
1.02
2.15
3.07
2.65
4.01
1.10
0.97
0.97
0.99
1.00
1.99
2.87
3.18
f1 (ppm)

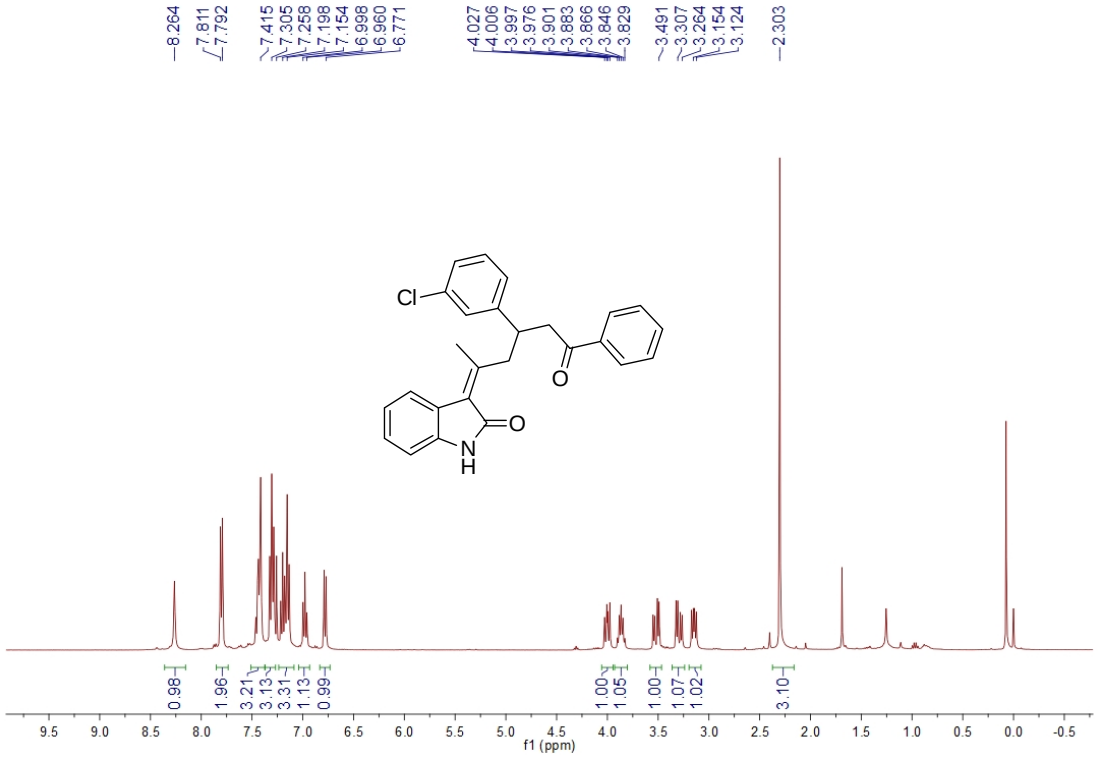

199.133
169.471
157.859
132.831
129.305
128.425
128.071
127.925
127.550
124.579
124.343
121.749
109.222
77.477
77.160
76.842
44.614
41.672
40.376
23.615
21.168
O
O
N
H
f1 (ppm)


8.088
7.796
7.777
7.257
7.182
7.121
6.952
6.761
6.741
4.132
4.110
4.102
4.080
3.815
3.500
3.283
3.240
3.067
3.037
2.311
2.303
O
O
N
H
0.93
1.89
2.07
2.18
3.84
2.01
0.95
1.00
0.95
0.97
0.93
0.93
2.72
3.40
f1 (ppm)


199.338
169.512
157.629
144.614
137.182
124.688
124.363
121.778
109.435
44.400
41.662
40.665
23.560
21.663
O
O
N
H
f1 (ppm)


8.421
7.820
7.801
7.208
7.165
7.146
7.116
7.038
7.001
6.974
6.869
6.800
6.763
3.918
3.898
3.870
3.850
3.832
3.814
3.483
3.357
3.314
3.291
3.264
2.286
PhO
O
O
N
H
0.98
2.03
2.14
2.06
5.36
1.02
2.19
1.95
2.00
1.95
1.00
2.04
2.98
f1 (ppm)


198.896
169.493
157.552
157.063
157.044
146.589
137.113
129.733
124.212
121.763
117.404
109.364
77.478
77.160
76.843
44.366
41.401
40.736
23.574
0.135
f1 (ppm)


8.264
7.811
7.792
7.415
7.305
7.258
7.198
7.154
6.998
6.960
6.771
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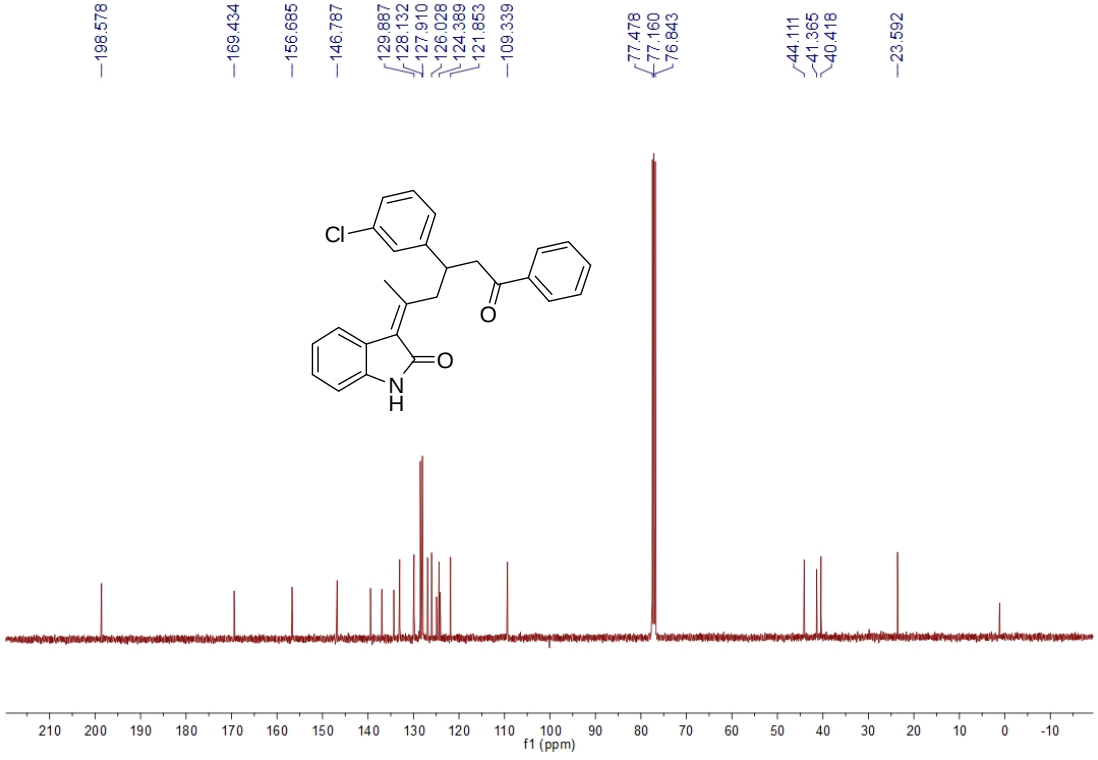
4.006
3.997
3.976
3.901
3.883
3.866
3.846
3.829
3.491
3.307
3.264
3.154
3.124
2.303
Cl
O
O
N
H
0.98
1.96
3.21
3.13
3.31
1.13
0.99
1.00
1.05
1.00
1.07
1.02
3.10
f1 (ppm)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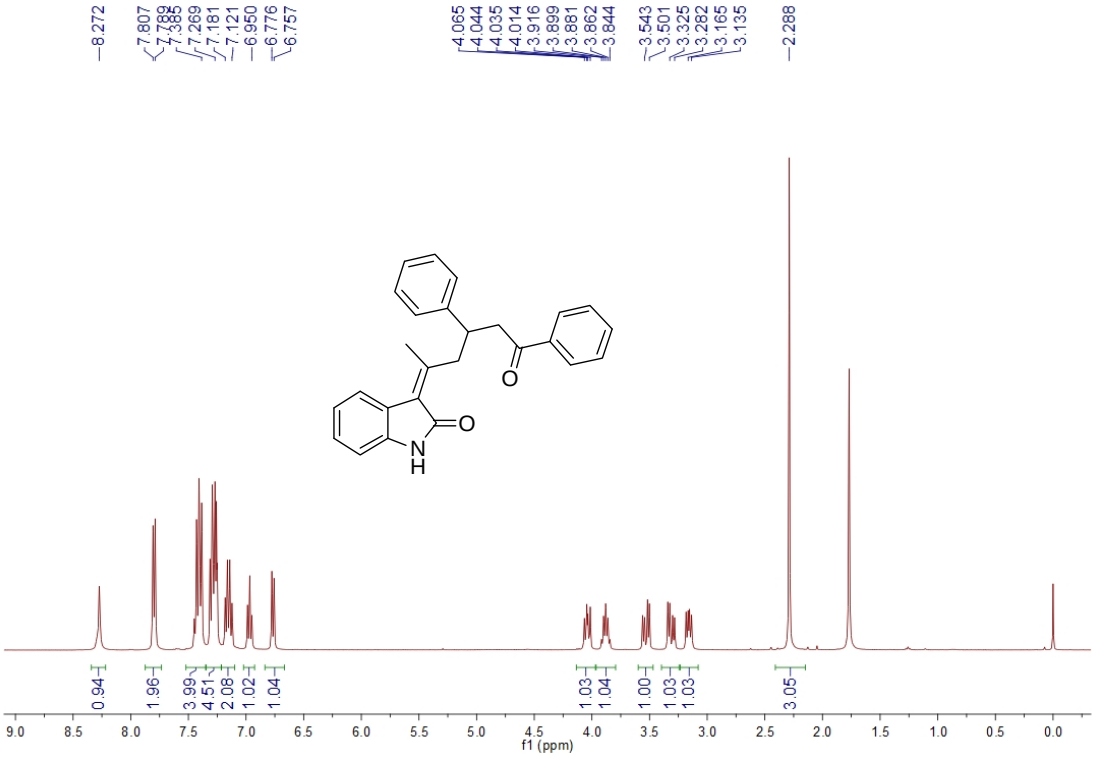
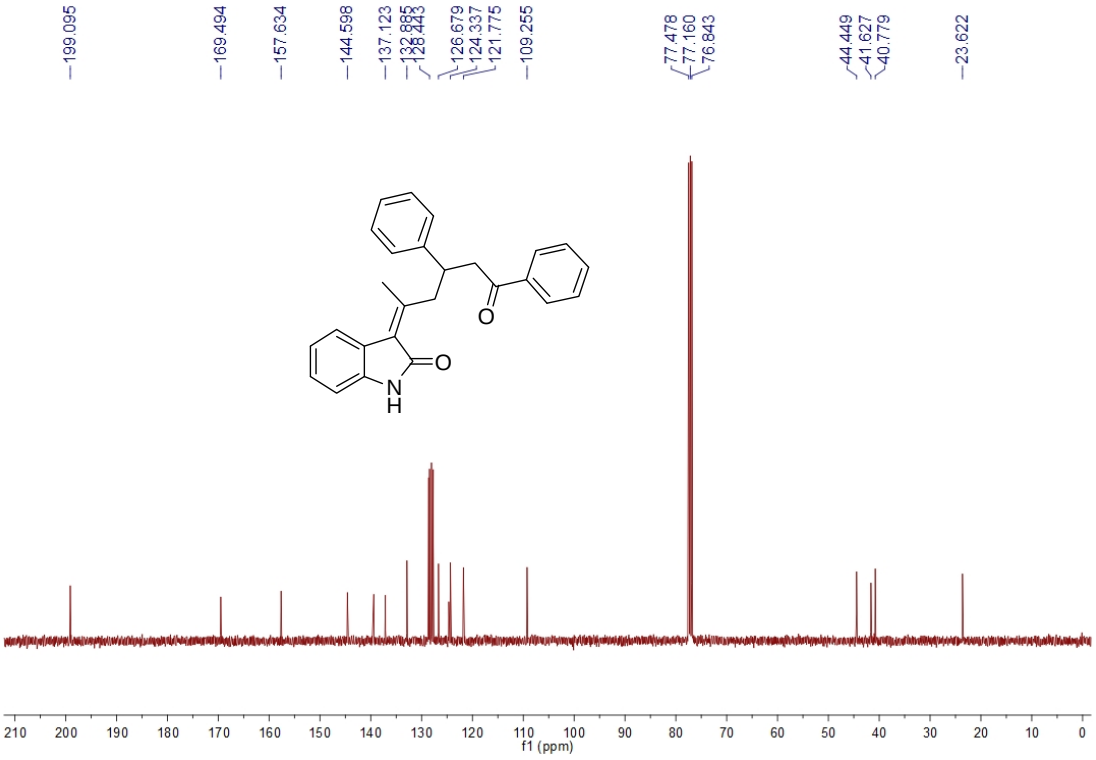
156.685
146.787
129.887
128.132
127.910
126.028
124.389
121.853
109.339
77.478
77.160
76.843
44.111
41.365
40.418
23.592
Cl
O
O
N
H
f1 (ppm)


8.272
7.807
7.269
7.181
7.121
6.950
6.776
6.757
4.065
4.044
4.035
4.014
3.916
3.899
3.881
3.862
3.844
3.543
3.501
3.325
3.282
3.165
3.135
2.288
O
O
N
H
0.94
1.96
3.99
4.51
2.08
1.02
1.04
1.03
1.04
1.00
1.03
1.03
3.05
f1 (ppm)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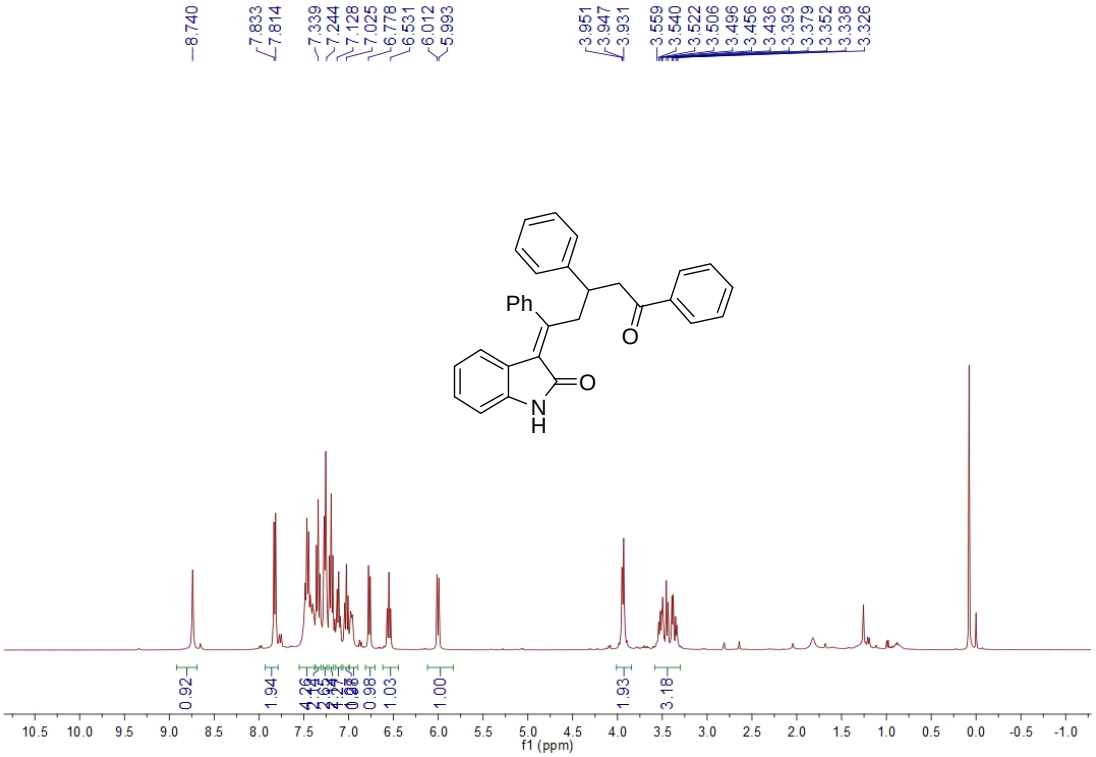
169.494
157.634
144.598
137.123
132.885
128.443
126.679
124.337
121.775
109.255
77.478
77.160
76.843
44.449
41.627
40.779
23.622
O
O
N
H
f1 (ppm)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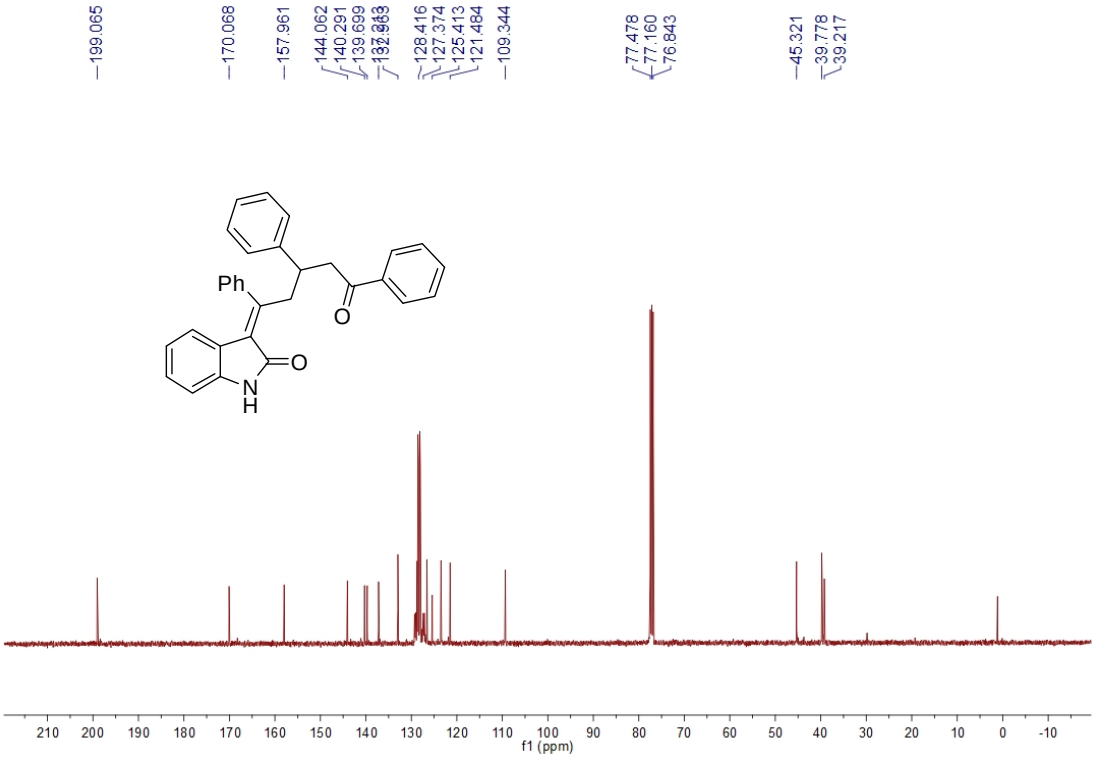
7.833
7.814
7.339
7.244
7.128
7.025
6.778
6.531
6.012
5.993
3.951
3.947
3.931
3.559
3.540
3.522
3.506
3.496
3.456
3.436
3.393
3.379
3.352
3.338
3.326
Ph
O
O
N
H
0.92
1.94
1.03
1.00
1.93
3.18
f1 (ppm)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170.068
157.961
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140.291
139.699
128.416
127.374
125.413
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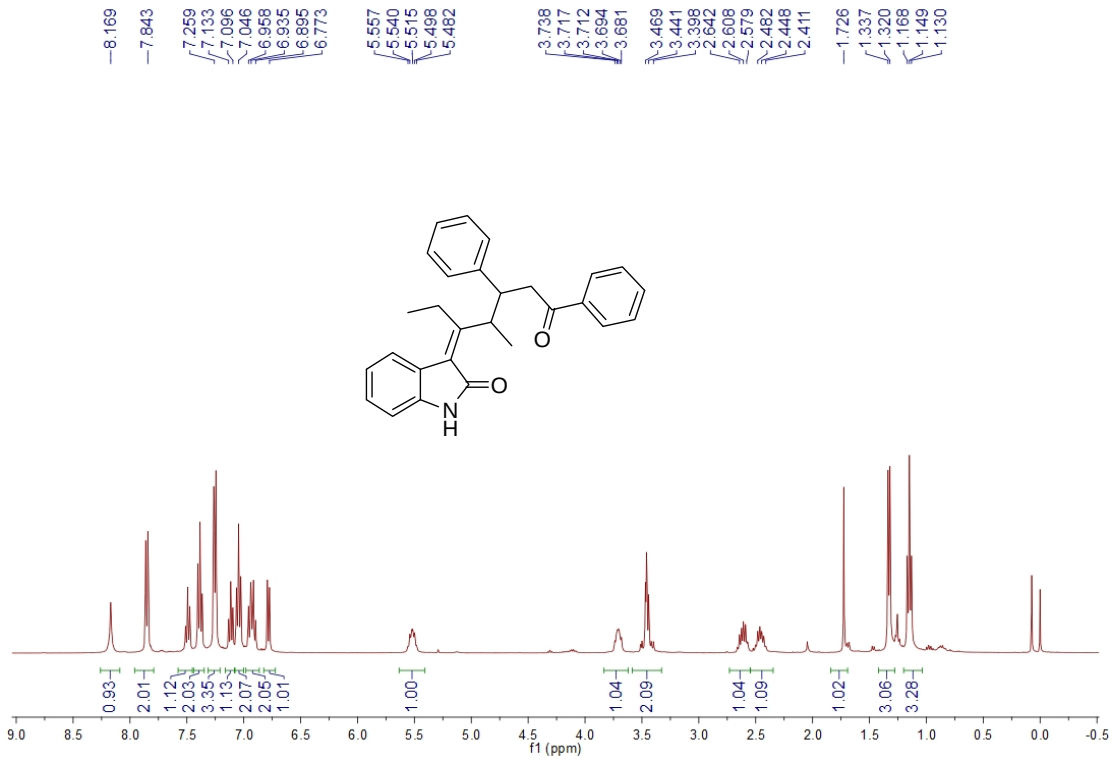
109.344
77.478
77.160
76.843
45.321
39.778
39.217
Ph
O
O
N
H
f1 (ppm)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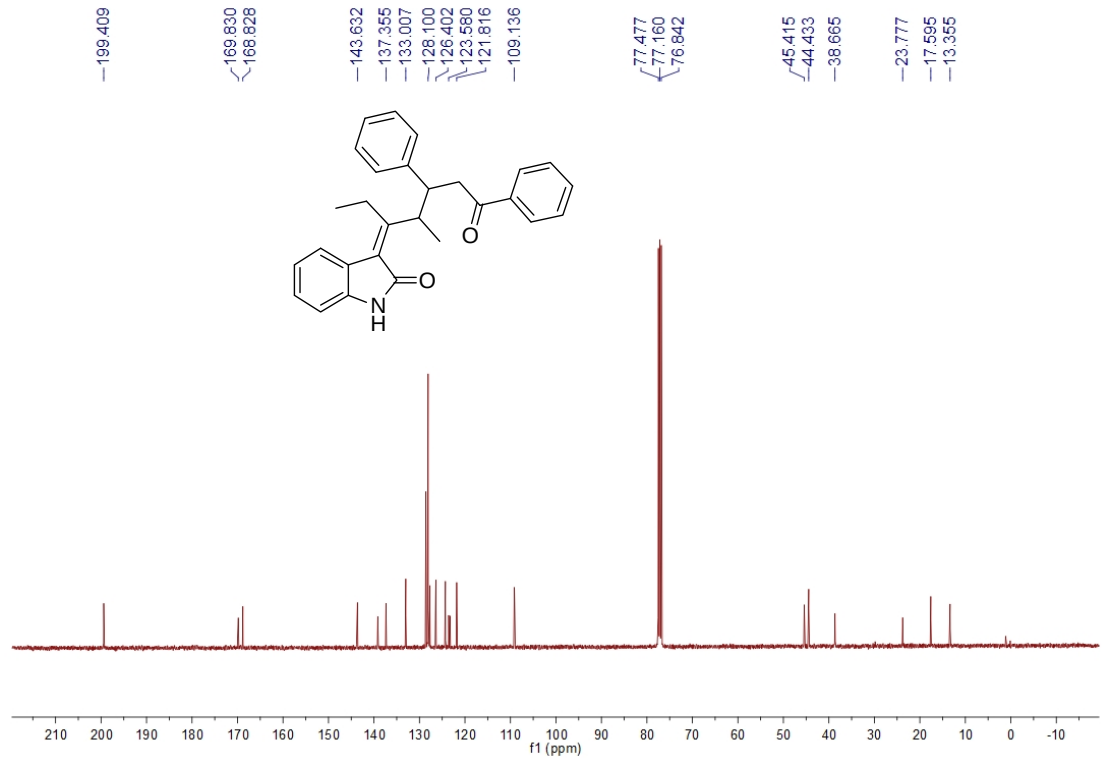
7.843
7.259
7.133
7.096
7.046
6.958
6.935
6.895
6.773
5.557
5.540
5.515
5.498
5.482
3.738
3.717
3.712
3.694
3.681
3.469
3.441
3.398
2.642
2.608
2.579
2.482
2.448
2.411
1.726
1.337
1.320
1.168
1.149
1.130
O
O
N
H
0.93
2.01
1.12
2.03
3.35
1.13
2.07
2.05
1.01
1.00
1.04
2.09
1.04
1.09
1.02
3.06
3.28
f1 (ppm)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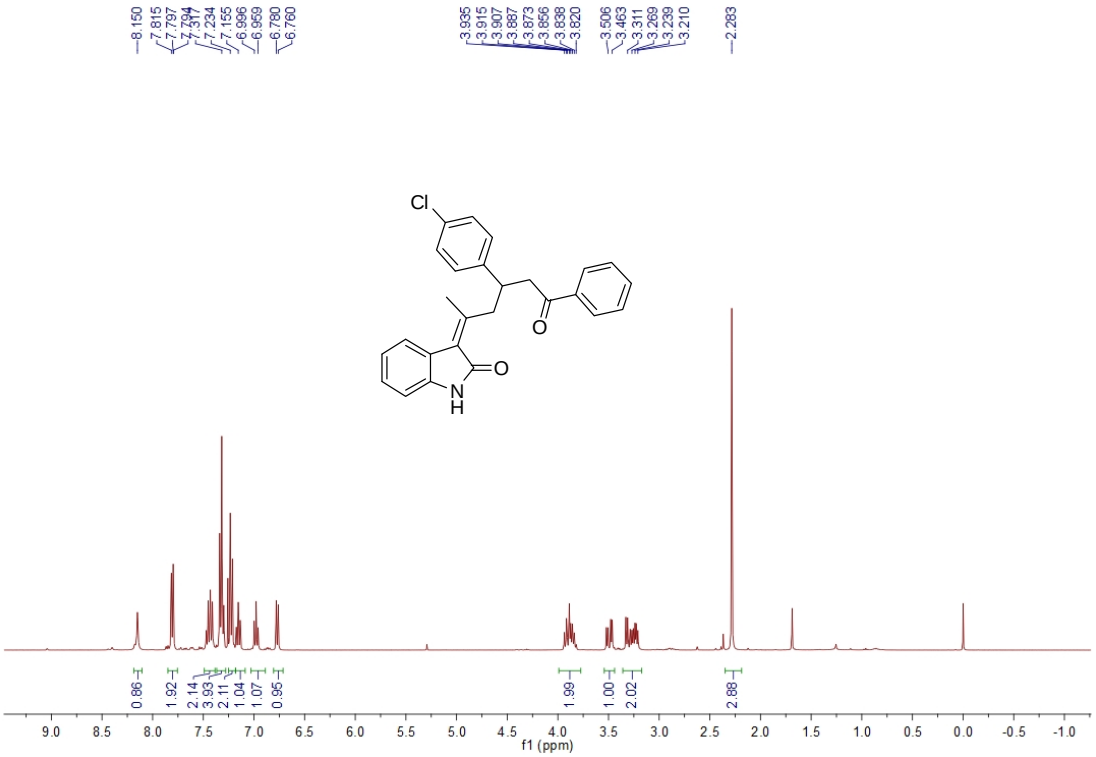
169.830
168.828
143.632
137.355
133.007
128.100
126.402
123.580
121.816
109.136
77.477
77.160
76.842
45.415
44.433
38.665
23.777
17.595
13.355
O
O
N
H
f1 (ppm)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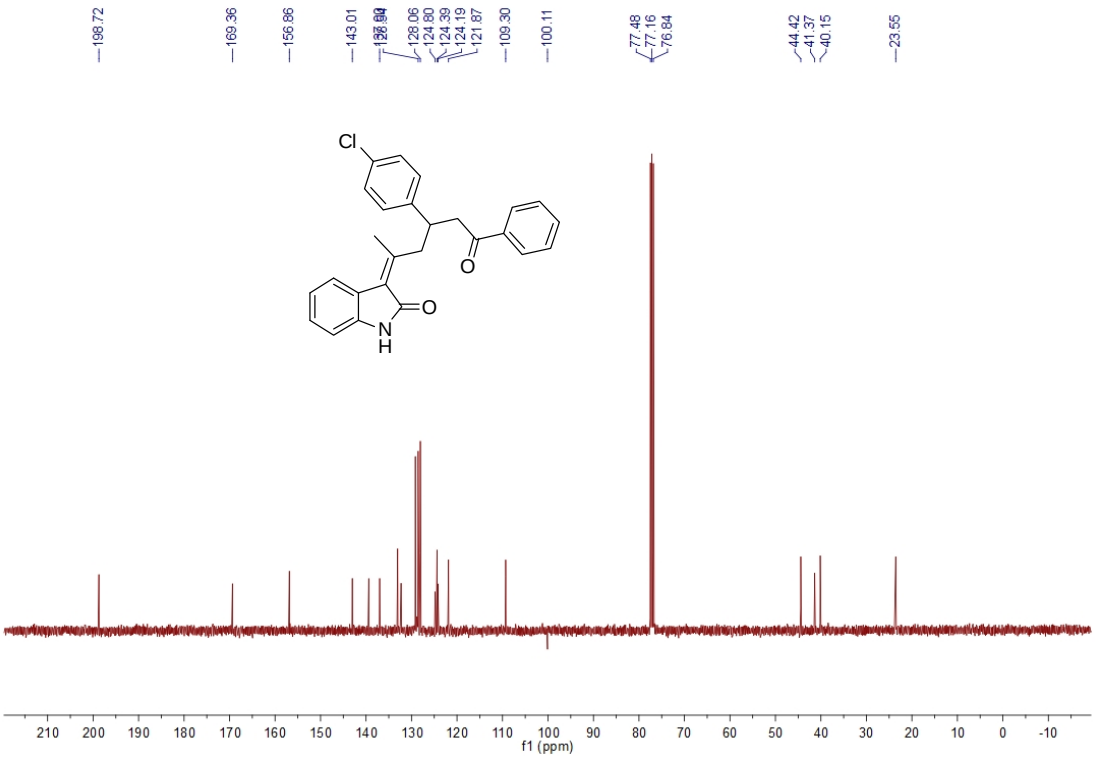
7.815
7.797
7.794
7.317
7.234
7.155
6.996
6.959
6.780
6.760
3.935
3.915
3.907
3.887
3.873
3.856
3.838
3.820
3.506
3.463
3.311
3.269
3.239
3.210
2.283
Cl
O
O
N
H
0.86
1.92
2.14
3.93
2.11
1.04
1.07
0.95
1.99
1.00
2.02
2.88
f1 (ppm)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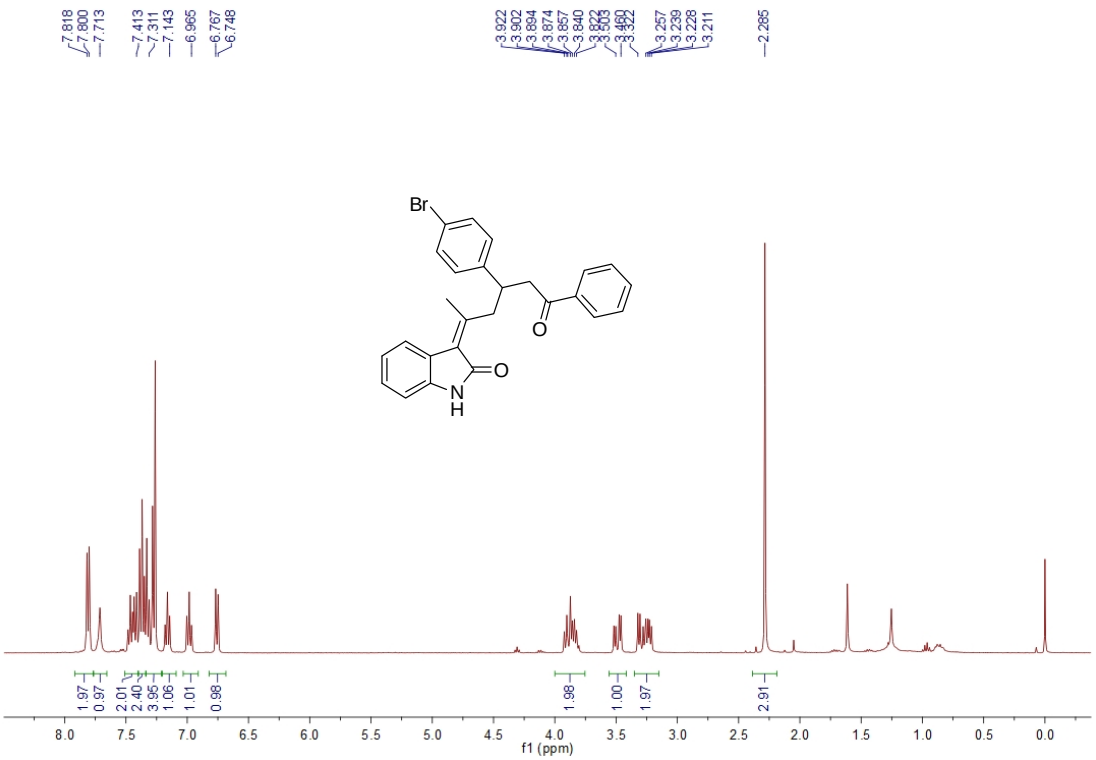
169.36
156.86
143.01
128.06
124.80
124.39
124.19
121.87
109.30
100.11
77.48
77.16
76.84
44.42
41.37
40.15
23.55
Cl
O
O
N
H
f1 (ppm)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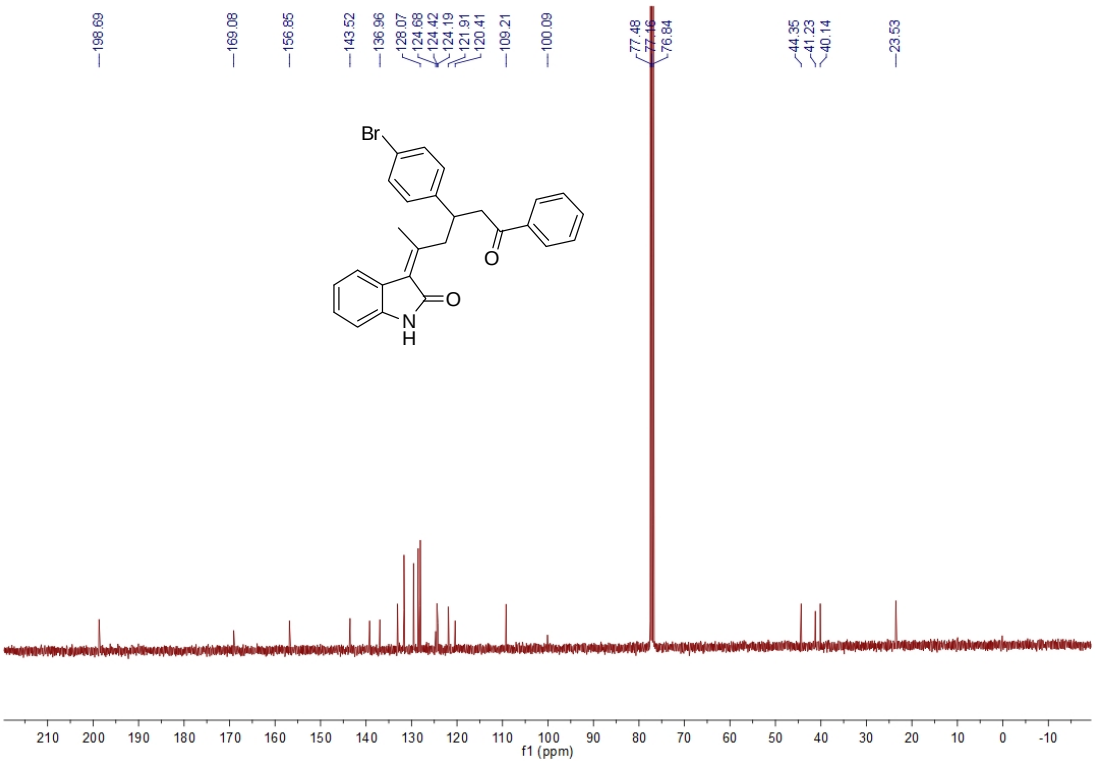
7.800
7.713
7.413
7.311
7.143
6.965
6.767
6.748
3.922
3.902
3.894
3.874
3.857
3.840
3.460
3.322
3.257
3.239
3.228
3.211
2.285
Br
O
O
N
H
1.97
0.97
2.01
2.40
3.95
1.06
1.01
0.98
1.98
1.00
1.97
2.91
f1 (ppm)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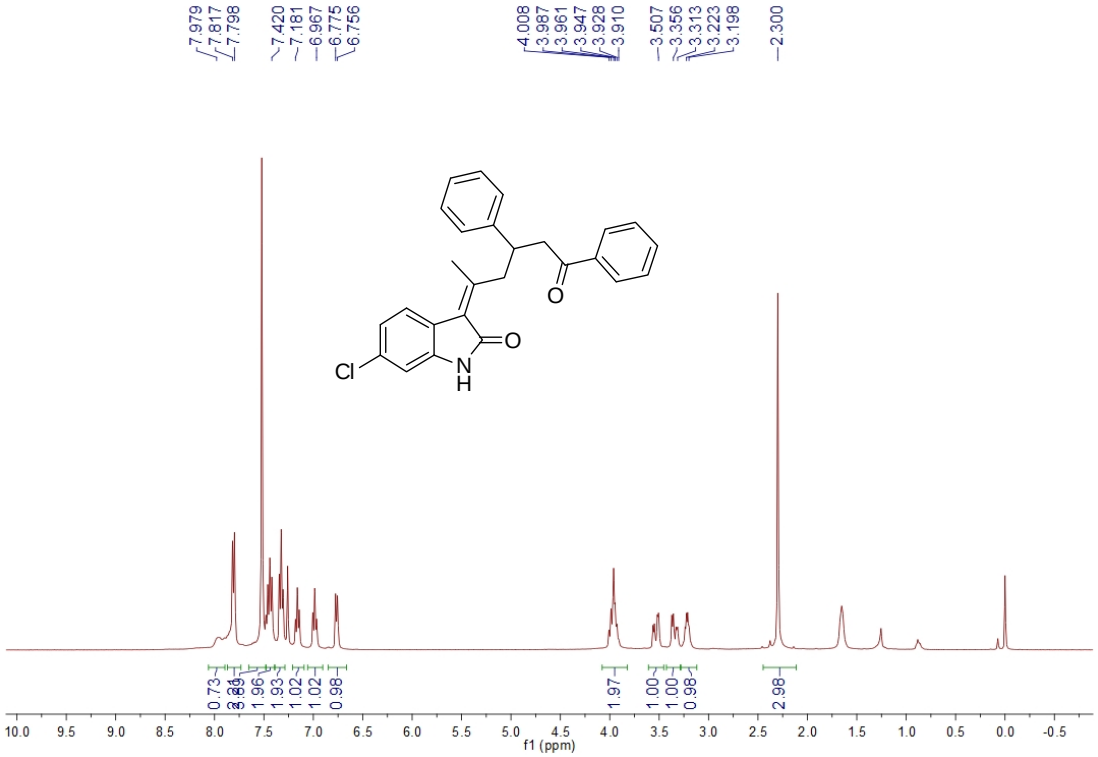
156.85
143.52
136.96
128.07
124.68
124.42
124.19
121.91
120.41
109.21
100.09
77.48
77.16
76.84
44.35
41.23
40.14
23.53
Br
O
O
N
H
f1 (ppm)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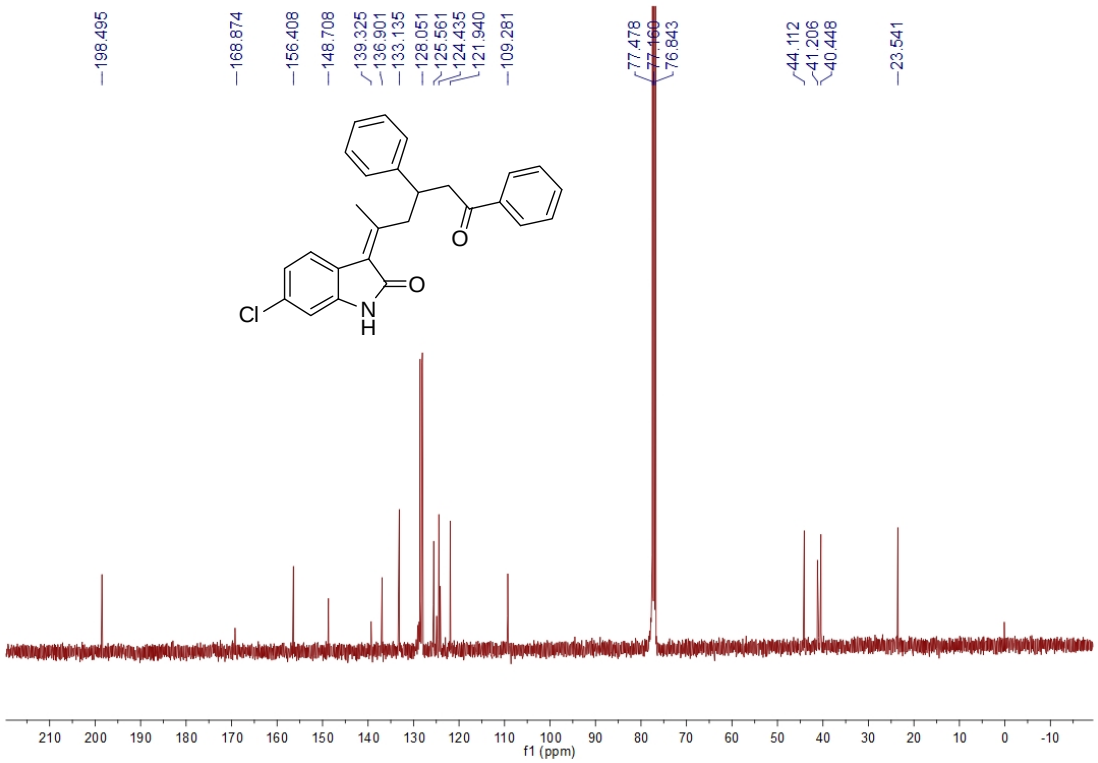
7.817
7.798
7.420
7.181
6.967
6.775
6.756
4.008
3.987
3.961
3.947
3.928
3.910
3.507
3.356
3.313
3.223
3.198
2.300
Cl
O
N
H
O
0.73
3.89
1.96
1.93
1.02
1.02
0.98
1.97
1.00
1.00
0.98
2.98
f1 (ppm)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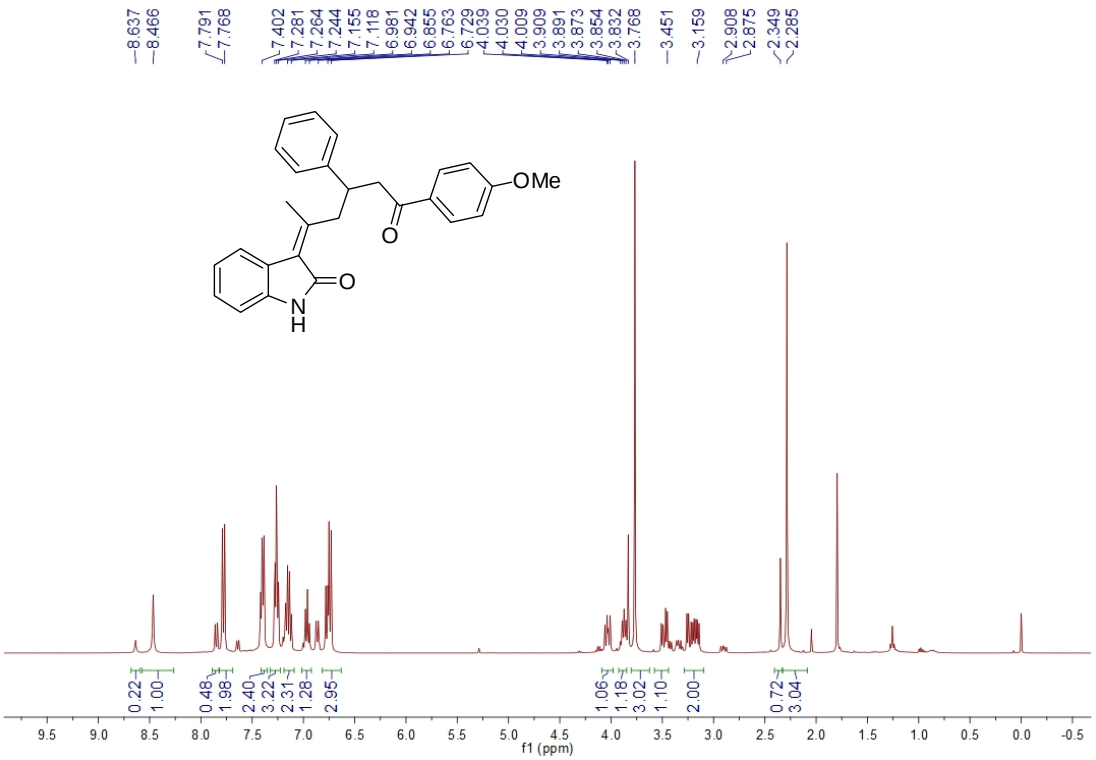
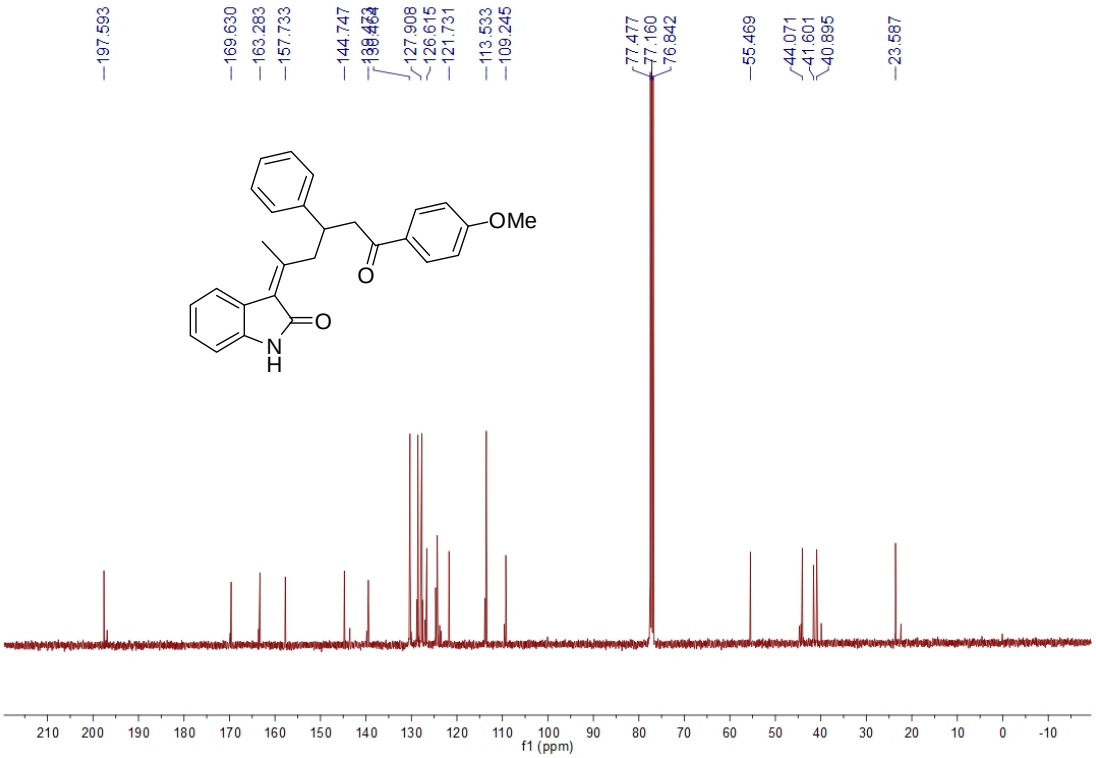
148.708
139.325
136.901
133.135
128.051
125.561
124.435
121.940
109.281
77.478
77.160
76.843
44.112
41.206
40.448
23.541
Cl
O
N
H
O
f1 (ppm)


8.637
8.466
7.791
7.768
7.402
7.281
7.264
7.244
7.155
7.118
6.981
6.942
6.855
6.763
6.729
4.039
4.030
4.009
3.909
3.891
3.873
3.854
3.832
3.768
3.451
3.159
2.908
2.875
2.349
2.285
OMe
O
O
N
H
0.22
1.00
0.48
1.98
2.40
3.22
2.31
1.28
2.95
1.06
1.18
3.02
1.10
2.00
0.72
3.04
f1 (ppm)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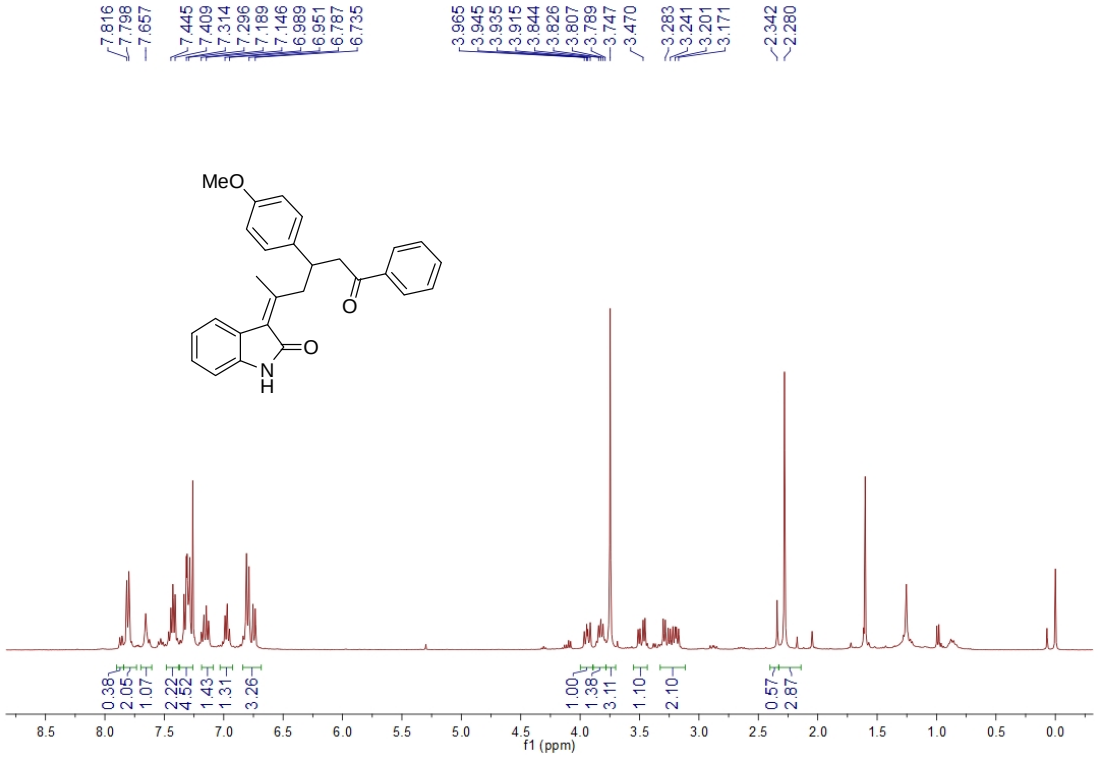
121.731
113.533
109.245
77.477
77.160
76.842
55.469
44.071
41.601
40.895
23.587
OMe
O
O
N
H
f1 (ppm)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7.798
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7.409
7.314
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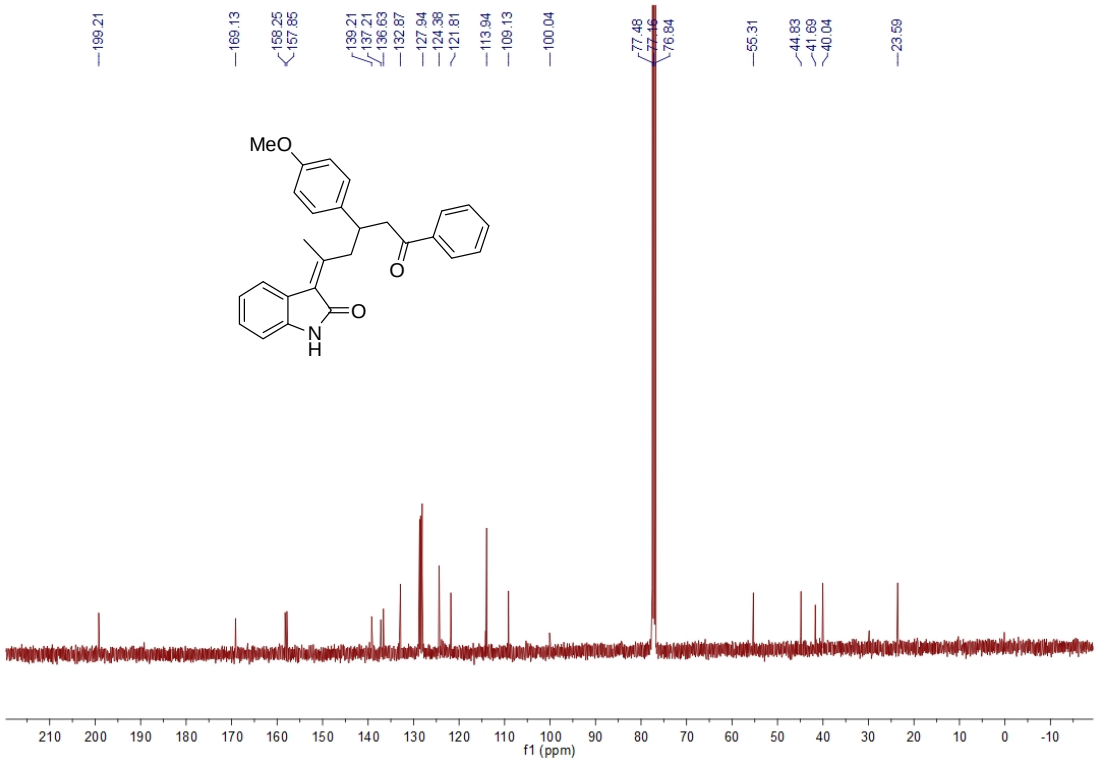
7.189
7.146
6.989
6.951
6.787
6.735
3.965
3.945
3.935
3.915
3.844
3.826
3.807
3.789
3.747
3.470
3.283
3.241
3.201
3.171
2.342
2.280
MeO
O
O
N
H
0.38
2.05
1.07
2.22
4.52
1.43
1.31
3.26
1.00
1.38
3.11
1.10
2.10
0.57
2.87
f1 (ppm)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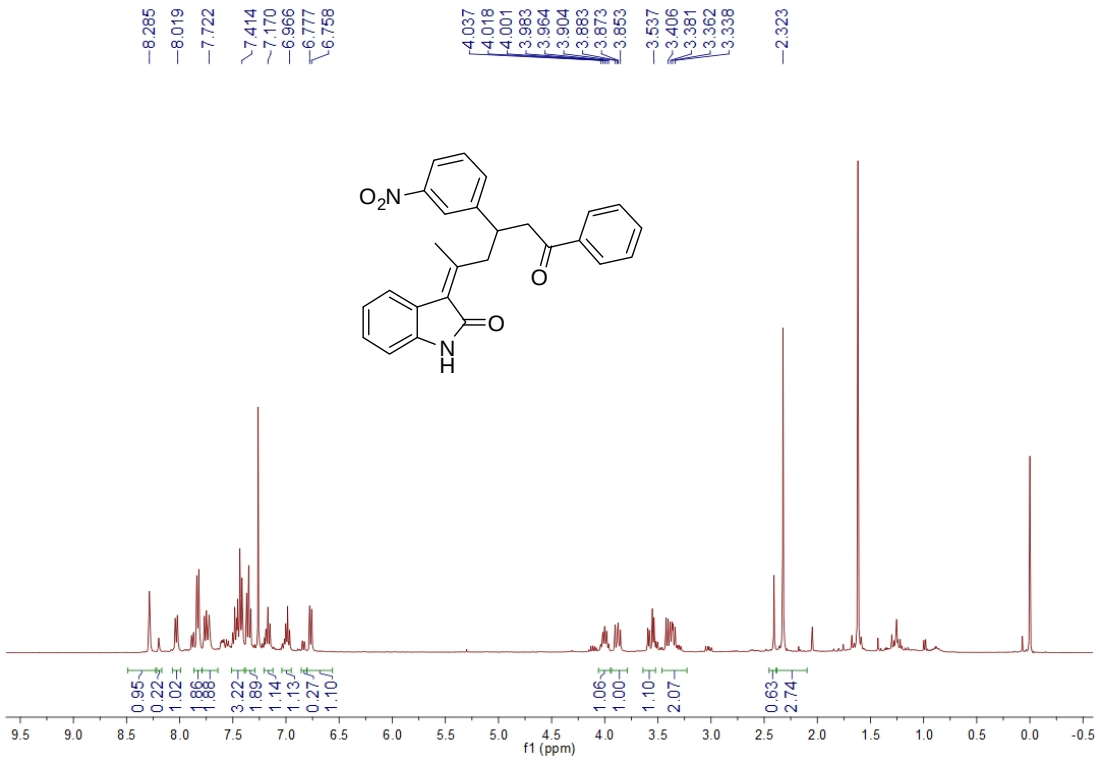
158.25
157.86
139.21
137.21
136.63
132.87
127.94
124.38
121.81
113.94
109.13
100.04
77.48
77.16
76.84
55.31
44.83
41.69
40.04
23.59
MeO
O
O
N
H
f1 (ppm)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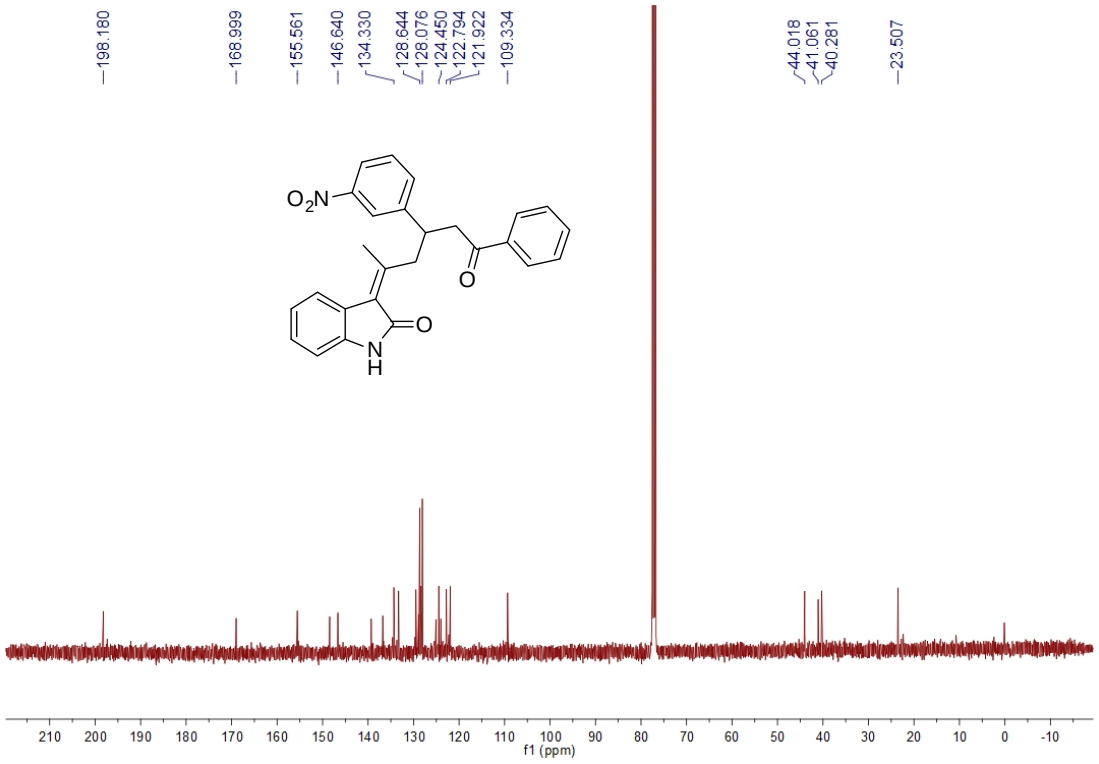
7.414
7.170
6.966
6.777
6.758
4.037
4.018
4.001
3.983
3.964
3.904
3.883
3.873
3.853
3.537
3.406
3.381
3.362
3.338
2.323
O2N
O
O
N
H
0.95
0.22
1.02
1.86
1.88
3.22
1.89
1.14
1.13
0.27
1.10
1.06
1.00
1.10
2.07
0.63
2.74
f1 (ppm)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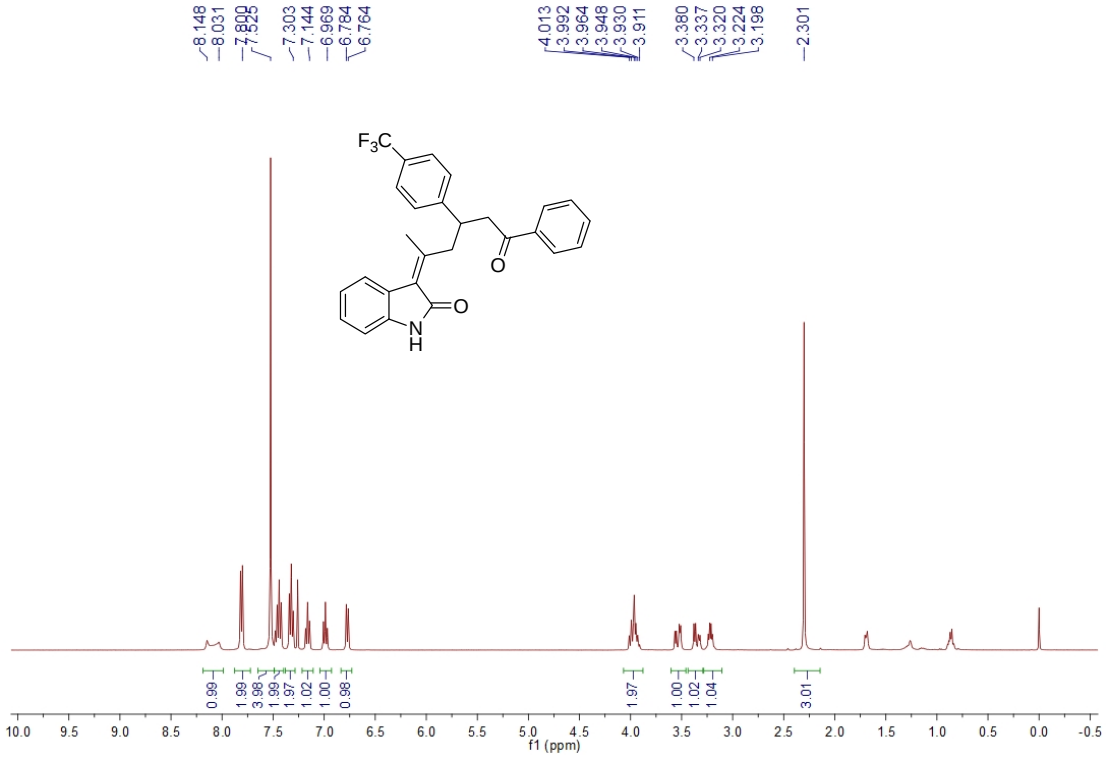
146.640
134.330
128.644
128.076
124.450
122.794
121.922
109.334
44.018
41.061
40.281
23.507
O2N
O
O
N
H
f1 (ppm)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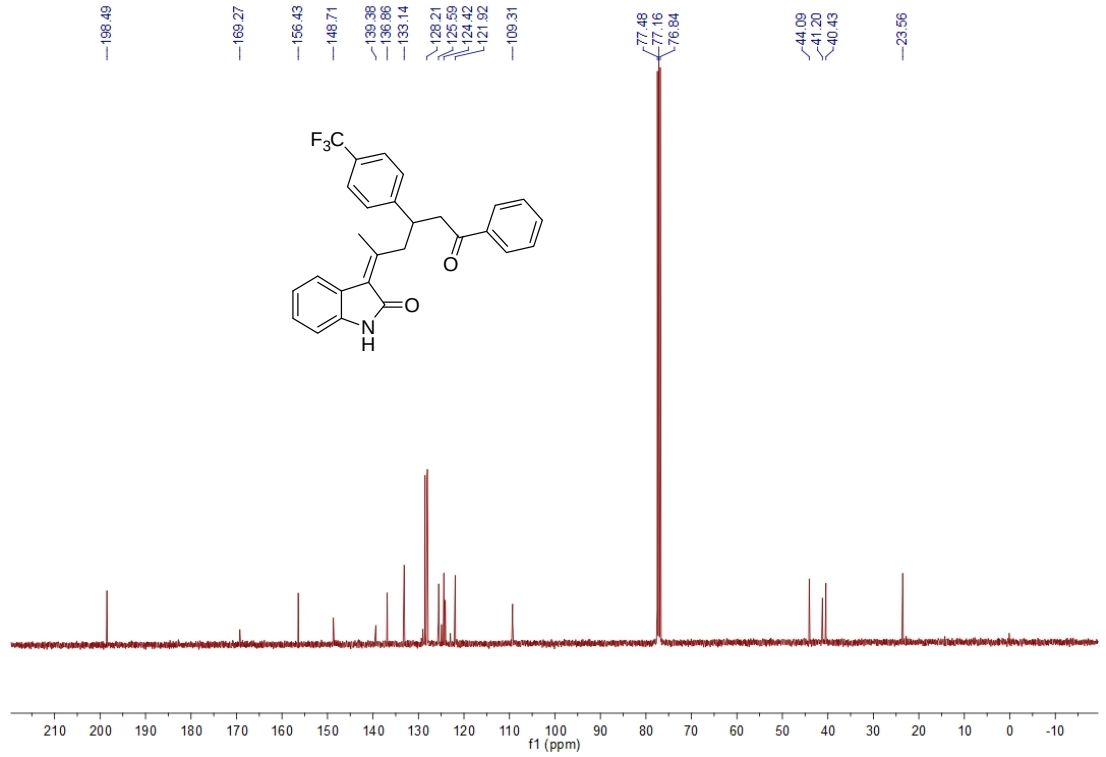
7.525
7.303
7.144
6.969
6.784
6.764
4.013
3.992
3.964
3.948
3.930
3.911
3.380
3.337
3.320
3.224
3.198
2.301
F3C
O
O
N
H
0.99
1.99
3.98
1.99
1.97
1.02
1.00
0.98
1.97
1.00
1.02
1.04
3.01
f1 (ppm)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128.21
125.59
124.42
121.92
109.31
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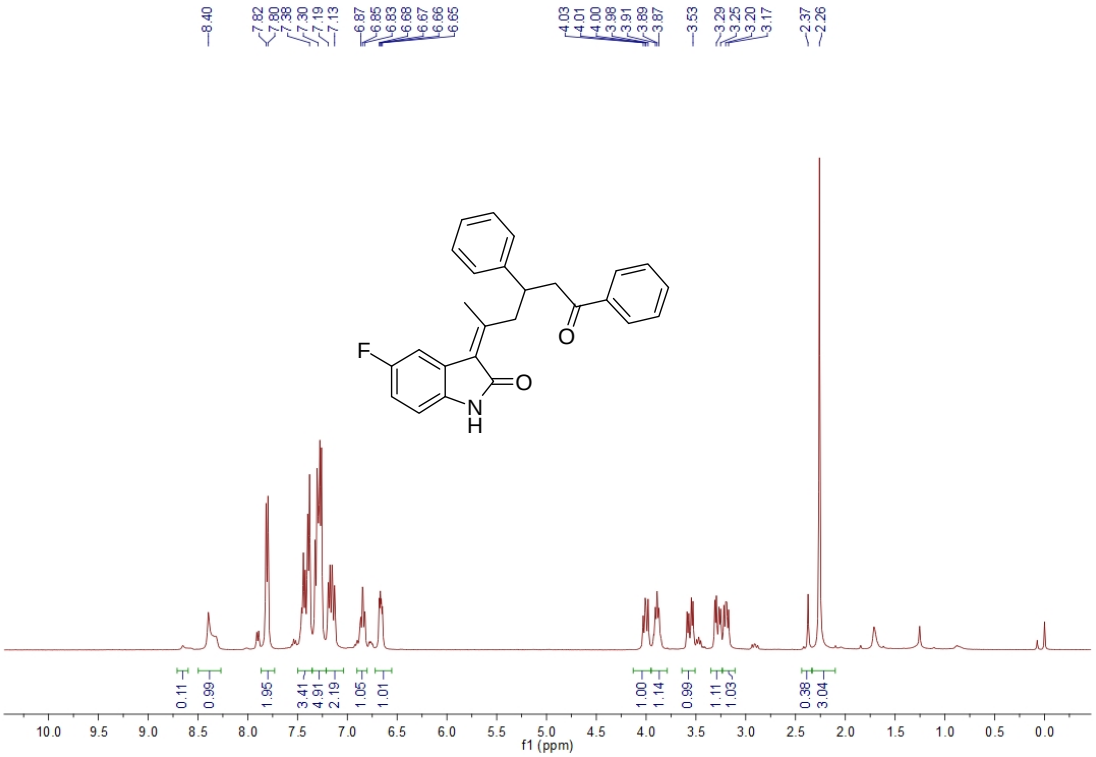
77.16
76.84
44.09
41.20
40.43
23.56
F3C
O
O
N
H
f1 (ppm)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7.38
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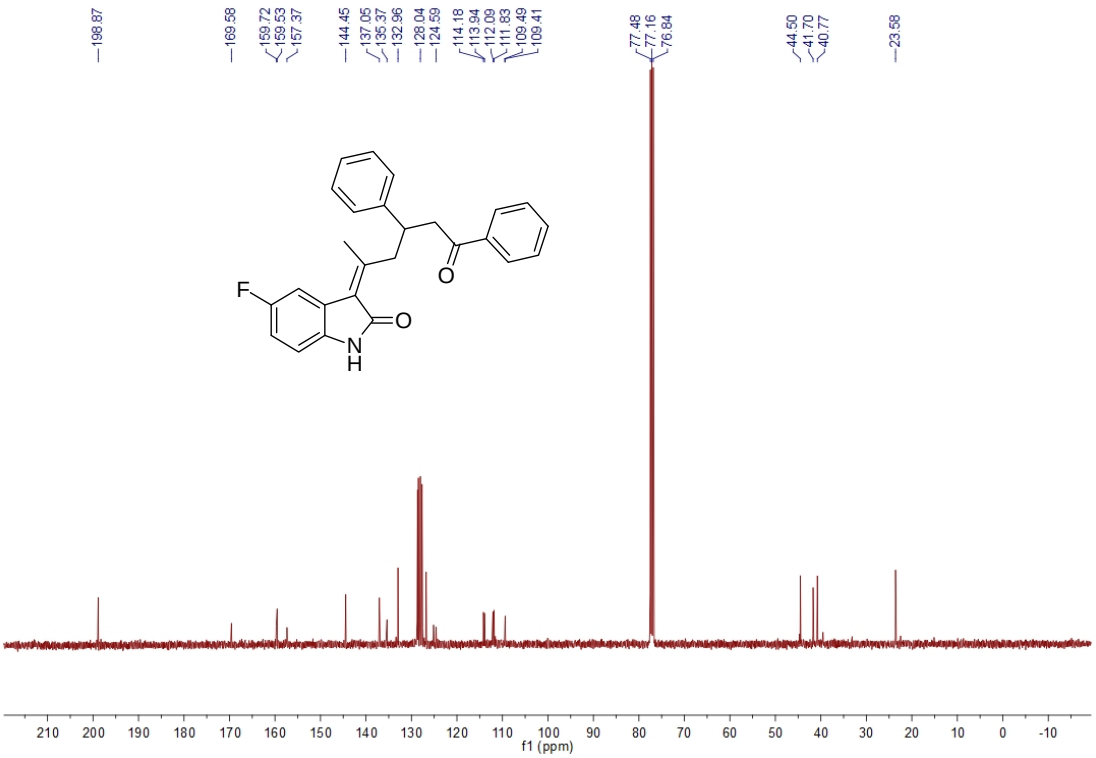
7.19
7.13
6.87
6.85
6.83
6.68
6.67
6.66
6.65
4.03
4.01
4.00
3.98
3.91
3.89
3.87
3.53
3.29
3.25
3.20
3.17
2.37
2.26
F
O
O
N
H
0.11
0.99
1.95
3.41
4.91
2.19
1.05
1.01
1.00
1.14
0.99
1.11
1.03
0.38
3.04
f1 (ppm)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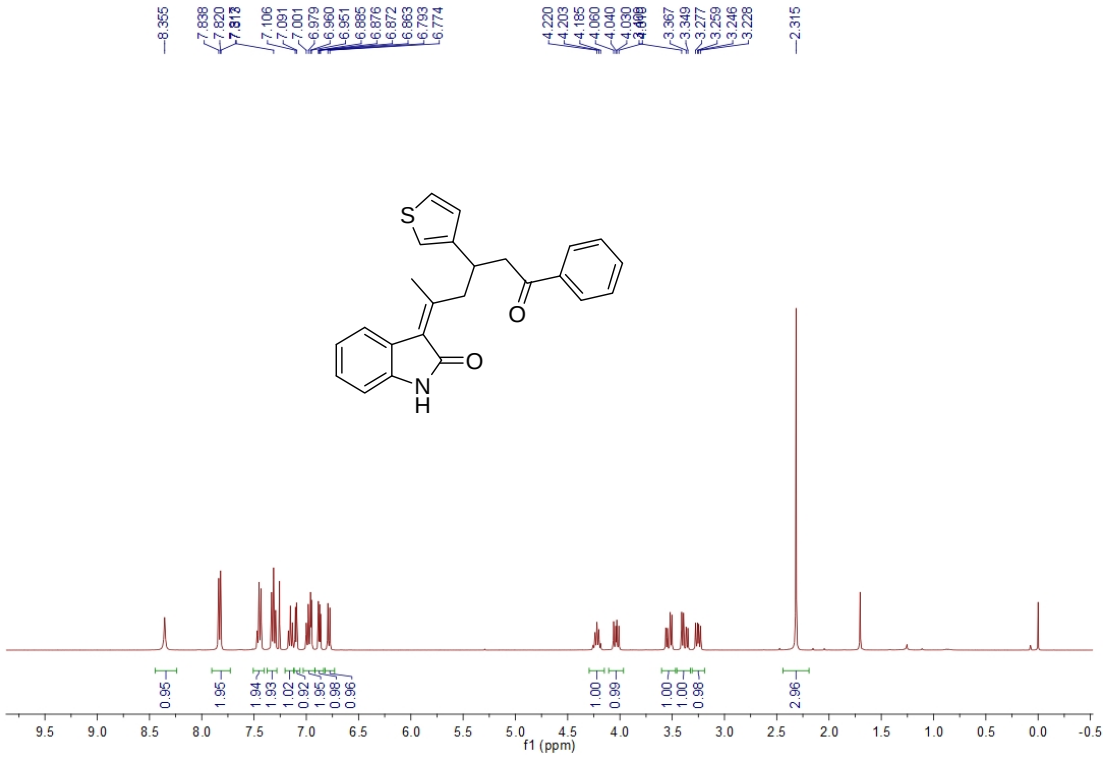
135.37
132.96
128.04
124.59
114.18
113.94
112.09
111.83
109.49
109.41
77.48
77.16
76.84
44.50
41.70
40.77
23.58
F
O
O
N
H
f1 (ppm)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7.091
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6.979
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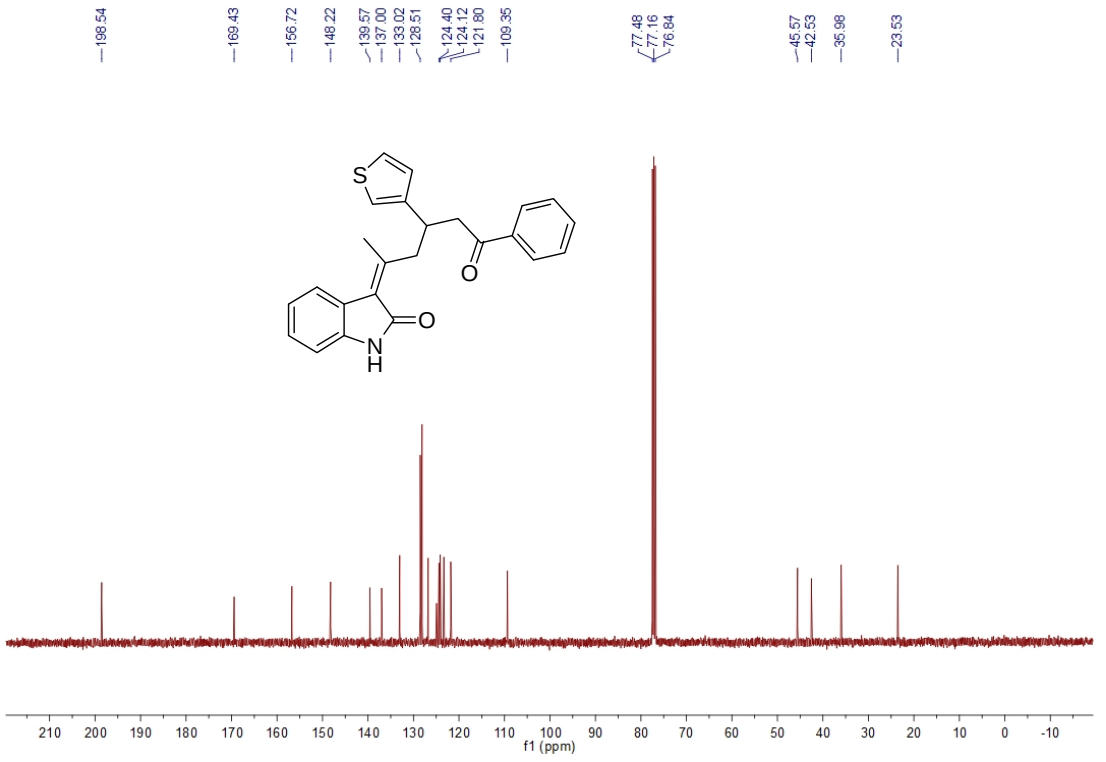
6.951
6.885
6.876
6.872
6.863
6.793
6.774
4.220
4.203
4.185
4.060
4.040
4.030
3.367
3.349
3.277
3.259
3.246
3.228
2.315
S
O
O
N
H
0.95
1.95
1.94
1.93
1.02
0.92
1.95
0.98
0.96
1.00
0.99
1.00
1.00
0.98
2.96
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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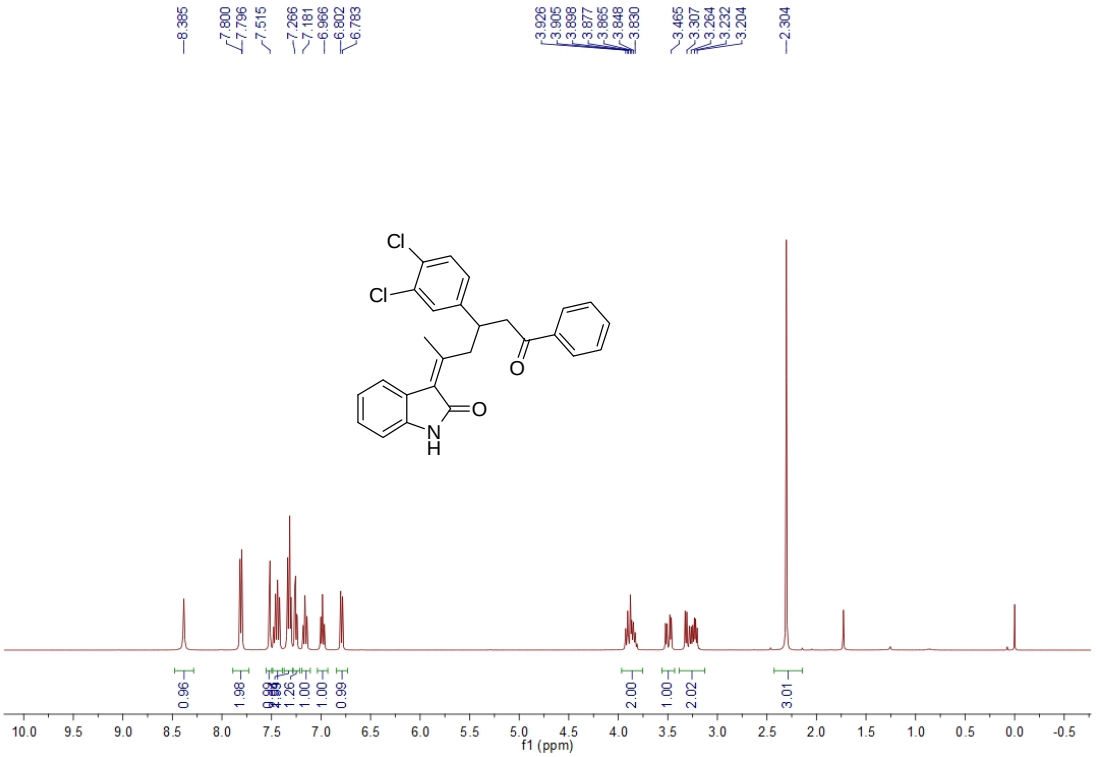
139.57
137.00
133.02
128.51
124.40
124.12
121.80
109.35
77.48
77.16
76.84
45.57
42.53
35.98
23.53
S
O
O
N
H
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.385
7.800
7.796
7.515
7.266
7.181
6.966
6.802
6.783
3.926
3.905
3.898
3.877
3.865
3.848
3.830
3.465
3.307
3.264
3.232
3.204
2.304
Cl
Cl
O
O
N
H
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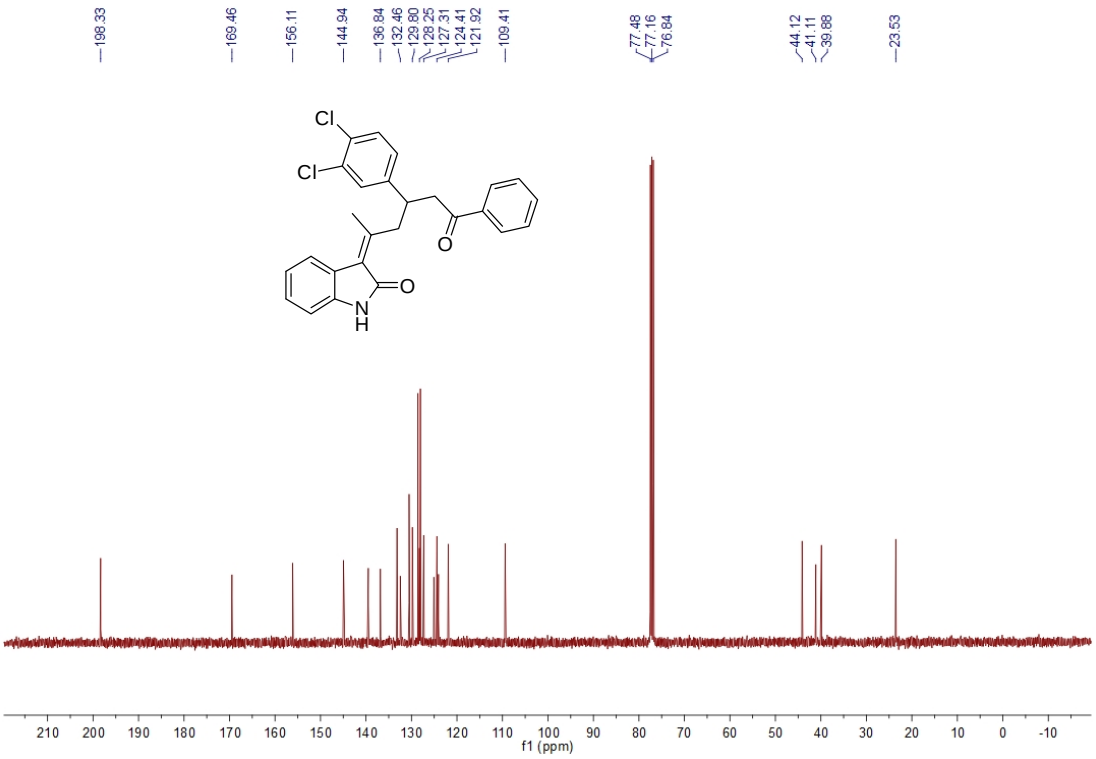
1.98
1.26
1.00
1.00
0.99
2.00
1.00
2.02
3.01
f1 (ppm)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169.46
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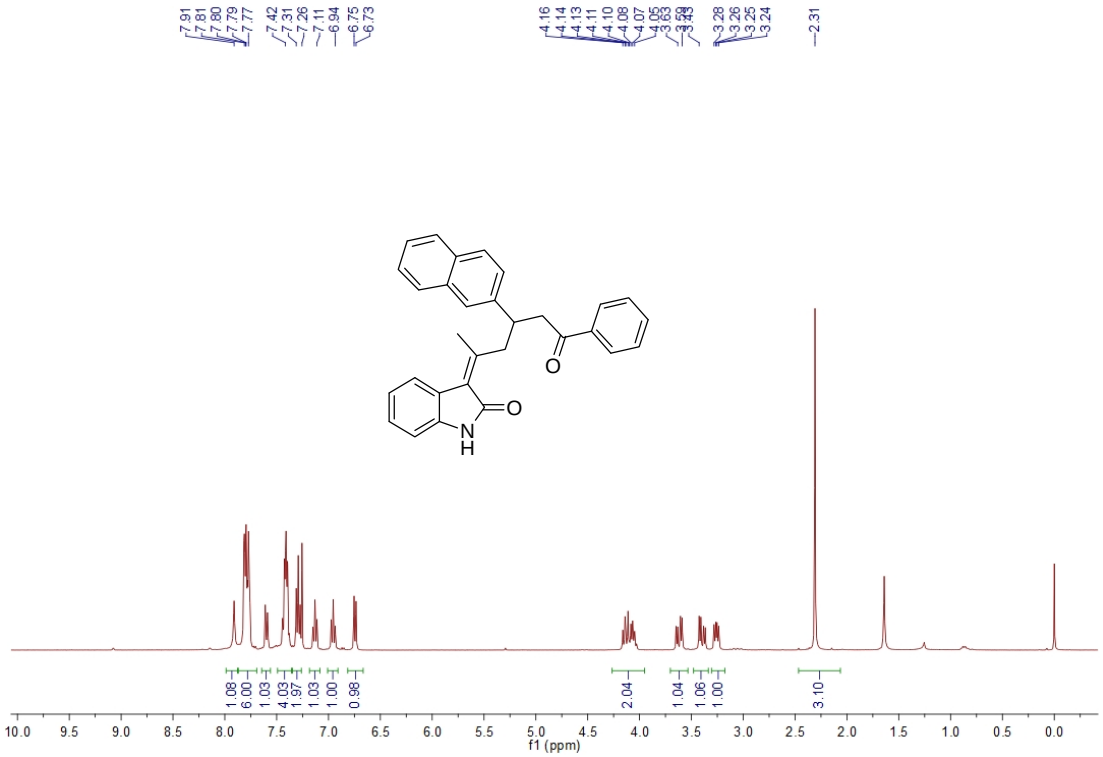
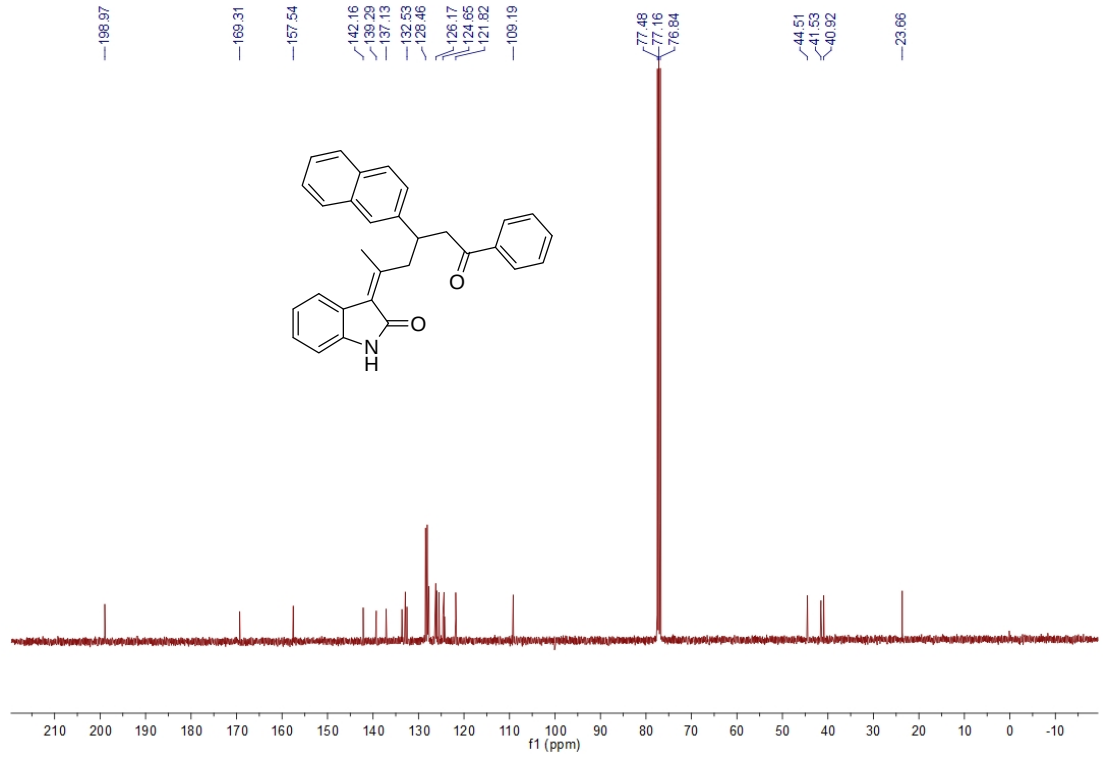
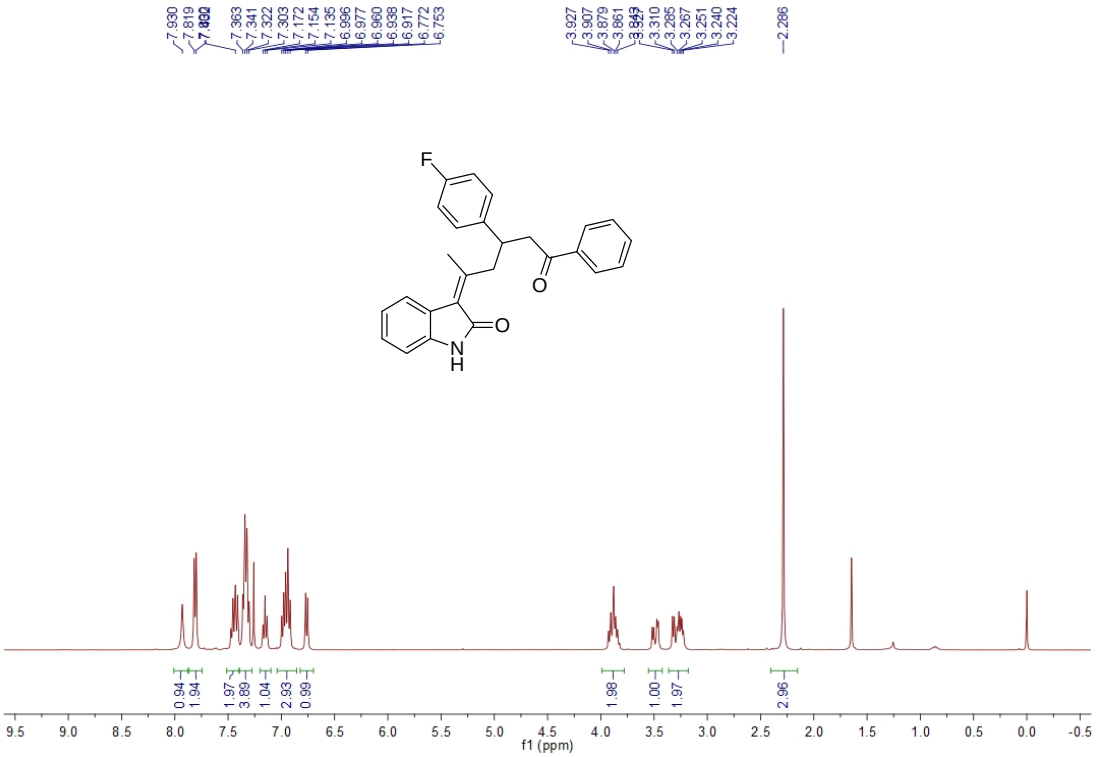
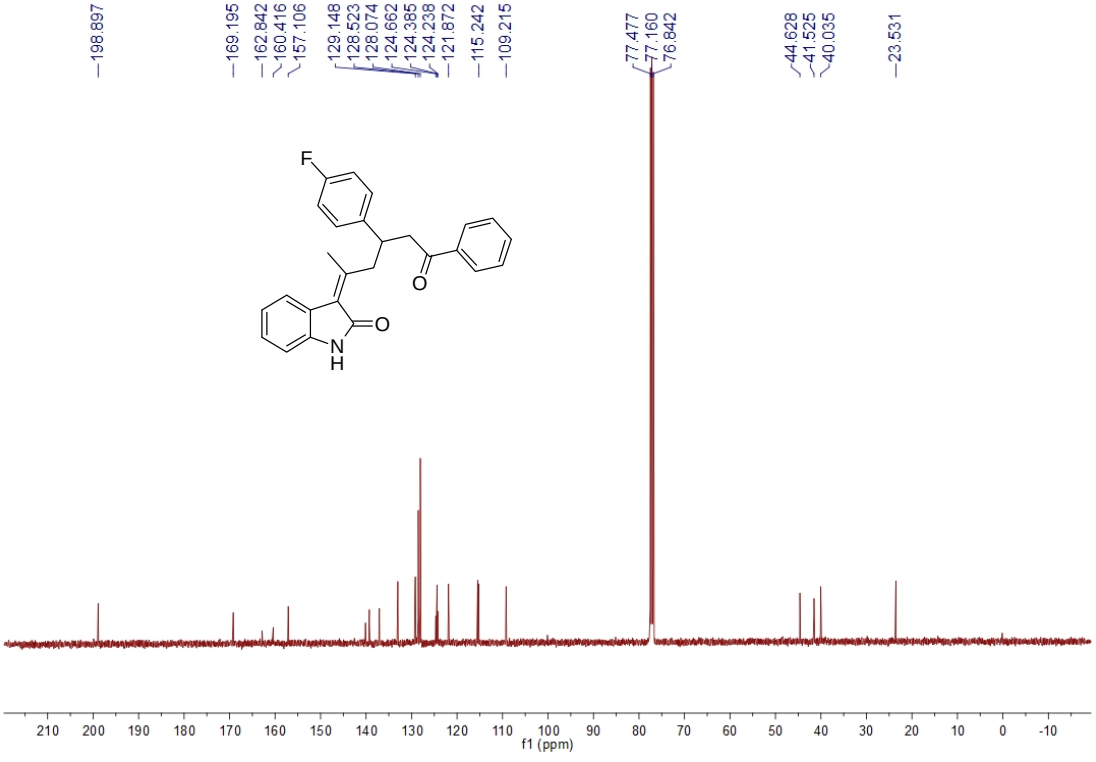
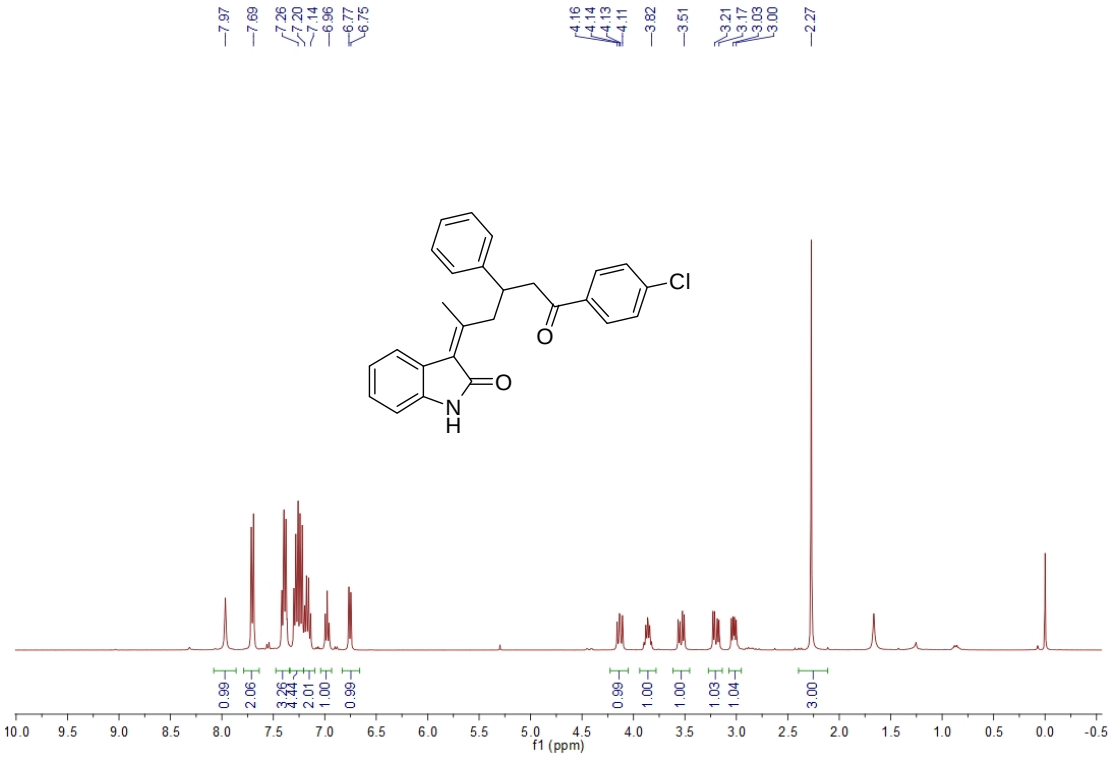
136.84
132.46
129.80
128.25
127.31
124.41
121.92
109.41
77.48
77.16
76.84
44.12
41.11
39.88
23.53
Cl
Cl
O
O
N
H
f1 (ppm)

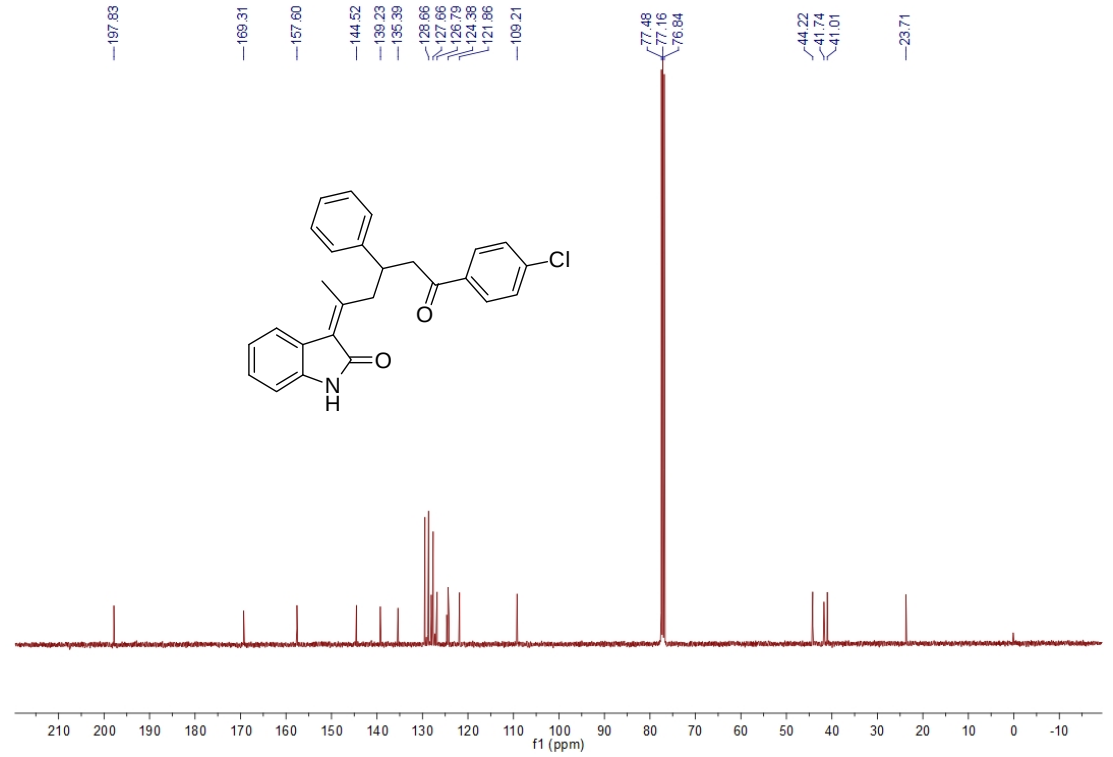

7.91
7.81
7.80
7.79
7.77
7.42
7.31
7.26
7.11
6.94
6.75
6.73
4.16
4.14
4.13
4.11
4.10
4.08
4.07
4.05
3.63
3.59
3.43
3.28
3.26
3.25
3.24
2.31
O
O
N
H
1.08
6.00
1.03
4.03
1.97
1.03
1.00
0.98
2.04
1.04
1.06
1.00
3.10
f1 (ppm)

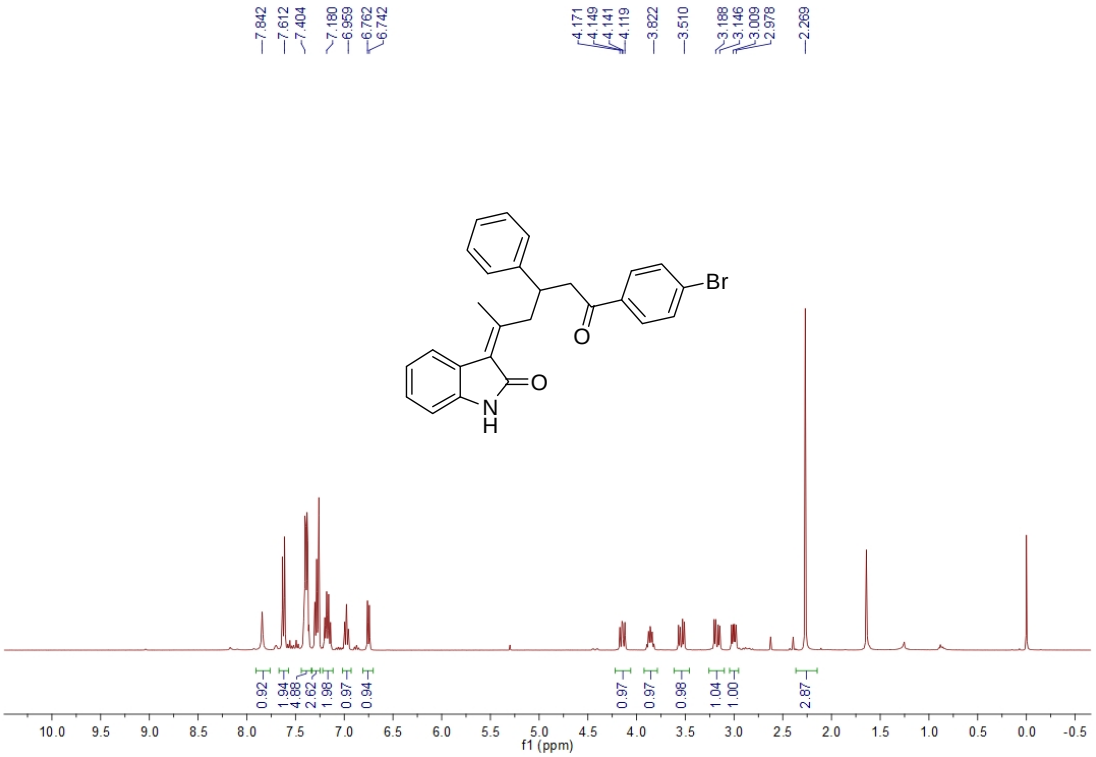

198.97
169.31
157.54
142.16
139.29
137.13
132.53
128.46
126.17
124.65
121.82
109.19
77.48
77.16
76.84
44.51
41.53
40.92
23.66
O
O
N
H
f1 (ppm)

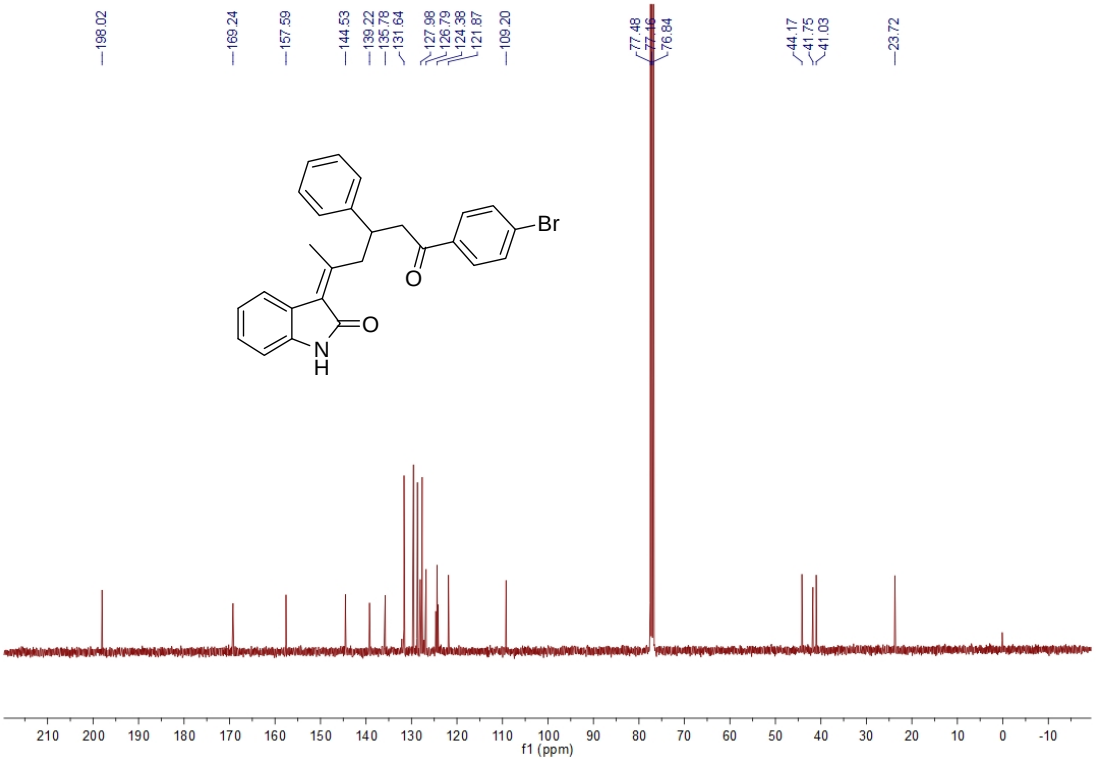

7.930
7.819
7.363
7.341
7.322
7.303
7.172
7.154
7.135
6.996
6.977
6.960
6.938
6.917
6.772
6.753
3.927
3.907
3.879
3.861
3.310
3.285
3.267
3.251
3.240
3.224
2.286
F
O
O
N
H
0.94
1.94
1.97
3.89
1.04
2.93
0.99
1.98
1.00
1.97
2.96
f1 (ppm)

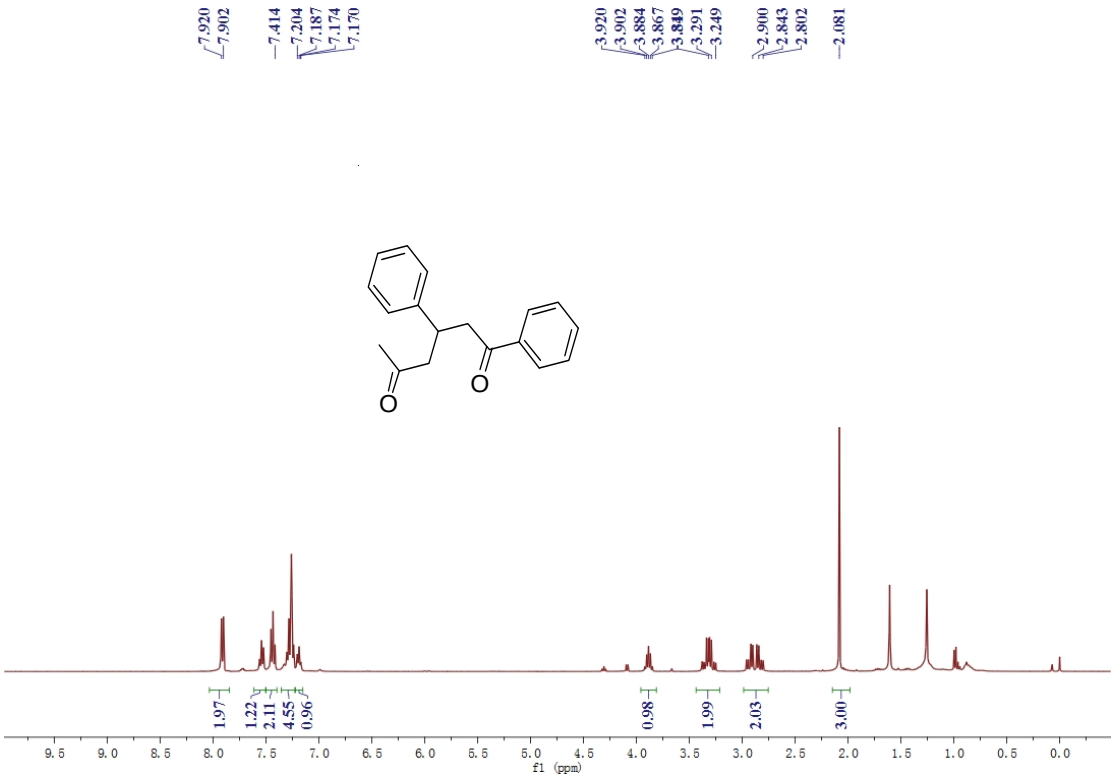

198.897
169.195
162.842
160.416
157.106
129.148
128.523
128.074
124.662
124.385
124.238
121.872
115.242
109.215
77.477
77.160
76.842
44.628
41.525
40.035
23.531
F
O
O
N
H
f1 (ppm)


7.97
7.69
7.26
7.20
7.14
6.96
6.77
6.75
4.16
4.14
4.13
4.11
3.82
3.51
3.21
3.17
3.03
3.00
2.27
Cl
O
O
N
H
0.99
2.06
3.26
4.44
2.01
1.00
0.99
0.99
1.00
1.00
1.03
1.04
3.00
f1 (ppm)


197.83
169.31
157.60
144.52
139.23
135.39
128.66
127.66
126.79
124.38
121.86
109.21
77.48
77.16
76.84
44.22
41.74
41.01
23.71
Cl
O
O
N
H
f1 (ppm)


7.842
7.612
7.404
7.180
6.959
6.762
6.742
4.171
4.149
4.141
4.119
3.822
3.510
3.188
3.146
3.009
2.978
2.269
Br
O
O
N
H
0.92
1.94
4.88
2.62
1.98
0.97
0.94
0.97
0.97
0.98
1.04
1.00
2.87
f1 (ppm)


198.02
169.24
157.59
144.53
139.22
135.78
131.64
127.98
126.79
124.38
121.87
109.20
77.48
77.16
76.84
44.17
41.75
41.03
23.72
Br
O
O
N
H
f1 (ppm)


7.920
7.902
7.414
7.204
7.187
7.174
7.170
3.920
3.902
3.884
3.867
3.849
3.291
3.249
2.900
2.843
2.802
2.081
O
O
1.97
1.22
2.11
4.55
0.96
0.98
1.99
2.03
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)