Enantioselective construction of dispirotriheterocycles featuring a 4-aminopyrazolone motif through a cascade Michael/cyclization process

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Content

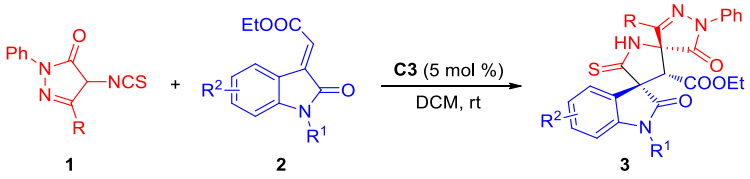
General information

Unless otherwise noted, materials were purchased from commercial suppliers and used without further purification. Column chromatography was performed on silica gel (200~300 mesh). Enantiomeric excesses (ee) were determined by HPLC using corresponding commercial chiral columns as stated at 30 °C with UV detector at 254 nm. Optical rotations were reported as follows: $[\alpha]^{T}_{D}$ (c g/100 mL, solvent). All ^{1}H NMR and ^{19}F NMR spectra were recorded on a Bruker Avance Ⅱ 400 MHz and Bruker Avance Ⅲ 471 MHz respectively, ^{13}C NMR spectra were recorded on a Bruker Avance Ⅱ 101 MHz or Bruker Avance Ⅲ 126 MHz with chemical shifts reported as ppm (in $CDCl_3$, TMS as internal standard). Data for ^{1}H NMR are recorded as follows: chemical shift (δ, ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet, br = broad singlet, dd = double doublet, coupling constants in Hz, integration). HRMS (ESI) was obtained with a HRMS/MS instrument (LTQ Orbitrap XL TM). The absolute configuration of **5** was assigned by the X-ray analysis.

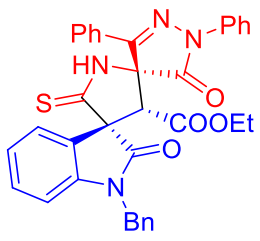
4-Isothiocyanato pyrazolones[1] and 3-ylideneoxindoles[2] were prepared according to the literature procedures. The racemic products were synthesized using quinine/quinidine = 1:1 as catalyst.

Experimental procedures and characterization of products 3aa-3ag and 4-7

General procedure: synthesis of compound 3aa-3ag



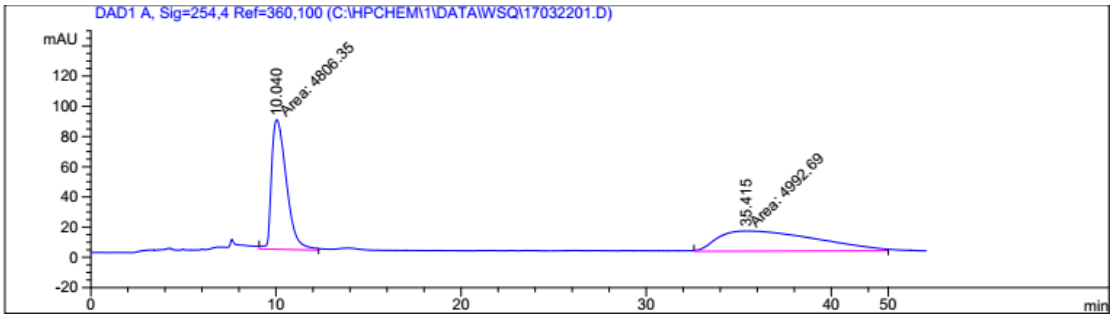
To a Schlenk tube equipped with a magnetic stir bar was charged with compound **1** (0.2 mmol) and **C3** (5 mmol %), followed with DCM (2 mL). Compound **2** (0.24 mmol) was then added in one portion. The reaction mixture was stirred at room temperature. When compound **1** was consumed as checked by TLC, the reaction was stopped and purified by column chromatography on silica gel directly to give the product **3.**



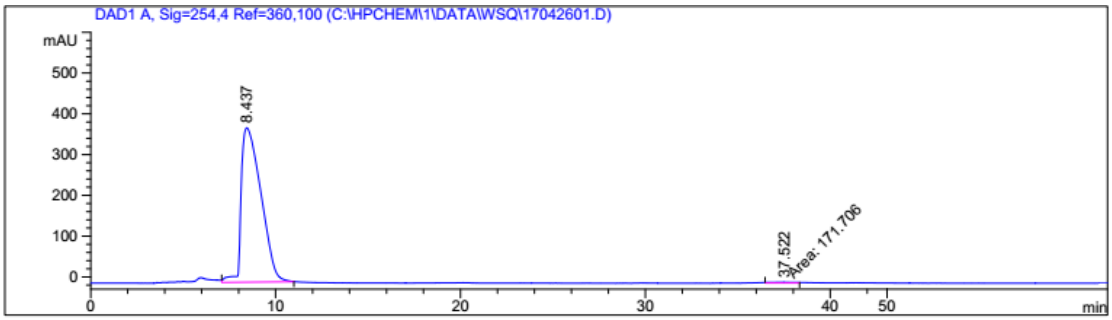
3aa

Prepared according to the general procedure within 7 h as white solid (104.4 mg, 89% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]^{19}_{D}$ = 97.7 (*c* 0.79, CH_2Cl_2); Mp 150.1-153 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.13 (s, 1H), 8.06 (d, *J* = 7.9 Hz, 2H), 7.82 (d, *J* = 6.9 Hz, 2H), 7.63-7.54 (m, 3H), 7.44 (t, *J* = 7.9 Hz, 2H), 7.41-7.36 (m, 2H), 7.30-7.24 (m, 4H), 7.05 (t, *J* = 7.7 Hz, 1H), 6.66 (d, *J* = 7.8 Hz, 1H), 6.47 (t, *J* = 7.6 Hz, 1H), 5.22 (d, *J* = 7.6 Hz, 1H), 5.05 (s, 1H), 4.99 (d, *J* = 16.0 Hz, 1H), 4.92 (d, *J* = 16.0 Hz, 1H), 3.75-3.67 (m, 1H), 3.57-3.49 (m, 1H),

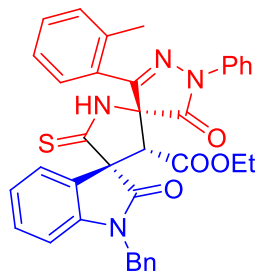
0.38 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.0 , 174.6 , 168.9 , 165.1 , 143.8 , 137.5 , 135.2 , 131.3 , 130.5 , 129.9 , 129.3 , 129.20 , 129.1 , 128.6 , 127.7 , 127.6 , 127.5 , 125.9 , 123.7 , 122.7 , 119.2, 109.5 , 73.9 , 68.2 , 61.4 , 58.4 , 44.7 , 12.9 ; HRMS (ESI) m/z Calcd for $C_{35}H_{29}N_4O_4S^+$ ([M+H]$^+$) 601.1904, Found 601.1901; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 8.4 min, t_{minor} = 37.5 min).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.040	MM	0.9337	4806.35059	85.79714	49.0492
2	35.415	MM	6.1768	4992.68652	13.47171	50.9508



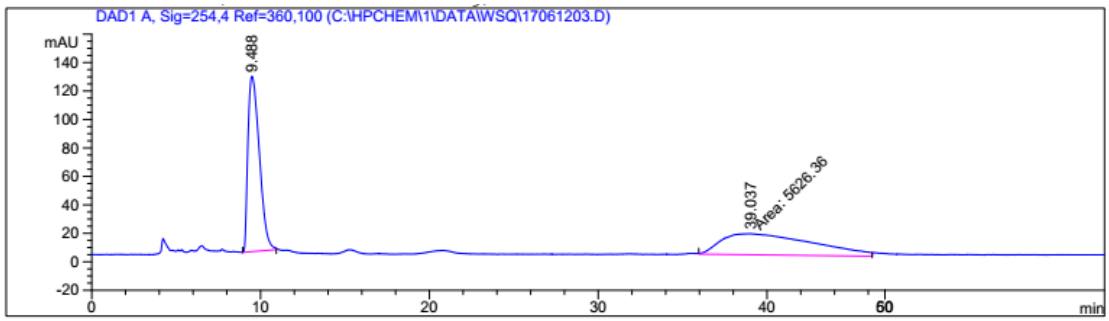
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.437	BB	0.9987	2.81896e4	378.57837	99.3946
2	37.522	MM	1.6306	171.70578	1.75504	0.6054



3ba

Prepared according to the general procedure within 7 h as white solid (105.6 mg, 86% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 92.6 (*c* 0.43, CH_2Cl_2); Mp 160.1-162.9 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.81 (s, 1H), 8.04 (dd, *J* = 8.7, 1.2 Hz, 2H), 7.55 (d, *J* = 7.7 Hz, 1H), 7.50-7.45 (m, 4H), 7.40 (d, *J* = 6.7 Hz, 2H), 7.30-7.25 (m, 5H), 7.04 (td, *J* = 7.8, 1.1 Hz, 1H), 6.65 (d, *J* = 7.9 Hz, 1H), 6.43 (td, *J* = 7.6, 1.0 Hz, 1H), 5.12 (s, 1H), 5.07 (dd, *J* = 7.7, 1.1 Hz, 1H), 4.99 (d, *J* = 8.0 Hz, 1H), 4.96 (d, *J* = 12.0 Hz, 1H), 3.86-3.78 (m, 1H), 3.60-3.47 (m, 1H), 2.67 (s, 3H), 0.43 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.9, 168.3, 143.8, 139.2, 137.5, 135.2, 132.1, 130.7, 130.4, 129.1, 128.6, 127.7, 127.6, 127.5, 126.5, 125.9, 123.6, 122.7, 119.1, 109.4, 67.6, 61.4, 58.4, 44.7, 20.5, 13.0; HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_4S^+$ ([M+H]$^+$) 615.2061, Found 615.2060; Enantiomeric excess was determined to be 98%

(determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 9.0 min, t_{minor} = 40.8 min)



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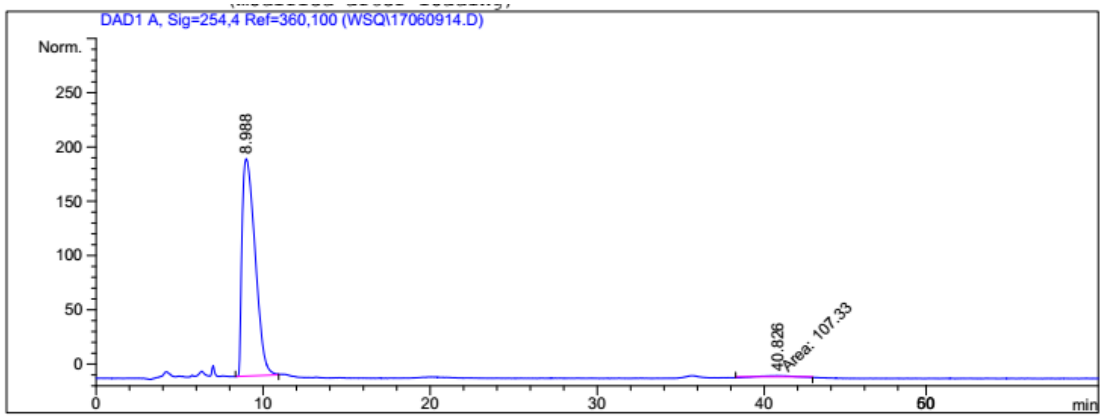
1	9.488	PB	0.6855	5784.91992	123.27118	50.6947
2	39.037	MM	6.3312	5626.36475	14.81122	49.3053



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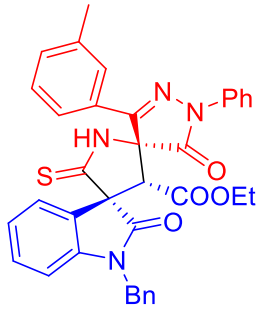
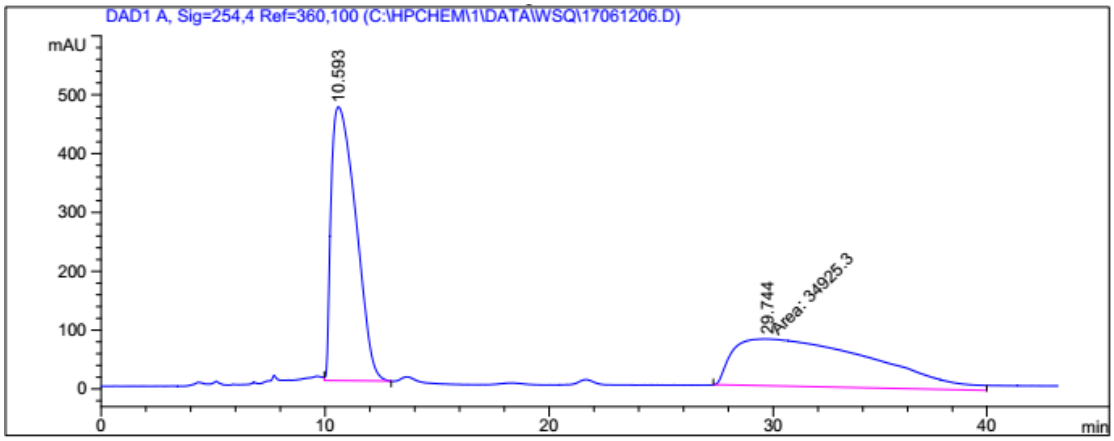
1	8.988	PB	0.9032	1.09070e4	200.31203	99.0255
2	40.826	MM	1.6750	107.33015	1.06794	0.9745



3ca

Prepared according to the general procedure within 7 h as white solid (110.5 mg, 90% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 70.2 (*c* 0.64, CH_2Cl_2); CH_2Cl_2); Mp 146.5-148.0 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.85 (s, 1H), 8.06 (d, *J* = 8.1 Hz, 2H), 7.61 (d, *J* = 7.2 Hz, 2H), 7.46-7.38 (m 6H), 7.31-7.24 (m, 4H), 7.06 (t, *J* = 7.7 Hz, 1H), 6.66 (d, *J* = 7.8 Hz, 1H), 6.48 (t, *J* = 7.6 Hz, 1H), 5.29 (d, *J* = 7.6 Hz, 1H), 5.05 (s, 1H), 4.96 (s, 2H), 3.77-3.65 (m, 1H), 3.57-3.49 (m, 1H), 2.41 (s, 3H), 0.39 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.1, 168.9, 165.1, 158.0, 143.9, 139.0, 137.6, 135.2, 131.2, 131.1, 130.3, 129.2, 129.2, 129.1, 128.6, 127.6, 127.5, 126.9, 125.9, 123.7, 122.6, 119.1, 109.5, 61.4, 58.3, 44.7, 21.5, 13.0; HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_4S^+$ ([M+H]$^+$) 615.2061, Found 615.2061; Enantiomeric excess was determined to be 99% (determined by

HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 9.4 min, t_{minor} = 35.8 min)



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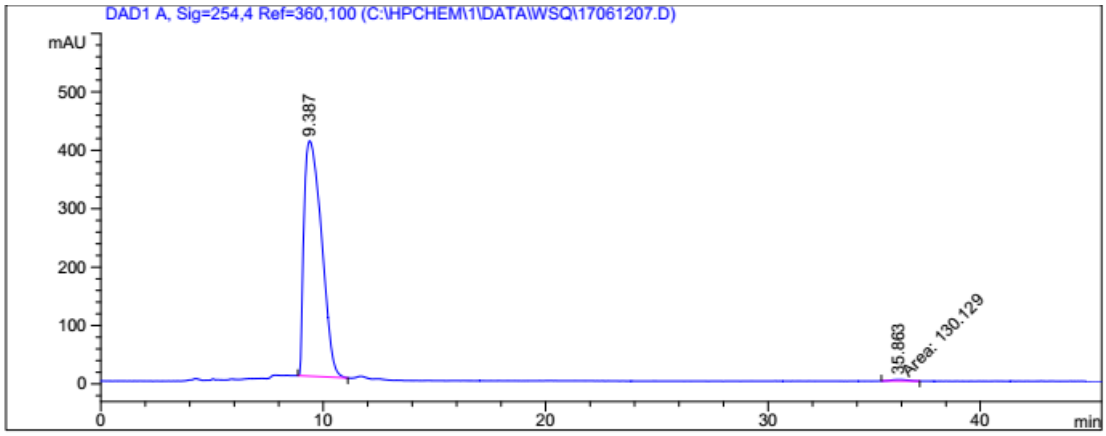
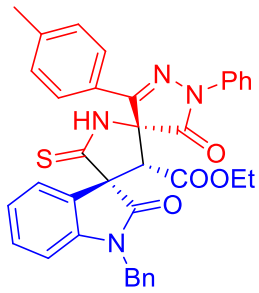
1	10.594	MM	1.2711	3.53410e4	463.37820	50.4437
2	29.582	MM	7.0395	3.47193e4	82.20084	49.5563



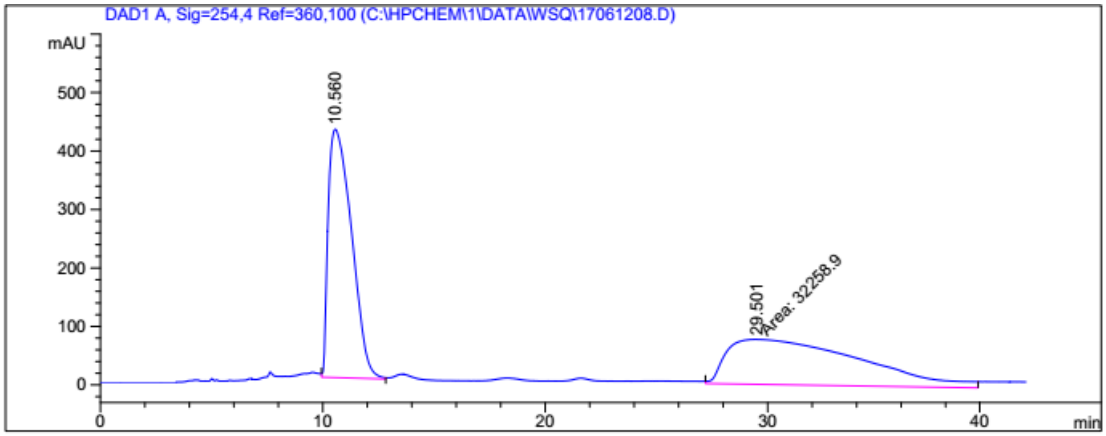
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.387	BB	0.8639	2.20894e4	402.76300	99.4143
2	35.863	MM	0.8972	130.12935	2.41743	0.5857



3da

Prepared according to the general procedure within 7 h as white solid (106.8 mg, 87% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 70.2 (*c* 0.64, CH_2Cl_2); Mp 146.5-148.0 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.90 (s, 1H), 8.06 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.47-7.35 (m, 6H), 7.29-7.23 (m, 4H), 7.06 (td, *J* = 7.8, 1.2 Hz, 1H), 6.66 (d, *J* = 7.8 Hz, 1H), 6.47 (td, *J* = 7.6, 1.0 Hz, 1H), 5.23 (dd, *J* = 7.8, 1.1 Hz, 1H), 5.05 (s, 1H), 5.00 (d, *J* = 16.0 Hz, 1H), 4.94 (d, *J* = 16.0 Hz, 1H), 3.75-3.65 (m, 1H), 3.57-3.49 (m, 1H), 2.48 (s, 3H), 0.38 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.0 , 168.9 , 165.1 , 143.9 , 140.9 , 137.6, 135.2, 129.9, 129.8, 129.2, 129.0, 128.6, 128.3, 127.6, 127.5, 125.8, 123.8, 122.5, 119.1, 109.5, 73.8, 68.1, 61.3, 58.3, 44.7, 21.5, 13.0; HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_4S^+$ ([M+H]$^+$) 615.2061, Found 615.2059; Enantiomeric excess was determined to be

99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 10.8 min, t_{minor} = 34.5 min).



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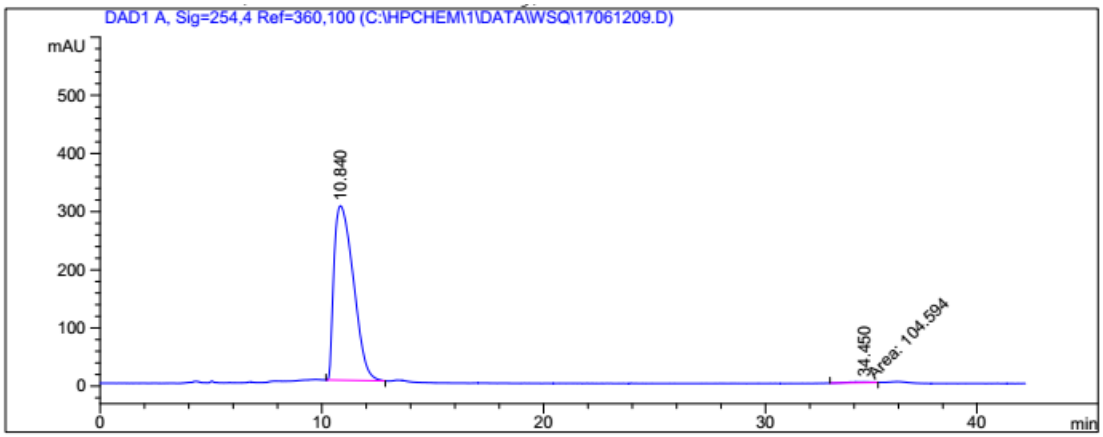
2	29.501	MM	6.8562	2.97880e4	72.41100	49.7044



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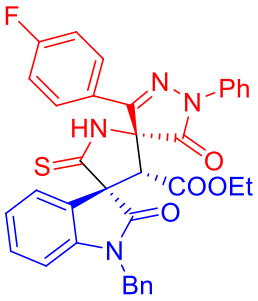
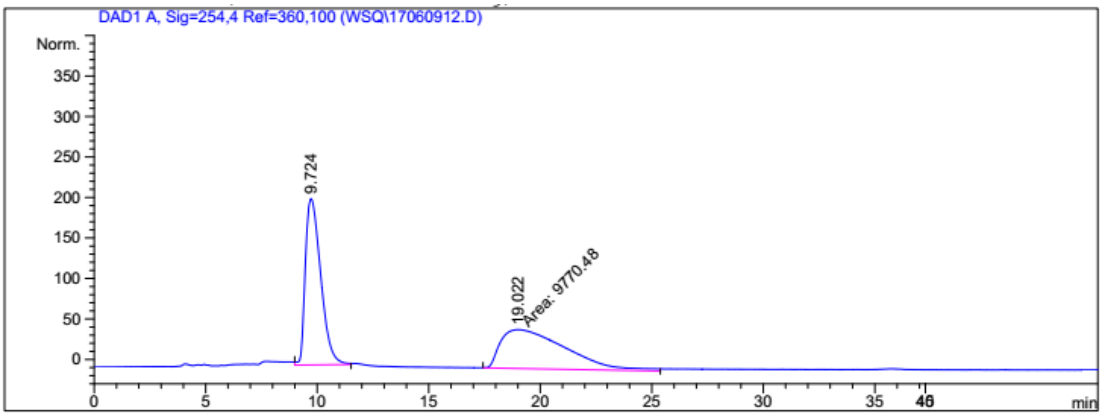
1	10.840	PB	0.9270	1.82658e4	299.72717	99.4306
2	34.450	MM	1.3645	104.59440	1.27757	0.5694



3ea

Prepared according to the general procedure within 5 h as white solid (107.5 mg, 87% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 73.4 (*c* 1.36, CH_2Cl_2); Mp 150.1-153.7 °C;^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.36 (s, 1H), 8.00 (d, *J* = 7.8 Hz, 2H), 7.87-7.80 (m, 2H), 7.44-7.35 (m, 4H), 7.30-7.22 (m, 6H), 7.09 (td, *J* = 7.8, 1.2 Hz, 1H), 6.68 (d, *J* = 7.8 Hz, 1H), 6.56 (d, *J* = 7.6 Hz, 1H), 5.35 (dd, *J* = 7.8, 1.1 Hz, 1H), 5.05 (s, 1H), 4.98 (d, *J* = 16.0 Hz, 1H), 4.91 (d, *J* = 16.0 Hz, 1H) 3.72-3.64 (, 1H), 3.55-3.47 (m, 1H), 0.36 (t, *J* = 7.2 Hz, 3H); ^{19}F NMR (470 MHz, Chloroform-*d*) δ -109.09 (m).^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.8, 169.1, 165.2, 164.1 (d, *J* = 253.5 Hz), 157.2, 143.9, 135.1, 132.2 (d, *J* = 9.0 Hz), 129.4, 129.0, 128.6, 127.8, 127.7, 127.5, 125.9, 123.4, 122.7, 119.2, 116.3 (d, *J* = 21.2

Hz), 109.7, 73.8, 68.3, 61.4, 58.4, 44.7, 13.0; HRMS (ESI) m/z Calcd. for $C_{35}H_{28}FN_4O_4S^+$ ($[M+H]^+$) 619.1810, Found 619.1810; Enantiomeric excess was determined to be 96% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 15.3 min, t_{minor} = 66.9 min)



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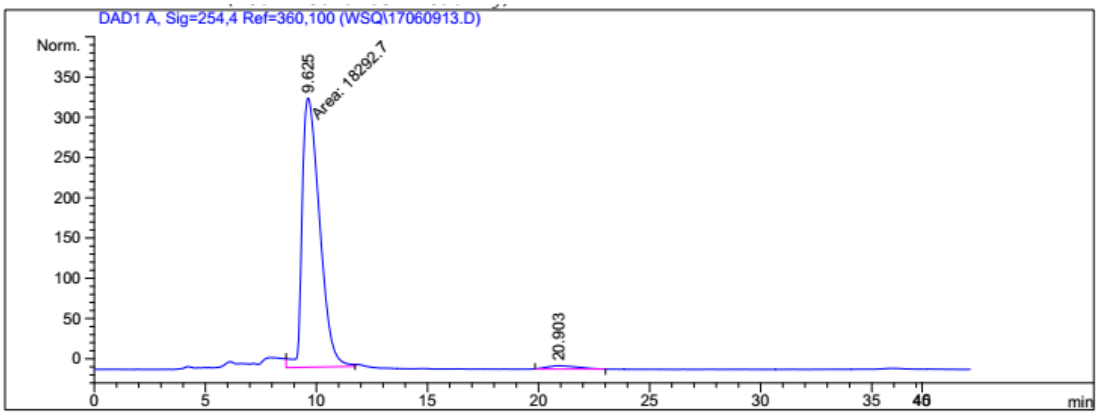
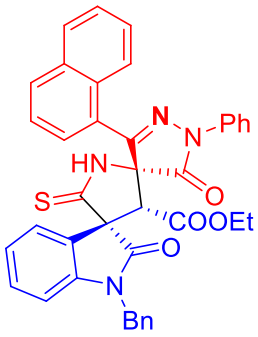
2	19.022	MM	3.3859	9770.48145	48.09373	49.7963



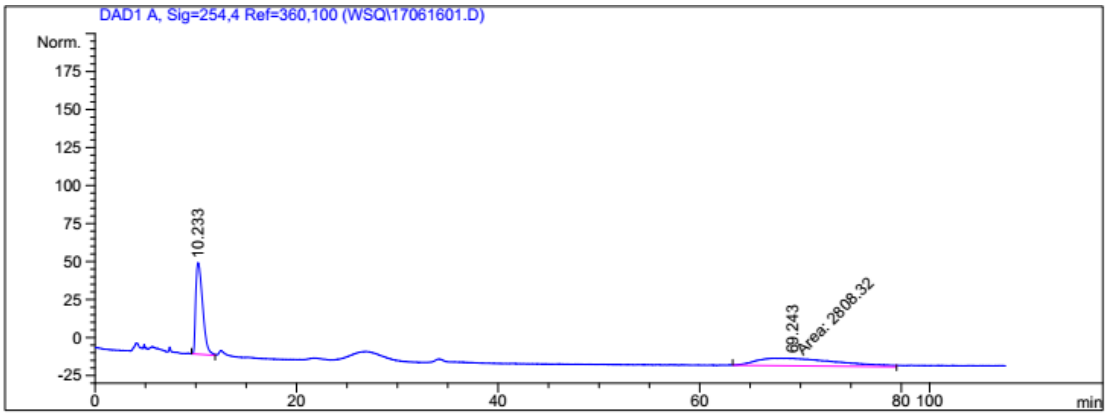
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.625	MM	0.9115	1.82927e4	334.47070	97.7859
2	20.903	BB	1.1706	414.19626	4.21462	2.2141



3fa

Prepared according to the general procedure within 18 h as white solid (110.5 mg, 85% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 50.6 (*c* 0.36, CH_2Cl_2); Mp 163.5-164.7 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.97 (s, 1H), 8.61 (d, *J* = 8.3 Hz, 1H), 8.06 (d, *J* = 8.2 Hz, 3H), 7.95 (d, *J* = 7.8 Hz, 1H), 7.77 (d, *J* = 7.2 Hz, 1H), 7.63-7.50 (m, 3H), 7.44 (t, *J* = 7.8 Hz, 2H), 7.34 (d, *J* = 7.0 Hz, 2H), 7.28-7.20 (m, 4H), 6.92 (t, *J* = 7.7 Hz, 1H), 6.56 (d, *J* = 7.8 Hz, 1H), 6.19 (t, *J* = 7.7 Hz, 1H), 5.14 (s, 1H), 4.92 (s, 2H), 4.81 (d, *J* = 7.7 Hz, 1H), 3.69-3.61 (m, 1H), 3.51-3.40 (m, 1H), 0.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.2, 168.5, 165.1, 143.7, 137.5, 135.1,

134.2, 131.6, 131.1, 129.1, 128.9, 128.9, 128.6, 128.3, 127.8, 127.7, 127.6, 127.4, 127.3, 126.9, 126.6, 126.0, 125.2, 123.5, 122.4, 119.2, 109.4, 67.6, 61.4, 58.5, 44.7, 12.9; HRMS (ESI) m/z Calcd. for $C_{39}H_{31}N_4O_4S^+$ ([M+H]$^+$) 651.2061, Found 651.2060; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 9.9 min, t_{minor} = 69.9 min).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
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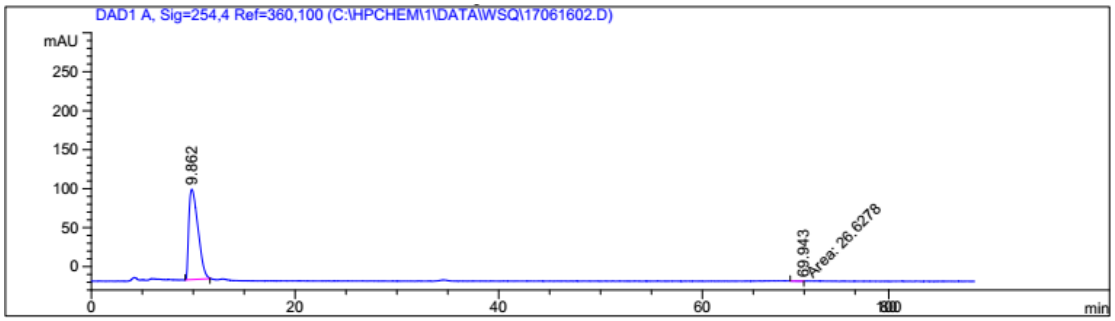
2	69.243	MM	9.3852	2808.32495	4.98717	49.3816



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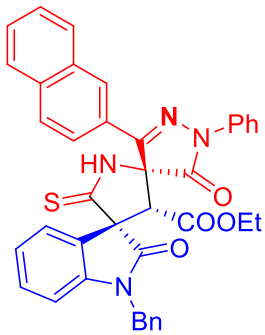
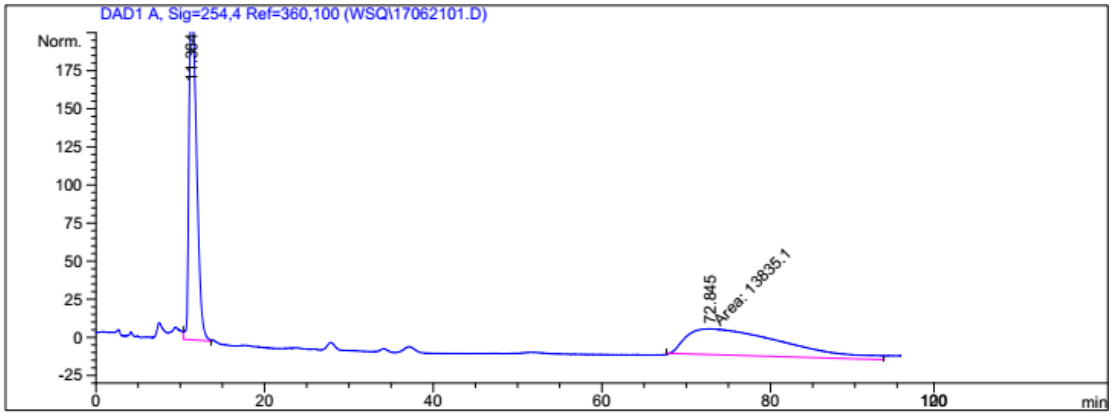
1	9.862	BB	0.8759	7265.90674	115.82347	99.6349
2	69.943	MM	0.8497	26.62778	5.22281e-1	0.3651



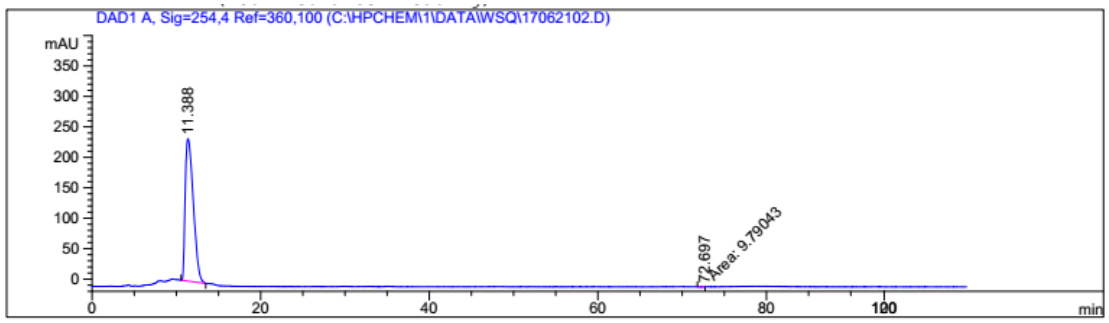
3ga

Prepared according to the general procedure within 7 h as white solid (113.1 mg, 87% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 61.0 (*c* 0.73, CH_2Cl_2); Mp 150.1-153.1 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (s, 1H), 8.26 (s, 1H), 8.12 (d, *J* = 8.1 Hz, 2H), 8.01 (q, *J* = 8.6 Hz, 2H), 7.90 (dd, *J* = 20.0, 8.2 Hz, 2H), 7.60 (t, *J* = 7.5 Hz, 1H), 7.50-7.44 (m, 3H), 7.41-7.33 (m, 2H), 7.28-7.21 (m, 4H), 6.91 (t, *J* = 7.7 Hz, 1H), 6.60 (d, *J* = 7.8 Hz, 1H), 5.98 (t, *J* = 7.6 Hz, 1H), 5.35 (d, *J* = 7.7 Hz, 1H), 5.10 (s, 1H), 4.94 (s, 2H), 3.69-3.58 (m, 1H), 3.57-3.45 (m, 1H), 0.34 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.1, 174.7, 169.0, 165.2, 157.6, 143.8, 137.6, 135.1, 133.9, 129.4, 129.1, 129.1, 129.0, 128.7, 128.6, 127.7, 127.6, 127.6, 127.5, 127.0, 126.2, 125.9, 123.7, 122.4, 119.2, 109.5, 73.8, 68.3, 61.3, 58.5, 44.7, 12.9; HRMS (ESI)

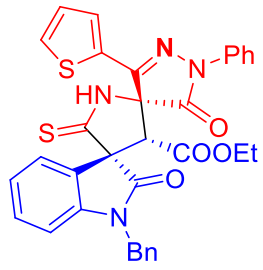
m/z Calcd. for $C_{39}H_{31}N_4O_4S^+$ ([M+H]$^+$) 651.2061, Found 651.2058; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 11.4 min, t_{minor} = 72.7 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.364	VB	0.9819	1.38567e4	221.49254	50.0390
2	72.845	MM	13.5739	1.38351e4	16.98738	49.9610

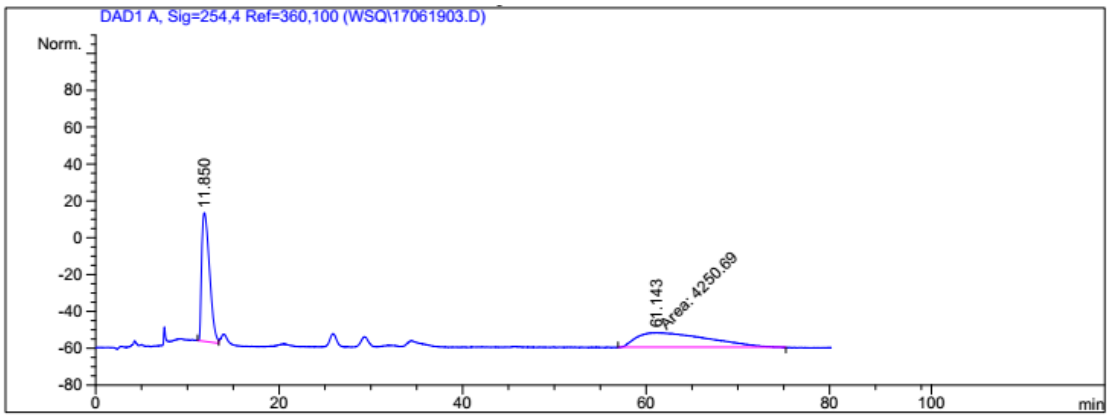


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.388	BB	0.9503	1.56004e4	233.84885	99.9373
2	72.697	MM	0.3188	9.79043	5.11898e-1	0.0627

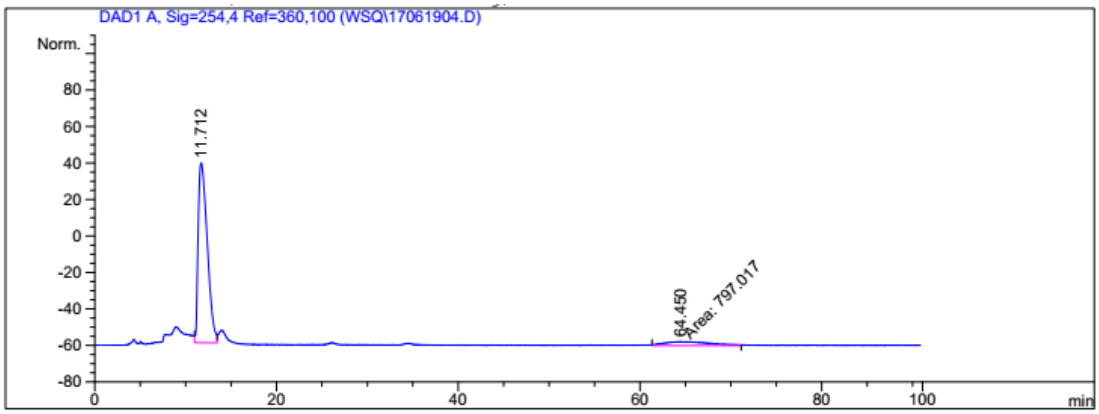


3ha

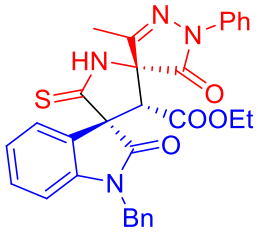
Prepared according to the general procedure within 15 h as white solid (93.2 mg, 77% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 68.8 (*c* 0.32, CH_2Cl_2); Mp 146.1-148.7 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.74 (s, 1H), 8.03 (d, *J* = 8.0 Hz, 2H), 7.62 (d, *J* = 5.1 Hz, 1H), 7.55 (d, *J* = 3.7 Hz, 1H), 7.46-7.39 (m, 4H), 7.31-7.24 (m, 4H), 7.20 (t, *J* = 4.4 Hz, 1H), 7.11 (t, *J* = 7.8 Hz, 1H), 6.79-6.57 (m, 2H), 5.80 (d, *J* = 7.6 Hz, 1H), 5.02 (d, *J* = 12.0 Hz, 1H), 4.99 (s, 1H), 4.95 (d, *J* = 12.0 Hz, 1H), 3.73-3.48 (m, 2H), 0.40 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.1, 165.0, 153.4, 144.0, 137.4, 135.1, 130.5, 129.5, 129.0, 128.6, 127.89, 127.9, 127.5, 125.9 , 124.0, 122.7, 119.1, 109.7, 73.5, 68.3, 61.5, 58.8, 44.7, 13.0; HRMS (ESI) m/z Calcd. for $C_{33}H_{27}N_4O_4S^+$ ([M+H]$^+$) 607.1468, Found 607.1464; Enantiomeric excess was determined to be 79% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 11.7 min, t_{minor} = 64.4 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.850	BV	0.9290	4171.83545	69.82580	49.5319
2	61.143	MM	8.9578	4250.69287	7.90870	50.4681

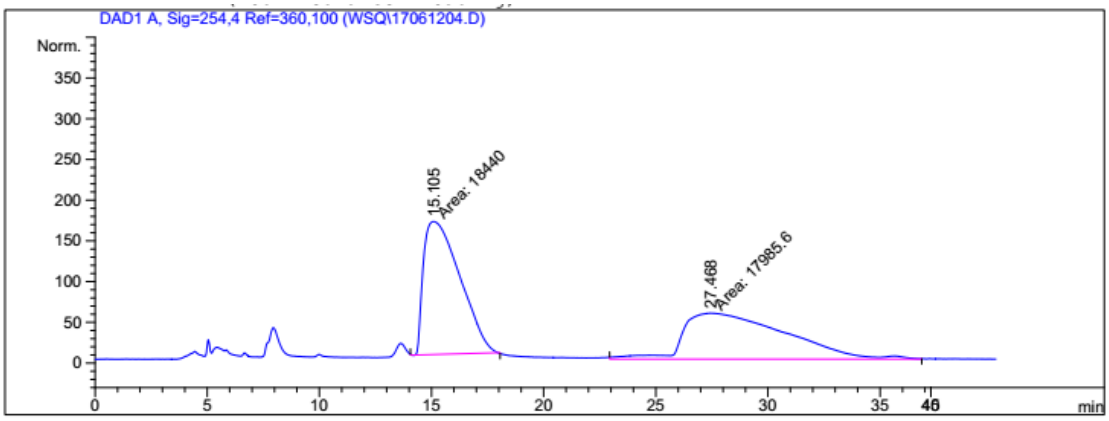


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.712	VV	1.0677	6860.05957	98.59518	89.5911
2	64.450	MM	5.7894	797.01672	2.29449	10.4089

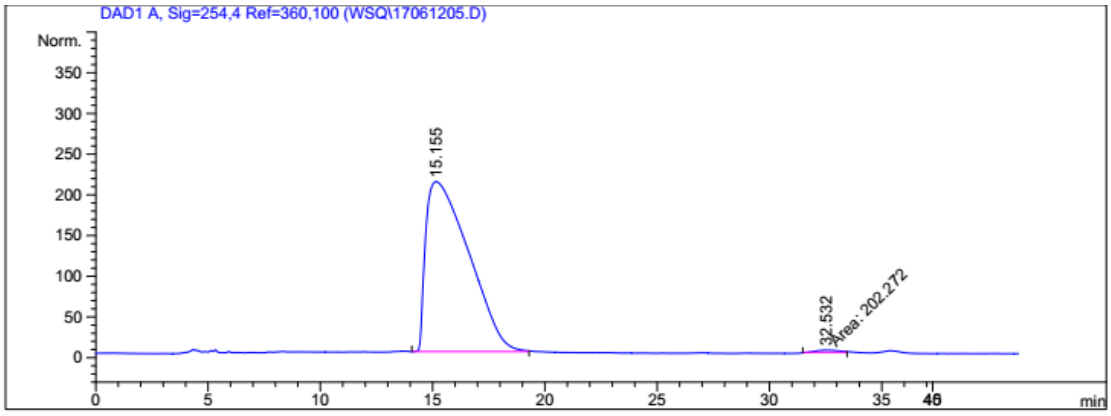


3ia

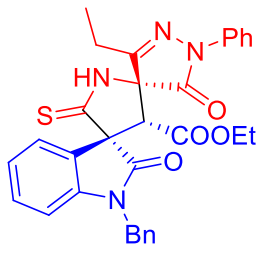
Prepared according to the general procedure within 2 h as white solid (97.9 mg, 91% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 85.3 (*c* 0.91, CH_2Cl_2); Mp 230.1-233.7 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.79 (s, 1H), 7.95 (d, *J* = 7.8 Hz, 2H), 7.46-7.37 (m, 4H), 7.36-7.20 (m, 6H), 7.09-7.00 (m, 1H), 6.80 (d, *J* = 7.8 Hz, 1H), 5.08 (d, *J* = 16.0 Hz, 1H), 4.99 (s, 1H), 4.95 (d, *J* = 16.0 Hz, 1H), 3.79-3.71 (m, 1H), 3.65-3.52 (m, 1H), 2.55 (s, 3H), 0.45 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.6, 174.2, 169.0, 165.6, 157.6, 144.1, 137.4, 135.1, 129.8, 129.0, 128.7, 128.5, 127.8, 127.6, 125.7, 123.2, 123.1, 118.9, 110.0, 73.3, 68.4, 61.6, 57.6, 44.7, 16.9, 13.0. HRMS (ESI) m/z Calcd. for $C_{30}H_{27}N_4O_4S^+$ ($[M+H]^+$) 539.1748, Found 539.1747; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 15.1 min, t_{minor} = 32.5 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.105	MM	1.8828	1.84400e4	163.23233	50.6237
2	27.468	MM	5.3149	1.79856e4	56.40002	49.3763

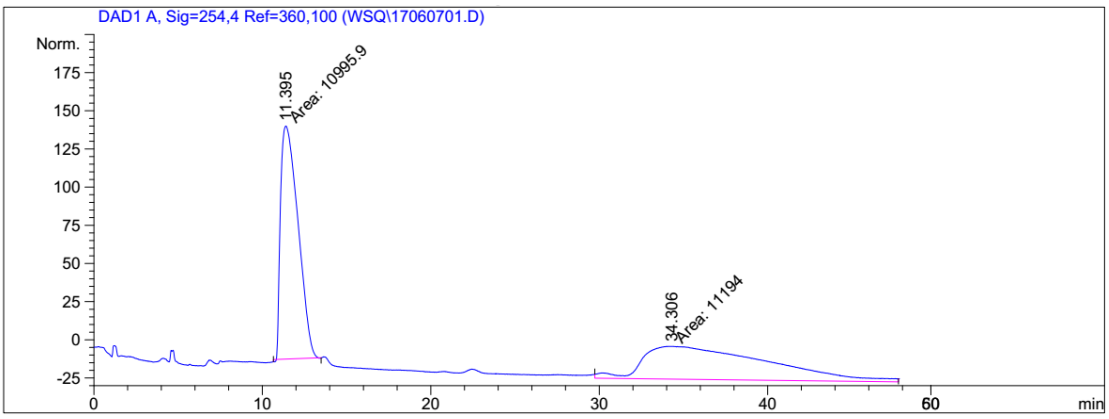


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.155	PB	1.8259	2.77879e4	208.63281	99.2773
2	32.532	MM	1.2038	202.27237	2.80043	0.7227

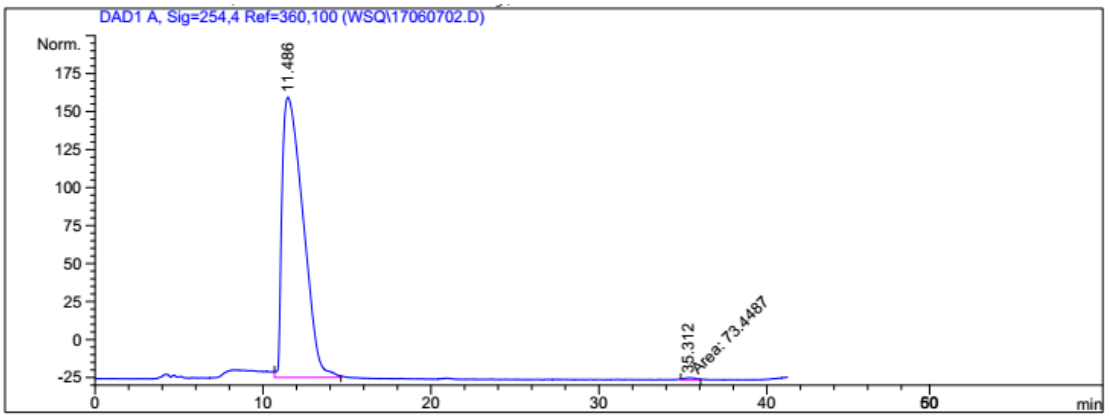


3ja

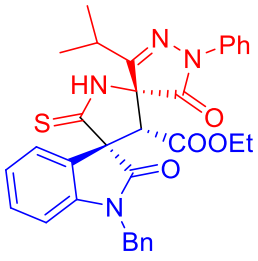
Prepared according to the general procedure within 2 h as white solid (100.5 mg, 91% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 85.5 (*c* 0.91, CH_2Cl_2); Mp 180.1-182.0 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (s, 1H), 8.00 (d, *J* = 8.2 Hz, 2H), 7.47-7.18 (m, 11H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.07 (d, *J* = 16.0 Hz, 2H), 5.01 (s, 1H), 4.95 (d, *J* = 16.0 Hz, 1H), 3.79-3.71 (m, 1H), 3.62-3.54 (m, 1H), 2.88 (q, *J* = 7.2 Hz, 2H), 1.48 (t, *J* = 7.1 Hz, 3H), 0.47 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.5, 165.7, 161.4, 144.1, 137.6, 135.1, 129.8, 128.9, 128.7, 128.7, 127.7, 127.6, 125.6, 123.4, 123.2, 119.0, 110.0, 73.6, 68.6, 61.6, 57.7, 44.7, 24.0, 13.1, 9.40； HRMS (ESI) m/z Calcd. for $C_{31}H_{29}N_4O_4S^+$ ([M+H]$^+$) 553.1904, Found 553.1904; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 11.5 min, t_{minor} = 35.3min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.395	MM	1.2003	1.09959e4	152.68690	49.5536
2	34.306	MM	8.6825	1.11940e4	21.48764	50.4464

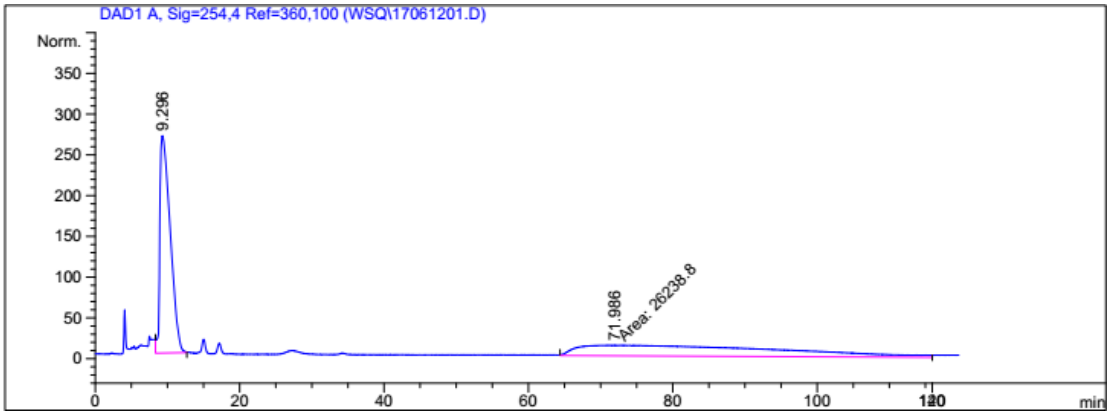


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.486	BB	1.3098	1.60314e4	184.47820	99.5439
2	35.312	MM	0.8494	73.44873	1.44117	0.4561

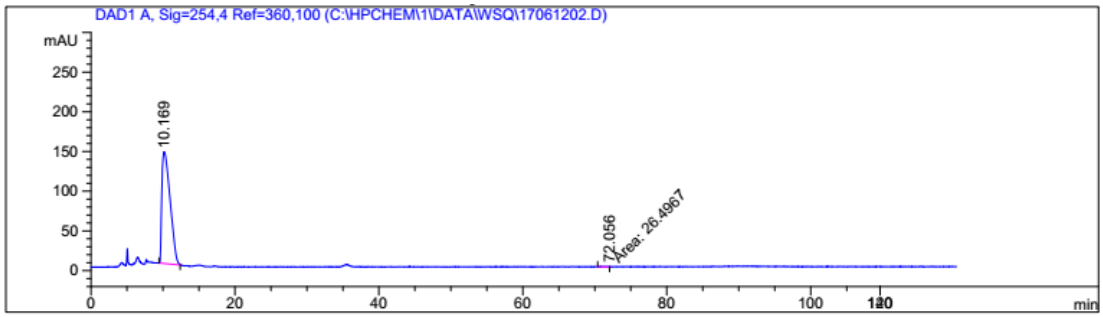


3ka

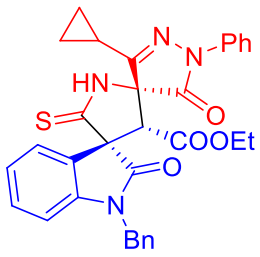
Prepared according to the general procedure within 3 h as white solid (101.9 mg, 90% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 96.1 (*c* 1.06, CH_2Cl_2); Mp 125.1-130.7 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.63 (s, 1H), 8.00 (d, *J* = 8.1 Hz, 2H), 7.49-7.37 (m, 4H), 7.35-7.23 (m, 6H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.10 (d, *J* = 16.0 Hz, 1H), 5.01 (s, 1H), 4.95 (d, *J* = 16.0 Hz, 1H), 3.80-3.72 (m, 1H), 3.62-3.54 (m, 1H), 3.16-3.10 (m, 1H), 1.55 (d, *J* = 6.6 Hz, 3H), 1.47 (d, *J* = 7.0 Hz, 3H), 0.48 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.2, 174.2, 168.8, 165.6, 164.4, 144.2, 137.6, 135.1, 129.8, 128.9, 128.7, 127.7, 127.6, 125.6, 123.1, 123.1, 118.8, 110.0, 73.6, 68.4, 61.54 , 57.9, 44.7, 30.4, 22.6, 19.7, 13.0; HRMS (ESI) m/z Calcd. for $C_{32}H_{31}N_4O_4S^+$ ($[M+H]^+$) 567.2061, Found 567.2057; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 10.2 min, t_{minor} = 72.0 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.296	BB	1.5113	2.65660e4	266.42447	50.3098
2	71.986	MM	33.6270	2.62388e4	13.00482	49.6902



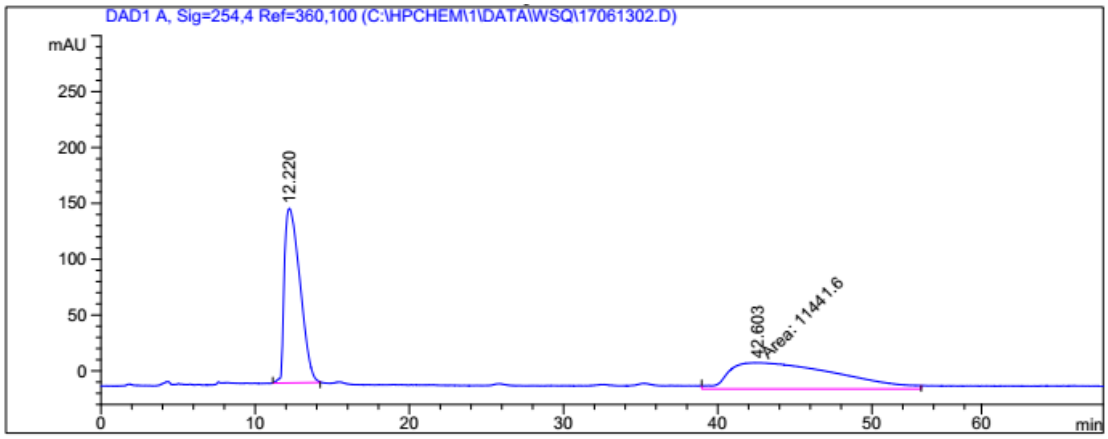
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.169	BB	1.0564	1.11923e4	140.65085	99.7638
2	72.056	MM	0.7466	26.49672	5.91495e-1	0.2362



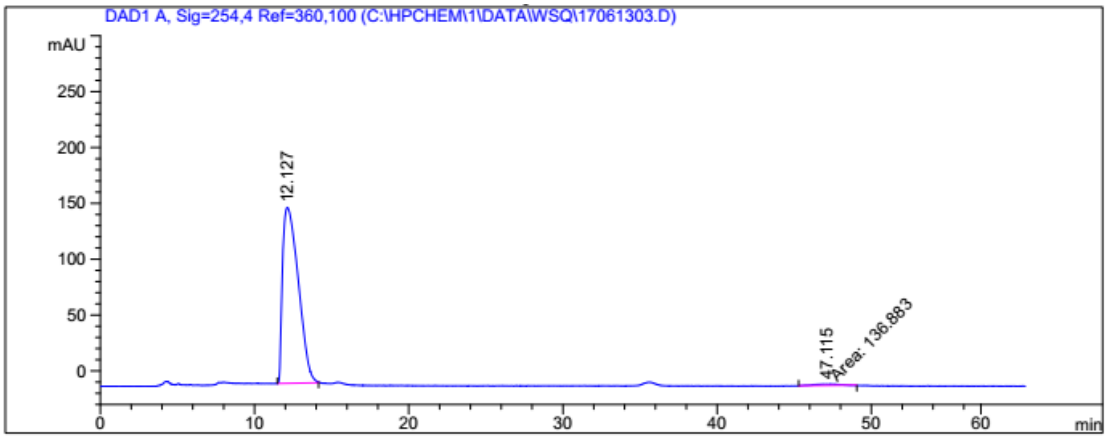
3la

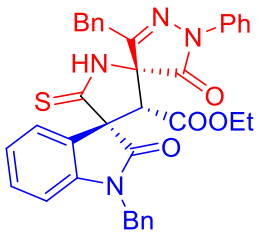
Prepared according to the general procedure within 2 h as white solid (106.0 mg, 94% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 64.2 (*c* 0.45, CH_2Cl_2); Mp 147.1-150.9 °C;^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.52 (s, 1H), 7.94 (d, *J* = 8.0 Hz), 7.47-7.38 (m, 5H), 7.34-7.19 (m, 5H), 7.02 (t, *J* = 7.6 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.10 (d, *J* = 16.0 Hz, 1H), 5.02 (s, 1H), 4.98 (d, *J* = 16.0 Hz, 1H), 3.82-3.76 (m, 1H), 3.64-3.56 (m, 1H), 1.99-1.92 (m, 1H), 1.49-1.38 (m, 1H), 1.34-1.26 (m, 1H), 1.24-1.10 (m, 2H), 0.49 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 174.3, 169.0, 165.5, 161.8, 144.2, 135.2, 129.7, 128.9, 128.7, 127.7, 127.6, 125.6 , 123.3, 122.9, 118.8, 110.0, 73.7, 68.2, 61.5, 57.7, 44.7, 13.1, 11.0, 9.3, 9.2; HRMS (ESI) m/z Calcd. for $C_{32}H_{29}N_4O_4S^+$ ([M+H]$^+$) 565.1904, Found 565.1906; Enantiomeric excess was determined to be 98% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 12.1 min, t_{minor} = 47.1 min)

.



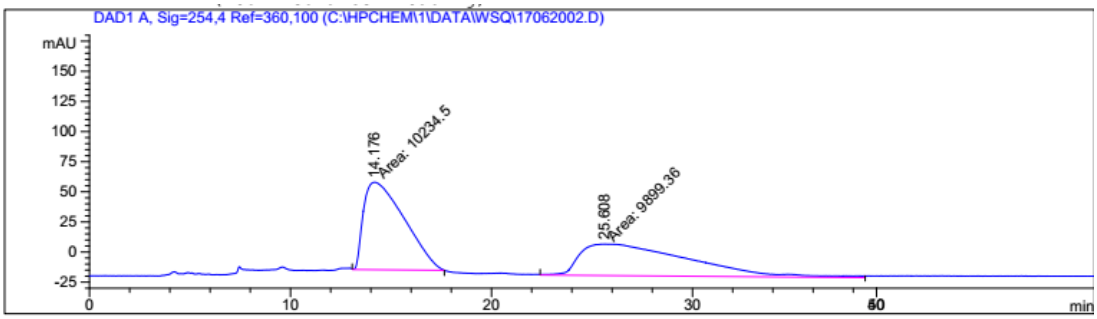
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.215	BB	1.1112	1.10930e4	156.45311	50.0533
2	42.603	MM	8.3663	1.10693e4	22.05153	49.9467





3ma

Prepared according to the general procedure within 2 h as white solid (106.0 mg, 94% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 38.3 (*c* 0.68, CH_2Cl_2); Mp 156.1-157.9 °C;^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.47 (s, 1H), 7.84 (d, *J* = 8.1 Hz, 2H), 7.46 (t, *J* = 6.9 Hz, 3H), 7.41 (d, *J* = 7.3 Hz, 2H), 7.36 (t, *J* = 7.5 Hz, 2H), 7.33-7.23 (m, 7H), 7.14 (t, *J* = 7.4 Hz, 1H), 7.07 (t, *J* = 7.6 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.06 (d, *J* = 15.8 Hz, 2H), 4.91 (d, *J* = 15.7 Hz, 1H), 4.33 (d, *J* = 16.4 Hz, 1H), 4.14 (d, *J* = 16.4 Hz, 1H), 3.84-3.70 (m, 1H), 3.67-3.53 (m, 1H), 0.47 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.2, 174.4, 169.2, 166.0, 159.9, 144.3, 137.5, 135.1, 134.5, 129.9, 129.9, 128.9, 128.7, 128.7, 127.7, 127.6, 127.2, 125.5, 123.4, 123.2, 118.8, 110.1, 73.6, 68.5, 61.7, 58.3, 44.8, 36.8, 13.1; HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_4S^+$ ([M+H]$^+$) 615.2061, Found 615.2058; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 14.2 min, t_{minor} = 27.2 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
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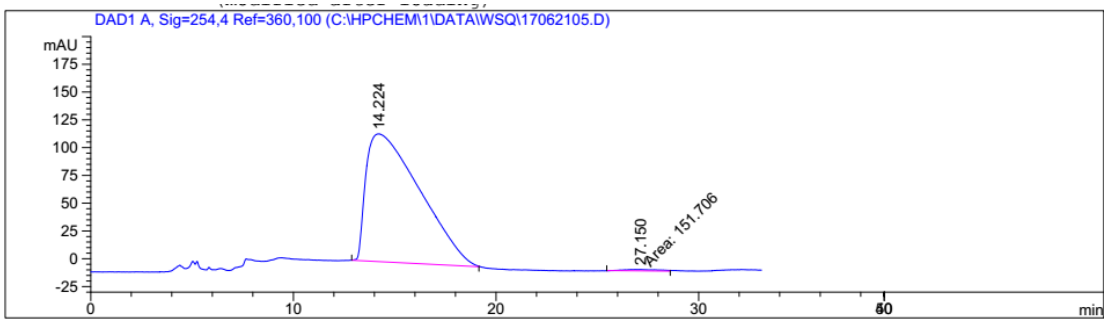
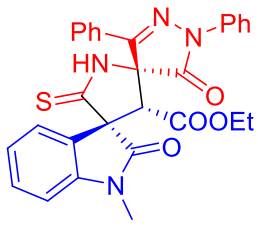
2	25.608	MM	6.3125	9899.36230	26.13711	49.1676

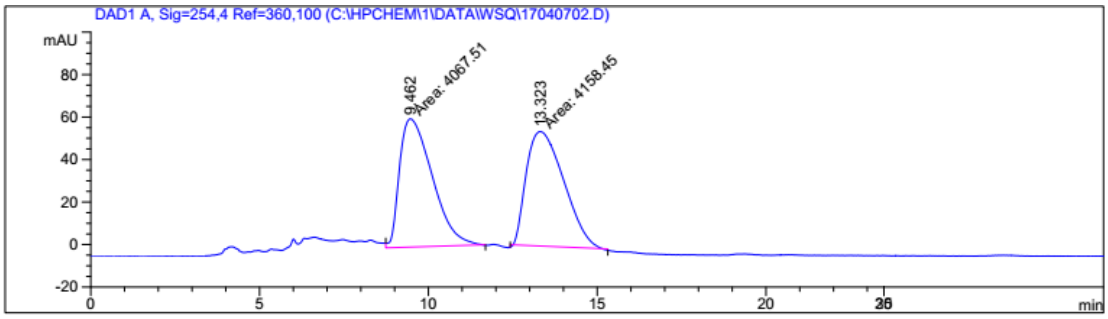


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.224	BB	2.1593	2.12533e4	115.04453	99.2913
2	27.150	MM	1.9634	151.70618	1.28780	0.7087

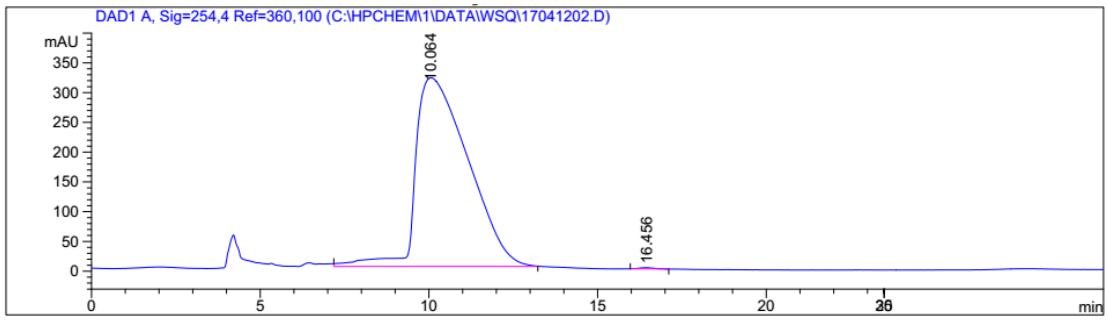


3ab

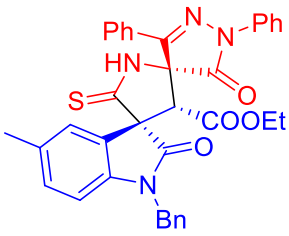
Prepared according to the general procedure within 8 h as white solid (89.08 mg, 85% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 105.1 (*c* 0.87, CH_2Cl_2); Mp 241.3-243.4 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.93 (s, 1H), 8.02 (dd, *J* = 8.7, 1.2 Hz, 2H), 7.77 (dt, *J* = 6.9, 1.6 Hz, 2H), 7.63-7.53 (m, 3H), 7.43 (t, *J* = 8.0 Hz, 2H), 7.29-7.22 (m, 1H), 7.17 (td, *J* = 7.8, 1.2 Hz, 1H), 6.78 (d, *J* = 7.8 Hz, 1H), 6.48 (td, *J* = 7.6, 1.1 Hz, 1H), 5.17 (d, *J* = 7.6 Hz, 1H), 4.92 (s, 1H), 3.72-3.66 (m, 1H), 3.62-3.54 (m, 1H), 3.23 (s, 3H), 0.52 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.1 , 174.3 , 165.0 , 157.9 , 144.7 , 131.2 , 130.5 , 129.9 , 129.4 , 129.2 , 129.0 , 127.6 , 125.9 , 123.6 , 122.6 , 119.1 , 108.3 , 73.7 , 68.1 , 61.3 , 58.2 , 27.3 , 13.1; HRMS (ESI) m/z Calcd. for $C_{29}H_{25}N_4O_4S^+$ ($[M+H]^+$) 525.1591, Found 525.1587; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 10.0 min, t_{minor} = 16.4 min).



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.462	MM	1.1233	4067.50562	60.35198	49.4472
2	13.323	MM	1.2866	4158.45312	53.86988	50.5528

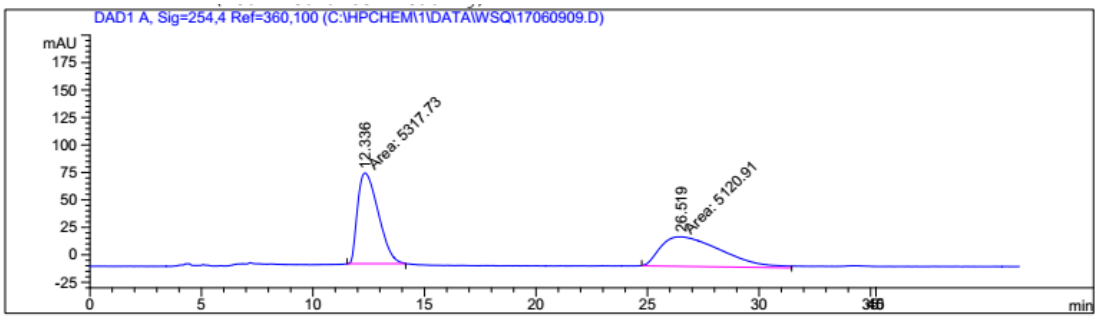


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.064	BB	1.4284	3.43626e4	317.07639	99.8165
2	16.456	BB	0.3679	63.18171	2.02546	0.1835

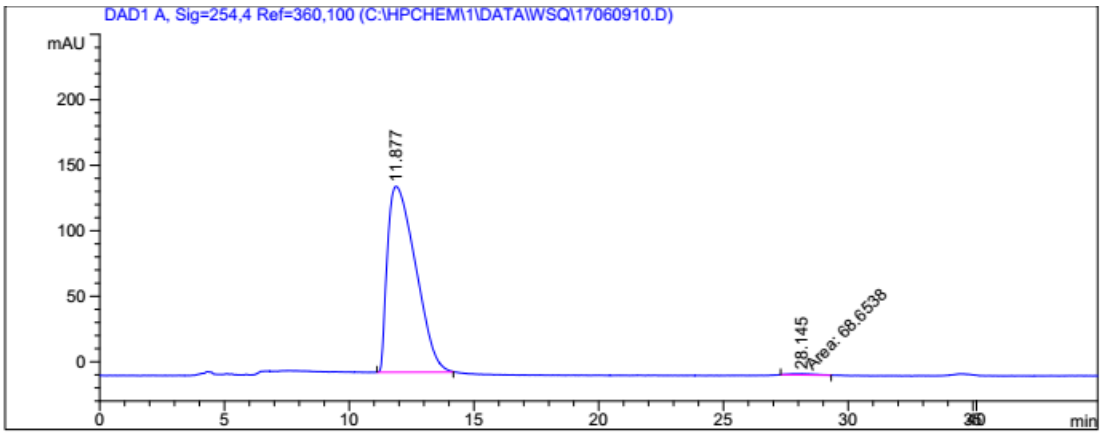


3ac

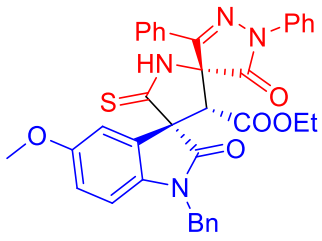
Prepared according to the general procedure within 6 h as white solid (104.4 mg, 85% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 91.5 (*c* 1.03, CH_2Cl_2); Mp 152.5-154.2 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.03 (s, 1H), 8.00 (d, *J* = 7.8 Hz, 2H), 7.81-7.75 (m, 2H), 7.57-7.49 (m, 3H), 7.38 (dd, *J* = 8.6, 7.4 Hz, 2H), 7.35-7.30 (m, 2H), 7.25-7.14 (m, 4H), 6.80 (d, *J* = 7.9 Hz, 1H), 6.48 (d, *J* = 8.0 Hz, 1H), 5.07 (d, *J* = 1.6 Hz, 1H), 5.00 (s, 1H), 4.90 (d, *J* = 16.0 Hz, 1H), 4.85 (d, *J* = 16.0 Hz, 1H), 3.72-3.64 (m, 1H), 3.50-3.42 (m, 1H), 1.75 (s, 3H), 0.31 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 202.3, 174.6, 169.0, 165.1, 141.4, 137.6, 135.3, 132.1, 130.7, 130.1, 129.5, 129.1, 128.6, 127.7, 127.6, 127.5, 125.9, 124.6, 119.2, 109.3, 73.8, 68.3, 61.3, 58.4, 44.7, 20.9, 12.9. HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_4S^+$ ([M+H]$^+$) 615.2061, Found 615.2053; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 11.9 min, t_{minor} = 28.1 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.336	MM	1.0733	5317.72754	82.57882	50.9428
2	26.519	MM	3.1634	5120.90625	26.98007	49.0572

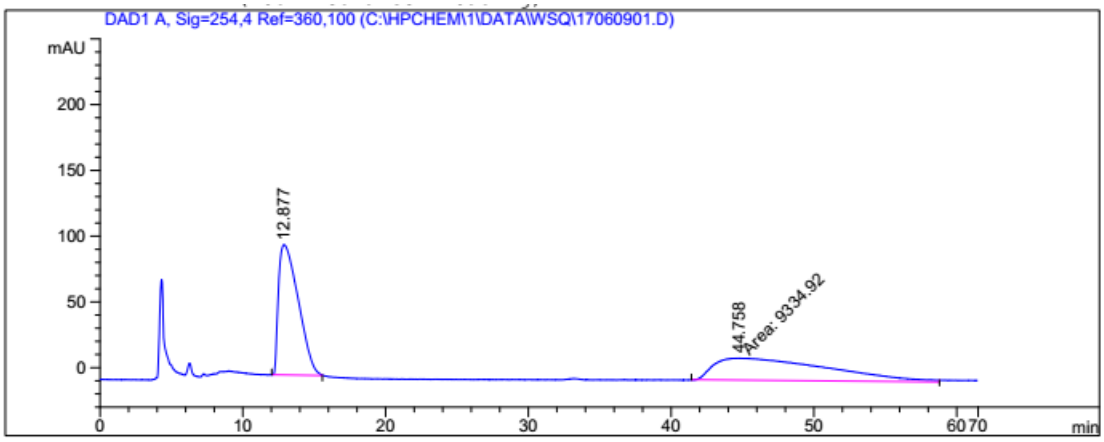


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.877	BB	1.0563	1.11493e4	141.95198	99.3880
2	28.145	MM	1.1516	68.65385	9.93619e-1	0.6120

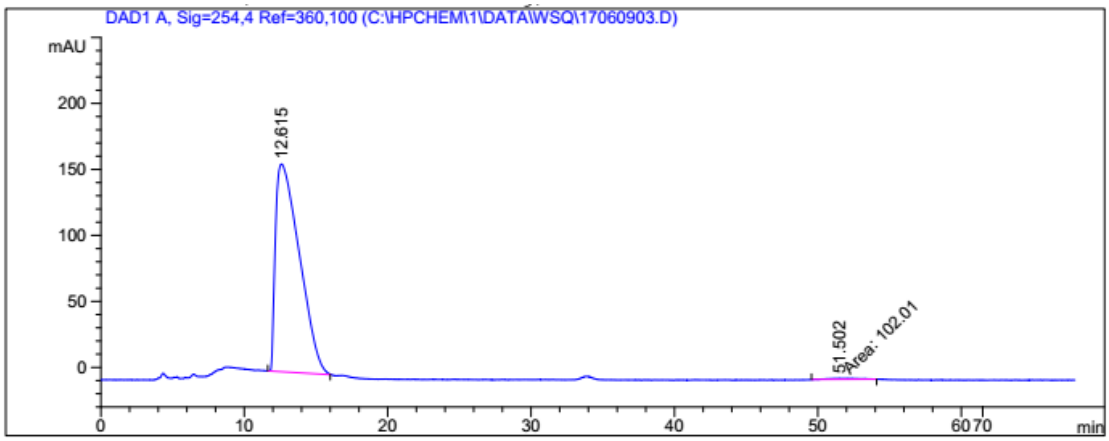


3ad

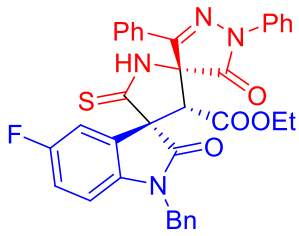
Prepared according to the general procedure within 6 h as white solid (107.1 mg, 87% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 77.8 (*c* 1.09, CH_2Cl_2); Mp 156.7-157.8 °C;^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.06 (s, 1H), 7.86 (dd, *J* = 6.5, 2.7 Hz, 2H), 7.59-7.49 (m, 3H), 7.41 (t, *J* = 7.9 Hz, 2H), 7.36 (d, *J* = 6.7 Hz, 2H), 7.29-7.21 (m, 4H), 6.60 (dd, *J* = 8.6, 2.4 Hz, 1H), 6.54 (d, *J* = 8.5 Hz, 1H), 5.31 (d, *J* = 2.4 Hz, 1H), 5.07 (s, 1H), 4.95 (d, *J* = 16.0 Hz, 1H), 4.87 (d, *J* = 16.0 Hz, 1H) 3.69-3.63 (m,1H), 3.58-3.50 (m, 1H), 3.31 (s, 3H), 0.41 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.9, 174.4, 169.2, 165.1, 157.9, 155.9, 137.3, 135.2, 131.6, 130.8, 129.4, 129.2, 129.0, 128.6, 127.6, 127.5, 125.8, 119.1, 114.3, 111.7, 109.9, 73.7, 68.7, 61.4, 58.6, 56.0, 44.8, 13.0; HRMS (ESI) m/z Calcd. for $C_{36}H_{31}N_4O_5S^+$ ([M+H]$^+$) 631.2010, Found 631.2003; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 12.6 min, t_{minor} = 51.5 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.877	PB	1.1415	9530.04785	99.13946	50.5255
2	44.758	MM	9.0985	9331.81738	17.09408	49.4745



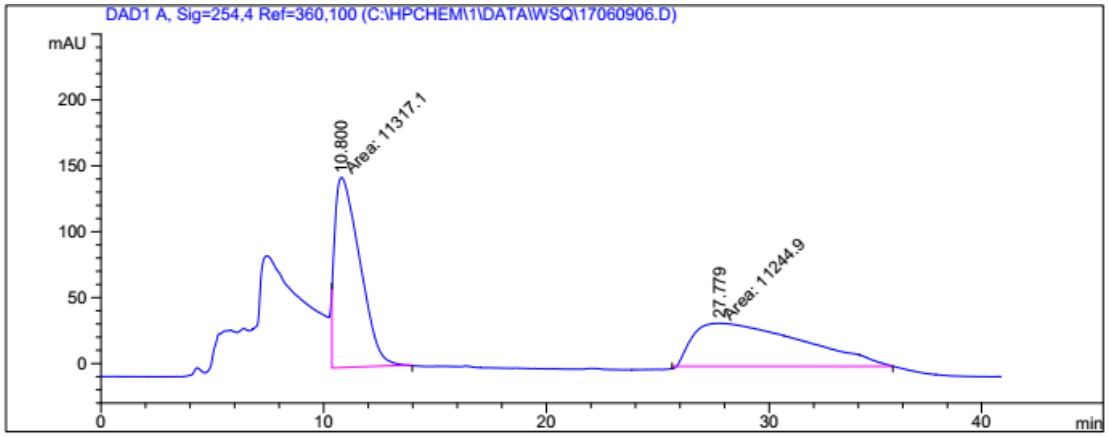
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.615	BB	1.3756	1.82280e4	157.34109	99.4435
2	51.502	MM	2.1500	102.00994	7.90771e-1	0.5565



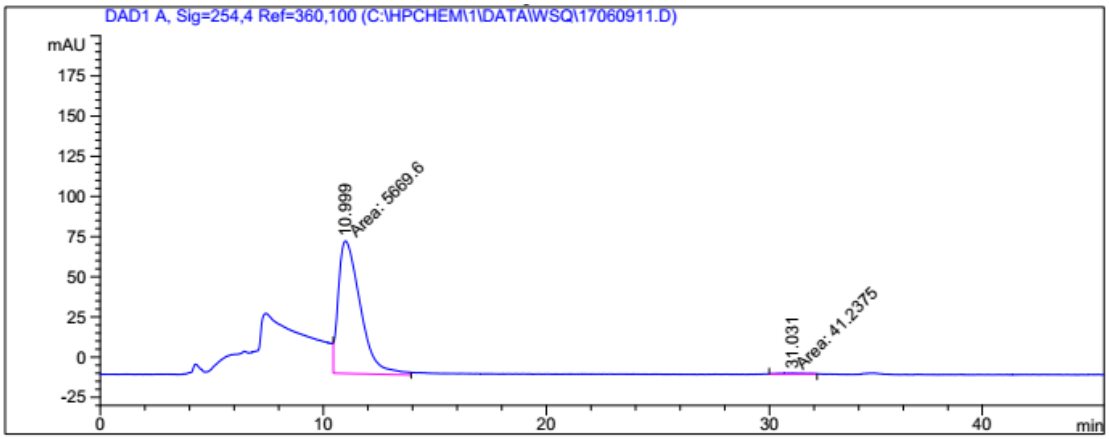
3ae

Prepared according to the general procedure within 30 min as white solid (101.1 mg, 82% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 88.8 (*c* 1.09, CH_2Cl_2); Mp 151.9-152.2 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.98 (s, 1H), 8.03-7.97 (m, 2H), 7.79-7.71 (m, 2H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.53 (t, *J* = 7.4 Hz, 2H), 7.39 (t, *J* = 8.0 Hz, 2H), 7.35-7.29 (m, 2H), 7.26-7.20 (m, 4H), 6.72 (td, *J* = 8.6, 2.6 Hz, 1H), 6.52 (dd, *J* = 8.6, 4.2 Hz, 1H), 5.03 (s, 1H), 4.92 (d, *J* = 16.0, 1H), 4.87 (d, *J* = 16.0, 1H), 4.79 (dd, *J* = 8.7, 2.6 Hz, 1H), 3.80-3.71 (m, 1H), 3.59-3.51 (dq, *J* = 10.7, 7.1 Hz, 1H), 0.43 (t, *J* = 7.1 Hz, 3H). ^{19}F NMR (470 MHz, Chloroform-*d*) δ -119.19 （m）; ^{13}C NMR (101 MHz, Chloroform-d) δ 115.47 (d, J = 23.5 Hz), 112.10 (d, J = 26.9 Hz), 109.99 (d, J = 7.9 Hz). ^{13}C NMR (101 MHz, Chloroform-d) δ 201.2, 174.4, 168.7, 164.8, 159.9, 157.80,157.5, 139.8, 137.5, 134.8, 131.1, 130.8, 129.9, 129.4, 129.1, 128.7, 127.8, 127.5, 125.9, 119.1, δ 115.5 (d, J = 23.5 Hz), 112.1 (d, J = 27.3 Hz), 110.0(d, J = 8.1 Hz), 73.9, 68.2, 61.56, 58.0, 44.8, 13.1; HRMS (ESI) m/z Calcd. for $C_{35}H_{28}FN_4O_4S^+$

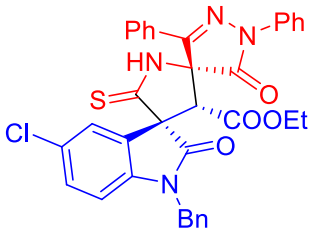
([M+H]$^+$) 619.1810, Found 619.1807; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 10.9 min, t_{minor} = 31.0 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.800	MM	1.3771	1.19551e4	144.69301	49.8014
2	27.779	MM	5.8843	1.20504e4	34.13159	50.1986



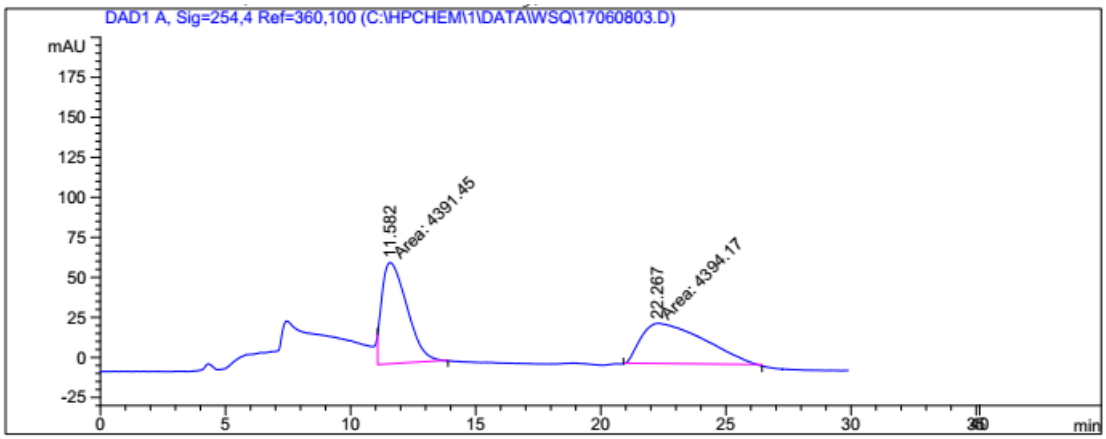
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.999	MM	1.1457	5669.59766	82.47813	99.2779
2	31.031	MM	1.2426	41.23751	5.53091e-1	0.7221



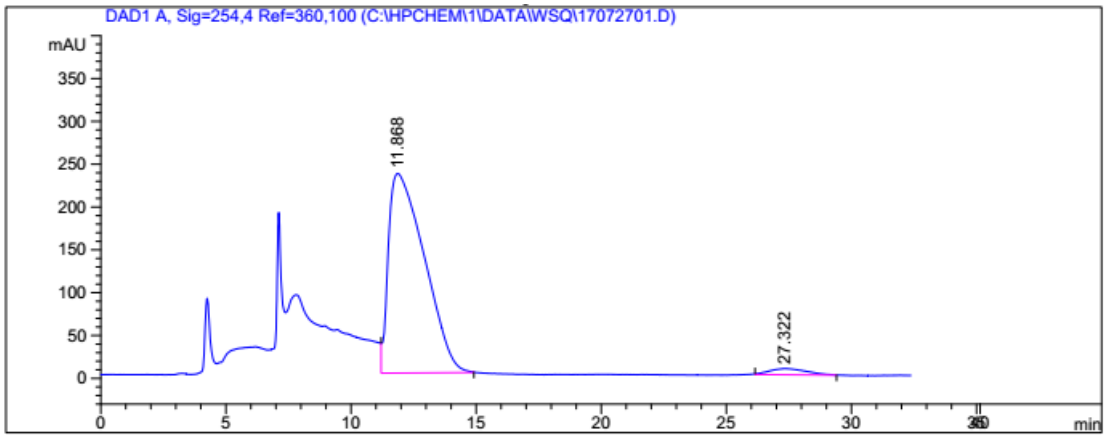
3af

Prepared according to the general procedure within 15 min as white solid (101.4 mg, 80% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 92.0 (*c* 1.09, CH_2Cl_2); Mp 156.7-157.8 °C;^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.00 (s, 1H), 7.99 (d, *J* = 8.2 Hz, 2H), 7.73 (d, *J* = 7.4 Hz, 2H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.53 (t, *J* = 7.6 Hz, 2H), 7.37 (t, *J* = 7.9 Hz, 2H), 7.32-7.28 (m, 2H), 7.26-7.16 (m, 5H), 6.99 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.52 (d, *J* = 8.4 Hz, 1H), 5.10 (d, *J* = 2.0 Hz, 1H), 5.01 (s, 1H), 4.91 (d, *J* = 16.0 Hz, 1H), 4.85 (d, *J* = 16.0 Hz, 1H), 3.80-3.72 (m, 1H), 3.56-3.48 (m, 1H), 0.40 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 201.0, 174.3, 168.7, 164.8, 157.8, 142.4, 134.7, 131.6, 130.6, 129.8, 129.3, 129.3, 129.3, 129.1, 128.7, 128.0, 127.8, 127.5, 125.9, 124.3, 119.1, 110.5,

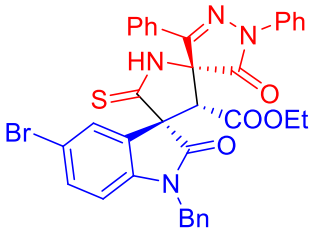
73.8, 67.9, 61.6, 58.0, 44.8, 13.1; HRMS (ESI) m/z Calcd. for $C_{35}H_{28}ClN_4O_4S^+$ ([M+H]$^+$) 635.1514, Found 635.1514; Enantiomeric excess was determined to be 94% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 11.8 min, t_{minor} = 27.3 min)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.582	MM	1.2463	4736.61133	63.34438	49.9808
2	22.267	MM	2.9861	4740.25195	26.45710	50.0192



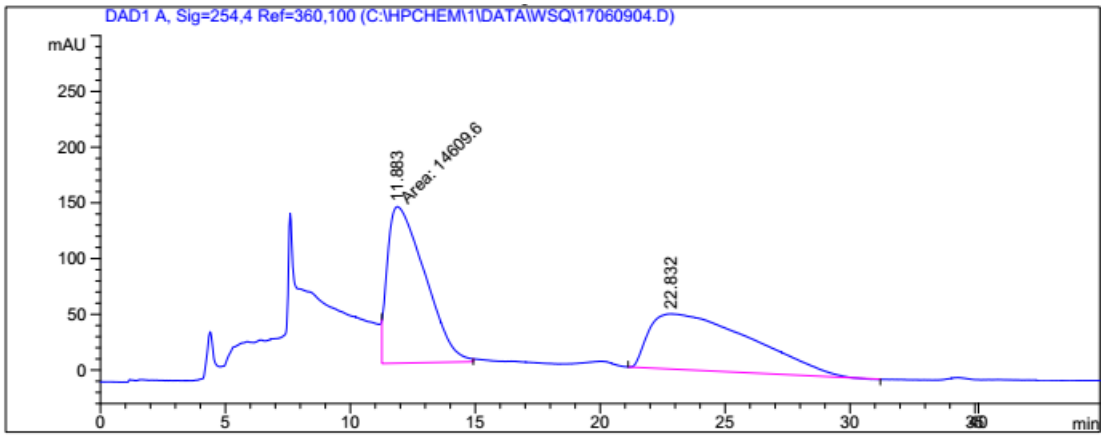
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.868	VB	1.1958	2.32366e4	232.94771	96.8530
2	27.322	BV	1.2200	755.01422	7.24384	3.1470



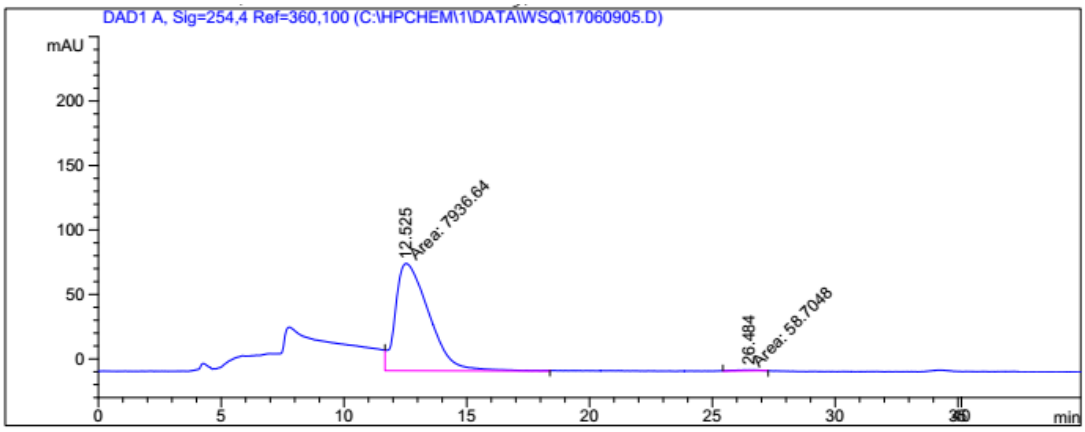
3ag

Prepared according to the general procedure within 15 min as white solid (108.5 mg, 79% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/6). $[\alpha]_D^{19}$ = 86.9 (*c* 1.27, CH_2Cl_2); Mp 154.1-155.9 °C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 9.06 (s, 1H), 8.04 (d, *J* = 8.0 Hz, 2H), 7.79 (d, *J* = 7.6 Hz, 2H), 7.67 (t, *J* = 7.4 Hz, 1H), 7.58 (t, *J* = 7.6 Hz, 2H), 7.42 (t, *J* = 7.8 Hz, 2H), 7.35 (d, *J* = 6.5 Hz, 2H), 7.30-7.22 (m, 4H), 7.19 (dd, *J* = 8.3, 1.8 Hz, 1H), 6.53 (d, *J* = 8.3 Hz, 1H), 5.38 (d, *J* = 1.9 Hz, 1H), 5.05 (s, 1H), 4.95 (d, *J* = 16.0 Hz, 1H), 4.80 (d, *J* = 16.0 Hz, 1H), 3.85-3.77 (m, 1H), 3.64-3.51 (m, 1H), 0.45 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz,

Chloroform-*d*) δ 174.2, 168.7, 164.7, 142.9, 137.5, 134.7, 132.3, 131.8, 130.6, 129.7, 129.6, 129.3, 129.1, 128.7, 127.8, 127.5, 126.9, 125.9, 119.1, 115.3, 111.1, 73.8, 67.9, 61.6, 58.1, 44.8, 13.1; HRMS (ESI) m/z Calcd. for $C_{35}H_{28}BrN_4O_4S^+$ ([M+H]$^+$) 679.1009, Found 679.1014; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 °C, 0.8 mL/min, t_{major} = 12.5 min, t_{minor} = 26.5 min)

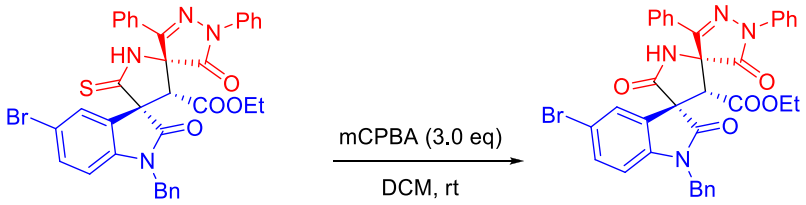


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.883	MM	1.7487	1.45863e4	139.02135	50.3758
2	22.832	PP	3.3976	1.43687e4	49.48407	49.6242



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.525	MM	1.5882	7936.63721	83.28960	99.2658
2	26.484	MM	1.2739	58.70482	7.68044e-1	0.7342

Synthesis of compound d



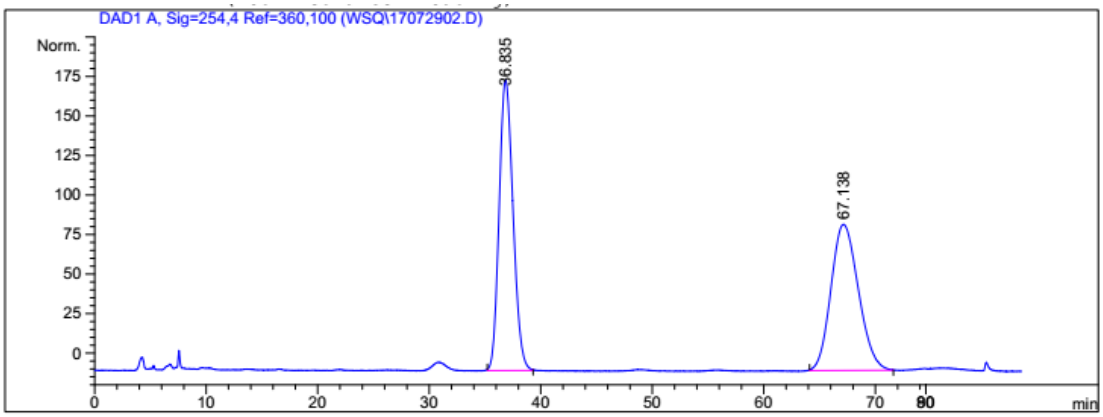
3ag

99% ee, >20:1 dr

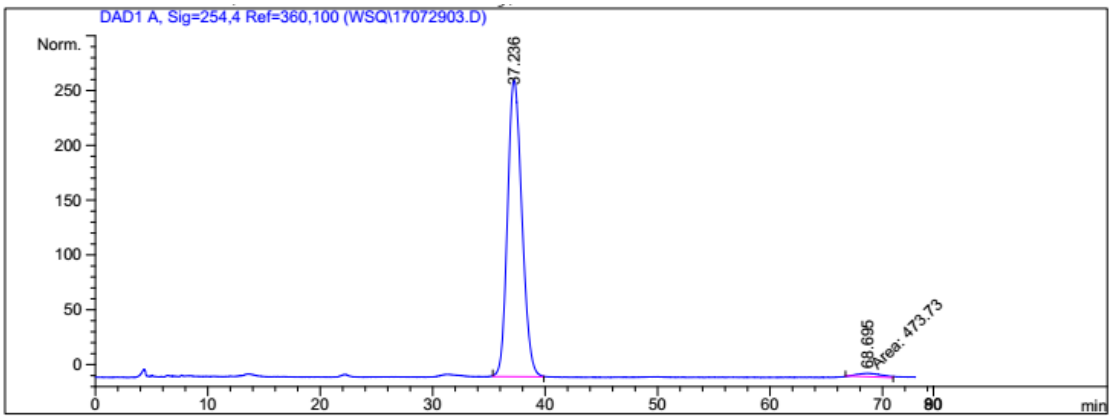
4

62% yield, 96% ee, >20:1 dr

To a Schlenk tube equipped with a magnetic stir bar was charged with compound **3ag** (0.1mmol, 64.3 mg) and DCM (2mL) at 0 ºC, mCPBA (0.3 mmol, 54 mg) was added in one portion, then the reaction was stirred at room temperature for 1 h as white solid (93.2 mg, 77% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/3). $[\alpha]_D^{19}$ = 60.9 (*c* 0.32, CH_2Cl_2); Mp 140.1-142.7 ºC;. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.00 (d, *J* = 7.5 Hz, 2H), 7.79-7.62 (m, 4H), 7.54 (t, *J* = 7.9 Hz, 2H), 7.42 (t, *J* = 7.9 Hz, 2H), 7.26-7.14 (m, 6H), 6.47 (d, *J* = 8.2 Hz, 1H), 5.32 (s, 1H), 5.02 (d, *J* = 15.8 Hz, 1H), 4.88 (s, 1H), 4.77 (d, *J* = 15.9 Hz, 1H), 3.86-3.80 (m, 1H), 3.60-3.56 (m, 1H), 0.44 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 173.4 , 171.3, 164.8, 158.4, 142.8, 137.6, 134.5, 133.5, 132.3, 131.8, 129.4, 129.3, 129.0, 128.7, 127.8, 127.2, 126.9, 125.8, 119.0, 111.0, 67.3, 61.6, 59.0, 55.4, 44.6, 13.1; HRMS (ESI) m/z Calcd. for $C_{35}H_{28}BrN_4O_5S^+$ ($[M+H]^+$) 663.1251, Found 663.1238; Enantiomeric excess was determined to be 96% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 30 ºC, 0.8 mL/min, t_{major} = 37.2 min, t_{minor} = 68.7min)

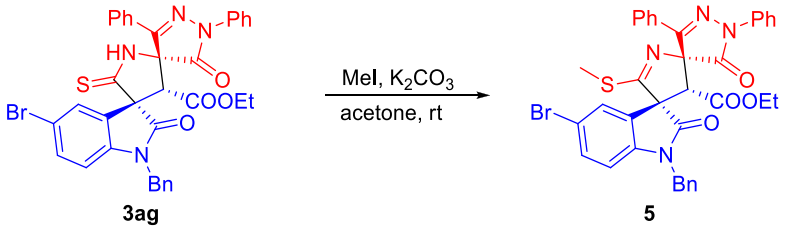


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	36.835	BB	1.3262	1.58980e4	183.59811	50.1103
2	67.138	BB	2.2213	1.58280e4	92.45415	49.8897



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	37.236	BB	1.3729	2.40418e4	270.50290	98.0676
2	68.695	MM	2.4755	473.72968	3.18944	1.9324

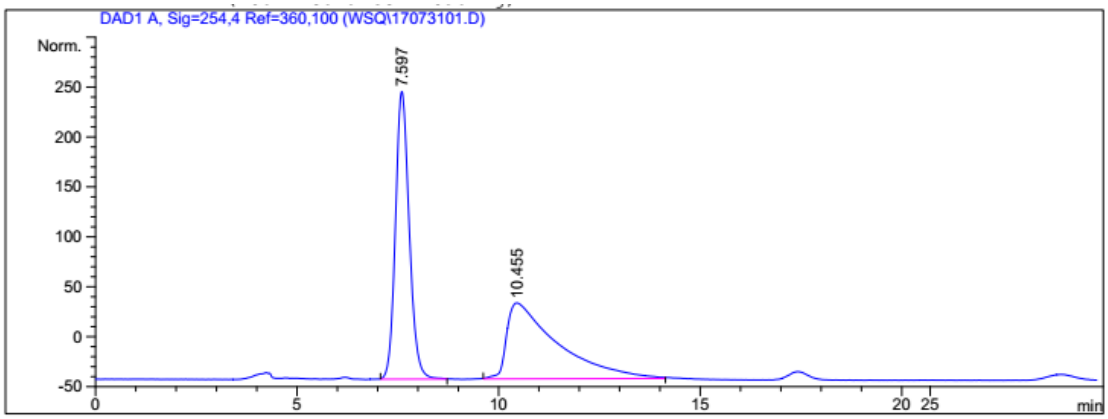
Synthesis of compound 5



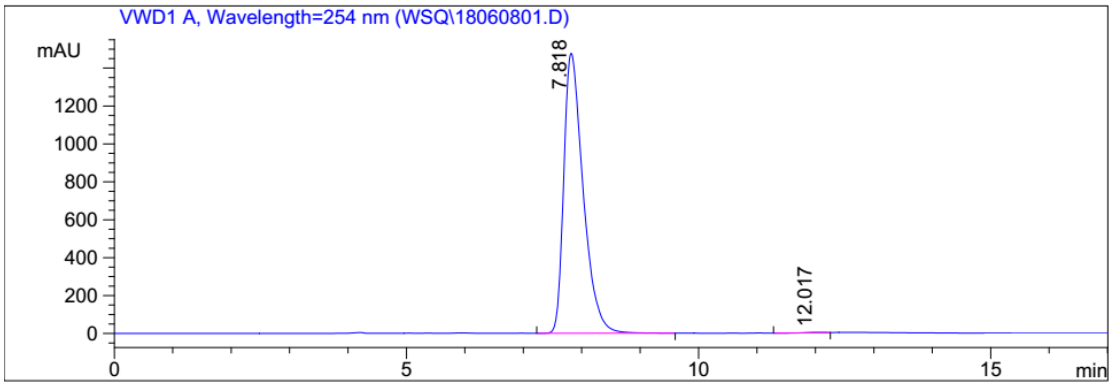
3ag 99% ee, >20:1 dr

5 70% yield, 99% ee, >20:1 dr

To a Schlenk tube equipped with a magnetic stir bar was charged with compound **3ag** (0.2 mmol, 136.6 mg) and K_2CO_3 (0.44 mmol, 60.7 mg), followed with acetone (5 mL) at 0 °C. MeI (0.44 mmol, 62.5 mg) was dropwise added into reaction mixture. Then the reaction was stirred at room temperature overnight as white solid (96.9 mg, 70% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/3). $[\alpha]_D^{19}$ = 36.1 (*c* 0.13, CH_2Cl_2); Mp 266.0-270.4.°C; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.17 (d, *J* = 8.0 Hz 2H), 7.89-7.82 (m, 2H), 7.66-7.57 (m, 3H), 7.48-7.44 (m, 4H), 7.40-7.29 (m, 4H), 7.24 (d, *J* = 7.4 Hz, 1H), 7.15 (d, *J* = 1.9 Hz, 1H), 6.60 (d, *J* = 8.4 Hz, 1H), 5.20 (d, *J* = 15.7 Hz, 1H), 4.78 (d, *J* = 15.7 Hz, 1H), 4.12 (s, 1H), 4.06-3.87 (m, 2H), 2.57 (s, 3H), 0.93 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 170.2, 168.5, 166.2, 138.3, 135.2, 132.7, 131.1, 130.0, 129.2, 128.8, 128.8, 127.8, 127.6, 127.4, 126.5, 125.0, 118.6, 115.2, 111.1, 84.5, 68.2, 62.2, 60.9, 44.6, 14.3, 13.6; HRMS (ESI) m/z Calcd. for $C_{36}H_{30}BrN_4O_4S^+$ ($[M+H]^+$) 693.1166, Found 693.1160; Enantiomeric excess was determined to be 99% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 25°C, 0.8 mL/min, t_{major} = 7.8min, t_{minor} = 12.0min)

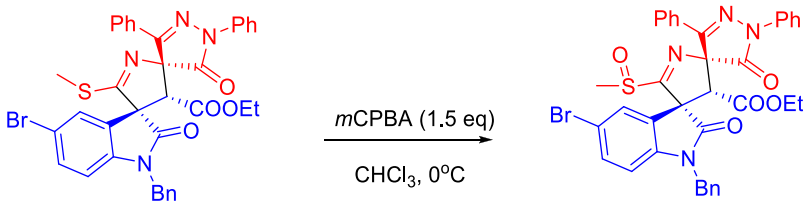


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.597	BB	0.3658	6859.83301	288.04718	50.7320
2	10.455	BB	1.1656	6661.86523	76.08209	49.2680



Peak #	RT [min]	Type	Width [min]	Area	Area %
1	7.818	VB	0.349	33998.891	99.840
2	12.017	VV	0.349	54.639	0.160

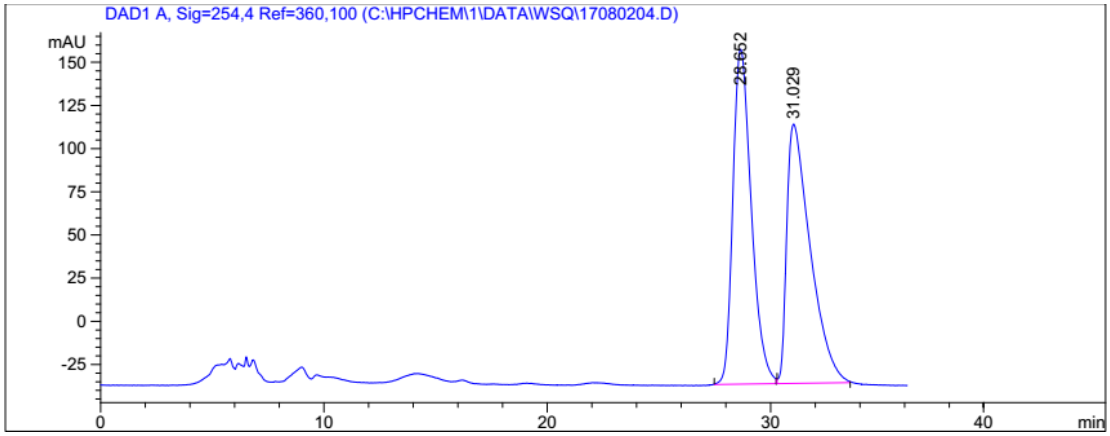
Synthesis of compound 6



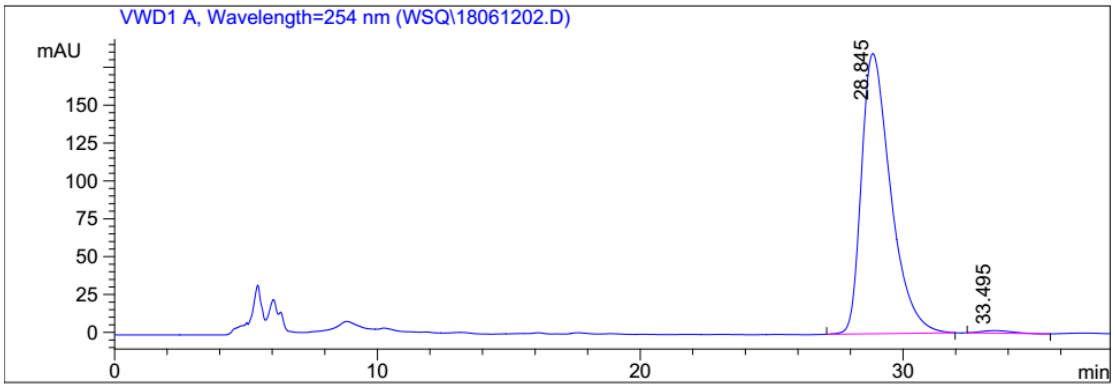
5
99% ee, >20:1 dr

6
95% yield, 98% ee, >20:1 dr

To a Schlenk tube equipped with a magnetic stir bar was charged with compound **5** (0.05 mmol, 34.6 mg) and chloroform (1 mL) at 0 °C, mCPBA (0.05 mmol, 8.6 mg) was added in one portion. Then the reaction was stirred at room temperature for 1 h as white solid (33.7 mg, 95% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/3). $[\alpha]_D^{19}$ = 199.1 (*c* 0.22, CH_2Cl_2); ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.11 (d, *J* = 7.7 Hz, 2H), 7.77-7.81 (m, 2H), 7.66 (q, *J* = 3.6 Hz, 3H), 7.51-7.42 (m, 4H), 7.41-7.31 (m, 3H), 7.31-7.24 (m, 2H), 7.19 (d, *J* = 1.9 Hz, 1H), 6.63 (d, *J* = 8.3 Hz, 1H), 5.04 (d, *J* = 16.0 Hz, 1H), 4.96 (d, *J* = 16.0 Hz, 1H), 4.13 (s, 1H), 4.08-3.90 (m, 2H), 2.93 (s, 3H), 1.29 (s, 1H), 0.94 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-*d*) δ 169.0, 165.4, 155.2, 142.8, 137.8, 134.9, 133.2, 131.5, 130.1, 129.7, 129.4, 129.1, 128.9, 128.8, 127.9, 127.7, 127.5, 126.4, 125.5, 118.7, 115.3, 111.4, 85.0, 67.1, 62.6, 61.1, 45.1, 40.5, 13.6; HRMS (ESI) m/z Calcd. for $C_{36}H_{30}BrN_4O_5S^+$ ($[M+H]^+$) 709.1115, Found 709.1132; Enantiomeric excess was determined to be 98% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 25 °C, 0.7 mL/min, t_{major} = 28.8min, t_{minor} = 33.5min.

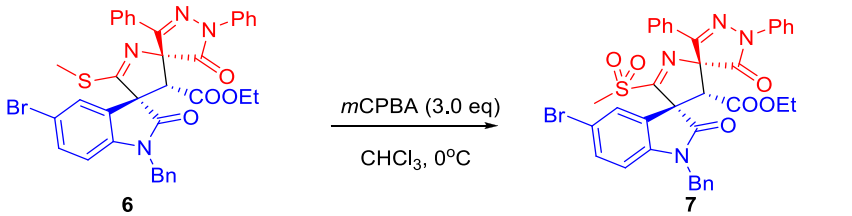


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.652	BB	0.8057	1.11326e4	193.93939	50.3354
2	31.029	BB	0.9891	1.09842e4	150.21072	49.6646



Peak #	RT [min]	Type	Width [min]	Area	Area %
1	28.845	BB	1.175	14314.832	99.071
2	33.495	BP	0.932	134.175	0.929

Synthesis of compound 7



6

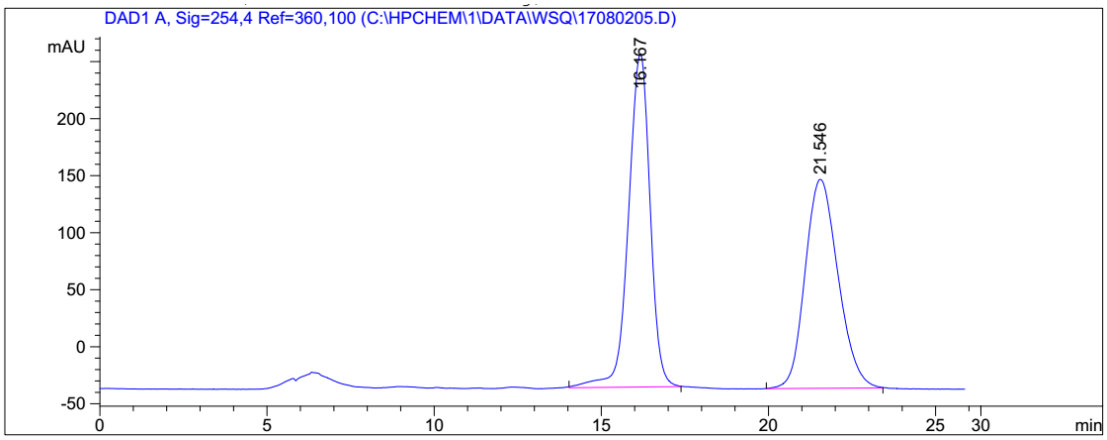
99% ee, >20:1 dr

7

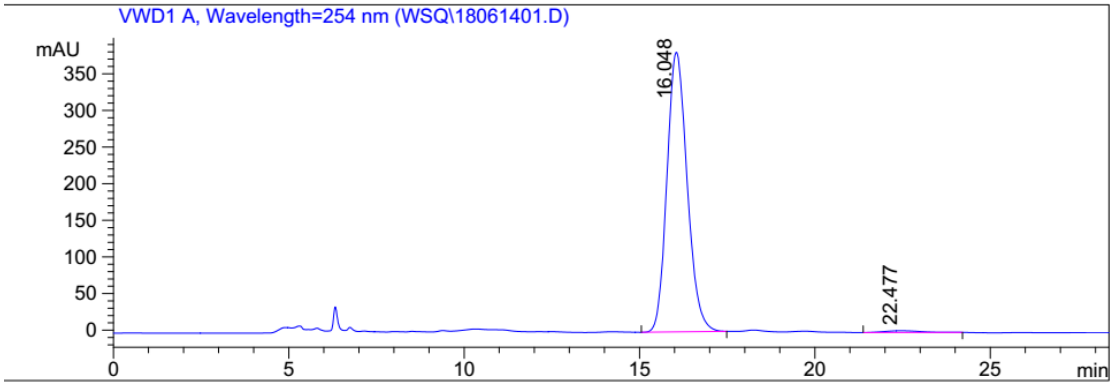
95% yield, 98% ee, >20:1 dr

To a Schlenk tube equipped with a magnetic stir bar was charged with compound **6** (0.05 mmol, 34.6 mg) and chloroform (1 mL) at 0 °C, *m*CPBA (0.1 mmol, 17.2 mg) was added in one portion. Then the reaction was stirred at room temperature for 1 h as white solid (33.7 mg, 95% yield) after silica gel chromatography (EtOAc/petroleum ether = 1/3). $[\alpha]_D^{19}$ = 108.5 (c 0.54,

CH_2Cl_2); ^1H NMR (400 MHz, Chloroform-d) δ 8.11 – 8.06 (m, 2H), 7.76 (dd, J = 6.7, 2.9 Hz, 2H), 7.66 – 7.63 (m, 2H), 7.51 – 7.40 (m, 5H), 7.26 (s, 5H), 7.18 (d, J = 1.9 Hz, 1H), 6.54 (d, J = 8.4 Hz, 1H), 5.03 (d, *J* = 16.0 Hz, 1H), 4.94 (d, *J* = 16.0 Hz, 1H), 4.09 (s, 1H), 4.06-3.98(m, 1H), 3.95-3.87 (m, 1H), 3.28 (s, 3H), 1.26 (s, 1H), 0.91 (t, J = 7.2 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 169.0, 165.4, 155.2, 142.8, 137.78, 134.9, 133.2, 131.5, 130.1, 129.78, 129.4, 129.1, 128.9, 128.9, 127.9, 127.7, 127.5, 126.4, 125.5, 118.7, 115.3, 111.4, 85.1, 67.10 , 62.7, 61.1, 45.2, 40.5, 13.6. Enantiomeric excess was determined to be 98% (determined by HPLC using chiral AD-H column, hexane/2-propanol = 70/30, λ = 254 nm, 25 °C, 0.6 mL/min, t_{major} = 16.0min, t_{minor} = 22.5min.

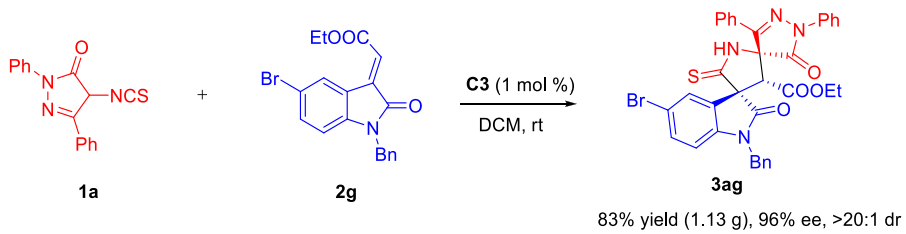


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.167	BB	0.6569	1.31524e4	292.31348	51.1929
2	21.546	BB	0.9010	1.25395e4	183.09987	48.8071



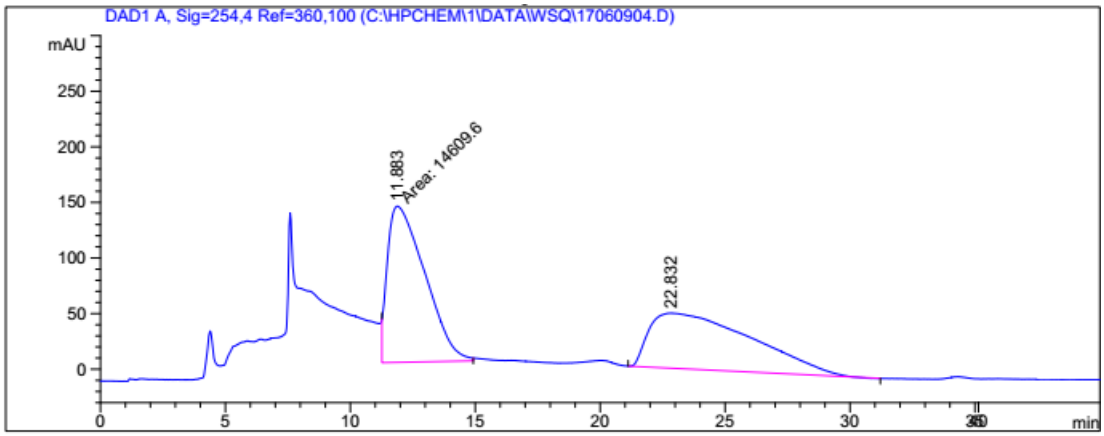
Peak #	RT [min]	Type	Width [min]	Area	Area %
1	16.048	VB	0.623	15305.246	98.893
2	22.477	BB	0.853	171.303	1.107

Gram scale synthesis of compound 3ag

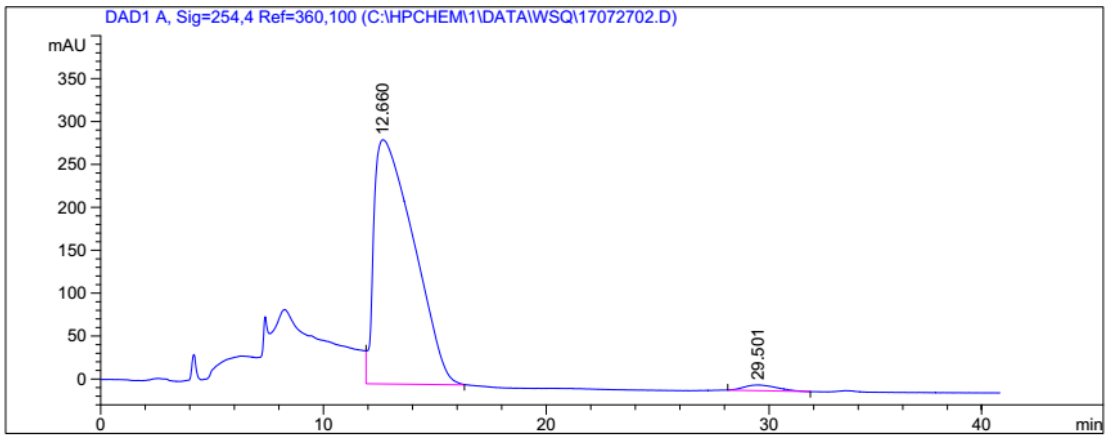


83% yield (1.13 g), 96% ee, >20:1 dr

To a Schlenk tube equipped with a magnetic stir bar was charged with compound **1a** (2 mmol, 594 mg) and **C3** (1% mmol, 6.3 mg), followed with DCM (10 ml). Compound **2g** (2.4 mmol, 926 mg) was added in one portion. The reaction was checked by TLC. When the compound **1a** was consumed up, the reaction was stopped and purified by column chromatography on silica gel directly to give the product **3ag**



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.883	MM	1.7487	1.45863e4	139.02135	50.3758
2	22.832	PP	3.3976	1.43687e4	49.48407	49.6242

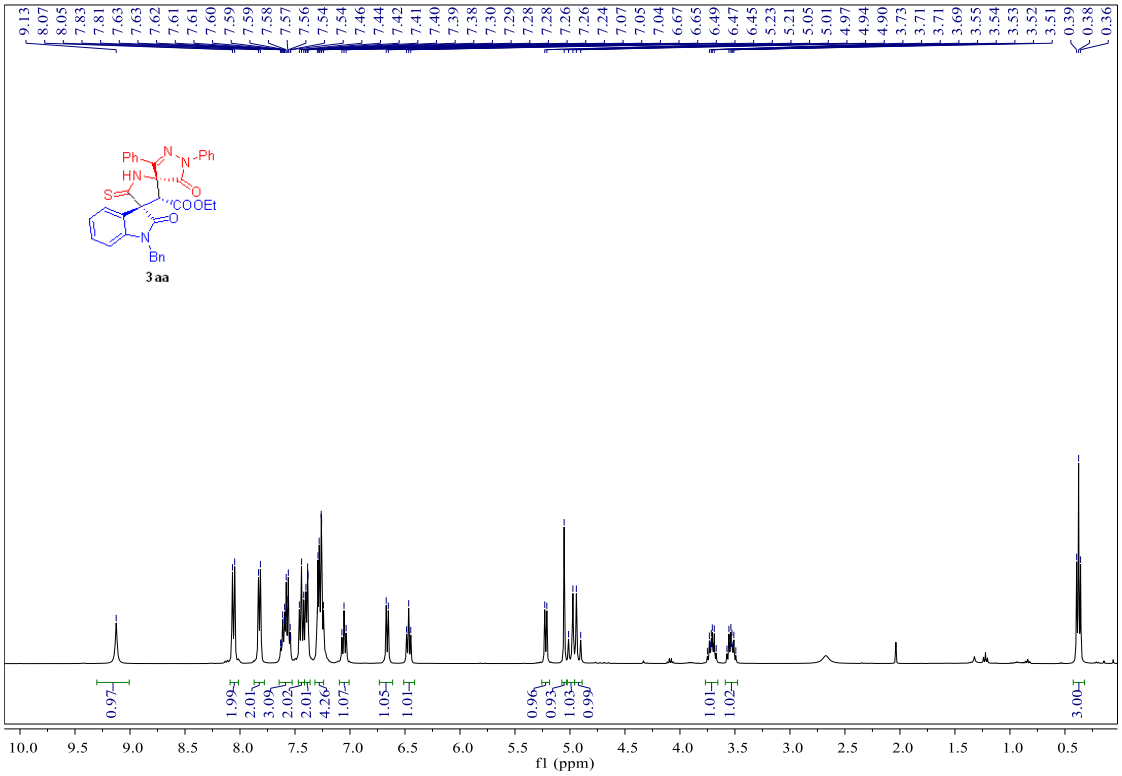


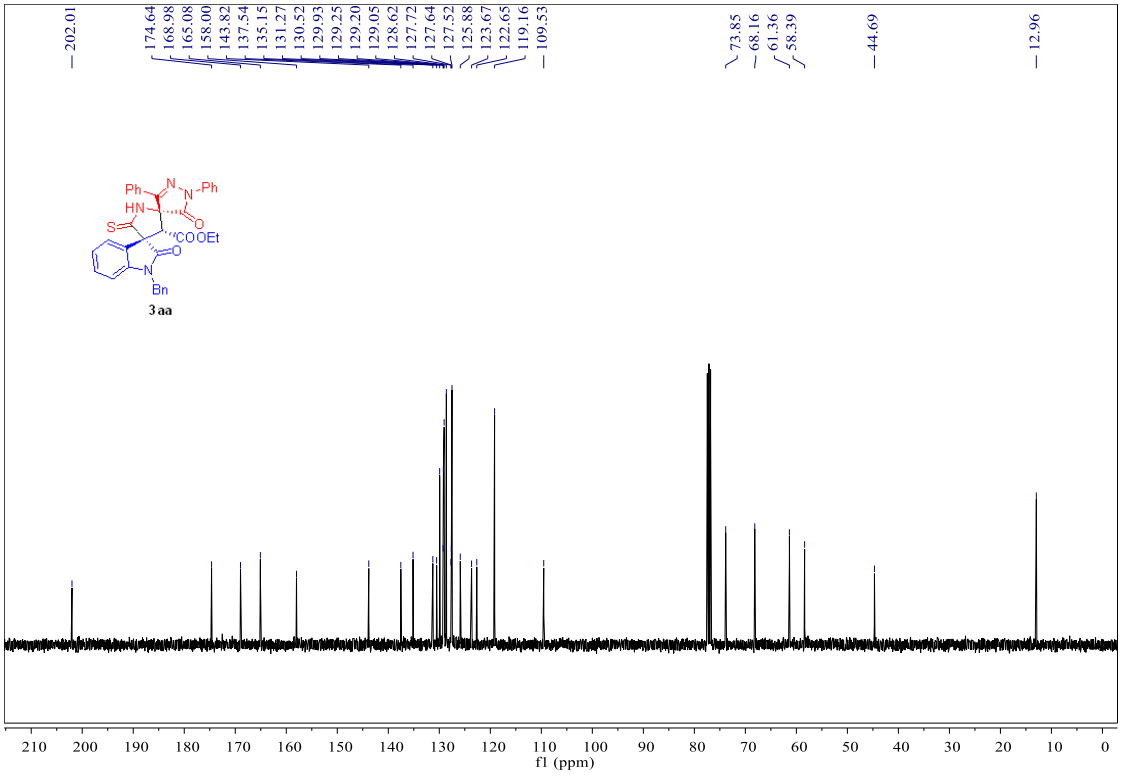
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.660	VB	1.4573	3.53199e4	284.32172	98.0705
2	29.501	BB	1.2104	694.89667	6.71990	1.9295

References

1. X. Bao, S. Wei, X. Qian, J. Qu, B. Wang, L. Zou, G. Ge, *Org. Lett*., 2018, **20**, 3394−3398.
2. X. Zhu, S. Chiba, *Chem. Commun.*, 2016, **52**, 2473−2476.

NMR spectra for compounds

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129.05
128.62
127.72
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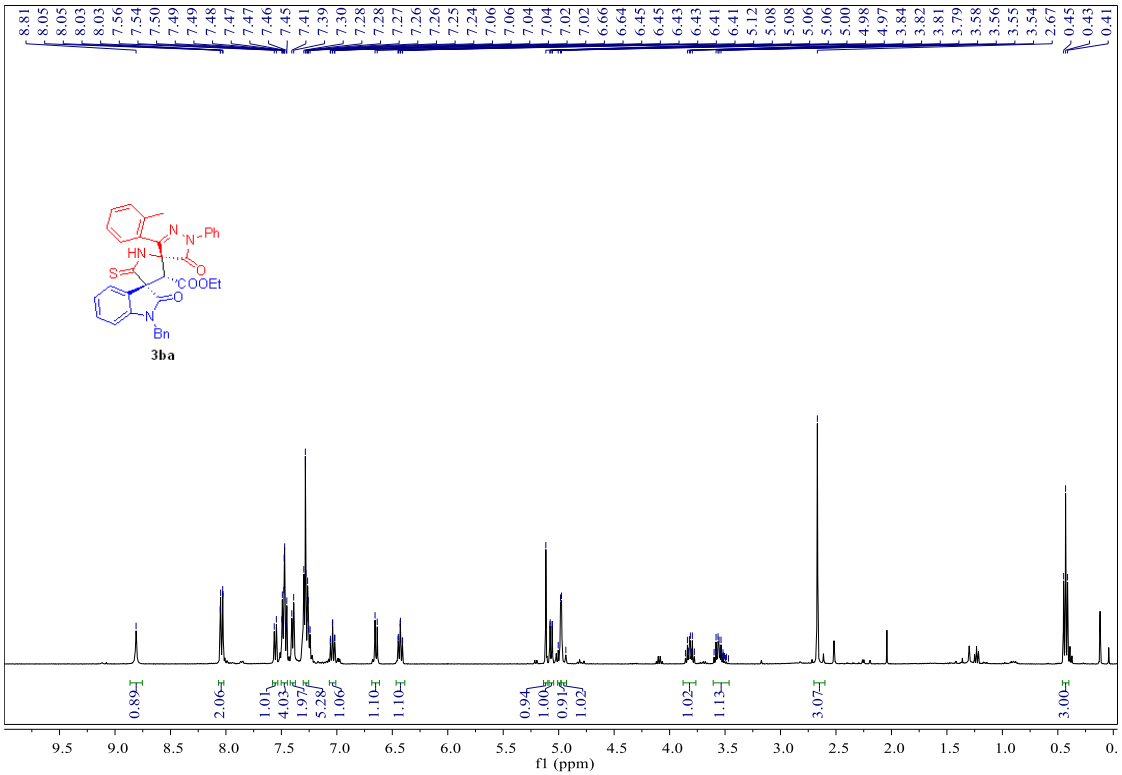
127.52
125.88
123.67
122.65
119.16
109.53
73.85
68.16
61.36
58.39
44.69
12.96
Ph
N
N-Ph
HN
S
O
COOEt
O
N
Bn
3aa
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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1.13
3.07
3.00
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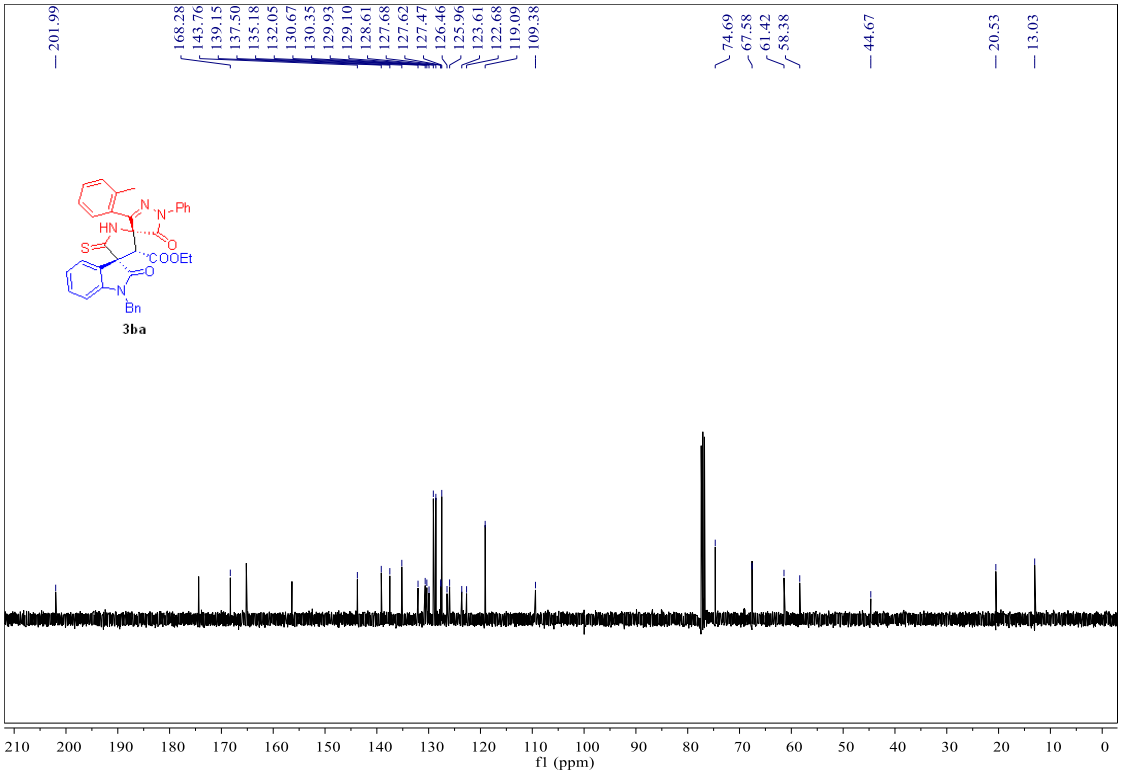
f1 (ppm)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122.68
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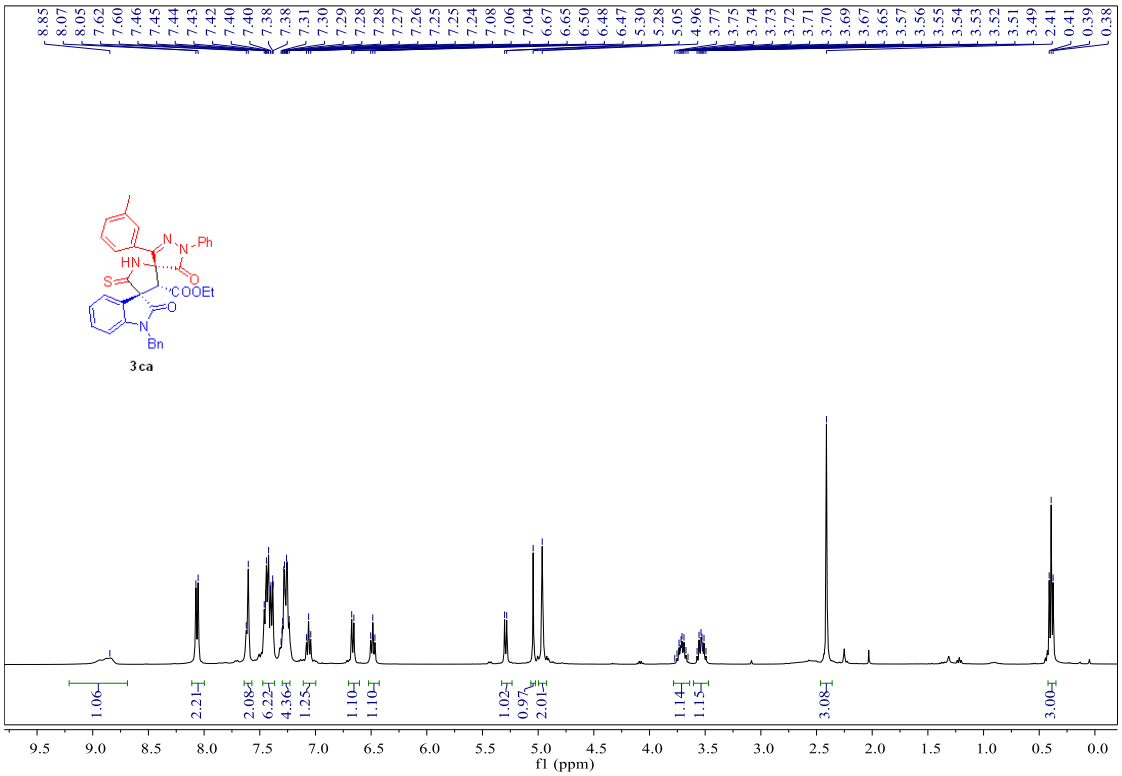
f1 (ppm)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COOEt
O
N
Bn
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2.08
6.22
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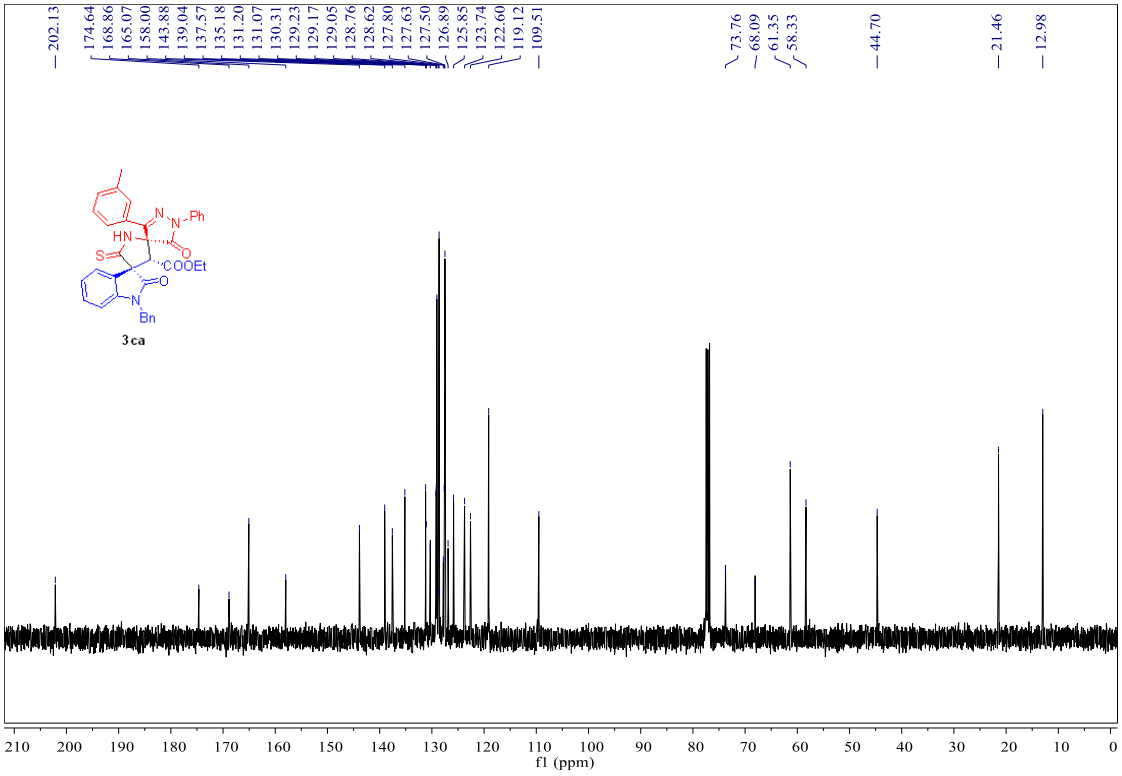
3.00
f1 (ppm)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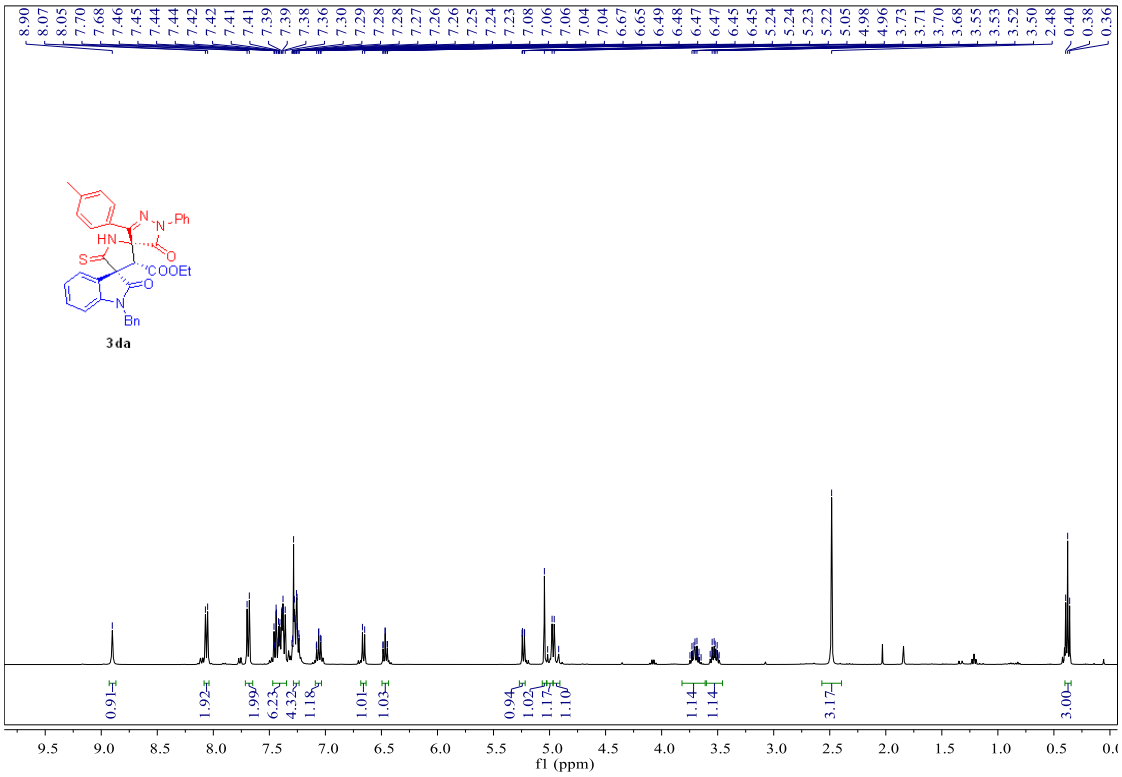
f1 (ppm)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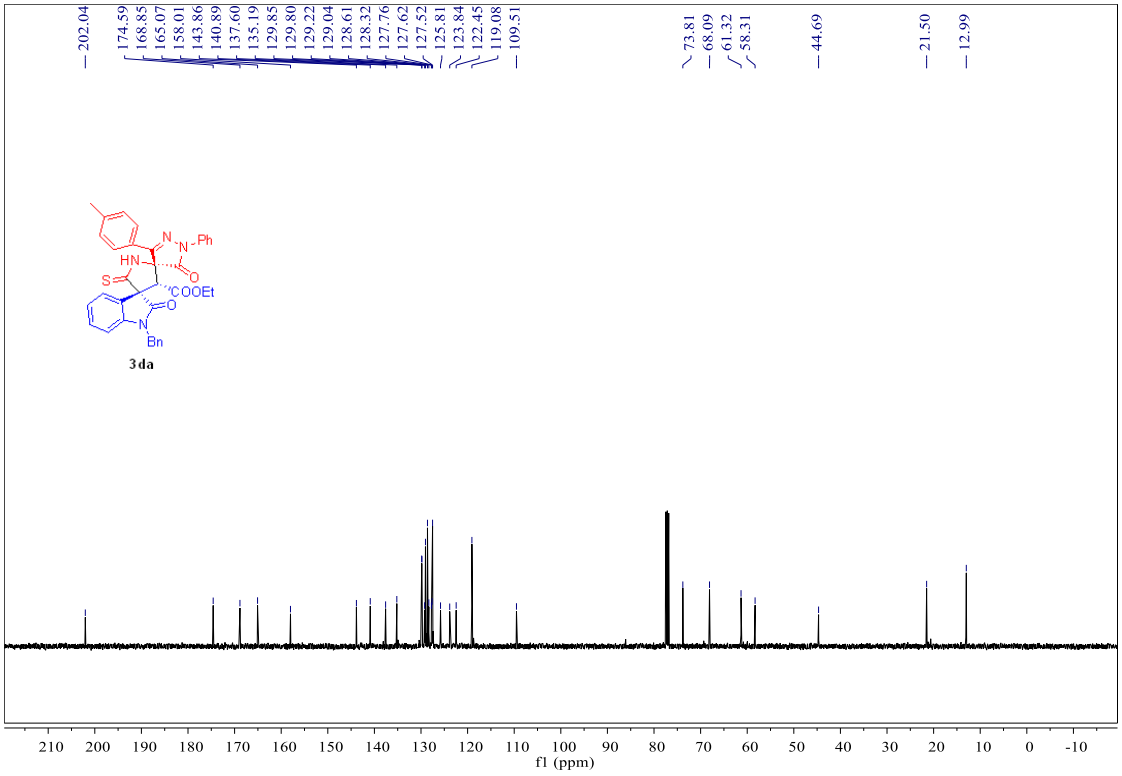
Ph
HN
S
COOEt
O
N
Bn
3da
0.91
1.92
1.99
6.23
4.32
1.18
1.01
1.03
0.94
1.02
1.17
1.10
1.14
1.14
3.17
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)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128.61
128.32
127.76
127.62
127.52
125.81
123.84
122.45
119.08
109.51
73.81
68.09
61.32
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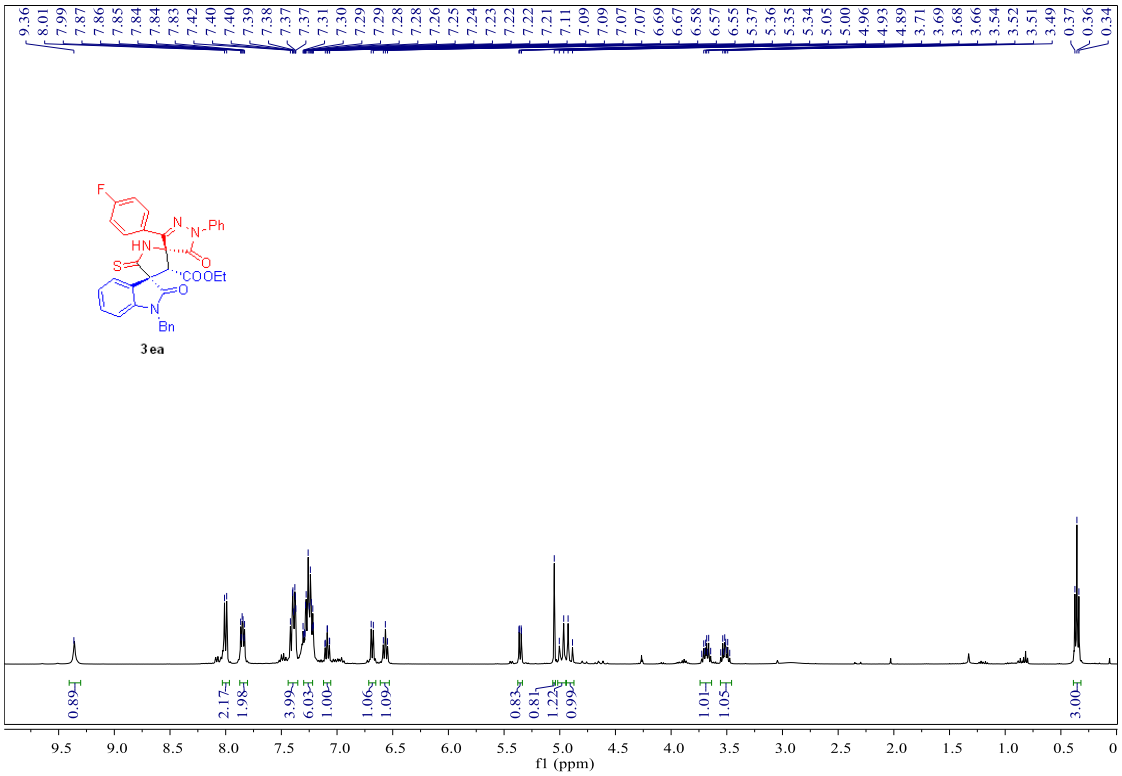
21.50
12.99
Ph
HN
S
O
COOEt
O
N
Bn
3da
f1 (ppm)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O
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O
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Bn
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3.99
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1.09
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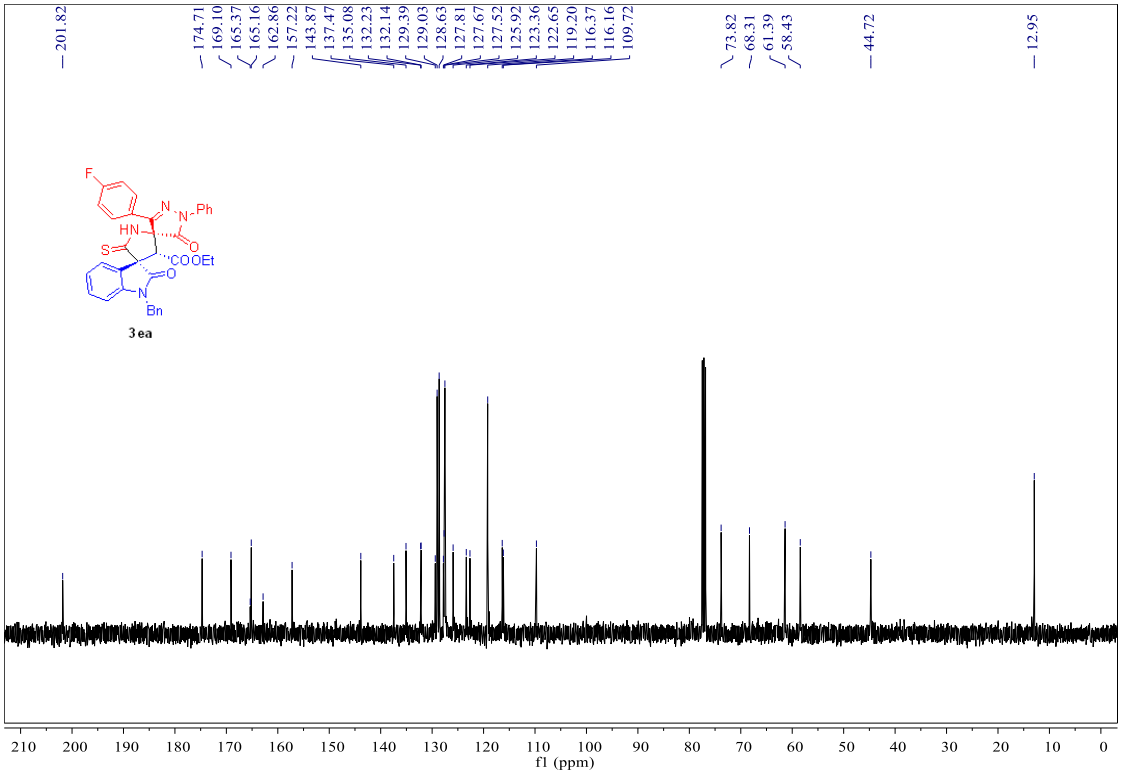
0.81
1.22
0.99
1.01
1.05
3.00
f1 (ppm)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132.23
132.14
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129.03
128.63
127.81
127.67
127.52
125.92
123.36
122.65
119.20
116.37
116.16
109.72
73.82
68.31
61.39
58.43
44.72
12.95
F
N
N
Ph
HN
S
O
COOEt
O
N
Bn
3ea
210
200
190
180
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130
120
110
100
90
80
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50
40
30
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10
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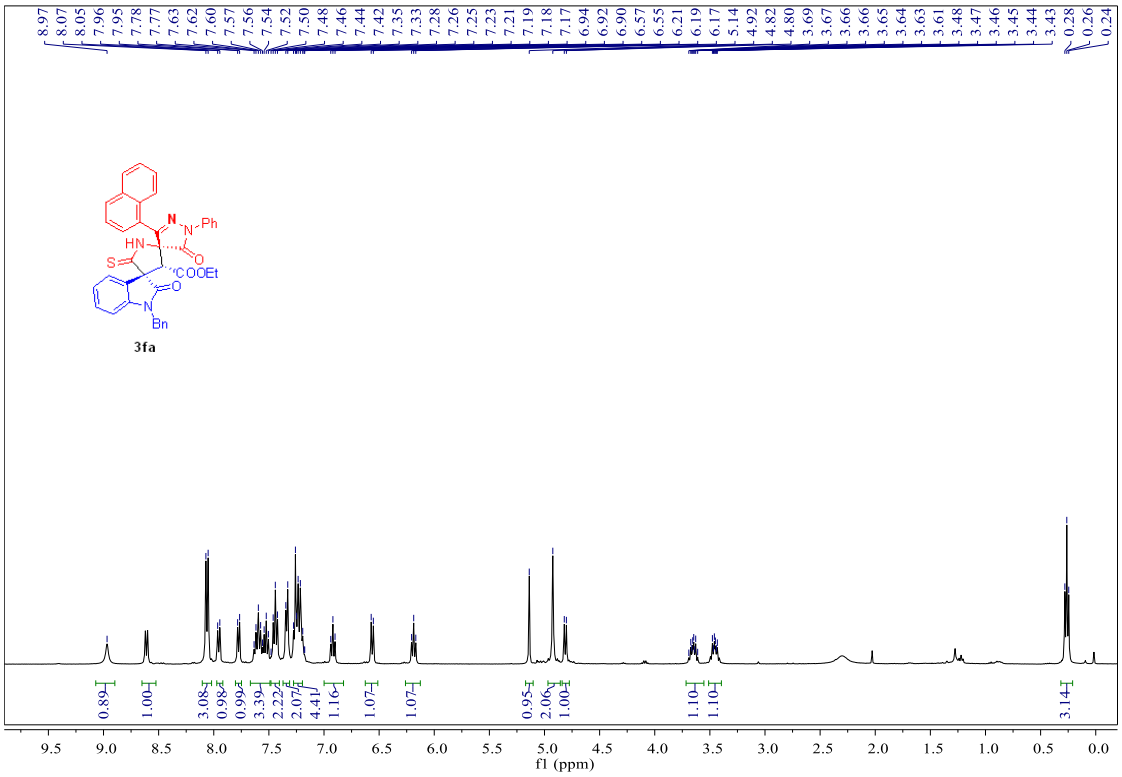
f1 (ppm)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7.56
7.54
7.52
7.50
7.48
7.46
7.44
7.42
7.35
7.33
7.28
7.26
7.25
7.23
7.21
7.19
7.18
7.17
6.94
6.92
6.90
6.57
6.55
6.21
6.19
6.17
5.14
4.92
4.82
4.80
3.69
3.67
3.66
3.66
3.65
3.64
3.63
3.61
3.48
3.47
3.46
3.45
3.44
3.43
0.28
0.26
0.24
N
N
Ph
HN
S
O
COOEt
O
N
Bn
3fa
0.89
1.00
3.08
0.98
0.99
3.39
2.22
2.07
4.41
1.16
1.07
1.07
0.95
2.06
1.00
1.10
1.10
3.14
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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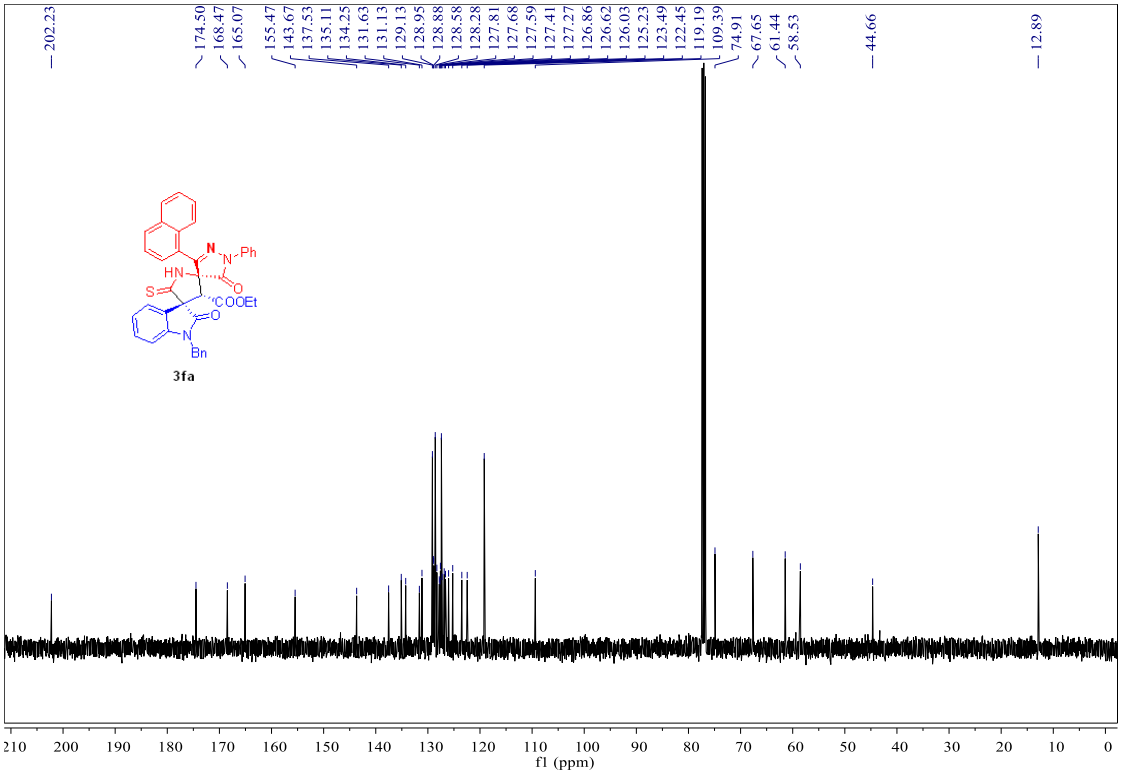
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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131.13
129.13
128.95
128.88
128.58
128.28
127.81
127.68
127.59
127.41
127.27
126.86
126.62
126.03
125.23
123.49
122.45
119.19
109.39
74.91
67.65
61.44
58.53
44.66
12.89
Ph
HN
S
COOEt
O
N
Bn
3fa
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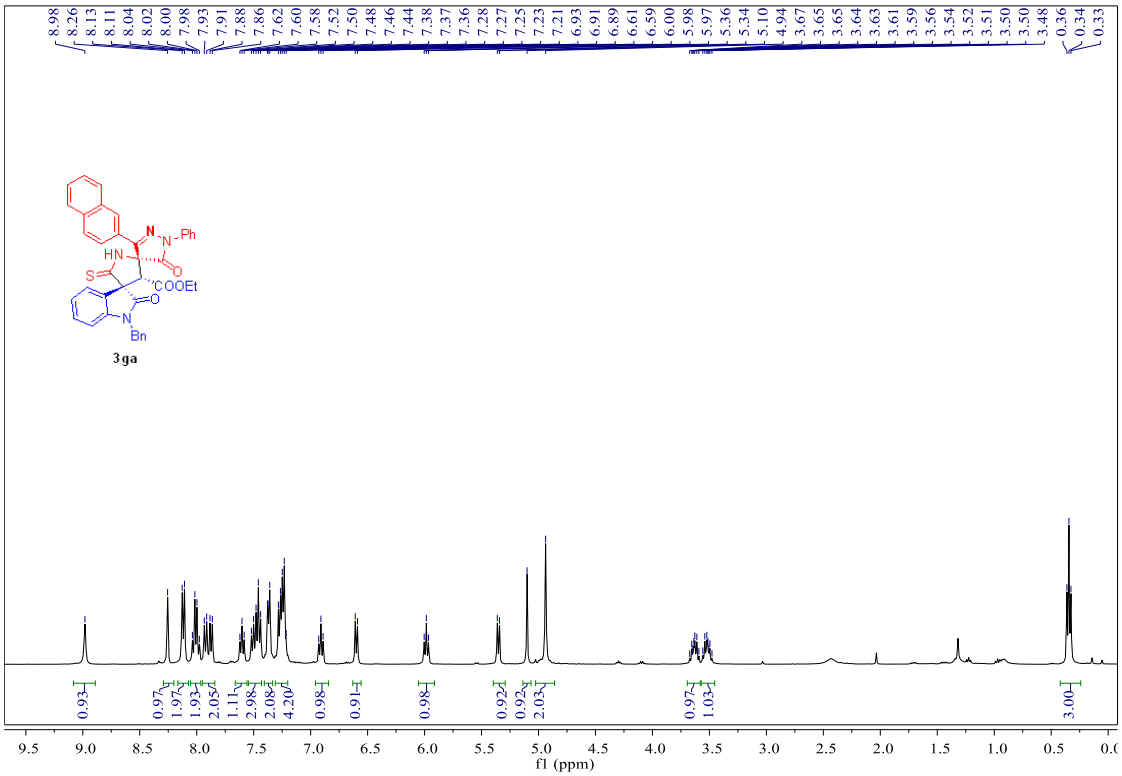
f1 (ppm)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8.00
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7.91
7.88
7.86
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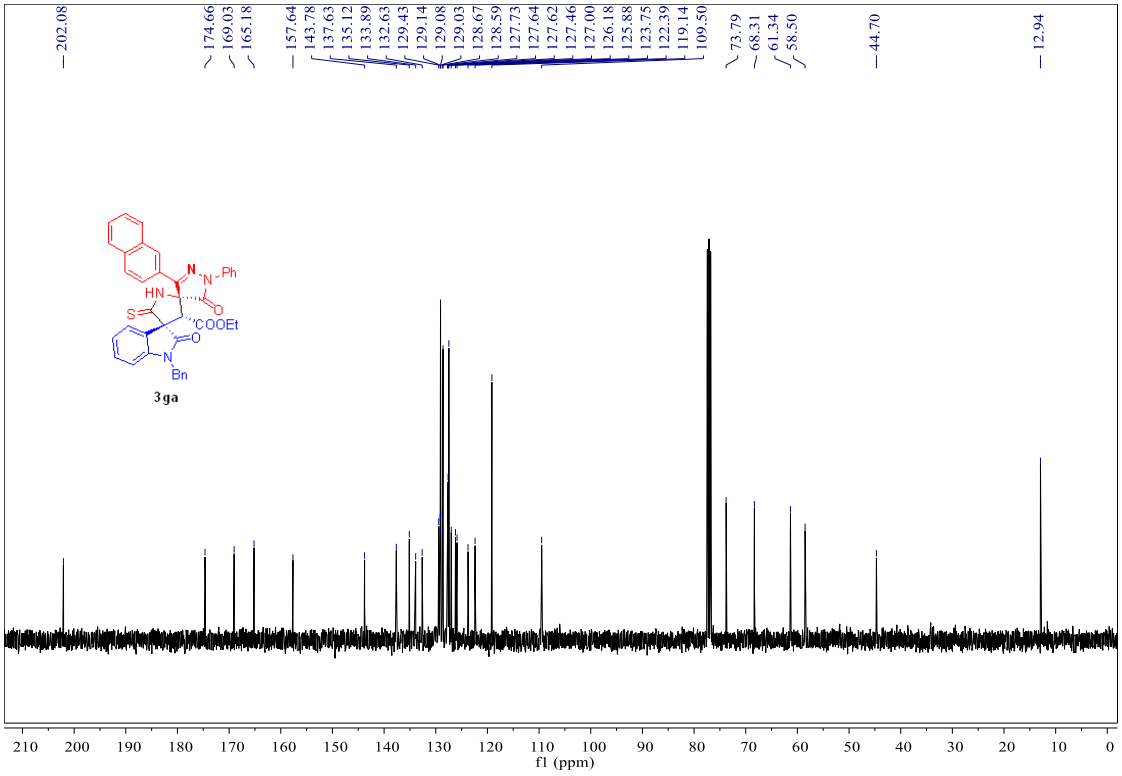
7.60
7.58
7.52
7.50
7.48
7.46
7.44
7.38
7.37
7.36
7.28
7.27
7.25
7.23
7.21
6.93
6.91
6.89
6.61
6.59
6.00
5.98
5.97
5.36
5.34
5.10
4.94
3.67
3.65
3.65
3.64
3.63
3.61
3.59
3.56
3.54
3.52
3.51
3.50
3.50
3.48
0.36
0.34
0.33
Ph
HN
S
COOEt
O
N
Bn
3ga
0.93
0.97
1.97
1.93
2.05
1.11
2.98
2.08
4.20
0.98
0.91
0.98
0.92
0.92
2.03
0.97
1.03
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)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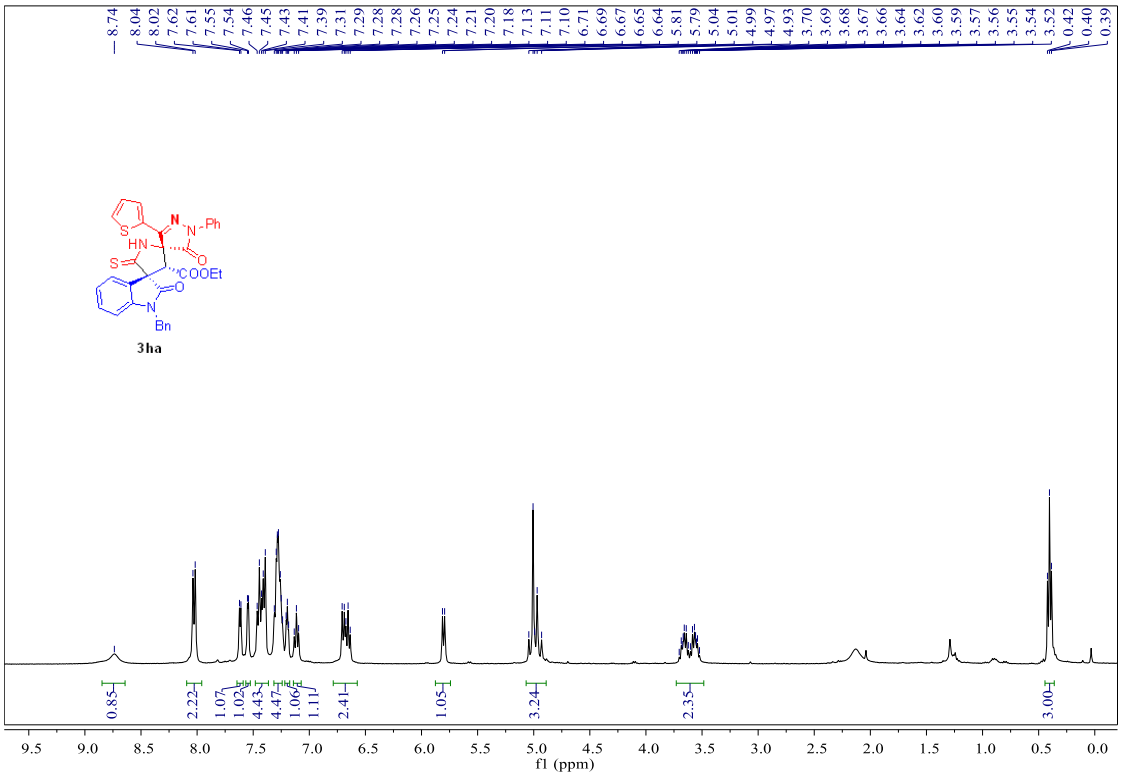
135.12
133.89
132.63
129.43
129.14
129.08
129.03
128.67
128.59
127.73
127.64
127.62
127.46
127.00
126.18
125.88
123.75
122.39
119.14
109.50
73.79
68.31
61.34
58.50
44.70
12.94
Ph
N
HN
S
O
COOEt
O
N
Bn
3ga
f1 (ppm)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7.43
7.41
7.39
7.31
7.29
7.28
7.28
7.26
7.25
7.24
7.21
7.20
7.18
7.13
7.11
7.10
6.71
6.69
6.67
6.65
6.64
5.81
5.79
5.04
5.01
4.99
4.97
4.93
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3.69
3.68
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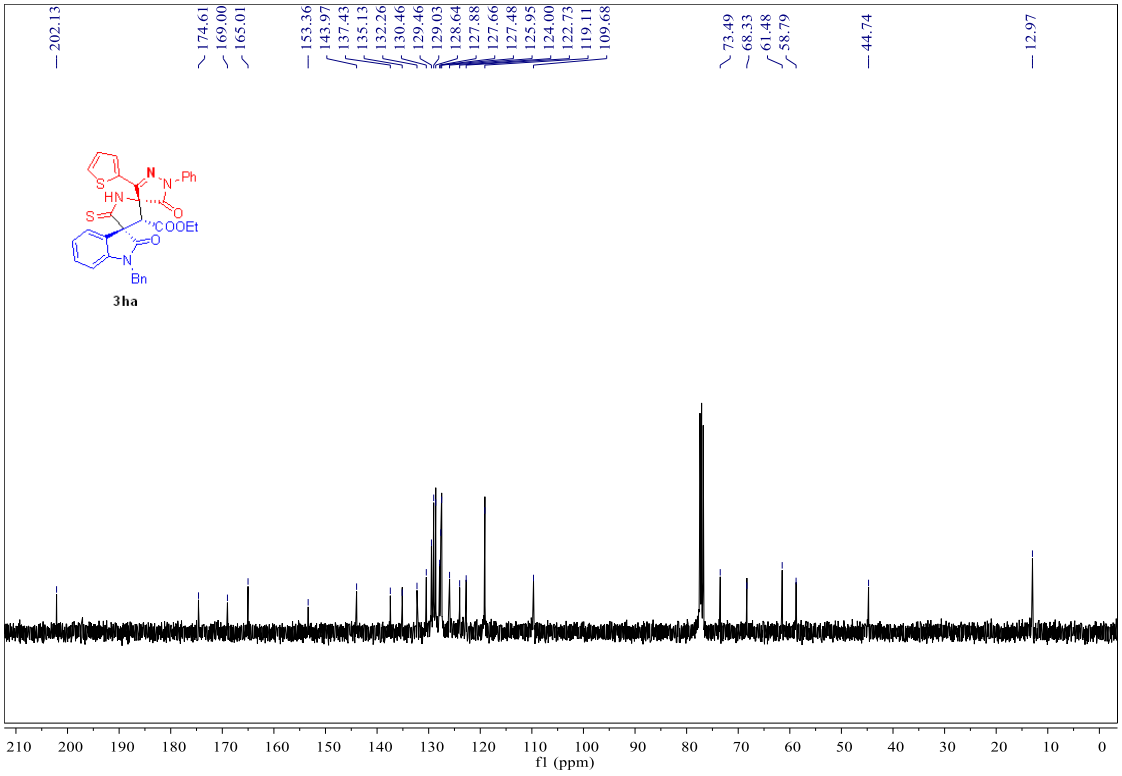
3.66
3.64
3.62
3.60
3.59
3.57
3.56
3.55
3.54
3.52
0.42
0.40
0.39
Ph
N
S
HN
S
O
COOEt
O
N
Bn
3ha
0.85
2.22
1.07
1.02
4.43
4.47
1.06
1.11
2.41
1.05
3.24
2.35
3.00
f1 (ppm)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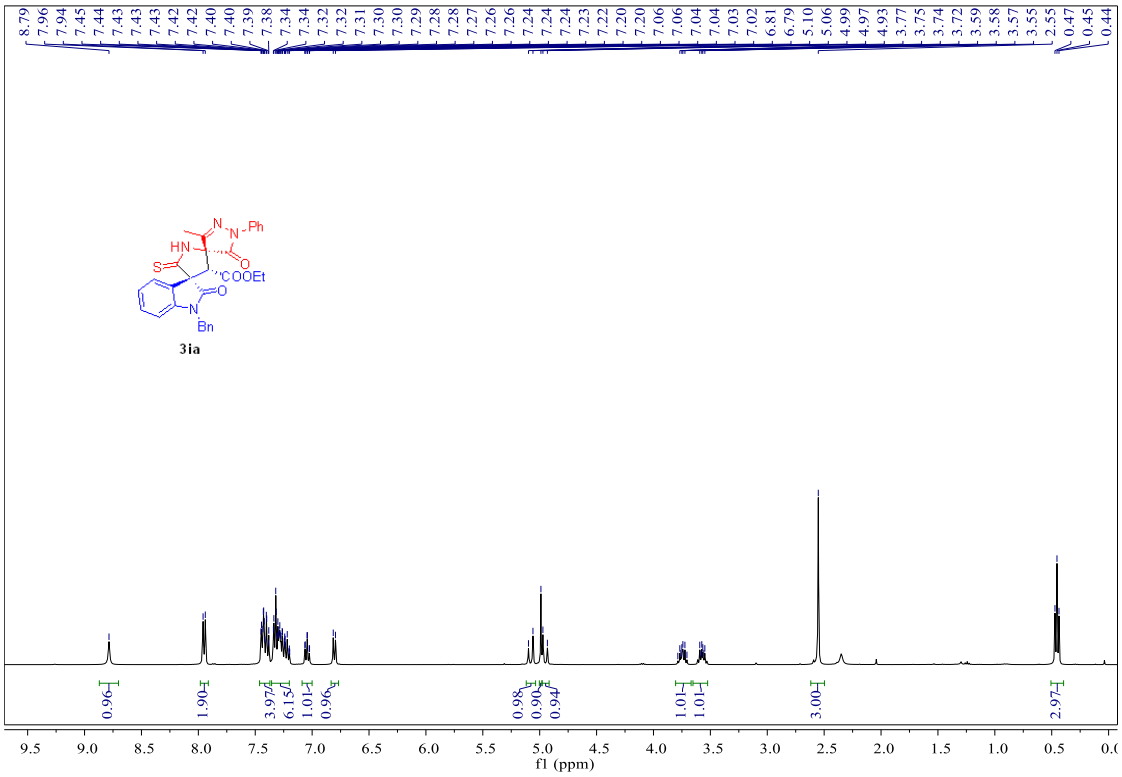
135.13
132.26
130.46
129.46
129.03
128.64
127.88
127.66
127.48
125.95
124.00
122.73
119.11
109.68
73.49
68.33
61.48
58.79
44.74
12.97
3ha
fl (ppm)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1.90
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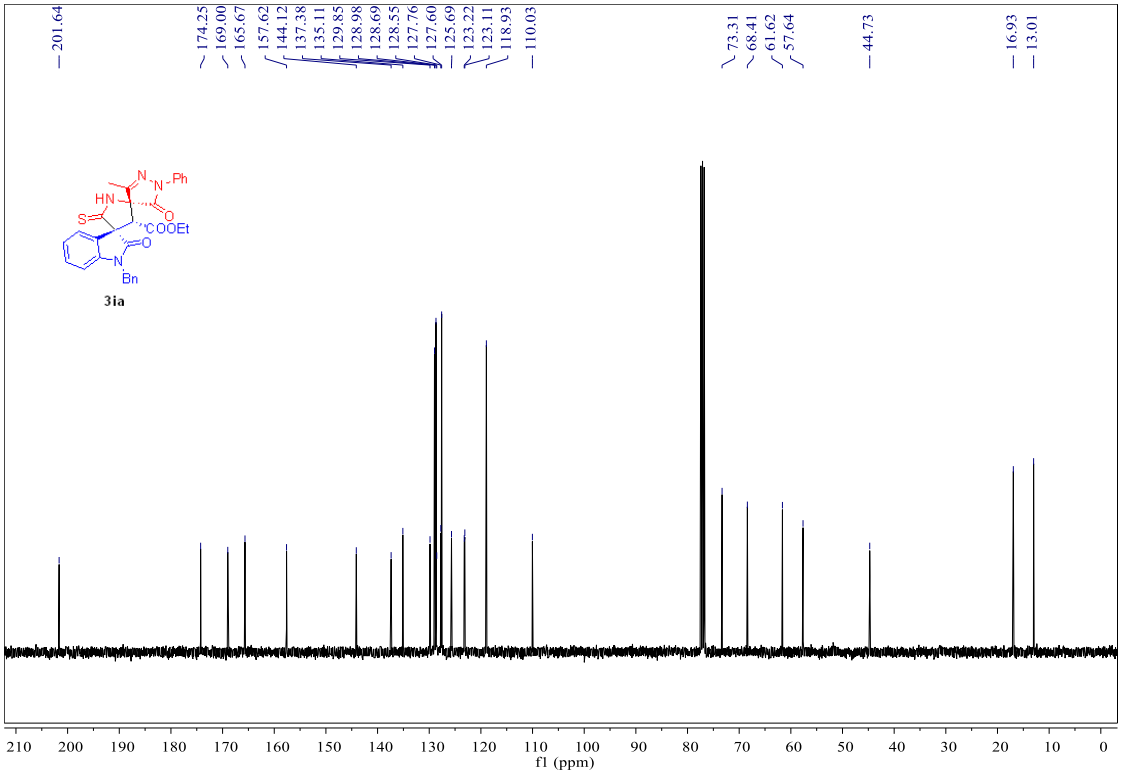
6.15
1.01
0.96
0.98
0.90
0.94
1.01
1.01
3.00
2.97
fl (ppm)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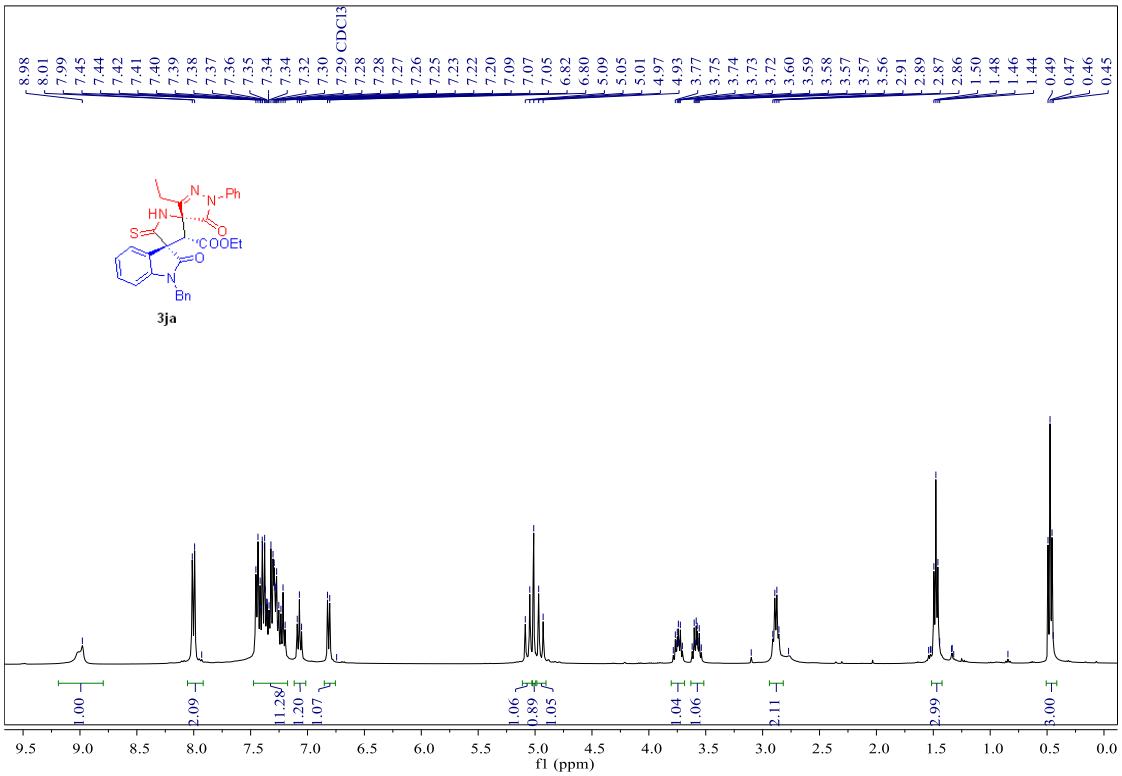
128.98
128.69
128.55
127.76
127.60
125.69
123.22
123.11
118.93
110.03
73.31
68.41
61.62
57.64
44.73
16.93
13.01
Ph
HN
S
O
COOEt
O
N
Bn
3ia
fl (ppm)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7.36
7.35
7.34
7.34
7.32
7.30
7.29 CDCl3
7.28
7.28
7.27
7.26
7.25
7.23
7.22
7.20
7.09
7.07
7.05
6.82
6.80
5.09
5.05
5.01
4.97
4.93
3.77
3.75
3.74
3.73
3.72
3.60
3.59
3.58
3.57
3.57
3.56
2.91
2.89
2.87
2.86
1.50
1.48
1.46
1.44
0.49
0.47
0.46
0.45
Ph
HN
S
O
COOEt
O
N
Bn
3ja
1.00
2.09
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1.20
1.07
1.06
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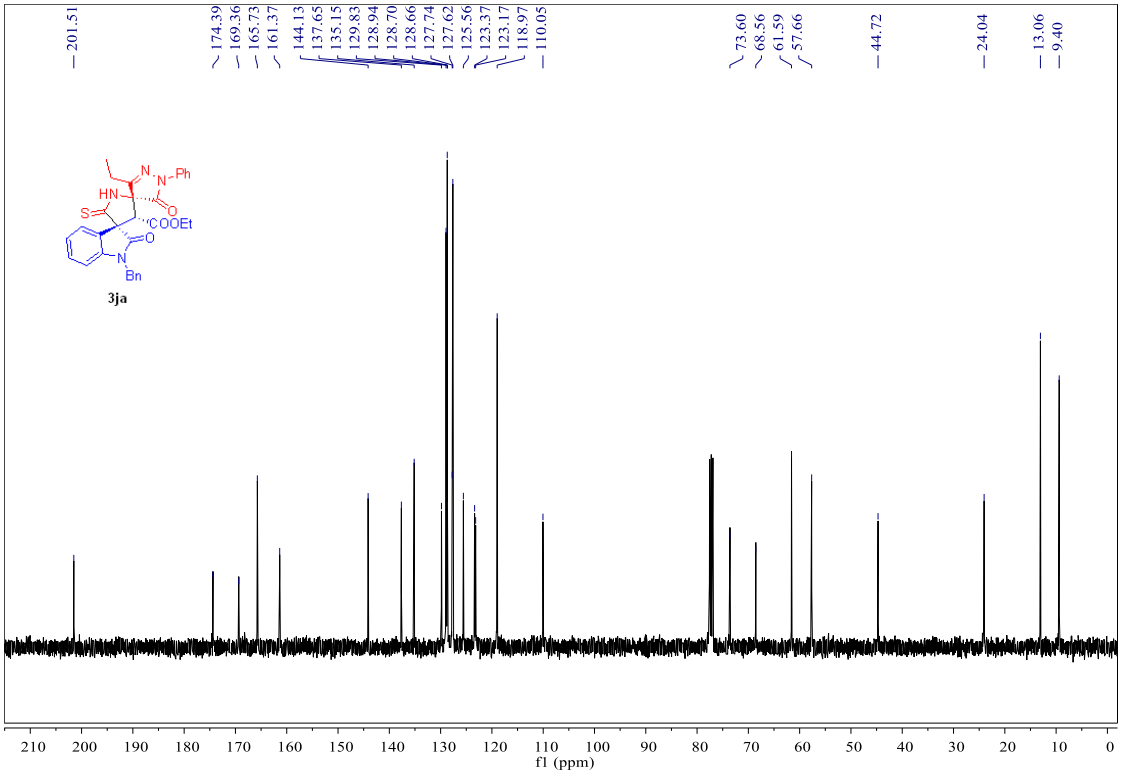
1.05
1.04
1.06
2.11
2.99
3.00
fl (ppm)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127.62
125.56
123.37
123.17
118.97
110.05
73.60
68.56
61.59
57.66
44.72
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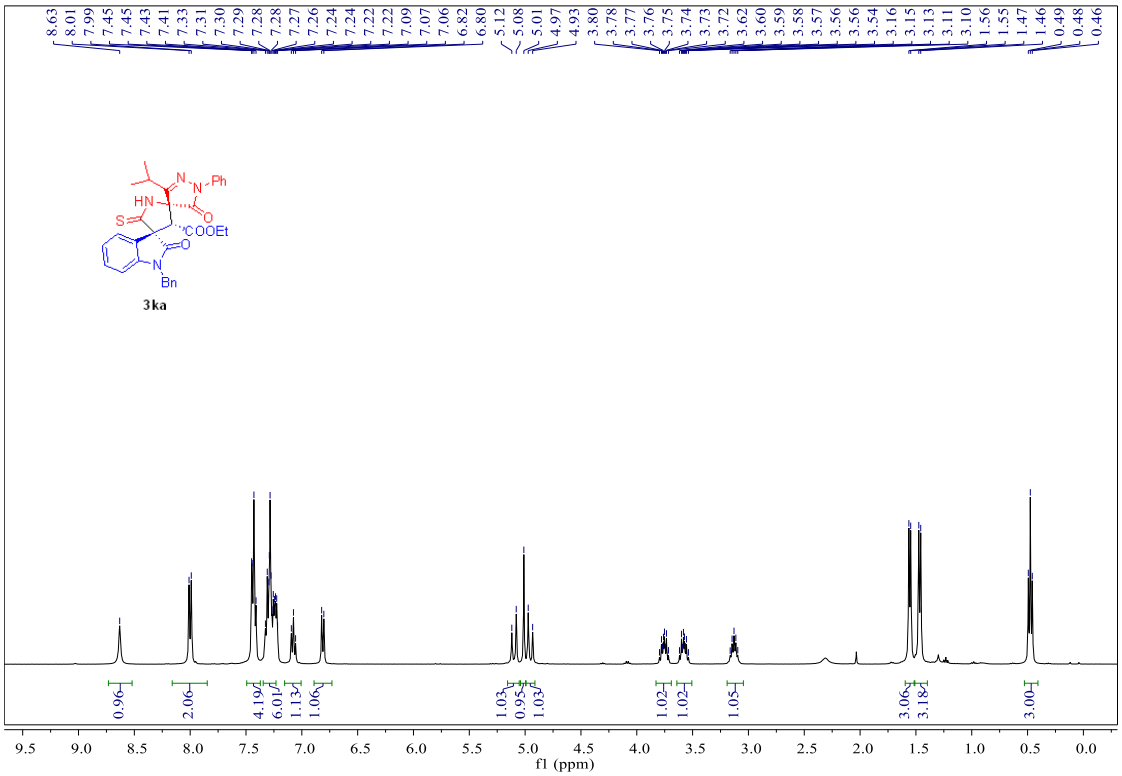
13.06
9.40
Ph
HN
S
O
COOEt
O
N
Bn
3ja
fl (ppm)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7.28
7.28
7.27
7.26
7.24
7.24
7.22
7.22
7.09
7.07
7.06
6.82
6.80
5.12
5.08
5.01
4.97
4.93
3.80
3.78
3.77
3.76
3.75
3.74
3.73
3.72
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3.58
3.57
3.56
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3.54
3.16
3.15
3.13
3.11
3.10
1.56
1.55
1.47
1.46
0.49
0.48
0.46
Ph
HN
S
O
COOEt
O
N
Bn
3ka
0.96
2.06
4.19
6.01
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1.06
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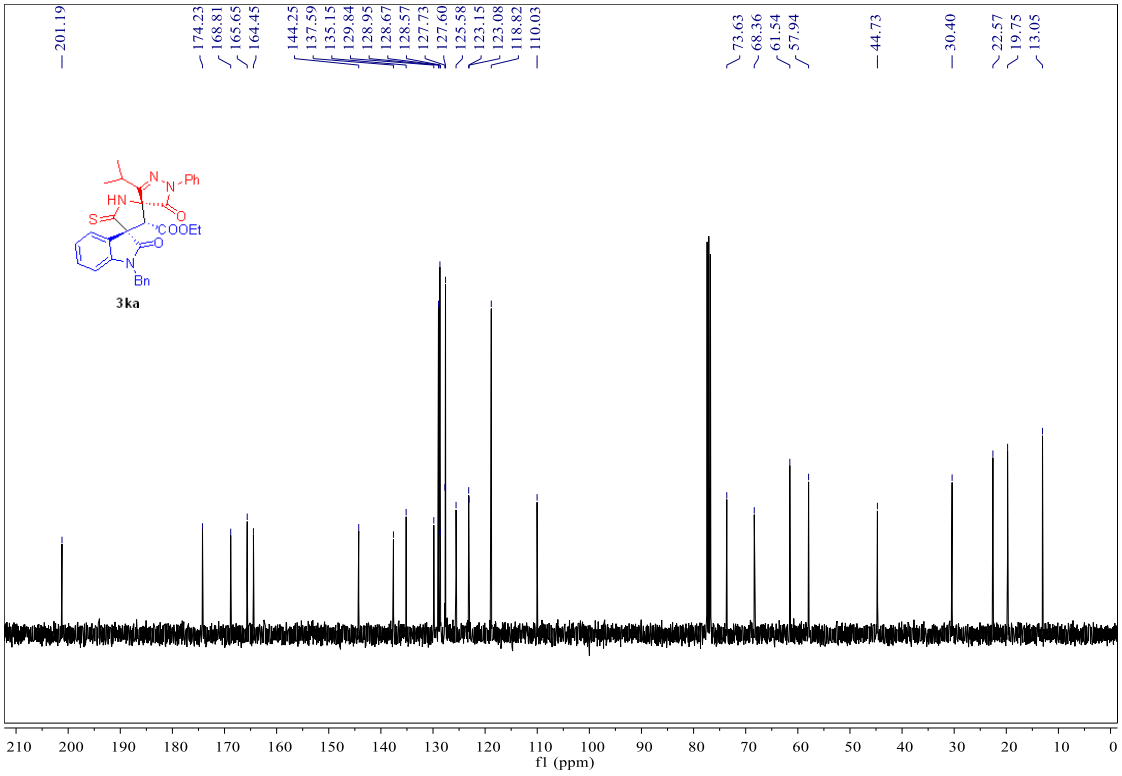
0.95
1.03
1.02
1.02
1.05
3.06
3.18
3.00
fl (ppm)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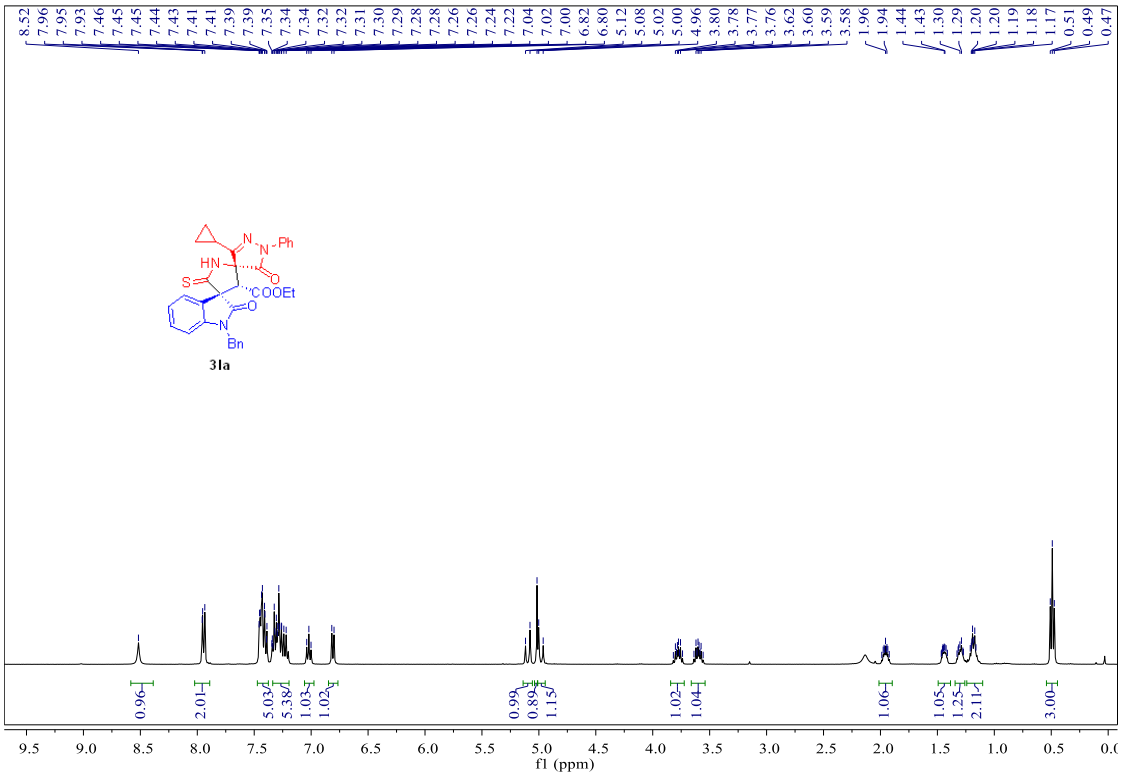
128.67
128.57
127.73
127.60
125.58
123.15
123.08
118.82
110.03
73.63
68.36
61.54
57.94
44.73
30.40
22.57
19.75
13.05
Ph
HN
S
O
COOEt
O
N
Bn
3ka
fl (ppm)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7.39
7.35
7.34
7.34
7.32
7.32
7.31
7.30
7.29
7.28
7.28
7.26
7.26
7.24
7.22
7.04
7.02
7.00
6.82
6.80
5.12
5.08
5.02
5.00
4.96
3.80
3.78
3.77
3.76
3.62
3.60
3.59
3.58
1.96
1.94
1.44
1.43
1.30
1.29
1.20
1.20
1.19
1.18
1.17
0.51
0.49
0.47
Ph
HN
S
O
COOEt
O
N
Bn
3la
0.96
2.01
5.03
5.38
1.03
1.02
0.99
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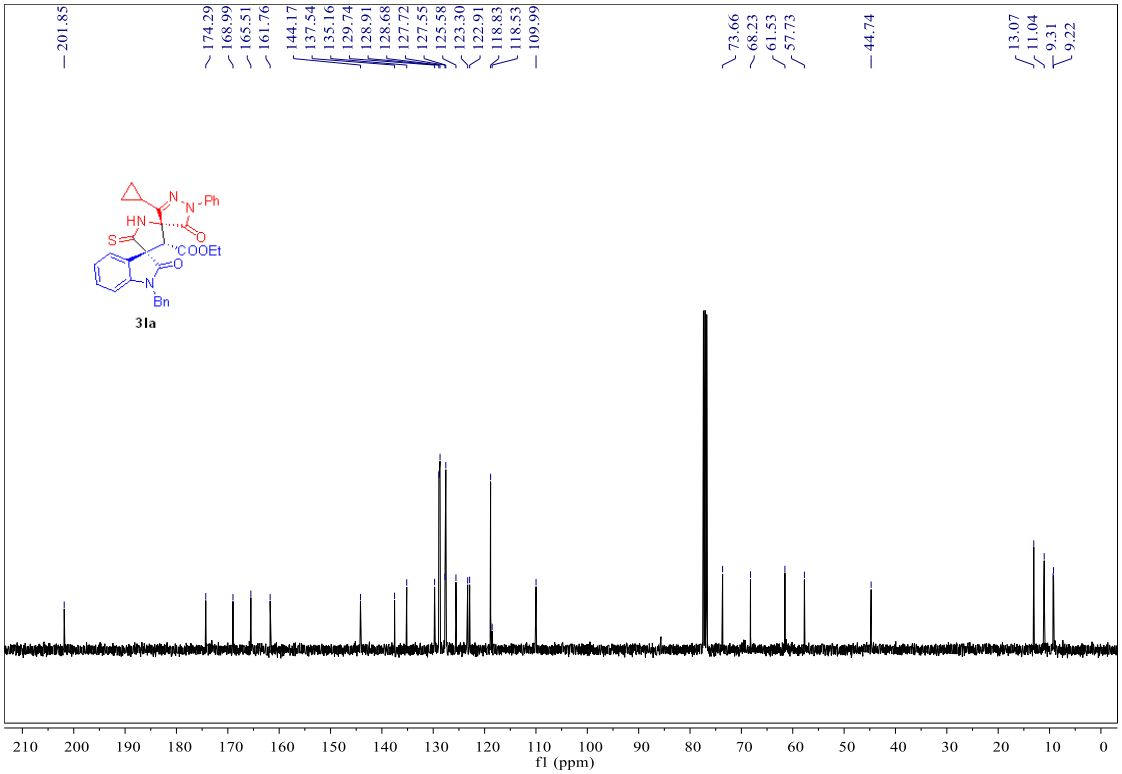
1.15
1.02
1.04
1.06
1.05
1.25
2.11
3.00
fl (ppm)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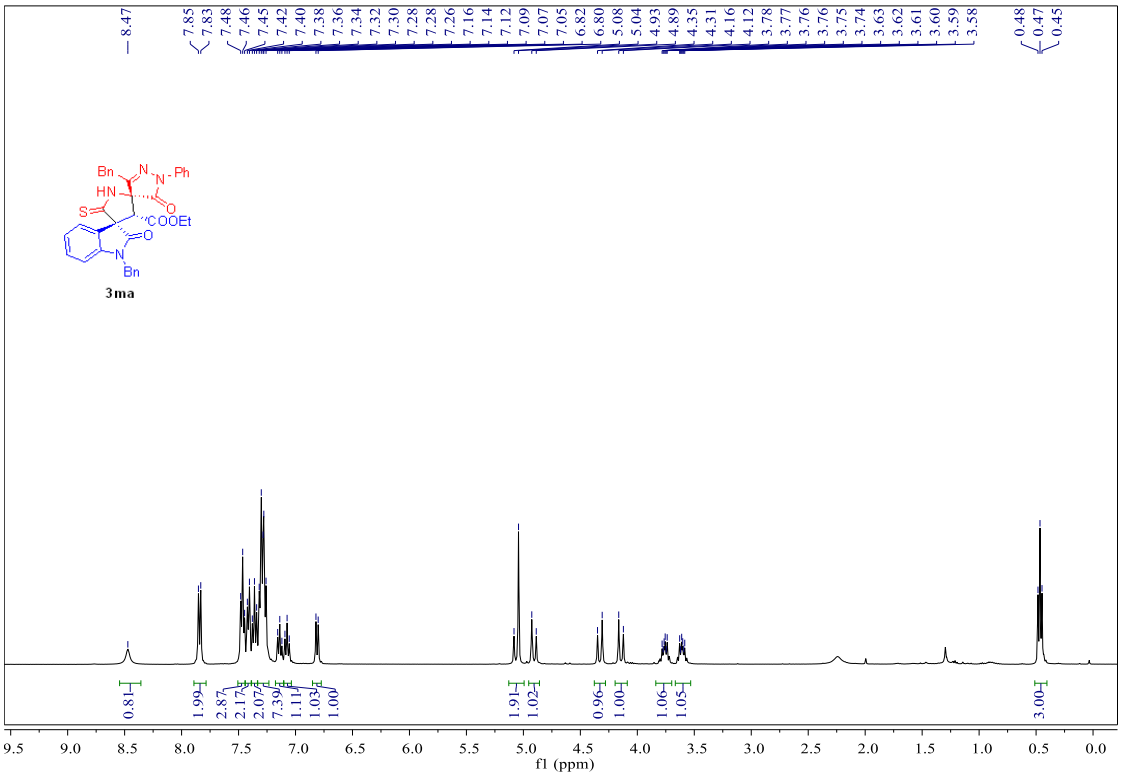
128.91
128.68
127.72
127.55
125.58
123.30
122.91
118.83
118.53
109.99
73.66
68.23
61.53
57.73
44.74
13.07
11.04
9.31
9.22
Ph
HN
S
O
COOEt
O
N
Bn
3la
fl (ppm)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7.32
7.30
7.28
7.28
7.26
7.16
7.14
7.12
7.09
7.07
7.05
6.82
6.80
5.08
5.04
4.93
4.89
4.35
4.31
4.16
4.12
3.78
3.77
3.76
3.76
3.75
3.74
3.63
3.62
3.61
3.60
3.59
3.58
0.48
0.47
0.45
Bn
Ph
HN
S
O
COOEt
O
N
Bn
3ma
0.81
1.99
2.87
2.17
2.07
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1.11
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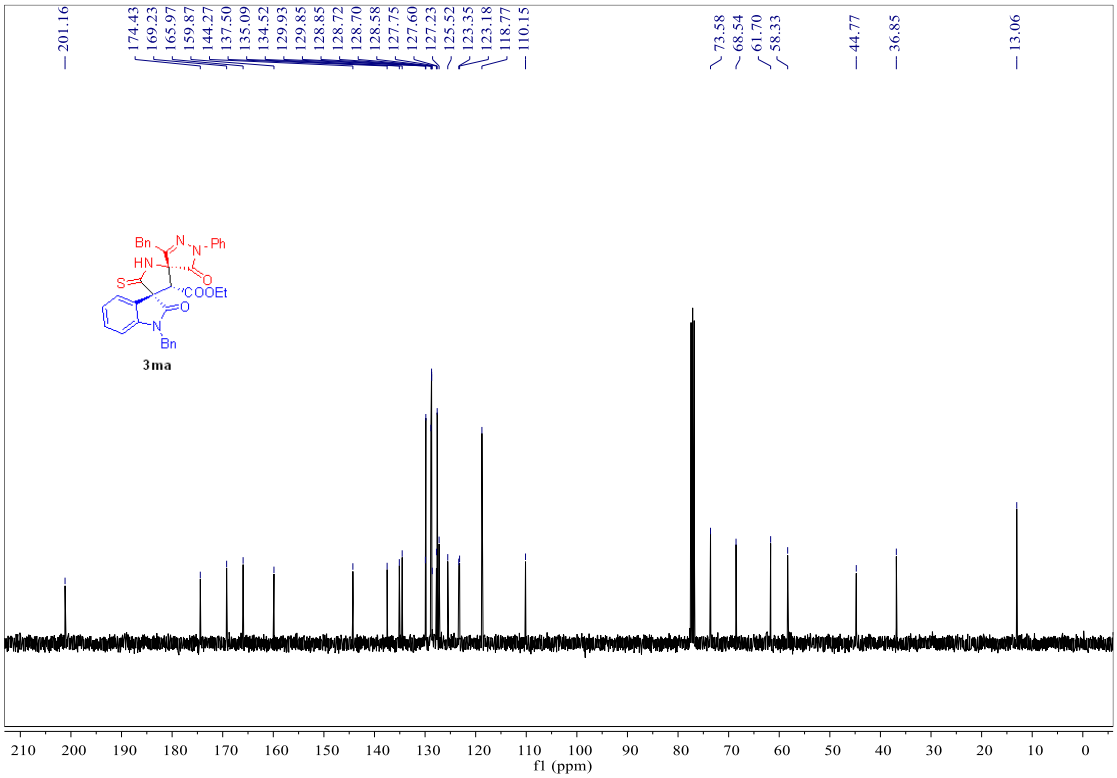
1.00
1.91
1.02
0.96
1.00
1.06
1.05
3.00
fl (ppm)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129.93
129.85
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128.72
128.70
128.58
127.75
127.60
127.23
125.52
123.35
123.18
118.77
110.15
73.58
68.54
61.70
58.33
44.77
36.85
13.06
Bn
N
N
Ph
HN
S
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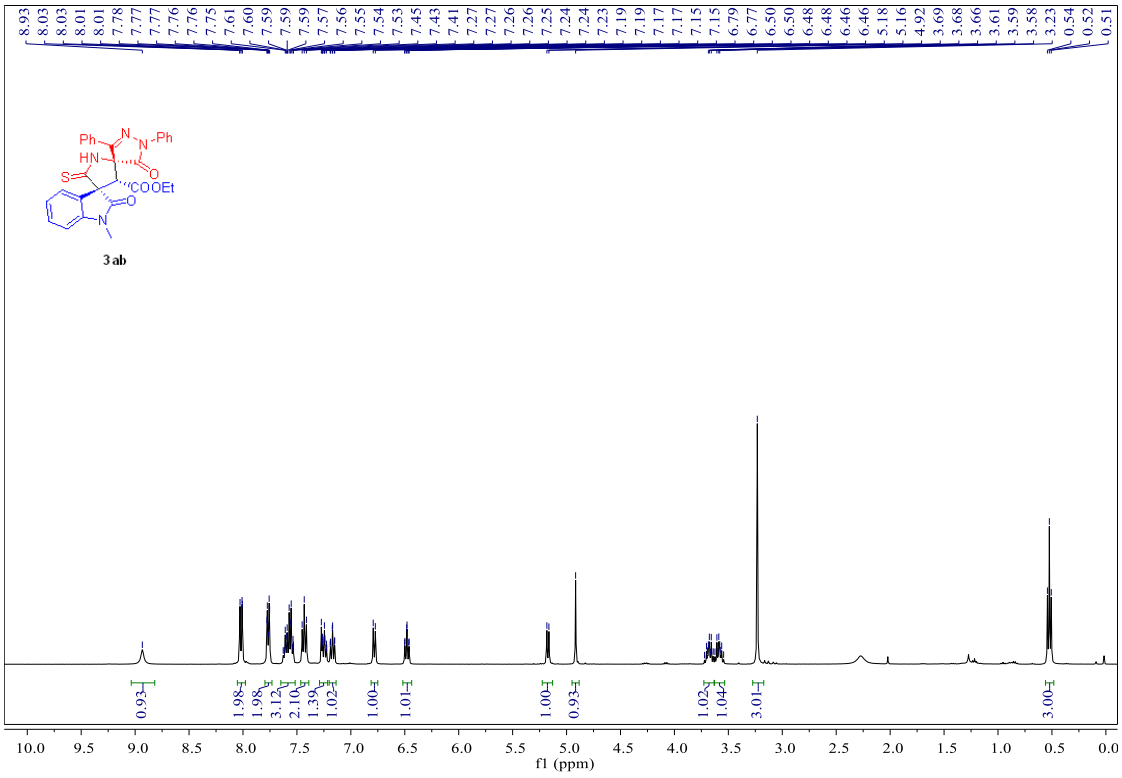
COOEt
O
N
Bn
3ma
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.54
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7.17
7.15
7.15
6.79
6.77
6.50
6.50
6.48
6.48
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3.68
3.66
3.61
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3.58
3.23
0.54
0.52
0.51
Ph
N
N
Ph
HN
S
O
COOEt
O
N
3ab
0.93
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1.98
3.12
2.10
1.39
1.02
1.00
1.01
1.00
0.93
1.02
1.04
3.01
3.00
10.0 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
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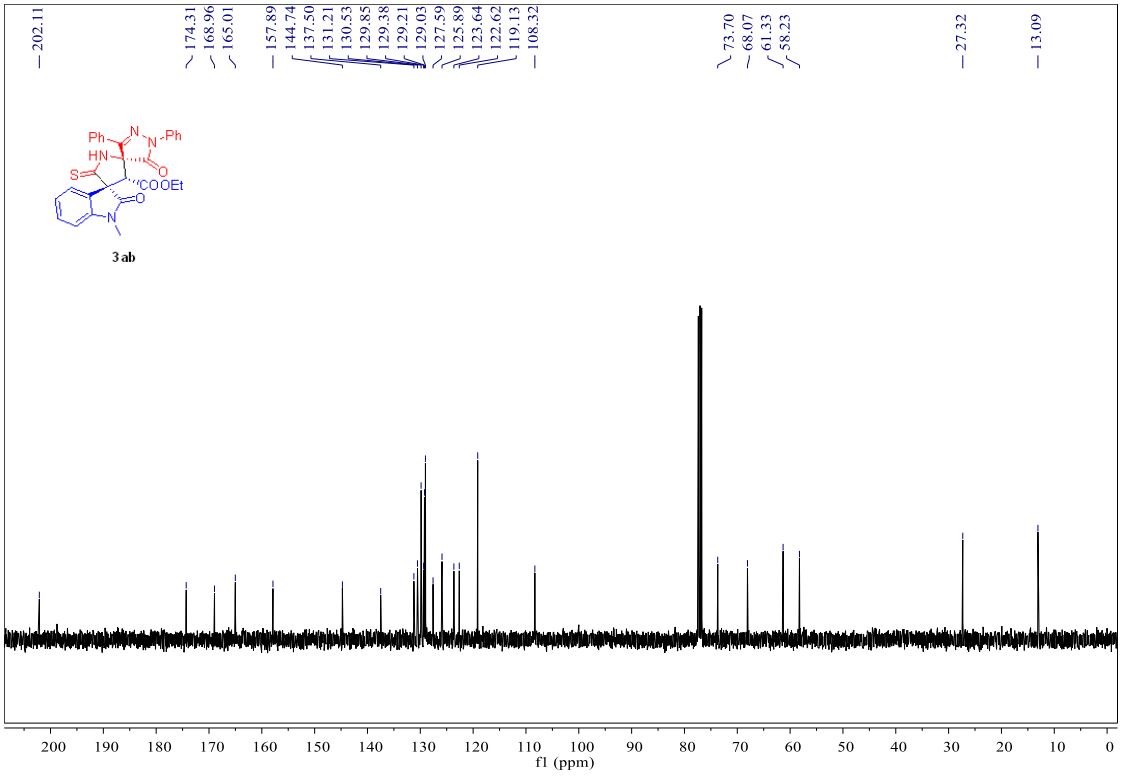
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129.21
129.03
127.59
125.89
123.64
122.62
119.13
108.32
73.70
68.07
61.33
58.23
27.32
13.09
Ph
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N
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Ph
O
COOEt
O
N
3ab
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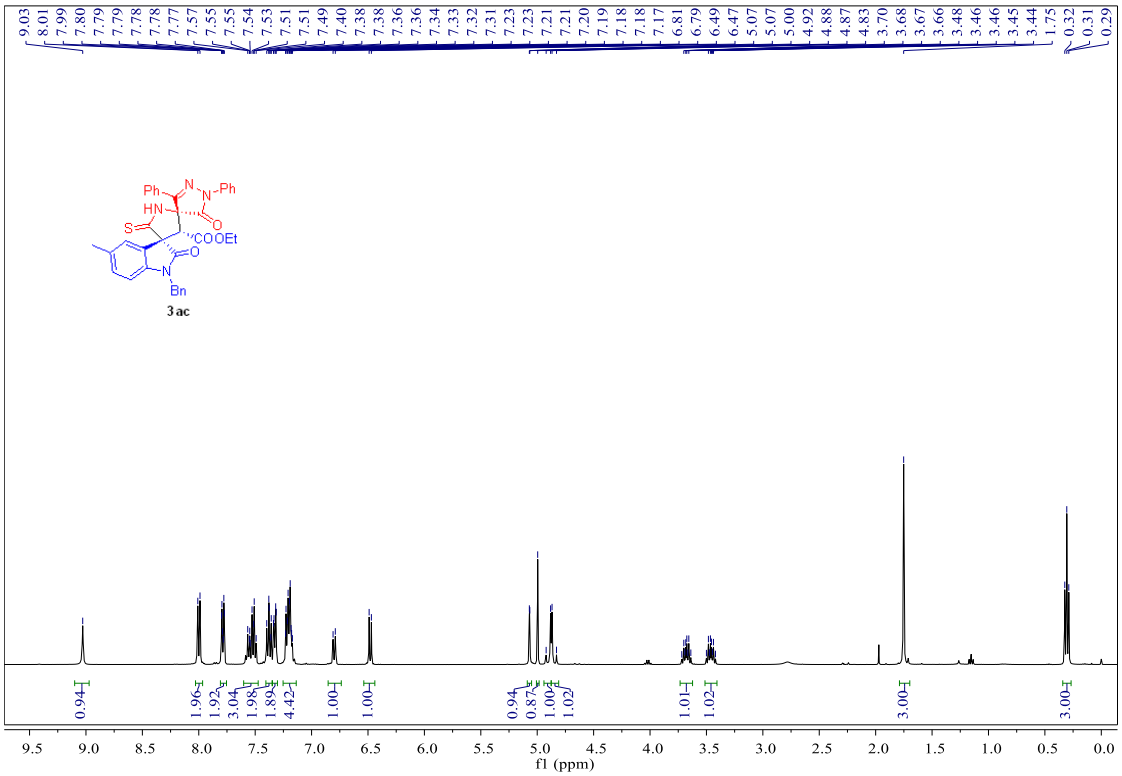
f1 (ppm)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7.54
7.53
7.51
7.51
7.49
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7.38
7.36
7.36
7.34
7.33
7.32
7.31
7.23
7.23
7.21
7.21
7.20
7.19
7.18
7.18
7.17
6.81
6.79
6.49
6.47
5.07
5.07
5.00
4.92
4.88
4.87
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3.70
3.68
3.67
3.66
3.48
3.46
3.46
3.45
3.44
1.75
0.32
0.31
0.29
Ph
HN
S
N
N
Ph
O
COOEt
O
N
Bn
3ac
0.94
1.96
1.92
3.04
1.98
1.89
4.42
1.00
1.00
0.94
0.87
1.00
1.02
1.01
1.02
3.00
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
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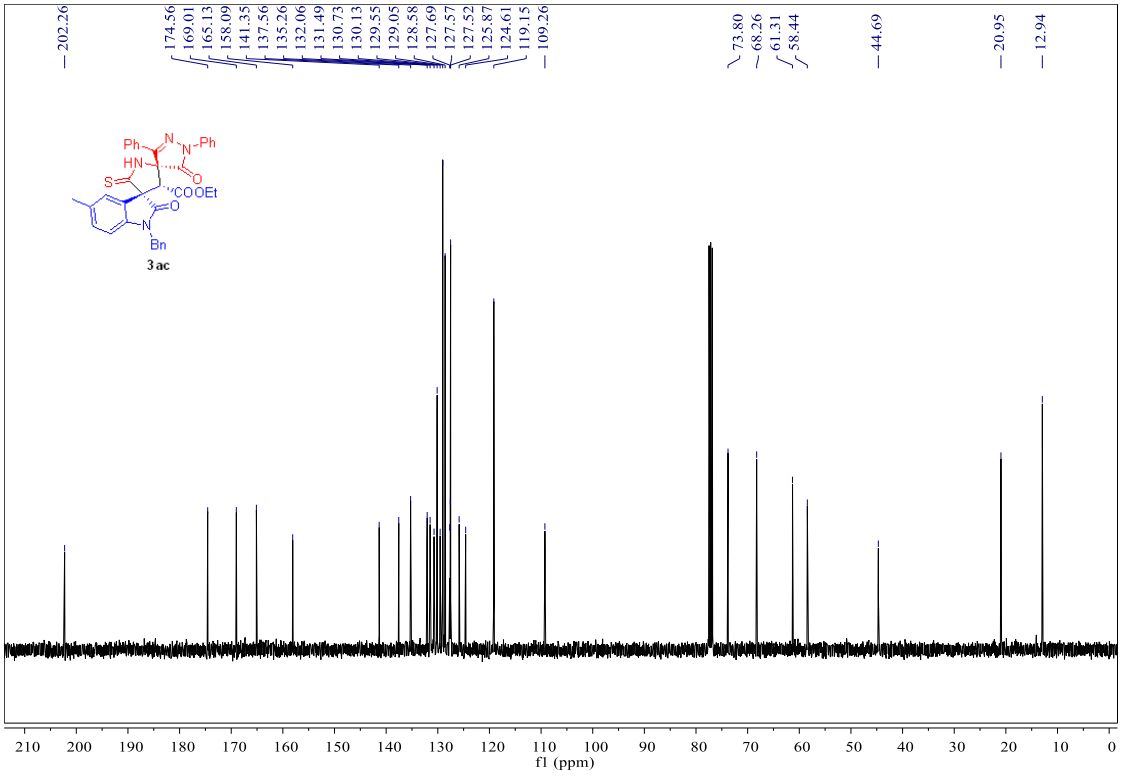
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127.69
127.57
127.52
125.87
124.61
119.15
109.26
73.80
68.26
61.31
58.44
44.69
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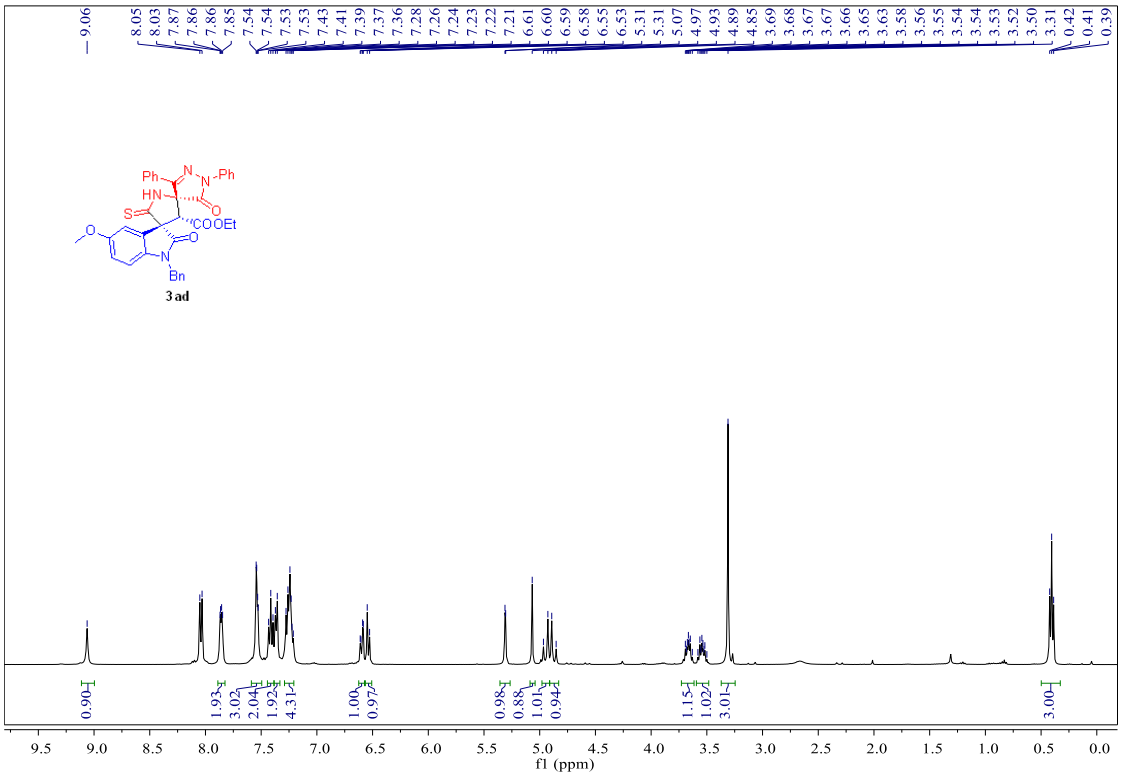
Ph
HN
S
N
N
Ph
O
COOEt
O
N
Bn
3ac
f1 (ppm)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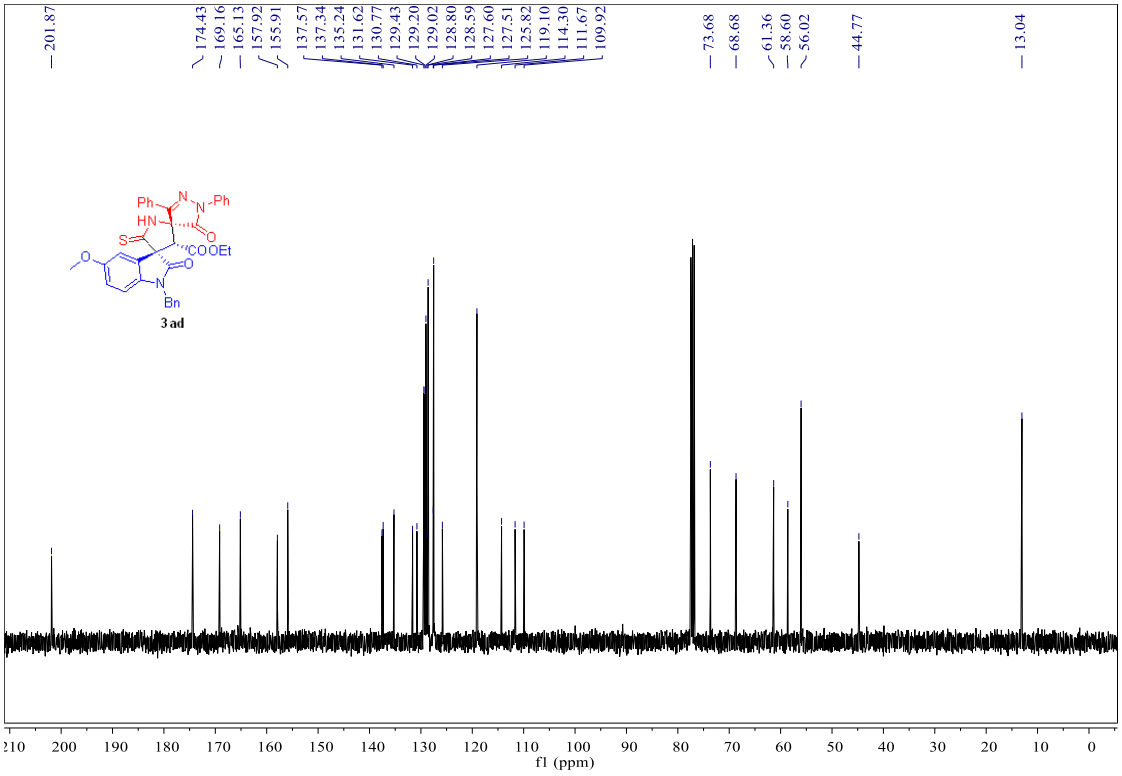
7.53
7.53
7.43
7.41
7.39
7.37
7.36
7.28
7.26
7.24
7.23
7.22
7.21
6.61
6.60
6.59
6.58
6.55
6.53
5.31
5.31
5.07
4.97
4.93
4.89
4.85
3.69
3.68
3.67
3.67
3.66
3.65
3.63
3.58
3.56
3.55
3.54
3.54
3.53
3.52
3.50
3.31
0.42
0.41
0.39
0.90
1.93
3.02
2.04
1.92
4.31
1.00
0.97
0.98
0.88
1.01
0.94
1.15
1.02
3.01
3.00
Ph
HN
S
N
N
Ph
O
COOEt
O
O
N
Bn
3ad
f1 (ppm)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129.43
129.20
129.02
128.80
128.59
127.60
127.51
125.82
119.10
114.30
111.67
109.92
73.68
68.68
61.36
58.60
56.02
44.77
13.04
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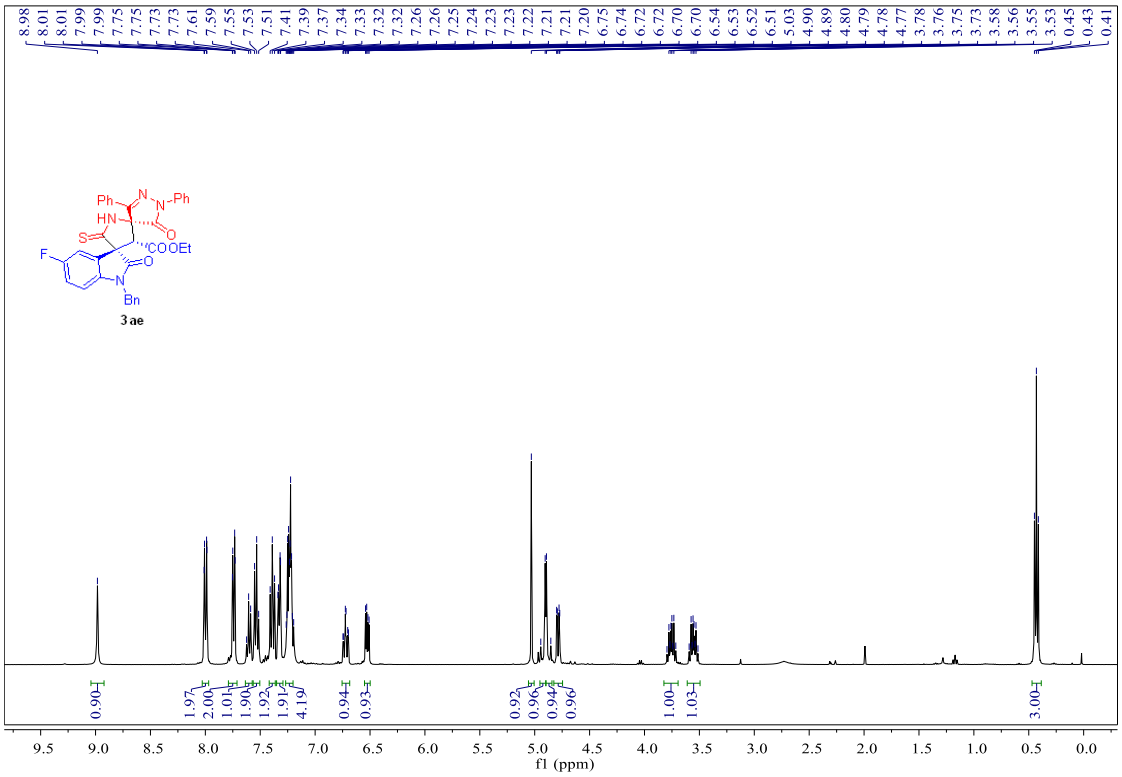
N
N
Ph
HN
S
O
COOEt
O
O
N
Bn
3ad
f1 (ppm)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7.75
7.73
7.73
7.61
7.59
7.55
7.53
7.51
7.41
7.39
7.37
7.34
7.33
7.32
7.32
7.26
7.25
7.24
7.23
7.23
7.22
7.21
7.21
7.20
6.75
6.74
6.72
6.72
6.70
6.70
6.54
6.53
6.52
6.51
5.03
4.90
4.89
4.80
4.79
4.78
4.77
3.78
3.76
3.75
3.73
3.58
3.56
3.55
3.53
0.45
0.43
0.41
Ph
N
N
Ph
HN
S
O
COOEt
F
O
N
Bn
3ae
0.90
1.97
2.00
1.01
1.90
1.92
1.91
4.19
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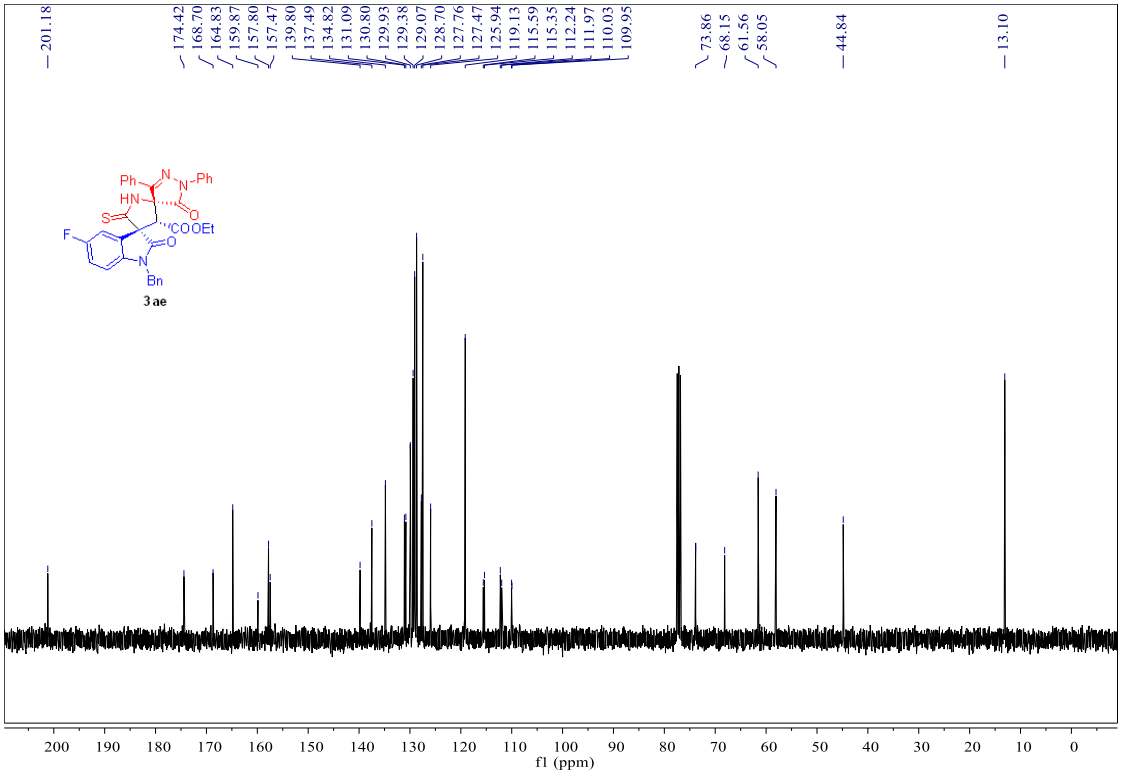
0.93
0.92
0.96
0.94
0.96
1.00
1.03
3.00
f1 (ppm)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157.47
139.80
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134.82
131.09
130.80
129.93
129.38
129.07
128.70
127.76
127.47
125.94
119.13
115.59
115.35
112.24
111.97
110.03
109.95
73.86
68.15
61.56
58.05
44.84
13.10
Ph
N
N
Ph
HN
S
O
COOEt
F
O
N
Bn
3ae
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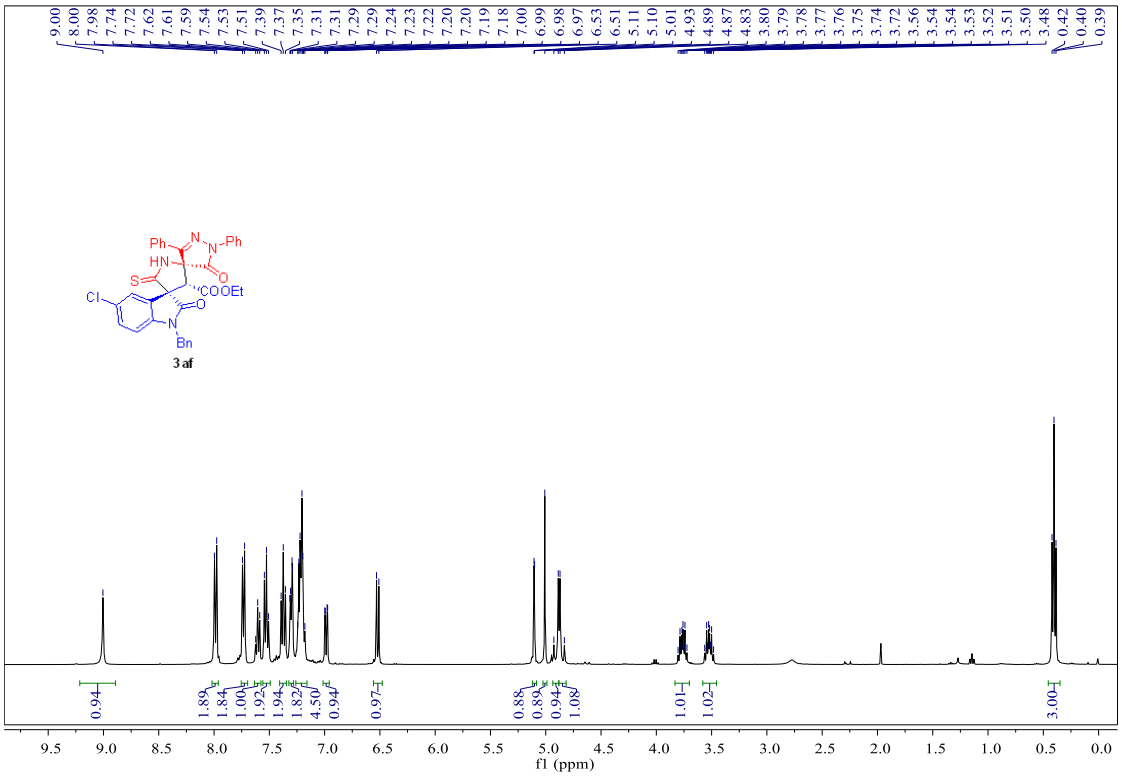
f1 (ppm)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8.00
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7.61
7.59
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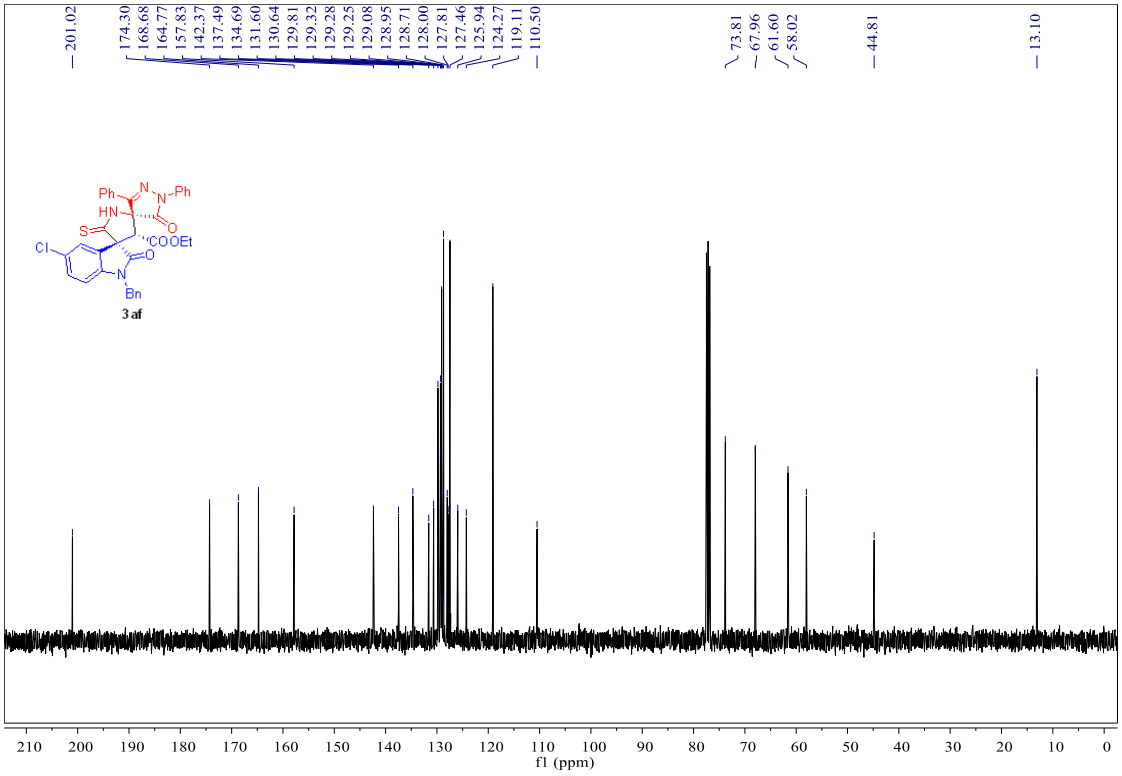
7.53
7.51
7.39
7.37
7.35
7.31
7.31
7.29
7.29
7.24
7.23
7.22
7.20
7.20
7.19
7.18
7.00
6.99
6.98
6.97
6.53
6.51
5.11
5.10
5.01
4.93
4.89
4.87
4.83
3.80
3.79
3.78
3.77
3.76
3.75
3.74
3.72
3.56
3.54
3.54
3.53
3.52
3.51
3.50
3.48
0.42
0.40
0.39
Ph
N
N
Ph
HN
S
O
COOEt
Cl
O
N
Bn
3af
0.94
1.89
1.84
1.00
1.92
1.94
1.82
4.50
0.94
0.97
0.88
0.89
0.94
1.08
1.01
1.02
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)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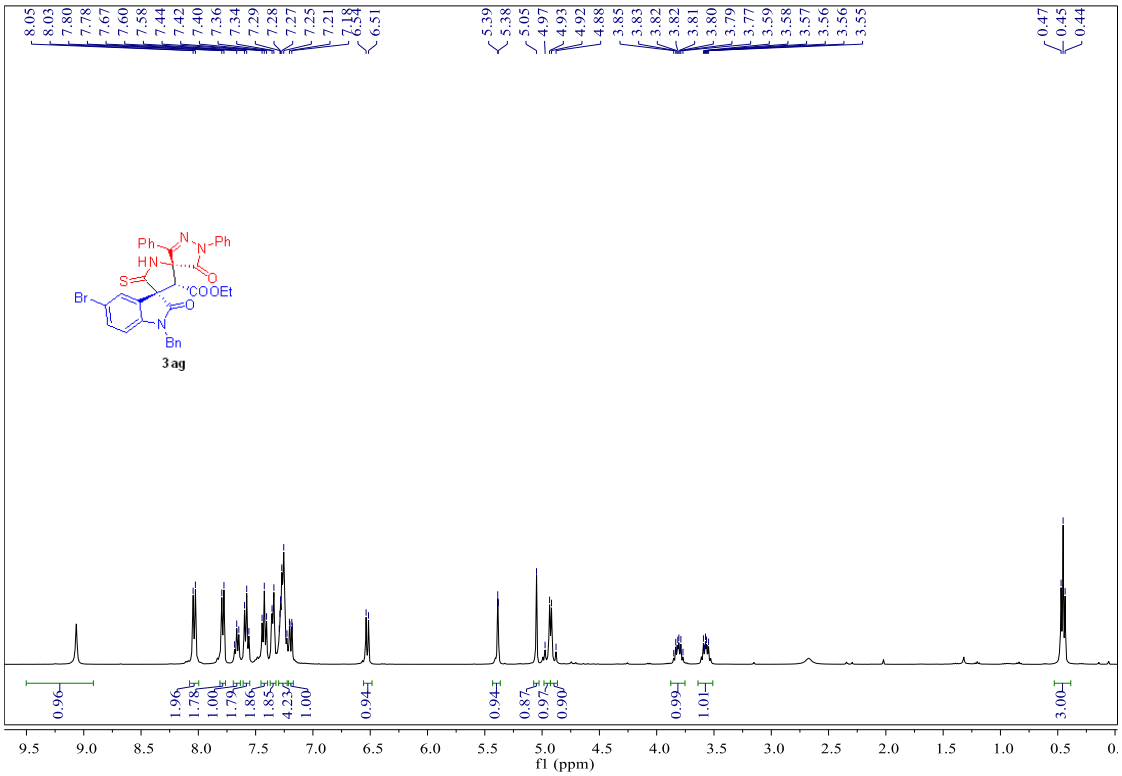
130.64
129.81
129.32
129.28
129.25
129.08
128.95
128.71
128.00
127.81
127.46
125.94
124.27
119.11
110.50
73.81
67.96
61.60
58.02
44.81
13.10
Ph
HN
N
N
Ph
S
O
COOEt
Cl
O
N
Bn
3af
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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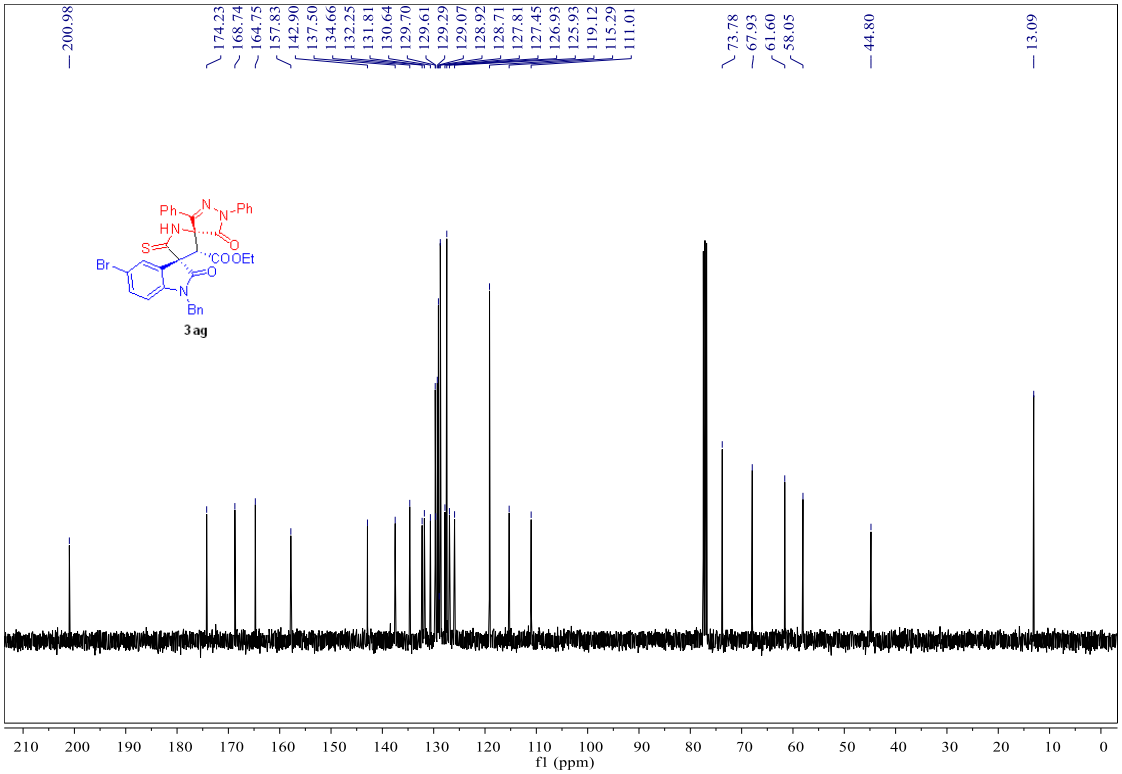
7.40
7.36
7.34
7.29
7.28
7.27
7.25
7.21
7.18
6.54
6.51
5.39
5.38
5.05
4.97
4.93
4.92
4.88
3.85
3.83
3.82
3.82
3.81
3.80
3.79
3.77
3.59
3.58
3.57
3.56
3.56
3.55
0.47
0.45
0.44
Ph
HN
N
N
Ph
S
O
COOEt
Br
O
N
Bn
3ag
0.96
1.96
1.78
1.00
1.79
1.86
1.85
4.23
1.00
0.94
0.94
0.87
0.97
0.90
0.99
1.01
3.00
9.5 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.
f1 (ppm)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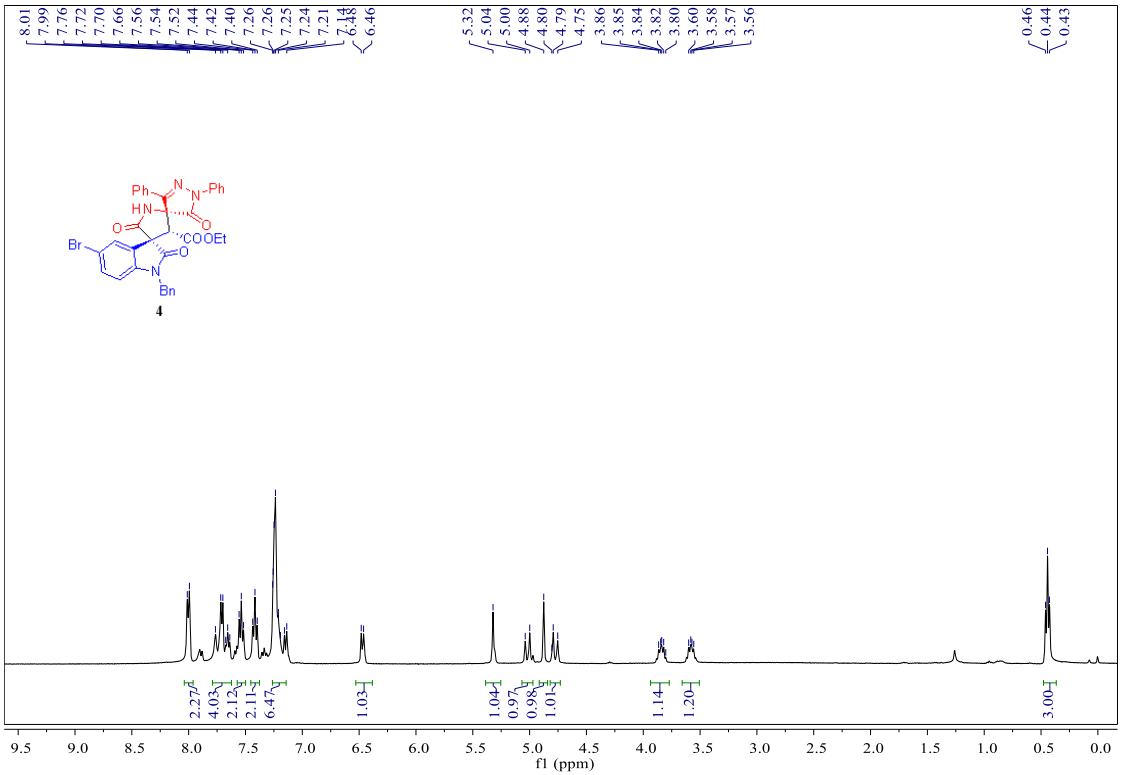
130.64
129.70
129.61
129.29
129.07
128.92
128.71
127.81
127.45
126.93
125.93
119.12
115.29
111.01
73.78
67.93
61.60
58.05
44.80
13.09
Ph
N
N-Ph
HN
S
O
COOEt
Br
O
N
Bn
3ag
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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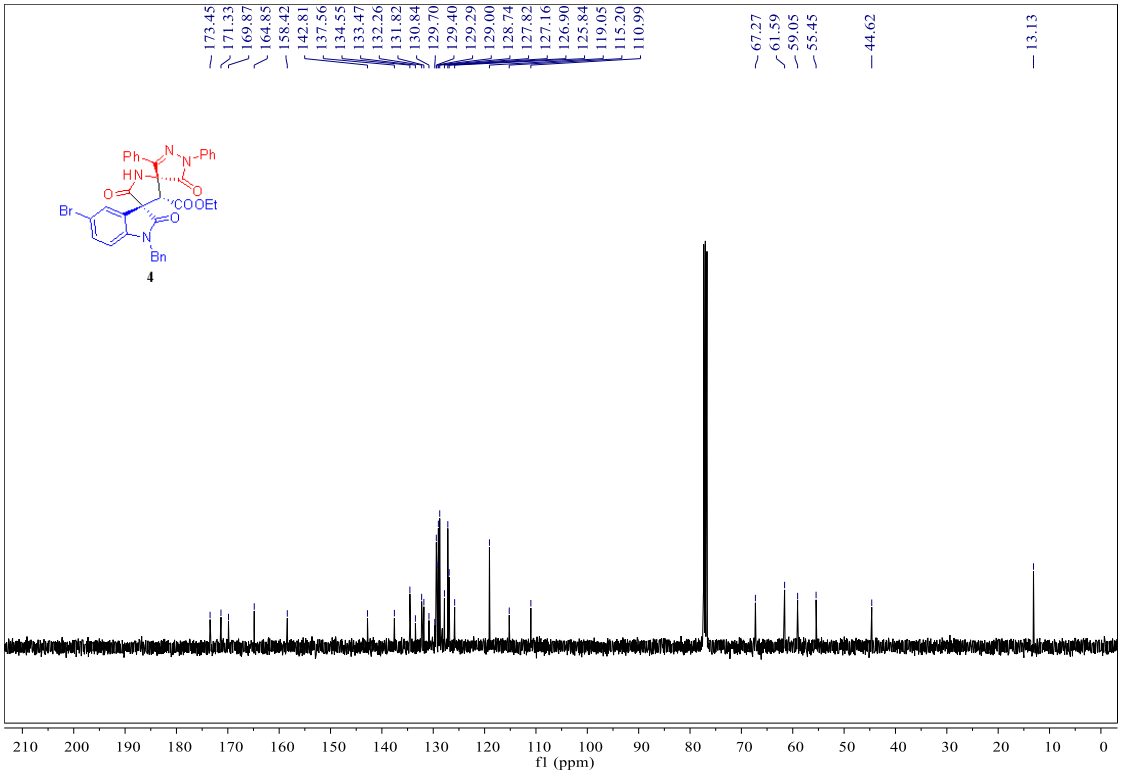
7.52
7.44
7.42
7.40
7.26
7.25
7.24
7.21
6.48
6.46
5.32
5.04
5.00
4.88
4.80
4.79
4.75
3.86
3.85
3.84
3.82
3.80
3.60
3.58
3.57
3.56
0.46
0.44
0.43
Ph
N
N-Ph
HN
O
O
COOEt
Br
O
N
Bn
4
2.27
4.03
2.12
2.11
6.47
1.03
1.04
0.97
0.98
1.01
1.14
1.20
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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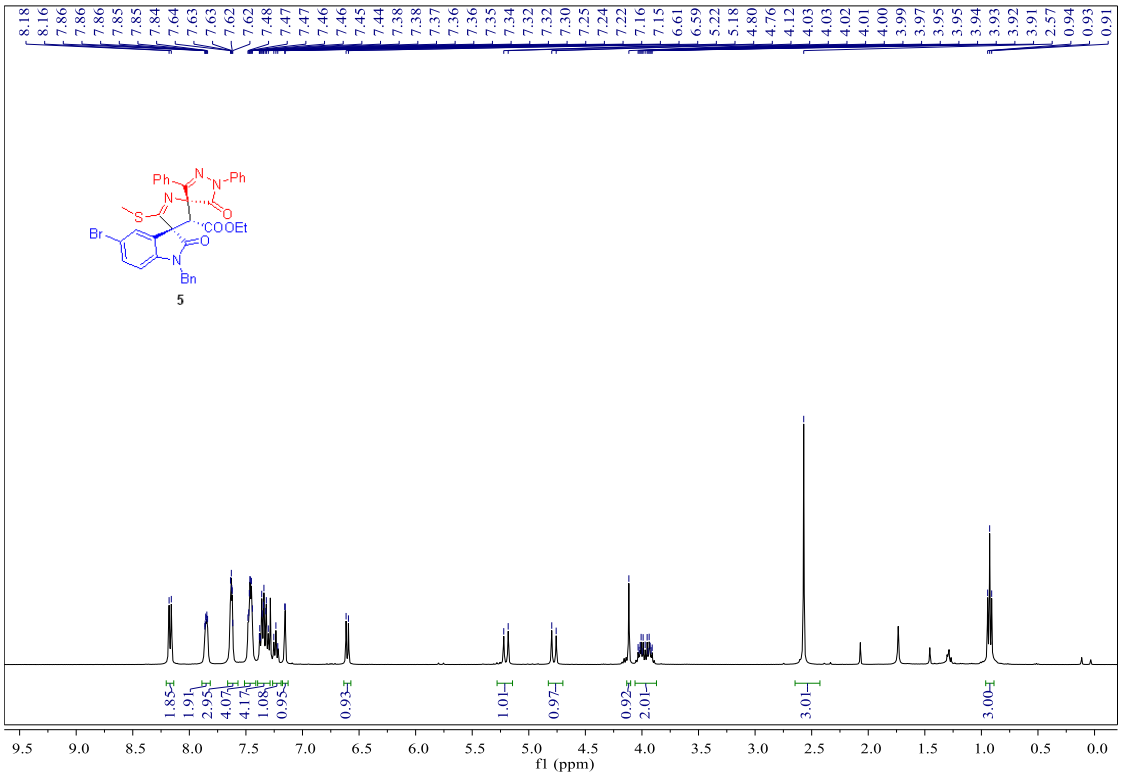
134.55
133.47
132.26
131.82
130.84
129.70
129.40
129.29
129.00
128.74
127.82
127.16
126.90
125.84
119.05
115.20
110.99
67.27
61.59
59.05
55.45
44.62
13.13
Ph
N
N-Ph
HN
O
O
COOEt
Br
O
N
Bn
4
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.63
7.63
7.62
7.62
7.48
7.47
7.47
7.46
7.46
7.45
7.44
7.38
7.38
7.37
7.36
7.36
7.35
7.34
7.32
7.32
7.30
7.25
7.24
7.22
7.16
7.15
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4.00
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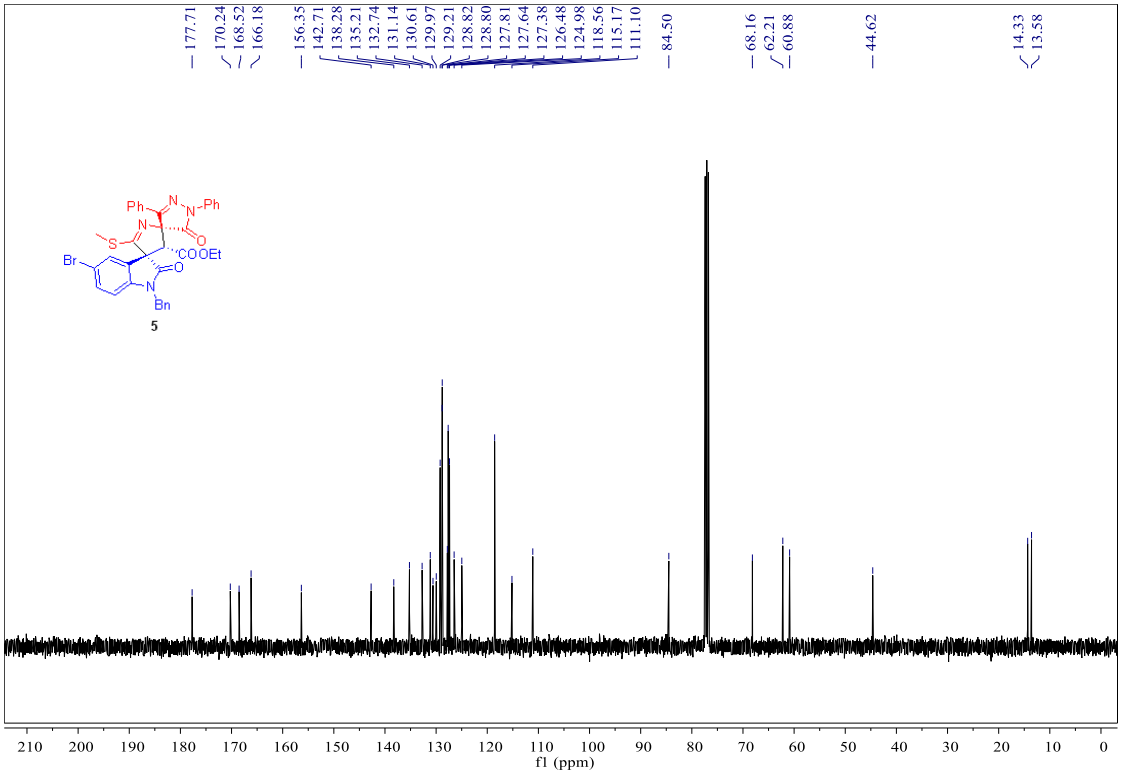
3.97
3.95
3.95
3.94
3.93
3.92
3.91
2.57
0.94
0.93
0.91
Ph
N
N-Ph
N
S
O
COOEt
Br
O
N
Bn
5
1.85
1.91
2.95
4.07
4.17
1.08
0.95
0.93
1.01
0.97
0.92
2.01
3.01
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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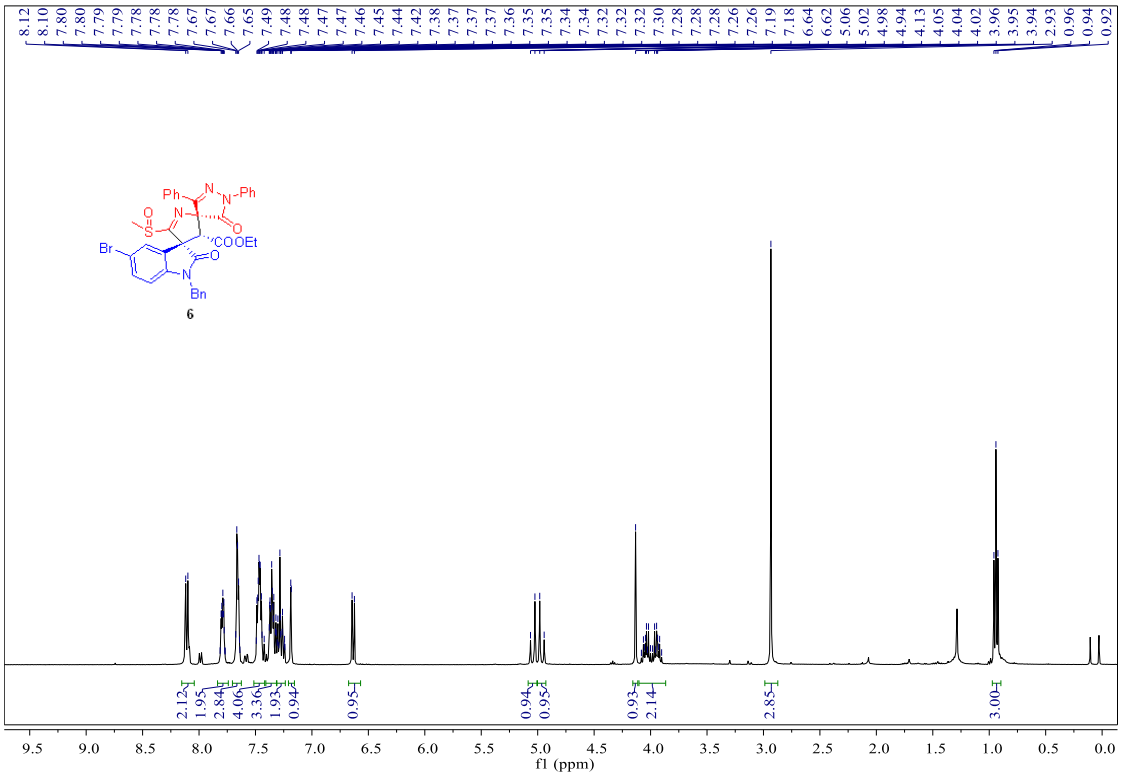
138.28
135.21
132.74
131.14
130.61
129.97
129.21
128.82
128.80
127.81
127.64
127.38
126.48
124.98
118.56
115.17
111.10
84.50
68.16
62.21
60.88
44.62
14.33
13.58
Ph
N
N-Ph
S
O
COOEt
Br
Bn
5
fl (ppm)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7.67
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7.48
7.48
7.47
7.47
7.46
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7.42
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7.36
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7.35
7.34
7.34
7.32
7.32
7.32
7.30
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7.28
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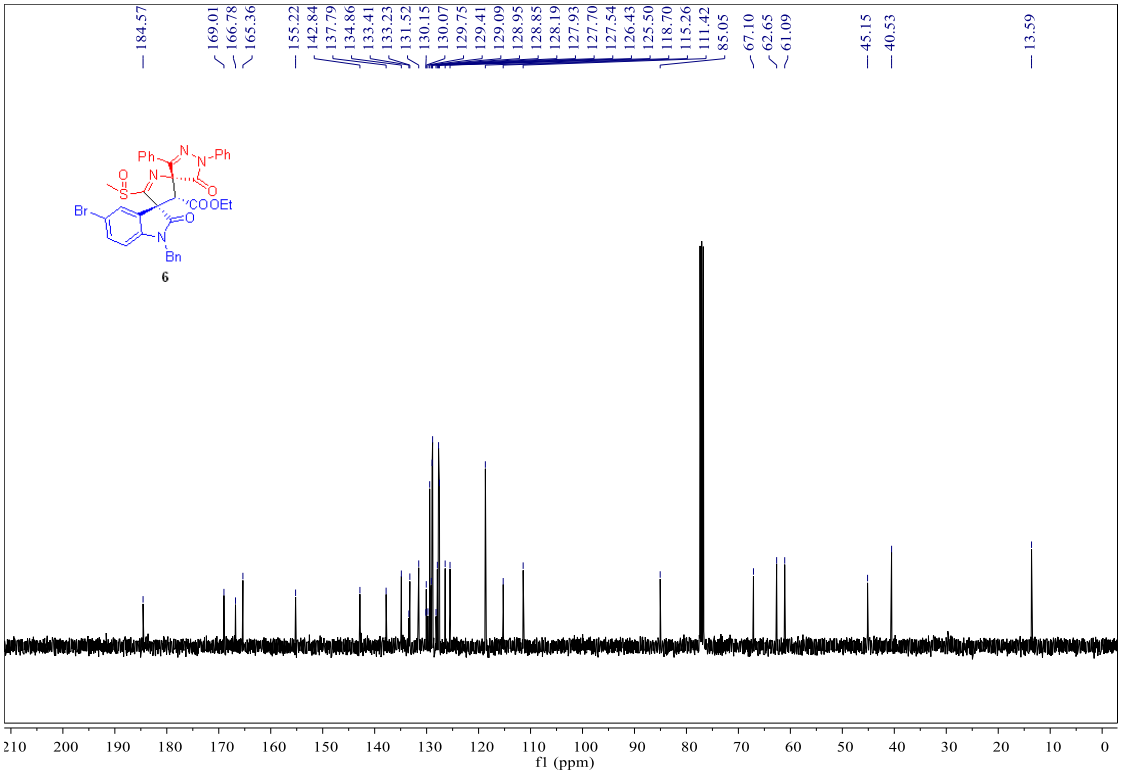
7.26
7.26
7.19
7.18
6.64
6.62
5.06
5.02
4.98
4.94
4.13
4.05
4.04
4.02
3.96
3.95
3.94
2.93
0.96
0.94
0.92
Ph
N
N-Ph
O
S
O
COOEt
Br
Bn
6
2.12
1.95
2.84
4.06
3.36
1.93
0.94
0.95
0.94
0.95
0.93
2.14
2.85
3.00
fl (ppm)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131.52
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130.07
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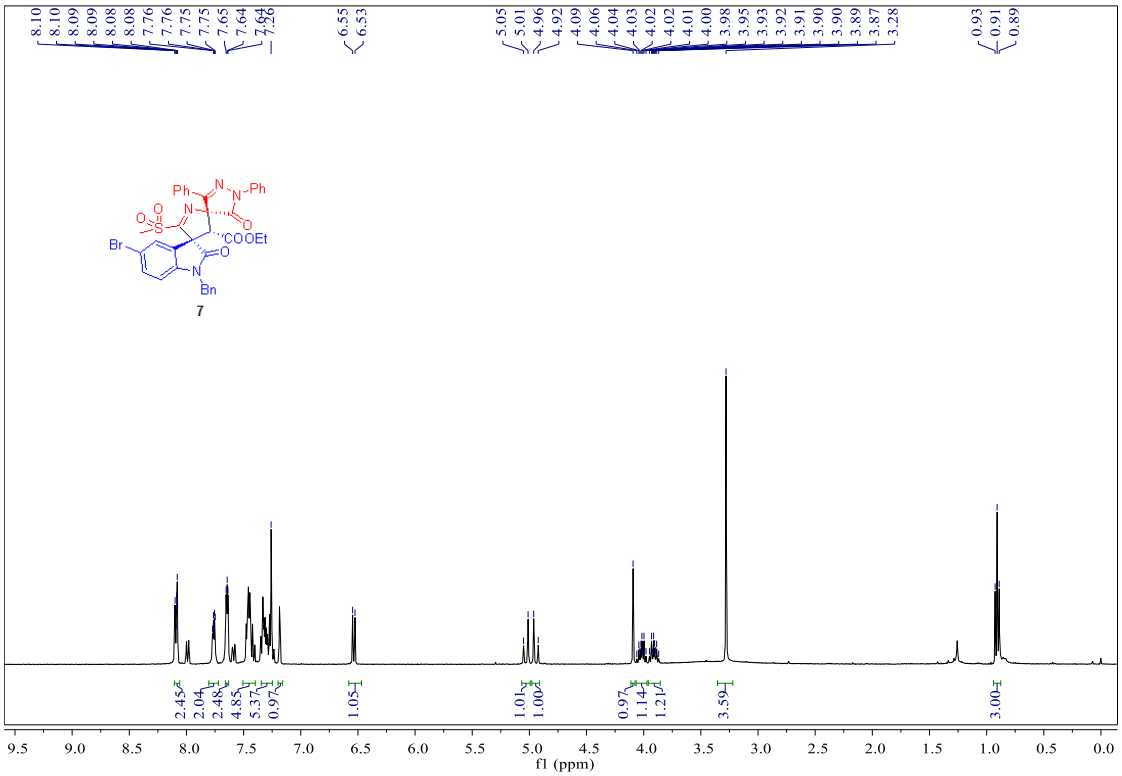
129.41
129.09
128.95
128.85
128.19
127.93
127.70
127.54
126.43
125.50
118.70
115.26
111.42
85.05
67.10
62.65
61.09
45.15
40.53
13.59
Ph
N
N-Ph
O
S
O
N
O
COOEt
Br
O
N
Bn
6
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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8.09
8.09
8.08
8.08
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7.76
7.75
7.75
7.65
7.64
7.64
7.26
6.55
6.53
5.05
5.01
4.96
4.92
4.09
4.06
4.04
4.03
4.02
4.02
4.01
4.00
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3.93
3.92
3.91
3.90
3.90
3.89
3.87
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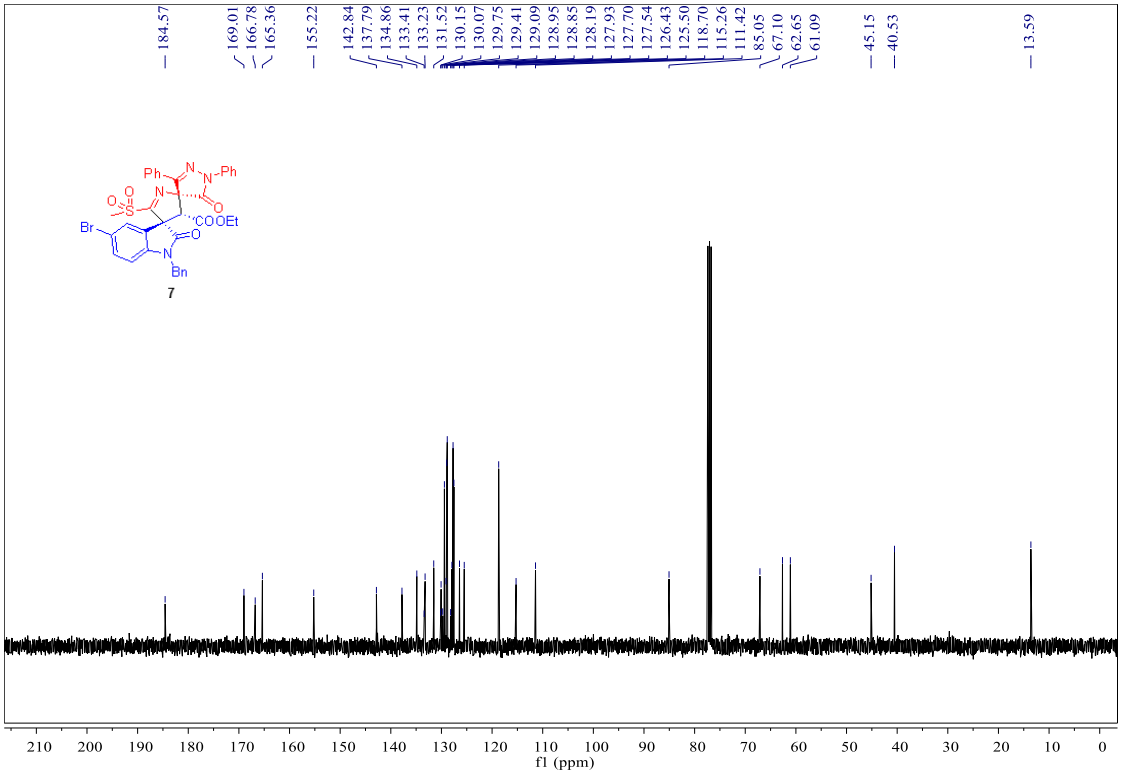
0.91
0.89
Ph
N
N-Ph
O
S
O
O
N
O
COOEt
Br
O
N
Bn
7
2.45
2.04
2.48
4.85
5.37
0.97
1.05
1.01
1.00
0.97
1.14
1.21
3.59
3.00
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


184.57
169.01
166.78
165.36
155.22
142.84
137.79
134.86
133.41
133.23
131.52
130.15
130.07
129.75
129.41
129.09
128.95
128.85
128.19
127.93
127.70
127.54
126.43
125.50
118.70
115.26
111.42
85.05
67.10
62.65
61.09
45.15
40.53
13.59
Ph
N
N
Ph
O
O
S
O
N
COOEt
Br
O
N
Bn
7
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)