Supporting Information

for

Two Reaction Modes of 1-Sulfonyl-1,2,3-triazoles and Pyridinium 1,4-Zwitterionic Thiolates: Catalyst-Free Synthesis of Pyrido[1,2-*a*]pyrazine Derivatives and 1,4-Thiazine Derivatives

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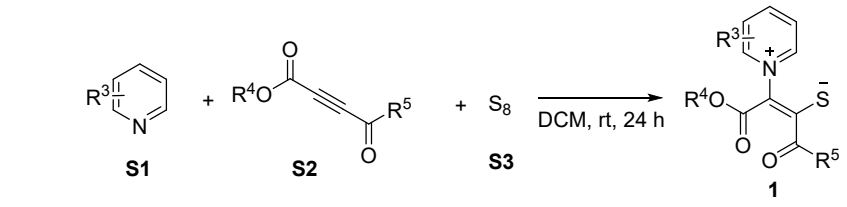
1 General information

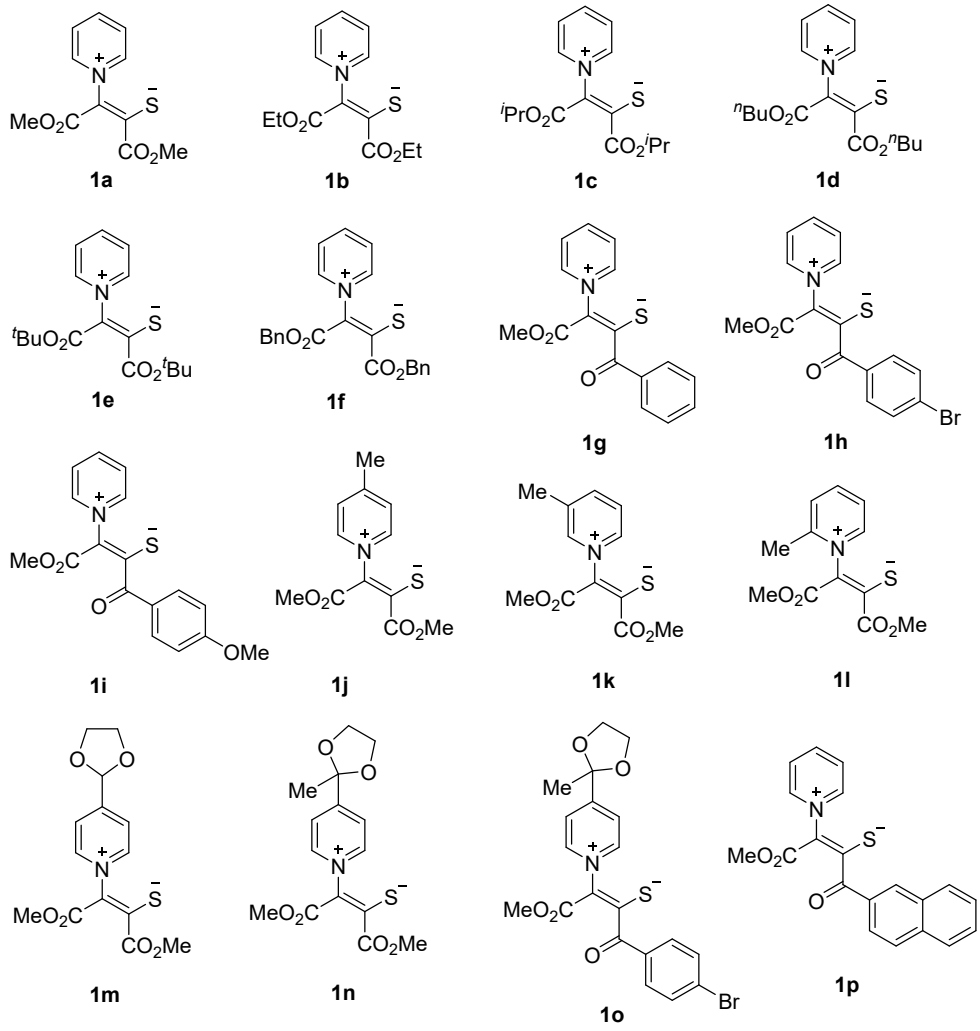
All reactions were conducted in oven-dried glassware under an inert atmosphere of dry nitrogen unless otherwise noted. All commercial reagents were used without further purification unless otherwise noted. All solvents were freshly distilled prior to use in synthesis unless otherwise noted. Analytical thin layer chromatography (TLC) was performed using silica gel HSGF254 pre-coated plates. Flash column chromatography was performed using silica gel (200-300 mesh). ^{1}H, ^{13}C NMR spectra were measured on Brucker Avance IIDMX 400MHz spectrometers (400 MHz for ^{1}H NMR, 101 MHz for ^{13}C NMR). Chemical shifts are reported as δ values relative to internal tetramethylsilane (TMS: 0.00 ppm) or deuterated solvent (chloroform-d: 7.26 ppm, 77.16 ppm; DMSO-d_6:2.50 ppm, 39.52 ppm; Acetone-d_6: 2.05 ppm, 206.26 ppm; Methanol-d_4: 3.31 ppm, 49.00 ppm). Abbreviations for signal couplings are as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet and br, broad. Coupling constants (*J*) were taken from the spectra directly and are uncorrected. Melting points are uncorrected. High resolution mass spectra (HRMS) were recorded on a Waters TOFMS GCT Premier using ESI ionization.

2 Preparation of pyridinium 1,4-zwitterionic thiolates

All pyridinium 1,4-zwitterionic thiolates were synthesized according to known procedure.[1,2]



S1 S2 S3 1



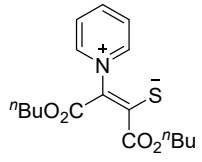
1a 1b 1c 1d 1e 1f 1g 1h 1i 1j 1k 1l 1m 1n 1o 1p

Typical procedure (1a):[1,2]

To a solution of pyridine (0.83 mL, 10.0 mmol) and S_8 (321 mg, 1.25 mmol) in DCM (50 mL) was added dimethyl acetylenedicarboxylate (1.2 mL, 10.0 mmol) dropwise at 0 °C. The mixture was stirred for 24 h at room temperature. Then, the mixture was filtered and the precipitate was washed with Et_2O (2 × 30 mL) to afford pure product **1a** as a yellow powder.

The ^{1}H NMR spectra of **1a**,[1] **1b**,[1] **1c**,[3] **1e**,[1] **1g**,[4] **1h**,[5] **1i**,[5] **1j**,[1] **1m**[3] and **1n**[3] were consistent with references.

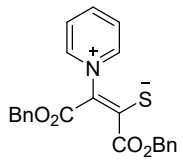
The spectral data of compounds **1d**, **1f**, **1k**, **1l**, **1o** and **1p** were shown below.



1d

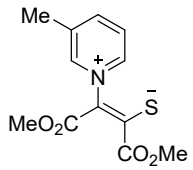
(*Z*)-1,4-Dibutoxy-1,4-dioxo-3-(pyridin-1-ium-1-yl)but-2-ene-2-thiolate (**1d**): yellow solid, m.p. 109 – 110 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (d, *J* = 6.1 Hz, 2H), 8.50 – 8.42 (m, 1H), 8.08 – 7.99 (m, 2H), 4.35 – 4.26 (m, 2H), 4.16 – 4.07 (m, 2H), 1.83 – 1.72 (m, 2H), 1.62 – 1.52 (m, 2H), 1.52 – 1.42 (m, 2H), 1.37 – 1.24 (m, 2H), 1.01 – 0.93 (m, 3H), 0.92 – 0.84

(m, 3H) ; ^{13}C NMR (101 MHz, $CDCl_3$) δ 178.78, 169.29, 160.06, 148.08, 144.92, 127.29, 125.33, 65.64, 64.82, 30.54, 30.37, 19.02, 18.90, 13.68, 13.55 ; ESI-HRMS *m/z* calcd for $C_{17}H_{24}NO_4S^+$ $[M + H]^+$ 338.1421, found 338.1429.



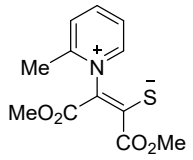
1f

(*Z*)-1,4-Bis(benzyloxy)-1,4-dioxo-3-(pyridin-1-ium-1-yl)but-2-ene-2-thiolate (**1f**): yellow solid, m.p. 147 – 148 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54 – 8.44 (m, 2H), 8.28 – 8.18 (m, 1H), 7.91 – 7.81 (m, 2H), 7.38 – 7.23 (m, 10H), 5.07 (s, 2H), 5.03 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.53, 168.89, 160.13, 148.31, 144.79, 135.72, 135.69, 128.65, 128.58, 128.48, 128.45, 128.19, 127.27, 125.38, 67.46, 67.09 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{23}H_{20}NO_4S^+$ $[M + H]^+$ 406.1108, found 406.1115.



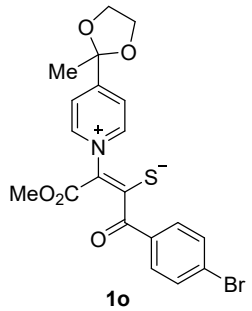
1k

(*Z*)-1,4-Dimethoxy-3-(3-methylpyridin-1-ium-1-yl)-1,4-dioxobut-2-ene-2-thiolate (**1k**): yellow solid, m.p. 153 – 154 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.38 – 8.29 (m, 2H), 7.87 (d, *J* = 8.0 Hz, 1H), 7.85 – 7.78 (m, 1H), 3.92 (s, 3H), 3.71 (s, 3H), 2.72 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.76, 169.71, 160.59, 158.69, 148.78, 144.99, 129.20, 125.51, 123.33, 52.91, 52.13, 20.02; ESI-HRMS *m/z* calcd for $C_{12}H_{14}NO_4S^+$ $[M + H]^+$ 268.0638, found 268.0645.



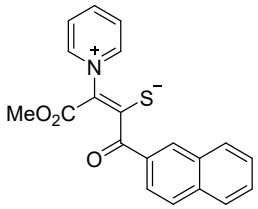
1l

(*Z*)-1,4-Dimethoxy-3-(2-methylpyridin-1-ium-1-yl)-1,4-dioxobut-2-ene-2-thiolate (**1l**): yellow solid, m.p. 184 – 185 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 – 8.38 (m, 2H), 8.20 (d, *J* = 8.0 Hz, 1H), 7.90 – 7.84 (m, 1H), 3.93 (s, 3H), 3.73 (s, 3H), 2.59 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 179.91, 169.71, 160.76, 148.11, 145.66, 145.33, 138.59, 126.76, 125.30, 53.02, 52.26, 18.78; ESI-HRMS *m/z* calcd for $C_{12}H_{14}NO_4S^+$ $[M + H]^+$ 268.0638, found 268.0647.



1o

(Z)-1-(4-bromophenyl)-4-methoxy-3-(4-(2-methyl-1,3-dioxolan-2-yl)pyridin-1-ium-1-yl)-1,4-dioxobut-2-ene-2-thiolate (**1l**): yellow solid, m.p. 119 – 120 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 – 8.67 (m, 2H), 8.07 – 8.01 (m, 2H), 7.96 – 7.90 (m, 2H), 7.61 – 7.54 (m, 2H), 4.22 – 4.11 (m, 2H), 3.93 – 3.82 (m, 2H), 3.52 (s, 3H), 1.72 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 190.75, 187.13, 162.24, 161.07, 148.22, 134.44, 131.70, 131.15, 127.53, 125.44, 123.88, 107.21, 65.60, 51.93, 26.94 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{20}H_{19}BrNO_5S^+$ $[M + H]^+$ 464.0162, found 464.0168.

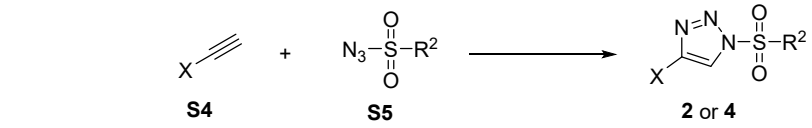


1p

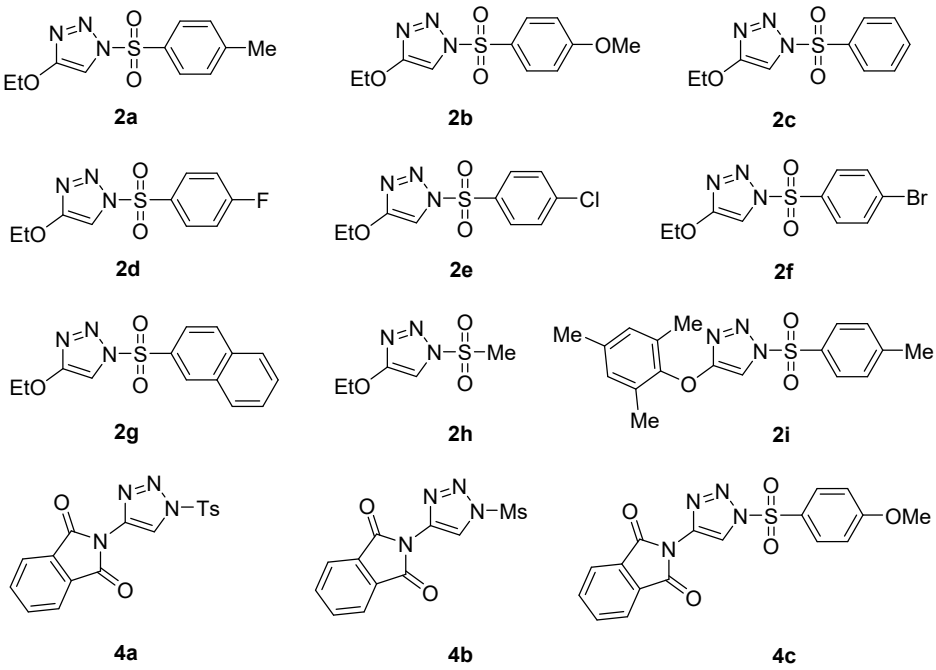
(Z)-4-methoxy-1-(naphthalen-2-yl)-1,4-dioxo-3-(pyridin-1-ium-1-yl)but-2-ene-2-thiolate (**1l**): yellow solid, m.p. 179 – 180 °C; ^{1}H NMR (400 MHz, DMSO-d6) δ 18.98 (d, *J* = 5.9 Hz, 2H), 18.53 – 18.46 (m, 1H), 18.38 (s, 1H), 18.09 – 18.02 (m, 2H), 17.98 – 17.93 (m, 1H), 17.89 – 17.84 (m, 1H), 17.83 – 17.77 (m, 2H), 17.49 – 17.38 (m, 2H), 13.20 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d6) δ 190.80, 186.00, 160.30, 148.84, 145.97, 134.78, 132.97, 132.23, 130.41, 129.46, 128.09, 127.82, 127.69, 127.62, 126.53, 125.33, 125.01, 51.16; ESI-HRMS *m/z* calcd for $C_{20}H_{16}NO_3S^+$ $[M + H]^+$ 350.0845, found 350.0845.

3 Preparation of triazoles

All triazoles were synthesized according to known procedure.[6-10]



S4 S5 2 or 4



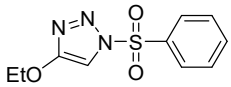
2a 2b 2c 2d 2e 2f 2g 2h 2i 4a 4b 4c

Typical procedure (2a):[6- 10]

To a stirring solution of ethyl ethynyl ether (2.0 mmol) in toluene (10 mL), copper(I) thiophene-2-carboxylate (19 mg, 0.10 mmol) was added at room temperature. After stirring for 2-4 minutes, a solution of tosyl azide (1.2 equiv) in ethyl acetate was added dropwise to the resulting mixture. The reaction media was then stirred at room temperature for 12 hrs. Once the starting alkyne had been completely consumed as judged by TLC analysis, the mixture was concentrated under reduced pressure, and filtered through a short plug of silica to remove copper catalyst (ethyl acetate as eluent). After removal of solvent under reduced pressure, an off-white solid was triturated with ether (x3) to afford the desired triazole.

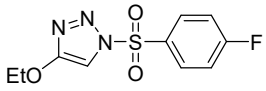
The ^{1}H NMR spectra of **2a**,[6] **2b**,[6] **2h**,[7] **4a**,[8] **4b**[9] and **4c**[10] were consistent with references.

The spectral data of compounds **2c**, **2d**, **2e**, **2f**, **2g** and **2i** were shown below.



2c

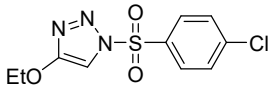
4-Ethoxy-1-(phenylsulfonyl)-1*H*-1,2,3-triazole (**2c**): white solid, m.p. 69 – 70 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11 – 8.03 (m, 2H), 7.70 (t, *J* = 7.6 Hz, 1H), 7.57 (t, *J* = 7.8 Hz, 2H), 7.52 (s, 1H), 4.23 (q, *J* = 7.0 Hz, 2H), 1.38 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.30, 136.19, 135.68, 129.88, 128.59, 105.04, 67.21, 14.71; ESI-HRMS *m/z* calcd for $C_{10}H_{12}N_3O_3S^+$ $[M + H]^+$ 254.0594, found 254.0598.



2d

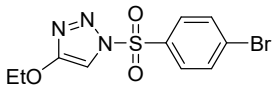
4-Ethoxy-1-((4-fluorophenyl)sulfonyl)-1*H*-1,2,3-triazole (**2d**): white solid, m.p. 86 – 87 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 – 8.10 (m, 2H), 7.55 (s, 1H), 7.33 – 7.24 (m, 2H), 4.26 (q, *J* = 7.0 Hz, 2H), 1.40 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.91 (d, *J* = 261.2 Hz), 160.31, 132.04 (d, *J* = 3.1 Hz), 131.80 (d, *J* = 10.2 Hz), 117.42 (d, *J* = 23.2 Hz),

104.95, 67.23, 14.69; ESI-HRMS *m/z* calcd for $C_{10}H_{11}FN_3O_3S^+$ $[M + H]^+$ 272.0500, found 272.0502.



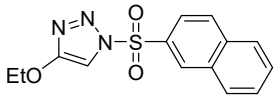
2e

1-((4-Chlorophenyl)sulfonyl)-4-ethoxy-1*H*-1,2,3-triazole (**2e**): white solid, m.p. 92 – 93 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 – 8.01 (m, 2H), 7.58 – 7.55 (m, 2H), 7.53 (s, 1H), 4.26 (q, *J* = 7.1 Hz, 2H), 1.40 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.32, 142.75, 134.50, 130.27, 130.04, 104.97, 67.24, 14.72; ESI-HRMS *m/z* calcd for $C_{10}H_{11}ClN_3O_3S^+$ $[M + H]^+$ 288.0204, found 288.0207.



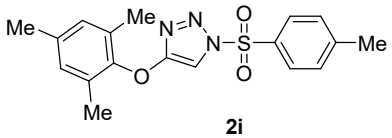
2f

1-((4-Bromophenyl)sulfonyl)-4-ethoxy-1*H*-1,2,3-triazole (**2f**): white solid, m.p. 93 – 94 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 – 7.92 (m, 2H), 7.78 – 7.70 (m, 2H), 7.54 (s, 1H), 4.34 – 4.18 (m, 2H), 1.47 – 1.34 (m, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.35, 135.05, 133.29, 131.49, 130.00, 104.99, 67.27, 14.76; ESI-HRMS *m/z* calcd for $C_{10}H_{11}BrN_3O_3S^+$ $[M + H]^+$ 331.9699, found 331.9706.



2g

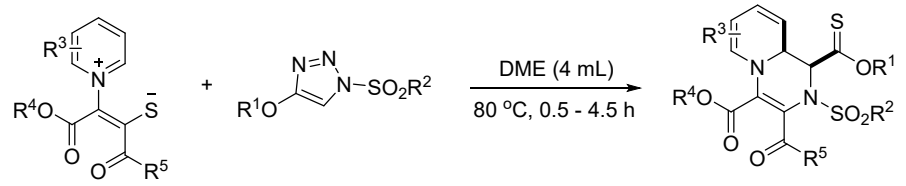
4-Ethoxy-1-(naphthalen-2-ylsulfonyl)-1*H*-1,2,3-triazole (**2g**): white solid, m.p. 70 – 71 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.04 – 7.94 (m, 3H), 7.94 – 7.88 (m, 1H), 7.75 – 7.62 (m, 2H), 7.62 – 7.56 (m, 1H), 4.29 – 4.19 (m, 2H), 1.43 – 1.33 (m, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.29, 136.06, 132.81, 131.96, 131.20, 130.58, 130.36, 129.87, 128.40, 128.20, 122.26, 105.09, 67.18, 14.74; ESI-HRMS *m/z* calcd for $C_{14}H_{14}N_3O_3S^+$ $[M + H]^+$ 304.0750, found 304.0752.



2i

4-(Mesityloxy)-1-tosyl-1*H*-1,2,3-triazole (**2i**): white solid, m.p. 130 – 131 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 – 7.90 (m, 2H), 7.37 (d, *J* = 8.2 Hz, 2H), 7.25 (s, 1H), 6.88 (s, 2H), 2.45 (s, 3H), 2.27 (s, 3H), 2.09 (s, 6H); ^{13}C NMR (101 MHz, Acetone-d6) δ 160.70, 150.72, 148.75, 136.32, 134.03, 131.62, 130.71, 129.39, 107.44, 21.79, 20.85, 16.19 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{18}H_{20}N_3O_3S^+$ $[M + H]^+$ 358.1220, found 358.1220.

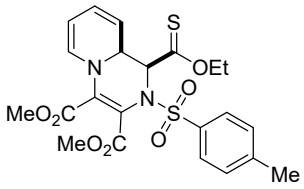
4 General procedure for synthesis of pyrido[1,2-*a*]pyrazine



1 0.20 mmol + **2** 0.40 mmol → **3**

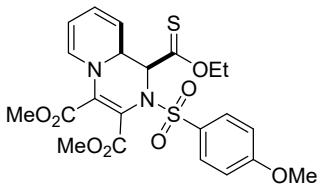
Typical procedure (3aa):

The mixture of **1a** (50.7 mg, 0.20 mmol) and **2a** (106.9 mg, 0.40 mmol) in anhydrous DME (4 mL) was stirred at 80 °C under N_2 for 2 hrs. After completed, the solvent was evaporated in vacuo and the residual was purified by silica gel column chromatography (PE : EA = 6 : 1 to 4 : 1) to give the desired product **3aa** (68.9 mg, 70% yield) as yellow thick oil.



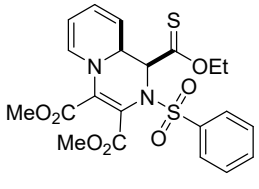
3aa

Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-tosyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3aa**): The reaction time was 2 hrs. Yellow thick oil; 68.9 mg, 70% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.79 (m, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 6.02 (d, *J* = 7.7 Hz, 1H), 5.91 – 5.84 (m, 1H), 5.41 – 5.35 (m, 1H), 4.91 – 4.82 (m, 2H), 4.40 – 4.28 (m, 2H), 4.08 – 4.03 (m, 1H), 3.88 (s, 3H), 3.81 (s, 3H), 2.44 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.32, 165.25, 163.59, 145.00, 134.05, 130.13, 130.01, 128.34, 127.38, 122.30, 116.78, 107.97, 100.46, 69.11, 61.87, 57.42, 53.34, 52.55, 21.85, 13.34; ESI-HRMS *m/z* calcd for $C_{22}H_{25}N_2O_7S_2^+$ $[M + H]^+$ 493.1098, found 493.1104.



3ab

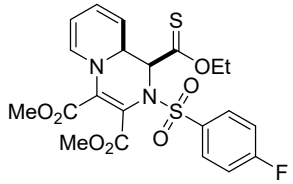
Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-((4-methoxyphenyl)sulfonyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ab**): The reaction time was 4 hrs. Yellow thick oil; 64.1 mg, 63% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.84 (m, 2H), 7.03 – 6.96 (m, 2H), 6.03 (d, *J* = 7.7 Hz, 1H), 5.92 – 5.85 (m, 1H), 5.42 – 5.36 (m, 1H), 4.90 – 4.84 (m, 1H), 4.82 (d, *J* = 3.8 Hz, 1H), 4.41 – 4.28 (m, 2H), 4.11 – 4.05 (m, 1H), 3.89 – 3.87 (m, 6H), 3.82 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.44, 165.32, 163.90, 163.62, 130.67, 130.01, 128.36, 127.44, 122.33, 116.80, 114.56, 108.11, 100.42, 69.09, 61.91, 57.41, 55.81, 53.30, 52.55, 13.33; ESI-HRMS *m/z* calcd for $C_{22}H_{25}N_2O_8S_2^+$ $[M + H]^+$ 509.1047, found 509.1057.



3ac

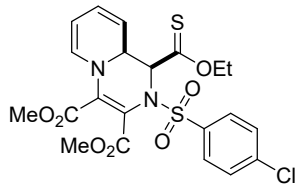
Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-(phenylsulfonyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ac**): The reaction time was 1.5 hrs. Yellow thick oil; 65.1 mg, 68% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 – 7.94 (m, 2H), 7.67 – 7.60 (m, 1H), 7.59 – 7.52 (m, 2H), 6.03 (d, *J* = 7.7 Hz, 1H), 5.92 – 5.84 (m, 1H), 5.43 – 5.36 (m, 1H), 4.92 – 4.85 (m, 2H), 4.39 – 4.29 (m, 2H), 4.18 – 4.11 (m, 1H), 3.89 (s, 3H), 3.80 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101

MHz, $CDCl_3$) δ 209.26, 165.14, 163.57, 137.31, 133.90, 130.53, 129.34, 128.31, 127.30, 122.34, 116.78, 107.42, 100.70, 69.14, 61.76, 57.63, 53.35, 52.52, 13.34; ESI-HRMS *m/z* calcd for $C_{21}H_{23}N_2O_7S_2^+$ $[M + H]^+$ 479.0941, found 479.0944.



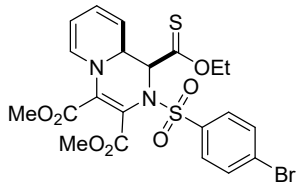
3ad

Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-((4-fluorophenyl)sulfonyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ad**): The reaction time was 1 h. Yellow thick oil; 65.5 mg, 66% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 – 8.00 (m, 2H), 7.26 – 7.17 (m, 2H), 6.05 (d, *J* = 7.7 Hz, 1H), 5.94 – 5.87 (m, 1H), 5.47 – 5.41 (m, 1H), 4.95 – 4.90 (m, 1H), 4.86 (d, *J* = 3.8 Hz, 1H), 4.39 – 4.30 (m, 3H), 3.89 (s, 3H), 3.79 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.28, 165.81 (d, *J* = 257.7 Hz), 165.01, 163.54, 133.78 (d, *J* = 3.0 Hz), 131.29 (d, *J* = 9.6 Hz), 131.00, 127.23, 122.42, 116.85, 116.60 (d, *J* = 22.8 Hz), 106.70, 101.00, 69.24, 61.64, 57.97, 53.36, 52.52, 13.35; ESI-HRMS *m/z* calcd for $C_{21}H_{22}FN_2O_7S_2^+$ $[M + H]^+$ 497.0847, found 497.0854.



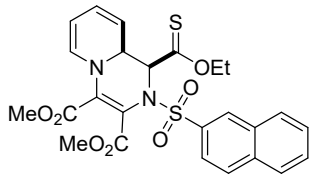
3ae

Dimethyl *cis*-2-((4-chlorophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ae**): The reaction time was 30 min. Yellow thick oil; 69.8 mg, 68% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.92 (m, 2H), 7.55 – 7.48 (m, 2H), 6.05 (d, *J* = 7.7 Hz, 1H), 5.95 – 5.88 (m, 1H), 5.48 – 5.42 (m, 1H), 4.96 – 4.90 (m, 1H), 4.89 (d, *J* = 3.9 Hz, 1H), 4.41 – 4.31 (m, 3H), 3.89 (s, 3H), 3.78 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.19, 164.95, 163.52, 140.49, 136.42, 131.12, 129.78, 129.58, 127.20, 122.42, 116.88, 106.59, 101.07, 69.28, 61.63, 58.11, 53.39, 52.52, 13.35; ESI-HRMS *m/z* calcd for $C_{21}H_{22}ClN_2O_7S_2^+$ $[M + H]^+$ 513.0551, found 513.0559.



3af

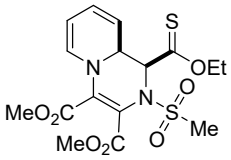
Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3af**): The reaction time was 30 min. Yellow thick oil; 74.7 mg, 67% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.84 (m, 2H), 7.71 – 7.65 (m, 2H), 6.05 (d, *J* = 7.7 Hz, 1H), 5.95 – 5.86 (m, 1H), 5.49 – 5.41 (m, 1H), 4.97 – 4.91 (m, 1H), 4.89 (d, *J* = 3.8 Hz, 1H), 4.41 – 4.31 (m, 3H), 3.89 (s, 3H), 3.78 (s, 3H), 1.26 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.09, 164.87, 163.44, 136.88, 132.51, 131.11, 129.74, 129.03, 127.10, 122.35, 116.82, 106.44, 101.04, 69.23, 61.52, 58.05, 53.35, 52.46, 13.31; ESI-HRMS *m/z* calcd for $C_{21}H_{22}BrN_2O_7S_2^+$ $[M + H]^+$ 557.0046, found 557.0045.



3ag

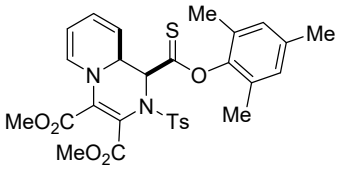
Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-(naphthalen-2-ylsulfonyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-

dicarboxylate (**3ag**): The reaction time was 2 hrs. Yellow thick oil; 72.9 mg, 69% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.03 – 7.95 (m, 3H), 7.92 (d, *J* = 8.0 Hz, 1H), 7.72 – 7.59 (m, 2H), 6.03 (d, *J* = 7.8 Hz, 1H), 5.90 – 5.81 (m, 1H), 5.43 – 5.35 (m, 1H), 5.01 – 4.94 (m, 1H), 4.87 (t, *J* = 6.6 Hz, 1H), 4.37 – 4.26 (m, 2H), 4.26 – 4.19 (m, 1H), 3.90 (s, 3H), 3.81 (s, 3H), 1.22 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.27, 165.21, 163.60, 135.32, 134.27, 132.02, 130.54, 130.11, 129.71, 129.57, 129.52, 128.12, 127.87, 127.30, 122.99, 122.30, 116.83, 107.46, 100.68, 69.13, 61.79, 57.80, 53.37, 52.53, 13.30; ESI-HRMS *m/z* calcd for $C_{25}H_{25}N_2O_7S_2^+$ $[M + H]^+$ 529.1098, found 529.1107.



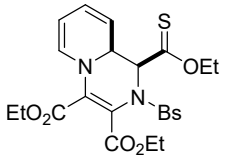
3ah

Dimethyl *cis*-1-(ethoxycarbonothioyl)-2-(methylsulfonyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ah**): The reaction time was 1.5 hrs. Yellow thick oil; 53.3 mg, 64% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.04 (d, *J* = 7.7 Hz, 1H), 5.96 – 5.89 (m, 1H), 5.57 – 5.50 (m, 1H), 5.23 – 5.18 (m, 1H), 4.98 – 4.92 (m, 1H), 4.63 – 4.58 (m, 1H), 4.46 (q, *J* = 7.1 Hz, 2H), 3.88 (s, 3H), 3.78 (s, 3H), 3.27 (s, 3H), 1.33 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 210.68, 164.58, 163.60, 130.48, 127.25, 122.29, 117.10, 107.01, 101.08, 69.45, 61.47, 59.43, 53.29, 52.46, 42.66, 13.43; ESI-HRMS *m/z* calcd for $C_{16}H_{21}N_2O_7S_2^+$ $[M + H]^+$ 417.0785, found 417.0799.



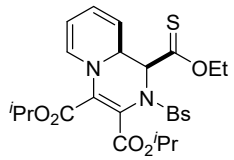
3ai

Dimethyl *cis*-1-((mesityloxy)carbonothioyl)-2-tosyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ai**): The reaction time was 4.5 hrs. Yellow thick oil; 42.0 mg, 36% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 – 7.88 (m, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 6.84 – 6.76 (m, 2H), 6.16 (d, *J* = 7.7 Hz, 1H), 6.00 – 5.91 (m, 1H), 5.62 – 5.54 (m, 1H), 5.17 (d, *J* = 4.3 Hz, 1H), 5.06 – 4.99 (m, 1H), 4.55 – 4.47 (m, 1H), 3.84 (s, 3H), 3.78 (s, 3H), 2.44 (s, 3H), 2.23 (s, 3H), 1.84 (s, 3H), 1.79 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.32, 165.10, 163.58, 149.29, 145.08, 136.02, 134.32, 131.53, 129.91, 129.84, 129.45, 129.32, 129.21, 128.54, 126.63, 122.49, 116.88, 105.31, 101.28, 61.34, 57.67, 53.39, 52.30, 21.82, 20.90, 16.25, 15.86; ESI-HRMS *m/z* calcd for $C_{29}H_{31}N_2O_7S_2^+$ $[M + H]^+$ 583.1567, found 583.1578.



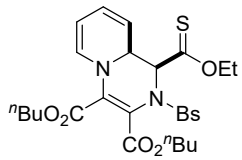
3bf

Diethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3bf**): The reaction time was 30 min. Yellow thick oil; 79.6 mg, 68% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.87 (m, 2H), 7.70 – 7.64 (m, 2H), 6.07 (d, *J* = 7.7 Hz, 1H), 5.95 – 5.87 (m, 1H), 5.49 – 5.41 (m, 1H), 4.96 – 4.88 (m, 1H), 4.87 (d, *J* = 3.8 Hz, 1H), 4.43 – 4.26 (m, 6H), 4.22 – 4.12 (m, 1H), 1.36 (t, *J* = 7.2 Hz, 3H), 1.32 – 1.24 (m, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.10, 164.37, 162.95, 136.84, 132.45, 131.00, 129.80, 128.97, 127.03, 122.32, 116.76, 106.61, 100.73, 69.21, 62.58, 61.64, 61.53, 57.96, 14.09, 13.88, 13.29; ESI-HRMS *m/z* calcd for $C_{23}H_{26}BrN_2O_7S_2^+$ $[M + H]^+$ 585.0359, found 585.0365.



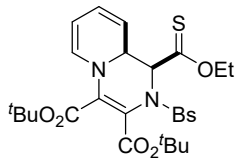
3cf

Diisopropyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3cf**): The reaction time was 10 min. Yellow thick oil; 85.9 mg, 70% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.89 (m, 2H), 7.67 (d, *J* = 9.3 Hz, 2H), 6.06 (d, *J* = 7.8 Hz, 1H), 5.95 – 5.86 (m, 1H), 5.46 – 5.40 (m, 1H), 5.27 – 5.09 (m, 2H), 4.93 – 4.87 (m, 1H), 4.81 (d, *J* = 3.8 Hz, 1H), 4.42 – 4.26 (m, 3H), 1.39 – 1.25 (m, 15H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.22, 163.92, 162.46, 136.89, 132.47, 131.26, 129.90, 128.97, 126.91, 122.35, 116.81, 106.55, 100.57, 70.60, 69.32, 69.25, 61.79, 57.82, 22.11, 21.84, 21.42, 21.35, 13.39; ESI-HRMS *m/z* calcd for $C_{25}H_{30}BrN_2O_7S_2^+$ $[M + H]^+$ 613.0672, found 613.0683.



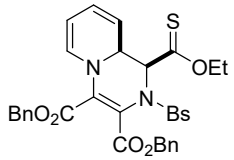
3df

Dibutyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3df**): The reaction time was 10 min. Yellow thick oil; 70.6 mg, 55% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.86 (m, 2H), 7.70 – 7.64 (m, 2H), 6.06 (d, *J* = 7.7 Hz, 1H), 5.94 – 5.87 (m, 1H), 5.48 – 5.40 (m, 1H), 4.94 – 4.88 (m, 1H), 4.86 (d, *J* = 3.8 Hz, 1H), 4.42 – 4.27 (m, 5H), 4.26 – 4.17 (m, 1H), 4.08 – 3.99 (m, 1H), 1.76 – 1.58 (m, 4H), 1.48 – 1.34 (m, 4H), 1.27 (t, *J* = 7.1 Hz, 3H), 1.00 – 0.90 (m, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.16, 164.50, 163.10, 136.89, 132.46, 131.02, 129.81, 128.98, 127.11, 122.36, 116.78, 106.72, 100.70, 69.19, 66.54, 65.50, 61.68, 57.96, 30.54, 30.27, 19.19, 19.16, 13.78, 13.31 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{27}H_{34}BrN_2O_7S_2^+$ $[M + H]^+$ 641.0985, found 641.0981.



3ef

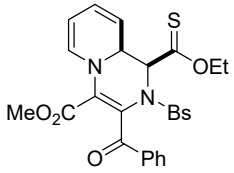
Di-tert-butyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ef**): The reaction time was 20 min. Yellow thick oil; 82.1 mg, 64% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.81 (m, 2H), 7.69 – 7.63 (m, 2H), 6.10 (d, *J* = 7.7 Hz, 1H), 5.92 – 5.84 (m, 1H), 5.40 – 5.32 (m, 1H), 4.89 – 4.82 (m, 1H), 4.73 (d, *J* = 3.8 Hz, 1H), 4.51 – 4.38 (m, 1H), 4.38 – 4.26 (m, 1H), 4.19 – 4.13 (m, 1H), 1.57 (s, 9H), 1.52 (s, 9H), 1.33 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.31, 163.79, 162.04, 136.47, 132.55, 131.63, 129.85, 128.97, 126.96, 122.39, 116.54, 107.13, 99.97, 83.97, 82.07, 69.05, 61.76, 57.12, 28.17, 27.88, 13.55; ESI-HRMS *m/z* calcd for $C_{27}H_{34}BrN_2O_7S_2^+$ $[M + H]^+$ 641.0985, found 641.0977.



3ff

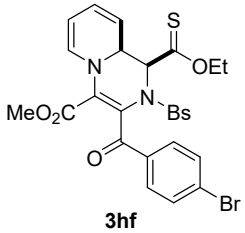
Dibenzyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3ff**): The reaction time was 30 min. Yellow thick oil; 76.6 mg, 54% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ

7.81 – 7.75 (m, 2H), 7.52 – 7.46 (m, 2H), 7.40 – 7.28 (m, 10H), 5.95 (d, *J* = 7.7 Hz, 1H), 5.91 – 5.84 (m, 1H), 5.48 – 5.42 (m, 1H), 5.25 (d, *J* = 12.2 Hz, 1H), 5.08 (s, 2H), 5.03 (d, *J* = 12.2 Hz, 1H), 4.88 – 4.82 (m, 1H), 4.81 (d, *J* = 3.9 Hz, 1H), 4.53 – 4.45 (m, 1H), 4.32 – 4.20 (m, 2H), 1.11 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.09, 164.36, 162.78, 136.81, 135.40, 134.53, 132.35, 131.72, 129.84, 128.93, 128.87, 128.80, 128.71, 128.61, 128.47, 126.82, 122.24, 117.05, 105.62, 101.20, 69.27, 68.39, 67.58, 61.51, 58.19, 13.25 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{33}H_{30}BrN_2O_7S_2^+$ $[M + H]^+$ 709.0672, found 709.0670.



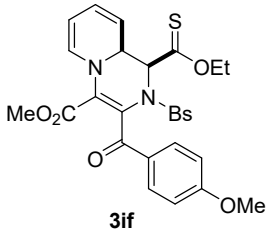
3gf

Methyl *cis*-3-benzoyl-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-4-carboxylate (**3gf**): The reaction time was 30 min. Yellow thick oil; 51.9 mg, 43% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.94 (m, 2H), 7.66 – 7.59 (m, 2H), 7.57 – 7.48 (m, 3H), 7.47 – 7.38 (m, 2H), 6.09 (d, *J* = 7.7 Hz, 1H), 6.00 – 5.91 (m, 1H), 5.43 – 5.35 (m, 1H), 4.95 (d, *J* = 3.4 Hz, 1H), 4.90 – 4.82 (m, 1H), 4.51 – 4.38 (m, 2H), 3.96 (s, 1H), 3.54 (s, 3H), 1.31 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.10, 190.08, 163.41, 138.39, 135.20, 132.73, 132.41, 129.77, 129.48, 129.35, 128.41, 128.30, 123.09, 118.37, 116.06, 99.70, 69.36, 63.69, 57.32, 53.13, 13.50 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{26}H_{24}BrN_2O_6S_2^+$ $[M + H]^+$ 603.0254, found 603.0250.



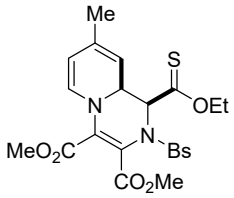
3hf

Methyl *cis*-3-(4-bromobenzoyl)-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-4-carboxylate (**3hf**): The reaction time was 25 min. Orange red solid, m.p. 70 – 71 °C; 73.7 mg, 54% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.5 Hz, 2H), 7.66 (d, *J* = 8.6 Hz, 2H), 7.60 – 7.48 (m, 4H), 6.08 (d, *J* = 7.7 Hz, 1H), 6.00 – 5.91 (m, 1H), 5.40 – 5.30 (m, 1H), 4.98 – 4.91 (m, 1H), 4.91 – 4.82 (m, 1H), 4.53 – 4.39 (m, 2H), 3.76 (s, 1H), 3.60 (s, 3H), 1.32 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.91, 188.97, 163.27, 137.23, 134.74, 132.90, 131.58, 130.84, 129.69, 129.64, 128.61, 128.30, 127.42, 123.10, 118.25, 116.02, 99.91, 69.37, 63.73, 57.06, 53.25, 13.55; ESI-HRMS *m/z* calcd for $C_{26}H_{23}Br_2N_2O_6S_2^+$ $[M + H]^+$ 680.9359, found 680.9343.



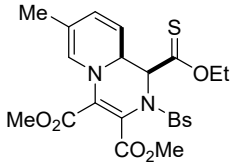
3if

Methyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-3-(4-methoxybenzoyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-4-carboxylate (**3if**): The reaction time was 2 hrs. Yellow thick oil; 71.0 mg, 56% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 – 7.96 (m, 2H), 7.67 – 7.58 (m, 4H), 6.93 – 6.87 (m, 2H), 6.10 – 6.03 (m, 1H), 5.99 – 5.91 (m, 1H), 5.40 – 5.33 (m, 1H), 5.00 (d, *J* = 3.4 Hz, 1H), 4.85 – 4.78 (m, 1H), 4.51 – 4.37 (m, 2H), 3.90 – 3.83 (m, 4H), 3.54 (s, 3H), 1.30 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.26, 188.75, 163.50, 163.17, 135.46, 132.73, 131.59, 131.33, 129.75, 129.38, 128.74, 127.33, 123.19, 119.51, 115.86, 113.60, 99.24, 69.33, 64.14, 57.44, 55.59, 53.07, 13.53; ESI-HRMS *m/z* calcd for $C_{27}H_{26}BrN_2O_7S_2^+$ $[M + H]^+$ 633.0359, found 633.0336.

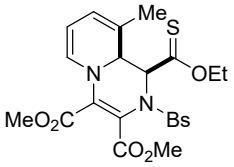


3jf

Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-8-methyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3jf**): The reaction time was 30 min. Yellow thick oil; 40.0 mg, 35% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.82 (m, 2H), 7.70 – 7.63 (m, 2H), 6.01 (d, *J* = 7.8 Hz, 1H), 5.18 – 5.11 (m, 1H), 4.85 (d, *J* = 3.8 Hz, 1H), 4.79 (dd, *J* = 7.8, 1.7 Hz, 1H), 4.40 – 4.27 (m, 2H), 4.27 – 4.22 (m, 1H), 3.89 (s, 3H), 3.77 (s, 3H), 1.71 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.47, 165.01, 163.58, 137.05, 132.56, 130.85, 130.73, 129.79, 129.03, 126.87, 111.95, 107.07, 104.69, 69.07, 61.96, 58.22, 53.35, 52.51, 20.88, 13.34; ESI-HRMS *m/z* calcd for $C_{22}H_{24}BrN_2O_7S_2^+$ $[M + H]^+$ 571.0203, found 571.0200.

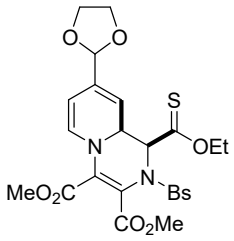


3kf1



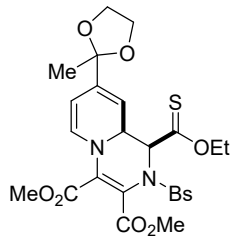
3kf2

Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-7-methyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate(**3kf1**), and Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-9-methyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3kf2**): The reaction time was 30 min. Yellow thick oil; 42.3 mg, 37% yield; ^{1}H NMR (400 MHz, $CDCl_3$; major product) δ 7.88 – 7.83 (m, 2H), 7.72 – 7.67 (m, 2H), 5.89 (d, *J* = 7.7 Hz, 1H), 5.76 – 5.70 (d, *J* = 5.8 Hz, 1H), 5.18 (d, *J* = 2.9 Hz, 1H), 4.84 (dd, *J* = 7.4, 6.3 Hz, 1H), 4.35 – 4.29 (m, 2H), 3.87 (s, 3H), 3.81 (s, 3H), 3.80 – 3.76 (m, 1H), 1.80 (s, 3H), 1.30 – 1.24 (m, 3H); ESI-HRMS *m/z* calcd for $C_{22}H_{24}BrN_2O_7S_2^+$ $[M + H]^+$ 571.0203, found 571.0204. The major product was **3kf2**. For the judging procedure and the explanation, see Page S15.



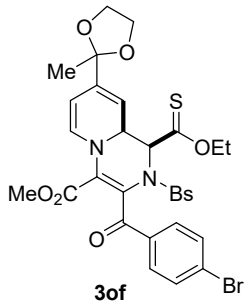
3mf

Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-8-(1,3-dioxolan-2-yl)-1-(ethoxycarbonothioyl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3mf**): The reaction time was 30 min. Yellow thick oil; 78.1 mg, 62% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 – 7.76 (m, 2H), 7.69 – 7.54 (m, 2H), 6.09 – 5.98 (m, 1H), 5.60 – 5.50 (m, 1H), 5.21 – 5.13 (m, 1H), 5.01 – 4.90 (m, 1H), 4.89 – 4.79 (m, 1H), 4.34 – 4.21 (m, 3H), 3.98 – 3.78 (m, 7H), 3.78 – 3.68 (m, 3H), 1.27 – 1.12 (m, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.76, 164.83, 163.33, 136.69, 132.59, 132.25, 130.63, 129.75, 129.16, 128.01, 114.97, 107.25, 102.26, 98.83, 69.33, 65.33, 65.09, 61.68, 57.85, 53.40, 52.56, 13.26; ESI-HRMS *m/z* calcd for $C_{24}H_{26}BrN_2O_9S_2^+$ $[M + H]^+$ 629.0258, found 629.0269.



3nf

Dimethyl *cis*-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-8-(2-methyl-1,3-dioxolan-2-yl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**3nf**): The reaction time was 30 min. Yellow thick oil; 104.3 mg, 81% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.4 Hz, 2H), 7.69 (d, *J* = 8.4 Hz, 2H), 6.08 (d, *J* = 7.9 Hz, 1H), 5.61 – 5.55 (m, 1H), 4.98 (dd, *J* = 7.9, 1.7 Hz, 1H), 4.94 (d, *J* = 3.7 Hz, 1H), 4.35 – 4.25 (m, 3H), 3.97 – 3.91 (m, 2H), 3.89 (s, 3H), 3.87 – 3.82 (m, 1H), 3.79 (s, 3H), 3.73 – 3.66 (m, 1H), 1.42 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 209.40, 164.89, 163.45, 136.66, 135.93, 132.64, 130.38, 129.79, 129.19, 127.80, 111.73, 107.39, 107.29, 99.70, 69.37, 64.79, 64.45, 61.96, 57.99, 53.42, 52.59, 24.50, 13.29; ESI-HRMS *m/z* calcd for $C_{25}H_{28}BrN_2O_9S_2^+$ $[M + H]^+$ 643.0414, found 643.0413.



3of

Methyl *cis*-3-(4-bromobenzoyl)-2-((4-bromophenyl)sulfonyl)-1-(ethoxycarbonothioyl)-8-(2-methyl-1,3-dioxolan-2-yl)-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-4-carboxylate (**3of**): The reaction time was 2 hrs. Red solid, m.p. 63 – 64 °C; 83.0 mg, 54% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 – 7.83 (m, 2H), 7.70 – 7.64 (m, 2H), 7.60 – 7.49 (m, 4H), 6.15 – 6.08 (m, 1H), 5.52 – 5.45 (m, 1H), 5.01 (d, *J* = 3.4 Hz, 1H), 4.93 (dd, *J* = 7.8, 1.7 Hz, 1H), 4.50 – 4.35 (m, 2H), 3.98 – 3.83 (m, 3H), 3.75 – 3.66 (m, 2H), 3.60 (s, 3H), 1.42 (s, 3H), 1.31 (t, *J* = 7.1 Hz, 3H); 13C NMR (101 MHz, CDCl3) δ 209.36, 188.90, 163.26, 137.21, 136.86, 134.70, 133.00, 131.64, 130.78, 129.78, 129.67, 128.84, 128.10, 127.50, 118.89, 110.85, 107.36, 98.85, 69.61, 64.88, 64.48, 64.17, 56.94, 53.25, 24.66, 13.54; ESI-HRMS *m/z* calcd for $C_{30}H_{29}Br_2N_2O_8S_2^+$ $[M + H]^+$ 766.9727, found 766.9724.

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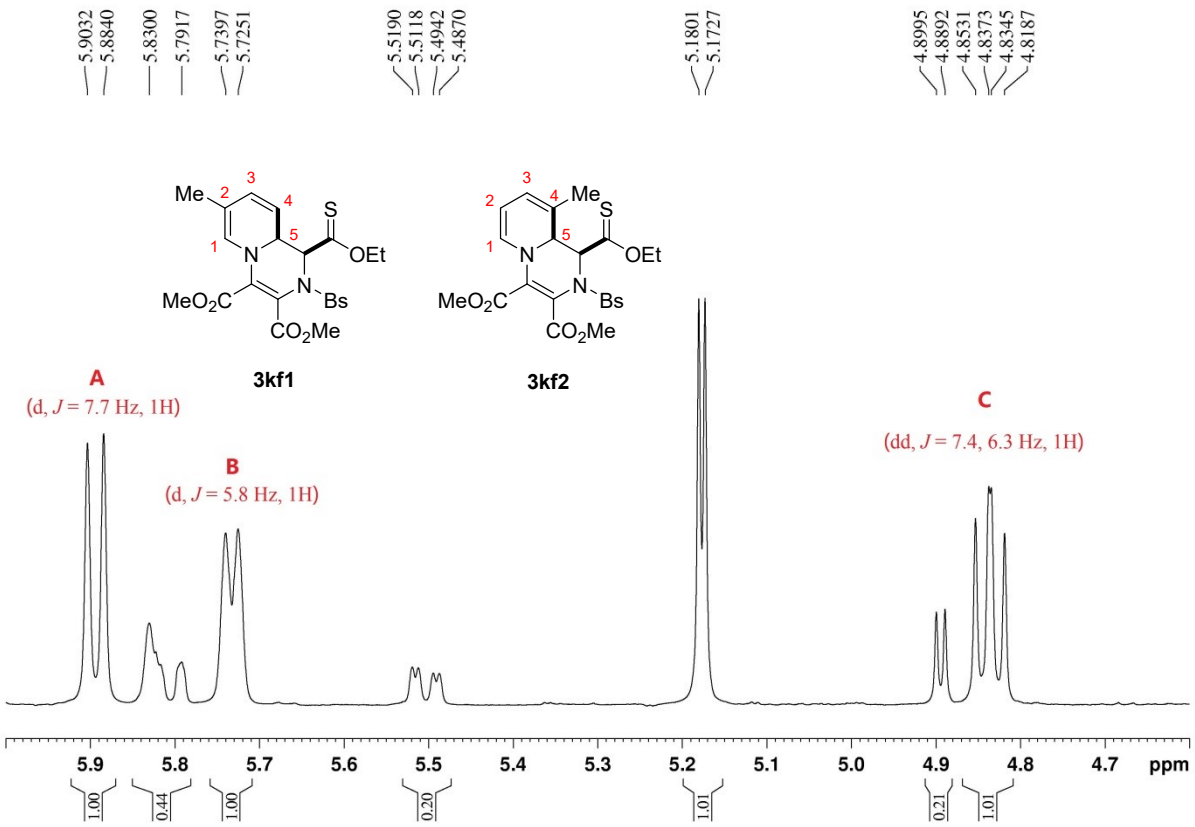
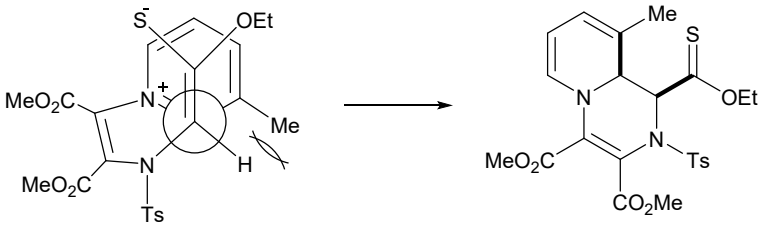
5 The judging procedure of the major product for 3kf and the explanation

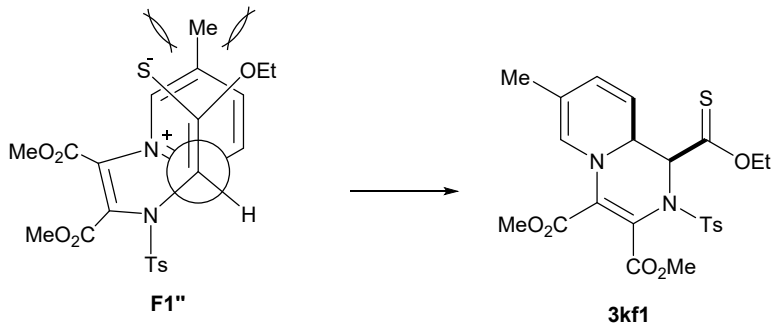
As shown in the local enlarged ^{1}H NMR spectrum of the mixture **3kf**, the major isomer H_A (d, J = 7.6 Hz, 1H)), H_B (d, J = 6.0 Hz, 1H), and H_C (dd, J = 7.2, 6.4 Hz, 1H) belong to the same spin-coupling system. It's obvious that this spin-coupling system was corresponding to the sp2(C-H) of **3kf2**. On the other hand, the H_1 of **3kf1** should be a single peak and this peak pattern was corresponding to the minor isomer.



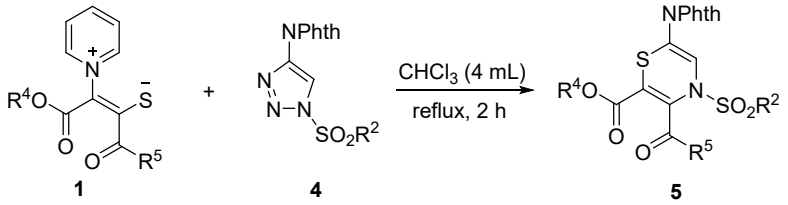
As shown in the proposed mechanism in main text, the intermediate **F1** determined the structures of the final products. For product **3kf**, it is obvious from the Newman projection that the steric hindrance of intermediate **F1'** was less than **F1''**, which led to the formation of **3kf2** as the major product.



VS

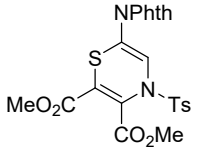


6 General procedure for synthesis of 1,4-thiazine



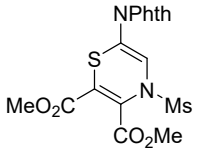
General procedure:

A 15-mL Schlenk-tube was charged with **1** (0.20 mmol), **4** (0.40 mmol) and chloroform (4 mL) under nitrogen, and then the mixture was stirred and heated to reflux for 2 hrs. After completed, the solvent was removed in vacuo, and the residual was purified by silica gel column chromatography with PE/EtOAc as eluent to give compound **5**.



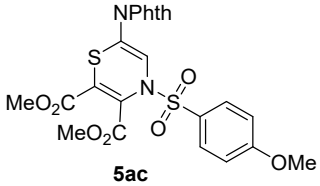
5aa

Dimethyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2,3-dicarboxylate (**5aa**): Yellow solid, m.p. 131 – 132 °C; 83.4 mg, 81% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.87 (m, 4H), 7.83 – 7.78 (m, 2H), 7.41 – 7.35 (m, 2H), 6.79 (s, 1H), 3.93 (s, 3H), 3.77 (s, 3H), 2.49 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.29, 162.55, 161.81, 145.72, 135.19, 134.65, 131.28, 130.23, 128.02, 127.47, 125.78, 124.41, 122.55, 53.57, 53.45, 21.95 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{23}H_{19}N_2O_8S_2^+$ $[M + H]^+$ 515.0577, found 515.0577.



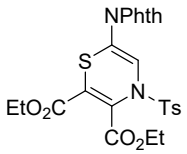
5ab

Dimethyl 6-(1,3-dioxoisoindolin-2-yl)-4-(methylsulfonyl)-4*H*-1,4-thiazine-2,3-dicarboxylate (**5ab**): Yellow solid, m.p. 154 – 155 °C; 61.4 mg, 70% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.91 (m, 2H), 7.86 – 7.80 (m, 2H), 6.85 (s, 1H), 3.87 (s, 3H), 3.81 (s, 3H), 3.30 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.42, 161.86, 161.78, 135.64, 135.31, 131.16, 125.24, 125.06, 124.52, 120.27, 53.63, 53.51, 40.80; ESI-HRMS *m/z* calcd for $C_{17}H_{15}N_2O_8S_2^+$ $[M + H]^+$ 439.0264, found 439.0262.



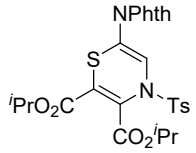
5ac

Dimethyl 6-(1,3-dioxoisoindolin-2-yl)-4-((4-methoxyphenyl)sulfonyl)-4*H*-1,4-thiazine-2,3-dicarboxylate (**5ac**): Yellow solid, m.p. 139 – 140 °C; 76.4 mg, 72% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.88 (m, 4H), 7.84 – 7.78 (m, 2H), 7.08 – 7.02 (m, 2H), 6.77 (s, 1H), 3.93 (s, 3H), 3.92 (s, 3H), 3.77 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.29, 164.67, 162.61, 161.81, 135.19, 134.57, 131.26, 130.30, 128.82, 127.46, 125.89, 124.39, 122.52, 114.82, 55.88, 53.55, 53.43; ESI-HRMS *m/z* calcd for $C_{23}H_{19}N_2O_9S_2^+$ $[M + H]^+$ 531.0526, found 531.0533.



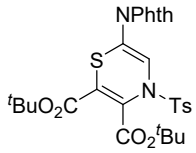
5ba

Diethyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2,3-dicarboxylate (**5ba**): Yellow solid, m.p. 111 – 112 °C; 78.1 mg, 72% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.87 (m, 4H), 7.84 – 7.77 (m, 2H), 7.41 – 7.35 (m, 2H), 6.79 (s, 1H), 4.38 (q, *J* = 7.2 Hz, 2H), 4.21 (q, *J* = 7.1 Hz, 2H), 2.49 (s, 3H), 1.41 (t, *J* = 7.1 Hz, 3H), 1.28 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.33, 162.04, 161.49, 145.62, 135.16, 134.74, 134.56, 131.30, 130.18, 128.04, 127.64, 125.81, 124.39, 122.63, 62.88, 62.85, 22.00, 14.02, 13.89; ESI-HRMS *m/z* calcd for $C_{25}H_{23}N_2O_8S_2^+$ $[M + H]^+$ 543.0890, found 543.0894.



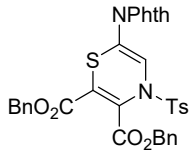
5ca

Diisopropyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2,3-dicarboxylate (**5ca**): Yellow oil; 70.8 mg, 62% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 – 7.87 (m, 4H), 7.84 – 7.77 (m, 2H), 7.41 – 7.34 (m, 2H), 6.78 (s, 1H), 5.21 (hept, *J* = 6.3 Hz, 1H), 5.03 (hept, *J* = 6.3 Hz, 1H), 2.49 (s, 3H), 1.40 (d, *J* = 6.3 Hz, 6H), 1.26 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.35, 161.46, 161.02, 145.51, 135.14, 134.79, 134.44, 131.31, 130.13, 128.06, 125.77, 124.37, 122.76, 71.01, 70.94, 22.01, 21.63, 21.53 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{27}H_{27}N_2O_8S_2^+$ $[M + H]^+$ 571.1203, found 571.1202.



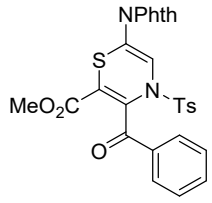
5ea

Di-*tert*-butyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2,3-dicarboxylate (**5ea**): Yellow solid, m.p. 122 – 123 °C; 77.8 mg, 65% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.85 (m, 4H), 7.83 – 7.76 (m, 2H), 7.39 – 7.33 (m, 2H), 6.73 (s, 1H), 2.48 (s, 3H), 1.61 (s, 9H), 1.47 (s, 9H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.36, 160.67, 160.60, 145.32, 135.10, 134.70, 133.45, 131.32, 130.26, 130.00, 128.14, 125.88, 124.33, 123.61, 84.21, 83.77, 27.90, 21.93 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{29}H_{31}N_2O_8S_2^+$ $[M + H]^+$ 599.1516, found 599.1516.



5fa

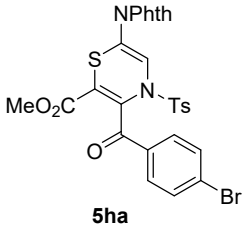
Dibenzyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2,3-dicarboxylate (**5fa**): Yellow oil; 82.7 mg, 62% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.84 (m, 4H), 7.81 – 7.75 (m, 2H), 7.41 – 7.26 (m, 12H), 6.77 (s, 1H), 5.15 (s, 2H), 5.07 (s, 2H), 2.46 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.27, 161.90, 161.22, 145.67, 135.15, 134.90, 134.83, 134.61, 134.43, 131.25, 130.20, 128.90, 128.77, 128.73, 128.66, 128.61, 128.03, 127.11, 125.71, 124.37, 122.30, 68.67, 68.43, 21.93 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{35}H_{27}N_2O_8S_2^+$ $[M + H]^+$ 667.1203, found 667.1194.



5ga

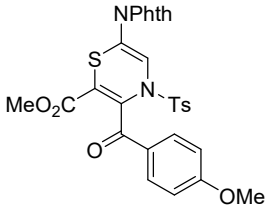
Methyl 3-benzoyl-6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2-carboxylate (**5ga**): Yellow solid, m.p. 84 – 85 °C; 53.8 mg, 48% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 – 7.97 (m, 2H), 7.97 – 7.88 (m, 4H), 7.86 – 7.79 (m, 2H), 7.66

– 7.59 (m, 1H), 7.58 – 7.50 (m, 2H), 7.40 (d, *J* = 8.1 Hz, 2H), 6.89 (s, 1H), 3.53 (s, 3H), 2.50 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 188.10, 165.47, 162.07, 145.77, 142.28, 135.59, 135.23, 135.01, 133.71, 131.33, 130.27, 129.30, 128.92, 127.95, 126.09, 125.53, 124.43, 121.90, 53.20, 21.98; ESI-HRMS *m/z* calcd for $C_{28}H_{21}N_2O_7S_2^+$ $[M + H]^+$ 561.0785, found 561.0787.



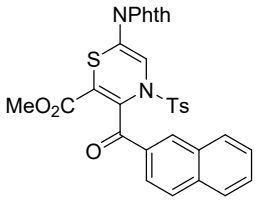
5ha

Methyl 3-(4-bromobenzoyl)-6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2-carboxylate (**5ha**): Yellow solid, m.p. 136 – 137 °C; 49.9 mg, 39% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.91 (m, 2H), 7.91 – 7.80 (m, 6H), 7.71 – 7.65 (m, 2H), 7.43 – 7.38 (m, 2H), 6.88 (s, 1H), 3.57 (s, 3H), 2.50 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 187.14, 165.44, 161.92, 145.90, 141.76, 135.27, 134.86, 134.44, 132.29, 131.32, 130.72, 130.32, 128.92, 127.93, 125.97, 125.84, 124.46, 121.74, 53.32, 21.98; ESI-HRMS *m/z* calcd for $C_{28}H_{19}BrN_2NaO_7S_2^+$ $[M + Na]^+$ 660.9709, found 660.9712.



5ia

Methyl 6-(1,3-dioxoisoindolin-2-yl)-3-(4-methoxybenzoyl)-4-tosyl-4*H*-1,4-thiazine-2-carboxylate (**5ia**): Yellow solid, m.p. 73 – 74 °C; 81.5 mg, 69% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.88 (m, 6H), 7.85 – 7.79 (m, 2H), 7.39 (d, *J* = 8.1 Hz, 2H), 7.04 – 6.99 (m, 2H), 6.90 (s, 1H), 3.90 (s, 3H), 3.54 (s, 3H), 2.49 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 186.66, 165.50, 164.08, 162.12, 145.68, 142.88, 135.21, 135.15, 131.64, 131.36, 130.23, 128.66, 127.95, 126.19, 124.69, 124.40, 121.73, 114.27, 55.69, 53.17, 22.02; ESI-HRMS *m/z* calcd for $C_{29}H_{23}N_2O_8S_2^+$ $[M + H]^+$ 591.0890, found 591.0897.



5pa

Methyl 3-(2-naphthoyl)-6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4*H*-1,4-thiazine-2-carboxylate (**5pa**): Yellow solid, m.p. 136 – 137 °C; 78.2 mg, 64% yield; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.50 – 8.46 (m, 1H), 8.11 – 8.05 (m, 2H), 8.00 – 7.89 (m, 6H), 7.87 – 7.80 (m, 2H), 7.67 – 7.56 (m, 2H), 7.40 (d, *J* = 8.1 Hz, 2H), 6.98 (s, 1H), 3.52 (s, 3H), 2.50 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 187.90, 165.54, 162.05, 145.76, 142.66, 136.09, 135.26, 135.22, 132.98, 132.70, 131.52, 131.39, 130.28, 130.11, 128.91, 127.98, 127.90, 126.98, 126.52, 125.25, 124.51, 124.45, 121.29, 53.23, 29.83, 21.98 (one carbon missed); ESI-HRMS *m/z* calcd for $C_{32}H_{23}N_2O_7S_2^+$ $[M + H]^+$ 611.0941, found 611.0945.

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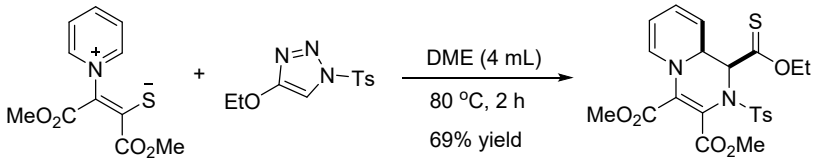
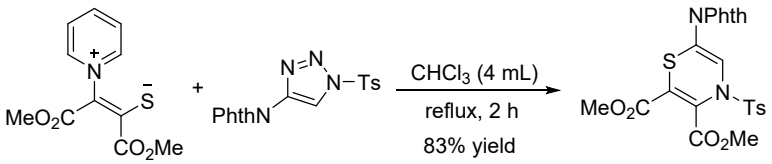
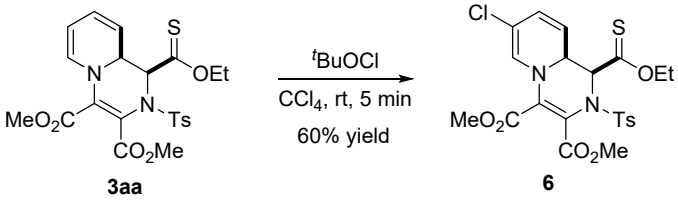
7 Large scale reaction and further transformation of 3aa and 5aa



The mixture of **1a** (253 mg, 1.00 mmol) and **2a** (535 mg, 2.00 mmol) in anhydrous DME (20 mL) was stirred at 80 °C under N_2 for 2 hrs. After completed, the solvent was evaporated in vacuo and the residual was purified by silica gel column chromatography (PE : EtOAc = 6 : 1 to 4 : 1) to give the desired product **3aa** in 69% yield (339 mg).

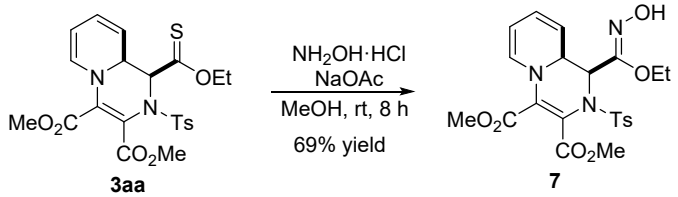


A 100-mL Schlenk-flask was charged with **1a** (253 mg, 1.00 mmol), **4a** (737 mg, 2.00 mmol) and chloroform (20 mL) under nitrogen, and then the mixture was stirred and heated to reflux for 2 hrs. After completed, the solvent was removed in vacuo, and the residual was purified by silica gel column chromatography with PE/EtOAc (4 : 1) as eluent to give compound **5aa** in 83% yield (427 mg).



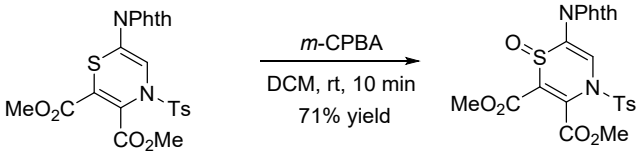
To a solution of **3aa** (99 mg, 0.20 mmol) in CCl_4 (4 mL) was added *tert*-butyl hypochlorite (23 μL, 0.20 mmol) dropwise. The solvent was evaporated in vacuo after stirred at room temperature for 10 min. Then the residual was purified by silica gel column chromatography with PE/EtOAc (5 : 1 to 4 : 1) as eluent to give compound **6** (63 mg, 60% yield) as colorless oil.

Dimethyl *cis*-7-chloro-1-(ethoxycarbonothioyl)-2-tosyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**6**): Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.79 (m, 2H), 7.33 (d, J = 8.1 Hz, 2H), 6.19 – 6.15 (m, 1H), 5.91 – 5.84 (m, 1H), 5.47 (ddd, J = 10.4, 3.4, 0.9 Hz, 1H), 4.86 (d, J = 3.7 Hz, 1H), 4.36 (q, J = 7.1 Hz, 2H), 4.03 – 3.98 (m, 1H), 3.89 (s, 3H), 3.81 (s, 3H), 2.44 (s, 3H), 1.28 – 1.23 (m, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 208.63, 164.97, 163.23, 145.22, 134.05, 130.08, 128.93, 128.39, 125.10, 124.58, 118.35, 109.24, 108.12, 69.30, 61.98, 56.78, 53.55, 52.70, 21.84, 13.36; ESI-HRMS m/z calcd for $C_{22}H_{24}ClN_2O_7S_2^+$ $[M + H]^+$ 527.0708, found 527.0711.



The mixture of **3aa** (99 mg, 0.20 mmol), hydroxylamine hydrochloride (42 mg, 0.60 mmol), and sodium acetate (49 mg, 0.60 mmol) in MeOH (4 mL) was stirred at room temperature for 8 hours. Water was added to the mixture and the mixture was extracted with ethyl acetate twice. The organic layers were combined, washed with brine, dried with anhydrous Na_2SO_4, filtered, and concentrated. The residual was purified by silica gel column chromatography with PE/EtOAc (4:1 to 3:1) as eluent to give compound **7** (68 mg, 69% yield) as yellow solid.

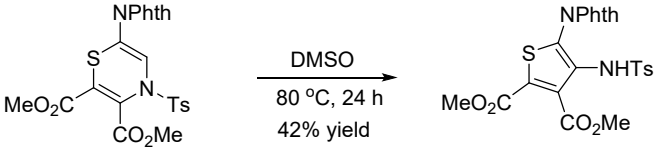
Dimethyl *cis*-1-((Z)-ethoxy(hydroxyimino)methyl)-2-tosyl-1,9a-dihydro-2*H*-pyrido[1,2-*a*]pyrazine-3,4-dicarboxylate (**7**): Yellow solid, m.p. 144 – 145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.79 (m, 2H), 7.36 – 7.30 (m, 2H), 6.69 (s, 1H), 6.04 (d, *J* = 7.7 Hz, 1H), 5.91 – 5.83 (m, 1H), 5.52 (d, *J* = 4.3 Hz, 1H), 5.29 – 5.22 (m, 1H), 4.95 – 4.88 (m, 1H), 4.26 – 4.20 (m, 1H), 3.89 – 3.79 (m, 5H), 3.77 (s, 3H), 2.43 (s, 3H), 1.15 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.34, 163.84, 159.48, 144.74, 134.58, 132.23, 129.87, 128.36, 127.06, 123.33, 116.35, 106.74, 101.20, 63.24, 56.26, 53.25, 52.33, 43.49, 21.79, 14.02; ESI-HRMS m/z calcd for $C_{22}H_{26}N_3O_8S^+$ $[M + H]^+$ 492.1435, found 492.1440.



5aa **8**

To a solution of **5aa** (103 mg, 0.20 mmol) in anhydrous dichloromethane (2 mL) was added *m*-CPBA (70%, 49 mg, 0.20 mmol) at room temperature. The reaction was completed within 10 min. The mixture was purified by silica gel column chromatography with PE/EtOAc (2:1 to 1:1) as eluent to give compound **8** (75 mg, 71% yield) as white solid.

Dimethyl 6-(1,3-dioxoisoindolin-2-yl)-4-tosyl-4H-1,4-thiazine-2,3-dicarboxylate 1-oxide (**8**): White solid, m.p. 87 – 88 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.99 – 7.93 (m, 2H), 7.89 (d, *J* = 8.2 Hz, 2H), 7.87 – 7.80 (m, 2H), 7.41 (d, *J* = 8.1 Hz, 2H), 4.06 (s, 3H), 3.87 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.88, 162.74, 161.76, 147.57, 139.39, 135.26, 132.97, 131.36, 130.63, 128.41, 127.89, 124.44, 122.29, 117.93, 54.28, 53.55, 22.01; ESI-HRMS m/z calcd for $C_{23}H_{19}N_2O_9S_2^+$ $[M + H]^+$ 531.0526, found 531.0530.



5aa **9**

The solution of **5aa** (103 mg, 0.20 mmol) in anhydrous DMSO (2 mL) was stirred at 80 °C for 24 hours. After completed, the reaction was diluted with ethyl acetate (100 mL) and washed with water (30 mL × 2) and brine (30 mL × 3). The organic layer was dried with anhydrous Na_2SO_4, filtered, and concentrated. The residual was purified by silica gel column chromatography with PE/EtOAc (2.5:1 to 2:1) as eluent to give compound **9** (43 mg, 42% yield) as light yellow oil.

Dimethyl 5-(1,3-dioxoisoindolin-2-yl)-4-((4-methylphenyl)sulfonamido)thiophene-2,3-dicarboxylate (**9**): Light yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.32 (s, 1H), 7.86 – 7.81 (m, 2H), 7.80 – 7.74 (m, 2H), 7.49 – 7.44 (m, 2H), 7.11 – 7.05 (m, 2H), 3.96 (s, 3H), 3.71 (s, 3H), 2.32 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.55, 162.22, 159.13, 145.64, 140.61, 134.52, 131.71, 130.03, 127.30, 126.68, 123.85, 117.88, 116.12, 53.00, 52.39, 21.81 (one carbon missed); ESI-HRMS m/z calcd for $C_{23}H_{19}N_2O_2S_2^+$ $[M + H]^+$ 515.0577, found 515.0582.

8 References

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9 Copies of NMR spectra

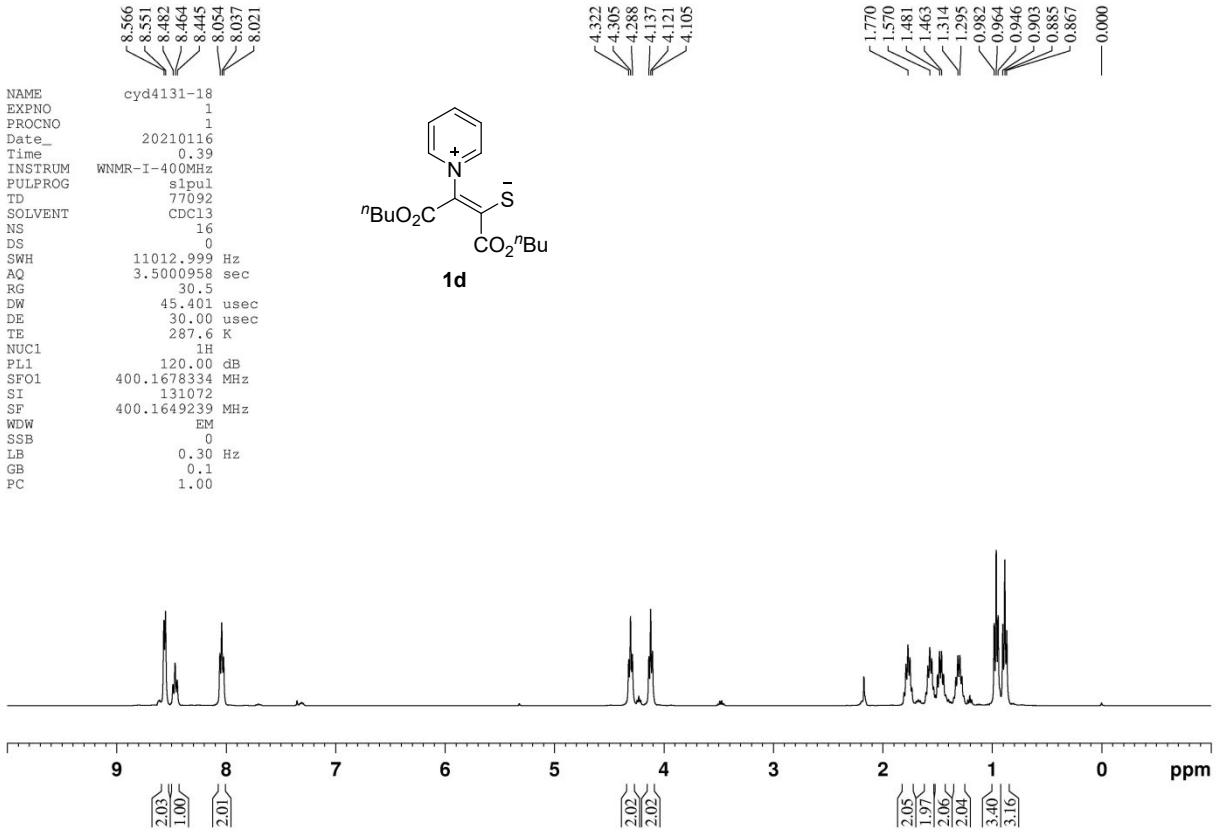


Figure S8-1. ^{1}H NMR of 1d ($CDCl_3$, 400 MHz)

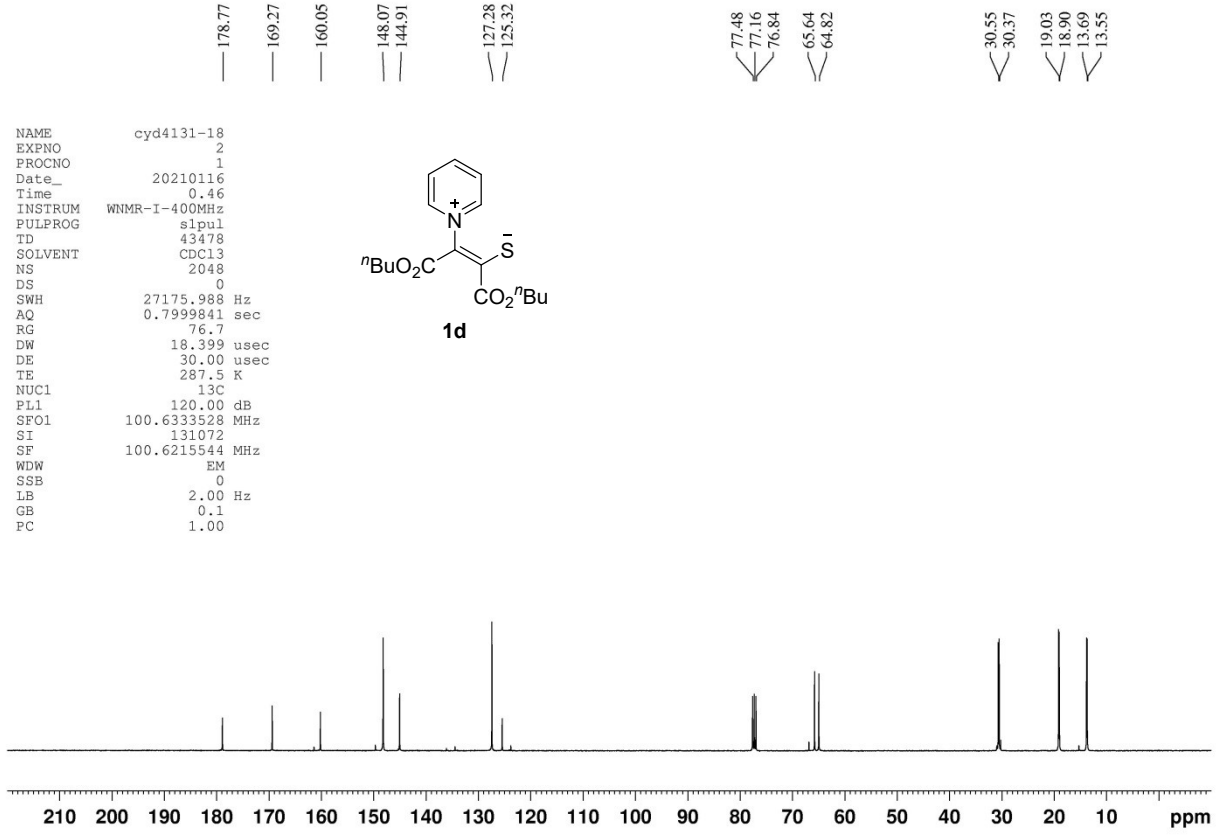


Figure S8-2. ^{13}C NMR of 1d ($CDCl_3$, 101 MHz)

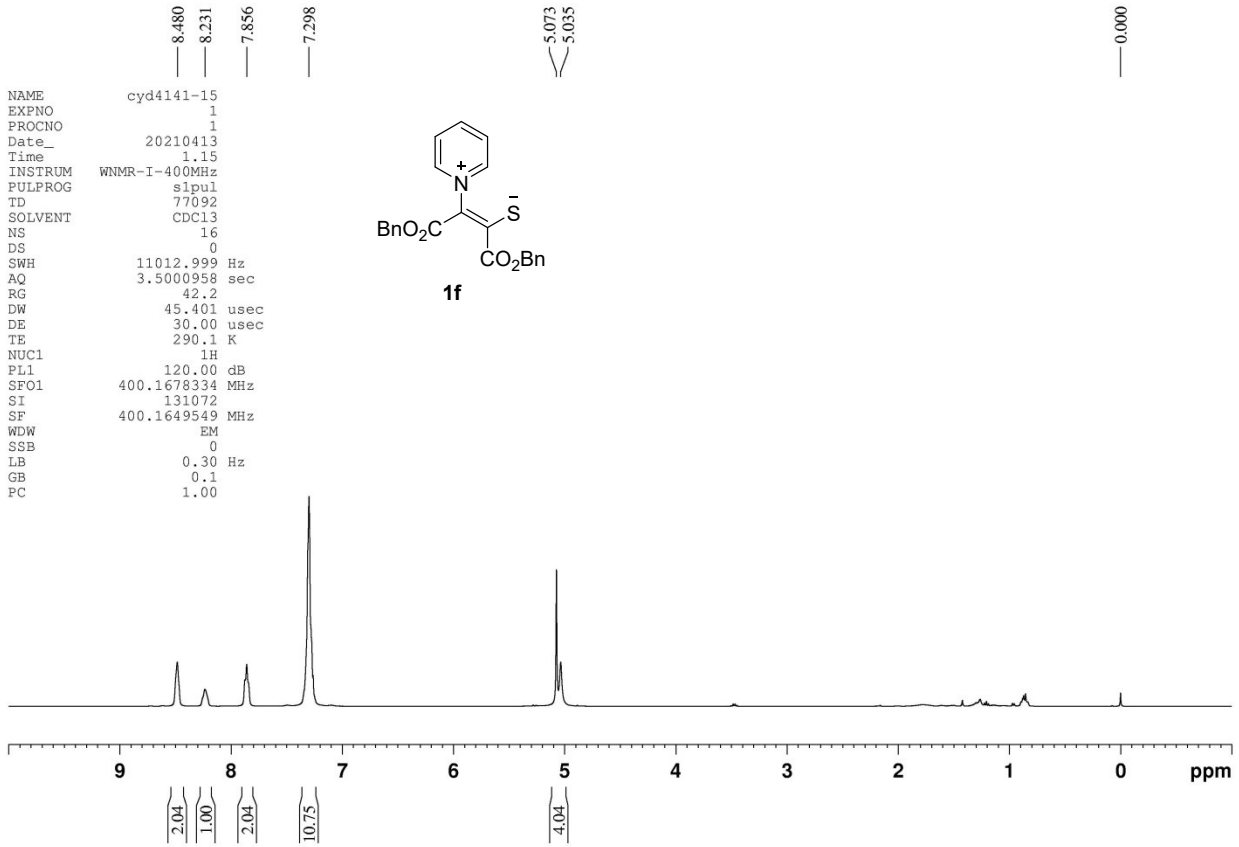


Figure S8-3. ^{1}H NMR of 1f ($CDCl_3$, 400 MHz)

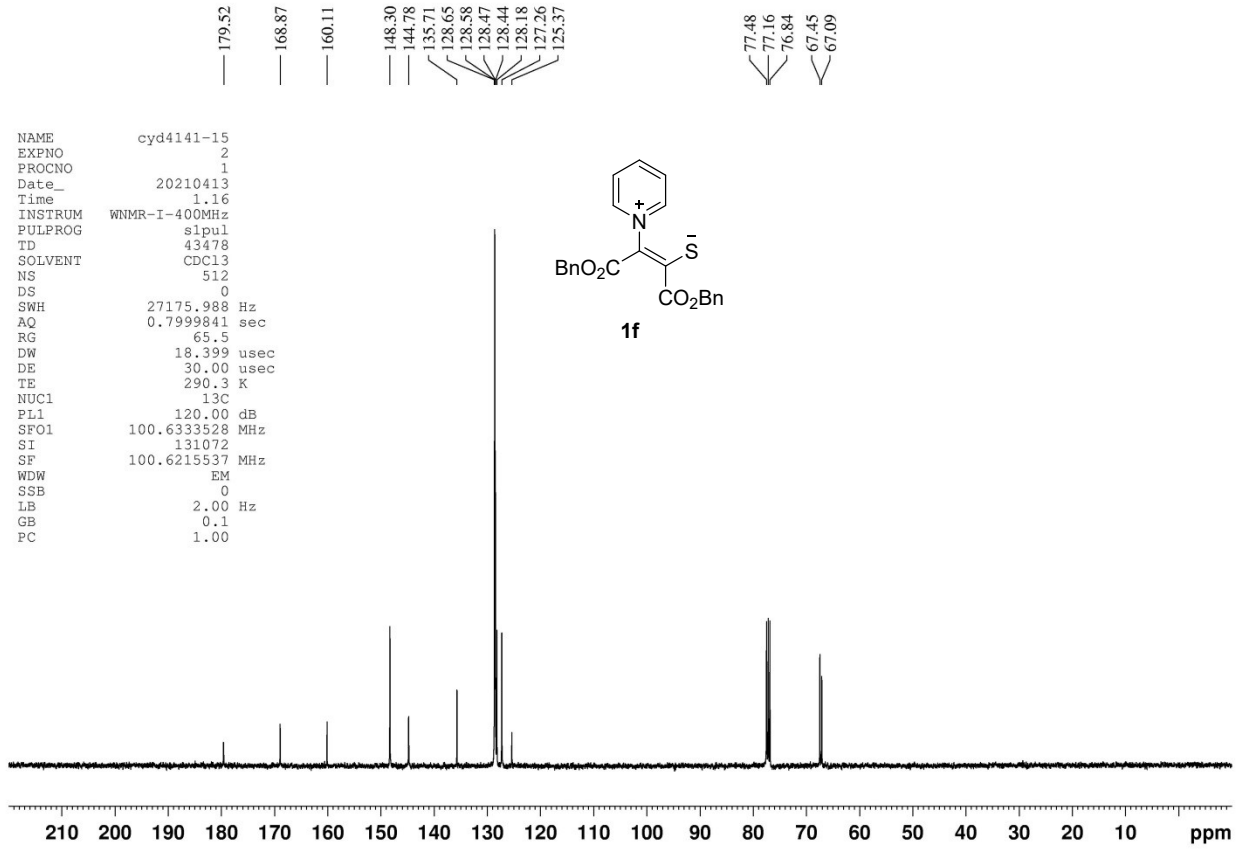


Figure S8-4. ^{13}C NMR of 1f ($CDCl_3$, 101 MHz)

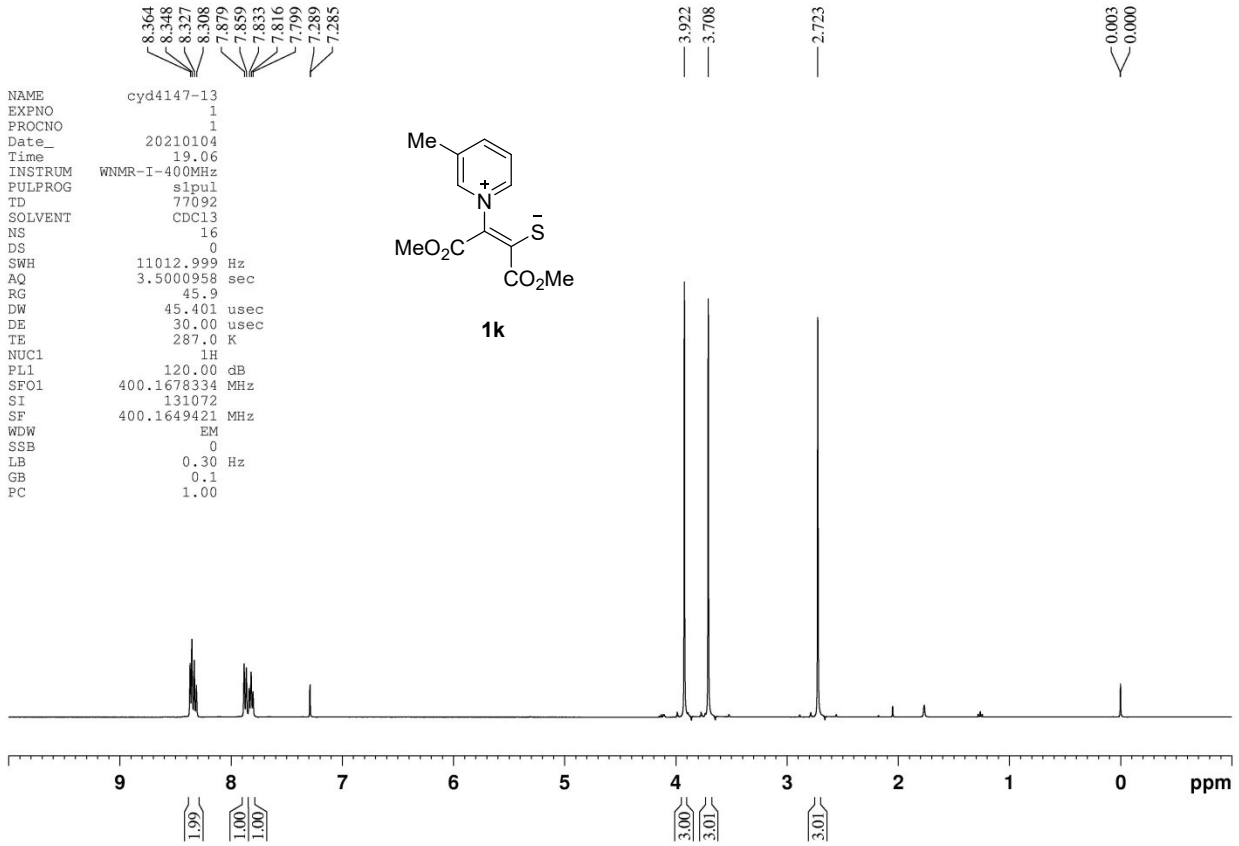


Figure S8-5. ^{1}H NMR of 1k ($CDCl_3$, 400 MHz)

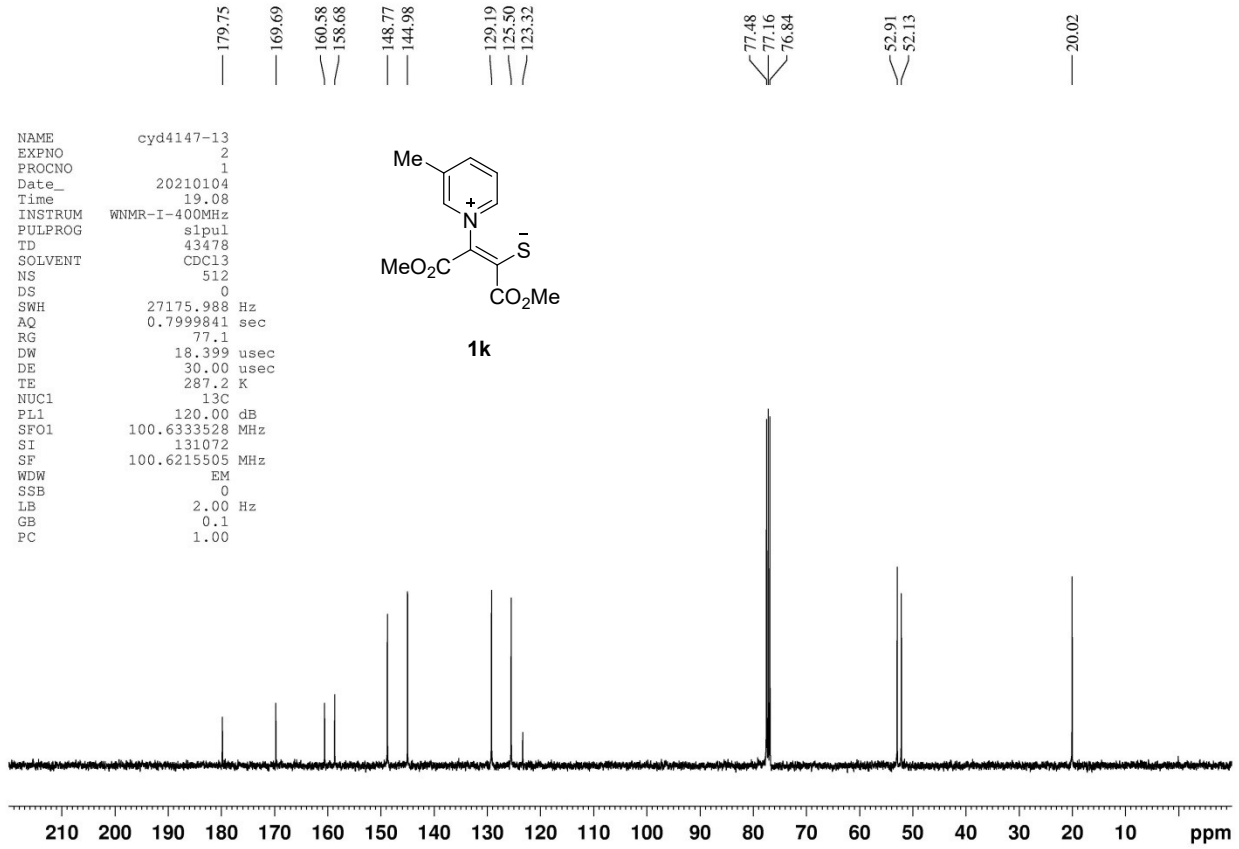


Figure S8-6. ^{13}C NMR of 1k ($CDCl_3$, 101 MHz)

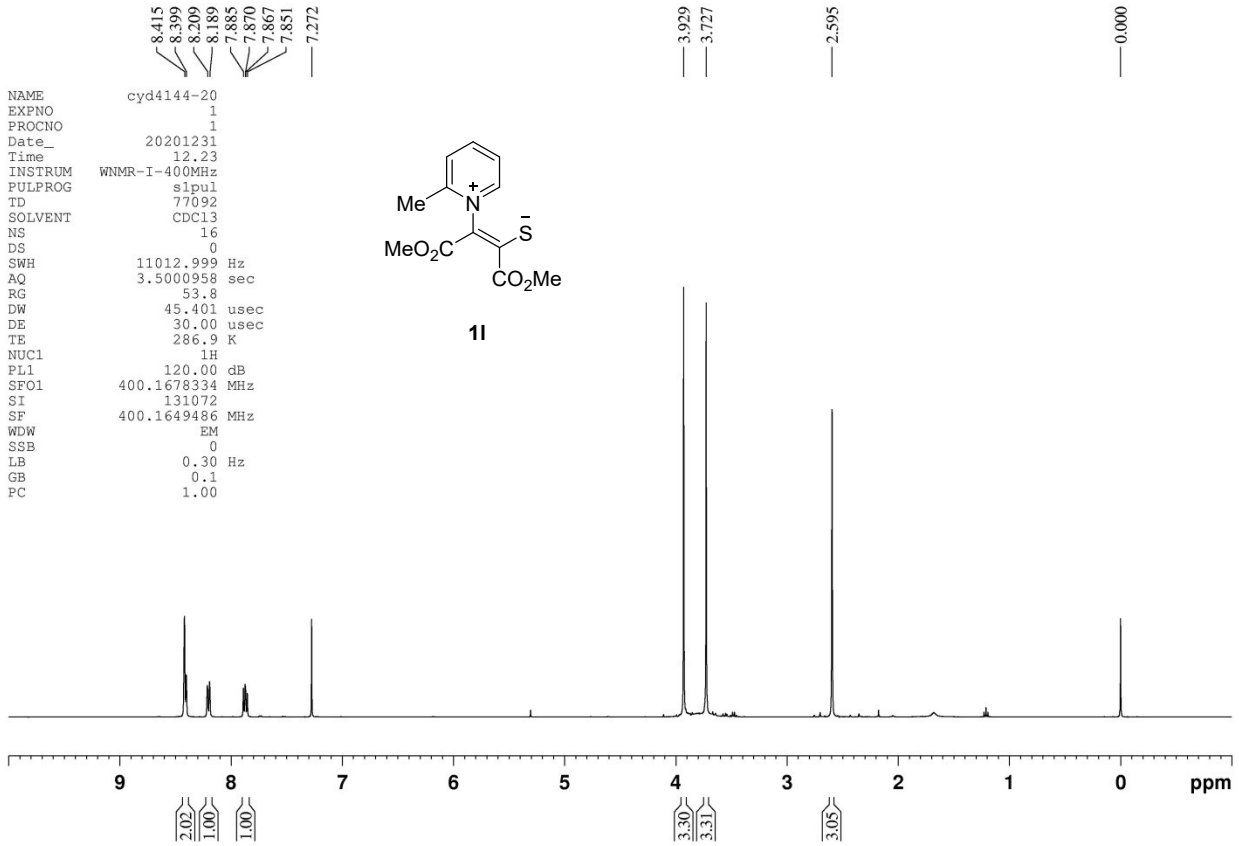


Figure S8-7. ^{1}H NMR of 1l ($CDCl_3$, 400 MHz)

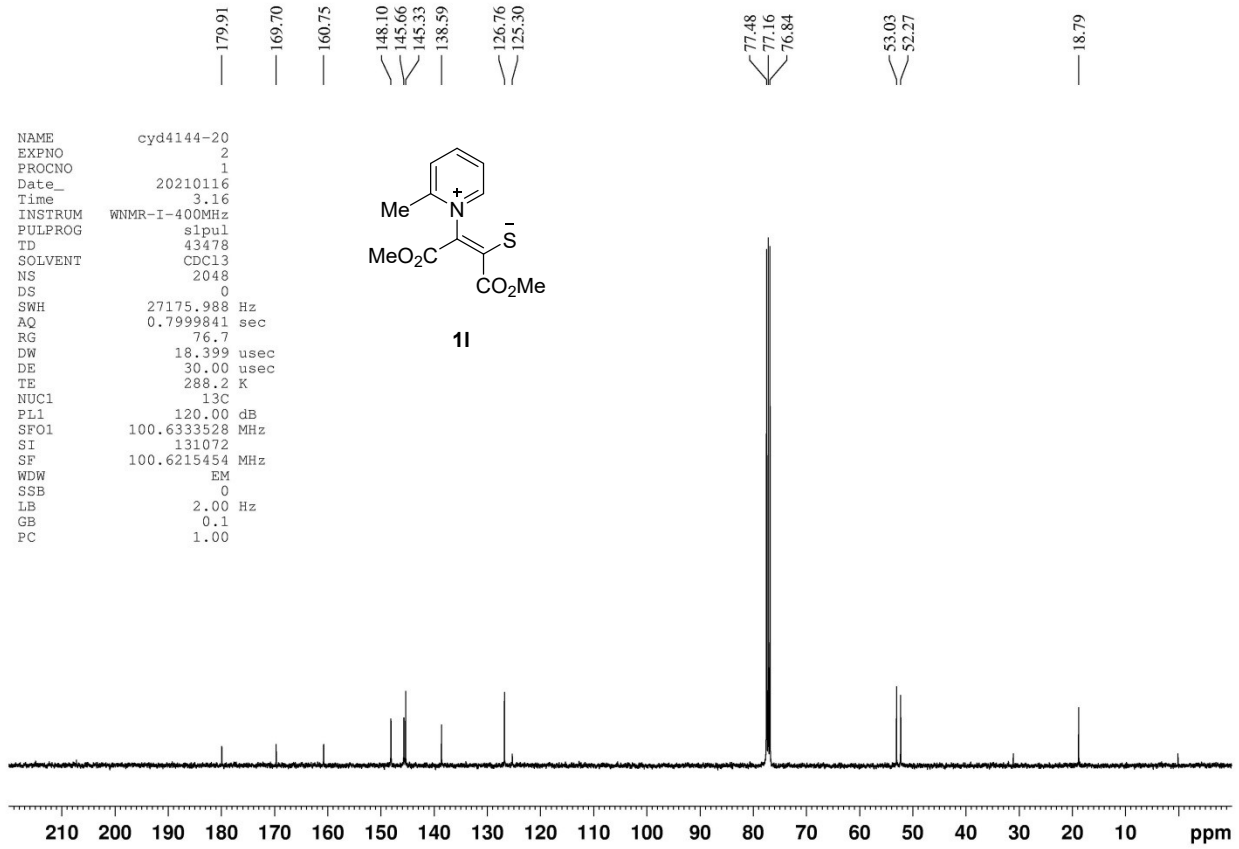


Figure S8-8. ^{13}C NMR of 1l ($CDCl_3$, 101 MHz)

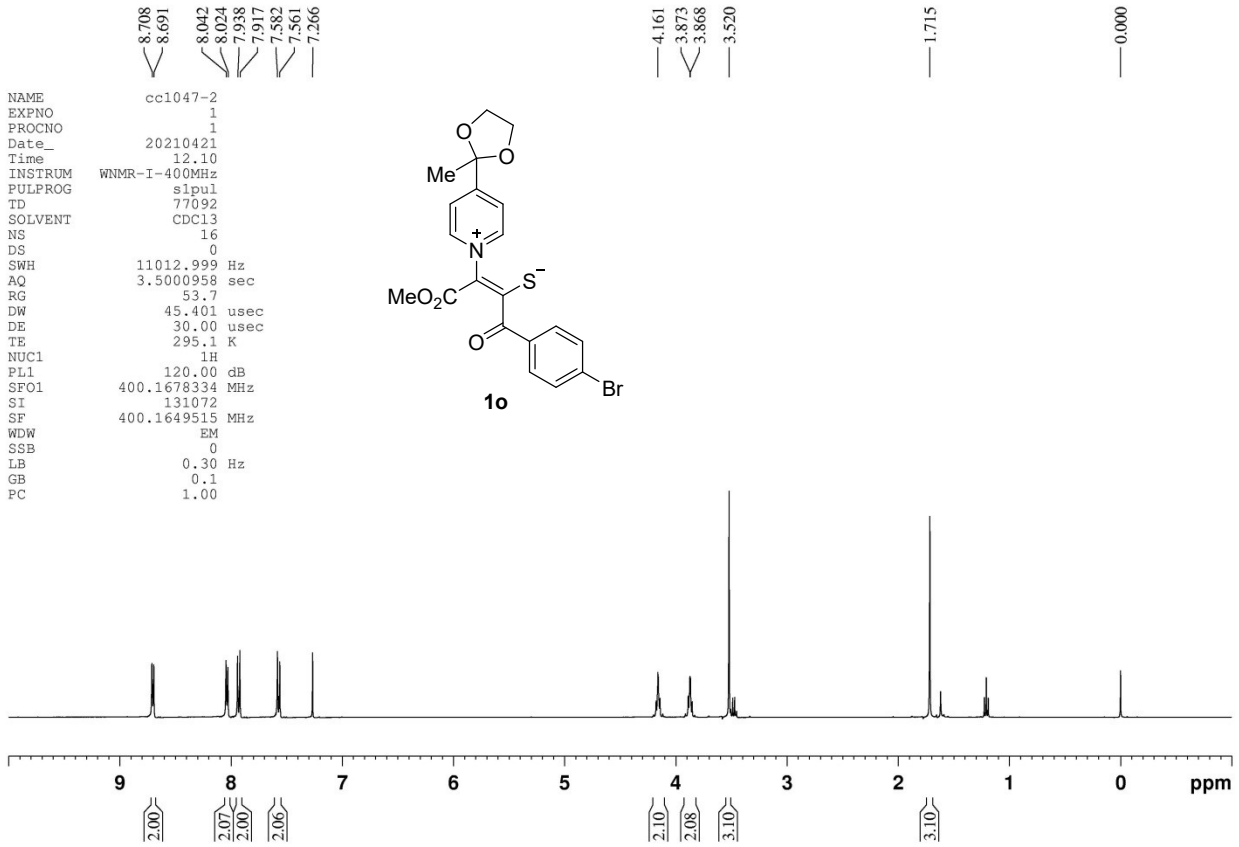


Figure S8-9. ^{1}H NMR of 1o ($CDCl_3$, 400 MHz)

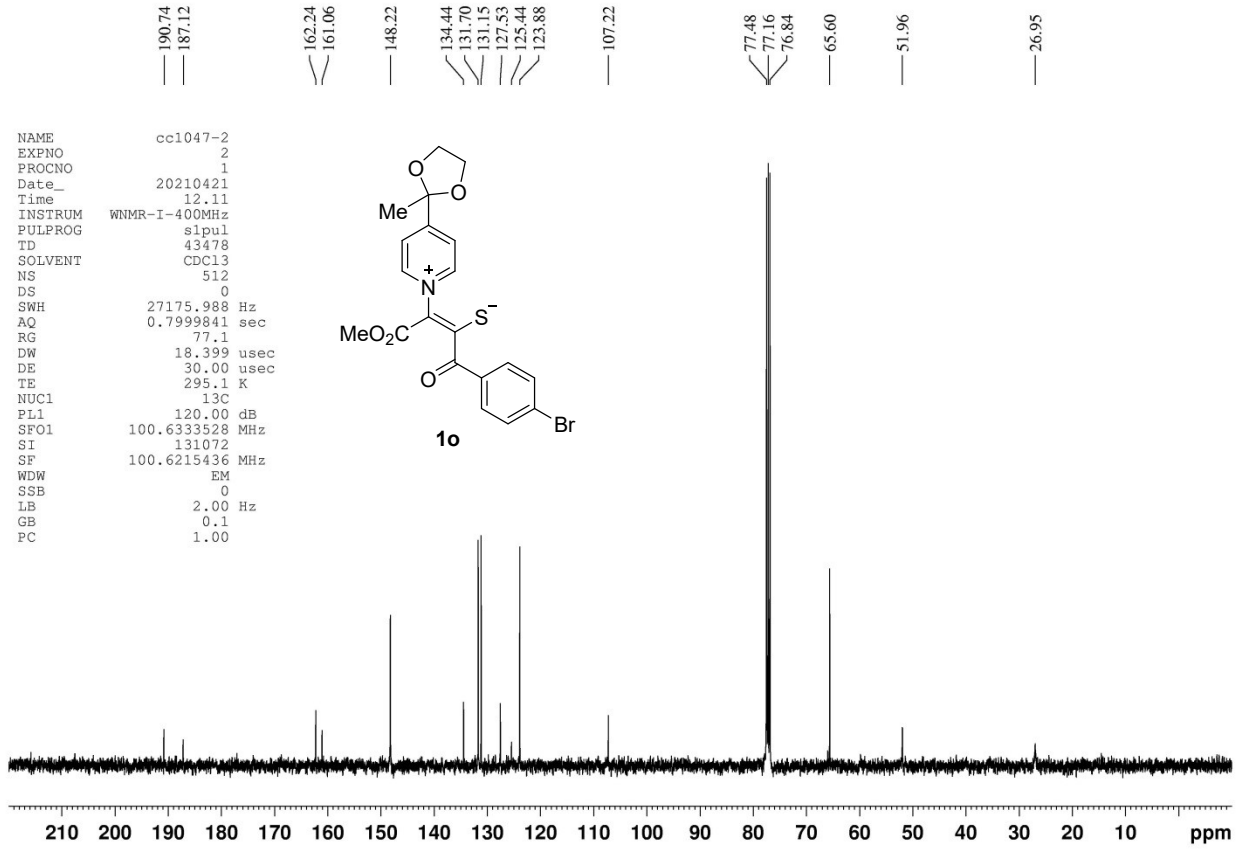


Figure S8-10. ^{13}C NMR of 1o ($CDCl_3$, 101 MHz)

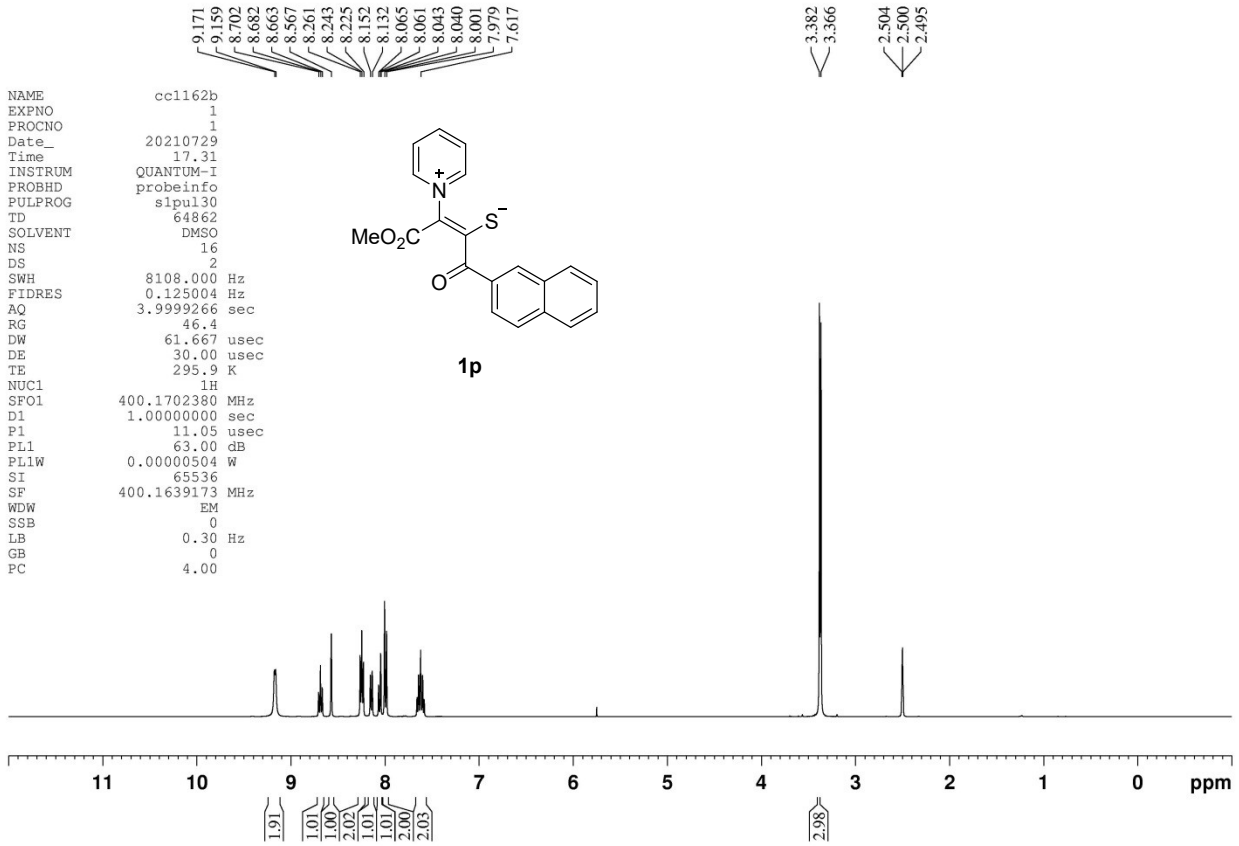


Figure S8-11. ^{1}H NMR of 1p (DMSO-d6, 400 MHz)

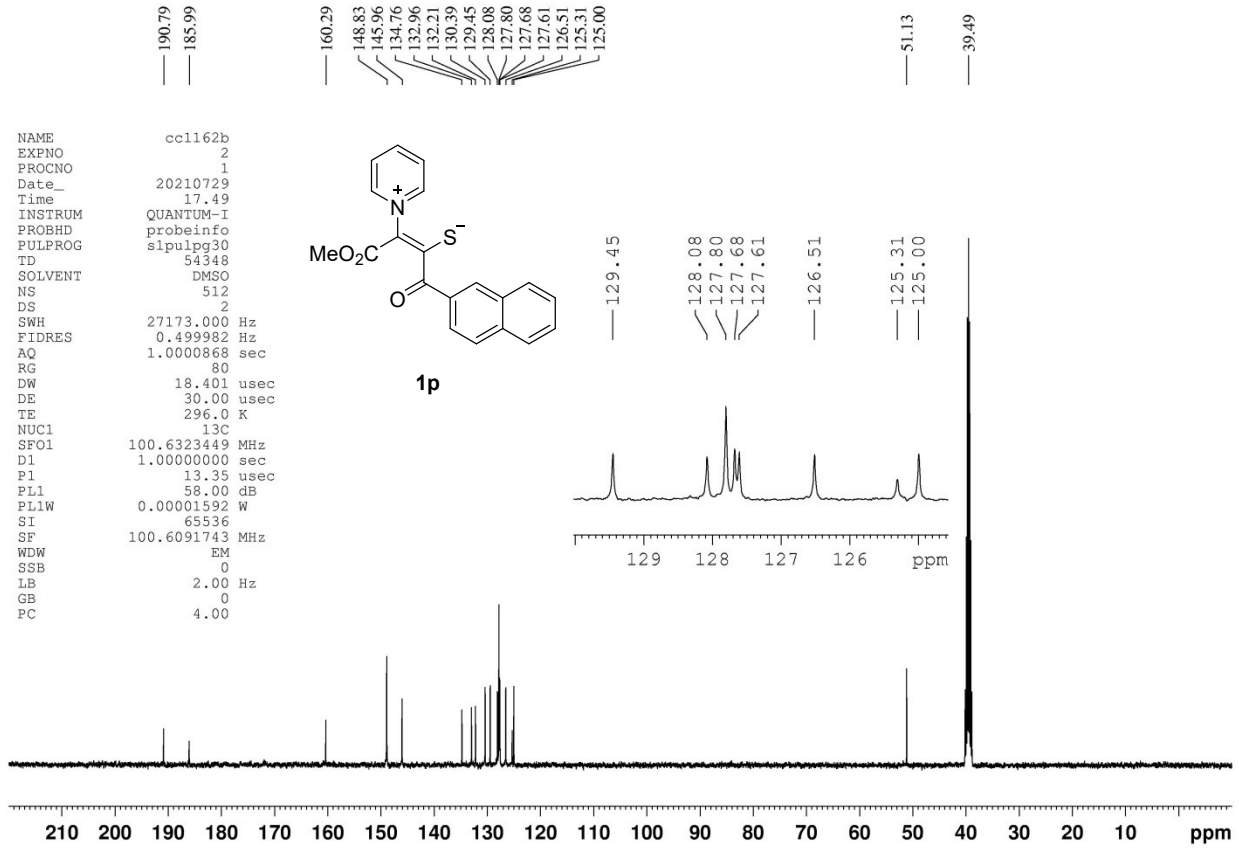


Figure S8-12. ^{13}C NMR of 1p (DMSO-d6, 101 MHz)

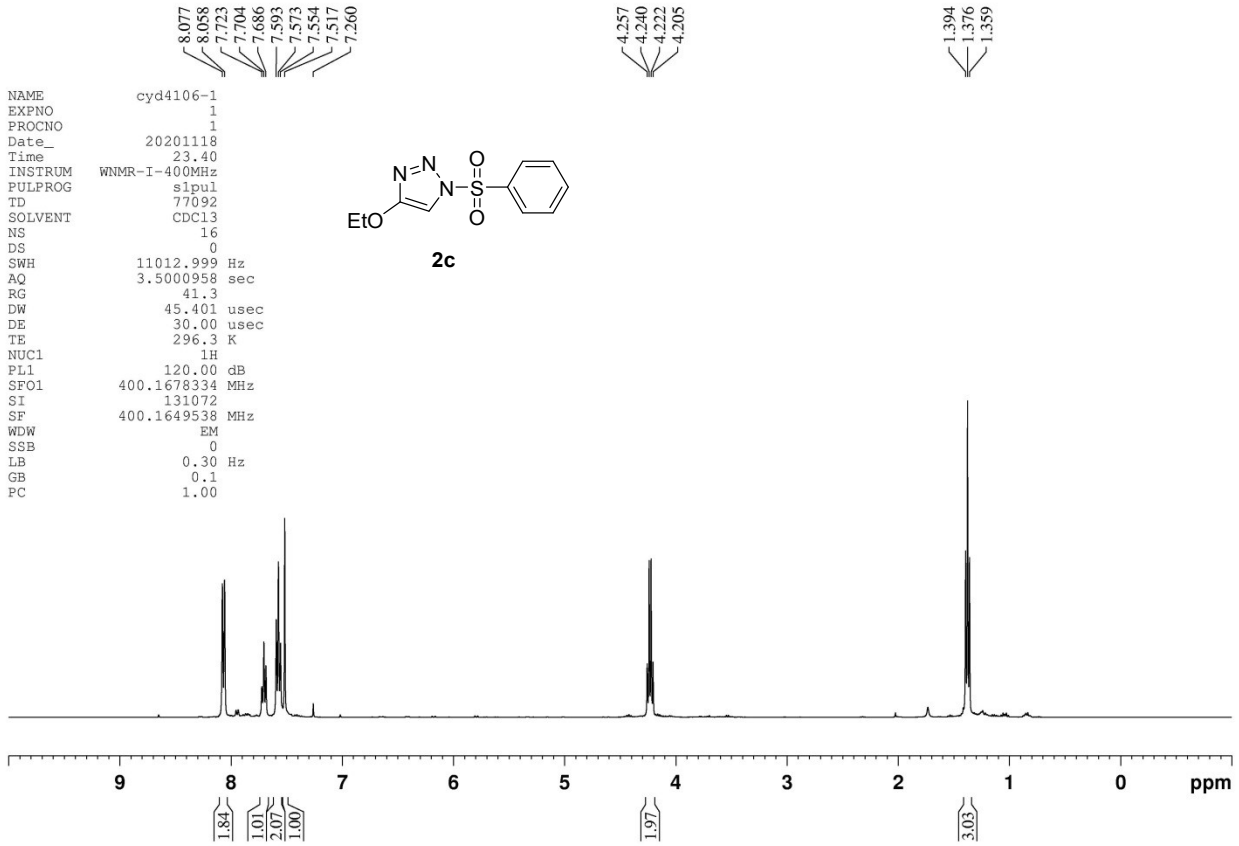


Figure S8-13. ^{1}H NMR of 2c ($CDCl_3$, 400 MHz)

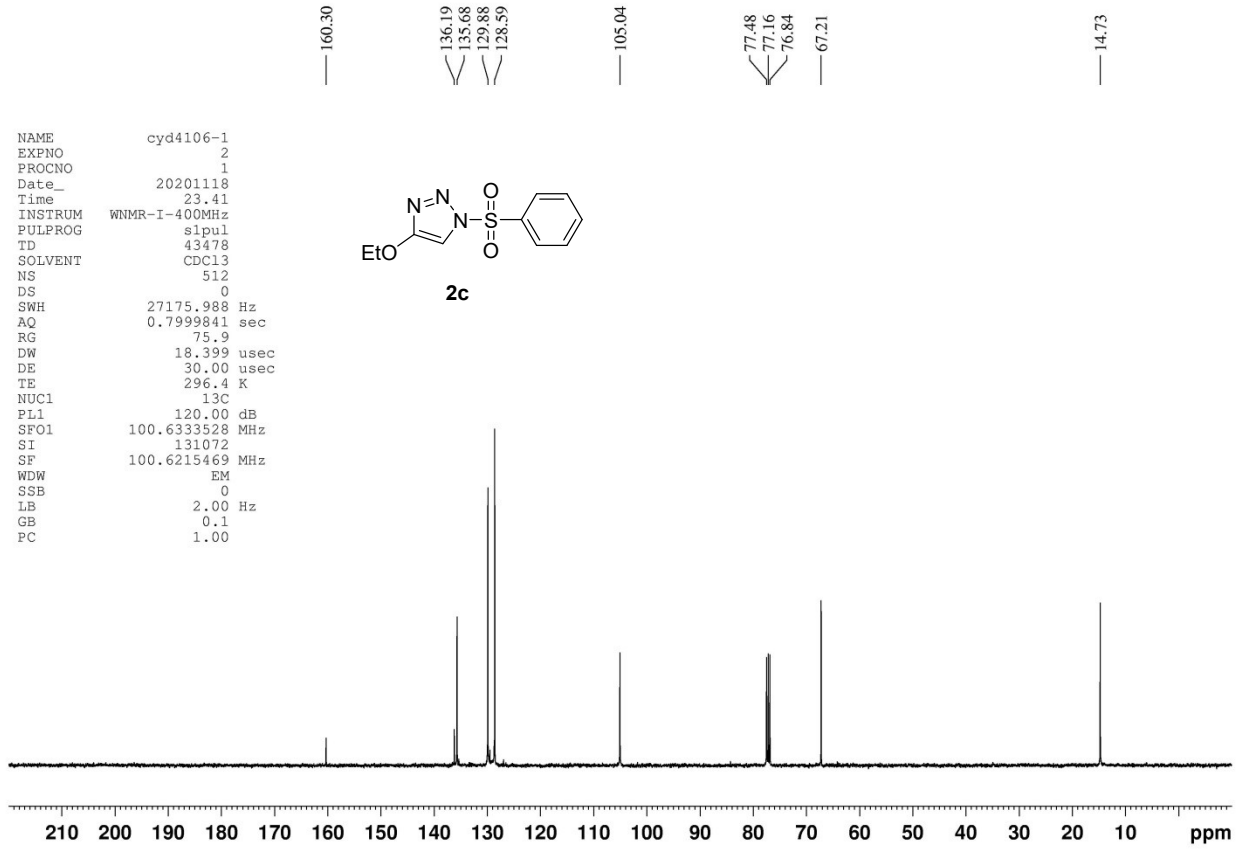


Figure S8-14. ^{13}C NMR of 2c ($CDCl_3$, 101 MHz)

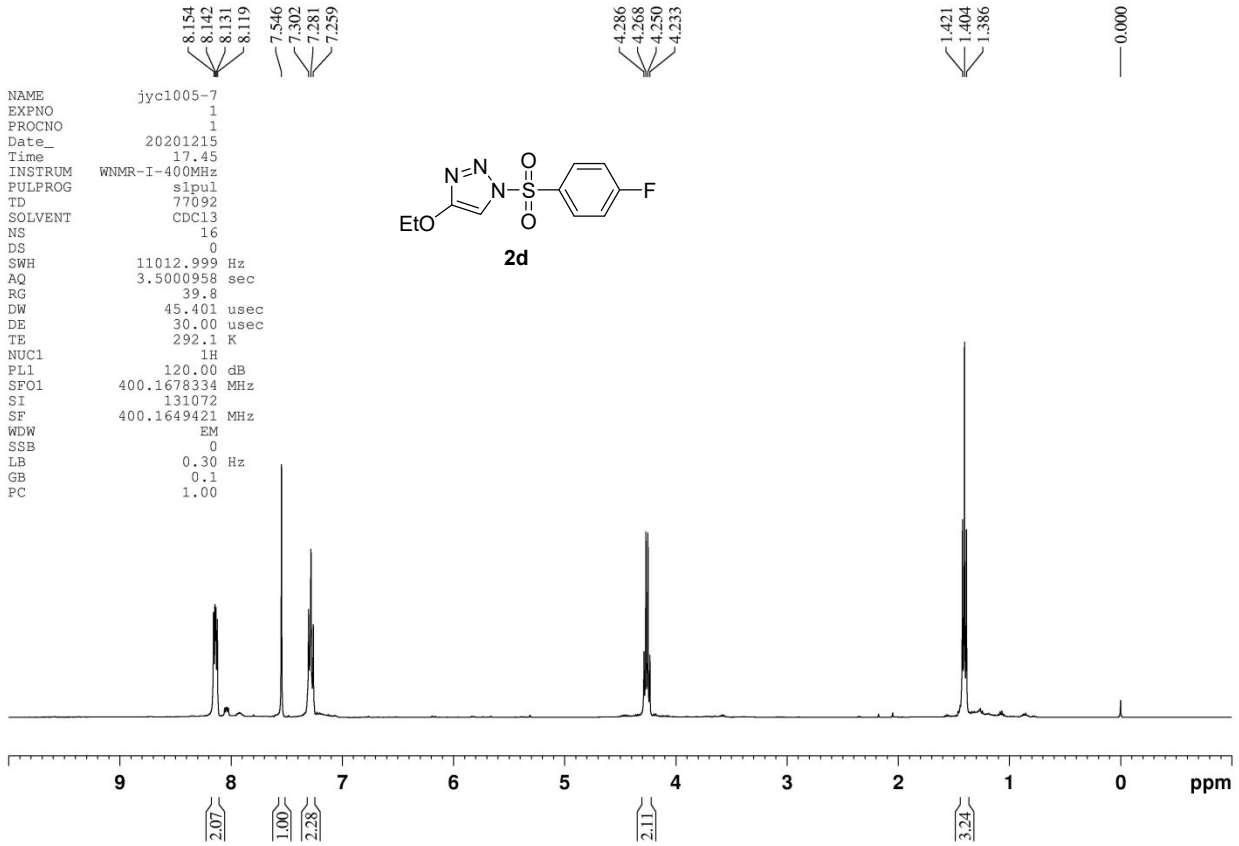


Figure S8-15. ^{1}H NMR of 2d ($CDCl_3$, 400 MHz)

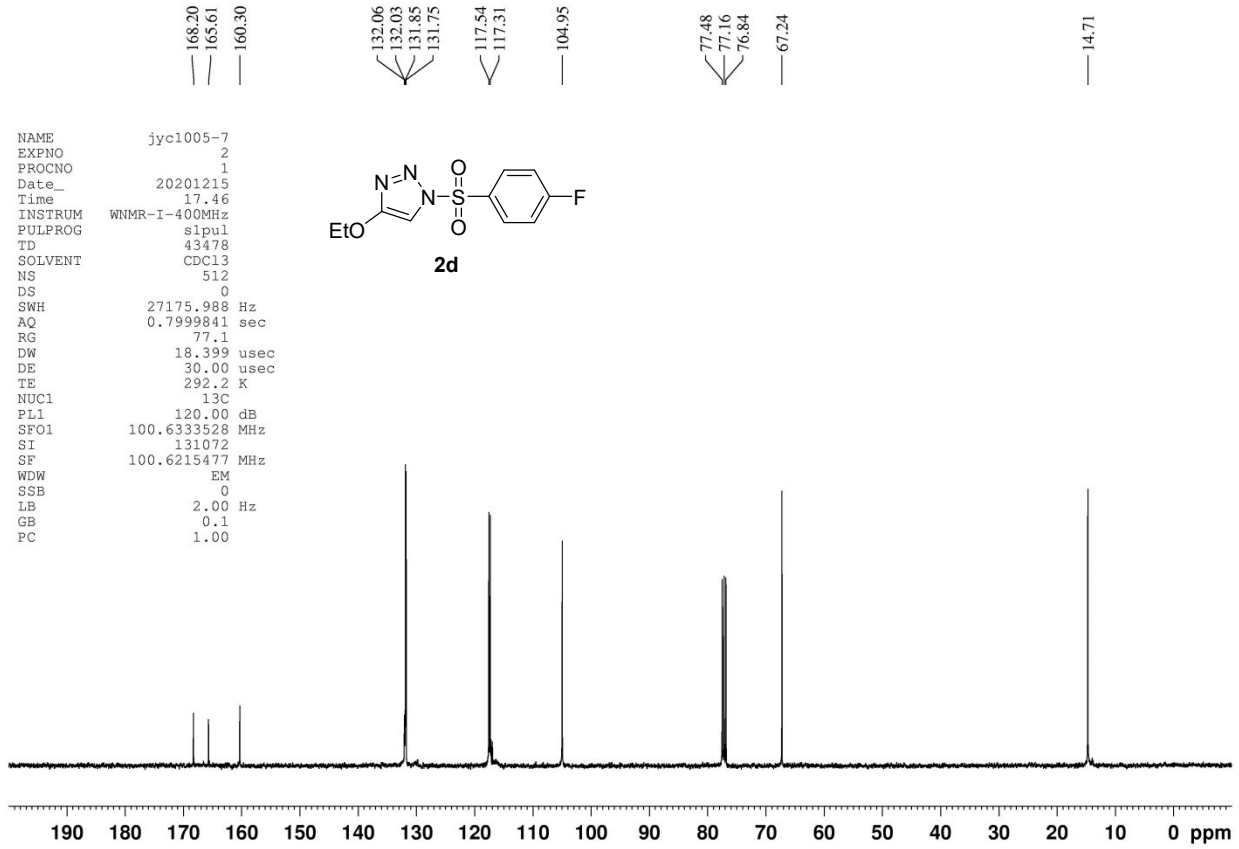


Figure S8-16. ^{13}C NMR of 2d ($CDCl_3$, 101 MHz)

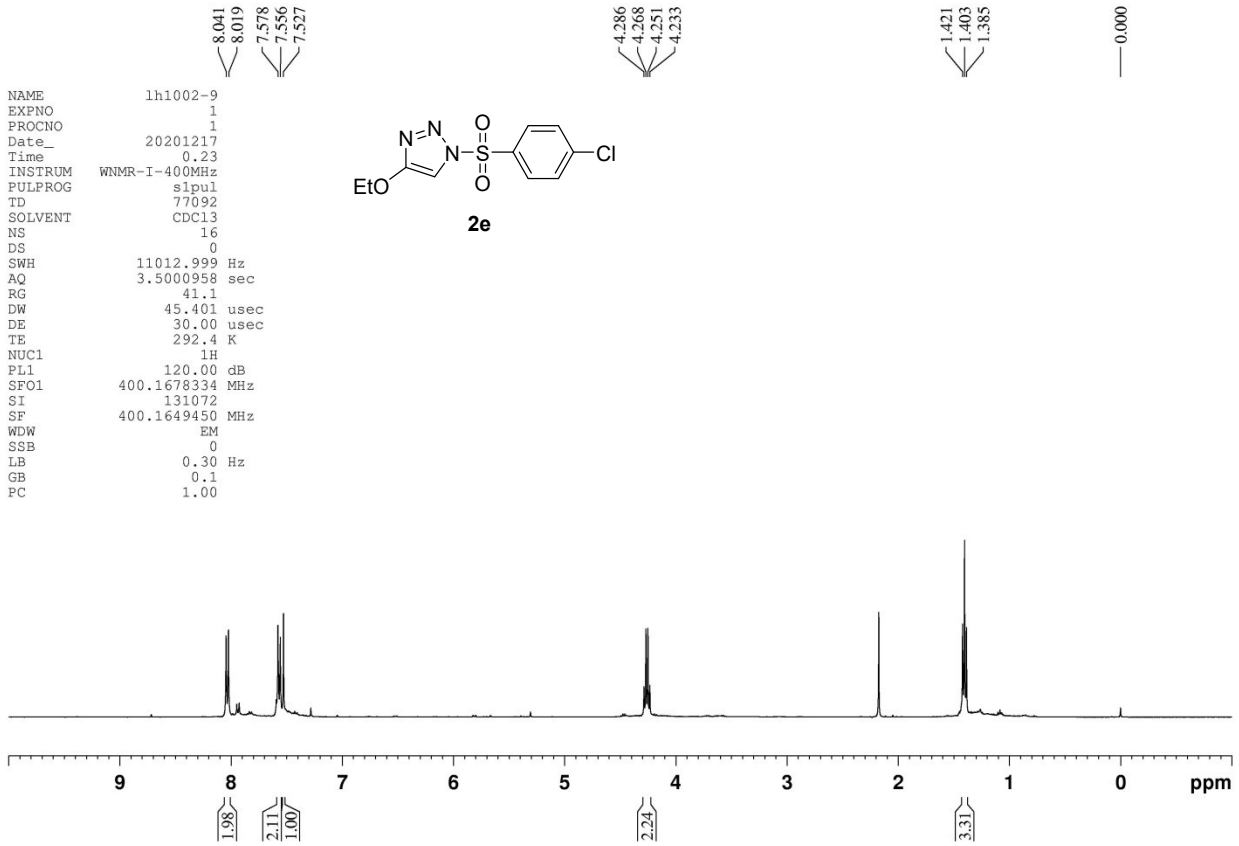


Figure S8-17. ^{1}H NMR of 2e ($CDCl_3$, 400 MHz)

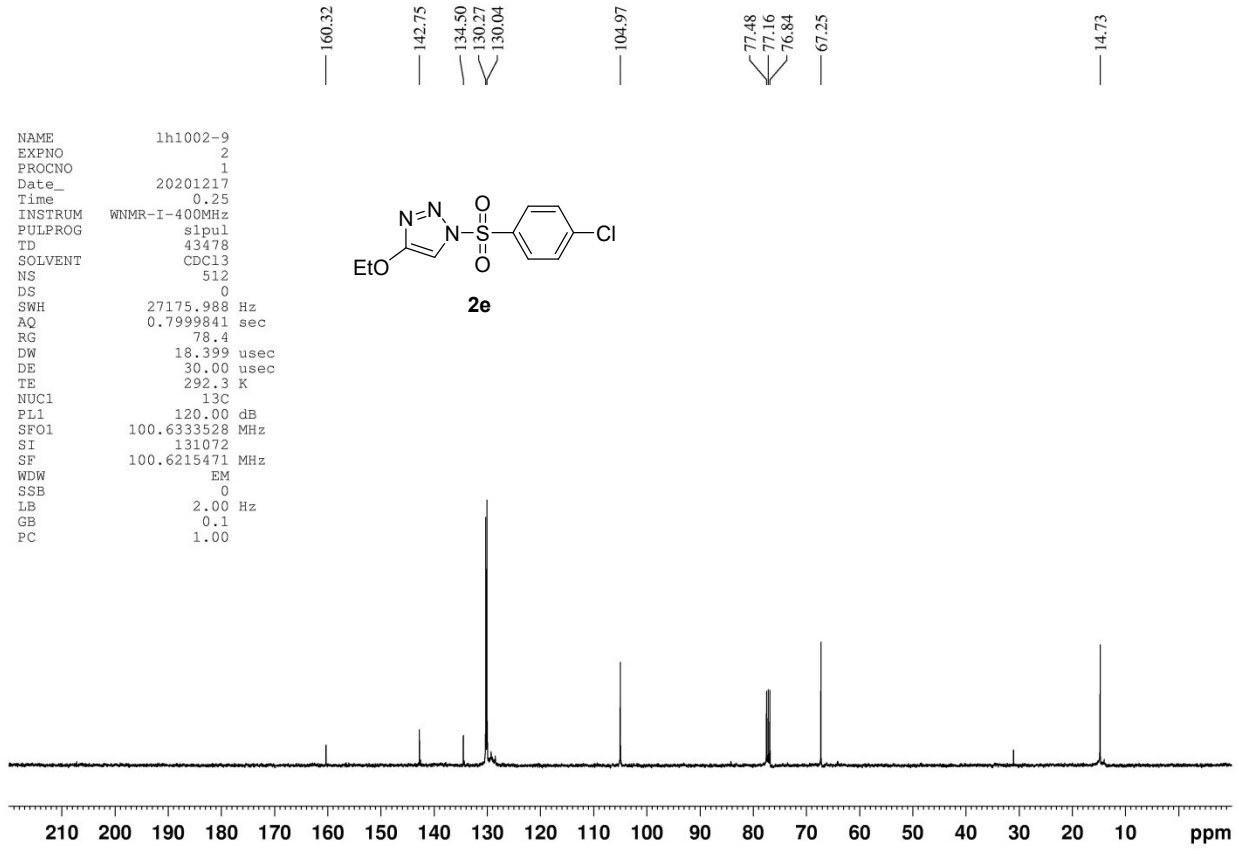


Figure S8-18. ^{13}C NMR of 2e ($CDCl_3$, 101 MHz)

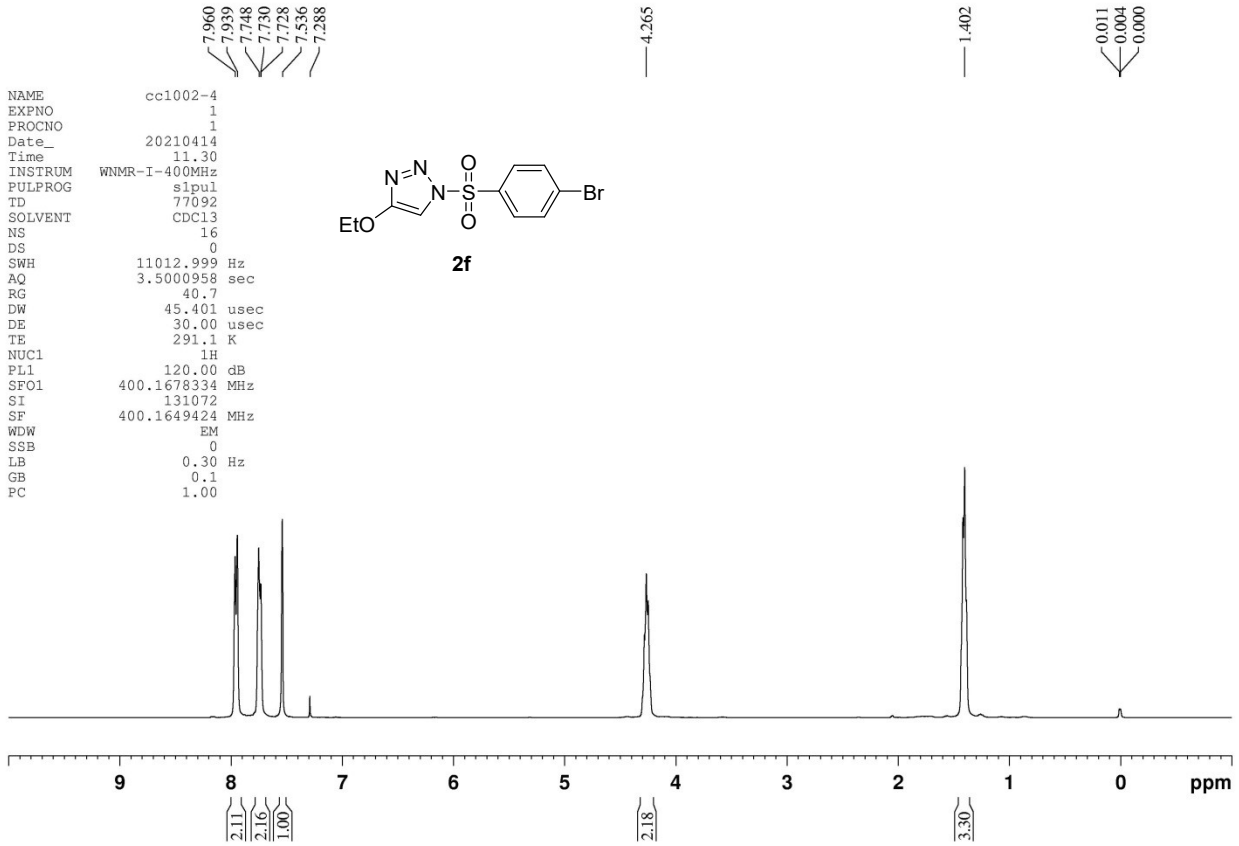


Figure S8-19. ^{1}H NMR of 2f ($CDCl_3$, 400 MHz)

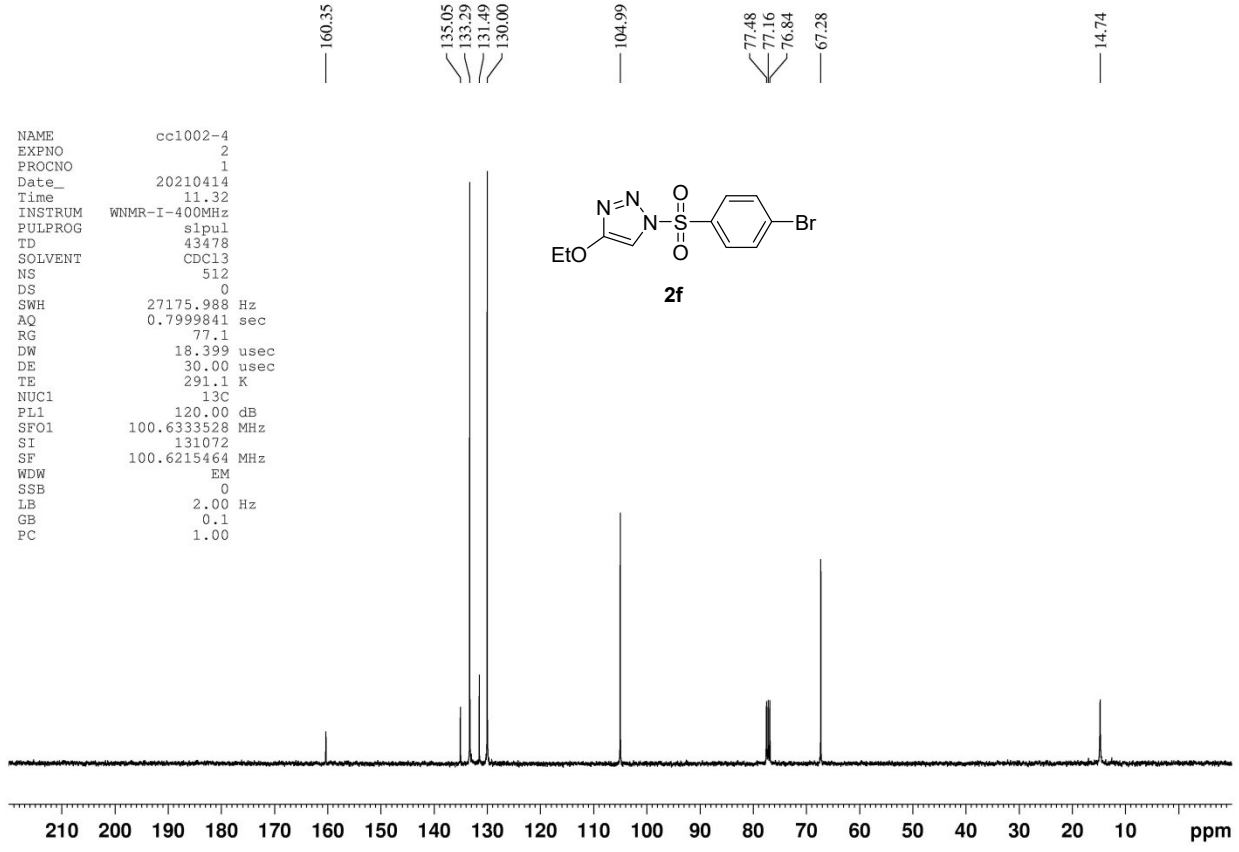


Figure S8-20. ^{13}C NMR of 2f ($CDCl_3$, 101 MHz)

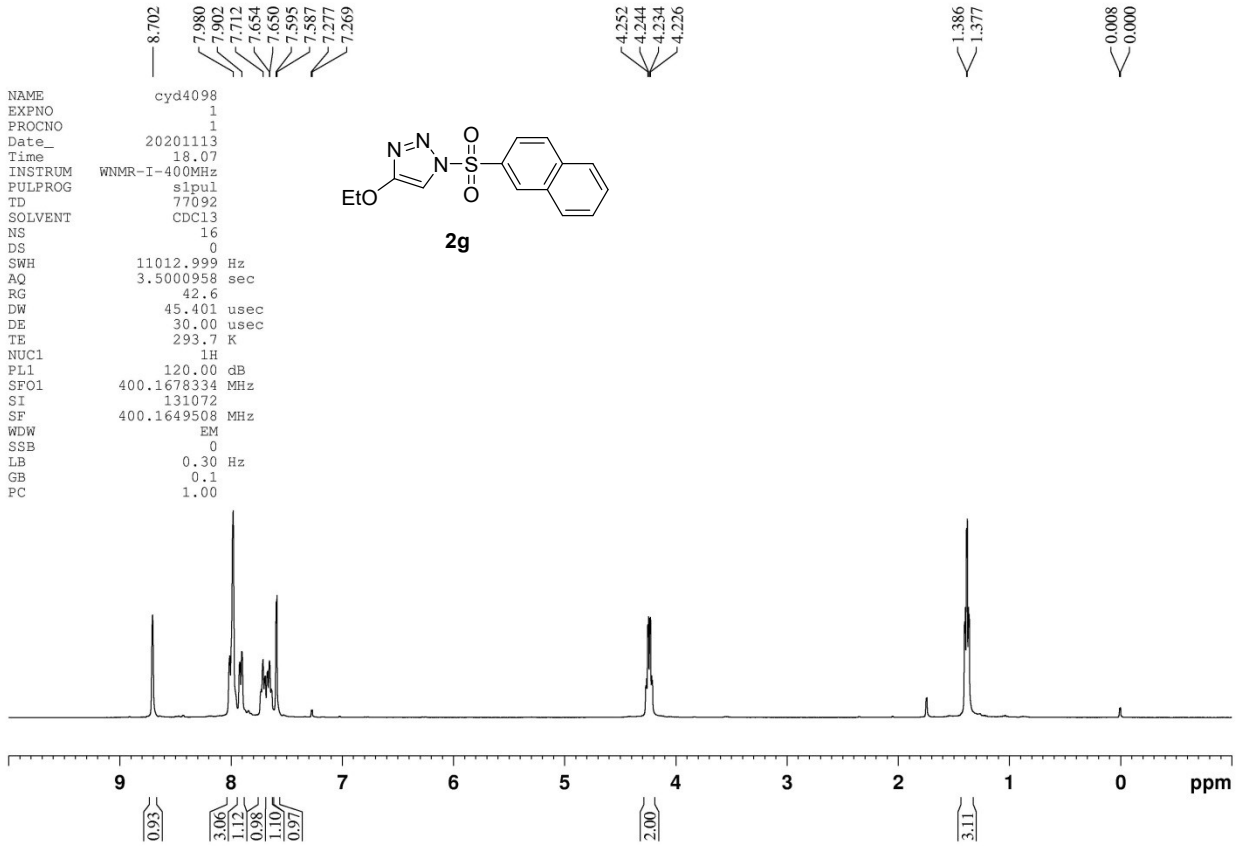


Figure S8-21. ^{1}H NMR of 2g ($CDCl_3$, 400 MHz)

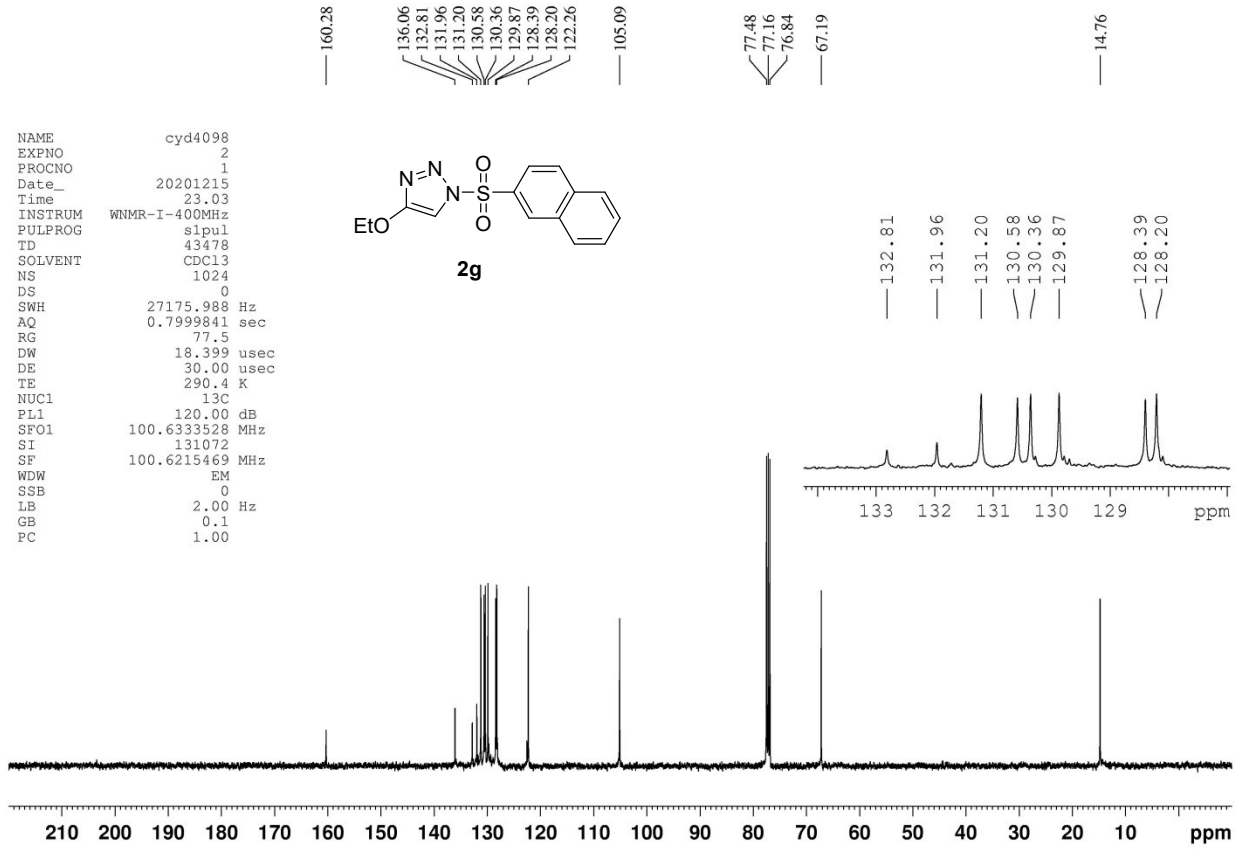


Figure S8-22. ^{13}C NMR of 2g ($CDCl_3$, 101 MHz)

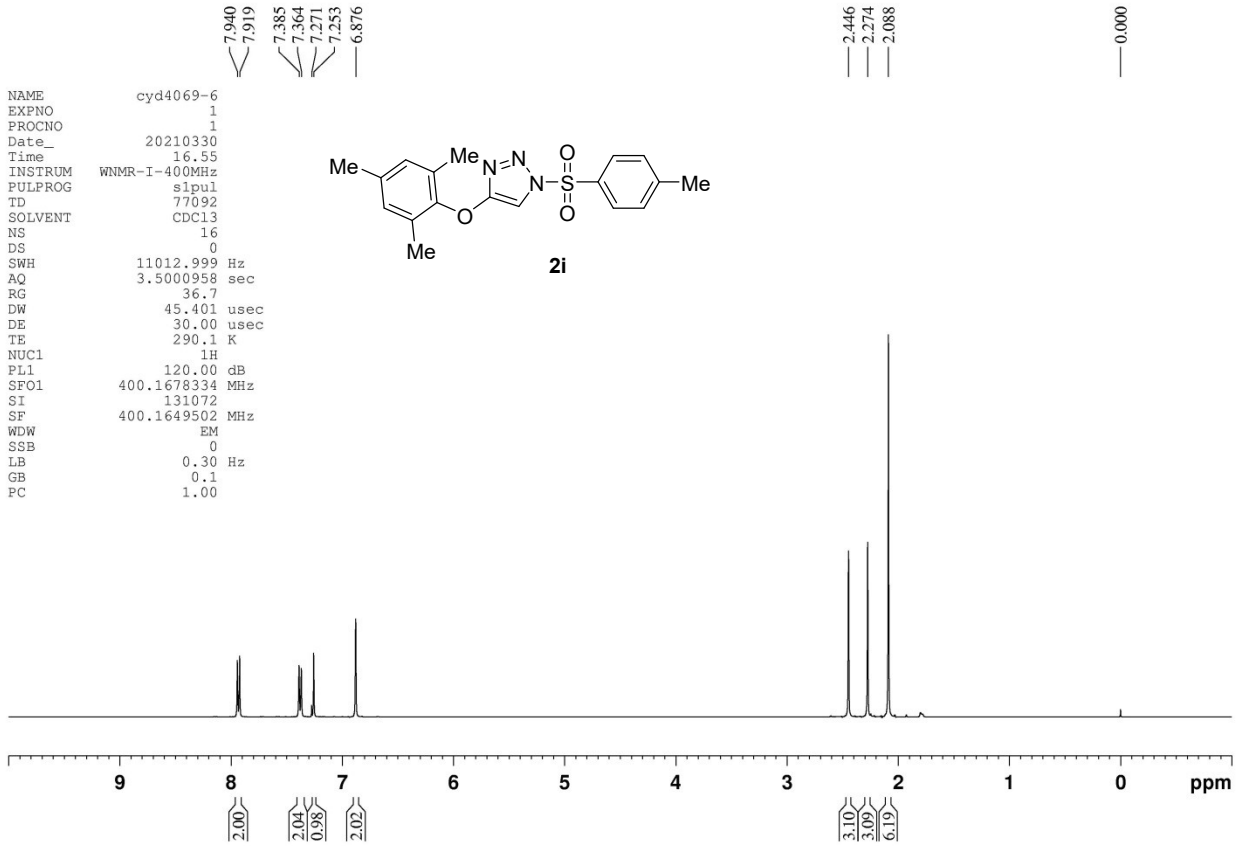


Figure S8-23. ^{1}H NMR of 2i ($CDCl_3$, 400 MHz)

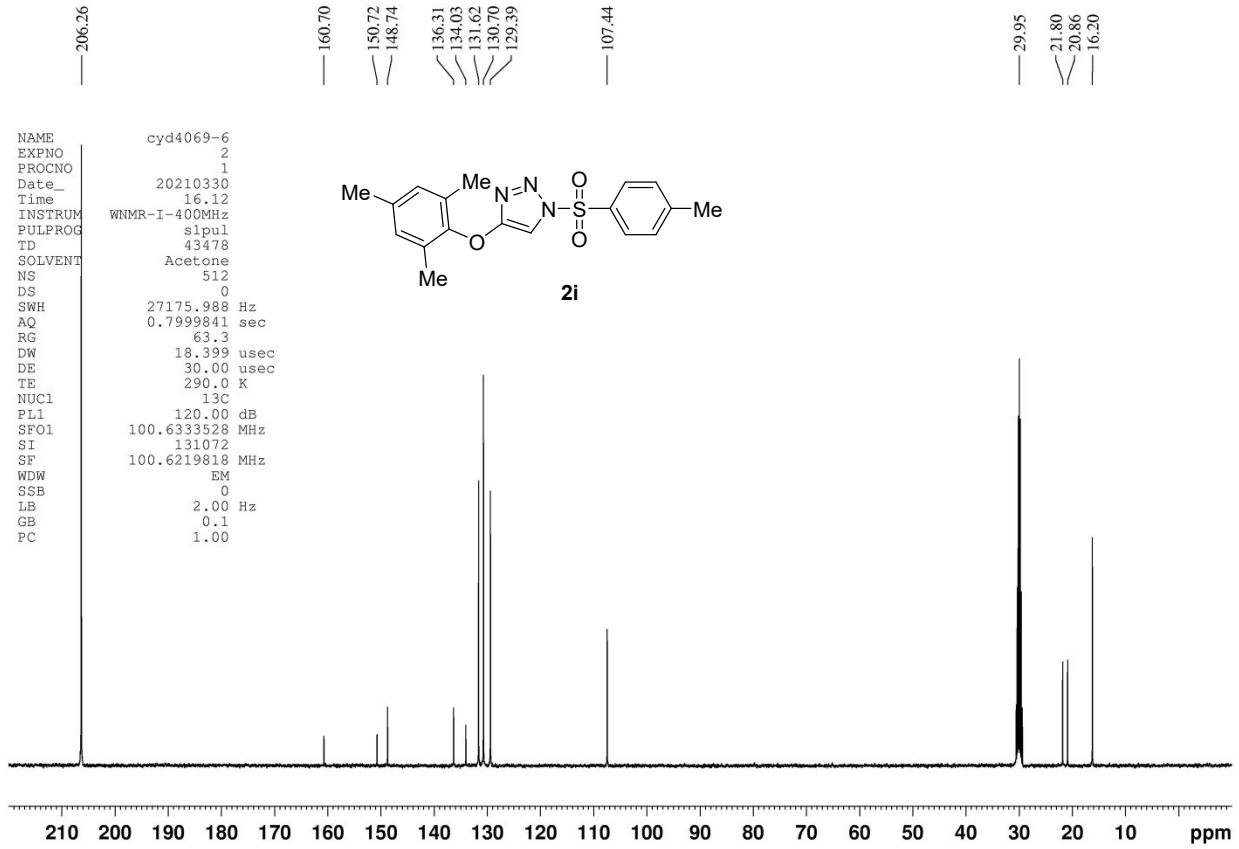


Figure S8-24. ^{13}C NMR of 2i (acetone-d6, 101 MHz)

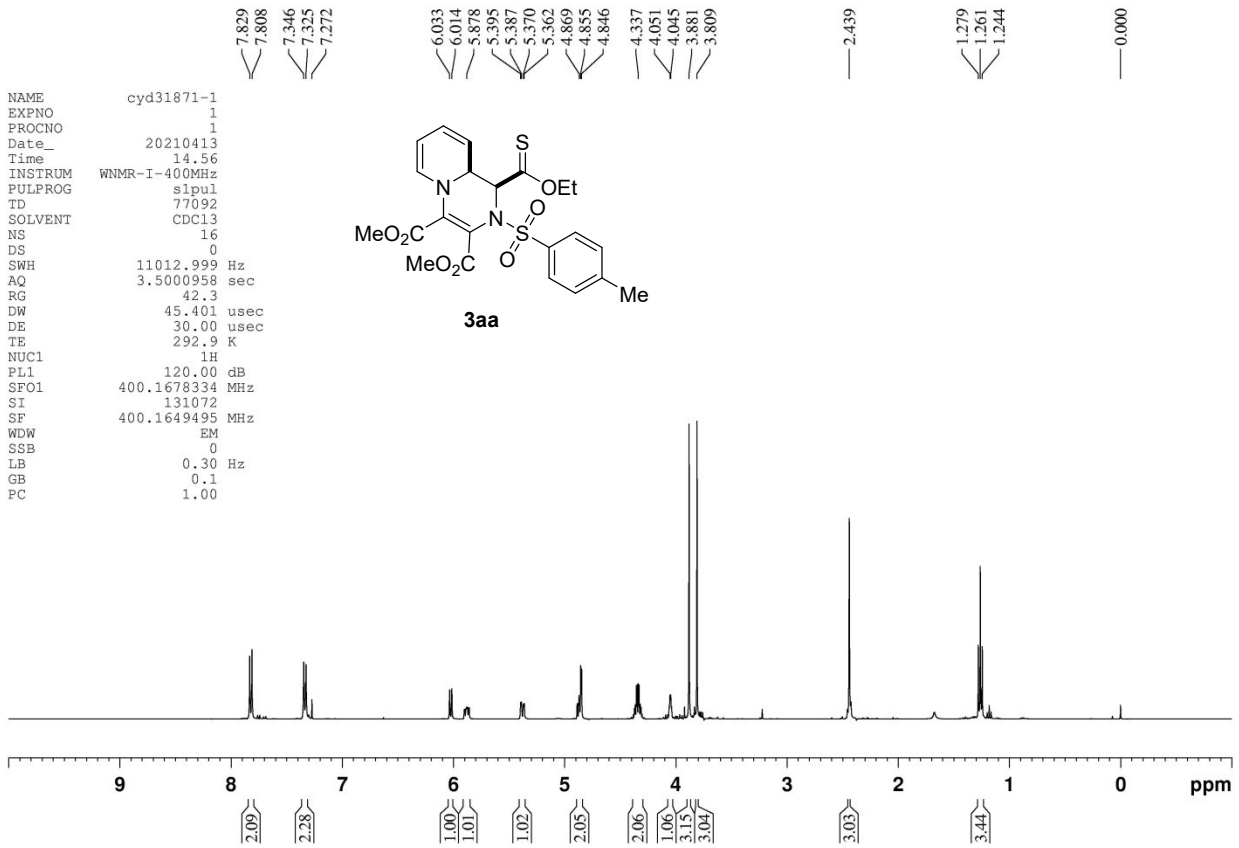


Figure S8-25. ^{1}H NMR of 3aa ($CDCl_3$, 400 MHz)

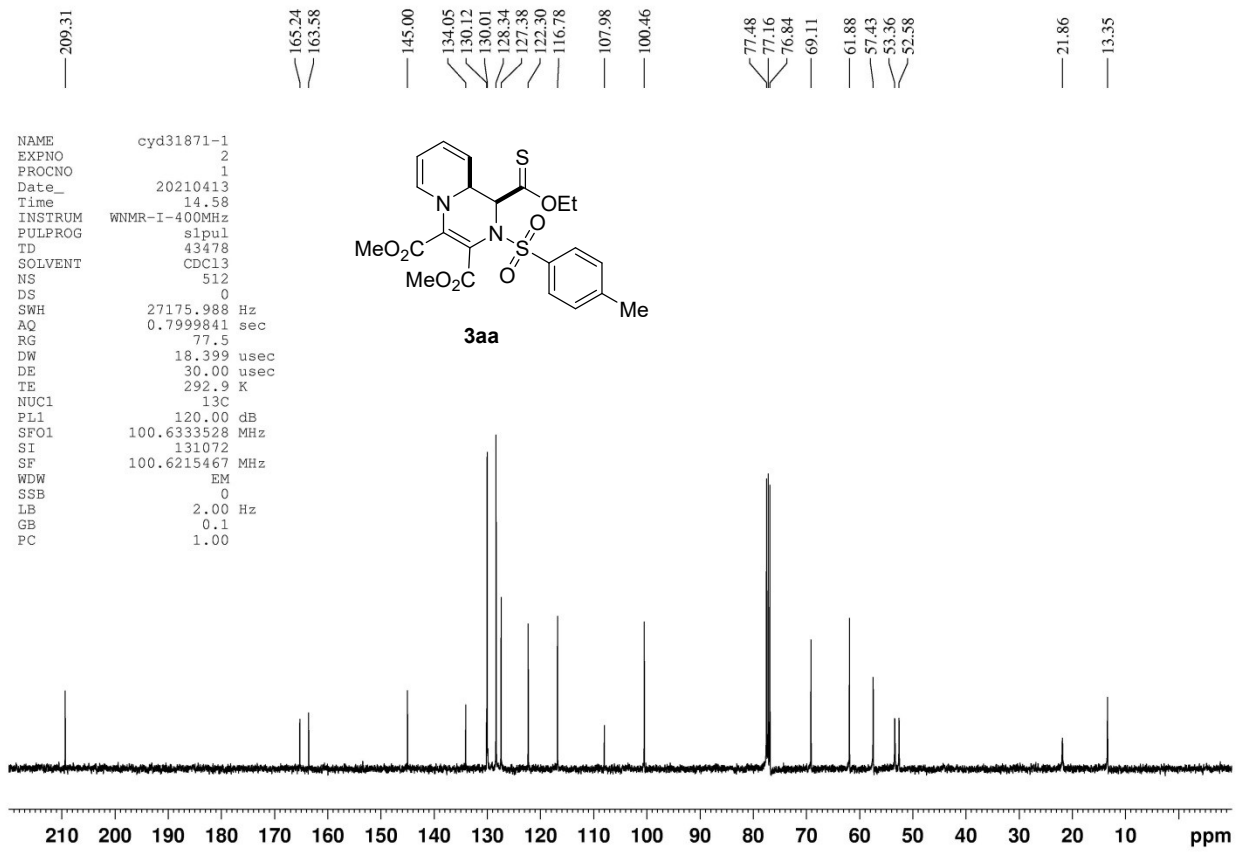


Figure S8-26. ^{13}C NMR of 3aa ($CDCl_3$, 101 MHz)

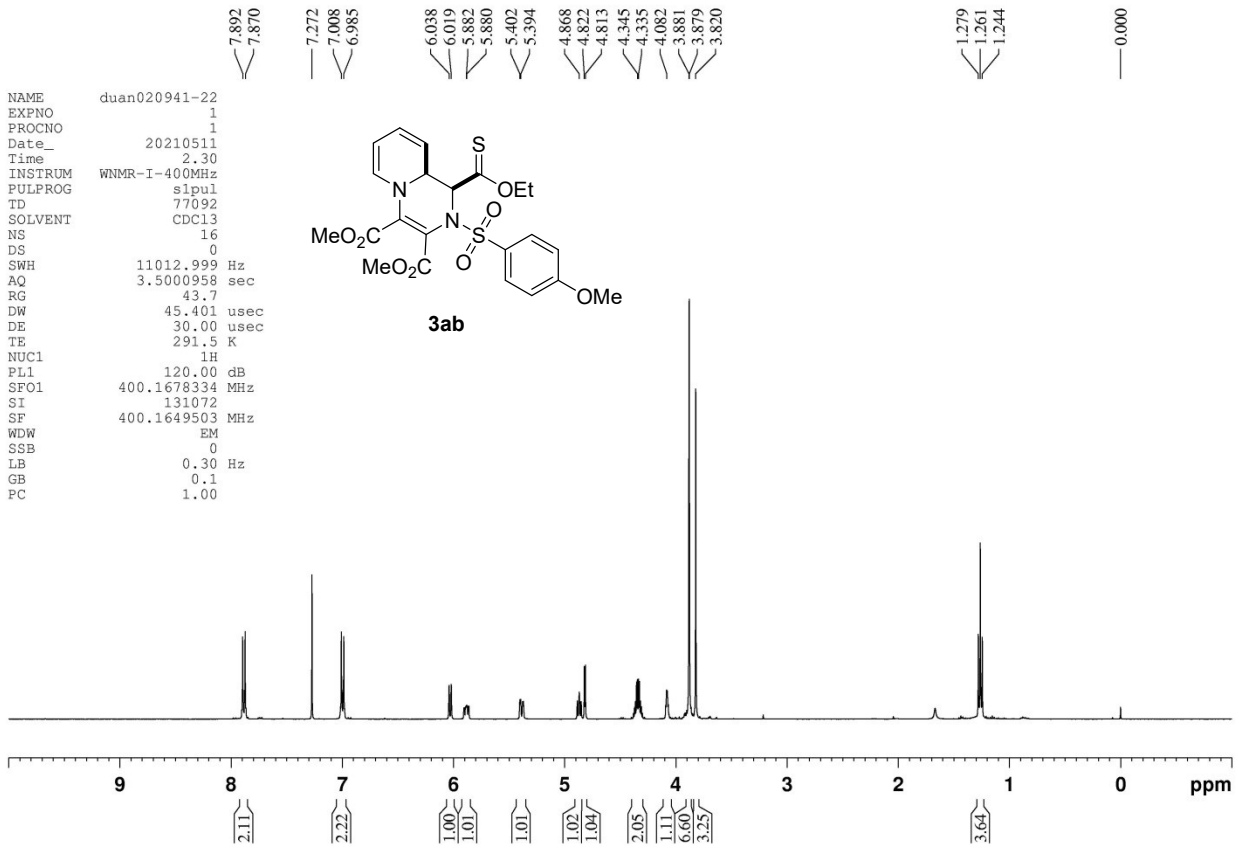


Figure S8-27. ^{1}H NMR of 3ab ($CDCl_3$, 400 MHz)

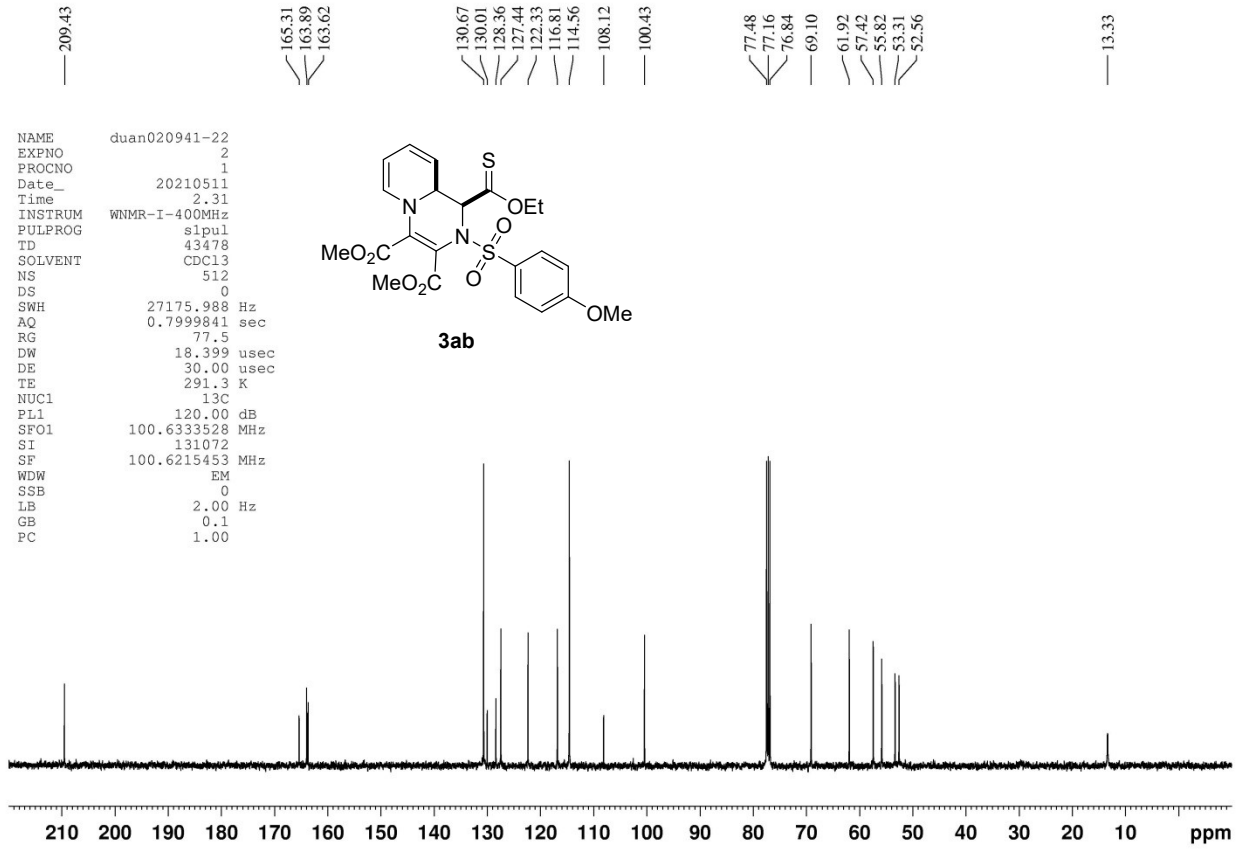


Figure S8-28. ^{13}C NMR of 3ab ($CDCl_3$, 101 MHz)

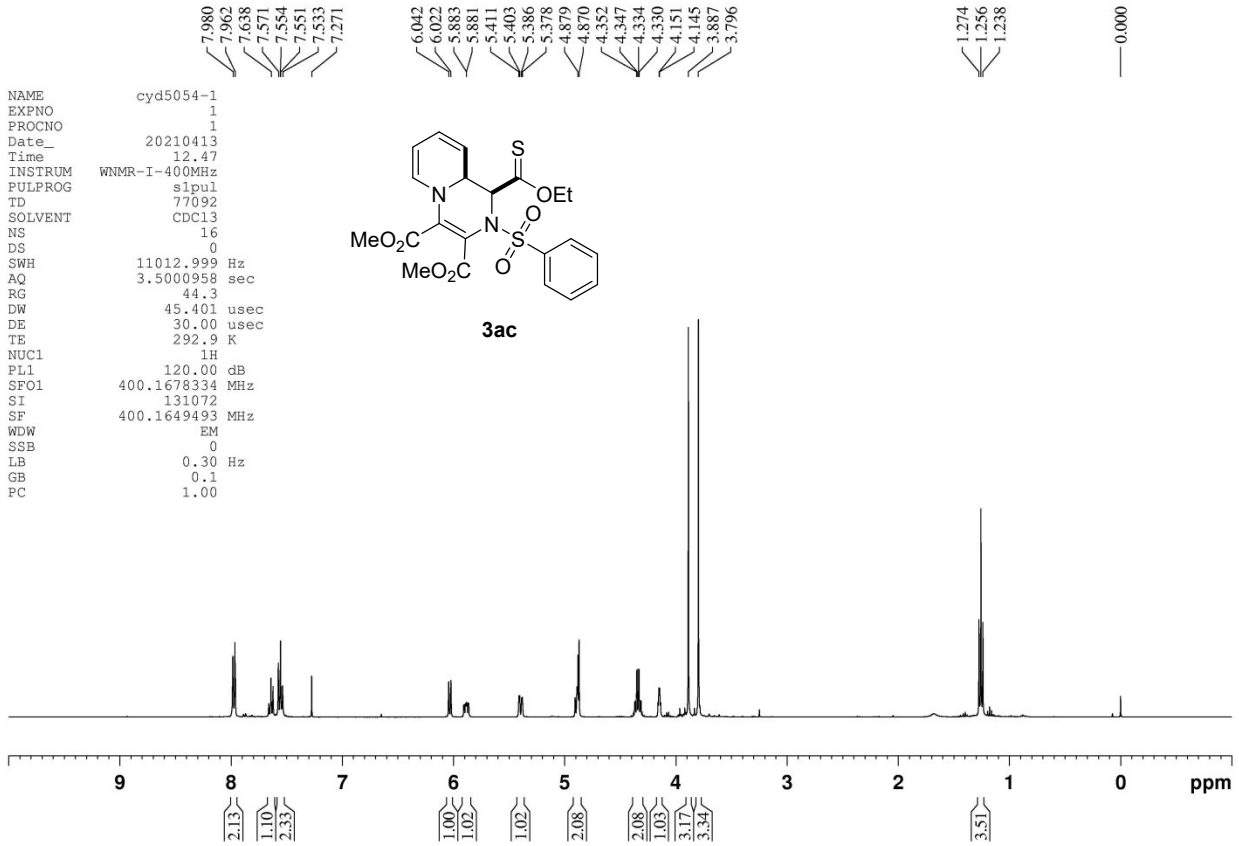


Figure S8-29. ^{1}H NMR of 3ac ($CDCl_3$, 400 MHz)

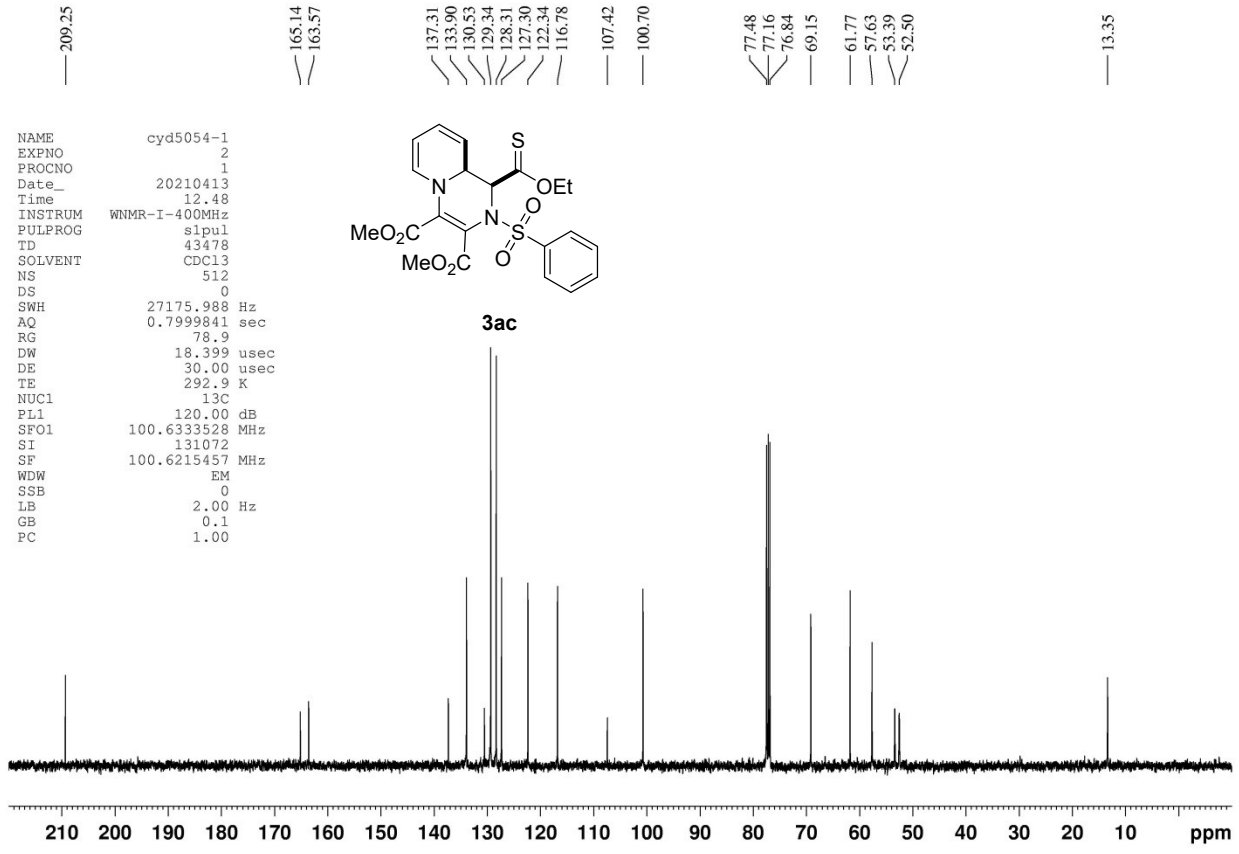


Figure S8-30. ^{13}C NMR of 3ac ($CDCl_3$, 101 MHz)

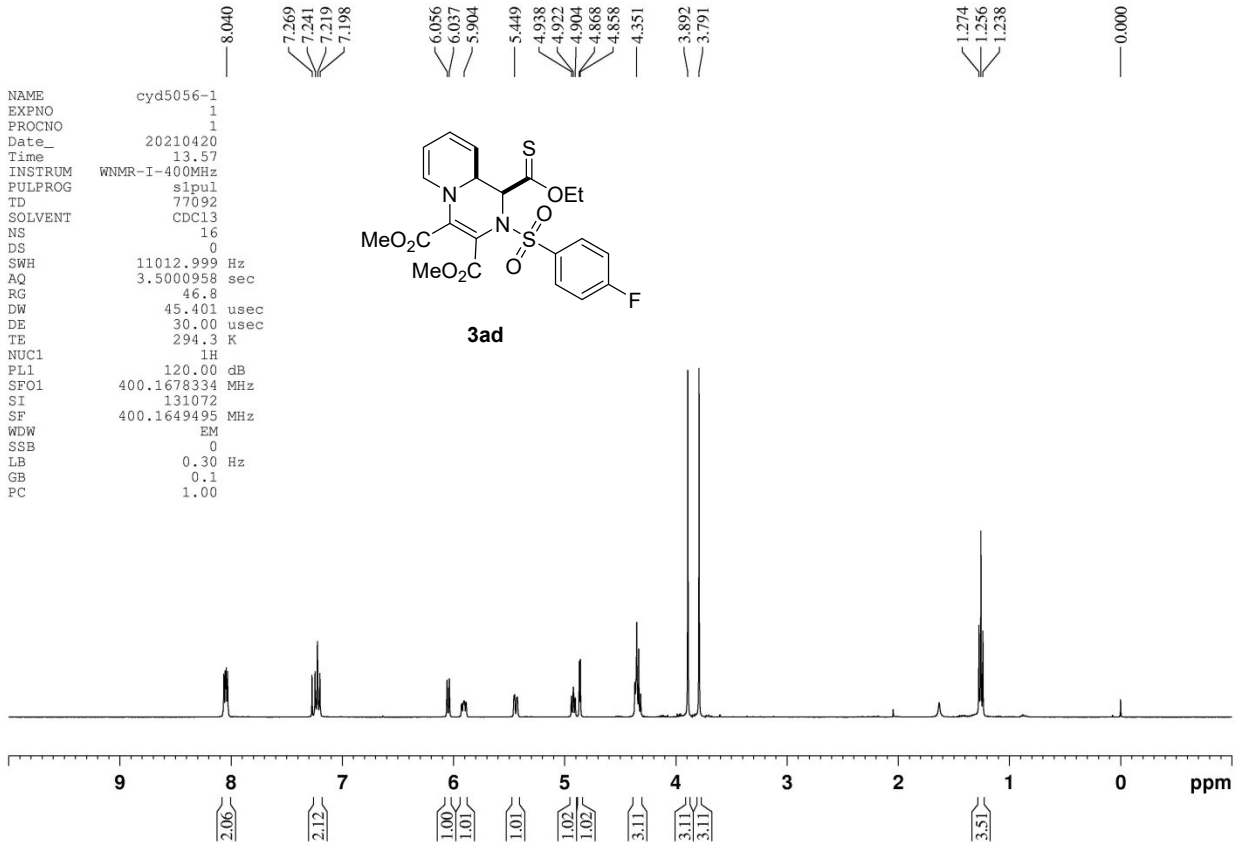


Figure S8-31. ^{1}H NMR of 3ad ($CDCl_3$, 400 MHz)

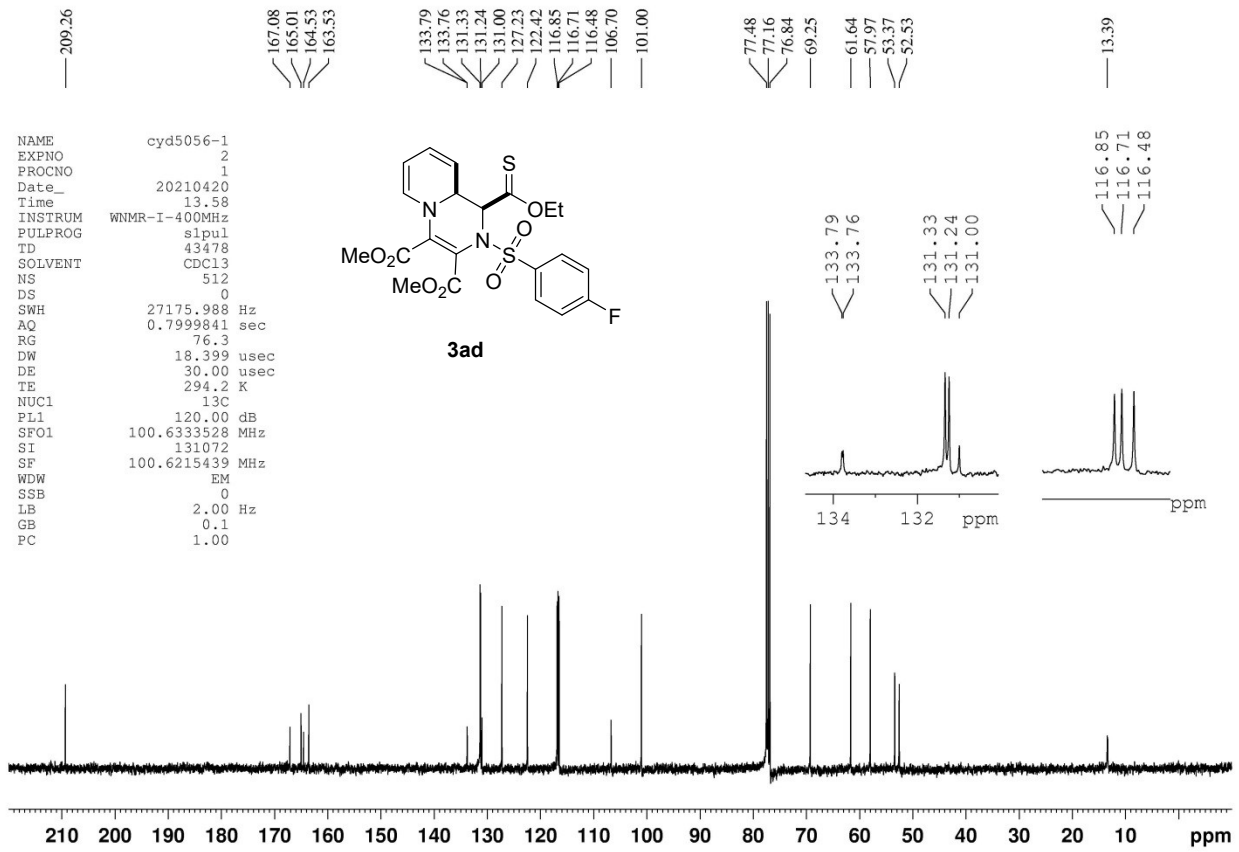


Figure S8-32. ^{13}C NMR of 3ad ($CDCl_3$, 101 MHz)

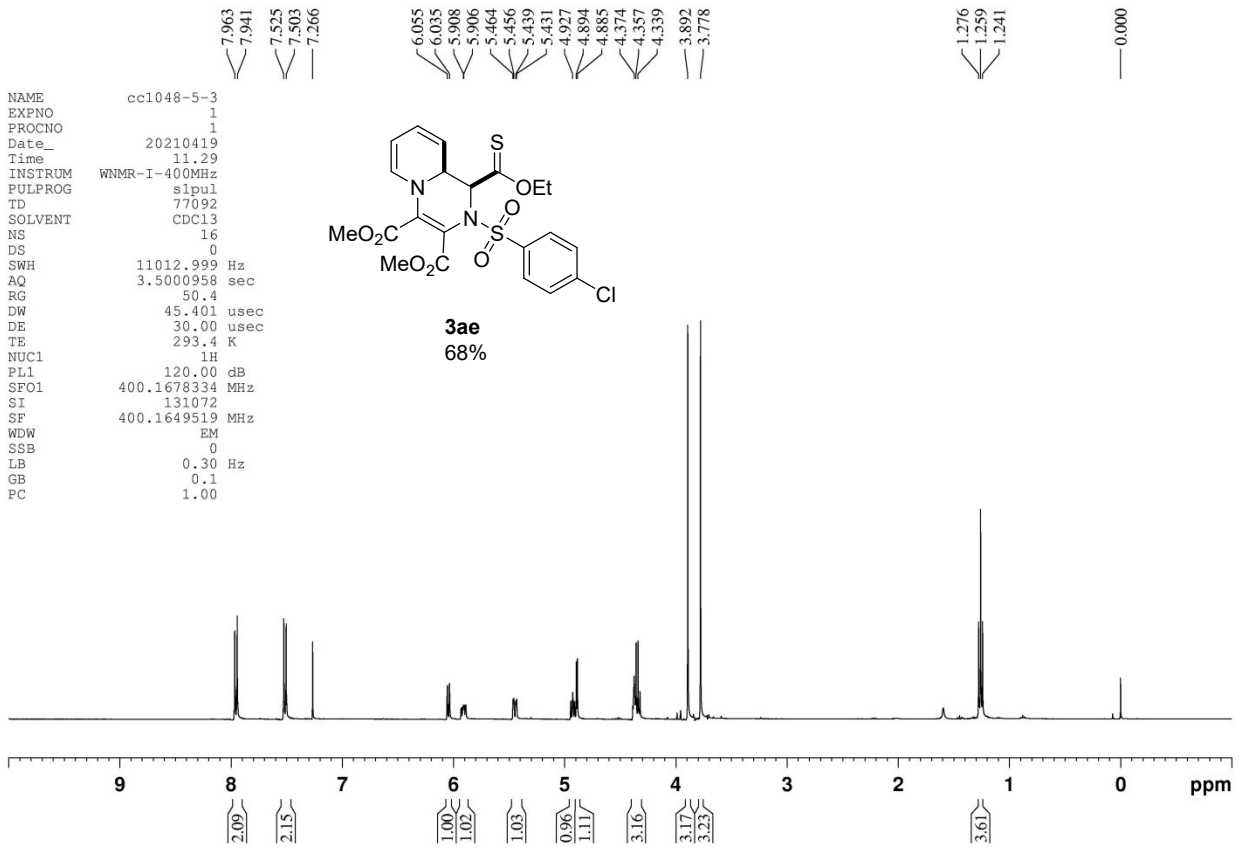


Figure S8-33. ^{1}H NMR of 3ae ($CDCl_3$, 400 MHz)

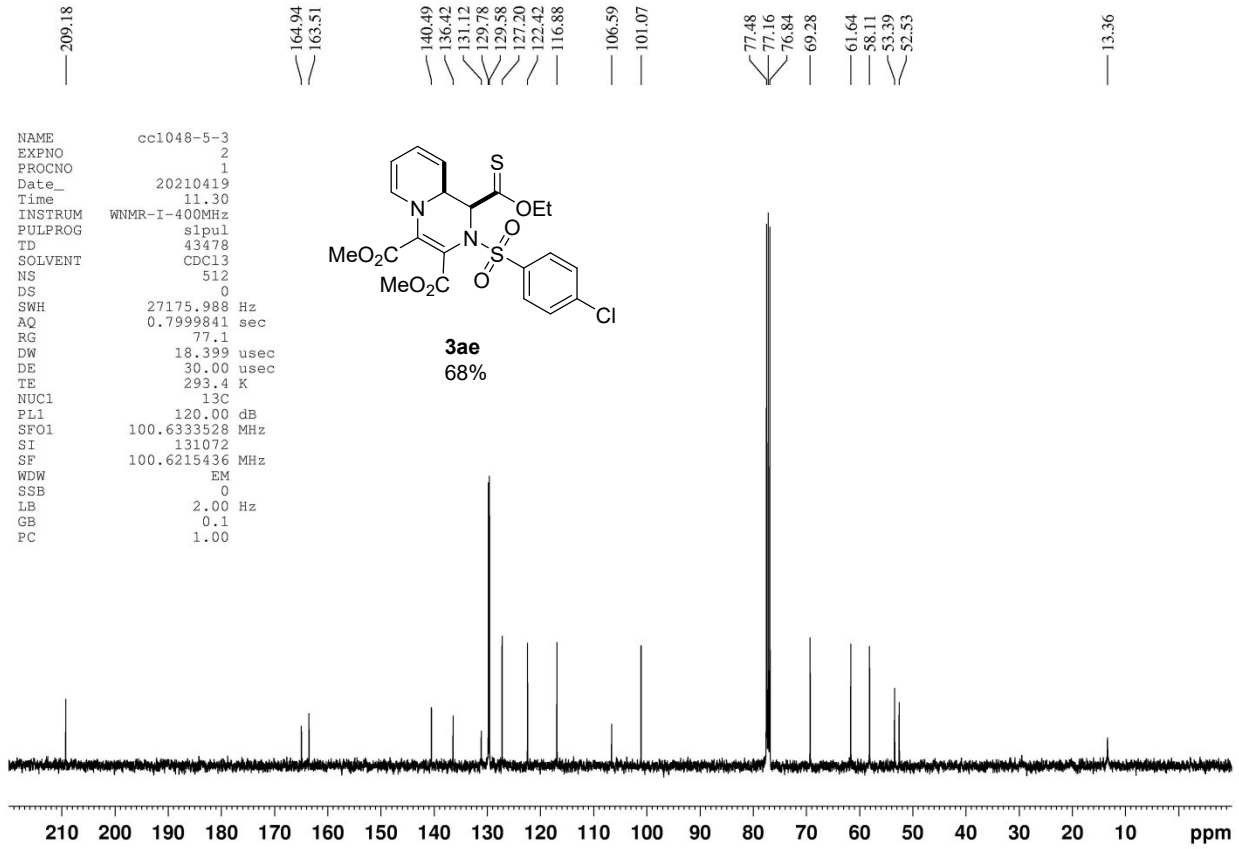


Figure S8-34. ^{13}C NMR of 3ae ($CDCl_3$, 101 MHz)

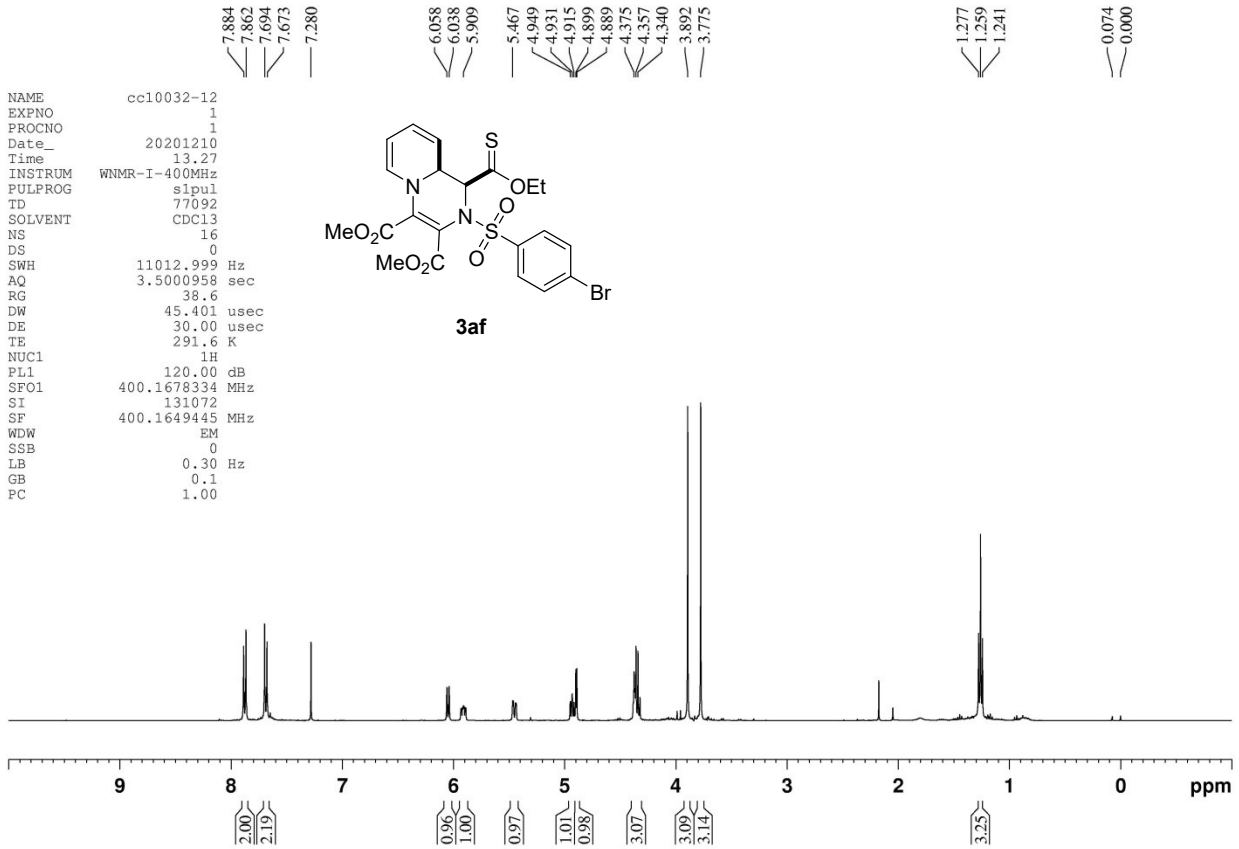


Figure S8-35. ^{1}H NMR of 3af ($CDCl_3$, 400 MHz)

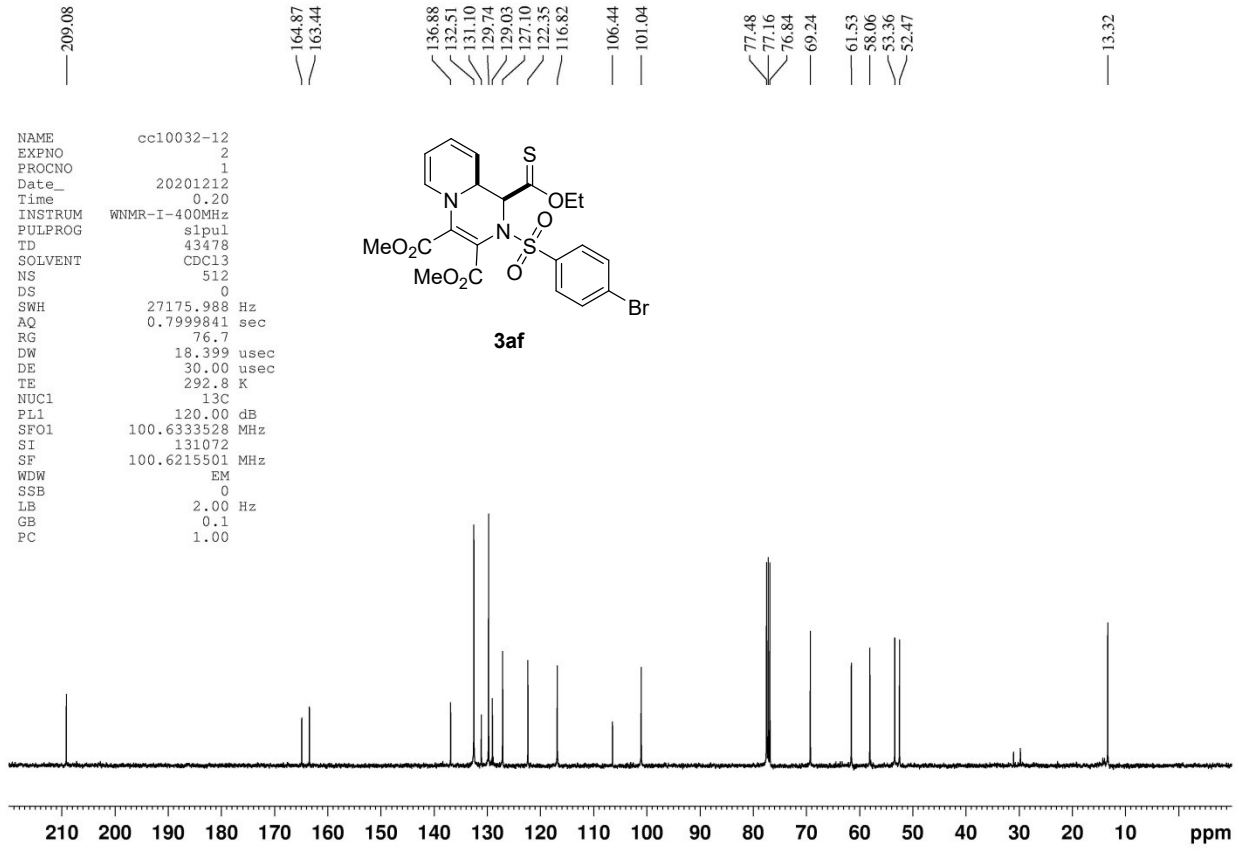


Figure S8-36. ^{13}C NMR of 3af ($CDCl_3$, 101 MHz)

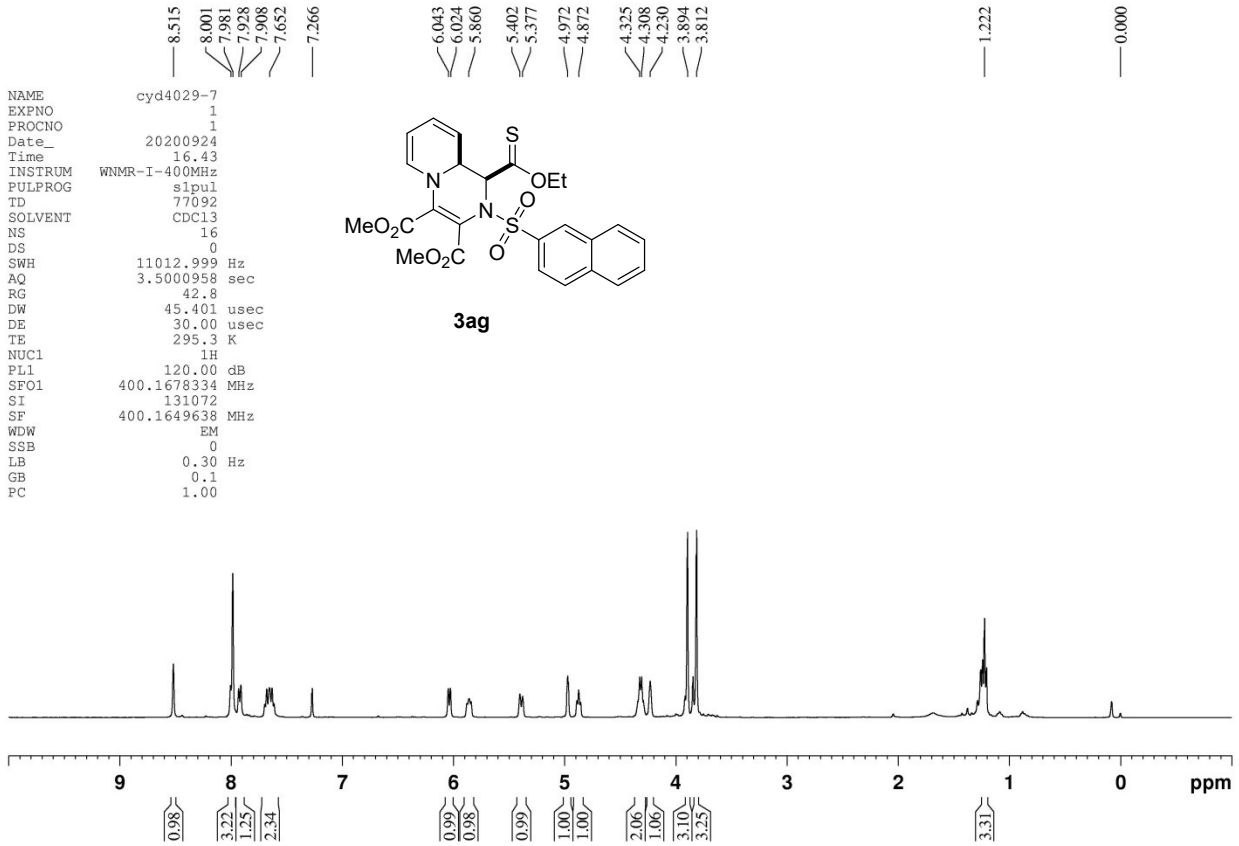


Figure S8-37. ^{1}H NMR of 3ag ($CDCl_3$, 400 MHz)

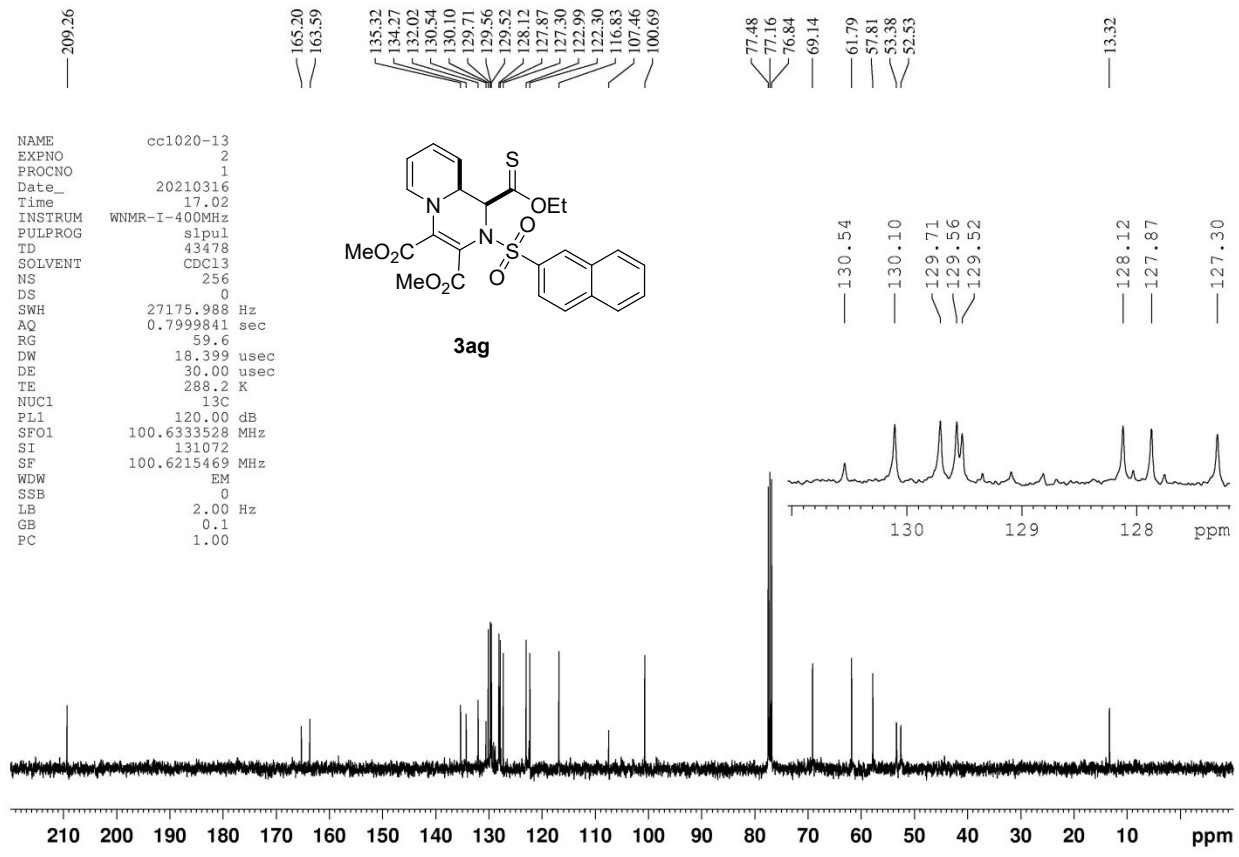


Figure S8-38. ^{13}C NMR of 3ag ($CDCl_3$, 101 MHz)

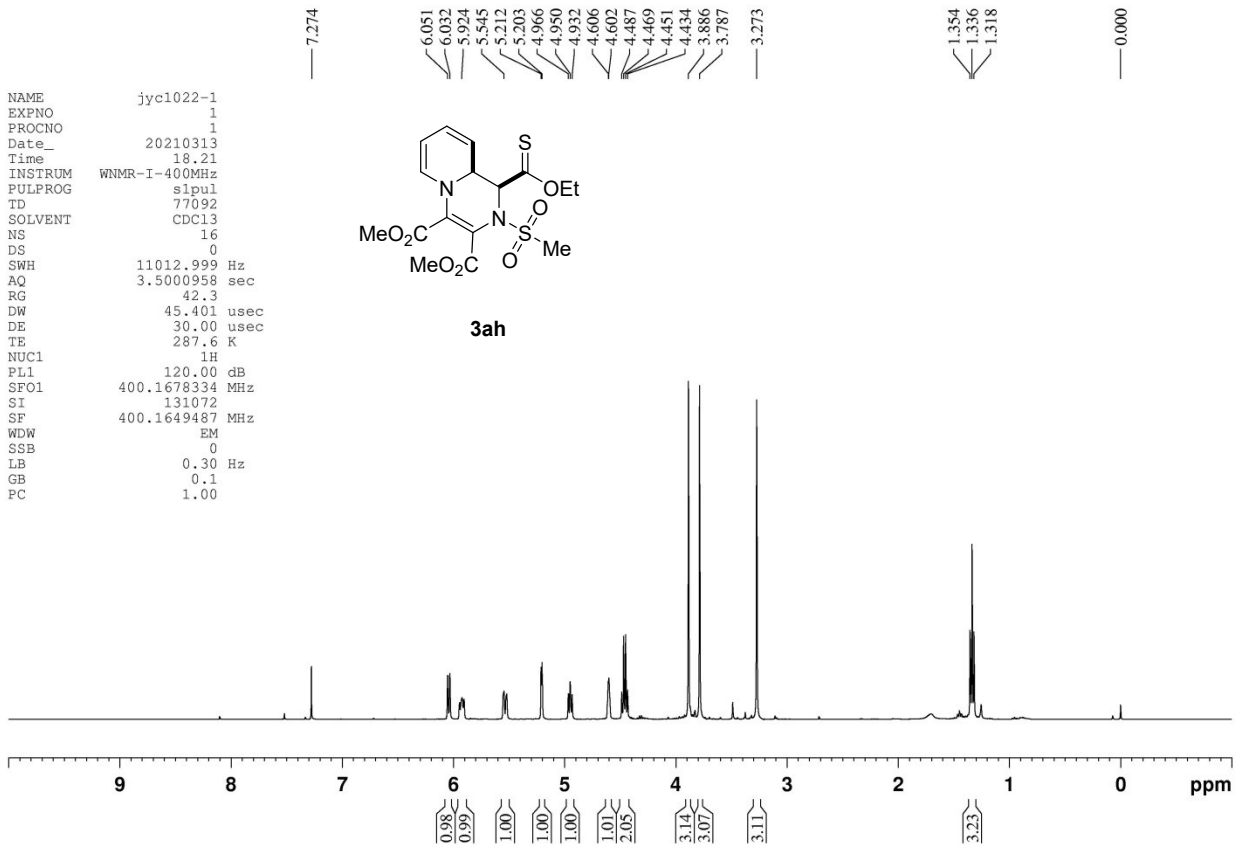


Figure S8-39. ^{1}H NMR of 3ah ($CDCl_3$, 400 MHz)

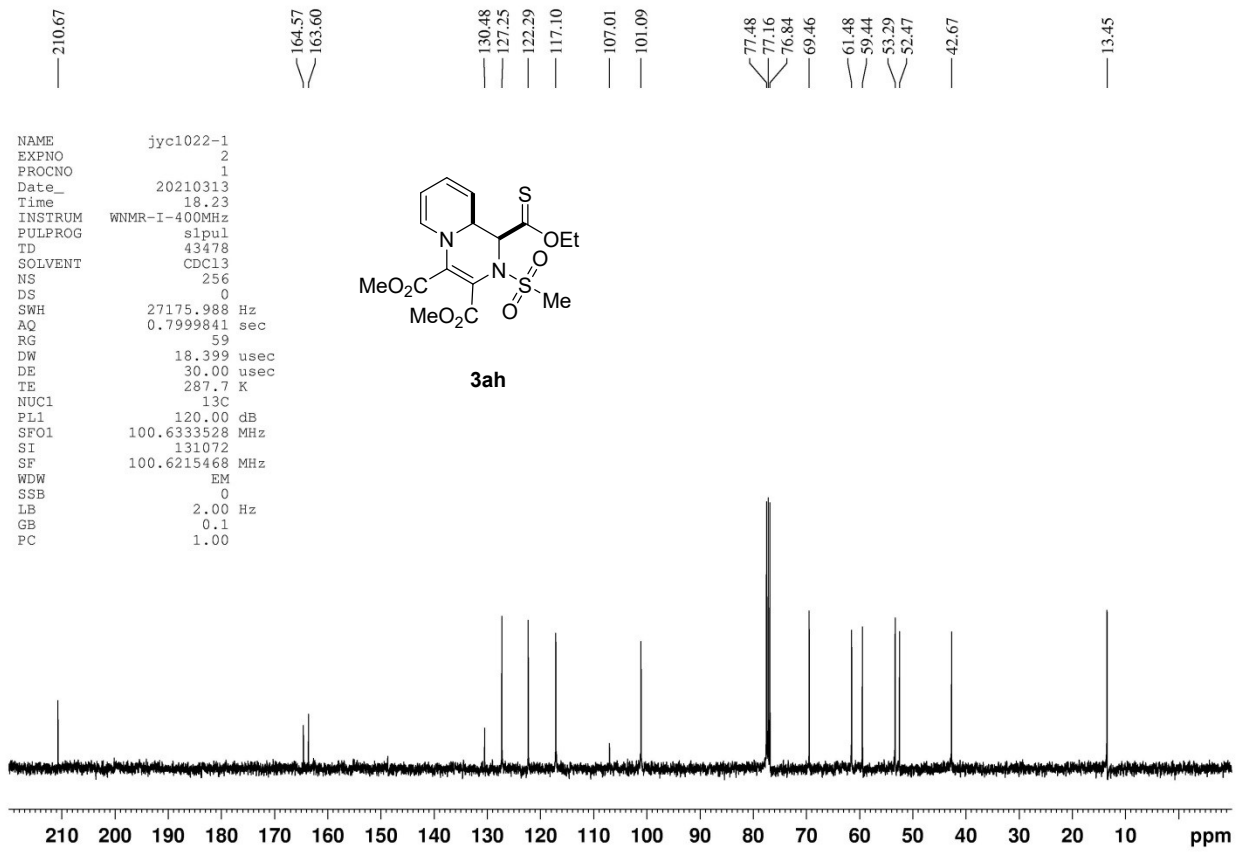


Figure S8-40. ^{13}C NMR of 3ah ($CDCl_3$, 101 MHz)

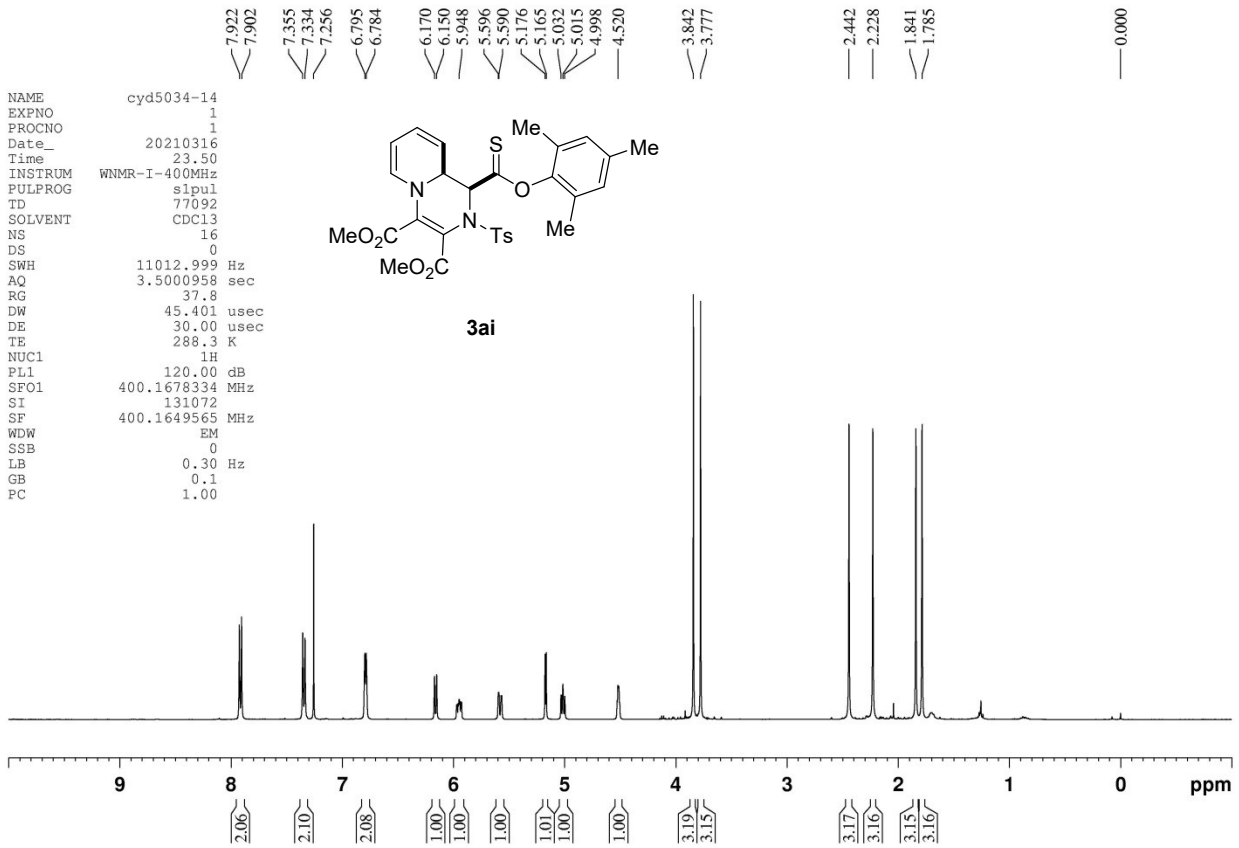


Figure S8-41. ^{1}H NMR of 3ai ($CDCl_3$, 400 MHz)

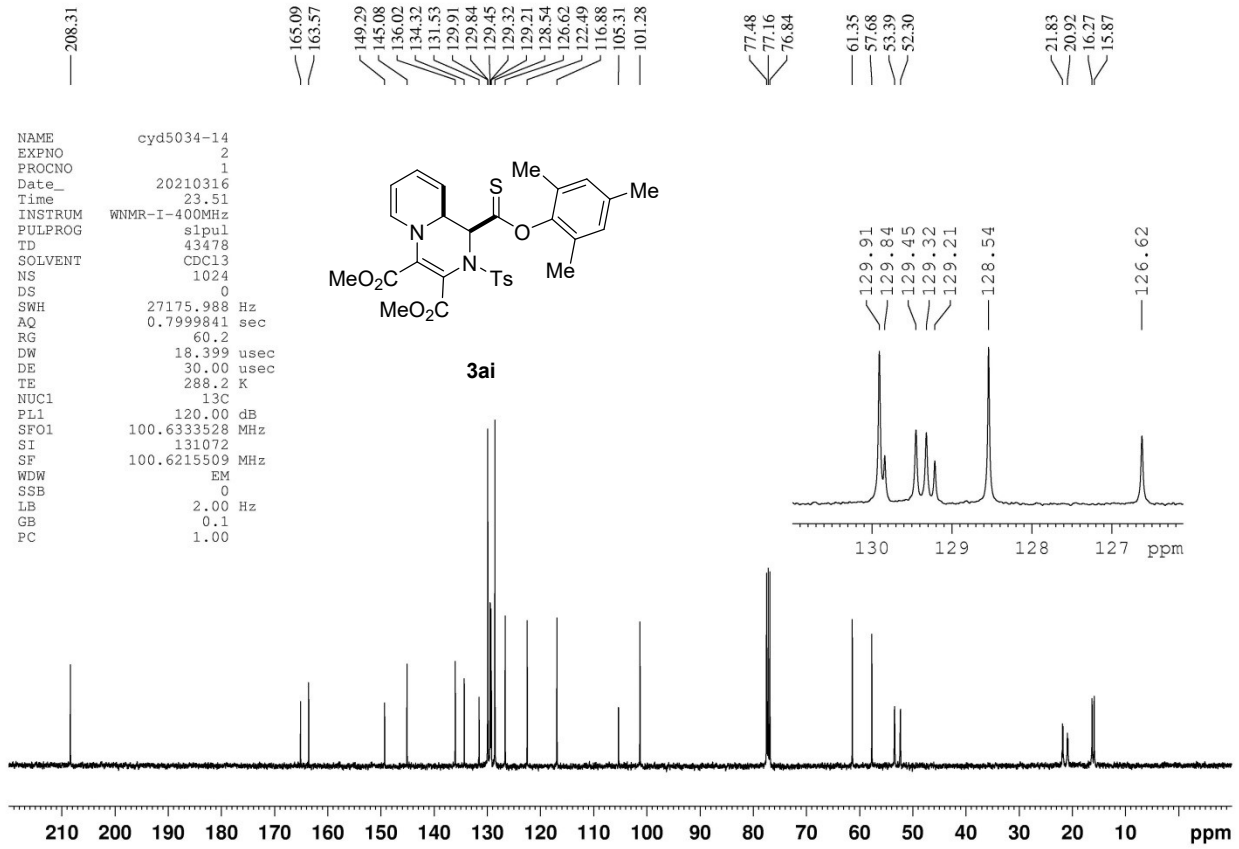


Figure S8-42. ^{13}C NMR of 3ai ($CDCl_3$, 101 MHz)

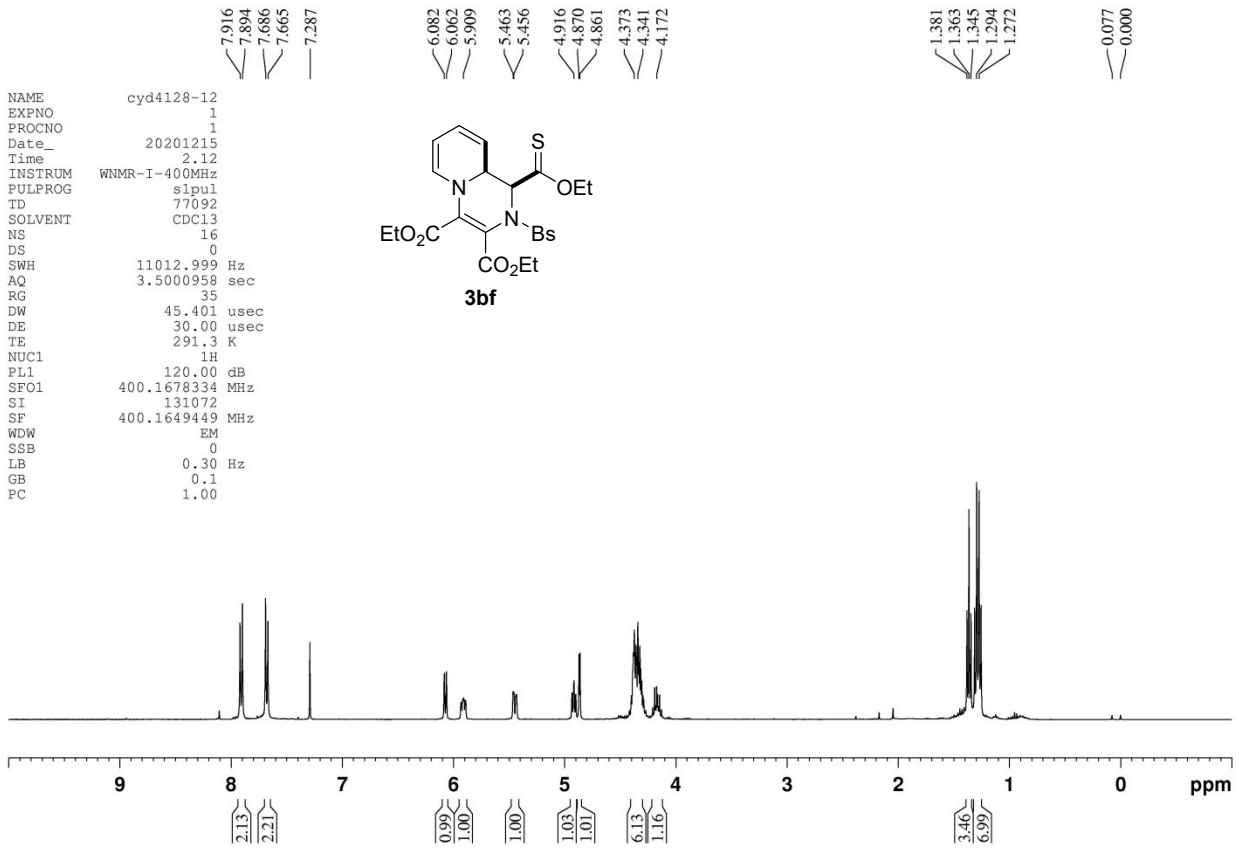


Figure S8-43. ^{1}H NMR of 3bf ($CDCl_3$, 400 MHz)

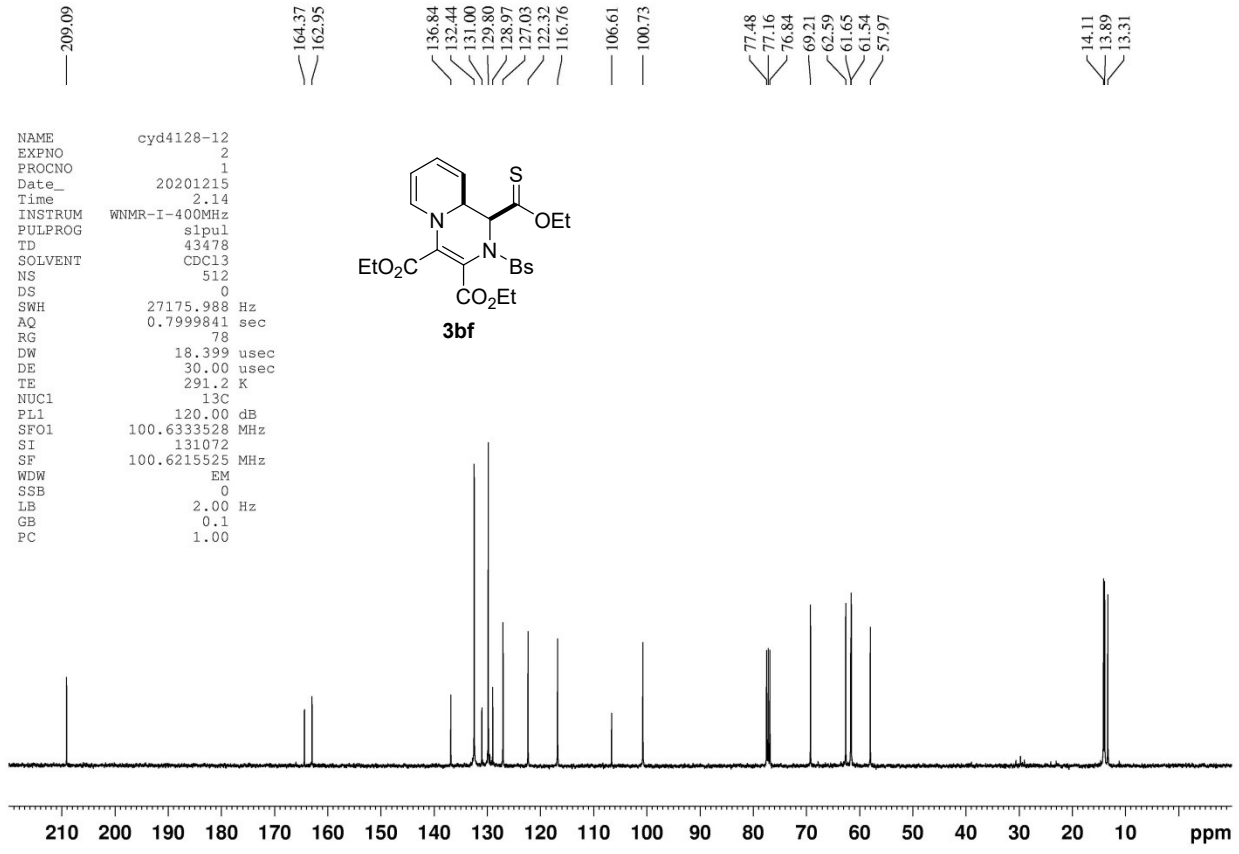


Figure S8-44. ^{13}C NMR of 3bf ($CDCl_3$, 101 MHz)

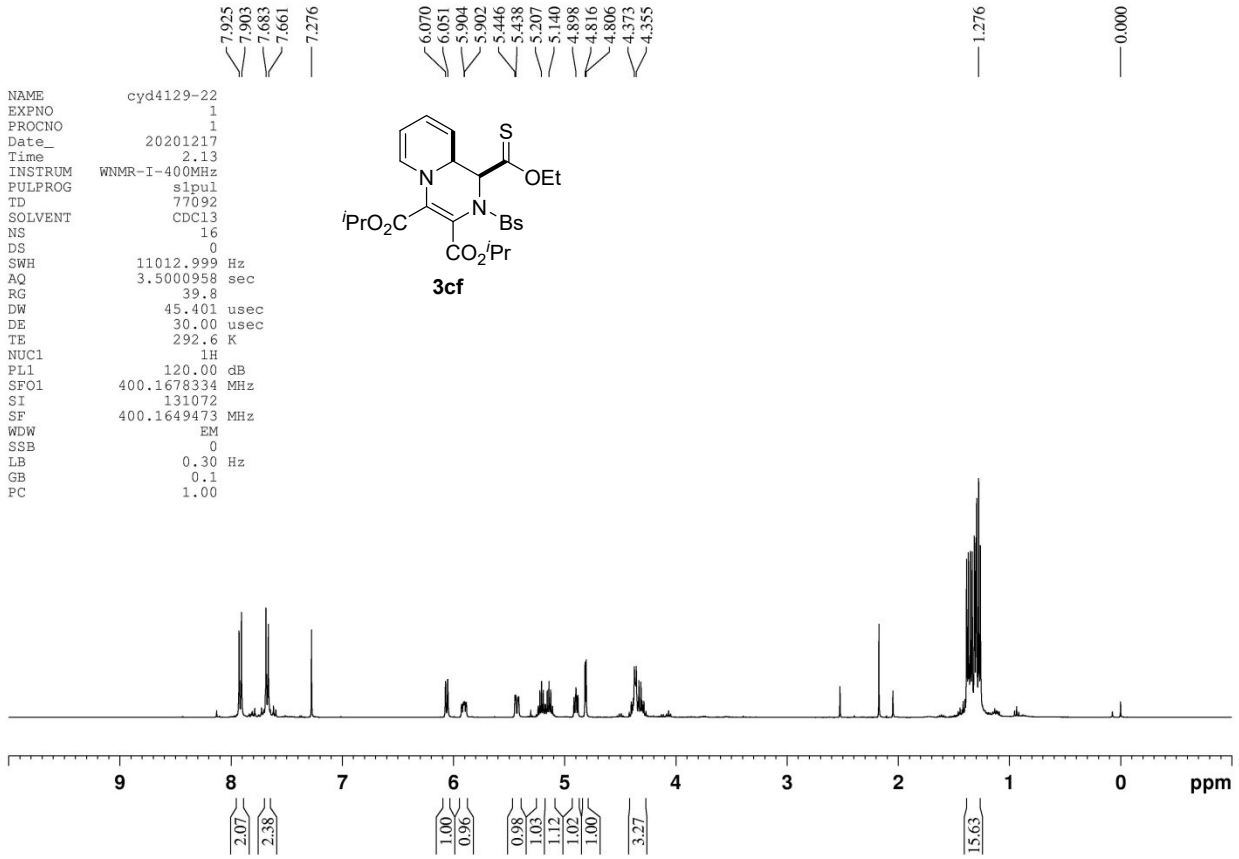


Figure S8-45. ^{1}H NMR of 3cf ($CDCl_3$, 400 MHz)

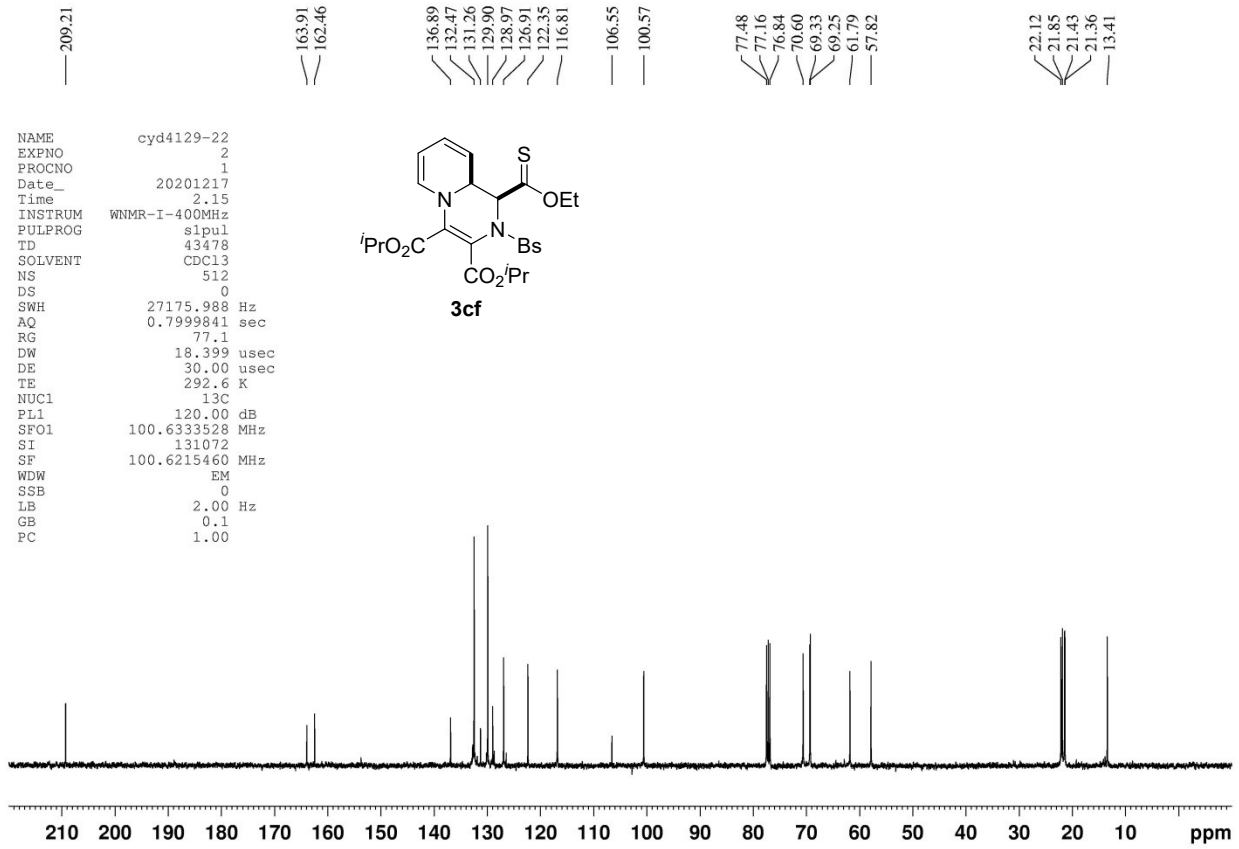


Figure S8-46. ^{13}C NMR of 3cf ($CDCl_3$, 101 MHz)

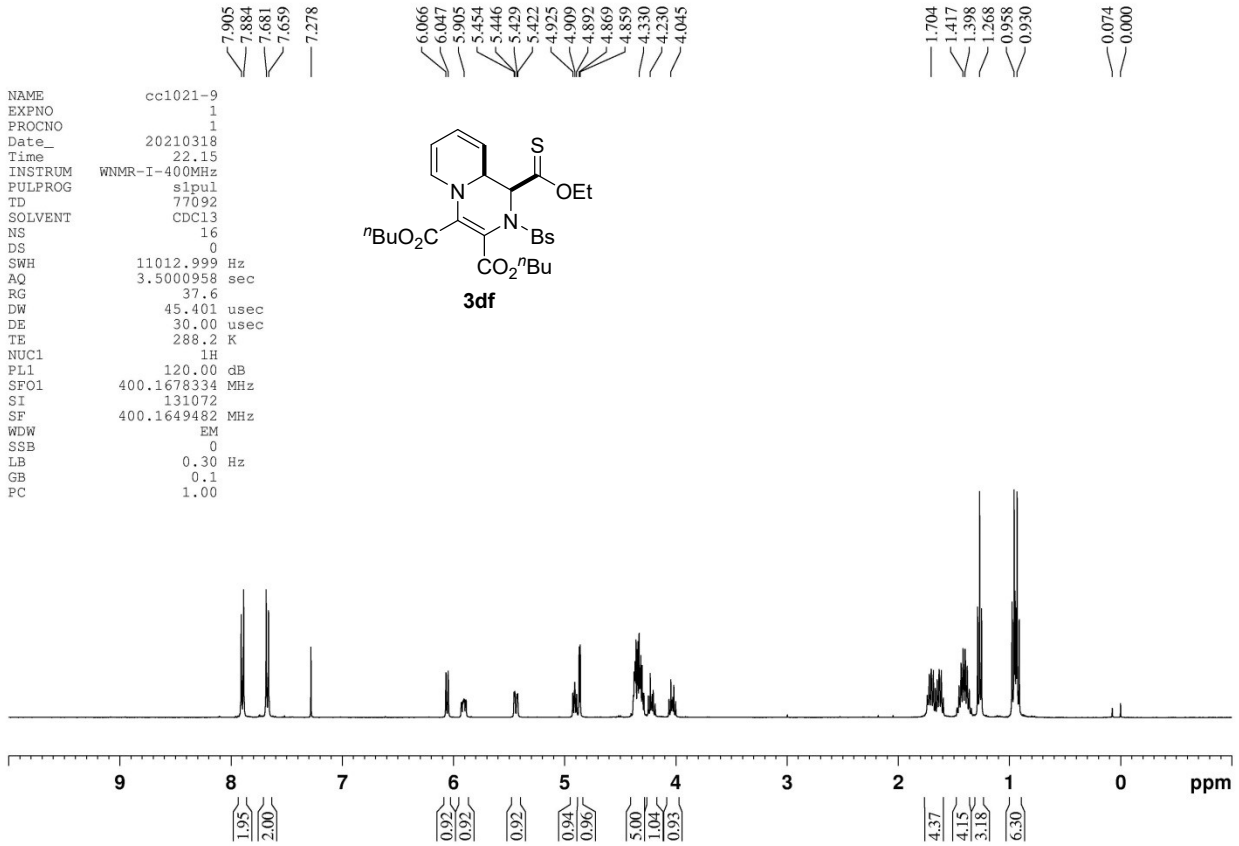


Figure S8-47. ^{1}H NMR of 3df ($CDCl_3$, 400 MHz)

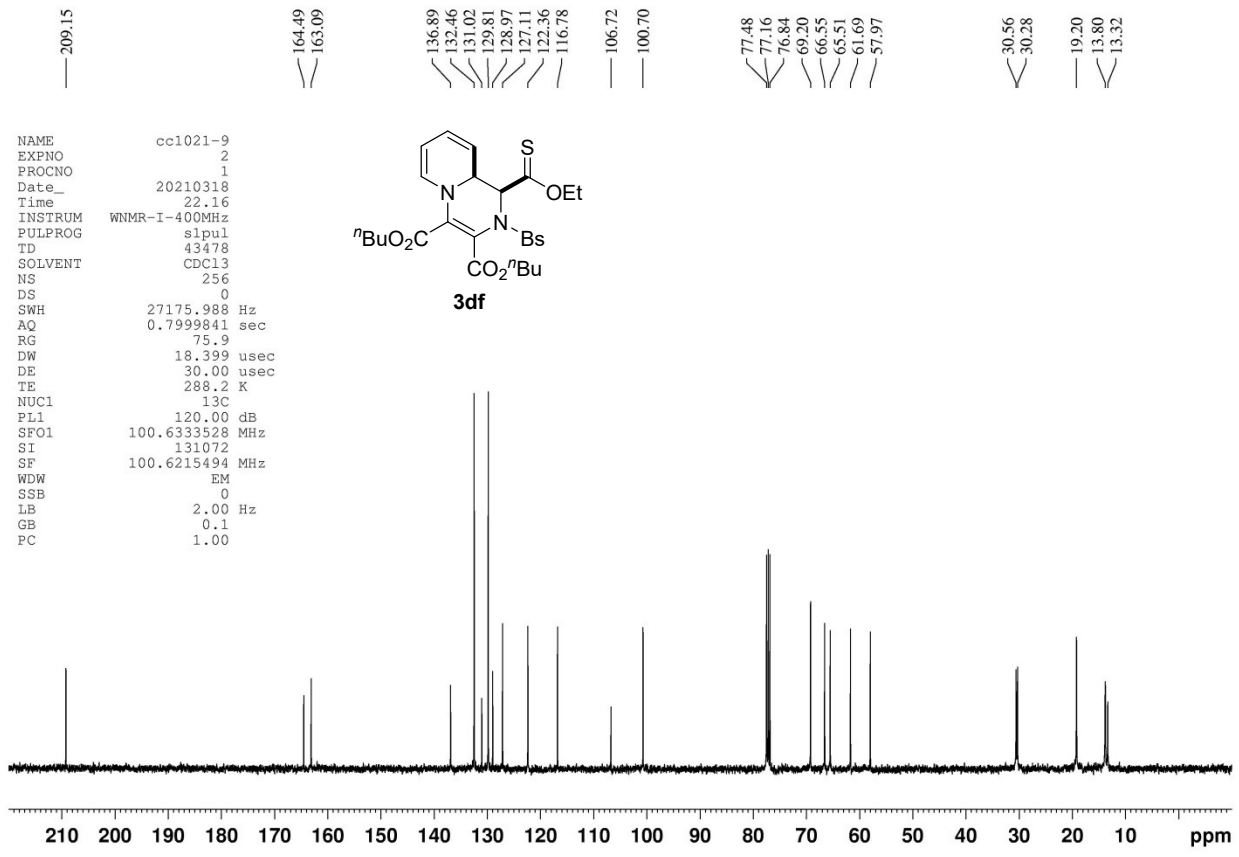


Figure S8-48. ^{13}C NMR of 3df ($CDCl_3$, 101 MHz)

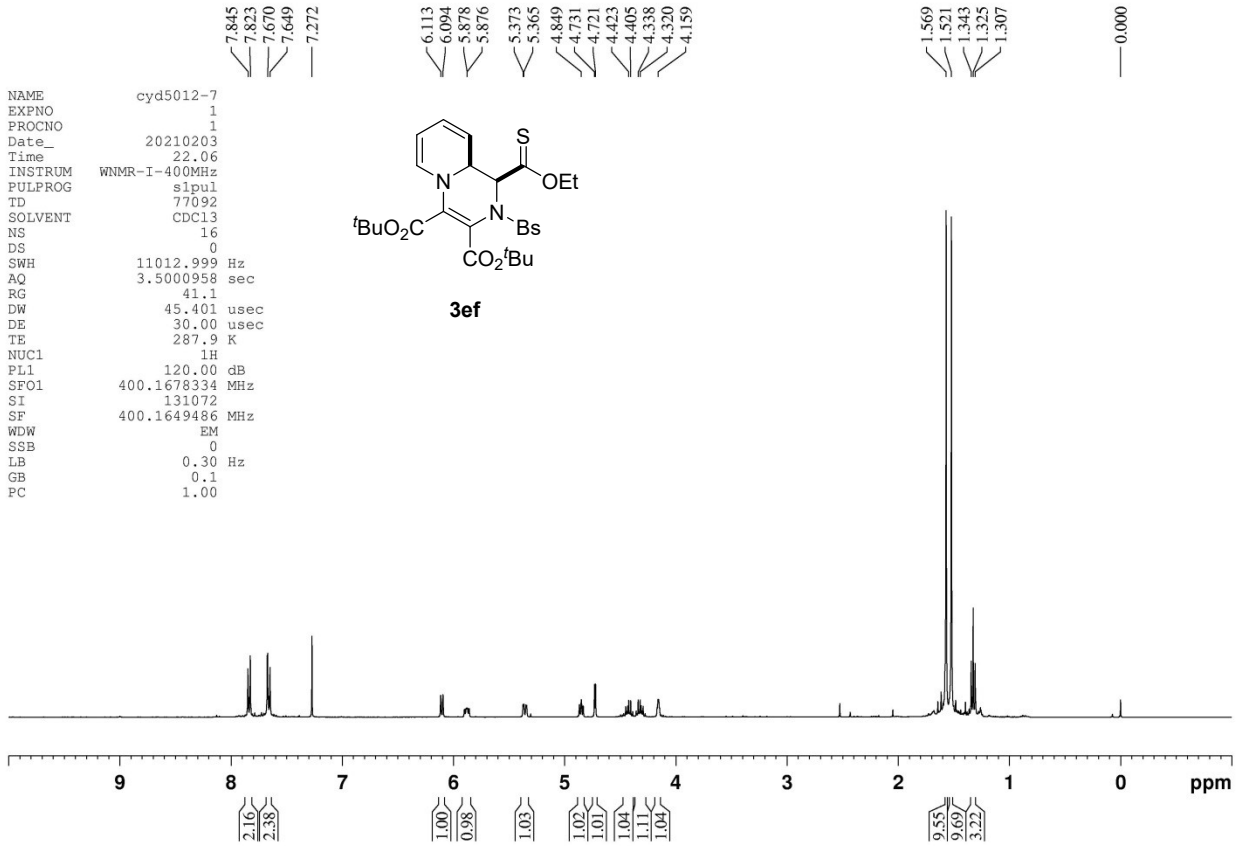


Figure S8-49. ^{1}H NMR of 3ef ($CDCl_3$, 400 MHz)

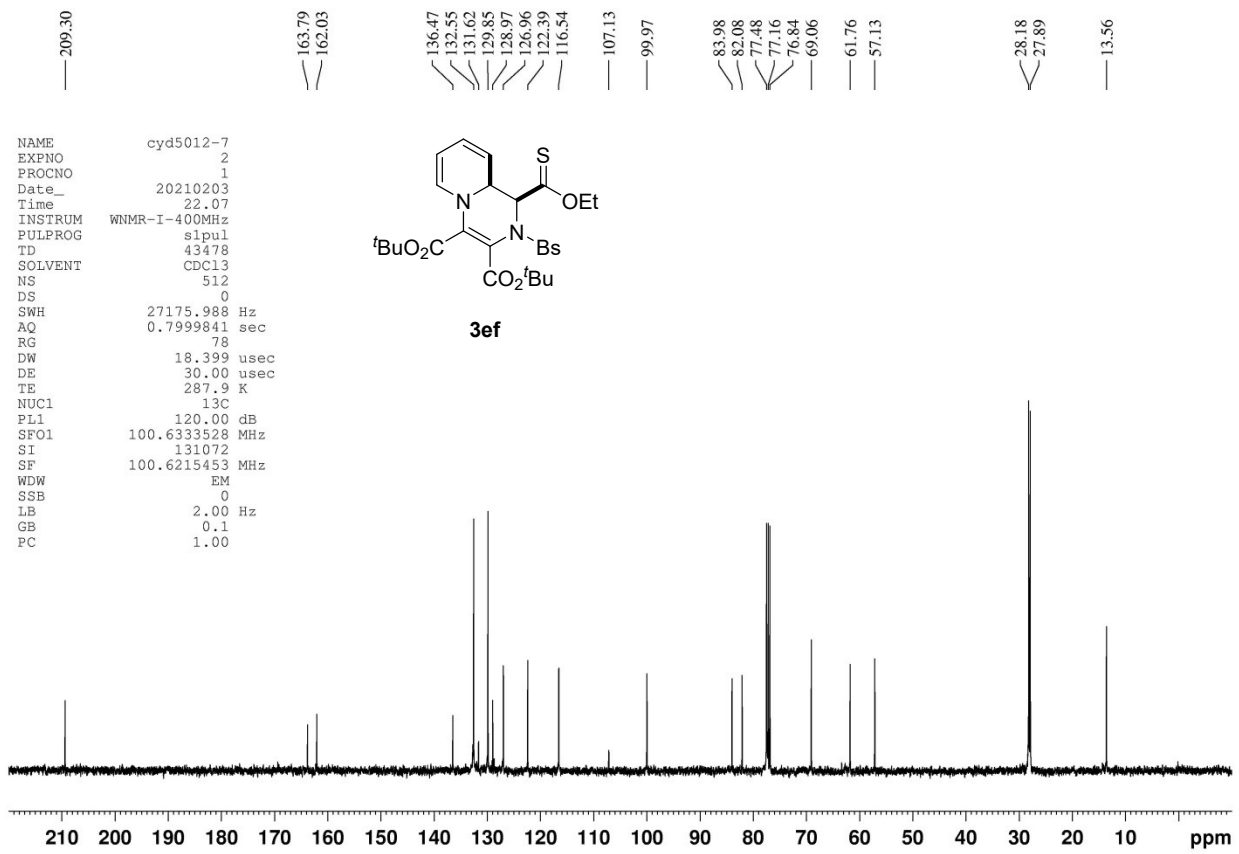


Figure S8-50. ^{13}C NMR of 3ef ($CDCl_3$, 101 MHz)

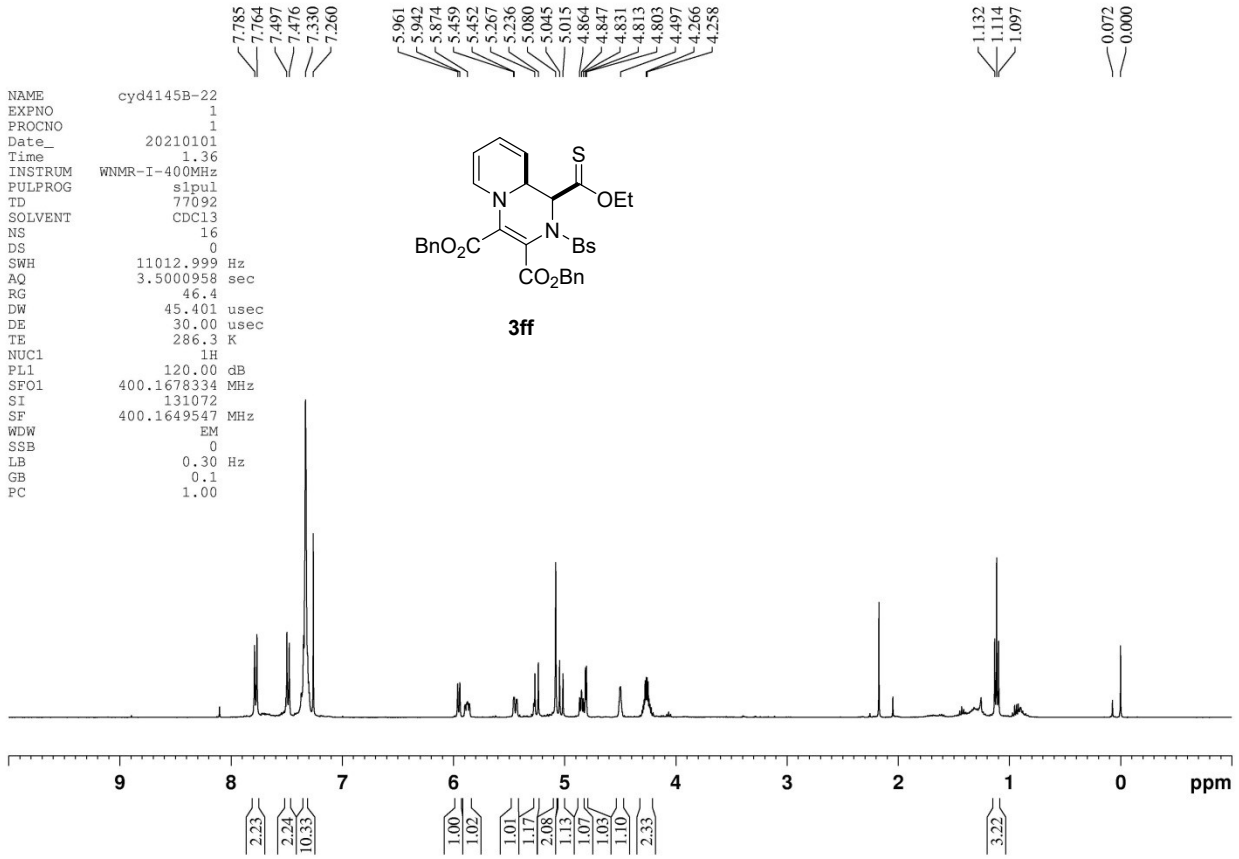


Figure S8-51. ^{1}H NMR of 3ff ($CDCl_3$, 400 MHz)

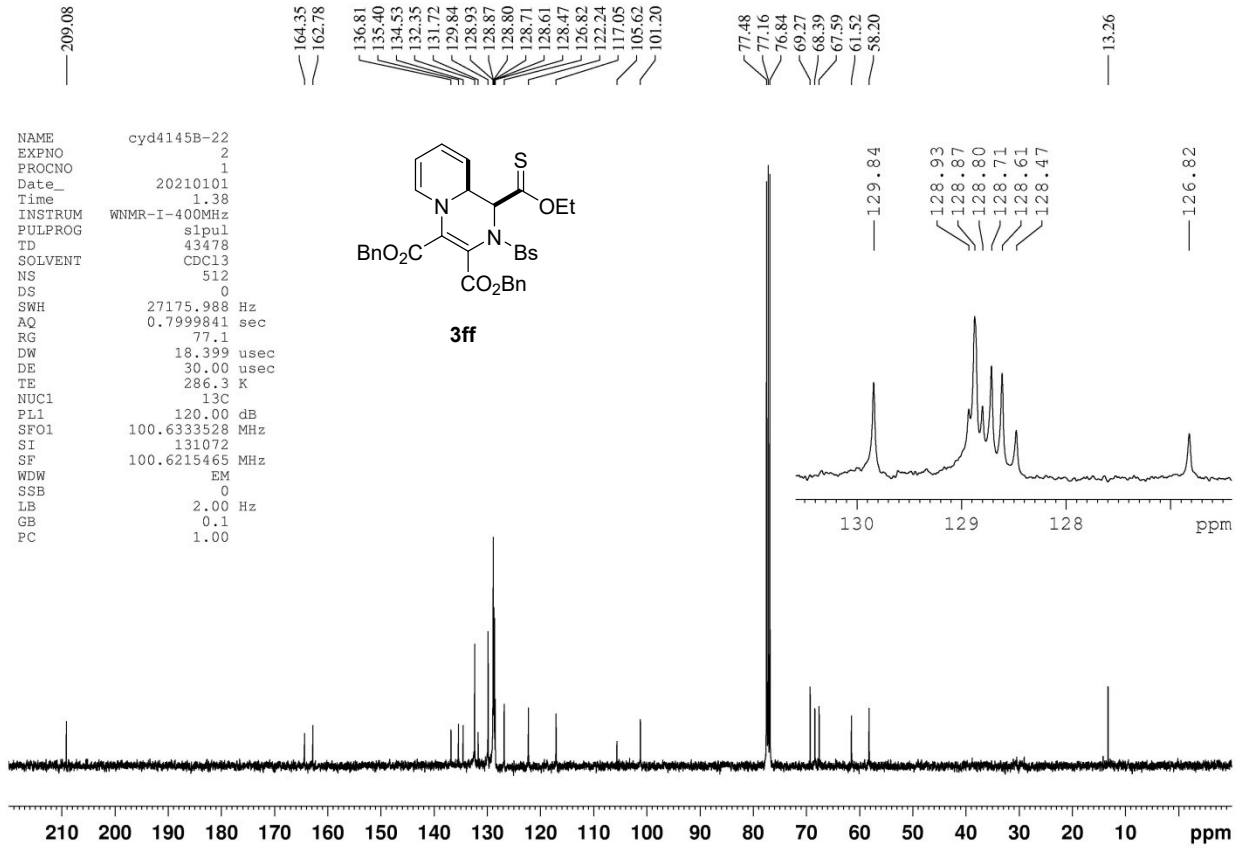


Figure S8-52. ^{13}C NMR of 3ff ($CDCl_3$, 101 MHz)

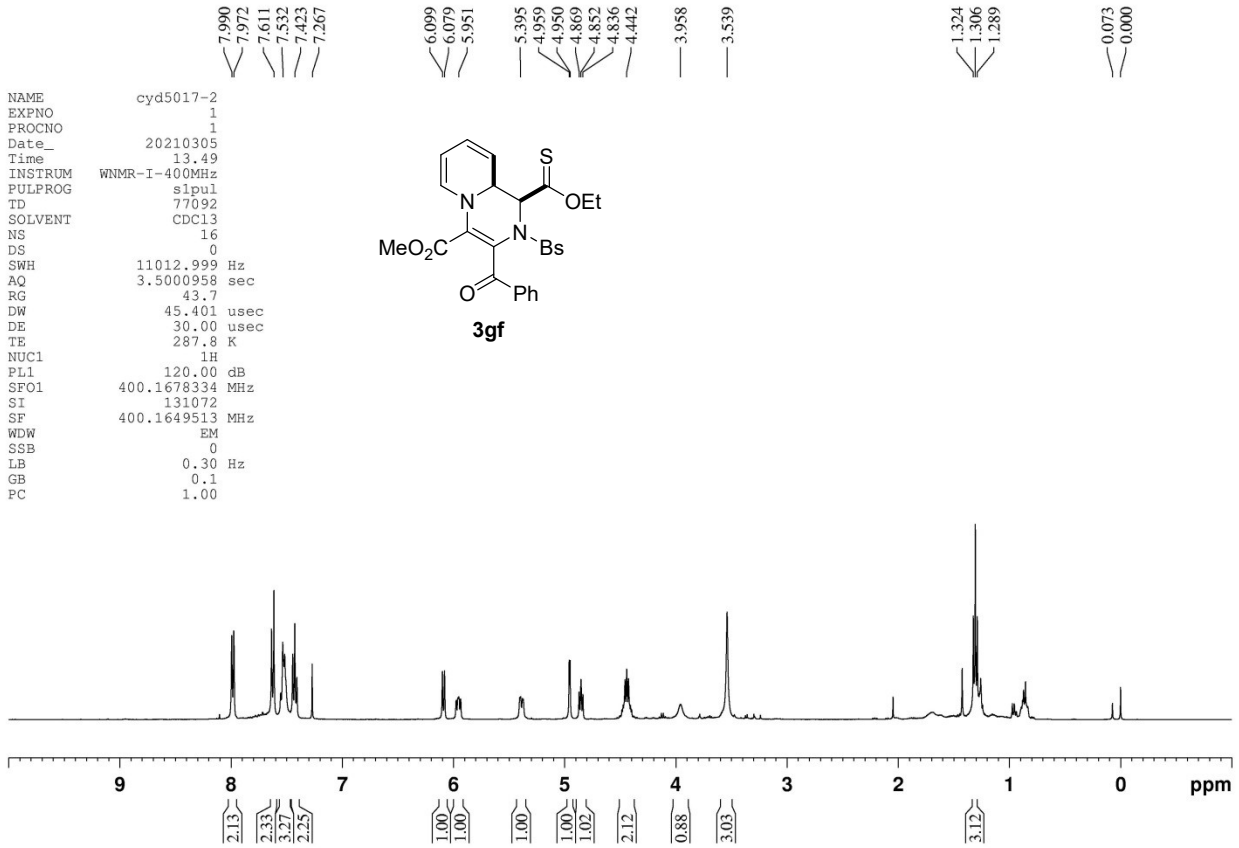


Figure S8-53. ^{1}H NMR of 3gf ($CDCl_3$, 400 MHz)

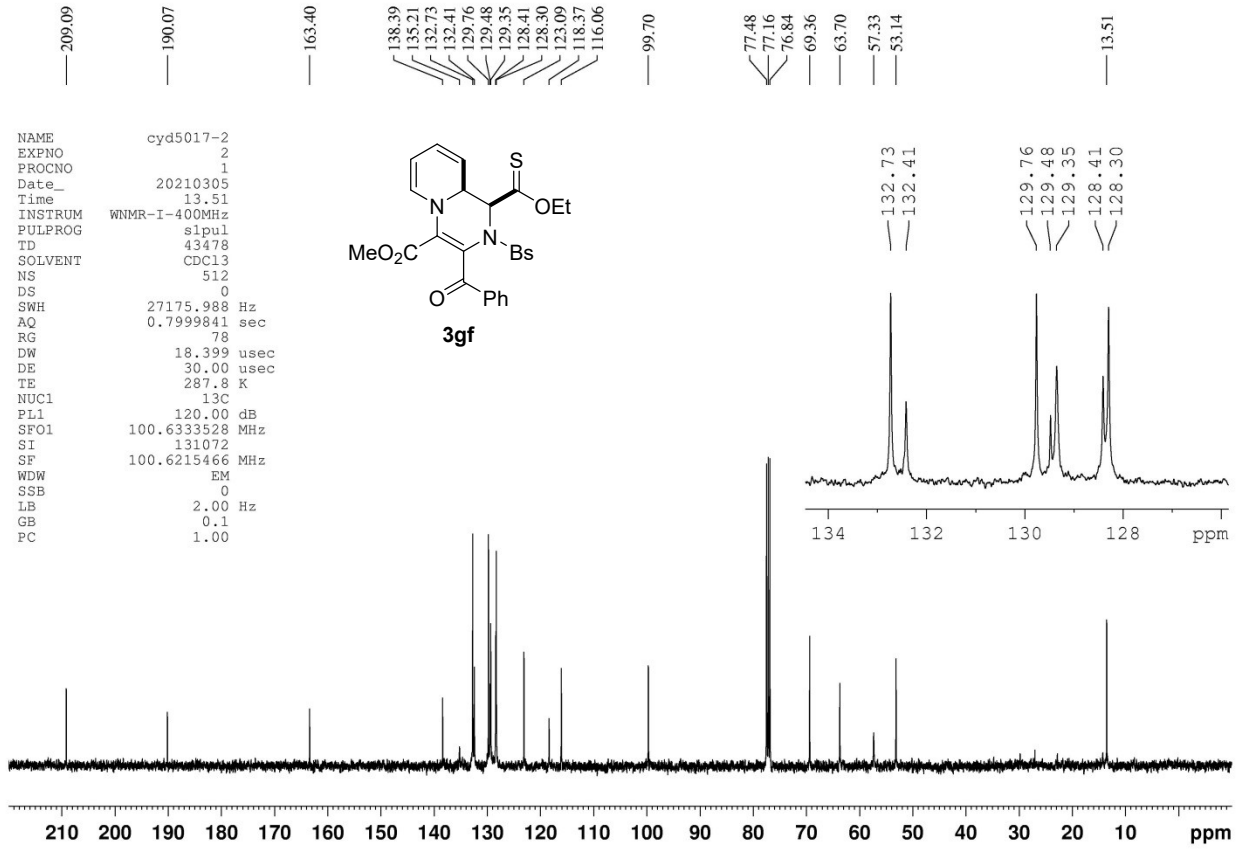


Figure S8-54. ^{13}C NMR of 3gf ($CDCl_3$, 101 MHz)

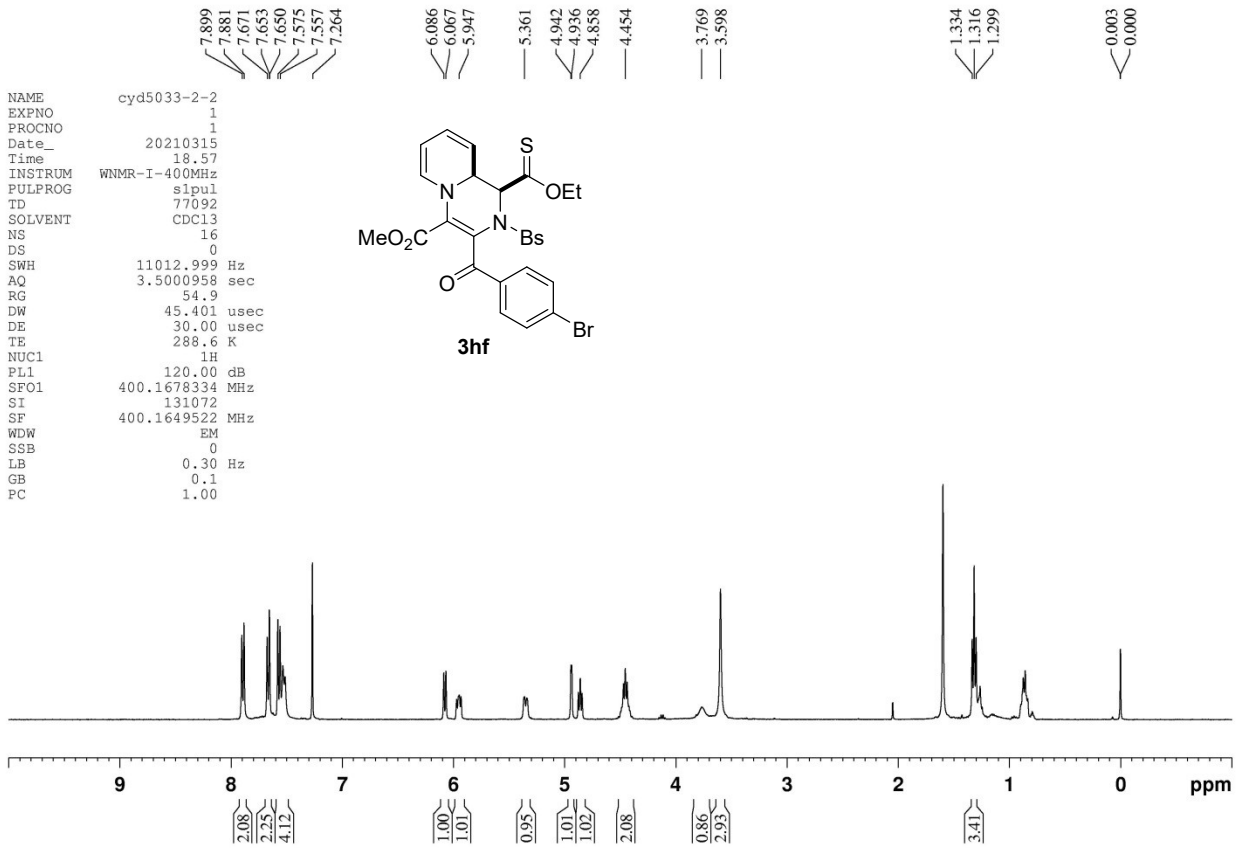


Figure S8-55. ^{1}H NMR of 3hf ($CDCl_3$, 400 MHz)

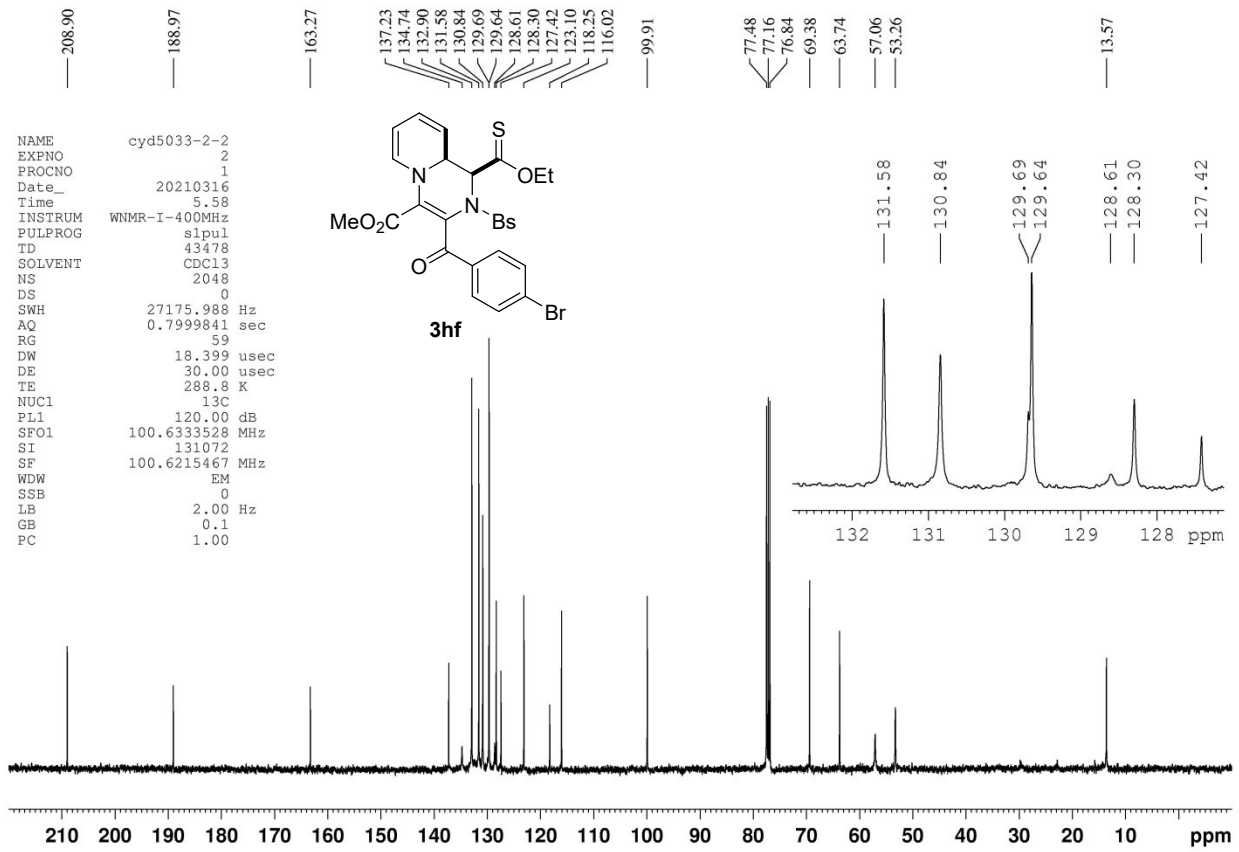


Figure S8-56. ^{13}C NMR of 3hf ($CDCl_3$, 101 MHz)

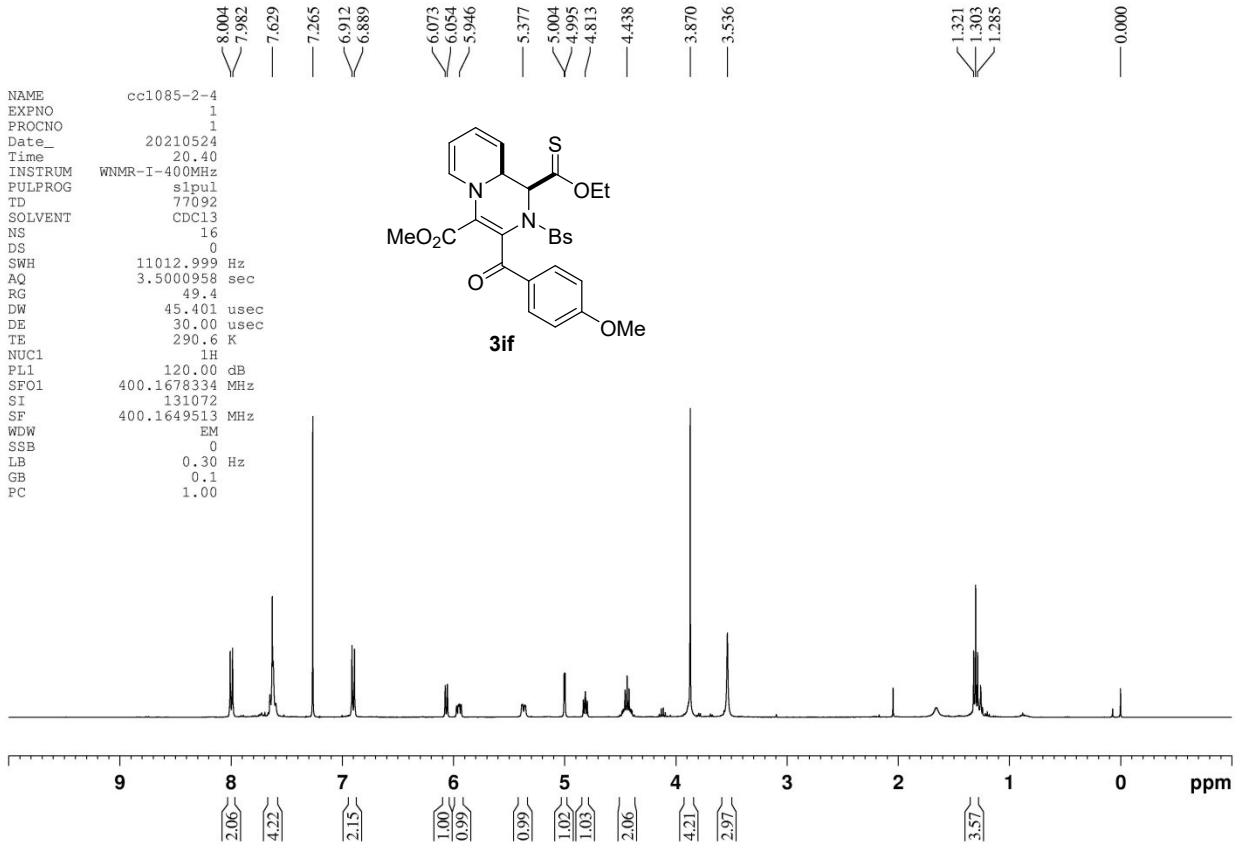


Figure S8-57. ^{1}H NMR of 3if ($CDCl_3$, 400 MHz)

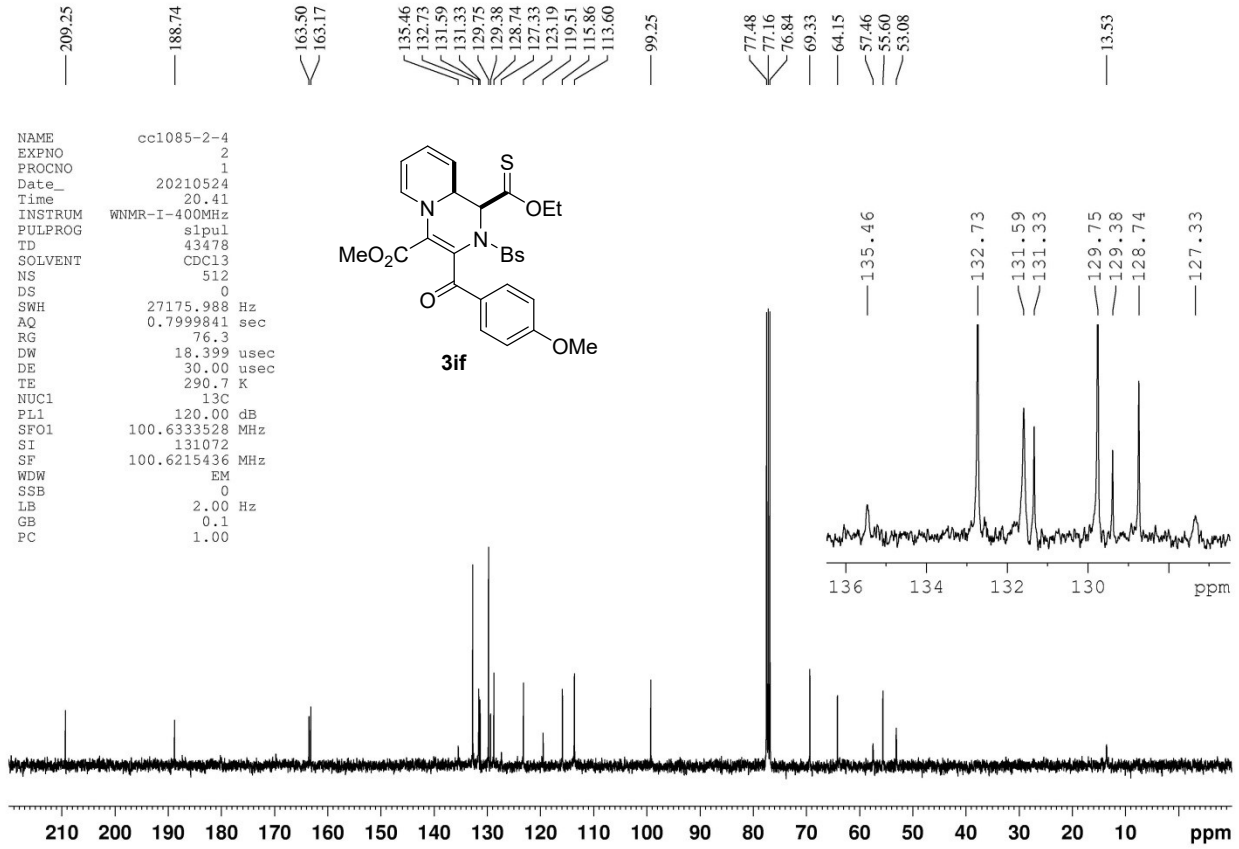


Figure S8-58. ^{13}C NMR of 3if ($CDCl_3$, 101 MHz)

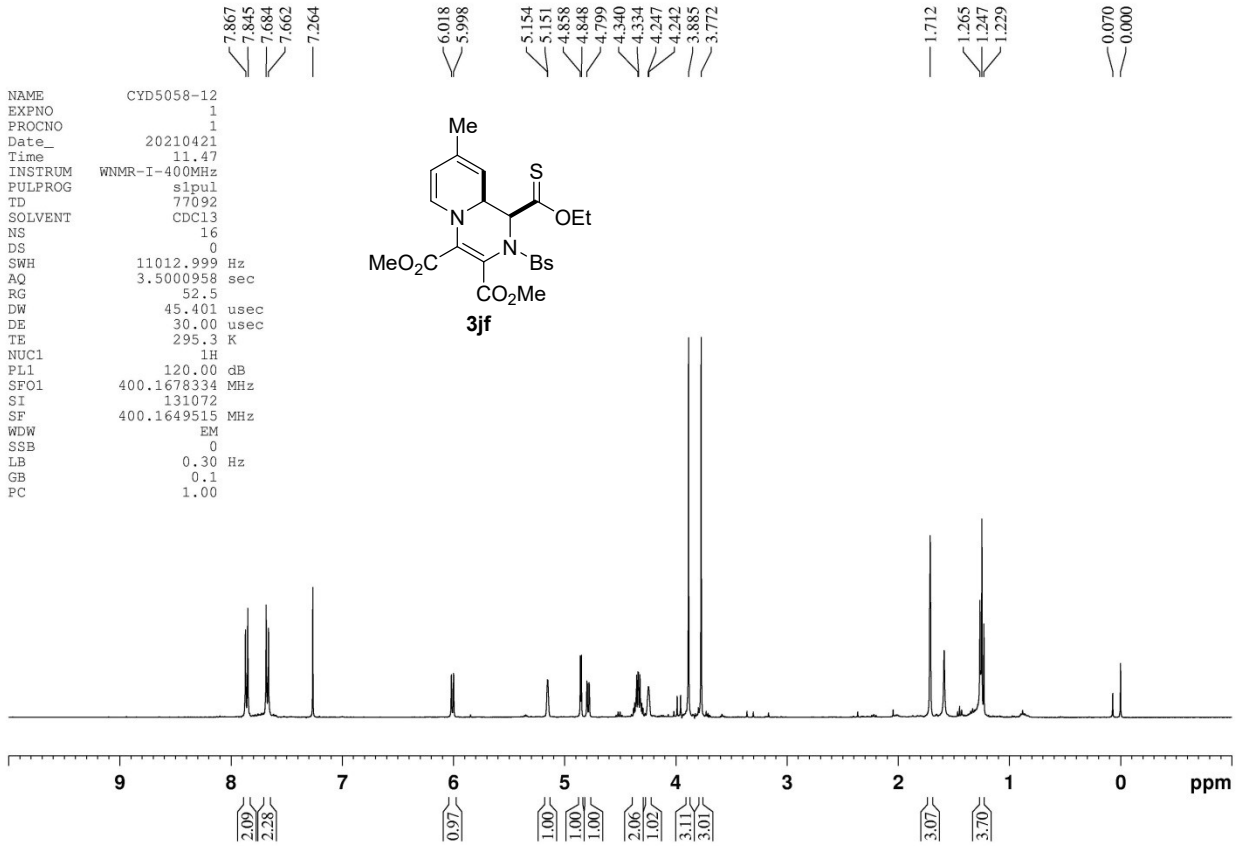


Figure S8-59. ^{1}H NMR of 3jf ($CDCl_3$, 400 MHz)

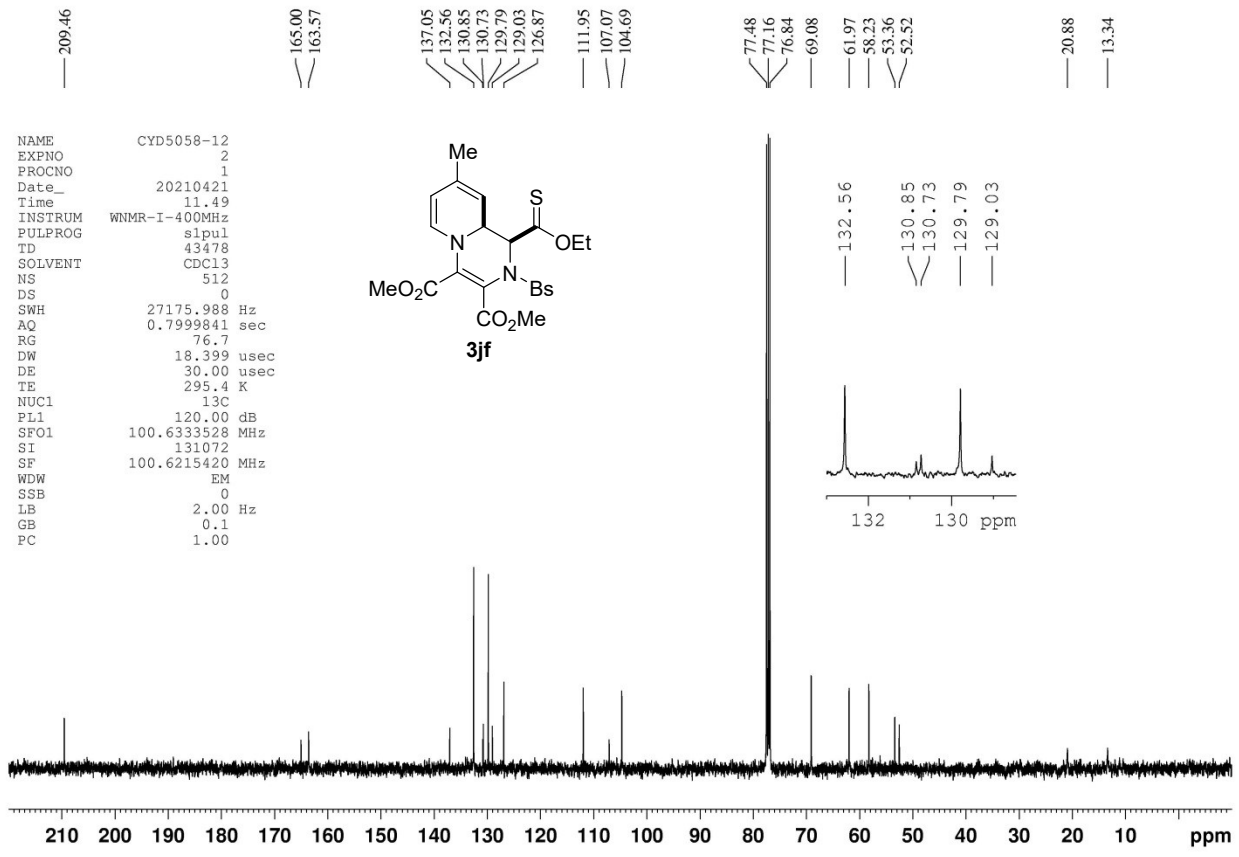


Figure S8-60. ^{13}C NMR of 3jf ($CDCl_3$, 101 MHz)

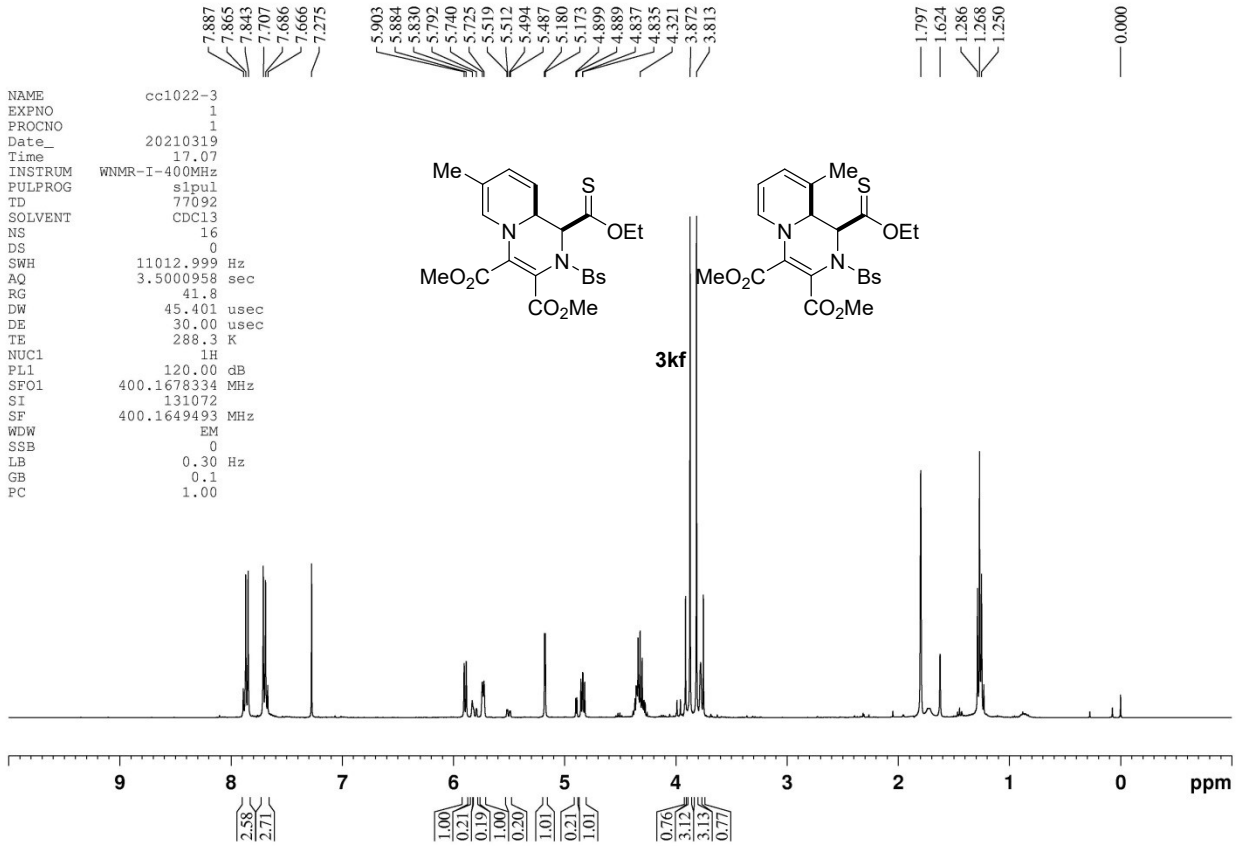


Figure S8-61. ^{1}H NMR of 3kf ($CDCl_3$, 400 MHz)

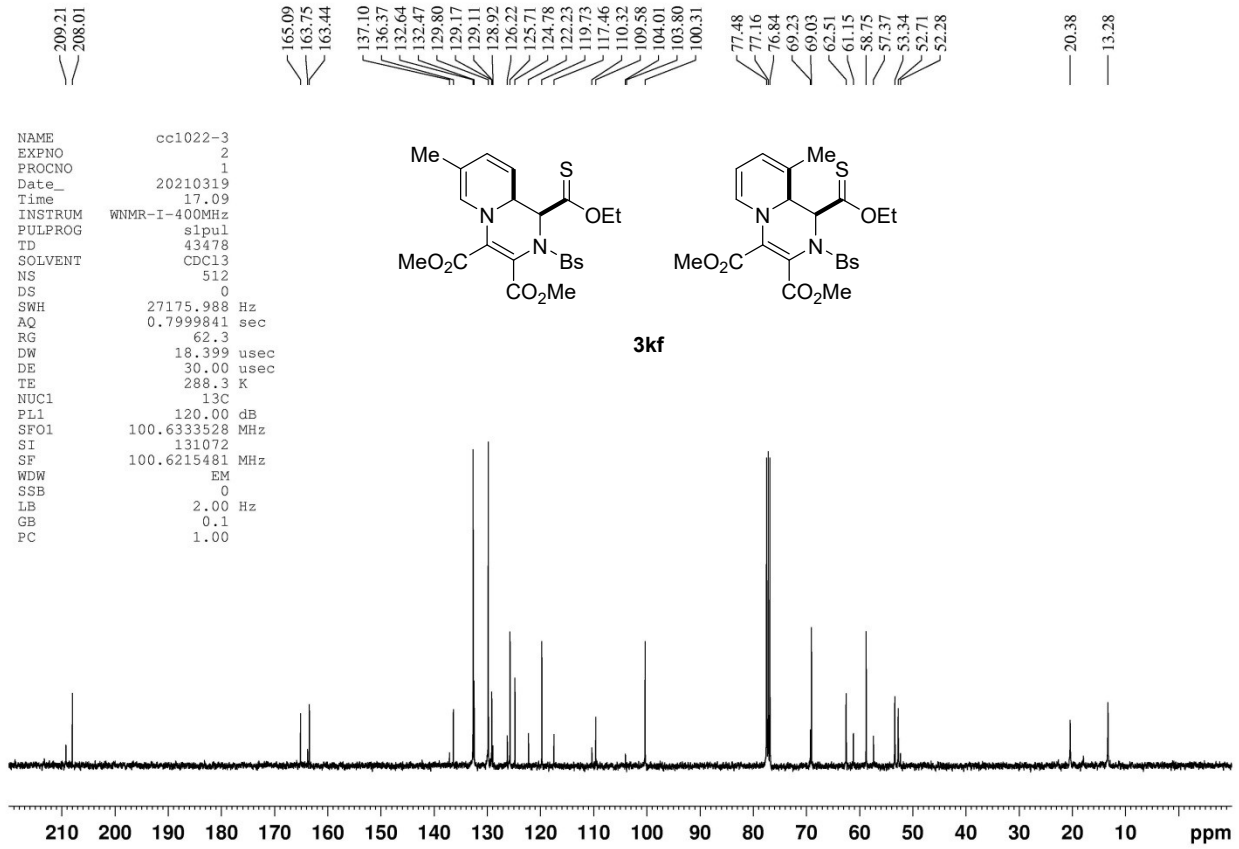


Figure S8-62. ^{13}C NMR of 3kf ($CDCl_3$, 101 MHz)

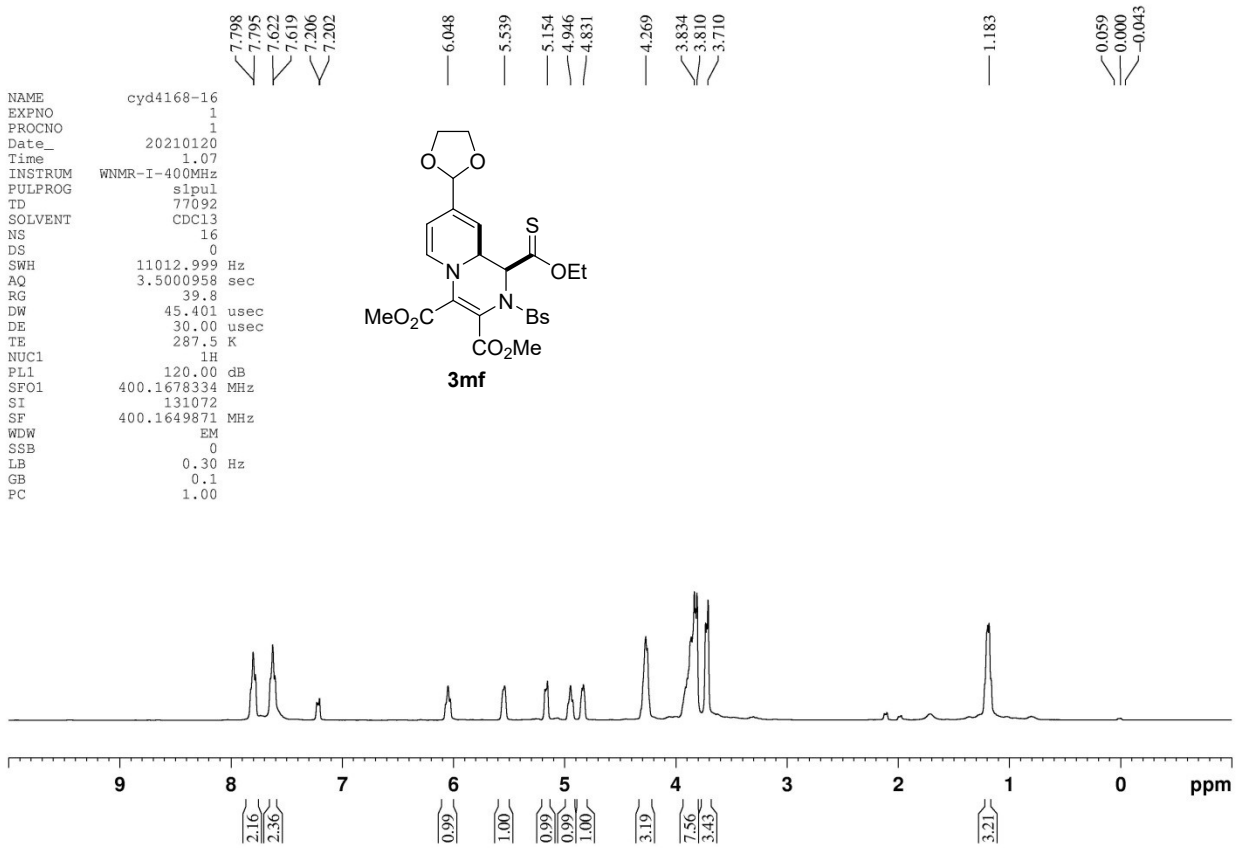


Figure S8-63. ^{1}H NMR of 3mf ($CDCl_3$, 400 MHz)

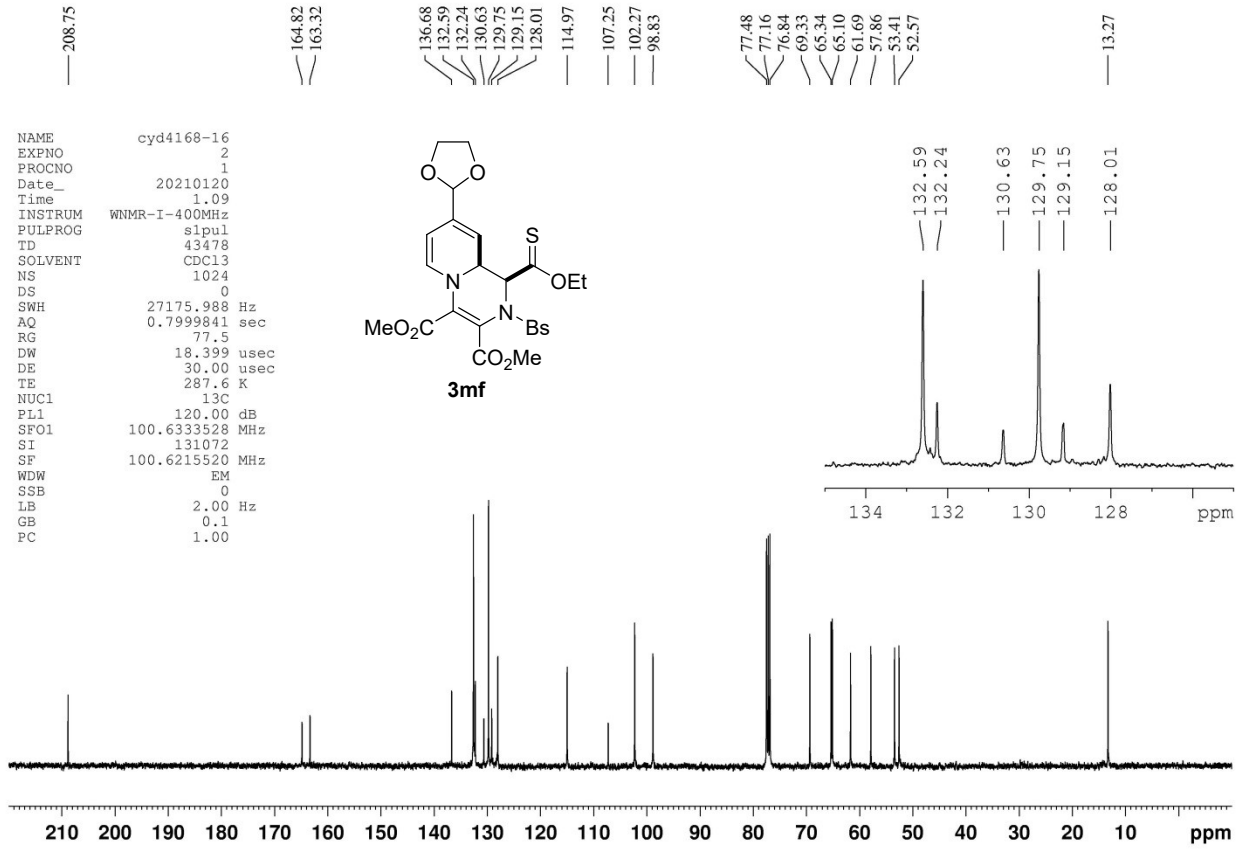


Figure S8-64. ^{13}C NMR of 3mf ($CDCl_3$, 101 MHz)

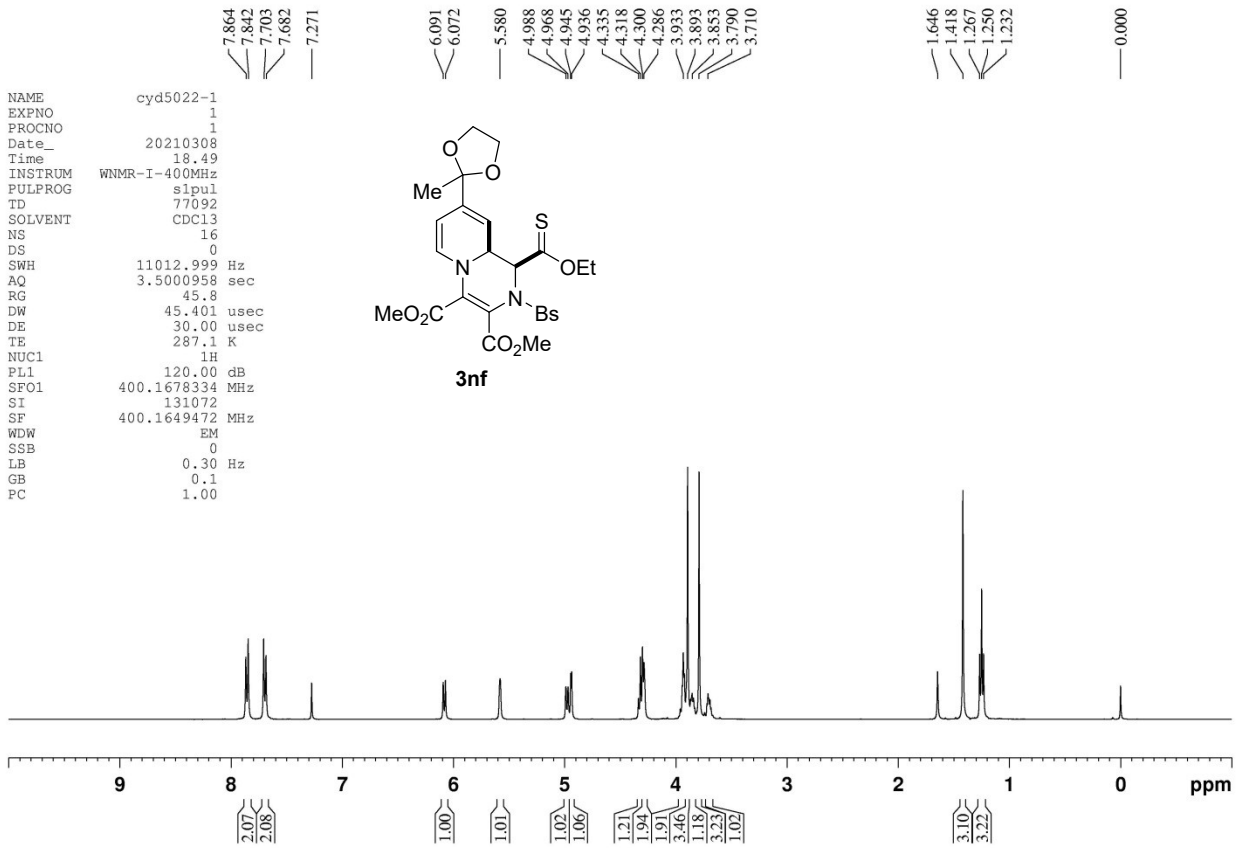


Figure S8-65. ^{1}H NMR of 3nf ($CDCl_3$, 400 MHz)

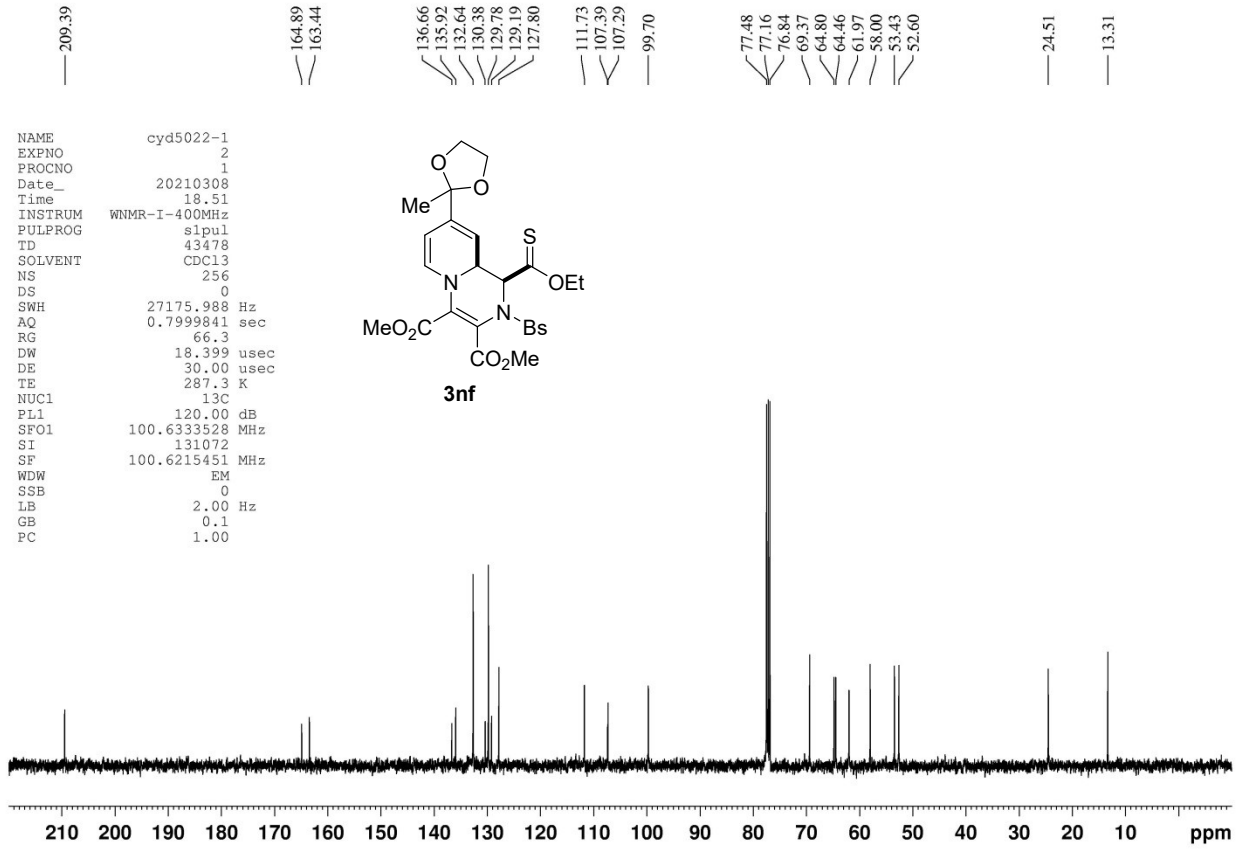


Figure S8-66. ^{13}C NMR of 3nf ($CDCl_3$, 101 MHz)

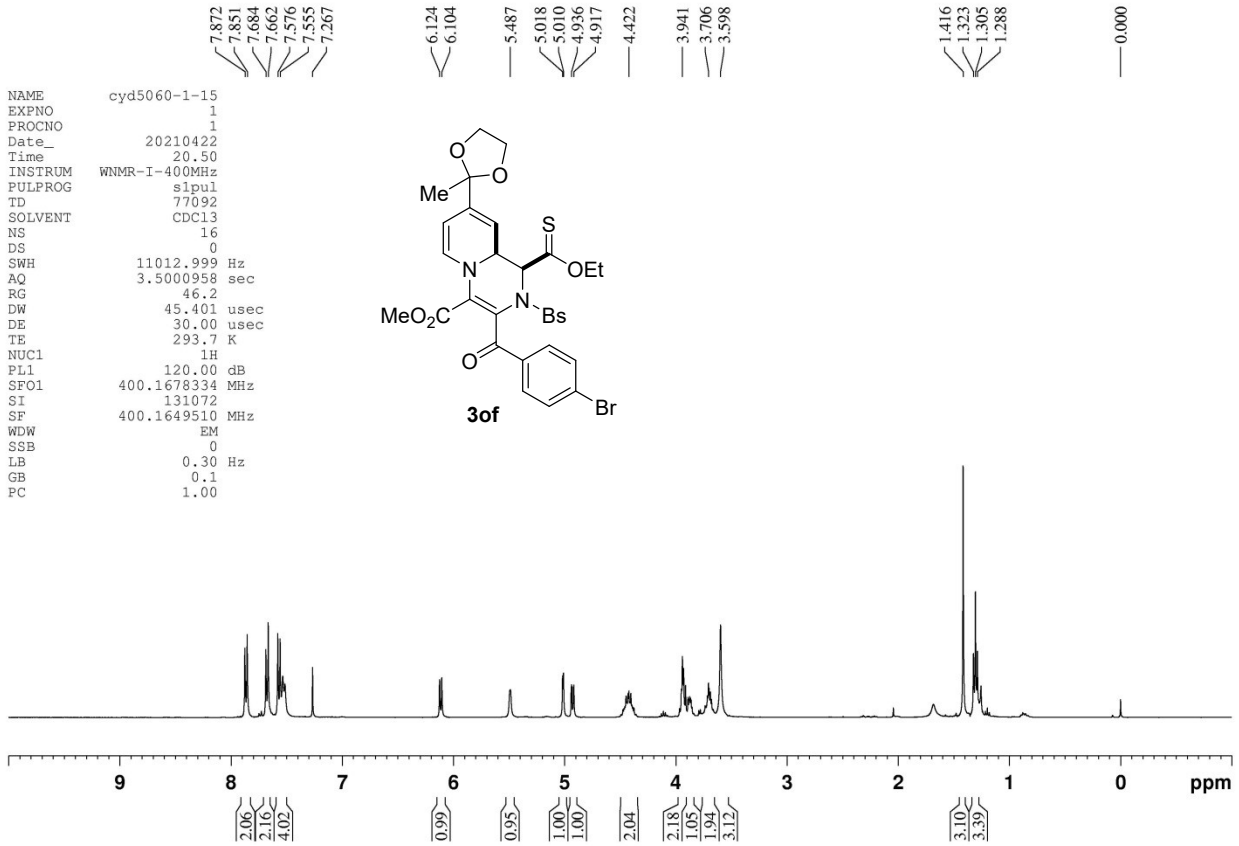


Figure S8-67. ^{1}H NMR of 3of ($CDCl_3$, 400 MHz)

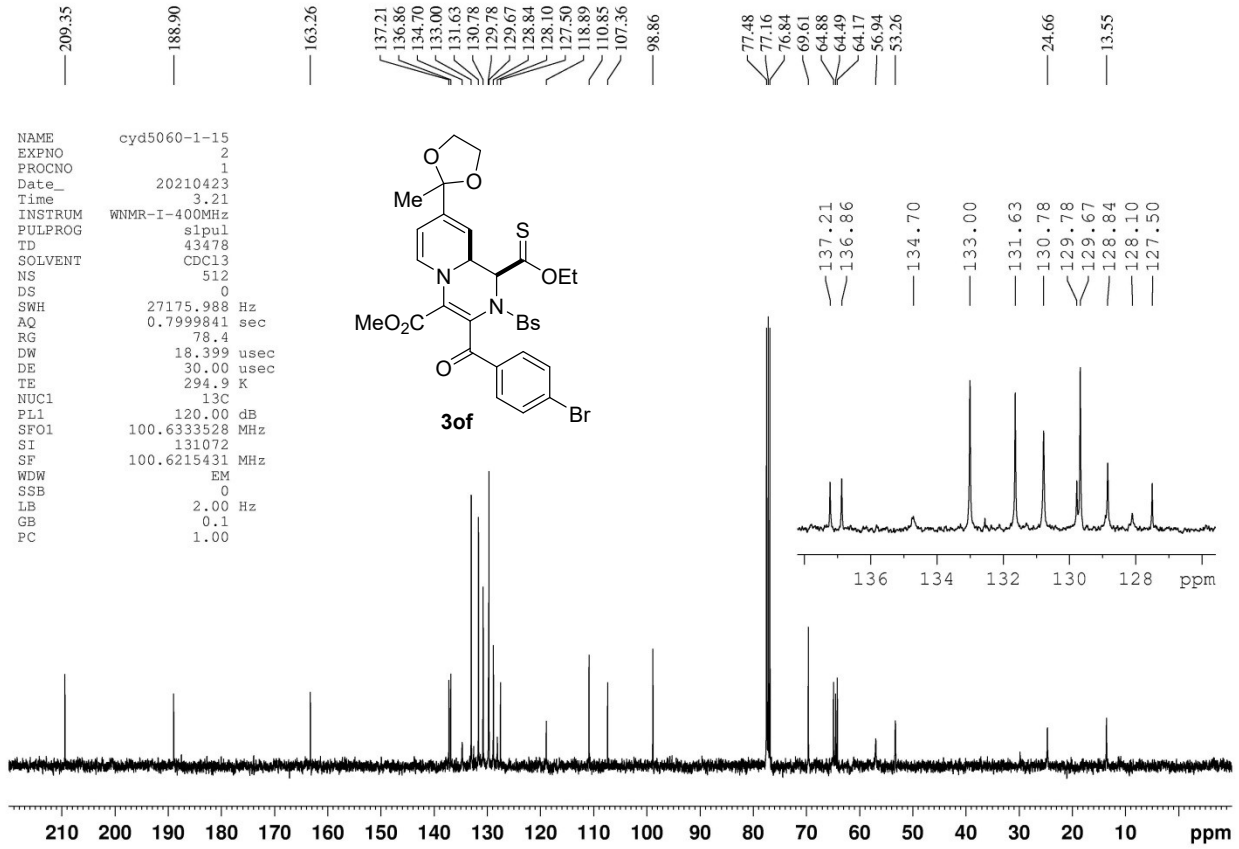


Figure S8-68. ^{13}C NMR of 3of ($CDCl_3$, 101 MHz)

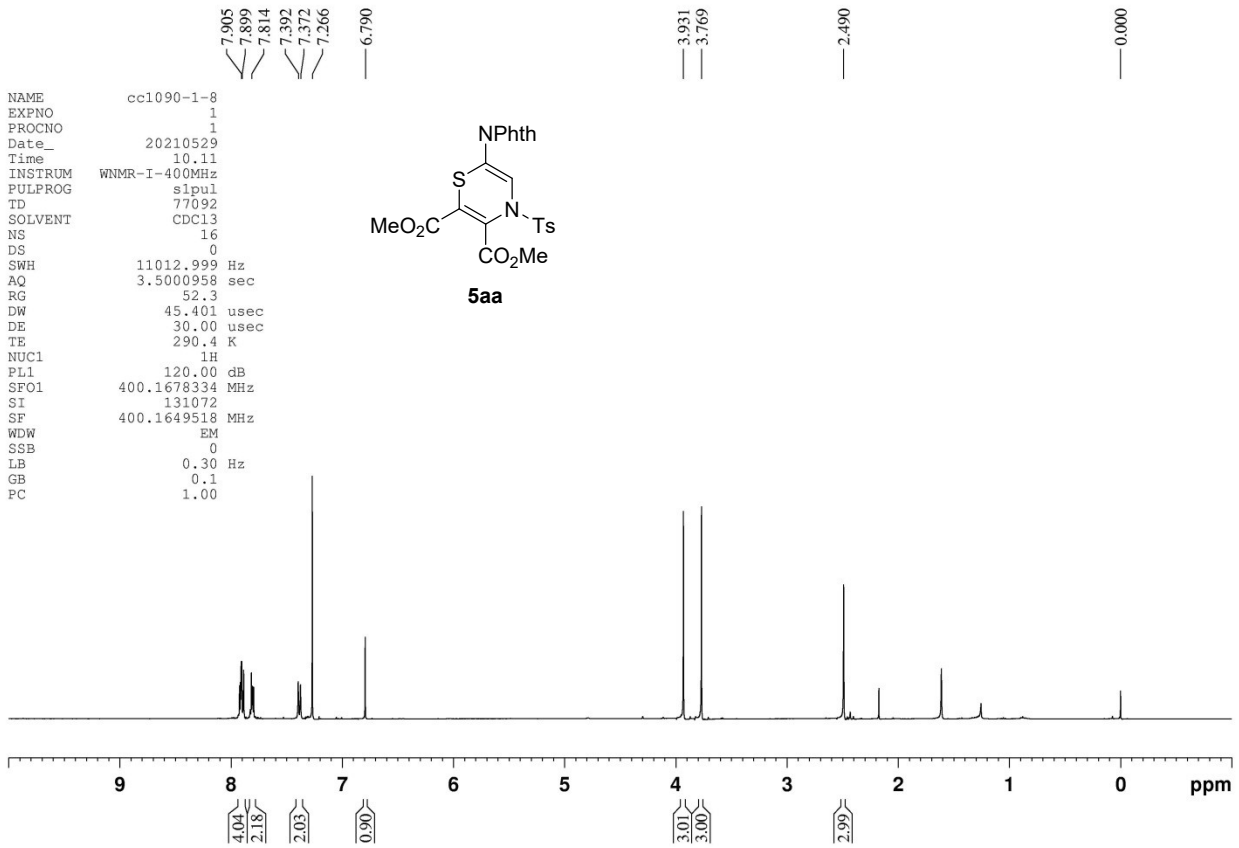


Figure S8-69. ^{1}H NMR of 5aa ($CDCl_3$, 400 MHz)

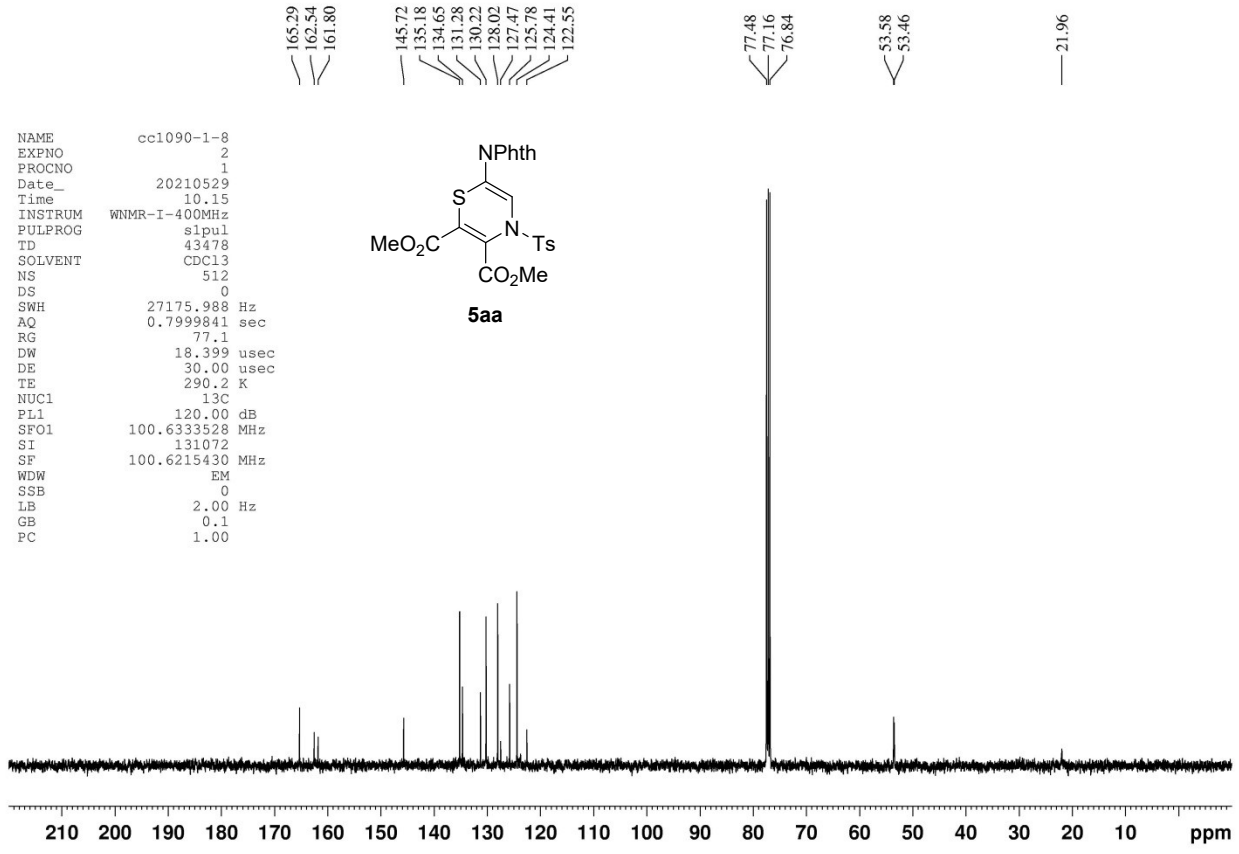


Figure S8-70. ^{13}C NMR of 5aa ($CDCl_3$, 101 MHz)

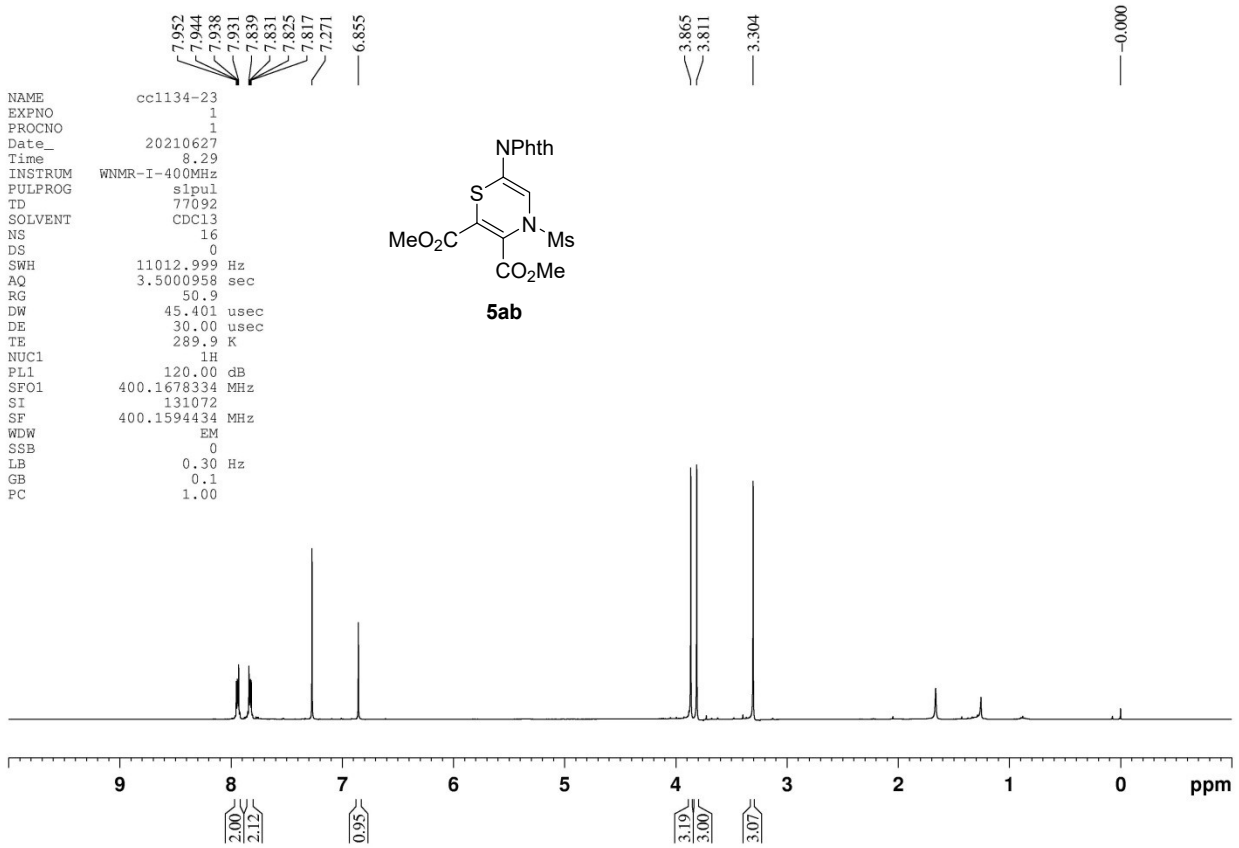


Figure S8-71. ^{1}H NMR of 5ab ($CDCl_3$, 400 MHz)

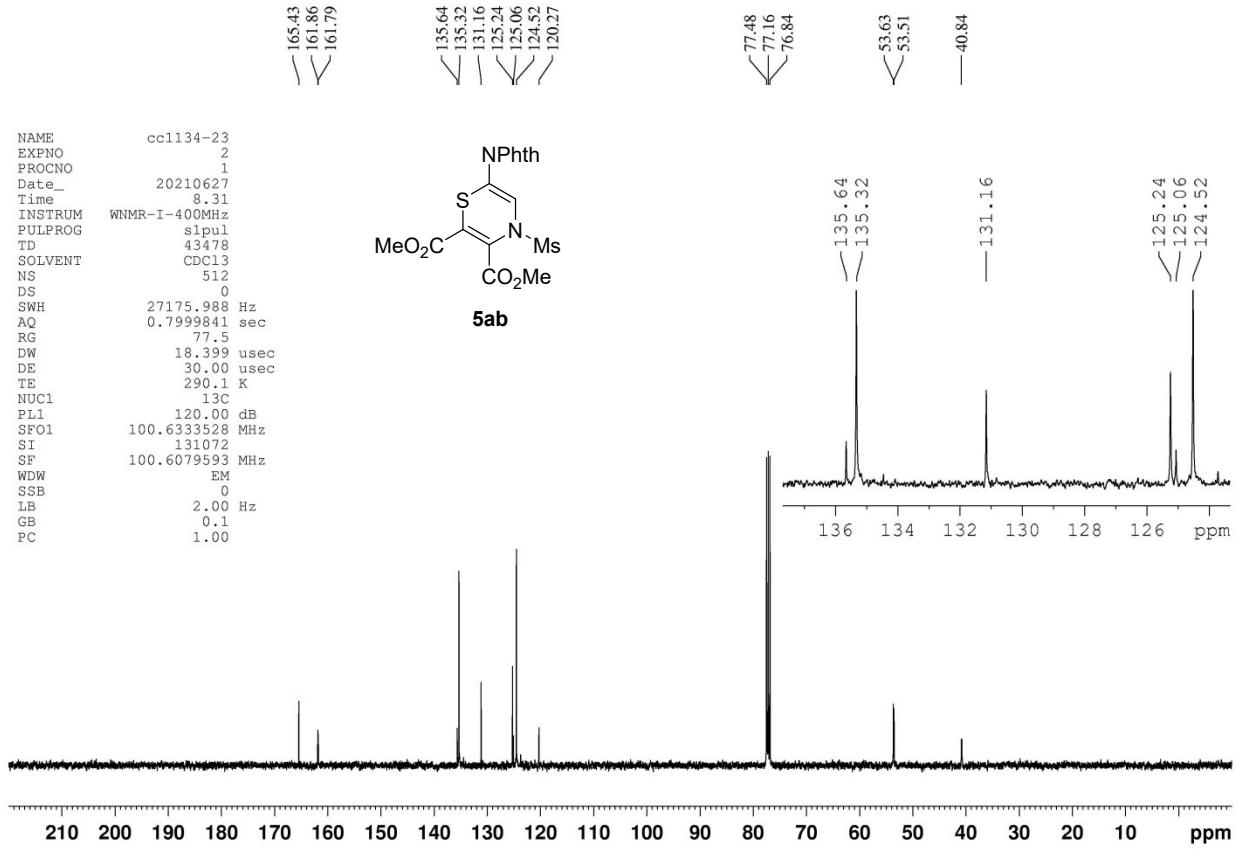


Figure S8-72. ^{13}C NMR of 5ab ($CDCl_3$, 101 MHz)

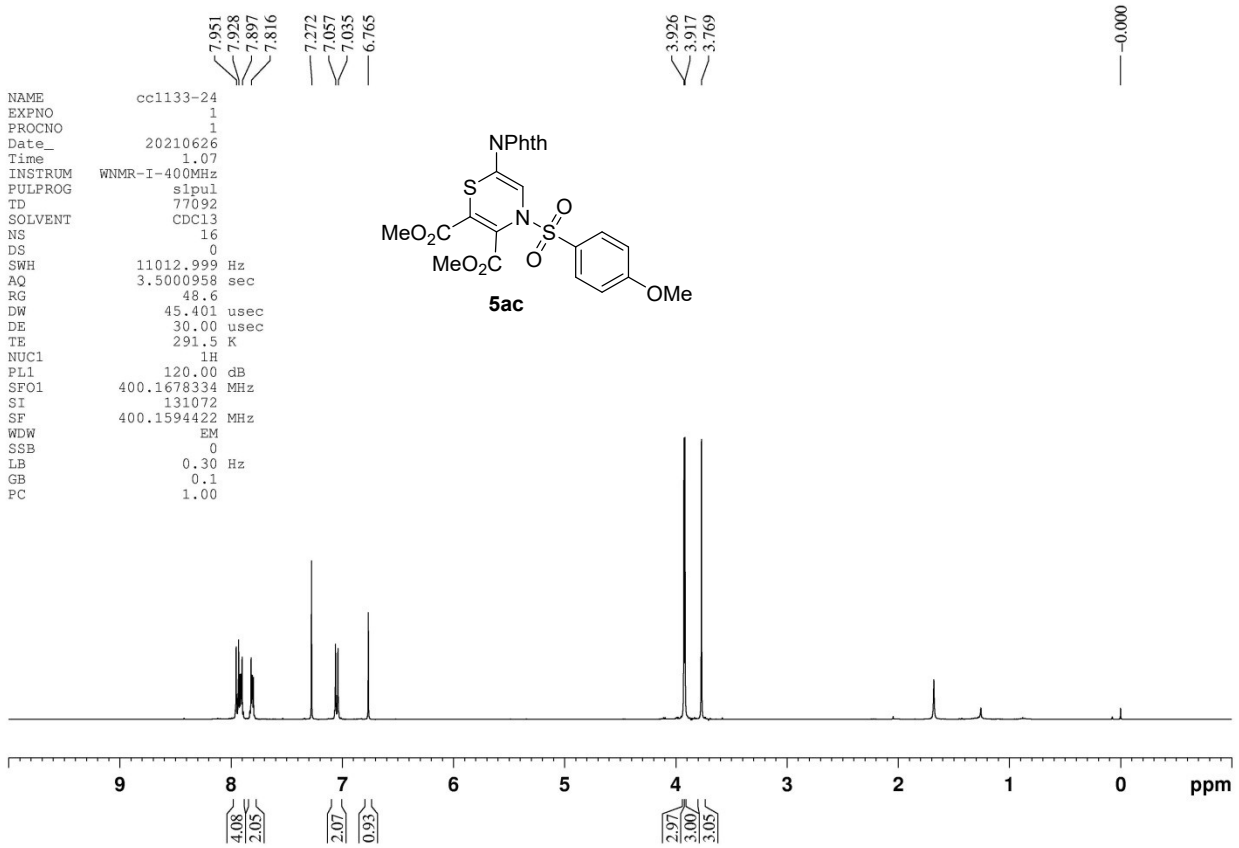


Figure S8-73. ^{1}H NMR of 5ac ($CDCl_3$, 400 MHz)

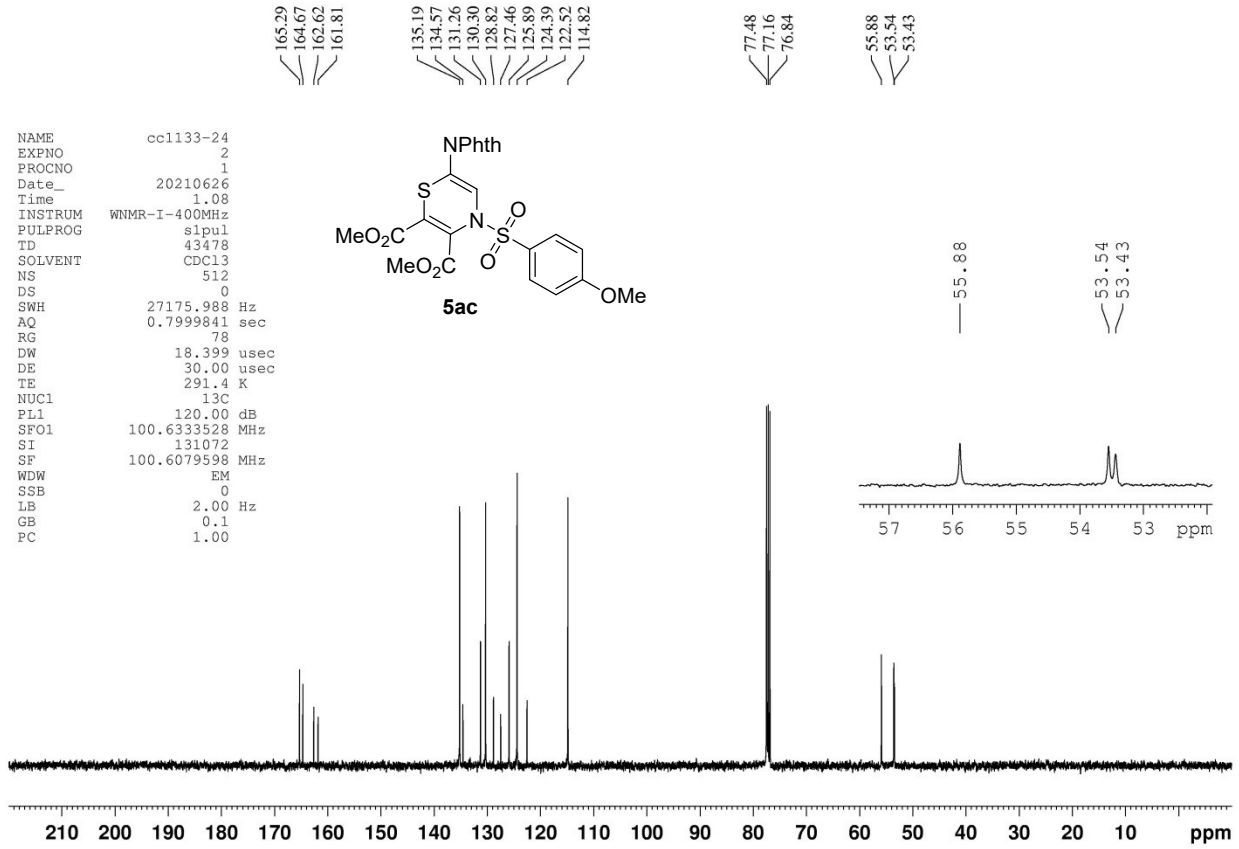


Figure S8-74. ^{13}C NMR of 5ac ($CDCl_3$, 101 MHz)

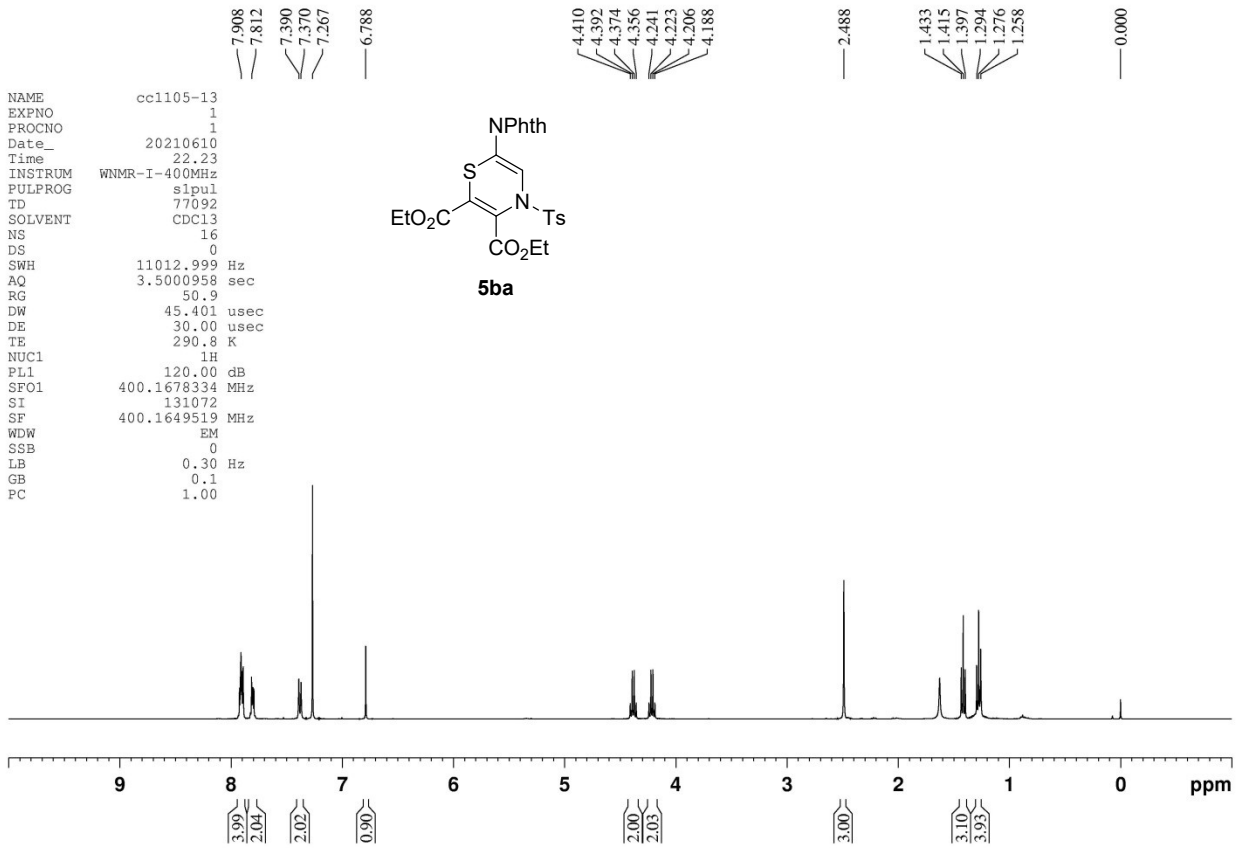


Figure S8-75. ^{1}H NMR of 5ba ($CDCl_3$, 400 MHz)

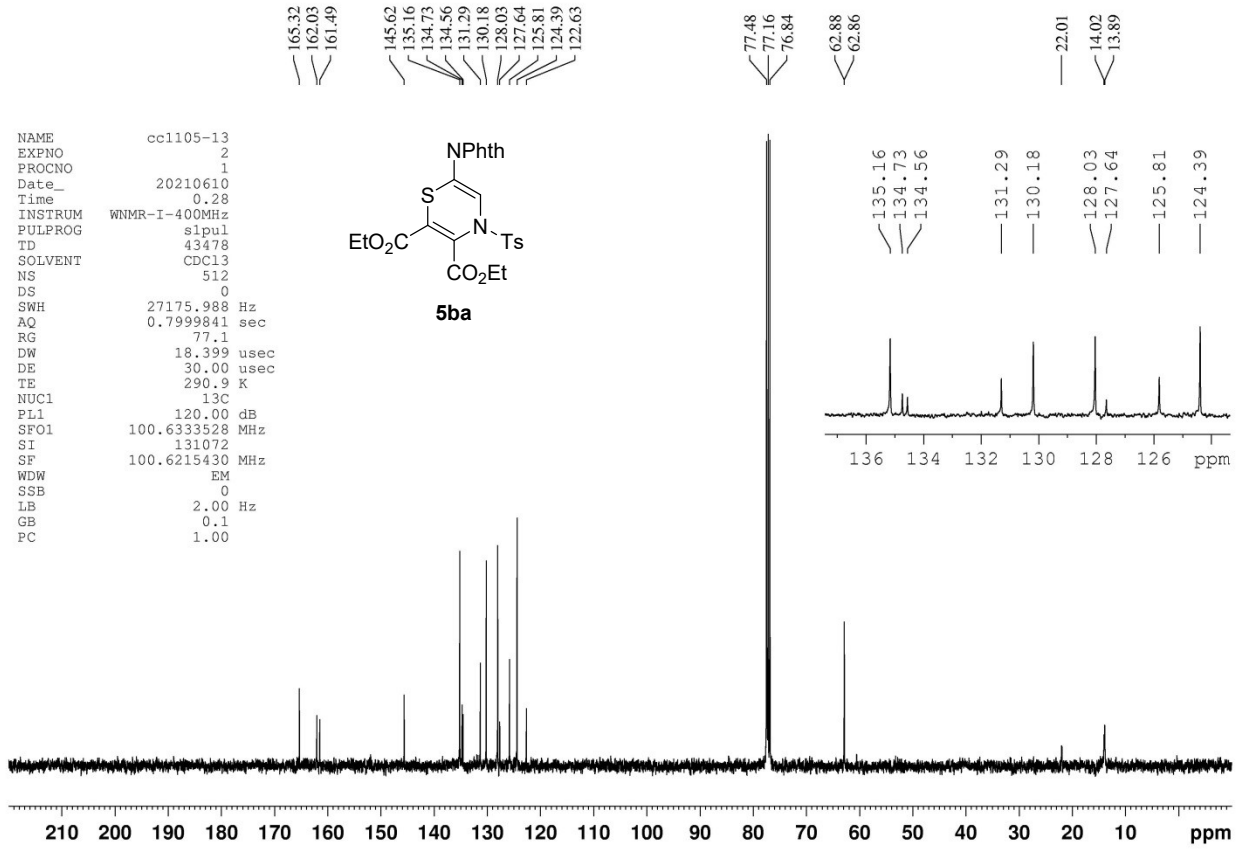


Figure S8-76. ^{13}C NMR of 5ba ($CDCl_3$, 101 MHz)

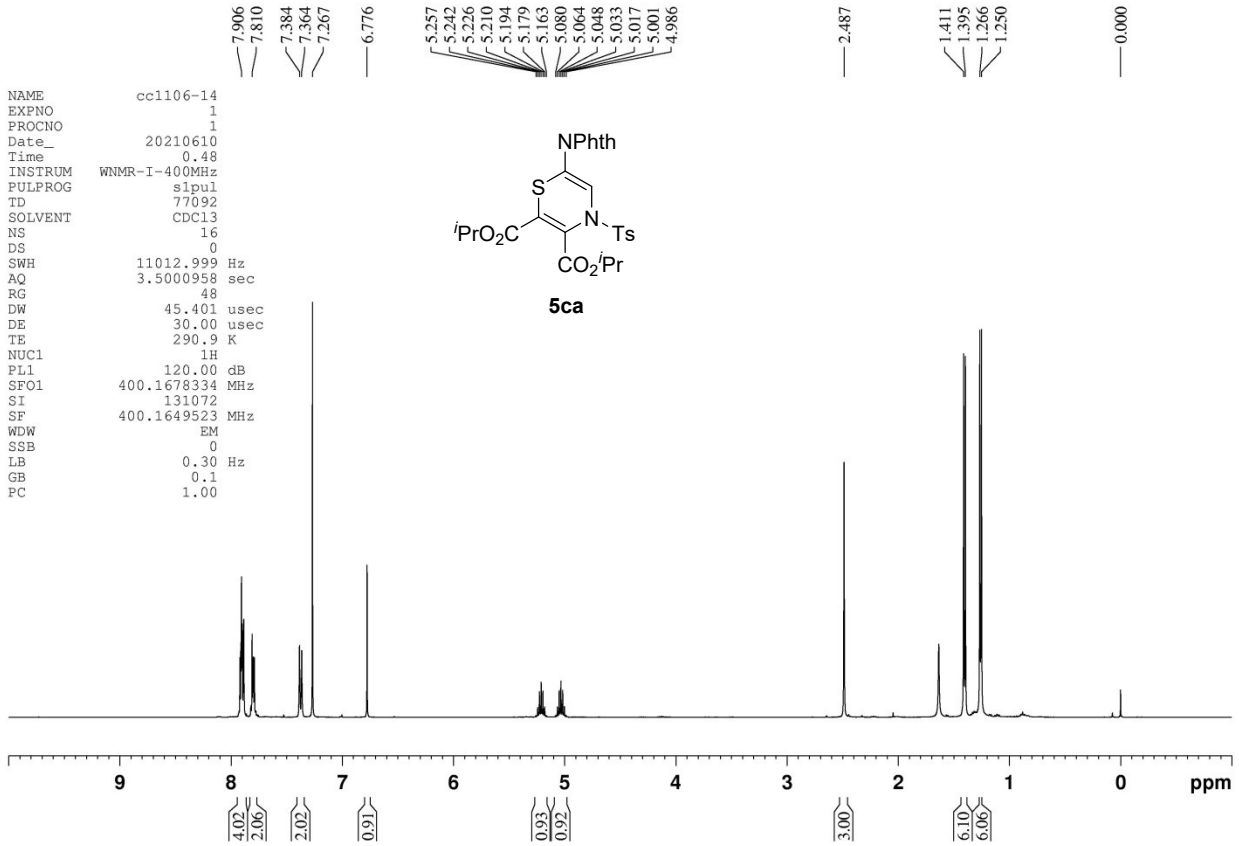


Figure S8-77. ^{1}H NMR of 5ca ($CDCl_3$, 400 MHz)

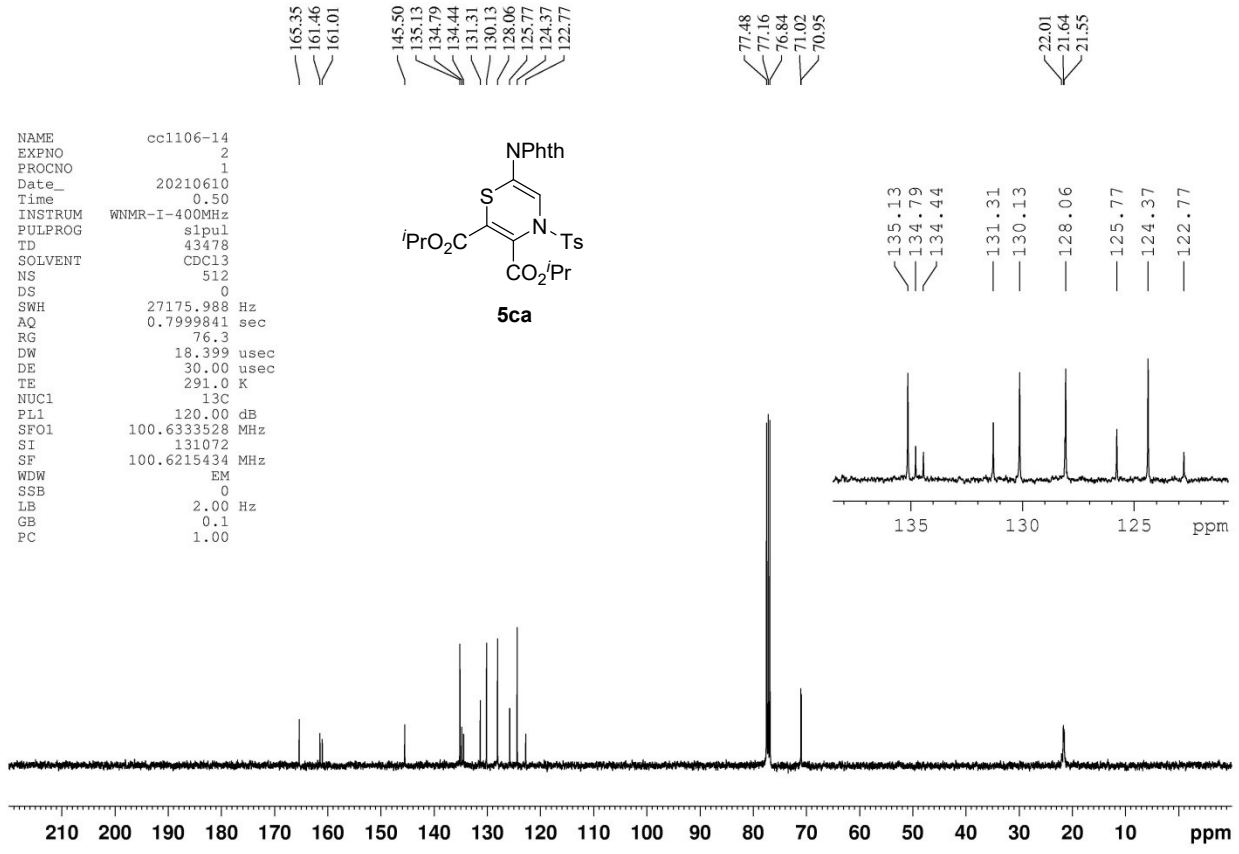


Figure S8-78. ^{13}C NMR of 5ca ($CDCl_3$, 101 MHz)

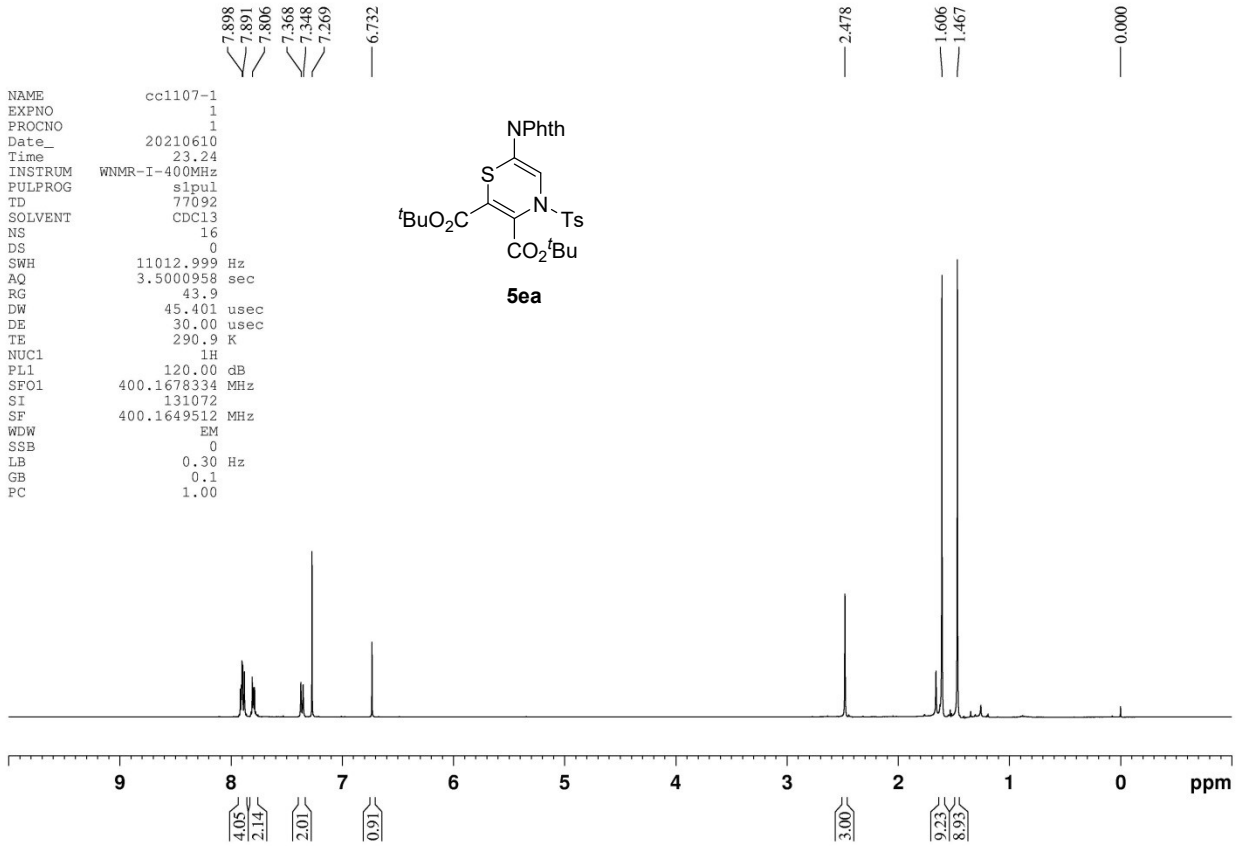


Figure S8-79. ^{1}H NMR of 5ea ($CDCl_3$, 400 MHz)

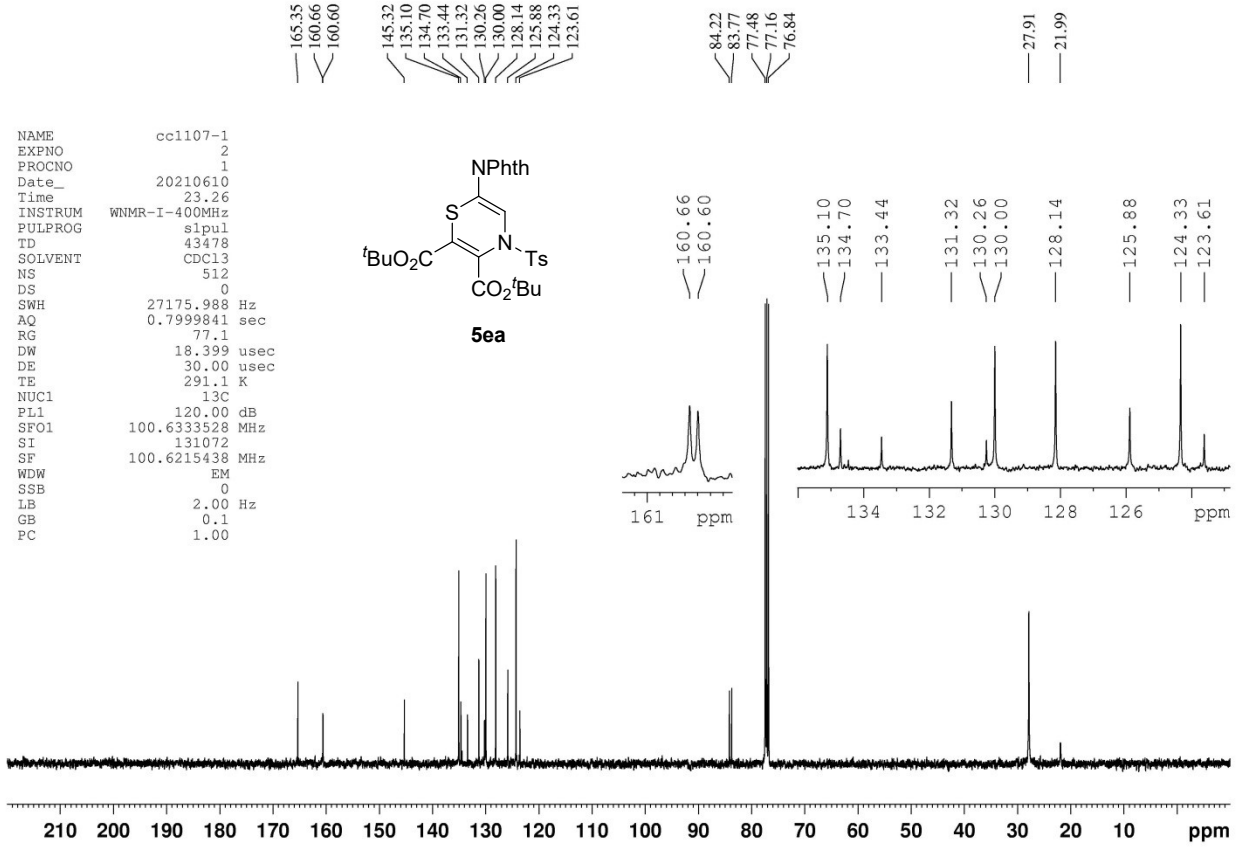


Figure S8-80. ^{13}C NMR of 5ea ($CDCl_3$, 101 MHz)

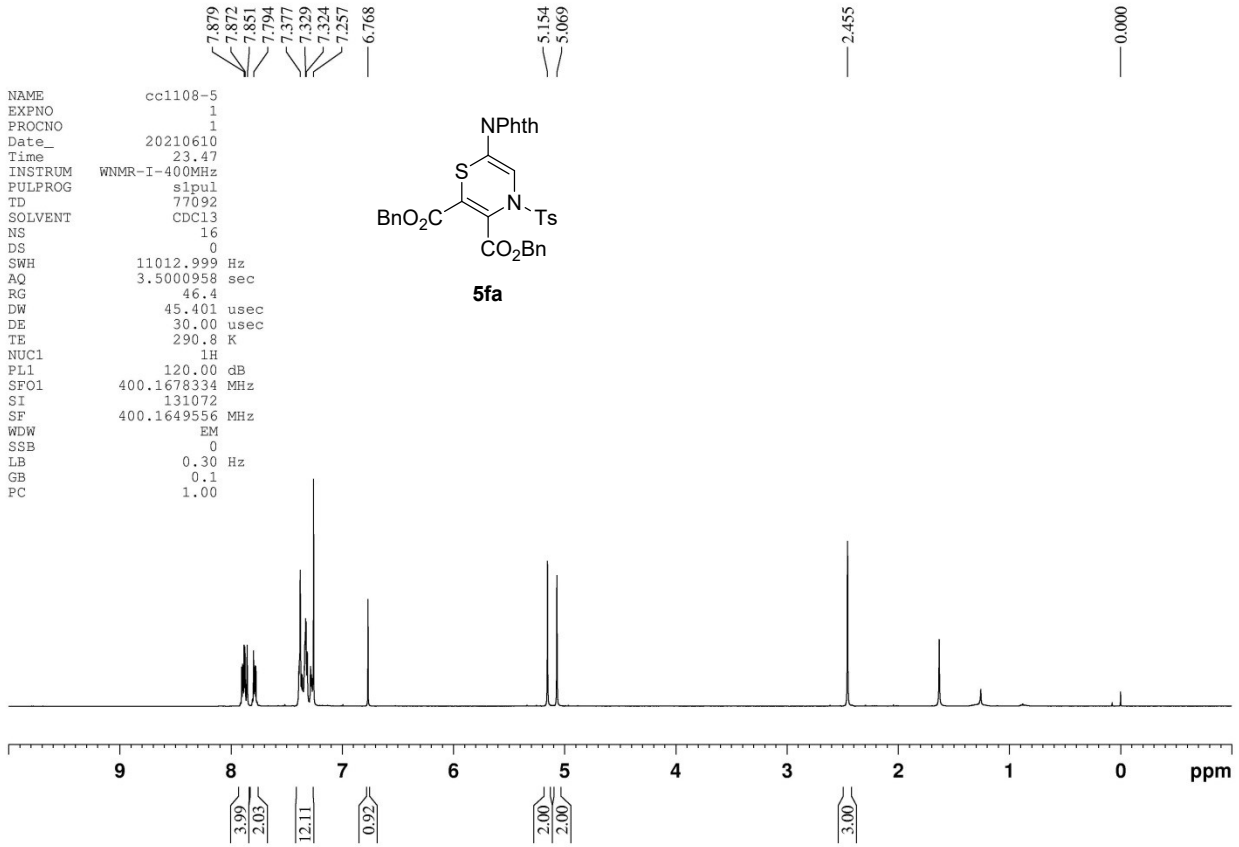


Figure S8-81. ^{1}H NMR of 5fa ($CDCl_3$, 400 MHz)

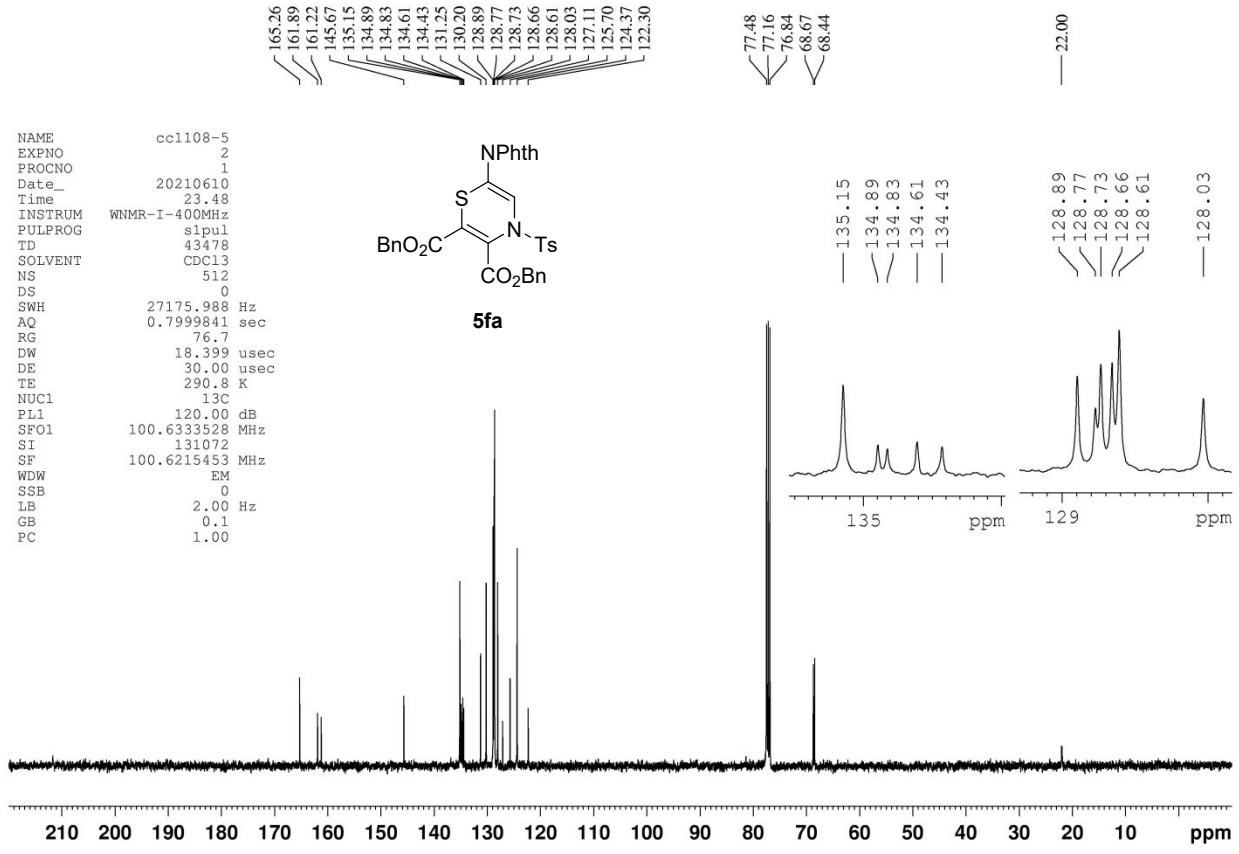


Figure S8-82. ^{13}C NMR of 5fa ($CDCl_3$, 101 MHz)

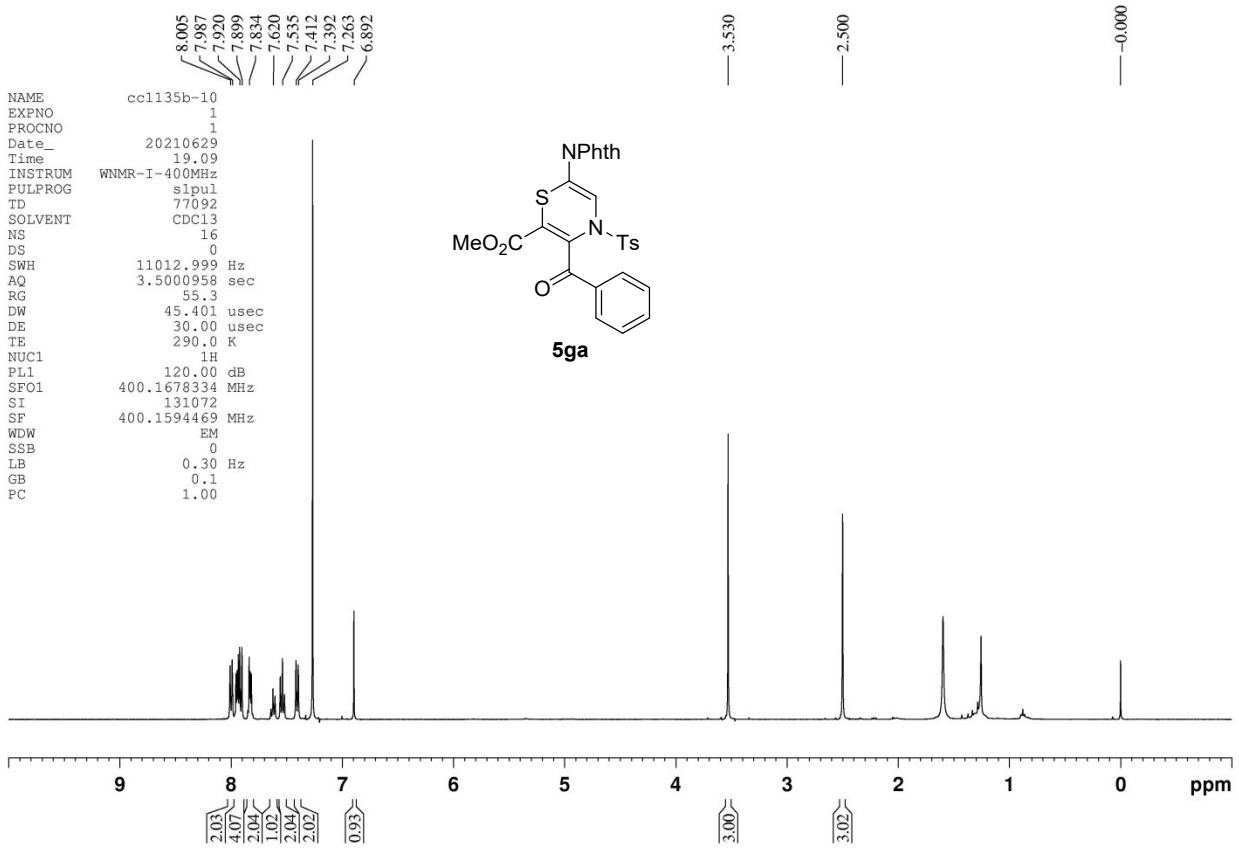


Figure S8-83. ^{1}H NMR of 5ga ($CDCl_3$, 400 MHz)

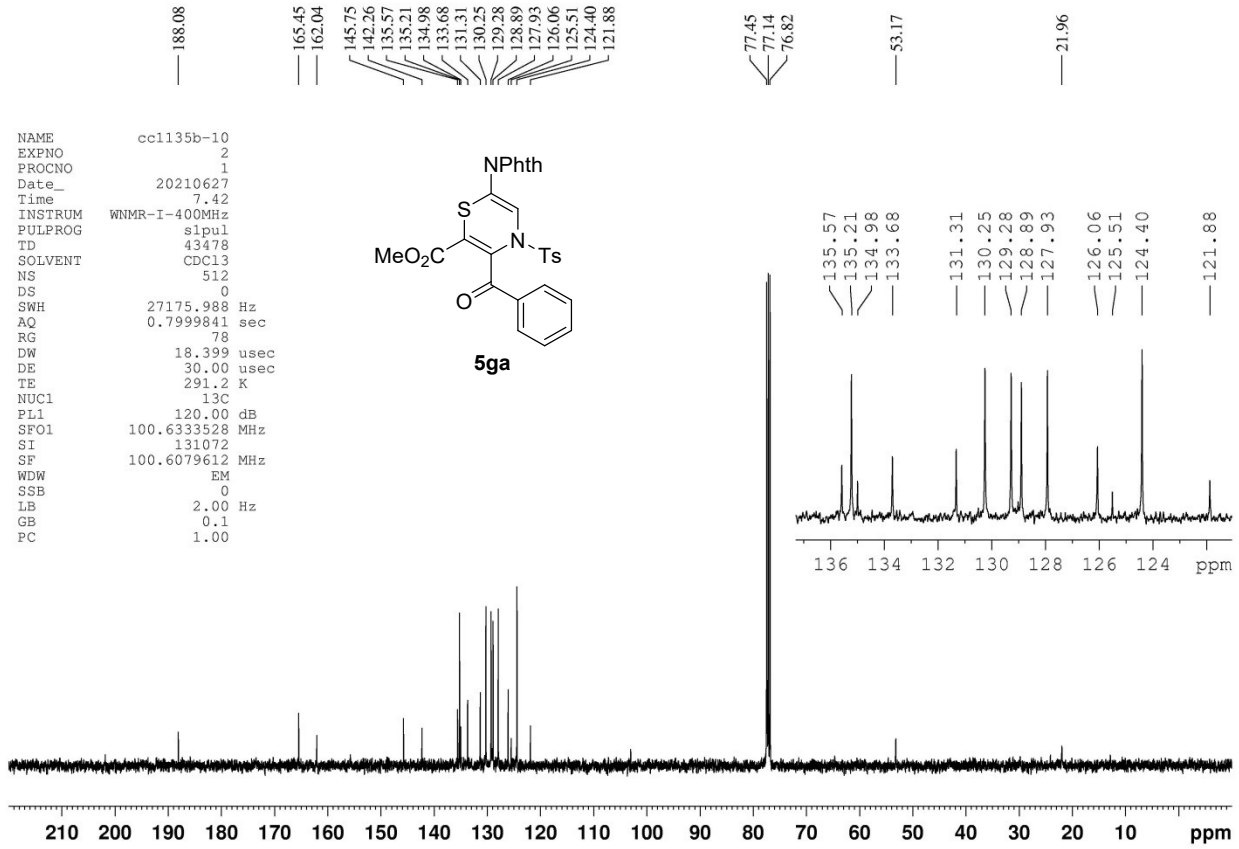


Figure S8-84. ^{13}C NMR of 5ga ($CDCl_3$, 101 MHz)

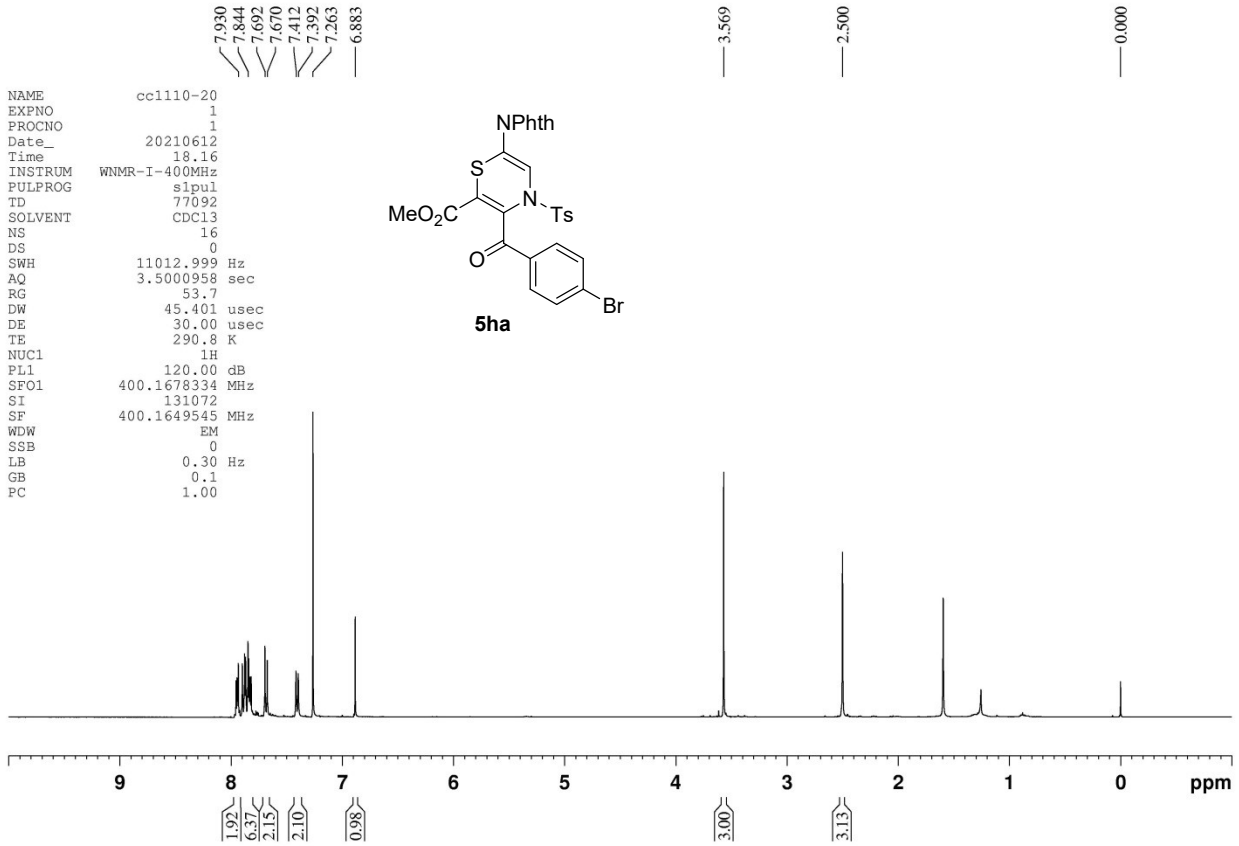


Figure S8-85. ^{1}H NMR of 5ha ($CDCl_3$, 400 MHz)

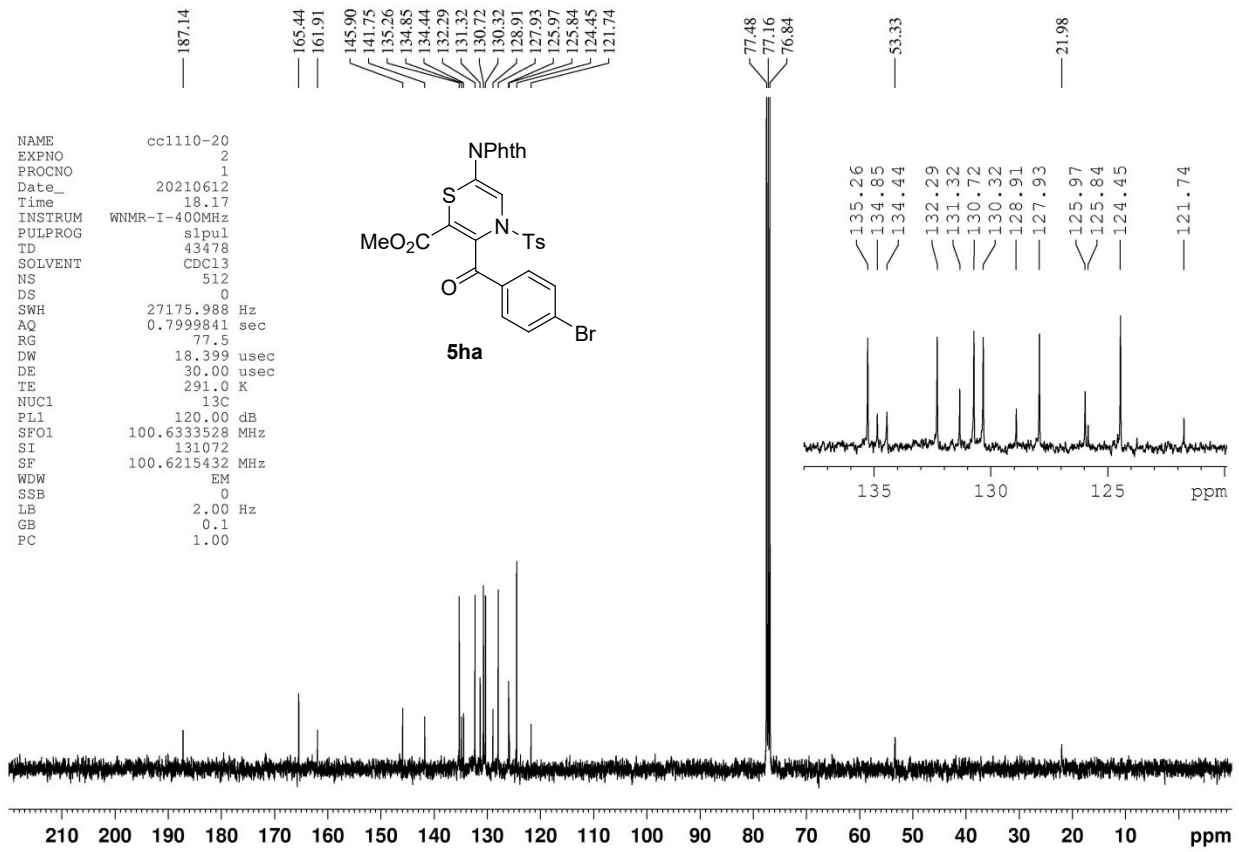


Figure S8-86. ^{13}C NMR of 5ha ($CDCl_3$, 101 MHz)

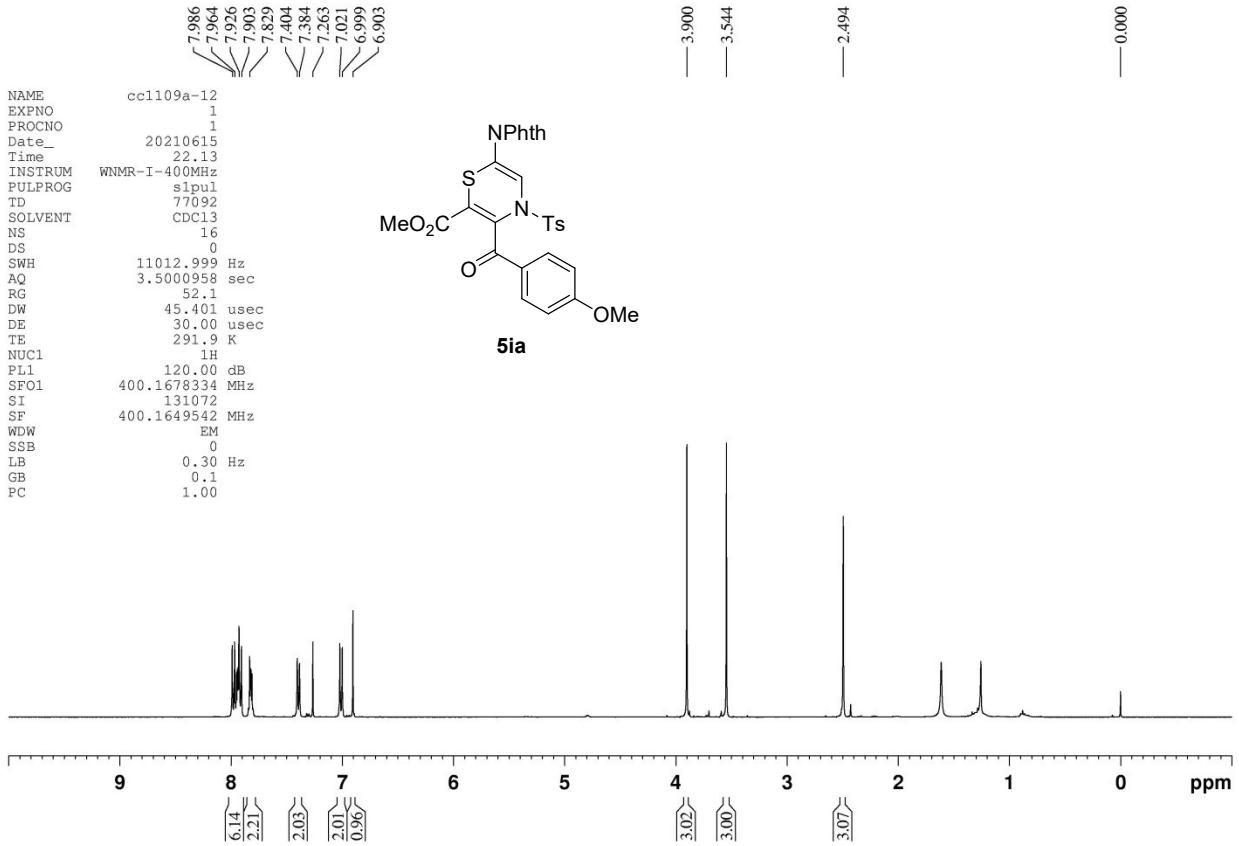


Figure S8-87. ^{1}H NMR of 5ia ($CDCl_3$, 400 MHz)

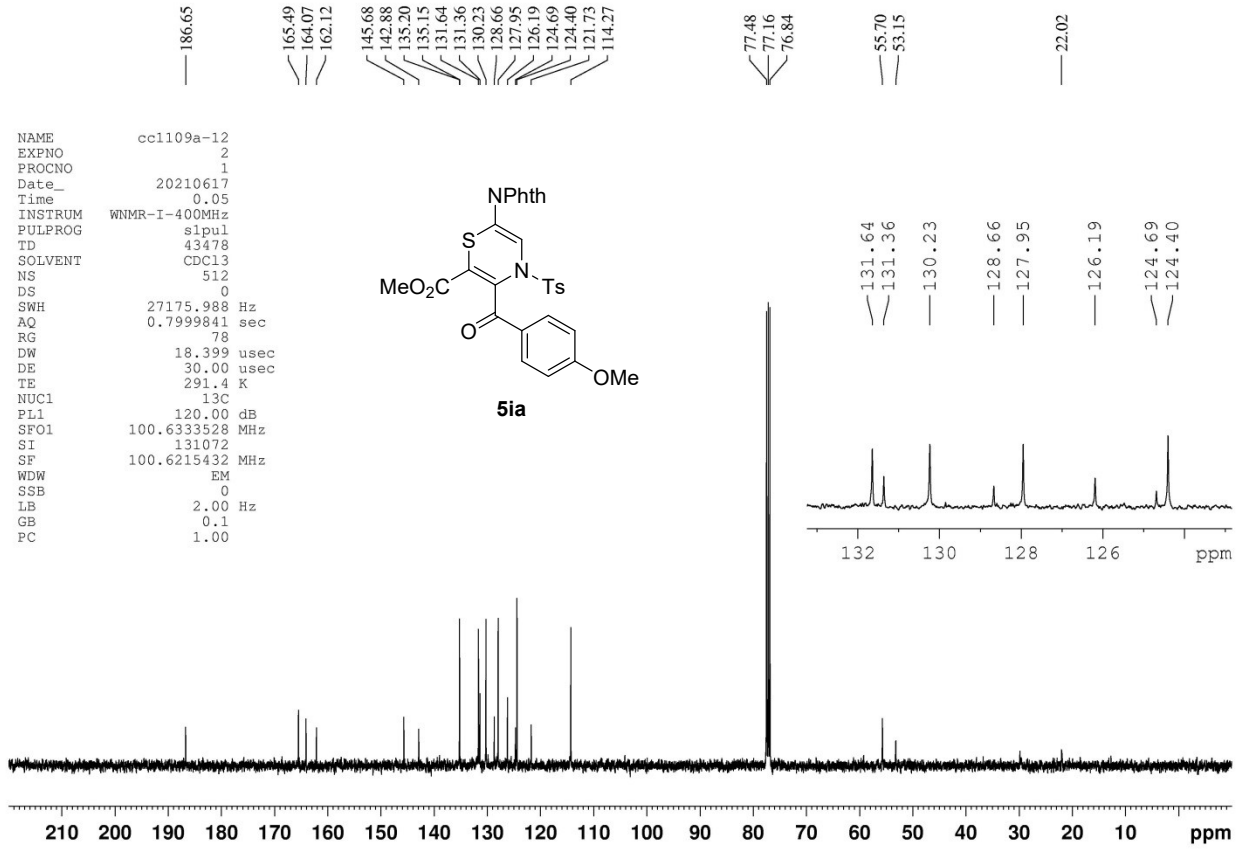


Figure S8-88. ^{13}C NMR of 5ia ($CDCl_3$, 101 MHz)

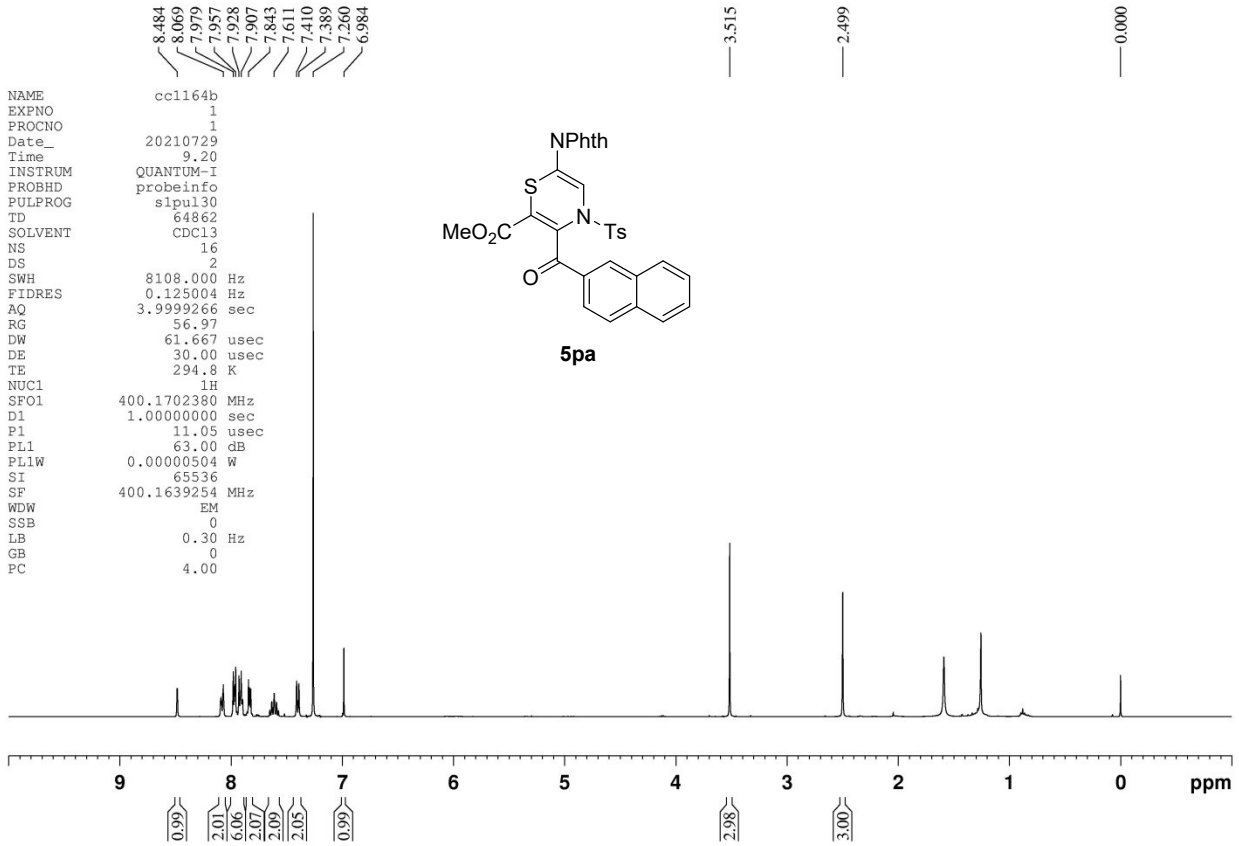


Figure S8-89. ^{1}H NMR of 5pa ($CDCl_3$, 400 MHz)

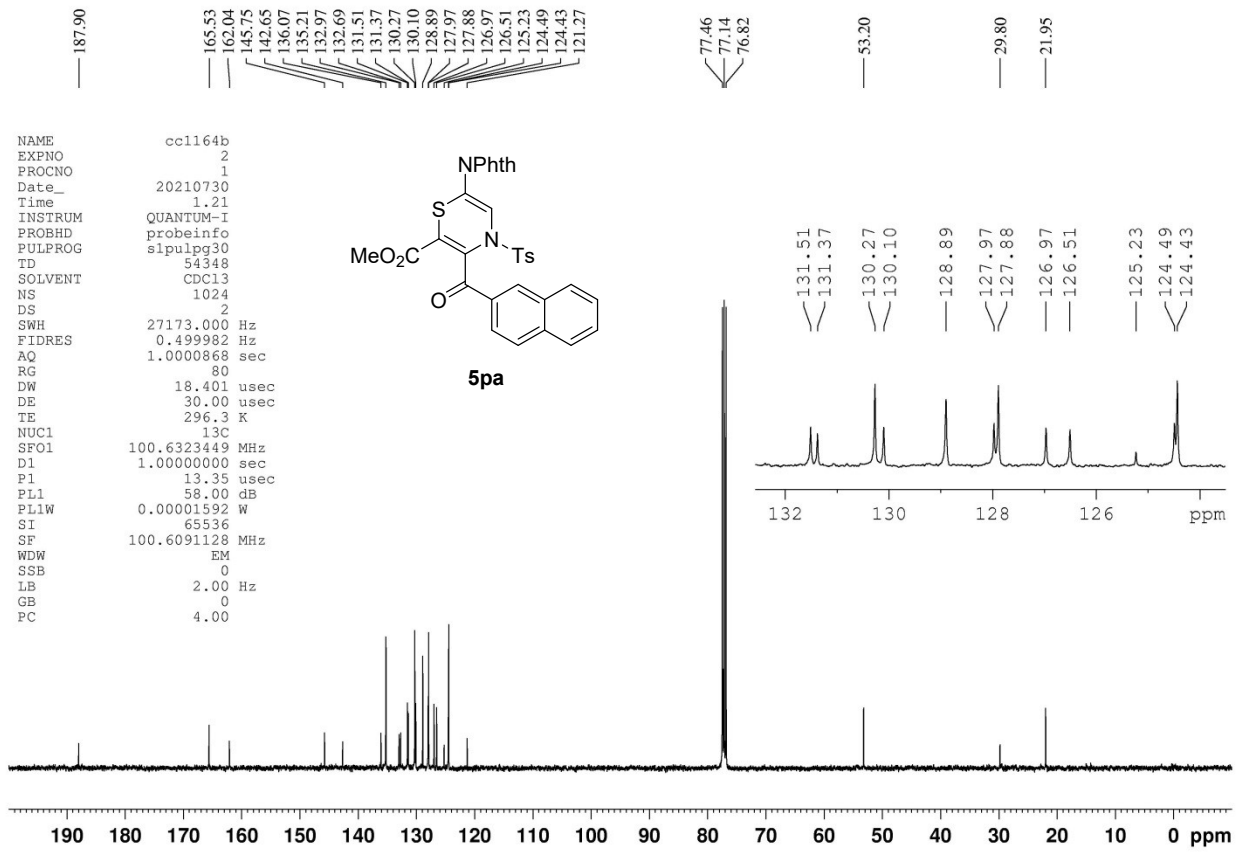


Figure S8-90. ^{13}C NMR of 5pa ($CDCl_3$, 101 MHz)

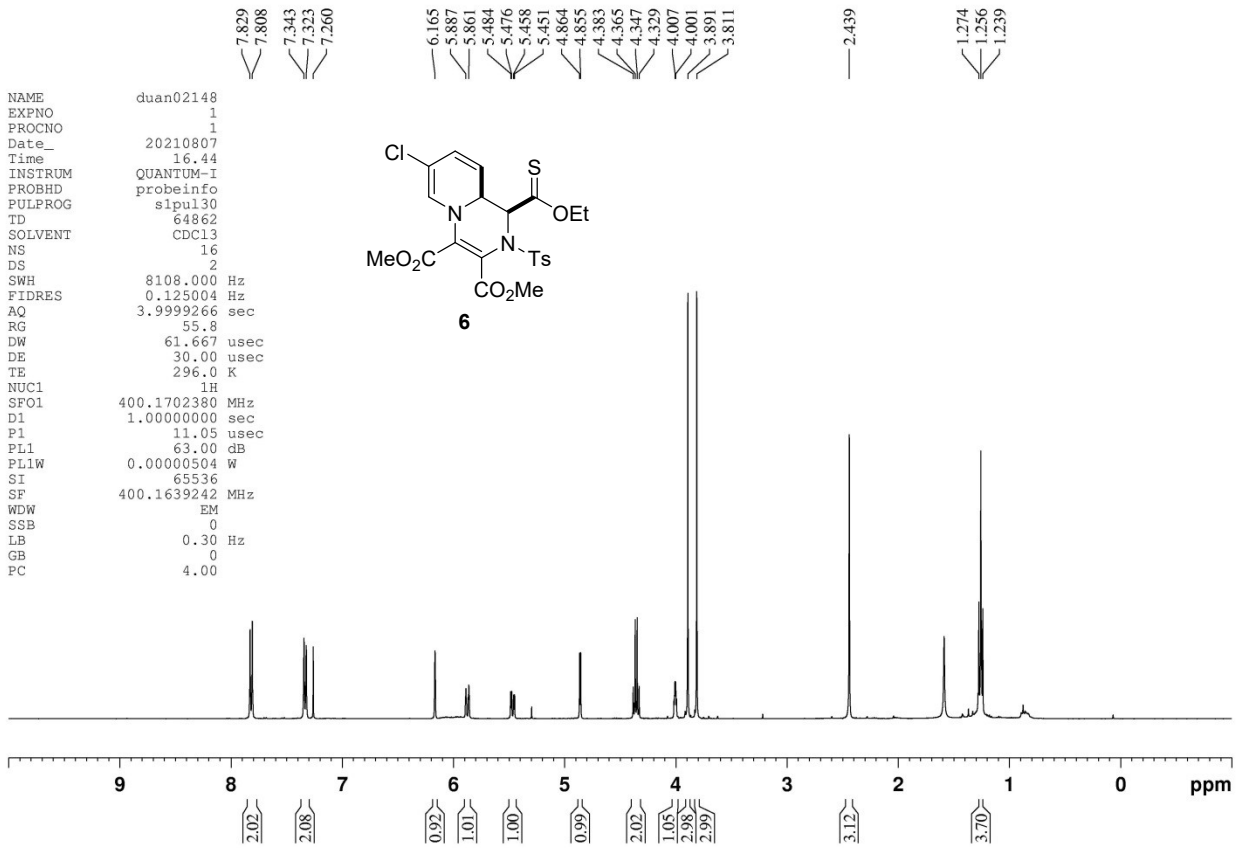


Figure S8-91. ^{1}H NMR of 6 ($CDCl_3$, 400 MHz)

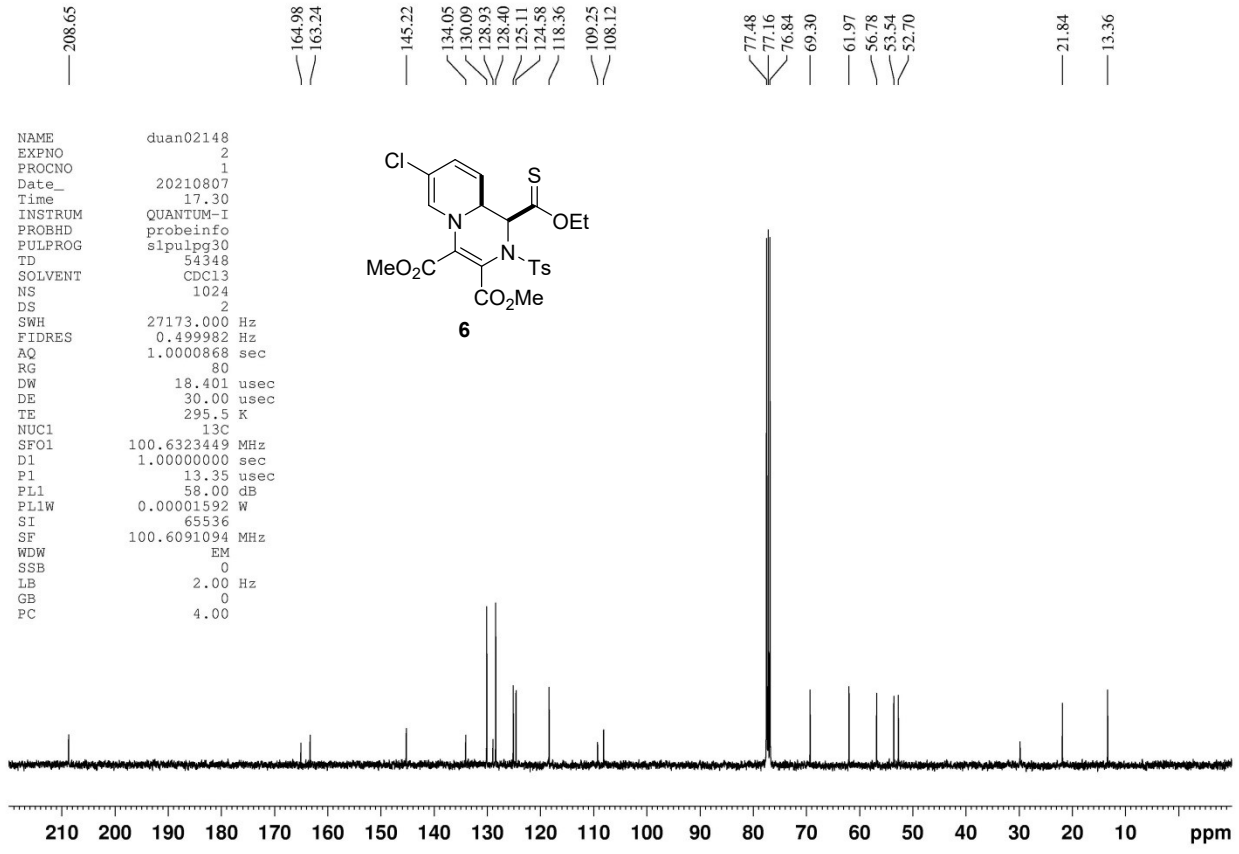


Figure S8-92. ^{13}C NMR of 6 ($CDCl_3$, 101 MHz)

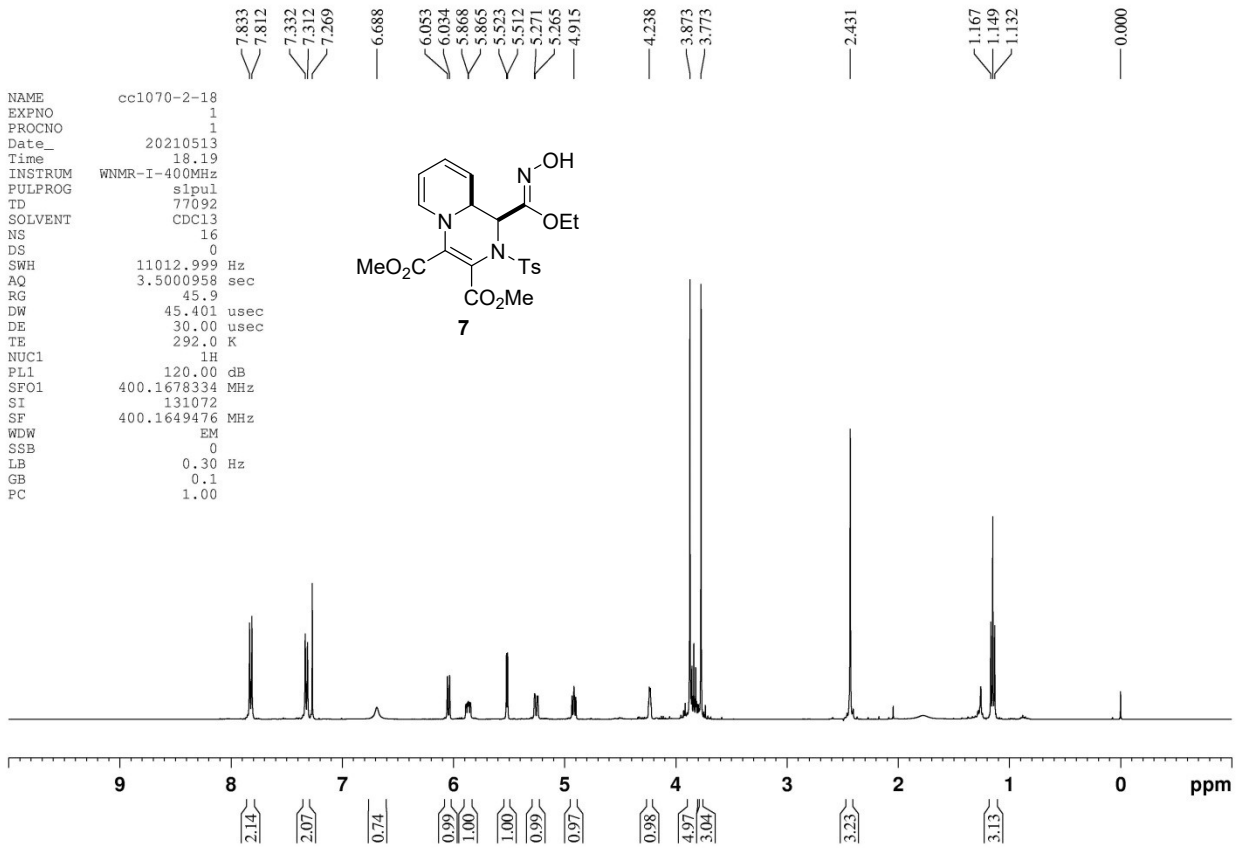


Figure S8-93. ^{1}H NMR of 7 ($CDCl_3$, 400 MHz)

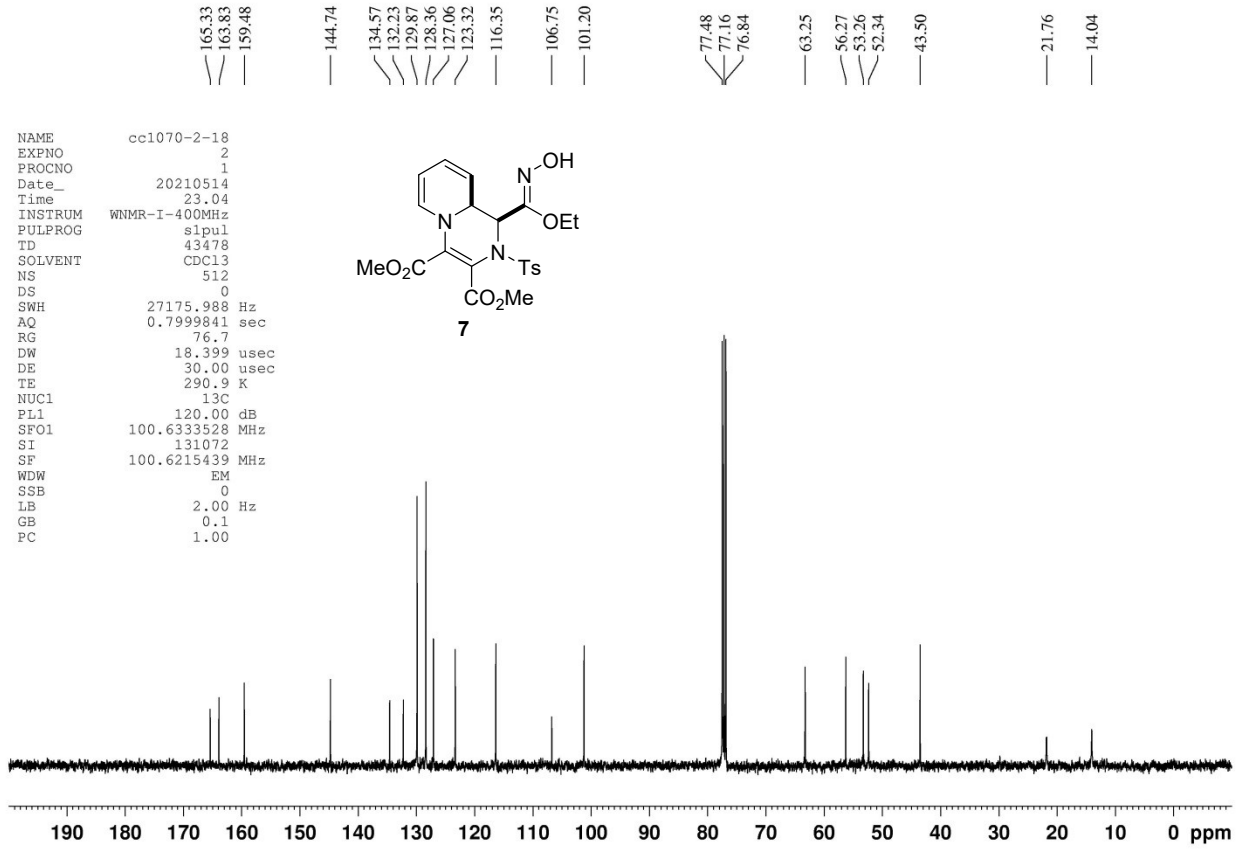


Figure S8-94. ^{13}C NMR of 7 ($CDCl_3$, 101 MHz)

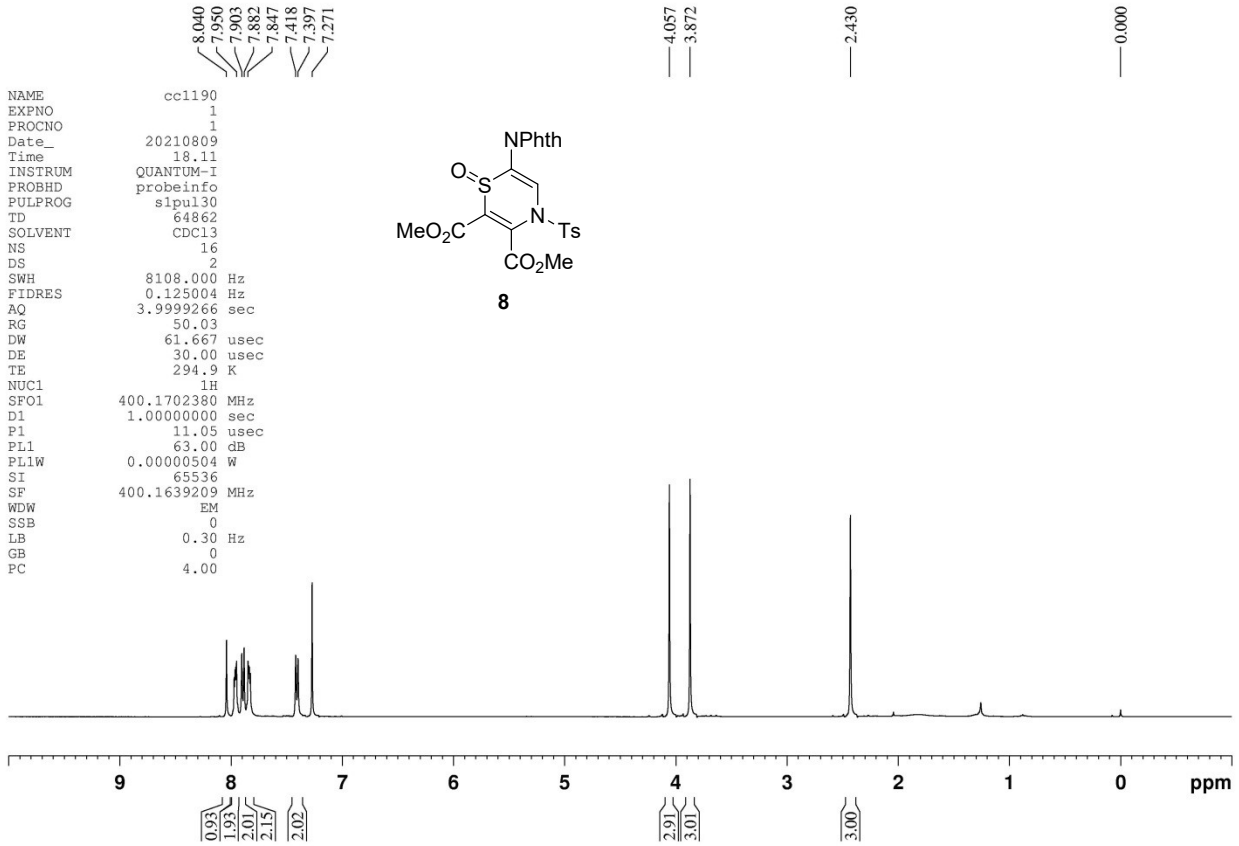


Figure S8-95. ^{1}H NMR of 8 ($CDCl_3$, 400 MHz)

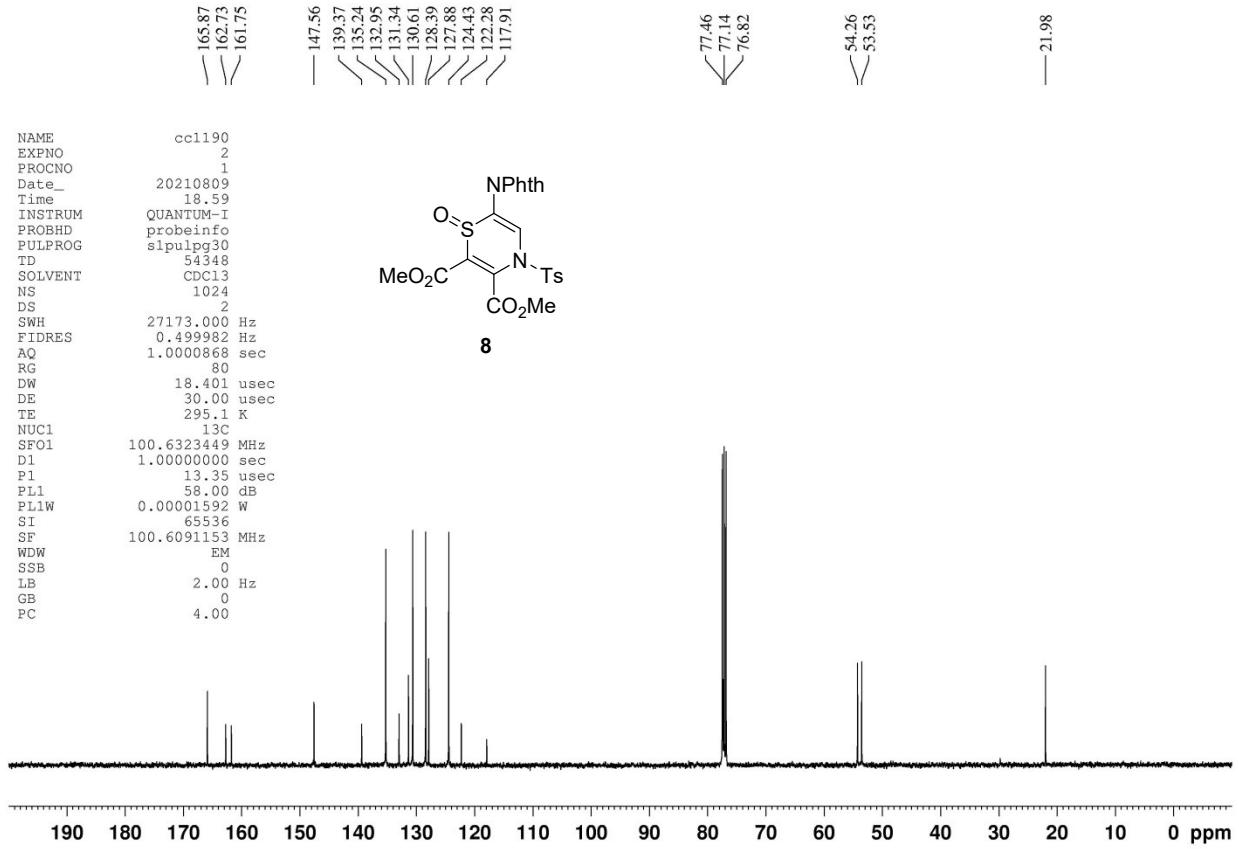


Figure S8-96. ^{13}C NMR of 8 ($CDCl_3$, 101 MHz)

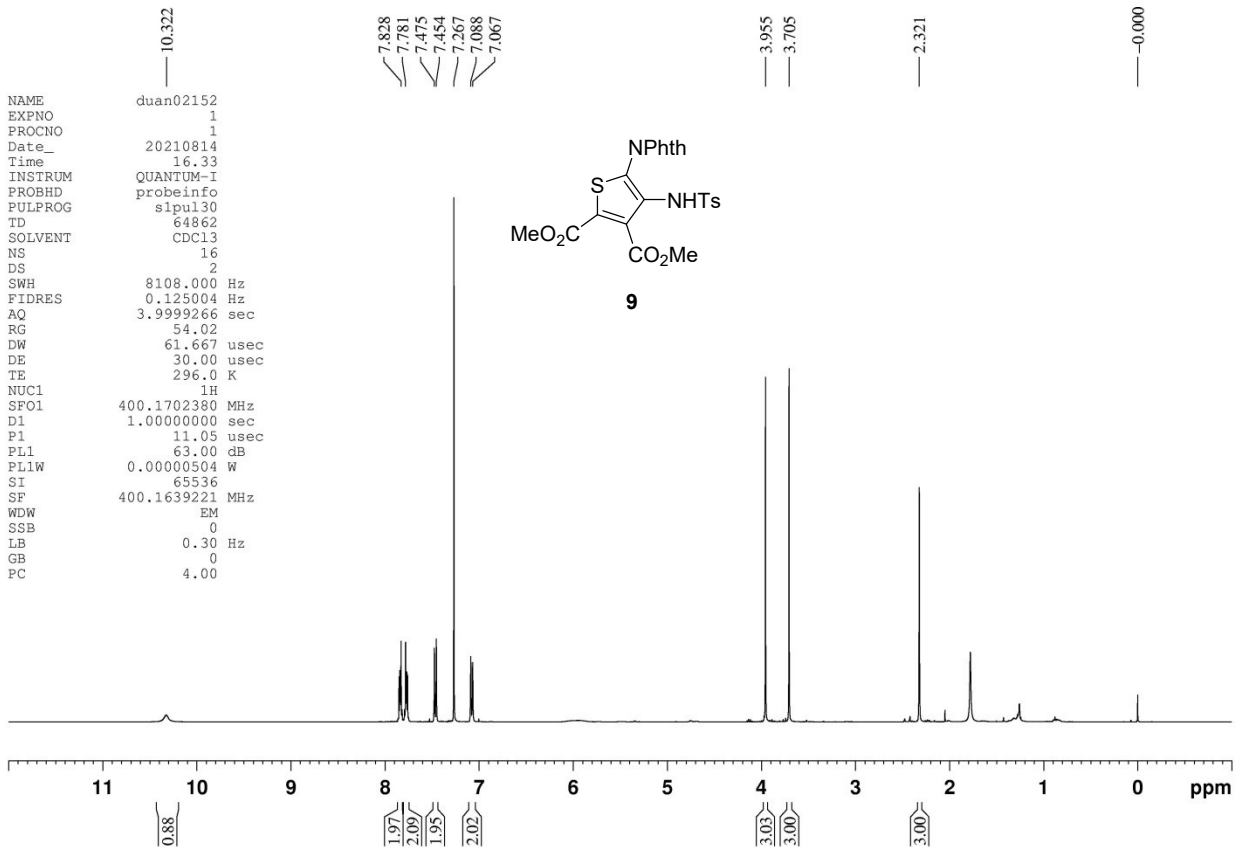


Figure S8-97. ^{1}H NMR of 9 ($CDCl_3$, 400 MHz)

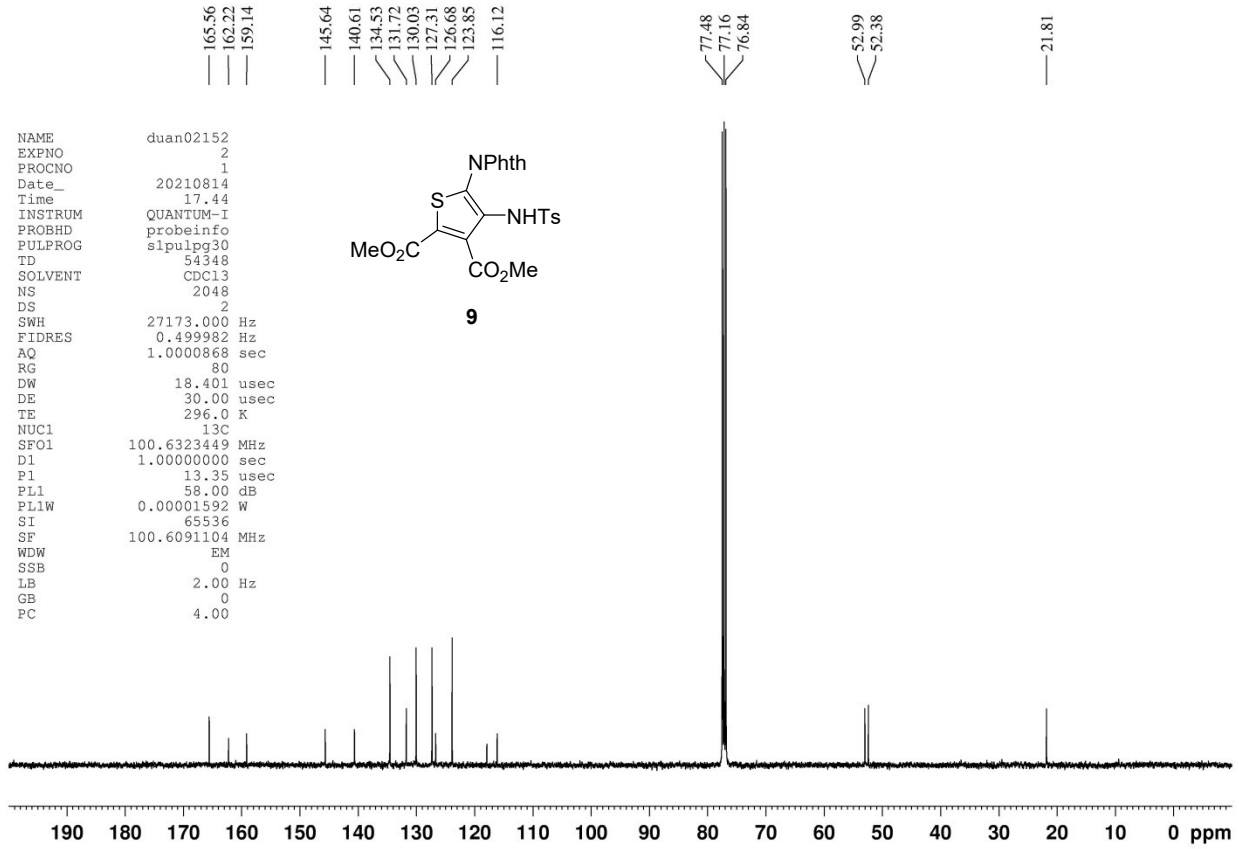
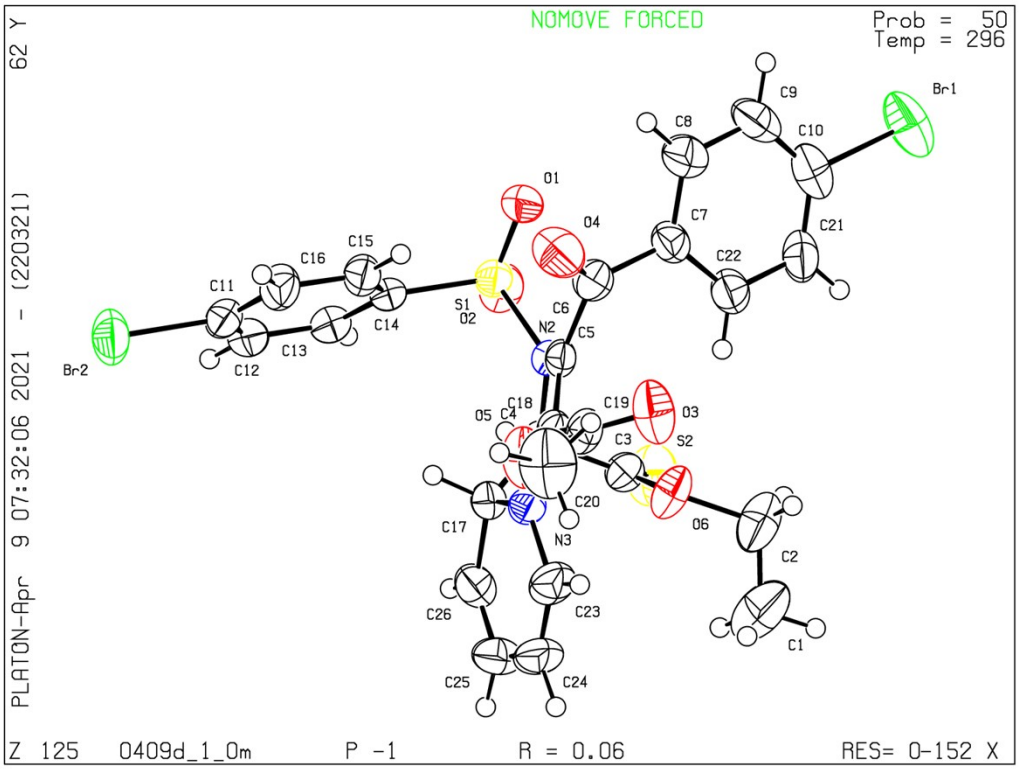


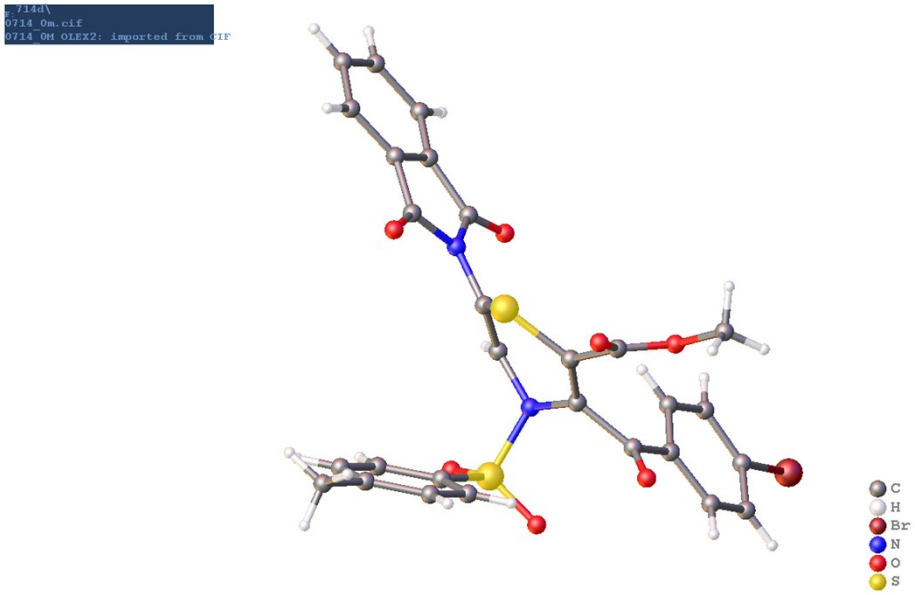
Figure S8-98. ^{13}C NMR of 9 ($CDCl_3$, 101 MHz)

10 X-ray data for compound 3hf and 5ha



CCDC 2102821

Table 1 Crystal data and structure refinement for 0409d_1_0m.	
Identification code	0409d_1_0m
Empirical formula	$C_{26}H_{22}Br_2N_2O_6S_2$
Formula weight	682.38
Temperature/K	296(2)
Crystal system	monoclinic
Space group	P-1
a/Å	9.708(3)
b/Å	10.645(3)
c/Å	14.207(4)
α/°	86.104(4)
β/°	71.609(3)
γ/°	84.982(4)
Volume/Å^3	1386.6(7)
Z	2
ρ_{calc}g/cm^3	1.634
μ/mm^{-1}	3.117
F(000)	684.0
Crystal size/mm^3	0.180 × 0.160 × 0.150
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	3.466 to 55.306
Index ranges	-12≤ h ≤ 12, -13 ≤ k ≤ 13, -18 ≤ l ≤ 18
Reflections collected	15621
Independent reflections	6221 [R_{int} = 0.0269, R_{sigma} = 0.0347]
Data/restraints/parameters	6221/0/345
Goodness-of-fit on F^2	1.054
Final R indexes [I>=2σ (I)]	R_1 = 0.0607, wR_2 = 0.1960
Final R indexes [all data]	R_1 = 0.0837, wR_2 = 0.1927
Largest diff. peak/hole / e Å^{-3}	0.72/-0.52



CCDC 2102822

Table 1 Crystal data and structure refinement for 0714_0m.	
Identification code	0714_0m
Empirical formula	$C_{28}H_{19}BrN_2O_7S_2$
Formula weight	639.48
Temperature/K	296(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	7.860(6)
b/Å	36.16(3)
c/Å	9.697(8)
α/°	90
β/°	92.082(12)
γ/°	90
Volume/Å^3	2754(4)
Z	4
ρ_{calc}g/cm^3	1.542
μ/mm^{-1}	1.694
F(000)	1296.0
Crystal size/mm^3	0.18 × 0.17 × 0.16
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.506 to 57.056
Index ranges	-10 ≤ h ≤ 10, -46 ≤ k ≤ 46, -12 ≤ l ≤ 13
Reflections collected	23225
Independent reflections	6388 [R_{int} = 0.1136, R_{sigma} = 0.1297]
Data/restraints/parameters	6388/0/363
Goodness-of-fit on F^2	0.988
Final R indexes [I>=2σ (I)]	R_1 = 0.0679, wR_2 = 0.1675
Final R indexes [all data]	R_1 = 0.1583, wR_2 = 0.2111
Largest diff. peak/hole / e Å^{-3}	0.72/-0.67