Supporting Information for

N-Heterocyclic carbene-catalyzed diastereoselective synthesis of sulfenylated indanes via sulfa-Michael-Michael (aldol) cascade reaction

Ze-Nan Feng, Jin-Yun Luo, Yang Zhang, Guang-Fen Du,* Lin He*

School of Chemistry and Chemical Engineering, Shihezi University, Xinjiang Uygur.

Autonomous Region 832000, PeopleIs Republic of China,

E-mail:duguangfen@shzu.edu.cn; helin@shzu.edu.cn

Contents:

1.General methods and typical experimental procedures

1.1General methods

Unless otherwise indicated, all reactions were conducted under nitrogen atmosphere in oven-dried glassware with magnetic stirring bar. Column chromatograph was performed with silica gel (200~300 mesh) and analytical TLC on silica gel 60-F_{254}. ^{1}H NMR (400 MHz, $CDCl_3$), ^{13}C NMR (100 MHz, $CDCl_3$) were recorded on a Bruker-DMX 400 spectrometer in $CDCl_3$, with tetramethylsilane as an internal standard and reported in ppm (δ). Benzenedi(enones) [1] and *o*-formyl chalcone[2] were synthesized according to the literature procedure. All other chemicals were obtained from commercial supplies and used as received without any further purification. Anhydrous THF, 1,4-dioxane and toluene were dried with the sodium/benzophenone system and distilled under nitrogen. Anhydrous DMSO, DMF, CH_2Cl_2 and CH_3CN were distilled from calcium hydride. $CHCl_3$ was distilled from phosphorus pentoxide. Petroleum ether, where used, has a boiling point range of 60–90 ^{o}C.

1.2 Representative procedure for NHC-catalyzed sulfa- Michael-Michael addition between mercaptans and benzenedi(enones)

To a solution of benzenedi(enone) **1a** (67.6 mg, 0.2 mmol) and ethanethiol **2a** (15 mg, 0.24 mmol) in toluene (2.0 mL) was added NHC **A** (0.78 mg, 1 mol%). The mixture was stirred at room temperature until full consumption of **1a** that was indicated by TLC (2 h). The solvent was

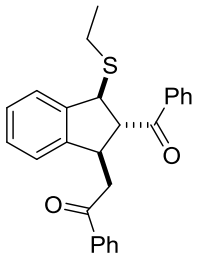
then removed under reduced pressure and the crude material was purified by flash column chromatography (silica gel, PE/EtOAc (v : v) = 20:1) to give the desired product **3a**.

1.3 Representative procedure for NHC-catalyzed sulfa-Michael-aldol cascade reaction of *o*-formyl chalcone and thiols.

To a solution of *o*-formyl chalcone 4**a** (47.29 mg, 0.2 mmol) and ethanethiol **2a** (mg, 0.24 mmol) in THF (2.0 mL) was added NHC **A** (7.8 mg, 10 mol%). The mixture was stirred at room temperature until full consumption of **4a** that was indicated by TLC (48h). The solvent was then removed under reduced pressure and the crude material was purified by column chromatography (silica gel, PE/EtOAc (v : v) = 20:1).

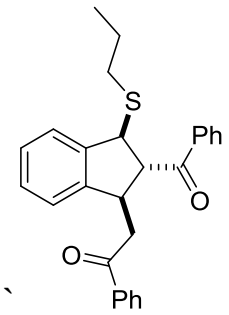
2. Spectroscopic data for all products

2-2-benzoyl-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3a)



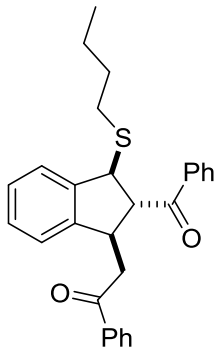
Yield: 92%, 73.6 mg; yellow liquid; ^{1}H NMR (400 MHz, CD_3Cl) δ 8.05 (dt, *J* = 8.5, 1.7 Hz, 2H), 7.87 (dt, *J* = 8.5, 1.6 Hz, 2H), 7.59–7.51 (m, 2H), 7.48–7.36 (m, 5H), 7.28–7.24 (m, 2H), 7.23–7.18 (m, 1H), 4.61 (d, *J* = 5.4 Hz, 1H), 4.24(dt, *J* = *J*= 8.5, 1H), 4.16 (dd, *J* = 14.8, 7.3 Hz, 1H), 3.60 (dd, *J* = 17.5, 5.5 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.2 Hz, 1H), 2.62–2.46 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, CD_3Cl) δ 200.7, 198.3, 144.3, 142.1, 136.9, 136.8, 133.2, 128.8, 128.7, 128.2, 128.1, 127.6, 124.9, 124.0, 60.8, 52.2, 44.6, 43.8, 25.9, 14.6; IR (KBr thin film) 3448, 3064, 2969, 2926, 1874, 1596, 1579, 1477, 1448, 1359, 1224, 1181, 1001, 981, 770, 749, 728, 691 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{25}O_2S^+$ $(M+H)^+$ 401.15698, found 401.15710.

2-2-benzoyl-3-(propylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3b)



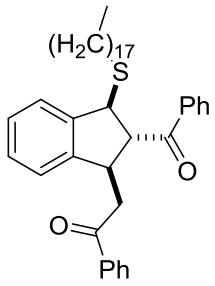
Yield: 83%, 68.8 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 – 8.01 (m, 2H), 7.89 – 7.82 (m, 2H), 7.57 – 7.50 (m, 3.3 Hz, 2H), 7.48 – 7.33 (m, 5H), 7.23 – 7.19 (m, 3H), 4.58 (d, *J* = 5.4 Hz, 1H), 4.25 (dt, *J* = 8.1, 5.5 Hz, 1H), 4.16 (dd, *J* = 10.9, 5.5 Hz, 1H), 3.60 (dd, *J* = 17.5, 5.4 Hz, 1H), 3.44 (dd, *J* = 17.5, 8.3 Hz, 1H), 2.59 – 2.43 (m, 2H), 1.61 – 1.52 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8, 198.3, 144.3, 142.1, 142.1, 137.0, 136.8, 133.3, 133.2, 128.8 , 128.7 , 128.6, 128.2, 128.1, 127.6, 124.9, 124.0, 60.9, 52.5, 44.6, 43.7, 33.9, 22.8, 13.5; IR (KBr thin film) 3443, 2961, 1680, 1631, 1596, 1447, 1384, 1357, 1222, 1180, 1071, 1001, 767, 748,728,689 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{27}O_2S^+$ $(M+H)^+$ 415.17263, found 415.17239.

2-2-benzoyl-3-(butylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3c)



Yield: 79%, 67.6 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 – 8.04 (m, 2H), 7.90 – 7.84 (m, 2H), 7.58 – 7.50 (m, 2H), 7.49 – 7.33 (m, 5H), 7.29 – 7.19 (m, 3H), 4.58 (d, *J* = 5.4 Hz, 1H), 4.25 (dt, *J* = 8.1, 5.5 Hz, 1H), 4.16 (dd, *J* = 10.9, 5.5 Hz, 1H), 3.60 (dd, *J* = 17.5, 5.4 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.3 Hz, 1H), 2.58 – 2.45 (m, 2H), 1.57 – 1.47 (m, 2H), 1.46 – 1.29 (m, 2H), 0.83 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8 , 198.3 , 144.3 , 142.1, 137.0, 136.8, 133.3, 133.2, 128.8, 128.7, 128.6, 128.2, 127.6, 124.9, 124.0, 60.9, 52.5, 44.7, 43.7, 31.5, 22.0, 13.63; IR (KBr thin film) 3446, 3064, 2957, 2929, 2871, 1965, 1916, 1815, 1682, 1596, 1579, 1557, 1447, 1359, 1223, 1001, 982, 928, 901, 846, 749, 728, 691 cm^{-1}; HRMS (ESI) m/z calcd for $C_{28}H_{29}O_2S^+$ $[M+H]^+$ 429.18828, found 429.18832.

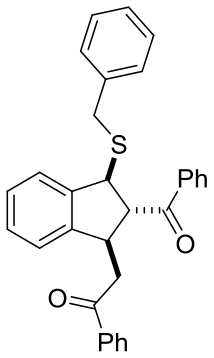
2-(2-benzoyl-3-(octadecylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3d)



Yield: 60%, 74.9 mg; yellow solid; mp 61.0-62.9 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 – 8.01 (m, 2H), 7.87 (dd, *J* = 8.3, 1.2 Hz, 2H), 7.58 – 7.52 (m, 2H), 7.48 – 7.40 (m, 4H), 7.38 – 7.33 (m, 1H), 7.28 – 7.18 (m, 3H), 4.57 (d, *J* = 5.3 Hz, 1H), 4.27 – 4.21 (m, 1H), 4.15 (t, *J* = 5.4 Hz, 1H),

3.60 (dd, *J* = 17.5, 5.4 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.3 Hz, 1H), 2.59 – 2.40 (m, 2H), 1.52 (d, *J* = 7.5 Hz, 2H), 1.23 (d, *J* = 20.2 Hz, 30H), 0.88 (t, *J* = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8, 193 144.3, 142.1, 137.0, 136.8, 133.2 , 128.8 , 128.6, 128.6, 128.2, 128.1, 127.6, 124.9, 124.0, 60.9 , 52.5, 44.7, 43.7, 31.98, 31.95 , 29.72, 29.68, 29.67 , 29.6 ,29.5, 29.4 2, 29.38 , 29.2, 28.9, 22.7, 14.2; IR (KBr thin film) 3445, 3064, 2923, 2852,1683, 1597, 1580, 1457, 1447, 1358,1222, 1180, 1072, 1001, 982, 767, 748, 726, 690 cm^{-1}; HRMS (ESI) m/z calcd for $C_{42}H_{57}O_2S^+$ $(M+H)^+$ 625.40738, found 625.40759.

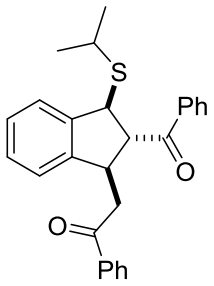
2-(2-benzoyl-3-(benzylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenyletha n-1-one (3e)



Yield: 86%, 79.4 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 – 7.88 (m, 2H), 7.88 – 7.82 (m, 2H), 7.58 – 7.51 (m, 2H), 7.44 – 7.39 (m, 4H), 7.33 – 7.14 (m, 9H), 4.57 (d, *J* = 5.3 Hz, 1H), 4.22 – 4.13 (m, 1H), 4.12 – 4.03 (m, 1H), 3.71 (s, 2H), 3.53 (dd, *J* = 17.5, 5.6 Hz, 1H), 3.35 (dd, *J* = 17.5, 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8, 198.3, 144.4, 141.5, 138.1, 136.9, 133.5, 133.2, 129.0, 128.8, 128.6, 128.6,

128.3, 128.1, 127.7, 127.1, 125.1, 60.5, 52.3, 44.6, 43.8, 36.4; IR (KBr thin film) 3435, 3061, 2360, 2341, 1682, 1596, 1579, 1493, 1476, 1447, 1384, 1357, 1223, 1180, 1070, 1025, 1001, 981, 748, 727, 690, 668 cm^{-1}; HRMS (ESI) m/z calcd for $C_{31}H_{27}O_2S^+$ $(M+H)^+$ 463.17263, found 463.17249.

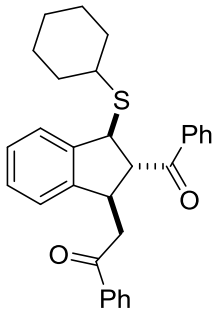
2-(2-benzoyl-3-(isopropylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3f)



Yield: 82%, 67.9 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 – 8.02 (m, 2H), 7.89 – 7.83 (m, 2H), 7.58 – 7.51 (m, 2H), 7.49 – 7.35 (m, 5H), 7.29 – 7.17 (m, 3H), 4.63 (d, *J* = 5.3 Hz, 1H), 4.26 – 4.20 (m, 1H), 4.14 (t, *J* = 5.4 Hz, 1H), 3.59 (dd, *J* = 17.5, 5.6 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.1 Hz, 1H), 2.99 – 2.92 (m, 1H), 1.26 (d, *J* = 6.7 Hz, 4H), 1.20 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8, 198.4, 144.1, 124.0, 61.6, 51.2, 44.8, 43.9, 36.0, 23.8, 23.5; IR (KBr thin film) 3458, 3064, 2960, 2925, 2865, 1682, 1596, 1579, 1476, 1447, 1360, 1223, 1181, 1156, 1001, 982, 769, 729, 691 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{27}O_2S^+$ $(M+H)^+$ 415.17263, found 415.17218.

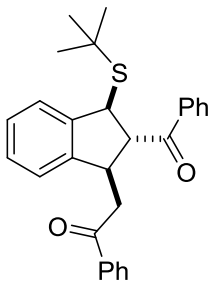
2-(2-benzoyl-3-(cyclohexylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenyle

than-1-one (3g)



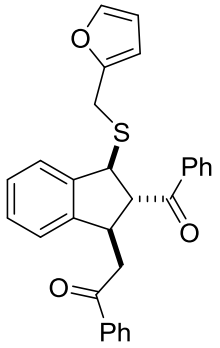
Yield: 79%, 71.76 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 – 8.01 (m, 2H), 7.88 (dd, *J* = 8.3, 1.1 Hz, 2H), 7.61 – 7.50 (m, 2H), 7.50 – 7.37 (m, 4H), 7.35 (d, *J* = 7.3 Hz, 1H), 7.27 – 7.18 (m, 3H), 4.63 (d, *J* = 5.3 Hz, 1H), 4.29 – 4.21 (m, 1H), 4.19 – 4.11 (m, 1H), 3.60 (dd, *J* = 17.5, 5.5 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.3 Hz, 1H), 2.70 – 2.62 (m, 1H), 1.97 – 1.81 (m, 2H), 1.72 – 1.62 (m,2H), 1.60 – 1.51 (m, 1H), 1.40 – 1.11 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.9, 198.4, 144.1, 142.8, 137.0, 136.8, 133.22, 133.18, 128.8, 128.6, 128.1, 128.08, 127.6, 125.0, 124.0, 61.7, 50.8, 44.9, 44.5, 43.8, 34.0, 33.6, 25.98, 25.96, 25.7; IR (KBr thin film) 3439, 3063, 3025, 2928, 2851, 1682, 1596, 1579, 1477, 1447, 1359, 1223, 1180, 1001, 982, 770, 748, 691 cm^{-1}; HRMS (ESI) m/z calcd for $C_{30}H_{31}O_2S^+$ $(M+H)^+$ 455.20393, found 455.20328.

2-(2-benzoyl-3-(tert-butylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3h)



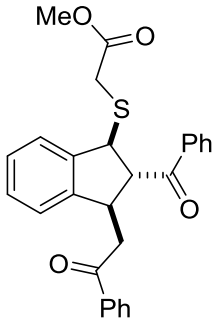
Yield: 81%, 69.4 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 – 7.98 (m, 2H), 7.86 – 7.80 (m, 2H), 7.58 – 7.49 (m, 2H), 7.47 – 7.37 (m, 5H), 7.28 (t, *J* = 7.4 Hz, 1H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.12 (d, *J* = 7.5 Hz, 1H), 4.64 (d, *J* = 6.4 Hz, 1H), 4.20 (dd, *J* = 12.8, 6.4 Hz, 1H), 4.14 (dd, *J* = 12.9, 6.5 Hz, 1H), 3.55 (dd, *J* = 17.3, 6.0 Hz, 1H), 3.36 (dd, *J* = 17.3, 7.3 Hz, 1H), 1.29 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 201.7, 198.2, 143.7, 143.4, 137.7, 136.7, 133.2, 133.16, 128.8, 128.58, 128.56, 128.1, 127.81, 127.79, 125.5, 123.53, 62.61, 49.74, 44.87, 44.80, 44.09, 31.55; IR (KBr thin film) 3350, 3064, 2960, 2898, 2863,1964, 1914, 1815, 1682, 1596, 1580, 1471, 1447, 1365, 1226, 1180, 1158, 1074, 1025, 1001, 981, 864, 791, 767, 748, 697 cm^{-1}; HRMS (ESI) m/z calcd for $C_{28}H_{29}O_2S^+$ $(M+H)^+$ 429.18828, found 429.18805.

2-(2-benzoyl-3-((furan-2-ylmethyl)thio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3i)



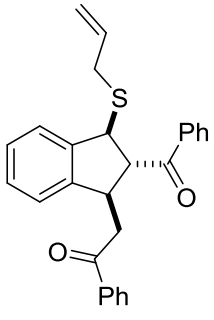
Yield: 88%, 79.5 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.94 (m, 2H), 7.89 – 7.80 (m, 2H), 7.57 – 7.49 (m, 2H), 7.42 (q, *J* = 7.9 Hz, 5H), 7.33 – 7.29 (m, 1H), 7.26 – 7.17 (m, 4H), 6.18 (dd, *J* = 3.2, 1.9 Hz, 1H), 6.02 – 5.99 (m, 1H), 4.64 (d, *J* = 5.1 Hz, 1H), 4.20 (dt, *J* = 8.0, 5.4 Hz, 1H), 4.10 (dd, *J* = 10.2, 5.1 Hz, 1H), 3.79 – 3.68 (m, 2H), 3.57 (dd, *J* = 17.5, 5.6 Hz, 1H), 3.43 (dd, *J* = 17.5, 8.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.6, 198.3, 151.2, 144.5, 142.2, 141.4, 136.8, 133.3, 133.2, 128.8, 128.63, 128.62, 128.3, 128.1, 127.8, 125.1, 124.1, 60.4, 52.3 , 44.8, 43.8, 28.5; IR (KBr thin film) 3435, 2360, 1681, 1596, 1579, 1447, 1384, 1356, 1222, 1149, 1069, 1010, 933, 747, 689 cm^{-1}; HRMS (ESI) m/z calcd for $C_{29}H_{25}O_3S^+$ $(M+H)^+$ 453.15189, found 453.15155.

Methyl 2-((2-benzoyl-3-(2-oxo-2-phenylethyl)-2,3-dihydro-1H-inden-1-yl)thio)acetate (3j)



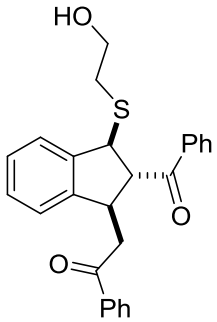
Yield: 79%, 70.1 mg; yellow liquid ; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 – 8.02 (m, 2H), 7.91 – 7.85 (m, 2H), 7.60 – 7.52 (m, 2H), 7.49 – 7.38 (m, 5H), 7.30 – 7.20 (m, 3H), 4.76 (d, *J* = 4.8 Hz, 1H), 4.29 – 4.18 (m, 2H), 3.59 (s, 3H), 3.49 (dd, *J* = 17.6, 7.8 Hz, 1H), 3.27(q, *J* = 33.0, 18.0 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.3, 198.2, 170.7, 144.7, 140.7, 136.8, 133.3, 128.8, 128.7, 128.6, 128.6, 128.1, 127.8, 125.2, 124.3, 59.8, 52.8, 52.5, 44.6, 43.6, 33.1; IR(KBr thin film) 3445, 3064, 2950, 2342, 1972,1737, 1682, 1633, 1596, 1579, 1556, 1478, 1447, 1435, 1405, 1357, 1282, 1223, 1182, 1157, 1129, 1001, 901, 846, 749, 728, 690 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{25}O_4S^{+}(M+H)^{+}$ 445.14681, found 445.14700.

2-(3-(allylthio)-2-benzoyl-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3k)



Yield: 80%, 65.9 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 – 7.99 (m, 2H), 7.91 – 7.86 (m, 2H), 7.61 – 7.50 (m, 2H), 7.50 – 7.34 (m, 5H), 7.31 – 7.17 (m, 3H), 5.82 – 5.72 (m,1H), 5.04 – 4.88 (m, 2H), 4.56 (d, *J* = 4.9 Hz, 1H), 4.25 – 4.18 (m, 2H), 3.60 (dd, *J* = 17.5, 5.2 Hz, 1H), 3.45 (dd, *J* = 17.5, 8.0 Hz, 1H), 3.19 – 3.09 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.6, 198.3, 144.4, 142.0, 136.9, 136.8, 133.9, 133.27, 133.26, 128.8, 128.7, 128.6, 128.3, 128.2, 127.7, 125.1 , 124.1, 117.9, 60.9, 51.4, 44.8, 43.9, 35.3; IR (KBr thin film) 3459, 3064, 3025, 2977, 2914, 1964, 1914, 1871, 1682, 1634, 1596, 1979, 1487, 1426, 1404, 1359, 1284, 1224, 1181, 1075, 1044, 1025, 1001, 987, 922, 890, 846, 796, 768, 749, 727, 690 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{25}O_2S^+$ $(M+H)^+$ 413.15698, found 413.15662.

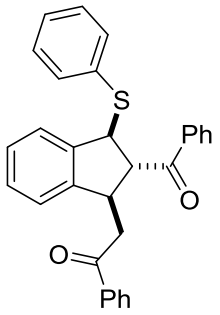
2-(2-benzoyl-3-((2-hydroxyethyl)thio)-2,3-dihydro-1H-inden-1-yl)-1-phenylethan-1-one (3l)



Yield: 65%, 53.8 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 – 8.01 (m, 2H), 7.90 – 7.82 (m, 2H), 7.60 – 7.51 (m, 2H), 7.42 (dq, *J* = 15.2, 7.8 Hz, 5H), 7.30 – 7.23 (m, 3H), 7.22 – 7.17 (m, 1H), 4.66 (d, *J* = 5.5 Hz,

1H), 4.26 – 4.17 (m, 2H), 3.74 – 3.65 (m, 2H), 3.60 (dd, *J* = 17.5, 5.1 Hz, 1H), 3.45 (dd, *J* = 17.5, 7.6 Hz, 1H), 2.74 (td, *J* = 6.1, 1.1 Hz, 2H), 1.97 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.8, 198.3, 144.1, 141.6, 137.0, 136.7, 133.4, 133.3, 128.743, 128.736 , 128.7, 128.4, 128.1, 127.9, 124.9, 124.0, 61.0, 60.9, 52.2, 44.3, 43.9, 34.9; IR (KBr thin film) 3437, 3064, 2923, 2359, 2341, 1682, 1596, 1579, 1476, 1447, 1403, 1384, 1359, 1224, 1181, 1046, 1001, 902, 749, 728, 690 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{25}O_3S^+$ $(M+H)^+$ 417.15189, found 417.15152.

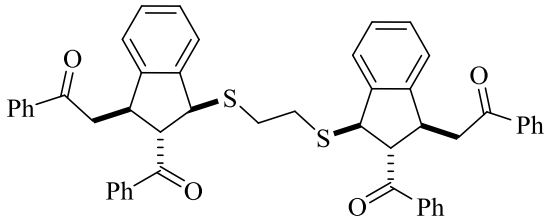
2-(2-benzoyl-3-(phenylthio)-2,3-dihydro-1H-inden-1-yl)-1-phenyletha n-1-one (3m)



Yield: 82%, 73.4 mg; yellow solid; mp 102-104 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (dd, *J* = 8.3, 1.1 Hz, 2H), 7.82 (dd, *J* = 8.2, 1.1 Hz, 2H), 7.56 – 7.48 (m, 2H), 7.39 (dt, *J* = 13.1, 7.7 Hz, 4H), 7.32 – 7.15 (m, 9H), 4.91 (d, *J* = 3.9 Hz, 1H), 4.25 (dt, *J* = 9.0, 4.7 Hz, 1H), 4.12 (t, *J* = 3.9 Hz, 1H), 3.42 (dd, *J* = 17.7, 5.3 Hz, 1H), 3.10 (dd, *J* = 17.7, 8.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.0, 198.4, 145.1, 141.4, 136.3, 133.4, 133.2, 133.1, 129.1, 128.8, 128.6, 128.5, 128.11, 128.06, 127.7, 125.3, 124.3, 58.7, 55.9, 44.9, 43.1; IR (KBr thin film) 3435, 3060, 1718, 1682,

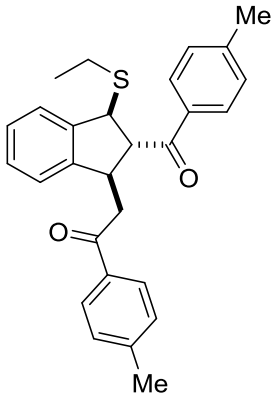
1596, 1579,1478, 1447, 1438, 1384, 1358, 1285, 1224, 1180, 1158, 1068, 1001, 986, 927, 901, 879, 846, 768, 747, 724, 689 cm^{-1}; HRMS (ESI) m/z calcd for $C_{30}H_{25}O_2S^+$ $(M+H)_+$ 449.15698, found 449.15662.

2,2'-((ethane-1,2-diylbis(sulfanediyl))bis(2-benzoyl-2,3-dihydro-1H-indene-3,1-diyl))bis(1-phenylethan-1-one) (3n)



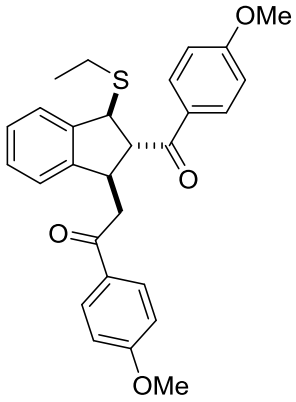
Yield: 68%, 52.3 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.95 (m, 4H), 7.87 – 7.82 (m, 4H), 7.52 – 7.47 (m, 4H), 7.41 – 7.36 (m,8H), 7.30 – 7.25 (m, 2H), 7.24 – 7.21 (m, 4H), 7.18 (d, *J* = 2.4 Hz, 2H), 4.54 (dd, *J* = 11.9, 5.9 Hz, 2H), 4.14 – 4.10 (m, 2H), 4.15 – 4.07 (m, 2H), 3.61 – 3.51 (m, 2H), 3.45 – 3.37 (m,2H), 2.68 (s, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.48 , 200.45, 198.20 , 144.21 ,141.54, 141.48, 136.82, 136.72, 136.91, 133.33, 133.30, 133.29, 133.27, 128.73, 128.70, 128.63, 128.36, 128.08, 127.71, 124.91, 124.89, 124.04, 124.02, 60.77, 52.47, 44.40, 43.65, 31.66 ; IR (KBr thin film) 3438, 3063, 2358, 1682, 1596, 1579, 1477, 1447, 1404, 1384, 1359, 1223, 1181, 1001, 982, 902, 748, 689 cm^{-1}; HRMS (ESI) m/z calcd for C_{50} $H_{43}O_4S_2^+$ $(M+H)^+$ 771.25973, found 771.26007.

2-(3-(ethylthio)-2-(4-methylbenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(p-tolyl)ethan-1-one (3o)



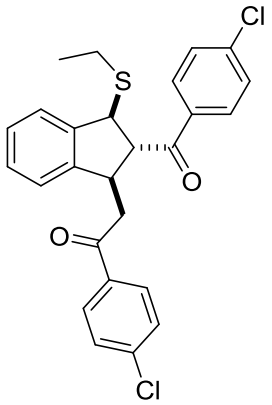
Yield:86%, 73.6 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.90 (m, 2H), 7.77 (d, *J* = 6.6 Hz, 2H), 7.39 – 7.33 (m, 1H), 7.28 – 7.17 (m, 7H), 4.60 (d, *J* = 5.5 Hz, 1H), 4.25 – 4.18 (m, 1H), 4.14 (dd, *J* = 11.3, 5.6 Hz, 1H), 3.54 (dd, *J* = 17.3, 5.6 Hz, 1H), 3.40 (dd, *J* = 17.3, 7.9 Hz, 1H), 2.61 – 2.47 (m, 2H), 2.39 (s, 6H), 2.38 (s, 3H), 1.21(t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.4 , 197.9, 144.4, 144.1, 144.0, 134.5, 129.4, 129.3, 128.9, 128.3, 128.1, 127.6, 124.9 , 124.0 , 60.7, 52.3 , 44.4, 44.0, 25.9 , 21.7, 14.6; IR (KBr thin film) 3444, 3029, 2968, 2924, 2870, 2590, 1921, 1806, 1679, 1606, 1571, 1477, 1455, 1407, 1358, 1286, 1254, 1228, 1205, 1181, 1119, 1039, 1017, 978, 903, 809, 753, 715, 637 cm^{-1}; HRMS (ESI) m/z calcd for $C_{28}H_{29}O_2S^{+}(M+H)^{+}$ 429.18828, found 429.18835.

2-(3-(ethylthio)-2-(4-methoxybenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(4-methoxyphenyl)ethan-1-one (3p)



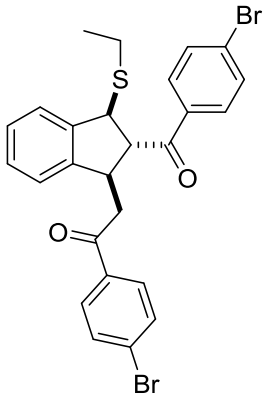
Yield: 89%, 81.7mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 – 7.99 (m, 2H), 7.88 – 7.81 (m, 2H), 7.36 (d, *J* = 6.9 Hz, 1H), 7.27 – 7.16 (m, 3H), 6.95 – 6.84 (m, 4H), 4.59 (d, *J* = 5.6 Hz, 1H), 4.21 (dd, *J* = 13.5, 5.8 Hz, 1H), 4.13 (dd, *J* = 11.5, 5.8 Hz, 1H), 3.85 (s, 3H), 3.84 (s, 3H), 3.50 (dd, *J* = 17.0, 5.6 Hz, 1H), 3.37 (dd, *J* = 17.0, 8.0 Hz, 1H), 2.63 – 2.45 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3, 196.9, 144.5, 142.2, 131.1, 130.4, 130.03, 129.99, 128.1, 127.5, 124.8, 113.8, 113.7, 60.6, 55.5, 52.4, 44.2, 44.0, 25.9, 14.65; IR (KBr thin film) 3459, 3068, 3006, 2965, 2931, 2839, 2574, 2427, 2308, 2054, 1913, 1673, 1600, 1574, 1510, 1456, 1420, 1359, 1309, 1258, 1171, 1114, 1028, 984, 903, 880, 839, 807, 756, 737, 702 cm^{-1}; HRMS (ESI) m/z calcd for $C_{28}H_{29}O_4S^+$ $(M+H)^+$ 461.17811, found 461.17838.

2-(2-(4-chlorobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(4-chlorophenyl)ethan-1-one (3q)



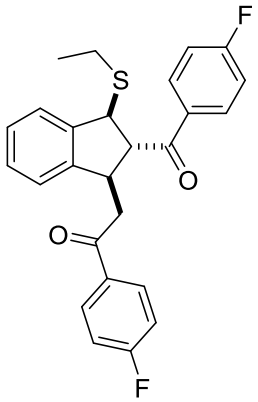
Yield: 68%, 63.6 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (t, *J* = 1.8 Hz, 1H), 7.93 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.82 (t, *J* = 1.7 Hz, 1H), 7.74 (dt, *J* = 7.8, 1.3 Hz, 1H), 7.55 – 7.50 (m, 2H), 7.44 – 7.33 (m, 3H), 7.29 – 7.24 (m, 2H), 7.23 – 7.18 (m, 1H), 4.54 (d, *J* = 5.5 Hz, 1H), 4.22 (dt, *J* = 9.6, 5.1 Hz, 1H), 4.04 (t, *J* = 5.5 Hz, 1H), 3.58 (dd, *J* = 17.7, 4.8 Hz, 1H), 3.40 (dd, *J* = 17.7, 9.1 Hz, 1H), 2.62 – 2.47 (m, 2H), 1.23 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.4, 197.1, 143.7, 141.8, 138.5, 138.1, 135.0, 133.3, 133.2, 130.0, 129.96, 128.9, 128.3, 128.2, 127.9, 126.8, 126.2, 125.0, 123.9, 61.0, 52.4, 44.6, 43.5, 25.9, 14.6; IR (KBr thin film) 3435, 3067, 2969，2927, 1954，1682，1634, 1590, 1570，1474，1456，1423，1357, 1285, 1223, 1075, 1052, 997, 944, 902, 787，749, 711 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{23}Cl_2O_2S^+(M+H)^+$ 469.07903, found 469.07910.

2-(2-(4-bromobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(4-bromophenyl)ethan-1-one (3r)



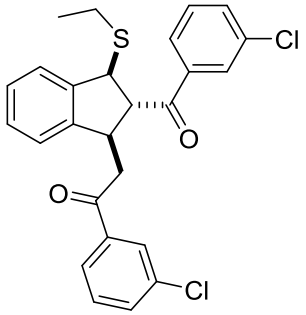
Yield: 67%, 74.4 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 – 7.88 (m, 2H), 7.74 – 7.69 (m, 2H), 7.62 – 7.53 (m, 4H), 7.39 – 7.34 (m, 1H), 7.30 – 7.24 (m, 2H), 7.22 – 7.17 (m, 1H), 4.52 (d, *J* = 5.5 Hz, 1H), 4.21 (dt, *J* = 9.6, 5.1 Hz, 1H), 4.04 (t, *J* = 5.5 Hz, 1H), 3.56 (dd, *J* = 17.6, 4.9 Hz, 1H), 3.37 (dd, *J* = 17.6, 9.1 Hz, 1H), 2.63 – 2.42 (m, 2H), 1.21 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.7, 197.4, 143.8, 141.9, 135.7, 135.3, 132.0, 130.3, 129.6, 128.6, 128.6, 128.3, 127.8, 125.0, 123.9, 60.8, 52.5, 44.5, 43.6, 26.0, 14.6; IR (KBr thin film) 3453, 3067, 2967, 2926,1919, 1682, 1631, 1584, 1567, 1535, 1482, 1455, 1396, 1358, 1249, 1221, 1177, 1107, 1071, 1025, 1009, 985, 903, 814, 770, 749 cm^{-1}.

2-(3-(ethylthio)-2-(3-fluorobenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(4-fluorophenyl)ethan-1-one (3s)



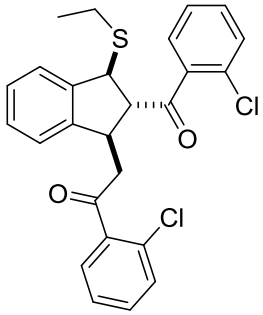
Yield: 67%, 58.4mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 – 8.05 (m, 2H), 7.92 – 7.87 (m, 2H), 7.38 – 7.34 (m, 1H), 7.27 (dd, *J* = 6.2, 2.8 Hz, 2H), 7.23 – 7.18 (m, 1H), 7.16 – 7.06 (m, 4H), 4.54 (d, *J* = 5.4 Hz, 1H), 4.23 (dt, *J* = 9.6, 5.1 Hz, 1H), 4.07 (t, *J* = 5.4 Hz, 1H), 3.58 (dd, *J* = 17.5, 5.0 Hz, 1H), 3.40 (dd, *J* = 17.5, 8.9 Hz, 1H), 2.62 – 2.47 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H).^{13}C NMR (100 MHz, $CDCl_3$) δ 199.1, 196.7, 167.2, 167.1, 164.6, 144.0, 141.9, 131.5, 131.4, 133.34, 133.31, 133.16, 133.13, 130.77, 130.68, 128.3, 127.8, 125.0, 123.9, 115.9, 115.9, 115.7, 115.6, 60.7, 52.4, 44.5, 43.7, 25.9, 14.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ -104.65, -105.04; IR (KBr thin film) 3434, 2926, 2359, 2342, 1682, 1597, 1506, 1457, 1384, 1358, 1228, 1156, 1099, 987, 845, 747, 668 cm^{-1};HRMS (ESI) m/z calcd for $C_{26}H_{23}F_2O_2S^+$ $(M+H)^+$ 437.13813, found 437.13788.

2-(2-(3-chlorobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(3-chlorophenyl)ethan-1-one (3t)



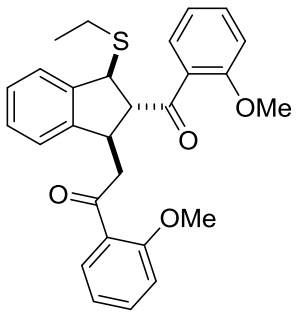
Yield: 76%, 71.1 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 – 7.94 (m, 2H), 7.84 – 7.73 (m, 2H), 7.46 – 7.33 (m, 5H), 7.30 – 7.23 (m, 2H), 7.22 – 7.16 (m, 1H), 4.53 (d, *J* = 5.5 Hz, 1H), 4.22 (dt, *J* = 9.7, 5.1 Hz, 1H), 4.05 (t, *J* = 5.5 Hz, 1H), 3.57 (dd, *J* = 17.6, 4.9 Hz, 1H), 3.38 (dd, *J* = 17.6, 9.0 Hz, 1H), 2.61 – 2.45 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 197.1, 143.9, 141.9, 139.9, 139.8, 135.2, 135.0, 130.2, 129.5, 128.98, 128.96, 128.3, 127.8, 125.0, 123.9, 60.8, 52.5, 44.5, 43.6, 26.0, 14.6; IR (KBr thin film) 3443, 2969, 2926, 1682, 1632, 1598, 1570, 1487, 1456, 1400, 1384, 1359, 1283, 1205，1221, 1207, 1176, 1091, 1012，986，902，818, 773, 748 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{23}Cl_2O_2S^{+}(M+H)^{+}$ 469.07903, found 469.07913.

2-(2-(2-chlorobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(2-chlorophenyl)ethan-1-one (3u)



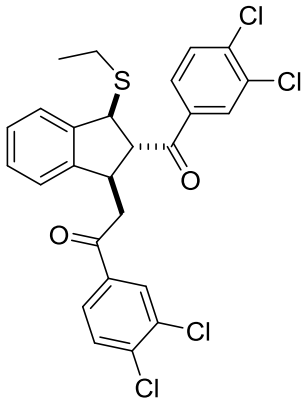
Yield: 63%, 58.9 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 – 7.97 (m, 2H), 7.82 – 7.77 (m, 2H), 7.46 – 7.38 (m, 4H), 7.36 (dd, *J* = 6.2, 2.5 Hz, 1H), 7.29 – 7.25 (m, 2H), 7.22 – 7.17 (m, 1H), 4.53 (d, *J* = 5.5 Hz, 1H), 4.22 (dt, *J* = 9.7, 5.1 Hz, 1H), 4.05 (t, *J* = 5.5 Hz, 1H), 3.57 (dd, *J* = 17.6, 4.9 Hz, 1H), 3.38 (dd, *J* = 17.6, 9.0 Hz, 1H), 2.59 – 2.45 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 197.1, 143.9, 141.9, 139.9,139.8, 135.2, 135.0, 130.2, 129.5, 128.98, 128.96, 128.3 , 127.8 , 124.97 , 123.88 , 60.82 , 52.45 , 44.49 , 43.63 , 25.95 , 14.56 ; IR (KBr thin film) 3440, 2990, 2924, 2360, 2343, 1677, 1630, 1588, 1571, 152, 1400, 1364, 1208, 1091, 1050, 1012, 988, 774, 749, 668 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{23}Cl_2O_2S^+$ $(M^+H)^+$ 469.07903, found 469.07922.

2-(3-(ethylthio)-2-(2-methoxybenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(2-methoxyphenyl)ethan-1-one (3v)



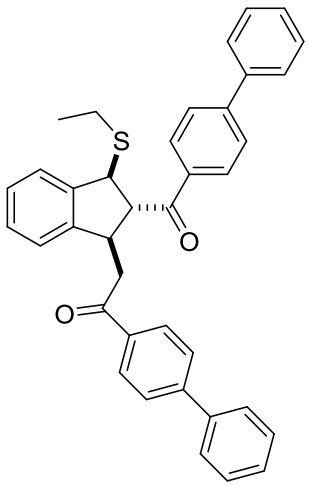
Yield: 65%, 59.8mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.60 (m, 1H), 7.58 – 7.52 (m, 1H), 7.45 – 7.39 (m, 2H), 7.37 (d, *J* = 6.8 Hz, 1H), 7.19 (dt, *J* = 19.8, 6.1 Hz, 3H), 7.00 (t, *J* = 7.3 Hz, 1H), 6.92 (dt, *J* = 15.3, 7.6 Hz, 3H), 4.72 (d, *J* = 5.7 Hz, 1H), 4.32 (t, *J* = 5.9 Hz, 1H), 4.14 (dd, *J* = 12.6, 6.3 Hz,1H), 3.81 (s, 3H), 3.73 (s, 3H), 3.56 (dd, *J* = 17.6, 6.2 Hz, 1H), 3.44 (dd, *J* = 17.7, 7.1 Hz, 1H), 2.59 – 2.45 (m, 2H), 1.20 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 203.39, 200.38, 158.5, 158.0, 144.8, 142.3, 133.5, 133.2, 130.7, 130.4, 128.7, 128.1, 127.9, 127.3, 124.8, 124.0, 120.8, 120.7, 111.50, 111.46, 64.7, 55.2, 51.2, 50.2, 43.9, 25.5, 14.7; IR (KBr thin film) 3447, 3069,2966, 2926, 2837, 1671, 1596, 1578, 1484, 1435, 1396, 1353, 1285, 1244, 1179,1162, 1112, 1051, 1021, 987, 885, 804, 755, 658 cm^{-1}; HRMS (ESI) m/z calcd for $C_{28}H_{29}O_4S^+$ $(M+H)^+$ 461.17811, found 461.17819.

2-(2-(3,4-dichlorobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(3,4-dichlorophenyl)ethan-1-one (3W)



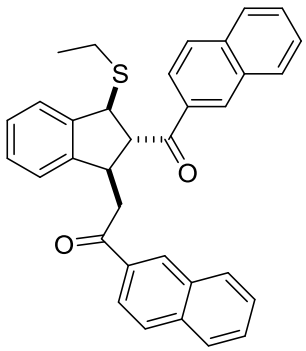
Yield: 67%, 71.8 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, *J* = 2.0 Hz, 1H), 7.93 (d, *J* = 2.0 Hz, 1H), 7.89 (dd, *J* = 8.4, 2.1 Hz, 1H), 7.69 (dd, *J* = 8.4, 2.1 Hz, 1H), 7.53 (dd, *J* = 15.7, 8.4 Hz, 2H), 7.38 – 7.33 (m, 1H), 7.31 – 7.27 (m, 2H), 7.23 – 7.18 (m, 1H), 4.49 (d, *J* = 5.6 Hz, 1H), 4.21 (dt, *J* = 9.7, 4.9 Hz, 1H), 3.97 (t, *J* = 5.5 Hz, 1H), 3.57 (dd, *J* = 17.7, 4.5 Hz, 1H), 3.37 (dd, *J* = 17.7, 9.5 Hz, 1H), 2.61 – 2.46 (m, 2H), 1.23 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.4, 196.2, 143.4, 141.7, 138.1, 13.9, 136.5, 136.0,133.5, 133.4, 130.8, 130.79, 130.75, 130.1, 128.4, 128.0, 127.8, 127.1, 125.0, 123.8, 60.9, 52.5, 44.4, 43.5, 25.9, 14.5; IR (KBr thin film) 3435, 2359, 2341, 1684, 1636, 1583, 1559, 1457, 1384, 1201, 1030, 749, 668 cm^{-1}; HRMS (ESI) m/z calcd for $C_{26}H_{21}Cl_4O_2S^+(M+H)^+$ 537.00109, found537.00018.

2-(2-([1,1'-biphenyl]-4-carbonyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-([1,1'-biphenyl]-4-yl)ethan-1-one (3x)



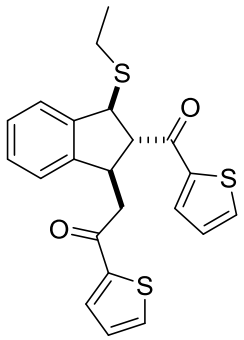
Yield: 75%, 82.9mg; yellow solid; mp 92.3-94.3; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J* = 8.4 Hz, 2H), 7.95 – 7.88 (m, 2H), 7.68 – 7.63 (m, 2H), 7.63 – 7.51 (m, 6H), 7.46 – 7.34 (m, 7H), 7.30 – 7.18 (m, 3H), 4.66 (d, *J* = 5.72 Hz), 4.33 – 4.26 (m, 1H), 4.21 (t, *J* = 5.8 Hz, 1H), 3.61 (dd, *J* = 17.3, 5.3 Hz, 1H), 3.50 (dd, *J* = 17.3, 8.4 Hz, 1H), 2.65 – 2.48 (m, 2H), 1.23 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.4, 197.9, 144.1, 142.1, 135.7, 135.5, 129.4, 128.97, 128.96, 128.7, 128.3, 128.23, 128.20, 127.7, 127.27, 127.26, 127.2, 125.0, 123.9, 61.1, 52.4, 44.4, 44.1, 26.0, 14.7; IR (KBr thin film) 3446, 3058, 3031, 2965, 2926, 2870, 2359, 2341, 1951, 1807, 1682, 1673, 1603, 1581, 1558, 1514, 1486, 1404, 1360, 1264, 1228, 1191, 1157, 1116, 1076, 1050, 1025, 1006, 986, 904, 850, 811, 763, 747, 696 cm^{-1}; HRMS (ESI) m/z calcd for $C_{38}H_{33}O_2S^+$ $(M+H)^+$ 553.21958, found 553.21906.

2-(2-(2-naphthoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(naphthalen-2-yl)ethan-1-one (3y)



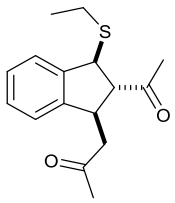
Yield: 80%, 80.02 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.58 (s, 1H), 8.34 (s, 1H), 8.11 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.80 (ddd, *J* = 29.8, 16.0, 8.6 Hz, 8H), 7.58 – 7.38 (m, 6H), 7.33 – 7.25 (m, 3H), 4.70 (d, *J* = 5.3 Hz, 1H), 4.37 (dd, *J* = 10.3, 5.7 Hz, 2H), 3.75 – 3.59 (m, 2H), 2.66 – 2.49 (m, 2H), 1.22 (t, *J* = 7.4 Hz, 3H);^{13}C NMR (100 MHz, $CDCl_3$) δ 200.7, 198.3, 144.3, 142.2, 135.7, 135.6, 134.3, 134.1, 132.5, 132.4, 130.6, 129.9, 129.7, 129.6, 128.6, 128.5, 128.5, 128.4, 128.2, 127.72, 127.71, 127.69, 126.8, 126.7, 125.0, 124.5, 124.0, 123.7, 61.2, 52.5, 44.5, 44.3, 26.2, 14.7; IR (KBr thin film) 3434, 3058, 2966, 2926, 2870, 2357, 2342, 1924, 1675, 1626, 1595, 1577, 1507, 1468, 1436, 1384, 1358, 1336, 1276, 1219, 1184, 1123, 1048, 1024, 986, 942, 897, 863, 821, 775, 755, 703 cm^{-1}; HRMS (ESI) m/z calcd for $C_{34}H_{29}O_2S^+$ $(M+H)^+$ 501.18828, found 501.18845.

2-3-(ethylthio)-2-(thiophene-2-carbonyl)-2,3-dihydro-1H-inden-1-yl)-1-(thiophen-2-yl)ethan-1-one (3z)



Yield: 70%, 57.6 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (dd, *J* = 3.9, 1.2 Hz, 1H), 7.69 (dd, *J* = 3.8, 1.2 Hz, 1H), 7.66 (dd, *J* = 5.0, 1.1 Hz, 1H), 7.62 (dd, *J* = 5.0, 1.1 Hz, 1H), 7.39 (d, *J* = 7.6 Hz, 1H), 7.28 – 7.17 (m, 3H), 7.12 – 7.08 (m, 2H), 4.64 (d, *J* = 6.1 Hz, 1H), 4.22 (dd, *J* = 13.6, 6.8 Hz, 1H), 4.03 (dd, *J* = 12.4, 6.0 Hz, 1H), 3.54–3.35 (m, 2H), 2.65–2.44 (m, 2H), 1.23 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 191.1, 143.7, 141.9, 134.7, 134.1, 132.9, 132.2, 128.4, 128.2, 127.8 , 124.9, 123.8, 62.4, 52.4, 44.6, 44.3, 25.7, 14.7; IR (KBr thin film) 3445, 2966,2925, 1656, 1558, 1517, 1476, 1415, 1383, 1356, 1238, 856, 751, 724, 666 cm^{-1}.

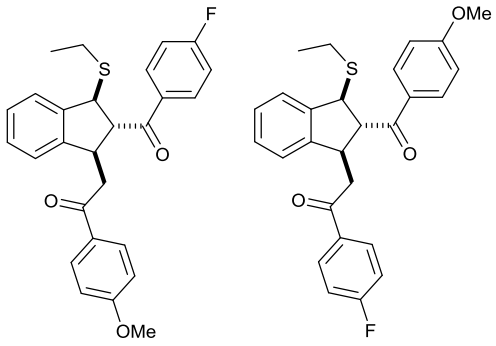
1-(2-acetyl-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)propan-2-one (3aa)



Yield: 67%, 37.0 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.34 (m, 1H), 7.26 – 7.19 (m, 2H), 7.13 – 7.08 (m, 1H), 4.43 (d, *J* = 5.8

Hz, 1H), 3.89 – 3.84 (m, 1H), 3.13 (dd, *J* = 11.5, 6.0 Hz, 1H), 3.05 (dd, *J* = 17.6, 4.9 Hz, 1H), 2.87 (dd, *J* = 17.6, 9.0 Hz, 1H), 2.65 – 2.48 (m, 2H), 2.39 (s, 3H), 2.20 (s, 3H), 1.28 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 208.5, 207.4, 143.5, 141.7, 128.1, 127.7, 125.0, 123.7, 65.6, 50.6, 49.8, 42.0, 30.9, 30.3, 29.8, 25.1, 14.6; IR (KBr thin film) 3435, 3069, 2968, 2927, 1713, 1654, 1477, 1456, 1404, 1359, 1255, 1228, 1159, 1067, 1023, 970, 747 cm^{-1}; HRMS (ESI) m/z calcd for $C_{16}H_{21}O_2S^+$ $(M+H)^+$ 277.12568, found 277.12585.

2-3-(ethylthio)-2-(4-fluorobenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(4-methoxyphenyl)ethan-1-one (3ac) and **2-3-(ethylthio)-2-(4-methoxybenzoyl)-2,3-dihydro-1H-inden-1-yl)-1-(4-fluorophenyl)ethan-1-one (3ac′)**

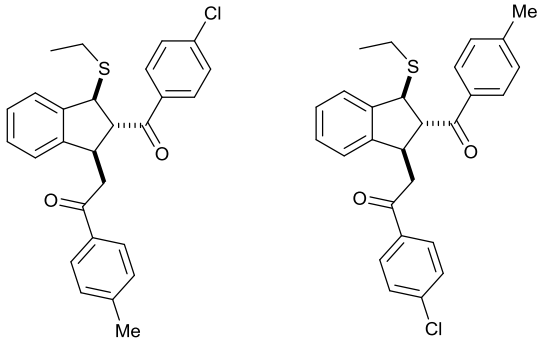


A mixture of inseparable regioisomers, **3ac**/**3ac'** = 3:1; Pale yellow liquid (61.0 mg, 68% yield); ^{1}H NMR (400 MHz, $CDCl_3$) of **3ac**: δ 8.10 – 8.00 (m, 2 H), 7.87 – 7.83 (m, 2H), 7.39 – 7.35 (m, 1H), 7.28 – 7.24 (m, 2H), 7.24 – 7.17 (m, 1H), 7.15 – 7.05 (m, 2H), 6.91 – 6.87(m, 2H), 4.55 (d, *J* = 5.5 Hz, 1H), 4.23 – 4.18(m, 1H), 4.15 – 4.06 (m, 1H), 3.86 (s, 3H), 3.54

(dd, *J* = 17.2, 5.1 Hz, 1H), 3.37 (dd, *J* = 17.2, 9.0 Hz, 1H), 2.61 – 2.46 (m, 2H), 1.22 (td, *J* = 7.4, 2.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) of **3ac** and **3ac′**, δ 199.4, 199.1, 196.82, 196.77, 167.1, 164.6, 163.74, 163.65, 144.24, 144.18, 142.16, 141.94, 133.43, 133.41, 131.5, 131.4, 131.1, 130.8, 130.7, 130.4, 129.92, 129.85, 128.2, 128.1, 127.7, 127.62, 124.9, 123.93 , 123.9, 115.8, 115.6, 113.85, 113.78, 60.8, 60.6, 55.5, 52.5, 52.4, 44.3, 44.2, 44.0, 43.9, 31.6, 26.0, 25.9, 22.7, 14.63, 14.58; IR (KBr thin film) **3ac** and **3ac′**3435, 2358, 1673, 1599, 1505, 1384, 1228, 1169, 1047,838 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{26}FO_2S^+$ $(M+H)^+$ 433.16321, found 433.16260.

^{1}H NMR (400 MHz, $CDCl_3$) of **3ac′**: 8.10 – 8.00 (m, 0.7 H), 7.92 – 7.88 (m, 0.7H), 7.39 – 7.35 (m, 0.33H), 7.28 – 7.24 (m, 0.8H), 7.24 – 7.17 (m, 0.4H), 7.15 – 7.05 (m, 0.7H), 6.94 – 6.92(m, 0.7H), 4.58 (d, J = 5.6 Hz, 0.33H), 4.55 (d, J = 5.5 Hz, 1H), 4.23 – 4.18(m, 0.33H), 4.15 – 4.06 (m, 0.33H), 3.87 (s, 1H), 3.54 (dd, J = 17.2, 5.1 Hz, 0.33H), 3.37 (dd, J = 17.2, 9.0 Hz, 0.33 H), 2.61 – 2.46 (m, 0.7H), 1.22 (td, J = 7.4, 2.7 Hz, 1.0H).

1-(4-chlorophenyl)-2-3-(ethylthio)-2-(4-methylbenzoyl)-2,3-dihydro-1 H-inden-1-yl)ethan-1-one (3ad) and **2-2-(4-chlorobenzoyl)-3-(ethylthio)-2,3-dihydro-1H-inden-1-yl)-1-(p-t olyl)ethan-1-one (3ad′)**

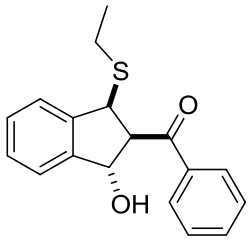


A mixture of inseparable regioisomers, **3ad**/**3ad'** = 2.5:1; Pale yellow liquid (78.1 mg, 87% yield); ^{1}H NMR (400 MHz, CD3Cl) of **3ad**: δ 8.01–7.97 (m, 2H), 7.76 (d, J = 8.2 Hz, 2H), 7.45–7.34 (m, 3H), 7.31–7.15 (m, 5H), 4.54 (d, J = 5.6 Hz, 1H), 4.25–4.15 (m, 1H), 4.16–4.04 (m, 1H), 3.62–3.50 (m, 1H), 3.44–3.35 (m, 1H), 2.60–2.45 (m, 2H), 2.39 (s, 3H), 1.25–1.18 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) of **3ad** and **3ad′**: δ 200.1, 199.8, 197.9, 197.1, 144.22, 144.18, 144.12, 144.07 , 142.1, 141.9, 139.68, 139.65 , 135.4, 135.1, 134.4, 134.2, 130.2, 129.5, 129.4, 129.3, 128.9, 128.87, 128.23, 128.20, 128.17, 127.70, 127.67, 124.9, 123.9, 60.9, 60.8, 52.5, 52.21, 44.4, 44.36, 43.9, 43.8, 21.7, 14.62, 14.59; IR (KBr thin film) of **3ad** and **3ad′**: 3442, 2968, 2925, 1679, 1606, 1588, 1571, 1456, 1384, 1360, 1226, 1180, 1091, 1002, 991, 810, 749 cm^{-1}; HRMS (ESI) m/z calcd for $C_{27}H_{26}ClO_2S^{+}$ $(M+H)^{+}$ 449.13365, found 449.13330.

^{1}H NMR (400 MHz, $CDCl_3$) of **3ad′**: ^{1}H NMR (400 MHz, CD_3Cl) δ7.95–7.92 (m, 0.82H), 7.81–7.78 (m, 0.86H), 7.45–7.34 (m, 1.2H), 7.31–7.15 (m, 2H), 4.62–4.58 (m, 0.42 H), 4.25–4.15 (m, 0.47 H),

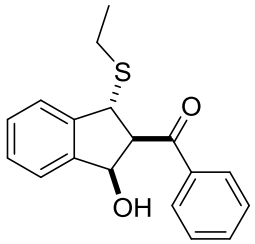
4.16–4.04 (m, 0.58 H), 3.62–3.50 (m, 0.51 H), 3.44–3.35 (m, 0.46 H), 2.60–2.45 (m, 1.2H), 2.41 (s, 1.1H),1.25–1.18 (m, 1H).

1-(ethylthio)-3-hydroxy-2,3-dihydro-1H-inden-2-yl)(phenyl)methano ne (5a)



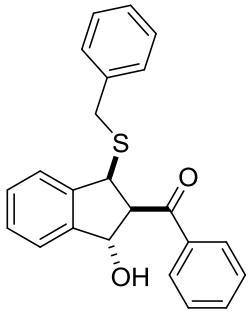
Yield: 57%, 33.9 mg; yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 – 8.14 (m, 2H), 7.65 – 7.59 (m, 1H), 7.55 – 7.48 (m, 2H), 7.47 – 7.42 (m, 1H), 7.39 – 7.29 (m, 3H), 5.28 (d, *J* = 4.2 Hz, 1H), 4.75 (d, *J* = 6.0 Hz, 1H), 4.36 – 4.24 (m, 1H), 2.74 – 2.35 (m, 3H), 1.22 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.5, 142.2, 142.0, 136.6, 133.7, 129.4, 129.1, 128.8, 128.5 , 125.2, 124.4, 65.8, 48.6, 25.5, 14.6; IR (KBr thin film) 3435, 1667, 1595, 1557, 1538, 1447, 1384, 1250, 1052, 781, 700 cm^{-1}; HRMS (ESI) m/z calcd for $C_{18}H_{17}O_2S^+$ $(M+H)^+$ 297.09438, found 297.09476.

1-(ethylthio)-3-hydroxy-2,3-dihydro-1H-inden-2-yl)(phenyl)methano ne (5a′)



Yield: 10%, 5.96 mg; yellow liquid , ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.66 – 7.61 (m, 1H), 7.56 – 7.52 (m, 2H), 7.50 – 7.45 (m, 1H), 7.44 – 7.38 (m, 2H), 7.37 – 7.31 (m, 1H), 5.57 (dd, *J* = 8.6, 6.6 Hz, 1H), 5.04 (d, *J* = 6.5 Hz, 1H), 4.49 (dd, *J* =13.2, 6.6 Hz, 1H), 2.67 – 2.49 (m, 2H), 2.28 (d, *J* = 8.9 Hz, 1H), 1.27 (d, *J* = 7.5 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.44 , 142.59 , 142.54 , 136.73 , 133.63 , 129.59 , 128.92 , 128.49 , 128.42 , 125.39 , 124.61 , 61.61 , 48.38 , 25.66 , 14.77 .

1-(benzylthio)-3-hydroxy-2,3-dihydro-1H-inden-2-yl)(phenyl)methanone (5b)



Yield: 64%, 46.1 mg; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 – 7.98 (m, 2H), 7.63 – 7.56 (m, 1H), 7.47 (t, *J* = 7.7 Hz, 2H), 7.40 – 7.28 (m, 4H), 7.25 – 7.13 (m, 5H), 5.17 (dd, *J* = 7.6, 5.3 Hz, 1H), 4.74 (d, *J* = 6.0 Hz, 1H), 4.21 – 4.11 (m, 1H), 3.77 – 3.61 (m, 2H), 2.41 (d, *J* = 8.4 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.6, 142.4, 141.2, 138.2, 136.6, 133.6, 129.4, 129.1, 129.0, 128.7, 128.6, 128.5, 127.2, 125.3, 124.5, 78.6, 65.6, 48.9, 35.8; IR (KBr thin film) 3445, 3062, 3028, 2916, 1673, 1596, 1579, 1497, 1474, 1358, 1250, 1158, 1105, 1027, 1001, 912, 889, 825, 782, 767,

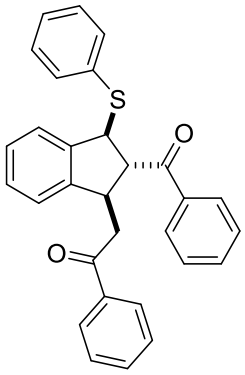
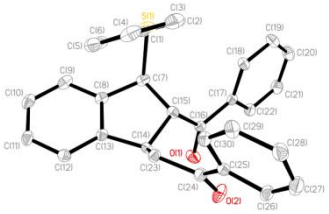
747, 730, 699 cm^{-1}; HRMS (ESI) m/z calcd for $C_{18}H_{19}O_2S^+$ $(M+H)^+$ 299.11003, found 299.11020.

3. References

(1) X. Q. Fang, K. Jiang, Ch. Xing, L. Hao, Y. R. Chi, *Angew. Chem. Int. Ed.*, 2011, **50**, 1910.

(2) N. Li, G. G. Liu, J. Chen, F. F. Pan, B. Wu and X. W. Wang, *Eur. J. Org. Chem.*, 2014, **13**, 2677.

4. Single-crystal X-ray structure analysis

Compounds	X-ray structures
 **3m**	 **3m**

CCDC 1905585 (**3m**) , contain the supplementary crystallographic data for this paper. These data are provided free of charge by The Cambridge Crystallographic Data Centre.

Table 1 Crystal data and structure refinement for **3m**	
Identification code	3m

Empirical formula	$C_{30}H_{24}O_2S$
Formula weight	448.55
Temperature/K	293(2)
Crystal system	orthorhombic
Space group	$P2_12_12_1$
a/Å	7.6174(3)
b/Å	26.7210(13)
c/Å	34.0314(14)
α/°	90.00
β/°	90.00
γ/°	90.00
Volume/$Å^3$	6926.9(5)
Z	12
$\rho_{calc}g/cm^3$	1.290
μ/mm^{-1}	0.166
F(000)	2832.0
Crystal size/mm^3	0.2 × 0.18 × 0.18
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.72 to 52.8
Index ranges	$-9 \leq h \leq 9$, $-28 \leq k \leq 33$, $-42 \leq l \leq 39$
Reflections collected	37759
Independent reflections	13802 [R_{int} = 0.1019, R_{sigma} = 0.1321]
Data/restraints/parameters	13802/0/894
Goodness-of-fit on F^2	1.031
Final R indexes [I>=2σ (I)]	R_1 = 0.0637, wR_2 = 0.1007
Final R indexes [all data]	R_1 = 0.1403, wR_2 = 0.1306
Largest diff. peak/hole / e $Å^{-3}$	0.28/-0.30
Flack parameter	0.39(8)

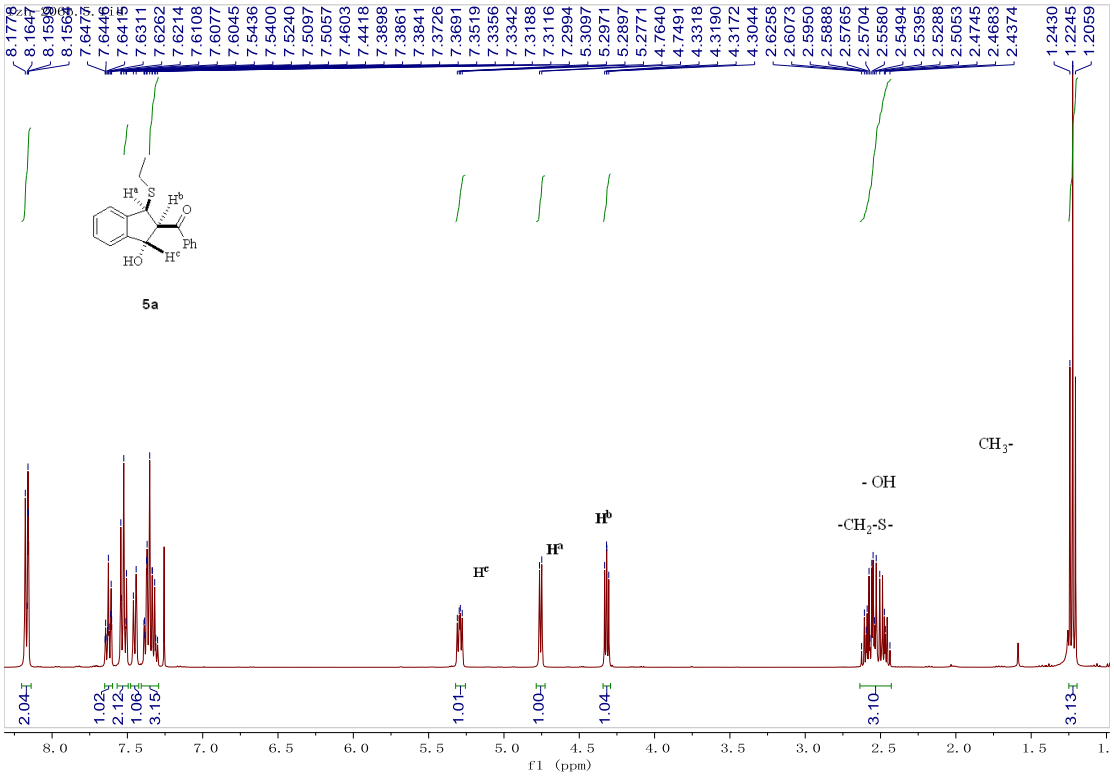
5. Determination of the relative configuration of the diastereomers 5a and 5a′

Through the analysis of ^{1}H ~ ^{1}H COSY, HSQC and HMBC of **5a**, three characteristic protons (H^a ~ H^c) at the high field are assigned as shown in ^{1}H NMR. Further analysis of the NOESY spectra of **5a** indicates that H^a has correlation with H^b, while H^c has no obvious

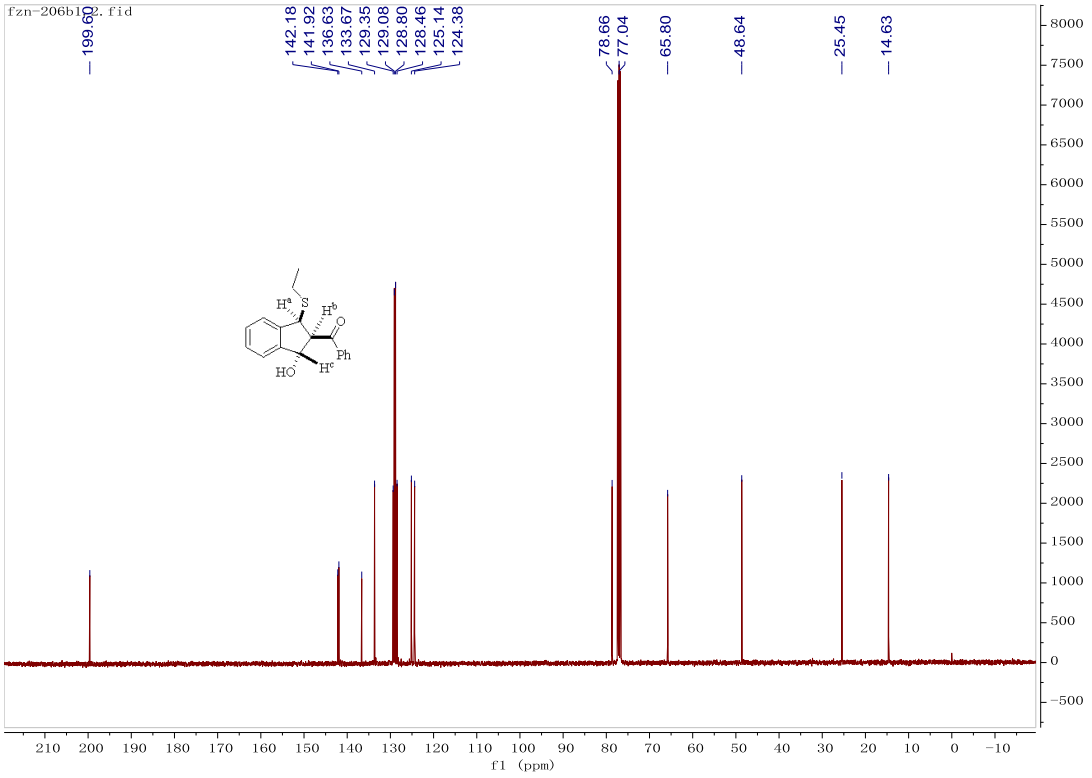
correlation with H^a and H^b. Therefore, H^a adapts cis-position with H^b, while H^c adapts the trans-position with H^a and H^b. Based on these results, we confirm that **5a** is the *cis, trans*-diastereomer.

Similarly, through the analysis of ^{1}H ~ ^{1}H COSY, ^{1}H NMR and ^{13}C NMR of **5a′**, three characteristic protons of **5a′** (H^a ~ H^c) at the high field are assigned as shown in ^{1}H NMR. Further analysis of the NOESY spectra of **5a′** indicates that H^b has correlation with H^c, while H^a has no obvious correlation with H^b and H^c. Therefore, H^b adapts cis-position with H^c, while H^a adapts the trans-position with H^b and H^c. Based on these results, we confirm that **5a** is the *trans, cis*-diastereomer.

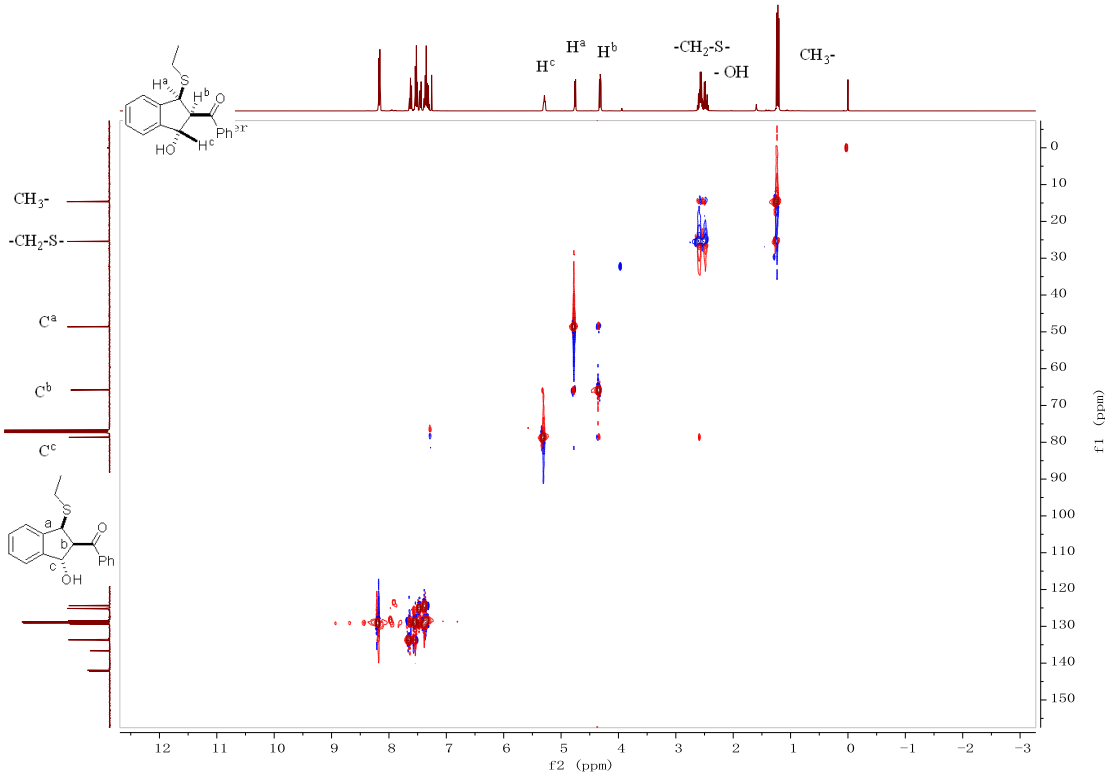
^{1}H NMR of **5a**



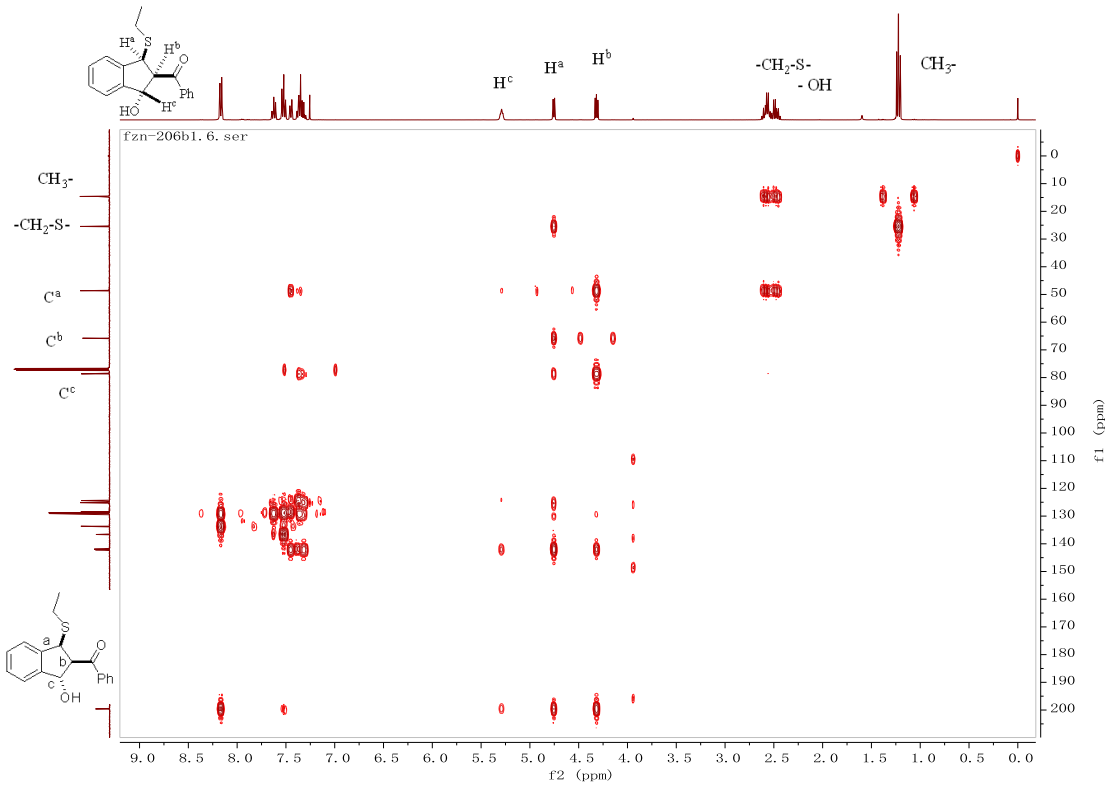
^{13}C NMR of **5a**



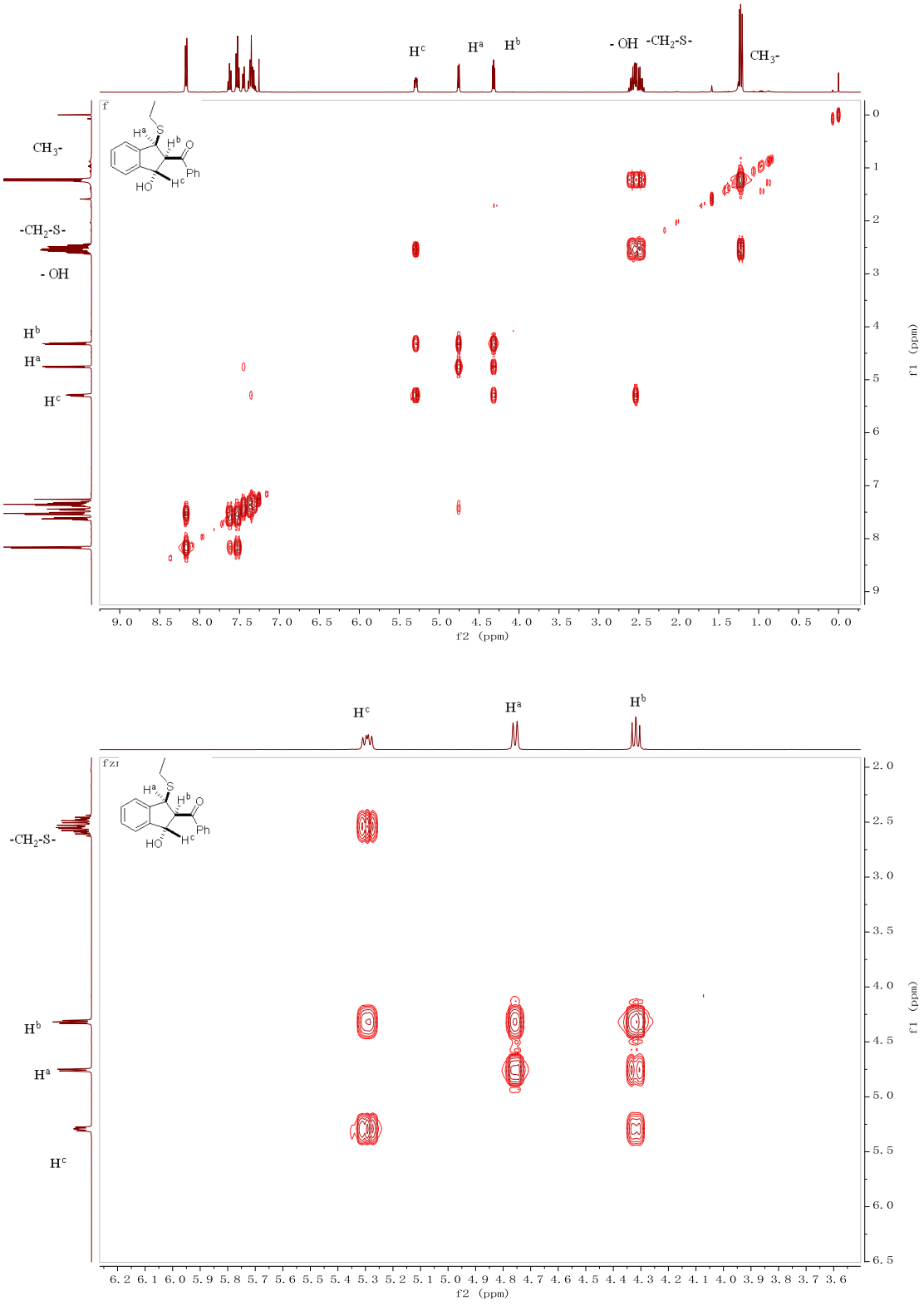
HSQC of **5a**



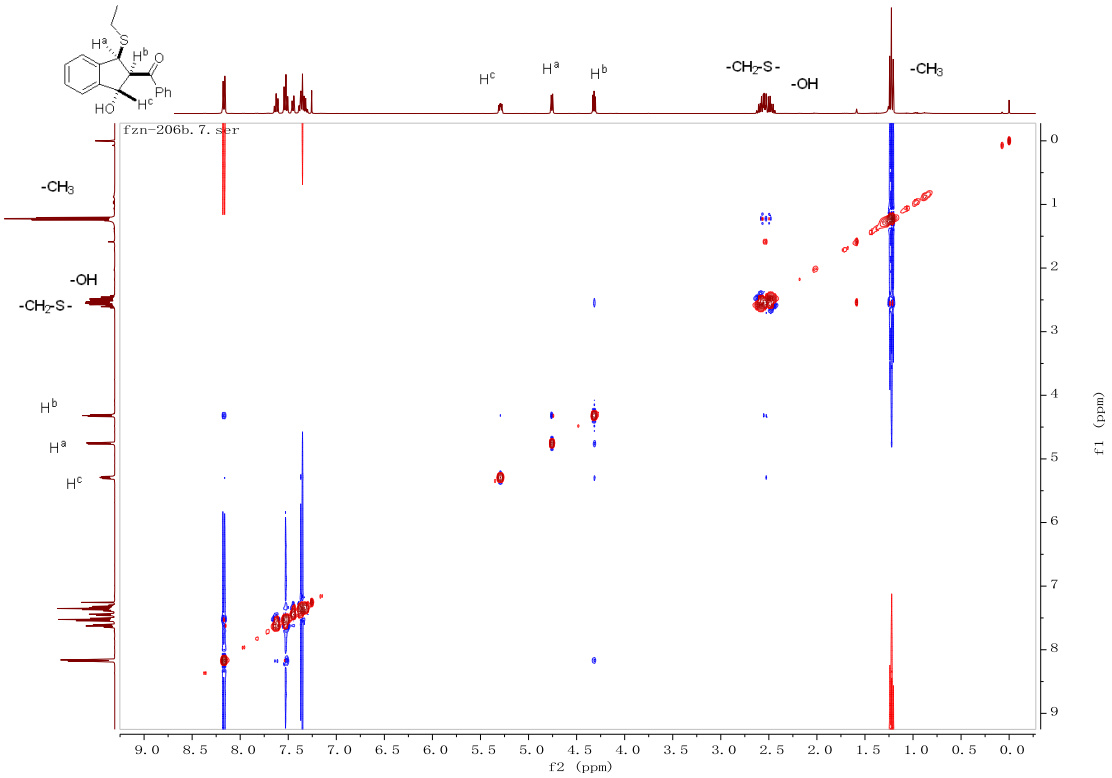
HMBC of **5a**

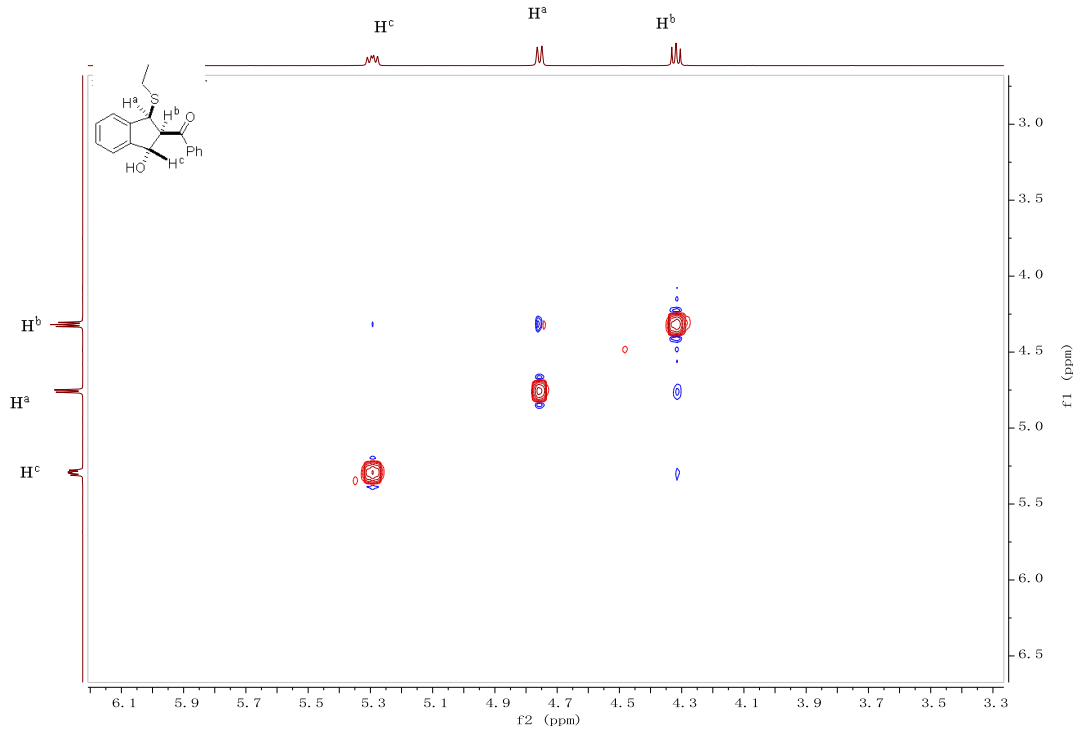


^{1}H-^{1}H COSY of **5a**

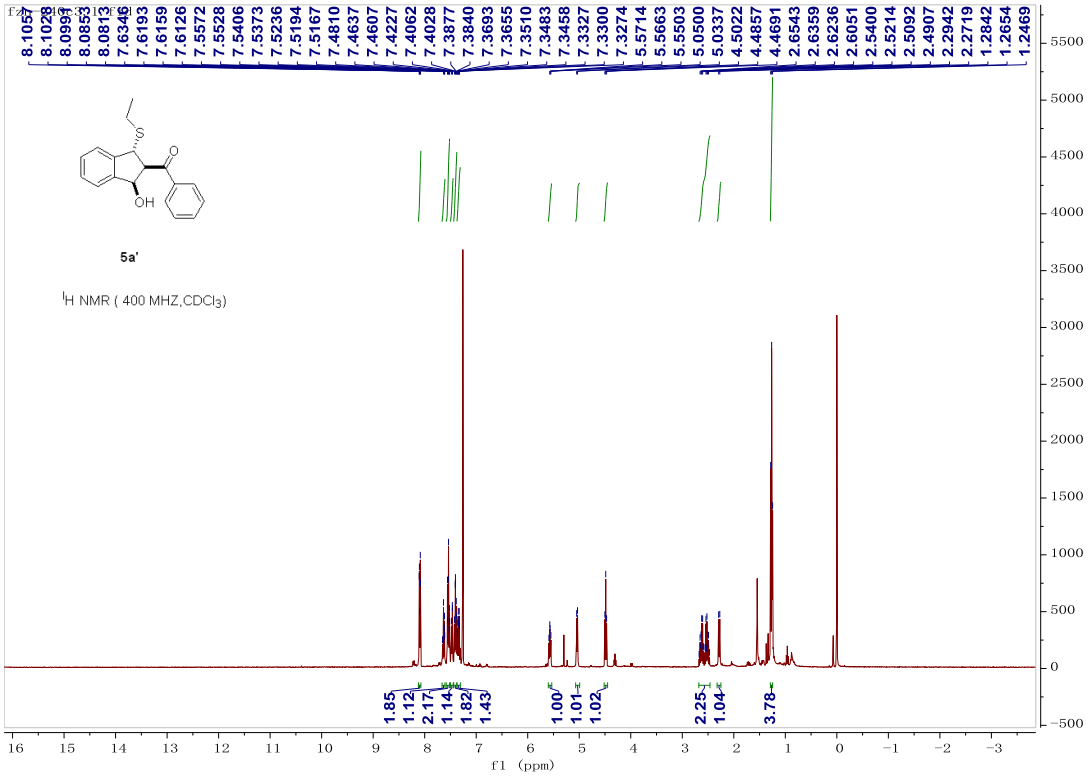


NOESY of **5a**

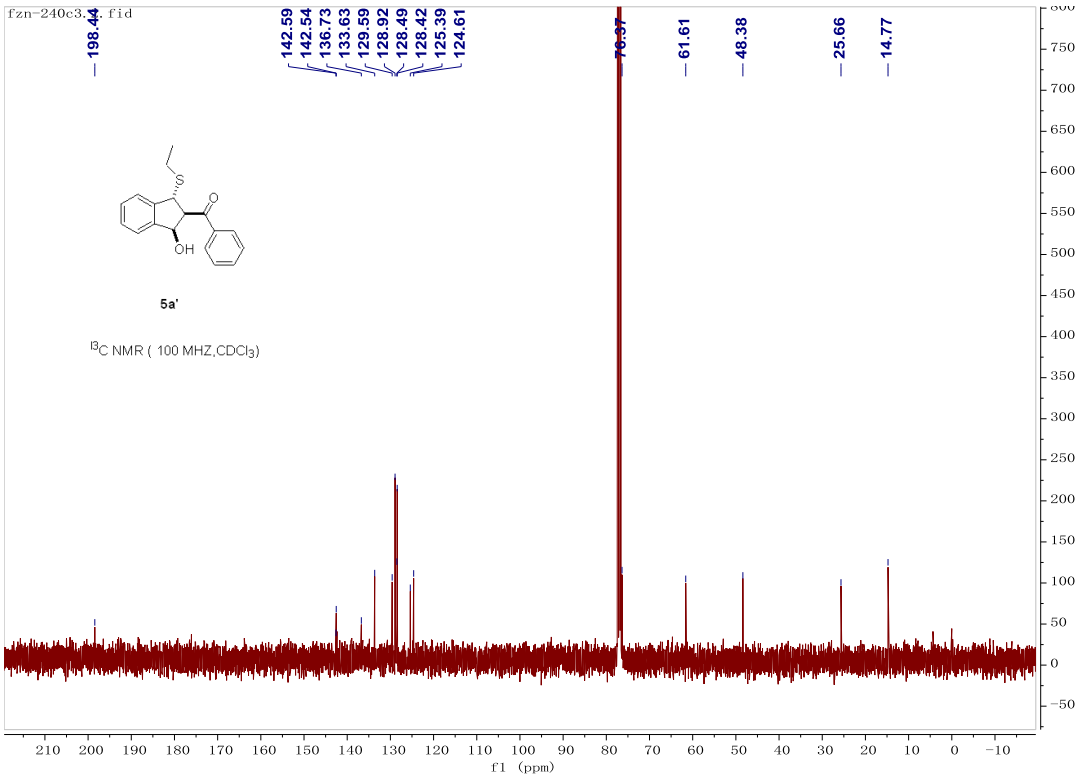

fzn-206b. 7. ser
-CH3
-OH
-CH2-S-
Hb
Ha
Hc
f2 (ppm)
f1 (ppm)


Hc
Ha
Hb
f2 (ppm)
f1 (ppm)

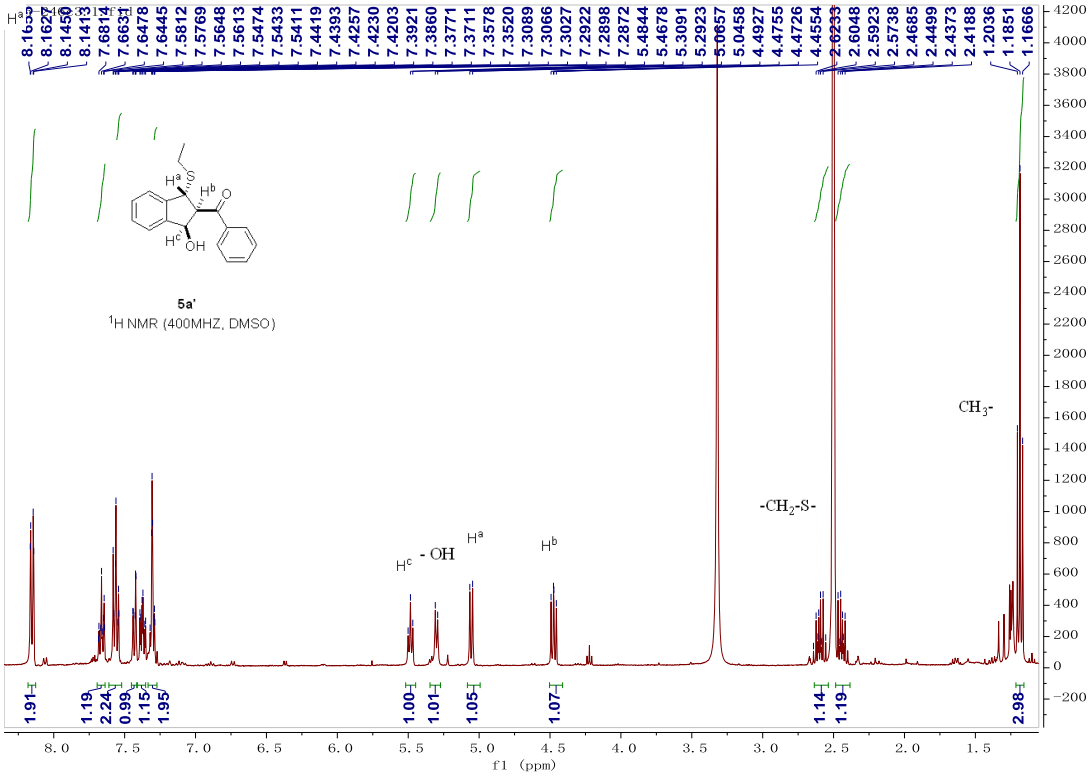
^{1}H NMR of **5a′**



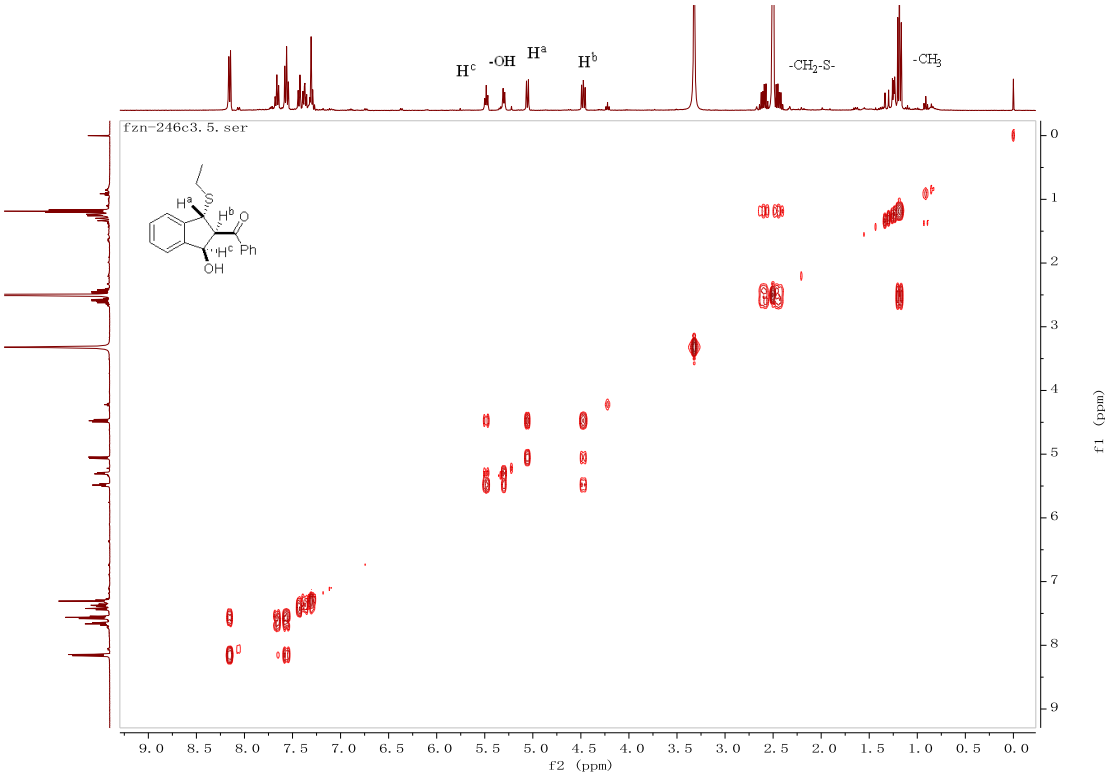
^{13}C NMR of **5a′**



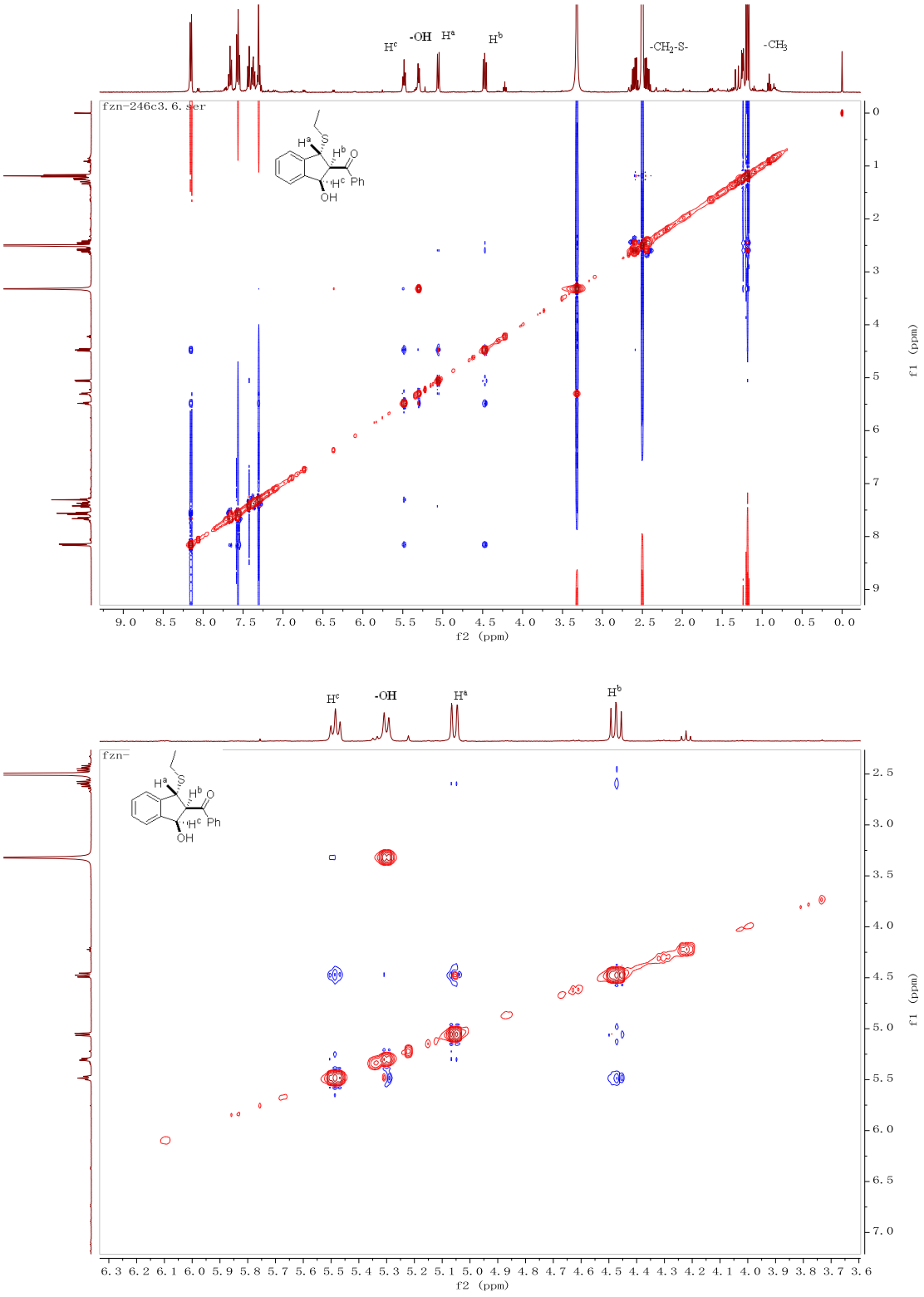
^{1}H NMR (400 MHz, DMSO-d_6) of **5a′**



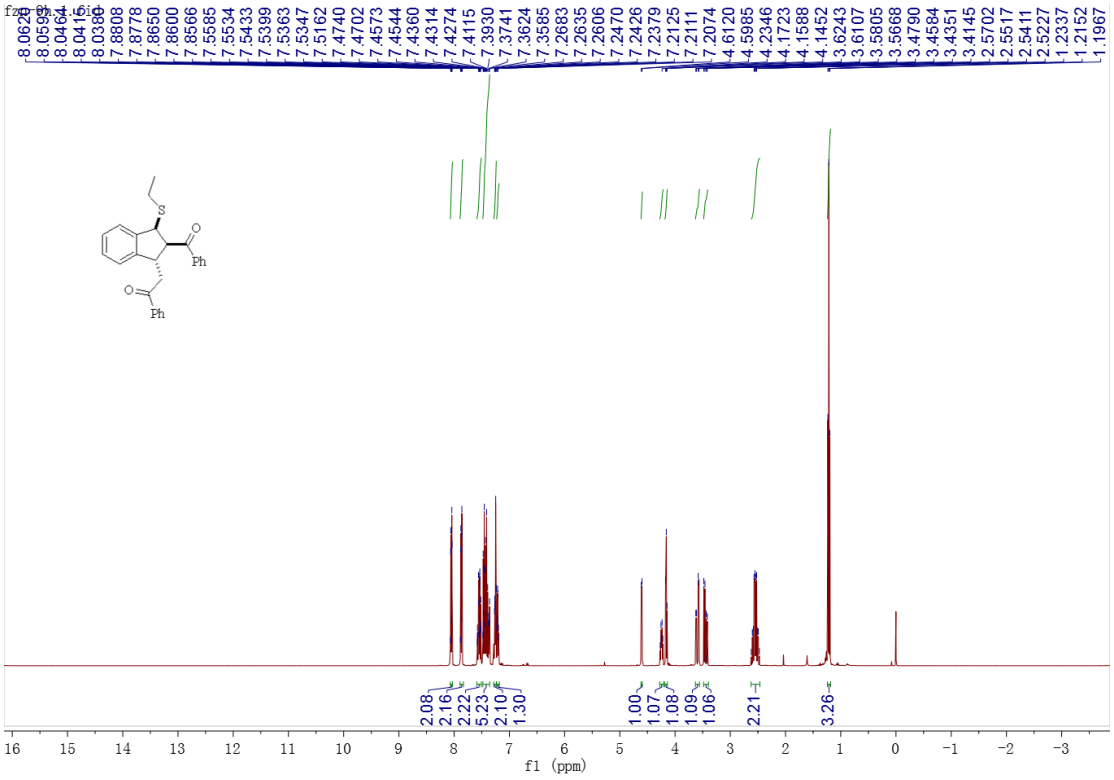
^{1}H-^{1}H COSY (DMSO-d_6) of **5a′**

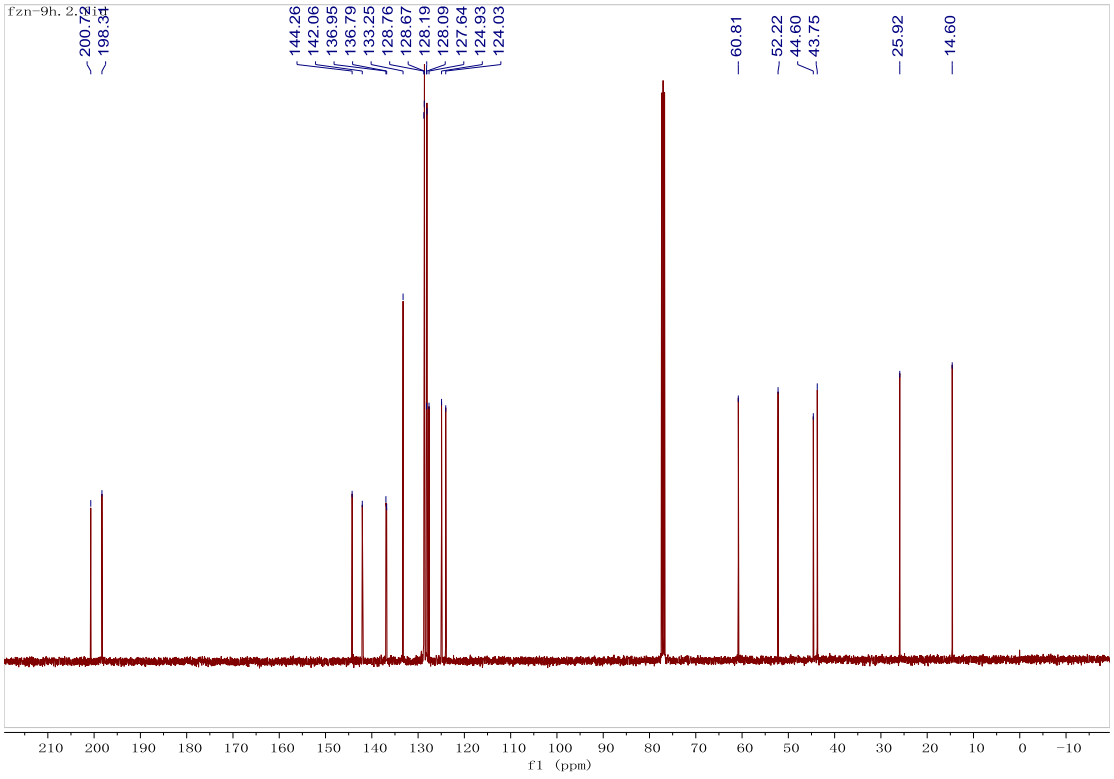


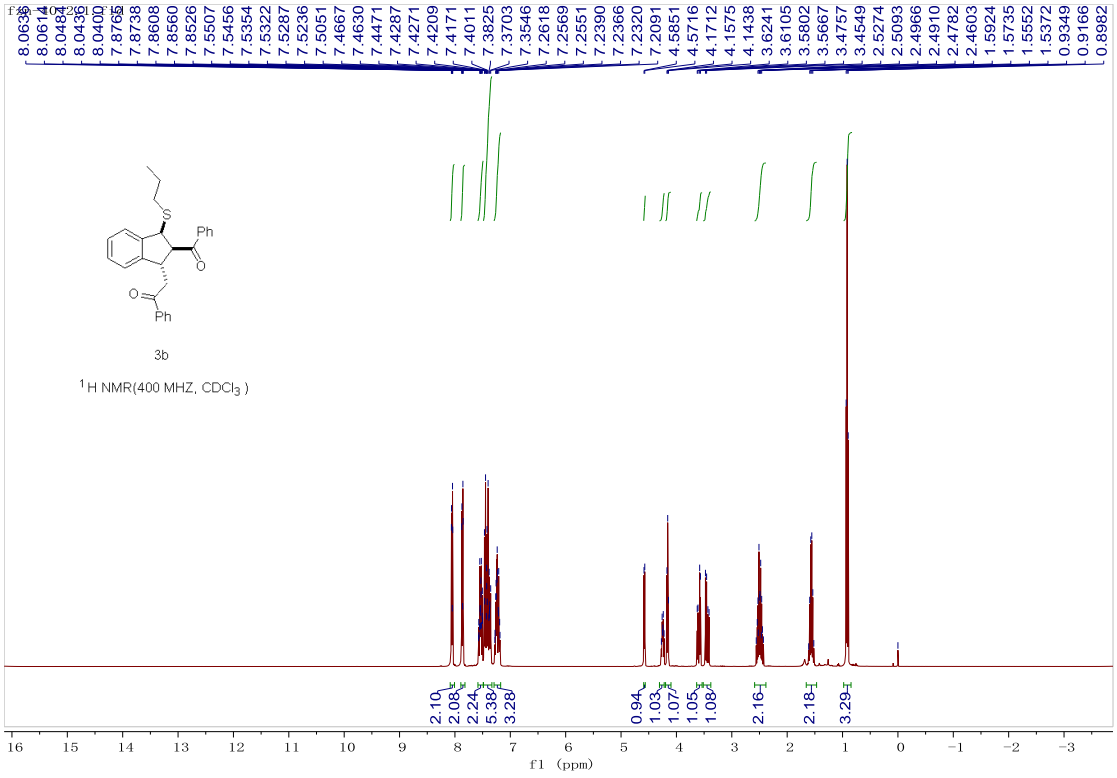
NOESY (400 MHz, DMSO-d_6) of **5a′**

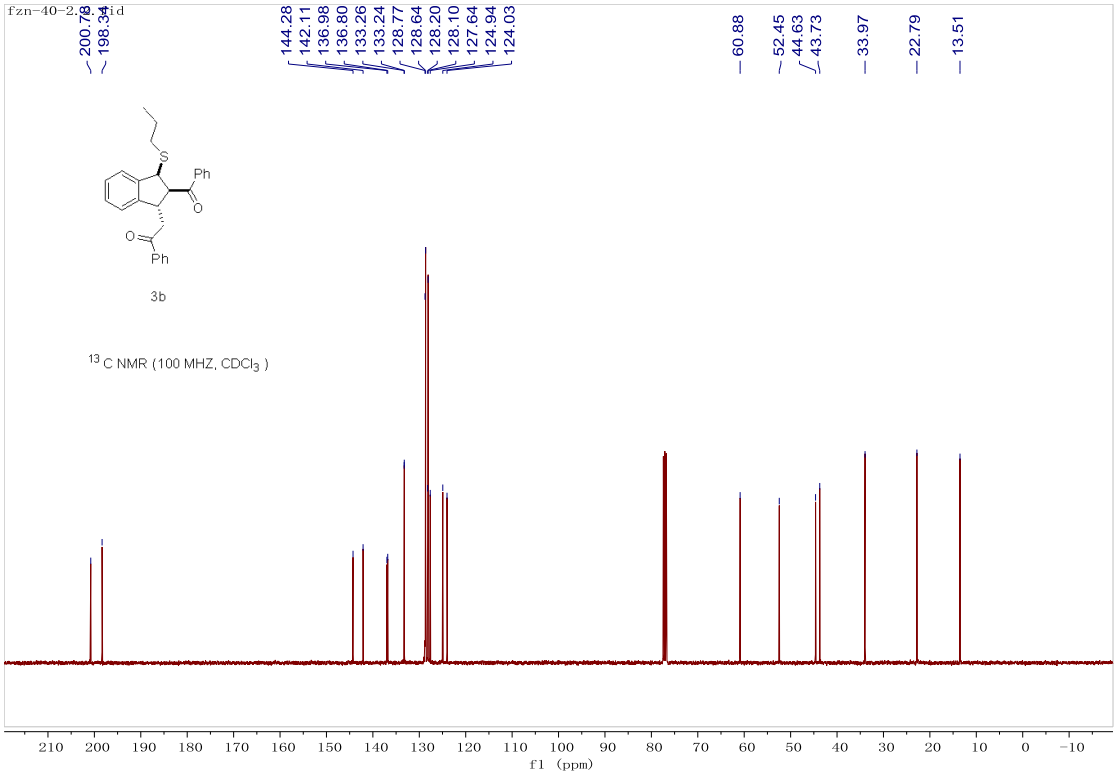


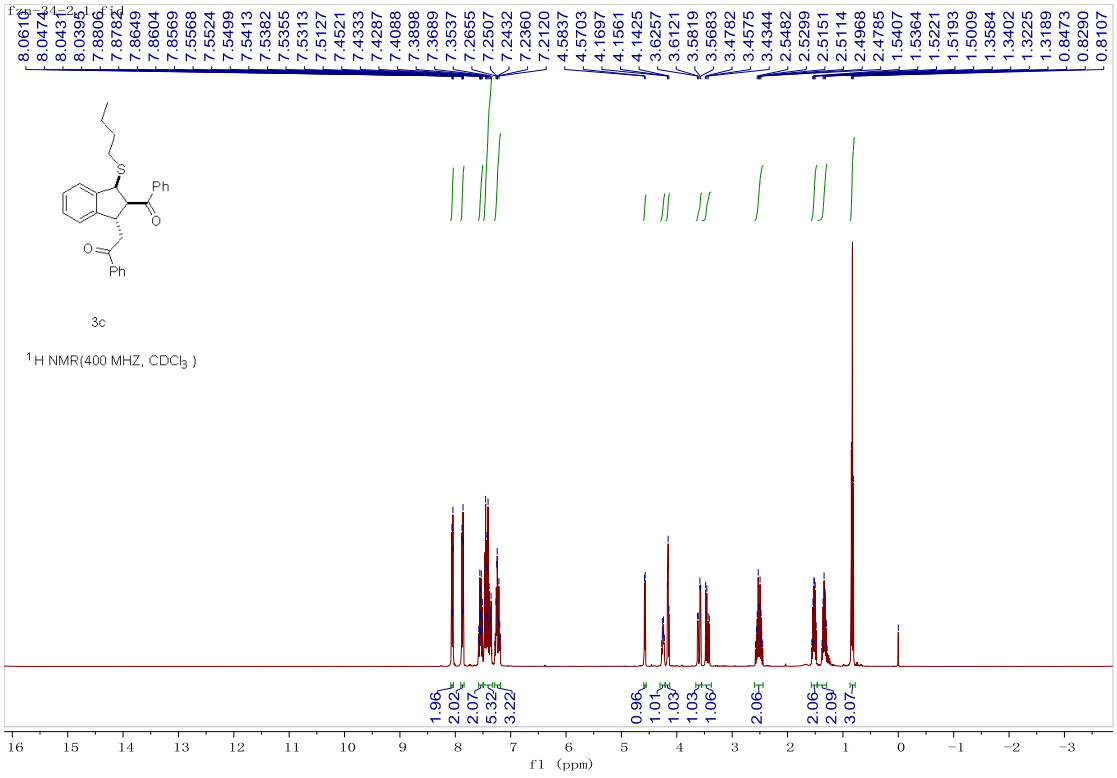
6. Copies of ^{1}H NMR and ^{13}C NMR spectra

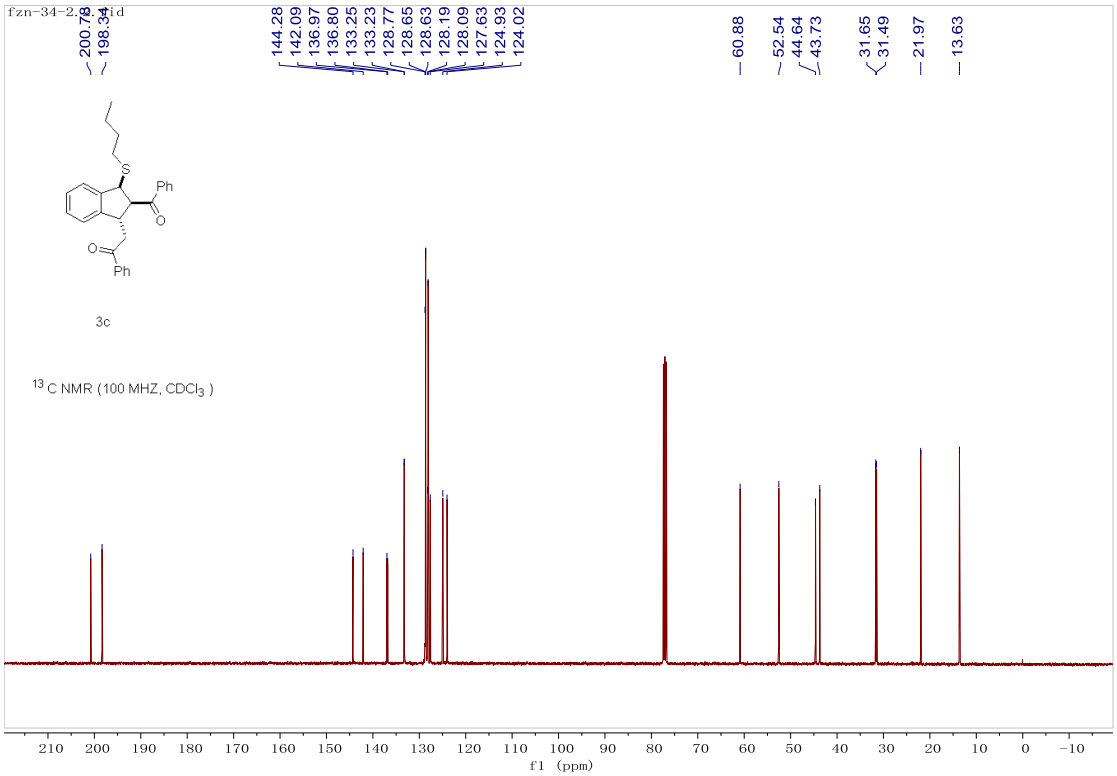


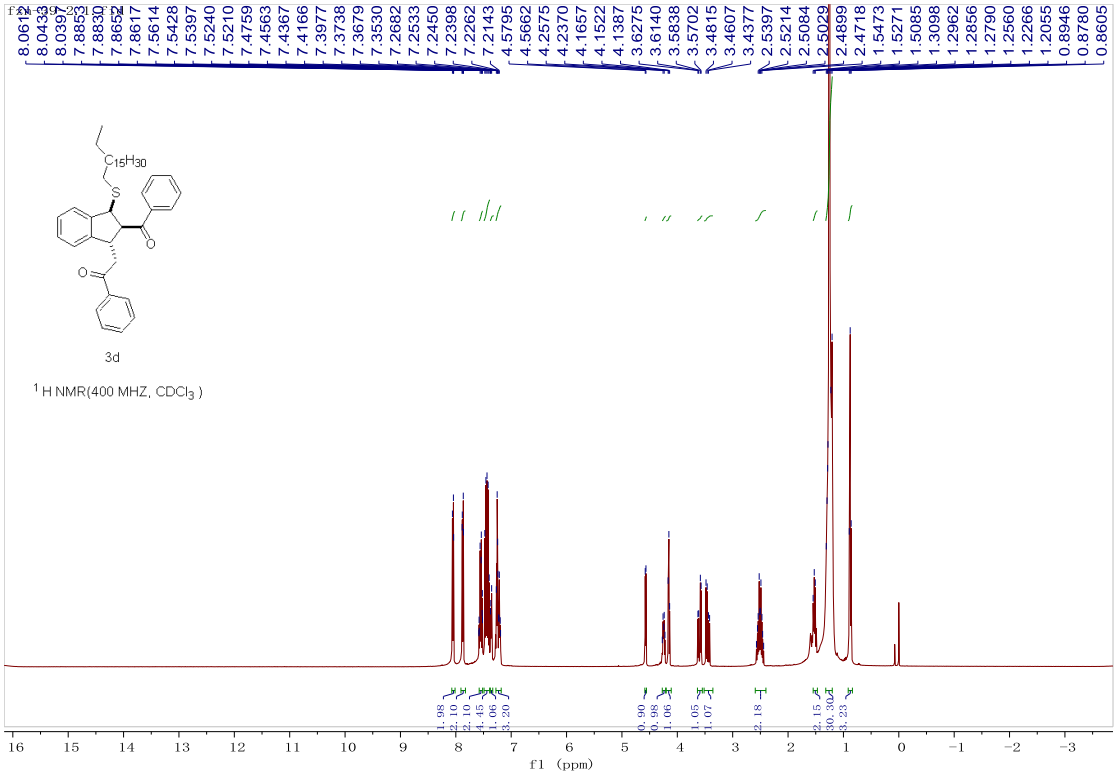


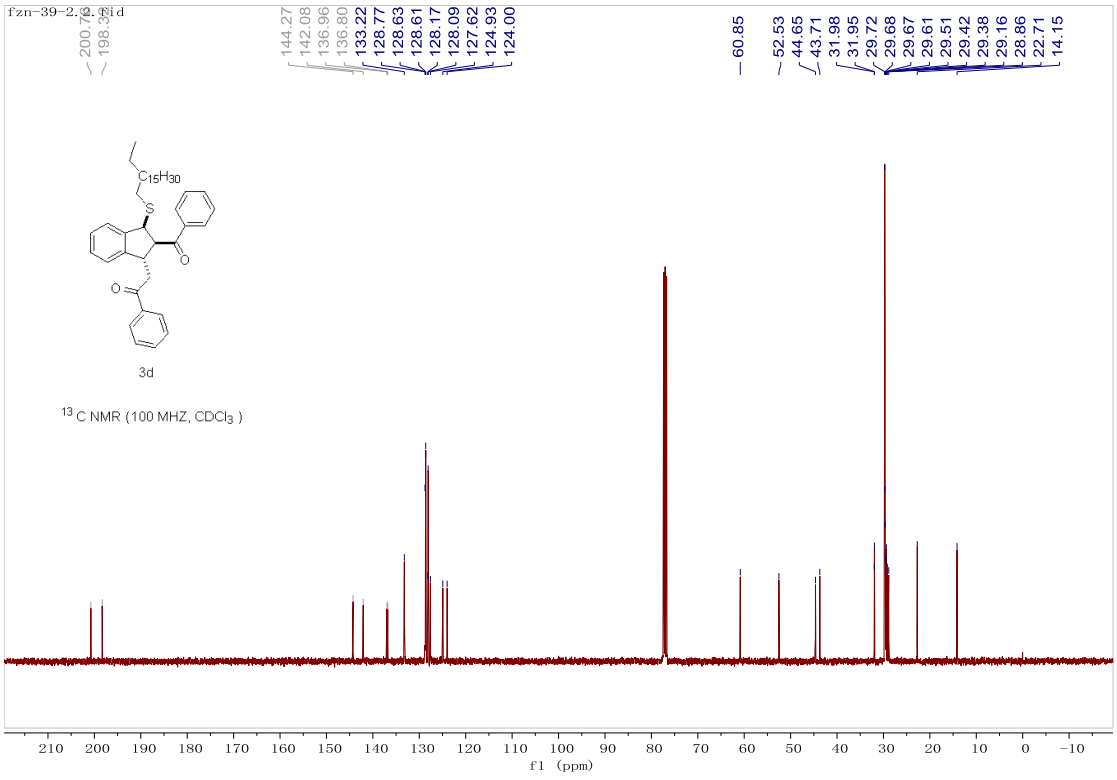

3b
1H NMR(400 MHZ, CDCl3)
f1 (ppm)

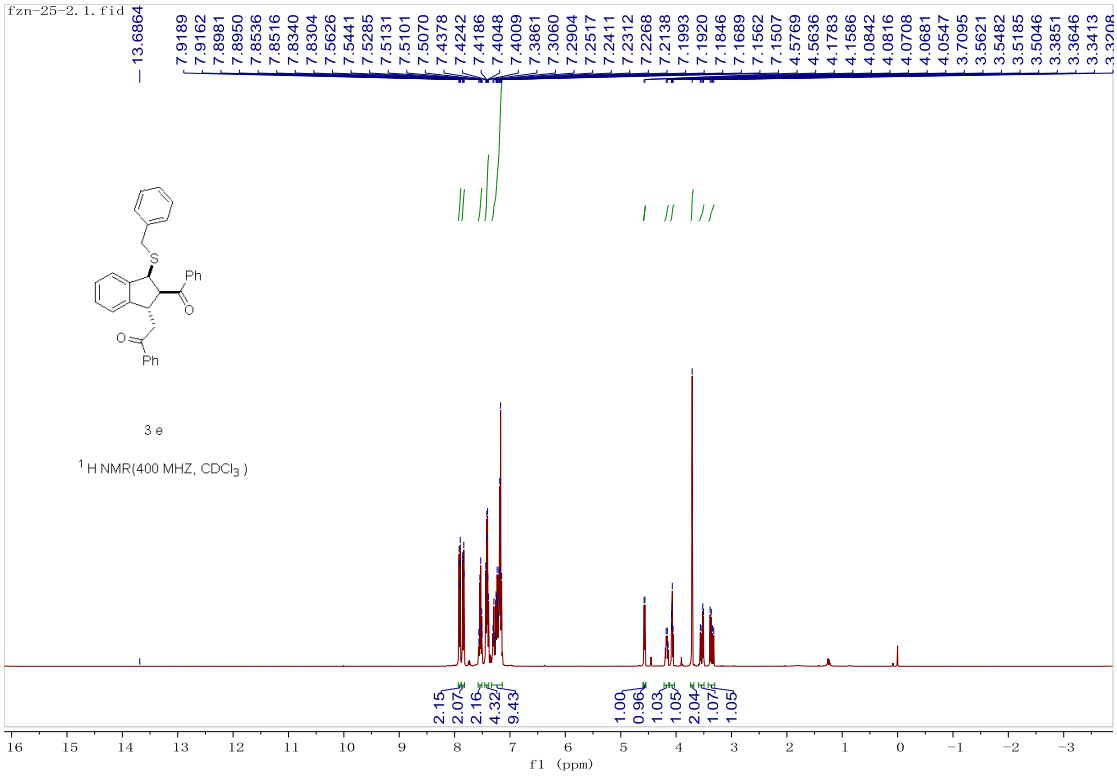

3b
13C NMR (100 MHZ, CDCl3)
f1 (ppm)

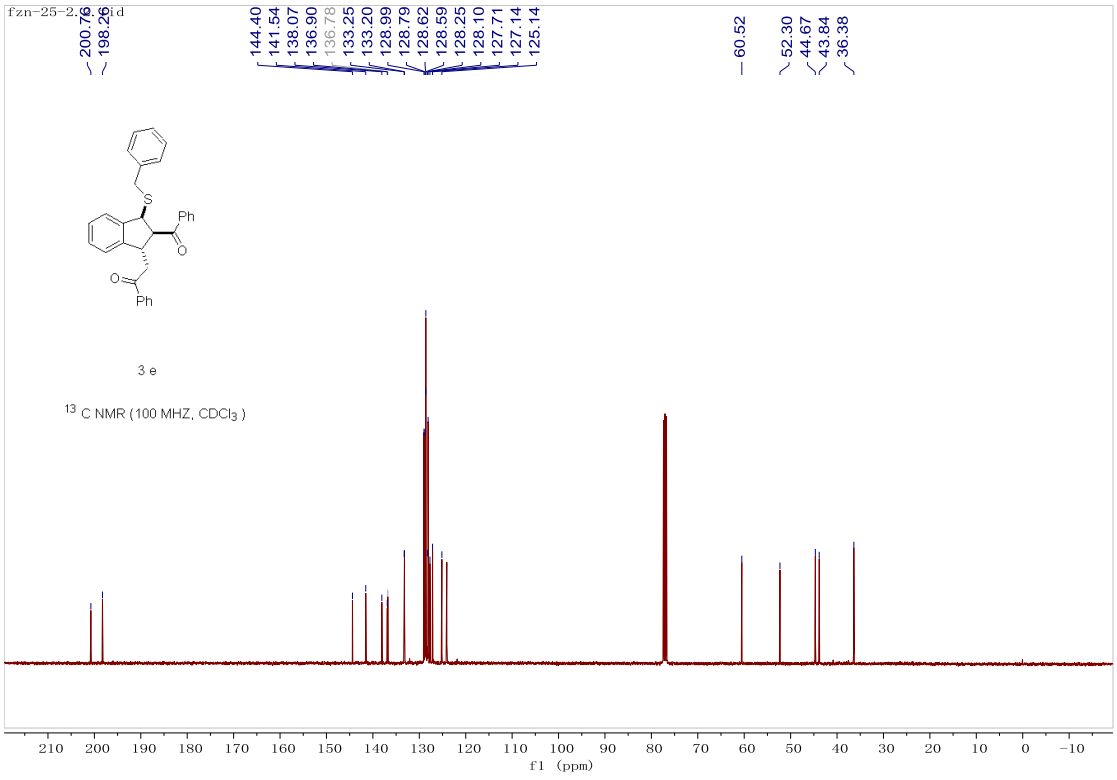

fzn-34-2.fid
8.0610
8.0474
8.0435
8.0395
7.8806
7.8782
7.8649
7.8604
7.8569
7.5568
7.5524
7.5499
7.5413
7.5382
7.5355
7.5313
7.5127
7.4521
7.4333
7.4287
7.4088
7.3898
7.3689
7.3537
7.2655
7.2507
7.2432
7.2360
7.2120
4.5837
4.5703
4.1697
4.1561
4.1425
3.6257
3.6121
3.5819
3.5683
3.4782
3.4575
3.4344
2.5482
2.5299
2.5151
2.5114
2.4968
2.4785
1.5407
1.5364
1.5221
1.5193
1.5009
1.3584
1.3402
1.3225
1.3189
0.8473
0.8290
0.8107
S
Ph
O
O
Ph
3c
1H NMR(400 MHZ, CDCl3)
1.96
2.02
2.07
5.32
3.22
0.96
1.01
1.03
1.06
2.06
2.06
2.09
3.07
f1 (ppm)

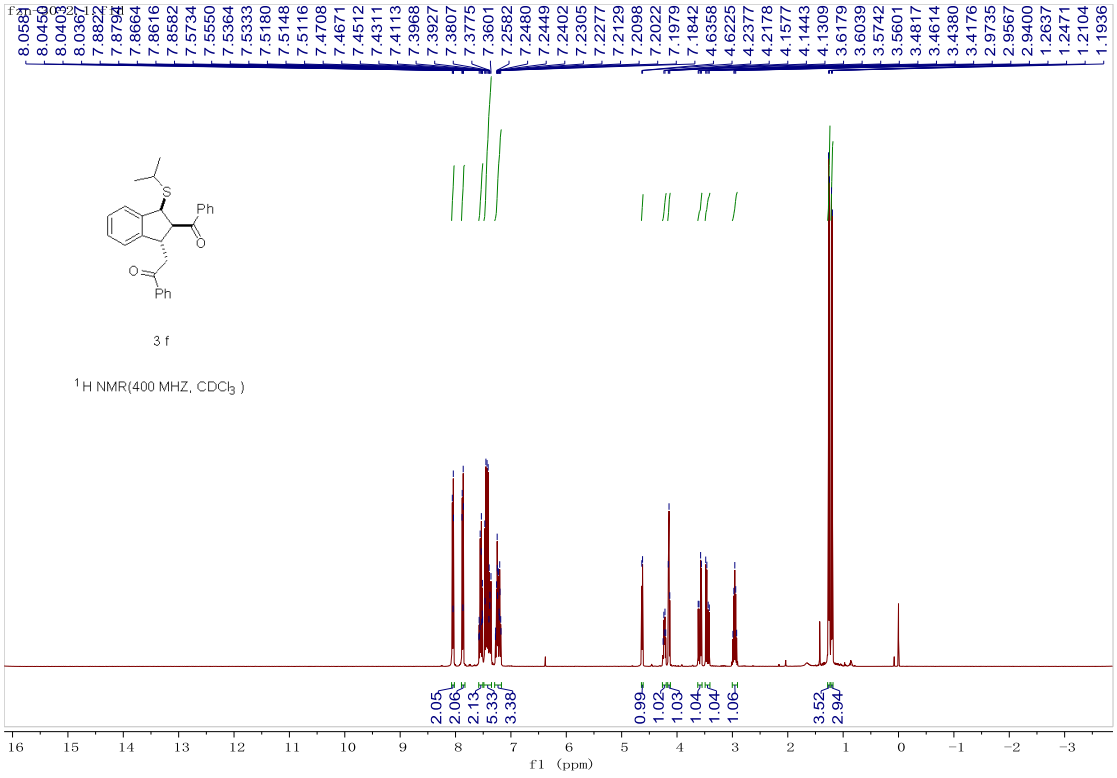

fzn-34-2.fid
200.78
198.34
144.28
142.09
136.97
136.80
133.25
133.23
128.77
128.65
128.63
128.19
128.09
127.63
124.93
124.02
60.88
52.54
44.64
43.73
31.65
31.49
21.97
13.63
S
Ph
O
O
Ph
3c
13C NMR (100 MHZ, CDCl3)
f1 (ppm)

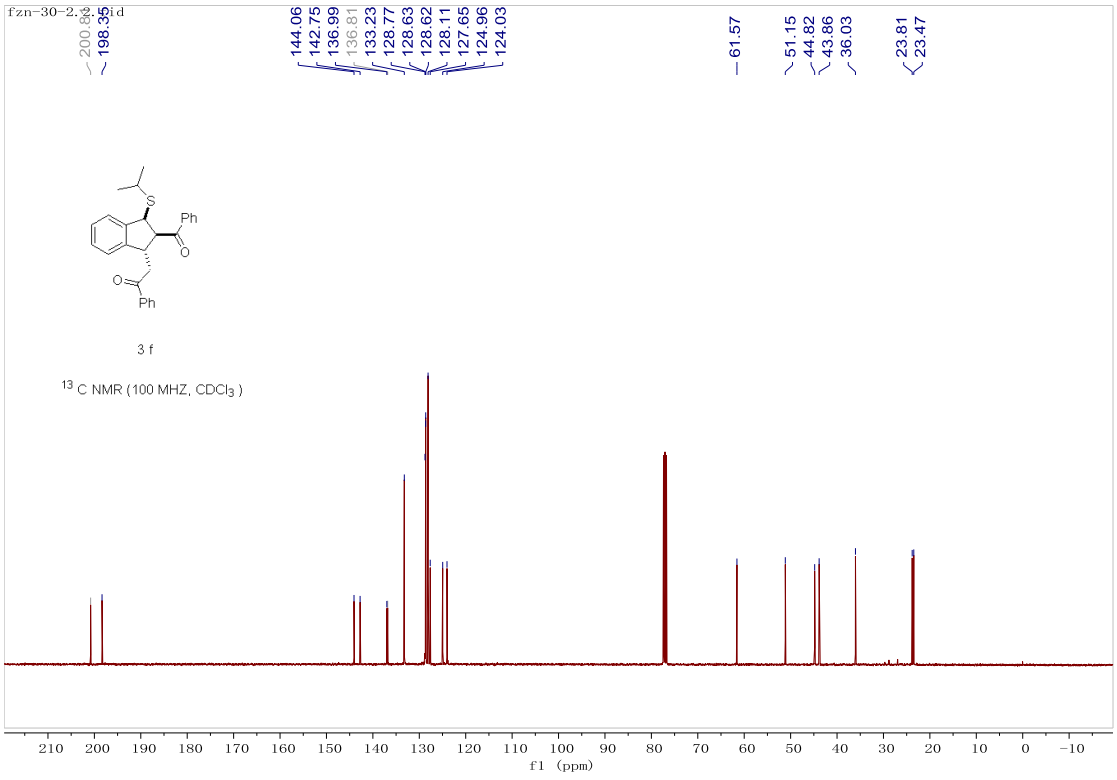

fzn-39-2.2.fid
8.0612
8.0433
8.0397
7.8853
7.8830
7.8652
7.8617
7.5614
7.5428
7.5397
7.5240
7.5210
7.4759
7.4563
7.4367
7.4166
7.3977
7.3738
7.3679
7.3530
7.2682
7.2533
7.2450
7.2398
7.2262
7.2143
4.5795
4.5662
4.2575
4.2370
4.1657
4.1522
4.1387
3.6275
3.6140
3.5838
3.5702
3.4815
3.4607
3.4377
2.5397
2.5214
2.5084
2.5029
2.4899
2.4718
1.5473
1.5271
1.5085
1.3098
1.2962
1.2856
1.2790
1.2560
1.2266
1.2055
0.8946
0.8780
0.8605
C15H30
S
O
O
3d
1 H NMR(400 MHZ, CDCl3)
1.98
2.10
2.10
4.45
1.06
3.20
0.90
0.98
1.06
1.05
1.07
2.18
2.15
30.30
3.23
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

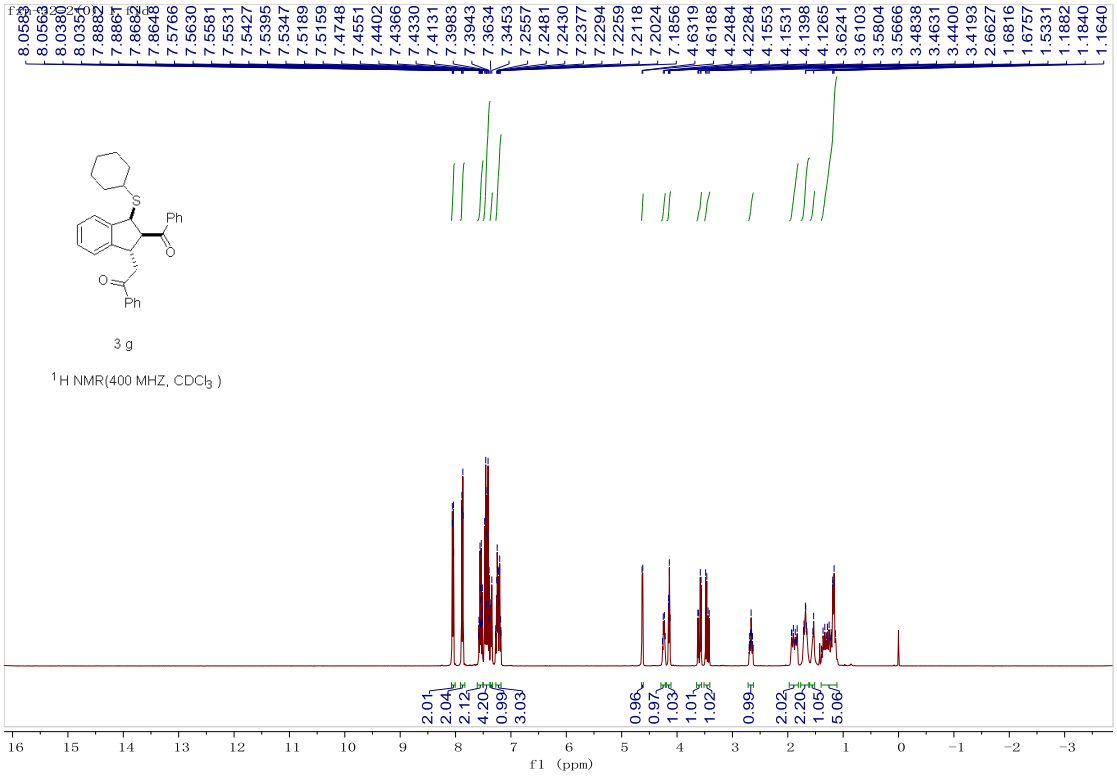

fzn-39-2.2.fid
200.76
198.38
144.27
142.08
136.96
136.80
133.22
128.77
128.63
128.61
128.17
128.09
127.62
124.93
124.00
60.85
52.53
44.65
43.71
31.98
31.95
29.72
29.68
29.67
29.61
29.51
29.42
29.38
29.16
28.86
22.71
14.15
C15H30
S
O
O
3d
13 C NMR (100 MHZ, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

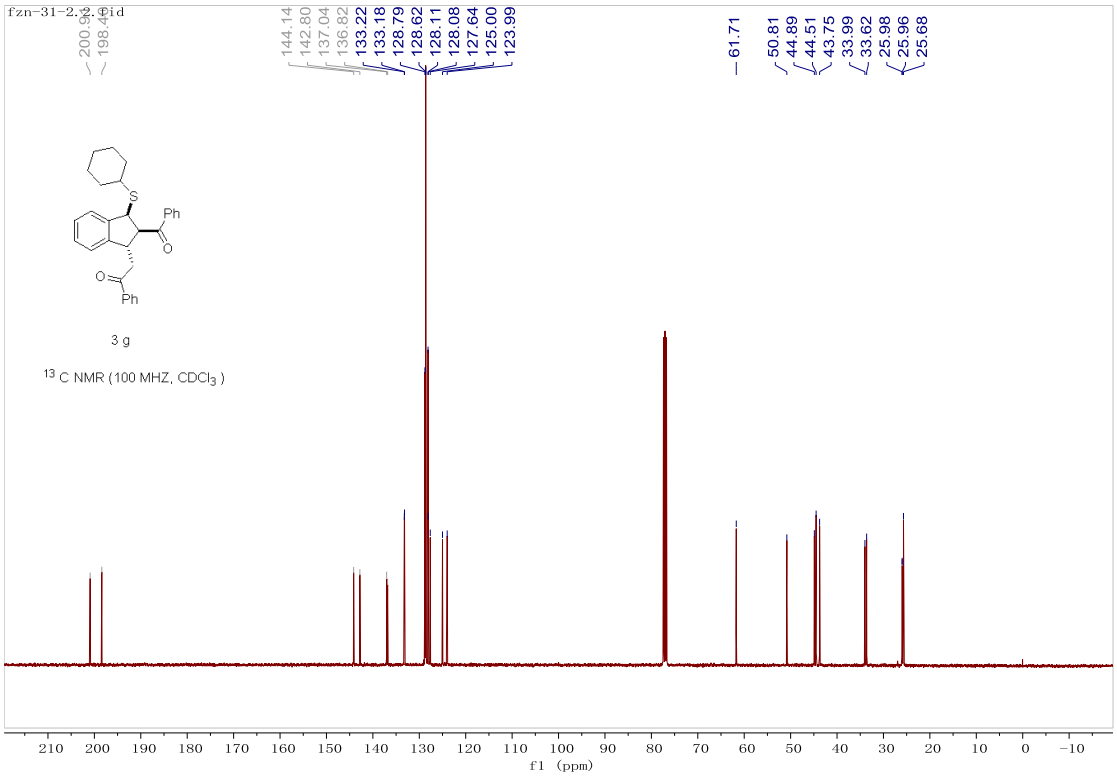

fzn-25-2.1.fid
13.6864
7.9189
7.9162
7.8981
7.8950
7.8536
7.8516
7.8340
7.8304
7.5626
7.5441
7.5285
7.5131
7.5101
7.5070
7.4378
7.4242
7.4186
7.4048
7.4009
7.3861
7.3060
7.2904
7.2517
7.2411
7.2312
7.2268
7.2138
7.1993
7.1920
7.1846
7.1689
7.1562
7.1507
4.5769
4.5636
4.1783
4.1586
4.0842
4.0816
4.0708
4.0681
4.0547
3.7095
3.5621
3.5482
3.5185
3.5046
3.3851
3.3646
3.3413
Ph
O
S
O
Ph
3 e
1 H NMR(400 MHZ, CDCl3)
2.15
2.07
2.16
4.32
9.43
1.00
0.96
1.03
1.05
2.04
1.07
1.05
f1 (ppm)

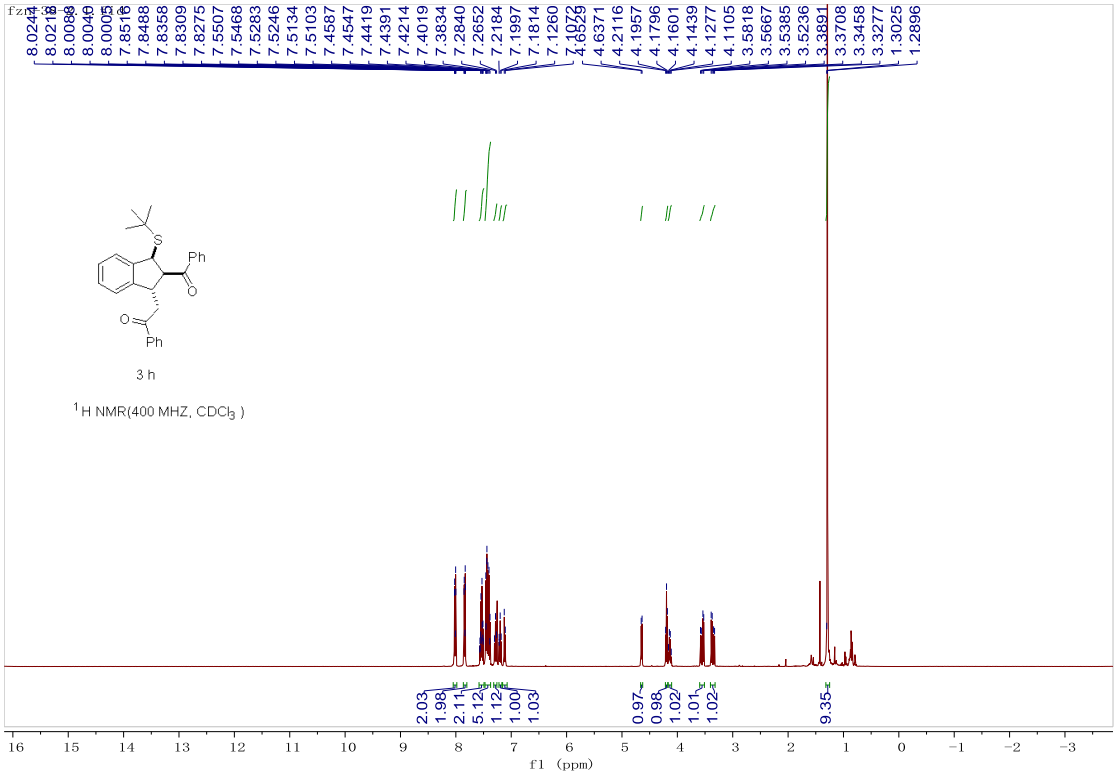

fzn-25-2.13.fid
200.76
198.26
144.40
141.54
138.07
136.90
136.78
133.25
133.20
128.99
128.79
128.62
128.59
128.25
128.10
127.71
127.14
125.14
60.52
52.30
44.67
43.84
36.38
Ph
O
S
O
Ph
3 e
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

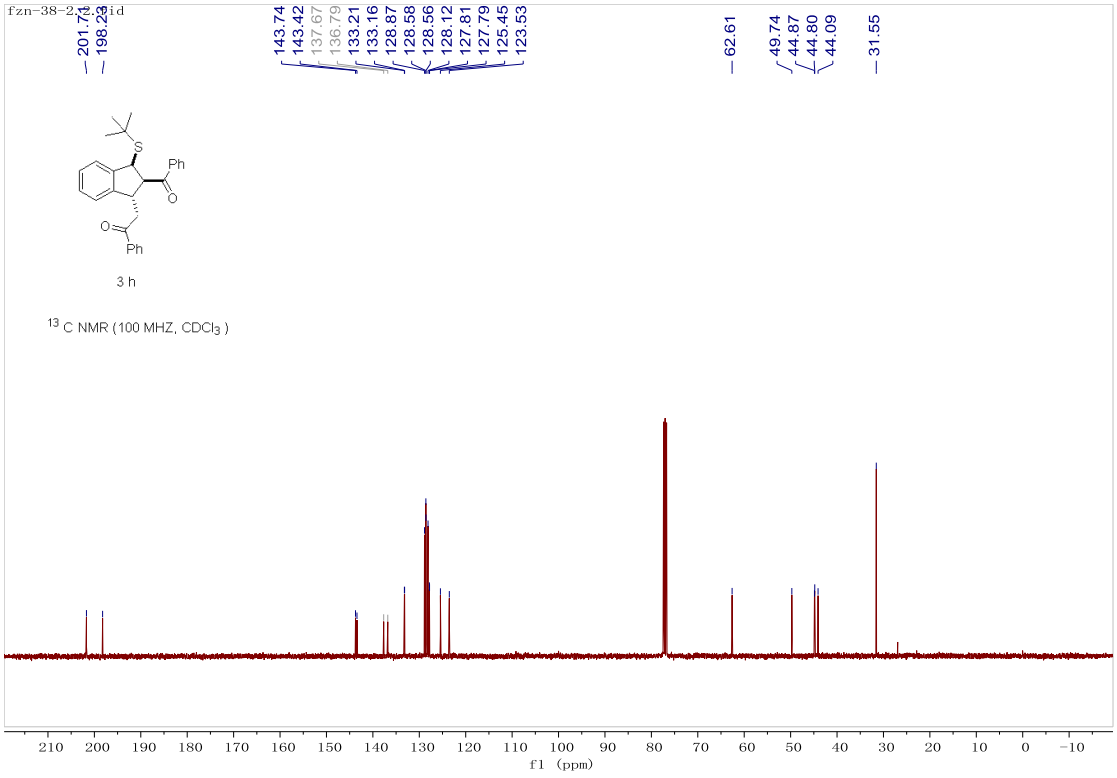

3 f
^{1}H NMR(400 MHZ, CDCl$_3$)
f1 (ppm)

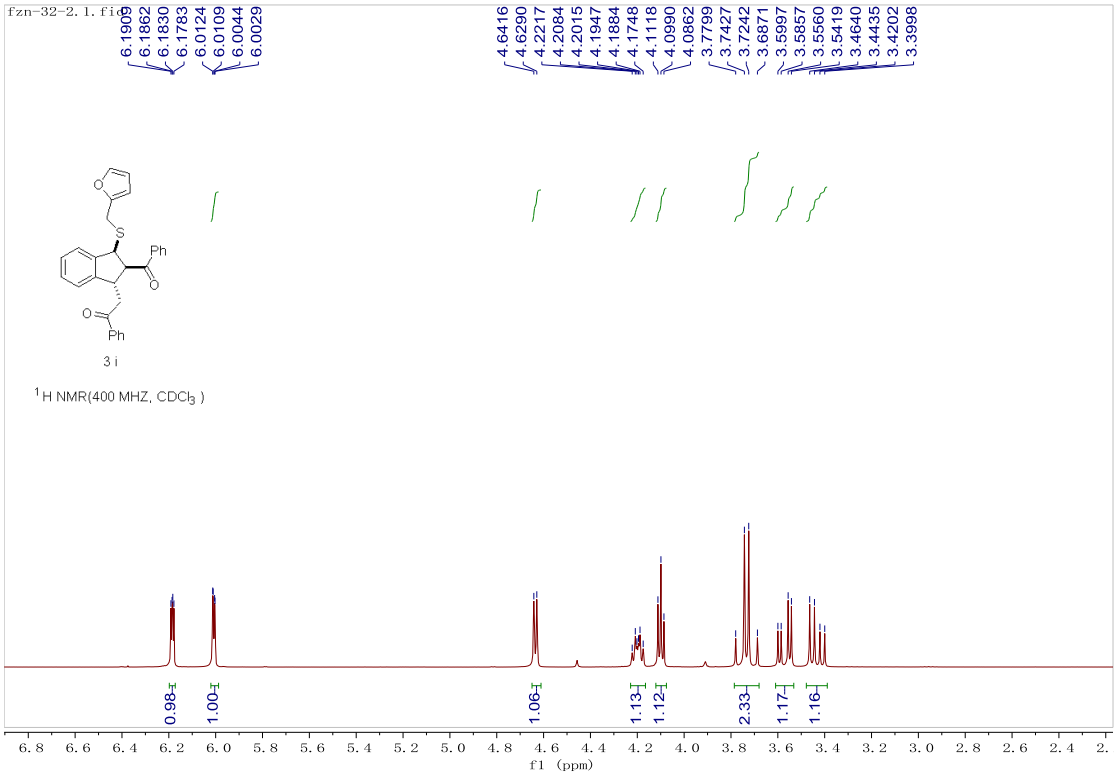

fzn-30-2.2.fid
3 f
^{13}C NMR (100 MHZ, CDCl$_3$)
f1 (ppm)

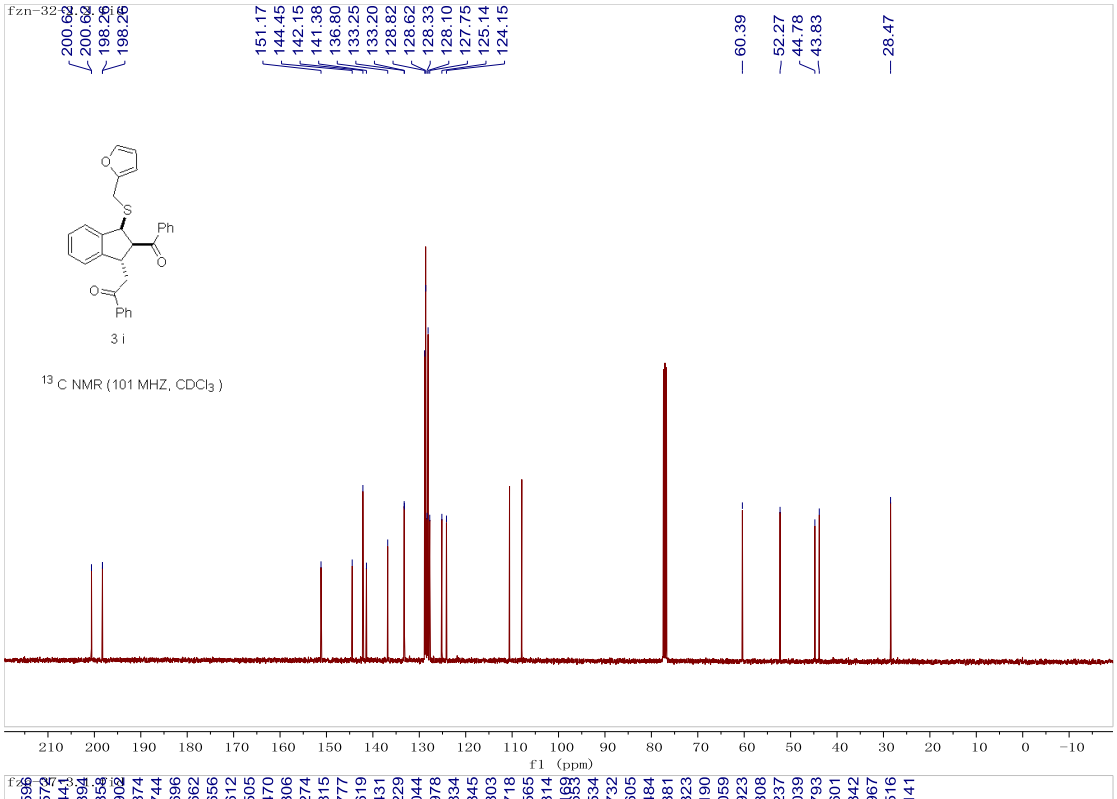

3 g
^{1}H NMR(400 MHZ, $CDCl_3$)
f1 (ppm)

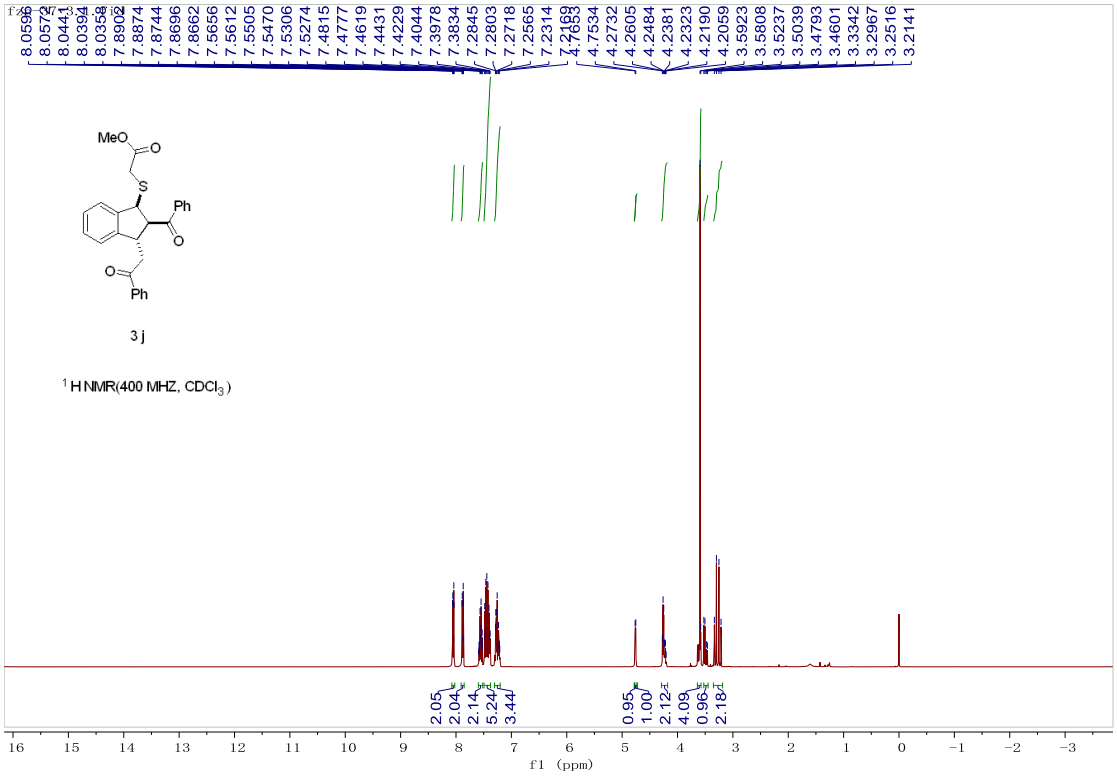

fzn-31-2.2.fid
3 g
^{13}C NMR (100 MHZ, $CDCl_3$)
f1 (ppm)

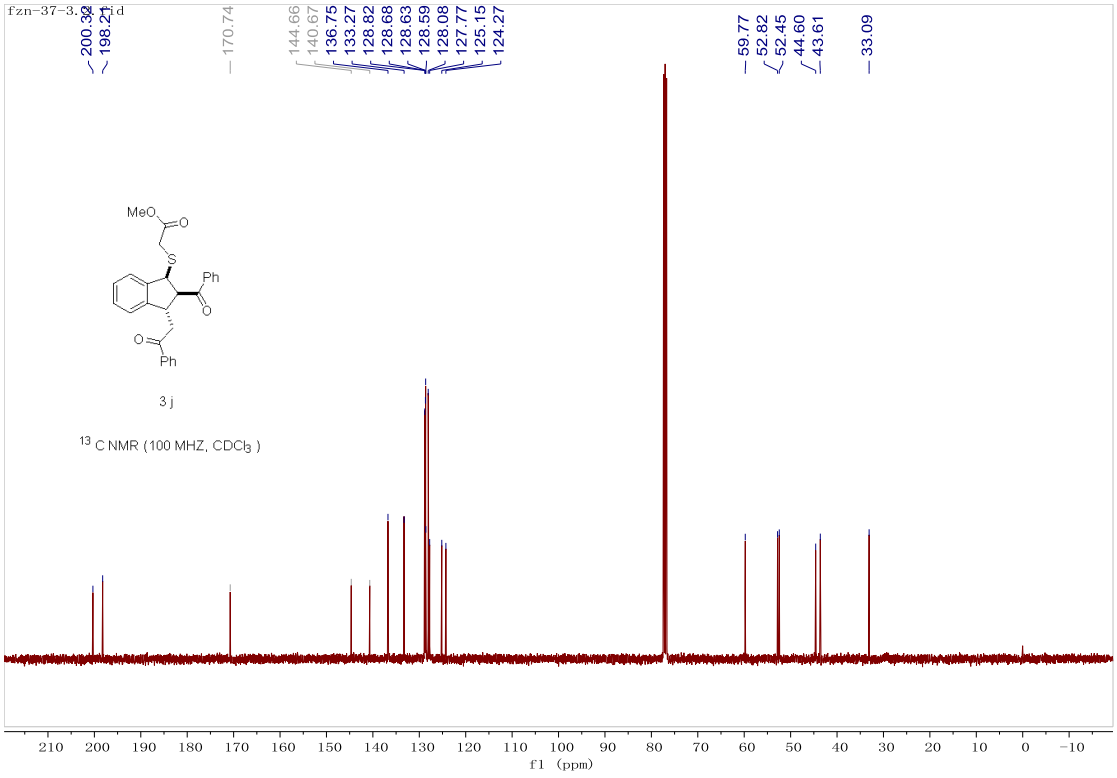

3 h
1H NMR(400 MHZ, CDCl3)
f1 (ppm)

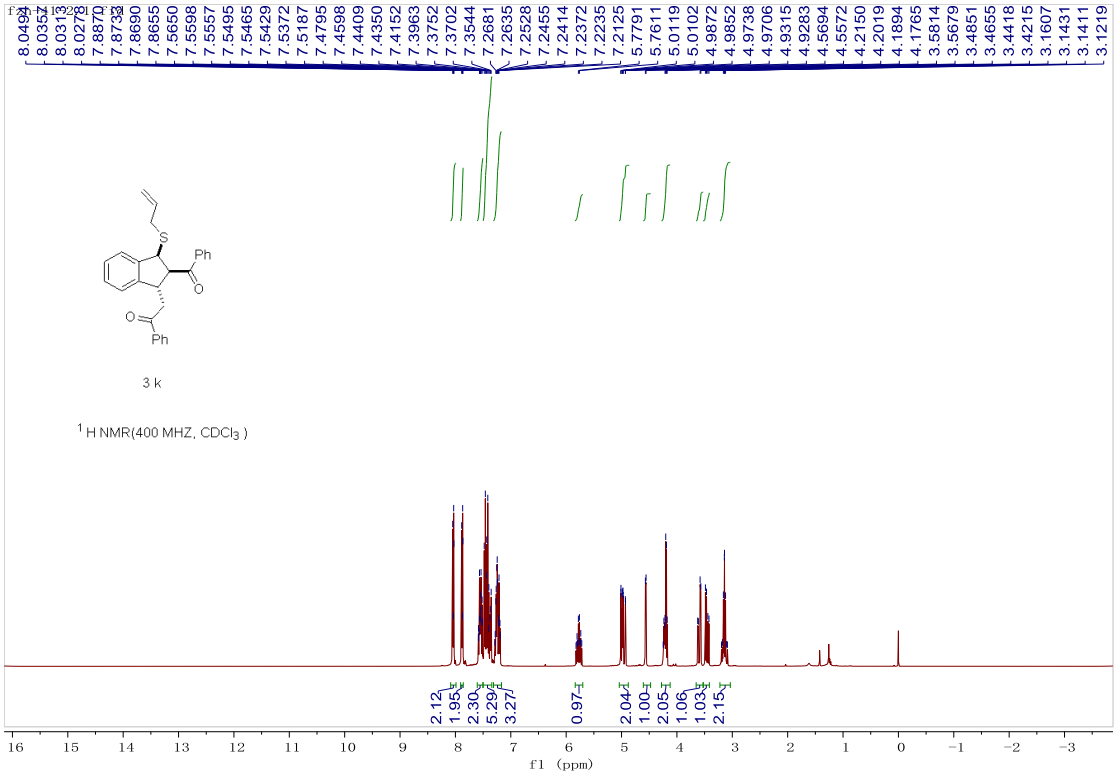

3 h
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

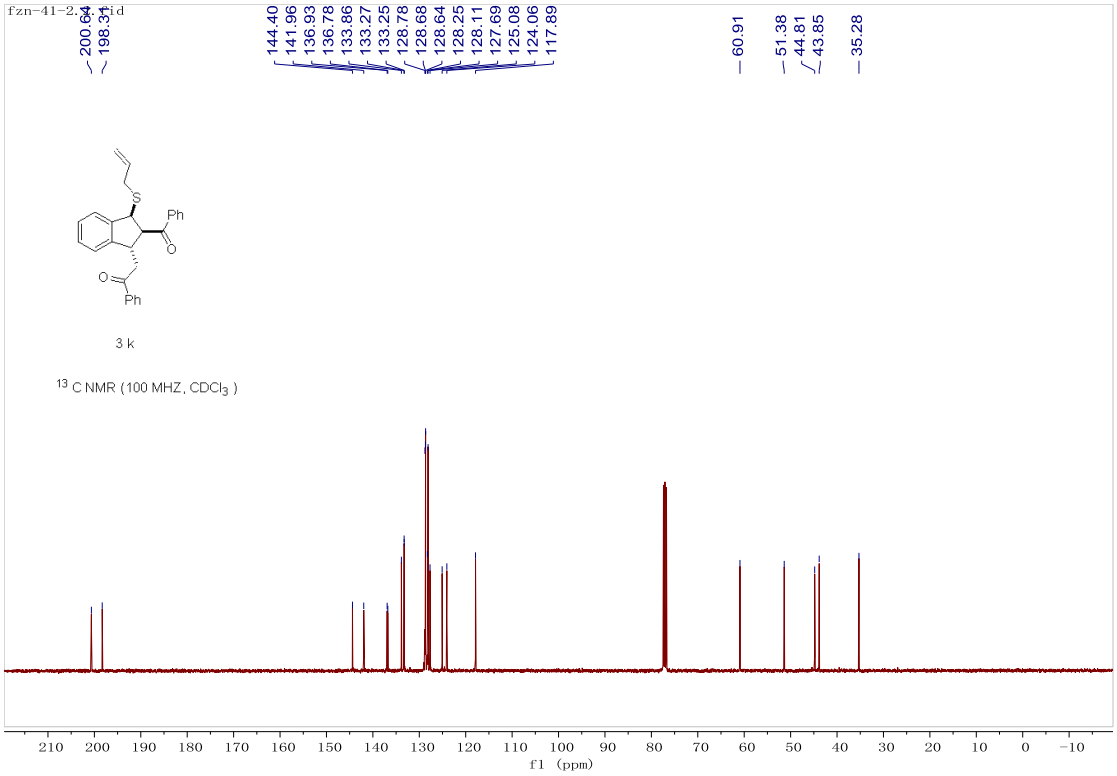

fzn-32-2.1.fid
6.1909
6.1862
6.1830
6.1783
6.0124
6.0109
6.0044
6.0029
4.6416
4.6290
4.2217
4.2084
4.2015
4.1947
4.1884
4.1748
4.1118
4.0990
4.0862
3.7799
3.7427
3.7242
3.6871
3.5997
3.5857
3.5560
3.5419
3.4640
3.4435
3.4202
3.3998
O
S
Ph
O
O
Ph
3 i
1H NMR(400 MHZ, CDCl3)
0.98
1.00
1.06
1.13
1.12
2.33
1.17
1.16
6.8 6.6 6.4 6.2 6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 4.2 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 2.
f1 (ppm)

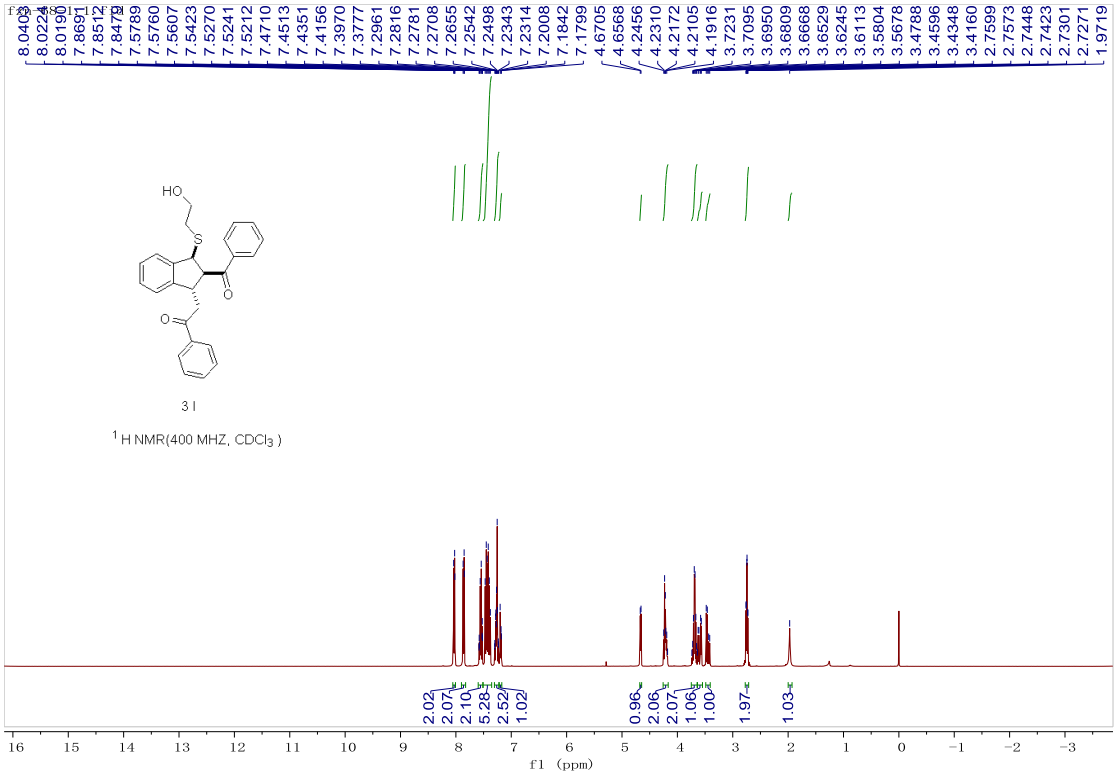

fzn-32
200.62
200.04
198.26
198.26
151.17
144.45
142.15
141.38
136.80
133.25
133.20
128.82
128.62
128.33
128.10
127.75
125.14
124.15
60.39
52.27
44.78
43.83
28.47
Ph
Ph
3 i
13 C NMR (101 MHZ, CDCl3)
f1 (ppm)

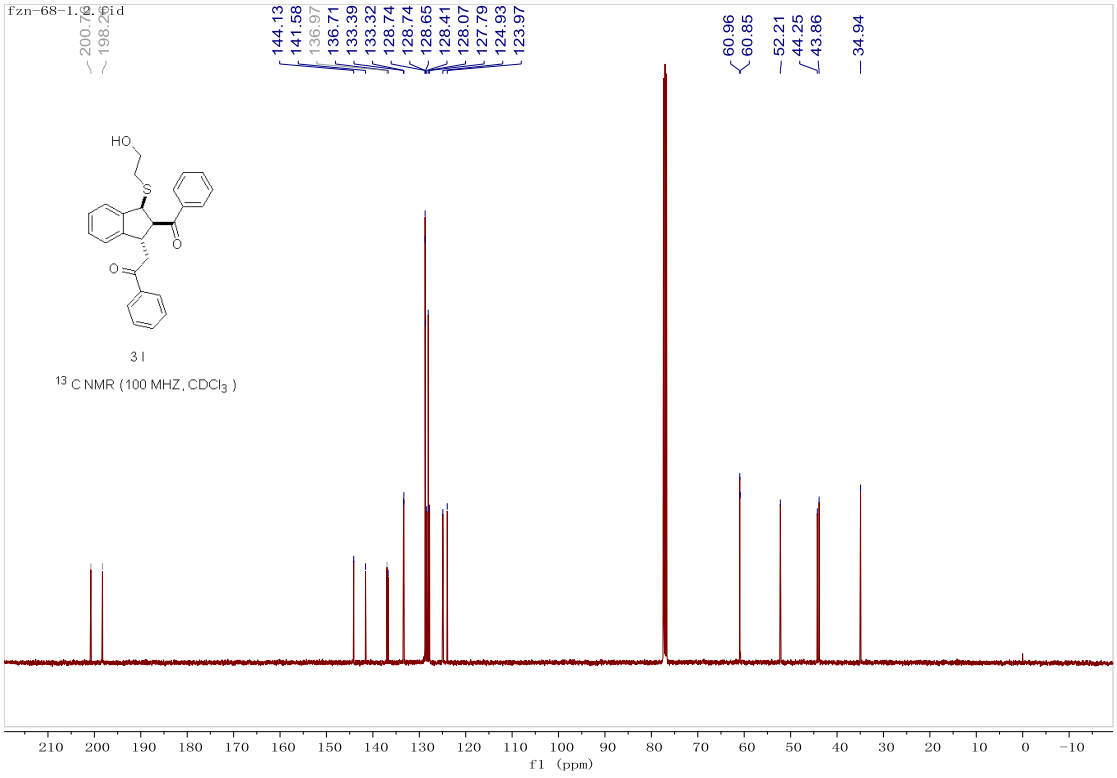

MeO
Ph
Ph
3 j
1 H NMR(400 MHZ, CDCl3)
2.05
2.04
2.14
5.24
3.44
0.95
1.00
2.12
4.09
0.96
2.18
f1 (ppm)

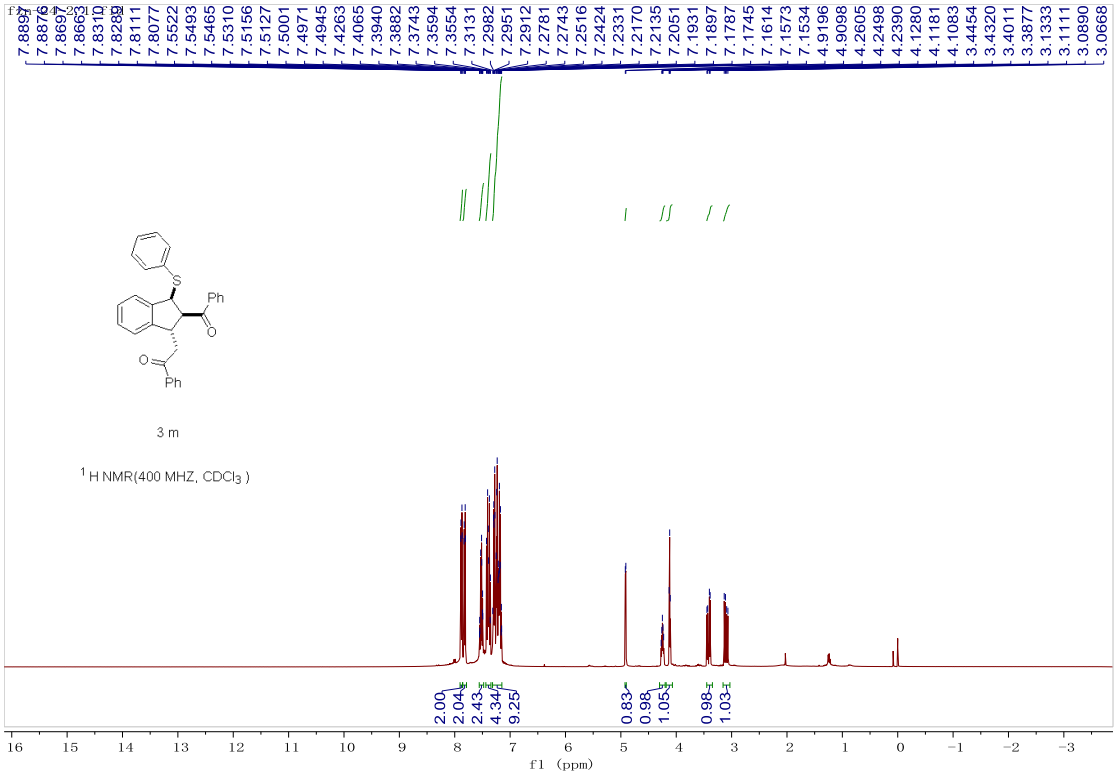

fzn-37-3.fid
200.34
198.21
170.74
144.66
140.67
136.75
133.27
128.82
128.68
128.63
128.59
128.08
127.77
125.15
124.27
59.77
52.82
52.45
44.60
43.61
33.09
MeO
O
S
Ph
O
O
Ph
3 j
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

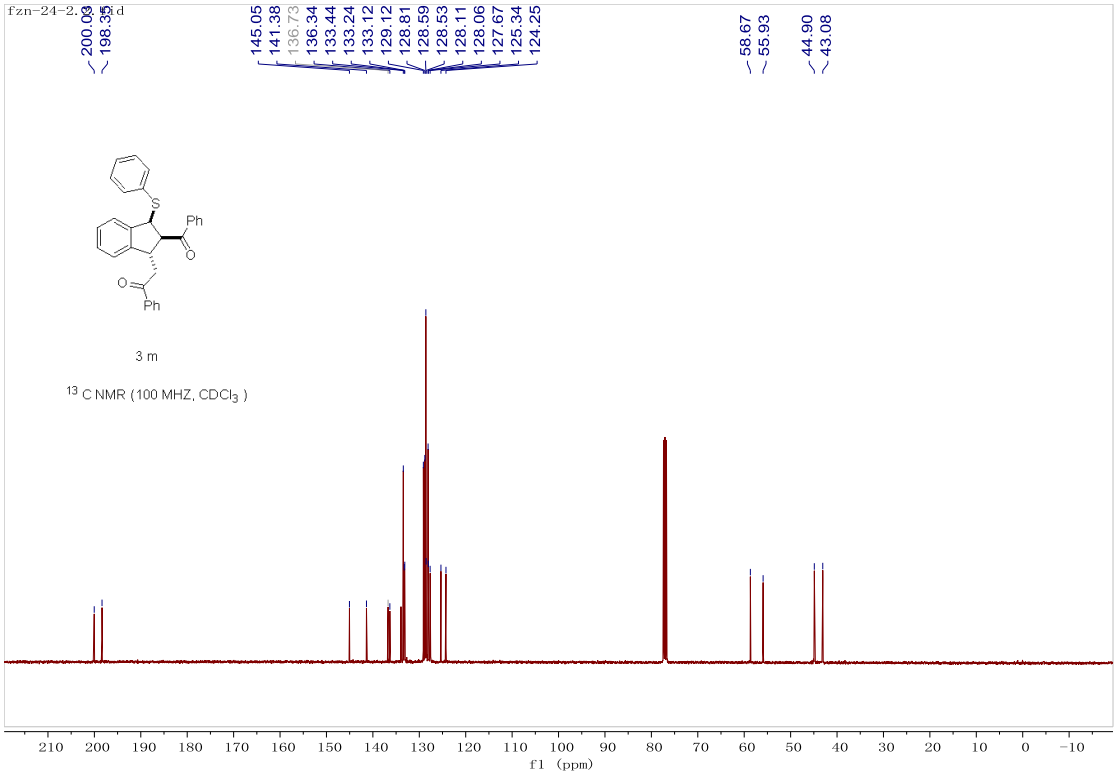

8.0492
8.0352
8.0312
8.0278
7.8870
7.8732
7.8690
7.8655
7.5650
7.5598
7.5557
7.5495
7.5465
7.5429
7.5372
7.5187
7.4795
7.4598
7.4409
7.4350
7.4152
7.3963
7.3752
7.3702
7.3544
7.2681
7.2635
7.2528
7.2455
7.2414
7.2372
7.2235
7.2125
5.7791
5.7611
5.0119
5.0102
4.9872
4.9852
4.9738
4.9706
4.9315
4.9283
4.5694
4.5572
4.2150
4.2019
4.1894
4.1765
3.5814
3.5679
3.4851
3.4655
3.4418
3.4215
3.1607
3.1431
3.1411
3.1219
S
Ph
O
O
Ph
3 k
1 H NMR(400 MHZ, CDCl3)
2.12
1.95
2.30
5.29
3.27
0.97
2.04
1.00
2.05
1.06
1.03
2.15
f1 (ppm)

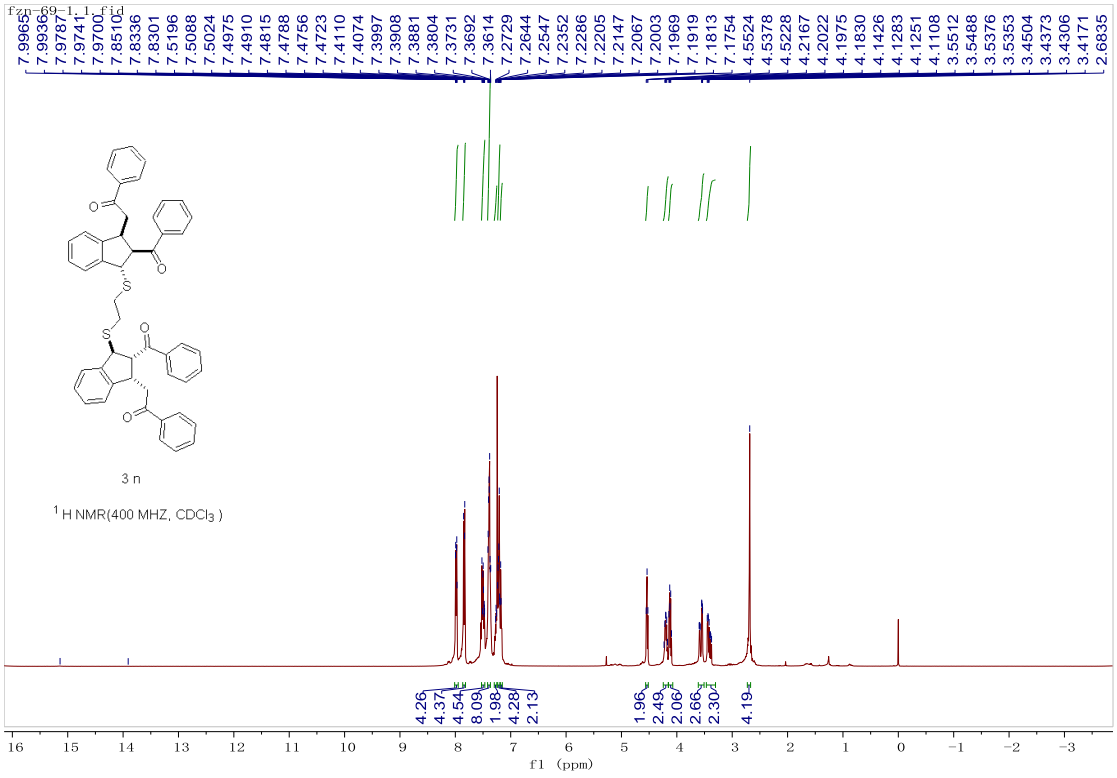

fzn-41-2.fid
200.64
198.34
144.40
141.96
136.93
136.78
133.86
133.27
133.25
128.78
128.68
128.64
128.25
128.11
127.69
125.08
124.06
117.89
60.91
51.38
44.81
43.85
35.28
Ph
Ph
3 k
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

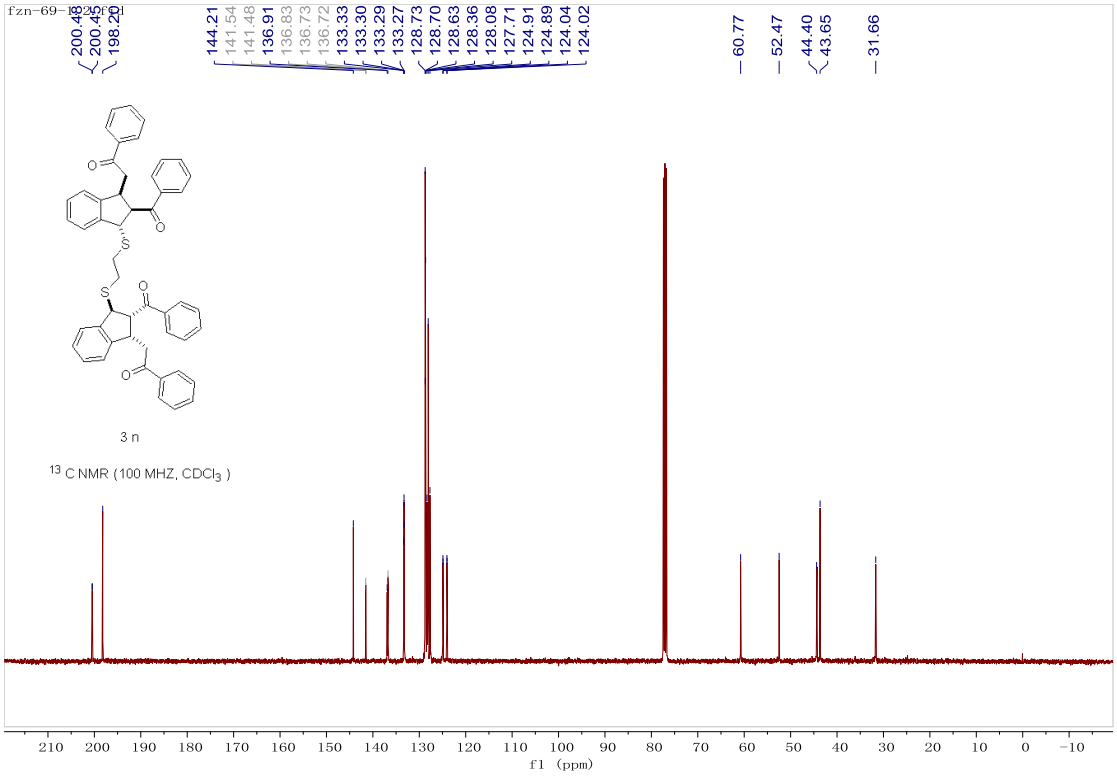

8.0404
8.0224
8.0190
7.8691
7.8512
7.8479
7.5789
7.5760
7.5607
7.5423
7.5270
7.5241
7.5212
7.4710
7.4513
7.4351
7.4156
7.3970
7.3777
7.2961
7.2816
7.2781
7.2708
7.2655
7.2542
7.2498
7.2343
7.2314
7.2008
7.1842
7.1799
4.6705
4.6568
4.2456
4.2310
4.2172
4.2105
4.1916
3.7231
3.7095
3.6950
3.6809
3.6668
3.6529
3.6245
3.6113
3.5804
3.5678
3.4788
3.4596
3.4348
3.4160
2.7599
2.7573
2.7448
2.7423
2.7301
2.7271
1.9719
HO
3 l
1 H NMR(400 MHZ, CDCl3)
2.02
2.07
2.10
5.28
2.52
1.02
0.96
2.06
2.07
1.06
1.00
1.97
1.03
f1 (ppm)

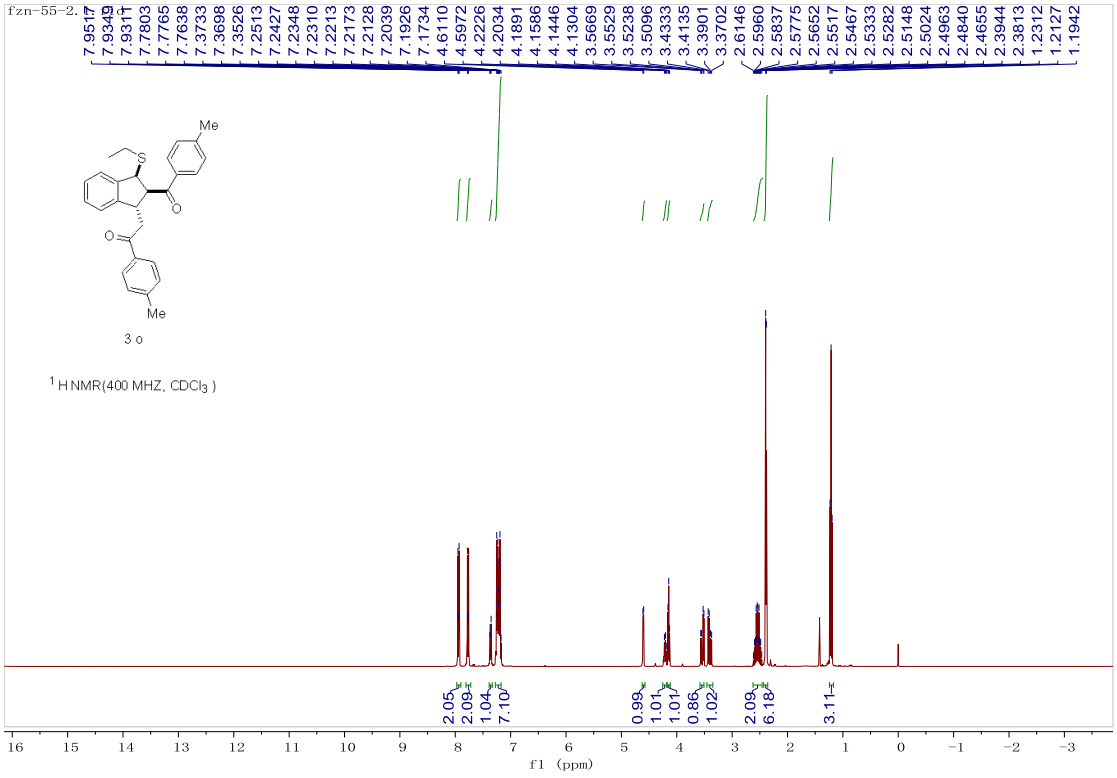

fzn-68-1.2.fid
200.7
198.2
144.13
141.58
136.97
136.71
133.39
133.32
128.74
128.74
128.65
128.41
128.07
127.79
124.93
123.97
60.96
60.85
52.21
44.25
43.86
34.94
HO
S
O
O
3 l
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

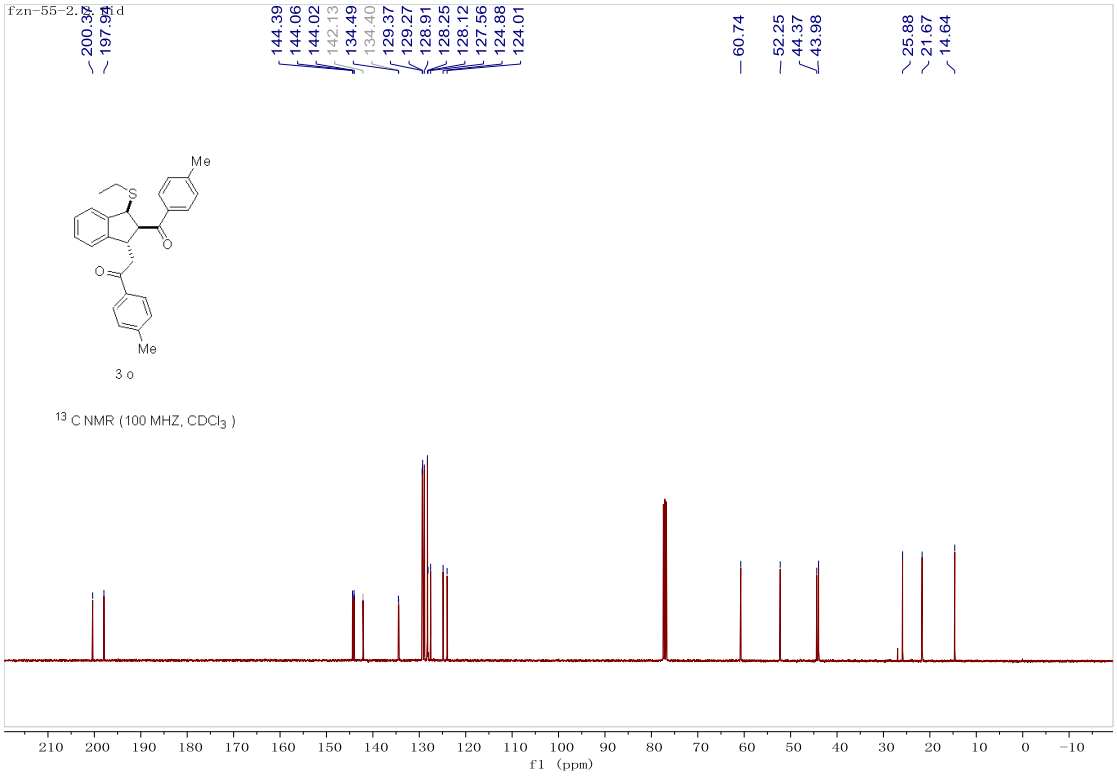

7.8897
7.8876
7.8697
7.8663
7.8310
7.8289
7.8111
7.8077
7.5522
7.5493
7.5465
7.5310
7.5156
7.5127
7.5001
7.4971
7.4945
7.4263
7.4065
7.3940
7.3882
7.3743
7.3594
7.3554
7.3131
7.2982
7.2951
7.2912
7.2781
7.2743
7.2516
7.2424
7.2331
7.2170
7.2135
7.2051
7.1931
7.1897
7.1787
7.1745
7.1614
7.1573
7.1534
4.9196
4.9098
4.2605
4.2498
4.2390
4.1280
4.1181
4.1083
3.4454
3.4320
3.4011
3.3877
3.1333
3.1111
3.0890
3.0668
S
Ph
O
O
Ph
3 m
1 H NMR(400 MHZ, CDCl3)
2.00
2.04
2.43
4.34
9.25
0.83
0.98
1.05
0.98
1.03
f1 (ppm)

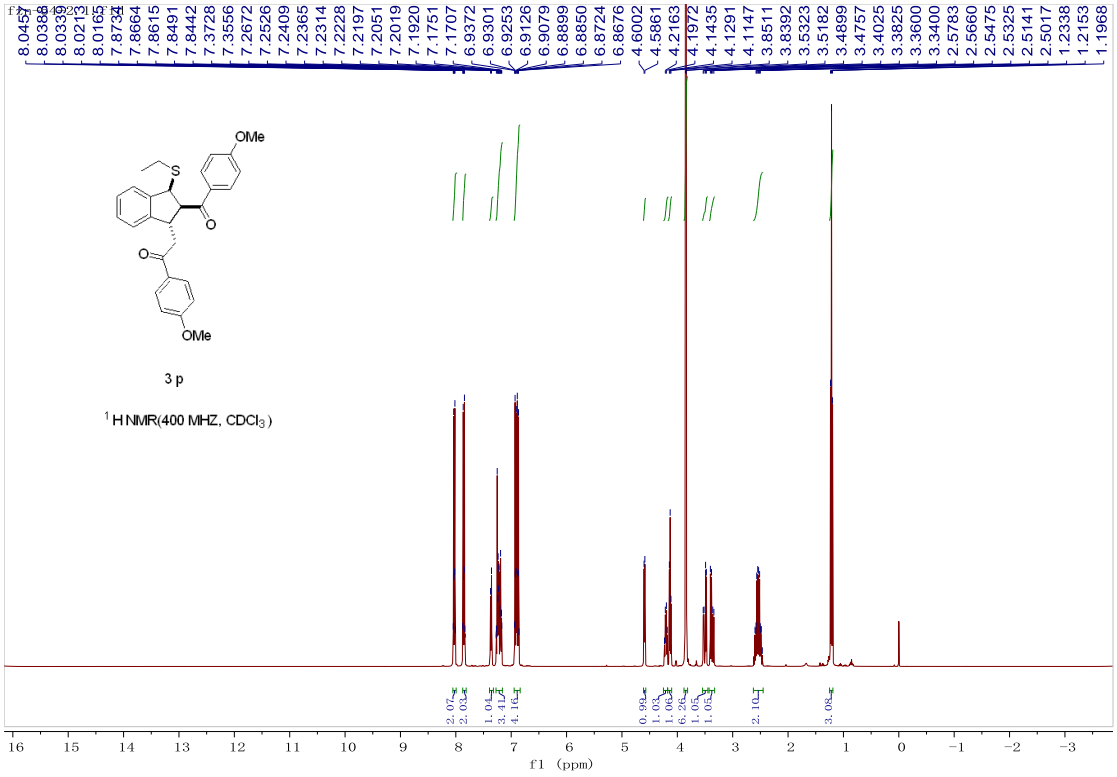

fzn-24-2.esp
200.03
198.35
145.05
141.38
136.73
136.34
133.44
133.24
133.12
129.12
128.81
128.59
128.53
128.11
128.06
127.67
125.34
124.25
58.67
55.93
44.90
43.08
S
Ph
O
O
Ph
3 m
13 C NMR (100 MHZ, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

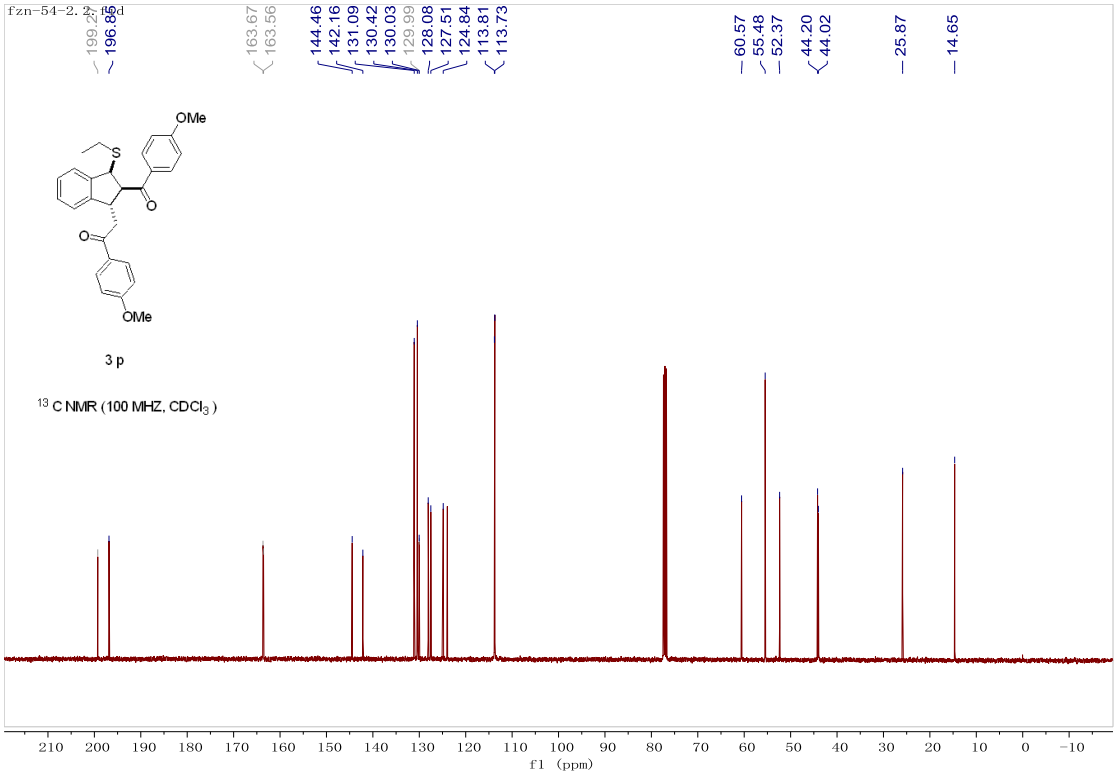

fzn-69-1_1.fid
3 n
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

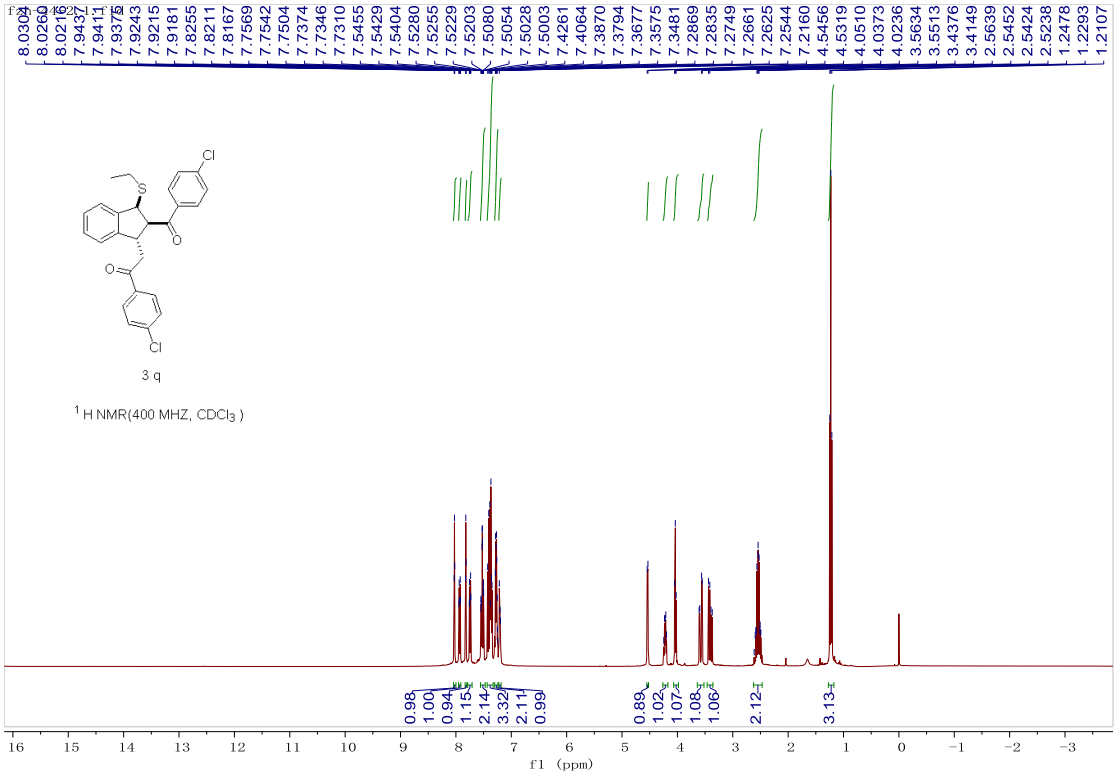

3 n
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

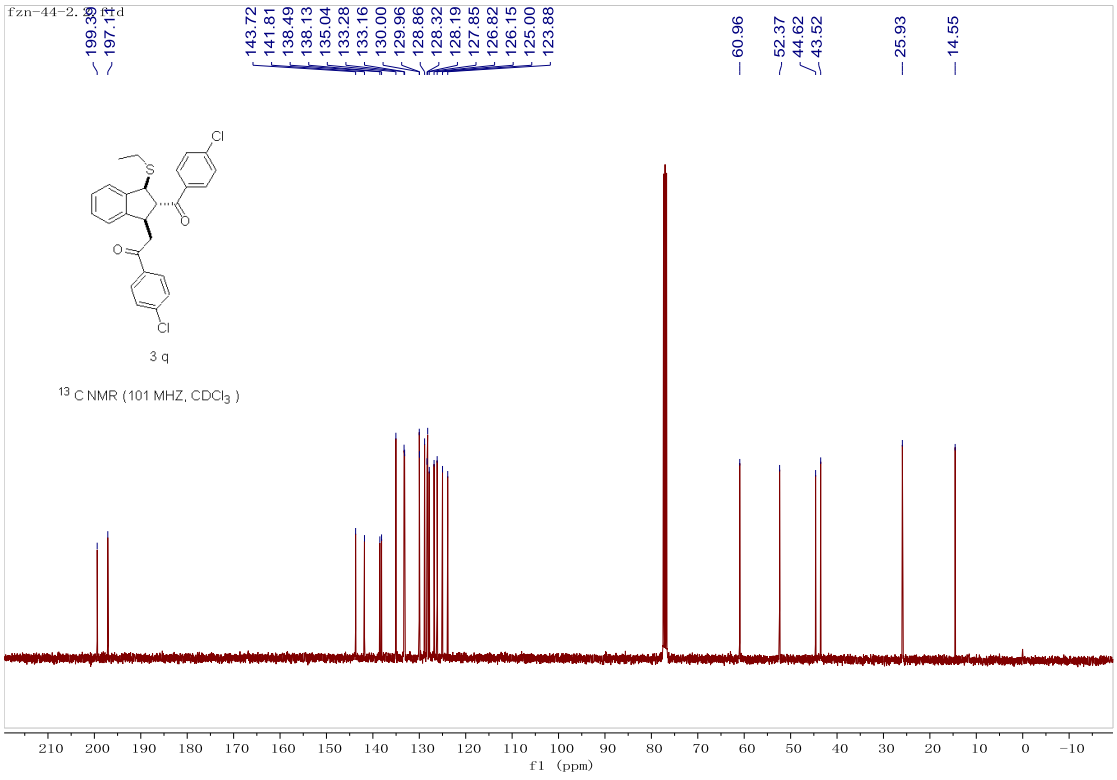

fzn-55-2.
7.9517
7.9349
7.9311
7.7803
7.7765
7.7638
7.3733
7.3698
7.3526
7.2513
7.2427
7.2348
7.2310
7.2213
7.2173
7.2128
7.2039
7.1926
7.1734
4.6110
4.5972
4.2226
4.2034
4.1891
4.1586
4.1446
4.1304
3.5669
3.5529
3.5238
3.5096
3.4333
3.4135
3.3901
3.3702
2.6146
2.5960
2.5837
2.5775
2.5652
2.5517
2.5467
2.5333
2.5282
2.5148
2.5024
2.4963
2.4840
2.4655
2.3944
2.3813
2.2312
2.2127
1.1942
Me
S
O
O
Me
3 o
1 H NMR(400 MHZ, CDCl3)
2.05
2.09
1.04
7.10
0.99
1.01
1.01
0.86
1.02
2.09
6.18
3.11
f1 (ppm)

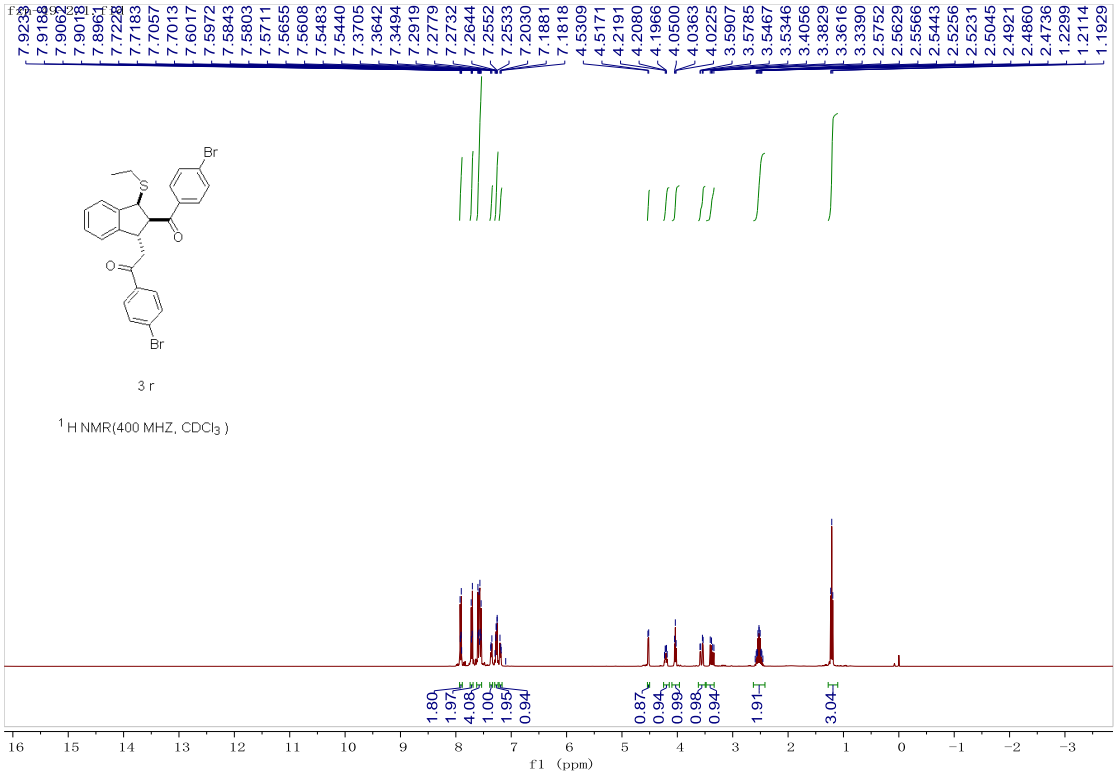

fzn-55-2.
200.37
197.94
144.39
144.06
144.02
142.13
134.49
134.40
129.37
129.27
128.91
128.25
128.12
127.56
124.88
124.01
60.74
52.25
44.37
43.98
25.88
21.67
14.64
Me
S
O
O
Me
3 o
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

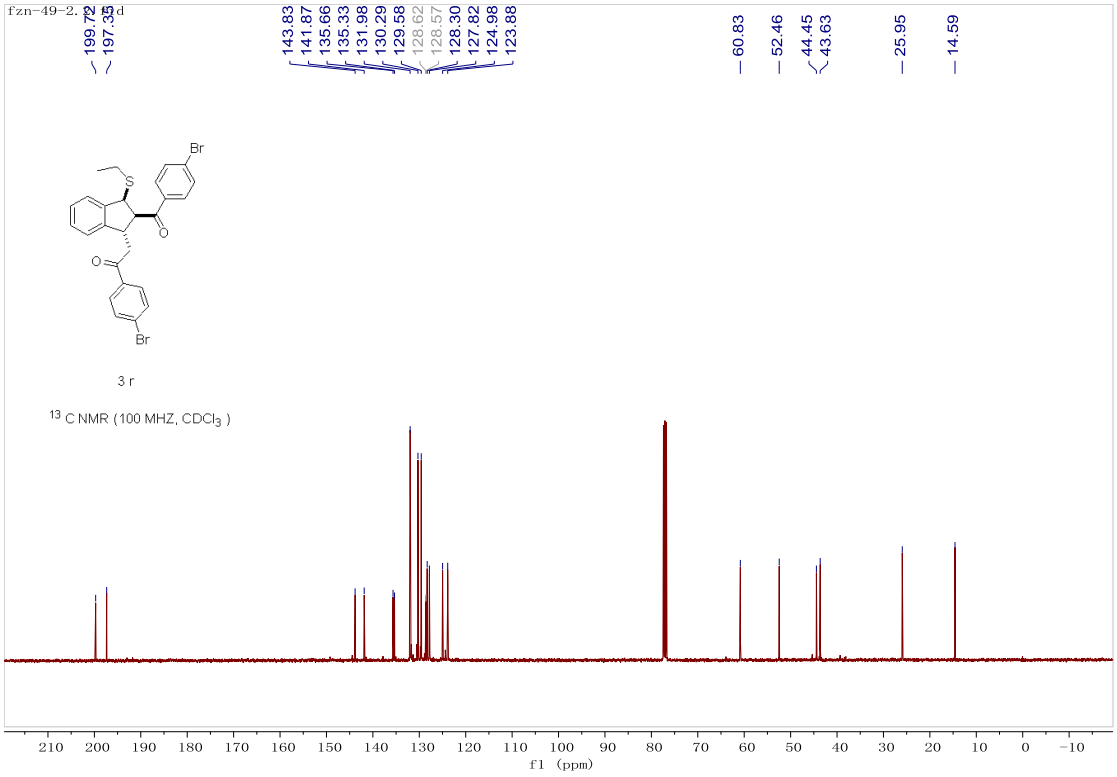

OMe
S
O
O
OMe
3 p
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

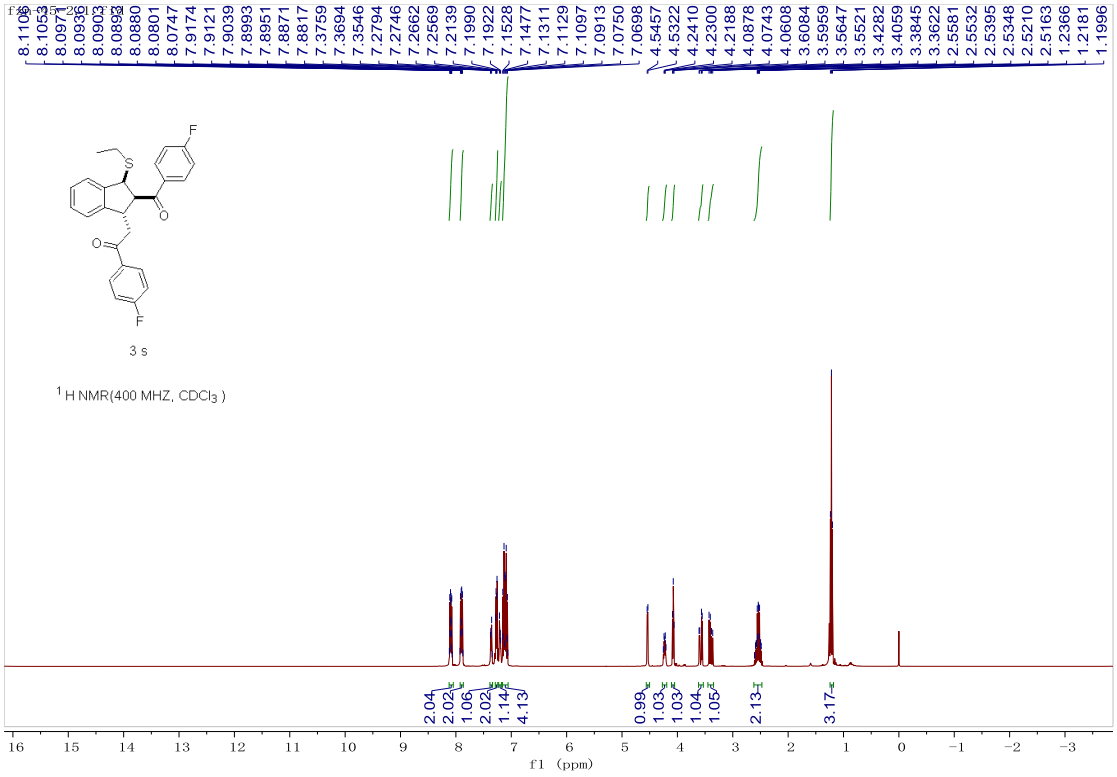

OMe
S
O
O
OMe
3 p
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

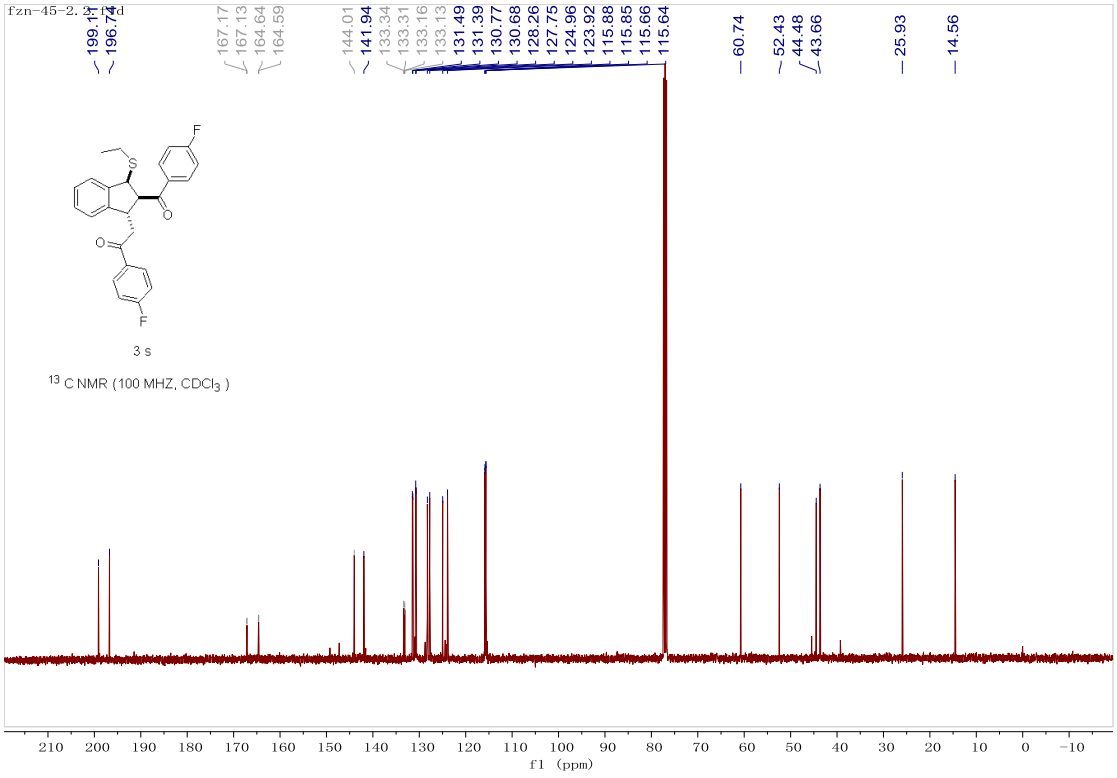

3 q
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

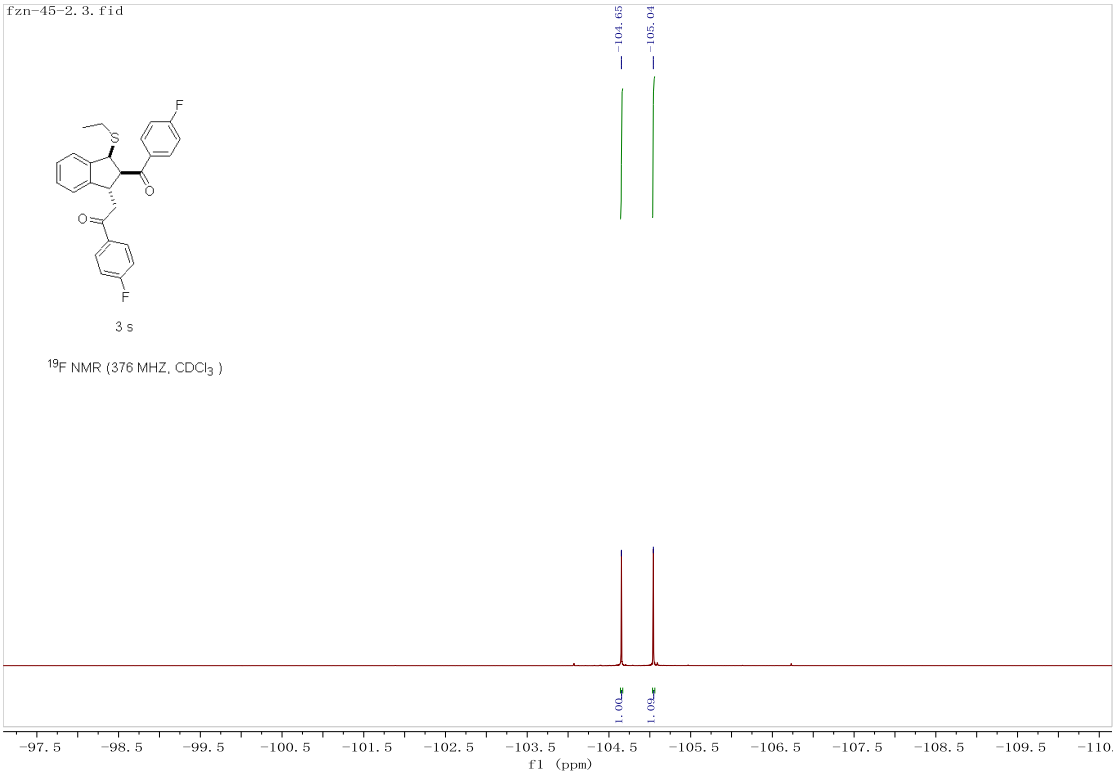

fzn-44-2.
3 q
13 C NMR (101 MHZ, CDCl3)
f1 (ppm)

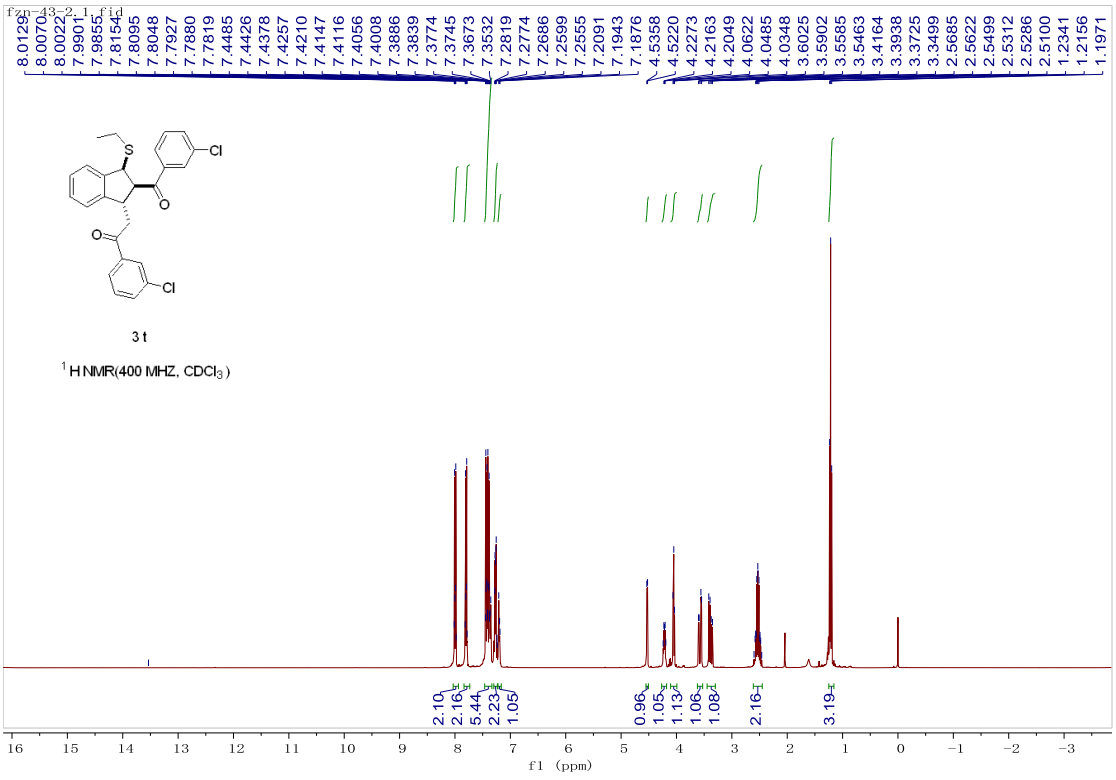

3 r
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

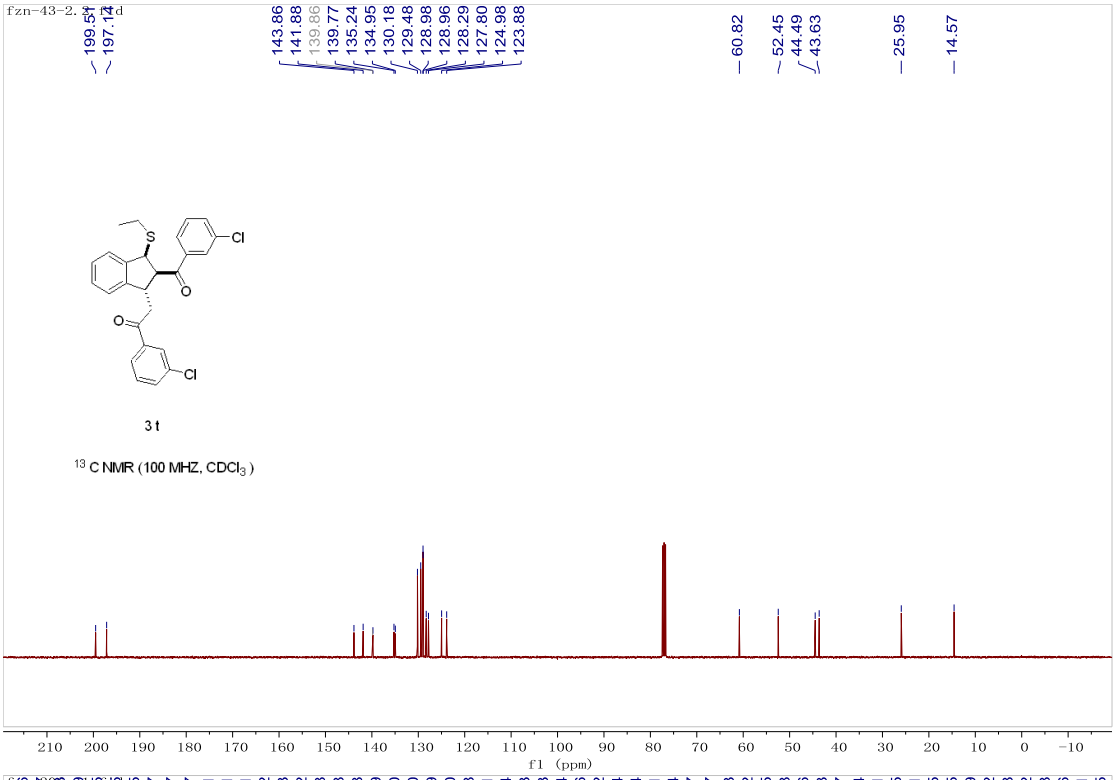

3 r
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

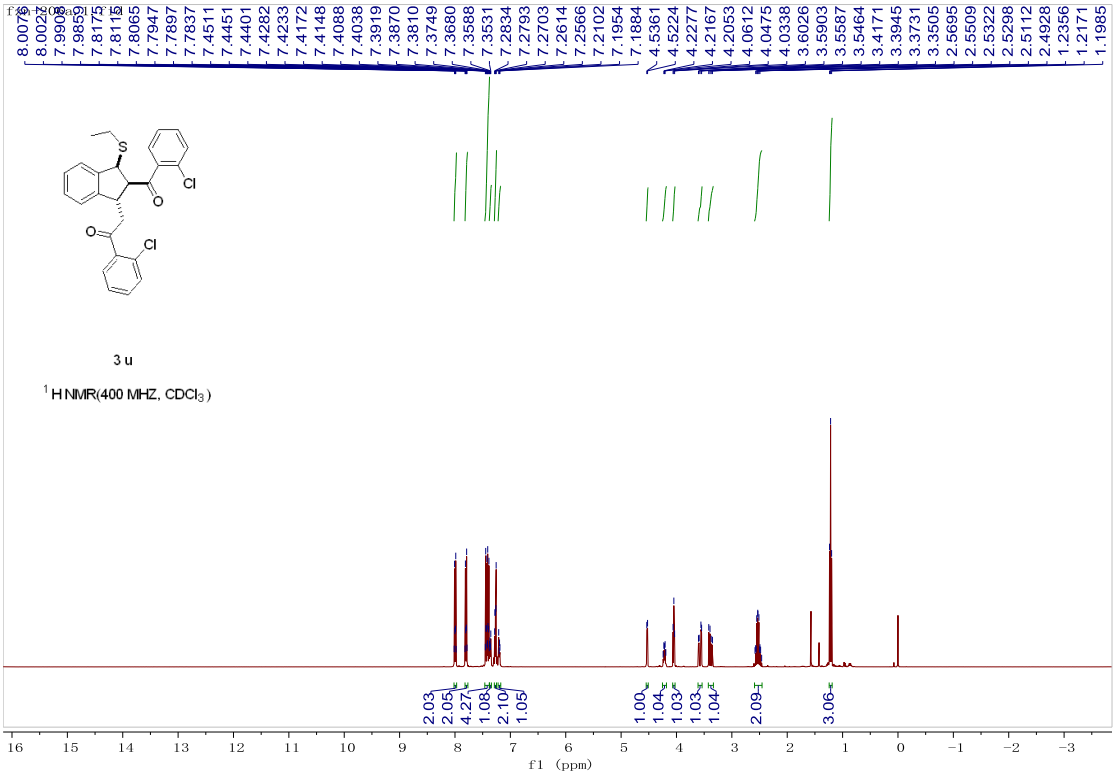

3 s
1H NMR(400 MHZ, CDCl3)
f1 (ppm)

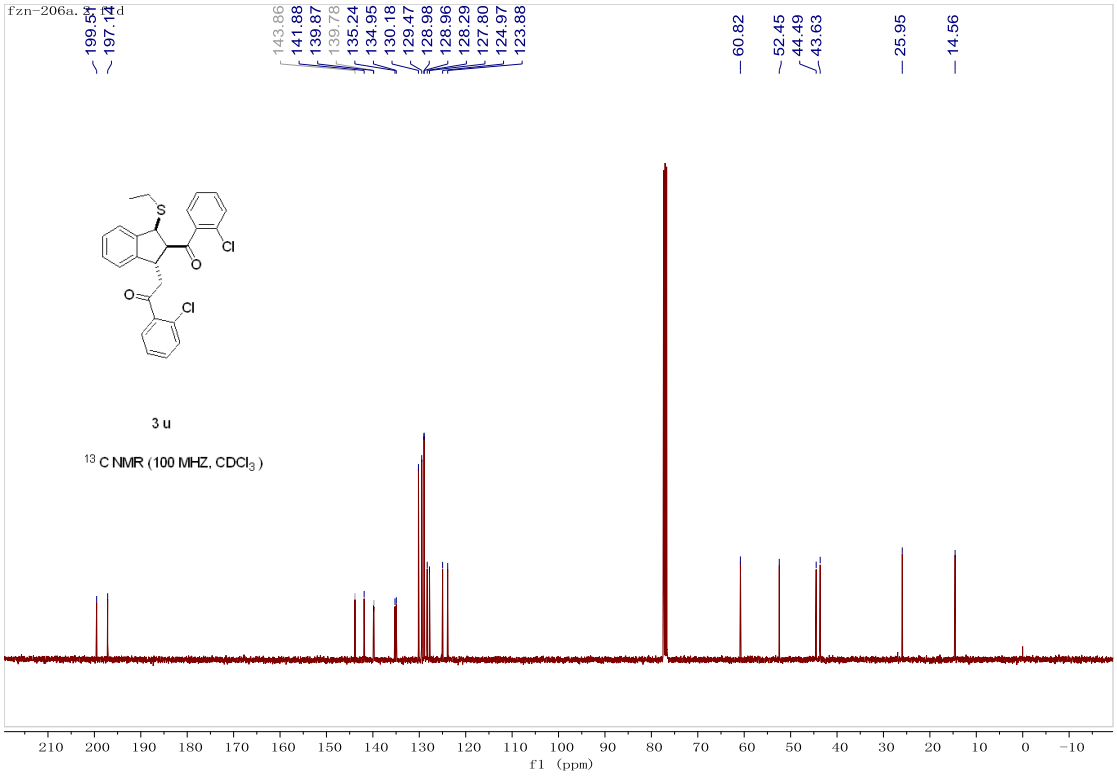

3 s
13C NMR (100 MHZ, CDCl3)
f1 (ppm)

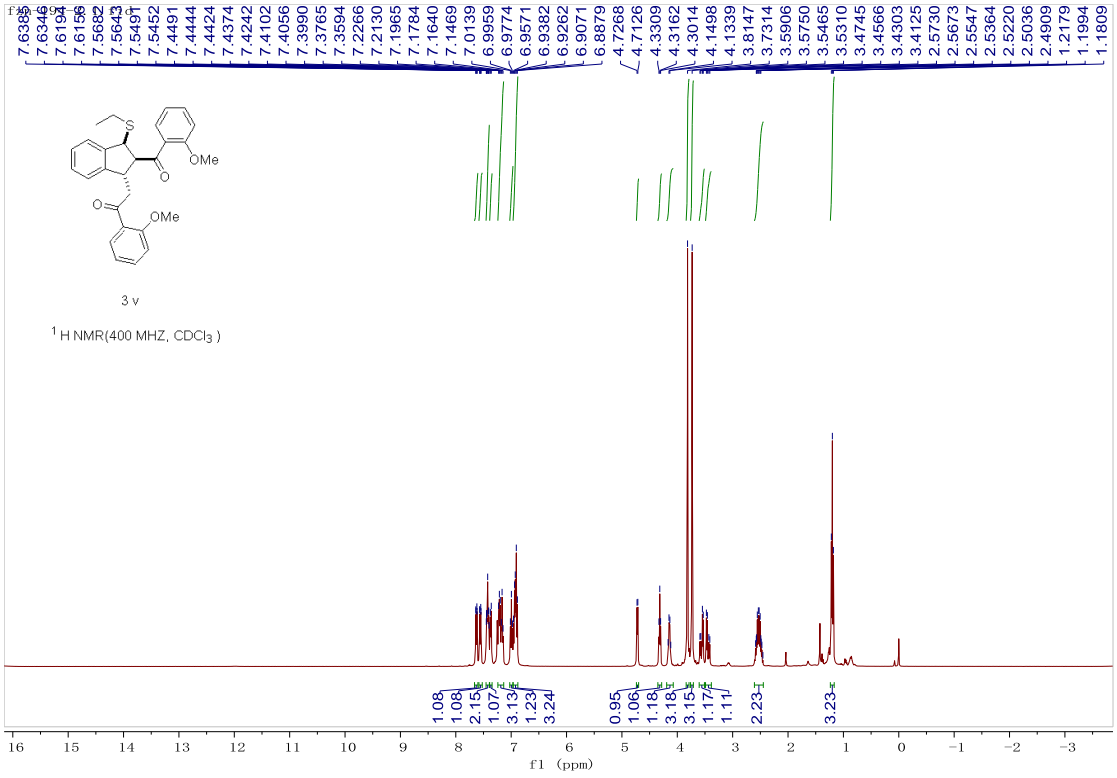

fzn-45-2.3.fid
-104.65
-105.04
F
S
O
O
F
3 s
19F NMR (376 MHZ, CDCl3)
1.00
1.09
-97.5
-98.5
-99.5
-100.5
-101.5
-102.5
-103.5
-104.5
-105.5
-106.5
-107.5
-108.5
-109.5
-110.
f1 (ppm)

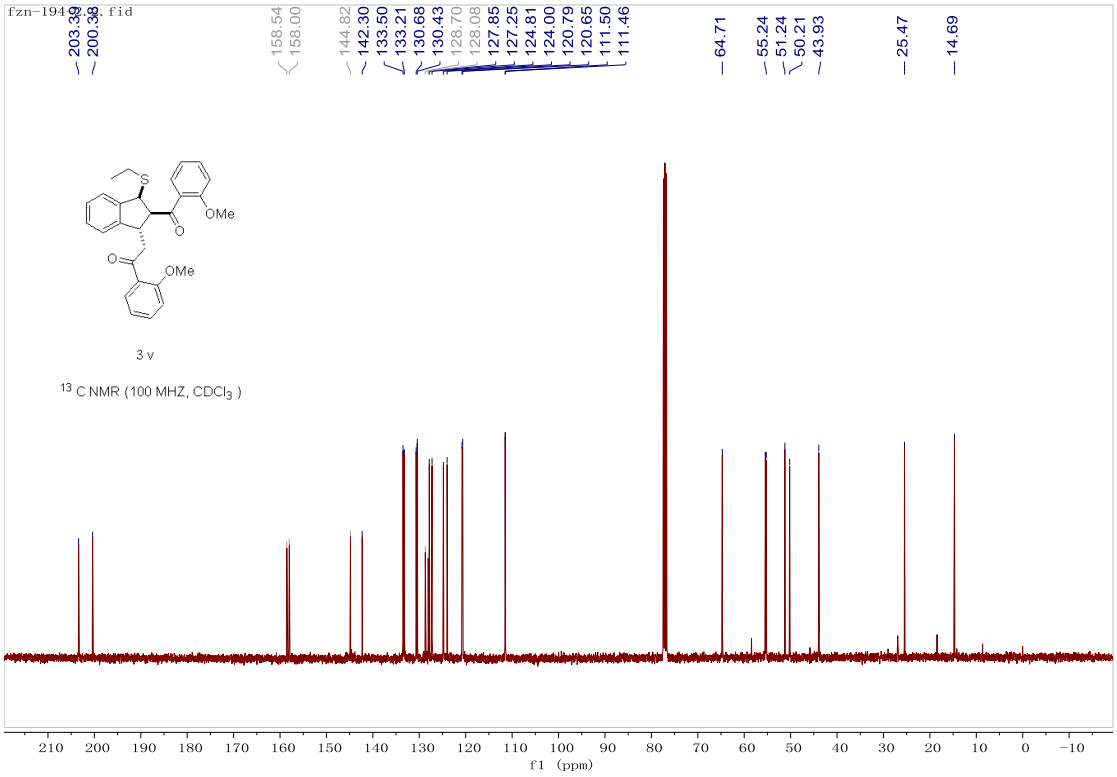

fzn-43-2_1.fid
8.0129
8.0070
8.0022
7.9901
7.9855
7.8154
7.8095
7.8048
7.7927
7.7880
7.7819
7.4485
7.4426
7.4378
7.4257
7.4210
7.4147
7.4116
7.4056
7.4008
7.3886
7.3839
7.3774
7.3745
7.3673
7.3532
7.2819
7.2774
7.2686
7.2599
7.2555
7.2091
7.1943
7.1876
4.5358
4.5220
4.2273
4.2163
4.2049
4.0622
4.0485
4.0348
3.6025
3.5902
3.5585
3.5463
3.4164
3.3938
3.3725
3.3499
2.5685
2.5622
2.5499
2.5312
2.5286
2.5100
1.2341
1.2156
1.1971
S
Cl
O
O
Cl
3 t
1 H NMR(400 MHZ, CDCl3)
2.10
2.16
5.44
2.23
1.05
0.96
1.05
1.13
1.06
1.08
2.16
3.19
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

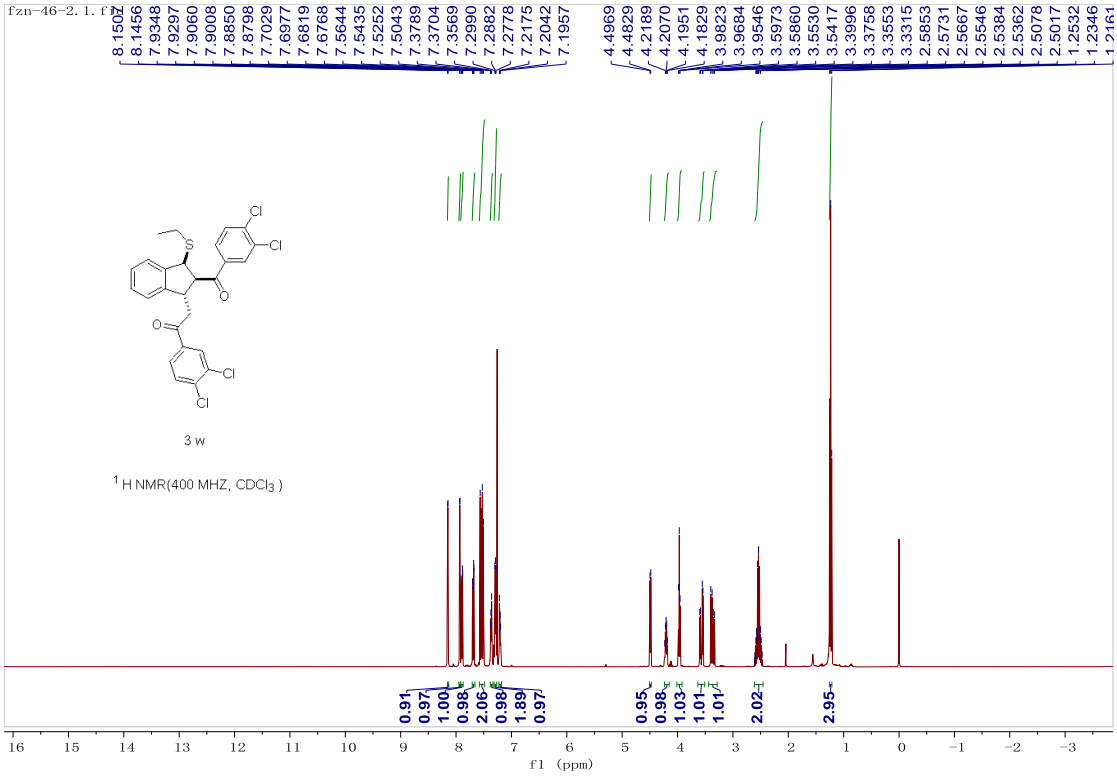

fzn-43-2.1.fid
199.54
197.12
143.86
141.88
139.86
139.77
135.24
134.95
130.18
129.48
128.98
128.96
128.29
127.80
124.98
123.88
60.82
52.45
44.49
43.63
25.95
14.57
S
Cl
O
O
Cl
3 t
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

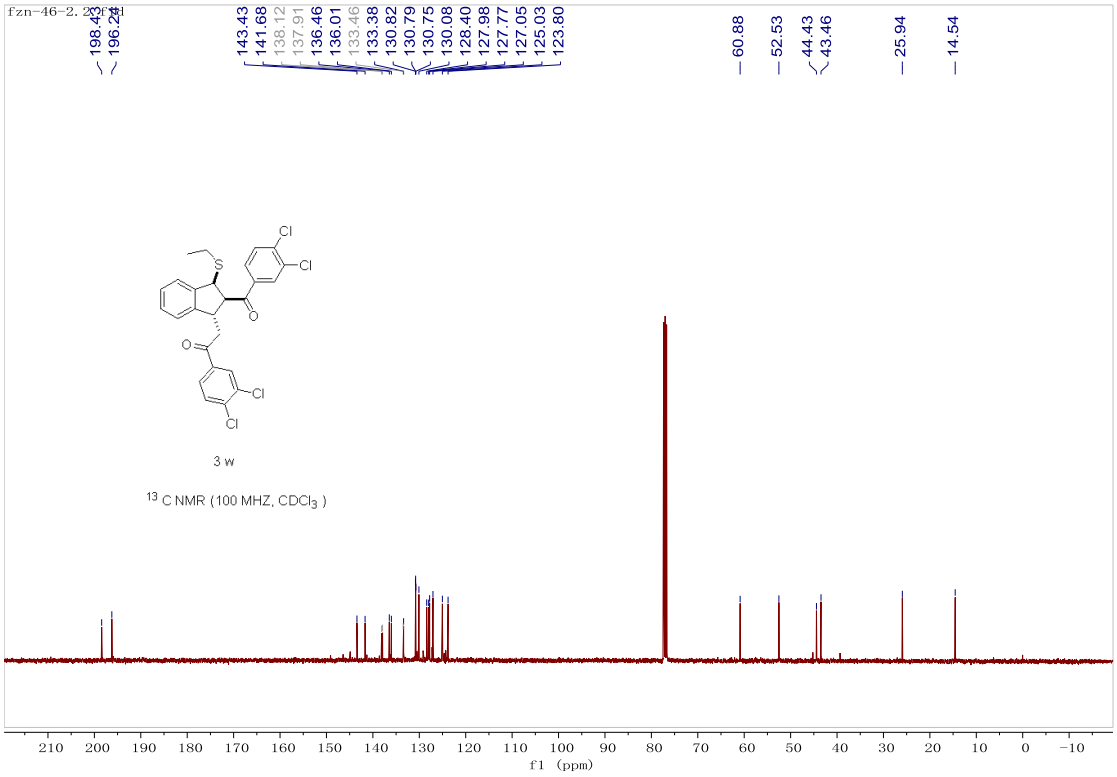

8.0076
8.0021
7.9908
7.9859
7.8175
7.8115
7.8065
7.7947
7.7897
7.7837
7.4511
7.4451
7.4401
7.4282
7.4233
7.4172
7.4148
7.4088
7.4038
7.3919
7.3870
7.3810
7.3749
7.3680
7.3588
7.3531
7.2834
7.2793
7.2703
7.2614
7.2566
7.2102
7.1954
7.1884
4.5361
4.5224
4.2277
4.2167
4.2053
4.0612
4.0475
4.0338
3.6026
3.5903
3.5587
3.5464
3.4171
3.3945
3.3731
3.3505
2.5695
2.5509
2.5322
2.5298
2.5112
2.4928
1.2356
1.2171
1.1985
S
Cl
O
O
Cl
3 u
1 H NMR(400 MHZ, CDCl3)
2.03
2.05
4.27
1.08
2.10
1.05
1.00
1.04
1.03
1.03
1.04
2.09
3.06
f1 (ppm)

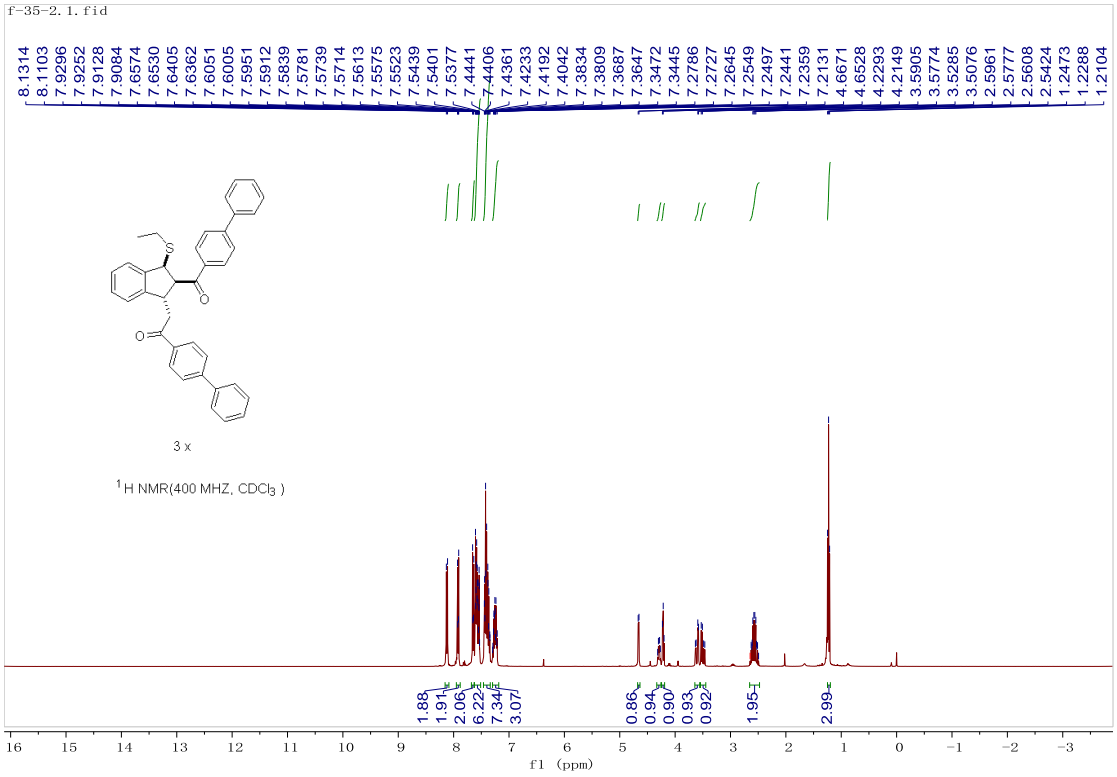

fzn-206a.10.fid
199.54
197.12
143.86
141.88
139.87
139.78
135.24
134.95
130.18
129.47
128.98
128.96
128.29
127.80
124.97
123.88
60.82
52.45
44.49
43.63
25.95
14.56
S
Cl
O
O
Cl
3 u
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

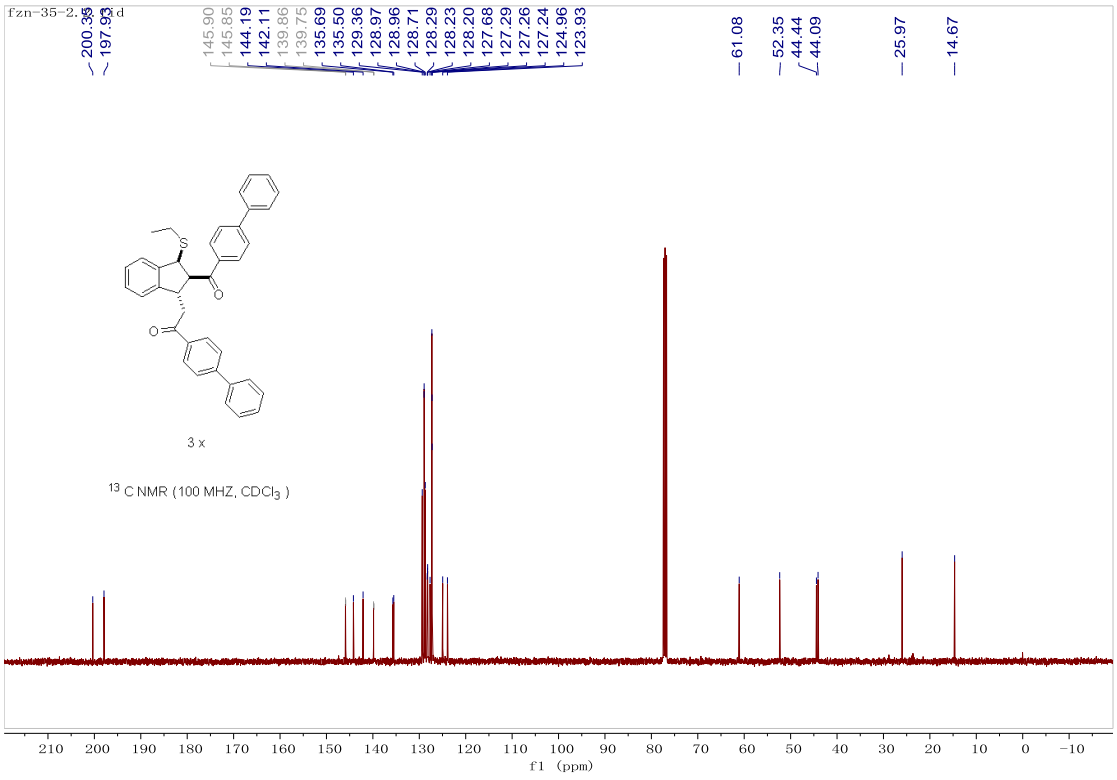

7.6389
7.6346
7.6194
7.6156
7.5682
7.5643
7.5491
7.5452
7.4491
7.4444
7.4424
7.4374
7.4242
7.4102
7.4056
7.3990
7.3765
7.3594
7.2266
7.2130
7.1965
7.1784
7.1640
7.1469
7.0139
6.9959
6.9774
6.9571
6.9382
6.9262
6.9071
6.8879
4.7268
4.7126
4.3309
4.3162
4.3014
4.1498
4.1339
3.8147
3.7314
3.5906
3.5750
3.5465
3.5310
3.4745
3.4566
3.4303
3.4125
2.5730
2.5673
2.5547
2.5364
2.5220
2.5036
2.4909
2.2179
1.1994
1.1809
S
OMe
O
O
OMe
3 v
1 H NMR(400 MHZ, CDCl3)
1.08
1.08
2.15
1.07
3.13
1.23
3.24
0.95
1.06
1.18
3.18
3.15
1.17
1.11
2.23
3.23
f1 (ppm)

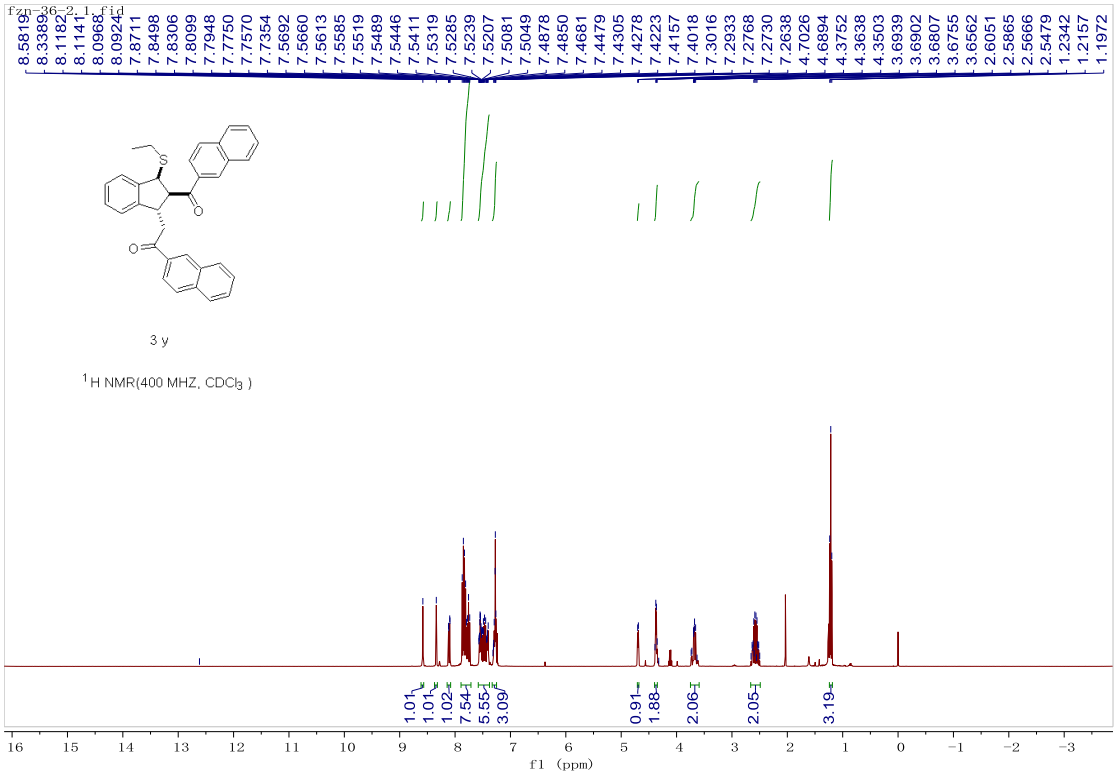

fzn-194-3. fid
203.39
200.36
158.54
158.00
144.82
142.30
133.50
133.21
130.68
130.43
128.70
128.08
127.85
127.25
124.81
124.00
120.79
120.65
111.50
111.46
64.71
55.24
51.24
50.21
43.93
25.47
14.69
OMe
OMe
3 v
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

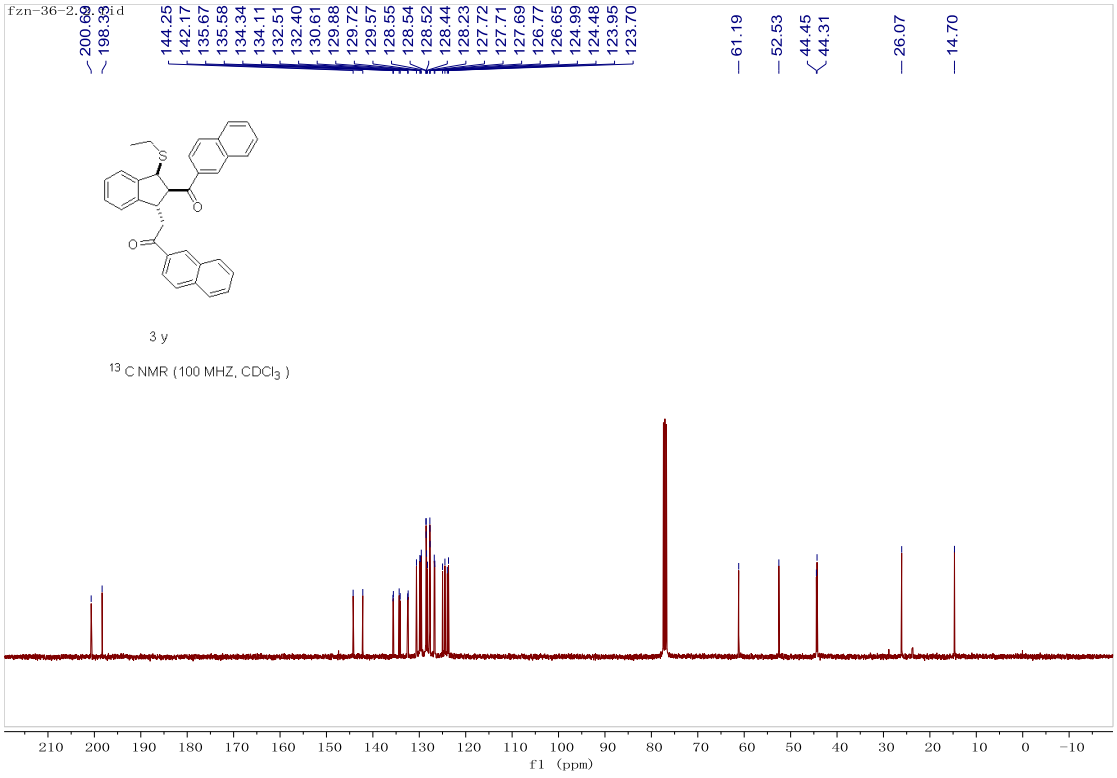

fzn-46-2. 1. fid
8.1502
8.1456
7.9348
7.9297
7.9060
7.9008
7.8850
7.8798
7.7029
7.6977
7.6819
7.6768
7.5644
7.5435
7.5252
7.5043
7.3789
7.3704
7.3569
7.2990
7.2882
7.2778
7.2175
7.2042
7.1957
4.4969
4.4829
4.2189
4.2070
4.1951
4.1829
3.9823
3.9684
3.9546
3.5973
3.5860
3.5530
3.5417
3.3996
3.3758
3.3553
3.3315
2.5853
2.5731
2.5667
2.5546
2.5384
2.5362
2.5078
2.5017
1.2532
1.2346
Cl
Cl
Cl
Cl
3 w
1 H NMR(400 MHZ, CDCl3)
0.91
0.97
1.00
0.98
2.06
0.98
1.89
0.97
0.95
0.98
1.03
1.01
1.01
2.02
2.95
f1 (ppm)

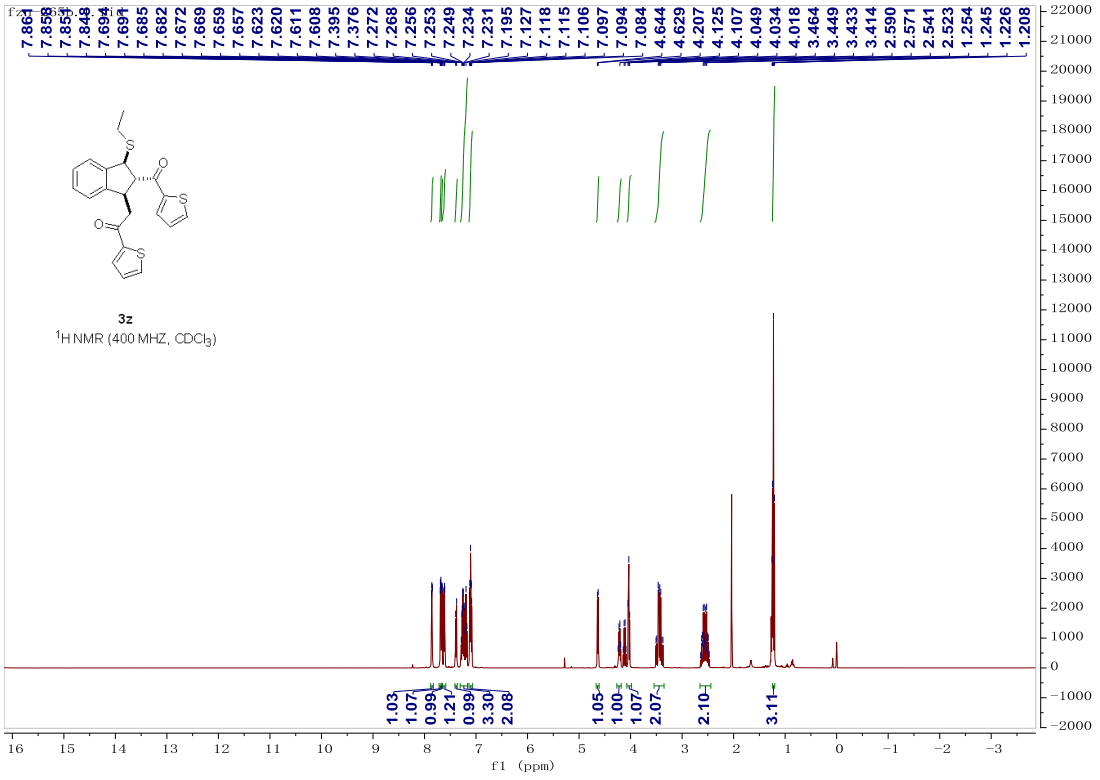

fzn-46-2.2.fid
198.43
196.24
143.43
141.68
138.12
137.91
136.46
136.01
133.46
133.38
130.82
130.79
130.75
130.08
128.40
127.98
127.77
127.05
125.03
123.80
60.88
52.53
44.43
43.46
25.94
14.54
Cl
Cl
S
O
O
Cl
Cl
3 w
13 C NMR (100 MHZ, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

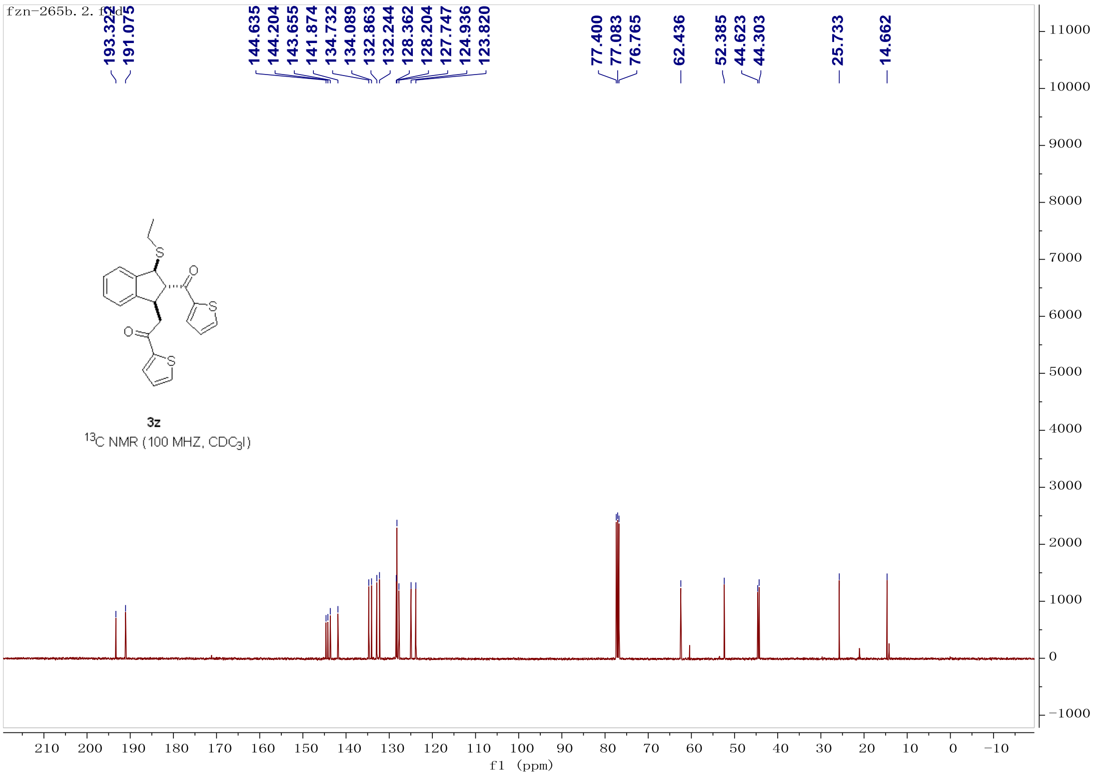

f-35-2.1.fid
8.1314
8.1103
7.9296
7.9252
7.9128
7.9084
7.6574
7.6530
7.6405
7.6362
7.6051
7.6005
7.5951
7.5912
7.5839
7.5781
7.5739
7.5714
7.5613
7.5575
7.5523
7.5439
7.5401
7.5377
7.4441
7.4406
7.4361
7.4233
7.4192
7.4042
7.3834
7.3809
7.3687
7.3647
7.3472
7.3445
7.2786
7.2727
7.2645
7.2549
7.2497
7.2441
7.2359
7.2131
4.6671
4.6528
4.2293
4.2149
3.5905
3.5774
3.5285
3.5076
2.5961
2.5777
2.5608
2.5424
1.2473
1.2288
1.2104
S
O
O
3 x
1H NMR(400 MHZ, CDCl3)
1.88
1.91
2.06
6.22
7.34
3.07
0.86
0.94
0.90
0.93
0.92
1.95
2.99
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

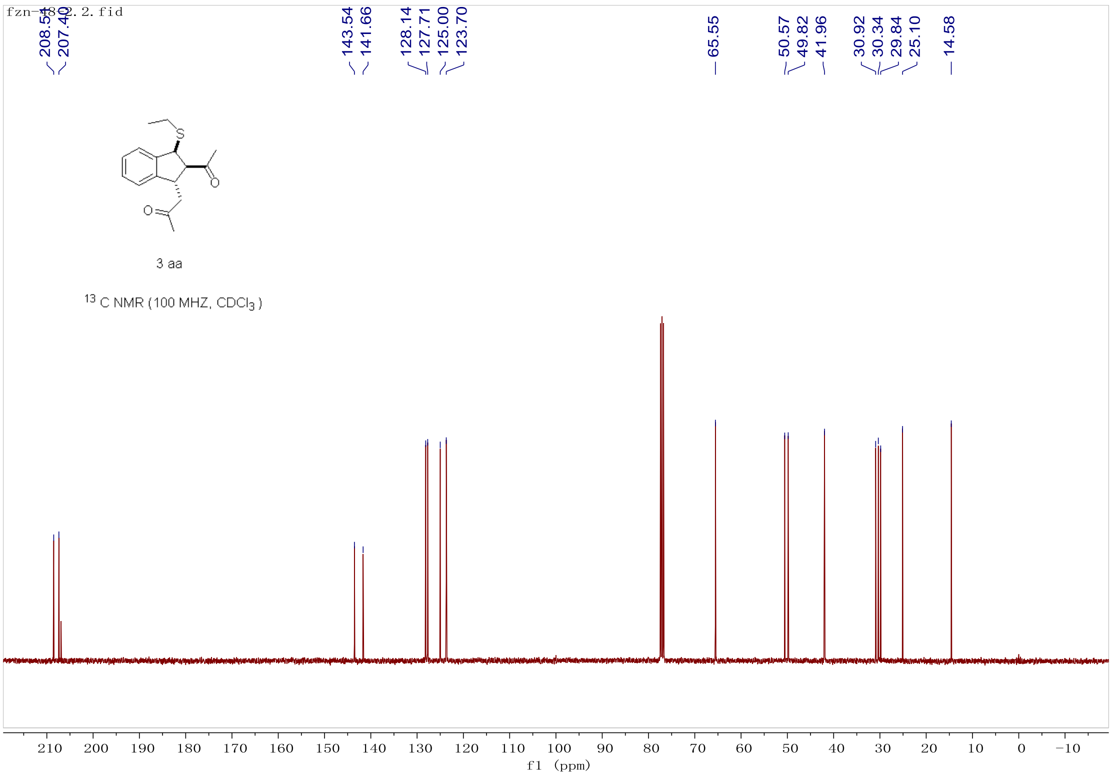

fzn-35-2.
200.38
197.93
145.90
145.85
144.19
142.11
139.86
139.75
135.69
135.50
129.36
128.97
128.96
128.71
128.29
128.23
128.20
127.68
127.29
127.26
127.24
124.96
123.93
61.08
52.35
44.44
44.09
25.97
14.67
3 x
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

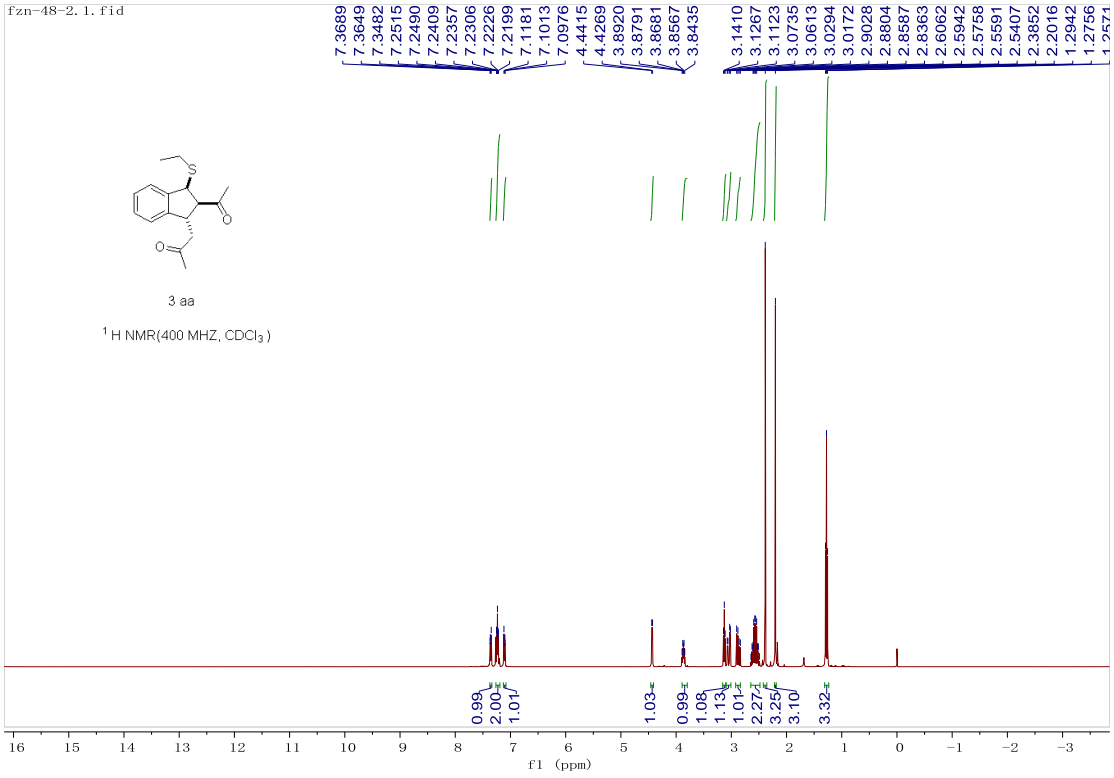

fzh-36-2_1.fid
8.5819
8.3389
8.1182
8.1141
8.0968
8.0924
7.8711
7.8498
7.8306
7.8099
7.7948
7.7750
7.7570
7.7354
7.5692
7.5660
7.5613
7.5585
7.5519
7.5489
7.5446
7.5411
7.5319
7.5285
7.5239
7.5207
7.5081
7.5049
7.4878
7.4850
7.4681
7.4479
7.4305
7.4278
7.4223
7.4157
7.4018
7.3016
7.2933
7.2768
7.2730
7.2638
7.7026
4.6894
4.3752
4.3638
4.3503
3.6939
3.6902
3.6807
3.6755
3.6562
2.6051
2.5865
2.5666
2.5479
1.2342
1.2157
1.1972
3 y
1H NMR(400 MHZ, CDCl3)
1.01
1.01
1.02
7.54
5.55
3.09
0.91
1.88
2.06
2.05
3.19
f1 (ppm)

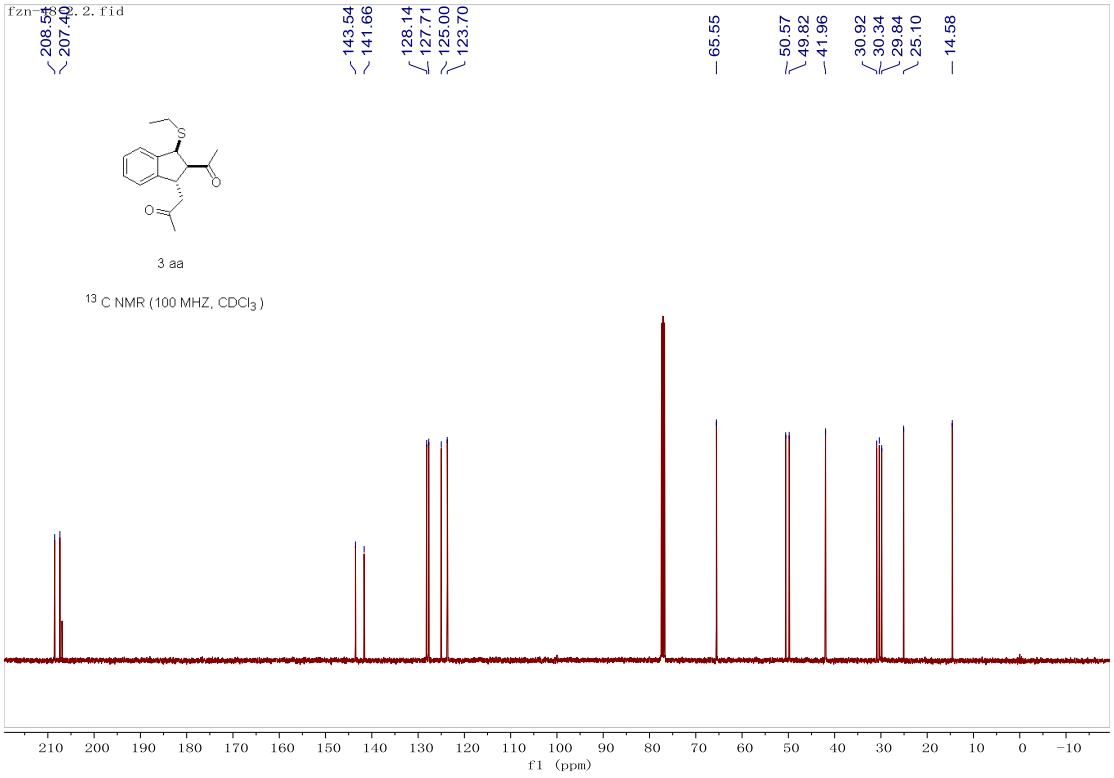

fzn-36-2.esp
200.69
198.33
144.25
142.17
135.67
135.58
134.34
134.11
132.51
132.40
130.61
129.88
129.72
129.57
128.55
128.54
128.52
128.44
128.23
127.72
127.71
127.69
126.77
126.65
124.99
124.48
123.95
123.70
61.19
52.53
44.45
44.31
26.07
14.70
3 y
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

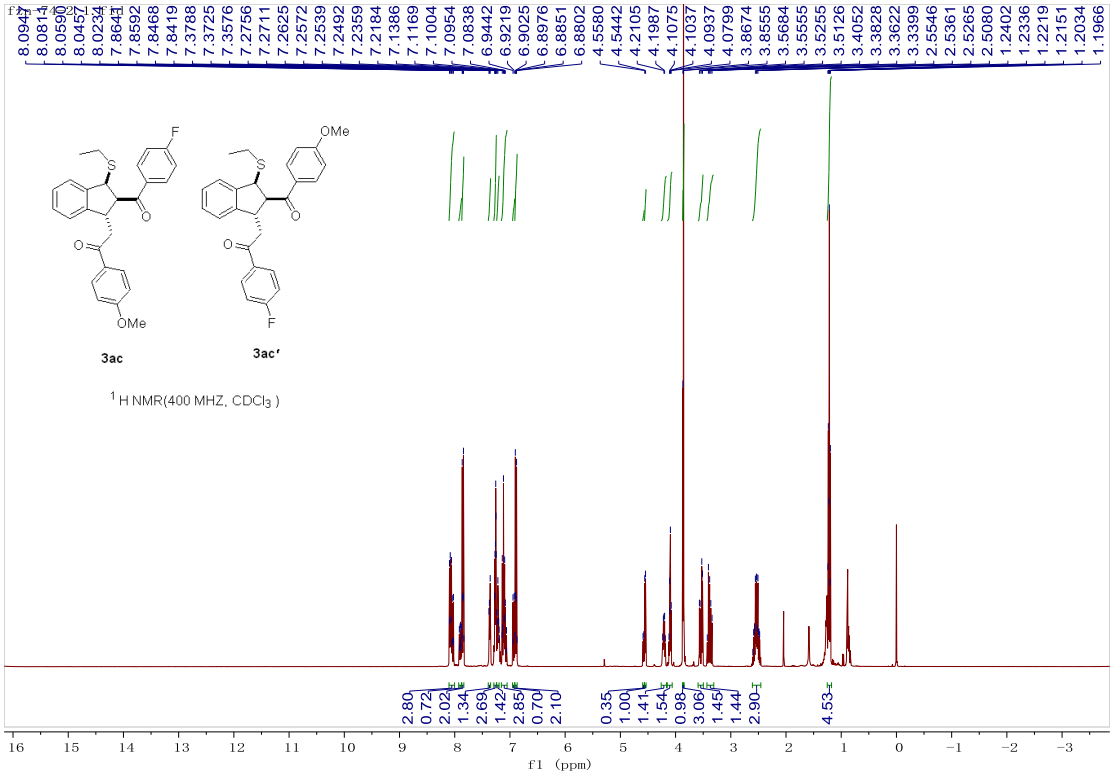

7.861
7.858
7.851
7.848
7.694
7.691
7.685
7.682
7.672
7.669
7.659
7.657
7.623
7.620
7.611
7.608
7.395
7.376
7.272
7.268
7.256
7.253
7.249
7.234
7.231
7.195
7.127
7.118
7.115
7.106
7.097
7.094
7.084
4.644
4.629
4.207
4.125
4.107
4.049
4.034
4.018
3.464
3.449
3.433
3.414
2.590
2.571
2.541
2.523
1.254
1.245
1.226
1.208
1.03
1.07
0.99
1.21
0.99
3.30
2.08
1.05
1.00
1.07
2.07
2.10
3.11
3z
1H NMR (400 MHZ, CDCl3)
f1 (ppm)

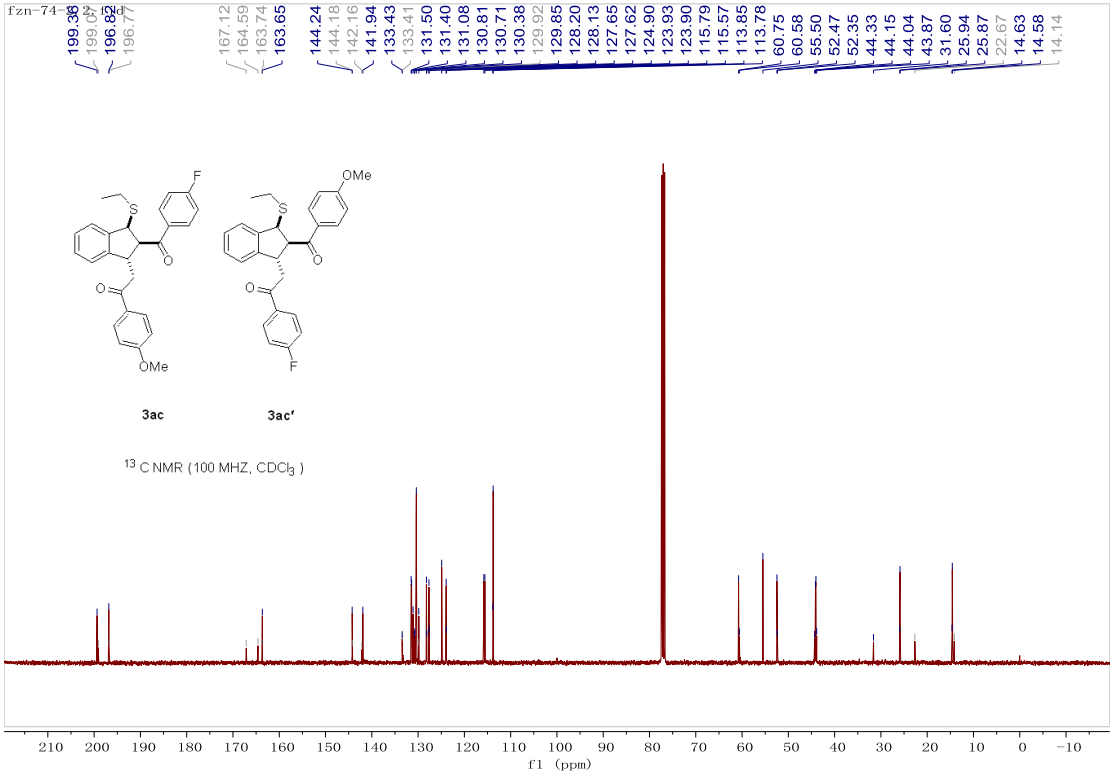

fzn-265b.2.fid
193.322
191.075
144.635
144.204
143.655
141.874
134.732
134.089
132.863
132.244
128.362
128.204
127.747
124.936
123.820
77.400
77.083
76.765
62.436
52.385
44.623
44.303
25.733
14.662
3z
13C NMR (100 MHZ, CDC3l)
f1 (ppm)

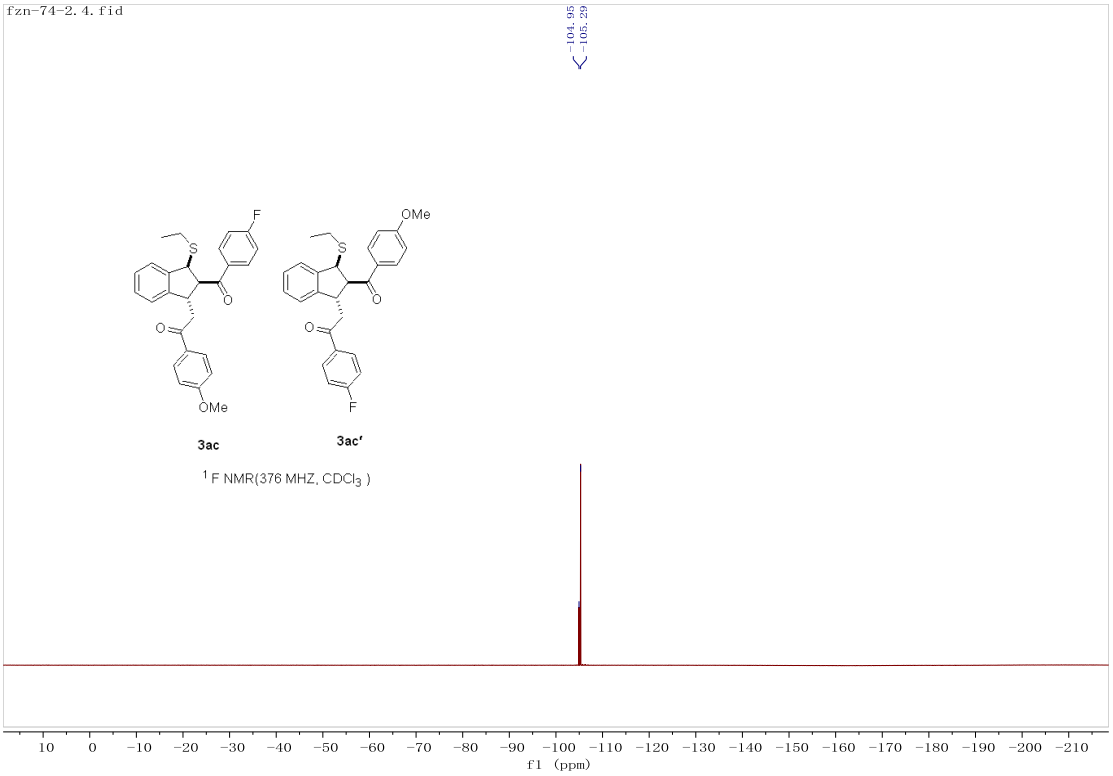

208.54
207.40
143.54
141.66
128.14
127.71
125.00
123.70
65.55
50.57
49.82
41.96
30.92
30.34
29.84
25.10
14.58
3 aa
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

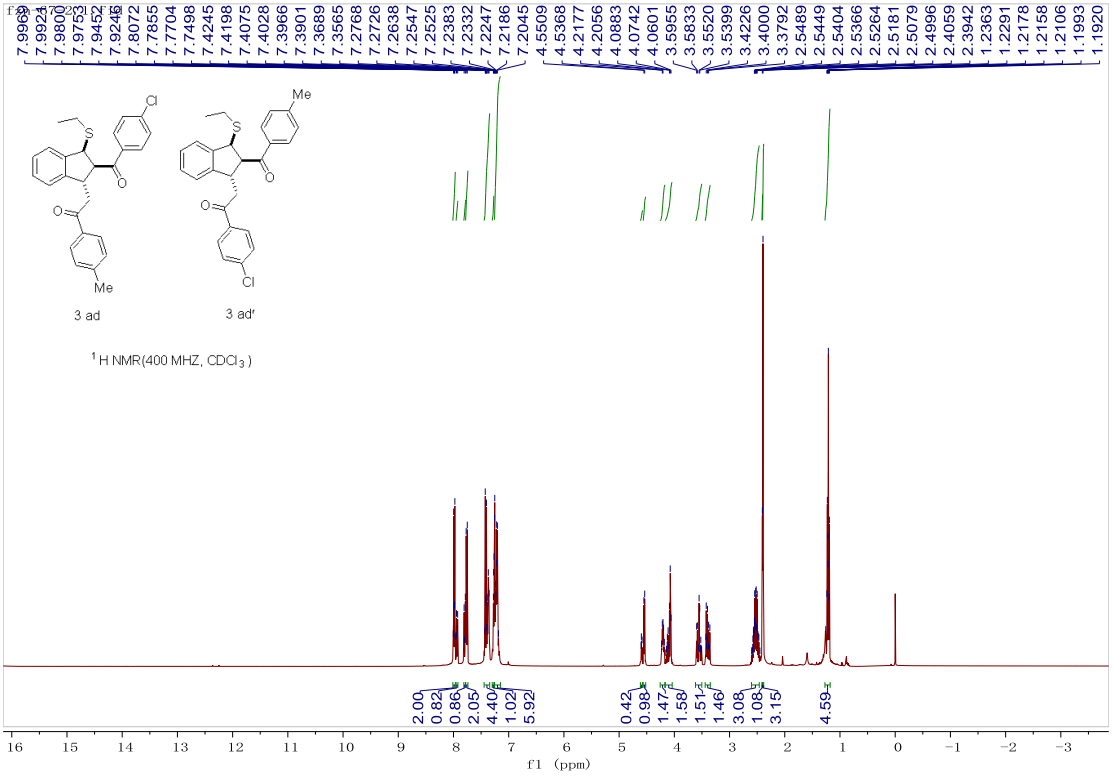

fzn-48-2.1.fid
3 aa
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

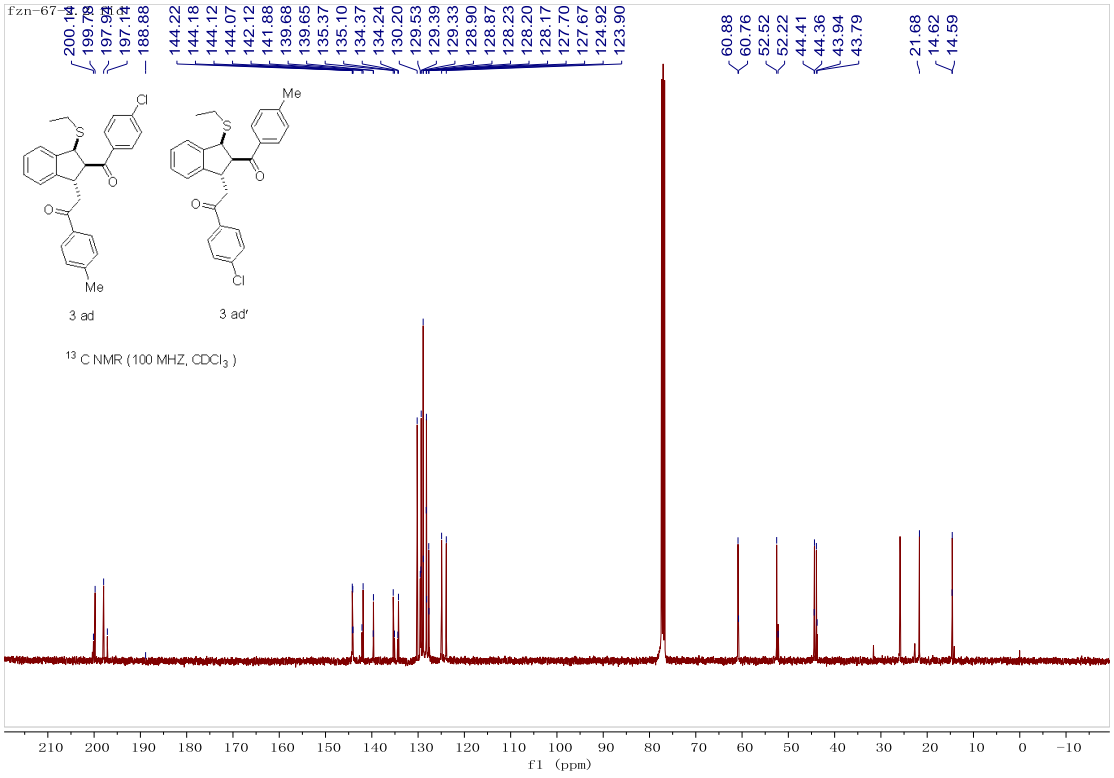

fzn-48-2.2.fid
3 aa
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

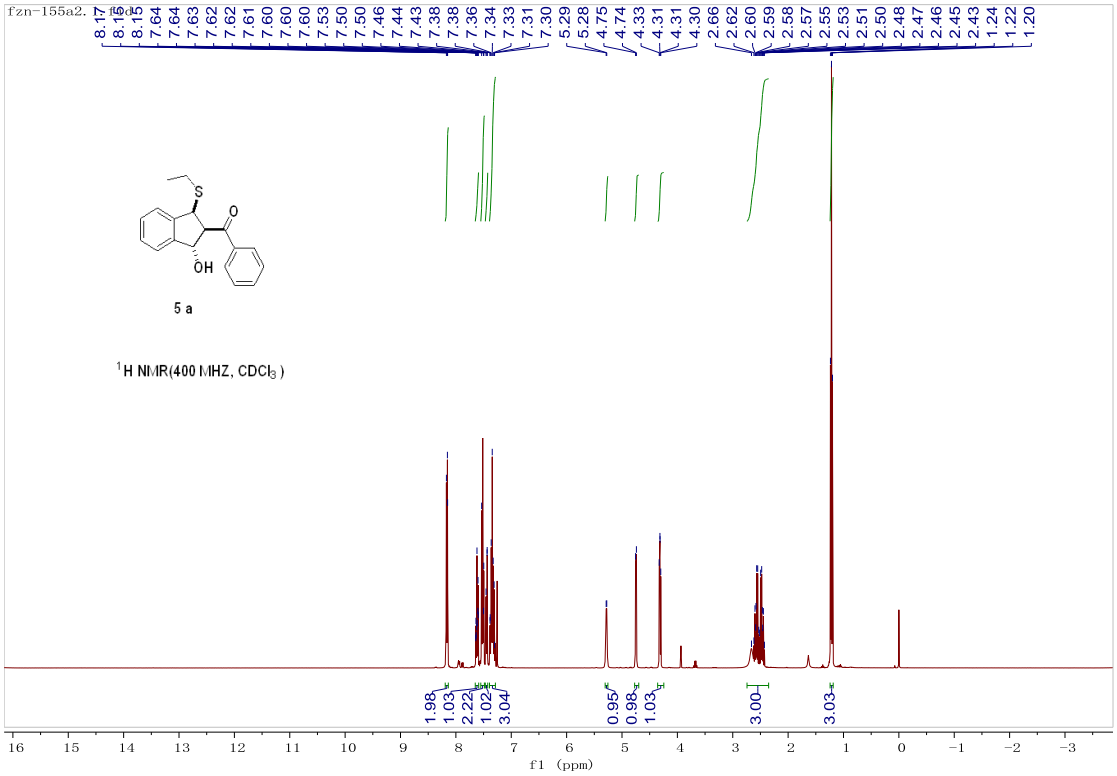

3ac
3ac'
1 H NMR(400 MHZ, CDCl3)
f1 (ppm)

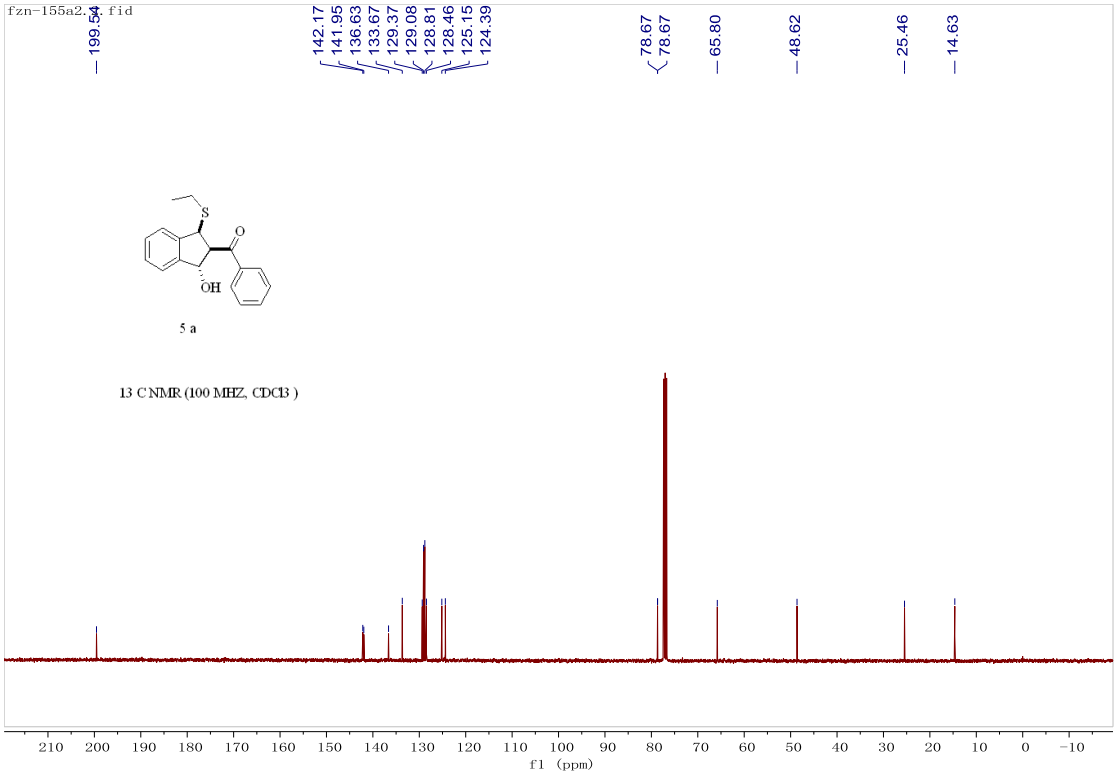

3ac
3ac'
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)

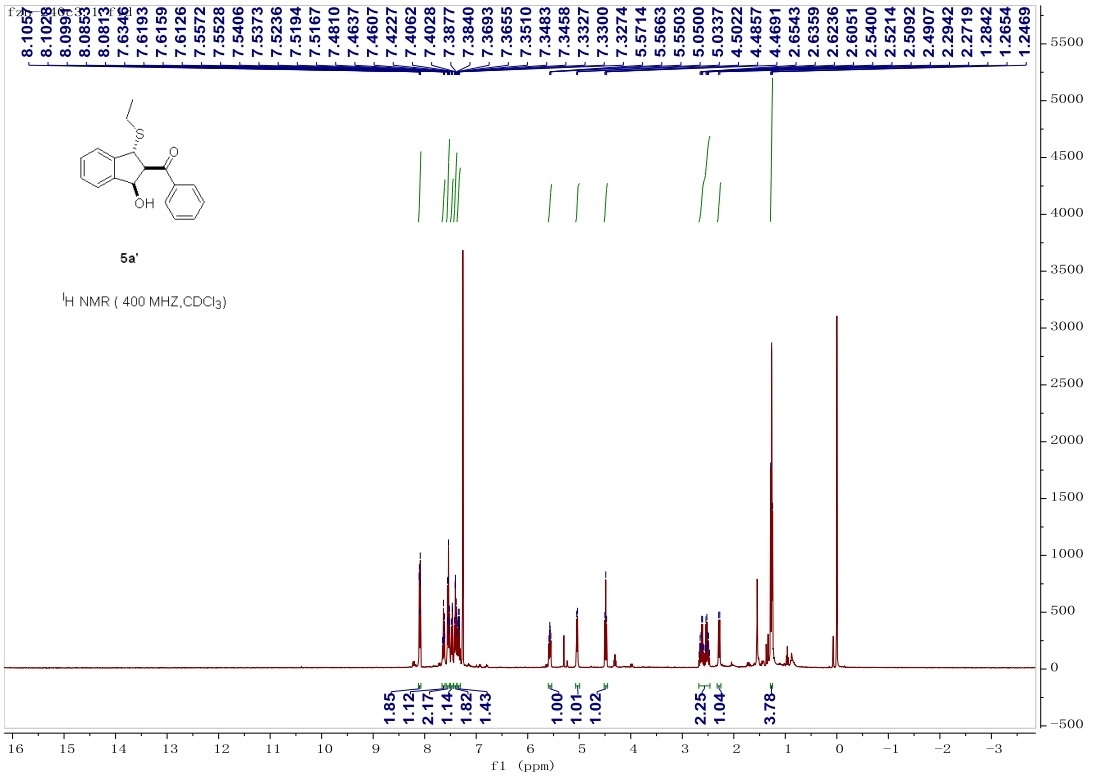

fzn-74-2.4.fid
-104.95
-105.29
F
S
O
O
OMe
OMe
S
O
O
F
3ac
3ac'
^{1}F NMR(376 MHZ, CDCl$_3$)
10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160 −170 −180 −190 −200 −210
f1 (ppm)

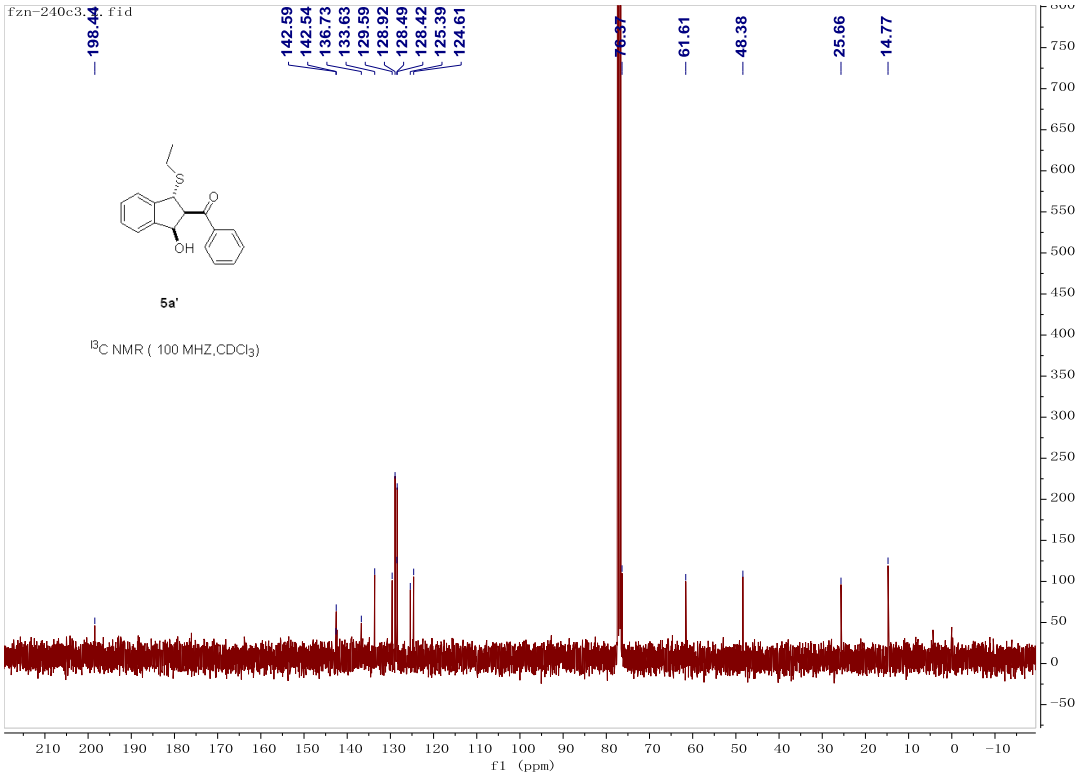

7.9969
7.9924
7.9800
7.9753
7.9452
7.9245
7.8072
7.7855
7.7704
7.7498
7.4245
7.4198
7.4075
7.4028
7.3966
7.3901
7.3689
7.3565
7.2768
7.2726
7.2638
7.2547
7.2525
7.2383
7.2332
7.2247
7.2186
7.2045
4.5509
4.5368
4.2177
4.2056
4.0883
4.0742
4.0601
3.5955
3.5833
3.5520
3.5399
3.4226
3.4000
3.3792
2.5489
2.5449
2.5404
2.5366
2.5264
2.5181
2.5079
2.4996
2.4059
2.3942
1.2363
1.2291
1.2178
1.2158
1.2106
1.1993
1.1920
Cl
S
O
O
Me
Me
S
O
O
Cl
3 ad
3 ad'
^{1}H NMR(400 MHZ, CDCl$_3$)
2.00
0.82
0.86
2.05
4.40
1.02
5.92
0.42
0.98
1.47
1.58
1.51
1.46
3.08
1.08
3.15
4.59
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)

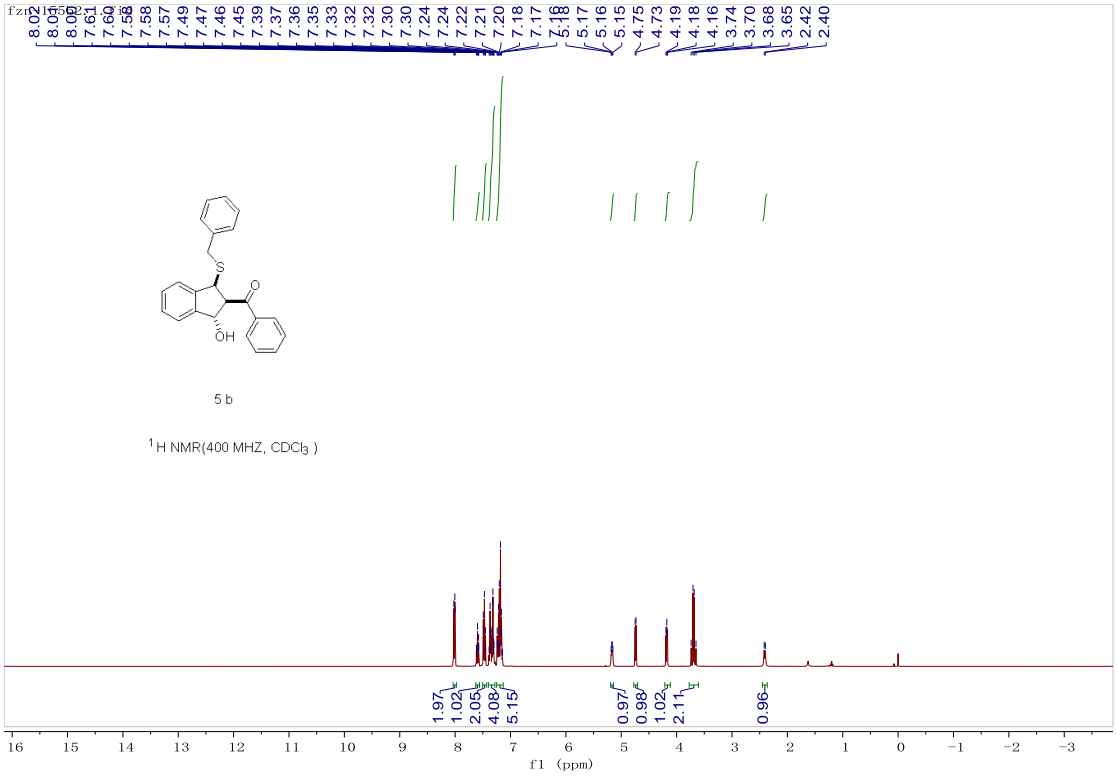

fzn-67-4
200.14
199.79
197.99
197.12
188.88
144.22
144.18
144.12
144.07
142.12
141.88
139.68
139.65
135.37
135.10
134.37
134.24
130.20
129.53
129.39
129.33
128.90
128.87
128.23
128.20
128.17
127.70
127.67
124.92
123.90
60.88
60.76
52.52
52.22
44.41
44.36
43.94
43.79
21.68
14.62
14.59
Cl
S
O
O
Me
3 ad
Me
S
O
O
Cl
3 ad'
13 C NMR (100 MHZ, CDCl3)
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)

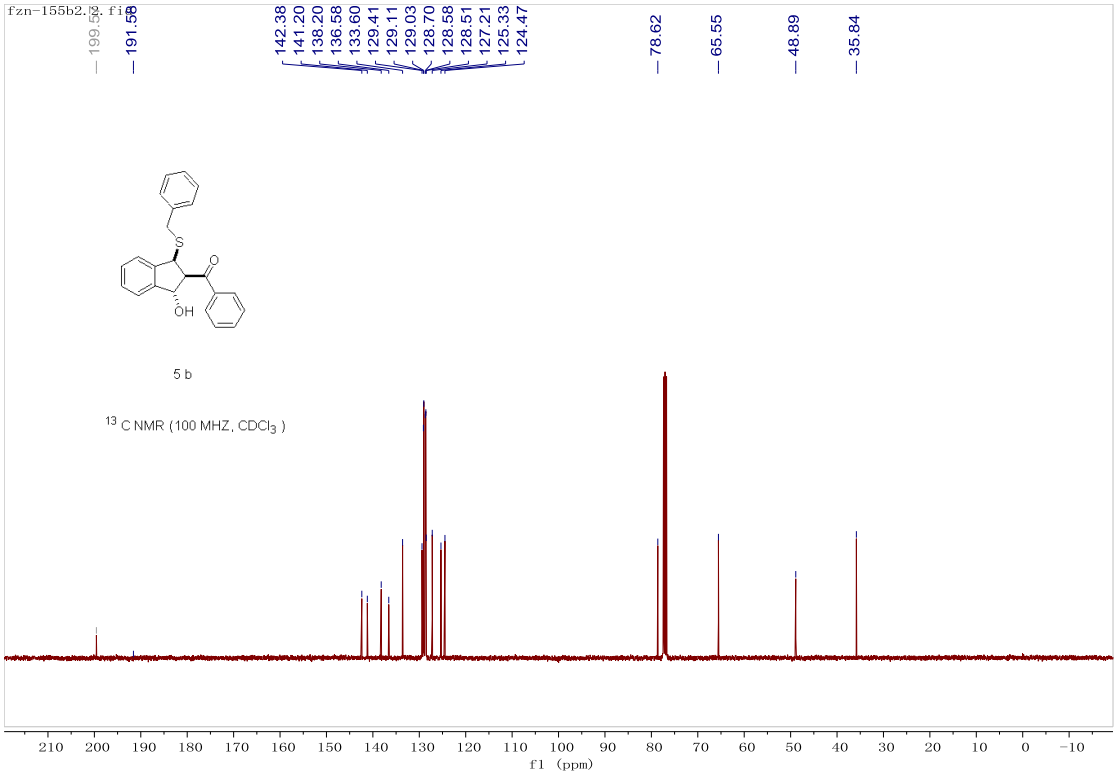

fzn-155a2.
8.17
8.15
7.64
7.64
7.63
7.62
7.62
7.61
7.60
7.60
7.60
7.53
7.50
7.50
7.46
7.44
7.43
7.38
7.38
7.36
7.34
7.33
7.31
7.30
5.29
5.28
4.75
4.74
4.33
4.31
4.31
4.30
2.66
2.62
2.60
2.59
2.58
2.57
2.55
2.53
2.51
2.50
2.48
2.47
2.46
2.45
2.43
1.24
1.22
1.20
S
O
OH
5 a
1H NMR(400 MHZ, CDCl3)
1.98
1.03
2.22
1.02
3.04
0.95
0.98
1.03
3.00
3.03
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2 −3
f1 (ppm)


fzn-155a2.4.fid
199.54
142.17
141.95
136.63
133.67
129.37
129.08
128.81
128.46
125.15
124.39
78.67
78.67
65.80
48.62
25.46
14.63
S
O
OH
5 a
13 C NMR (100 MHZ, CDCl3)
f1 (ppm)


8.1057
8.1028
8.0993
8.0853
8.0813
7.6346
7.6193
7.6159
7.6126
7.5572
7.5528
7.5406
7.5373
7.5236
7.5194
7.5167
7.4810
7.4637
7.4607
7.4227
7.4062
7.4028
7.3877
7.3840
7.3693
7.3655
7.3510
7.3483
7.3458
7.3327
7.3300
7.3274
5.5714
5.5663
5.5503
5.0500
5.0337
4.5022
4.4857
4.4691
2.6543
2.6359
2.6236
2.6051
2.5400
2.5214
2.5092
2.4907
2.2942
2.2719
1.2842
1.2654
1.2469
S
O
OH
5a'
1H NMR (400 MHZ,CDCl3)
1.85
1.12
2.17
1.14
1.82
1.43
1.00
1.01
1.02
2.25
1.04
3.78
f1 (ppm)


fzn-240c3.1.fid
198.44
142.59
142.54
136.73
133.63
129.59
128.92
128.49
128.42
125.39
124.61
76.97
61.61
48.38
25.66
14.77
5a'
13C NMR (100 MHZ,CDCl3)
f1 (ppm)


8.02
8.01
8.00
7.61
7.60
7.58
7.57
7.49
7.47
7.46
7.45
7.39
7.37
7.36
7.35
7.33
7.32
7.32
7.30
7.30
7.24
7.24
7.22
7.21
7.20
7.18
7.17
5.17
5.16
5.15
4.75
4.73
4.19
4.18
4.16
3.74
3.70
3.68
3.65
2.42
2.40
1.97
1.02
2.05
4.08
5.15
0.97
0.98
1.02
2.11
0.96
5 b
1H NMR(400 MHZ, CDCl3)
f1 (ppm)


fzn-155b2.3.fid
199.52
191.58
142.38
141.20
138.20
136.58
133.60
129.41
129.11
129.03
128.70
128.58
128.51
127.21
125.33
124.47
78.62
65.55
48.89
35.84
S
O
OH
5 b
13 C NMR (100 MHZ, CDCl3)
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)