Supporting Information

Cobalt catalyzed electrochemical [4+2] annulation for the synthesis of sultams

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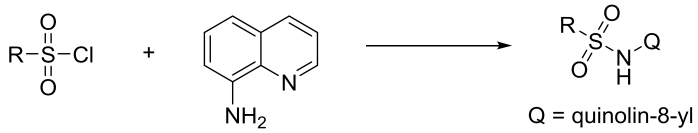
General Information

The instrument for electrolysis was dual display potentiostat (DJS-292B) (made in China). The electrodes were purchased from Gaoss Union. Thin layer chromatography (TLC) employed glass 0.25 mm silica gel plates. Flash chromatography columns were packed with 200-300 mesh silica gel in petroleum (boiling point is between 60-90 ^{o}C). Gradient flash chromatography was conducted eluting with a continuous gradient from petroleum to the indicated solvent, and they are listed as volume/volume ratios. EPR spectra were recorded on a Bruker X-band A-200 spectrometer. NMR spectra were recorded on a Bruker spectrometer at 400 MHz (^{1}H NMR), 100 MHz (^{13}C NMR), 376 MHz (^{19}F NMR). Tetramethylsilane was used as an internal standard. All ^{1}H, ^{13}C and ^{19}F NMR data spectra were reported in delta (δ) units, parts per million (ppm) downfield from the internal standard. Coupling constants are reported in Hertz (Hz). High resolution mass spectra (HRMS) were measured with a Waters Micromass GCT instrument, accurate masses are reported for the molecular ion + sodium ($[M+Na]^+$).

Experimental procedure

General procedure for the preparation of the sulfonamide derivatives:[1]



Unless stated the standard synthesis is as follows: To a solution of 8-aminoquinoline (3.5 mmol) in pyridine (7.0 mL) was added sulfonyl chloride (3.5 mmol) and the reaction was heated to 130 ^{o}C for 30 minutes. After this time the mixture was left to cool to 70 ^{o}C and poured over 50 mL of cold water. The resulting suspension was then filtered and washed with cold water (ca.100 mL) until the filtrate became clear. The solid was then dried under vacuum and recrystallized from toluene to afford a pale white/yellow crystalline solid.

General procedure for electrochemical oxidative annulation of sulfonamides with alkynes:

In an oven-dried undivided three-necked bottle equipped with a stir bar, sulfonamides (0.25 mmol), $Co(OAc)_2 \cdot 4H_2O$ (20 mol%) and NaOAc (0.5 mmol) were combined and added. The bottle was equipped with carbon cloth (15 mm × 20 mm × 0.33 mm) as the anode and stainless steel plate (15 mm × 20 mm × 1 mm) as the cathode. Under air conditions (open to air by four thick syringe needles), alkynes (0.5 mmol), HOAc (1.0 mL), and EtOH (10 mL) were injected respectively into the tubes via syringes. The reaction mixture was **strong** stirred and electrolyzed at a constant current of 4 mA at 75 ^{o}C for 8 h. When the reaction was finished, the pure product was obtained by flash column chromatography on silica gel.

Experimental setup:

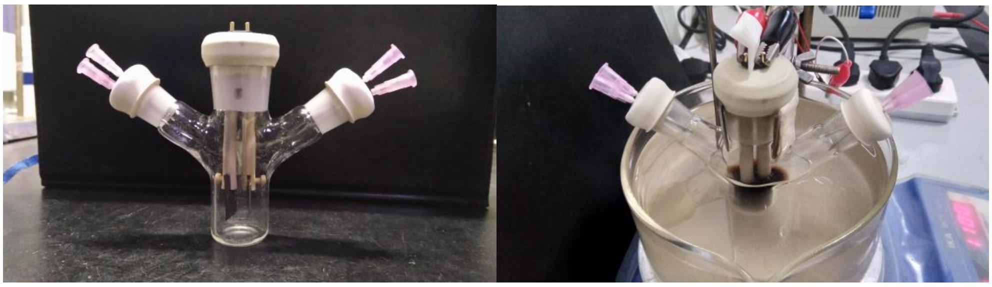


Figure S1. The experimental setup for electrolysis.

Procedure for gram-scale reaction:

In an oven-dried undivided three-necked bottle equipped with a stir bar, 4-methyl-*N*-(quinolin-8-yl)benzenesulfonamide (1.942 g, 5.0 mmol), phenylacetylene (1.12 mL, 10 mmol), $Co(OAc)_2 \cdot 4H_2O$ (254 mg, 1.0 mmol), NaOAc (820 mg, 10 mmol), were combined and added. The bottle was equipped with two carbon cloths (20 mm × 30 mm × 0.33 mm) as the anodes and two stainless steel plates (20 mm × 30 mm × 1 mm) as the cathodes. Under air conditions (air bubbling), EtOH (115 mL) and HOAc (11.5 mL) were injected respectively into the tubes via syringes. The reaction mixture was **strong** stirred and electrolyzed under an air atmosphere (air bubbling) at a constant current of 8 mA at 75 ^{o}C for 40 h. When the reaction was finished, the pure product was obtained by flash column chromatography on silica gel.

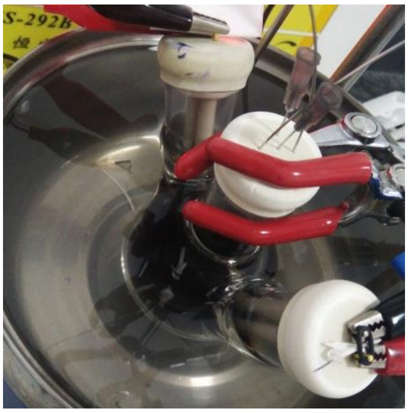


Figure S2. The experimental setup for gram-scale reaction.

Procedure for cyclic voltammetry (CV):

Cyclic voltammetry was performed in a three-electrode cell connected to a schlenk line under nitrogen at room temperature. The working electrode was a steady glassy carbon disk electrode while the counter electrode was a platinum wire. The reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. 11 mL of ethanol containing 0.2 mmol of $^{n}Bu_4NBF_4$ were poured into the electrochemical cell in all experiments. The scan rate is 0.05 V/s, ranging from 0 V to 2.2 V.

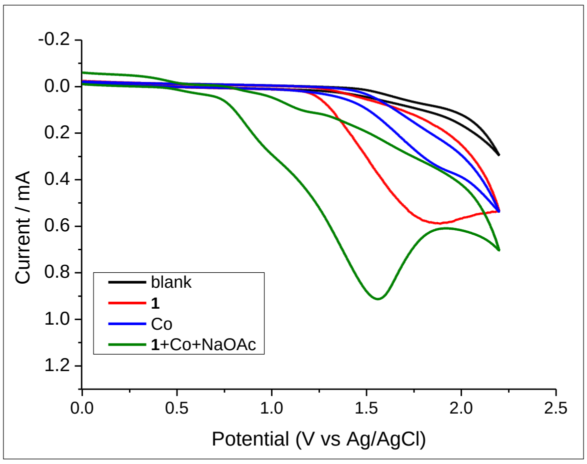


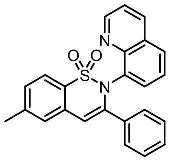
Figure S3. Cyclic voltammograms: 1, 0.1 mmol, $Co(OAc)^{\cdot}4H_2O$, 0.1 mmol, NaOAc, 0.2 mmol.

Procedure for electron paramagnetic resonance (EPR) experiments:

In an oven-dried undivided three-necked bottle equipped with a stir bar, **1** (0.25 mmol), $Co(OAc)_2{\cdot}4H_2O$ (20 mol%) and NaOAc (0.5 mmol) were combined and added. The bottle was equipped with carbon cloth (15 mm × 20 mm × 0.33 mm) as the anode and stainless steel plate (15 mm × 20 mm × 1 mm) as the cathode. Under air conditions (open to air by four thick syringe needles), **2** (0.5 mmol), HOAc (0.5 mL), and EtOH (10.5 mL) were injected respectively into the tubes via syringes. The reaction mixture was **strong** stirred and electrolyzed at a constant current of 4 mA at 75 ^{o}C for 15min. When the reaction was finished, the solution sample was taken out into a small tube and analyzed by EPR. After fitting, we proposed that this radical signal belongs to the alkoxy radical (g = 2.0068, A_N = 13.58 G, A_H = 7.48 G).

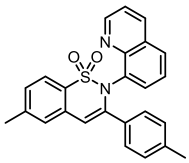
In an oven-dried undivided three-necked bottle equipped with a stir bar, **1** (0.25 mmol), $Co(OAc)_2{\cdot}4H_2O$ (20 mol%) and NaOAc (0.5 mmol) were combined and added. The bottle was equipped with carbon cloth (15 mm × 20 mm × 0.33 mm) as the anode and stainless steel plate (15 mm × 20 mm × 1 mm) as the cathode. Under air conditions (open to air by four thick syringe needles), **2** (0.5 mmol), HOAc (0.5 mL), and MeCN (10.5 mL) were injected respectively into the tubes via syringes. The reaction mixture was **strong** stirred and electrolyzed at a constant current of 4 mA at 75 ^{o}C for 15min. When the reaction was finished, the solution sample was taken out into a small tube and analyzed by EPR. After fitting, we proposed that this radical signal belongs to the superoxide radical anion (g = 2.0068, A_N = 12.9 G, A_H = 10.7 G).

Detailed descriptions for products



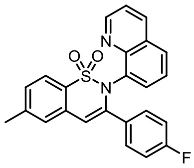
6-Methyl-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide (3).[1]

White solid was obtained in 80% isolated yield (80 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.06 (d, *J* = 2.68 Hz, 1H), 8.34 (d, *J* = 8.16 Hz, 1H), 7.86 (d, *J* = 8.18 Hz, 1H), 7.82 – 7.73 (m, 2H), 7.67 (s, 1H), 7.64 – 7.53 (m, 2H), 7.46 – 7.34 (m, 2H), 7.31 (s, 1H), 7.26 – 7.12 (m, 4H), 2.48 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.17, 145.01, 143.40, 142.80, 136.18, 135.15, 134.74, 132.83, 129.42, 129.37, 129.09, 128.95, 128.72, 128.40, 128.32, 127.23, 125.99, 122.06, 121.98, 112.87, 112.85, 21.25.



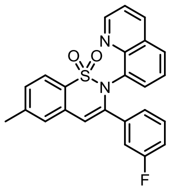
6-Methyl-2-(quinolin-8-yl)-3-(*p*-tolyl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide (4). [1]

White solid was obtained in 73% isolated yield (75.3 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.07 (dd, *J* = 4.06, 1.40 Hz, 1H), 8.02 (dd, *J* = 8.28, 1.30 Hz, 1H), 7.69 – 7.57 (m, 4H), 7.41 – 7.35 (m, 2H), 7.27 – 7.20 (m, 2H), 7.20 – 7.16 (m, 1H), 6.91 (d, *J* = 8.03 Hz, 2H), 6.88 (s, 1H), 2.47 (s, 3H), 2.15 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.98, 145.72, 144.35, 142.53, 139.16, 135.60, 135.42, 133.26, 132.78, 129.21, 128.92, 128.71, 128.56, 128.53, 127.64, 127.59, 125.56, 122.56, 121.59, 111.85, 111.83, 21.64, 21.12.



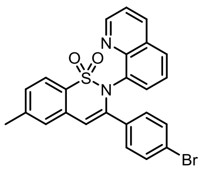
3-(4-Fluorophenyl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(5).[2]

White solid was obtained in 73% isolated yield (75.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.06 (d, *J* = 2.64 Hz, 1H), 8.36 (d, *J* = 6.58 Hz, 1H), 7.89 (d, *J* = 7.88 Hz, 1H), 7.86 – 7.77 (m, 2H), 7.66 (s, 1H), 7.64 – 7.56 (m, 2H), 7.47 – 7.35 (m, 2H), 7.31 (s, 1H), 7.21 (d, *J* = 6.96 Hz, 1H), 7.05 (t, *J* = 8.76 Hz, 2H), 2.49 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 163.00 (d, $^{1}J_{C-F}$ = 247.4 Hz), 151.71, 145.39, 143.31, 142.76, 136.69, 135.00, 133.20, 132.08 (d, $^{4}J_{C-F}$ = 3.0 Hz), 129.94, 129.86 (d, $^{3}J_{C-F}$ = 8.6 Hz), 129.65, 129.31, 129.19, 128.84, 128.78, 126.48, 122.57, 122.46, 115.91 (d, $^{2}J_{C-F}$ = 21.9 Hz).113.32, 21.68. ^{19}F NMR (376 MHz, DMSO-d_6) δ -111.51.



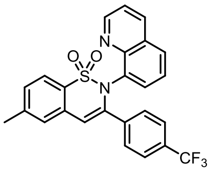
3-(3-Fluorophenyl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(6).

White solid was obtained in 77% isolated yield (79.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.10 (dd, *J* = 4.20, 1.72 Hz, 1H), 8.37 (dd, *J* = 8.34, 1.74 Hz, 1H), 7.89 (d, *J* = 8.12 Hz, 1H), 7.70 – 7.57 (m, 5H), 7.49 – 7.42 (m, 2H), 7.38 (t, *J* = 7.84 Hz, 1H), 7.29 – 7.20 (m, 1H), 7.16 (d, *J* = 7.36 Hz, 1H), 7.08 – 6.99 (m, 1H), 2.48 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 161.95 (d, $^{1}J_{C-F}$ = 243.9 Hz), 151.31, 145.01, 142.98, 141.92 (d, $^{4}J_{C-F}$ = 2.6 Hz) , 137.61, 137.53, 136.31, 134.59, 132.51, 130.51 (d, $^{3}J_{C-F}$ = 8.4 Hz), 129.88, 129.32, 129.13, 128.80, 128.60, 128.15, 126.10, 123.19 (d, *J* = 2.6 Hz), 122.16 (d, $^{3}J_{C-F}$ = 7.0 Hz), 116.22 (d, $^{2}J_{C-F}$ = 20.9 Hz), 114.10, 113.86 (d, $^{2}J_{C-F}$ = 23.1 Hz), 21.24. ^{19}F NMR (376 MHz, DMSO-d_6) δ -112.90. HRMS (ESI): calculated for $C_{24}H_{17}FN_2NaO_2S$ $[M+Na]^+$: 439.0887; Found: 439.0894.



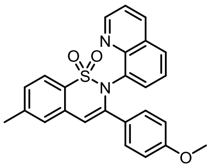
3-(4-Bromophenyl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(7).[3]

White solid was obtained in 81% isolated yield (97.1 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.09 (d, *J* = 4.10 Hz, 1H), 8.41 (d, *J* = 7.92 Hz, 1H), 7.93 (d, *J* = 8.22 Hz, 1H), 7.82 – 7.69 (m, 3H), 7.65 (d, *J* = 8.44 Hz, 2H), 7.53 – 7.35 (m, 5H), 7.24 (d, *J* = 6.96 Hz, 1H), 2.53 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.32, 144.95, 142.97, 142.31, 136.30, 134.51, 134.46, 132.69, 131.48, 129.73, 129.32, 129.23, 129.05, 128.80, 128.49, 126.09, 122.87, 122.20, 122.08, 113.40, 21.28.



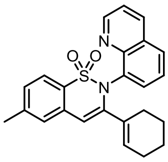
6-Methyl-2-(quinolin-8-yl)-3-(4-(trifluoromethyl)phenyl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(8).[1]

White solid was obtained in 80% isolated yield (93.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.06 (d, *J* = 2.42 Hz, 1H), 8.36 (d, *J* = 6.58 Hz, 1H), 7.89 (d, *J* = 7.88 Hz, 1H), 7.86 – 7.77 (m, 2H), 7.66 (s, 1H), 7.64 – 7.56 (m, 2H), 7.47 – 7.36 (m, 2H), 7.31 (s, 1H), 7.21 (d, *J* = 6.96 Hz, 1H), 7.05 (t, *J* = 8.76 Hz, 2H), 2.49 (s, 3H). ^{13}C NMR (100 MHz, CD_2Cl_2) δ 151.74, 146.08, 143.82, 143.38, 139.71, 136.52, 135.50, 133.20, 131.13 (q, $^{2}J_{C-F}$ = 32.4 Hz), 130.23, 129.68, 129.13, 128.83, 128.50, 126.21, 125.80 (q, $^{3}J_{C-F}$ = 3.8 Hz), 124.49 (q, $^{1}J_{C-F}$ = 272.3 Hz), 122.98, 122.50, 114.70, 114.67, 21.98. ^{19}F NMR (376 MHz, DMSO-d_6) δ -61.25.



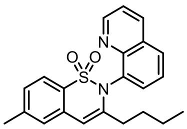
3-(4-Eethoxyphenyl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide (9).[1]

White solid was obtained in 73% isolated yield (77.9 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.09 (d, *J* = 2.92 Hz, 1H), 8.37 (d, *J* = 8.14 Hz, 1H), 7.88 (d, *J* = 8.08 Hz, 1H), 7.74 (d, *J* = 8.54 Hz, 2H), 7.65 (s, 1H), 7.64 – 7.57 (m, 2H), 7.39 (t, *J* = 7.36 Hz, 2H), 7.23 (s, 1H), 7.17 (d, *J* = 7.28 Hz, 1H), 6.76 (d, *J* = 8.56 Hz, 2H), 3.64 (s, 3H), 2.49 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 160.13, 151.16, 145.08, 143.37, 142.73, 136.21, 136.15, 134.96, 133.11, 129.01, 128.75, 128.72, 128.07, 127.55, 126.01, 122.05, 122.00, 113.90, 113.78, 111.48, 111.38, 55.18, 21.29.



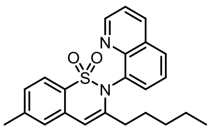
3-(Cyclohex-1-en-1-yl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(10).[1]

Yellow solid was obtained in 69% isolated yield (69.5 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.10 (d, *J* = 3.52 Hz, 1H), 8.44 (d, *J* = 8.42 Hz, 1H), 7.97 (d, *J* = 8.18 Hz, 1H), 7.69 – 7.59 (m, 2H), 7.55 (d, *J* = 7.92 Hz, 1H), 7.47 (t, *J* = 7.60 Hz, 1H), 7.39 (d, *J* = 8.12 Hz, 1H), 7.09 – 6.97 (m, 2H), 6.59 (s, 1H), 2.48 (s, 3H), 2.37 (d, *J* = 17.76 Hz, 1H), 2.15 (d, *J* = 17.08 Hz, 1H), 1.95 (d, *J* = 16.46 Hz, 1H), 1.72 – 1.47 (m, 2H), 1.46 – 1.28 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 150.97, 145.23, 145.04, 142.72, 136.17, 135.74, 132.85, 132.12, 131.23, 129.22, 128.88, 128.81, 128.44, 126.56, 126.03, 122.30, 121.94, 111.54, 25.43, 25.04, 21.88, 21.28, 21.18.



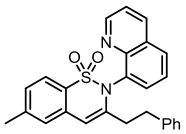
3-Butyl-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(11).

Yellow solid was obtained in 85% isolated yield (94.1 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81 (dd, *J* = 4.18, 1.76 Hz, 1H), 8.14 (dd, *J* = 8.30, 1.72 Hz, 1H), 7.85 (dd, *J* = 8.26, 1.46 Hz, 1H), 7.70 (dd, *J* = 7.38, 1.42 Hz, 1H), 7.66 (d, *J* = 8.98 Hz, 1H), 7.61 – 7.49 (m, 1H), 7.36 (dd, *J* = 8.28, 4.18 Hz, 1H), 7.25 – 7.18 (m, 2H), 6.38 (s, 1H), 2.45 (s, 3H), 2.20 – 2.09 (m, 1H), 2.09 – 1.99 (m, 1H), 1.58 – 1.48 (m, 2H), 1.27 – 1.15 (m, 2H), 0.75 (t, *J* = 7.32 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.12, 145.68, 144.96, 142.15, 135.79, 133.35, 133.28, 130.75, 129.27, 129.08, 128.77, 127.72, 126.83, 125.73, 121.69, 121.66, 108.53, 33.81, 29.54, 21.77, 21.59, 13.62. HRMS (ESI): calculated for $C_{22}H_{22}N_2NaO_2S$ $[M+Na]^+$: 401.1294; Found: 401.1304.



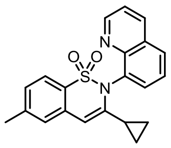
6-Methyl-3-pentyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(12).

Yellow solid was obtained in 79% isolated yield (77.1 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.78 (d, *J* = 3.98 Hz, 1H), 8.43 (d, *J* = 8.32 Hz, 1H), 8.09 (d, *J* = 7.90 Hz, 1H), 7.72 (d, *J* = 7.96 Hz, 1H), 7.67 (t, *J* = 7.78 Hz, 1H), 7.58 (d, *J* = 8.06 Hz, 1H), 7.54 (dd, *J* = 8.26, 4.14 Hz, 1H), 7.42 (s, 1H), 7.30 (d, *J* = 8.02 Hz, 1H), 6.52 (s, 1H), 2.42 (d, *J* = 2.16 Hz, 3H), 2.11 – 1.99 (m, 1H), 1.98 – 1.87 (m, 1H), 1.39 (t, *J* = 7.18 Hz, 2H), 1.11 – 1.00 (m, 4H), 0.69 (t, *J* = 6.12 Hz, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.36, 144.94, 144.50, 142.35, 136.42, 133.15, 132.42, 130.99, 129.76, 128.89, 128.46, 127.98, 127.00, 126.16, 122.18, 121.13, 108.10, 33.56, 30.18, 26.64, 21.57, 21.19, 13.69. HRMS (ESI): calculated for $C_{23}H_{24}N_2NaO_2S$ $[M+Na]^+$: 415.1451; Found: 415.1462.



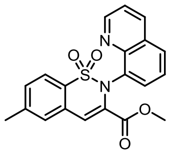
6-Methyl-3-phenethyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(13).

Yellow solid was obtained in 89% isolated yield (95.1 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.82 (d, *J* = 2.56 Hz, 1H), 8.45 (d, *J* = 7.94 Hz, 1H), 8.12 (d, *J* = 7.38 Hz, 1H), 7.78 (d, *J* = 7.22 Hz, 1H), 7.69 (t, *J* = 7.76 Hz, 1H), 7.61 (d, *J* = 8.02 Hz, 1H), 7.56 (dd, *J* = 8.34, 4.20 Hz, 1H), 7.40 (s, 1H), 7.32 (d, *J* = 7.88 Hz, 1H), 7.13 (t, *J* = 7.06 Hz, 2H), 7.08 (d, *J* = 6.98 Hz, 1H), 6.91 (d, *J* = 7.14 Hz, 2H), 6.50 (s, 1H), 2.81 – 2.72 (m, 2H), 2.42 (s, 3H), 2.36 – 2.25 (m, 1H), 2.25 – 2.12 (m, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.51, 144.98, 143.53, 142.43, 140.54, 136.50, 132.97, 132.43, 131.18, 129.92, 128.93, 128.53, 128.22, 128.16, 127.10, 126.26, 125.95, 122.27, 121.18, 108.42, 36.04, 33.43, 21.18. HRMS (ESI): calculated for $C_{26}H_{22}N_2NaO_2S$ $[M+Na]^+$: 449.1294; Found: 449.1305.



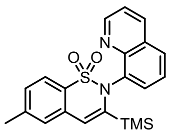
3-Cyclopropyl-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(14).[2]

White solid was obtained in 88% isolated yield (80.1 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.77 (dd, *J* = 4.28, 1.76 Hz, 1H), 8.45 (dd, *J* = 8.28, 1.76 Hz, 1H), 8.11 (d, *J* = 7.76 Hz, 1H), 7.81 (d, *J* = 7.00 Hz, 1H), 7.69 (t, *J* = 7.78 Hz, 1H), 7.60 (d, *J* = 8.02 Hz, 1H), 7.55 (dd, *J* = 8.28, 4.18 Hz, 1H), 7.40 (s, 1H), 7.31 (d, *J* = 7.88 Hz, 1H), 6.39 (s, 1H), 2.43 (s, 3H), 1.24 – 1.21 (m, 1H), 0.71 – 0.63 (m, 1H), 0.54 – 0.45 (m, 1H), 0.35 – 0.27 (m, 1H), 0.26 – 0.18 (m, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.27, 146.06, 145.17, 142.25, 136.38, 133.30, 132.94, 131.68, 129.86, 128.88, 128.45, 127.79, 127.03, 126.21, 122.15, 121.06, 104.10, 21.21, 14.79, 7.22, 6.76.



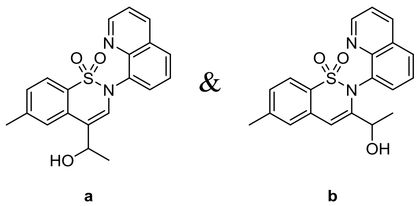
Methyl 6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine-3-carboxylate 1,1-dioxide(15).[3]

Yellow solid was obtained in 65% isolated yield (61.7 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.73 (dd, *J* = 4.22, 1.76 Hz, 1H), 8.44 (dd, *J* = 8.32, 1.78 Hz, 1H), 8.06 (dd, *J* = 6.16, 3.54 Hz, 1H), 7.88 (s, 2H), 7.72 (d, *J* = 8.02 Hz, 1H), 7.67 – 7.62 (m, 2H), 7.60 (d, *J* = 8.16 Hz, 1H), 7.55 (dd, *J* = 8.32, 4.18 Hz, 1H), 3.56 (s, 3H), 2.54 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 162.18, 150.78, 144.52, 143.03, 136.22, 134.32, 132.71, 131.71, 130.98, 130.91, 129.82, 129.53, 129.05, 128.60, 125.96, 121.97, 121.64, 120.53, 52.57, 21.16.



6-Methyl-2-(quinolin-8-yl)-3-(trimethylsilyl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(16).[2]

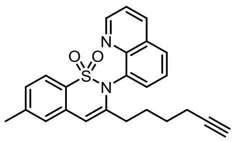
White solid was obtained in 51% isolated yield (50.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.09 (dd, *J* = 4.18, 1.72 Hz, 1H), 8.70 (dd, *J* = 8.38, 1.72 Hz, 1H), 8.36 (dd, *J* = 7.80, 1.92 Hz, 1H), 7.95 – 7.85 (m, 3H), 7.84 – 7.79 (m, 2H), 7.66 (d, *J* = 8.04 Hz, 1H), 7.17 (s, 1H), 2.72 (s, 3H), 0.00 (s, 9H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.20, 147.74, 145.64, 142.19, 136.24, 134.78, 132.81, 131.39, 129.88, 129.43, 129.25, 128.88, 127.47, 125.93, 122.14, 121.04, 119.62, 21.23, -1.32.



3-(1-Hydroxyethyl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(17).

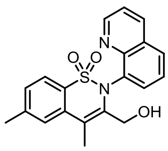
Yellow solid was obtained in 70% isolated yield (64 mg) (a/b = 1.3:1). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.06 – 8.97 (m, 1H), 8.48 – 8.42 (m, 1H), 8.03 (d, *J* = 8.10 Hz, 1H), 7.62 – 7.58 (m, 2H), 7.55 (d, *J* = 7.34 Hz, 2H), 7.35 (d, *J* = 8.02 Hz, 1H), 7.24 (d, *J* = 7.22 Hz, 1H), 6.97 (s, 1H), 5.43 (d, *J* = 4.96 Hz, 1H), 3.90 – 3.80 (m, 1H), 2.44 (s, 3H), 1.30 – 1.27 (m, 3H). ^{13}C NMR (100

MHz, DMSO-d_6) δ 151.37, 149.44, 145.48, 142.51, 136.24, 133.98, 132.42, 132.03, 129.40, 128.88, 128.82, 127.84, 127.52, 126.25, 122.14, 121.57, 108.27, 65.19, 23.20, 21.13. HRMS (ESI): calculated for $C_{20}H_{18}N_2NaO_3S$ $[M+Na]^+$: 389.0930; Found: 389.0941.



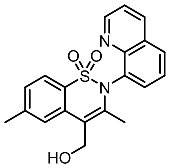
3-(Hex-5-yn-1-yl)-6-methyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(18).

White solid was obtained in 70% isolated yield (70.3 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.77 (dd, *J* = 4.20, 1.68 Hz, 1H), 8.43 (dd, *J* = 8.34, 1.68 Hz, 1H), 8.09 (d, *J* = 7.76 Hz, 1H), 7.74 (d, *J* = 6.54 Hz, 1H), 7.67 (t, *J* = 7.76 Hz, 1H), 7.59 (d, *J* = 8.06 Hz, 1H), 7.54 (dd, *J* = 8.30, 4.20 Hz, 1H), 7.42 (s, 1H), 7.31 (d, *J* = 7.96 Hz, 1H), 6.55 (s, 1H), 2.69 (t, *J* = 2.64 Hz, 1H), 2.43 (s, 3H), 2.15 – 2.05 (m, 1H), 2.04 – 1.97 (m, 2H), 1.97 – 1.90 (m, 1H), 1.55 – 1.45 (m, 2H), 1.36 – 1.27 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.38, 144.90, 144.14, 142.38, 136.42, 133.09, 132.31, 131.06, 129.79, 128.88, 128.48, 128.05, 127.02, 126.17, 122.19, 121.13, 108.31, 84.21, 71.24, 33.05, 26.87, 26.10, 21.19, 17.34. HRMS (ESI): calculated for $C_{24}H_{22}N_2NaO_2S$ $[M+Na]^+$: 425.1294; Found: 425.1299.



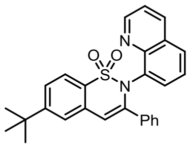
3-(Hydroxymethyl)-4,6-dimethyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(19a).

White solid was obtained in 47% isolated yield (43 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.86 (dd, *J* = 4.22, 1.68 Hz, 1H), 8.47 (dd, *J* = 8.36, 1.68 Hz, 1H), 8.11 (d, *J* = 7.94 Hz, 1H), 7.77 (s, 1H), 7.66 (t, *J* = 7.78 Hz, 1H), 7.62 – 7.54 (m, 3H), 7.35 (d, *J* = 8.04 Hz, 1H), 5.15 (t, *J* = 5.26 Hz, 1H), 4.59 (d, *J* = 5.22 Hz, 2H), 2.49 (s, 3H), 1.89 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.45, 145.14, 142.05, 139.41, 136.39, 134.17, 133.21, 130.60, 129.75, 129.20, 128.92, 127.68, 126.27, 125.46, 122.22, 121.04, 117.95, 57.45, 21.55, 17.46. HRMS (ESI): calculated for $C_{20}H_{18}N_2NaO_3S$ $[M+Na]^+$: 389.0930; Found: 389.0923.



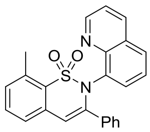
4-(Hydroxymethyl)-3,6-dimethyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(19b).

White solid was obtained in 21% isolated yield (23 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.79 (d, *J* = 3.42 Hz, 1H), 8.44 (d, *J* = 7.82 Hz, 1H), 8.05 (d, *J* = 7.94 Hz, 1H), 7.68 (s, 1H), 7.65 – 7.53 (m, 3H), 7.51 (d, *J* = 7.28 Hz, 1H), 7.40 (d, *J* = 7.82 Hz, 1H), 4.97 (s, 1H), 4.21 (d, *J* = 11.48 Hz, 1H), 3.68 (d, *J* = 13.52 Hz, 1H), 2.50 (s, 3H), 2.36 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.24, 145.29, 142.31, 139.28, 136.41, 134.75, 133.30, 130.88, 130.15, 129.41, 128.77, 128.66, 126.21, 125.72, 122.08, 121.22, 116.39, 58.38, 21.46, 14.35. HRMS (ESI): calculated for $C_{20}H_{18}N_2NaO_3S$ $[M+Na]^+$: 389.0930; Found: 389.0931.



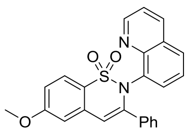
6-(Tert-butyl)-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(20).[2]

White solid was obtained in 85% isolated yield (93.9 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.10 (d, *J* = 3.26 Hz, 1H), 8.06 (d, *J* = 8.18 Hz, 1H), 7.80 – 7.70 (m, 3H), 7.63 (d, *J* = 7.74 Hz, 1H), 7.60 (s, 1H), 7.52 (d, *J* = 8.28 Hz, 1H), 7.42 (dd, *J* = 8.26, 4.04 Hz, 1H), 7.28 – 7.20 (m, 2H), 7.15 – 7.08 (m, 3H), 6.97 (s, 1H), 1.41 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.71, 151.02, 145.68, 144.09, 135.75, 135.67, 135.39, 132.87, 129.29, 129.05, 128.97, 128.71, 128.61, 128.18, 127.75, 125.63, 124.27, 122.41, 121.67, 112.98, 35.23, 31.19.



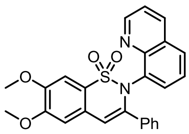
8-Methyl-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(21).[1]

White solid was obtained in 56% isolated yield (55.6 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.10 (dd, *J* = 4.19, 1.69 Hz, 1H), 8.03 (dd, *J* = 8.32, 1.66 Hz, 1H), 7.77 – 7.71 (m, 2H), 7.62 (dd, *J* = 6.44, 3.14 Hz, 1H), 7.50 – 7.43 (m, 1H), 7.43 – 7.37 (m, 2H), 7.27 – 7.20 (m, 3H), 7.14 – 7.07 (m, 3H), 6.89 (s, 1H), 2.61 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.05, 145.90, 143.24, 135.69, 135.64, 135.51, 135.34, 133.88, 131.45, 131.44, 131.25, 129.03, 128.91, 128.78, 128.77, 128.12, 127.51, 126.06, 125.55, 121.60, 113.03, 20.47.



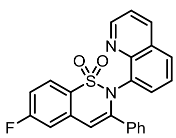
6-Methoxy-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(22). [1]

White solid was obtained in 71% isolated yield (73.6 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.03 (dd, *J* = 4.18, 1.69 Hz, 1H), 7.97 (dd, *J* = 8.32, 1.64 Hz, 1H), 7.75 – 7.71 (m, 2H), 7.69 (d, *J* = 8.68 Hz, 1H), 7.56 (dd, *J* = 6.70, 2.89 Hz, 1H), 7.33 (dd, *J* = 8.29, 4.20 Hz, 1H), 7.25 – 7.16 (m, 2H), 7.11 – 7.06 (m, 3H), 7.02 (d, *J* = 2.39 Hz, 1H), 6.95 (dd, *J* = 8.68, 2.44 Hz, 1H), 6.87 (s, 1H), 3.86 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.27, 150.90, 145.56, 144.69, 135.58, 135.41, 135.12, 135.06, 129.09, 128.86, 128.62, 128.56, 128.08, 127.67, 125.46, 124.49, 124.42, 121.53, 114.58, 112.33, 111.07, 55.56



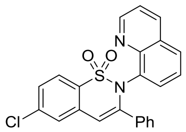
6,7-Dimethoxy-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(23). [2]

White solid was obtained in 83% isolated yield (92.2 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.13 (d, *J* = 2.46 Hz, 1H), 8.38 (d, *J* = 7.40 Hz, 1H), 7.89 (d, *J* = 8.16 Hz, 1H), 7.85 – 7.78 (m, 2H), 7.62 (dd, *J* = 8.32, 4.18 Hz, 1H), 7.51 (s, 1H), 7.42 (t, *J* = 7.80 Hz, 1H), 7.35 (s, 1H), 7.25 – 7.16 (m, 5H), 3.99 (s, 3H), 3.85 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 152.02, 151.10, 149.17, 145.09, 141.75, 136.11, 135.24, 134.82, 129.03, 128.96, 128.70, 128.35, 128.15, 126.92, 126.73, 125.95, 123.75, 121.98, 112.86, 110.34, 104.18, 55.97, 55.90.



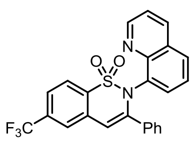
6-Fluoro-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(24). [3]

White solid was obtained in 68% isolated yield (68.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.01 (dd, *J* = 4.18, 1.70 Hz, 1H), 8.32 (dd, *J* = 8.34, 1.72 Hz, 1H), 7.87 (dd, *J* = 8.14, 1.48 Hz, 1H), 7.80 (dd, *J* = 8.72, 5.36 Hz, 1H), 7.78 – 7.72 (m, 3H), 7.56 (dd, *J* = 8.34, 4.18 Hz, 1H), 7.47 – 7.41 (m, 1H), 7.39 (d, *J* = 7.92 Hz, 1H), 7.36 – 7.31 (m, 2H), 7.23 – 7.15 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.51 (d, $^1J_{C\text{-}F}$ = 252.2 Hz), 150.94, 145.62, 145.44, 135.94 (d, $^3J_{C\text{-}F}$ = 9.7 Hz), 135.66, 135.14, 134.81, 129.42, 129.16, 128.91, 128.90, 128.18, 127.96 (d, $^4J_{C\text{-}F}$ = 2.7 Hz), 127.88, 125.25 (d, $^3J_{C\text{-}F}$ = 9.8 Hz), 125.20, 121.67, 115.36 (d, $^2J_{C\text{-}F}$ = 23.5 Hz), 113.55 (d, $^2J_{C\text{-}F}$ = 23.0 Hz), 111.42 (d, $^4J_{C\text{-}F}$ = 2.4 Hz). ^{19}F NMR (376 MHz, $CDCl_3$) δ -106.40.



6-Chloro-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(25). [1]

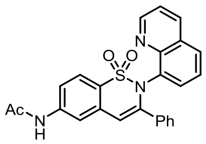
White solid was obtained in 56% isolated yield (58.3 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.01 (dd, *J* = 4.16, 1.61 Hz, 1H), 8.33 (dd, *J* = 8.34, 1.52 Hz, 1H), 8.00 (d, *J* = 1.93 Hz, 1H), 7.87 (dd, *J* = 8.07, 1.18 Hz, 1H), 7.80 – 7.72 (m, 3H), 7.64 (dd, *J* = 8.39, 2.01 Hz, 1H), 7.56 (dd, *J* = 8.30, 4.19 Hz, 1H), 7.43 – 7.37 (m, 1H), 7.37 – 7.31 (m, 2H), 7.23 – 7.16 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.26, 144.88, 144.69, 137.20, 136.26, 134.92, 134.83, 134.37, 129.88, 129.76, 129.40, 129.19, 128.71, 128.48, 127.62, 127.47, 126.04, 124.12, 122.17, 111.77.



3-Phenyl-2-(quinolin-8-yl)-6-(trifluoromethyl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(26).[2]

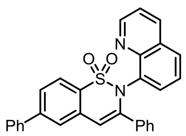
White solid was obtained in 63% isolated yield (71.5 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 (d, *J* = 3.96 Hz, 1H), 8.04 (d, *J* = 8.14 Hz, 1H), 7.94 – 7.87 (m, 2H), 7.74 – 7.68 (m, 3H), 7.66 (d, *J* = 8.02 Hz, 1H), 7.40 – 7.35 (m, 2H), 7.31 (t, *J* = 7.72 Hz, 1H), 7.19 – 7.11 (m, 3H), 6.96 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 151.00, 145.98, 145.37, 135.77, 135.07, 134.69, 134.24, 134.05, 133.72, 129.66, 129.61, 129.12, 128.94, 128.28, 128.04, 125.61, 124.52 (q, $^3J_{C\text{-}F}$ = 3.8 Hz), 124.32

(q, $^{3}J_{C\text{-}F}$ = 3.4 Hz), 123.40 (q, $^{1}J_{C\text{-}F}$ = 273.2 Hz), 123.39, 121.81, 111.36. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.88.



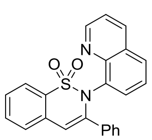
N-(1,1-Dioxido-3-phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazin-6-yl)acetamide(27).[2]

White solid was obtained in 75% isolated yield (82.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 10.44 (s, 1H), 9.06 (d, *J* = 3.88 Hz, 1H), 8.34 (d, *J* = 8.78 Hz, 1H), 8.18 (s, 1H), 7.86 (d, *J* = 8.16 Hz, 1H), 7.80 (dd, *J* = 6.76, 2.90 Hz, 2H), 7.65 (s, 2H), 7.58 (dd, *J* = 8.32, 4.20 Hz, 1H), 7.38 (t, *J* = 7.82 Hz, 1H), 7.33 (s, 1H), 7.23 (d, *J* = 7.48 Hz, 1H), 7.21 – 7.14 (m, 3H), 2.15 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.10, 151.20, 145.00, 143.63, 142.84, 136.13, 135.09, 134.74, 133.81, 129.33, 129.02, 128.69, 128.41, 128.29, 127.33, 125.95, 125.83, 123.12, 122.01, 118.80, 117.02, 113.09, 24.18.



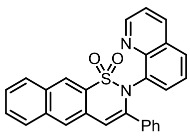
3,6-Diphenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(28).[1]

White solid was obtained in 64% isolated yield (73 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.06 (dd, *J* = 4.18, 1.74 Hz, 1H), 8.35 (d, *J* = 8.20 Hz, 1H), 8.20 (d, *J* = 1.78 Hz, 1H), 7.92 – 7.84 (m, 2H), 7.86 – 7.75 (m, 5H), 7.63 – 7.53 (m, 3H), 7.50 (d, *J* = 7.34 Hz, 1H), 7.46 (s, 1H), 7.39 (t, *J* = 7.80 Hz, 1H), 7.28 (d, *J* = 6.02 Hz, 1H), 7.23 – 7.16 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.14, 144.97, 144.13, 143.64, 138.61, 136.15, 135.08, 134.66, 133.45, 130.16, 129.40, 129.18, 129.12, 128.68, 128.63, 128.59, 128.38, 127.24, 127.14, 126.86, 126.35, 125.96, 122.62, 122.04, 112.95.



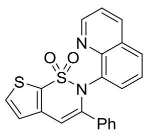
3-Phenyl-2-(quinolin-8-yl)-2H-benzo[*e*][1,2]thiazine 1,1-dioxide(29).[1]

White solid was obtained in 76% isolated yield (73.2 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.05 (d, *J* = 2.80 Hz, 1H), 8.33 (d, *J* = 8.19 Hz, 1H), 7.87 (dd, *J* = 14.02, 7.98 Hz, 2H), 7.83 – 7.76 (m, 3H), 7.73 (d, *J* = 7.69 Hz, 1H), 7.64 – 7.52 (m, 2H), 7.43 – 7.32 (m, 2H), 7.22 (d, *J* = 7.32 Hz, 1H), 7.21 – 7.14 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.16, 144.98, 143.31, 136.17, 135.07, 134.67, 132.80, 132.60, 131.38, 129.39, 129.13, 128.70, 128.68, 128.59, 128.38, 128.27, 127.27, 125.97, 122.06, 121.90, 112.88.



3-Phenyl-2-(quinolin-8-yl)-2H-naphtho[2,3-*e*][1,2]thiazine 1,1-dioxide(30).[1]

White solid was obtained in 65% isolated yield (70.6 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.04 (dd, *J* = 4.24, 1.74 Hz, 1H), 8.42 (d, *J* = 14.38 Hz, 2H), 8.34 (dd, *J* = 8.34, 1.74 Hz, 1H), 8.21 – 8.12 (m, 2H), 7.90 – 7.83 (m, 3H), 7.78 – 7.71 (m, 1H), 7.68 – 7.61 (m, 1H), 7.60 – 7.54 (m, 2H), 7.35 (t, *J* = 7.82 Hz, 1H), 7.28 – 7.16 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.93, 145.72, 143.83, 135.63, 135.47, 134.76, 132.10, 131.35, 129.50, 129.12, 129.08, 129.03, 128.69, 128.54, 128.23, 128.10, 127.56, 126.86, 126.70, 125.59, 123.44, 121.64, 113.68.



3-Phenyl-2-(quinolin-8-yl)-2H-thieno[3,2-*e*][1,2]thiazine 1,1-dioxide(31).[1]

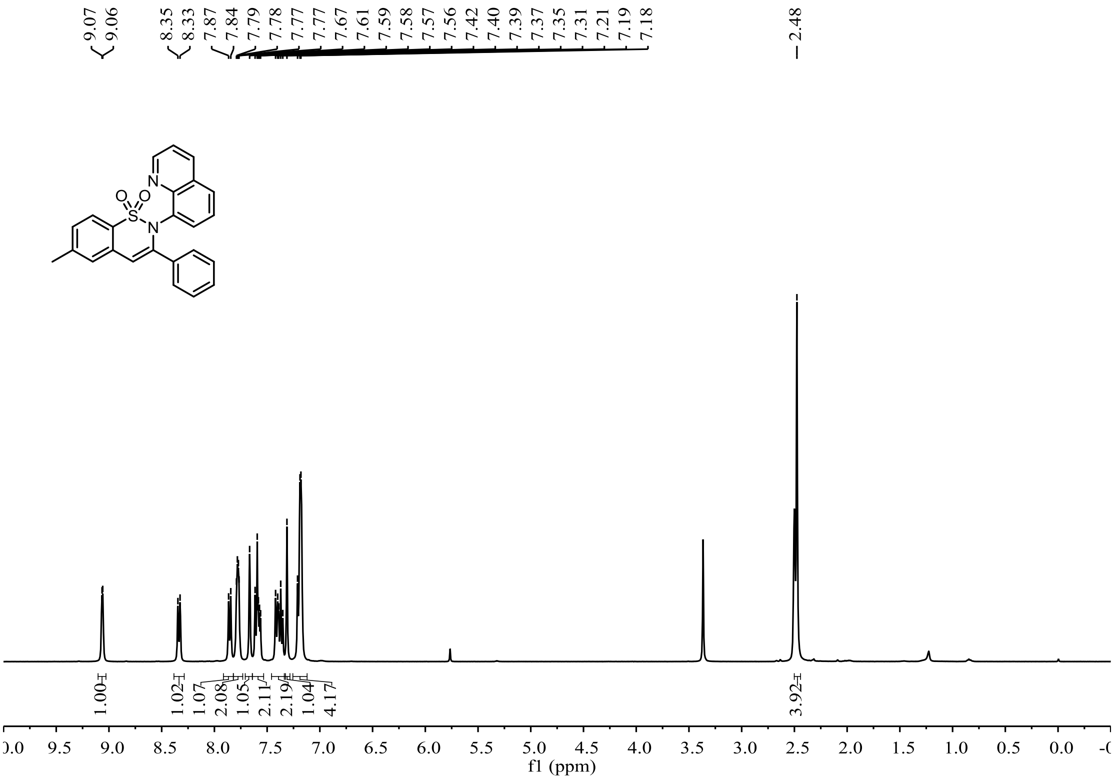
White solid was obtained in 75% isolated yield (73.3 mg). ^{1}H NMR (400 MHz, DMSO-d_6) δ 9.09 (dd, *J* = 4.18, 1.66 Hz, 1H), 8.36 (dd, *J* = 8.36, 1.61 Hz, 1H), 8.06 (d, *J* = 5.04 Hz, 1H), 7.89 (dd, *J* = 8.22, 1.14 Hz, 1H), 7.75 – 7.68 (m, 2H), 7.60 (dd, *J* = 8.30, 4.20 Hz, 1H), 7.48 (d, *J* = 5.05 Hz, 1H), 7.44 – 7.35 (m, 2H), 7.24 (dd, *J* = 7.41, 1.25 Hz, 1H), 7.18 – 7.12 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 151.30, 144.99, 143.62, 141.35, 136.24, 134.96, 134.39, 131.18, 129.35, 129.33, 128.69, 128.61, 128.40, 127.28, 127.13, 126.55, 126.06, 122.13, 109.28.

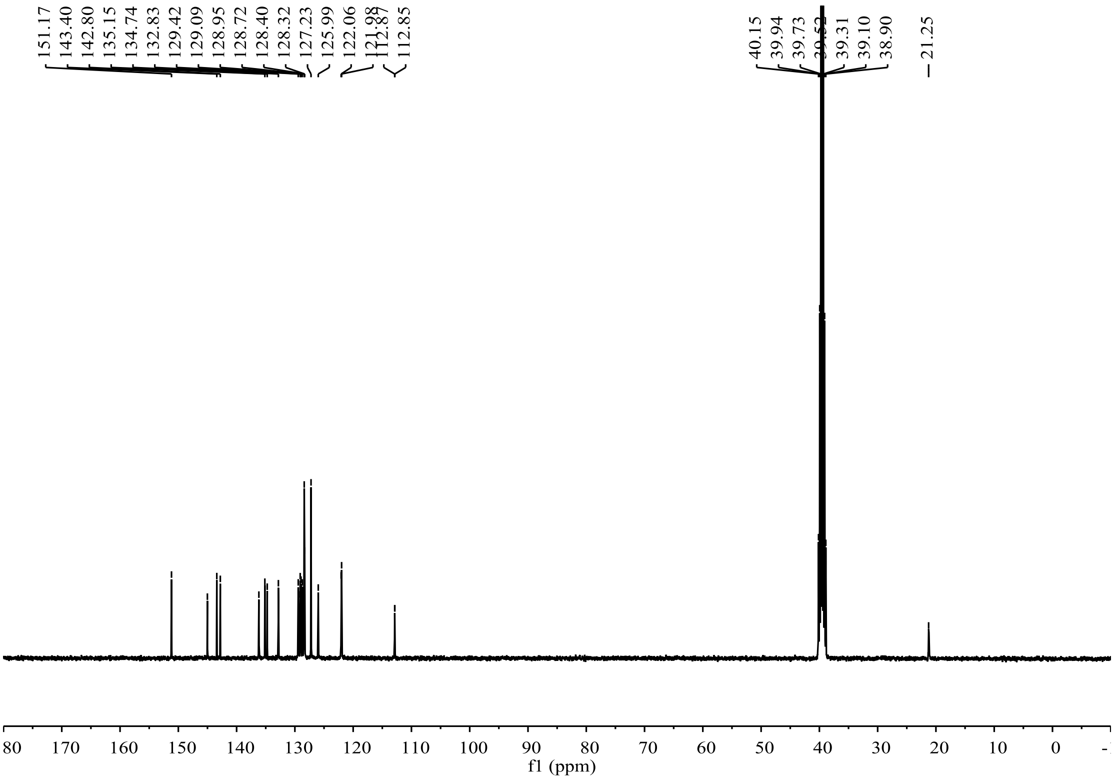
References

1. O. Planas.; C. J. Whiteoak.; A. Company.; X. Ribas. Regioselective Access to Sultam Motifs through Cobalt-Catalyzed Annulation of Aryl Sulfonamides and Alkynes using an 8-Aminoquinoline Directing Group. *Adv. Synth. Catal.* **2015**, *357*, 4003-4012.
2. D. Kalsi,; B. Sundararaju.; Cobalt Catalyzed C-H and N-H Bond Annulation of Sulfonamide with Terminal and Internal Alkynes. *Org. Lett*. **2015**, *17*, 6118-6121.
3. Y. Ran.; Y. Yang.; L. Zhang.; Sodium chlorate as a viable substoichiometric oxidant for cobalt-catalyzed oxidative annulation of aryl sulfonamides with alkynes. *Tetrahedron Lett*. **2016**, *57*, 3322-3325.

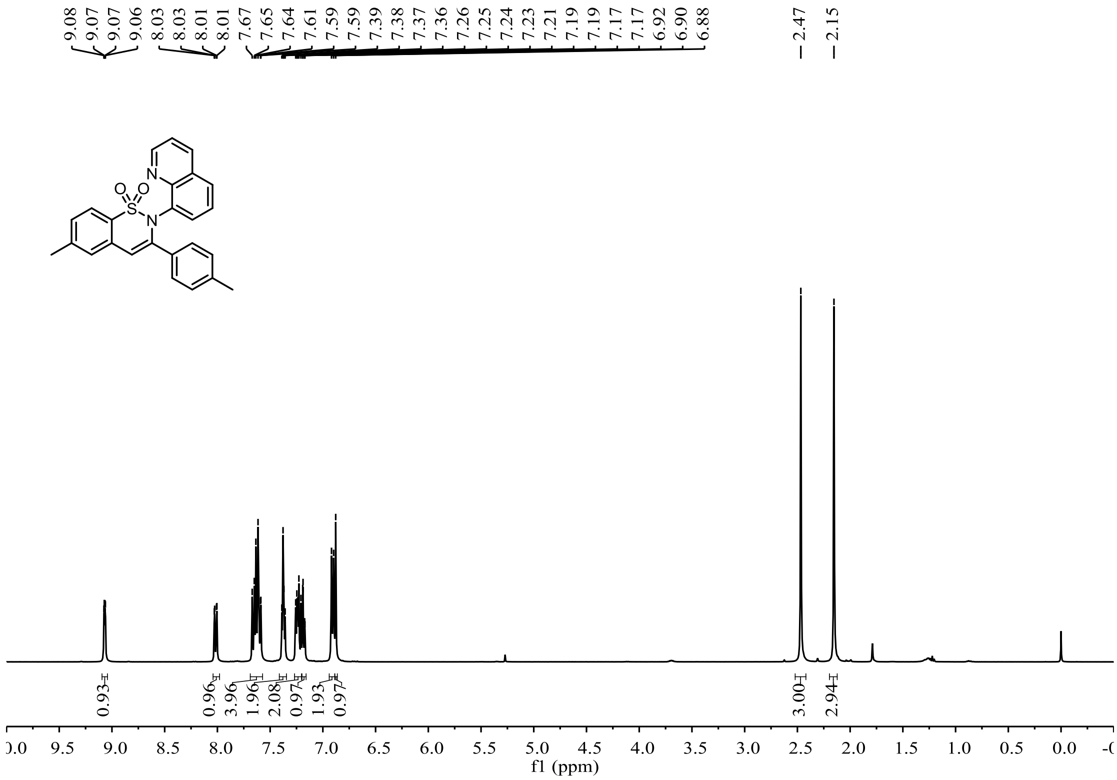
Copies of ^{1}H NMR, ^{13}C NMR and ^{19}F NMR Spectra

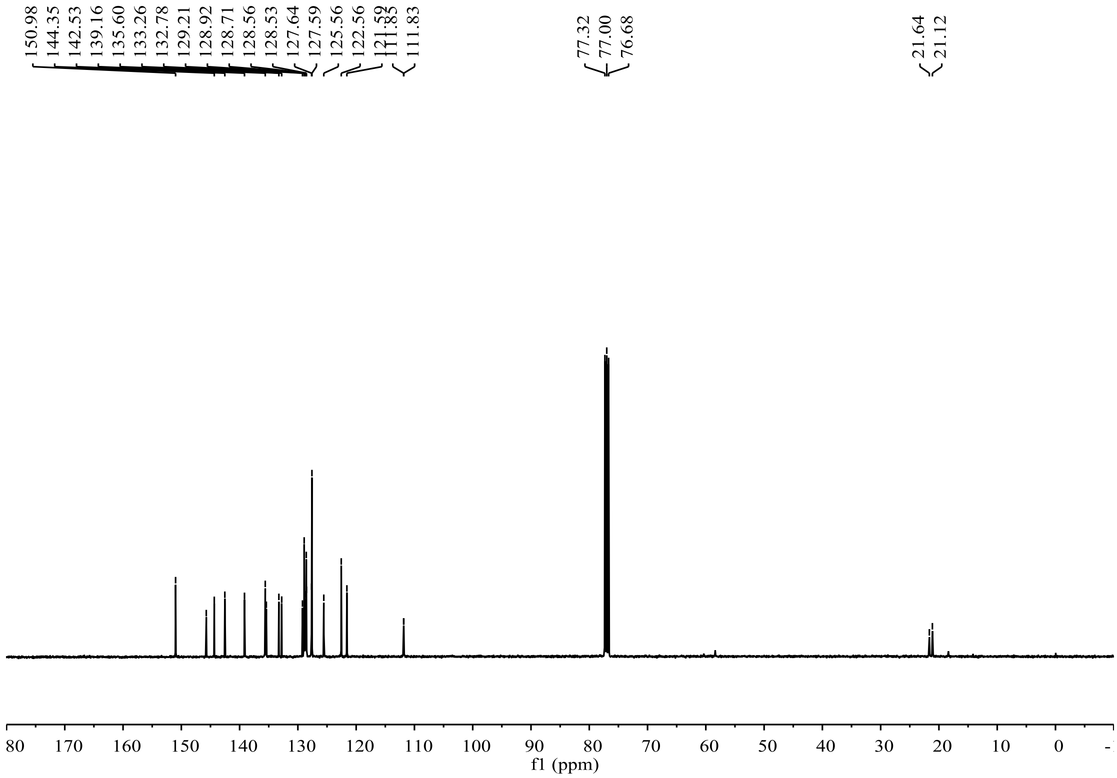
Compound 3



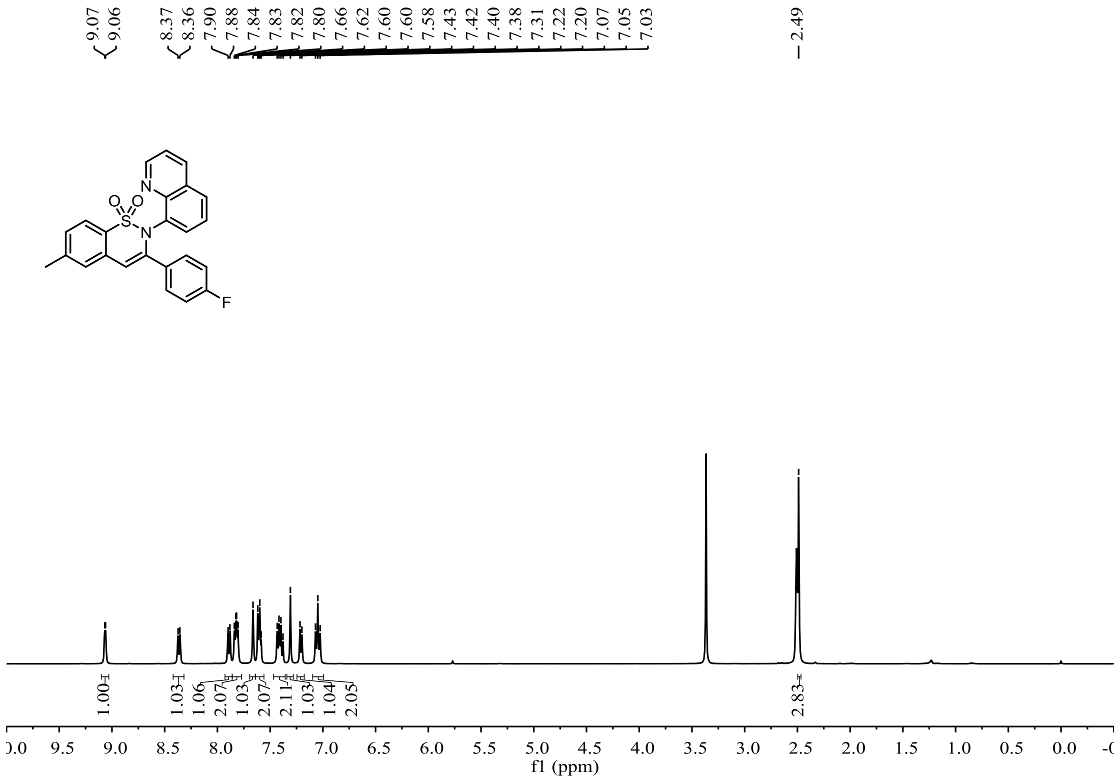


Compound 4





Compound 5



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7.60
7.60
7.58
7.43
7.42
7.40
7.38
7.31
7.22
7.20
7.07
7.05
7.03
2.49
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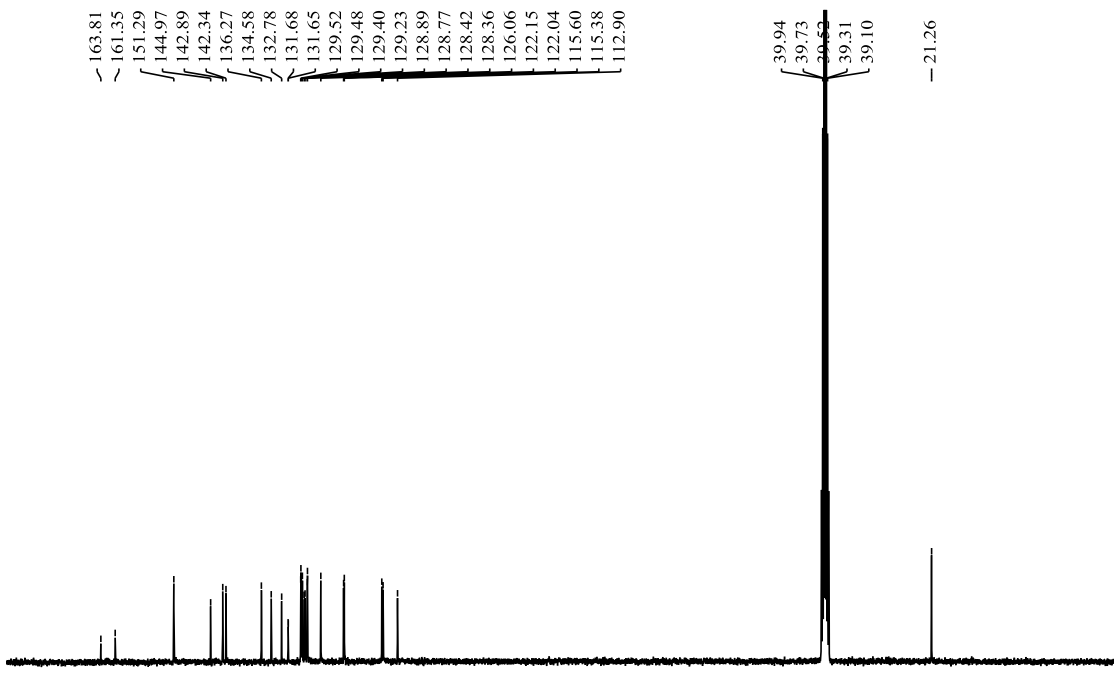
O
O
S
N
F
1.00
1.03
1.06
2.07
1.03
2.07
2.11
1.03
1.04
2.05
2.83
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)



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126.06
122.15
122.04
115.60
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39.10
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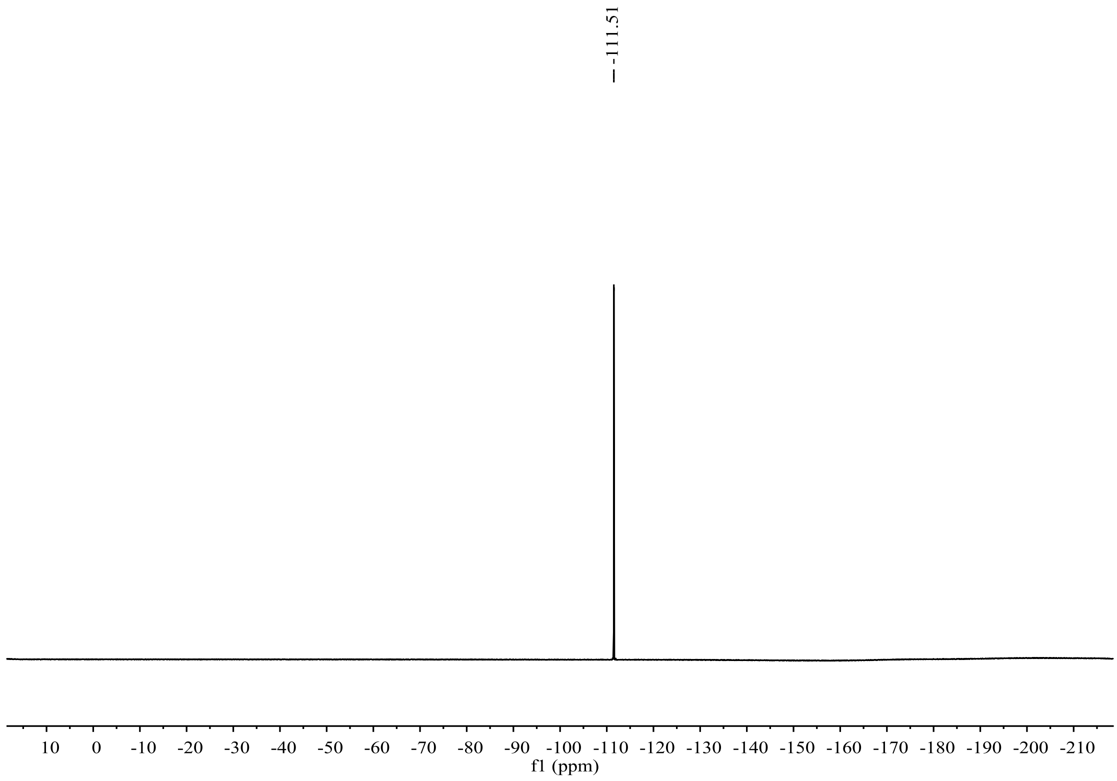
f1 (ppm)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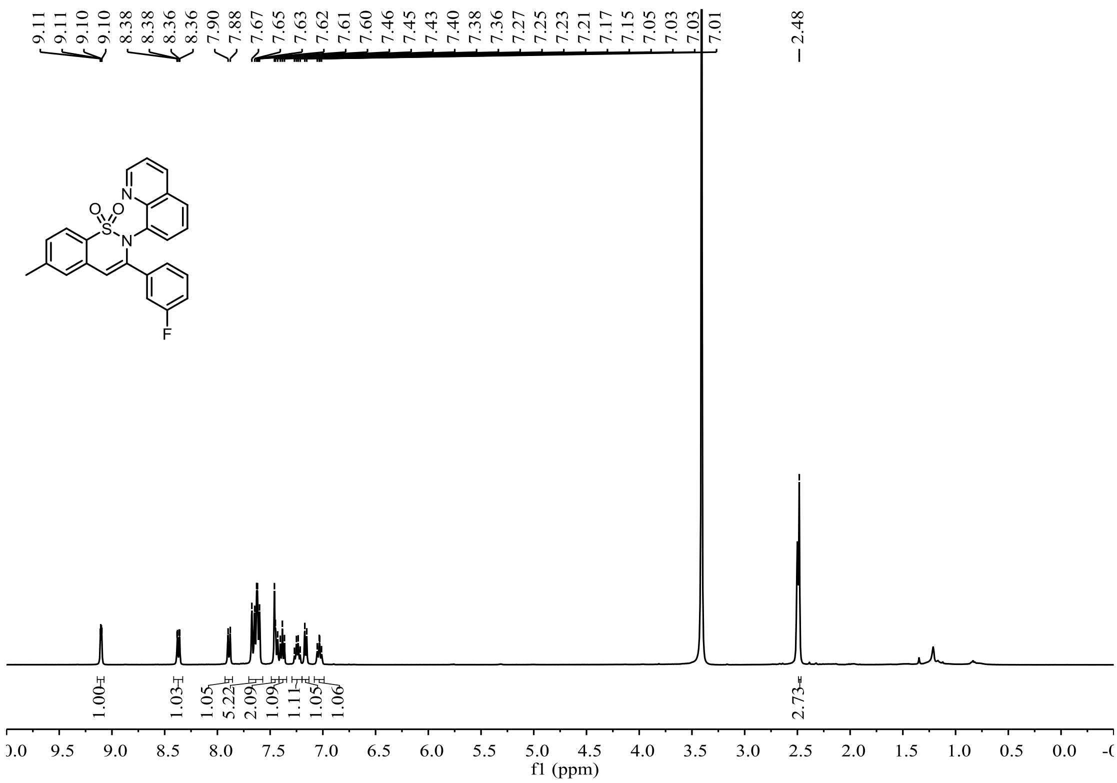
f1 (ppm)

Compound 6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7.63
7.62
7.61
7.60
7.46
7.45
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7.40
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7.36
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7.25
7.23
7.21
7.17
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7.05
7.03
7.03
7.01
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O
S
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2.09
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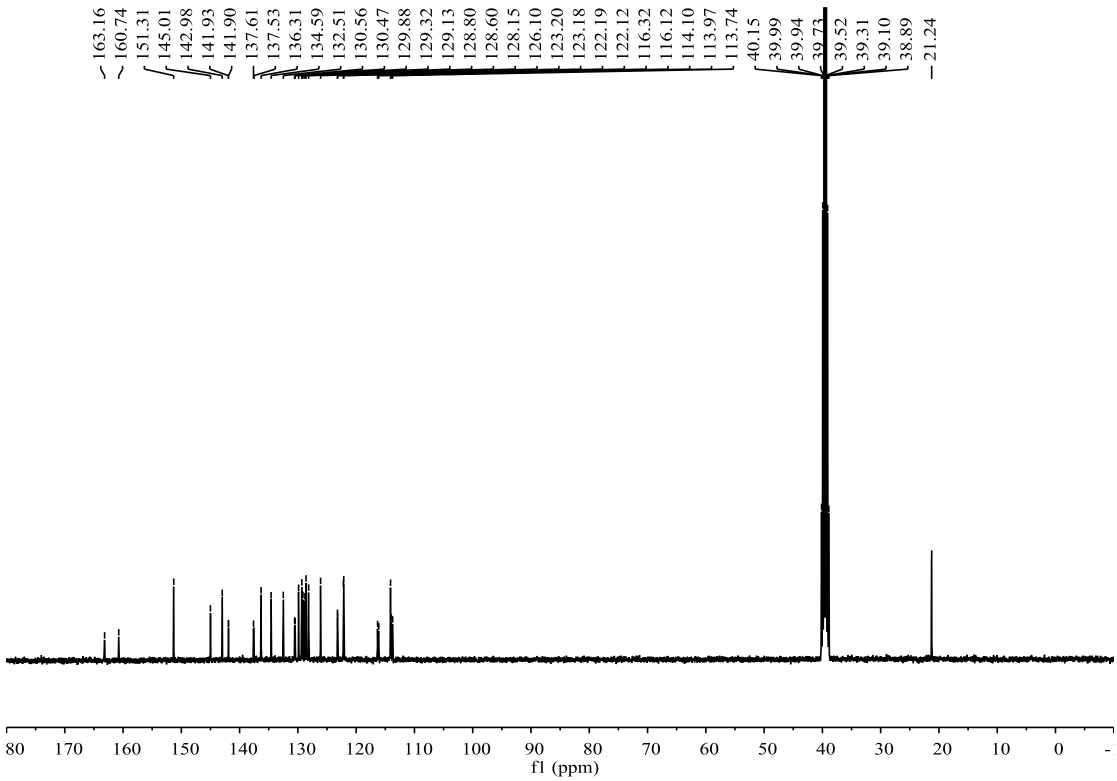
f1 (ppm)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123.20
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116.12
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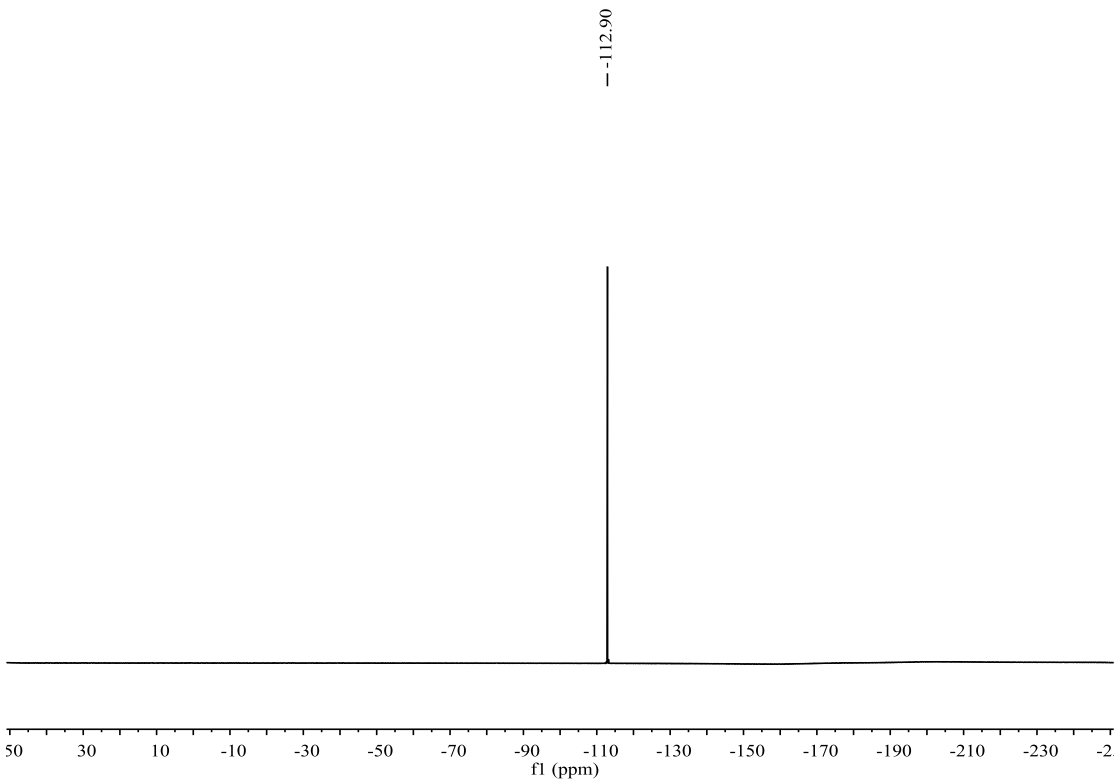
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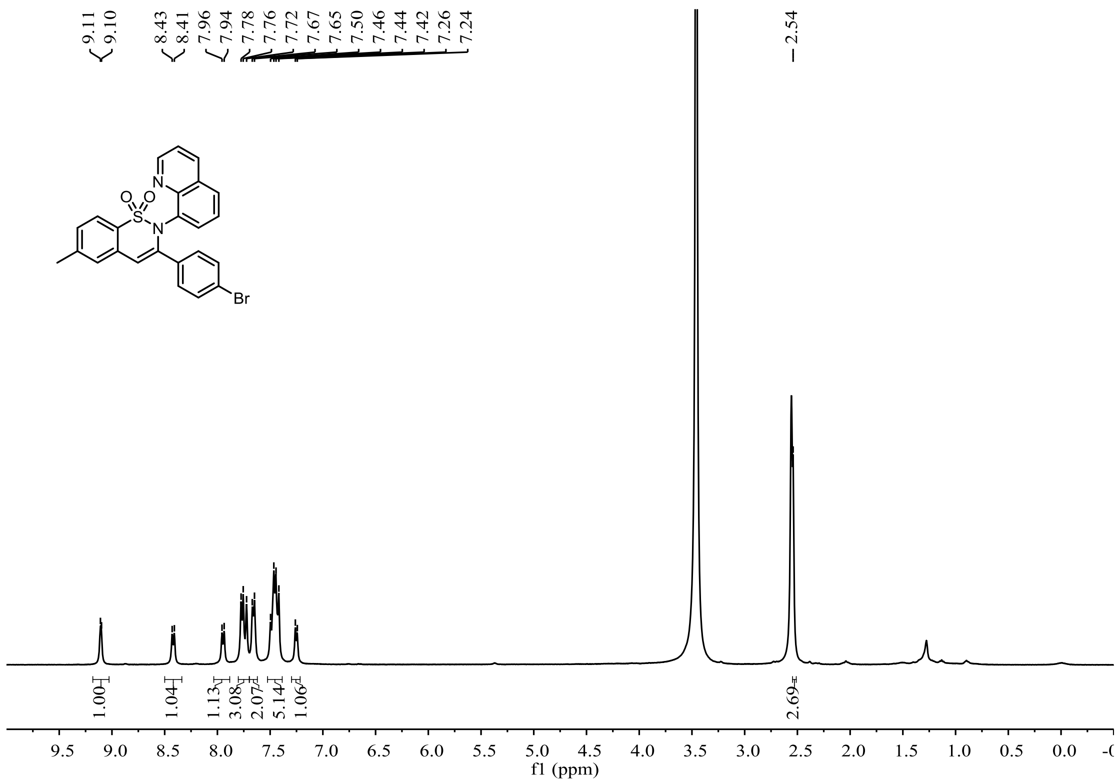
f1 (ppm)

Compound 7



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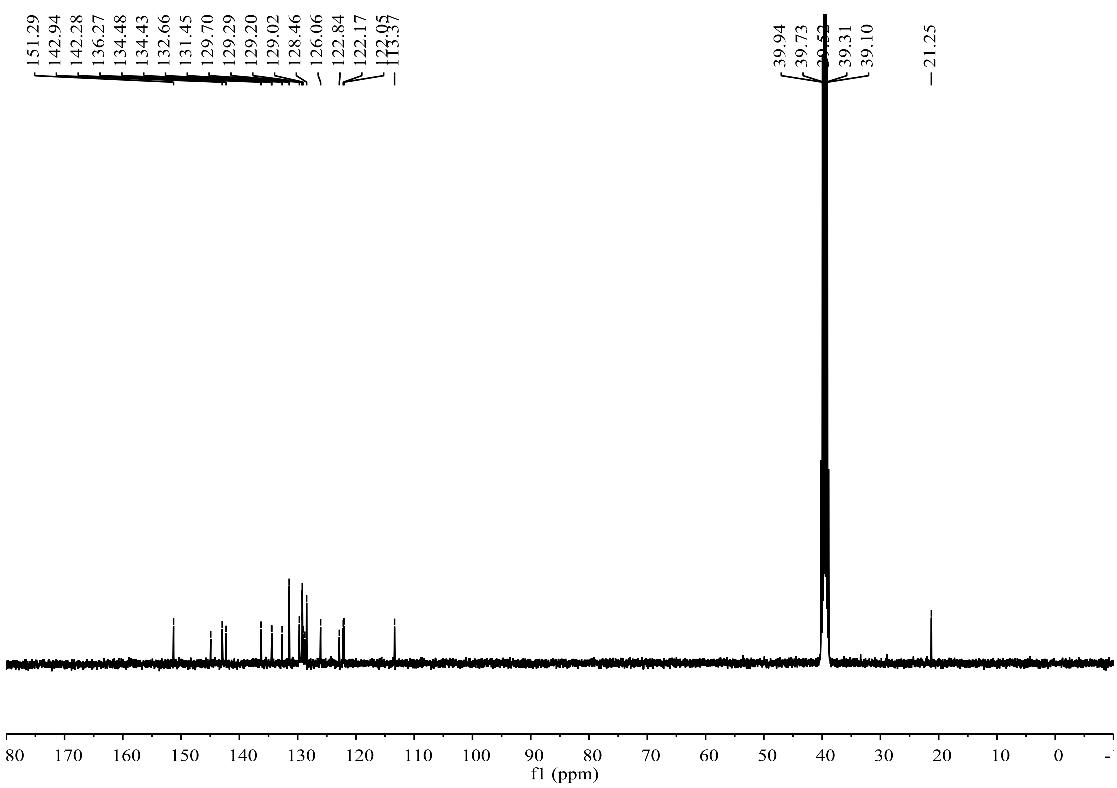

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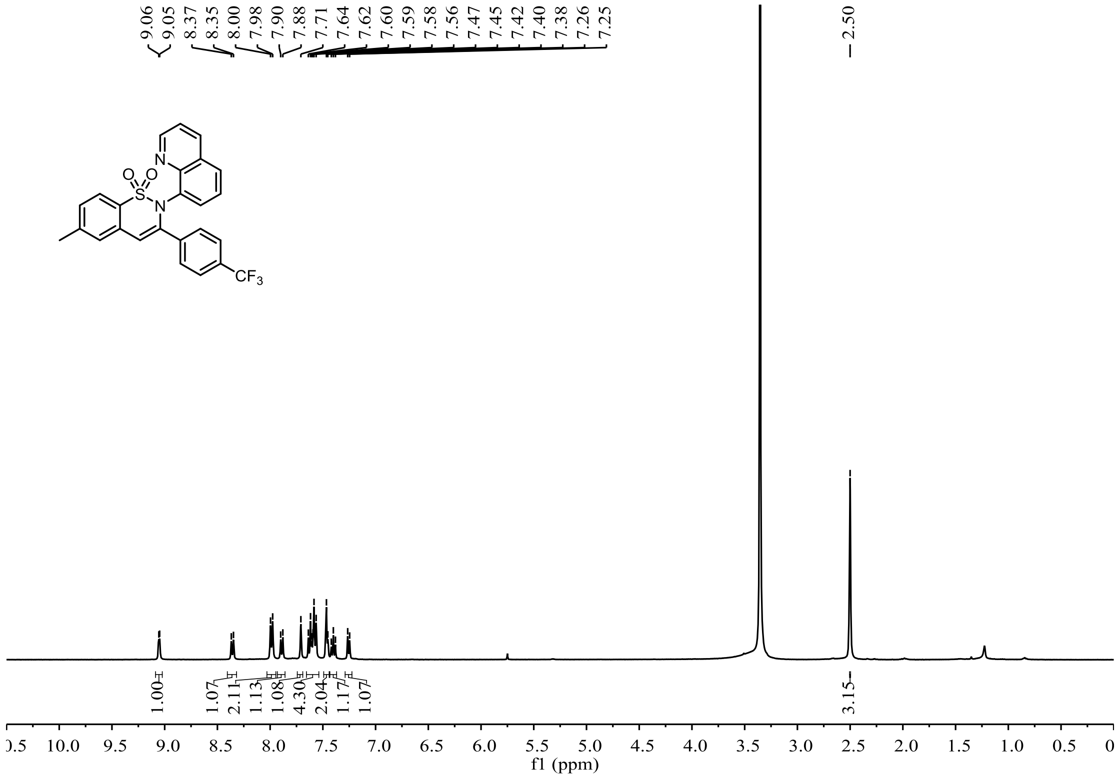
39.10
21.25
f1 (ppm)

Compound 8



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7.59
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7.45
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7.40
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7.26
7.25
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1.13
1.08
4.30
2.04
1.17
1.07
3.15
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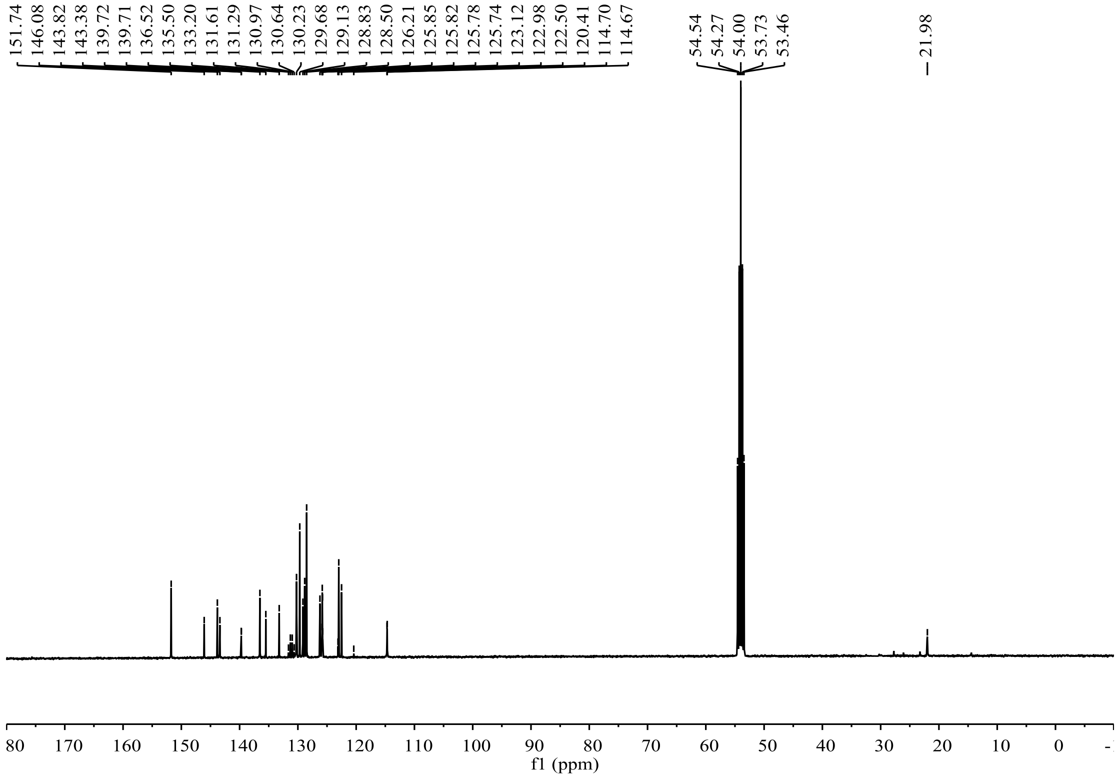
f1 (ppm)



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125.78
125.74
123.12
122.98
122.50
120.41
114.70
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53.46
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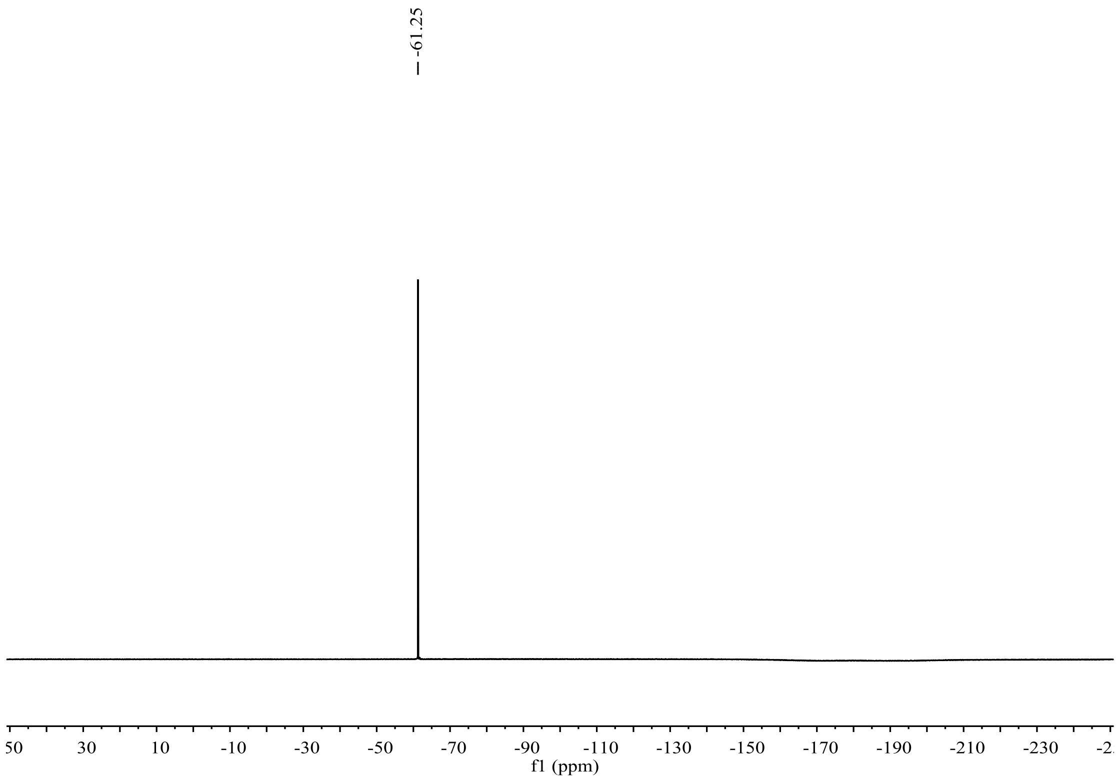
f1 (ppm)



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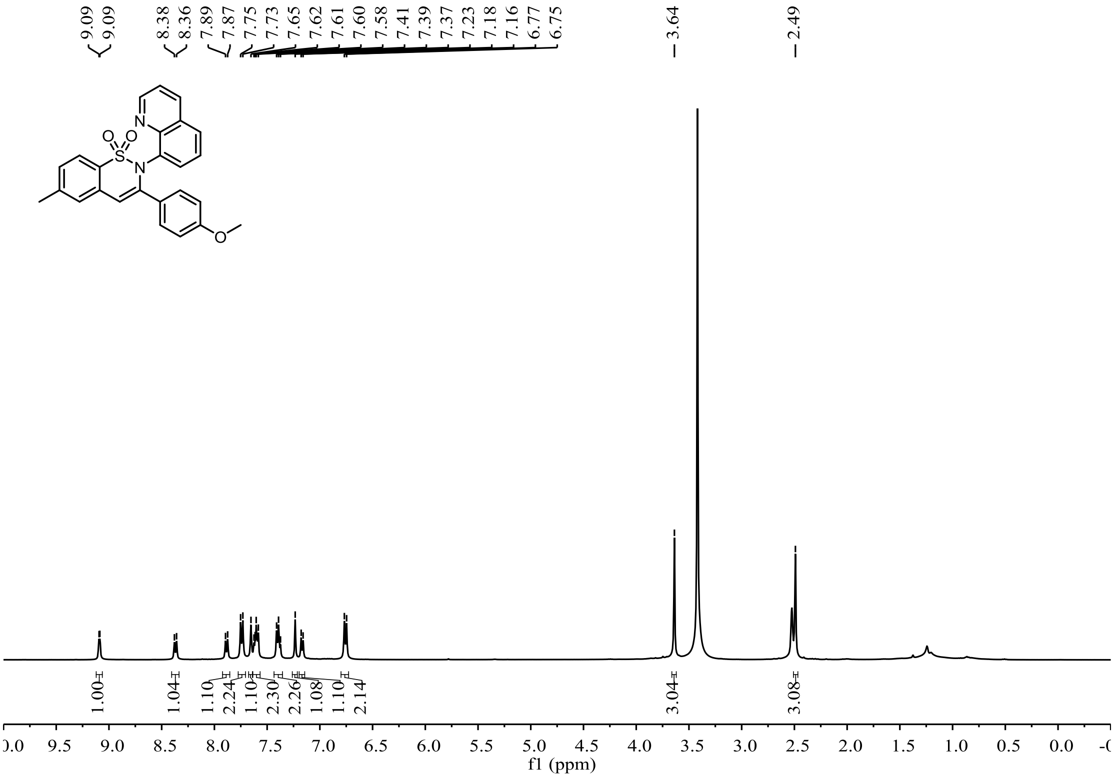
f1 (ppm)

Compound 9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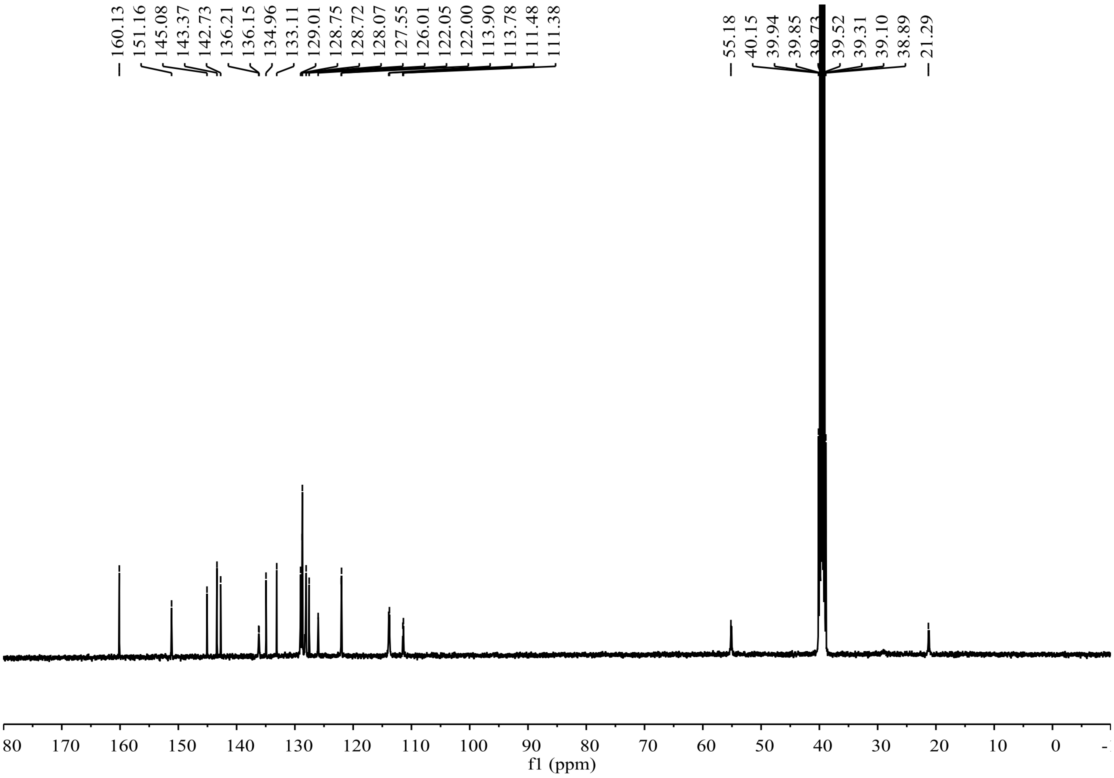
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122.00
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113.78
111.48
111.38
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39.73
39.52
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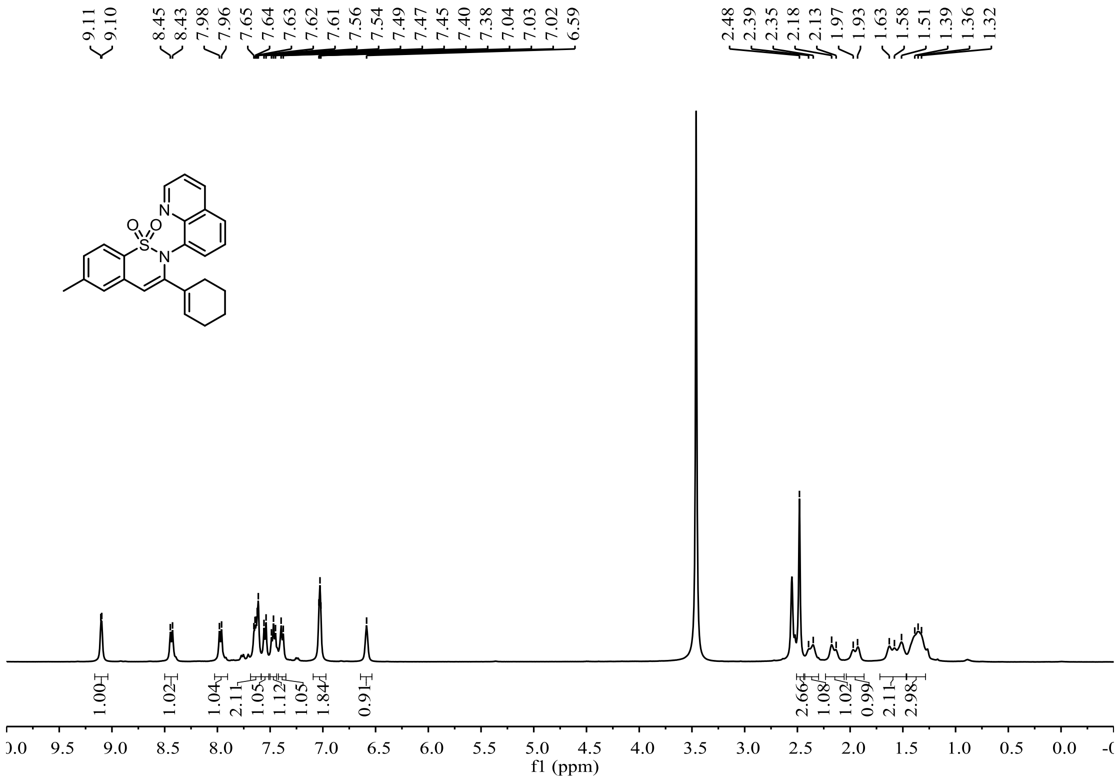
38.89
21.29
f1 (ppm)

Compound 10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7.38
7.04
7.03
7.02
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1.39
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1.32
1.00
1.02
1.04
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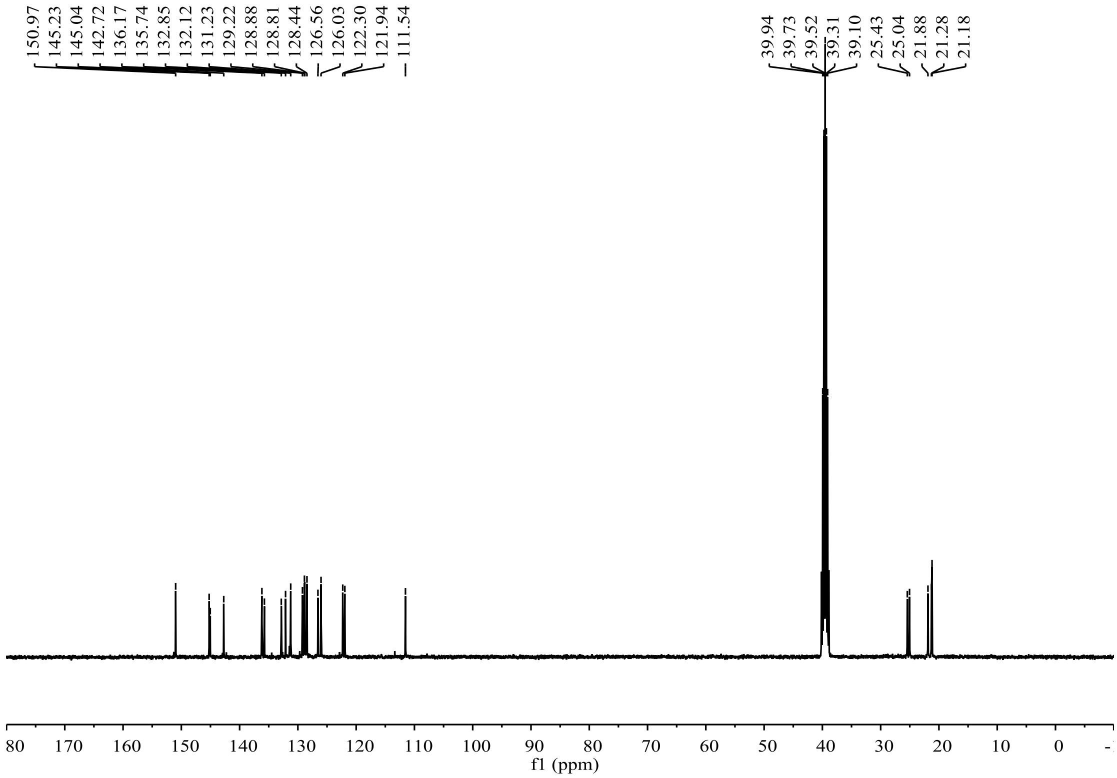
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39.31
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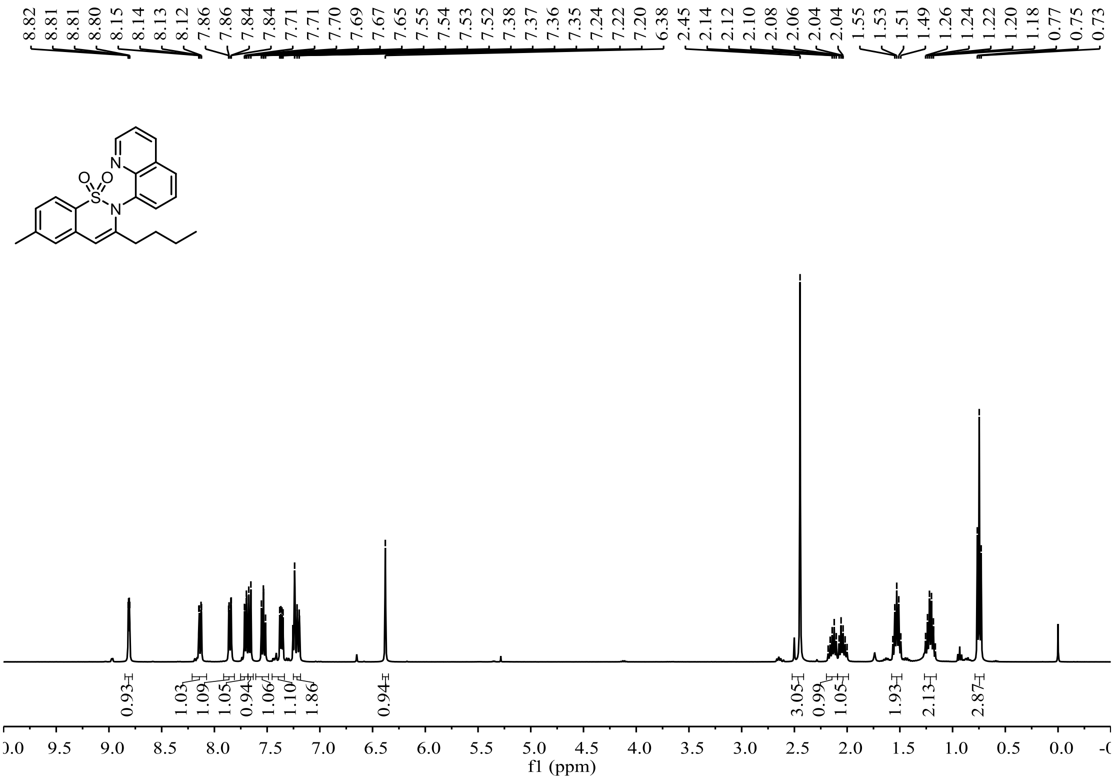
f1 (ppm)

Compound 11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O
S
N
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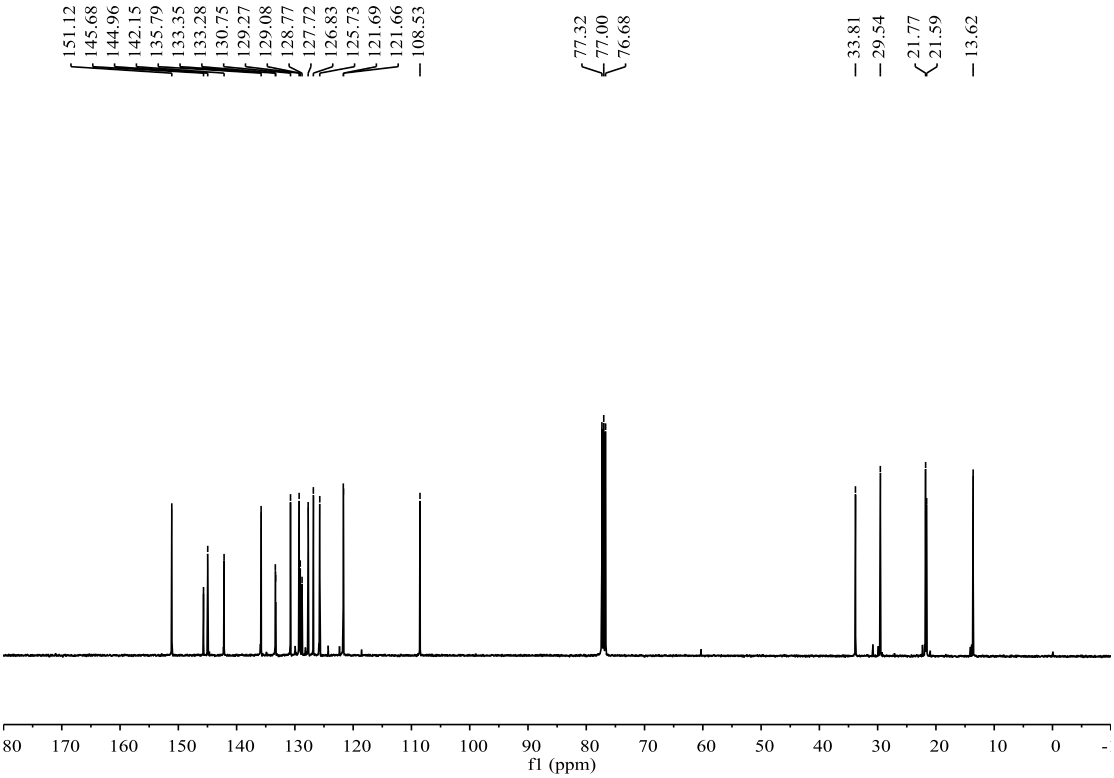
1.09
1.05
0.94
1.06
1.10
1.86
0.94
3.05
0.99
1.05
1.93
2.13
2.87
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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33.81 29.54 21.77 21.59 13.62
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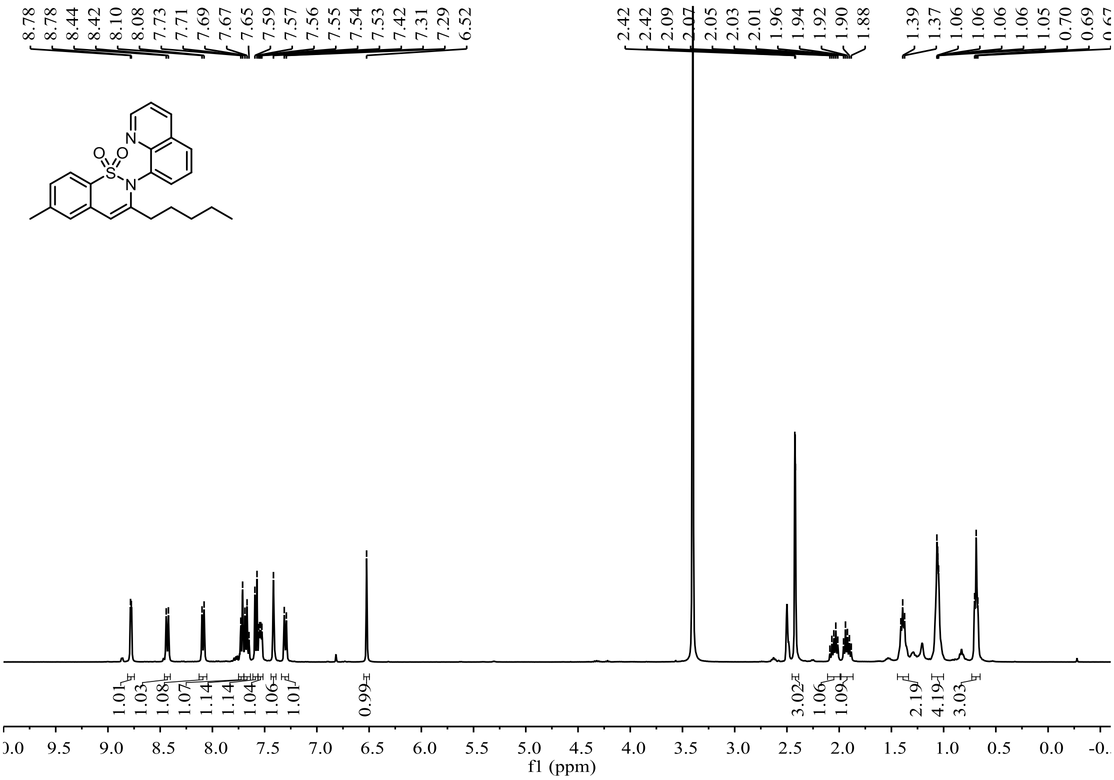
f1 (ppm)

Compound 12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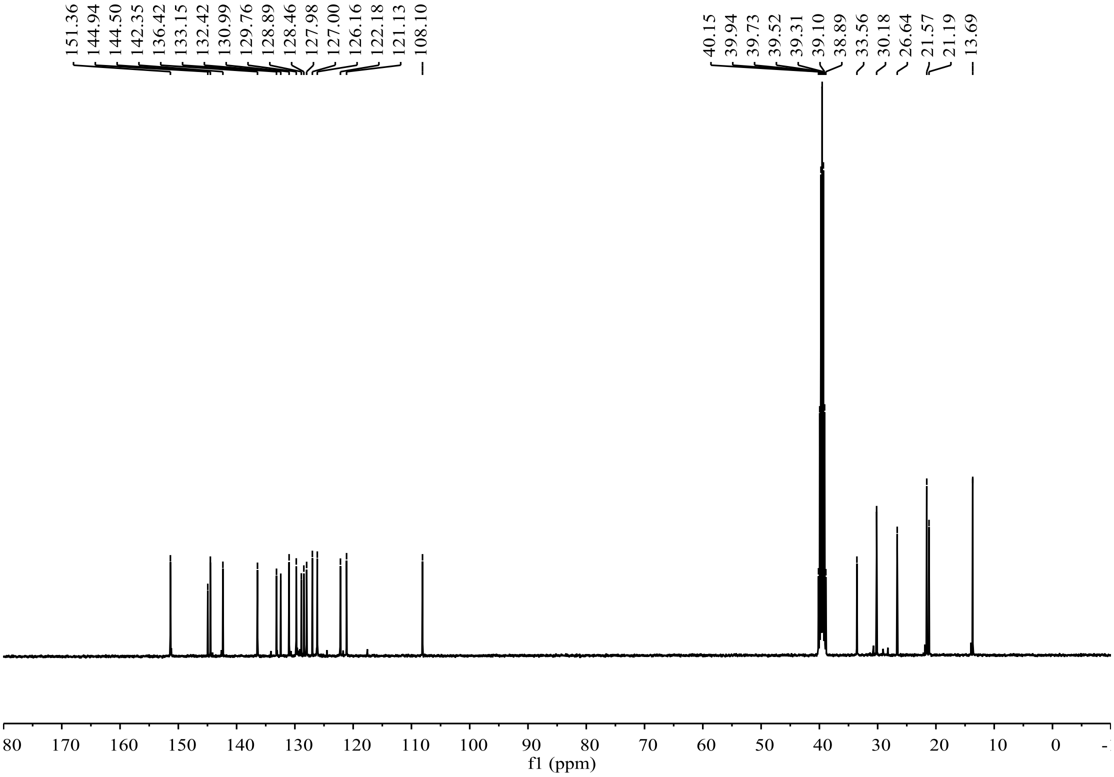
2.42 2.42 2.09 2.07 2.05 2.03 2.01 1.96 1.94 1.92 1.90 1.88
1.39 1.37 1.06 1.06 1.06 1.06 1.05 0.70 0.69
O
O
S
N
N
1.01 1.03 1.08 1.07 1.14 1.14 1.04 1.06 1.01 0.99
3.02 1.06 1.09 2.19 4.19 3.03
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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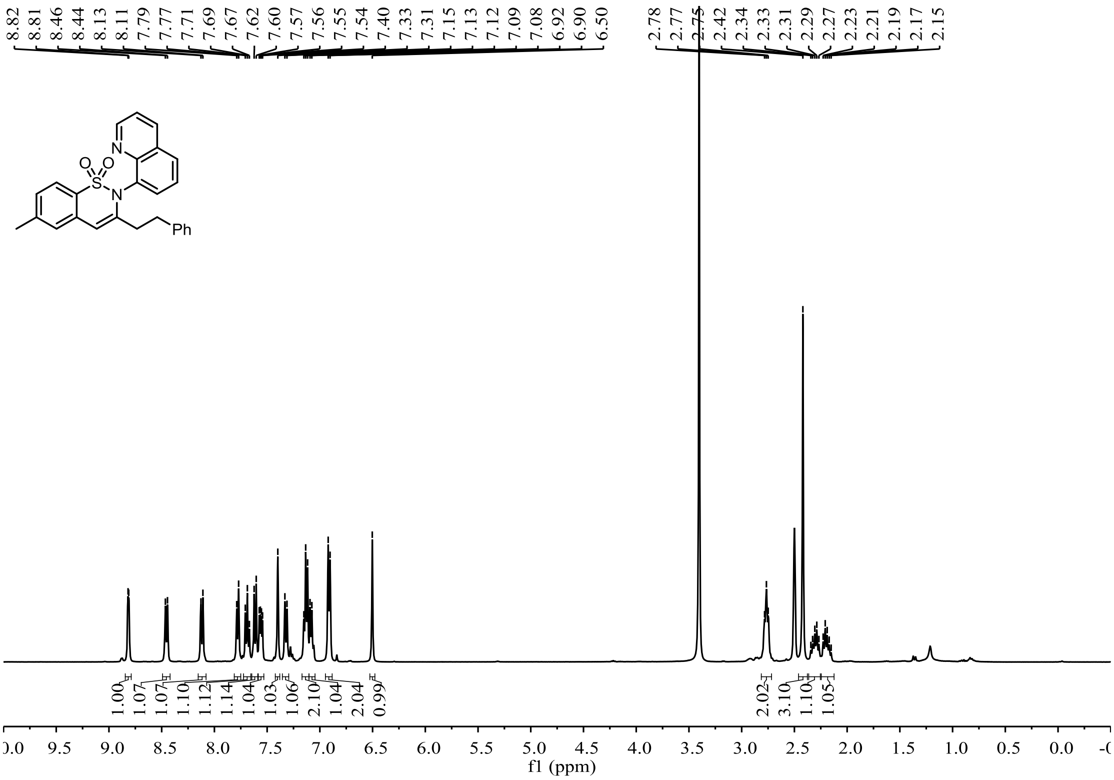
f1 (ppm)

Compound 13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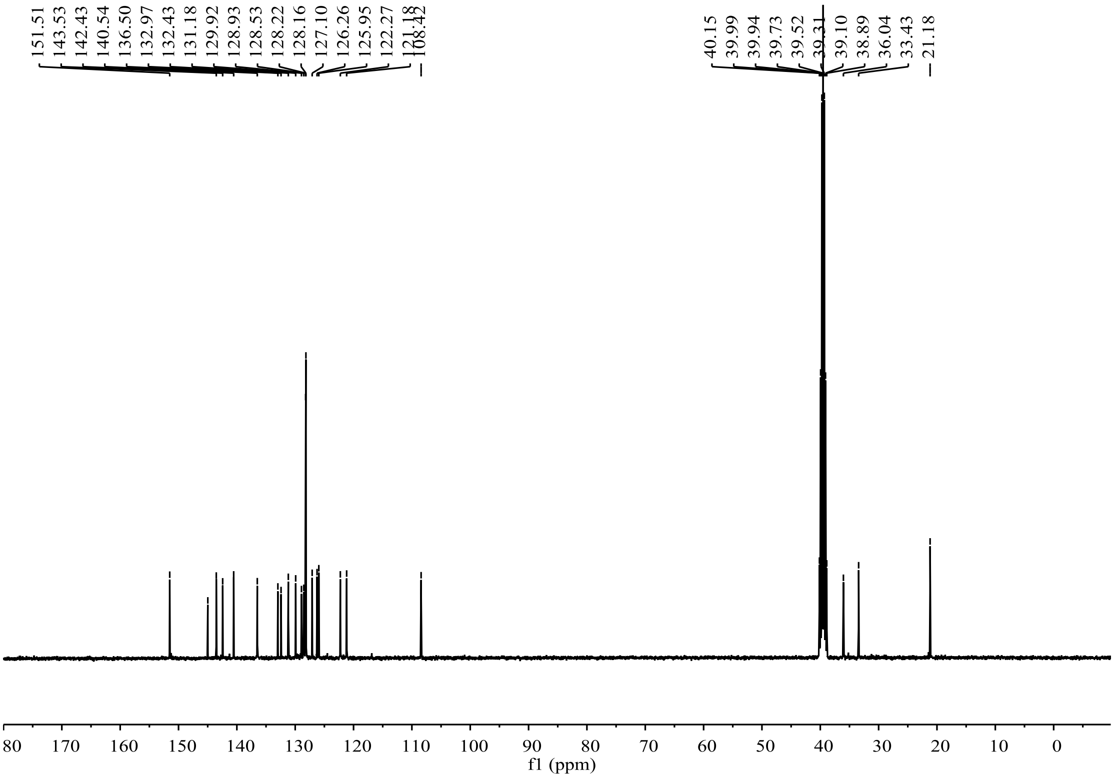
N
O
O
S
N
Ph
1.00 1.07 1.07 1.10 1.12 1.14 1.04 1.03 1.06 2.10 1.04 2.04 0.99
2.02 3.10 1.10 1.05
)0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -(
f1 (ppm)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40.15 39.99 39.94 39.73 39.52 39.31 39.10 38.89 36.04 33.43 21.18
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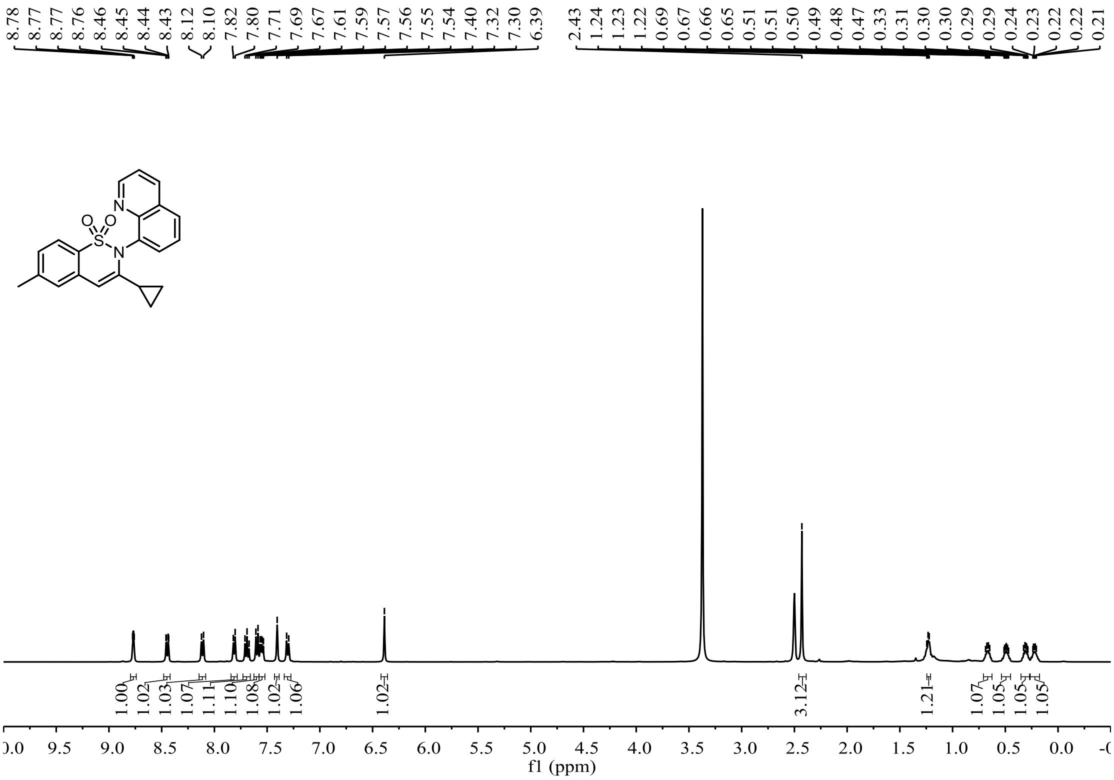
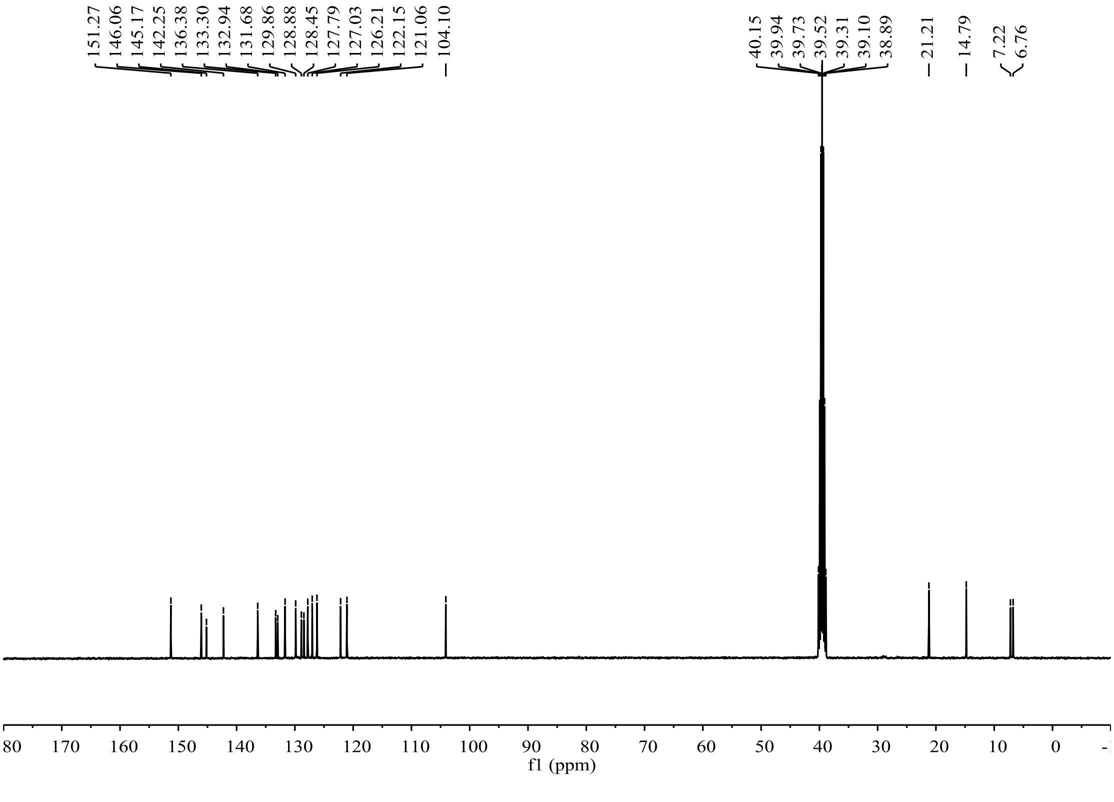
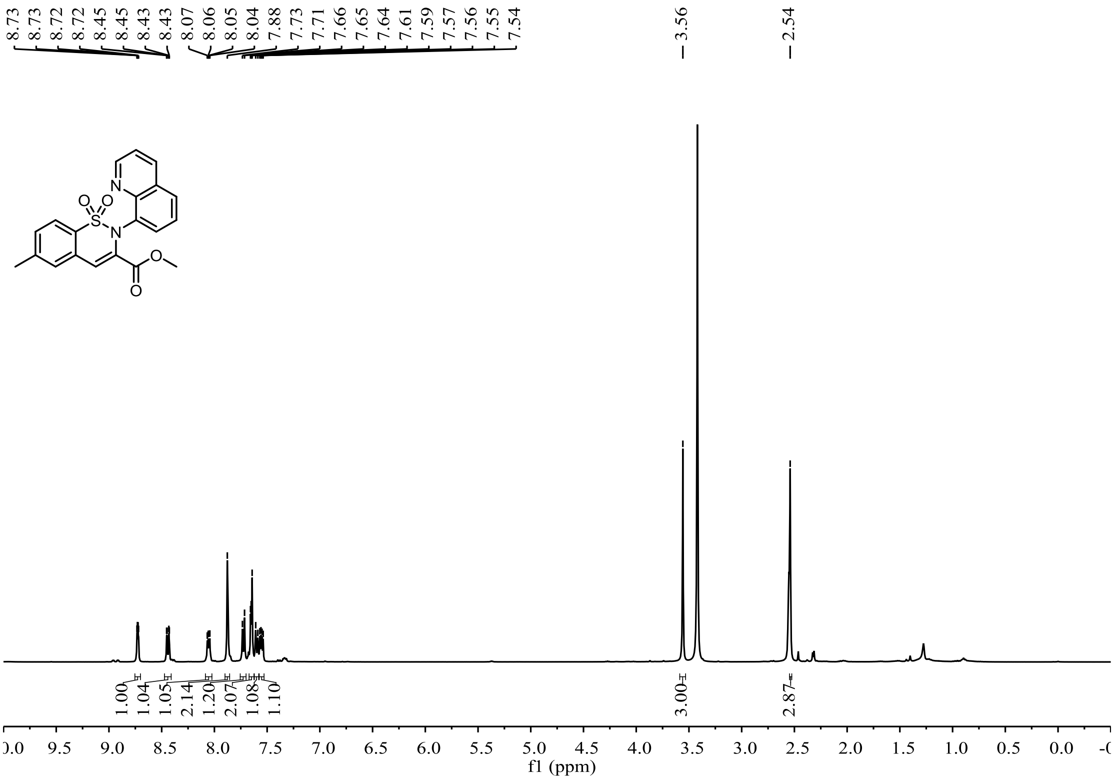
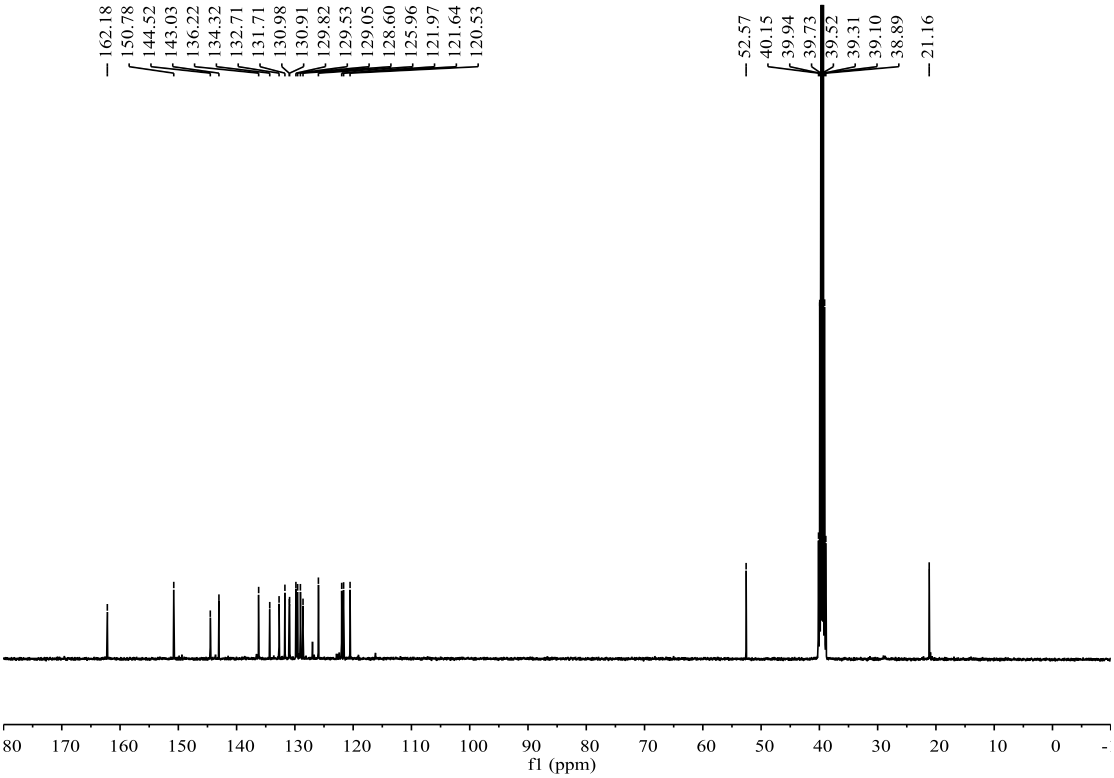
Compound 14


8.78 8.77 8.77 8.76 8.46 8.45 8.44 8.43 8.12 8.10 7.82 7.80 7.71 7.69 7.67 7.61 7.59 7.57 7.56 7.55 7.54 7.40 7.32 7.30 6.39
2.43 1.24 1.23 1.22 0.69 0.67 0.66 0.65 0.51 0.51 0.50 0.49 0.48 0.47 0.33 0.31 0.30 0.30 0.29 0.29 0.24 0.23 0.22 0.22 0.21
1.00 1.02 1.03 1.07 1.11 1.10 1.08 1.02 1.06 1.02 3.12 1.21 1.07 1.05 1.05 1.05
f1 (ppm)

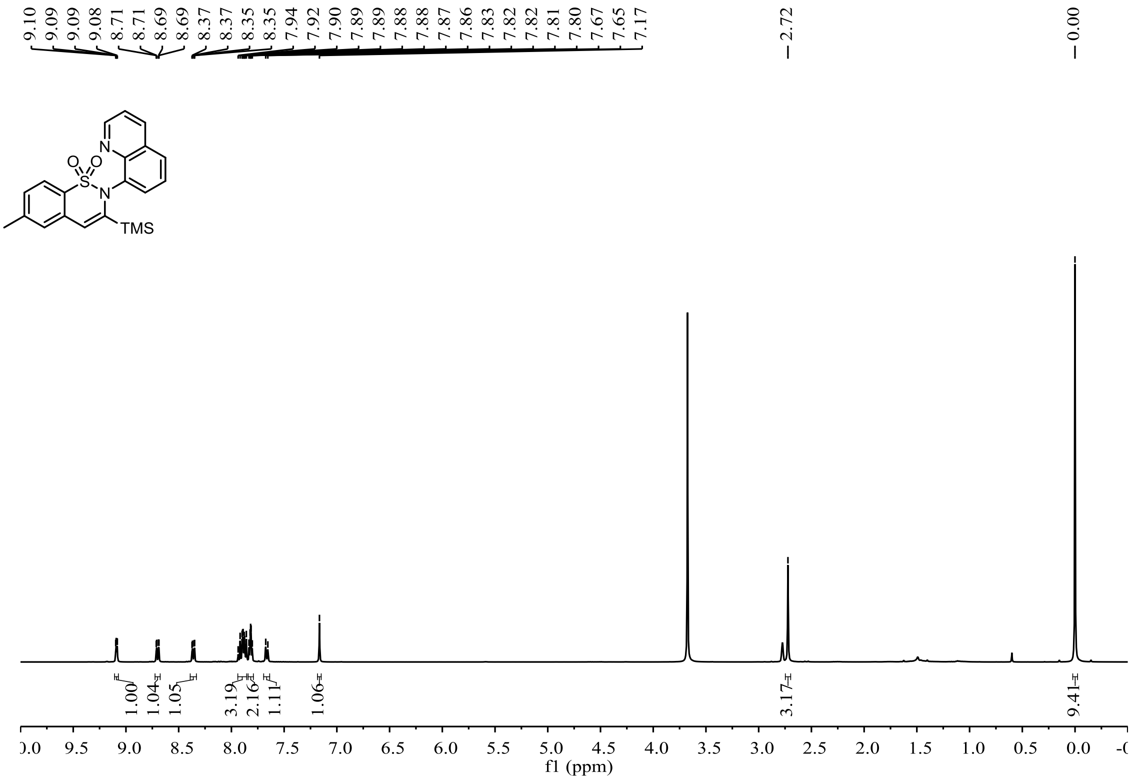

151.27 146.06 145.17 142.25 136.38 133.30 132.94 131.68 129.86 128.88 128.45 127.79 127.03 126.21 122.15 121.06 104.10
40.15 39.94 39.73 39.52 39.31 39.10 38.89 21.21 14.79 7.22 6.76
f1 (ppm)

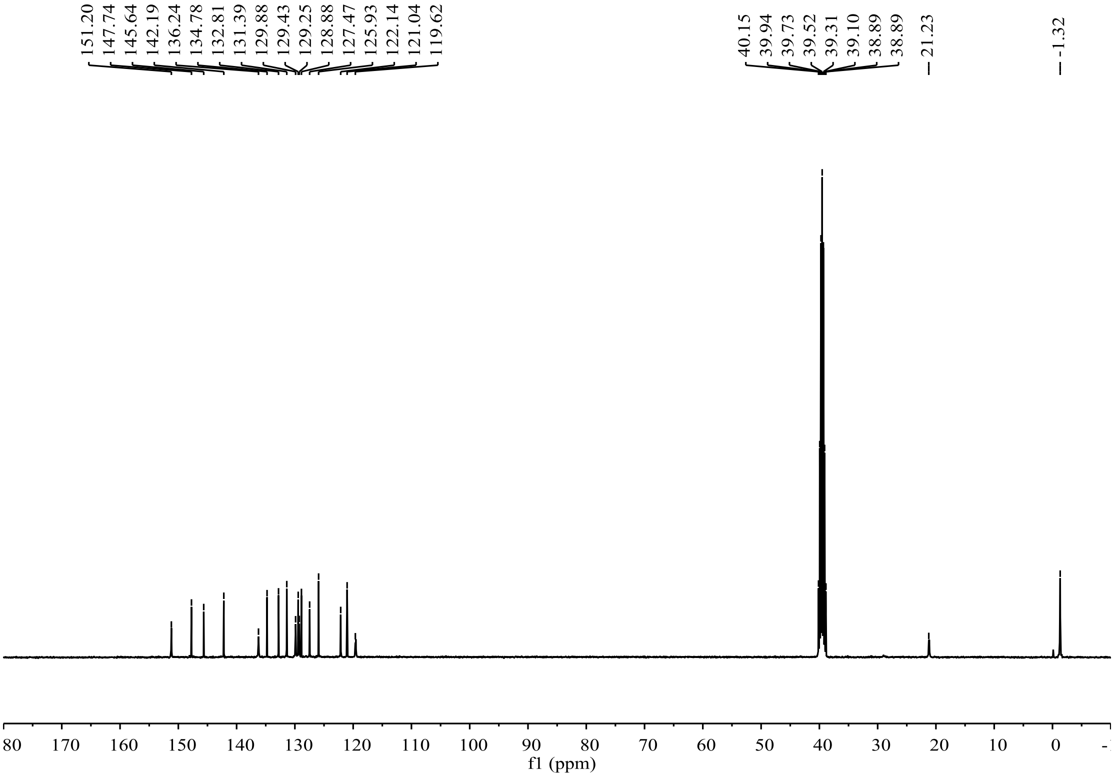
Compound 15


8.73
8.73
8.72
8.72
8.45
8.45
8.43
8.43
8.07
8.06
8.05
8.04
7.88
7.73
7.71
7.66
7.65
7.64
7.61
7.59
7.57
7.56
7.55
7.54
3.56
2.54
1.00
1.04
1.05
2.14
1.20
2.07
1.08
1.10
3.00
2.87
f1 (ppm)

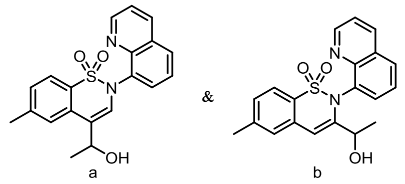

162.18
150.78
144.52
143.03
136.22
134.32
132.71
131.71
130.98
130.91
129.82
129.53
129.05
128.60
125.96
121.97
121.64
120.53
52.57
40.15
39.94
39.73
39.52
39.31
39.10
38.89
21.16
f1 (ppm)

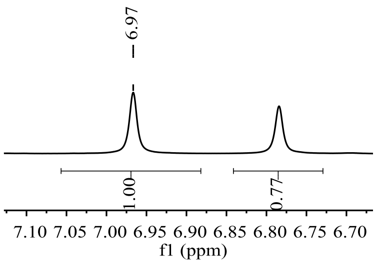
Compound 16

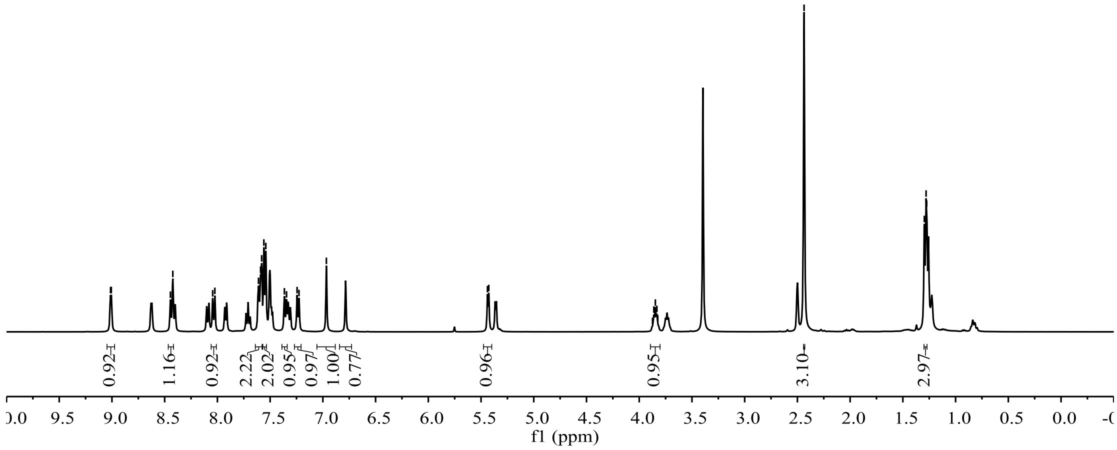

9.10
9.09
9.09
9.08
8.71
8.71
8.69
8.69
8.37
8.37
8.35
8.35
7.94
7.92
7.90
7.89
7.89
7.88
7.88
7.87
7.86
7.83
7.82
7.82
7.81
7.80
7.67
7.65
7.17
2.72
0.00
N
O
O
S
N
TMS
1.00
1.04
1.05
3.19
2.16
1.11
1.06
3.17
9.41
f1 (ppm)

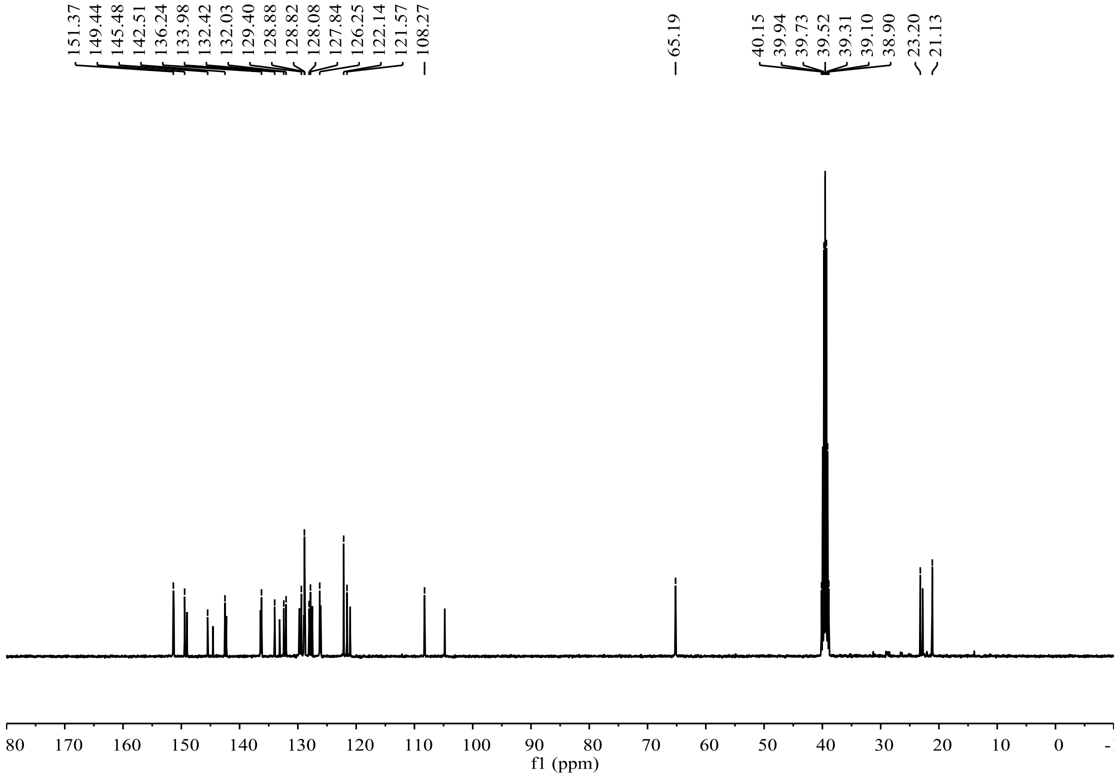

151.20
147.74
145.64
142.19
136.24
134.78
132.81
131.39
129.88
129.43
129.25
128.88
127.47
125.93
122.14
121.04
119.62
40.15
39.94
39.73
39.52
39.31
39.10
38.89
38.89
21.23
-1.32
f1 (ppm)

Compound 17(a/b = 1.3:1)

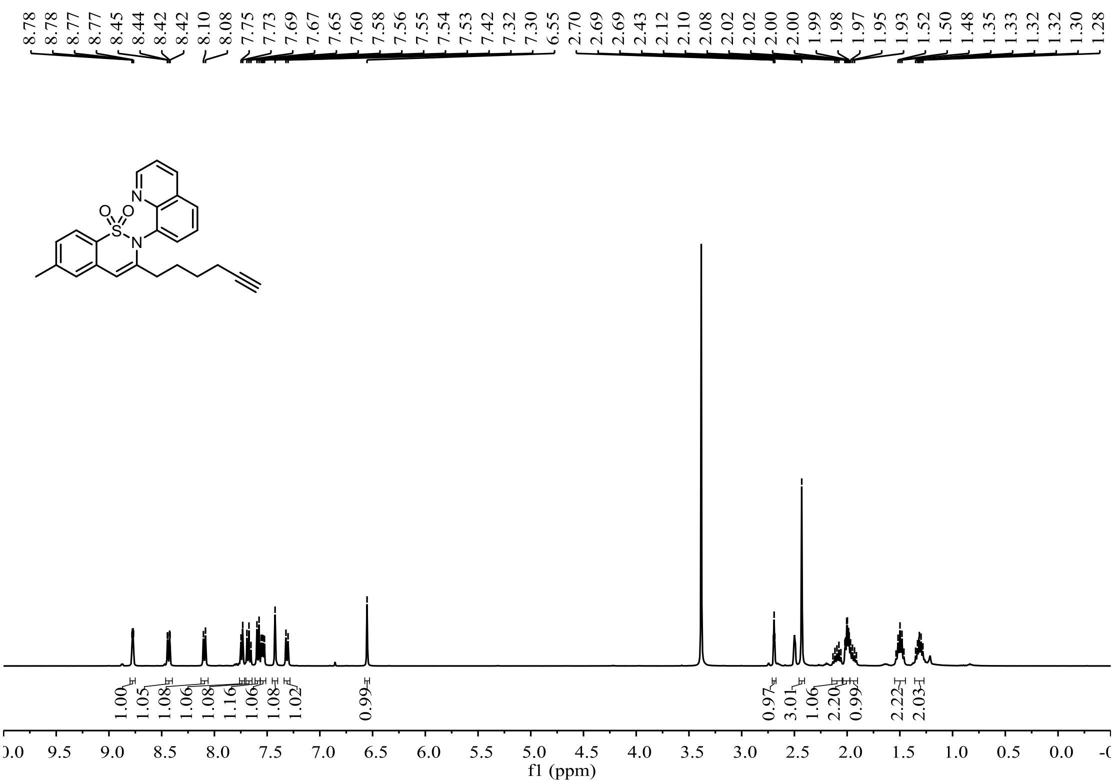


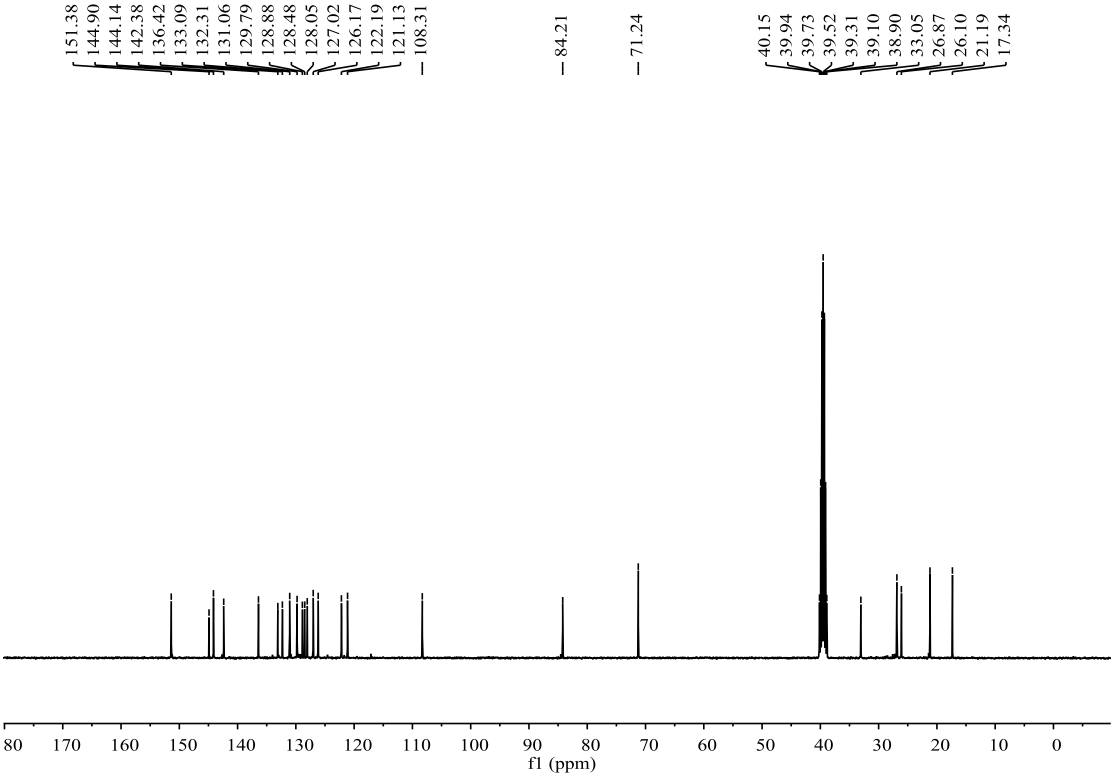




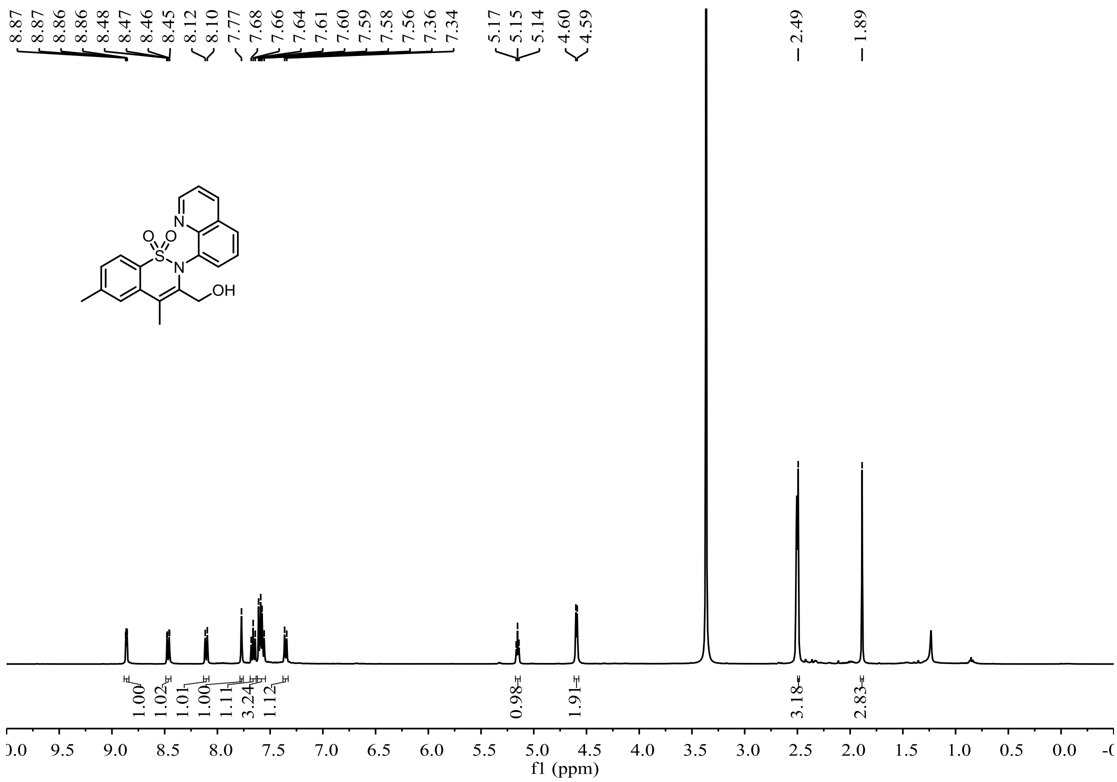


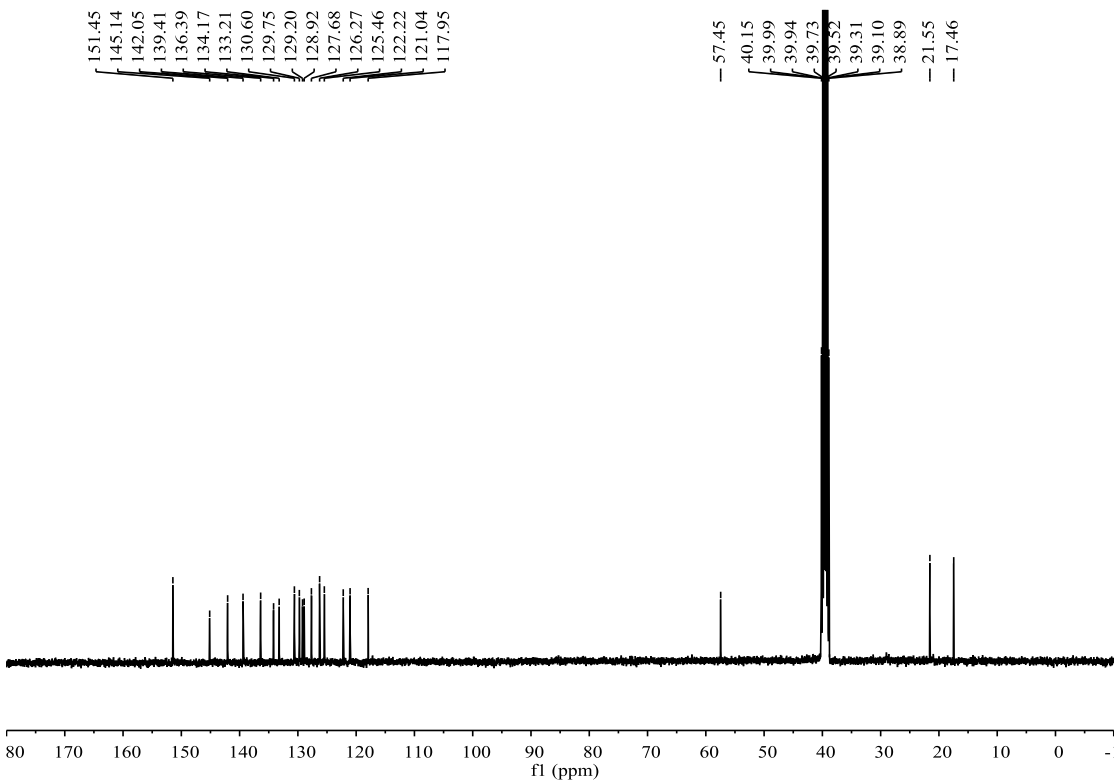
Compound 18



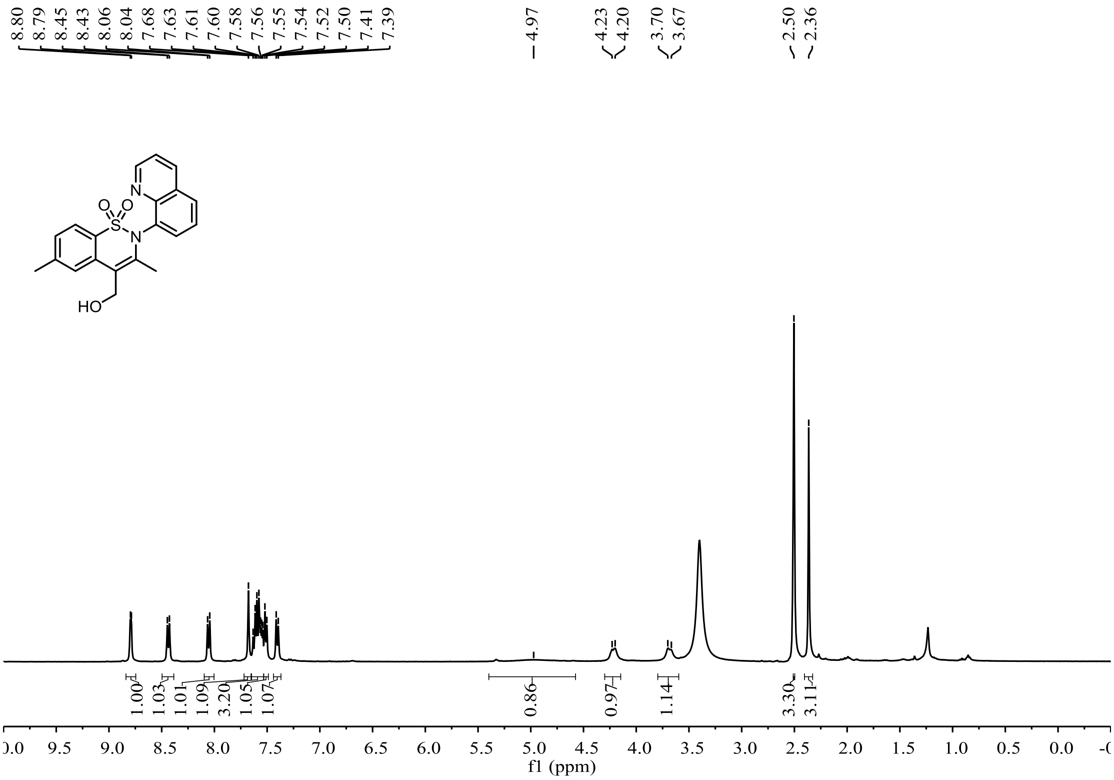


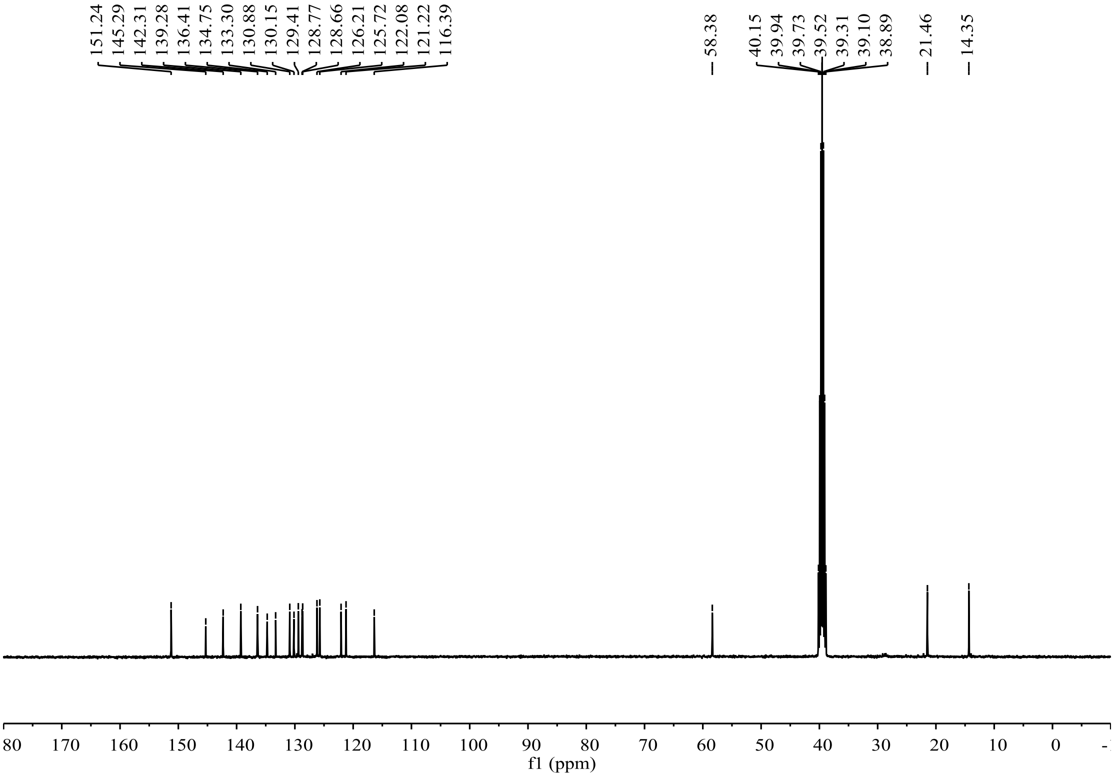
Compound 19(a)



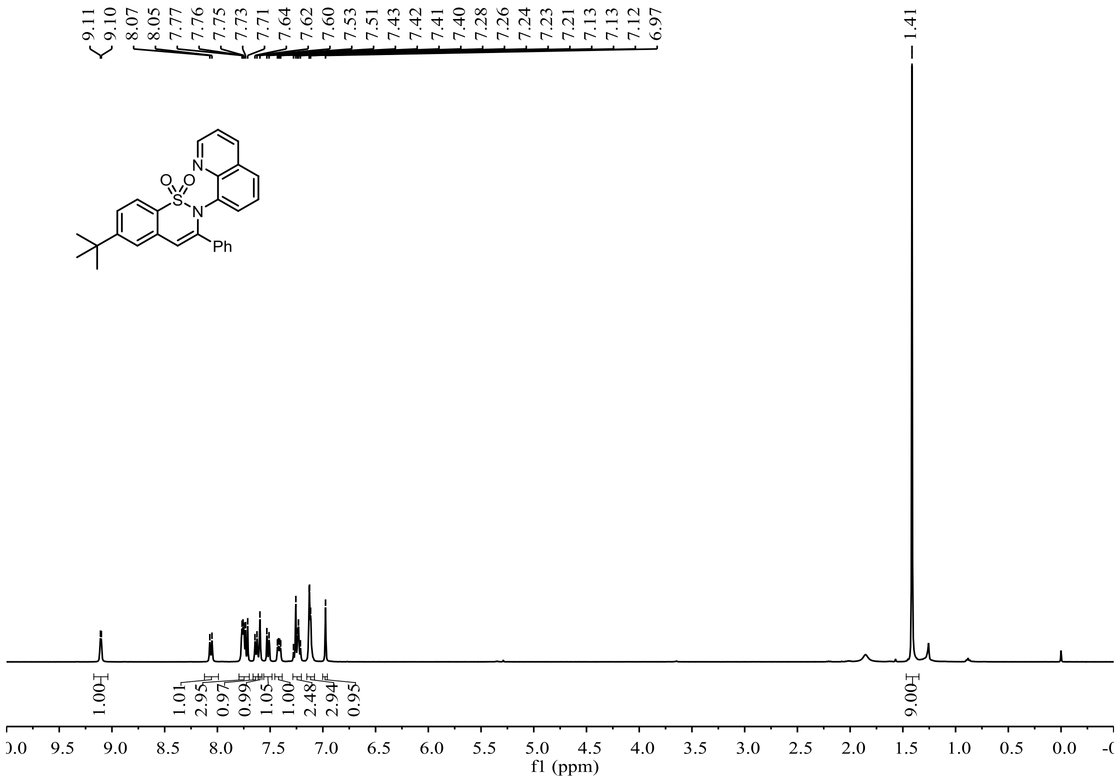


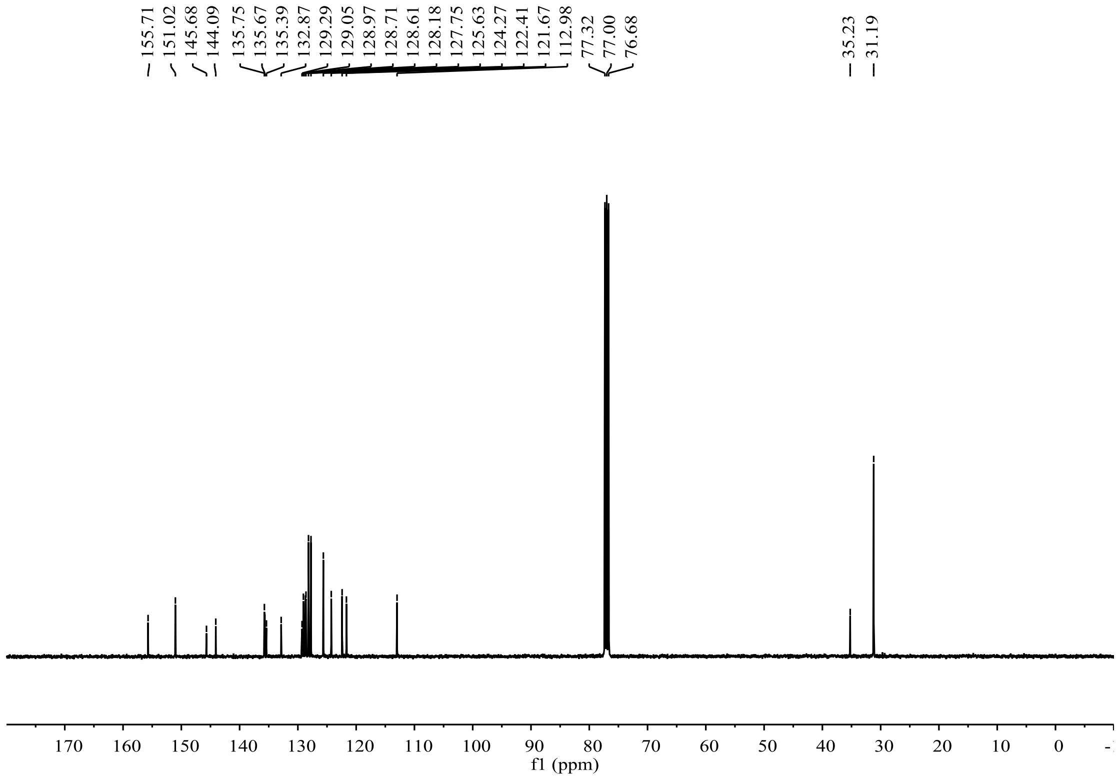
Compound 19(b)



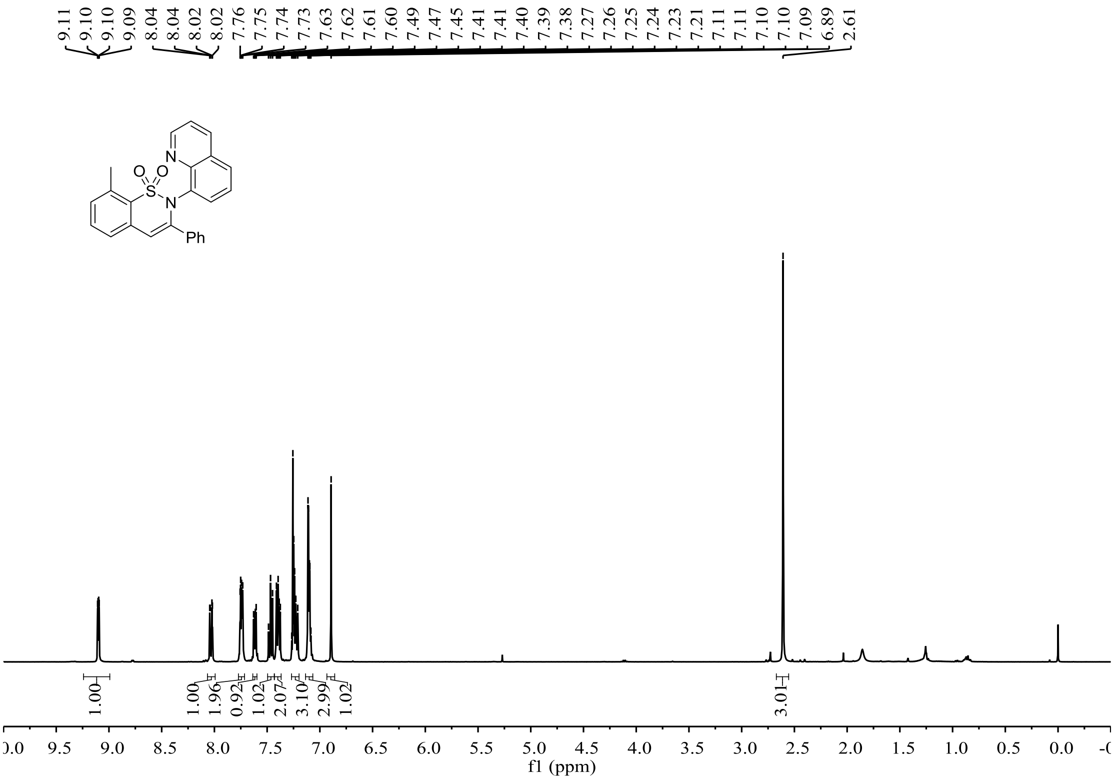


Compound 20

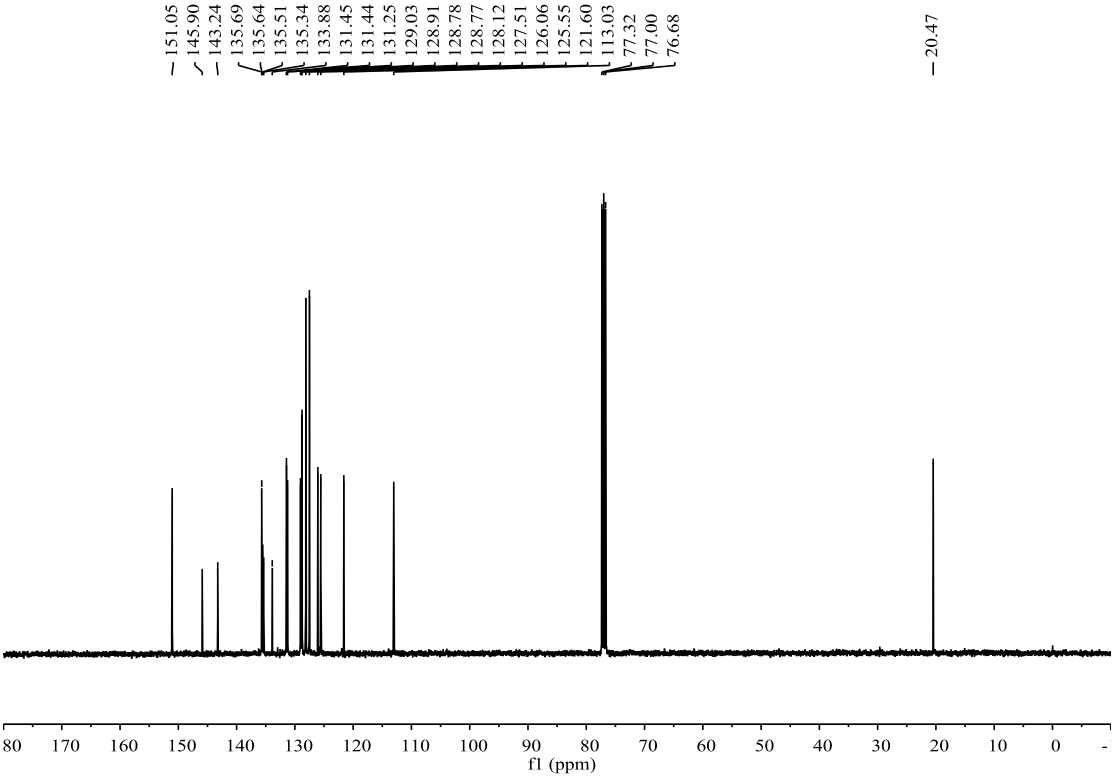

9.11
9.10
8.07
8.05
7.77
7.76
7.75
7.73
7.71
7.64
7.62
7.60
7.53
7.51
7.43
7.42
7.41
7.40
7.28
7.26
7.24
7.23
7.21
7.13
7.13
7.12
6.97
1.41
N
O
O
S
N
Ph
1.00
1.01
2.95
0.97
0.99
1.05
1.00
2.48
2.94
0.95
9.00
f1 (ppm)


155.71
151.02
145.68
144.09
135.75
135.67
135.39
132.87
129.29
129.05
128.97
128.71
128.61
128.18
127.75
125.63
124.27
122.41
121.67
112.98
77.32
77.00
76.68
35.23
31.19
f1 (ppm)

Compound 21

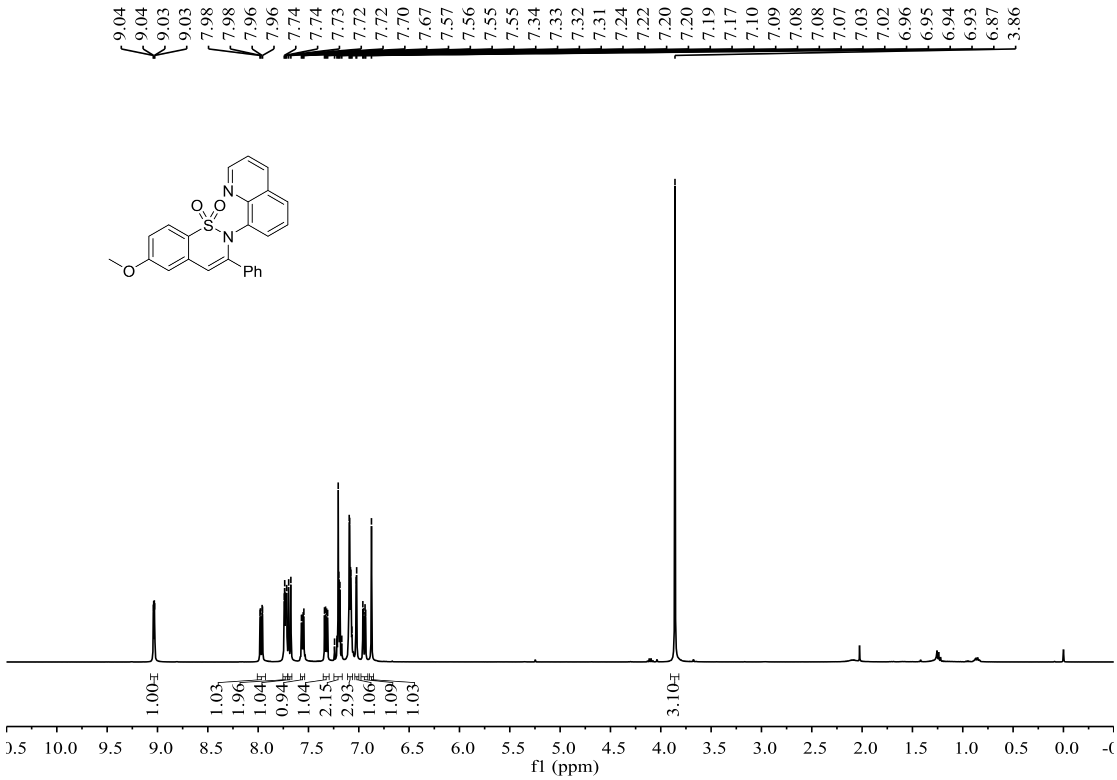


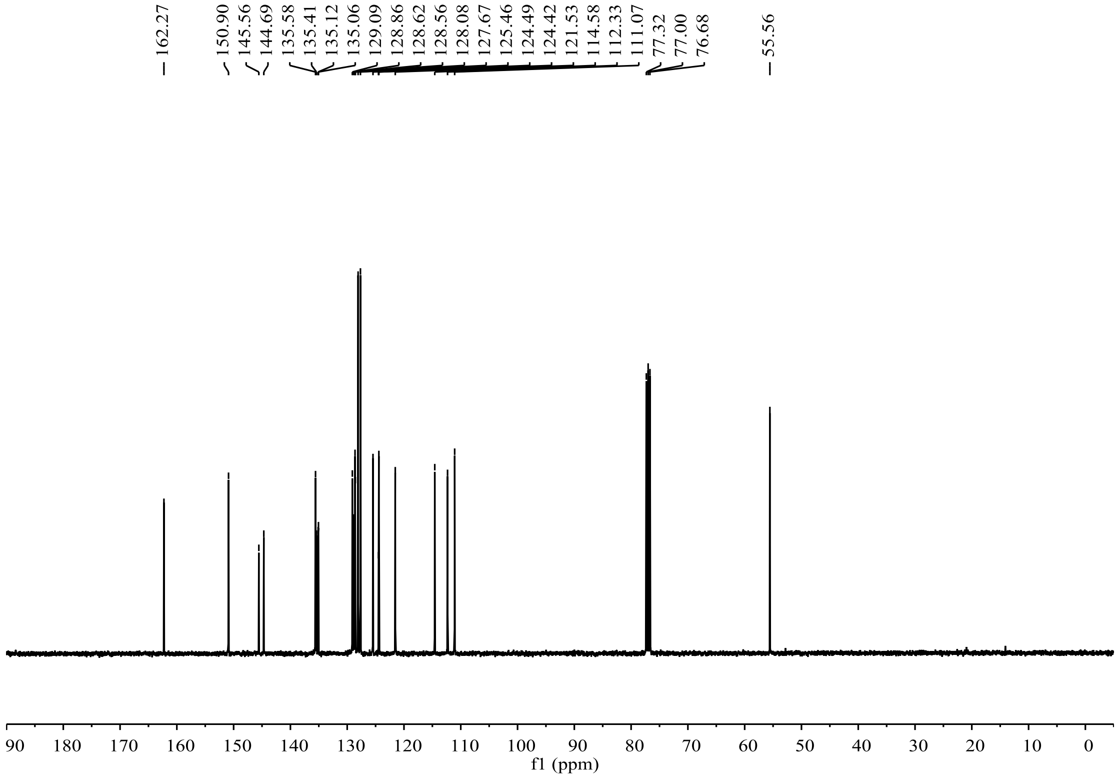
9.11 9.10 9.10 9.09 8.04 8.04 8.02 8.02 7.76 7.75 7.74 7.73 7.63 7.62 7.61 7.60 7.49 7.47 7.45 7.41 7.41 7.40 7.39 7.38 7.27 7.26 7.25 7.24 7.23 7.21 7.11 7.11 7.10 7.10 7.09 6.89 2.61
O O
S
N
N
Ph
1.00 1.00 1.96 0.92 1.02 2.07 3.10 2.99 1.02 3.01
f1 (ppm)



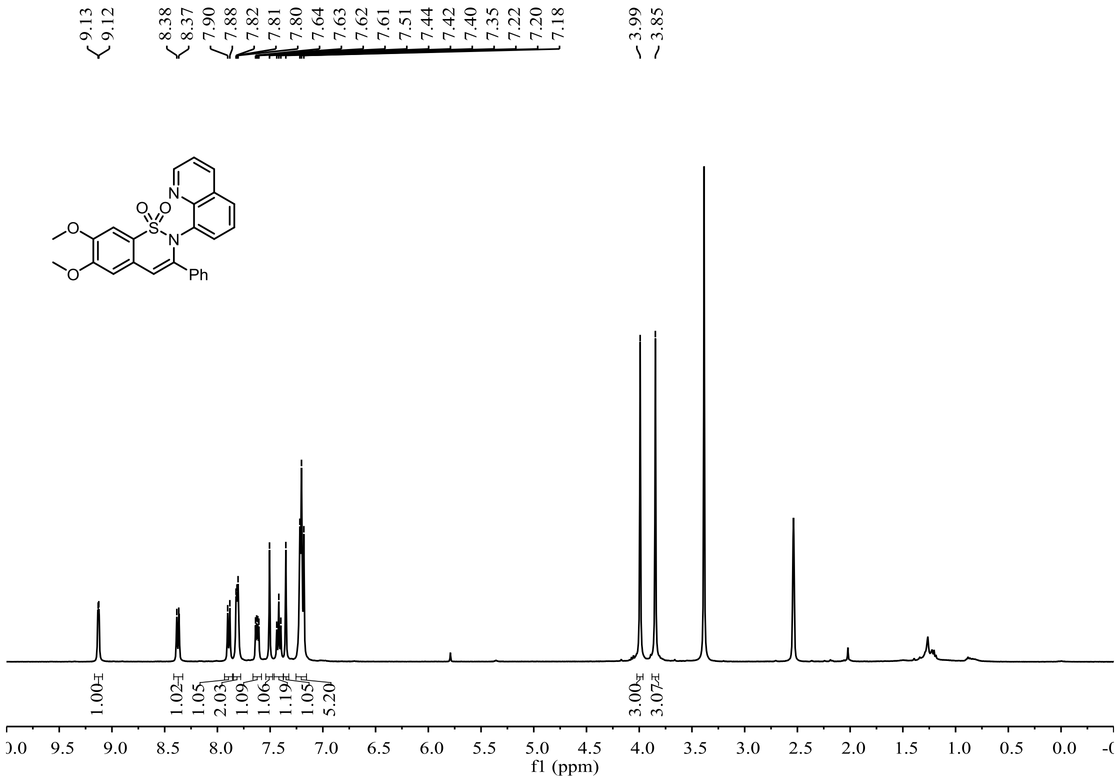
151.05 145.90 143.24 135.69 135.64 135.51 135.34 133.88 131.45 131.44 131.25 129.03 128.91 128.78 128.77 128.12 127.51 126.06 125.55 121.60 113.03 77.32 77.00 76.68 20.47
f1 (ppm)

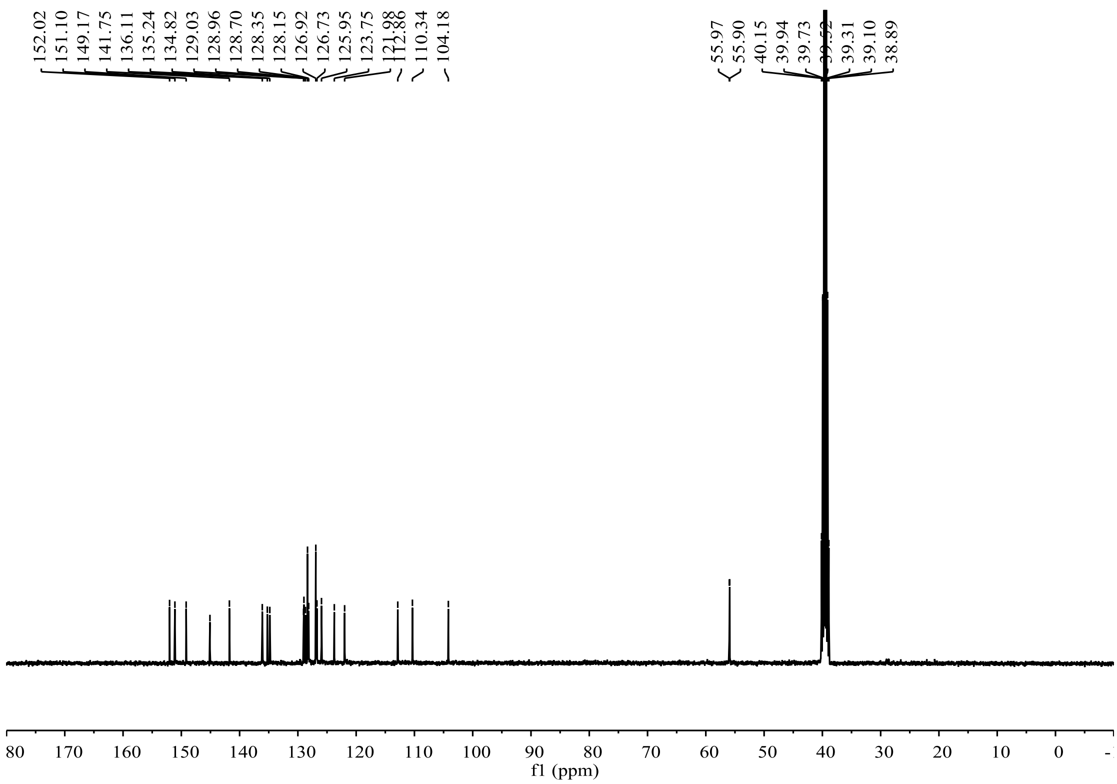
Compound 22


9.04 9.04 9.03 9.03 7.98 7.98 7.96 7.96 7.74 7.74 7.73 7.72 7.72 7.70 7.67 7.57 7.56 7.55 7.55 7.34 7.33 7.32 7.31 7.24 7.22 7.20 7.20 7.19 7.17 7.10 7.09 7.08 7.08 7.07 7.03 7.02 6.96 6.95 6.94 6.93 6.87 3.86
N
O
S
Ph
1.00
1.03 1.96 1.04 0.94 1.04 2.15 2.93 1.06 1.09 1.03
3.10
f1 (ppm)

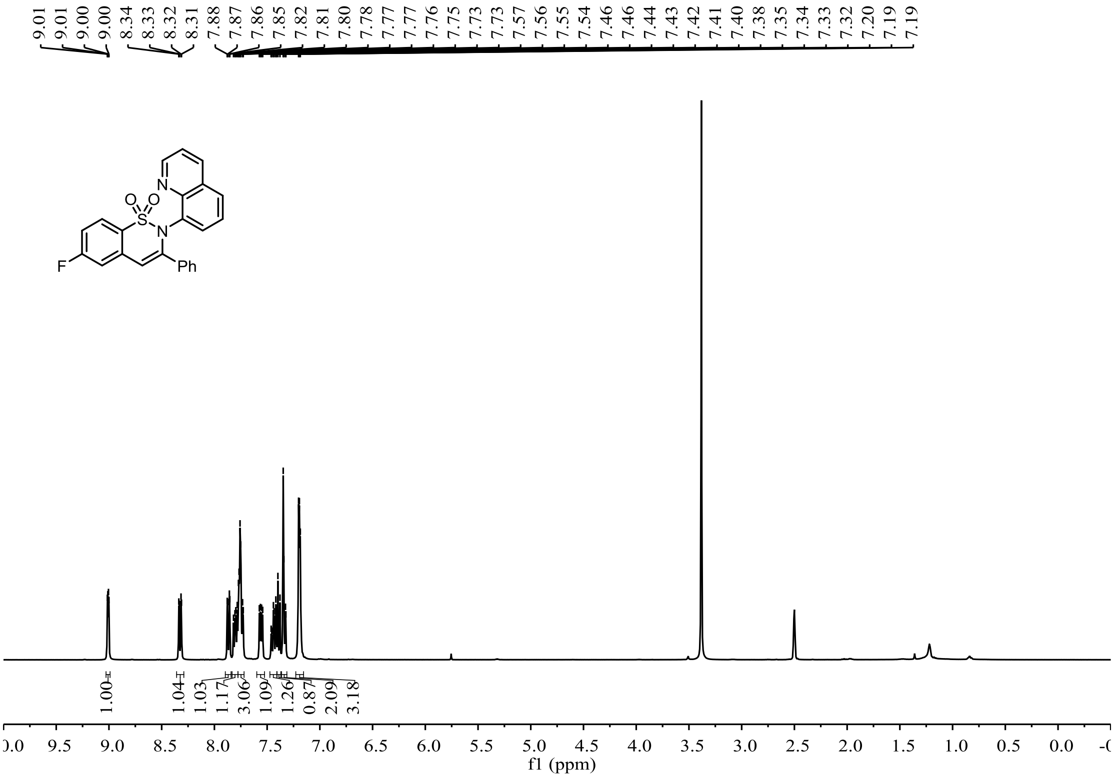

162.27
150.90 145.56 144.69 135.58 135.41 135.12 135.06 129.09 128.86 128.62 128.56 128.08 127.67 125.46 124.49 124.42 121.53 114.58 112.33 111.07 77.32 77.00 76.68
55.56
f1 (ppm)

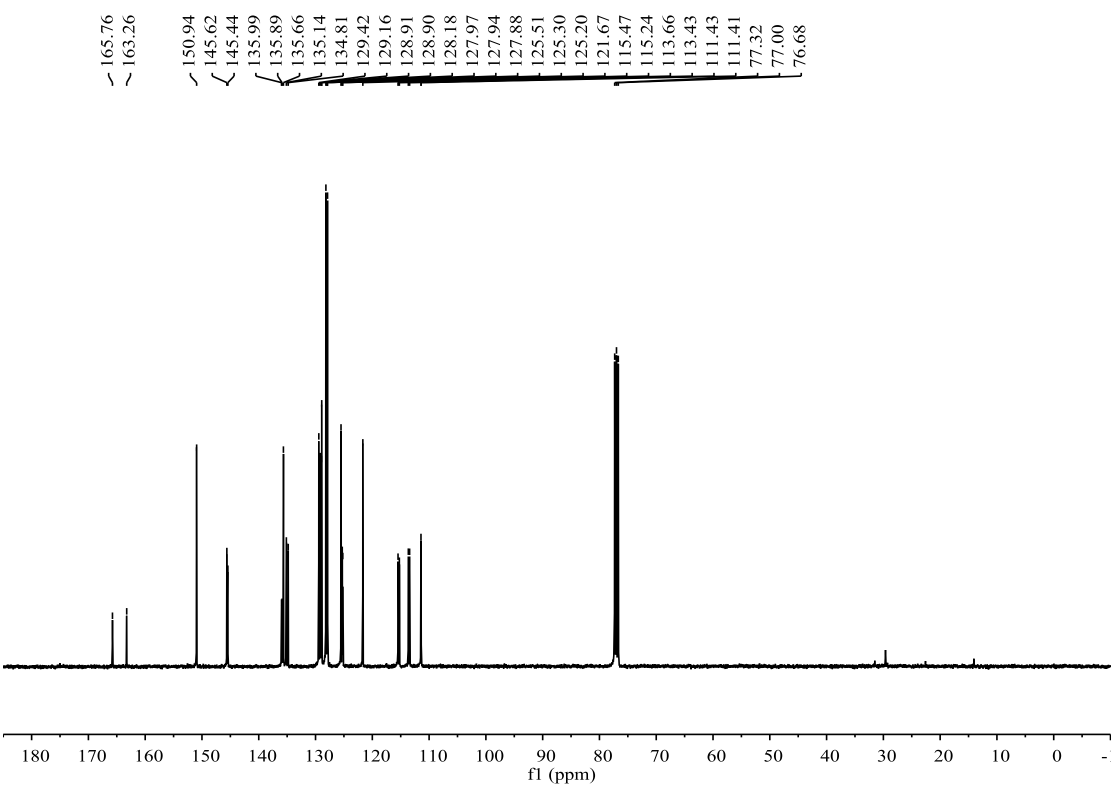
Compound 23

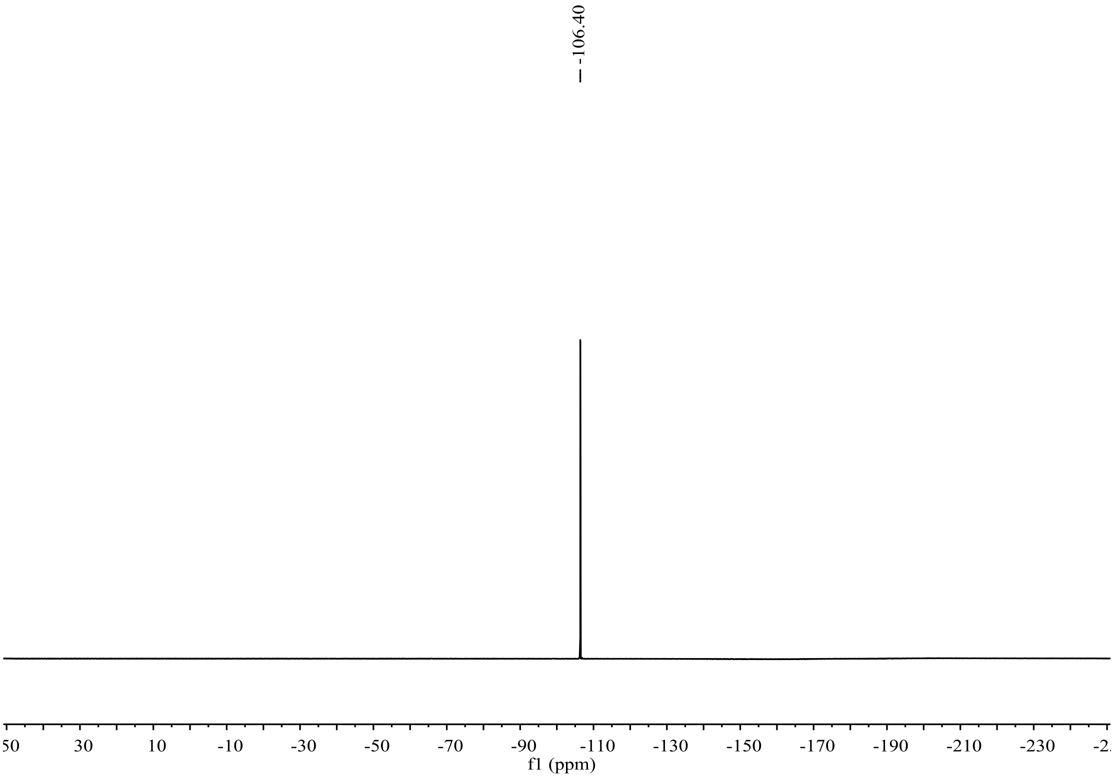

9.13
9.12
8.38
8.37
7.90
7.88
7.82
7.81
7.80
7.64
7.63
7.62
7.61
7.51
7.44
7.42
7.40
7.35
7.22
7.20
7.18
3.99
3.85
O
O
S
N
N
O
O
Ph
1.00
1.02
1.05
2.03
1.09
1.06
1.19
1.05
5.20
3.00
3.07
f1 (ppm)


152.02
151.10
149.17
141.75
136.11
135.24
134.82
129.03
128.96
128.70
128.35
128.15
126.92
126.73
125.95
123.75
121.98
112.86
110.34
104.18
55.97
55.90
40.15
39.94
39.73
39.31
39.10
38.89
f1 (ppm)

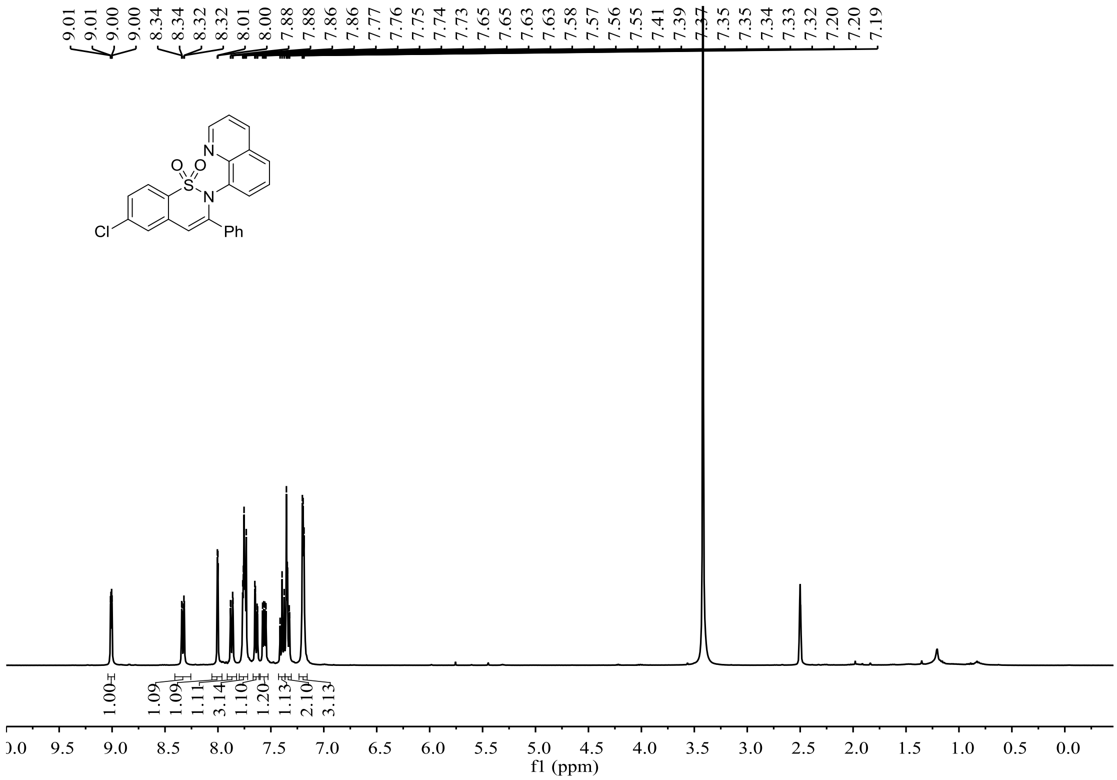
Compound 24

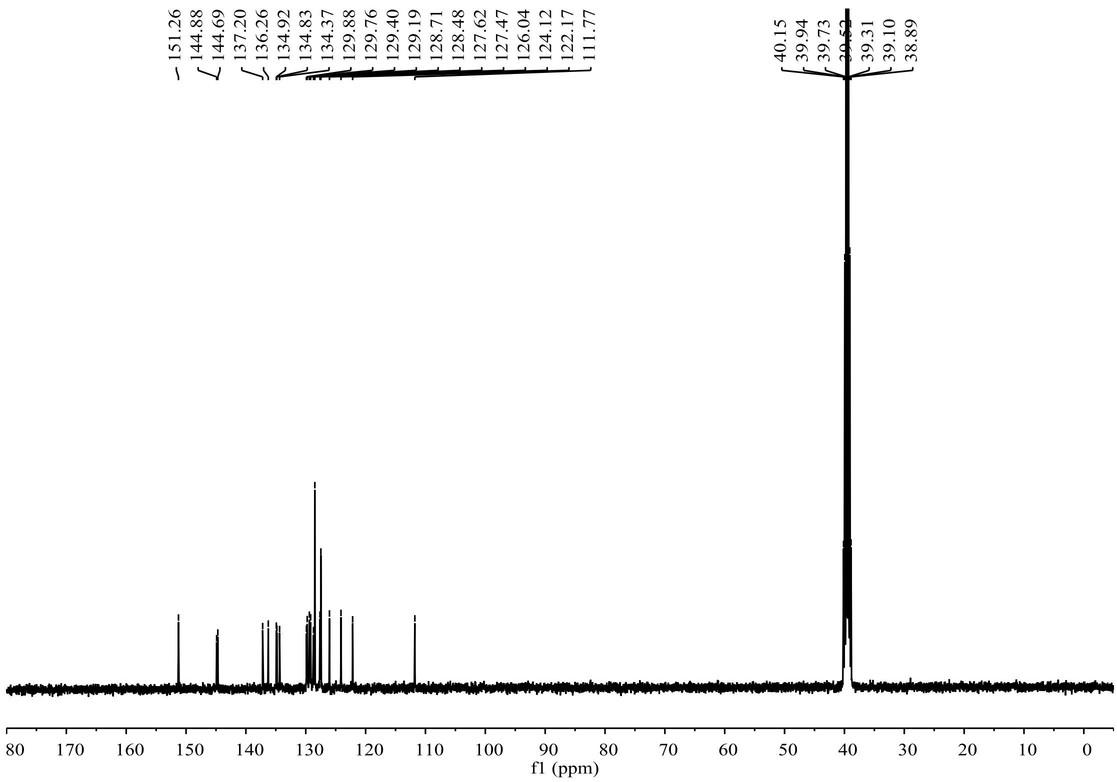

9.01 9.01 9.00 9.00 8.34 8.33 8.32 8.31 7.88 7.87 7.86 7.85 7.82 7.81 7.80 7.78 7.77 7.77 7.76 7.75 7.73 7.73 7.57 7.56 7.55 7.54 7.46 7.46 7.44 7.43 7.42 7.41 7.40 7.38 7.35 7.34 7.33 7.32 7.20 7.19 7.19
O
O
S
N
N
F
Ph
1.00
1.04
1.03
1.17
3.06
1.09
1.26
0.87
2.09
3.18
f1 (ppm)


165.76 163.26 150.94 145.62 145.44 135.99 135.89 135.66 135.14 134.81 129.42 129.16 128.91 128.90 128.18 127.97 127.94 127.88 125.51 125.30 125.20 121.67 115.47 115.24 113.66 113.43 111.43 111.41 77.32 77.00 76.68
f1 (ppm)

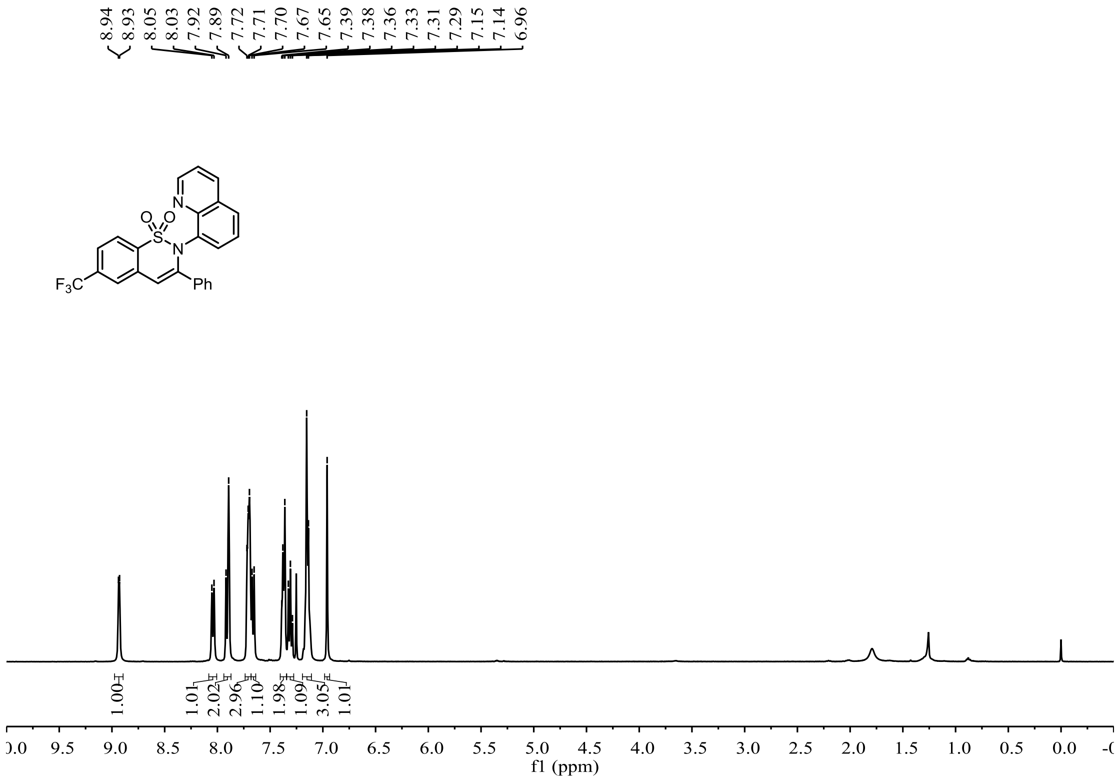

-106.40
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
f1 (ppm)

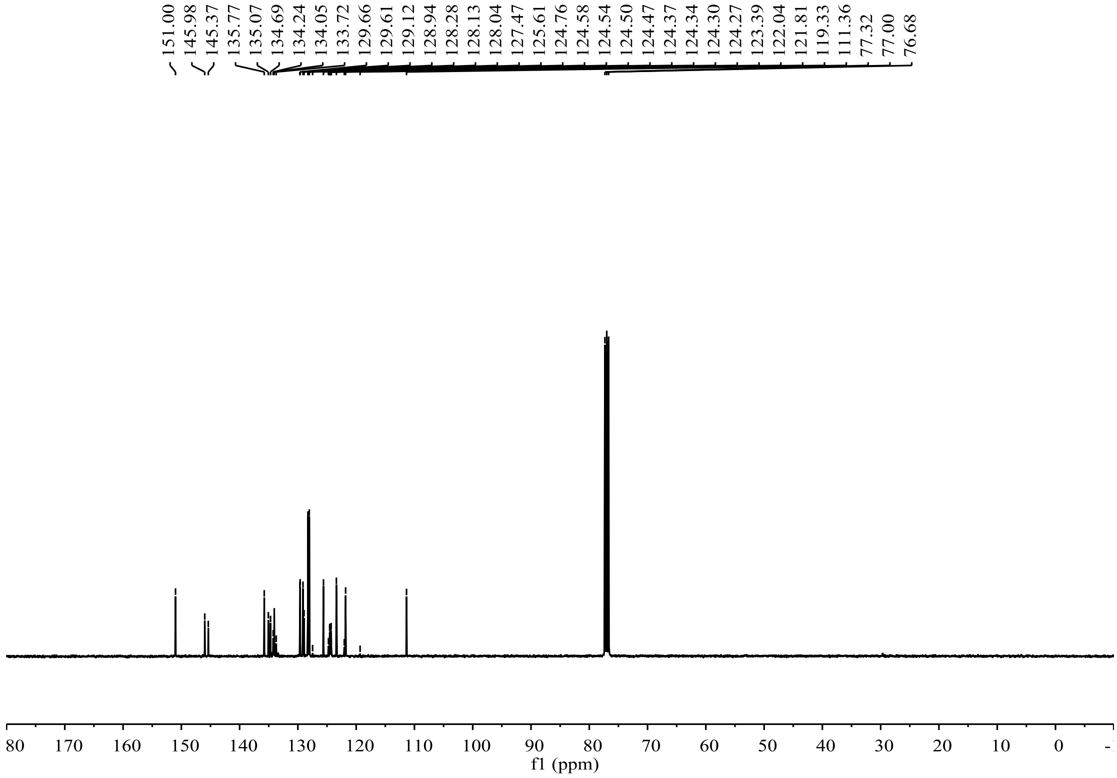
Compound 25

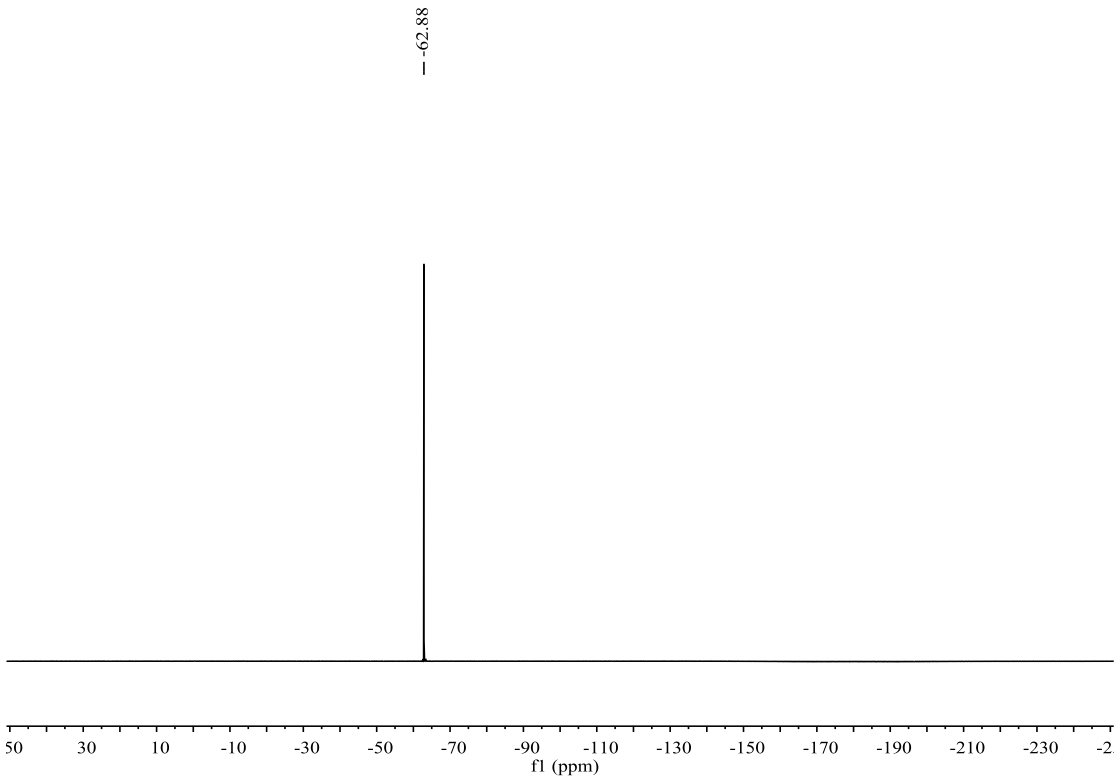

9.01
9.01
9.00
9.00
8.34
8.34
8.32
8.32
8.01
8.00
7.88
7.88
7.86
7.86
7.77
7.76
7.75
7.74
7.73
7.65
7.65
7.63
7.63
7.58
7.57
7.56
7.55
7.41
7.39
7.37
7.35
7.35
7.34
7.33
7.32
7.20
7.20
7.19
N
O
O
S
N
Cl
Ph
1.00
1.09
1.09
1.11
3.14
1.10
1.20
1.13
2.10
3.13
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


151.26
144.88
144.69
137.20
136.26
134.92
134.83
134.37
129.88
129.76
129.40
129.19
128.71
128.48
127.62
127.47
126.04
124.12
122.17
111.77
40.15
39.94
39.73
39.52
39.31
39.10
38.89
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

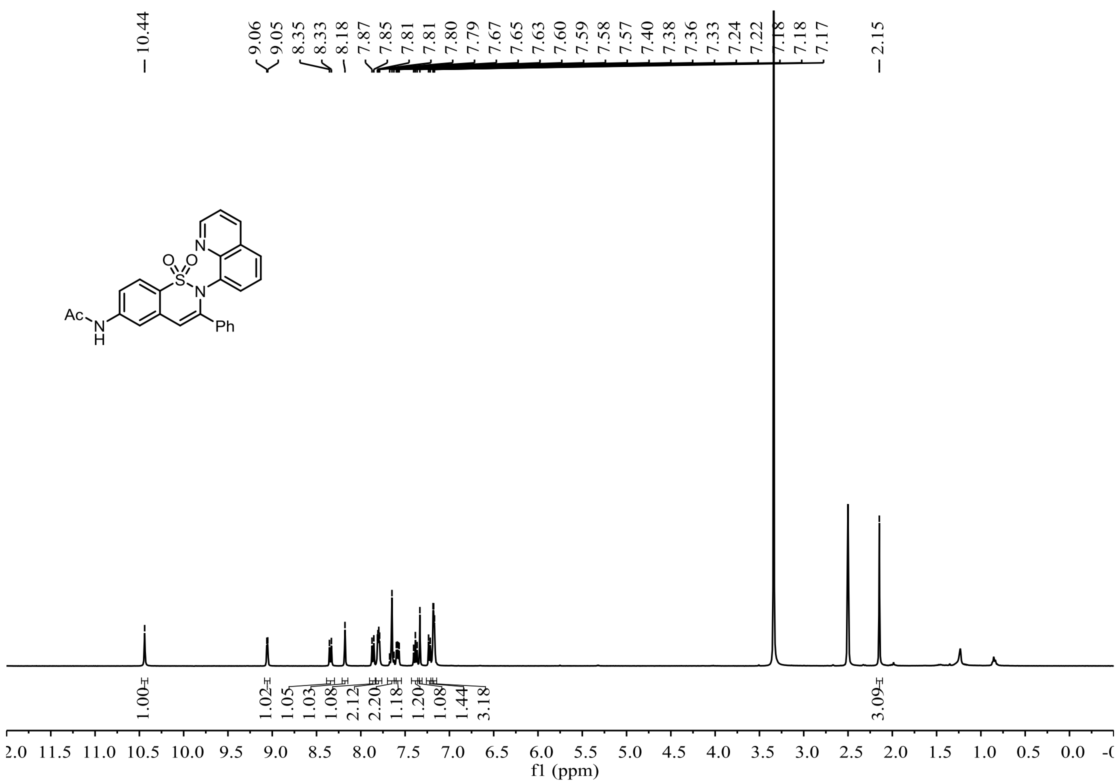
Compound 26

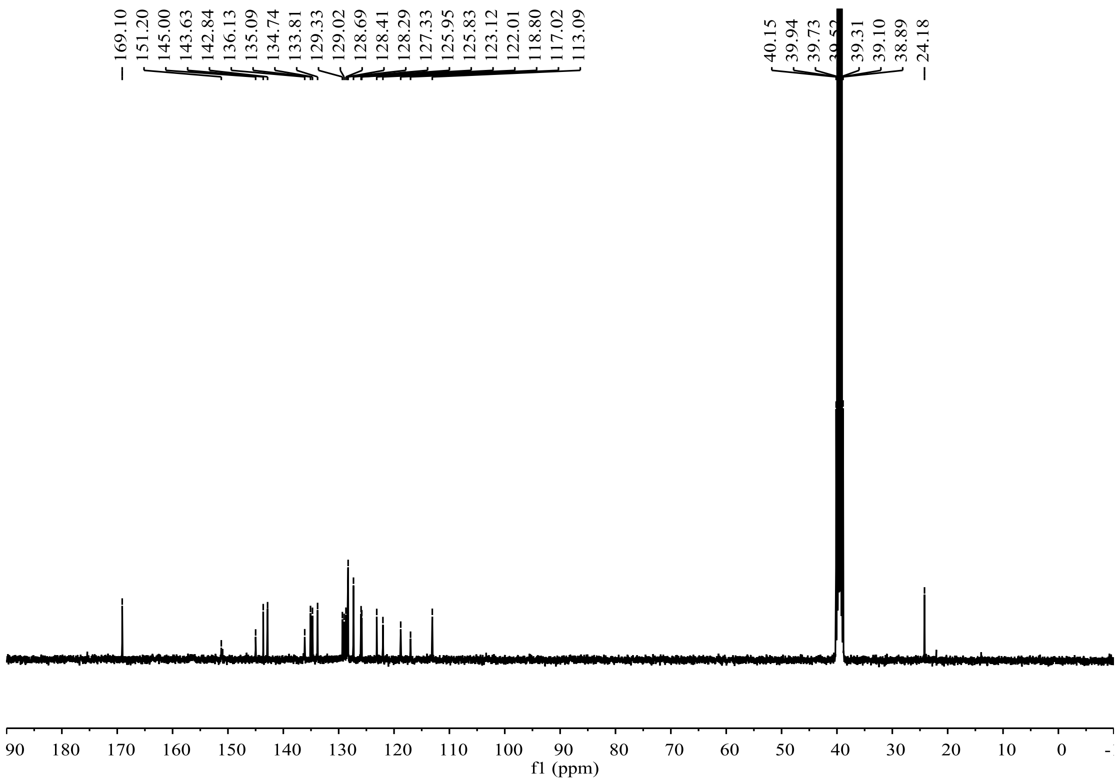

8.94
8.93
8.05
8.03
7.92
7.89
7.72
7.71
7.70
7.67
7.65
7.39
7.38
7.36
7.33
7.31
7.29
7.15
7.14
6.96
1.00
1.01
2.02
2.96
1.10
1.98
1.09
3.05
1.01
f1 (ppm)


151.00
145.98
145.37
135.77
135.07
134.69
134.24
134.05
133.72
129.66
129.61
129.12
128.94
128.28
128.13
128.04
127.47
125.61
124.76
124.58
124.54
124.50
124.47
124.37
124.34
124.30
124.27
123.39
122.04
121.81
119.33
111.36
77.32
77.00
76.68
f1 (ppm)

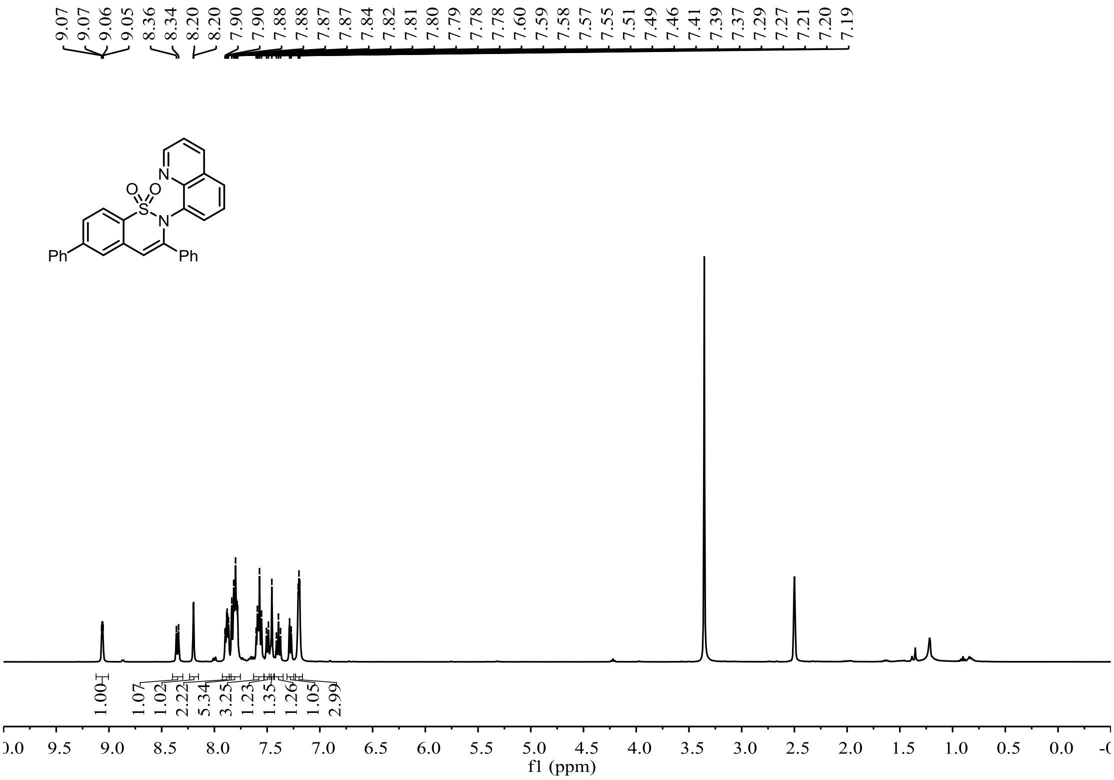

-62.88
50
30
10
-10
-30
-50
-70
-90
-110
-130
-150
-170
-190
-210
-230
f1 (ppm)

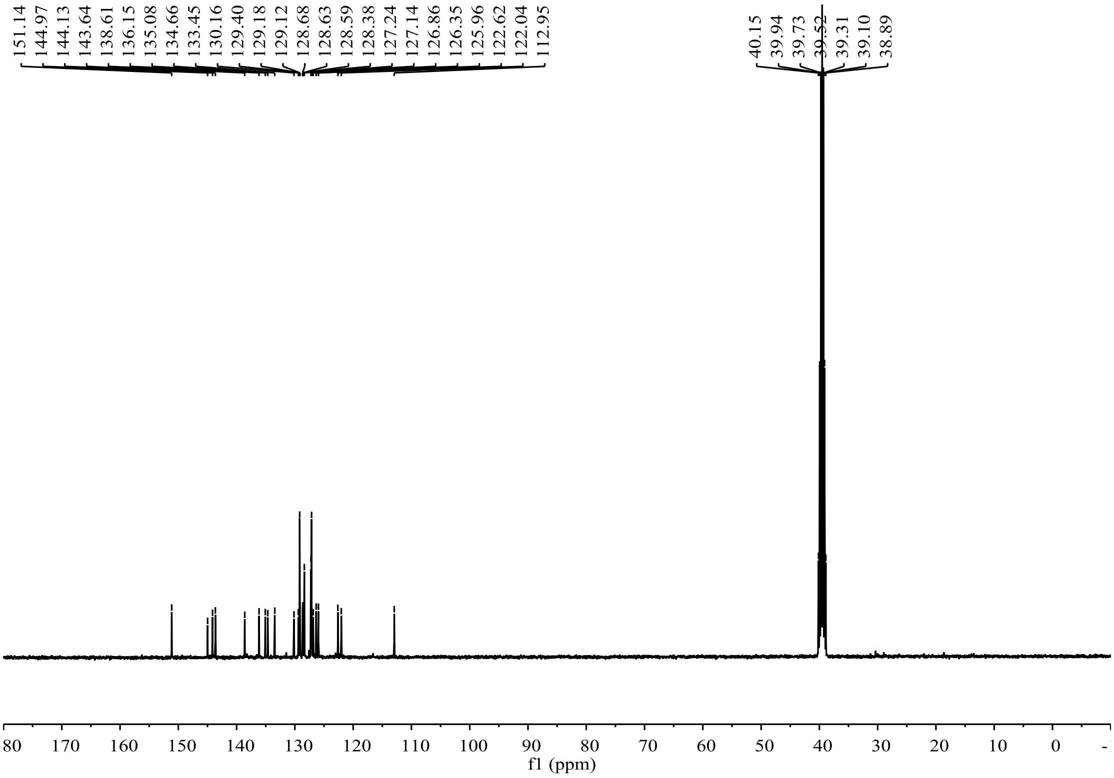
Compound 27


10.44
9.06
9.05
8.35
8.33
8.18
7.87
7.85
7.81
7.81
7.80
7.79
7.67
7.65
7.63
7.60
7.59
7.58
7.57
7.40
7.38
7.36
7.33
7.24
7.22
7.18
7.18
7.17
2.15
Ac
N
H
O
S
O
N
N
Ph
1.00
1.02
1.05
1.03
1.08
2.12
2.20
1.18
1.20
1.08
1.44
3.18
3.09
f1 (ppm)

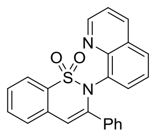

169.10
151.20
145.00
143.63
142.84
136.13
135.09
134.74
133.81
129.33
129.02
128.69
128.41
128.29
127.33
125.95
125.83
123.12
122.01
118.80
117.02
113.09
40.15
39.94
39.73
39.31
39.10
38.89
24.18
f1 (ppm)

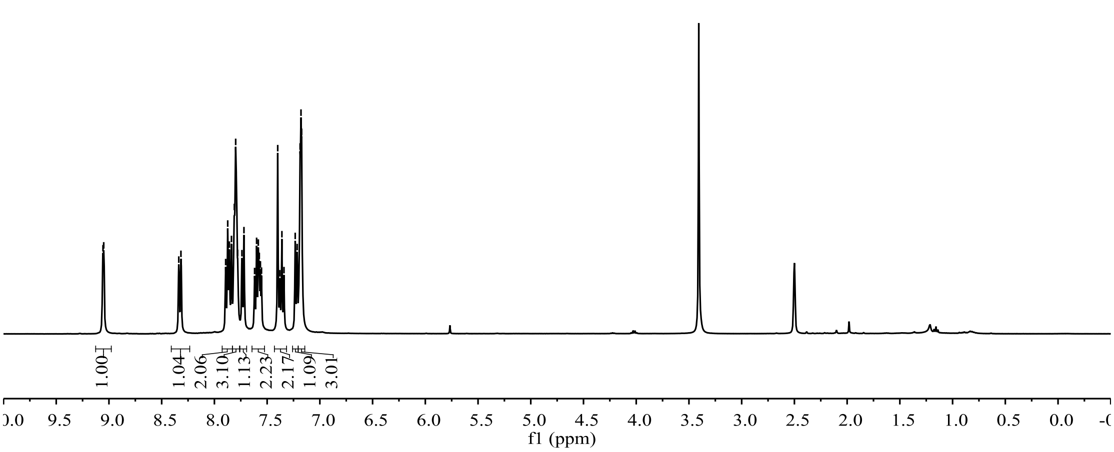
Compound 28

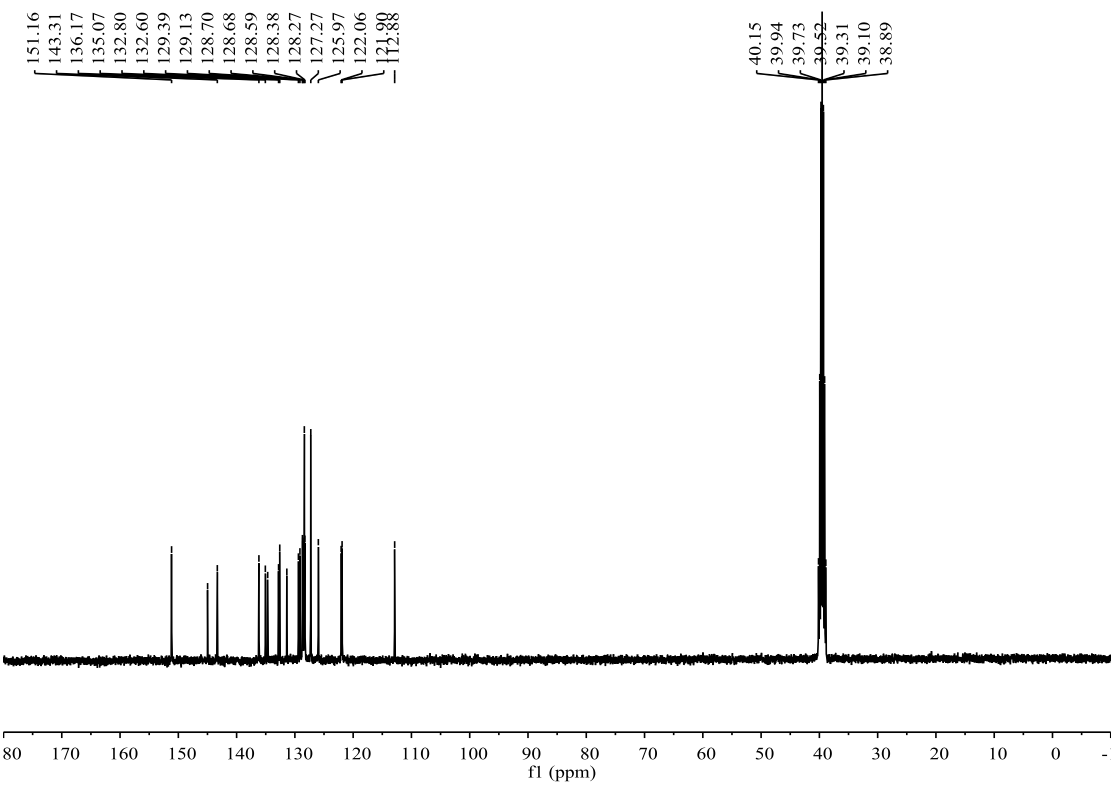

9.07 9.07 9.06 9.05 8.36 8.34 8.20 8.20 7.90 7.90 7.88 7.88 7.87 7.87 7.84 7.82 7.81 7.80 7.79 7.78 7.78 7.60 7.59 7.58 7.57 7.55 7.51 7.49 7.46 7.41 7.39 7.37 7.29 7.27 7.21 7.20 7.19
O O
S
N
N
Ph
Ph
1.00
1.07 1.02 2.22 5.34 3.25 1.23 1.35 1.26 1.05 2.99
f1 (ppm)


151.14 144.97 144.13 143.64 138.61 136.15 135.08 134.66 133.45 130.16 129.40 129.18 129.12 128.68 128.63 128.59 128.38 127.24 127.14 126.86 126.35 125.96 122.62 122.04 112.95
40.15 39.94 39.73 39.52 39.31 39.10 38.89
f1 (ppm)

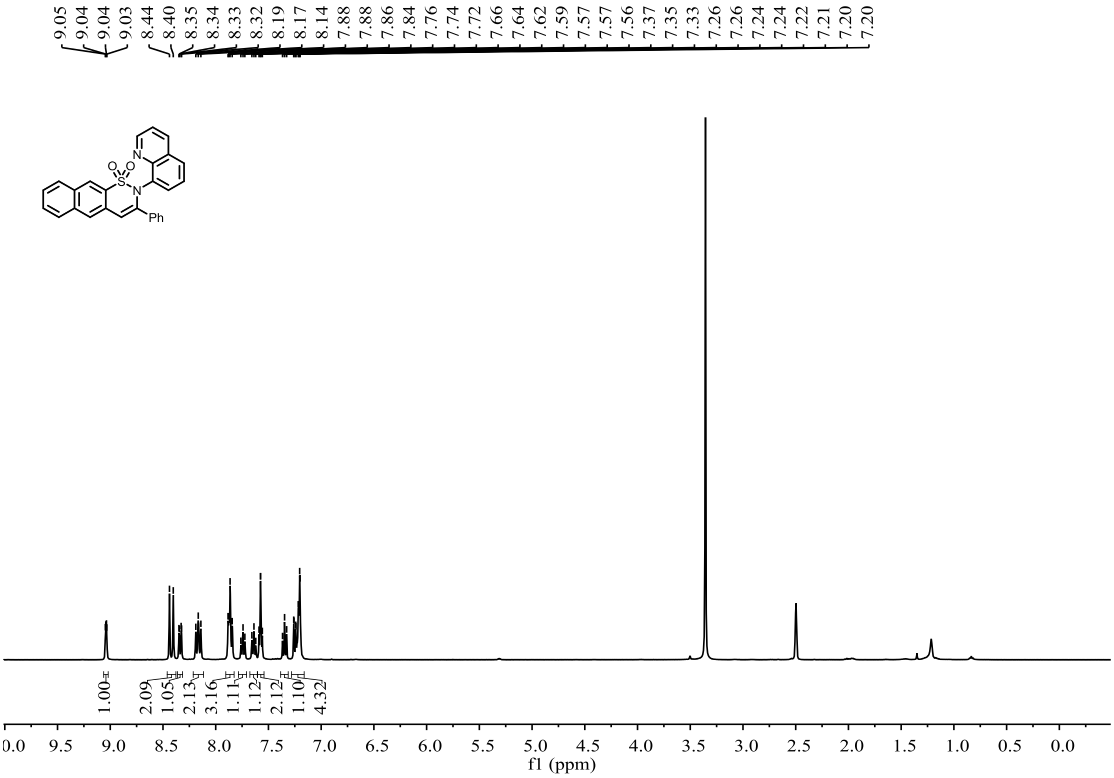
Compound 29

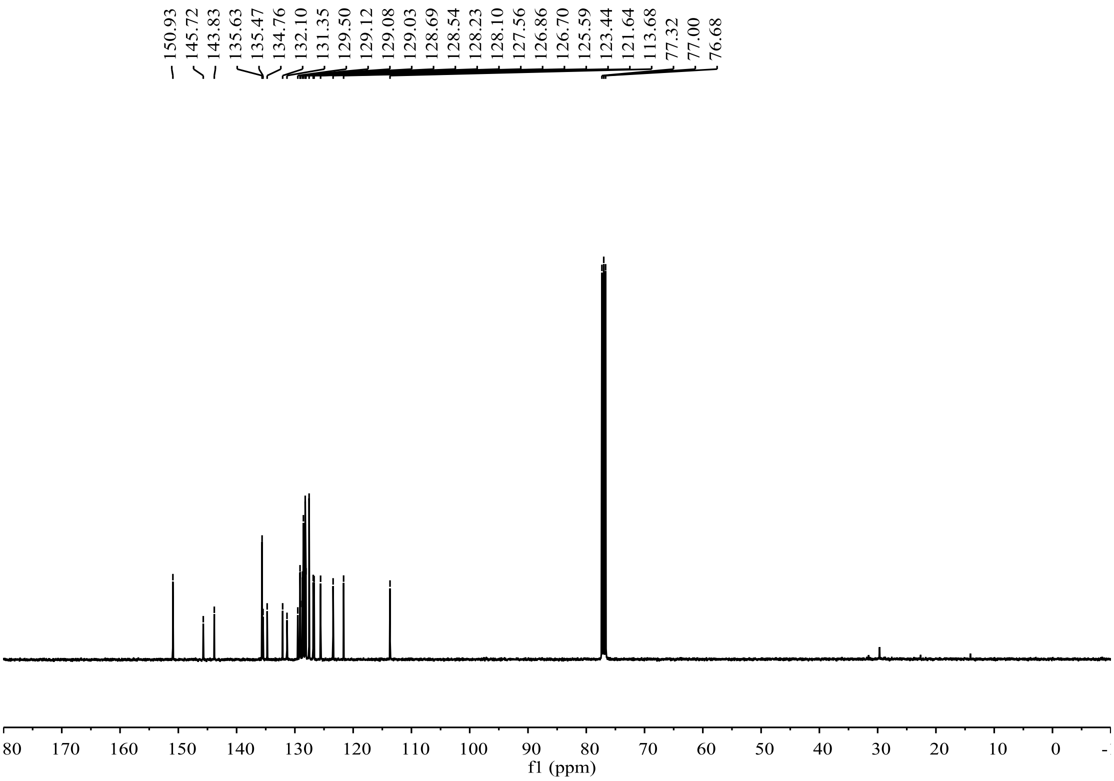



9.06
9.05
8.34
8.32
7.89
7.87
7.86
7.84
7.81
7.80
7.78
7.74
7.72
7.62
7.60
7.58
7.57
7.56
7.55
7.40
7.38
7.36
7.34
7.23
7.22
7.19
7.18
7.17
1.00
1.04
2.06
3.10
1.13
2.23
2.17
1.09
3.01
f1 (ppm)

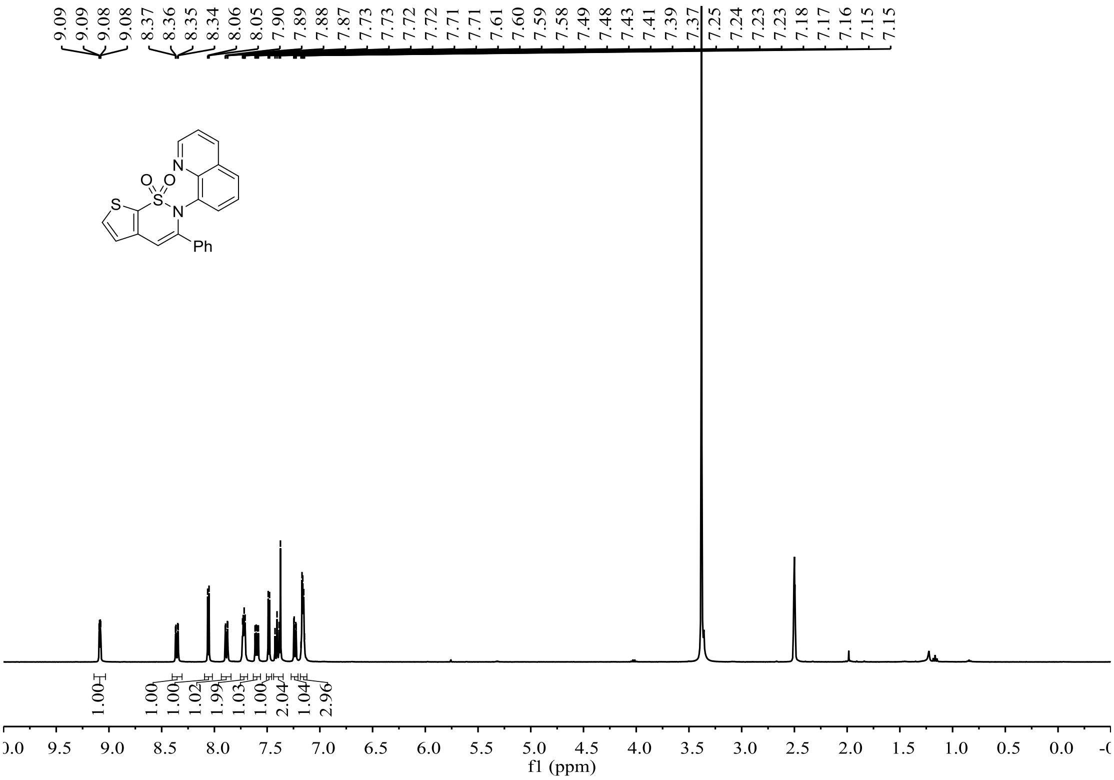

151.16
143.31
136.17
135.07
132.80
132.60
129.39
129.13
128.70
128.68
128.59
128.38
128.27
127.27
125.97
122.06
121.90
112.88
40.15
39.94
39.73
39.52
39.31
39.10
38.89
f1 (ppm)

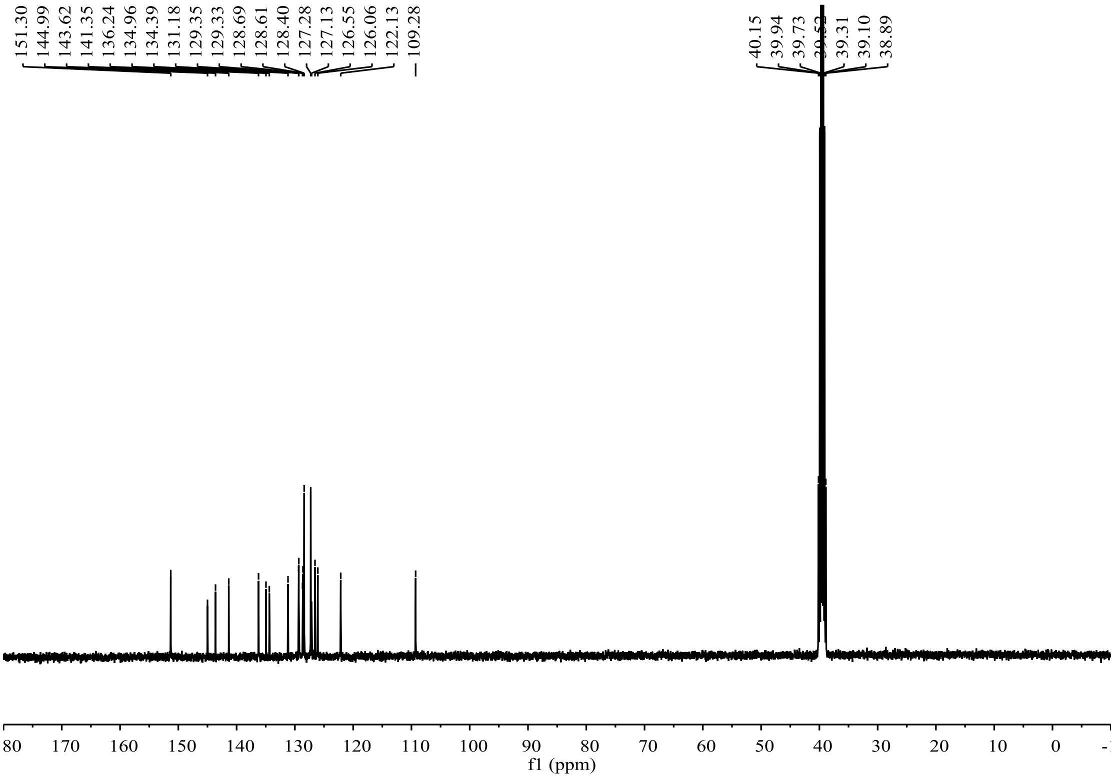
Compound 30


9.05
9.04
9.04
9.03
8.44
8.40
8.35
8.34
8.33
8.32
8.19
8.17
8.14
7.88
7.88
7.86
7.84
7.76
7.74
7.72
7.66
7.64
7.62
7.59
7.57
7.57
7.56
7.37
7.35
7.33
7.26
7.26
7.24
7.24
7.22
7.21
7.20
7.20
N
O
O
S
N
Ph
1.00
2.09
1.05
2.13
3.16
1.11
1.12
2.12
1.10
4.32
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


150.93
145.72
143.83
135.63
135.47
134.76
132.10
131.35
129.50
129.12
129.08
129.03
128.69
128.54
128.23
128.10
127.56
126.86
126.70
125.59
123.44
121.64
113.68
77.32
77.00
76.68
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Compound 31


9.09
9.09
9.08
9.08
8.37
8.36
8.35
8.34
8.06
8.05
7.90
7.89
7.88
7.87
7.73
7.73
7.72
7.72
7.71
7.71
7.61
7.60
7.59
7.58
7.49
7.48
7.43
7.41
7.39
7.37
7.25
7.24
7.23
7.23
7.18
7.17
7.16
7.15
7.15
S
O
O
N
N
Ph
1.00
1.00
1.00
1.02
1.99
1.03
1.00
2.04
1.04
2.96
f1 (ppm)


151.30
144.99
143.62
141.35
136.24
134.96
134.39
131.18
129.35
129.33
128.69
128.61
128.40
127.28
127.13
126.55
126.06
122.13
109.28
40.15
39.94
39.73
39.52
39.31
39.10
38.89
f1 (ppm)