Enantioselective alkynykation of benzo[e][1,2,3]-oxathiazine 2,2-dioxides by (R)-VAPOL-Zn complexes: Synthesis of chiral propargylic cyclic sulfamidates

Lode De Munck[a], Alicia Monleón[a], Carlos Vila[a], M. Carmen Muñoz[b], José R. Pedro[a*]

[a] *Departament de Química Orgànica, Facultat de Química, Universitat de València, C/Dr. Moliner, 50, E-46100 Burjassot (València), Spain*

[b] *Departament de Física Aplicada, Universitat Politècnica de València, Camino de Vera s/n, 46022 València (Spain)*

SUPPORTING INFORMATION

Table of Contents:

General Experimental Methods S2

Typical procedures and characterization data for compounds **1** S3

Typical procedures and characterization data for compounds **3** S4

Procedures and characterization data for compounds **4** and **5**.....S12

^{1}H and ^{13}C NMR spectra S14

Chiral analysis chromatograms S44

X-Ray data for compound **3fd**.....S69

References S70

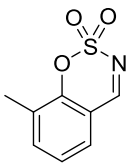
General Experimental Methods

Reactions were carried out under nitrogen in test tubes or round bottom flasks oven-dried overnight at 120 ºC. Dicloromethane, 1,2-dichloroethane and toluene were distilled from CaH_2. THF was distilled from sodium benzophenone ketyl. Reactions were monitored by TLC analysis using Merck Silica Gel 60 F-254 thin layer plates. Flash column chromatography was performed on Merck silica gel 60, 0.040-0.063 mm. Melting points were determined in capillary tubes. NMR spectra were run at 300 MHz for ^{1}H and at 75 MHz for ^{13}C NMR using residual non-deuterated solvent as internal standard ($CHCl_3$: δ 7.26 and 77.0 ppm). Chemical shifts are given in ppm. The carbon type was determined by DEPT experiments. High resolution mass spectra (ESI) were recorded on a AB SCIEX Triple TOF^{TM} spectrometer equipped with an electrospray source with a capillary voltage of 4.5 kV(ESI). Specific optical rotations were measured using sodium light (D line 589 nm). Chiral HPLC analyses were performed in a chromatograph equipped with a UV diode-array detector using chiral stationary columns from Daicel. Commercially available alkynes were used as received.

Typical procedures and characterization data for compounds 1

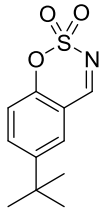
Benzoxathiazine 2,2-dioxides were prepared from the corresponding salicylaldehyde as described in the literature.[1] Products **1c**, **1d** and **1e** were not described in the literature:

8-methylbenzo-[*e*][1,2,3]oxathiazine 2,2-dioxide (1c)



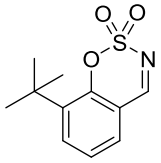
White solid; mp 89.5-90.9 °C; **^{1}H NMR (300 MHz, $CDCl_3$)** δ = 8.56 (s, 1H), 7.58 – 7.36 (m, 2H), 7.21 (t, *J* = 7.6 Hz, 1H), 2.25 (t, *J* = 0.8 Hz, 3H) ppm; **^{13}C NMR (75 MHz, $CDCl_3$)** δ = 168.2 (CH), 152.1 (C), 139.1 (CH), 128.6 (CH), 127.98 (C), 125.5 (CH), 114.9 (C), 14.2 (CH_3) ppm; **HRMS** (ESI) m/z: 198.0212 $[M + H]^+$, $C_8H_8NO_3S$ requires 198.0225.

6-(*tert*-butyl)benzo-[*e*][1,2,3]oxathiazine 2,2-dioxide (1d)



Yellow solid; mp 56.5-59.2 °; **^{1}H NMR (300 MHz, $CDCl_3$)** δ = 8.60 (d, *J* = 0.6 Hz, 1H), 7.71 (dd, *J* = 8.7, 2.4 Hz, 1H), 7.59 (d, *J* = 2.5 Hz, 1H), 7.19 – 7.07 (m, 1H), 1.28 (s, 9H) ppm; **^{13}C NMR (75 MHz, $CDCl_3$)** δ = 168.7 (CH), 152.5 (C), 150.2 (C), 135.7 (CH), 127.8 (CH), 118.5 (CH), 115.3 (C), 35.2 (C), 31.5 (CH_3) ppm; **HRMS** (ESI) m/z: 240.0678 $[M + H]^+$, $C_{11}H_{14}NO_3S$ requires 240.0694.

8-(*tert*-butyl)benzo-[*e*][1,2,3]oxathiazine 2,2-dioxide (1e)



White solid; **^{1}H NMR (300 MHz, $CDCl_3$)** δ = 8.56 (s, 1H), 7.65 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.45 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.27 (d, *J* = 7.7 Hz, 1H), 1.35 (s, 9H) ppm; **^{13}C NMR (75 MHz, $CDCl_3$)** δ = 169.3 (CH), 153.5 (C), 140.7 (C), 135.8 (CH), 129.7 (CH), 126.4 (CH), 116.6 (C), 35.4 (C), 30.1 (CH_3) ppm; **HRMS** (ESI) m/z: 240.0682 $[M + H]^+$, $C_{11}H_{14}NO_3S$ requires 240.0694.

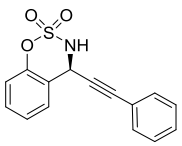
Typical procedures and characterization data for compounds 3, 4 and 5

General procedure for the enantioselective alkynylation reaction

A 2 M Me_2Zn solution in toluene (0.18 mL, 0.360 mmol) was added dropwise on a solution of **L7** (9.7 mg, 0.018 mmol) and alkyne **2** (0.360 mmol) in dichloroethane (0.3 mL) at room temperature under nitrogen. After stirring 1 hour, a solution of benzoxathiazine 2,2-dioxide **1** (0.090 mmol) in dichloroethane (1.0 mL) was added via syringe. The reaction was stirred until the reaction was complete (TLC). The reaction mixture was quenched with NH_4Cl (10 mL), extracted with dichloromethane (3x15 mL), washed with brine (10 mL), dried over $MgSO_4$ and dried under reduced pressure. Purification by flash chromatography on silica gel afforded compound **3**.

General procedure for the racemic alkynylation reaction A 1 M Et_2Zn solution in hexane (0.30 mL, 0.300 mmol) was added dropwise on a solution of racemic BINOL (5.7 mg, 0.020 mmol) and alkyne **2** (0.720 mmol) in dichloroethane (0.4 mL) at room temperature under nitrogen. After stirring 1 hour, a solution of benzoxathiazine 2,2-dioxide **1** (0.100 mmol) in dichloroethane (1.0 mL) was added via syringe. The reaction was stirred until the reaction was complete (TLC). The reaction mixture was quenched with NH_4Cl (10 mL), extracted with dichloromethane (3x15 mL), washed with brine (10 mL), dried over $MgSO_4$ and dried under reduced pressure. Purification by flash chromatography on silica gel afforded compound **3**.

(-)-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3aa)

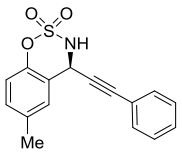


3aa

The enantiomeric excess (82%) was determined by chiral HPLC (Chiralpak ODH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 15.82 min, minor enantiomer t_r = 13.68 min.

Orange oil; $[\alpha]_D^{20}$ = -32.6 (*c* 1.0, $CHCl_3$, 82% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.61 (ddd, J = 7.8, 1.6, 1.1 Hz, 1H), 7.50 (dd, J = 7.8, 1.8 Hz, 2H), 7.44-7.33 (m, 4H), 7.28 (dd, *J* = 7.6, 1.3 Hz, 1H), 7.05 (dd, *J* = 8.2, 1.3 Hz,1H), 5.94 (d, *J* = 10.0 Hz, 1H), 4.93 (d, *J* = 9.6 Hz, 1H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ 150.6 (C), 132 (CH), 130.4 (CH), 129.5 (CH), 128.5 (CH), 127.6 (CH), 125.6 (CH), 121.1 (C), 119.6 (C), 118.7 (CH), 87.7 (C), 82.3 (C), 50.3 (CH); **IR** 3258, 2234, 1579, 1421, 1365, 1199, 1160, 1099, 880, 780, 685 cm^{-1}; **HRMS** (ESI) m/z: 284.0376 $[M - H]^-$, $C_{15}H_{10}NO_3S$ requires 284.0381.

(-)-6-methyl-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ba)



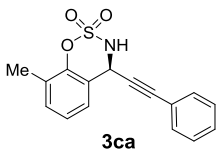
3ba

The enantiomeric excess (87%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 16.46 min, minor enantiomer t_r = 25.98 min.

Orange oil; $[\alpha]_D^{20}$ -76.73 (*c* 1.0, $CHCl_3$, 87% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.52-7.49 (m, 2H), 7.41-7.33 (m, 4H), 7.19-7.15 (m, 1H), 6.94 (d, *J* = 8.4 Hz,

1H), 5.90 (d, *J* = 9.9 Hz, 1H), 4.88 (d, *J* = 9.9 Hz, 1H), 2.39 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.5 (C), 135.5 (C), 132.0 (CH), 130.9 (CH), 129.5 (CH), 128.52 (CH), 127.7 (CH), 121.1 (C), 119.1 (C), 118.5 (CH), 87.6 (C), 82.5 (C), 50.3 (CH), 20.8 (CH_3); **IR** 3256, 2920, 2204, 1524, 1488, 1377, 1352, 1199, 1174, 1096, 1032, 864, 764, 680 cm^{-1}; **HRMS** (ESI) m/z: 298.0532 $[M - H]^-$, $C_{16}H_{12}NO_3S$ requires 298.0538.

(-)-8-methyl-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ca)

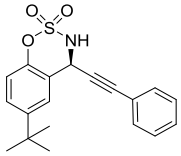


3ca

The enantiomeric excess (73%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 12.22 min, minor enantiomer t_r = 21.42 min.

Orange oil;$[\alpha]_D^{20}$ -6.00 (*c* 1.0, $CHCl_3$, 73% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.51 – 7.48 (m, 2H), 7.48 – 7.42 (m, 1H), 7.41 – 7.32 (m, 3H), 7.26 – 7.22 (m, 1H), 7.15 (t, *J* = 7.6 Hz, 1H), 5.92 (d, *J* = 10.2 Hz, 1H), 4.84 (d, *J* = 10.0 Hz, 1H), 3.30 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ149.1 (C), 131.9 (CH), 131.8 (C), 129.4 (CH), 128.5 (CH), 128.1 (C), 125.0 (CH), 121.1 (C), 119.5 (CH), 87.8 (C), 82.6 (C), 50.3 (CH), 15.4 (CH_3); **IR** 3261, 2920, 2204, 1582, 1421, 1377, 1341, 1202, 1146, 863, 827, 705, 688 cm^{-1}; **HRMS** (ESI) m/z: 298.0545 $[M - H]^-$, $C_{16}H_{12}NO_3S$ requires 298.0538.

(-)-6-(tert-butyl)-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3da)

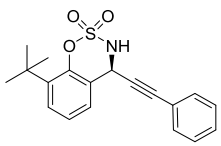


3da

The enantiomeric excess (56%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 8.16 min, minor enantiomer t_r = 9.15 min.

Brown oil; $[\alpha]_D^{20}$ -77.26 (*c* 1.0, $CHCl_3$, 56% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.61 (dd, *J* = 2.4, 1.1, 1H), 7.55-7.45 (m, 2H), 7.43-7.30 (m, 4H), 6.98 (d, *J* = 8.7 Hz, 1H), 5.93 (d, *J* = 10 Hz, 1H), 4.83 (d, *J* = 10,0 Hz, 1H), 1.34 (s, 9H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.8 (C), 148.3 (C), 131.9 (CH), 129.4 (CH), 128.6 (CH), 127.4 (CH), 124.3 (CH), 121.2 (C), 118.7 (C), 118.1 (CH), 87.7 (C), 82.7 (C), 50.51 (CH), 34.6 (C), 31.3 (CH_3); **IR** 3264, 2948, 2201, 1873, 1488, 1424, 1365, 1210, 1166, 1116, 1093, 845, 780, 685 cm^{-1}; **HRMS** (ESI) m/z: 340.1007 $[M - H]^-$, $C_{19}H_{18}NO_3S$ requires 340.1007.

(-)-8-(tert-butyl)-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ea)

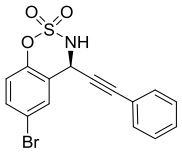


3ea

The enantiomeric excess (81%) was determined by chiral HPLC (Chiralpak OD-H), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 10.08 min, minor enantiomer t_r = 8.42 min.

Mp 119 °C; $[\alpha]_D^{20}$ +8.08 (*c* 1.0, $CHCl_3$, 81% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.52-7.48 (m, 3H), 7.42-7.34 (m, 4H), 7.20 (t, *J* = 7.8Hz, 1H), 5.90 (d, *J* = 10.1Hz, 1H), 4.86 (d, *J* = 10.1Hz, 1H), 1.44 (s, 9H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ 149,9 (C), 140.1 (C), 131.9 (CH), 129.4 (CH), 128.5 (CH), 128.0 (CH), 125.4 (CH), 125.1 (CH), 121.3 (C), 121.2 (C), 87.8 (C), 82.6 (C), 50.1 (CH), 35.0 (C), 30.0 (CH_3); **IR** 3217, 2961, 2249, 2208, 1596, 1485, 1427, 1391, 1357, 1182, 1154, 1093, 1032, 872, 733, 689 cm^{-1}; **HRMS** (ESI) m/z: 342.1159 $[M + H]^+$, $C_{19}H_{20}NO_3S$ requires 342.1164.

(-)-6-bromo-4-(phenylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3fa)

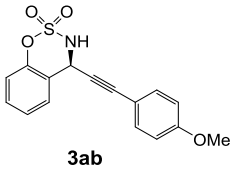


3fa

The enantiomeric excess (80%) was determined by chiral HPLC (Chiralpak AD-H), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 10.63 min, minor enantiomer t_r = 12.47 min.

Aceite naranja; $[\alpha]_D^{20}$ -114.82 (*c* 1.0, $CHCl_3$, 80% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.73 (dd, *J* = 2.4, 1.1 Hz, 1H), 7.58-7.46 (m, 3H), 7.45-7.33 (m, 3H), 6.94 (d, *J* = 8.8Hz, 1H), 5.91 (d, *J* = 10.0 Hz, 1H), 4.94 (d, *J* = 10.0 Hz, 1H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ149.6 (C), 133.4 (CH), 132.1 (CH), 130.4 (CH), 129.7 (CH), 128.6 (CH), 121.5 (C), 120.7 (C), 120.4 (CH), 118.3 (C), 88.4 (C), 81.4 (C), 49.9 (CH); **IR** 3276, 2914, 2237, 2196, 1596, 1427, 1366, 1210, 1185, 1107, 874, 753, 686 cm^{-1}; **HRMS** (ESI) m/z: 361.9472 $[M - H]^-$, $C_{15}H_9BrNO_3S$ requires 361.9487.

(-)-4-((4-methoxyphenyl)ethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ab)

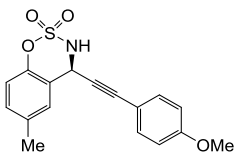


3ab

The enantiomeric excess (83%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 23.85 min, minor enantiomer t_r = 32.73 min.

Yellow oil; $[\alpha]_D^{20}$ -26.13 (*c* 1.0, $CHCl_3$, 83% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.61 (dt, *J* = 7.9, 1.4 Hz, 1H), 7.48 – 7.37 (m, 2H), 7.37 (ddd, *J* = 8.3, 1.7, 0.8Hz, 1H), 7.31 (td, *J* = 7.5, 1.2 Hz, 1H), 7.05 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.87 (dt, *J* = 9.2, 2.7 Hz, 2H), 5.92 (d, *J* = 10.0 Hz, 1H), 4.85 (d, *J* = 10.0 Hz, 1H), 3.83 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.5 (C), 150.6 (C), 133.5 (CH), 130.3 (CH), 127.6 (CH), 125.6 (CH), 119.9 (C), 118.7 (CH), 114.2 (CH), 113.0 (C), 87.9 (C), 81.1 (C), 55.35 (CH), 50.40 (CH_3); **IR** 3256, 2925, 2234, 2181, 1596, 1507, 1418, 1371, 1246, 1160, 1093, 1021, 758 cm^{-1}; **HRMS** (ESI) m/z: 316.0638 $[M + H]^+$, $C_{16}H_{14}NO_4S$ requires 316.0644.

(-)-4-((4-methoxyphenyl)ethynyl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bb)

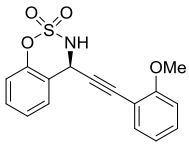


3bb

The enantiomeric excess (87%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 29.96 min, minor enantiomer t_r = 40.36 min.

Yellow oil; $[\alpha]_D^{20}$ -47.60 (*c* 1.0, $CHCl_3$, 87% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.47 – 7.39 (m, 2H), 7.36 (dt, *J* = 2.1, 0.9 Hz, 1H), 7.17 (ddt, *J* = 8.4, 2.2, 0.8 Hz, 1H), 6.94 (d, *J* = 8.4 Hz, 1H), 6.92 – 6.83 (m, 1H), 5.88 (d, *J* = 9.9 Hz, 1H), 4.78 (d, *J* = 9.9 Hz, 1H), 3.83 (s, 3H), 2.37 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.5 (C), 148.5 (C), 135.5 (C), 133.6 (CH), 130.9 (CH), 127.7 (CH), 119.3 (C), 118.4 (CH), 114.2 (CH), 113.1 (C), 87.6 (C), 81.3 (C), 55.4 (CH_3), 50.4 (CH), 20.8 (CH_3); **IR** 3253, 2920, 2184, 1604, 1510, 1426, 1363, 1247, 1169, 1102, 824, 752, 690 cm^{-1}; **HRMS** (ESI) m/z: 330.0793 $[M + H]^+$, $C_{17}H_{16}NO_4S$ requires 330.0800.

(-)-4-((2-methoxyphenyl)ethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ac)

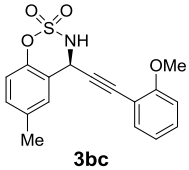


3ac

The enantiomeric excess (65%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 19.21 min, minor enantiomer t_r = 28.89 min.

Mp 104 °C; $[\alpha]_D^{20}$ -25.47 (*c* 1.0, $CHCl_3$, 65% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.69 (dt, *J* = 7.7, 1.5 Hz, 1H), 7.43 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.42 – 7.34 (m, 2H), 7.26 (td, *J* = 7.5, 1.2 Hz, 1H), 7.04 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.96 – 6.90 (m, 2H), 5.99 (d, *J* = 10.1 Hz, 1H), 4.91 (d, *J* = 10.1 Hz, 1 H), 3.89 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.5 (C), 150.6 (C), 133.7 (CH), 130.9 (CH), 130.2 (CH), 127.8 (CH), 125.5 (CH), 120.5 (CH), 119.8 (C), 118.5 (CH), 110.8 (CH), 110.3 (C), 86.2 (C), 84.2 (C), 55.7 (CH_3), 50.5 (CH); **IR** 3203, 2902, 2237, 2193, 1590, 1485, 1443, 1349, 1318, 1279, 1252, 1185, 1149, 1116, 932, 874, 771 cm^{-1}; **HRMS** (ESI) m/z: 316.0638 $[M + H]^+$, $C_{16}H_{14}NO_4S$ requires 316.0644.

(-)-4-((2-methoxyphenyl)ethynyl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bc)



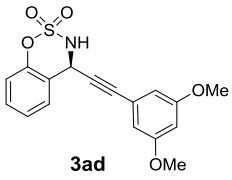
3bc

The enantiomeric excess (68%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 25.23 min, minor enantiomer t_r = 41.05 min.

Mp 158 °C; $[\alpha]_D^{20}$ -58.26 (*c* 1.0, $CHCl_3$, 68% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.48 – 7.43 (m, 2H), 7.40 – 7.32 (m, 1H), 7.19 – 7.15 (m, 1H), 6.98 – 6.88 (m, 3H), 5.94 (d, *J* = 10.2 Hz, 1H), 4.85 (d, *J* = 10.0 Hz, 1H), 3.90 (s, 3H), 2.37 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.6 (C), 148.5 (C), 135.5 (C), 133.7 (CH), 130.9 (CH), 130.8 (CH), 129.0 (CH), 120.5 (CH), 119.4 (C), 118.3 (CH), 110.7 (CH), 110.4 (C), 86.3 (C), 84.2 (C), 55.7 (CH_3), 50.5 (CH), 20.9 (CH_3); **IR** 3222, 2845, 2234,

2193, 1565, 1482, 1460, 1426, 1349, 1174, 1157, 1035, 785, 680 cm^{-1}; **HRMS** (ESI) m/z: 330.0804 $[M + H]^+$, $C_{17}H_{16}NO_4S$ requires 330.0800.

(-)-4-((3,5-dimethoxyphenyl)ethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ad)

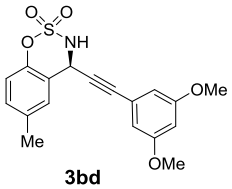


3ad

The enantiomeric excess (80%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 12.32 min, minor enantiomer t_r = 19.33 min.

Mp 127 °C; $[\alpha]_D^{20}$ -25.50 (*c* 1.0, $CHCl_3$, 80% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.61 – 7.57 (m, 1H), 7.42 – 7.36 (m, 1H), 7.27 (td, *J* = 7.6, 1.3 Hz, 1H), 7.05 (dd, *J* = 8.1, 1.3 Hz, 1H), 6.63 (d, *J* = 2.3 Hz, 2H), 6.48 (dt, *J* = 10.1, 2.3 Hz, 1H), 5.92 (d, *J* = 9.87 Hz, 1H), 4.96 (d, *J* = 9.9 Hz, 1H), 3.79 (s, 6H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.6 (C), 150.5 (C), 130.4 (CH), 127.6 (CH), 125.6 (CH), 122.3 (C), 119.5 (C), 118.7 (CH), 109.8 (CH), 102.6 (CH), 87.6 (C), 81.8 (C), 55.5 (CH_3), 50.2 (CH); **IR** 3233, 2945, 2248, 2217, 1576, 1415, 1388, 1357, 1191, 1152, 1071, 932, 846, 746, 672 cm^{-1}; **HRMS** (ESI) m/z: 346.0757 $[M + H]^+$, $C_{17}H_{16}NO_5S$ requires 346.0749.

(-)-4-((3,5-dimethoxyphenyl)ethynyl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]-oxathiazine 2,2-dioxide (3bd)

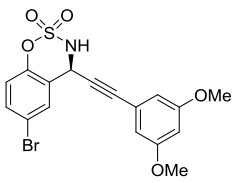


3bd

The enantiomeric excess (82%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r =12.10 min, minor enantiomer t_r = 19.93 min.

Mp 135 °C; $[\alpha]_D^{20}$ -65.18 (*c* 1.0, $CHCl_3$, 82% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.36 – 7.34 (m, 1H), 7.20 – 7.15 (m, 1H), 6.93 (d, *J* = 8.4 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 2H), 6.50 (t, *J* = 2.3 Hz, 1H), 5.87 (d, *J* = 10.0 Hz, 1H), 4.91 (d, *J* = 9.9 Hz, 1H), 3.79 (s, 6H), 2.37 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ160.6 (C), 148.4 (C), 135.5 (C), 130.9 (C), 127.6 (CH), 122.4 (C), 119.0 (C), 118.4 (CH), 109.8 (CH), 102.6 (CH), 87.4 (C), 82.0 (C), 55.5 (CH_3), 50.2 (CH), 20.8 (CH_3); **IR** 3253, 2950, 2245, 2221, 1587, 1424, 1365, 1340, 1204, 1177, 1149, 1102, 1038, 838, 799, 677 cm^{-1}; **HRMS** (ESI) m/z: 360.0905 $[M + H]^+$, $C_{18}H_{18}NO_5S$ requires 360.0906.

(-)-6-bromo-4-((3,5-dimethoxyphenyl)ethynyl)-3,4-dihydrobenzo[e][1,2,3]-oxathiazine 2,2-dioxide (3fd)

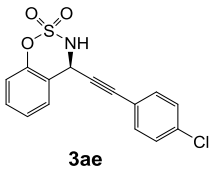


3fd

The enantiomeric excess (82%) (96% ee after crystalization) was determined by chiral HPLC (Chiralpak ODH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 22.01 min, minor enantiomer t_r = 39.14 min.

Orange oil; $[\alpha]_D^{20}$ -109.36 (*c* 1.0, $CHCl_3$, 82% *ee*); **NMR ^{1}H (300 MHz, $CDCl_3$)** δ7.71 (dd, J = 2.5, 1.2 Hz, 1H), 7.49 (dd, J = 8.8, 2.4 Hz, 1H), 6.93 (d, J = 9.1 Hz, 1H), 6.64 (d, J = 2.2 Hz, 2H), 6.51 (t, J = 2.3 Hz, 1H), 5.88 (d, J = 7.0 Hz, 1H), 4.97 (d, J = 8.0 Hz, 1H), 3.80 (s, 6H); **^{13}C (75,5 MHz, $CDCl_3$)** δ160.6 (C), 149.6 (C), 133.4 (CH), 130.4 (CH), 121.9 (C), 121.4 (C), 120.4 (CH), 118.3 (C), 109.9 (CH), 102.8 (CH), 88.3 (C), 81.0 (C), 55.5 (CH_3), 49.9 (CH); **HRMS** (ESI) m/z: 423.9851 $[M + H]^+$, $C_{17}H_{15}BrNO_5S$ requires 422.9854.

(-)-4-((4-chlorophenyl)ethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ae)

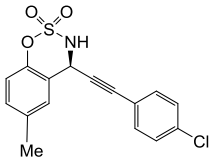


3ae

The enantiomeric excess (81%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 11.95 min, minor enantiomer t_r = 19.02 min.

Mp 93 °C; $[\alpha]_D^{20}$ -26.41 (*c* 1.0, $CHCl_3$, 81% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.57 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.45 – 7.39 (m, 3H), 7.37 – 7.32 (m, 2H), 7.27 (td, *J* = 7.8, 1.5 Hz, 1H), 7.05 (dd, *J* = 8.2, 1.2 Hz, 1H), 5.93 (d, *J* = 9.9 Hz, 1H), 4.98 (d, *J* = 9.9 Hz, 1H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ150.5 (C), 135.7 (C), 133.2 (CH), 130.4 (CH), 128.9 (CH), 127.5 (CH), 125.6 (CH), 119.5 (C), 119.4 (C), 118.8 (CH), 86.5 (C), 83.4 (C), 50.2 (CH); **IR** 3226, 2920, 2234, 2206, 1525, 1485, 1421, 1371, 1185, 1160, 1088, 941, 855, 655 cm^{-1}; **HRMS** (ESI) m/z: 317.9993 $[M - H]^-$, $C_{15}H_9ClNO_3S$ requires 317.9992.

(-)-4-((4-chlorophenyl)ethynyl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3be)

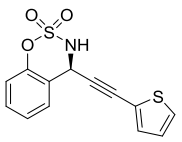


3be

The enantiomeric excess (86%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 14.06 min, minor enantiomer t_r = 20.77 min.

Brown oil; $[\alpha]_D^{20}$ -46.06 (*c* 1.0, $CHCl_3$, 86% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.46 – 7.41 (m, 2H), 7.36 – 7.33 (m, 3H), 7.20 – 7.16 (m, 1H), 6.94 (d, *J* = 8.4 Hz, 1H), 5.88 (d, *J* = 9.6 Hz, 1H), 4.82 (d, *J* = 9.8 Hz, 1H), 2.37 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.4 (C), 135.7 (C), 135.6 (C), 133.2 (CH), 131.0 (CH), 128.9 (CH), 127.6 (CH), 119.6 (C), 118.9 (C), 118.6 (CH), 86.4 (C), 83.6 (C), 50.2 (CH), 20.9 (C); **IR** 3256, 2926, 2206, 1530, 1485, 1418, 1360, 1177, 1105, 1015, 852, 824, 780 cm^{-1}; **HRMS** (ESI) m/z: 332.0141 $[M - H]^-$, $C_{16}H_{11}ClNO_3S$ requires 332.0148.

(-)-4-(thiophen-2-ylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3af)



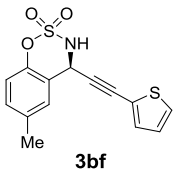
3af

The enantiomeric excess (79%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 8.82 min, minor enantiomer t_r = 11.89 min.

Brown oil; $[\alpha]_D^{20}$ = -13.4 (*c* 1.0, $CHCl_3$, 79% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.58 (dt, *J* = 7.8, 1.4 Hz, 1H), 7.46 – 7.34 (m, 1H), 7.35 (dd, *J* = 5.2, 1.2 Hz,

1H), 7.32 (dd, *J* = 3.6, 1.2 Hz, 1H), 7.27 (td, *J* = 7.6, 1.3 Hz, 1H), 7.06 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.02 (dd, *J* = 5.1, 3.7 Hz, 1H), 5.96 (d, *J* = 9.8 Hz, 1H), 4.93 (d, *J* = 9.9 Hz, 1H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ150.5 (C), 133.7 (CH), 130.4 (CH), 128.7 (CH), 127.6 (CH), 127.2 (C), 125.7 (CH), 120.7 (C), 119.3 (C), 118.8 (CH), 86.2 (C), 81.2 (C), 50.5 (CH); **IR** 3256, 3097, 2228, 2182, 1579, 1418, 1369, 1191, 1163, 1093, 1021, 877, 752 cm^{-1}; **HRMS** (ESI) m/z: 289.9946 $[M - H]^-$, $C_{13}H_8NO_3S_2$ requires 289.9946.

(-)-6-methyl-4-(thiophen-2-ylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bf)

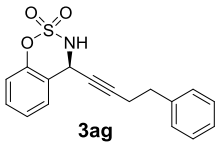


3bf

The enantiomeric excess (86%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 17.86 min, minor enantiomer t_r = 24.74 min.

Brown oil; $[\alpha]_D^{20}$ -24.1 (*c* 1.0, $CHCl_3$, 86% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.36 (dd, *J* = 5.1, 1.2 Hz, 1H), 7.33 (dt, *J* = 3.7, 1.2 Hz, 1H), 7.20 – 7.16 (m, 1H), 7.03 (dd, *J* = 5.1, 3.7 Hz, 1H), 6.94 (d, *J* = 8.4 Hz, 1H), 5.91 (Br s, 1H), 4.84 (br s, 1H), 2.37 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.4 (C), 135.6 (C), 133.7 (CH), 131.0 (CH), 128.6 (CH), 127.6 (CH), 127.2 (CH), 120.9 (C), 118.8 (C), 118.5 (CH), 86.4 (C), 81.0 (C), 50.4 (CH), 20.8 (CH_3); **IR** 3256, 2978, 2229, 2184, 1488, 1421, 1365, 1166, 1105, 1035, 846, 791, 652 cm^{-1}; **HRMS** (ESI) m/z: 304.0107 $[M - H]^-$, $C_{14}H_{10}NO_3S_2$ requires 304.0102.

(-)-4-(4-phenylbut-1-yn-1-yl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ag)

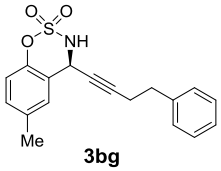


3ag

The enantiomeric excess (60%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 14.04 min, minor enantiomer t_r = 16.72 min.

Brown oil; $[\alpha]_D^{20}$ -30.34 (*c* 1.0, $CHCl_3$, 60% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.37 – 7.27 (m, 4H), 7.24 – 7.15 (m, 4H), 7.00 (dd, *J* = 8.2, 1.1 Hz, 1H), 5.64 (d, *J* = 8.2 Hz, 1H), 4.64 (d, 8.3 Hz, 1H), 2.88 (t, *J* = 7.3 Hz, 2H), 2.61 (td, *J* = 7.2, 2.2 Hz, 2H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ150.4 (C), 139.9 (C), 130.1 (C), 128.5 (CH), 127.6 (CH), 126.6 (CH), 125.4 (CH), 119.9 (C), 118.5 (CH), 88.1 (C), 74.9 (C), 49.9 (CH), 34.4 (CH_2), 20.7 (CH_2); **IR** 3275, 2928, 2245, 2226, 1576, 1421, 1396, 1360,1191, 1160, 1085, 1021, 871, 749, 699 cm^{-1}; **HRMS** (ESI) m/z: 312.0689 $[M - H]^-$, $C_{17}H_{14}NO_3S$ requires 312.0694.

(-)-6-methyl-4-(4-phenylbut-1-yn-1-yl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bg)

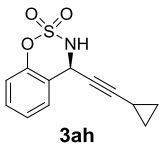


3bg

The enantiomeric excess (65%) was determined by chiral HPLC (Chiralpak IC), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 16.53 min, minor enantiomer t_r = 19.80 min.

Mp 84 °C; $[\alpha]_D^{20}$ -55.94 (*c* 1.0, $CHCl_3$, 65% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.35 – 7.29 (m, 2H), 7.27 – 7.21 (m, 3H), 7.15 – 7.11 (m, 2H), 6.89 (d, *J* = 9 Hz, 1H), 5.60 (d, *J* = 9.9 Hz, 1H), 4.57 (d, *J* = 10 Hz, 1H), 2.88 (t, *J* = 7.3 Hz, 2H), 2.61 (dt, *J* = 6.9, 2.4 Hz, 2H), 2.32 (s, 3H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.3 (C), 140.0 (C), 135.3 (C), 130.7 (CH), 128.5 (CH), 127.7 (CH), 126.6 (CH), 119.4 (C), 118.3 (C), 87.9 (C), 75.0 (C), 49.9 (CH), 34.4 (CH_2), 20.81 (CH_2), 20.8 (C); **IR** 3259, 2925, 2235, 1404, 1352, 1207, 1179, 1143, 1099, 849, 749, 696 cm^{-1}; **HRMS** (ESI) m/z: 345.1262 $[M + NH_4]^+$, $C_{18}H_{21}N_2O_3S$ requires 345.1273.

(-)-4-(cyclopropylethynyl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ah)

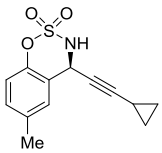


3ah

The enantiomeric excess (74%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 9.49 min, minor enantiomer t_r = 11.12min.

Mp 85 °C; $[\alpha]_D^{20}$ -57.19 (*c* 1.0, $CHCl_3$, 74% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.50 (dt, *J* = 7.7, 1.2 Hz, 1H), 7.38 – 7.32 (m, 1H), 7.23 (td, *J* = 7.6, 1.4 Hz, 1H), 5.64 (d, *J* = 10.0 Hz, 1H), 4.70 (d, *J* = 9.9 Hz, 1H), 1.36 – 1.28 (m, 1H), 0.90 – 0.83 (m, 2H), 0.79 – 0.74 (m, 2H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ150.5 (C), 130.1 (CH), 127.6 (CH), 125.4 (CH), 120.1 (C), 118.5 (CH), 92.1 (C), 68.9 (C), 50.0 (CH), 8.5 (CH_2), 8.4 (CH_2), 0.7 (CH); **IR** 3239, 2925, 2245, 2201, 1574, 1415, 1363, 1185, 1157, 1088, 885, 774, 647 cm^{-1}; **HRMS** (ESI) m/z: 248.0374 $[M - H]^-$, $C_{12}H_{10}NO_3S$ requires 248.0381.

(-)-4-(cyclopropylethynyl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bh)

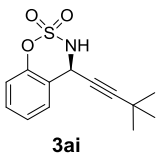


3bh

The enantiomeric excess (78%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 10.76 min, minor enantiomer t_r = 9.49 min.

Orange oil; $[\alpha]_D^{20}$ -83.56 (*c* 1.0, $CHCl_3$, 78% *ee*). **^{1}H MR (300 MHz, $CDCl_3$)** δ 7.26 (br s, 1H), 7.15 – 7.12 (m, 1H), 6.89 (d, *J* = 8.4 Hz, 1H), 5.59 (d, *J* = 9.9 Hz, 1H), 4.65 (d, *J* = 9.0 Hz, 1H), 2.36 (s, 3H), 1.36 – 1.31 (m, 1H), 0.90-0.8 (m, 2H), 0.80 - 0.74 (m, 2H). **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.4 (C), 135.3 (C), 130.7 (CH), 127.7 (CH), 119.6 (C), 118.3 (CH), 91.9 (C), 69.1 (C), 50.0 (CH), 20.81 (CH_3), 8.5 (CH_2), 8.4 (CH_2), 0.6 (CH). **IR** 3264, 2923, 2248, 2215, 1529, 1421, 1365, 1202, 1168, 1102, 846, 658 cm^{-1}; **HRMS** (ESI) m/z: 262.0523 $[M - H]^-$, $C_{13}H_{12}NO_3S$ requires 262.0538.

(-)-4-(3,3-dimethylbut-1-yn-1-yl)-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3ai)

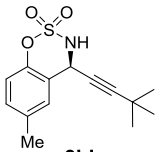


3ai

The enantiomeric excess (79%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 4.98 min, minor enantiomer t_r = 5.31 min.

Orange oil; $[\alpha]_D^{20}$ -58.46 (*c* 1.0, $CHCl_3$, 79% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ 7.49 (dt, *J* = 7.7, 1.6 Hz, 1H), 7.39 – 7.33 (m, 1H), 7.24 (dt, *J* = 7.5, 1.4 Hz, 1H), 7.01 (dd, *J* = 8.2, 1.2 Hz, 1H), 5.68 (d, *J* = 10.2 Hz, 1H), 4.67 (d, *J* = 10.1 Hz, 1H), 1.28 (s, 9H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ150.5 (C), 130.1 (CH), 127.5 (CH), 125.5 (CH), 120.3 (C), 118.5 (CH), 97.2 (C), 72.4 (C), 49.9 (CH), 30.6 (CH_3), 27.6 (C); **IR** 3259, 2967, 2240, 2212, 1418, 1369, 1193, 1160, 1071, 880, 752 cm^{-1}; **HRMS** (ESI) m/z: 264.0693 $[M - H]^-$, $C_{13}H_{15}NO_3S$ requires 264.0694.

(-)-4-(3,3-dimethylbut-1-yn-1-yl)-6-methyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (3bi)



3bi

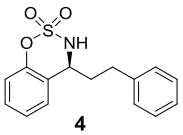
The enantiomeric excess (86%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 4.70 min, minor enantiomer t_r = 5.33 min.

Mp 103 °C; $[\alpha]_D^{20}$ -93.85 (*c* 1.0, $CHCl_3$, 86% *ee*); **^{1}H NMR (300 MHz, $CDCl_3$)** δ7.27 – 7.25 (m, 1H), 7.14 – 7.12 (m, 1H), 6.90 (d, *J* = 8.4 Hz, 1H), 5.63 (d, *J* = 10.2 Hz, 1H), 4.81 (d, *J* = 10.2 Hz, 1H), 2.36 (s, 3H), 1.28 (s, 9H); **^{13}C NMR (75.5 MHz, $CDCl_3$)** δ148.4 (C), 135.3 (C), 130.7 (CH), 127.9 (CH), 119.8 (C), 118.2 (CH), 97.0 (C), 72.6 (C), 49.8 (CH), 30.6 (CH_3), 27.6 (C), 20.9 (CH_3); **IR** 3256, 2967, 2242, 2220, 1492, 1410, 1371, 1202, 1177, 1141, 1081, 863, 688 cm^{-1}; **HRMS** (ESI) m/z: 278.0842 $[M - H]^-$, $C_{14}H_{16}NO_3S$ requires 278.0851.

<u>Procedures and characterization data for compounds 4 and 5</u>

(-)-4-phenethyl-3,4-dihydrobenzo[e][1,2,3]oxathiazine 2,2-dioxide (4)

A solution of **3aa** (23.09mg, 0.081 mmol) in absolute EtOH (7.5ml) is stirred under H_2 in the presence of $Pd/CaCO_3$ (5%) (10.5 mg) during 1h. Afterwards, the mixture is filtered over silica gel using EtOAc as eluent, and the solvent is removed under reduced pressure. Purification by flash chromatography on silica gel afforded compound **4** (98%).



4

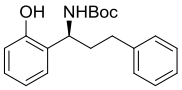
The enantiomeric excess (80%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 80:20, 1 mL/min, major enantiomer t_r = 10.55 min, minor enantiomer t_r = 9.01 min.

Orange oil; $[\alpha]_D^{20}$ –33.7 (*c* 1.0, $CHCl_3$, 80% *ee*); **NMR ^{1}H (300 MHz, $CDCl_3$)** δ7.36 (m, 3H), 7.26-7.23 (m, 3H), 7.18-7.16 (m, 2H), 7.02-6.99 (m, 1H), 4.73-4.64 (m, 2H), 2.97 (ddd, *J* = 13.5, 7.6, 5.7 Hz, 1H), 2.81 (dt, *J* = 13.9, 8.3 Hz, 1H), 2.42-2.34 (m, 2H); **^{13}C (75,5 MHz, $CDCl_3$)** δ151.18 (C), 140.3 (C), 129.4 (CH), 128.8 (CH), 128.5 (CH), 126.5 (CH), 126.3 (CH), 125.3 (CH), 122.5 (C), 118.9 (CH), 56.6 (CH), 35.6 (CH), 31.3 (CH); **HRMS** (ESI) m/z: 307.1113 $[M + NH_4]^+$, $C_{15}H_{19}N_2O_3S$ requires 307.1116.

tert-butyl (-)-(1-(2-hydroxyphenyl)-3-phenylpropyl)carbamate (5)

To a solution of the cyclic sulfamate **4** (0.08 mmol, 23 mg) in THF (1 ml), $LiAlH_4$ (1.0 M in THF, 3,3 equivalents, 0.264 mmol, 0.26 ml) was added dropwise at r.t. over 4 min. The mixture was heated to 60ºC for 2,5 hours, allowed to cool down to r.t., and then

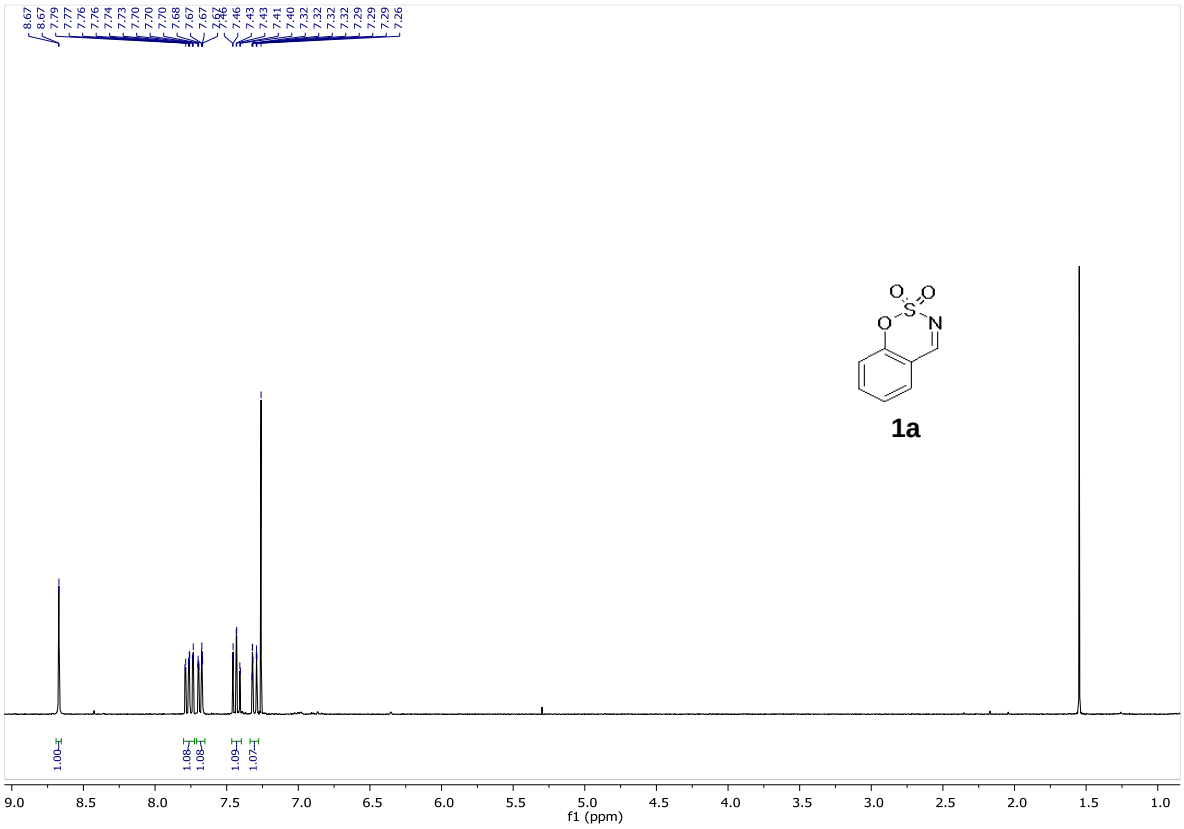
cooled with an ice bath. The reaction was quenched with EtOAc (1 ml), followed by the addition of EtOH (1 ml) and H_2O (1 ml). To the resulting turbid mixture Boc_2O (3 equivalents, 52 mg, 0.24 mmol) was added in one portion and the resulting mixture was stirred at r.t. for 1 hour. The mixture was diluted with EtOAc (15 ml) and acidified with aq 2 M HCl until the aqueous layer became clear. The aqueous layer was then separated and extracted with EtOAc (2 x 15 ml). The combined organic layers were dried ($MgSO_4$), filtered, and concentrated in vacuo. Purification of the residue by flash chromatography afforded compound **5**.[2]



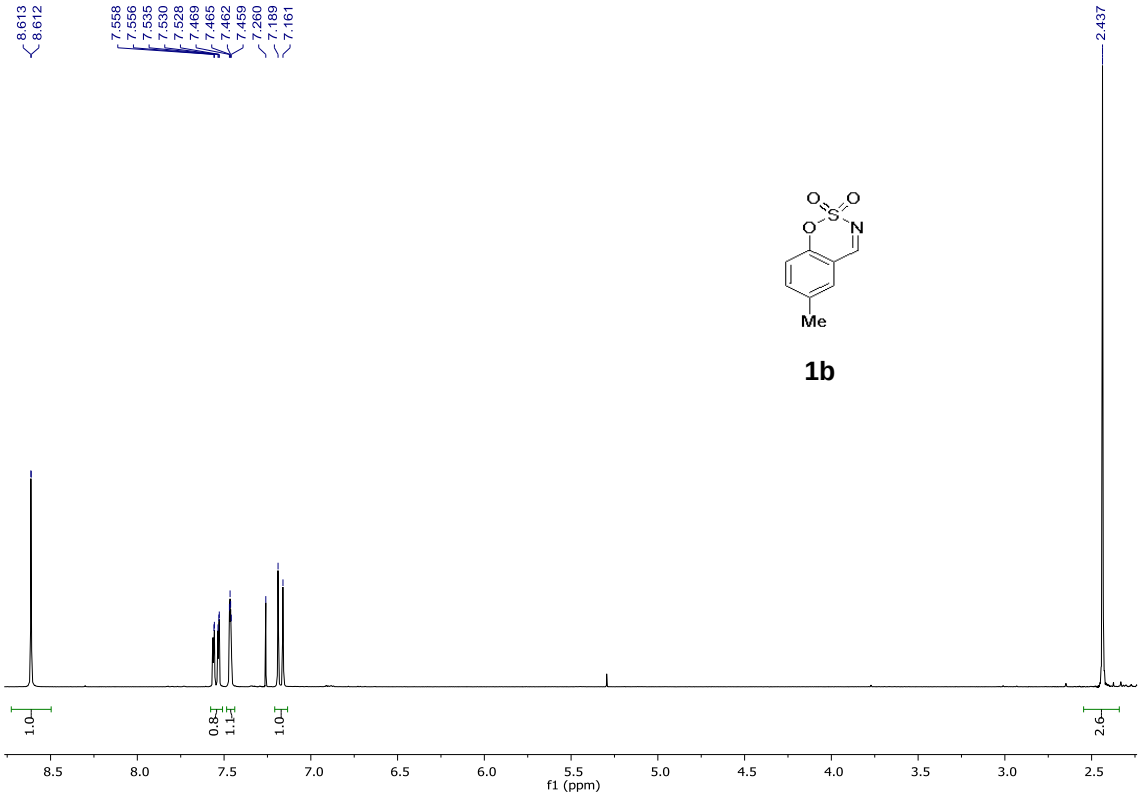
5

The enantiomeric excess (80%) was determined by chiral HPLC (Chiralpak ADH), hexane-iPrOH 90:10, 1 mL/min, major enantiomer t_r = 8.11 min, minor enantiomer t_r = 10.23 min.

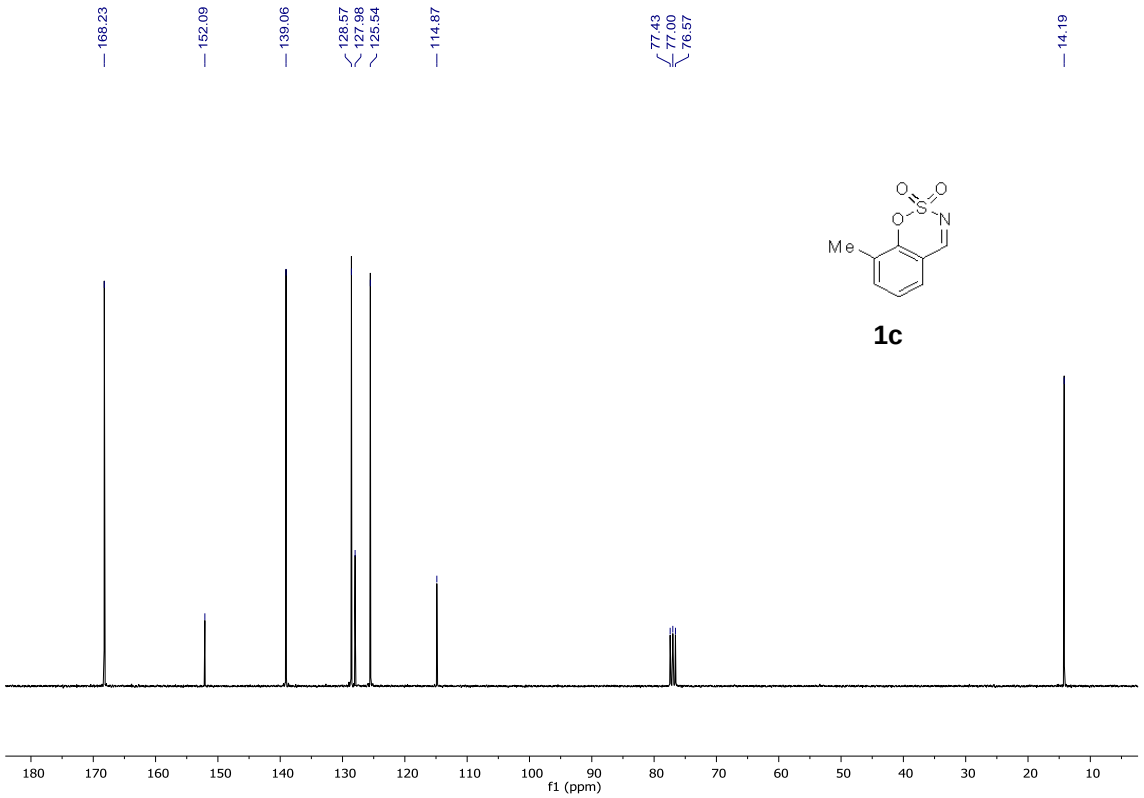
Yellow solid; $[\alpha]_D^{20}$ –31.7 (*c* 1.0, $CHCl_3$, 80% *ee*);**NMR ^{1}H (300 MHz, $CDCl_3$)** δ8.38 (s, 1H), 7.31 – 7.25 (m, 2H), 7.20 (t, J = 7.3 Hz, 1H), 7.20 – 7.13 (m, 4H), 6.95 – 6.91 (m, 1H), 6.88 (td, J = 7.5, 1.3 Hz, 1H), 5.02 (s, 1H), 4.81 (s, 1H), 2.77 – 2.60 (m, 2H), 2.26 – 2.16 (m, 2H), 1.44 (s, 9H); **^{13}C (75,5 MHz, $CDCl_3$)** δ157.4 8 (C), 156.1 (C), 141.1 (C), 128.9 (CH), 128.5 (CH), 128.4 (CH), 126.1 (C), 120.3 (CH), 80.9 (C), 35.6 (CH_2), 33.0 (CH_2), 28.3 (CH_3); 211.1120 $[M-H]^-$, $C_{15}H_{15}O$ requires 211.1123.

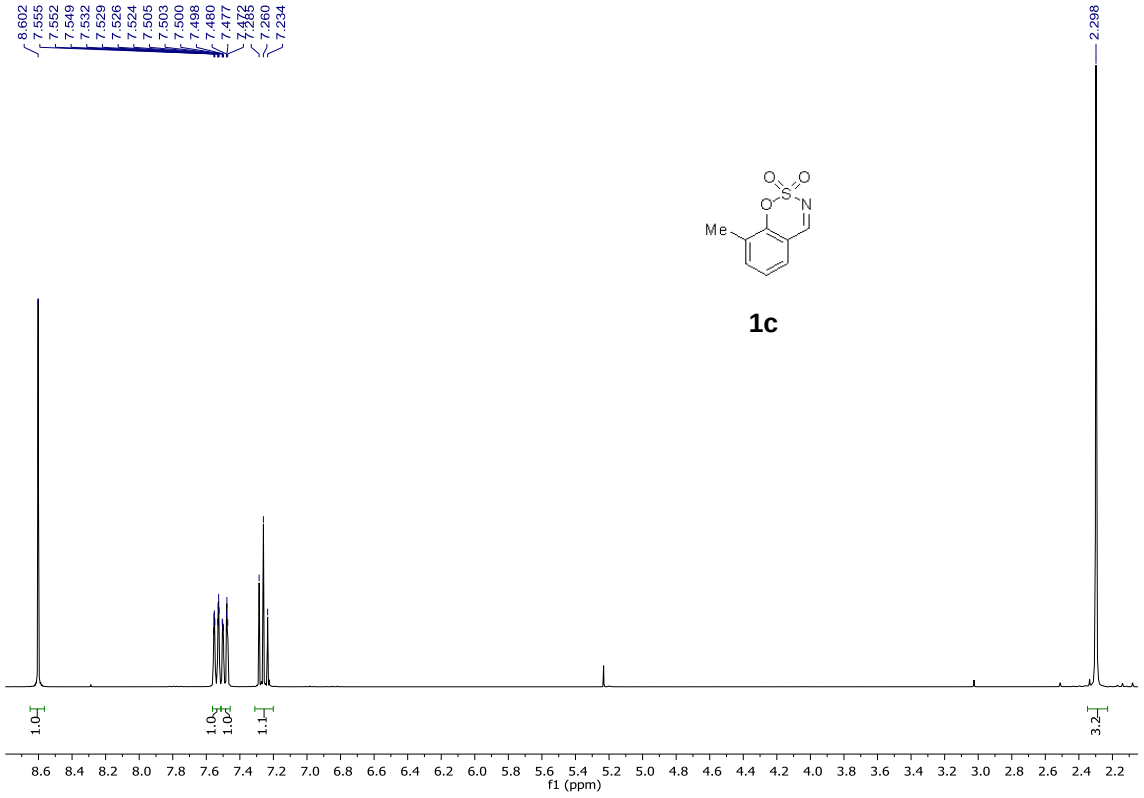

8.67
8.67
7.79
7.77
7.76
7.76
7.74
7.73
7.70
7.70
7.70
7.68
7.67
7.67
7.46
7.43
7.41
7.40
7.32
7.32
7.32
7.29
7.29
7.29
7.26
1.00
1.08
1.08
1.09
1.07
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

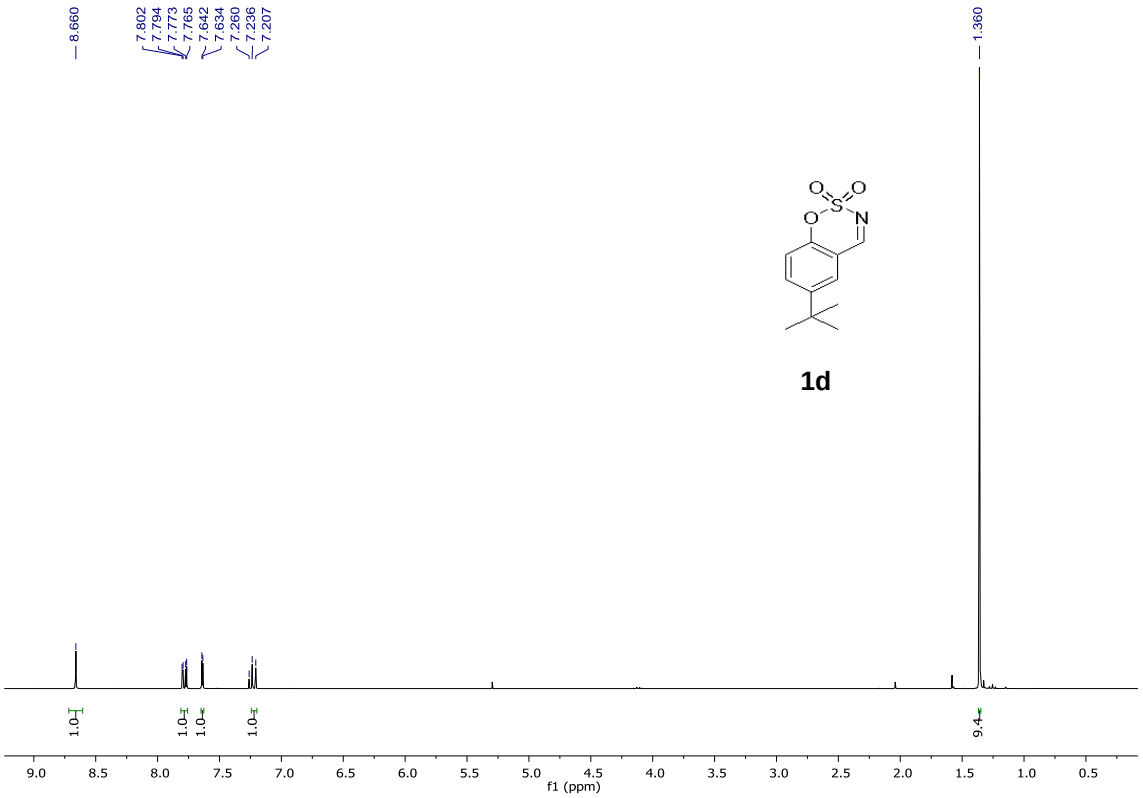
1a


8.613
8.612
7.558
7.556
7.535
7.530
7.528
7.469
7.465
7.462
7.459
7.260
7.189
7.161
2.437
1.0
0.8
1.1
1.0
2.6
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
f1 (ppm)

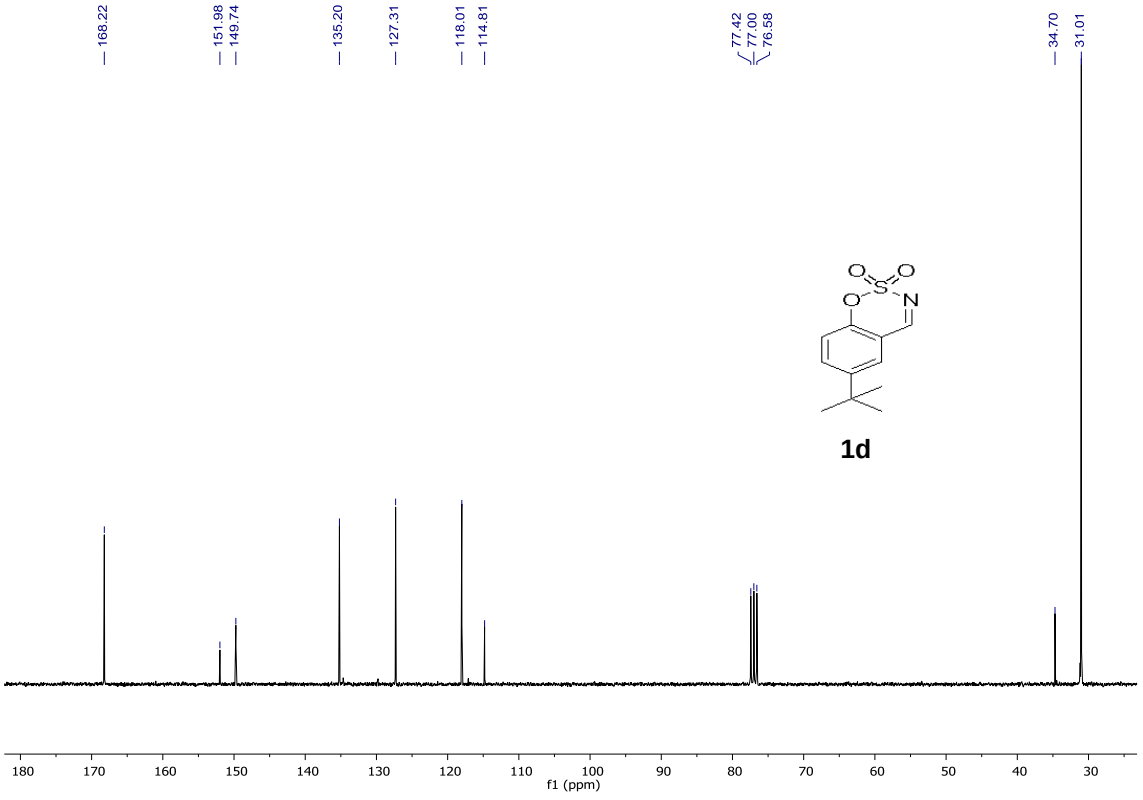
1b


168.23
152.09
139.06
128.57
127.98
125.54
114.87
77.43
77.00
76.57
14.19
Me
1c
f1 (ppm)

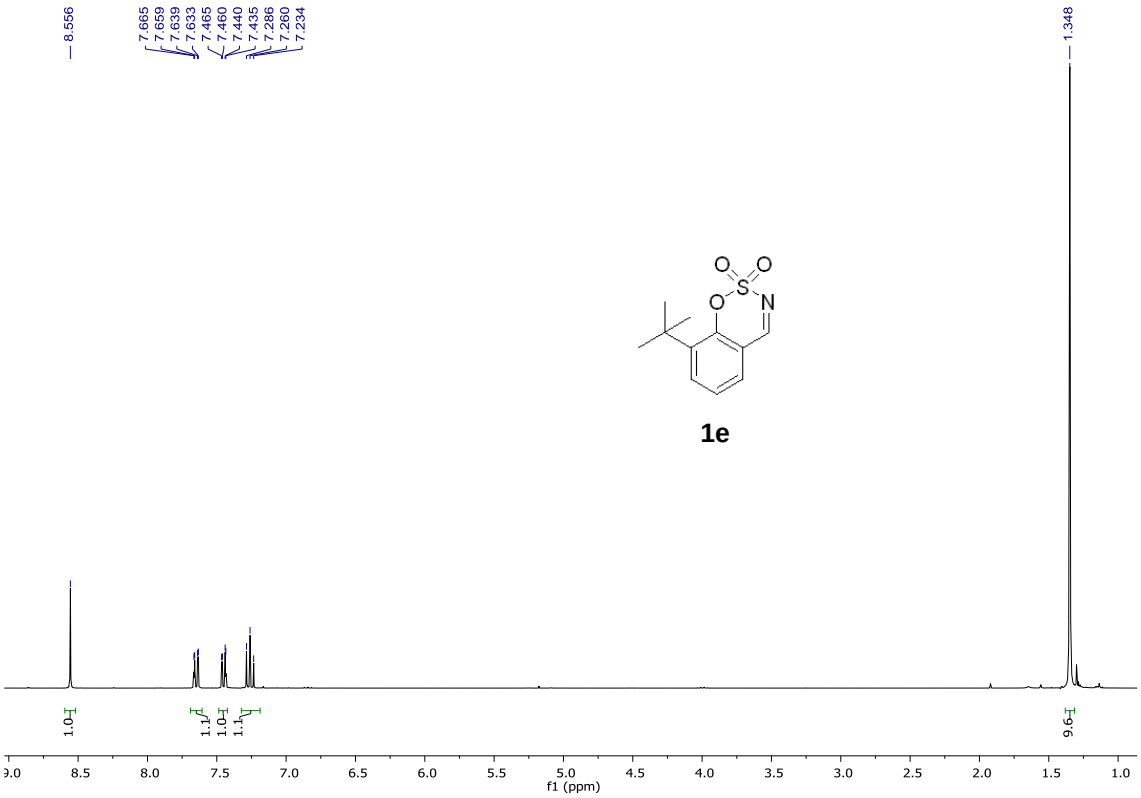

8.602
7.555
7.552
7.549
7.532
7.529
7.526
7.524
7.505
7.503
7.500
7.498
7.480
7.477
7.260
7.234
2.298
Me
1c
1.0
1.0
1.0
1.1
3.2
f1 (ppm)


8.660
7.802
7.794
7.773
7.765
7.642
7.634
7.260
7.236
7.207
1.360
1.0
1.0
1.0
1.0
9.4
f1 (ppm)

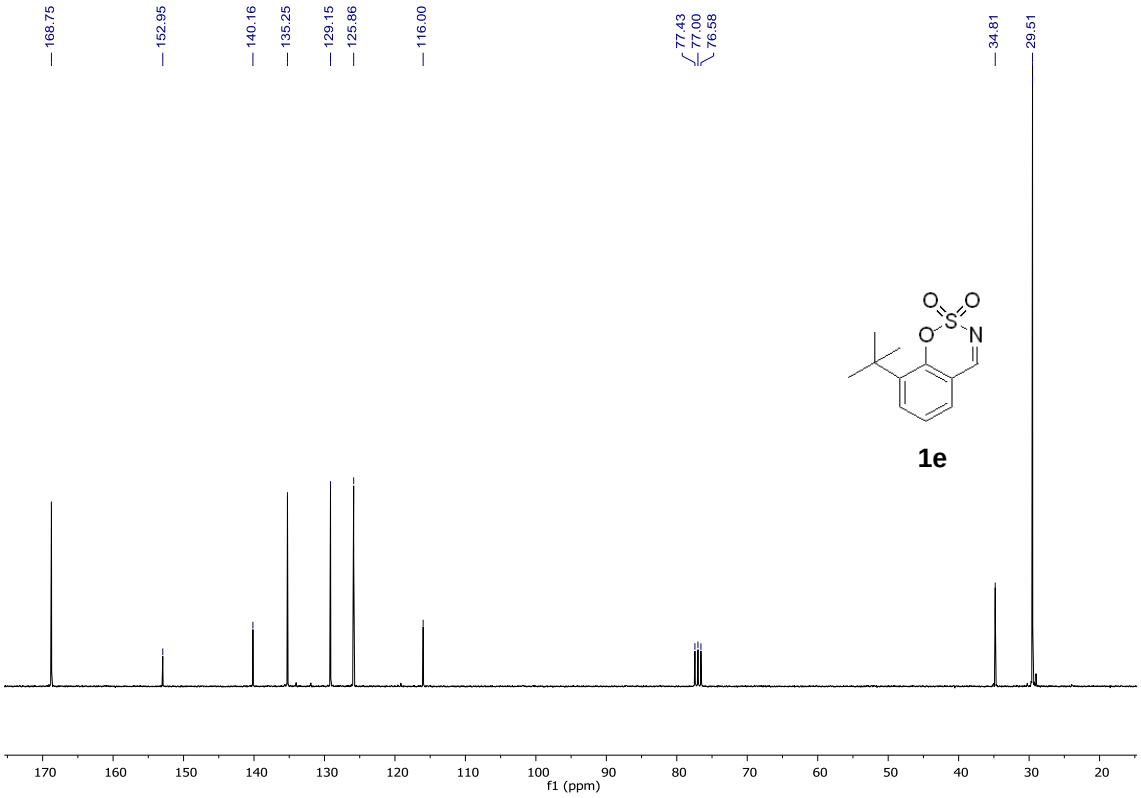
1d


168.22
151.98
149.74
135.20
127.31
118.01
114.81
77.42
77.00
76.58
34.70
31.01
f1 (ppm)

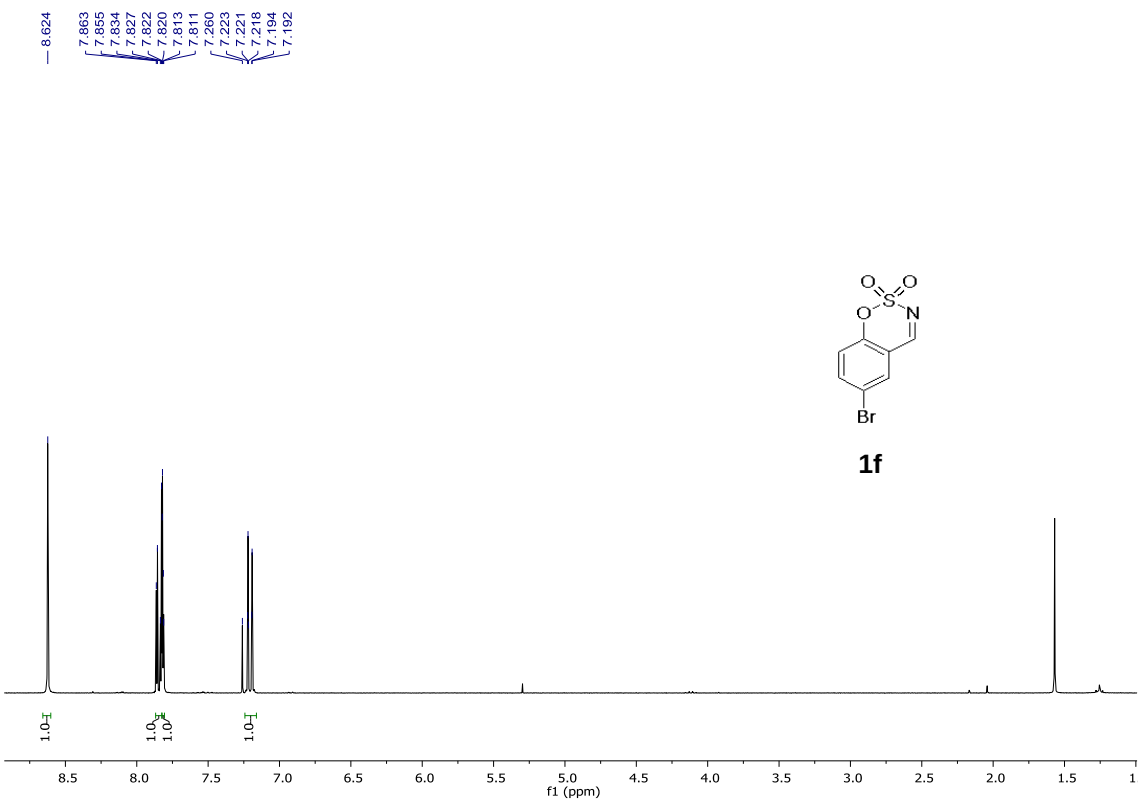
1d


8.556
7.665
7.659
7.639
7.633
7.465
7.460
7.440
7.435
7.286
7.260
7.234
1.348
1.0
1.1
1.0
1.1
9.6
f1 (ppm)

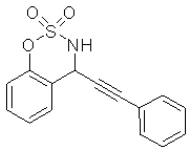
1e


168.75
152.95
140.16
135.25
129.15
125.86
116.00
77.43
77.00
76.58
34.81
29.51
f1 (ppm)

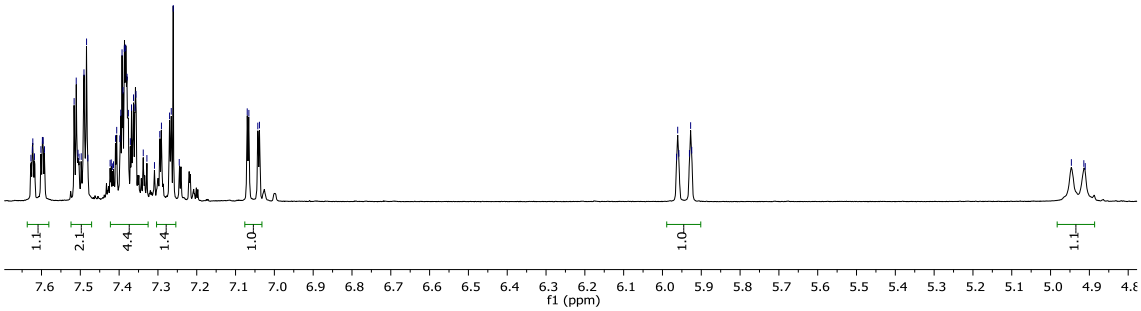
1e


8.624
7.863
7.855
7.834
7.827
7.822
7.820
7.813
7.811
7.260
7.223
7.221
7.218
7.194
7.192
O
O
S
O
N
Br
1f
1.0
1.0
1.0
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
f1 (ppm)

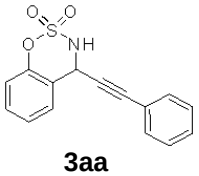

7.627
7.624
7.622
7.618
7.602
7.598
7.596
7.592
7.516
7.511
7.506
7.503
7.498
7.491
7.484
7.481
7.423
7.420
7.417
7.414
7.409
7.406
7.398
7.396
7.392
7.390
7.387
7.383
7.380
7.376
7.371
7.368
7.363
7.359
7.357
7.338
7.328
7.309
7.295
7.291
7.270
7.266
7.261
7.245
7.070
7.066
7.043
7.038
5.964
5.961
5.958
5.930
5.927
5.925
4.946
4.914
4.911



3aa

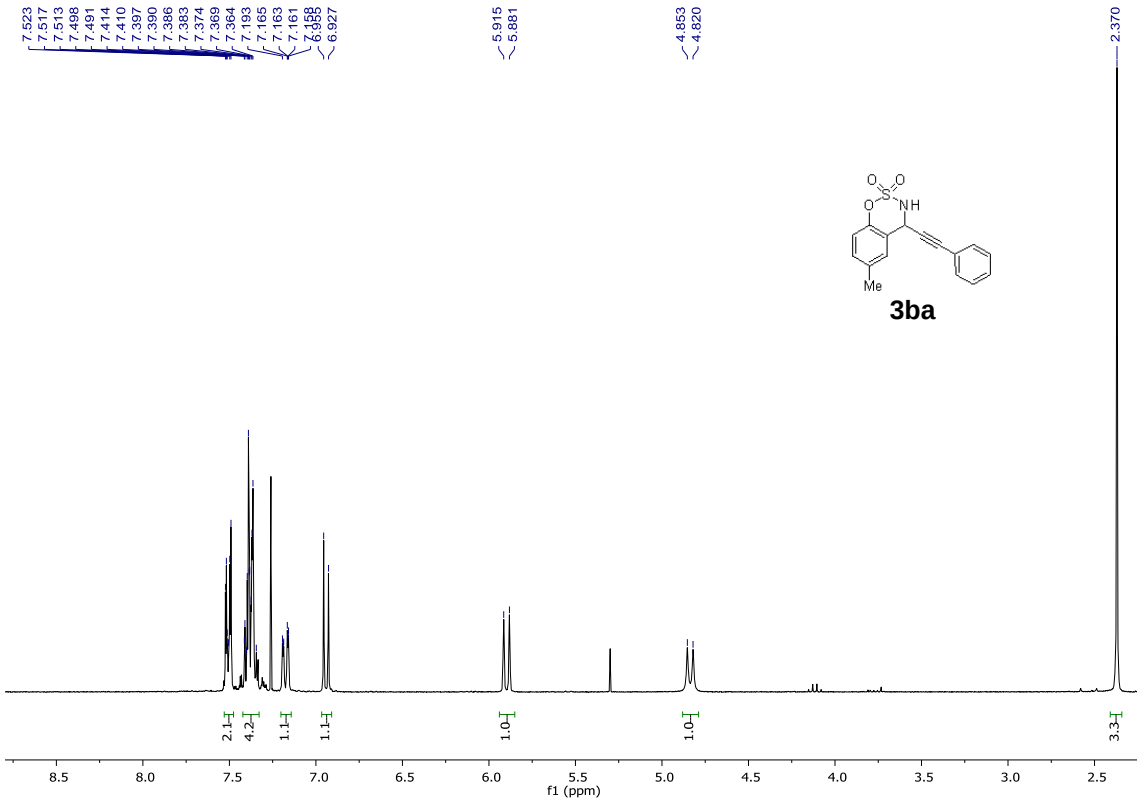

1.1
2.1
4.4
1.4
1.0
1.0
1.1
7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8 6.7 6.6 6.5 6.4 6.3 6.2 6.1 6.0 5.9 5.8 5.7 5.6 5.5 5.4 5.3 5.2 5.1 5.0 4.9 4.8
f1 (ppm)


150.57
131.97
130.35
129.49
128.51
127.57
125.61
121.05
119.61
118.70
87.74
82.34
77.42
77.00
76.58
50.26

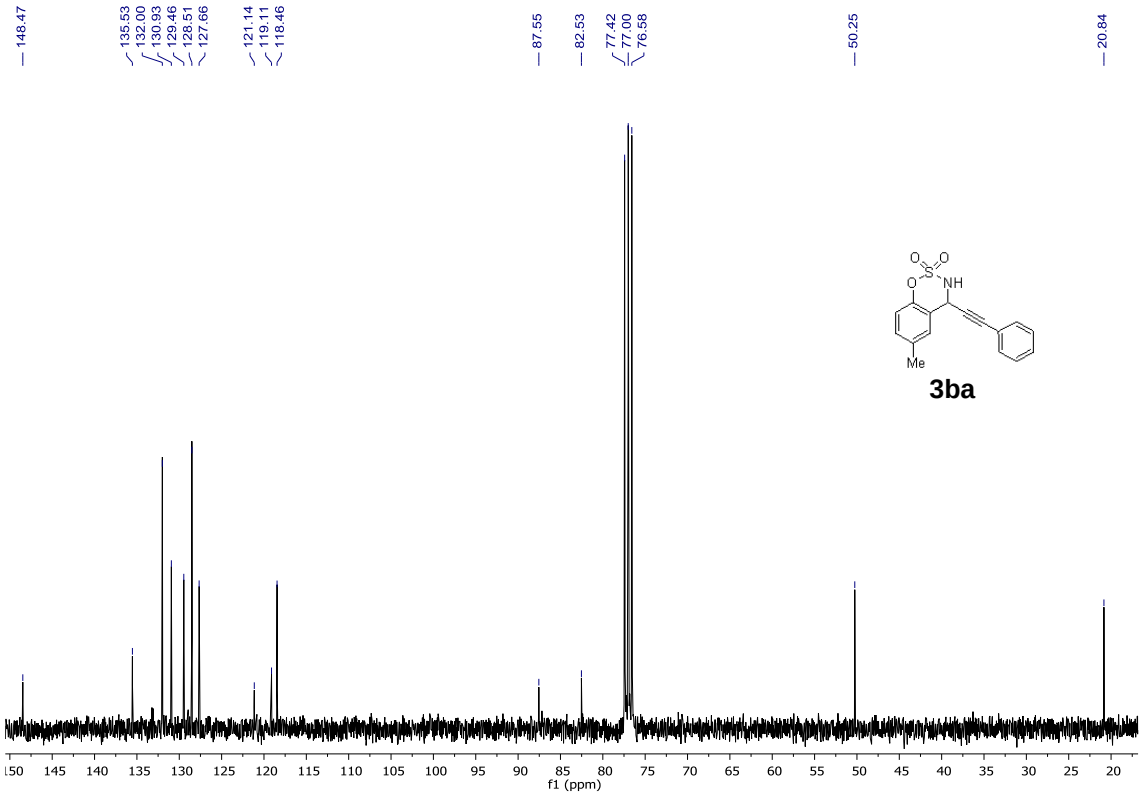


3aa

55 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45
f1 (ppm)

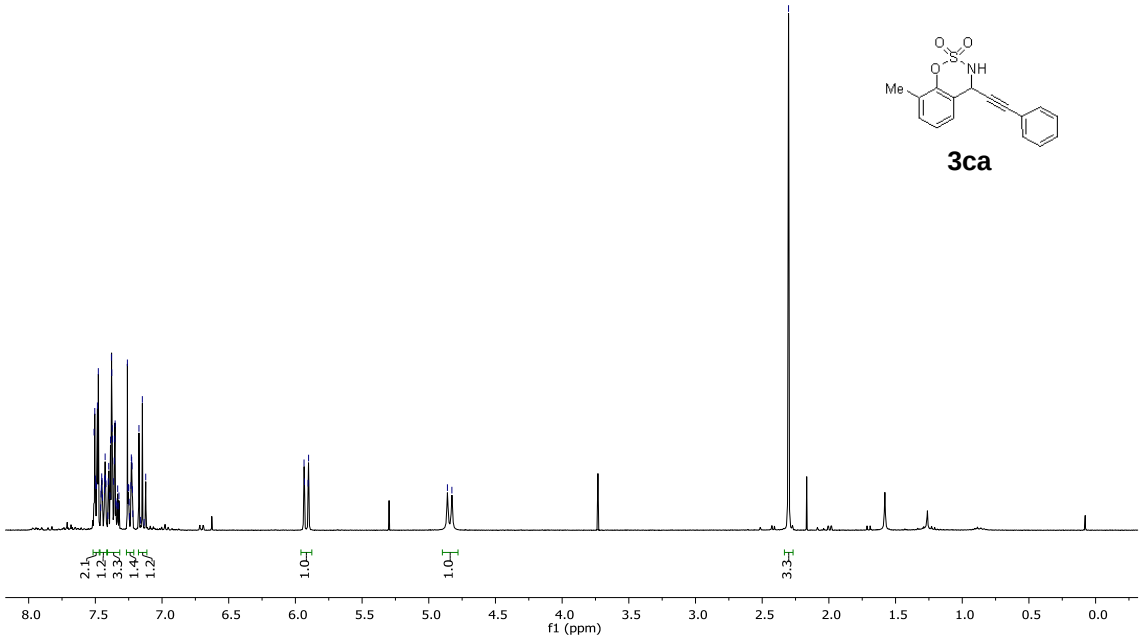

7.523
7.517
7.513
7.498
7.491
7.414
7.410
7.397
7.390
7.386
7.383
7.374
7.369
7.364
7.193
7.165
7.163
7.161
7.158
6.955
6.927
5.915
5.881
4.853
4.820
2.370
O
O
S
O
NH
Me
2.1
4.2
1.1
1.1
1.0
1.0
3.3
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
f1 (ppm)

3ba

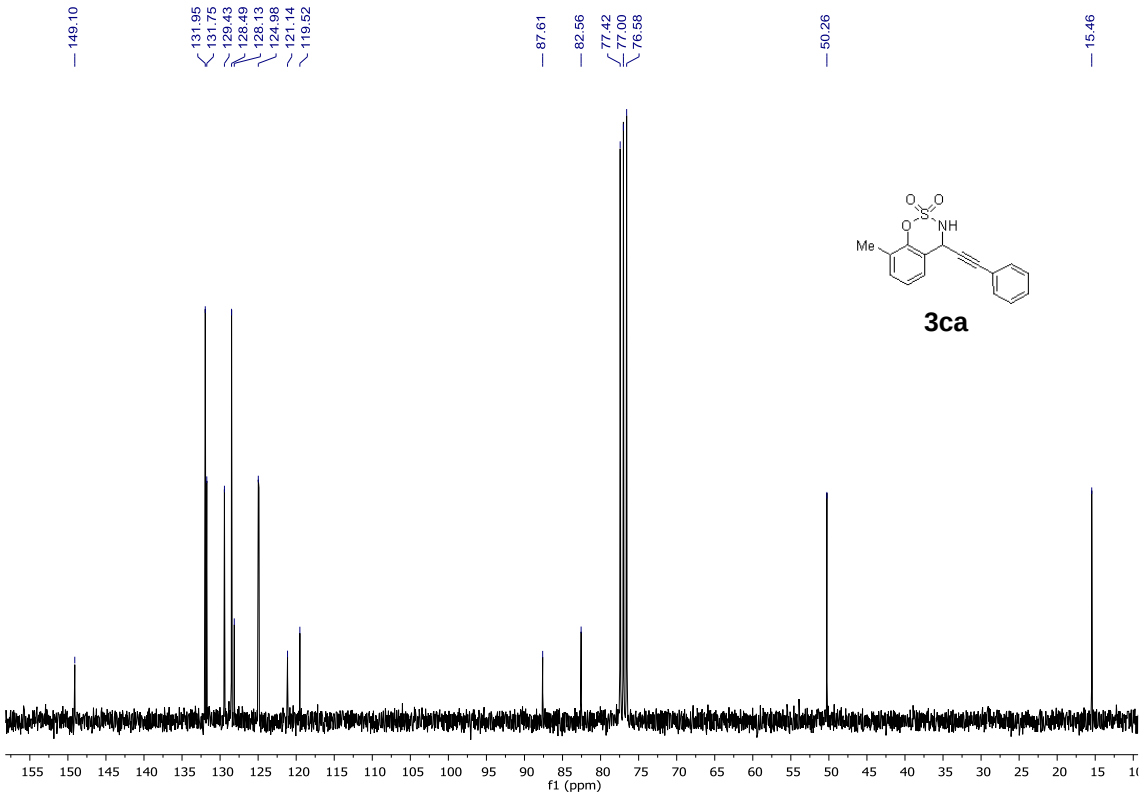

148.47
135.53
132.00
130.93
129.46
128.51
127.66
121.14
119.11
118.46
87.55
82.53
77.42
77.00
76.58
50.25
20.84
O
O
S
O
NH
Me
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
f1 (ppm)

3ba

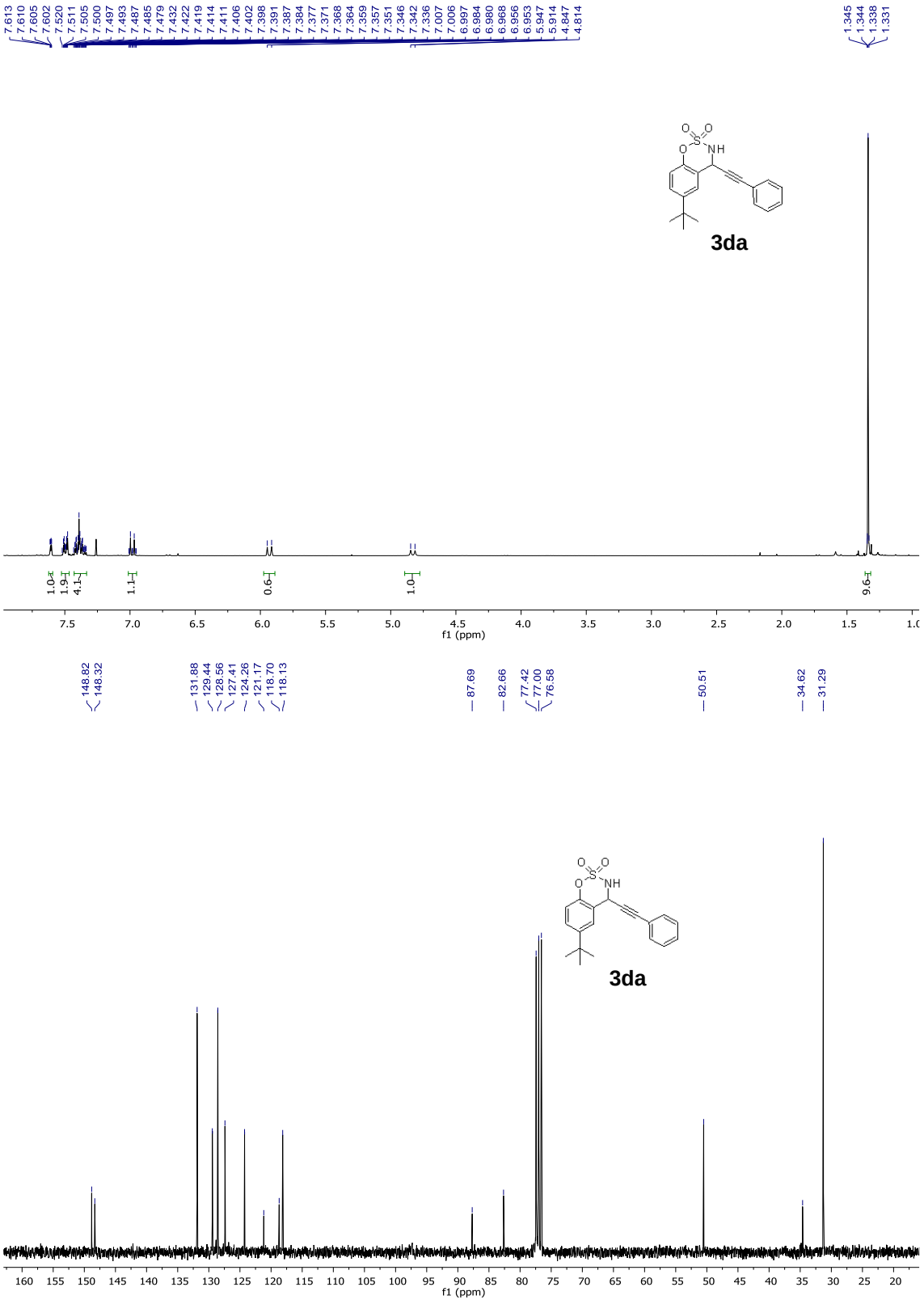

7.510
7.504
7.500
7.497
7.492
7.485
7.478
7.460
7.458
7.455
7.452
7.450
7.447
7.432
7.429
7.427
7.424
7.421
7.406
7.403
7.400
7.391
7.386
7.380
7.377
7.374
7.371
7.363
7.358
7.354
7.352
7.346
7.344
7.338
7.333
7.329
7.323
7.260
7.256
7.253
7.250
7.247
7.244
7.233
7.230
7.228
7.225
7.222
7.219
7.173
7.161
7.148
7.135
7.122
5.935
5.932
5.905
5.901
4.860
4.827
2.302

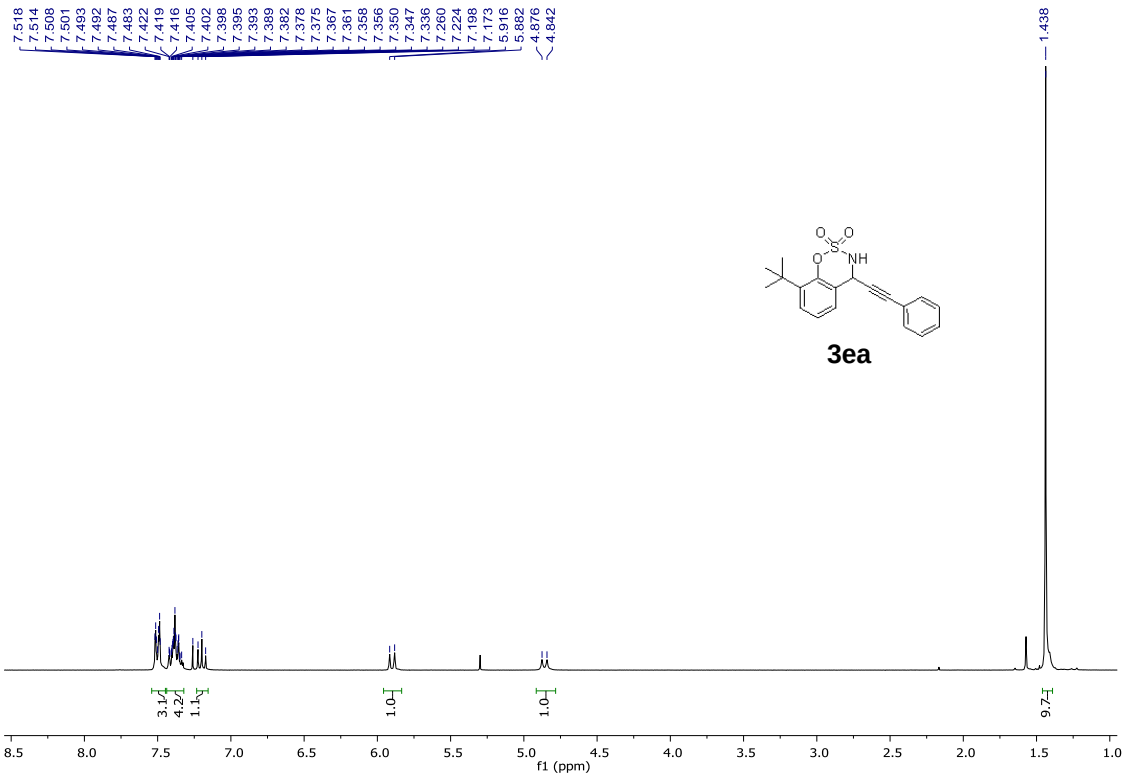

O
O
S
O
NH
Me
2.1
1.2
3.3
1.4
1.2
1.0
1.0
3.3
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

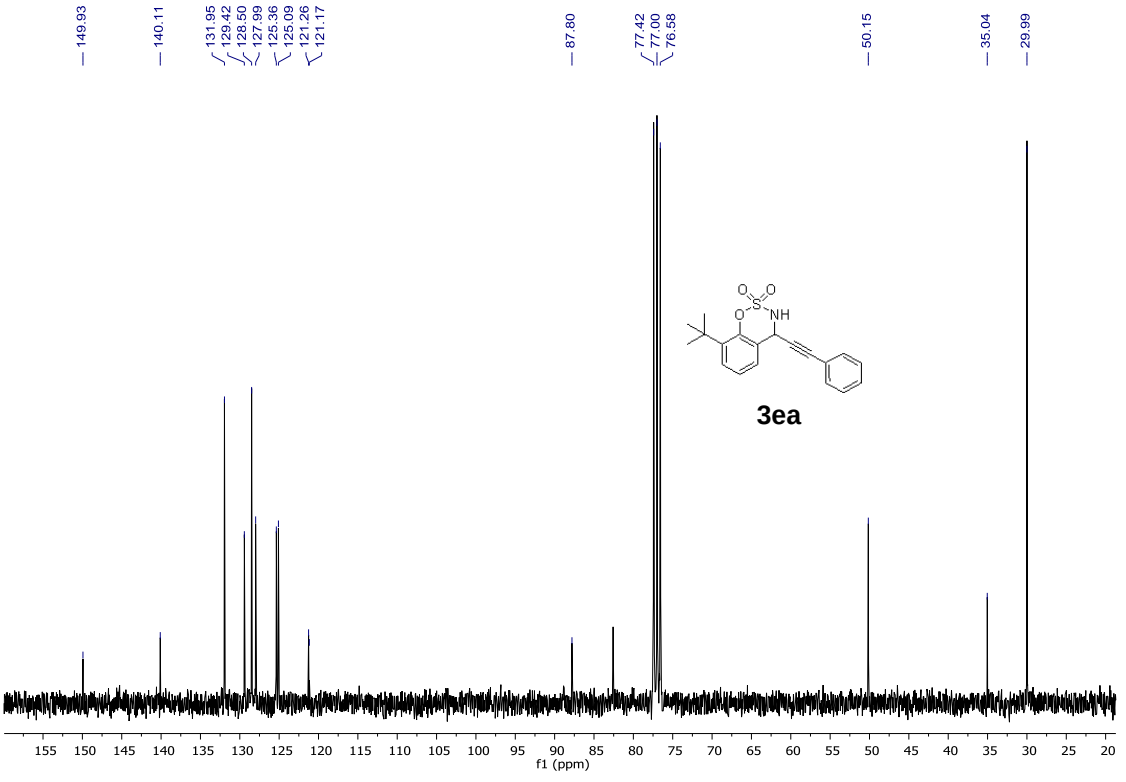
3ca


149.10
131.95
131.75
129.43
128.49
128.13
124.98
121.14
119.52
87.61
82.56
77.42
77.00
76.58
50.26
15.46
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
f1 (ppm)

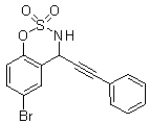
3ca


7.613
7.610
7.605
7.602
7.520
7.511
7.505
7.500
7.497
7.493
7.487
7.485
7.479
7.432
7.422
7.419
7.414
7.411
7.406
7.402
7.398
7.391
7.387
7.384
7.377
7.371
7.368
7.364
7.359
7.357
7.351
7.346
7.342
7.336
7.007
7.006
6.997
6.984
6.980
6.968
6.956
6.953
5.947
5.914
4.847
4.814
1.345
1.344
1.338
1.331
3da
1.0
1.9
4.1
1.1
0.6
1.0
9.6
f1 (ppm)
148.82
148.32
131.88
129.44
128.56
127.41
124.26
121.17
118.70
118.13
87.69
82.66
77.42
77.00
76.58
50.51
34.62
31.29
3da
f1 (ppm)

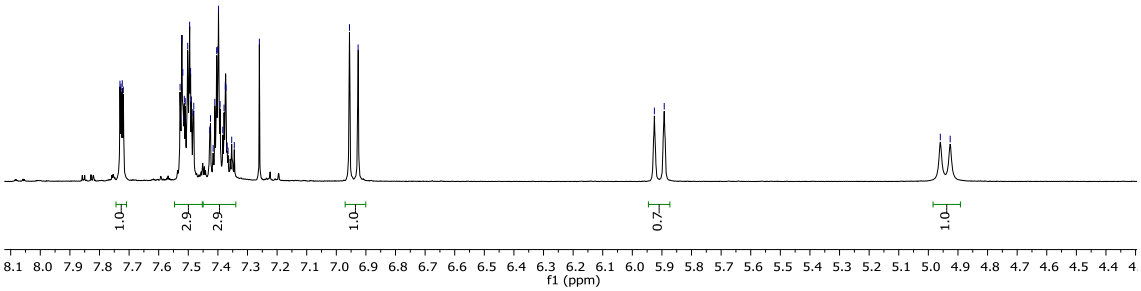

7.518
7.514
7.508
7.501
7.493
7.492
7.487
7.483
7.422
7.419
7.416
7.405
7.402
7.398
7.395
7.393
7.389
7.382
7.378
7.375
7.367
7.361
7.358
7.356
7.350
7.347
7.336
7.260
7.224
7.198
7.173
5.916
5.882
4.876
4.842
1.438
O
O
S
O
NH
3ea
3.14
4.21
1.11
1.00
1.00
9.71
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f1 (ppm)

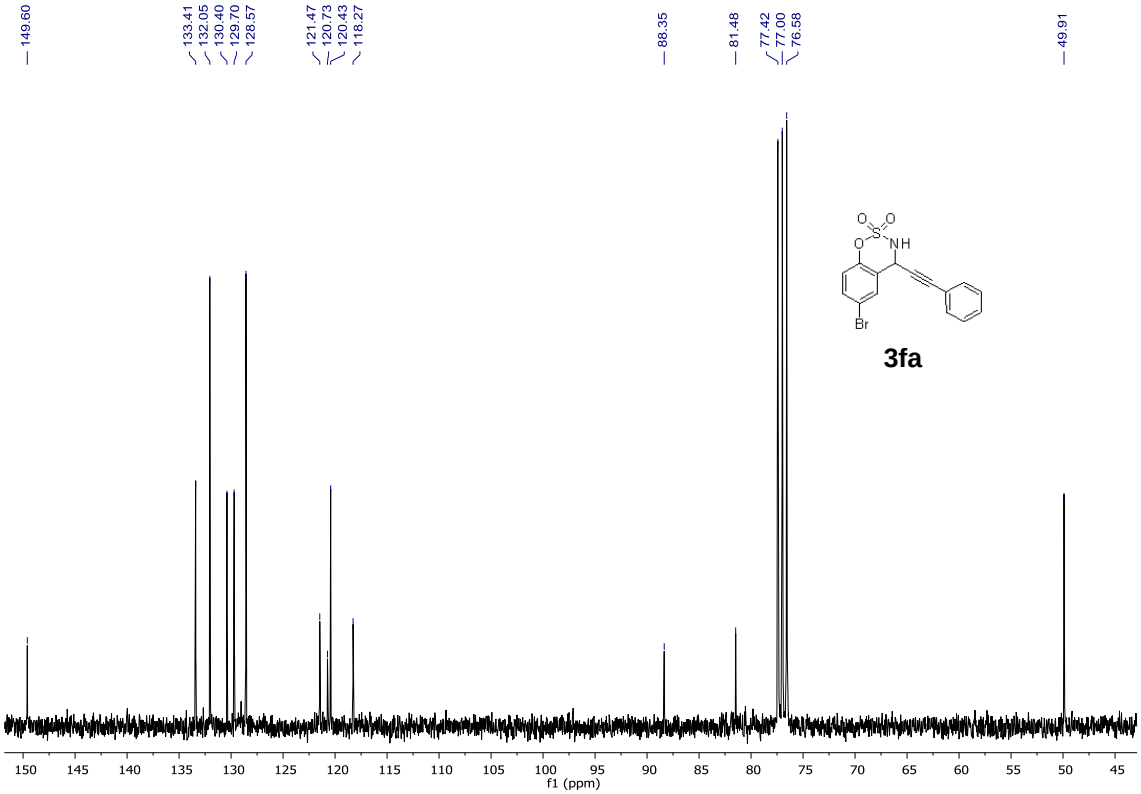

149.93
140.11
131.95
129.42
128.50
127.99
125.36
125.09
121.26
121.17
87.80
77.42
77.00
76.58
50.15
35.04
29.99
O
O
S
O
NH
3ea
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
f1 (ppm)


7.731
7.727
7.723
7.719
7.528
7.522
7.519
7.516
7.514
7.510
7.502
7.496
7.492
7.489
7.485
7.481
7.428
7.425
7.416
7.410
7.404
7.400
7.398
7.392
7.383
7.379
7.375
7.373
7.369
7.366
7.353
7.345
7.260
6.955
6.926
5.926
5.892
4.960
4.926


O
O
S
O
NH
Br

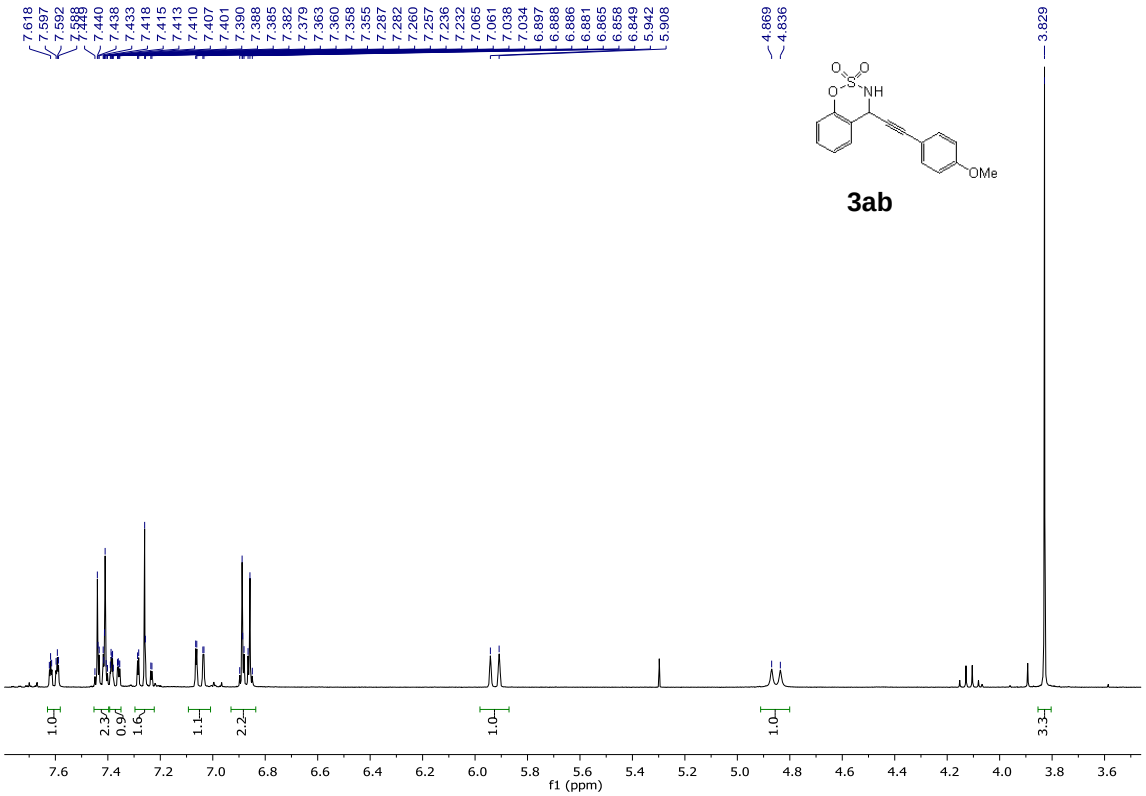
3fa

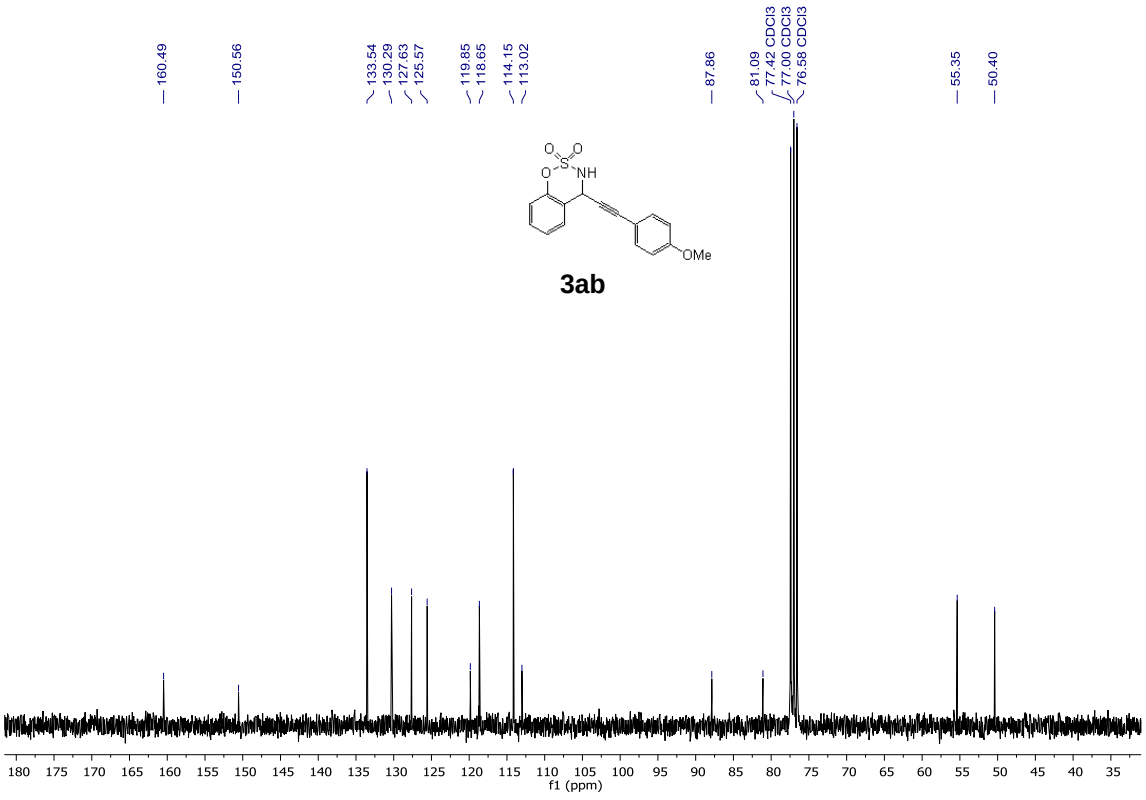

1.0
2.9
2.9
1.0
0.7
1.0
8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8 6.7 6.6 6.5 6.4 6.3 6.2 6.1 6.0 5.9 5.8 5.7 5.6 5.5 5.4 5.3 5.2 5.1 5.0 4.9 4.8 4.7 4.6 4.5 4.4
f1 (ppm)

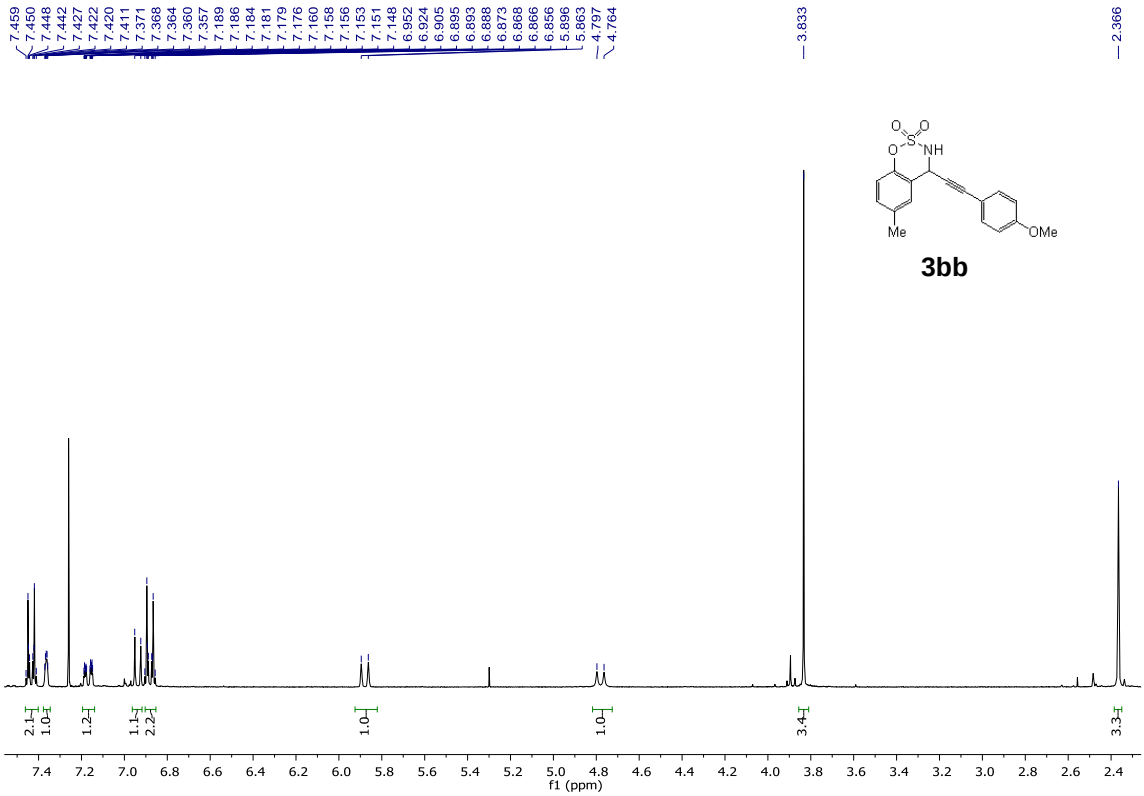

149.60
133.41
132.05
130.40
129.70
128.57
121.47
120.73
120.43
118.27
88.35
81.48
77.42
77.00
76.58
49.91
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45
f1 (ppm)

O
O
S
O
NH
Br

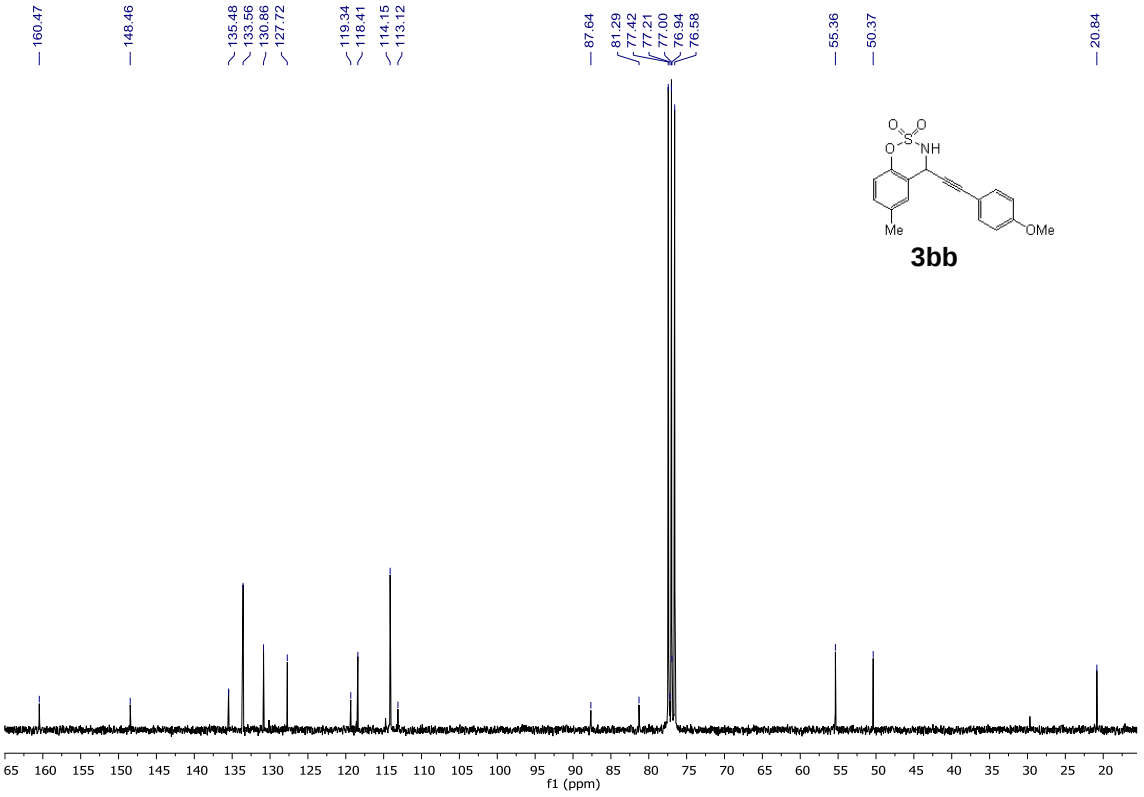
3fa


7.618
7.597
7.592
7.440
7.438
7.433
7.418
7.415
7.413
7.410
7.407
7.401
7.390
7.388
7.385
7.382
7.379
7.363
7.360
7.358
7.355
7.287
7.282
7.260
7.257
7.236
7.232
7.065
7.061
7.038
7.034
6.897
6.888
6.886
6.881
6.865
6.858
6.849
5.942
5.908
4.869
4.836
3.829
OMe
3ab
1.0
2.3
0.9
1.6
1.1
2.2
1.0
1.0
3.3
f1 (ppm)

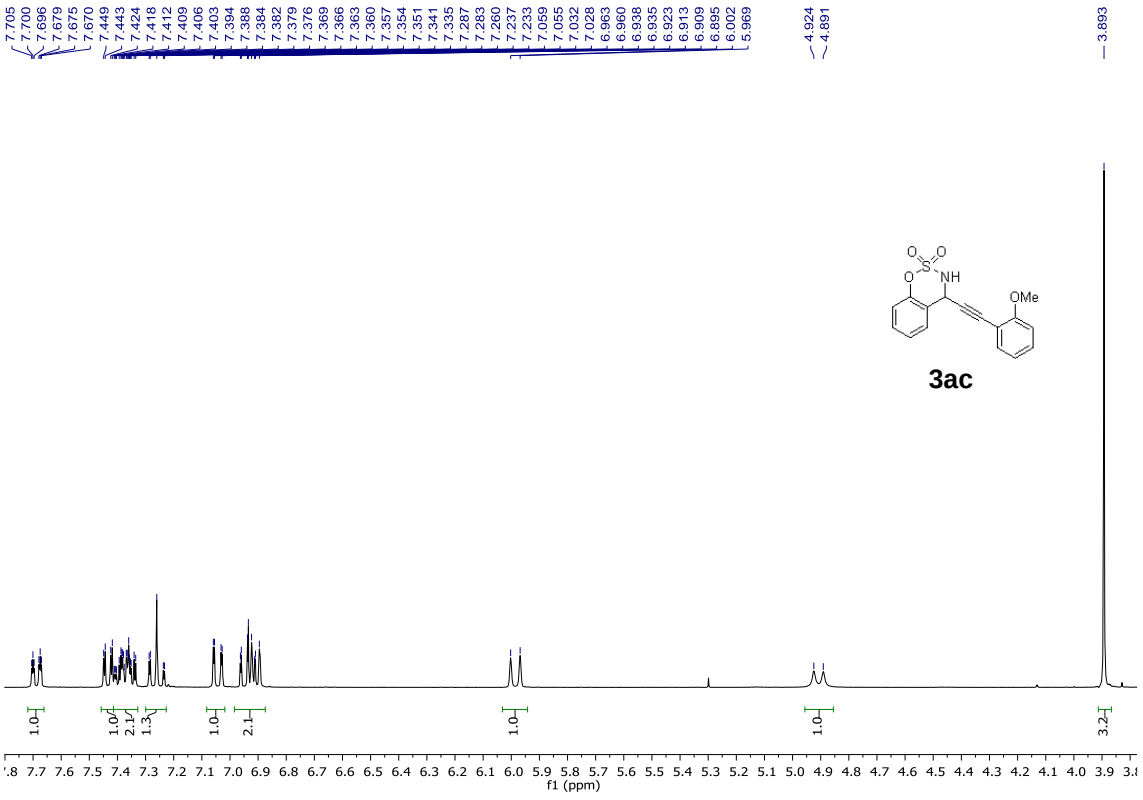

160.49
150.56
133.54
130.29
127.63
125.57
119.85
118.65
114.15
113.02
87.86
81.09
77.42 CDCl3
77.00 CDCl3
76.58 CDCl3
55.35
50.40
OMe
3ab
f1 (ppm)

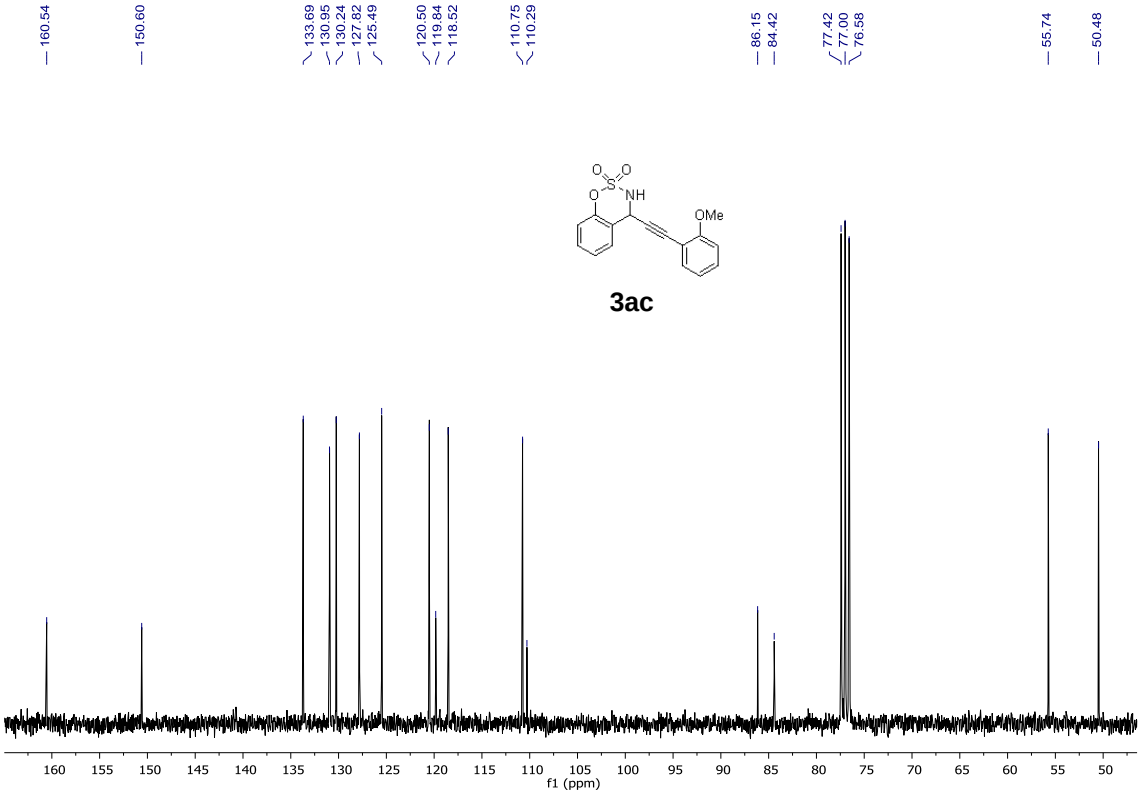

7.459
7.450
7.448
7.442
7.427
7.422
7.420
7.411
7.371
7.368
7.364
7.360
7.357
7.189
7.186
7.184
7.181
7.179
7.176
7.160
7.158
7.156
7.153
7.151
7.148
6.952
6.924
6.905
6.895
6.893
6.888
6.873
6.868
6.866
6.856
5.896
5.863
4.797
4.764
3.833
2.366
O
O
S
O
NH
Me
OMe
2.1
1.0
1.2
1.1
2.2
1.0
1.0
3.4
3.3
f1 (ppm)

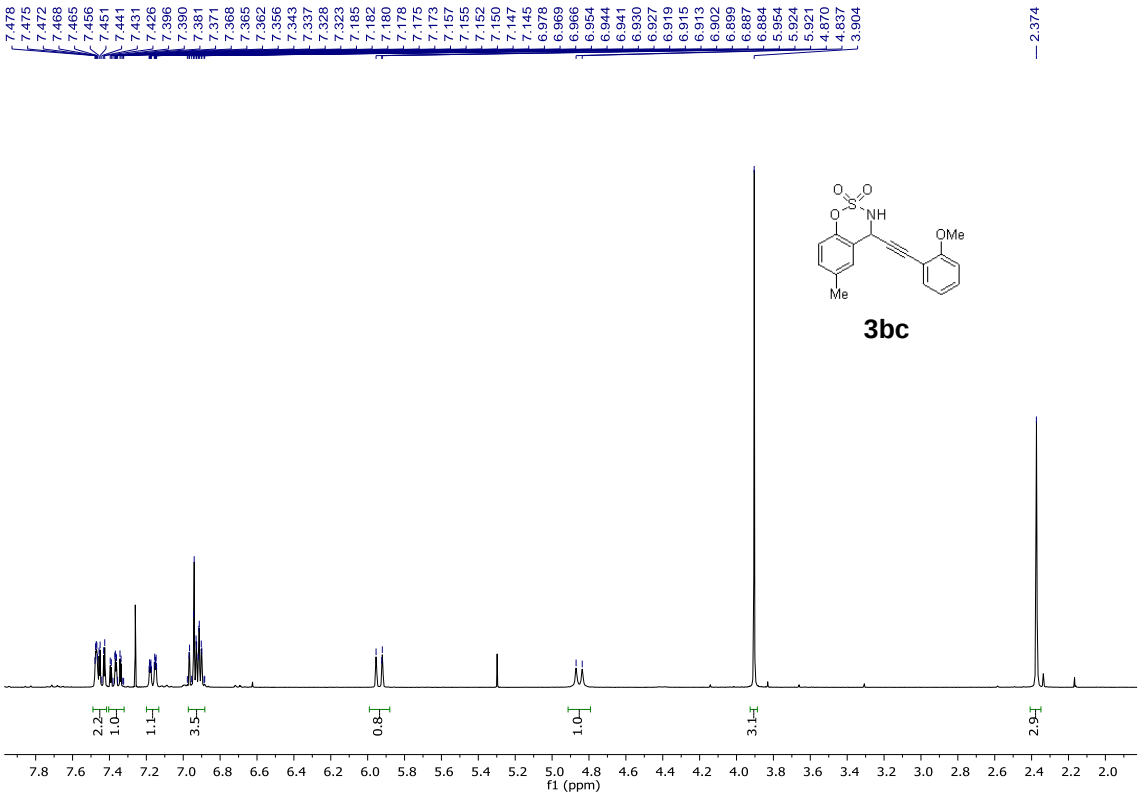
3bb

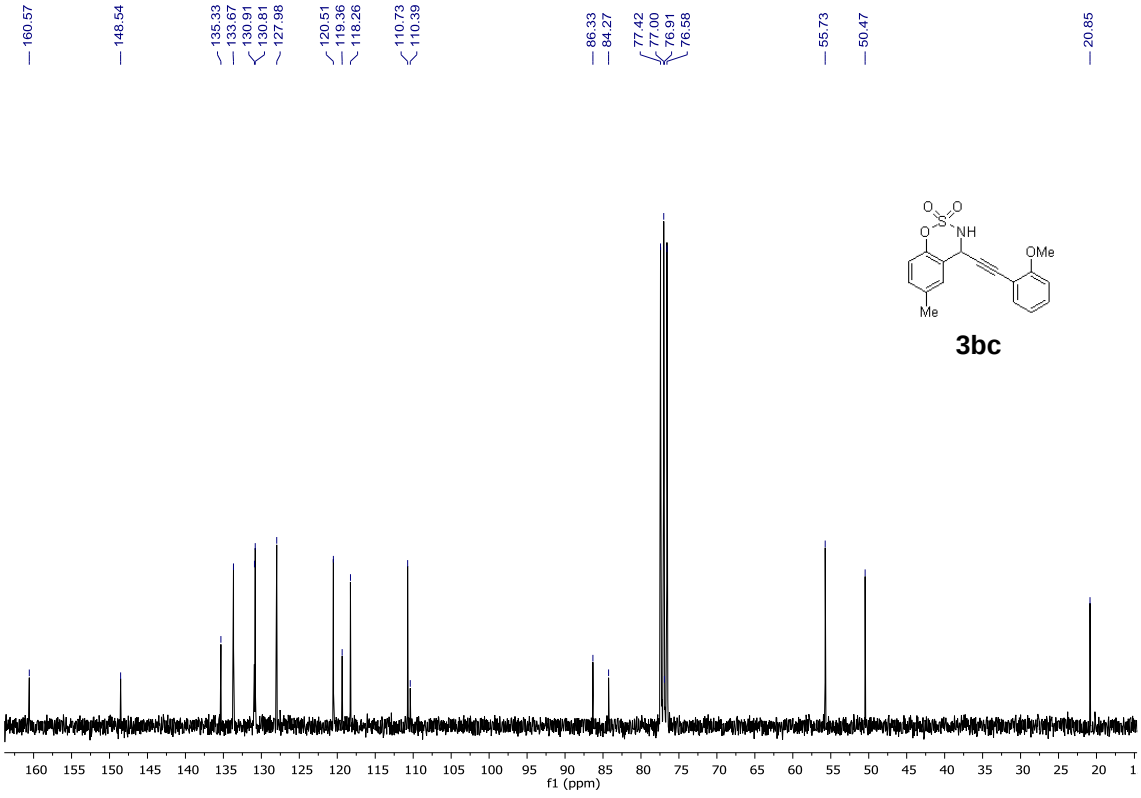

160.47
148.46
135.48
133.56
130.86
127.72
119.34
118.41
114.15
113.12
87.64
81.29
77.42
77.21
77.00
76.94
76.58
55.36
50.37
20.84
O
O
S
O
NH
Me
OMe
f1 (ppm)

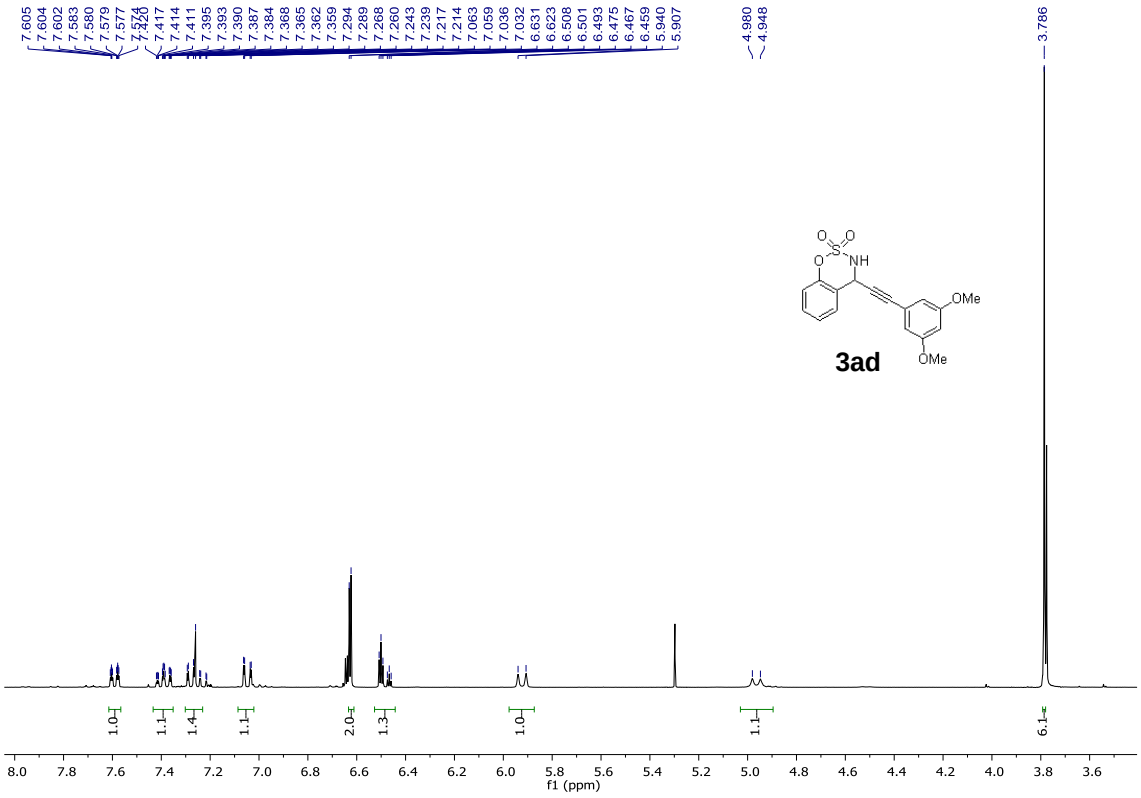
3bb

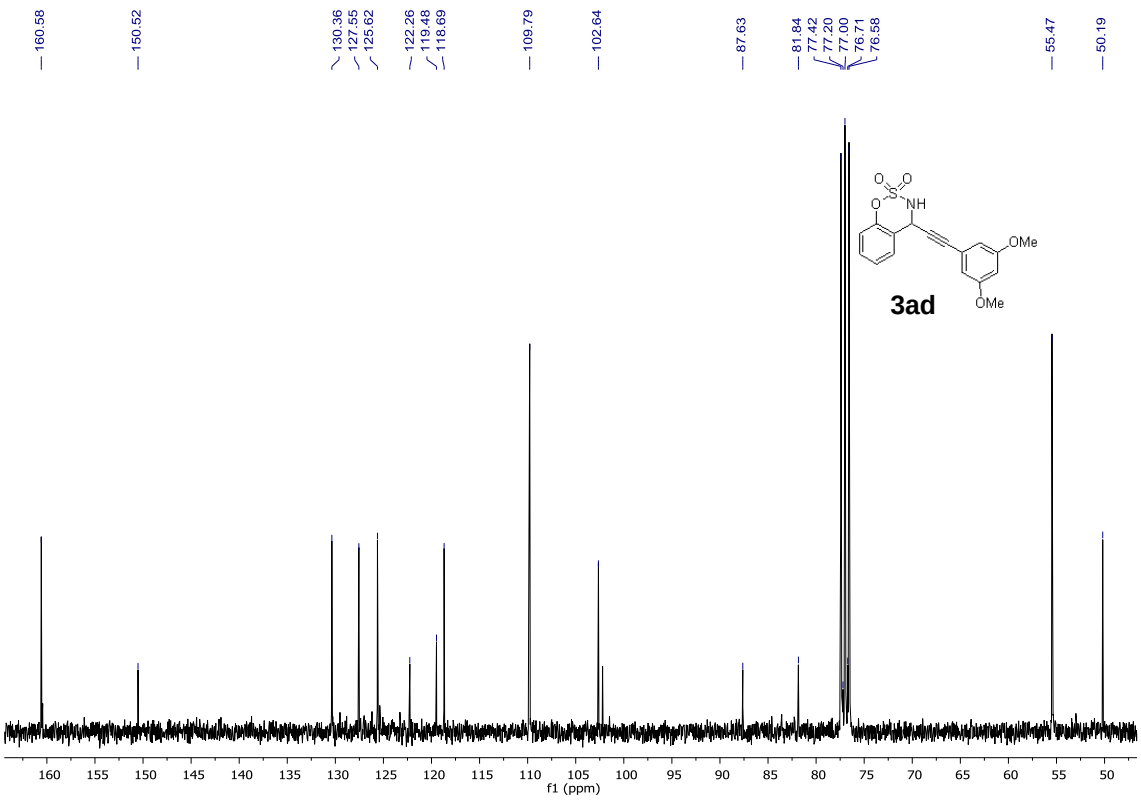

7.705
7.700
7.696
7.679
7.675
7.670
7.449
7.443
7.424
7.418
7.412
7.409
7.406
7.403
7.394
7.388
7.384
7.382
7.379
7.376
7.369
7.366
7.363
7.360
7.357
7.354
7.351
7.341
7.335
7.287
7.283
7.260
7.237
7.233
7.059
7.055
7.032
7.028
6.963
6.960
6.938
6.935
6.923
6.913
6.909
6.895
6.002
5.969
4.924
4.891
3.893
O
O
O
S
NH
OMe
3ac
1.0
1.0
2.1
1.3
1.0
2.1
1.0
1.0
3.2
f1 (ppm)

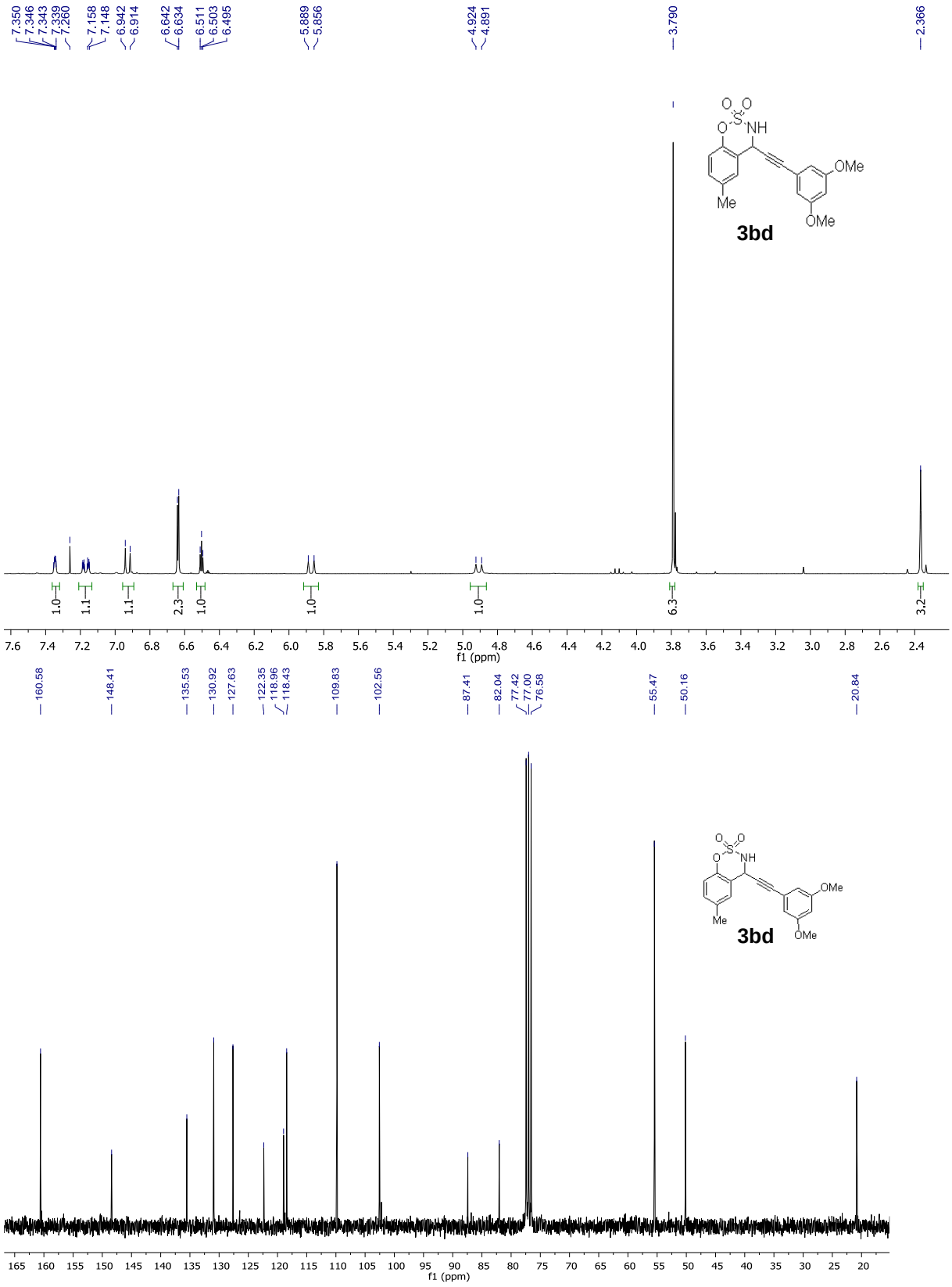

160.54
150.60
133.69
130.95
130.24
127.82
125.49
120.50
119.84
118.52
110.75
110.29
86.15
84.42
77.42
77.00
76.58
55.74
50.48
O
O
O
S
NH
OMe
3ac
f1 (ppm)

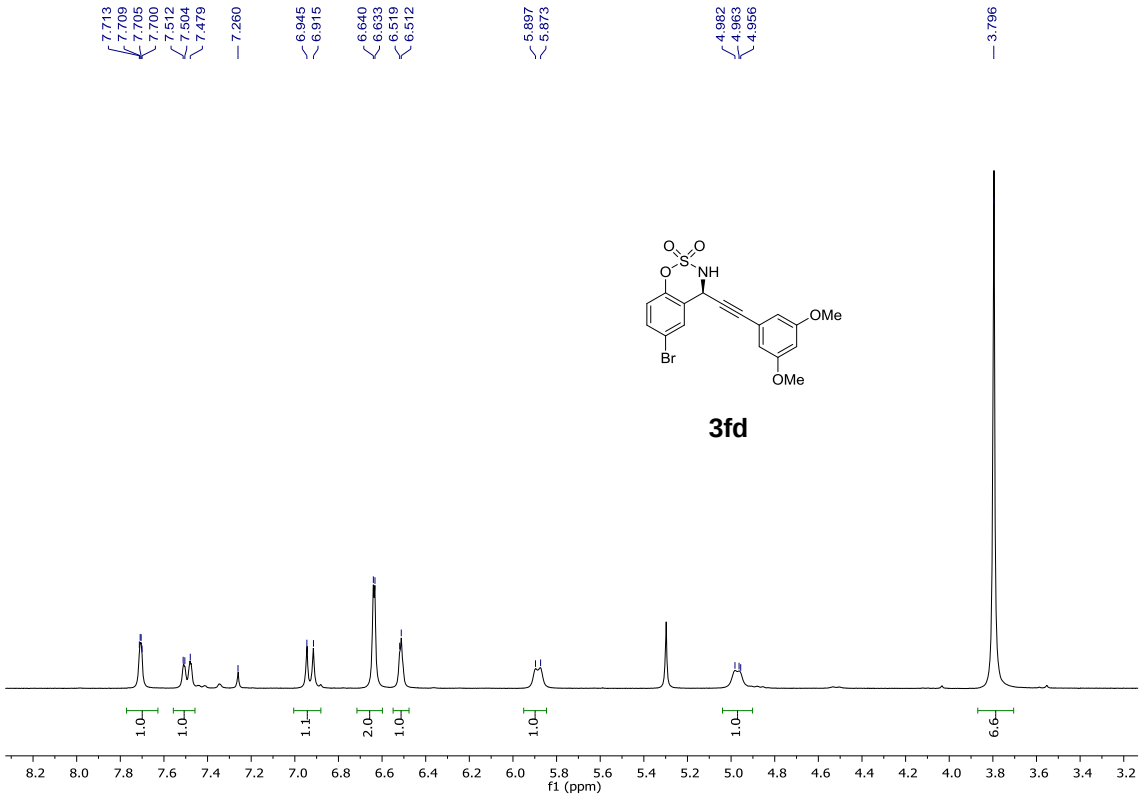

7.478
7.475
7.472
7.468
7.465
7.456
7.451
7.441
7.431
7.426
7.396
7.390
7.381
7.371
7.368
7.365
7.362
7.356
7.343
7.337
7.328
7.323
7.185
7.182
7.180
7.178
7.175
7.173
7.157
7.155
7.152
7.150
7.147
7.145
6.978
6.969
6.966
6.954
6.944
6.941
6.930
6.927
6.919
6.915
6.913
6.902
6.899
6.887
6.884
5.954
5.924
5.921
4.870
4.837
3.904
2.374
O
O
S
O
NH
OMe
Me
3bc
2.2
1.0
1.1
3.5
0.8
1.0
3.1
2.9
f1 (ppm)


160.57
148.54
135.33
133.67
130.91
130.81
127.98
120.51
119.36
118.26
110.73
110.39
86.33
84.27
77.42
77.00
76.91
76.58
55.73
50.47
20.85
O
O
S
O
NH
OMe
Me
3bc
f1 (ppm)

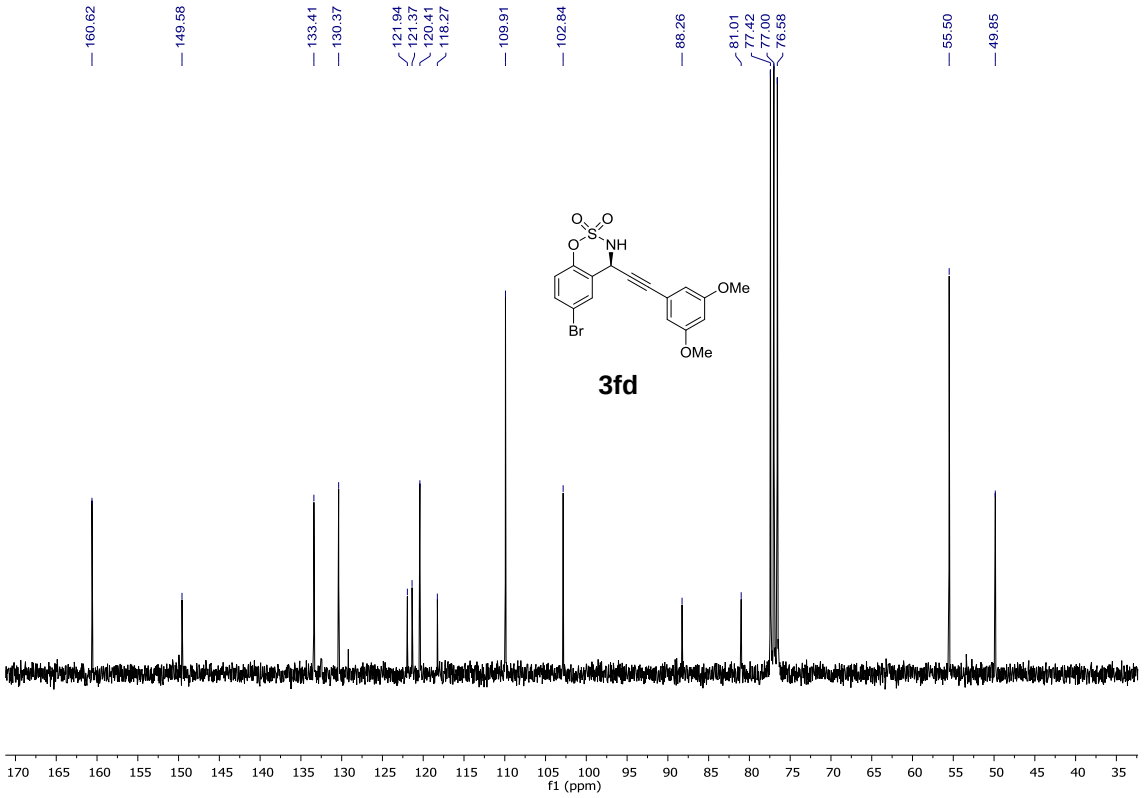

7.605
7.604
7.602
7.583
7.580
7.579
7.577
7.574
7.420
7.417
7.414
7.411
7.395
7.393
7.390
7.387
7.384
7.368
7.365
7.362
7.359
7.294
7.289
7.268
7.260
7.243
7.239
7.217
7.214
7.063
7.059
7.036
7.032
6.631
6.623
6.508
6.501
6.493
6.475
6.467
6.459
5.940
5.907
4.980
4.948
3.786
1.0
1.1
1.4
1.1
2.0
1.3
1.0
1.1
6.1
f1 (ppm)
3ad


160.58
150.52
130.36
127.55
125.62
122.26
119.48
118.69
109.79
102.64
87.63
81.84
77.42
77.20
77.00
76.71
76.58
55.47
50.19
f1 (ppm)
3ad

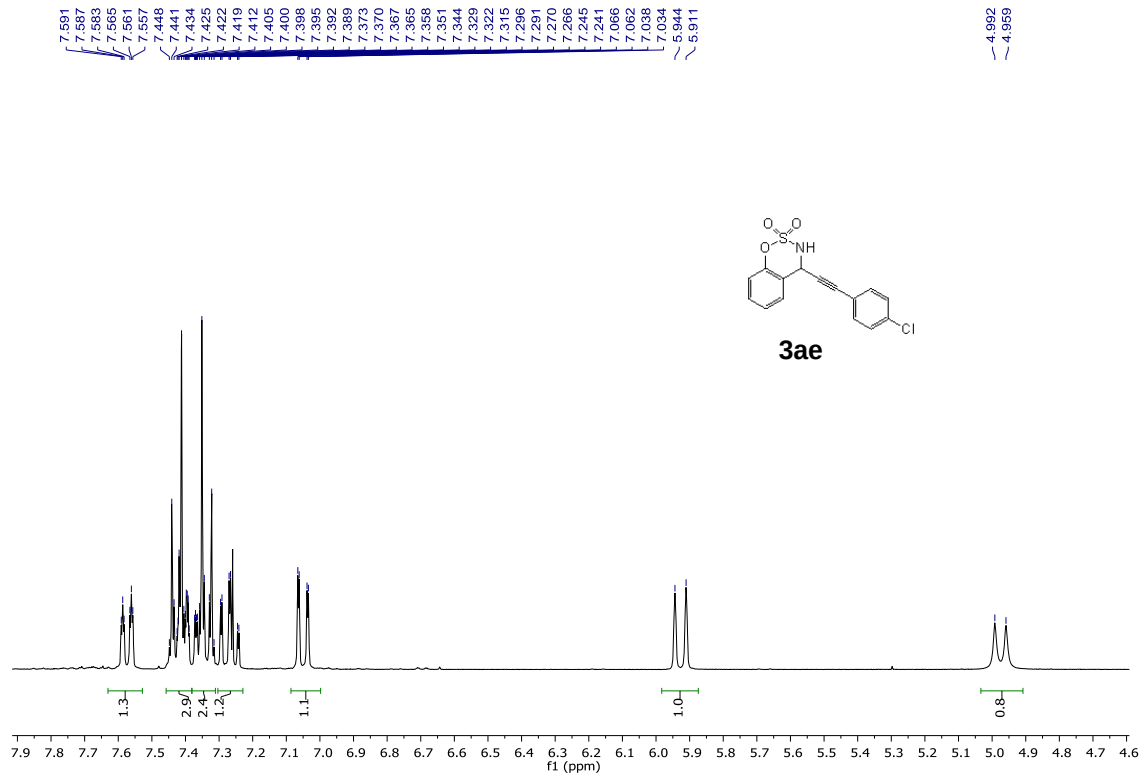

7.350
7.346
7.343
7.339
7.260
7.158
7.148
6.942
6.914
6.642
6.634
6.511
6.503
6.495
5.889
5.856
4.924
4.891
3.790
2.366
NH
OMe
Me
OMe
3bd
1.0
1.1
1.1
2.3
1.0
1.0
1.0
6.3
3.2
f1 (ppm)
160.58
148.41
135.53
130.92
127.63
122.35
118.96
118.43
109.83
102.56
87.41
82.04
77.42
77.00
76.58
55.47
50.16
20.84
NH
OMe
Me
OMe
3bd
f1 (ppm)

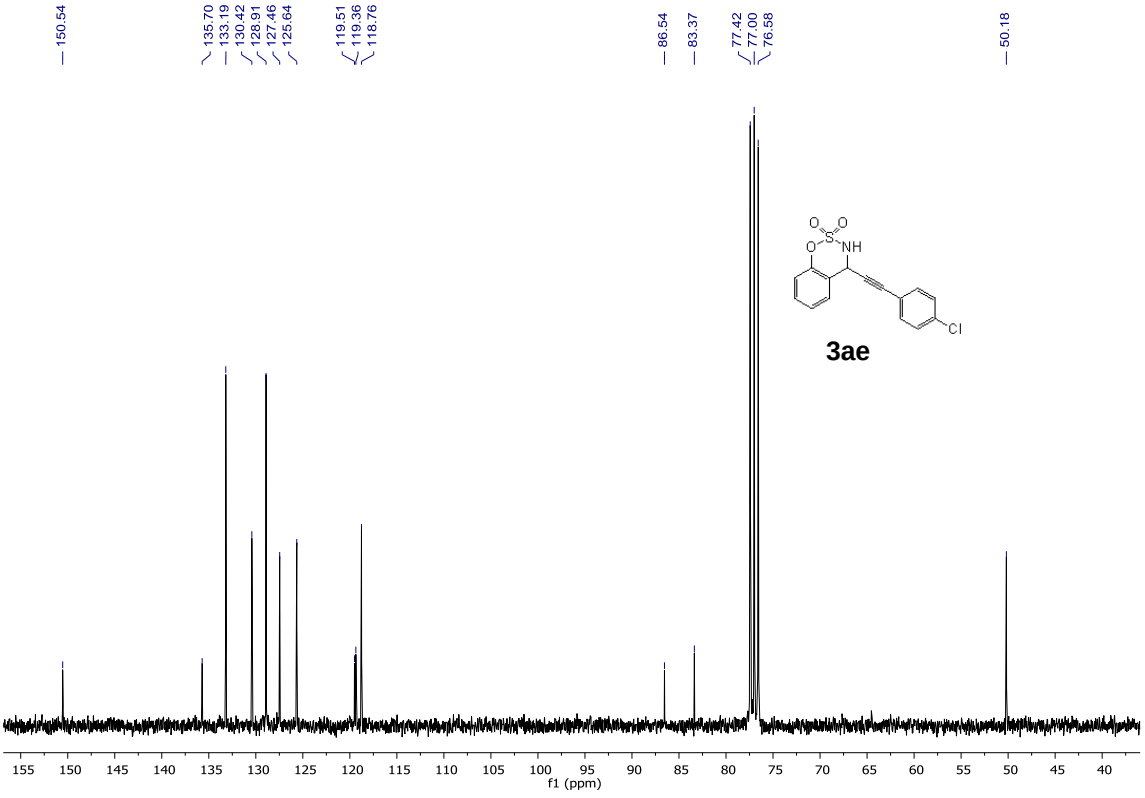

7.713
7.709
7.705
7.700
7.512
7.504
7.479
7.260
6.945
6.915
6.640
6.633
6.519
6.512
5.897
5.873
4.982
4.963
4.956
3.796
O
S
O
O
NH
OMe
Br
OMe
1.0
1.0
1.1
2.0
1.0
1.0
1.0
6.6
8.2 8.0 7.8 7.6 7.4 7.2 7.0 6.8 6.6 6.4 6.2 6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 4.2 4.0 3.8 3.6 3.4 3.2
f1 (ppm)

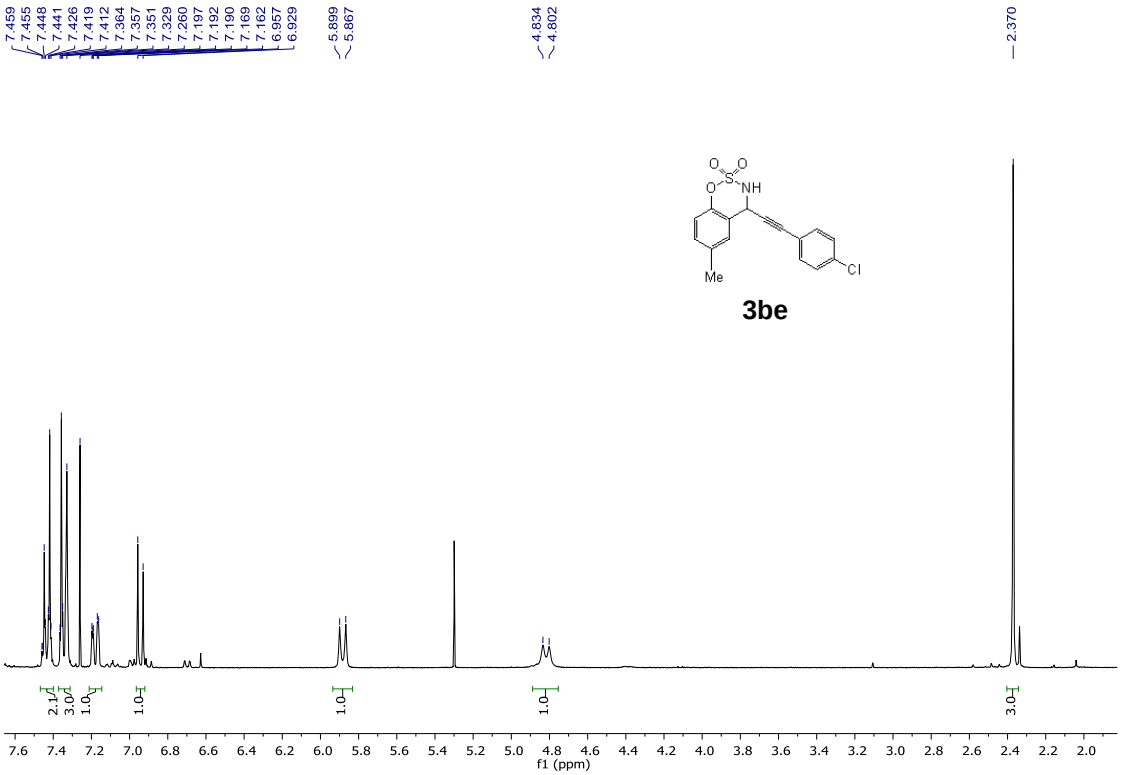
3fd


160.62
149.58
133.41
130.37
121.94
121.37
120.41
118.27
109.91
102.84
88.26
81.01
77.42
77.00
76.58
55.50
49.85
O
S
O
O
NH
OMe
Br
OMe
170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35
f1 (ppm)

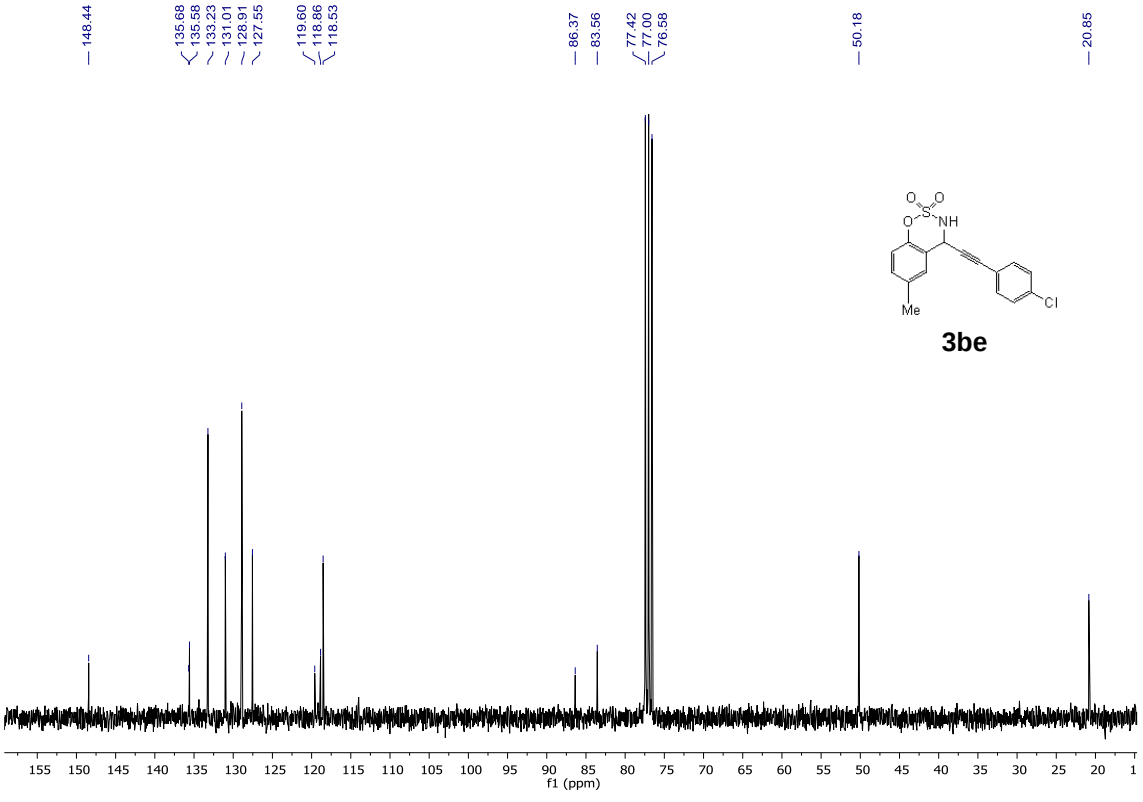
3fd


7.591
7.587
7.583
7.565
7.561
7.557
7.448
7.441
7.434
7.425
7.422
7.419
7.412
7.405
7.400
7.398
7.395
7.392
7.389
7.373
7.370
7.367
7.365
7.358
7.351
7.344
7.329
7.322
7.315
7.296
7.291
7.270
7.266
7.245
7.241
7.066
7.062
7.038
7.034
5.944
5.911
4.992
4.959
NH
Cl
3ae
1.3
2.9
2.4
1.2
1.1
1.0
0.8
f1 (ppm)


150.54
135.70
133.19
130.42
128.91
127.46
125.64
119.51
119.36
118.76
86.54
83.37
77.42
77.00
76.58
50.18
NH
Cl
3ae
f1 (ppm)

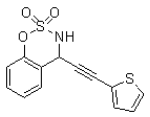

7.459
7.455
7.448
7.441
7.426
7.419
7.412
7.364
7.357
7.351
7.329
7.260
7.197
7.192
7.190
7.169
7.162
6.957
6.929
5.899
5.867
4.834
4.802
2.370
O
O
S
O
NH
Me
Cl
2.1
3.0
1.0
1.0
1.0
1.0
3.0
7.6 7.4 7.2 7.0 6.8 6.6 6.4 6.2 6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 4.2 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 2.2 2.0
f1 (ppm)

3be

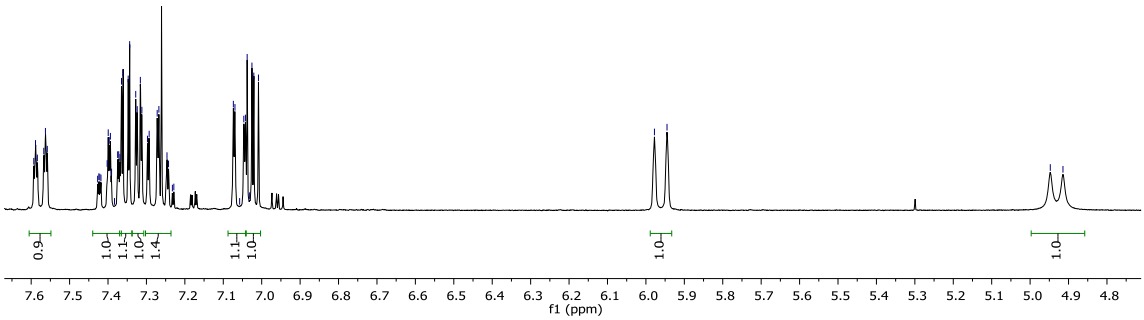

148.44
135.68
135.58
133.23
131.01
128.91
127.55
119.60
118.86
118.53
86.37
83.56
77.42
77.00
76.58
50.18
20.85
O
O
S
O
NH
Me
Cl
155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 1
f1 (ppm)

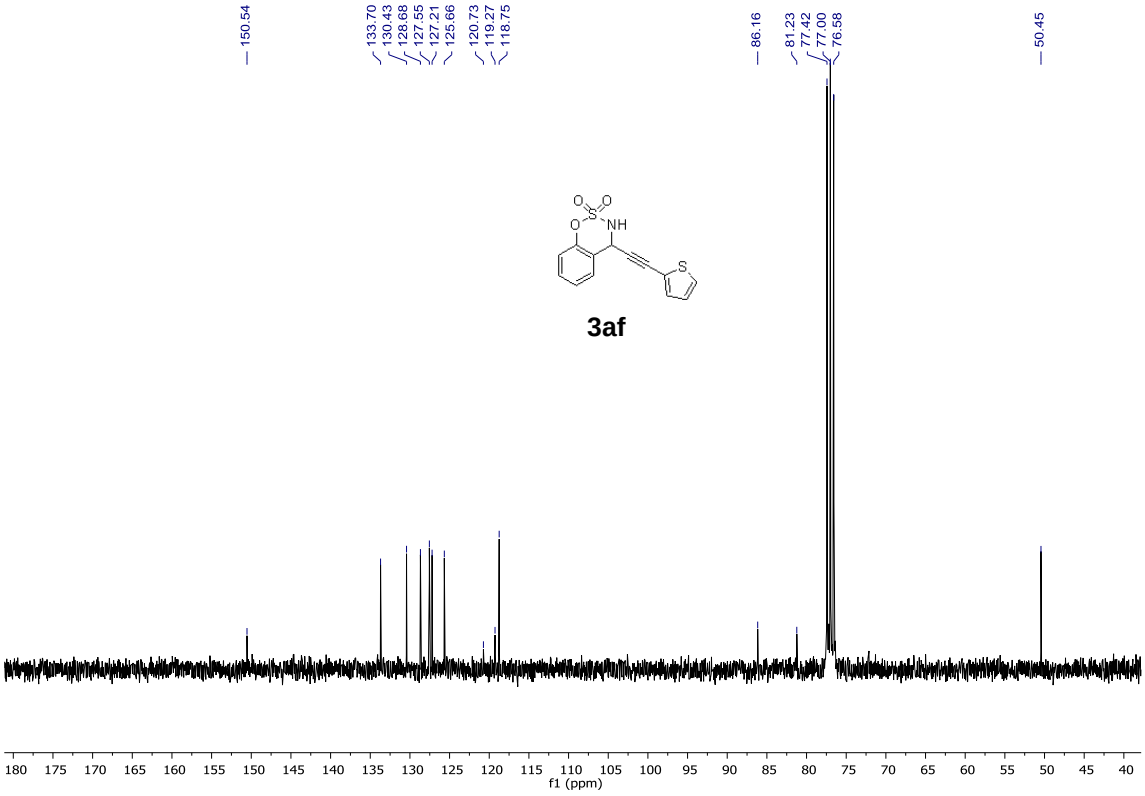
3be


7.593
7.589
7.584
7.567
7.563
7.558
7.427
7.424
7.421
7.418
7.402
7.399
7.397
7.394
7.391
7.383
7.375
7.372
7.369
7.365
7.361
7.347
7.344
7.328
7.324
7.316
7.312
7.297
7.293
7.272
7.268
7.247
7.243
7.232
7.229
7.074
7.070
7.057
7.047
7.042
7.038
7.031
7.025
7.021
7.008
5.978
5.945
4.947
4.915

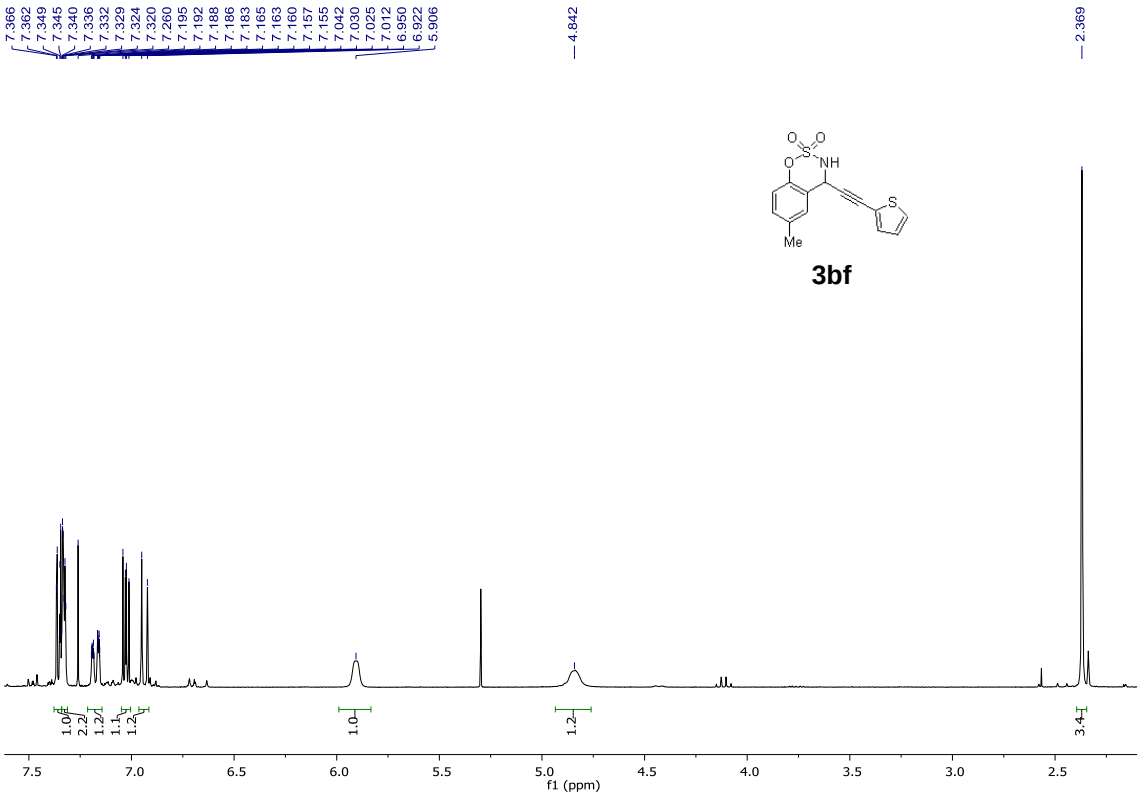

O
O
S
O
NH
S

3af

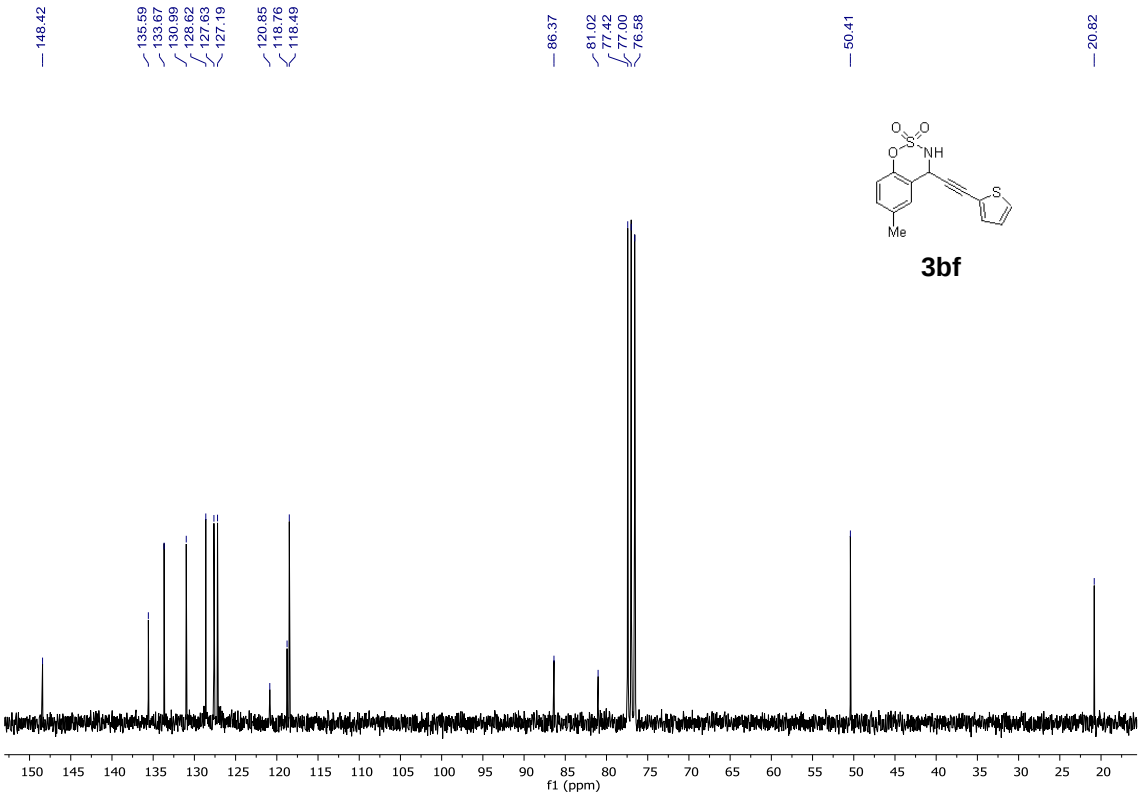

0.9
1.0
1.1
1.0
1.4
1.1
1.0
1.0
1.0
7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8 6.7 6.6 6.5 6.4 6.3 6.2 6.1 6.0 5.9 5.8 5.7 5.6 5.5 5.4 5.3 5.2 5.1 5.0 4.9 4.8
f1 (ppm)


150.54
133.70
130.43
128.68
127.55
127.21
125.66
120.73
119.27
118.75
86.16
81.23
77.42
77.00
76.58
50.45
O
O
S
O
NH
S
180 175 170 165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40
f1 (ppm)

3af

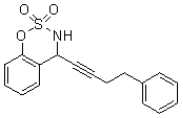

7.366
7.362
7.349
7.345
7.340
7.336
7.332
7.329
7.324
7.320
7.260
7.195
7.192
7.188
7.186
7.183
7.165
7.163
7.160
7.157
7.155
7.042
7.030
7.025
7.012
6.950
6.922
5.906
4.842
2.369
O
S
O
O
NH
S
Me
1.0
2.2
1.2
1.1
1.2
1.0
1.2
3.4
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
f1 (ppm)

3bf

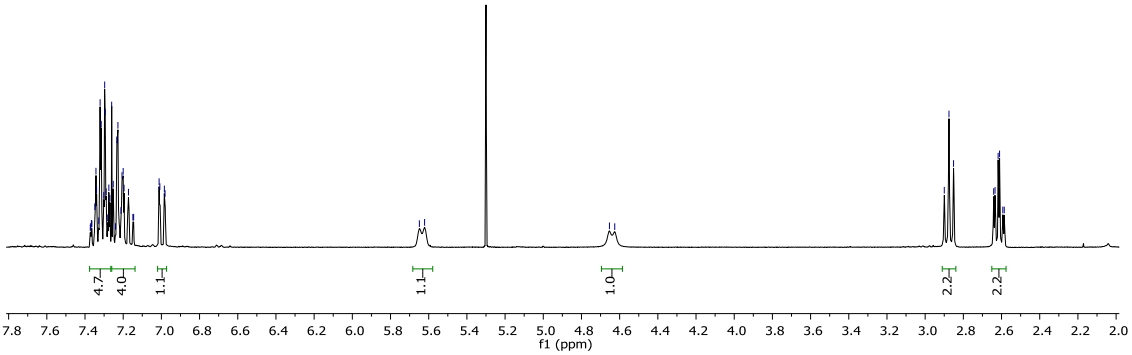

148.42
135.59
133.67
130.99
128.62
127.63
127.19
120.85
118.76
118.49
86.37
81.02
77.42
77.00
76.58
50.41
20.82
O
S
O
O
NH
S
Me
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
f1 (ppm)

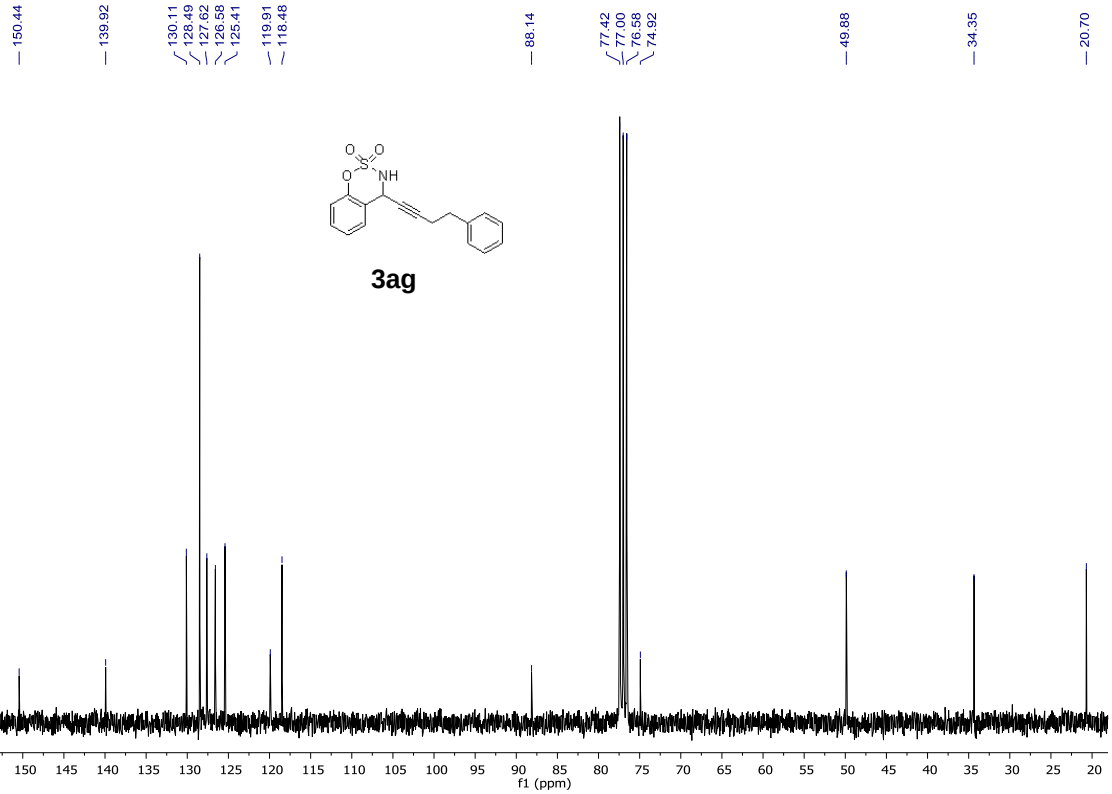
3bf


7.372
7.370
7.367
7.364
7.349
7.343
7.339
7.328
7.321
7.315
7.302
7.297
7.294
7.289
7.281
7.275
7.270
7.260
7.252
7.240
7.233
7.228
7.212
7.206
7.200
7.196
7.172
7.149
7.145
7.012
7.008
6.984
6.981
5.649
5.622
4.653
4.626
2.900
2.875
2.851
2.641
2.634
2.618
2.610
2.593
2.586

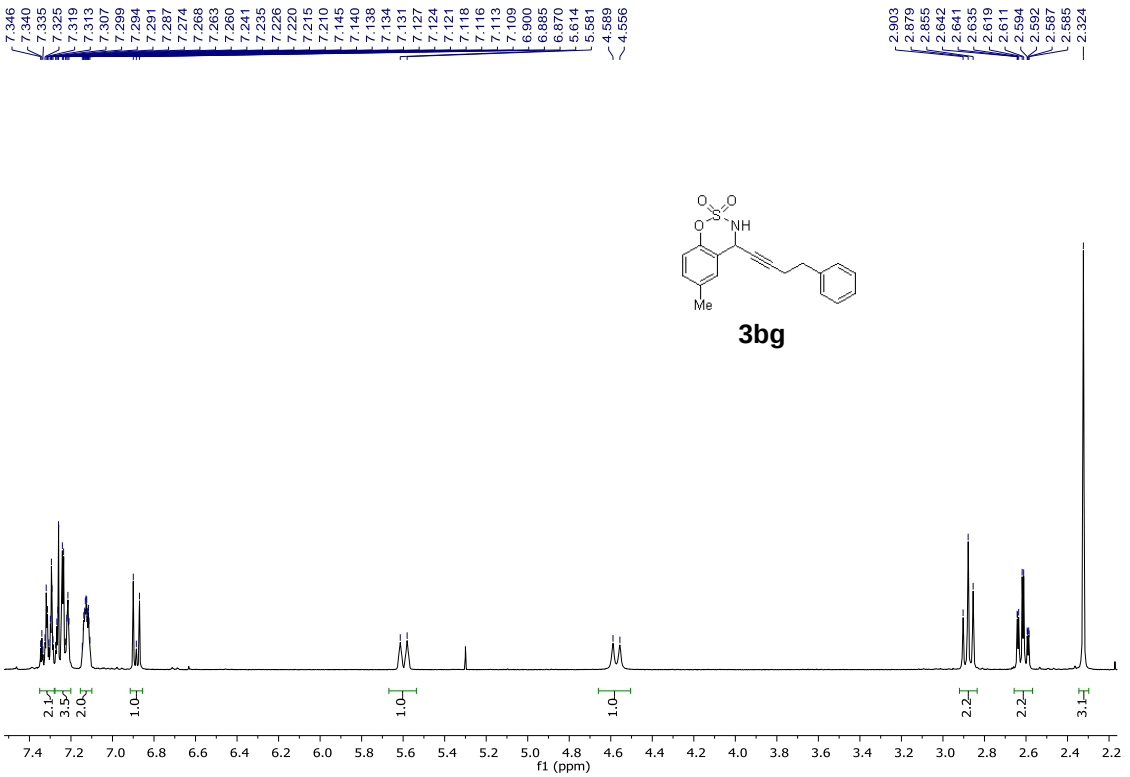


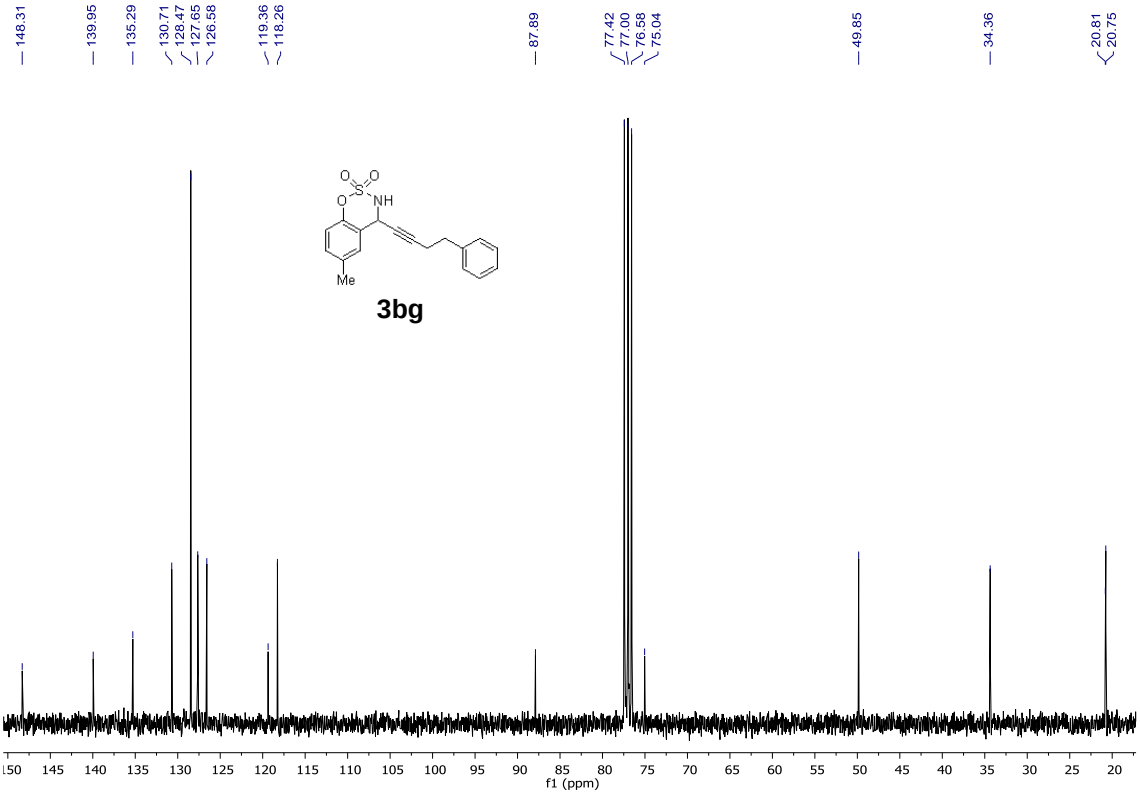
3ag

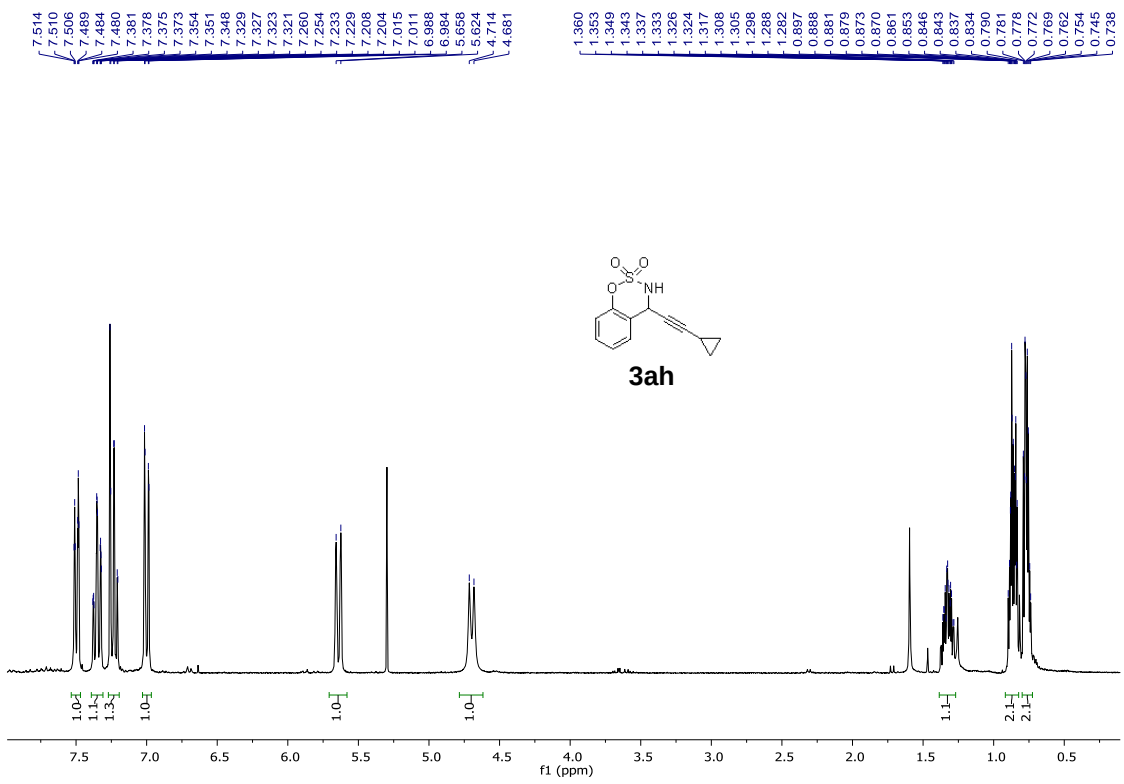

4.7
4.0
1.1
1.1
1.0
2.2
2.2
f1 (ppm)

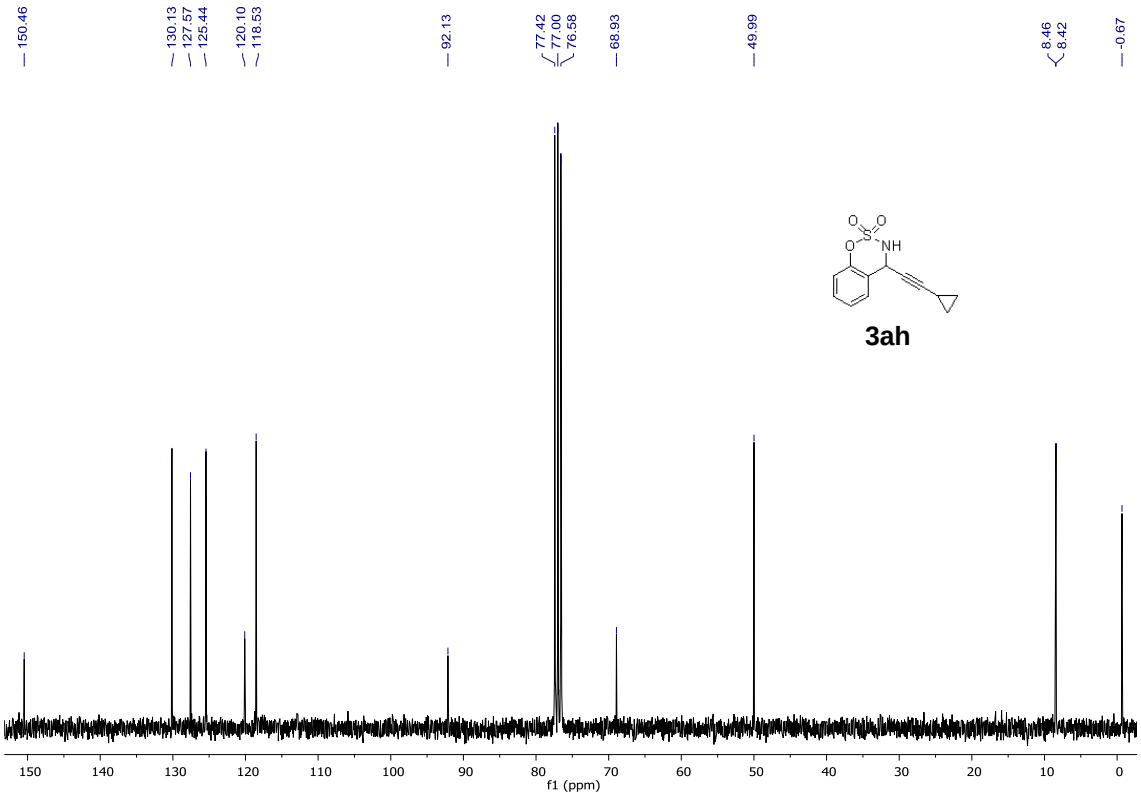

150.44
139.92
130.11
128.49
127.62
126.58
125.41
119.91
118.48
88.14
77.42
77.00
76.58
74.92
49.88
34.35
20.70
f1 (ppm)

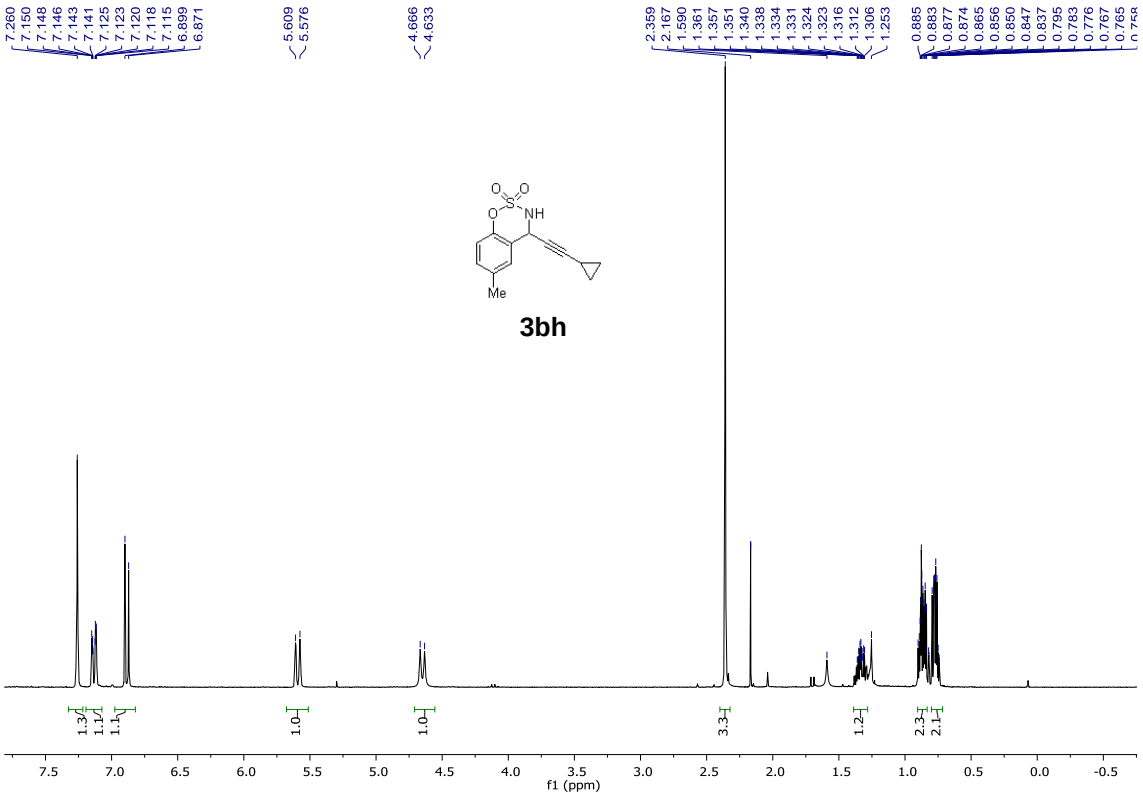
3ag


7.346
7.340
7.335
7.325
7.319
7.313
7.307
7.299
7.294
7.291
7.287
7.274
7.268
7.263
7.260
7.241
7.235
7.226
7.220
7.215
7.210
7.145
7.140
7.138
7.134
7.131
7.127
7.124
7.121
7.118
7.116
7.113
7.109
6.900
6.885
6.870
5.614
5.581
4.589
4.556
2.903
2.879
2.855
2.642
2.641
2.635
2.619
2.611
2.594
2.592
2.587
2.585
2.324
O
O
S
O
NH
Me
3bg
2.1
3.5
2.0
1.0
1.0
1.0
2.2
2.2
3.1
7.4 7.2 7.0 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 2.2
f1 (ppm)

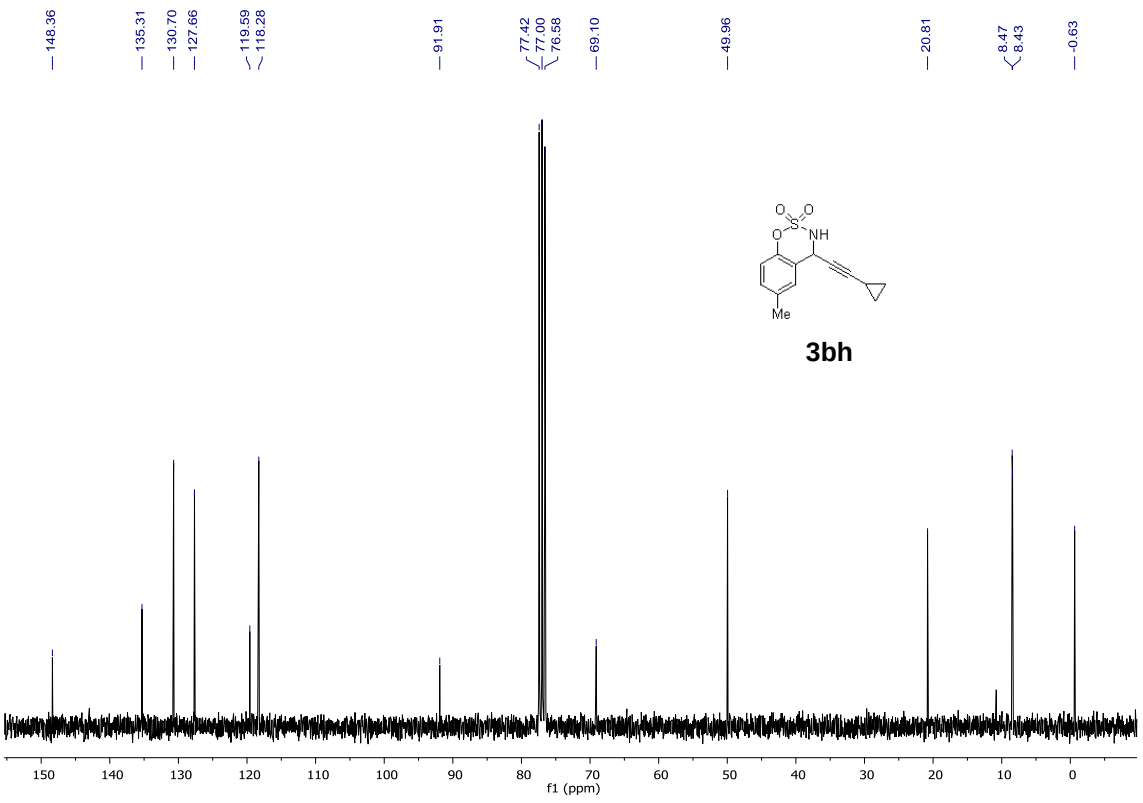

148.31
139.95
135.29
130.71
128.47
127.65
126.58
119.36
118.26
87.89
77.42
77.00
76.58
75.04
49.85
34.36
20.81
20.75
O
O
S
O
NH
Me
3bg
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
f1 (ppm)


7.514
7.510
7.506
7.489
7.484
7.480
7.381
7.378
7.375
7.373
7.354
7.351
7.348
7.329
7.327
7.323
7.321
7.260
7.254
7.233
7.229
7.208
7.204
7.015
7.011
6.988
6.984
5.658
5.624
4.714
4.681
1.360
1.353
1.349
1.343
1.337
1.333
1.326
1.324
1.317
1.308
1.305
1.298
1.288
1.282
0.897
0.888
0.881
0.879
0.873
0.870
0.861
0.853
0.846
0.843
0.837
0.834
0.790
0.781
0.778
0.772
0.769
0.762
0.754
0.745
0.738
O
S
O
O
NH
3ah
1.0
1.1
1.3
1.0
1.0
1.0
1.1
2.1
2.1
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)

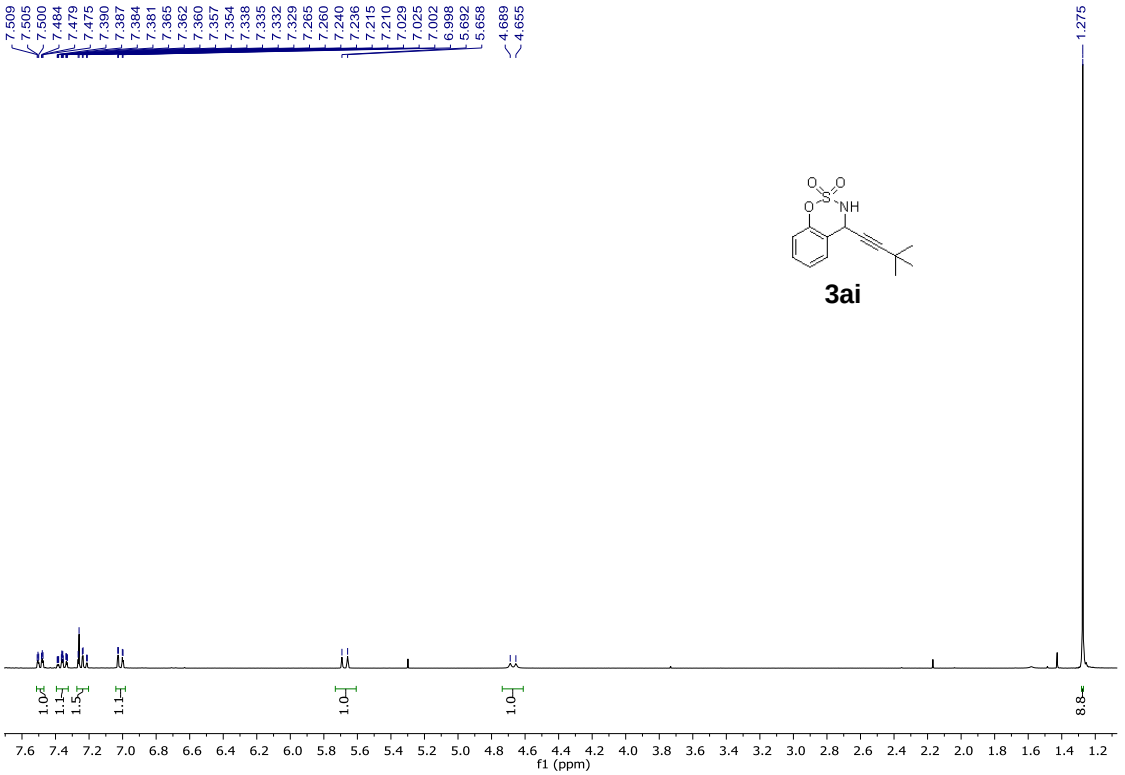

150.46
130.13
127.57
125.44
120.10
118.53
92.13
77.42
77.00
76.58
68.93
49.99
8.46
8.42
-0.67
O
S
O
O
NH
3ah
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.260
7.150
7.148
7.146
7.143
7.141
7.125
7.123
7.120
7.118
7.115
6.899
6.871
5.609
5.576
4.666
4.633
2.359
2.167
1.590
1.361
1.357
1.351
1.340
1.338
1.334
1.331
1.324
1.323
1.316
1.312
1.306
1.253
0.885
0.883
0.877
0.874
0.865
0.856
0.850
0.847
0.837
0.795
0.783
0.776
0.767
0.765
O
O
S
O
NH
Me
1.3
1.1
1.1
1.0
1.0
3.3
1.2
2.3
2.1
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

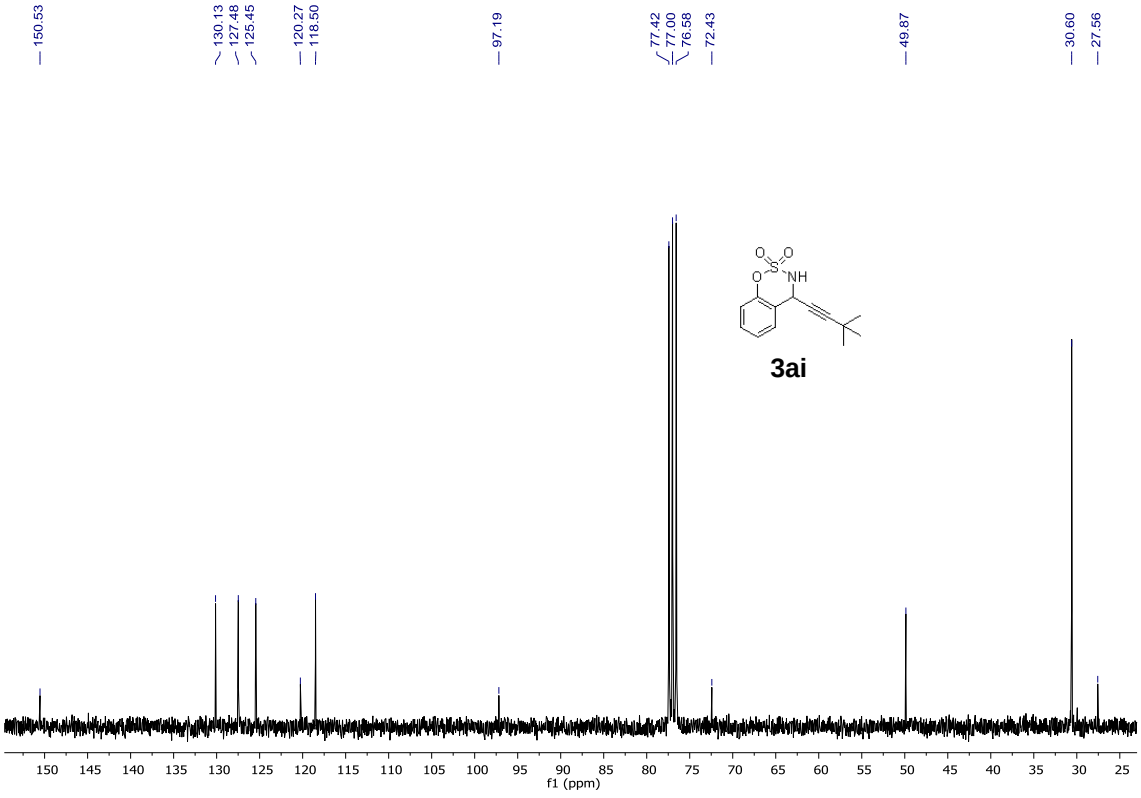
3bh


148.36
135.31
130.70
127.66
119.59
118.28
91.91
77.42
77.00
76.58
69.10
49.96
20.81
8.47
8.43
-0.63
O
O
S
O
NH
Me
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

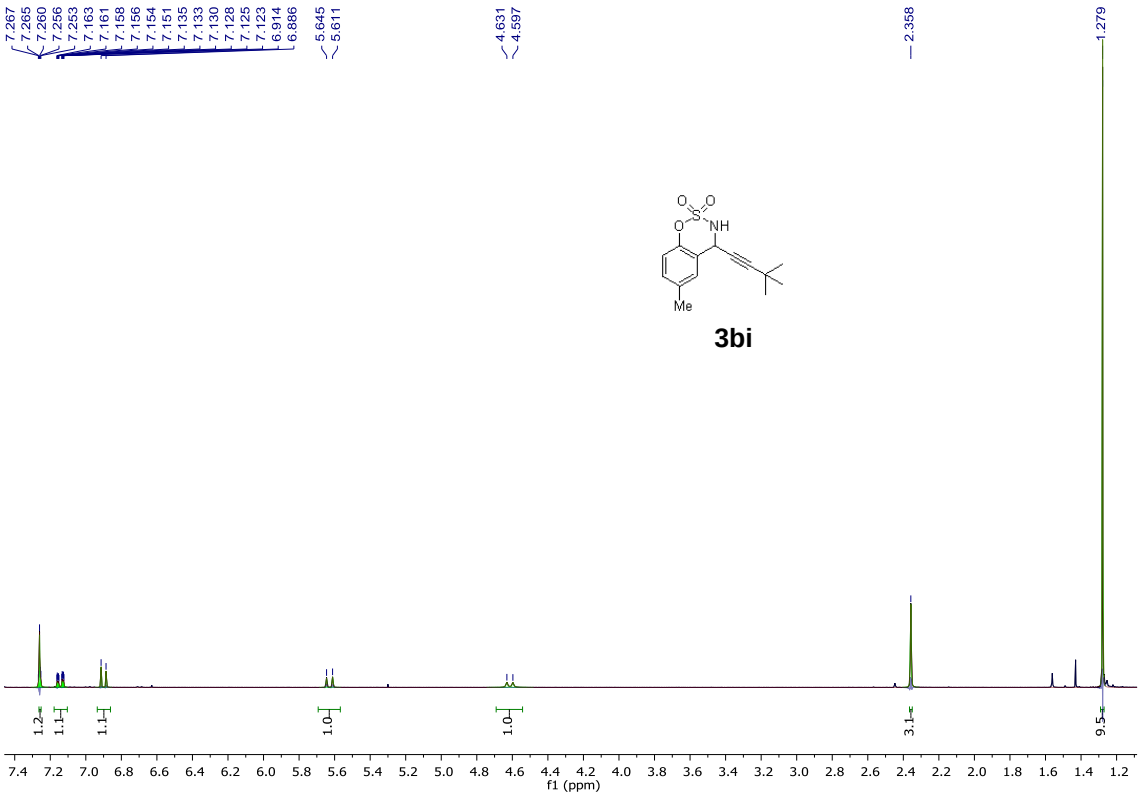
3bh


7.509
7.505
7.500
7.484
7.479
7.475
7.390
7.387
7.384
7.381
7.365
7.362
7.360
7.357
7.354
7.338
7.335
7.332
7.329
7.265
7.260
7.240
7.236
7.215
7.210
7.029
7.025
7.002
6.998
5.692
5.658
4.689
4.655
1.275
1.0
1.1
1.5
1.1
1.0
1.0
8.8
f1 (ppm)

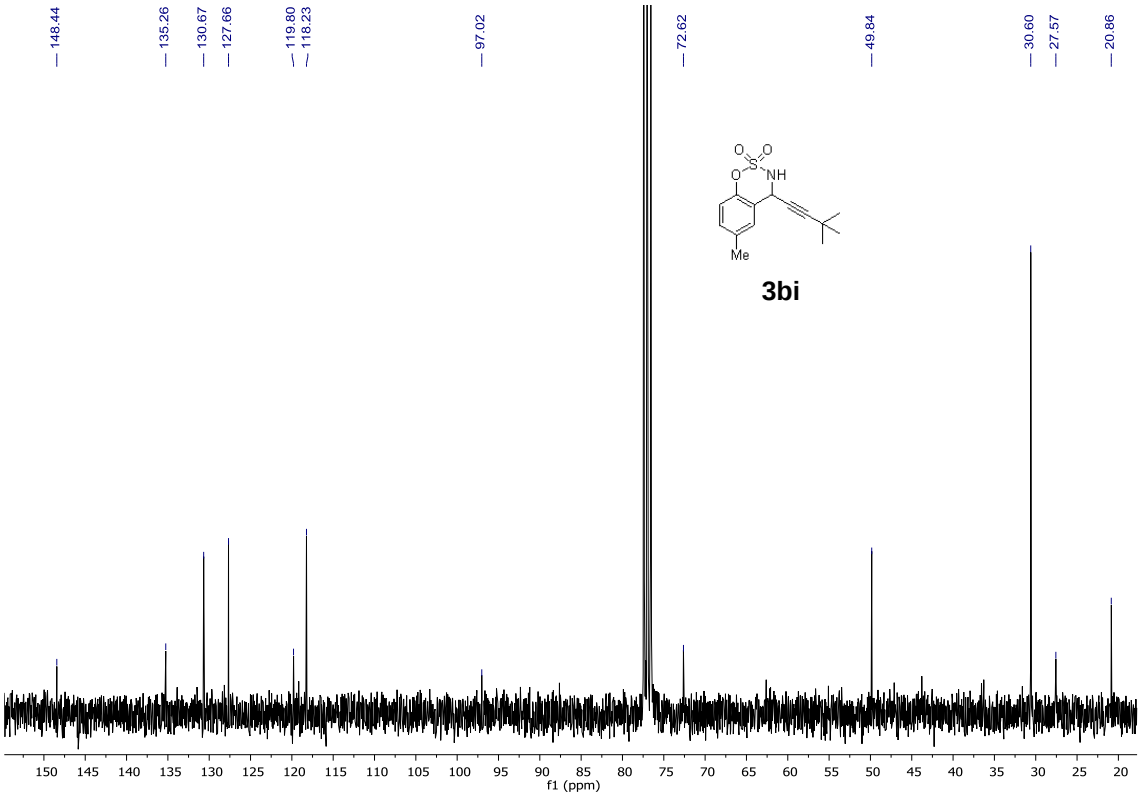
3ai


150.53
130.13
127.48
125.45
120.27
118.50
97.19
77.42
77.00
76.58
72.43
49.87
30.60
27.56
f1 (ppm)

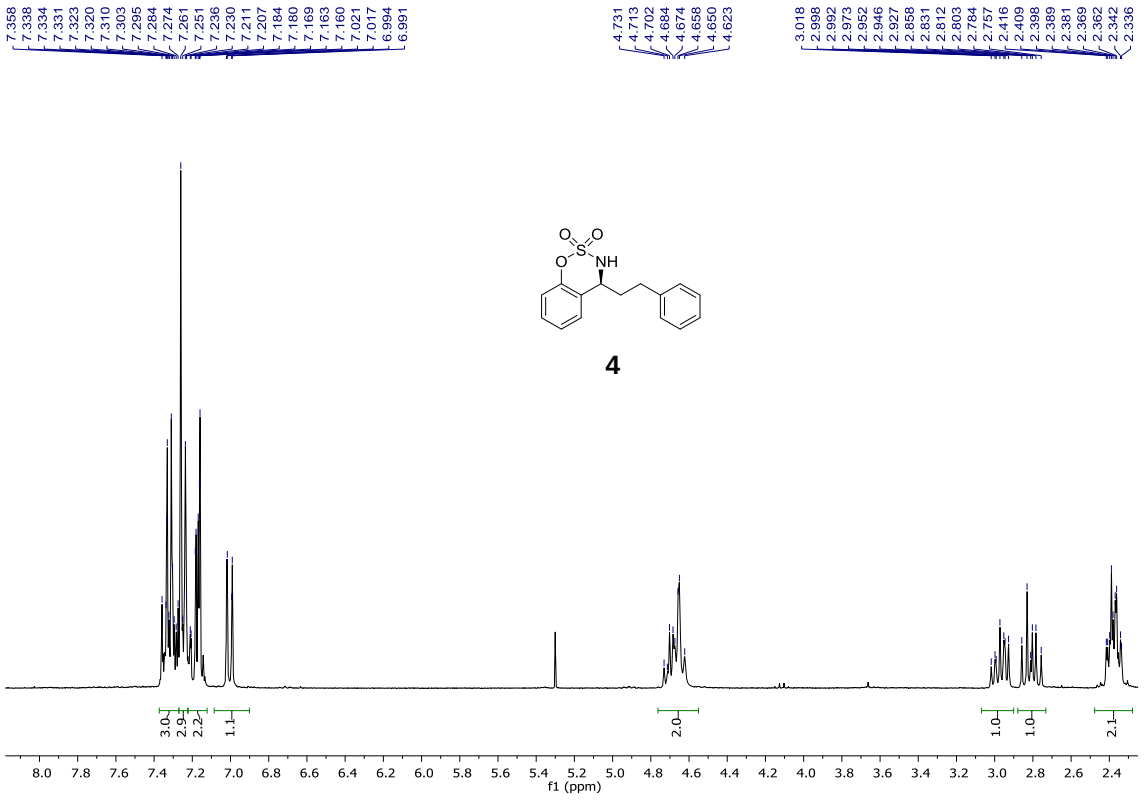
3ai

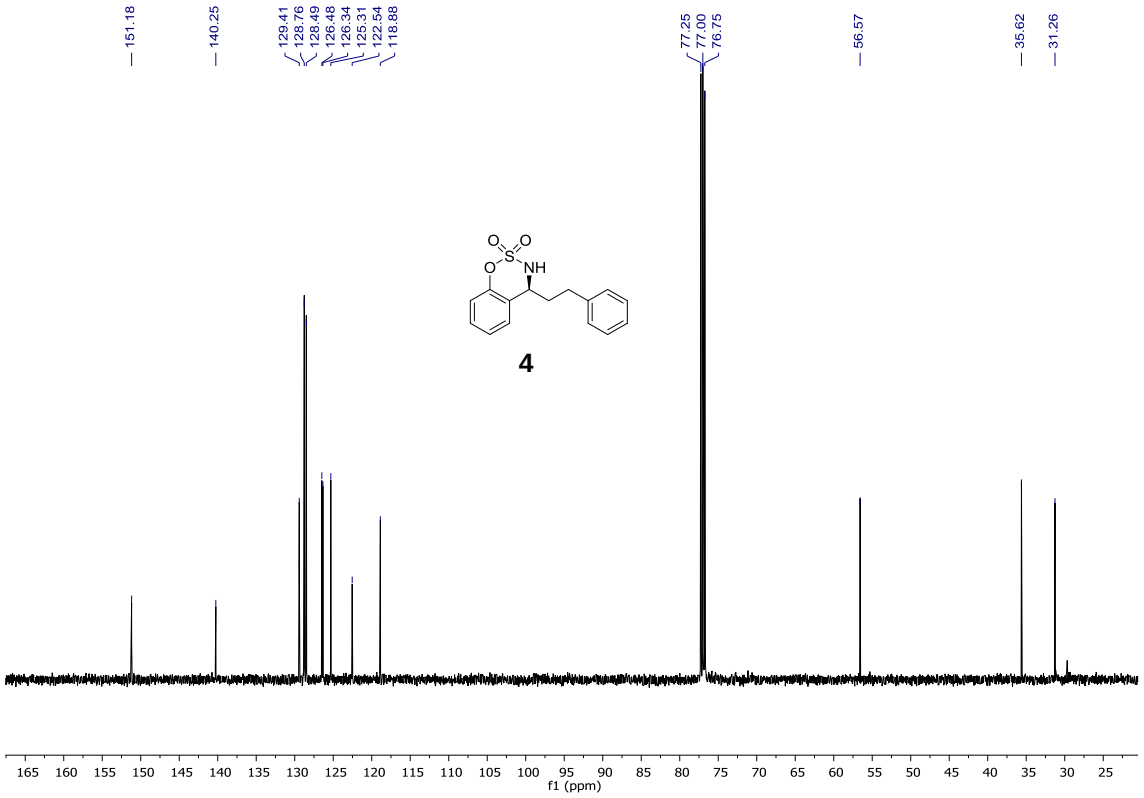

7.267
7.265
7.260
7.256
7.253
7.163
7.161
7.158
7.156
7.154
7.151
7.135
7.133
7.130
7.128
7.125
7.123
6.914
6.886
5.645
5.611
4.631
4.597
2.358
1.279
O
O
S
O
NH
Me
1.2
1.1
1.1
1.0
1.0
3.1
9.5
f1 (ppm)

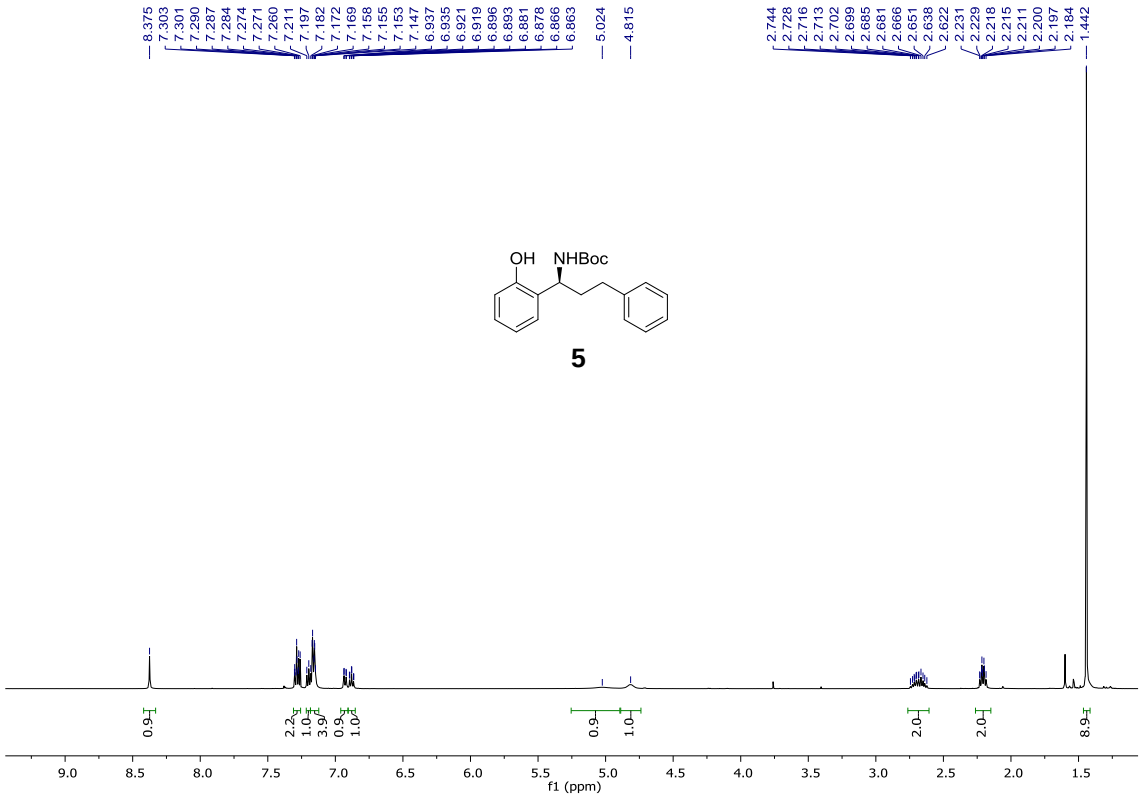
3bi

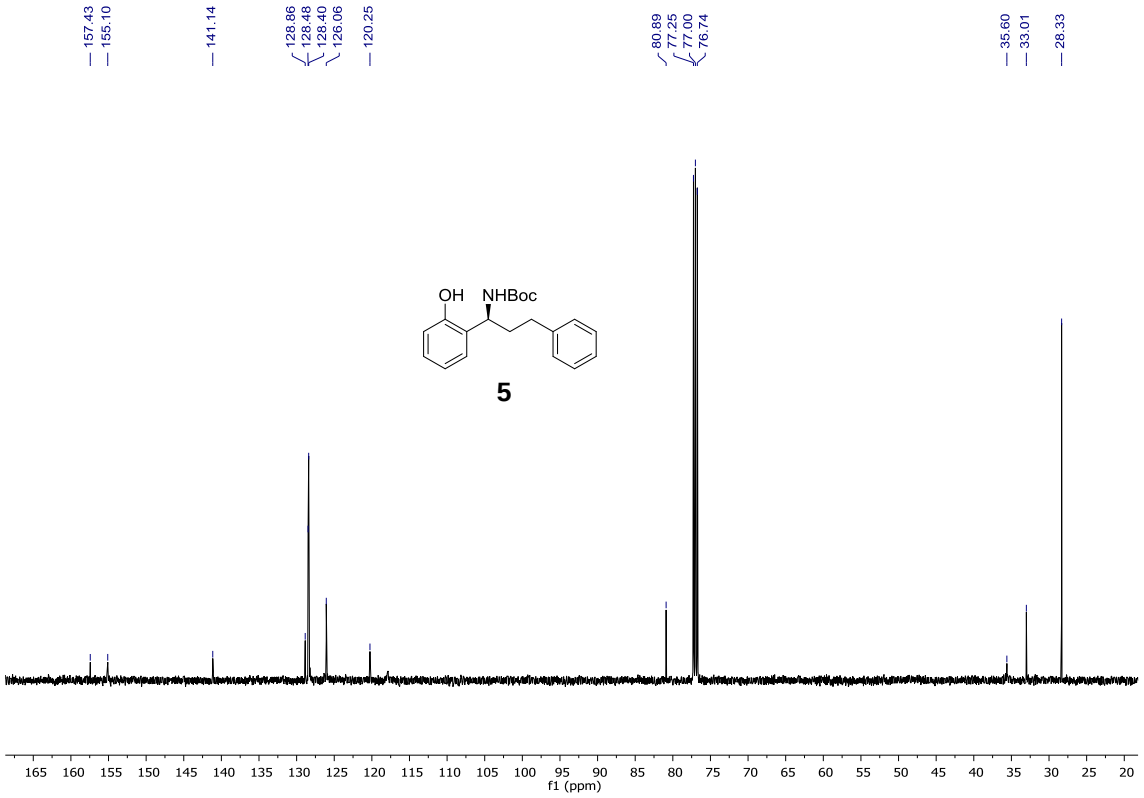

148.44
135.26
130.67
127.66
119.80
118.23
97.02
72.62
49.84
30.60
27.57
20.86
O
O
S
O
NH
Me
f1 (ppm)

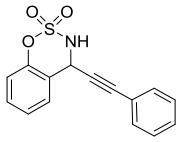
3bi


7.358
7.338
7.334
7.331
7.323
7.320
7.310
7.303
7.295
7.284
7.274
7.261
7.251
7.236
7.230
7.211
7.207
7.184
7.180
7.169
7.163
7.160
7.021
7.017
6.994
6.991
4.731
4.713
4.702
4.684
4.674
4.658
4.650
4.623
3.018
2.998
2.992
2.973
2.952
2.946
2.927
2.858
2.831
2.812
2.803
2.784
2.757
2.416
2.409
2.398
2.389
2.381
2.369
2.362
2.342
2.336
O
S
O
O
NH
4
3.0
2.9
2.2
1.1
2.0
1.0
1.0
2.1
8.0 7.8 7.6 7.4 7.2 7.0 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
f1 (ppm)

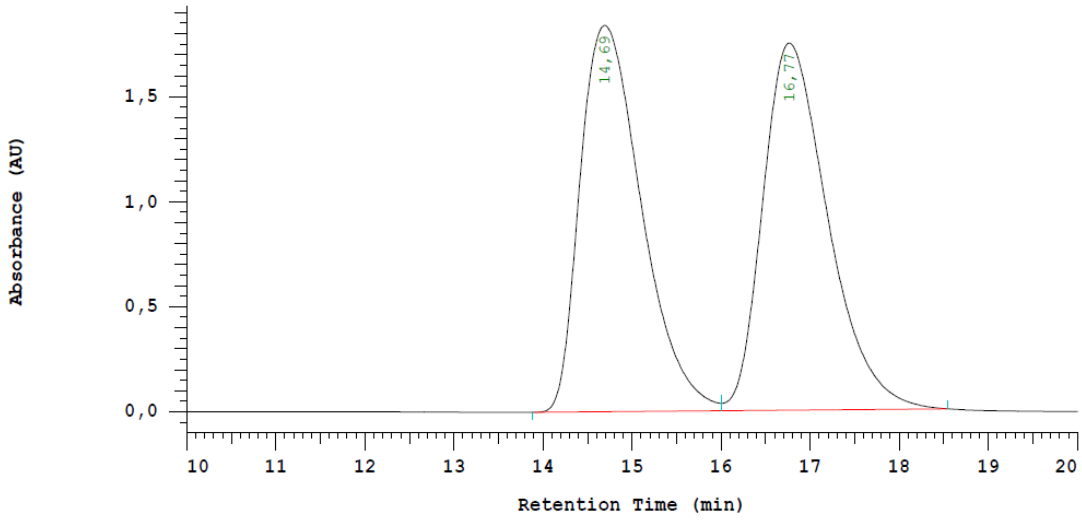

151.18
140.25
129.41
128.76
128.49
126.48
126.34
125.31
122.54
118.88
77.25
77.00
76.75
56.57
35.62
31.26
O
S
O
O
NH
4
165 160 155 150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25
f1 (ppm)


8.375
7.303
7.301
7.290
7.287
7.284
7.274
7.271
7.260
7.211
7.197
7.182
7.172
7.169
7.158
7.155
7.153
7.147
6.937
6.935
6.921
6.919
6.896
6.893
6.881
6.878
6.866
6.863
5.024
4.815
2.744
2.728
2.716
2.713
2.702
2.699
2.685
2.681
2.666
2.651
2.638
2.622
2.231
2.229
2.218
2.215
2.211
2.200
2.197
2.184
1.442
OH
NHBoc
5
0.9
2.2
1.0
3.9
0.9
1.0
0.9
1.0
2.0
2.0
8.9
f1 (ppm)

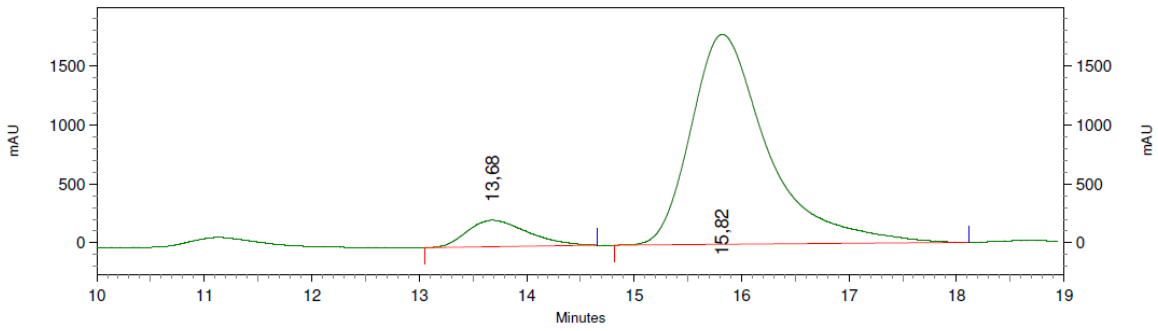

157.43
155.10
141.14
128.86
128.48
128.40
126.06
120.25
80.89
77.25
77.00
76.74
35.60
33.01
28.33
OH
NHBoc
5
f1 (ppm)



3aa

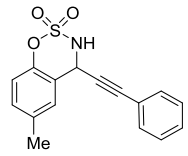


No.	RT	Area	Area %	Name
1	14,69	44046144	49,831	
2	16,77	44344188	50,169	
		88390332	100,000	

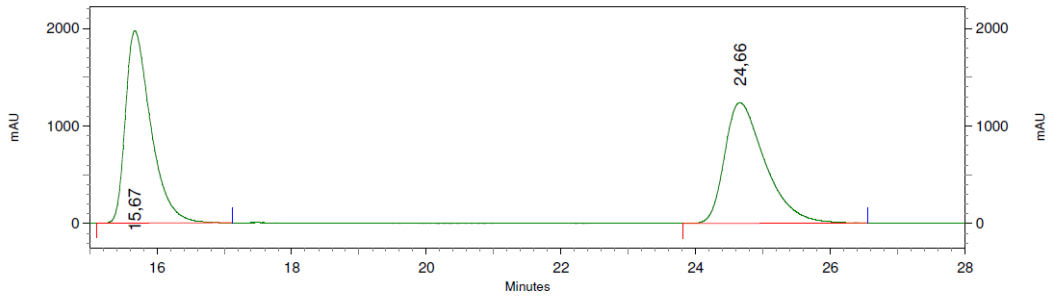


1: 247 nm, 4 nm Results

Retention Time	Area	Area Percent
13,68	35001253	9,033
15,82	352473501	90,967

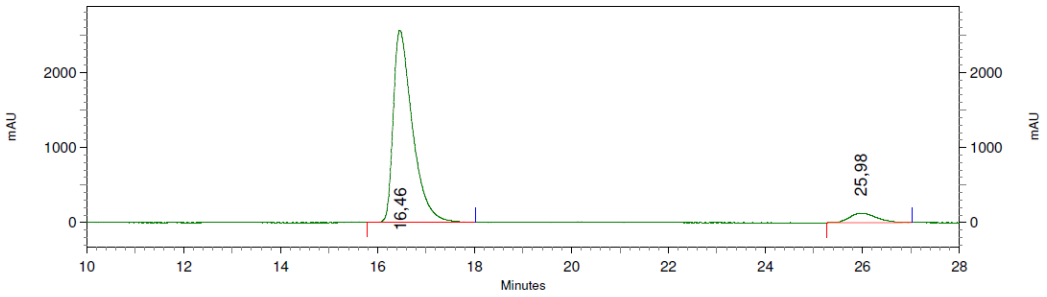


3ba



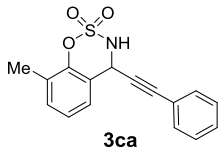
1: 229 nm, 4 nm Results

Retention Time	Area	Area Percent
15,67	207685139	50,174
24,66	206243723	49,826

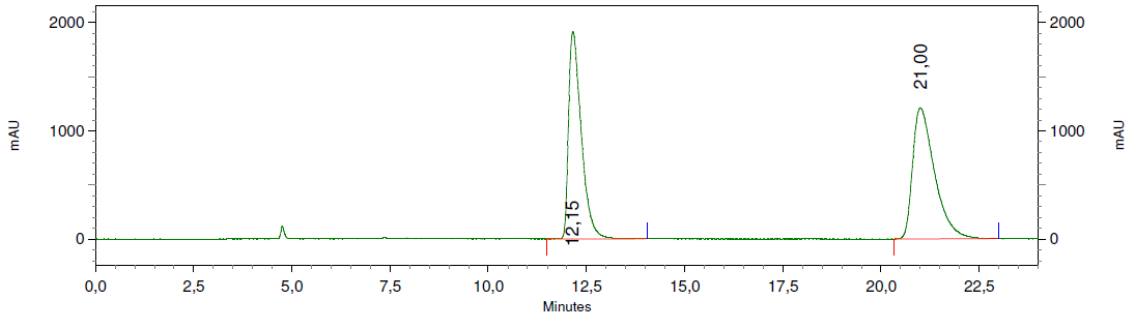


1: 229 nm, 4 nm Results

Retention Time	Area	Area Percent
16,46	280553252	93,475
25,98	19584947	6,525

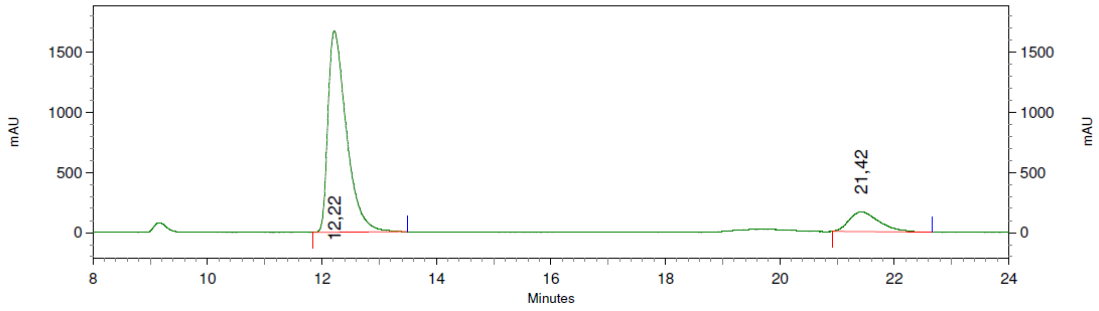


3ca



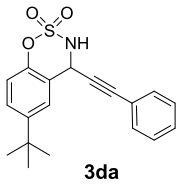
1: 255 nm, 4 nm Results

Retention Time	Area	Area Percent
12,15	172850419	47,827
21,00	188560231	52,173

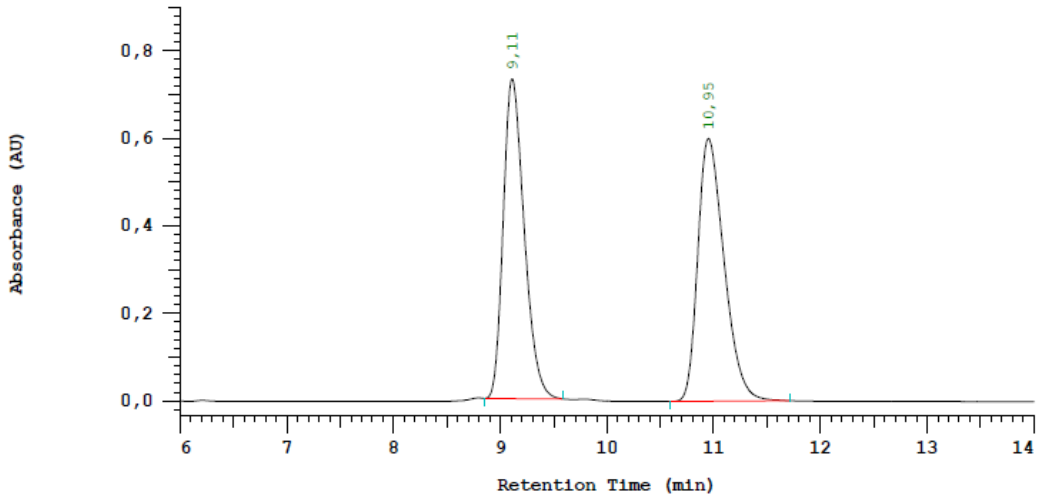


1: 255 nm, 4 nm Results

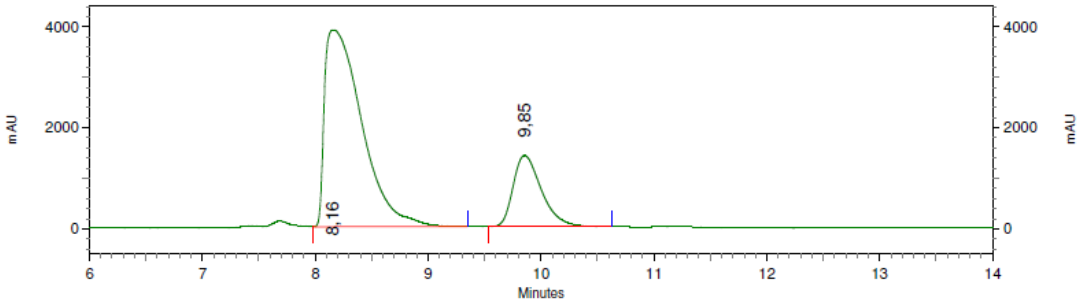
Retention Time	Area	Area Percent
12,22	149867682	86,288
21,42	23815134	13,712



3da

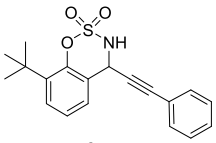


No.	RT	Area	Area %	Name
1	9,11	4993679	49,240	
2	10,95	5147916	50,760	
		10141595	100,000	

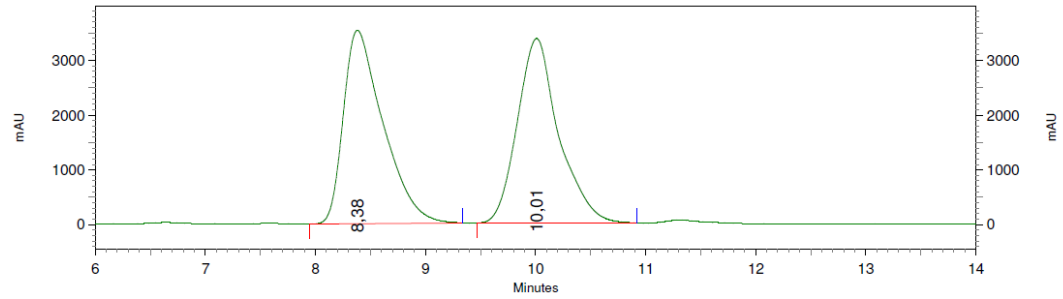


1: 254 nm, 4 nm Results

Retention Time	Area	Area Percent
8,16	357350265	78,407
9,85	98411365	21,593

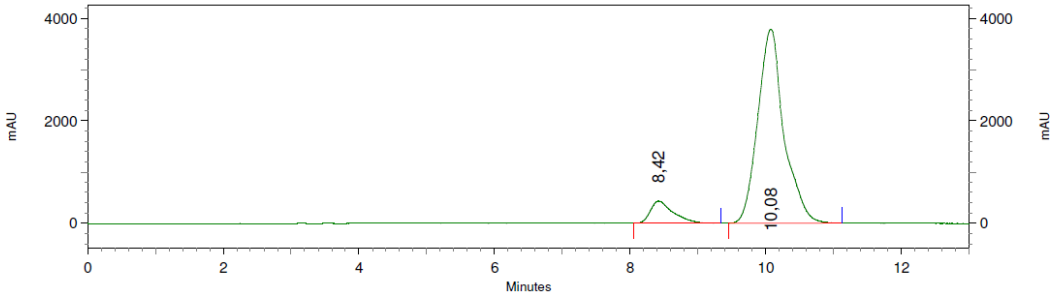


3ea



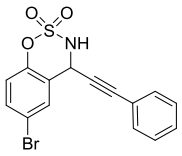
1: 235 nm, 4 nm Results

Retention Time	Area	Area Percent
8,38	354051746	50,082
10,01	352892165	49,918

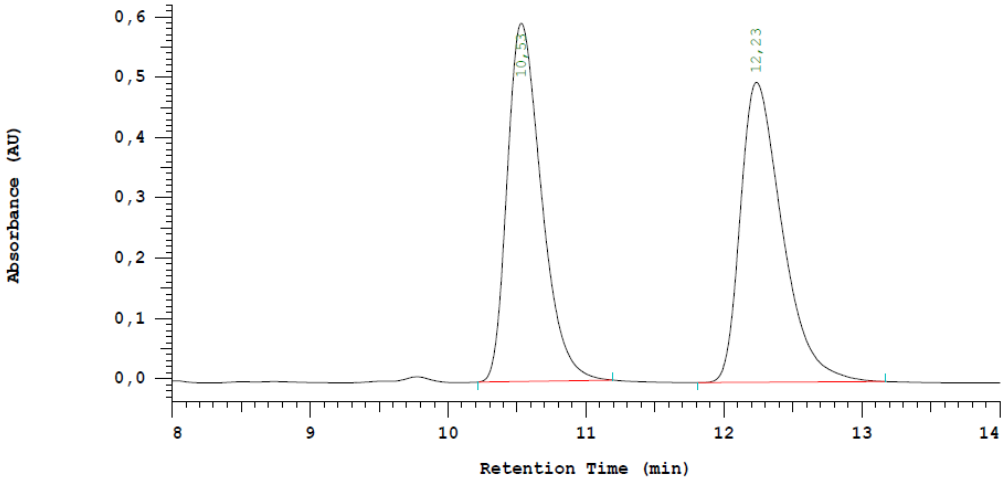


1: 230 nm, 4 nm Results

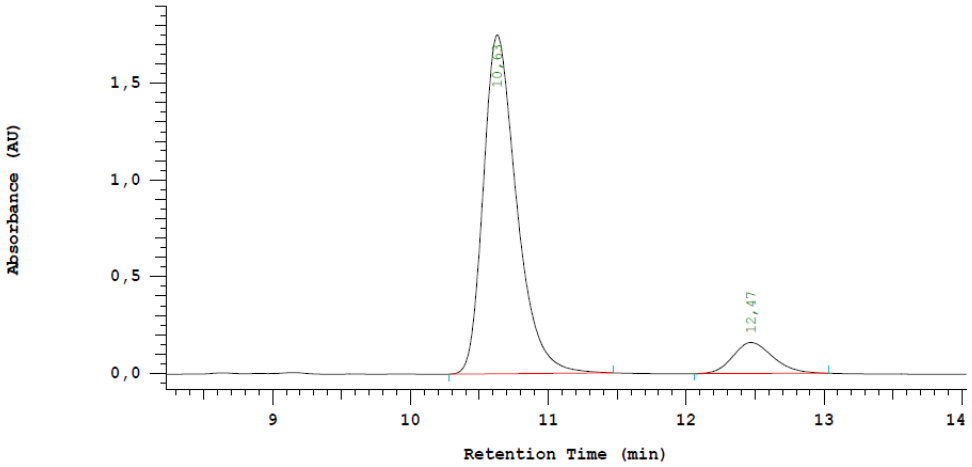
Retention Time	Area	Area Percent
8,42	40718544	9,142
10,08	404694852	90,858



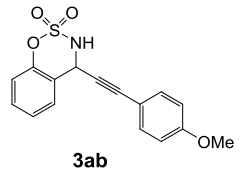
3fa



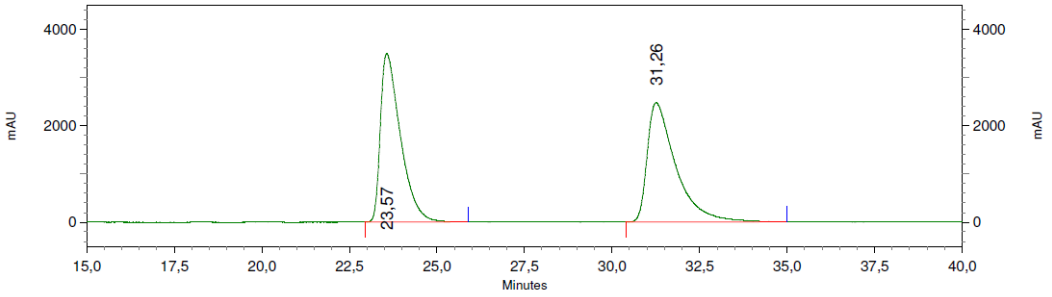
No.	RT	Area	Area %	Name
1	10,53	5124505	49,448	
2	12,23	5238924	50,552	
		10363429	100,000	



No.	RT	Area	Area %	Name
1	10,63	14698747	90,082	
2	12,47	1618241	9,918	
		16316988	100,000	

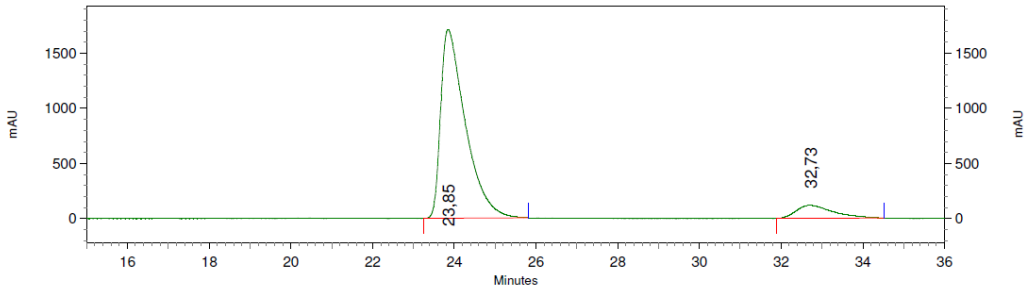


3ab



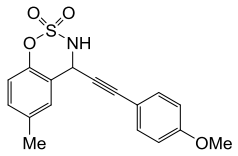
1: 250 nm, 4 nm Results

Retention Time	Area	Area Percent
23,57	556079342	49,768
31,26	561270912	50,232

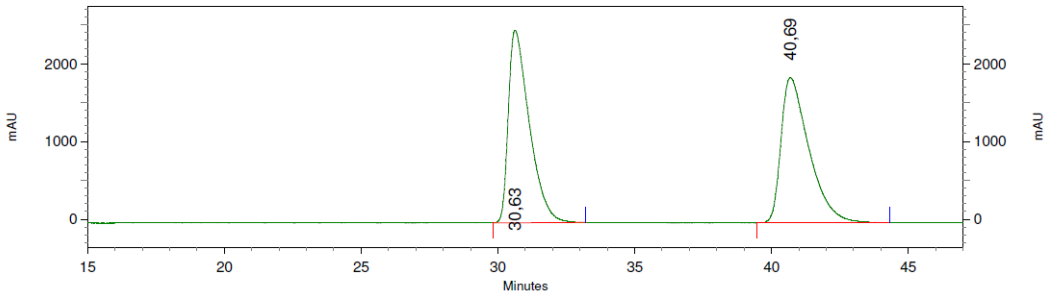


1: 237 nm, 4 nm Results

Retention Time	Area	Area Percent
23,85	287489105	90,667
32,73	29594950	9,333

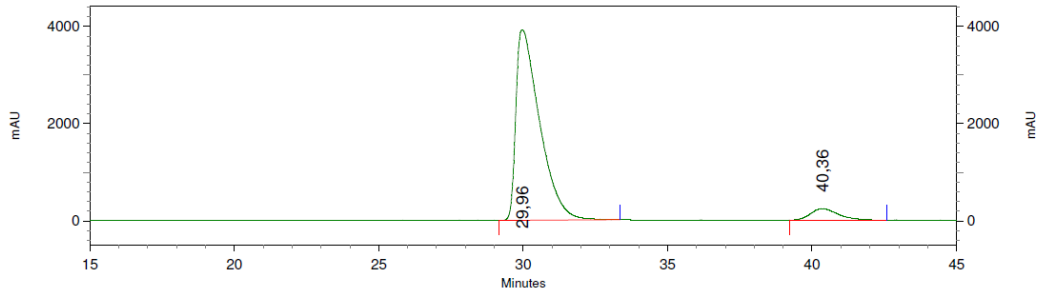


3bb



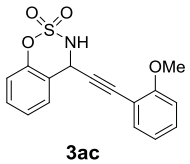
1: 250 nm, 4 nm Results

Retention Time	Area	Area Percent
30,63	526652951	49,843
40,69	529960752	50,157

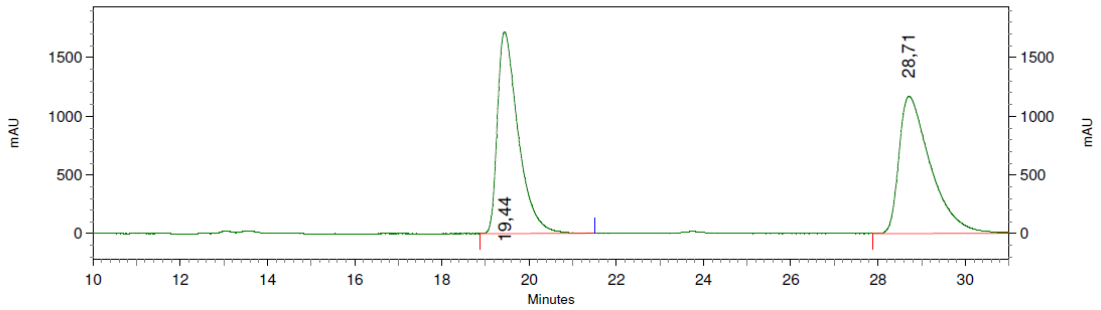


1: 250 nm, 4 nm Results

Retention Time	Area	Area Percent
29,96	894453965	93,528
40,36	61895044	6,472

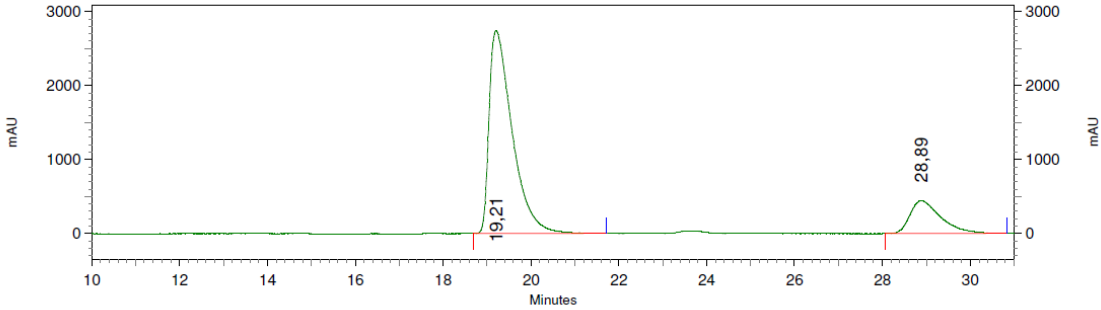


3ac



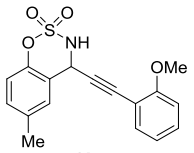
1: 255 nm, 4 nm Results

Retention Time	Area	Area Percent
19,44	227544899	48,977
28,71	237055081	51,023

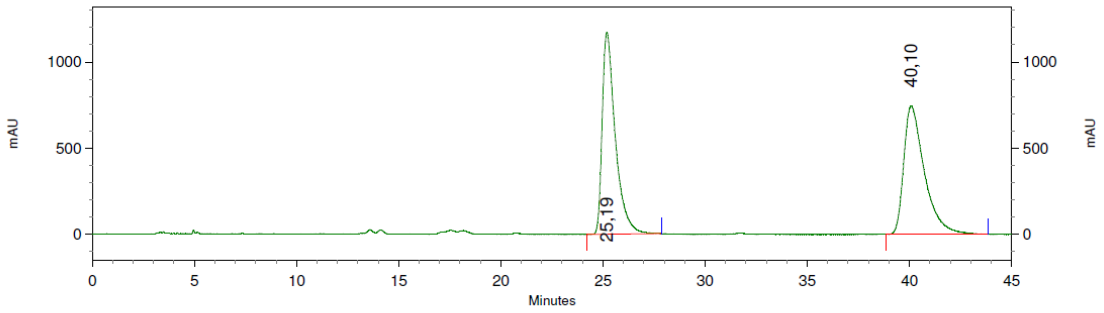


1: 255 nm, 4 nm Results

Retention Time	Area	Area Percent
19,21	399785143	82,148
28,89	86878970	17,852

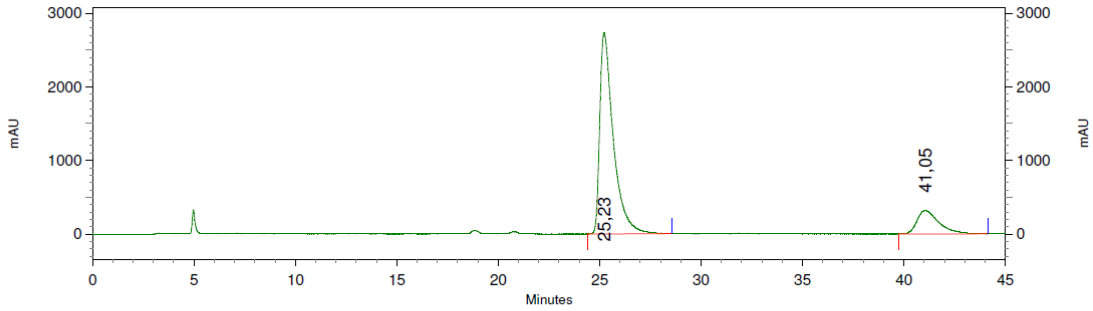


3bc



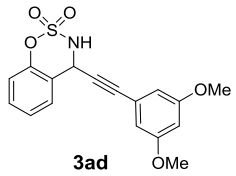
1: 212 nm, 4 nm Results

Retention Time	Area	Area Percent
25,19	209612896	49,827
40,10	211068884	50,173

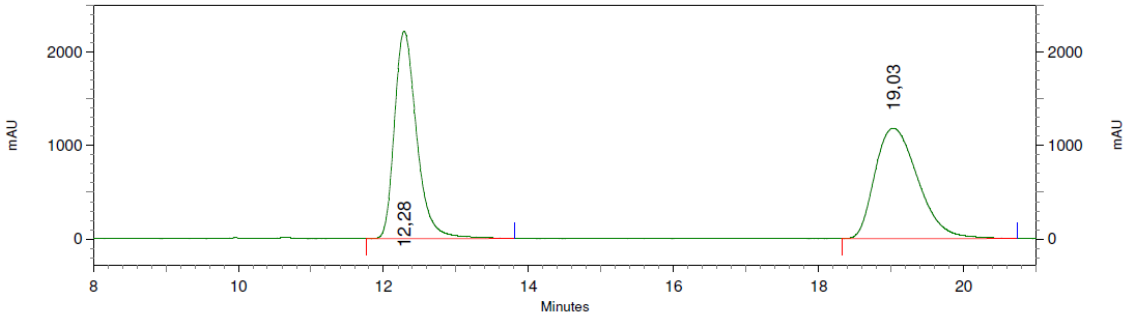


1: 212 nm, 4 nm Results

Retention Time	Area	Area Percent
25,23	507736811	84,096
41,05	96023903	15,904

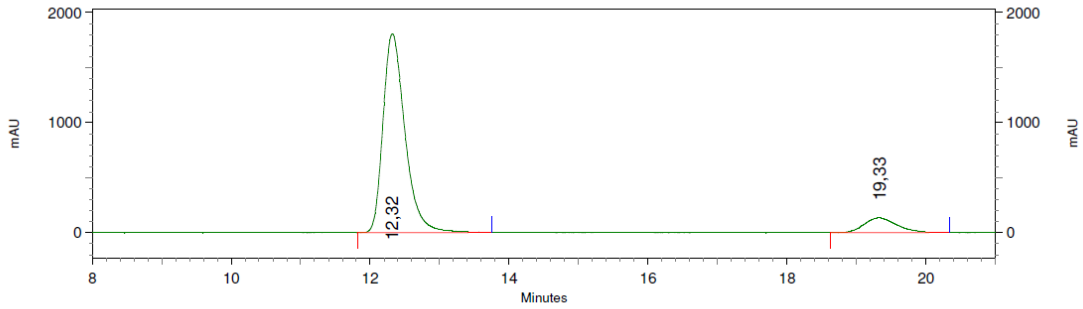


3ad



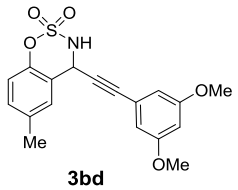
1: 267 nm, 4 nm Results

Retention Time	Area	Area Percent
12,28	189634322	49,309
19,03	194949902	50,691

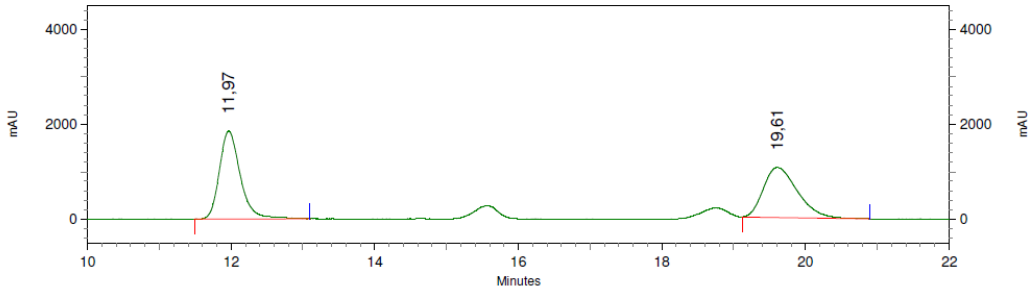


1: 267 nm, 4 nm Results

Retention Time	Area	Area Percent
12,32	158702029	89,929
19,33	17773541	10,071

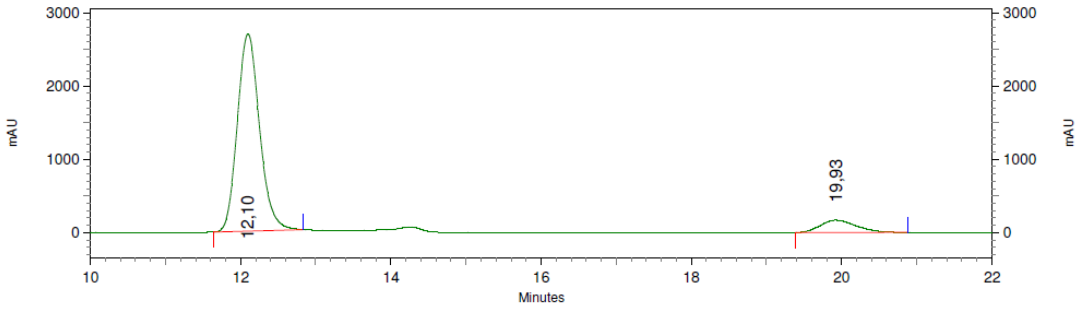


3bd



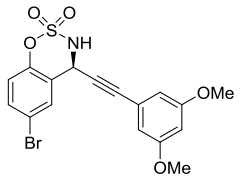
1: 253 nm, 4 nm Results

Retention Time	Area	Area Percent
11,97	150368895	51,993
19,61	138840384	48,007

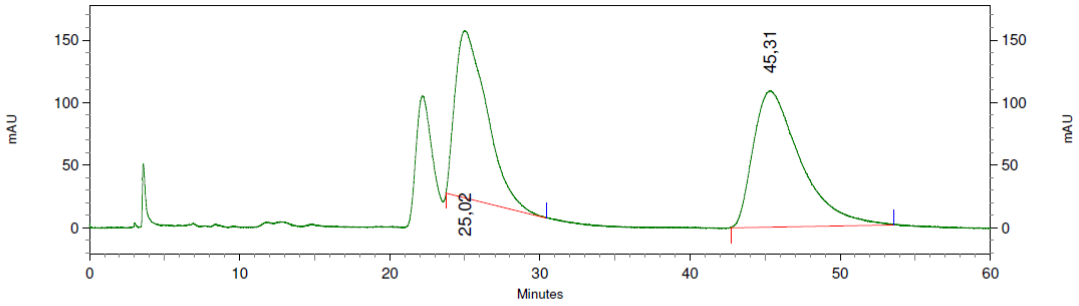


1: 267 nm, 4 nm Results

Retention Time	Area	Area Percent
12,10	220939667	90,787
19,93	22420193	9,213

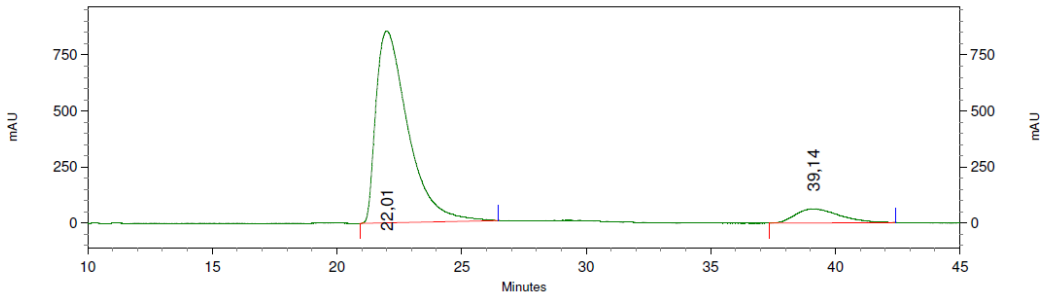


3fd



1: 229 nm, 4 nm Results

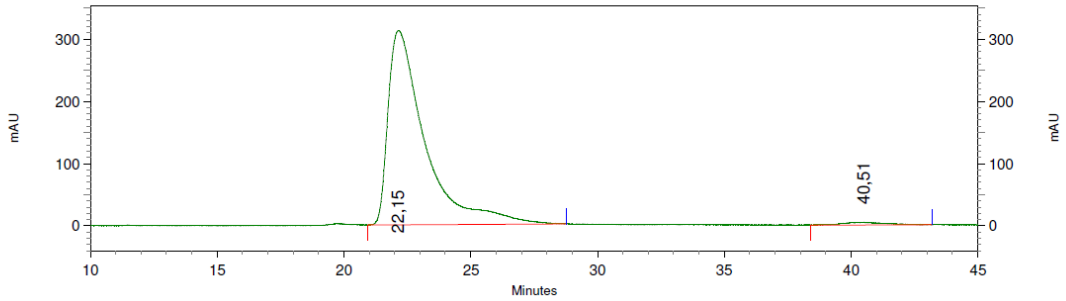
Retention Time	Area	Area Percent
25,02	78882755	45,322
45,31	95166370	54,678



1: 254 nm, 4 nm Results

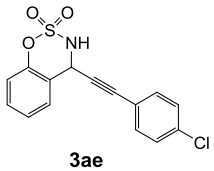
Retention Time	Area	Area Percent
22,01	305302273	90,747
39,14	31129066	9,253

e.e. after crystalization

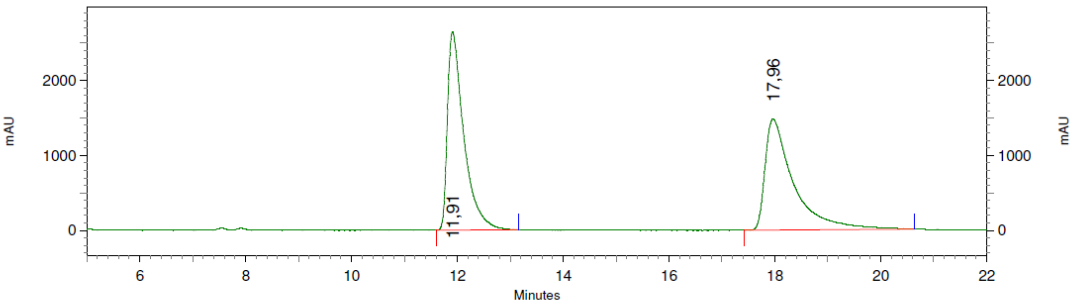


1: 231 nm, 4 nm Results

Retention Time	Area	Area Percent
22,15	126469741	98,195
40,51	2325369	1,805

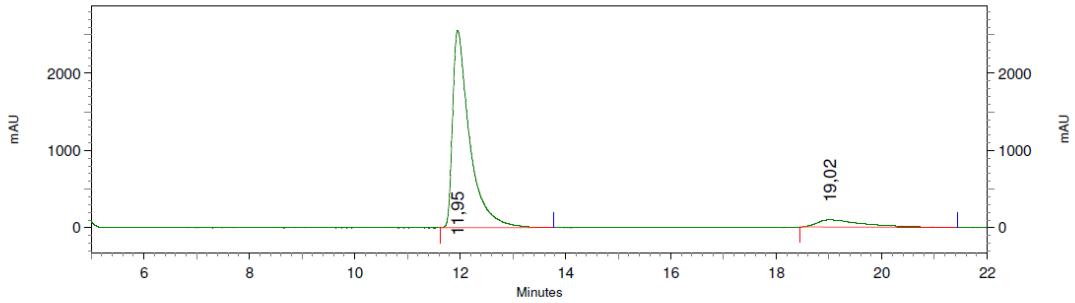


3ae



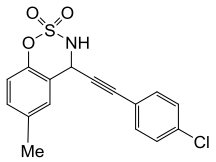
1: 228 nm, 4 nm Results

Retention Time	Area	Area Percent
11,91	226827638	50,567
17,96	221738707	49,433

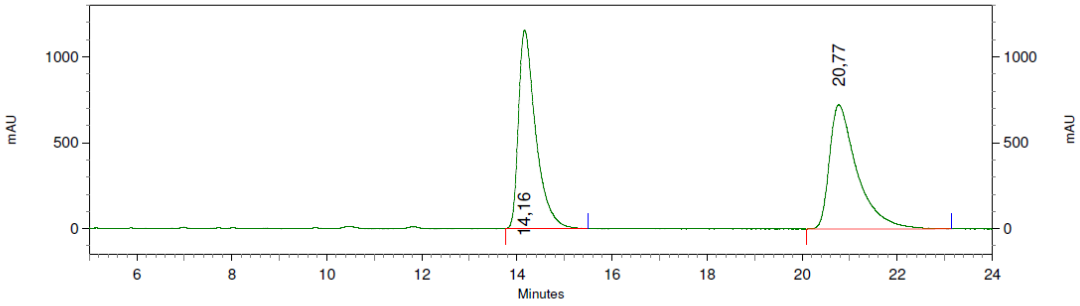


1: 228 nm, 4 nm Results

Retention Time	Area	Area Percent
11,95	229404235	90,804
19,02	23232088	9,196

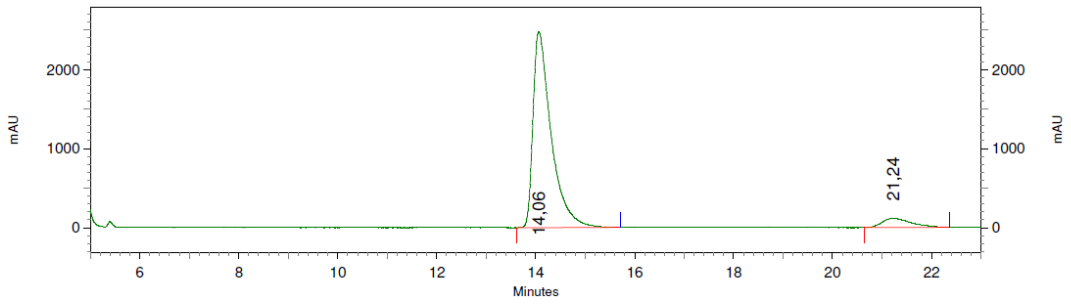


3be



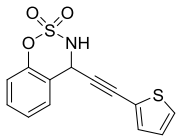
1: 230 nm, 4 nm Results

Retention Time	Area	Area Percent
14,16	115903165	49,856
20,77	116573469	50,144

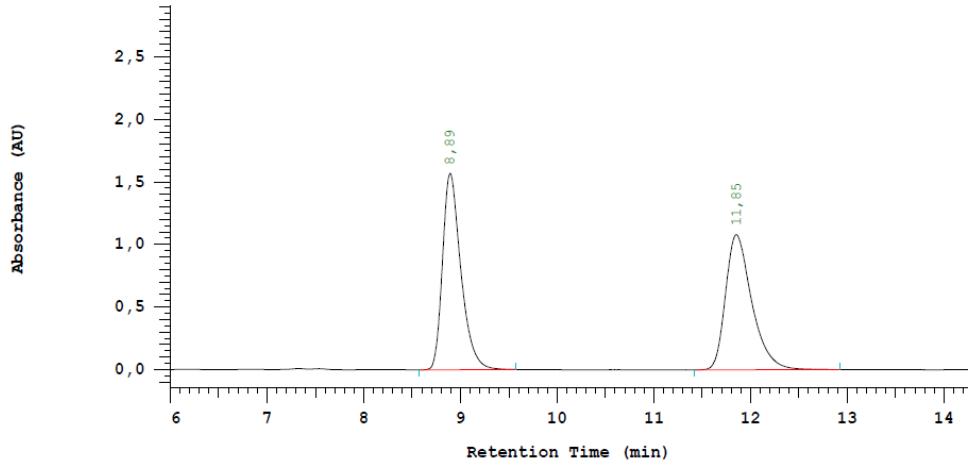


1: 230 nm, 4 nm Results

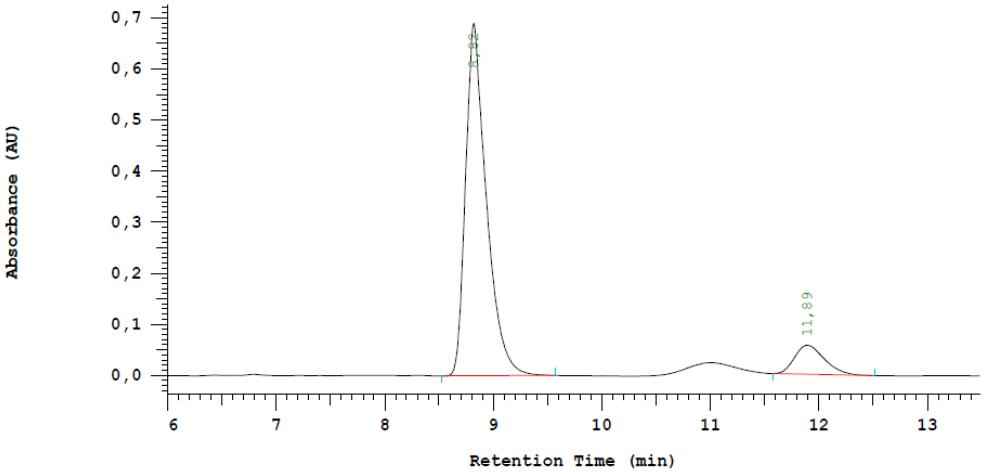
Retention Time	Area	Area Percent
14,06	251590977	92,985
21,24	18980214	7,015



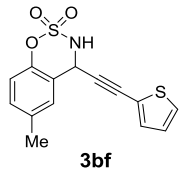
3af



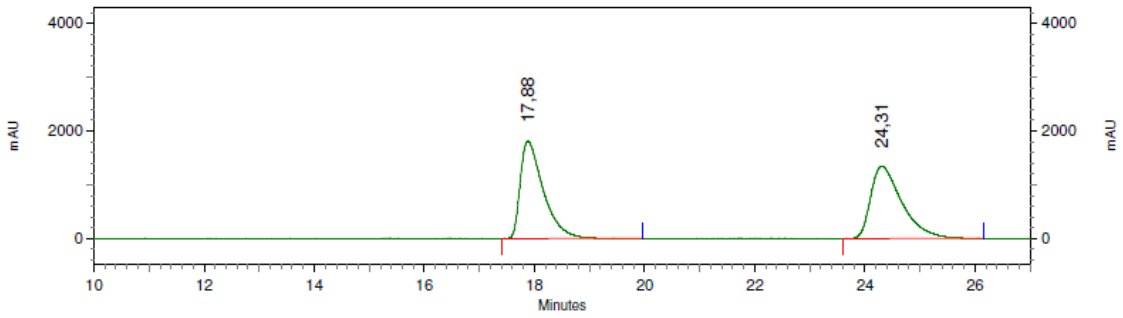
No.	RT	Area	Area %	Name
1	8,89	10317951	50,370	
2	11,85	10166531	49,630	
		20484482	100,000	



No.	RT	Area	Area %	Name
1	8,82	4594979	89,390	
2	11,89	545372	10,610	
		5140351	100,000	

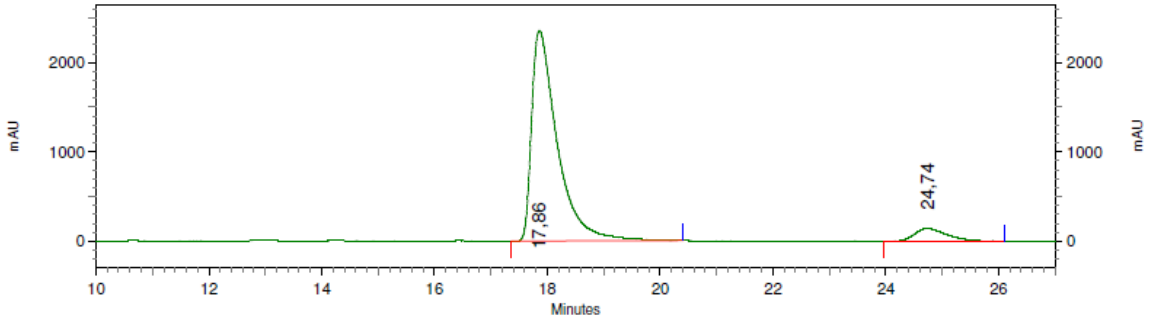


3bf



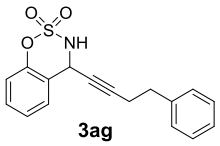
1: 280 nm, 4 nm Results

Retention Time	Area	Area Percent
17,88	211198721	49,945
24,31	211666091	50,055

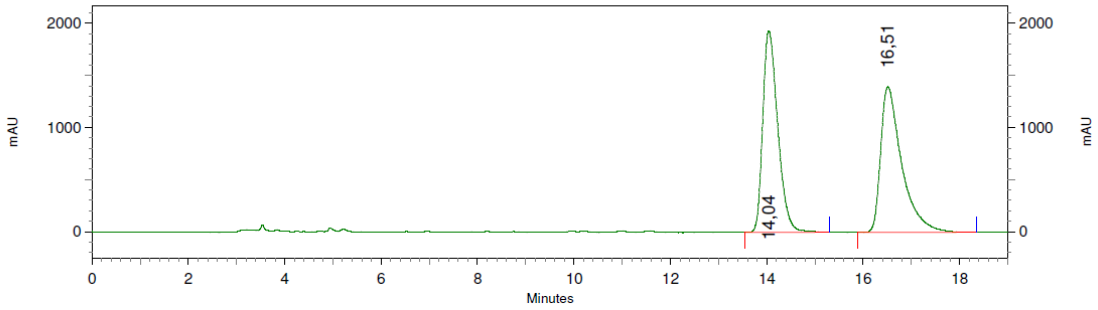


1: 280 nm, 4 nm Results

Retention Time	Area	Area Percent
17,86	297758809	92,967
24,74	22524367	7,033

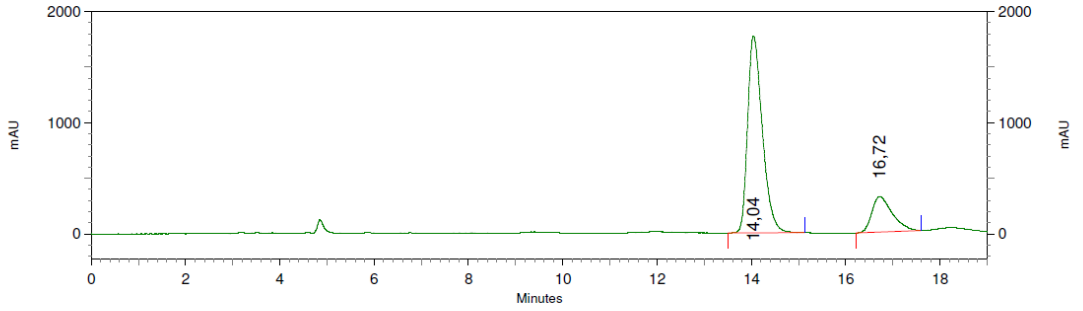


3ag



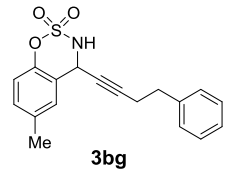
1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
14,04	167753714	49,724
16,51	169618586	50,276

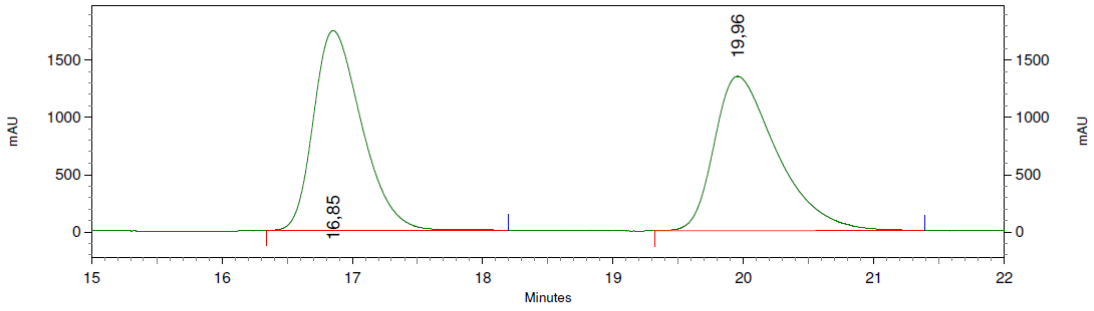


1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
14,04	153461868	80,047
16,72	38251645	19,953

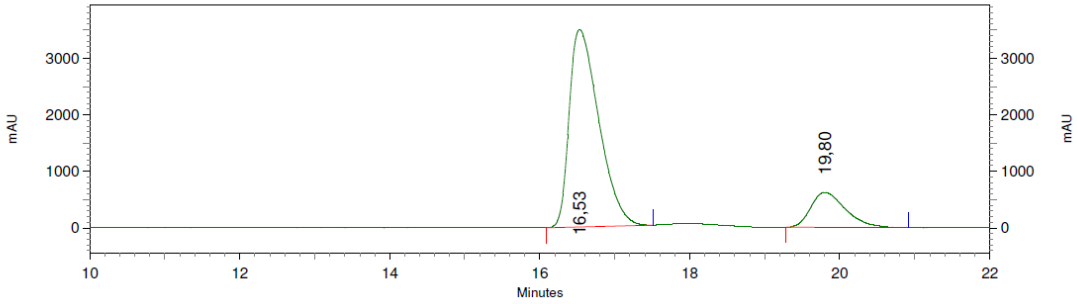


3bg



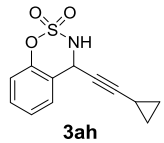
1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
16,85	179124519	49,893
19,96	179891454	50,107

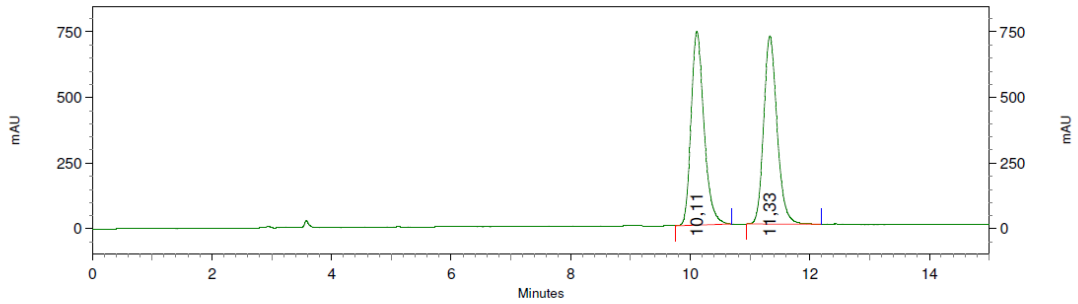


1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
16,53	382511321	82,786
19,80	79538375	17,214

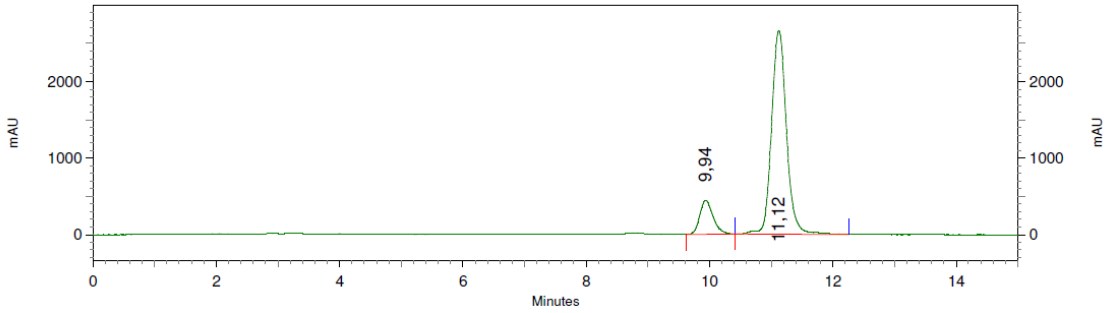


3ah



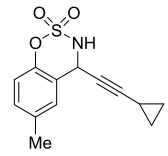
1: 210 nm, 4 nm Results

Retention Time	Area	Area Percent
10,11	44281803	49,845
11,33	44557963	50,155

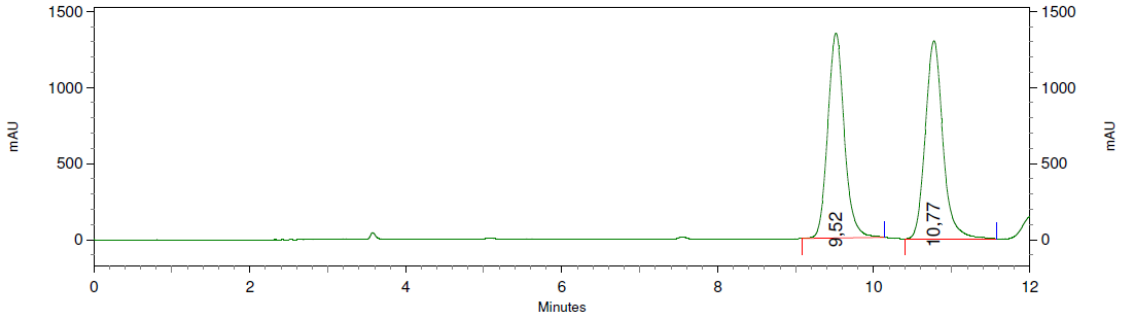


1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
9,94	26545863	12,947
11,12	178482072	87,053

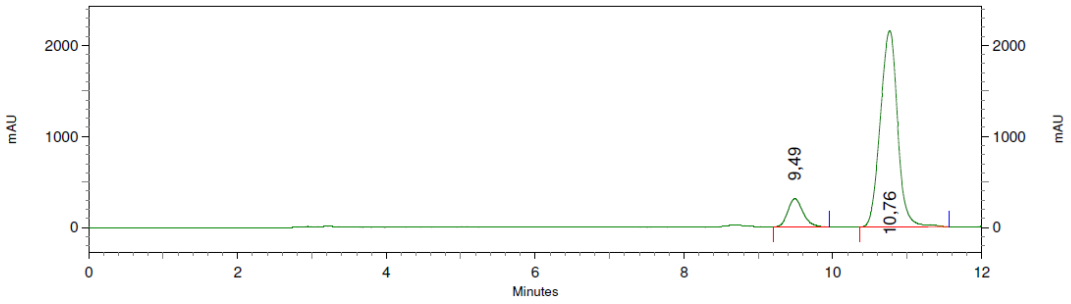


3bh



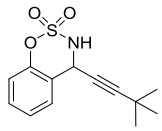
1: 225 nm, 4 nm Results

Retention Time	Area	Area Percent
9,52	79264482	49,408
10,77	81164208	50,592

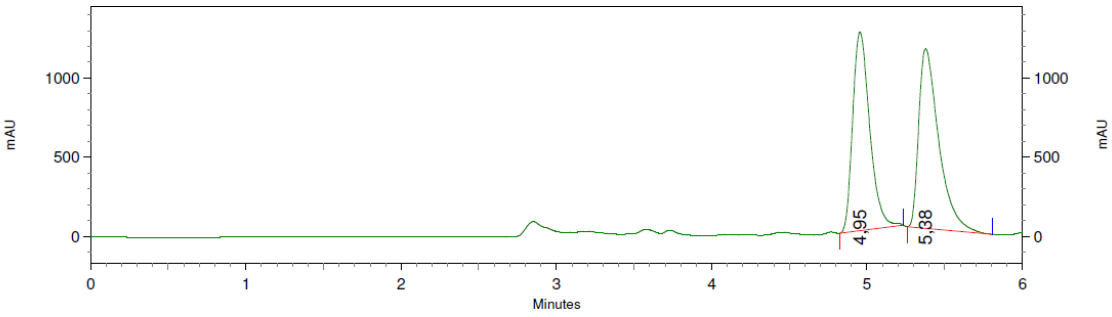


1: 225 nm, 4 nm Results

Retention Time	Area	Area Percent
9,49	17444165	11,109
10,76	139588115	88,891

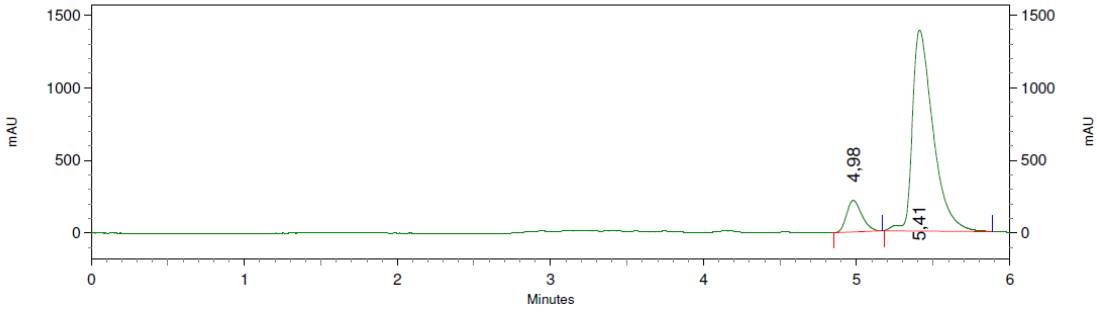


3ai



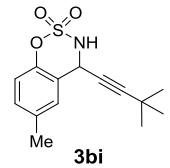
1: 224 nm, 4 nm Results

Retention Time	Area	Area Percent
4,95	38343084	48,526
5,38	40673134	51,474

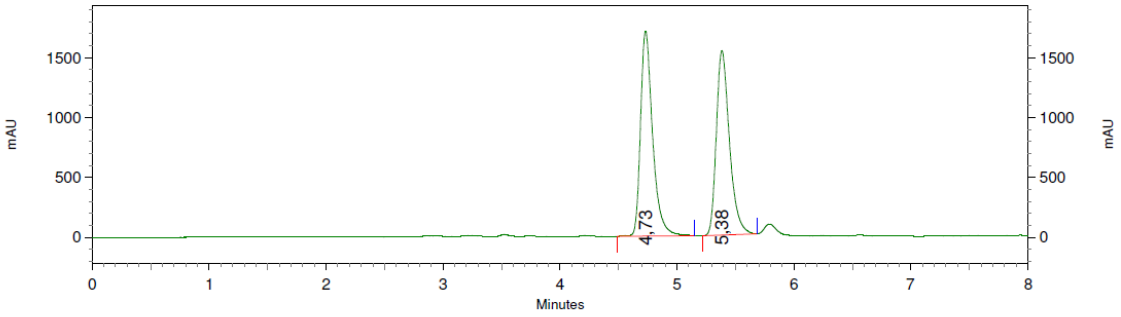


1: 224 nm, 4 nm Results

Retention Time	Area	Area Percent
4,98	6017924	10,383
5,41	51942094	89,617

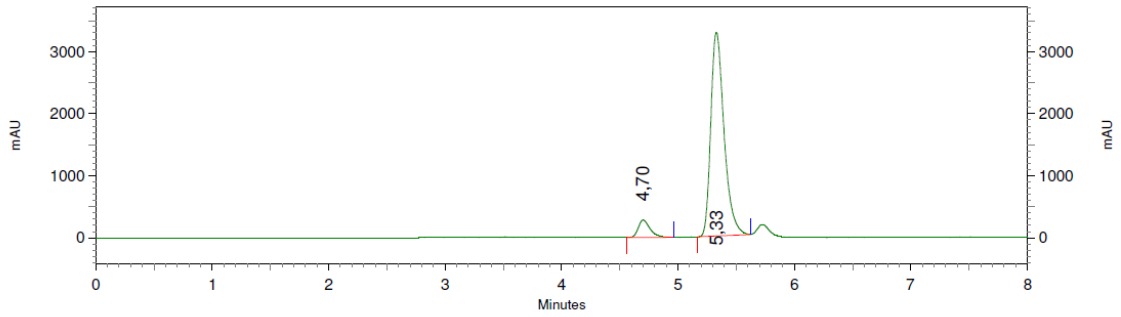


3bi



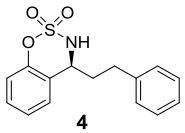
1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
4,73	49137817	50,557
5,38	48055880	49,443

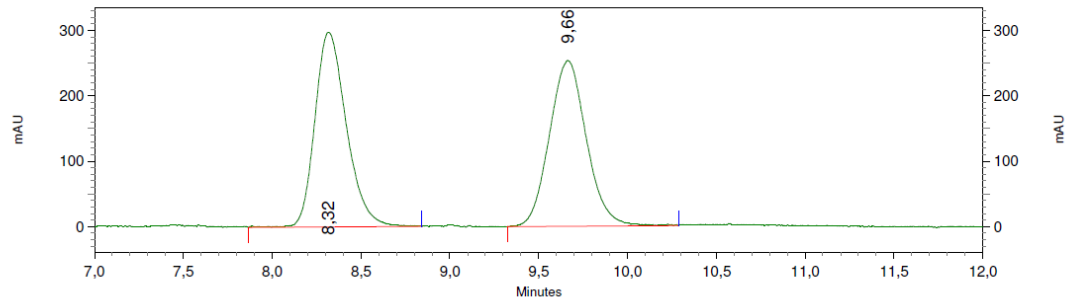


1: 216 nm, 4 nm Results

Retention Time	Area	Area Percent
4,70	7927622	7,091
5,33	103873680	92,909

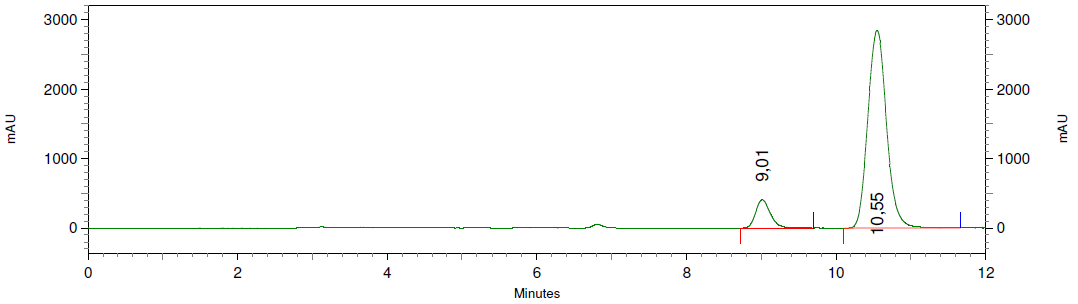


4



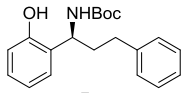
1: 267 nm, 4 nm Results

Retention Time	Area	Area Percent
8,32	14721455	49,997
9,66	14723077	50,003

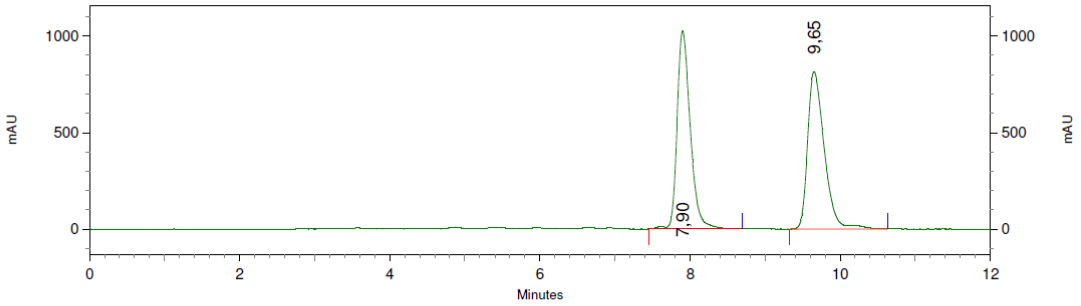


1: 217 nm, 4 nm Results

Retention Time	Area	Area Percent
9,01	22348875	10,139
10,55	198079898	89,861

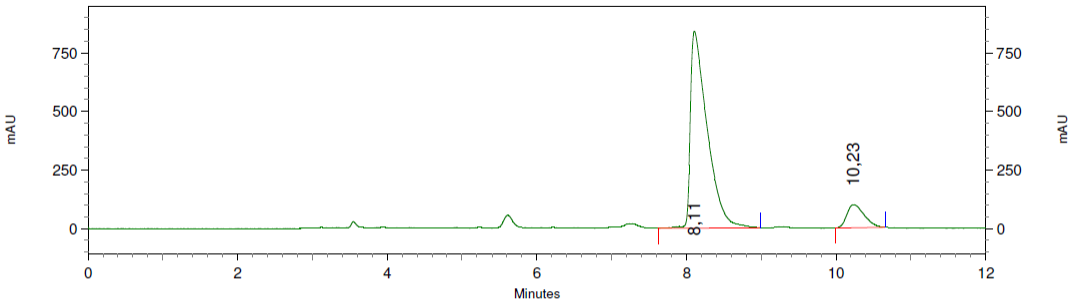


5



1: 224 nm, 4 nm Results

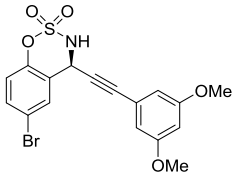
Retention Time	Area	Area Percent
7,90	50218319	50,033
9,65	50152175	49,967



1: 256 nm, 4 nm Results

Retention Time	Area	Area Percent
8,11	52467108	89,218
10,23	6340453	10,782

X-ray data for compound 3fd



3fd

X-ray data for compound **3fd**: crystallized from CH_2Cl_2/n-hexane; $C_{17}H_{14}BrNO_5S$; Mr= 424,26; orthorhombic; space group=P212121; a=10.47600(10), b=8.88300(10); c=18.1540(2) Å; V=1689.38(3) $Å^3$; Z=4; ρcalcd=1.668 Mg m^{-3}; μ=2.585 mm^{-1}; F(000)=856. A colourless crystal of 0.06x0.08x0.08 mm^3 was used; 3868 [R(int)=0.0185] independent reflections were collected on a Enraf Nonius CCD diffractomer by using graphite-monochromated MoKα radiation (λ=0.71073 Å) operating at 50 kV and 30 mA. The structure was solved by direct methods and Fourier synthesis and refined by full matrix least-squares procedures on F^2 (SHELXL-97).[3] All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were included in calculated positions and refined riding on the respective carbon atoms. The H1 and H1N atoms were located in a difference map and refined isotropically. Final R(ωR) values were R=0.0285 and ωR=0.0799. CCDC 1401764 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

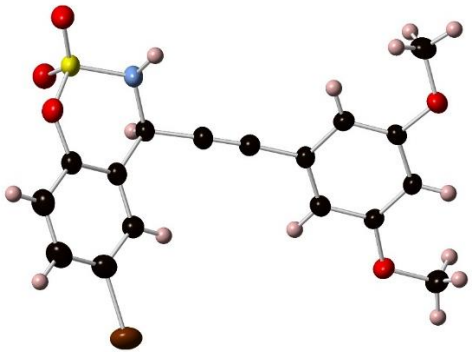


Figure 1. ORTEP plot for the X-ray structure of compound **3fd**.

References

[1] Luo, Y.; Carnell, A. J.; Lam, H. W. *Angew. Chem Int. Ed*. **2012**, 51, 6762.

[2] Hepburn, H.B., Chotsaeng, N., Luo, Y., Lam, H.W., *Synthesis*, **2013**, 45, 2649-2661

[3] G. M. Sheldrick, *Acta Cryst*. **2008**, A64, 112-122