Supporting Information

$(NH_4)_2S_2O_8$-Promoted cross-coupling of thiols/diselenides and sulfoxides for the synthesis of unsymmetrical disulfides/selenosulfides

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CONTENTS:

1. General Information

All reactions were conducted under an inert N_2 atmosphere with oven-dried glassware fitted with a magnetic stirrer bar, unless otherwise stated.

All reagents and solvents were purchased from TCI, Sigma-Aldrich, Alfa Aesar, Acros and Meryer. All commercial reagents were used as supplied unless otherwise stated. Organic solutions were concentrated by rotary evaporation below 45°C. All reactions were monitored by TLC, GC-MS. Analytical thin-layer chromatography was performed using Merck Kieselgel 60 F254 0.20 mm precoated glass-backed silica gel plates. Visualization of the chromatogram was performed by UV absorbance (λ_{max} = 254 nm) and/or by staining with aqueous potassium permanganate. Flash column chromatography was performed using silica gel (EM 60 F254 300 - 400 mesh) with the appropriate solvent system.

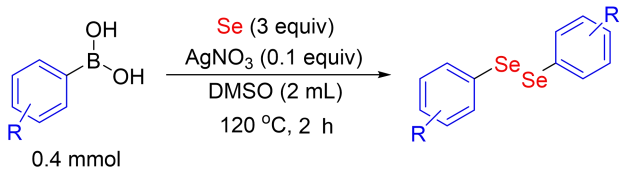
Proton nuclear magnetic resonance (^{1}H NMR) spectra were recorded on a Bruker DPX 400 (400 MHz) or Avance 500 (500 MHz) spectrometer. Chemical shifts (δ) are recorded in parts per million (ppm) and are quoted to the nearest 0.01 ppm relative to the residual solvent protons ($CDCl_3$ = 7.26 ppm, DMSO-d_6 = 2.50 ppm). Coupling constants (*J*) are quoted in Hertz (Hz), and data reported as follows: Chemical shift (multiplicity, coupling constant, number of protons). Coupling constants were reported to the nearest 0.1 Hz and multiplicity reported according to the following: s = singlet, d = doublet, t = triplet, q = quartet, qui = quintet m = multiplet, br = broad, with associated combinations e.g. dd = doublet of doublets.

Carbon nuclear magnetic resonance (^{13}C NMR) spectra were recorded on a Bruker AVANCE 500 (125 MHz) spectrometer. Chemical shifts (δ) are recorded in parts per million (ppm) and are quoted to the nearest 0.1 ppm relative to the residual solvent protons ($CDCl_3$ = 77.2 ppm, DMSO-d_6 = 29.8 ppm).High-resolution mass spectra were recorded on a micrOTOF-Q II 10410 mass spectrometer.

Unless otherwise noted, all reagents and solvents were obtained commercially and used without further purification.

2. Substrate Preparation

2.1 Synthesis of Diselenides

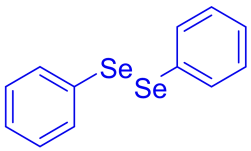


Scheme S1

General Procedure A: [1] To a Schlenk tube were added arylboronic acid (0.4 mmol), selenium (1.2 mmol), $AgNO_3$ (0.04 mmol), and DMSO (2.0 mL). The mixture was stirred in a heating mantle preheated to 120 °C for 2 h. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), and extracted with EtOAc (3×10 mL). The combined organic phase was washed with water and brine (30 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was purified by column chromatography to give the desired diselenides (**4a**-**4v**).

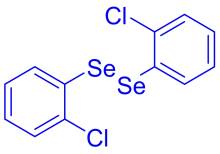
2.2 Characterization of Diselenides in Details

1,2-diphenyldiselane (4a)[1]



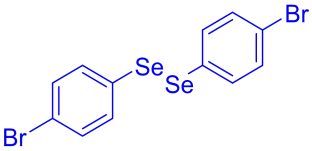
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4a** as yellow oil (60 mg, 96%). **M.p.**: 62.8 - 64.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 6.9 Hz, 4H), 7.26 (d, *J* = 6.9 Hz, 6H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 131.5, 130.9, 129.2, 127.7.

1,2-*bis*(2-chlorophenyl)diselane (4b) [2]



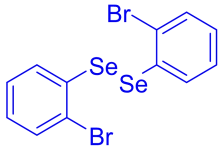
The **General Procedure A** was followed, and hexane was used as the eluant to afford 4**b** as yellow solid (69 mg, 90%). **M.p.**: 73.1 - 74.8 °C **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.62 - 7.56 (m, 2H), 7.31 - 7.15 (m, 6H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 133.3, 130.7, 129.3, 129.2, 128.4, 127.9.

1,2-*bis*(4-bromophenyl)diselane (4c) [2]



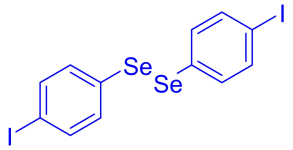
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4c** as red solid (86 mg, 92%). **M.p.**: 72.8 - 74.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.43 (d, *J* = 8.5 Hz, 4H), 7.37 (d, *J* = 8.5 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 133.4, 132.3, 129.5, 122.4.

1,2-*bis*(2-bromophenyl)diselane (4d) [3]



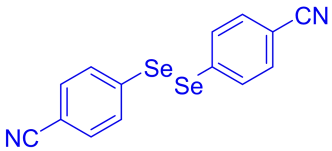
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4d** as yellow solid (69 mg, 73%). **M.p.**: 75.8 - 77.4 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.59 - 7.57 (m, 2H), 7.50 - 7.48 (m, 2H), 7.22 - 7.19 (m, 2H), 7.10 - 7.06 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 132.5, 131.4, 130.5, 128.6, 128.4, 122.9.

1,2-*bis*(4-iodophenyl)diselane (4e) [4]



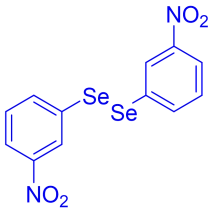
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4e** as red solid (96 mg, 85%). **M.p.**: 72.8 - 74.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.4 Hz, 4H), 7.30 (d, *J* = 8.4 Hz, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 138.2, 133.4, 130.4, 93.7.

4,4'-diselanediyldibenzonitrile (4f) [5]



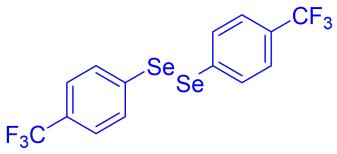
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4f** as red solid (62 mg, 85%). **M.p.**: 70.4 - 72.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.68 (dd, J_1 = 8.2 Hz, J_2 = 1.9 Hz, 4H), 7.58 - 7.53 (m, 4H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.4, 132.7, 130.5, 118.2, 111.4.

1,2-*bis*(3-nitrophenyl)diselane (4g) [6]



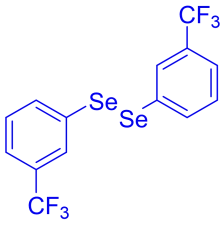
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4g** as yellow solid (64 mg, 80%). **M.p.**: 75.2 - 80.4 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.46 (d, *J* = 2.4 Hz, 2H), 8.11 (d, *J* = 8.2 Hz, 2H), 7.91 (d, *J* = 7.7 Hz, 2H), 7.48 (t, *J* = 8.0 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 148.5, 136.8, 131.8, 130.2, 125.9, 123.0.

1,2-*bis*(4-(trifluoromethyl)phenyl)diselane (4h) [5]



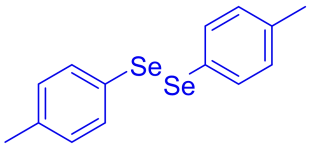
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4h** as yellow solid (76 mg, 85%). **M.p.**: 69.2 - 71.4 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.0 Hz, 4H), 7.52 (d, *J* = 8.0 Hz, 4H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.8, 130.7, 129.94 (q, *J* = 32.6 Hz), 126.13 (q, *J* = 3.7 Hz), 123.85 (q, *J* = 272.1 Hz). **^{19}F NMR** (470 MHz, $CDCl_3$) δ -62.6.

1,2-*bis*(3-(trifluoromethyl)phenyl)diselane (4i) [7]



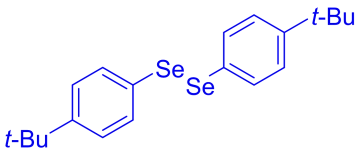
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4i** as yellow soild (75 mg, 84%). **M.p.**: 70.1 - 71.8 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.85 (s, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 7.8 Hz, 2H), 7.39 (t, *J* = 7.9 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.9, 131.6 (q, *J* = 32.5 Hz), 131.3 (m), 129.7, 128.3 (q, *J* = 4.1 Hz), 124.9 (q, *J* = 3.7 Hz), 123.5 (q, *J* = 272.8 Hz). **^{19}F NMR** (470 MHz, $CDCl_3$) δ -62.8.

1,2-di-*p*-tolyldiselane (4j) [5]



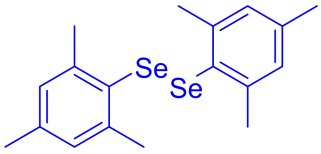
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4j** as yellow soild (56 mg, 83%). **M.p.**: 45.1 - 47.5 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.48 (d, *J* = 8.1 Hz, 4H), 7.07 (d, *J* = 7.9 Hz, 4H), 2.33 (s, 6H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.9, 133.0, 132.3, 129.9, 21.1.

1,2-*bis*(4-(*tert*-butyl)phenyl)diselane (4k) [8]



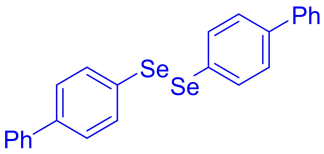
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4k** as yellow soild (55 mg, 65%). **M.p.**: 74.1 - 76.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.3 Hz, 4H), 7.29 (d, *J* = 8.3 Hz, 4H), 1.30 (s, 18H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 133.0, 131.6, 127.7, 126.3, 34.6, 31.3.

1,2-dimesityldiselane (4l) [8]



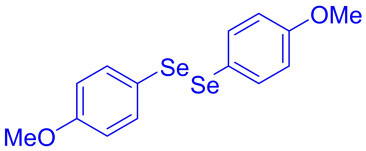
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4l** as yellow soild (67 mg, 84%). **M.p.**: 114.0 - 116.8 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.82 (s, 4H), 2.25 (s, 6H), 2.22 (s, 12H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 143.7, 139.1, 128.8, 128.3, 24.2, 21.1.

1,2-di([1,1'-biphenyl]-4-yl)diselane (4m) [5]



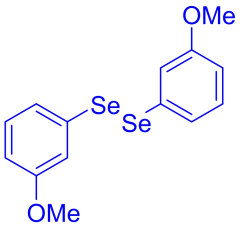
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4m** as yellow soild (78 mg, 84%). **M.p.**: 183.5 - 185.8 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.72 - 7.69 (m, 4H), 7.59 - 7.55 (m, 4H), 7.52 - 7.50 (m, 4H), 7.44 (t, *J* = 7.6 Hz, 4H), 7.36 (d, *J* = 7.4 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 140.9, 140.2, 132.2, 129.9, 128.9, 127.9, 127.6, 127.0.

1,2-*bis*(4-methoxyphenyl)diselane (4n) [6]



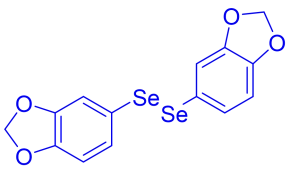
The **General Procedure** A was followed, and hexane was used as the eluant to afford **4n** as yellow soild (49 mg, 66%). **M.p.**: 52.5 - 55.0 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.4 Hz, 4H), 6.81 (d, *J* = 8.3 Hz, 4H), 3.81 (s, 6H); **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.1, 135.5, 121.9, 114.7, 55.4.

1,2-*bis*(3-methoxyphenyl)diselane (4o) [2]



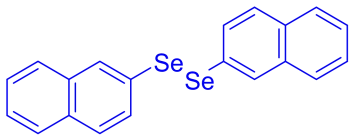
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4o** as white solid (41 mg, 55%). **M.p.**: 193.8 - 195.2 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.23 - 7.15 (m, 6H), 6.79 (d, *J* = 7.6 Hz, 2H), 3.77 (s, 6H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.9, 131.9, 129.9, 123.5, 116.6, 113.8, 55.3.

1,2-*bis*(benzo[*d*][1,3]dioxol-5-yl)diselane (4p) [9]



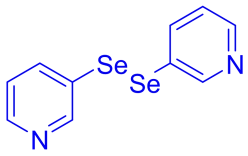
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4p** as yellow solid (50 mg, 63%). **M.p.**: 99.3 - 111.5 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.00 (dd, J_1 = 8.0 Hz, J_2 = 1.7 Hz, 2H), 6.93 (d, J = 1.7 Hz, 2H), 6.73 (d, J = 8.0 Hz, 2H), 5.94 (s, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 148.3, 147.5, 126.9, 123.0, 113.7, 109.1, 101.2.

1,2-di(naphthalen-2-yl)diselane (4q) [5]



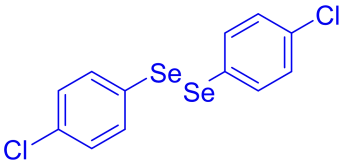
The **General Procedure A** was followed, and hexane was used as the eluant to afford **4q** as yellow solid (62 mg, 75%). **M.p.**: 126.2 - 127.8 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.17 (d, J = 8.4 Hz, 2H), 7.79 - 7.70 (m, 6H), 7.43 (t, J = 7.7 Hz, 2H), 7.36 (t, J = 7.7 Hz, 2H), 7.21 (t, J = 7.6 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.1, 134.1, 134.0, 130.1, 129.9, 128.6, 128.0, 126.7, 126.4, 125.7.

1,2-di(pyridin-3-yl)diselane (4r) [2]



The **General Procedure A** was followed, and hexane was used as the eluant to afford **4r** as yellow oil (47 mg, 75%). **1H NMR** (500 MHz, $CDCl_3$) δ 8.76 (s, 2H), 8.51 (d, J = 4.9 Hz, 2H), 7.90 (dt, J_1 = 7.9 Hz, J_2 = 2.1 Hz, 2H), 7.24 (d, J = 6.7 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 152.5, 149.3, 140.2, 127.8, 124.3.

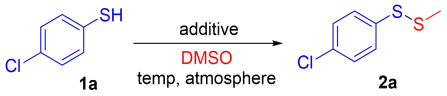
1,2-bis(4-chlorophenyl)diselane (4v)[2]



The **General Procedure A** was followed, and hexane was used as the eluant to afford **4v** as yellow soild (71 mg, 93%). **1H NMR** (500 MHz, $CDCl_3$) δ 7.50 - 7.48 (m, 4H), 7.23 - 7.21 (m, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.4, 133.3, 129.4, 128.8.

3. Reaction Optimization

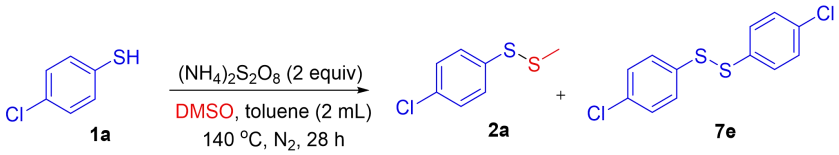
Table S1 Reaction optimization[a]



entry	Additive (x equiv)	T (°C)	atmosphere	yield (%)
1	$K_2S_2O_8$ (2)	140	N_2	31
2	$(NH_4)_2S_2O_8$ (2)	140	N_2	93
3	$Na_2S_2O_8$ (2)	140	N_2	trace
4	$PhI(OAc)_2$ (2)	140	N_2	trace
5	TBHP (2)	140	N_2	22
6	$(NH_4)_2SO_4$ (2)	140	N_2	62
7	NH_4Cl (2)	140	N_2	86
8	CH_3COOH (2)	140	N_2	85
9	CF_3COOH (2)	140	N_2	58
10	$(NH_4)_2S_2O_8$ (2)	150	N_2	82
11	$(NH_4)_2S_2O_8$ (2)	130	N_2	78
12	$(NH_4)_2S_2O_8$ (2)	120	N_2	66
13	$(NH_4)_2S_2O_8$ (1.5)	140	N_2	66
14	$(NH_4)_2S_2O_8$ (2)	140	N_2	25
15	$(NH_4)_2S_2O_8$ (2)	140	air	70
16	$(NH_4)_2S_2O_8$ (2)	140	O_2	73

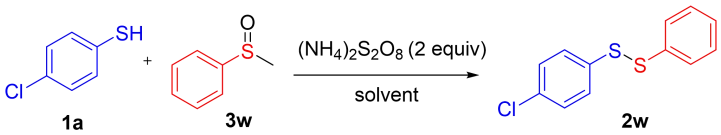
[a]Reactions conditions: **1a** (0.2 mmol), DMSO (2.0 mL), additive (2 equiv), 28 h, N_2 atmosphere, isolated yields.

Table S2 The Influence of the amount of DMSO on the Yield of **2a**



entry	DMSO (equiv.)	Yield of **2a**/%	Yield of **7e**/%
1	3	25	67
2	5	34	59
3	7	46	50
4	9	58	35

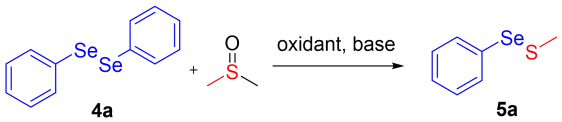
Table S3 Reaction Optimization for the Synthesis of **2w**[a]



entry	solvent	temp/°C	time/h	yields/%
1	toluene	130	12	<5
2	xylene	130	12	N.R.
3	PhCl	130	12	N.R.
4	DMF	130	12	trace
5	NMP	130	12	trace
6	$PhCF_3$	130	12	N.R.
7	toluene	140	12	3
8	toluene	150	12	14
9	toluene	160	12	13
10[b]	toluene	150	12	29
11[c]	toluene	150	12	25
14[b]	toluene	150	24	39
15[c]	toluene	150	24	63

[a]Reactions conditions: **1a** (0.2 mmol), **3w** (0.6 mmol), $(NH_4)_2S_2O_8$ (0.4 mmol), N_2, isolated yields. [b]**3w** (1.0 mmol). [c]**3w** (1.8 mmol).

Table S4 Reaction Optimization for the Synthesis of **5a**[a]

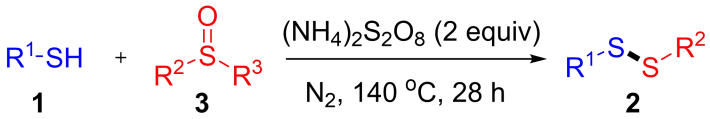


entry	oxidant	base	temp/°C	time/h	yields/%
1[b]	$(NH_4)_2S_2O_8$	K_3PO_4	140	24	47
2[c]	$(NH_4)_2S_2O_8$	K_3PO_4	140	24	41
3	$(NH_4)_2S_2O_8$	K_3PO_4	140	24	62
4	$(NH_4)_2S_2O_8$	*t*-BuOK	140	24	64
5	$(NH_4)_2S_2O_8$	KOH	140	24	64
6	$(NH_4)_2S_2O_8$	CH_3ONa	140	24	50
7	$Na_2S_2O_8$	*t*-BuOK	150	24	NR
8	$K_2S_2O_8$	*t*-BuOK	150	24	trace
9	$(NH_4)_2S_2O_8$	-	140	24	4
10[d]	$(NH_4)_2S_2O_8$	*t*-BuOK	140	24	71
11	-	*t*-BuOK	150	24	trace
12[e]	$(NH_4)_2S_2O_8$	*t*-BuOK	150	24	68
13[f]	$(NH_4)_2S_2O_8$	*t*-BuOK	150	12	72

[a]Reactions conditions: **4a** (0.2 mmol), oxidant (1.0 mmol), base (0.6 mmol), DMSO (2.0 mL), 140 °C, N_2, 12 h, isolated yields. [b]Air atmosphere. [c]O_2 atmosphere. [d]Base (0.8 mmol). [e]Oxidant (0.6 mmol). [f]Oxidant (0.6 mmol), base (0.8 mmol).

4. General Procedure for the Synthetic of Unsymmetrical Disulfides and Selenosulfides

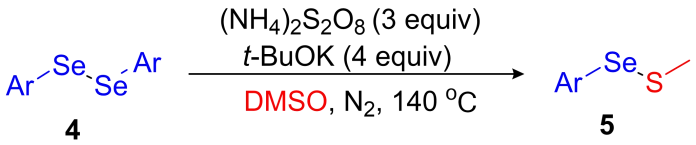
4.1 Synthesis of Unsymmetrical Disulfides



Scheme S2

General Procedure B: To a Schlenk tube were added thiols (0.2 mmol), sulfoxide (2 mL), $(NH_4)_2S_2O_8$ (91 mg, 0.4 mmol). The mixture was stirred in a heating mantle preheated to 140 °C for 28 h under N_2 atmosphere. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), and extracted with EtOAc (3×10 mL). The combined organic phase was washed with water and brine (30 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was purified by column chromatography to give the desired unsymmetrical disulfides.

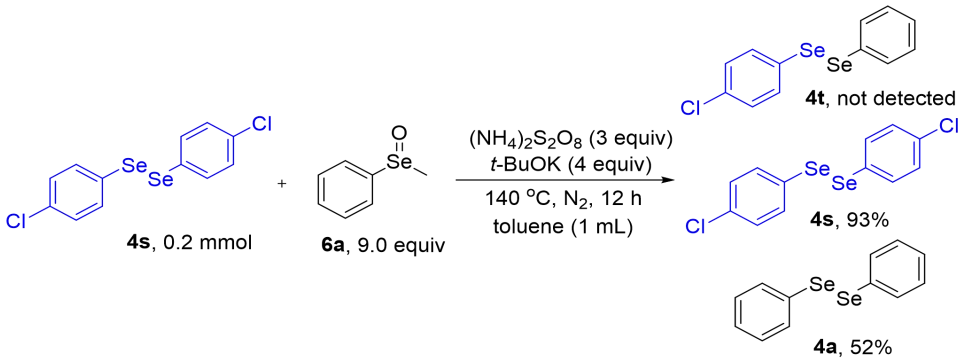
4.2 Synthesis of Unsymmetrical Selenosulfides



Scheme S3

General Procedure C: To a Schlenk tube were added diselenide (0.2 mmol), $(NH_4)_2S_2O_8$ (137 mg, 0.6 mmol), *t*-BuOK (90 mg, 0.8 mmol) and DMSO (2 mL). The mixture was stirred in a heating mantle preheated to 140 ℃ for 12 h under N_2 atmosphere. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), and extracted with EtOAc (3×10 mL). The combined organic phase was washed with water and brine (30 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was purified by column chromatography to give the desired unsymmetrical selenosulfides.

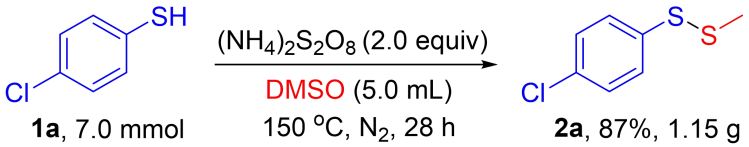
4.3 The reaction between diselenide **4s** and selenoxide **6a**.



Scheme S4

To a Schlenk tube were added diselenide **4s** (0.2 mmol), $(NH_4)_2S_2O_8$ (137 mg, 0.6 mmol), *t*-BuOK (90 mg, 0.8 mmol), **6a** (337 mg, 1.8 mmol) and toluene (1 mL). The mixture was stirred in a heating mantle preheated to 140 ℃ for 12 h under N_2 atmosphere. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), and extracted with EtOAc (3×10 mL). The combined organic phase was washed with water and brine (30 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was purified by column chromatography to give the desired products.

4.4 Gram-Scale Synthesis of **1a**

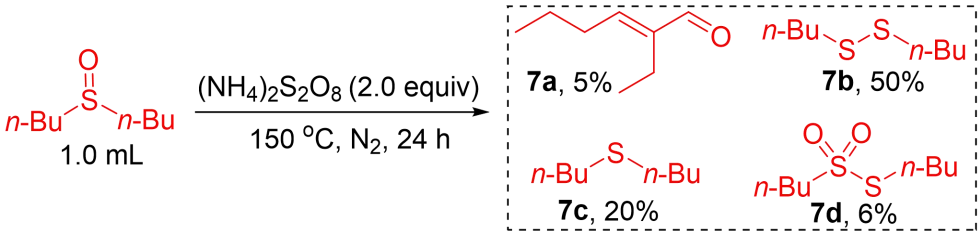


Scheme S5

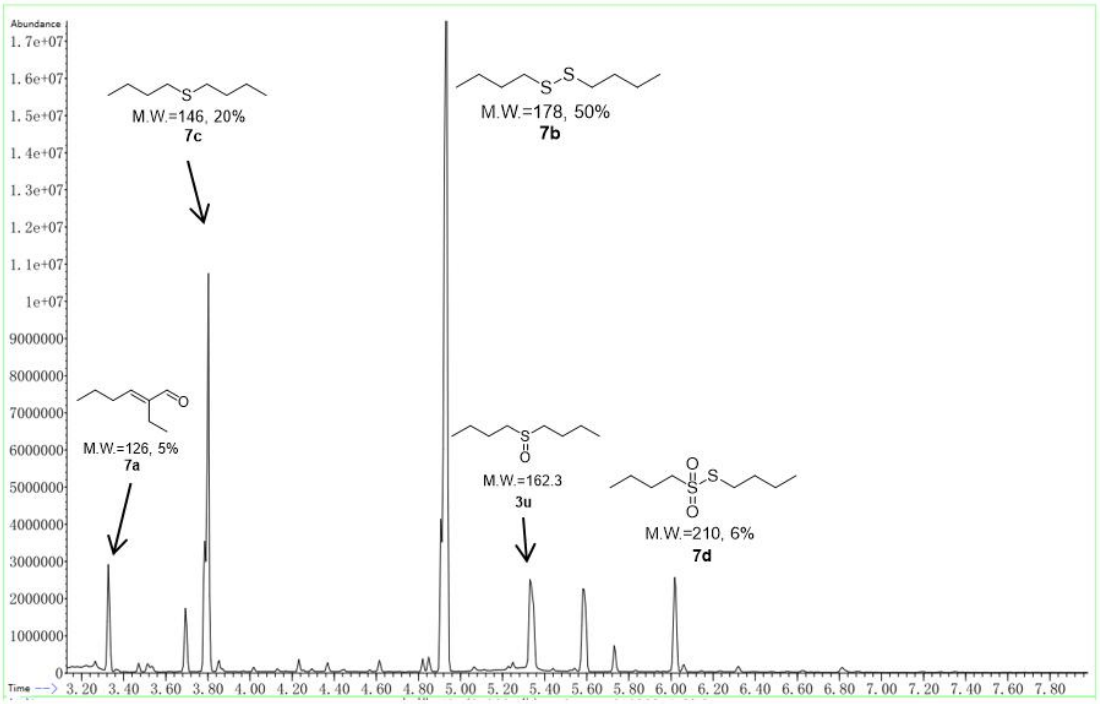
To a Schlenk tube were added **1a** (1.01 g, 7.0 mmol), $(NH_4)_2S_2O_8$ (3.2 g, 14 mmol), and DMSO (5 mL). The mixture was stirred in a heating mantle preheated to 140 ℃ for 28 h under N_2 atmosphere. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), extracted with EtOAc (3×20 mL). The combined organic phase was washed with water and brine (150 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether) to afford **2a** (1.15 g, 87 %) as yellow oil.

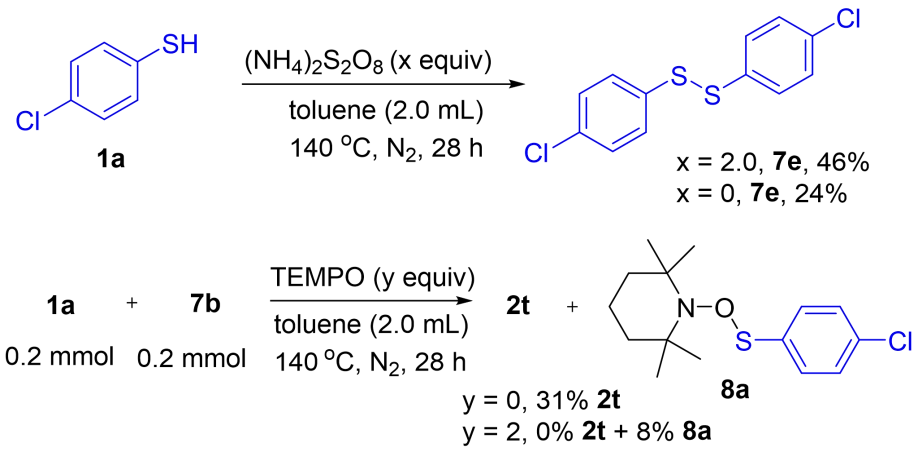
5. Preliminary Mechanistic Studies

5.1 GC-MS

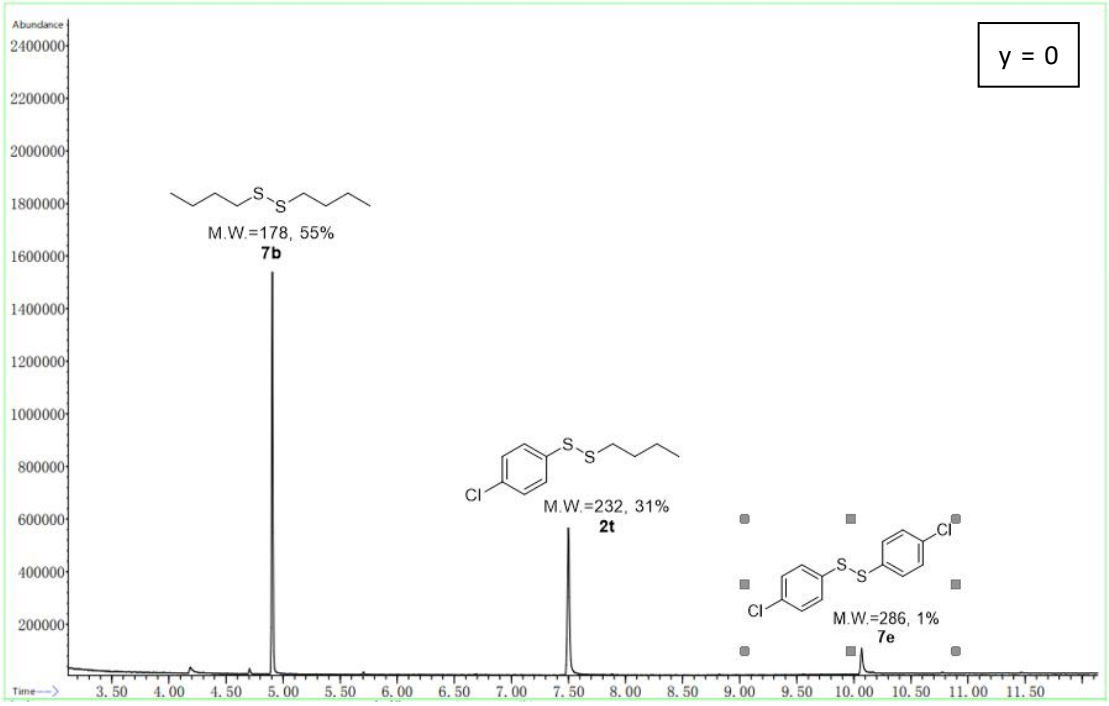


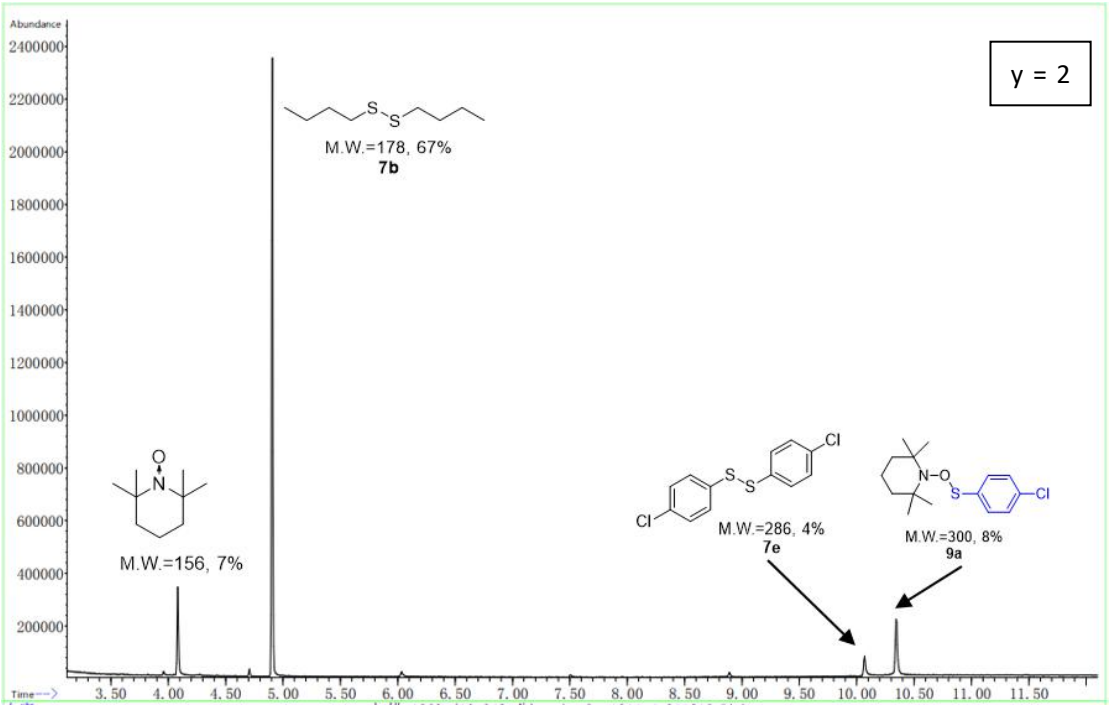
Scheme S6

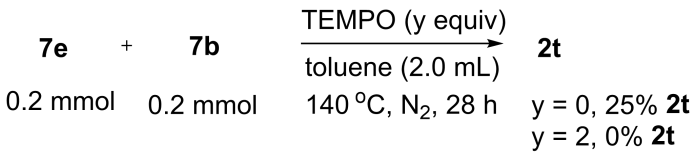




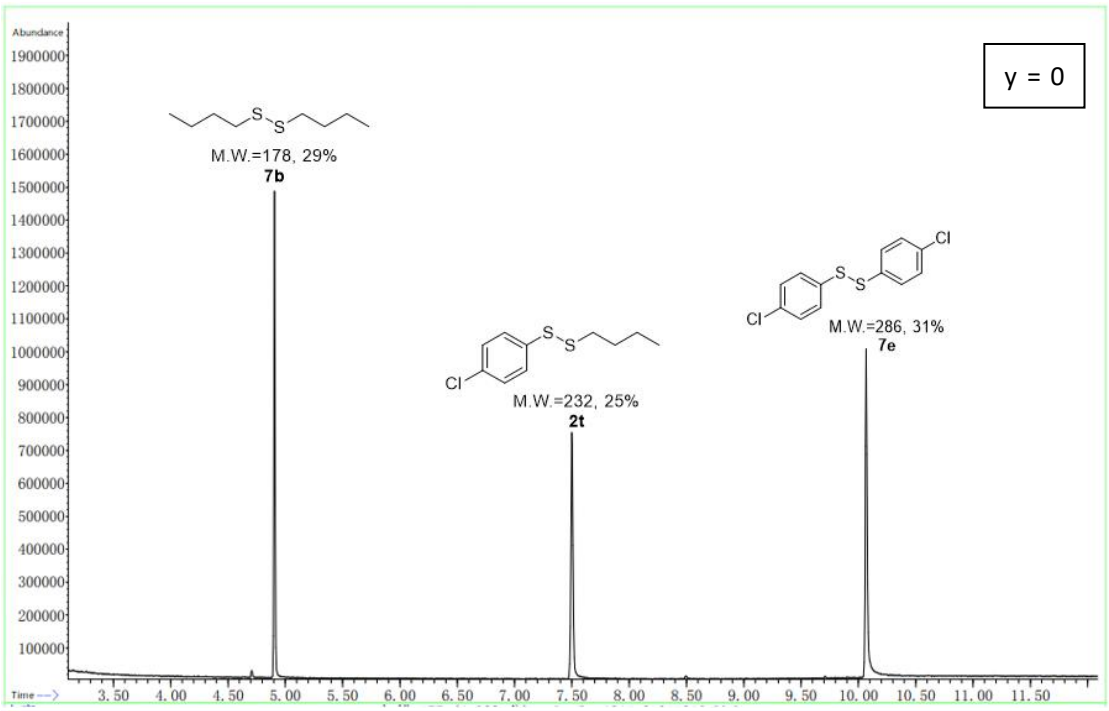
Scheme S7

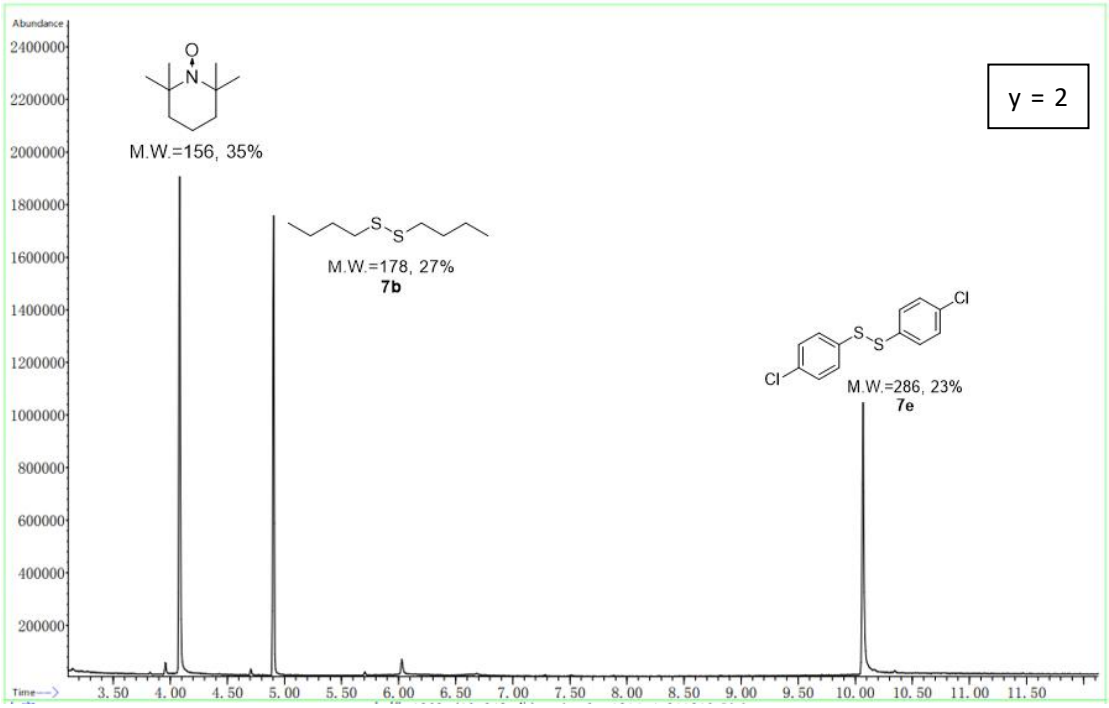

y = 0
Abundance
M.W.=178, 55%
7b
M.W.=232, 31%
2t
M.W.=286, 1%
7e
Time

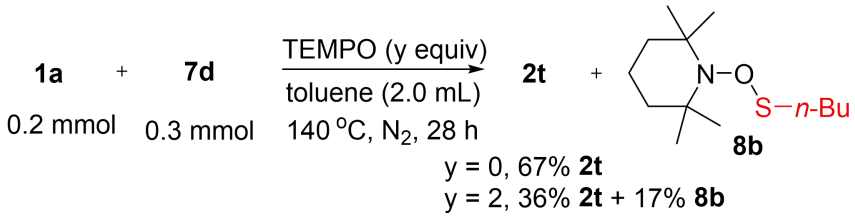

y = 2
Abundance
M.W.=178, 67%
7b
M.W.=156, 7%
M.W.=286, 4%
7e
M.W.=300, 8%
9a
Time


7e
+
7b
TEMPO (y equiv)
toluene (2.0 mL)
2t
0.2 mmol
0.2 mmol
140 °C, N2, 28 h
y = 0, 25% 2t
y = 2, 0% 2t

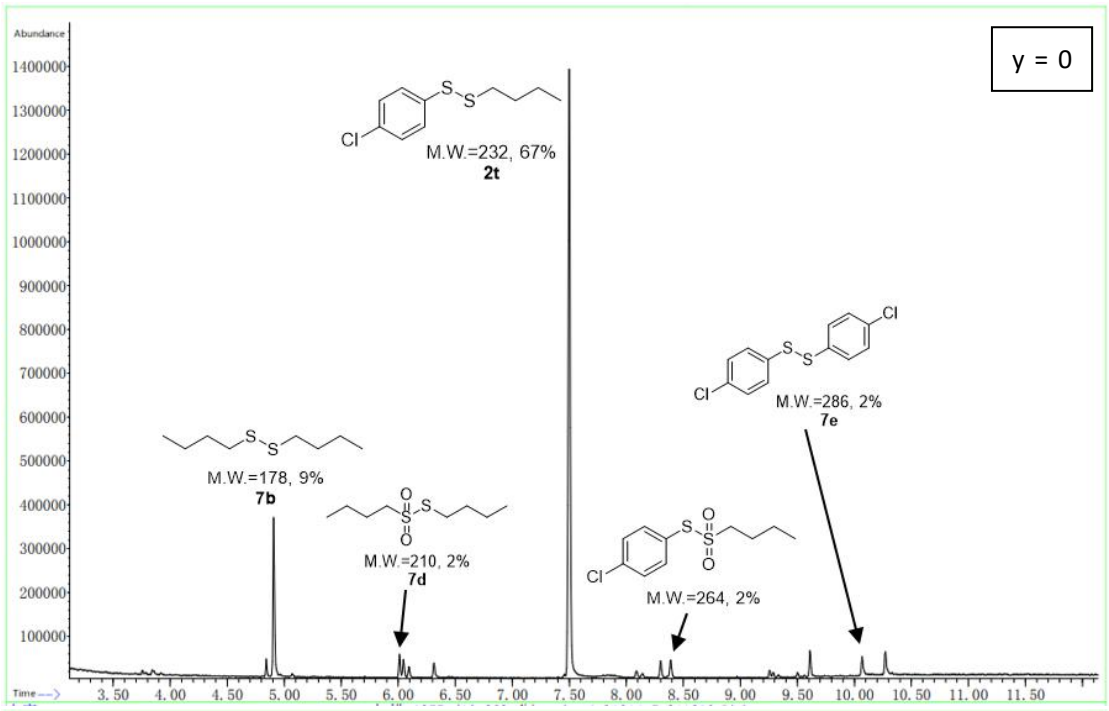
Scheme S8

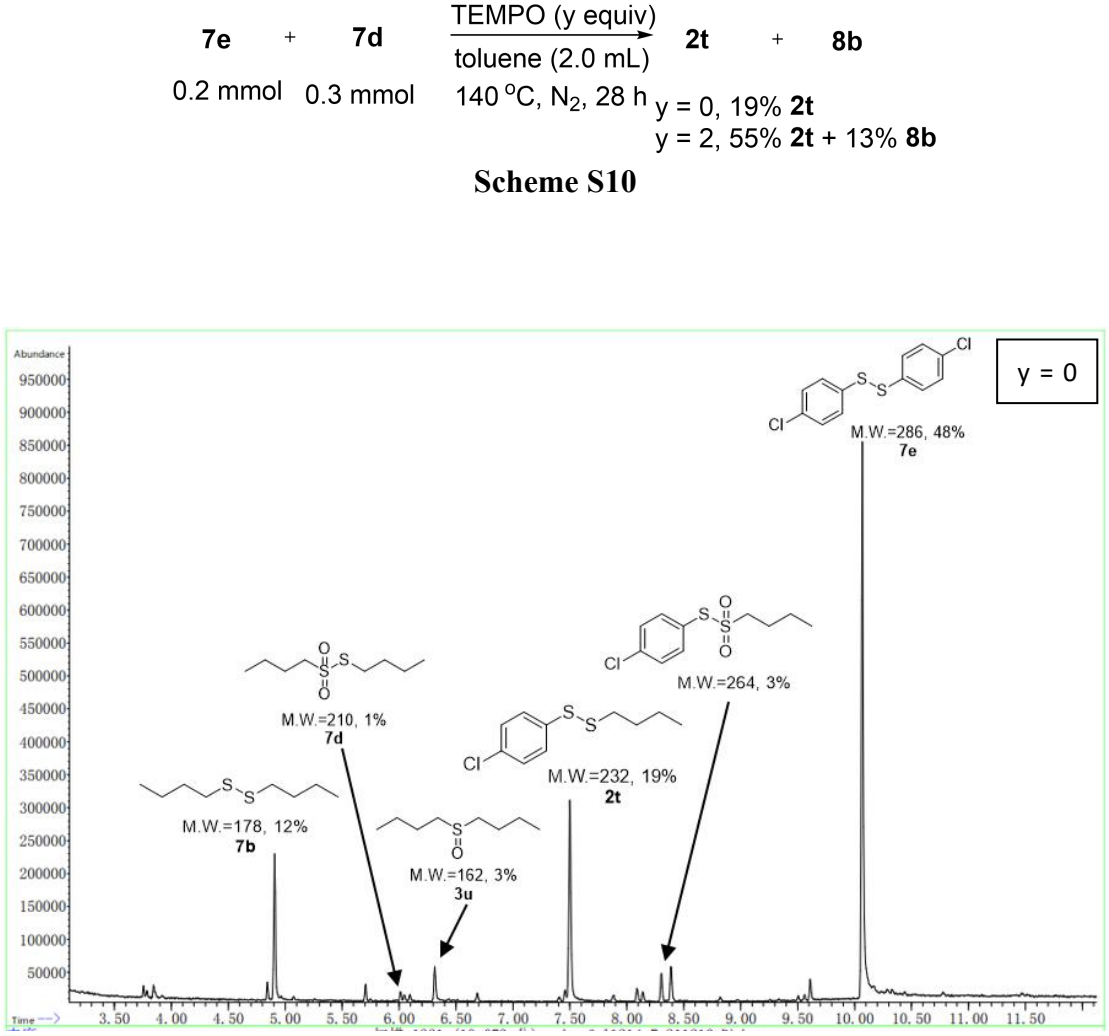

y = 0
M.W.=178, 29%
7b
M.W.=232, 25%
2t
M.W.=286, 31%
7e
Abundance
Time


y = 2
M.W.=156, 35%
M.W.=178, 27%
7b
M.W.=286, 23%
7e
Abundance
Time


1a
0.2 mmol
+
7d
0.3 mmol
TEMPO (y equiv)
toluene (2.0 mL)
140 °C, N2, 28 h
2t
+
N–O
S–n-Bu
8b
y = 0, 67% 2t
y = 2, 36% 2t + 17% 8b

Scheme S9

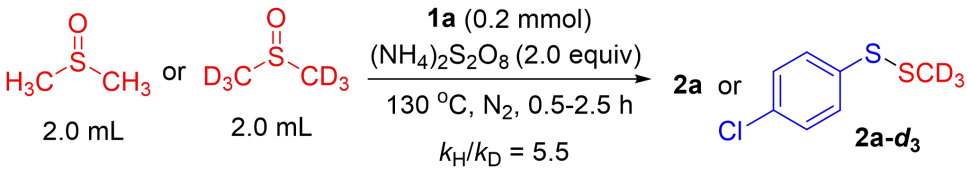

y = 0
M.W.=232, 67%
2t
M.W.=178, 9%
7b
M.W.=210, 2%
7d
M.W.=264, 2%
M.W.=286, 2%
7e
y = 2
M.W.=232, 36%
2t
M.W.=178, 14%
7b
M.W.=245, 17%
8b
M.W.=156, 2%
M.W.=200, 1%
M.W.=286, 4%
7e


7e
0.2 mmol
+
7d
0.3 mmol
TEMPO (y equiv)
toluene (2.0 mL)
140 °C, N2, 28 h
2t
+
8b
y = 0, 19% 2t
y = 2, 55% 2t + 13% 8b

Scheme S10

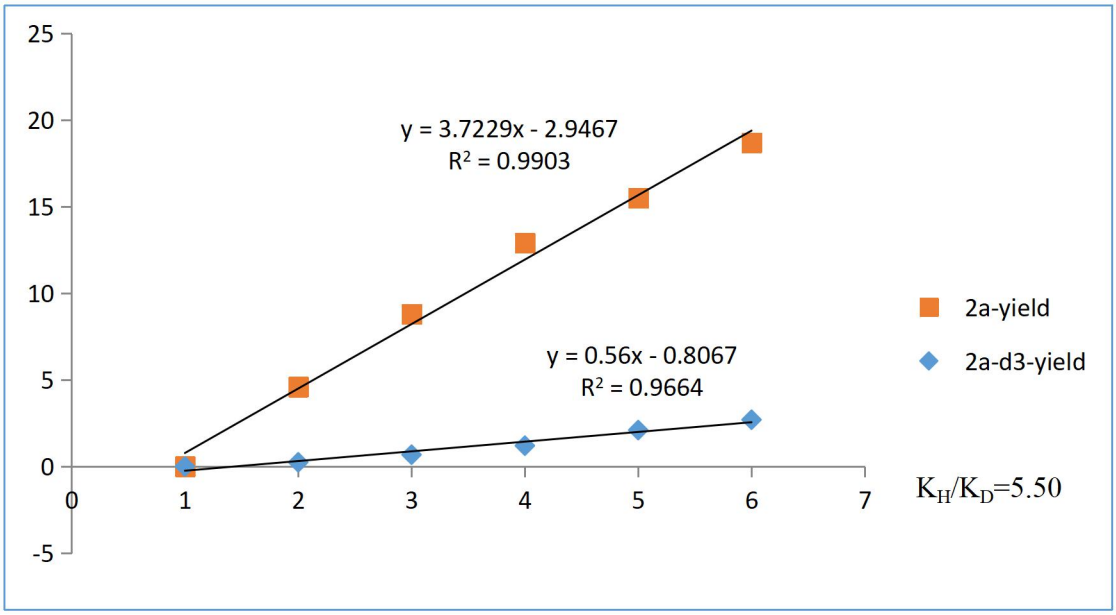
y = 0
M.W.=286, 48%
7e
M.W.=264, 3%
M.W.=210, 1%
7d
M.W.=232, 19%
2t
M.W.=178, 12%
7b
M.W.=162, 3%
3u
y = 2
M.W.=232, 55%
2t
M.W.=178, 8%
7b
M.W.=245, 13%
8b
M.W.=286, 18%
7e

5.2 Kinetic Isotope Effect Experiments

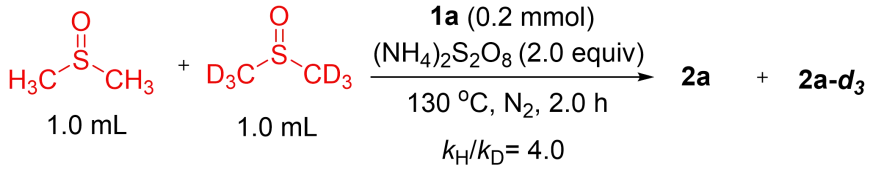


Scheme S11

Preparing five identical 20 mL-Schlenk tubes and each one equipped with a stir bar was charged with **1a** (0.2 mmol), $(NH_4)_2S_2O_8$ (0.4 mmol). Each tube was fitted with a rubber septum, then evacuated and refilled with nitrogen three times. Under nitrogen, DMSO (2 mL) was added in turn to the Schlenk tube through the rubber septum using syringes, and then the rubber septum was replaced by a Teflon screwcap under nitrogen flow. In the other five identical 25 mL-Schlenk tubes, DMSO-d_6 was used instead of DMSO. In each group, 30, 60, 90, 120 and 150 min was chosen the reaction time respectively and the corresponding yield was obtained by flash chromatography. A kinetic isotope effect value K_H/K_D = 3.7229/0.5600 = 5.5 was obtained.



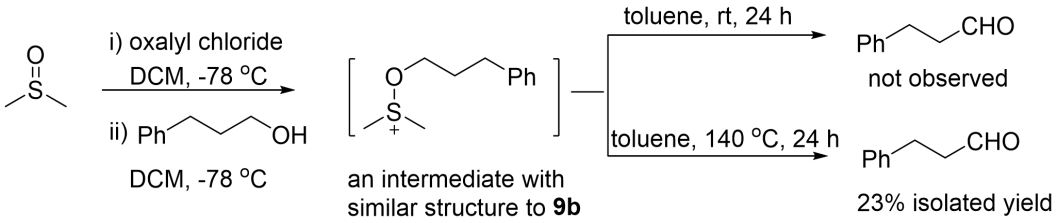
5.3 Competitive Reaction between **2a** and **2a-*d*$_3$**



Scheme S12

To a Schlenk tube were added **1a** (0.2 mmol), $(NH_4)_2S_2O_8$ (0.4 mmol), DMSO (1.0 mL) and DMSO-d_6 (1.0 mL). The mixture was stirred in a heating mantle preheated to 130 ℃ for 2 h under N_2 atmosphere. After cooled to room temperature, the reaction mixture was diluted with H_2O (10 mL), extracted with EtOAc (3×20 mL). The combined organic phase was washed with water and brine (150 mL), dried over anhydrous Na_2SO_4, and then evaporated under reduced pressure. The residue was detected by GC-MS and the ratio of **2a** to **2a-*d*$_3$** (4:1) was obtainted.

5.4 A Control Experiment for the Identification of Butoxydibutylsulfonium Salt **9b**

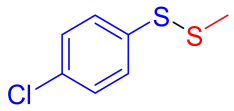


Scheme S13

For the identification of butoxydibutylsulfonium salt **9b**, a control experiment involving an intermediate with similar structure to **9b** was conducted. This intermediate was generated in-situ from swern oxidation of phenylpropanol, the general procedure for this control experiment was as followed: to a Schlenk tube were added DMSO (6.0 eq, 213*u*L) and DCM (1.0 mL). Oxalyl choride (5.0 eq, 212 *u*l) was added through a syringe at -78 ℃, and the mixture was stirred at -78 ℃ for 10 min. Then phenylpropanol (1.0 eq, 68 *u*L) was added through a syringe ,and the mixture was stirred at -78 ℃ for 1 h. After the removal of the DCM under reduced pressure followed by the addition of toluene (2 mL). When the resulting mixture was conducted at room temperature for 24 h, no formation of the desired phenylpropionaldehyde. When the resulting mixture was conducted at 140 ℃ for 24 h, 23% yield of phenylpropionaldehyde was isolated.

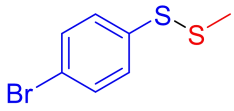
6. Characterization of Products in Details

1-(4-chlorophenyl)-2-methyldisulfane (2a)[10]



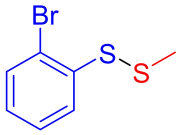
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2a** as yellow oil (36 mg, 93%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.47 (d, J = 7.1 Hz, 2H), 7.31 (d, J = 6.6 Hz, 2H), 2.44 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ135.6, 133.0, 129.2, 129.1, 22.8.

1-(4-bromophenyl)-2-methyldisulfane (2b)



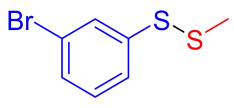
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2b** as white solid (37 mg, 78%). **M.p.** 42.4 - 47.7. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.48 - 7.42 (m, 2H), 7.42 - 7.36 (m, 2H), 2.43 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.3, 132.1, 129.2, 120.8, 22.8. **HRMS** (ESI): calculated for $C_7H_7BrS_2H$ $[M+H]^+$ 234.9245, found 234.9248.

1-(2-bromophenyl)-2-methyldisulfane (2c)



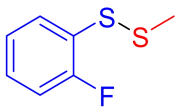
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2c** as a colorless oil (39 mg, 83%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.78 (dd, J_1=8.0 Hz, J_2=1.6 Hz, 1H), 7.52 (dd, J_1=7.9 Hz, J_2=1.3 Hz, 1H), 7.39 - 7.35 (m, 1H), 7.10 - 7.07 (m, 1H), 2.45 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.4, 133.0, 127.9, 127.5, 126.8, 121.5, 22.5. **HRMS** (ESI): calculated for $C_7H_7BrS_2H$ $[M+H]^+$ 234.9245, found 234.9250.

1-(3-bromophenyl)-2-methyldisulfane (2d)



The **General Procedure B** was followed, and hexane was used as the eluant to afford **2d** as a colorless oil (39 mg, 83%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.69 - 7.68 (m, 1H), 7.44 - 7.42 (m, 1H), 7.36 - 7.34 (m, 1H), 7.19 (t, *J* = 7.9 Hz, 1H), 2.45 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 139.4, 130.3, 129.8, 129.6, 125.7, 123.1, 22.9. **HRMS** (ESI): calculated for $C_7H_7BrS_2H$ $[M+H]^+$ 234.9245, found 234.9247.

1-(2-fluorophenyl)-2-methyldisulfane (2e)

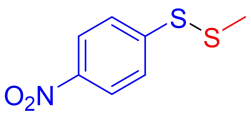


The **General Procedure B** was followed, and hexane was used as the eluant to afford **2e** as a colorless oil (20 mg, 58%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.68 - 7.64 (m, 1H), 7.25 (q, *J* = 7.1 Hz, 1H), 7.15 (t, *J* = 7.6 Hz, 1H), 7.09 - 7.02 (m, 1H), 2.46 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.6 (d, *J* = 245.5 Hz), 130.8, 129.2 (d, *J* = 7.6 Hz), 124.7 (d, *J* = 3.6 Hz), 124.1 (d, *J* = 17.5 Hz), 115.8 (d, *J* = 21.9 Hz), 23.0 (d, *J* = 4.7 Hz); **^{19}F NMR** (470 MHz, $CDCl_3$) δ -110.4 (s, 1F). **HRMS** (ESI): calculated for $C_7H_7FS_2H$ $[M+H]^+$ 175.0046, found 175.0051.

1-(2,4-difluorophenyl)-2-methyldisulfane (2f)

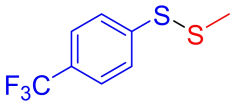
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2f** as a colorless oil (28 mg, 72%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.64 - 7.59 (m, 1H), 6.96 - 6.71 (m, 2H), 2.48 (s, 4H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 163.20 (dd, J_1 = 208.2 Hz, J_2 = 11.7 Hz), 162.16 - 160.26 (m), 133.46 (dd, J_1 = 9.5 Hz, J_2 = 2.6 Hz), 119.81 (dd, J_1 = 18.4 Hz, J_2 = 4.1 Hz), 112.00 (dd, J_1 = 21.7 Hz, J_2 = 3.7 Hz), 104.61 (t, *J* = 26.1 Hz), 23.13 (d, *J* = 3.4 Hz). **^{19}F NMR** (470 MHz, $CDCl_3$) δ -104.3 (s, 1F), -109.1 (s, 1F). **HRMS (ESI)**: calculated for $C_7H_6F_2S_2H$ $[M+H]^+$ 191.9879, found 191.9875.

1-methyl-2-(4-nitrophenyl)disulfane (2g)[11]



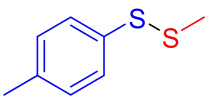
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2g** as a yellow oil (37 mg, 93%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.23 - 8.10 (m, 2H), 7.73 - 7.56 (m, 2H), 2.48 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 146.4, 146.3, 125.8, 124.1, 22.7.

1-methyl-2-(4-(trifluoromethyl)phenyl)disulfane (2h)



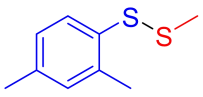
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2h** as a colorless oil (32.3 mg, 72%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.64 - 7.57 (m, 4H), 2.46 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 142.3 - 141.7 (m), 126.7 - 126.6 (m), 126.4 , 126.1 (t, J = 4.1 Hz), 125.9 (q, J = 3.8 Hz), 22.8. **^{19}F NMR** (470 MHz, $CDCl_3$) δ -62.4 (s, 3F). **HRMS** (ESI): calculated for $C_8H_7F_3S_2H$ $[M+H]^+$ 223.9941, found 223.9938.

1-methyl-2-(*p*-tolyl)disulfane (2i)[12]



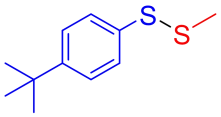
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2i** as a colorless oil (14 mg, 41%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.43 (d, J = 8.1 Hz, 2H), 7.15 (d, J = 7.9 Hz, 2H), 2.44 (s, 3H), 2.35 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.3, 133.6, 129.8, 128.7, 22.9, 21.0.

1-(2,4-dimethylphenyl)-2-methyldisulfane (2j)



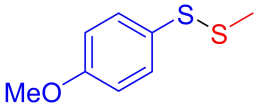
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2j** as a colorless oil (21 mg, 56%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.56 (d, J = 8.5 Hz, 1H), 7.03 (d, J = 6.3Hz, 2H), 2.42 (s, 3H), 2.41 (s, 3H), 2.32 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 138.1, 137.6, 131.9, 131.5, 129.8, 127.3, 22.6, 20.9, 20.1. **HRMS** (ESI): calculated for $C_9H_{12}S_2H$ $[M+H]^+$ 184.0380, found 184.0390.

1-(4-(tert-butyl)phenyl)-2-methyldisulfane (2k)



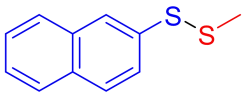
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2k** as a colorless oi (28 mg, 65%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.49 - 7.42 (m, 2H), 7.38 - 7.30 (m, 2H), 2.45 (s, 3H), 1.31 (s, 9H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 150.5, 133.6, 128.2, 126.1, 34.6, 31.3, 23.0. **HRMS** (ESI): calculated for $C_{11}H_{16}S_2H$ $[M+H]^+$ 212.0693, found 212.0688.

1-(4-methoxyphenyl)-2-methyldisulfane (2l)[13]



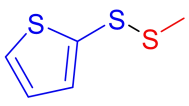
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2l** as a yellow oil (14 mg, 38%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.48 (d, J = 8.6 Hz, 2H), 6.87 (d, J = 8.3 Hz, 2H), 3.81 (s, 3H), 2.43 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.6, 132.0, 127.7, 114.6, 55.3, 55.3, 22.8.

1-methyl-2-(naphthalen-2-yl)disulfane (2m)[13]



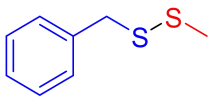
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2m** as a yellow solid (34 mg, 82%). **M.p.** 52.5 - 53.5. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.85 - 7.77 (m, 4H), 7.65 - 7.60 (m, 1H), 7.54 - 7.38 (m, 3H), 2.49 (s, 1H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.2, 133.6, 132.4, 128.9, 127.8, 127.4, 126.7, 126.3, 126.1, 125.8, 22.9.

2-(methyldisulfaneyl)thiophene (2n)[13]



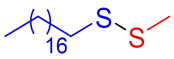
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2n** as a yellow oil (15 mg, 46%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.4 (d, J = 5.3 Hz, 1H), 7.3 - 7.2 (m, 1H), 7.0 (dd, J_1 = 5.4, J_1 = 3.2 Hz, 1H), 2.5 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.4, 134.2, 130.9, 127.7, 23.2.

1-benzyl-2-methyldisulfane (2o)[13]



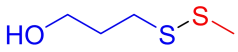
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2o** as a yellow oil (13 mg, 38%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.34 - 7.26 (m, 5H), 3.88 (s, 2H), 2.08 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.6, 129.4, 128.6, 127.5, 43.0, 23.1.

1-methyl-2-octadecyldisulfane (2p)



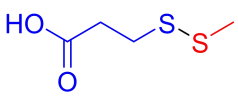
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2p** as a white soild (38 mg, 57%). **M.p**. 63.2 - 65.6. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.68 (t, *J* = 7.3, 2H), 1.70 - 1.56 (m, 2H), 1.56 (s, 3H), 1.38 (t, *J* = 7.4 Hz, 2H), 1.26 (s, 28H), 0.88 (t, *J* = 6.7 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 39.2, 31.9, 29.7, 29.7, 29.6, 29.5, 29.4, 29.3, 28.5, 22.7, 14.1. **HRMS** (ESI): calculated for $C_{19}H_{40}S_2H$ $[M+H]^+$ 332.2571, found 332.2575.

3-(methyldisulfaneyl)propan-1-ol (2q)[14]



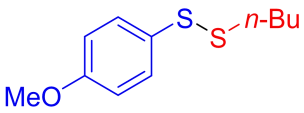
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2q** as a colorless oil (12 mg, 45%). **^{1}H NMR** δ 3.76 (t, *J* = 6.2 Hz, 2H), 2.82 (t, *J* = 7.1 Hz, 2H), 2.42 (d, *J* = 2.2 Hz, 3H), 2.17 (s, 1H), 1.97 (qui, *J* = 6.6 Hz, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 60.9, 34.4, 31.8, 23.1.

3-(methyldisulfaneyl)propanoic acid (2r)[15]



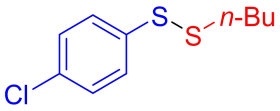
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2r** as a colorless oil (24 mg, 78%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 11.21 (s, 1H), 2.93 (t, *J* = 7.2 Hz, 2H), 2.82 (t, *J* = 7.1 Hz, 2H), 2.41 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.4, 34.0, 31.9, 23.2.

1-butyl-2-(4-methoxyphenyl)disulfane (2s)[15]



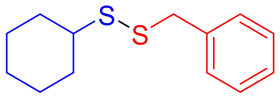
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2s** as a yellow oil (32 mg, 71%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.5 - 7.4 (m, 2H), 6.9 - 6.8 (m, 2H), 3.8 (s, 3H), 2.7 (t, J = 7.4 Hz, 2H), 1.68 -1.60 (m, 2H), 1.4 (q, J = 7.5 Hz, 2H), 0.9 (t, J = 7.5 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.5, 131.6, 128.5, 114.6, 55.4, 38.5, 30.8, 21.7, 13.7.

1-butyl-2-(4-chlorophenyl)disulfane (2t)[16]



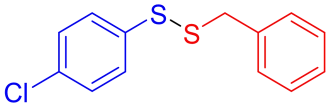
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2t** as a yellow oil (30 mg, 65%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42 - 7.38 (m, , 2H), 7.30 – 7.26 (m, 2H), 2.70 (q, J = 7.2 Hz, 2H), 1.66 (m, J = 7.6 Hz, 2H), 1.42 (m, J = 7.3 Hz, 2H), 0.93 (q, J = 7.4 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 135.1, 133.6, 129.3, 129.0, 38.9, 31.3, 21.7, 13.7.

1-benzyl-2-cyclohexyldisulfane (2u)[17]



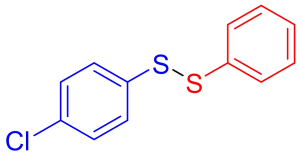
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2u** as a yellow oil (40 mg, 83%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 - 7.25 (m, 4H), 7.23 (m, 1H), 3.85 (s, 2H), 2.35 (tt, J = 10.9, 3.8 Hz, 1H), 1.90 (d, J = 12.4 Hz, 2H), 1.70 (dd, J_1 = 9.7, J_2 = 5.1 Hz, 2H), 1.28 - 1.12 (m, 5H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.7, 129.3, 128.5, 127.4, 49.3, 44.7, 32.8, 26.1, 25.7.

1-benzyl-2-(4-chlorophenyl)disulfane (2v)[18]



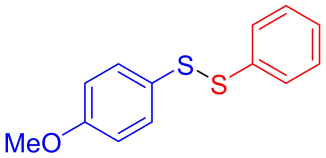
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2v** as a yellow oil (43 mg, 80%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.31 - 7.28 (m, 2H), 7.25 - 7.16 (m, 7H), 3.90 (s, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.4, 132.8, 129.4, 129.1, 129.0, 128.6, 127.6, 43.5.

1-(4-chlorophenyl)-2-phenyldisulfane (2w)[19]



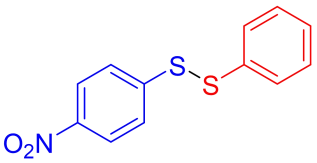
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2w** as a yellow oil (32 mg, 80%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.46 (d, *J* = 7.8 Hz, 2H), 7.40 (d, *J* = 8.3 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 2H), 7.24 (t, *J* = 7.1 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.6, 135.6, 133.3, 129.2, 129.2, 129.0, 127.8, 127.5.

1-(4-methoxyphenyl)-2-phenyldisulfane (2x)[8]



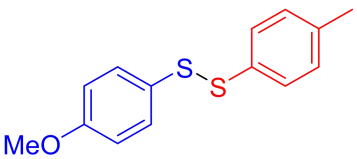
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2w** as a yellow oil (21 mg, 43%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ7.4 (dd, J_1 = 11.1 Hz, J_2 = 8.4 Hz, 4H), 7.3 (d, *J* = 8.3 Hz, 2H), 6.8 (d, *J* = 8.4 Hz, 2H), 3.8 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.1, 136.1, 133.4, 132.2, 129.8, 129.2, 127.6, 114.8, 55.4.

1-(4-nitrophenyl)-2-phenyldisulfane (2y)[24]



The **General Procedure B** was followed, and hexane was used as the eluant to afford **2y** as a yellow oil (33 mg, 62%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.2 - 8.1 (m, 2H), 7.7 - 7.6 (m, 2H), 7.5 - 7.4 (m, 2H), 7.3 (t, *J* = 7.6 Hz, 2H), 7.3 - 7.2 (m, 1H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 146.5, 146.2, 135.3, 129.4, 128.0, 127.8, 126.2, 124.2.

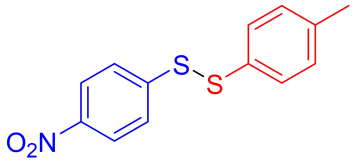
1-(4-methoxyphenyl)-2-(*p*-tolyl)disulfane (2z)[21]



The **General Procedure B** was followed, and hexane was used as the eluant to afford **2z** as a yellow soild (27 mg, 52%). **M.p.** 43.2 - 45.3. **^{1}H NMR** (500 MHz, $CDCl_3$) δ

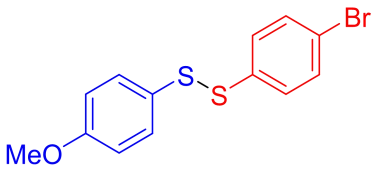
7.44 - 7.36 (m, 4H), 7.12 (d, J = 7.7 Hz, 2H), 6.87 - 6.77 (m, 2H), 3.79 (s, 3H), 2.33 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 159.8, 137.6, 134.1, 131.9, 129.8, 129.1, 128.31 , 114.7, 55.4, 21.1.

1-(4-nitrophenyl)-2-(p-tolyl)disulfane (2aa)[22]



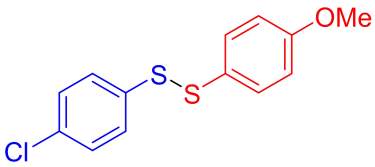
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2aa** as a yellow soild (28 mg, 50%). **M.p.** 63.0 -63.5. **^{1}H NMR** (400 MHz, CDCl3) δ 8.20 - 8.12 (m, 2H), 7.69 - 7.61 (m, 2H), 7.37 (d, J = 7.8 Hz, 2H), 7.13 (d, J = 7.8 Hz, 2H), 2.32 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 146.5, 146.4, 138.5, 131.9, 130.2, 128.7, 126.2, 124.1, 21.1.

1-(4-bromophenyl)-2-(4-methoxyphenyl)disulfane (2bb)[20]



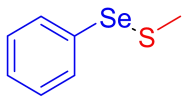
The **General Procedure B** was followed, and hexane was used as the eluant to afford **2x** as a yellow oil (20 mg, 31%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.46 - 7.32 (m, 6H), 6.83 (d, J = 8.4 Hz, 2H), 3.79 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.0, 136.7, 132.1, 132.1, 129.9, 127.5, 121.3, 114.8, 55.4.

1-(4-chlorophenyl)-2-(4-methoxyphenyl)disulfane (2cc)[6]



The **General Procedure B** was followed, and hexane was used as the eluant to afford **2cc** as a yellow oil (40 mg, 71%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.4 (dd, J_1 = 11.1 Hz, J_2 = 8.4 Hz, 4H), 7.3 (d, J = 8.3 Hz, 2H), 6.8 (d, J = 8.4 Hz, 2H), 3.8 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.1, 136.1, 133.4, 132.2, 129.8, 129.2, 127.6, 114.8, 55.4.

methyl(phenylselanyl)sulfane (5a)[23]

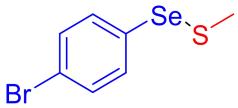


The **General Procedure C** was followed, and hexane was used as the eluant to afford **5a** as a yellow oil (29 mg, 72%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.65 - 7.58 (m, 2H), 7.31 (m, 2H), 7.26 (m, 1H), 2.61 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 131.7, 130.2, 129.2, 127.5, 22.3.

((2-chlorophenyl)selanyl)(methyl)sulfane (5b)

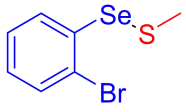
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5b** as a yellow oil (41 mg, 86%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.84 - 7.82 (m, 1H), 7.34 - 7.29 (m, 2H), 7.21 - 7.18 (m 1H), 2.60 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) 132.8, 131.1, 129.5, 128.1, 127.8, 127.6, 22.0. **HRMS** (ESI): calculated for $C_7H_7ClSSeH$ $[M+H]^+$ 238.9195, found 238.9199.

((4-bromophenyl)selanyl)(methyl)sulfane (5c)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5c** as a yellow oil (36 mg, 63%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.50 - 7.48 (m, 2H), 7.46 - 7.42 (m, 2H), 2.61 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 132.2, 131.7, 130.6, 121.6, 22.3. **HRMS** (ESI): calculated for $C_7H_7BrSSeH$ $[M+H]^+$ 282.8690, found 282.8698.

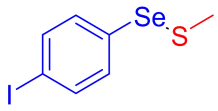
((2-bromophenyl)selanyl)(methyl)sulfane (5d)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5d** as a yellow oil (37 mg, 65%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.81 (d, J = 7.9 Hz, 1H), 7.48 (d, J = 7.9 Hz, 1H), 7.35 (t, J = 7.6 Hz, 1H), 7.11 (t, J = 7.6 Hz, 1H), 2.61 (s,

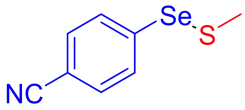
3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 132.2, 131.7, 130.6, 121.6, 22.3. **HRMS** (ESI): calculated for $C_7H_7BrSSeH$ $[M+H]^+$ 282.8690, found 282.8698.

((4-iodophenyl)selanyl)(methyl)sulfane (5e)



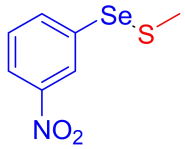
The **General Procedure C** was followed, and hexane was used as the eluant to afford, **5e** as a yellow oil (53 mg, 81%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.55 (d, J = 8.5 Hz, 2H), 7.14 (d, J = 8.3 Hz, 2H), 2.34 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.9, 132.1, 131.8, 91.0, 7.3. **HRMS** (ESI): calculated for C_7H_7ISSeH $[M+H]^+$ 330.8551, found 330.8560.

4-((methylthio)selanyl)benzonitrile (5f)



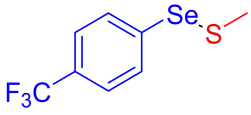
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5f** as a yellow oil (28 mg, 62%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.71 (dd, J_1 = 8.4, J_2= 1.6 Hz, 2H), 7.64 - 7.54 (m, 2H), 2.63 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) 138.9, 132.5, 128.8, 118.5, 110.5, 22.3. **HRMS** (ESI): calculated for C_8H_7NSSeH $[M+H]^+$ 229.9537, found 229.9544.

methyl((3-nitrophenyl)selanyl)sulfane (5g)



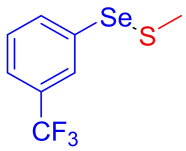
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5g** as a yellow oil (38 mg, 76%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.48 (d, J = 1.9 Hz, 1H), 8.11 - 8.09 (m, 1H), 7.93 - 7.91 (m, 1H), 7.50 (t, J = 8.0 Hz, 1H), 2.66 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 148.8, 134.8, 134.1, 129.8, 123.8, 122.1, 22.5. **HRMS** (ESI): calculated for $C_7H_8NO_2SSeH$ $[M+H]^+$ 249.9435, found 249.9428.

methyl((4-(trifluoromethyl)phenyl)selanyl)sulfane (5h)



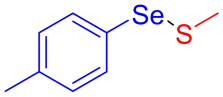
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5h** as a yellow oil (46 mg, 85%). **^{1}H NMR** (500 MHz, $CDCl_3$), δ 7.73 (d, *J* = 8.1 Hz, 2H), 7.57 (d, *J* = 8.1 Hz, 2H), 2.63 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 136.7, 129.0, 126.1, 126.0, 125.9 (q, *J* = 12.5 Hz), 125.9, 22.3. **^{19}F NMR** (470 MHz, $CDCl_3$) δ -62.5 (s, 3F). **HRMS** (ESI): calculated for $C_8H_7F_3SSeH$ $[M+H]^+$ 272.9459, found 272.9455.

methyl((3-(trifluoromethyl)phenyl)selanyl)sulfane (5i)



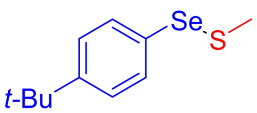
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5i** as a yellow oil (33 mg, 61 %). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.88 (s, 1H), 7.80 (d, *J* = 7.8 Hz, 1H), 7.52 (d, *J* = 7.8 Hz, 1H), 7.44 (t, *J* = 7.8 Hz, 1H), 2.63 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 132.9, 132.7, 131.6 (q, *J* = 37.5 Hz), 129.5, 126.1 (q, *J* = 4.0 Hz), 124.1 (q, *J* = 3.7 Hz), 123.8 (q, J = 275 Hz), 22.4. **^{19}F NMR** (470 MHz, $CDCl_3$) δ -62.7 (s, 3F). **HRMS** (ESI): calculated for $C_8H_7F_3SSeH$ $[M+H]^+$ 272.9459, found 272.9455.

methyl(*p*-tolylselanyl)sulfane (5j)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5j** as a yellow oil (29 mg, 66%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.52 (d, *J* = 8.0 Hz, 2H), 7.13 (d, *J* = 7.9 Hz, 2H), 2.59 (s, 3H), 2.34 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 137.8, 131.1, 130.0, 128.2, 22.3, 21.1. **HRMS** (ESI): calculated for $C_8H_{10}SSeH$ $[M+H]^+$ 218.9741, found 218.9738.

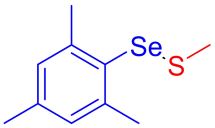
((4-(*tert*-butyl)phenyl)selanyl)(methyl)sulfane (5k)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5k** as a yellow oil (42 mg, 81%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.2 Hz,

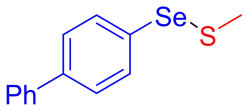
2H), 7.35 (d, J = 8.2 Hz, 2H), 2.62 (s, 3H), 1.32 (s, 9H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 151.0, 130.6, 128.3, 126.3, 34.6, 31.3, 22.4. **HRMS** (ESI): calculated for $C_{11}H_{16}SSeH$ $[M+H]^+$ 261.0211, found 2610207.

(mesitylselanyl)(methyl)sulfane (5l)



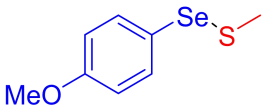
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5l** as a yellow oil (24 mg, 48%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 6.97 - 6.95 (m, 2H), 2.58 (s, 9H), 2.29 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 142.9, 139.3, 129.8, 128.8, 24.4, 21.9, 21.0. **HRMS** (ESI): calculated for $C_{10}H_{15}SSeH$ $[M+H]^+$ 247.0054, found 247.0061.

([1,1'-biphenyl]-4-ylselanyl)(methyl)sulfane (5m)



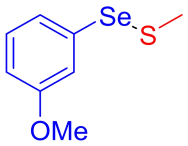
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5m** as a yellow oil (29 mg, 51%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.68 (d, J = 8.3 Hz, 2H), 7.59 - 7.51 (m, 4H), 7.42 (dd, J_1 = 8.4, J_2 = 6.9 Hz, 2H), 7.37 - 7.31 (m, 1H), 2.63 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 140.7, 140.4, 130.8, 130.8, 128.9, 128.0, 127.6, 127.1, 22.4. **HRMS** (ESI): calculated for $C_{13}H_{12}SSeH$ $[M+H]^+$ 280.9898, found 280.9891.

((4-methoxyphenyl)selanyl)(methyl)sulfane (5n)



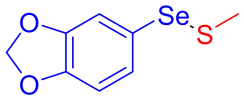
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5n** as a yellow oil (16 mg, 35%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.58 (d, J = 8.8 Hz, 2H), 6.87 (d, J = 8.7 Hz, 2H), 3.81 (s, 3H), 2.61 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.0, 134.1, 122.2, 114.9, 55.4, 22.2. **HRMS** (ESI): calculated for $C_8H_{10}OSSeH$ $[M+H]^+$ 234.9690, found 234.9696.

((3-methoxyphenyl)selanyl)(methyl)sulfane (5o)



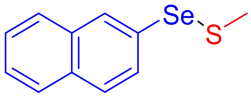
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5o** as a yellow oil (24 mg, 52%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.26 - 7.15 (m, 3H), 6.81 - 6.79 (m, 1H), 3.82 (s, 3H), 2.61 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.2, 132.8, 129.9, 122.0, 115.1, 113.3, 55.3, 22.4. **HRMS** (ESI): calculated for $C_8H_{10}OSSeH$ $[M+H]^+$ 234.9690, found 234.9696.

5-((methylthio)selanyl)benzo[*d*][1,3]dioxole (5p)



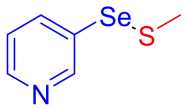
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5p** as a yellow oil (26 mg, 53%). **^{1}H NMR** (500 MHz, $CDCl_3$) 7.16 (d, J = 1.7 Hz, 1H), 7.11 (dd, J_1 = 8.0, J_2 = 1.7 Hz, 1H), 6.76 (d, J = 8.0 Hz, 1H), 5.98 (s, 2H), 2.61 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 148.3, 148.1, 125.9, 123.4, 112.6, 108.9, 101.3, 22.2. **HRMS** (ESI): calculated for $C_8H_8O_2SSeH$ $[M+H]^+$ 248.9483, found 248.9488.

methyl(naphthalen-2-ylselanyl)sulfane (5q)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5q** as a yellow soild (29 mg, 57%). **M.p**. 52.5 - 54.6. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.28 (d, J = 8.3 Hz, 1H), 8.05 (dd, J_1 = 7.1Hz, J_2 = 1.3 Hz, 1H), 7.89 - 7.82 (m, 2H), 7.62 - 7.52 (m, 2H), 7.48 - 7.43 (m, 1H), 2.62 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 134.2, 130.5, 130.1, 129.0, 128.7, 126.7, 126.3, 125.8, 22.1. **HRMS** (ESI): calculated for $C_{11}H_{11}SSeH$ $[M+H]^+$ 254.9741, found 254.9735.

3-((methylthio)selanyl)pyridine (5r)



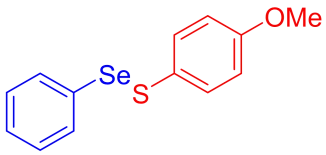
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5r** as a yellow oil (23 mg, 51%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.81 (s, 1H), 8.52 (s,

1H), 7.99 - 7.96 (m, 1H), 7.28 (s, 1H), 2.63 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 151.0, 148.6, 138.3, 124.3, 22.4. **HRMS** (ESI): calculated for C_6H_7NSSeH $[M+H]^+$ 205.9537, found 205.9545.

butyl(phenylselanyl)sulfane (5s)[15]

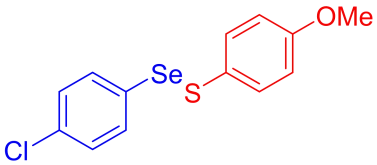
The **General Procedure C** was followed, and hexane was used as the eluant to afford **5s** as a yellow oil (60 mg, 61%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.6 (d, J = 7.6 Hz, 2H), 7.3 (t, J = 7.5 Hz, 3H), 2.8 (t, J = 7.4 Hz, 2H), 1.6 (q, J = 7.4 Hz, 2H), 1.4 (p, J = 7.4 Hz, 2H), 0.9 (t, J = 7.4 Hz, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 132.4, 130.9, 129.9, 129.1, 127.2, 38.0, 32.3, 21.6, 13.6.

(4-methoxyphenyl)(phenylselanyl)sulfane (5u)[25]



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5u** as a yellow oil (77 mg, 65%; 41 mg, 35%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.7 - 7.5 (m, 2H), 7.4 (dd, J_1 = 10.6Hz , J_2 = 8.6 Hz, 2H), 7.3 - 7.2 (m, 3H), 6.9 - 6.8 (m, 2H), 3.8 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.3, 133.9, 133.0, 131.9, 131.3, 129.6, 128.8, 115.0, 55.7.

((4-chlorophenyl)selanyl)(4-methoxyphenyl)sulfane (5v)



The **General Procedure C** was followed, and hexane was used as the eluant to afford **5v** as a yellow oil (91 mg, 69%; 62 mg, 47%). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.5 (d, J = 8.4 Hz, 2H), 7.4 - 7.4 (m, 2H), 7.3 (d, J = 8.4 Hz, 2H), 6.8 (d, J = 8.7 Hz, 2H), 3.8 (s, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 160.2, 134.1, 133.8, 132.5, 131.0, 129.3, 127.5, 114.7, 55.4. **HRMS** (ESI): calculated for $C_{13}H_{11}ClOSSeH$ $[M+H]^+$ 329.9384, found 329.9388.

7. Reference:

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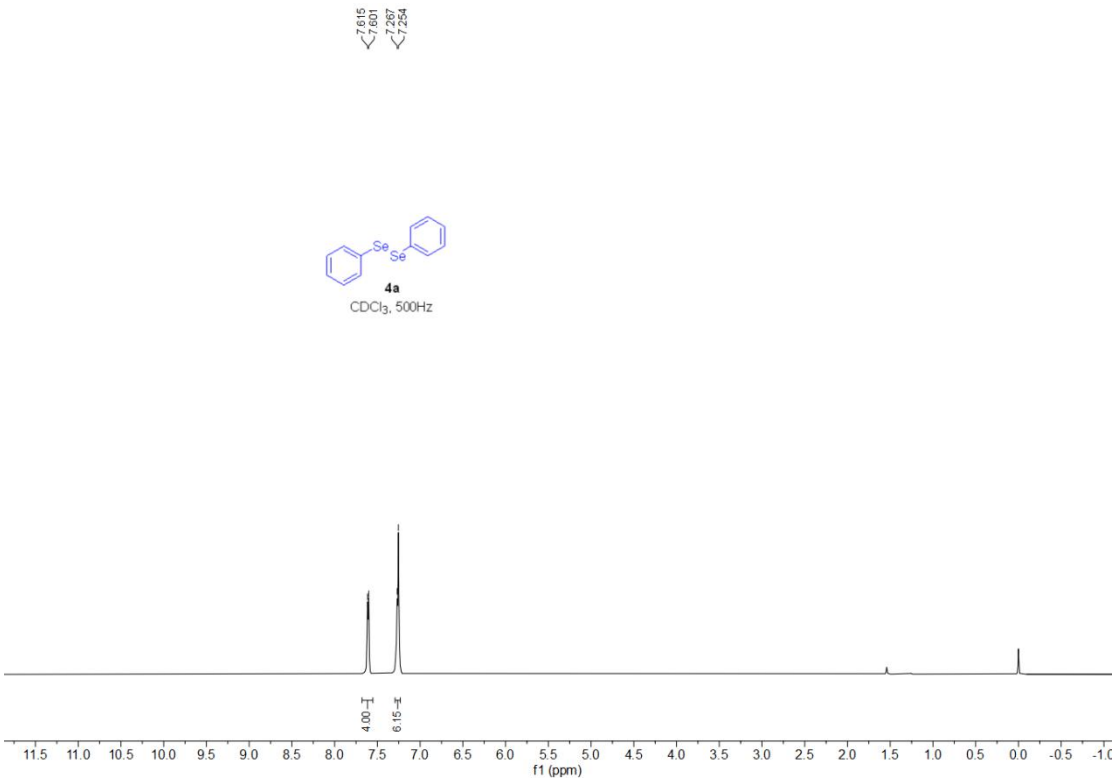
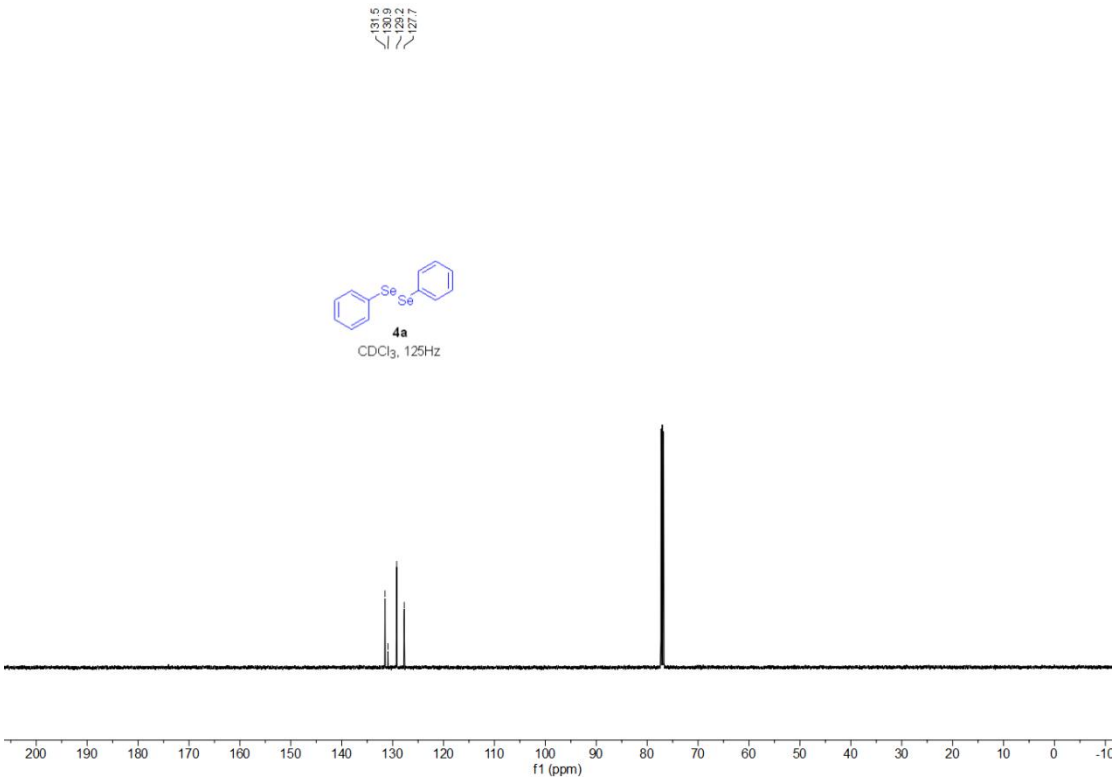
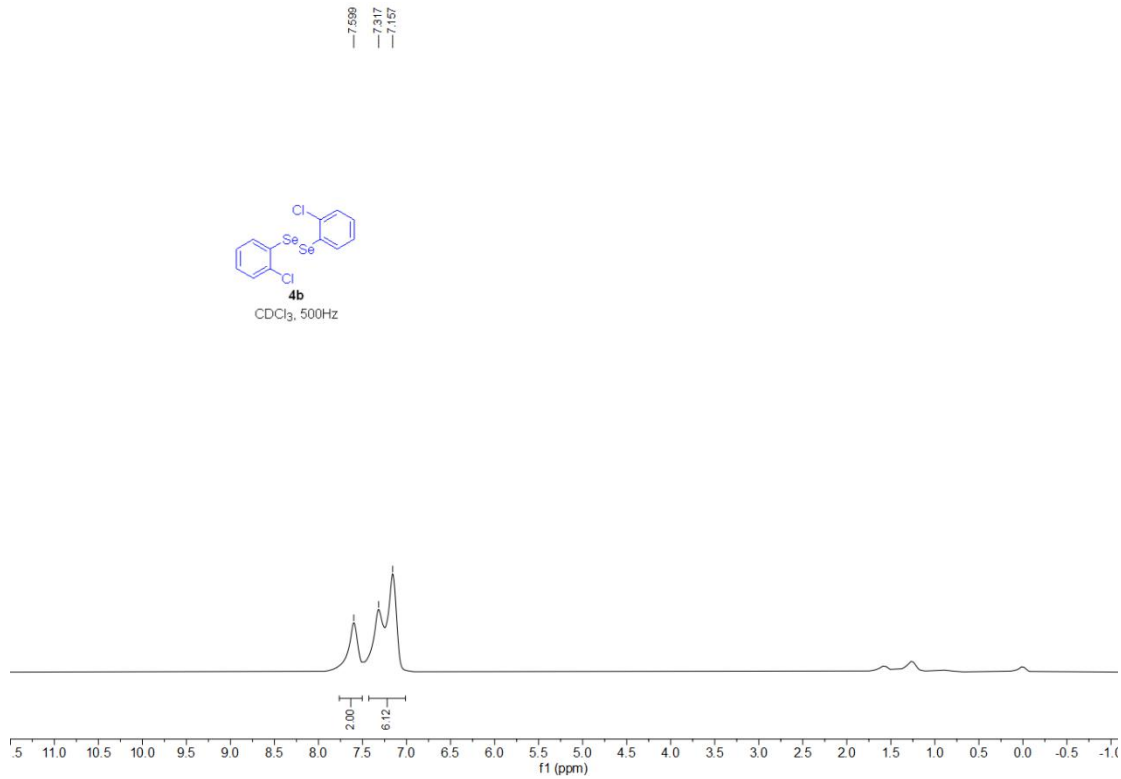
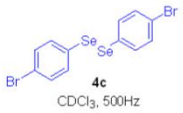
8. ^{1}H, ^{13}C and ^{19}F NMR Spectra of Products



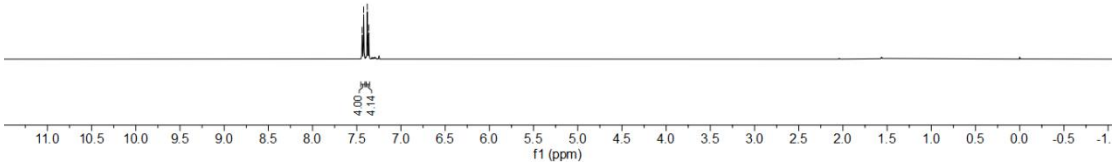


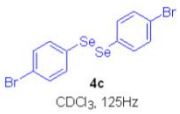

7.599
7.317
7.157
Cl
Se
Se
Cl
4b
CDCl3, 500Hz
2.00
6.12
f1 (ppm)
133.3
130.7
129.3
129.2
128.4
127.9
Cl
Se
Se
Cl
4b
CDCl3, 125Hz
f1 (ppm)



4c

$CDCl_3$, 500Hz





4c

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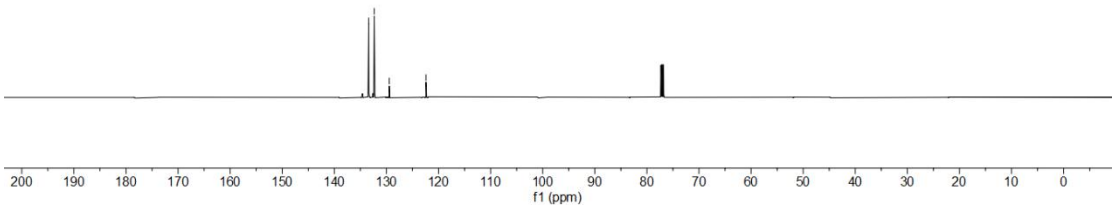
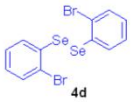
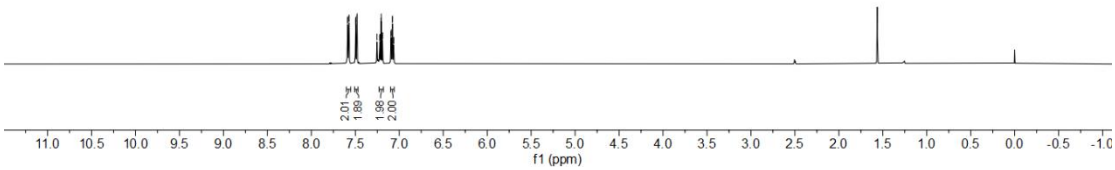
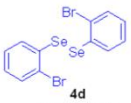




4d

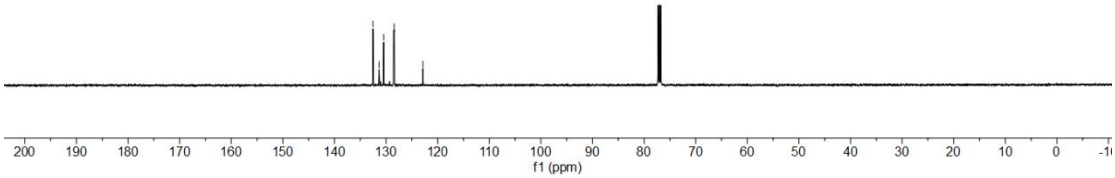
$CDCl_3$, 500Hz

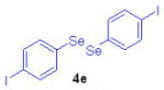




4d

$CDCl_3$, 125Hz





4e

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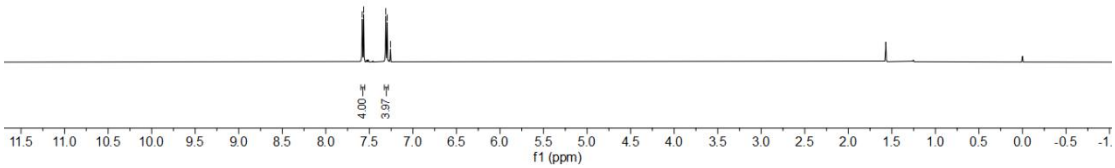
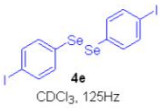
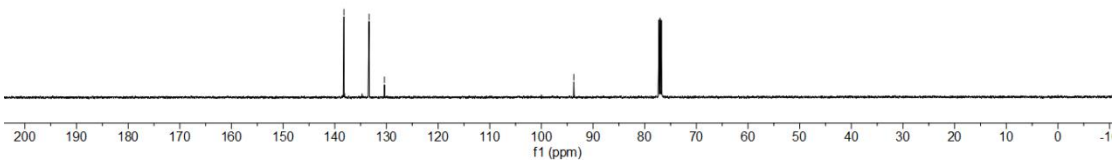
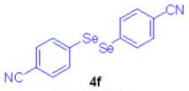




4e

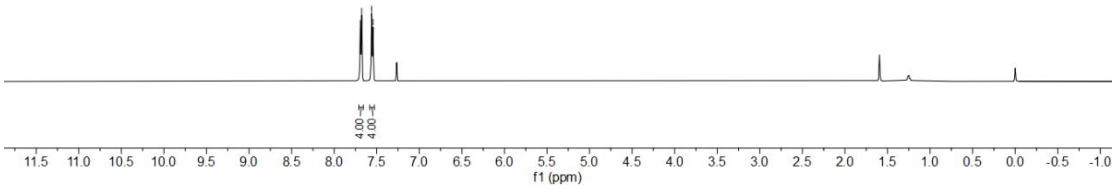
$CDCl_3$, 125Hz

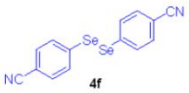




4f

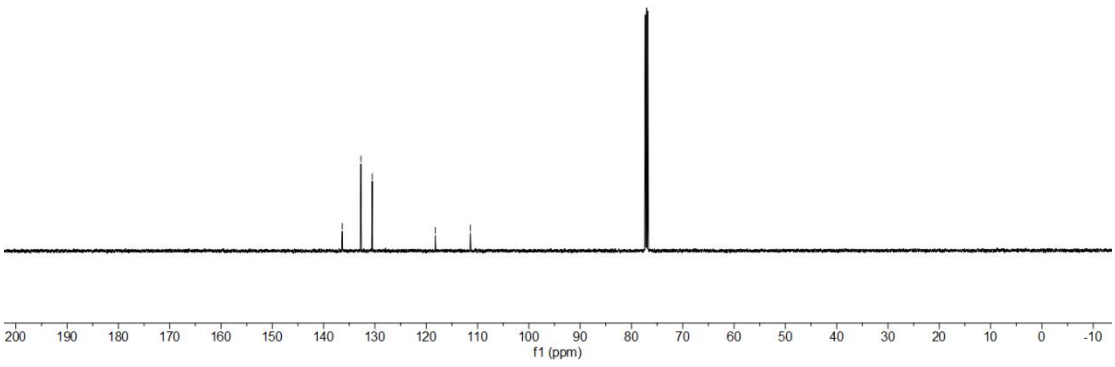
$CDCl_3$, 500Hz

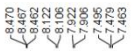




4f

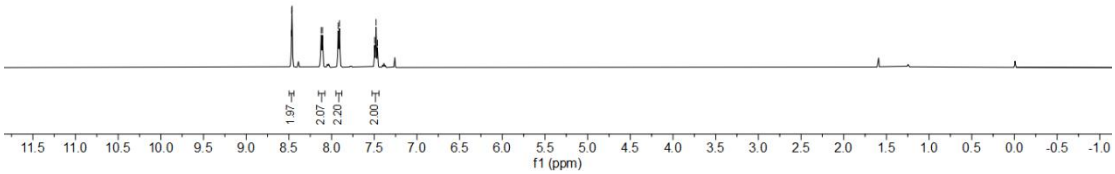
$CDCl_3$, 125Hz

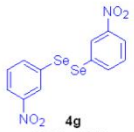




4g

$CDCl_3$, 500Hz





4g

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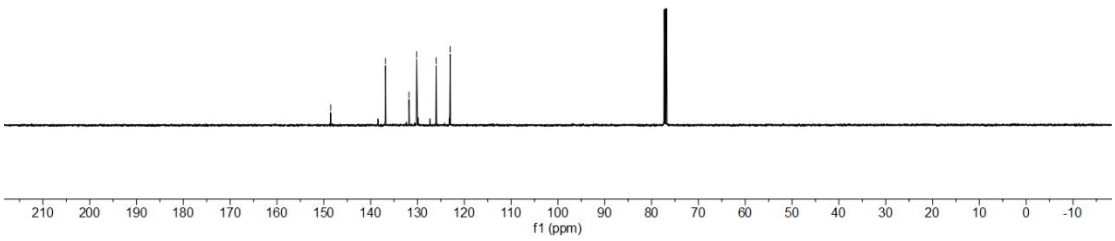
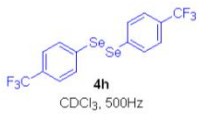
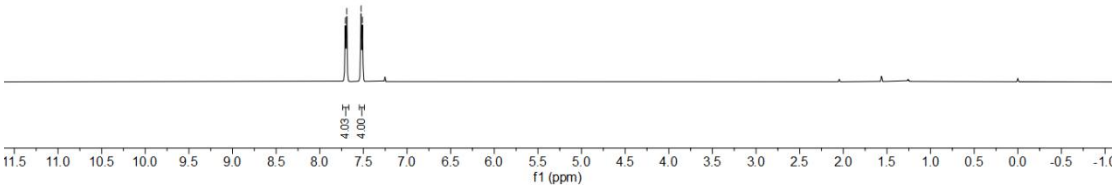
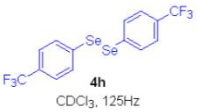




4h

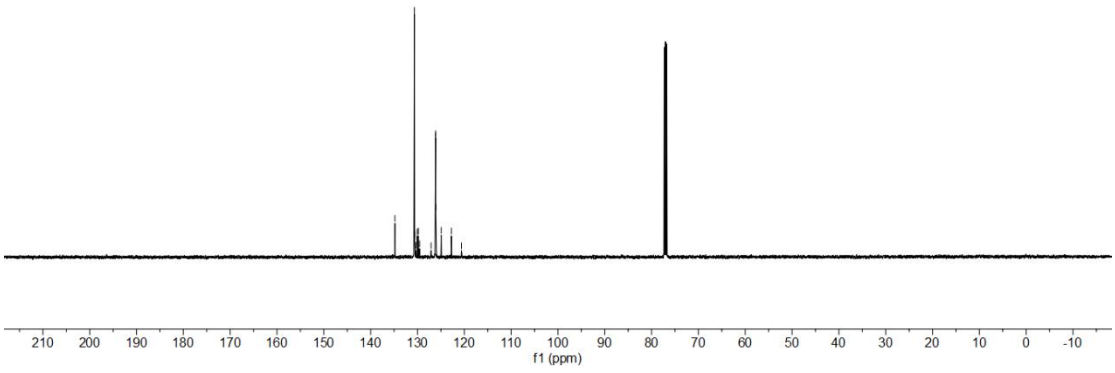
$CDCl_3$, 500Hz

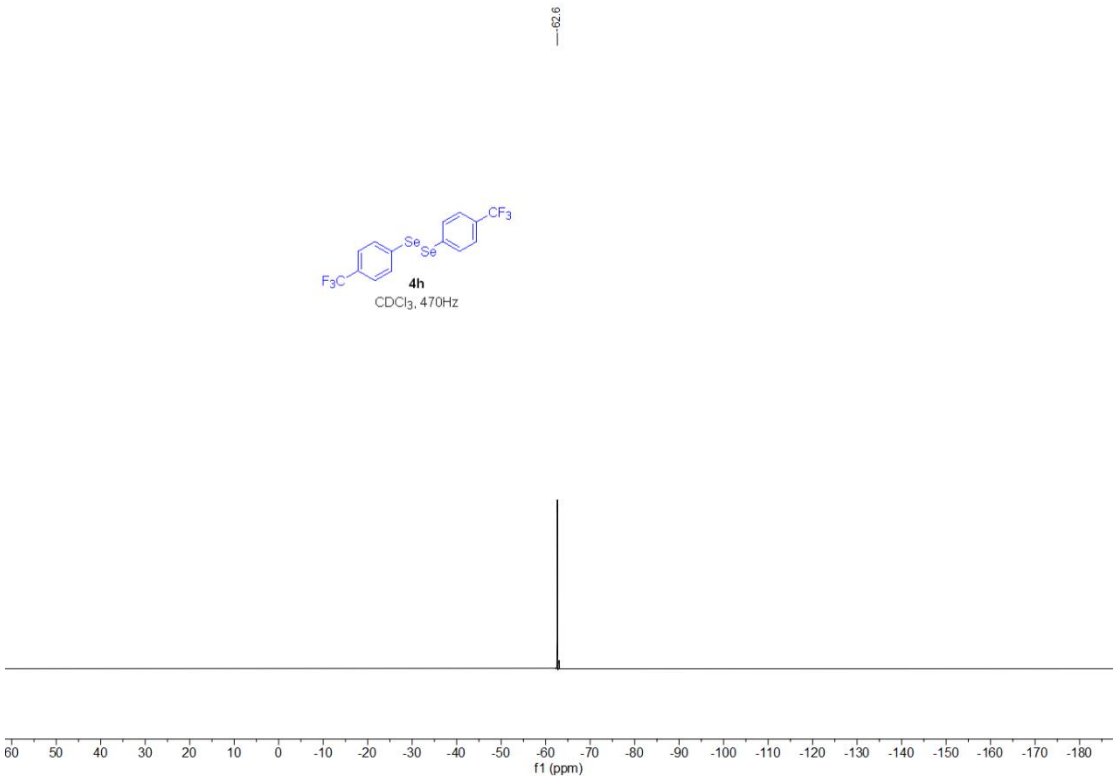


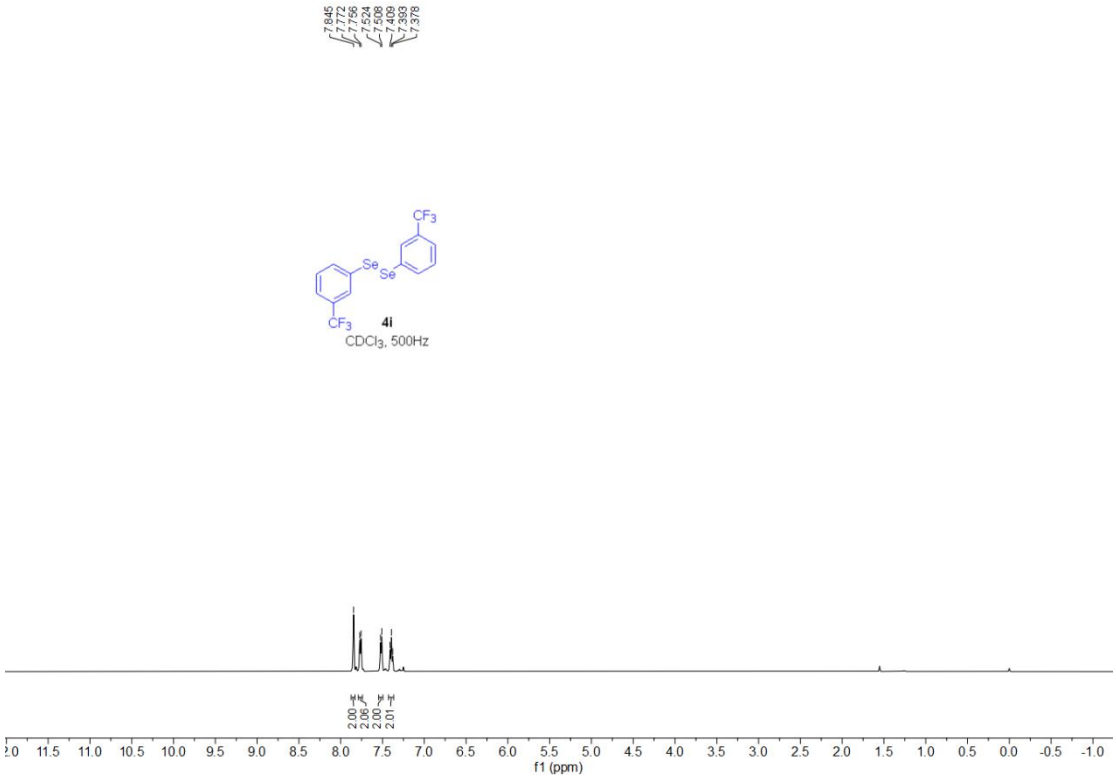


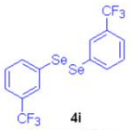
4h

$CDCl_3$, 125Hz



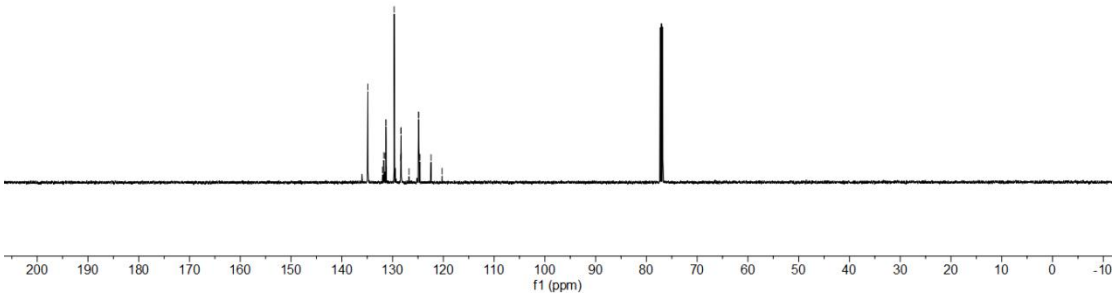

-62.6
4h
CDCl3, 470Hz
f1 (ppm)

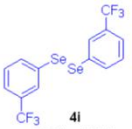

7.845
7.772
7.755
7.524
7.508
7.409
7.393
7.378
4i
CDCl3, 500Hz
2.00
2.06
2.00
2.01
f1 (ppm)



4i

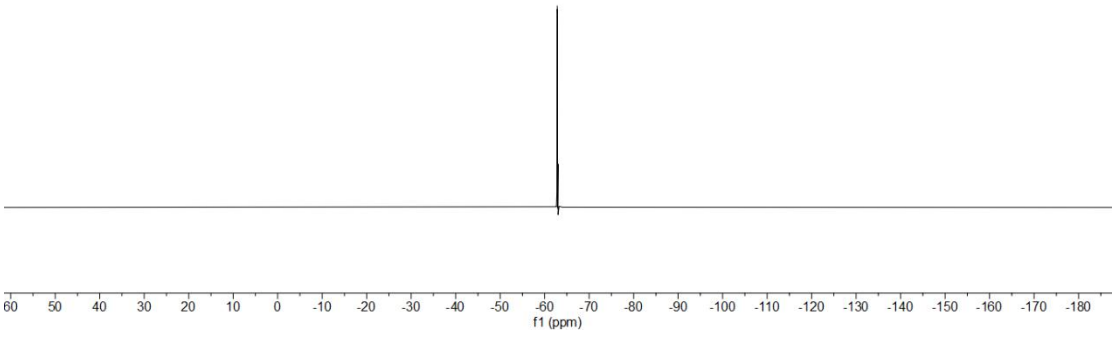
$CDCl_3$, 125Hz

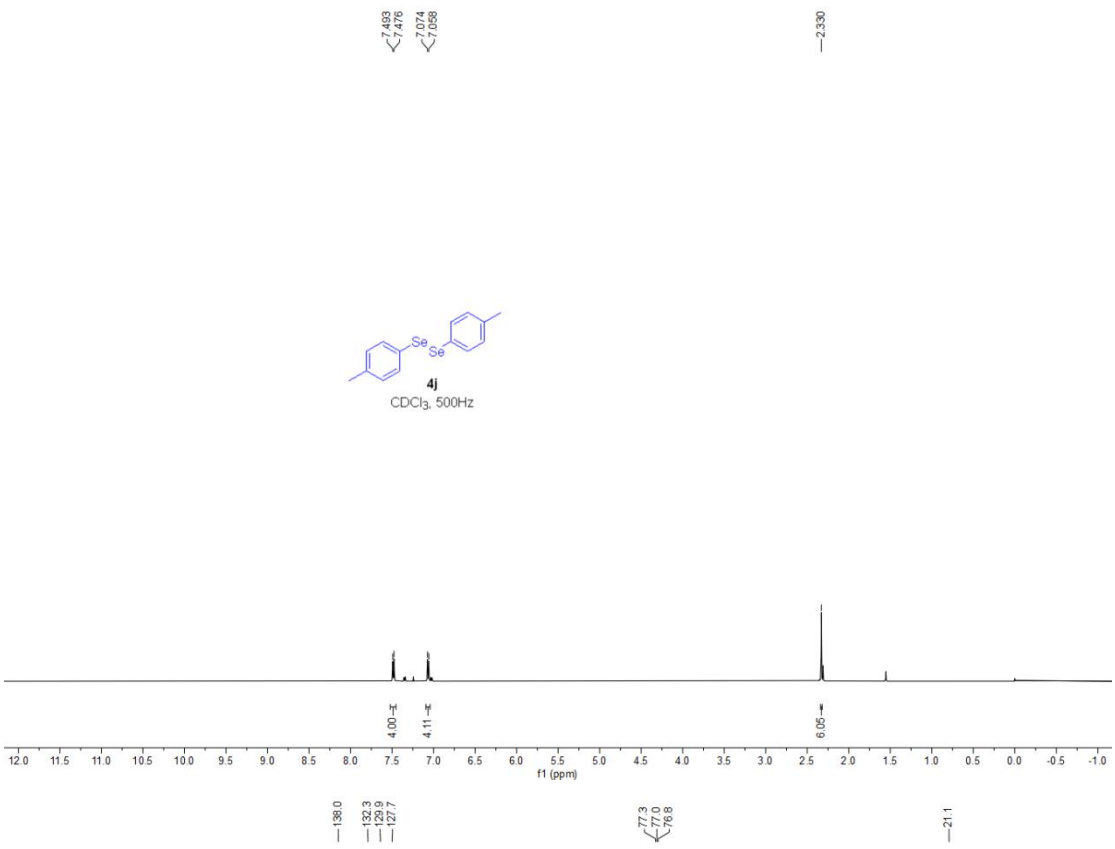


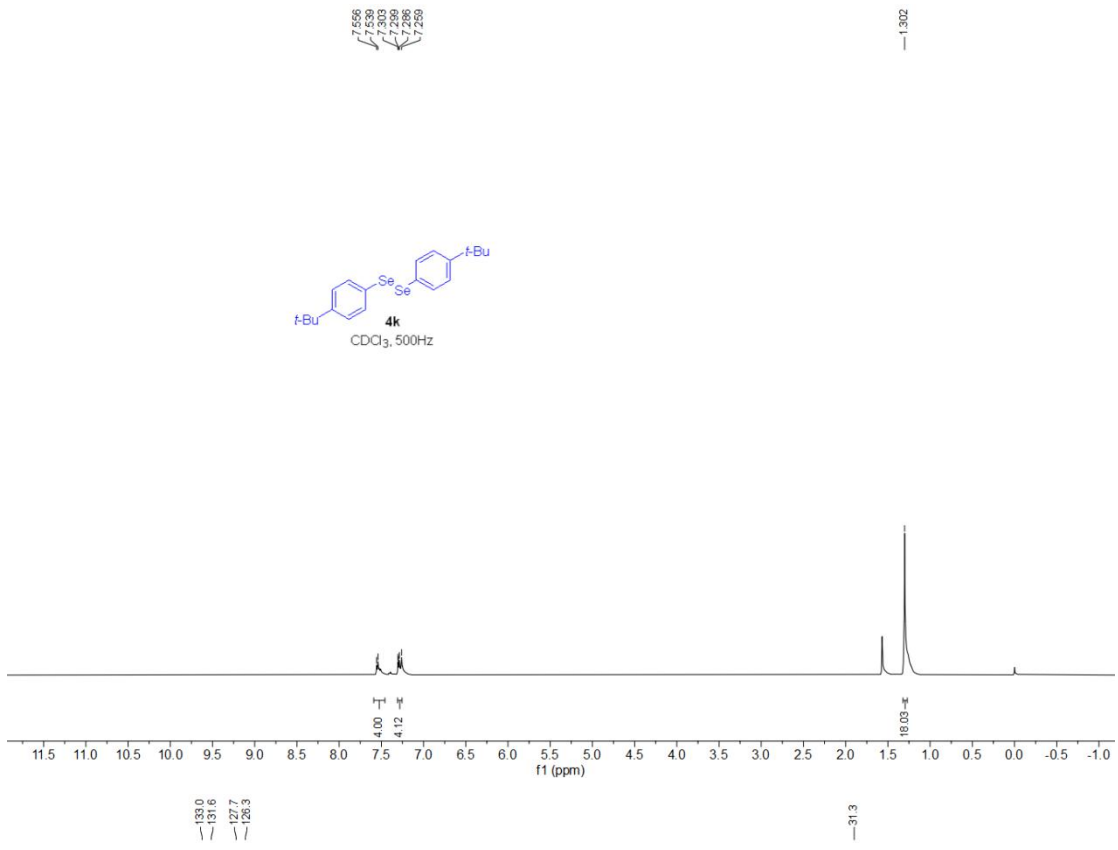


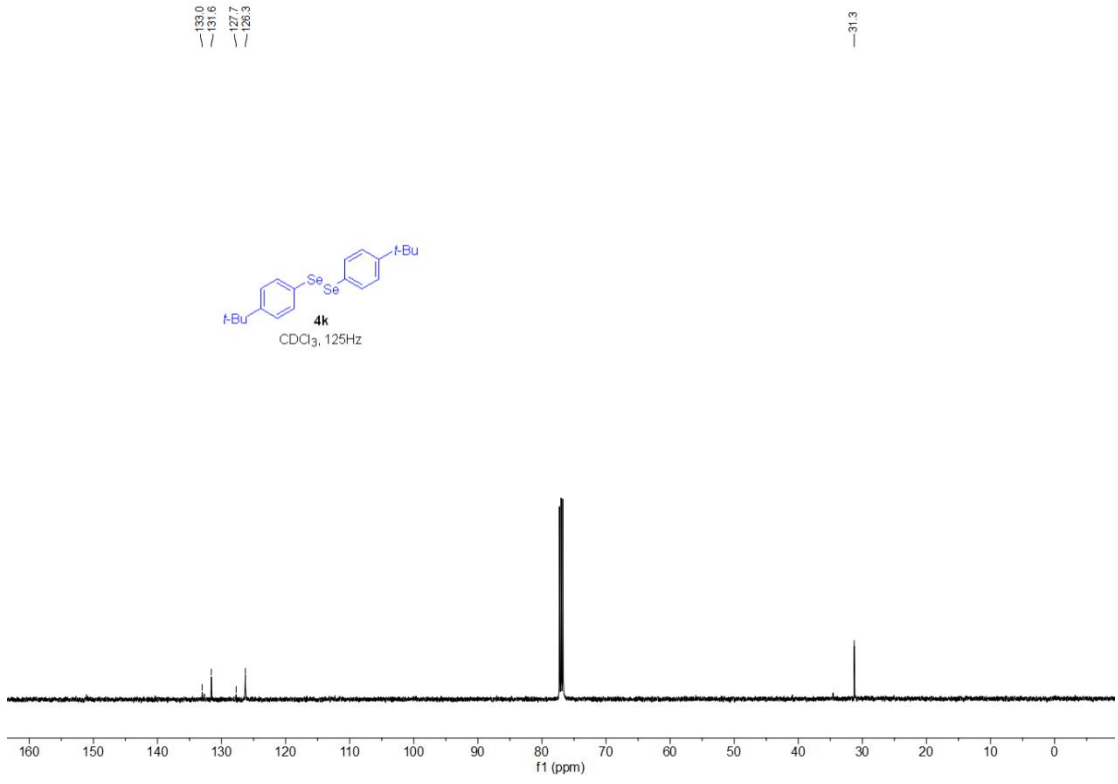
4i

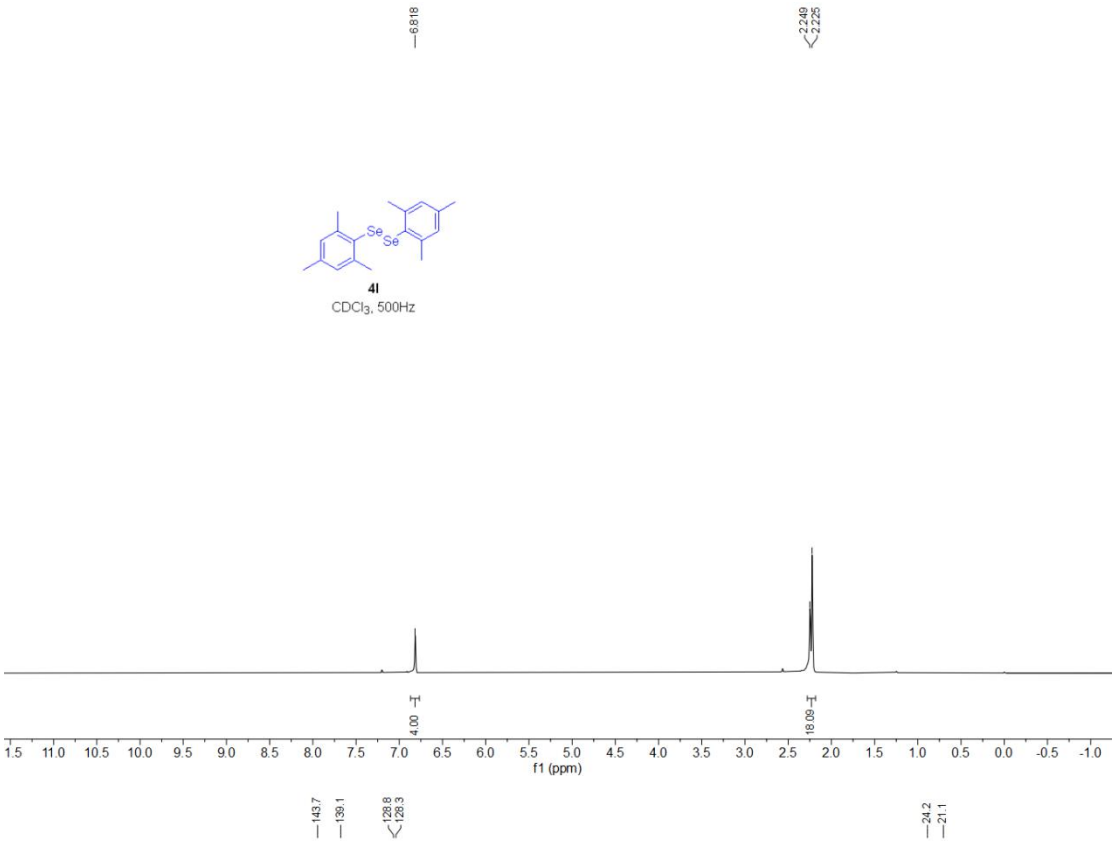
$CDCl_3$, 470Hz

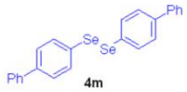



7.493
7.476
7.074
7.058
2.330
Se
Se
4j
CDCl3, 500Hz
4.00
4.11
6.05
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)
138.0
132.3
129.9
127.7
77.3
77.0
76.8
21.1
Se
Se
4j
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)


7.556
7.539
7.303
7.299
7.286
7.259
1.302
t-Bu
Se
Se
t-Bu
4k
CDCl3, 500Hz
4.00
4.12
18.03
11.5 11.0 10.5 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 -0.5 -1.0
f1 (ppm)

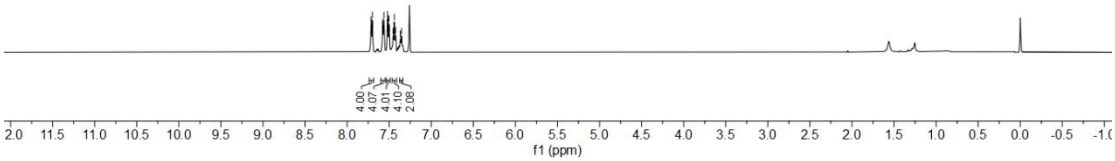

133.0
131.6
127.7
126.3
31.3
t-Bu
Se
Se
t-Bu
4k
CDCl3, 125Hz
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

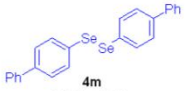

6.818
2.249
2.225
Se
Se
4l
CDCl3, 500Hz
4.00
18.09
1.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)
143.7
139.1
128.8
128.3
24.2
21.1
Se
Se
4l
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



4m

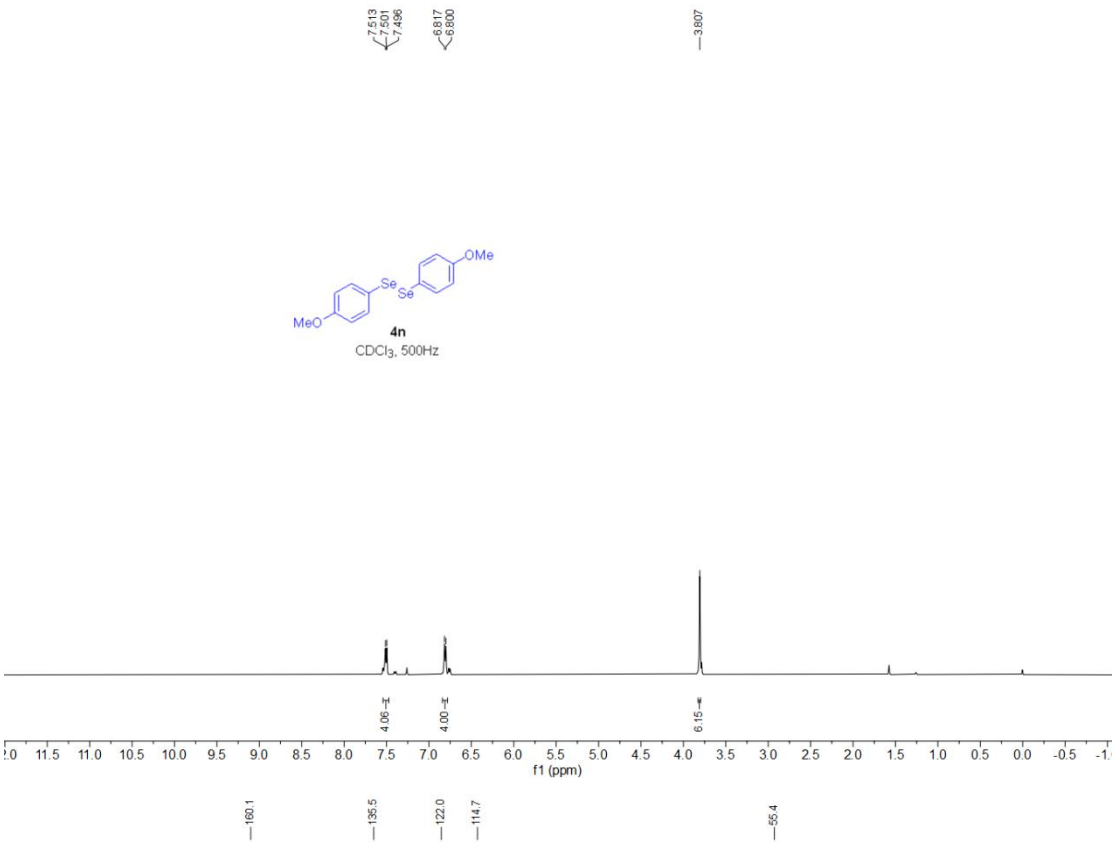
$CDCl_3$, 500Hz

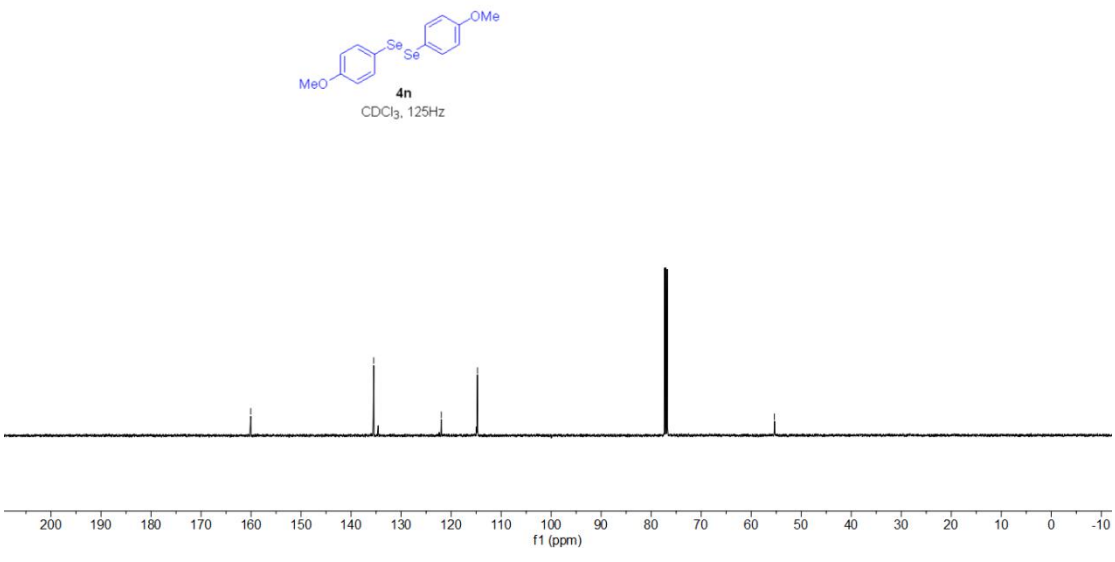


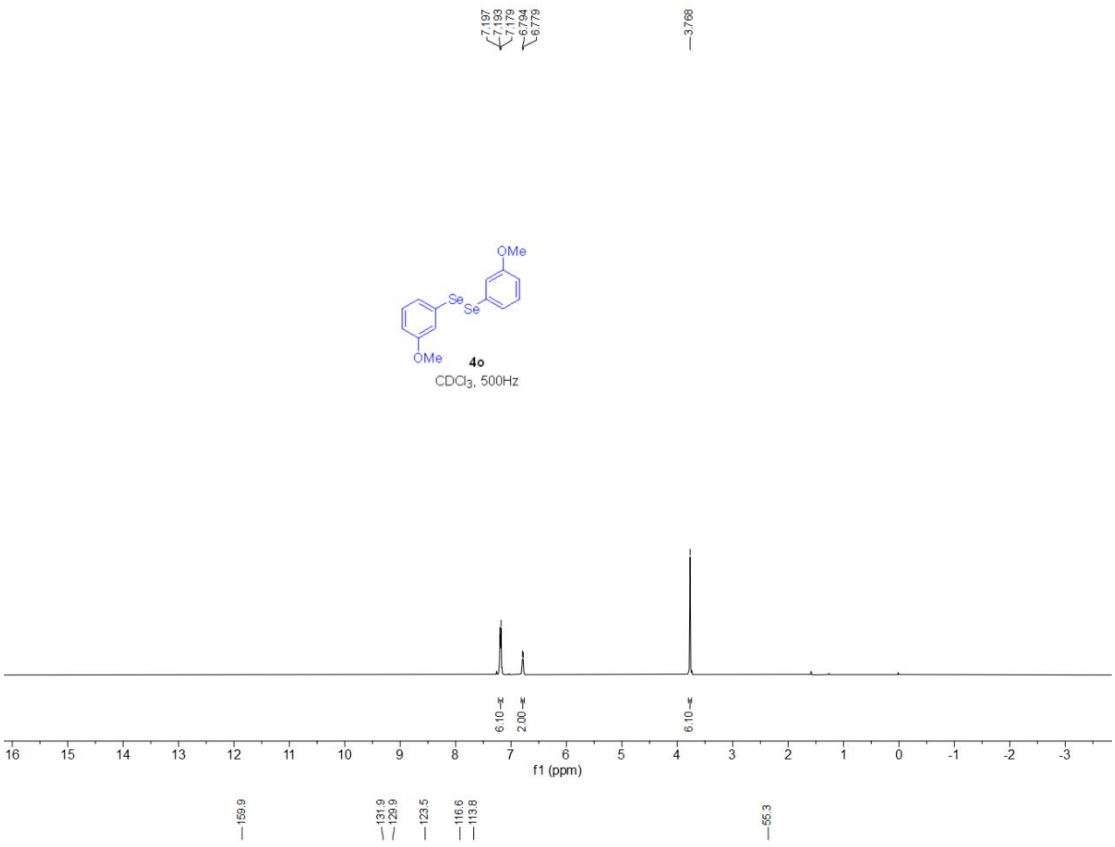


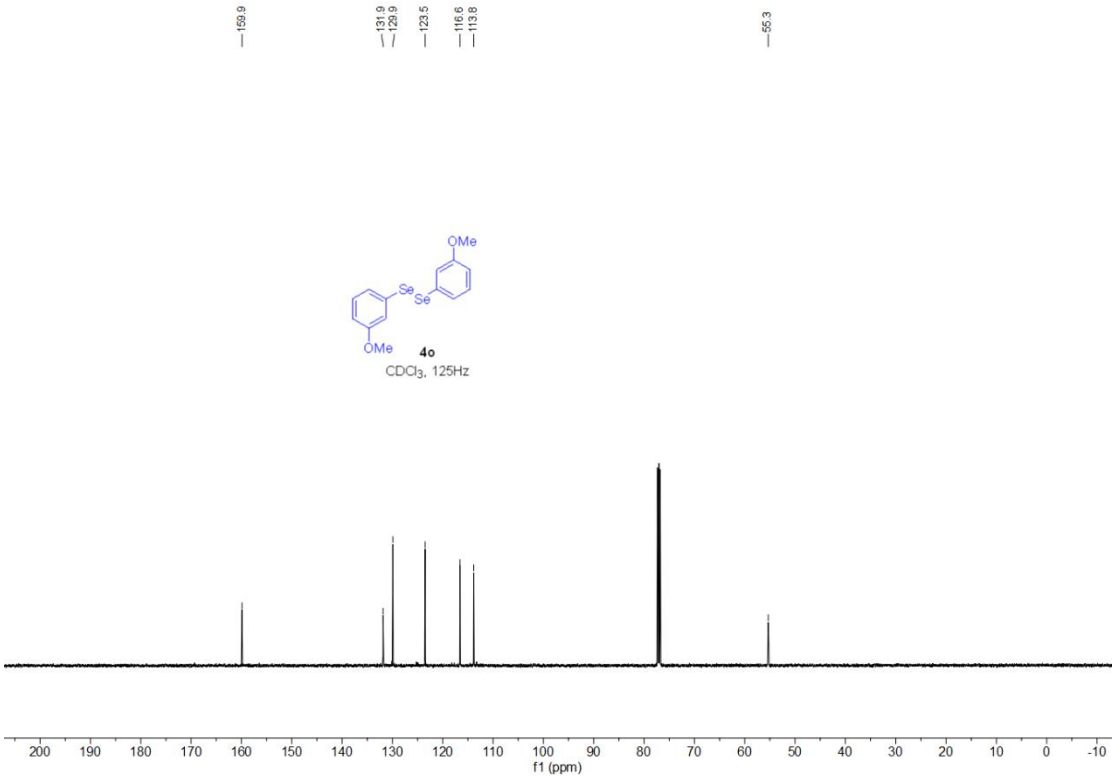
4m

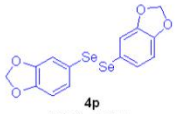
$CDCl_3$, 125Hz


7.513
7.501
7.496
6.817
6.800
3.807
OMe
Se
Se
MeO
4n
CDCl3, 500Hz
4.06
4.00
6.15
f1 (ppm)


160.1
135.5
122.0
114.7
55.4
OMe
Se
Se
MeO
4n
CDCl3, 125Hz
f1 (ppm)

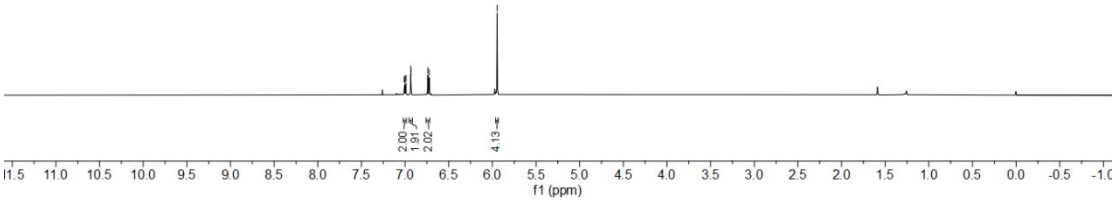

7.197
7.193
7.179
6.794
6.779
3.768
OMe
Se
Se
OMe
4o
CDCl3, 500Hz
6.10
2.00
6.10
f1 (ppm)

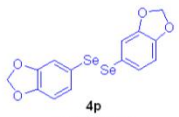

159.9
131.9
129.9
123.5
116.6
113.8
55.3
OMe
Se
Se
OMe
4o
CDCl3, 125Hz
f1 (ppm)



4p

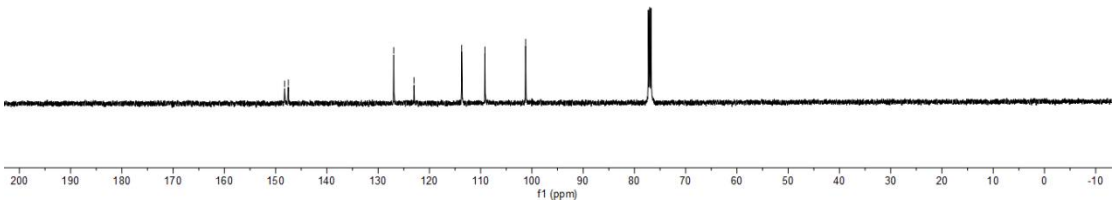
$CDCl_3$, 500Hz

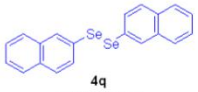




4p

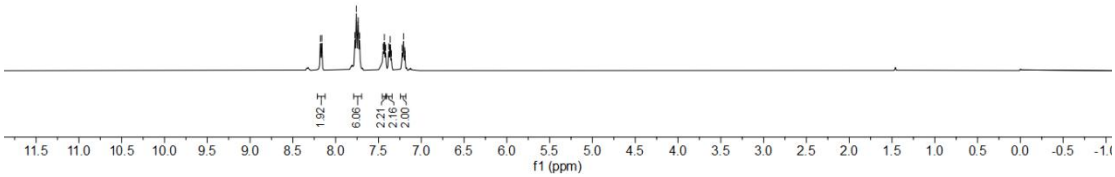
$CDCl_3$, 125Hz

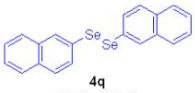




4q

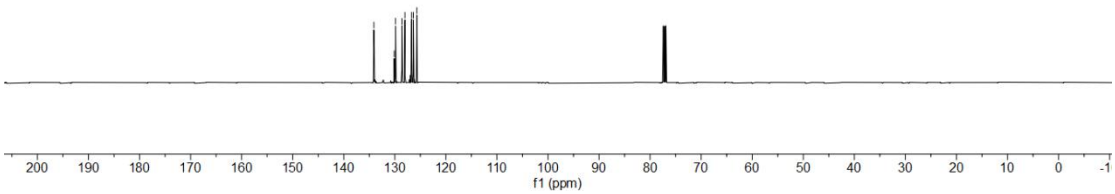
$CDCl_3$, 500Hz

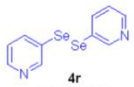




4q

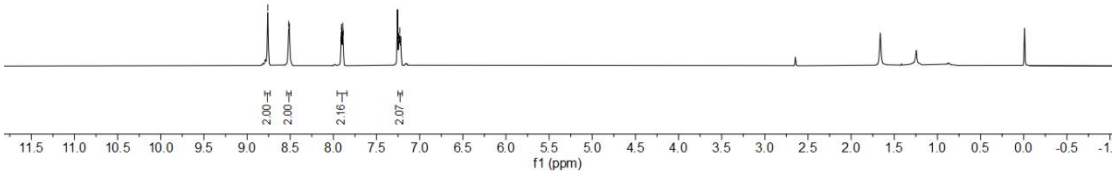
$CDCl_3$, 125Hz

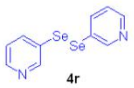




4r

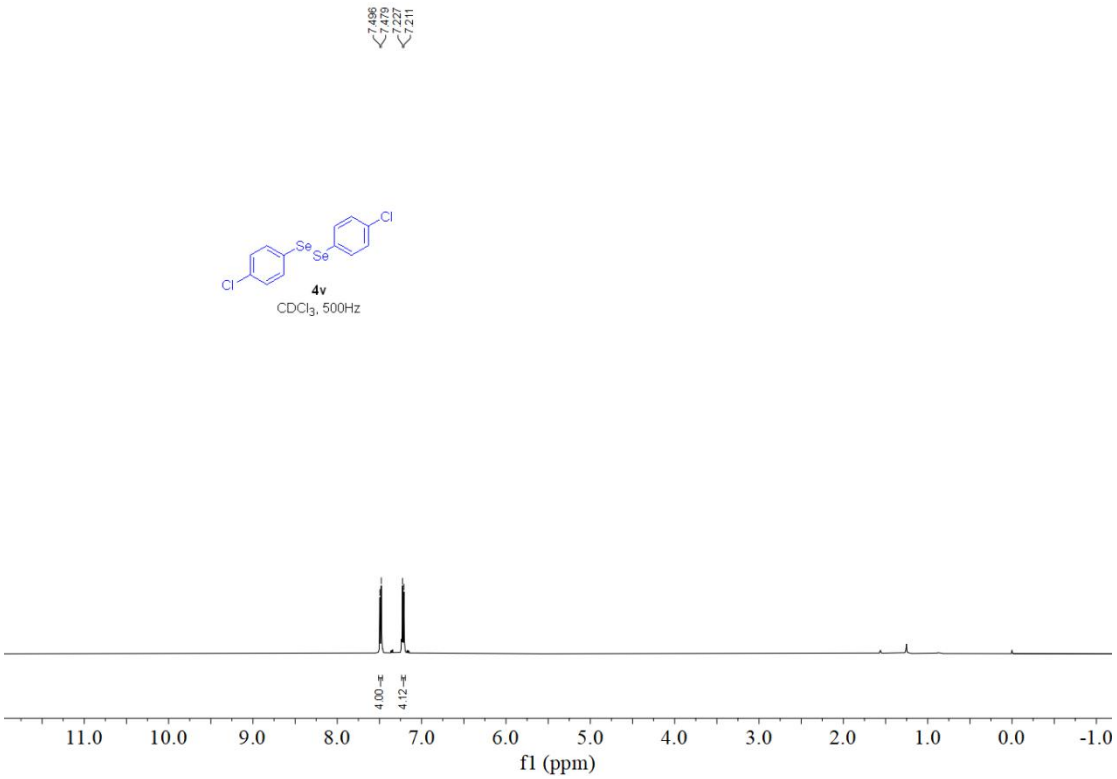
$CDCl_3$, 500Hz

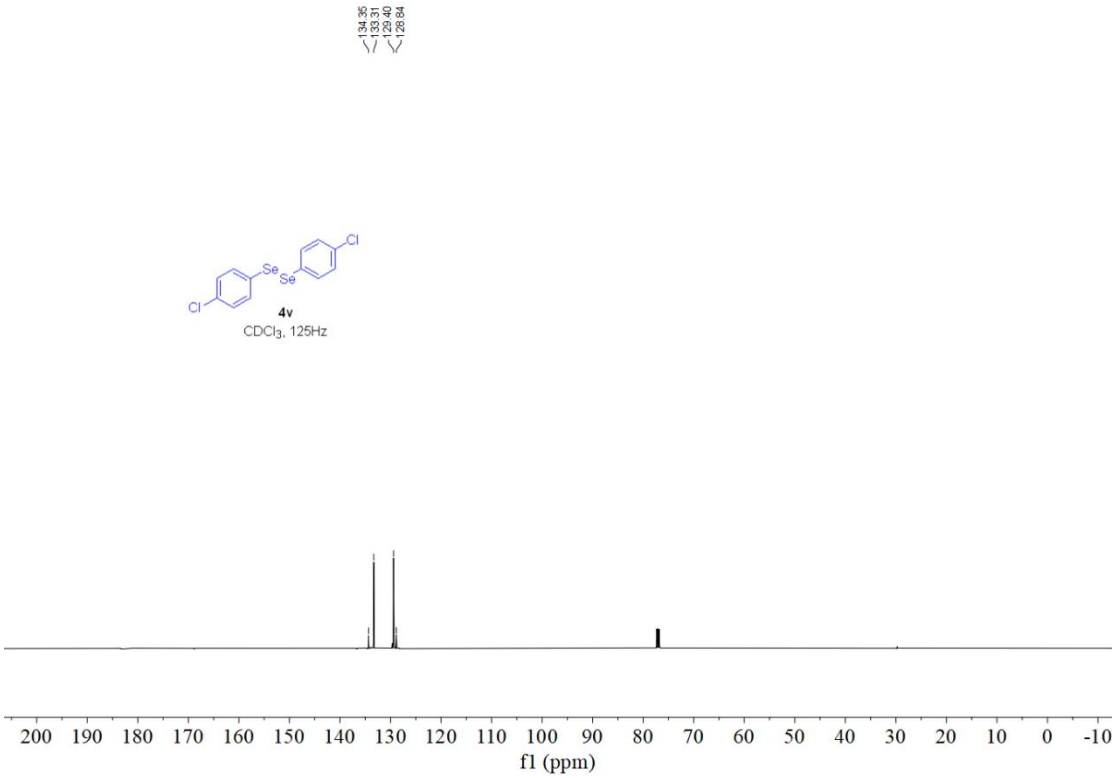


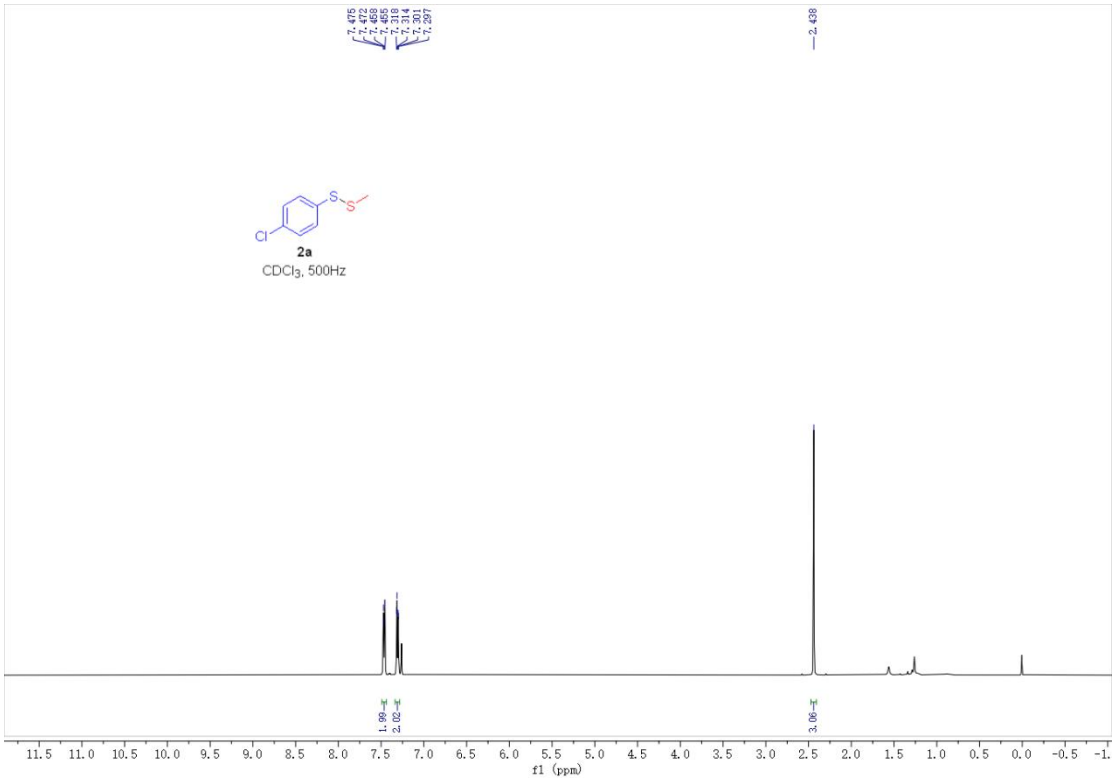


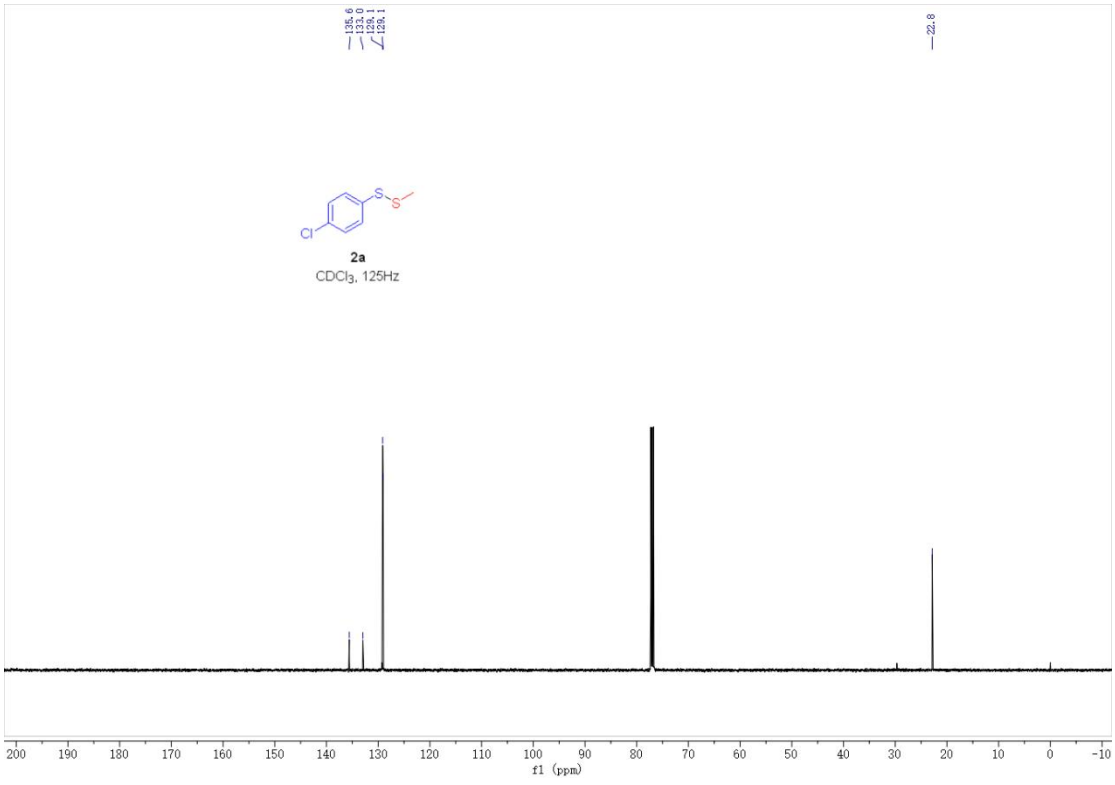
4r

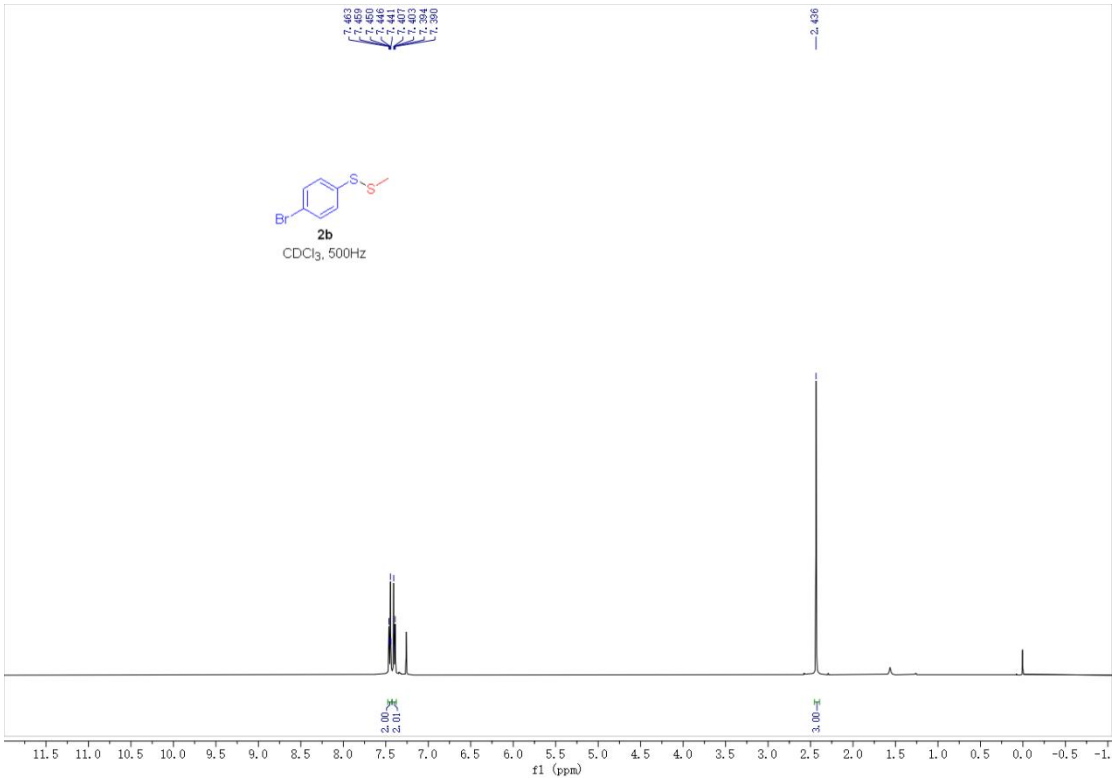
$CDCl_3$, 125Hz

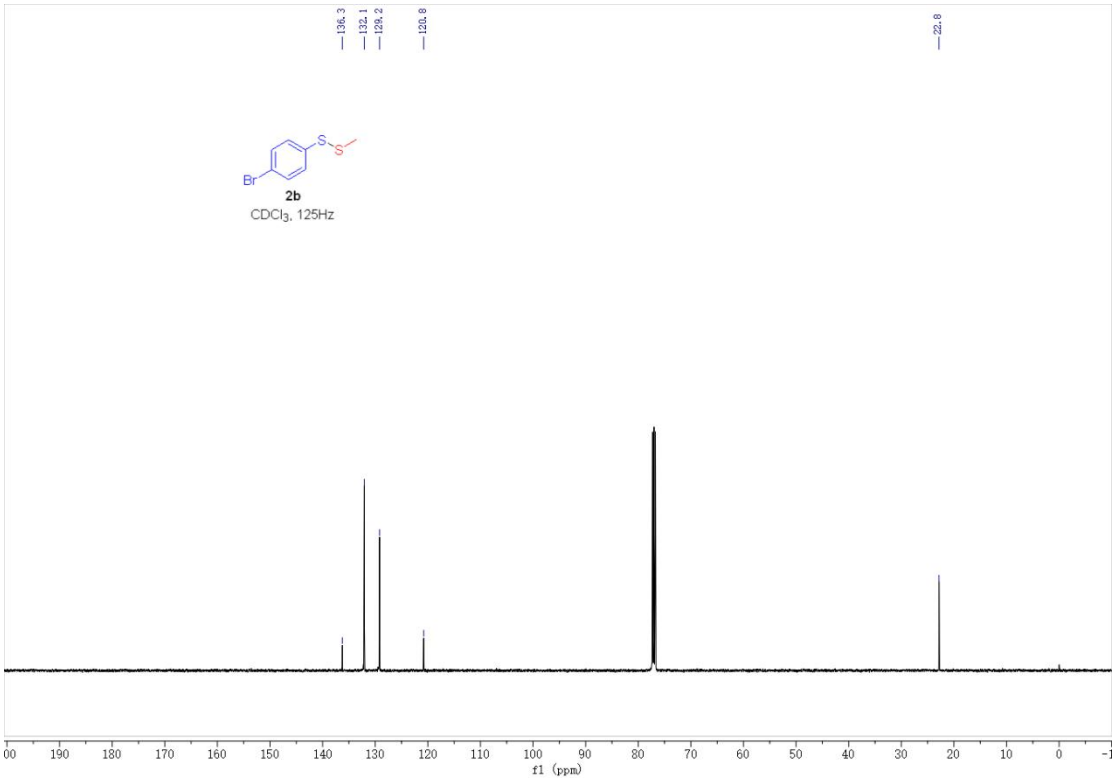

7.496
7.479
7.227
7.211
Cl
Se
Se
Cl
4v
CDCl3, 500Hz
4.00
4.12
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
f1 (ppm)

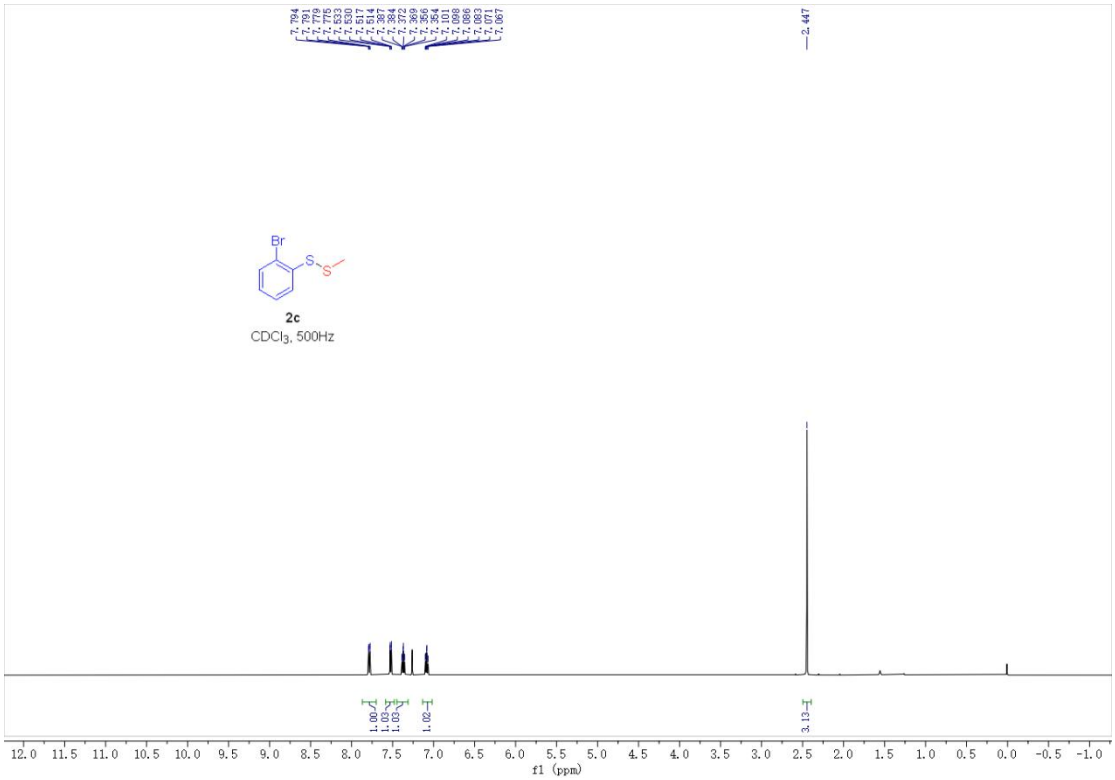

134.35
133.31
129.40
128.84
Cl
Se
Se
Cl
4v
CDCl3, 125Hz
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

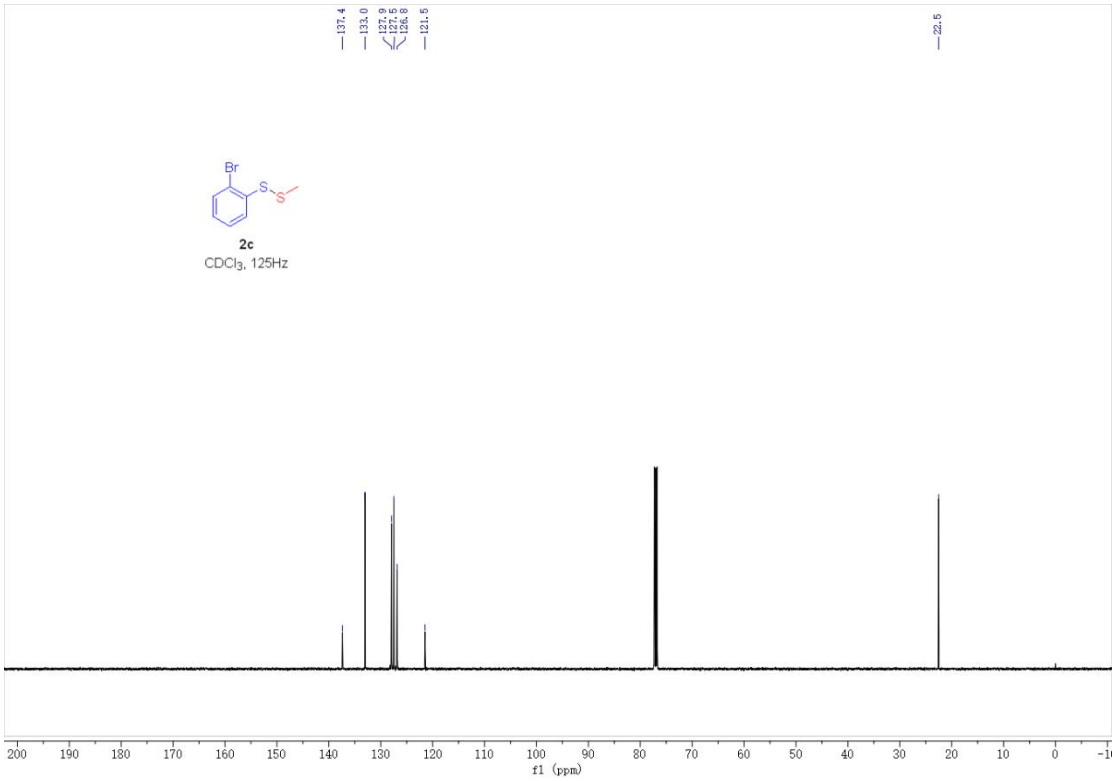

7.475
7.472
7.458
7.455
7.318
7.314
7.301
7.297
2.438
2a
CDCl3, 500Hz
1.00
2.02
3.06
f1 (ppm)

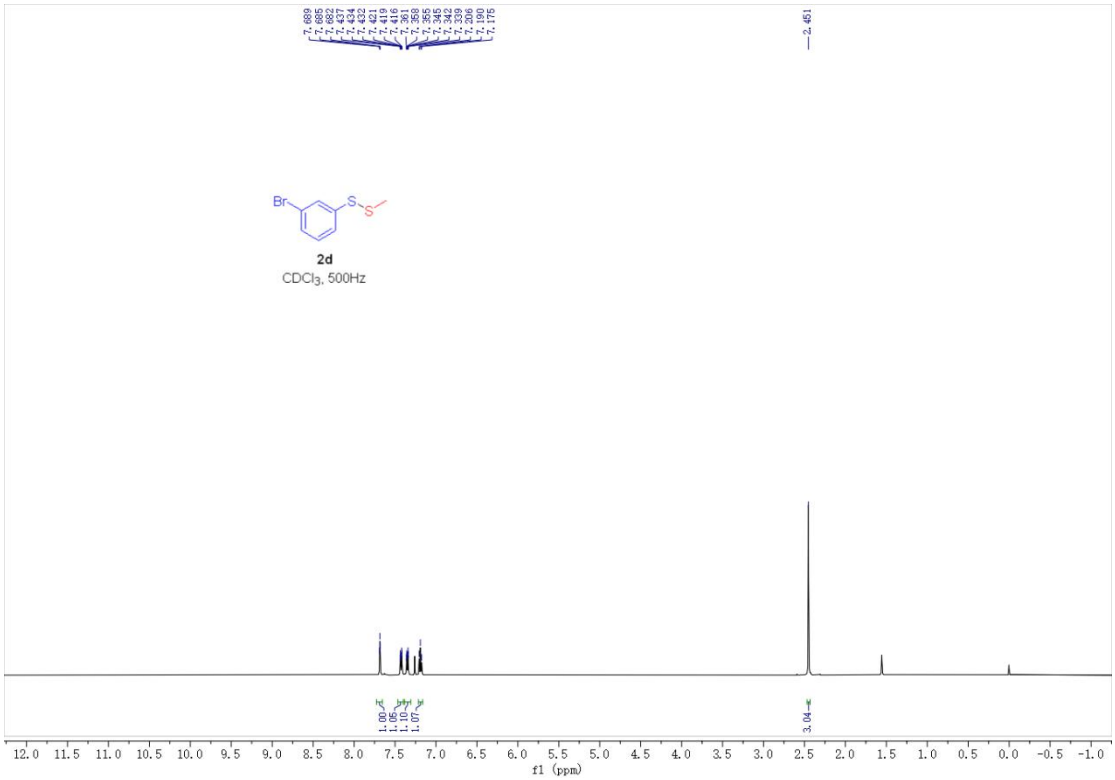

135.6
133.0
128.1
126.1
22.8
2a
CDCl3, 125Hz
f1 (ppm)

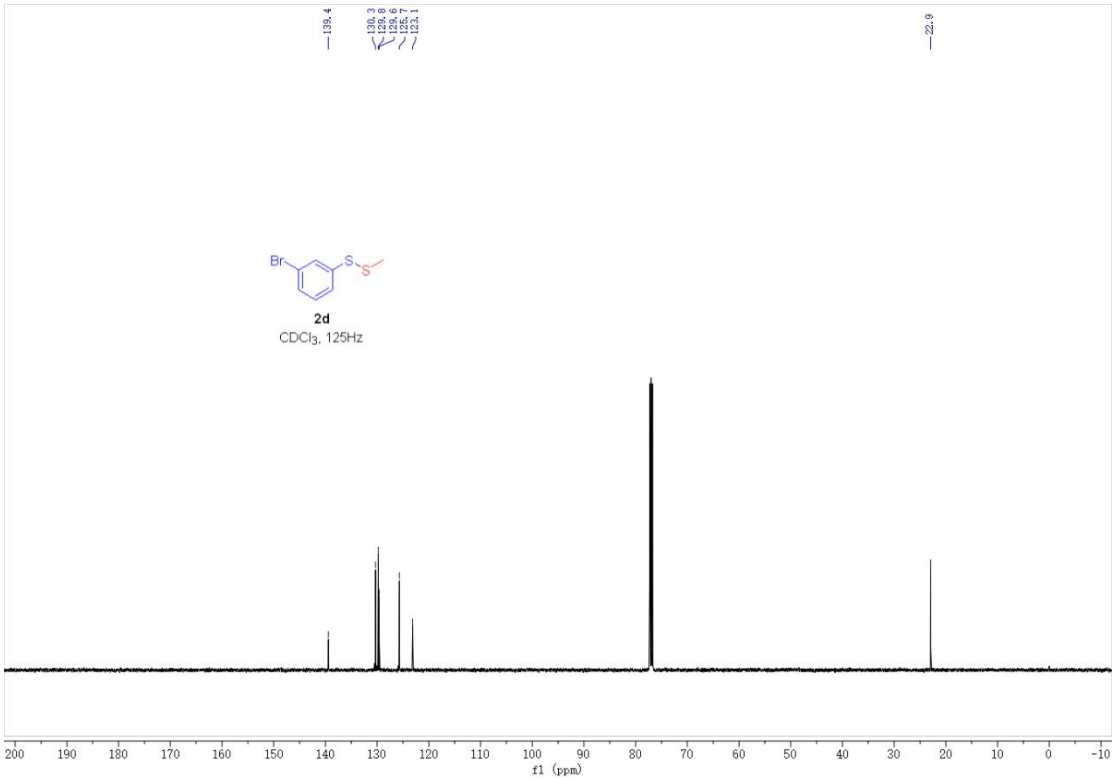

7.463
7.459
7.450
7.446
7.441
7.407
7.403
7.394
7.390
2.436
Br
S
S
2b
CDCl3, 500Hz
2.00
2.01
3.00
f1 (ppm)

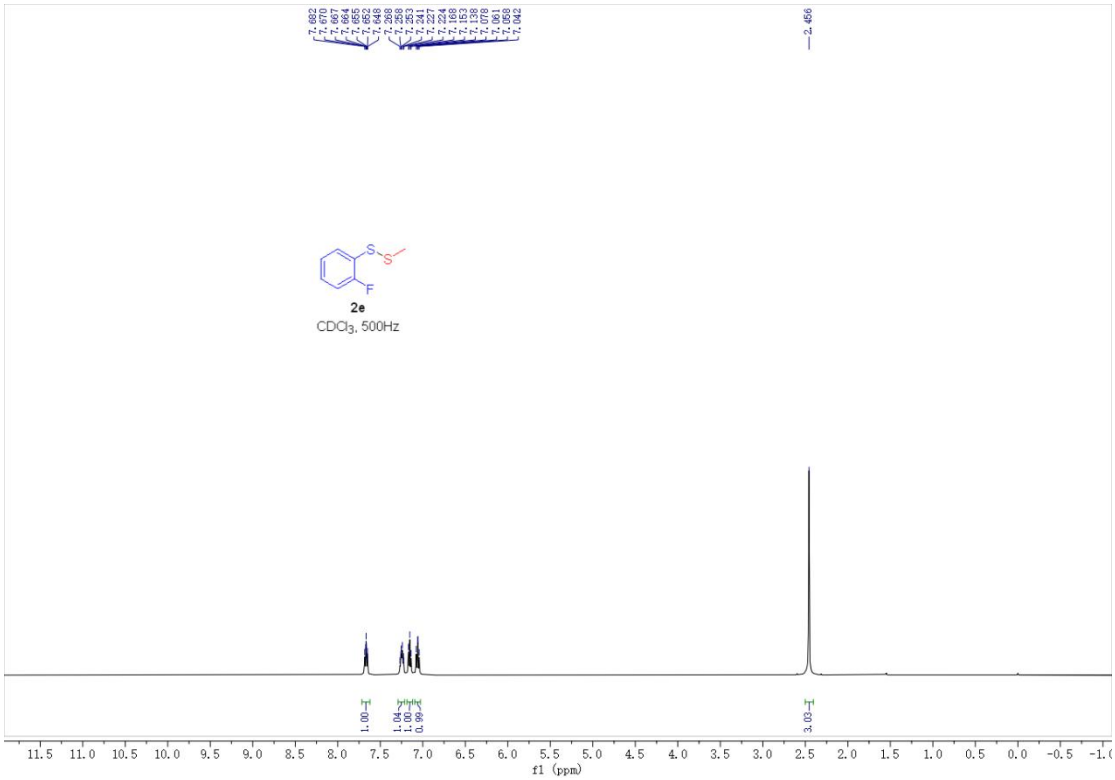

136.3
132.1
128.2
126.8
22.8
Br
S
S
2b
CDCl3, 125Hz
f1 (ppm)

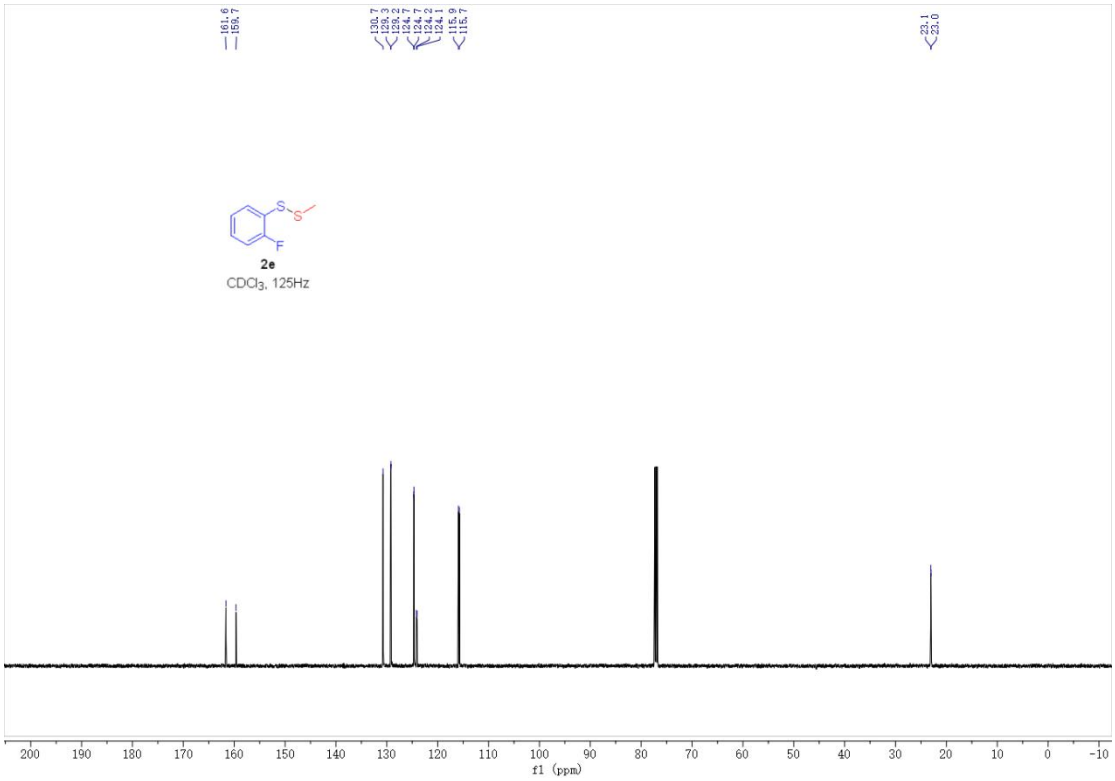

7.794
7.791
7.779
7.775
7.653
7.630
7.517
7.514
7.387
7.384
7.372
7.369
7.356
7.354
7.101
7.098
7.086
7.083
7.071
7.067
2.447
Br
S
S
2c
CDCl3, 500Hz
1.00
1.03
1.03
1.02
3.13
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

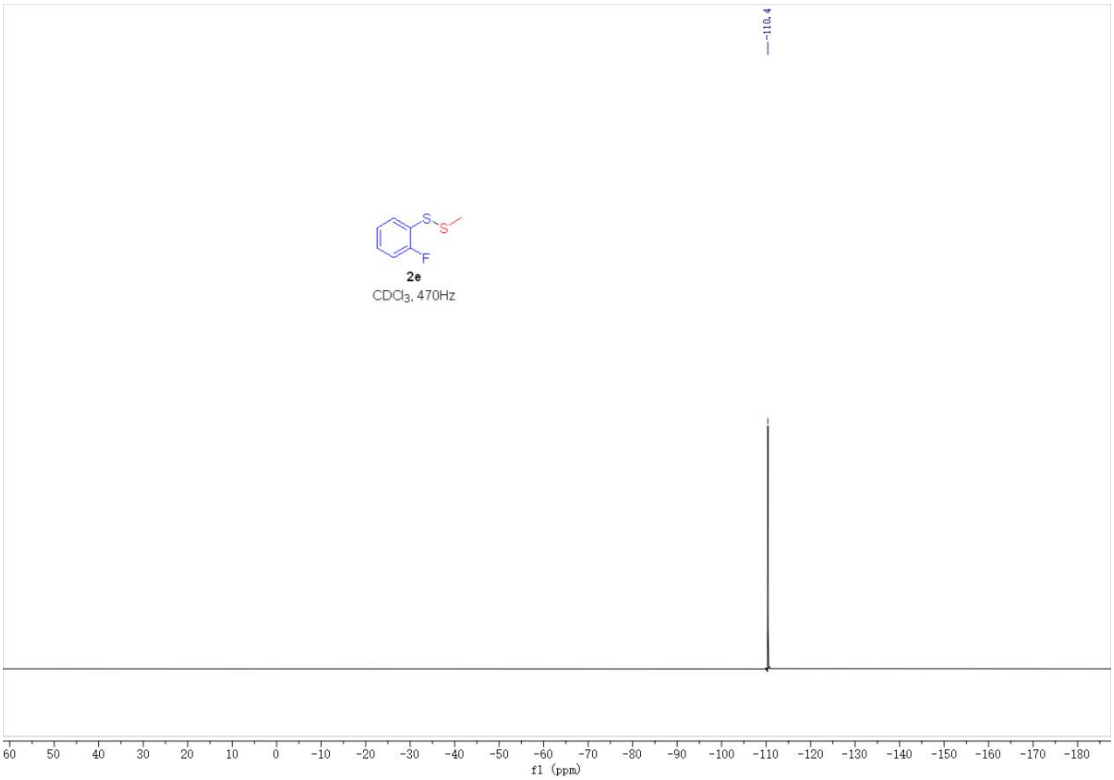

137.4
133.0
127.9
127.5
124.8
121.5
22.5
Br
S
S
2c
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

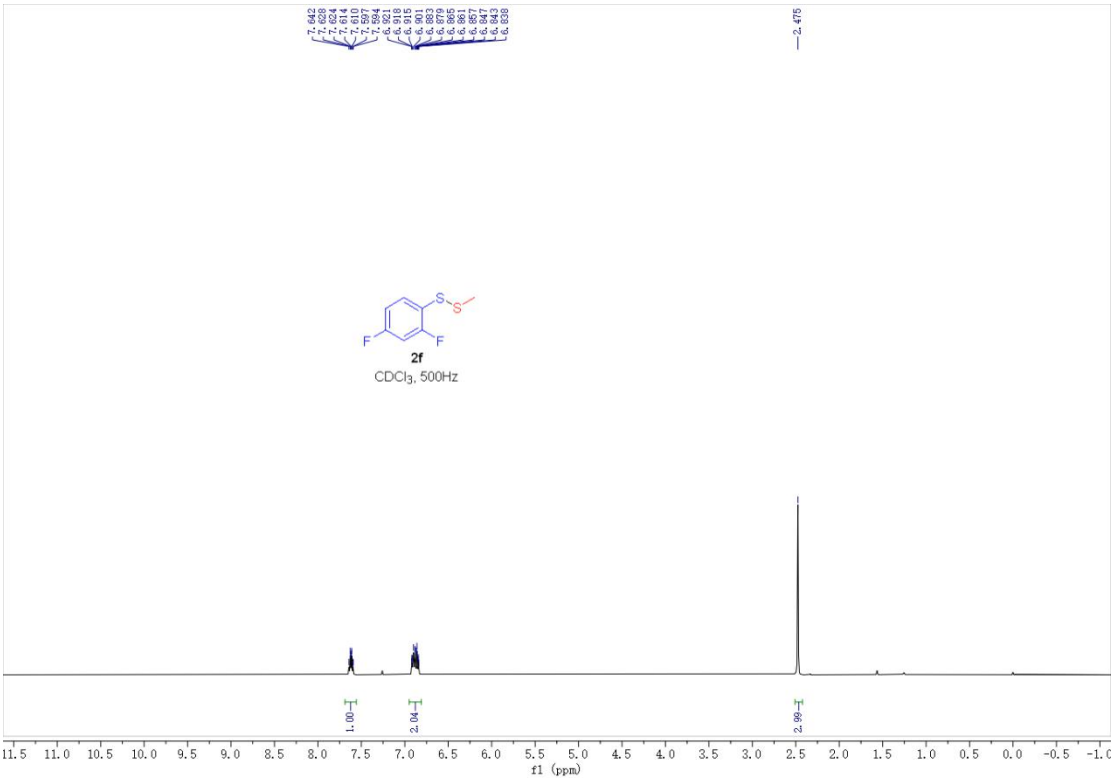

7.689
7.685
7.682
7.437
7.434
7.432
7.421
7.419
7.416
7.361
7.358
7.355
7.345
7.342
7.339
7.206
7.190
7.175
2.451
Br
S
S
2d
CDCl3, 500Hz
1.00
1.95
1.10
1.07
3.04
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

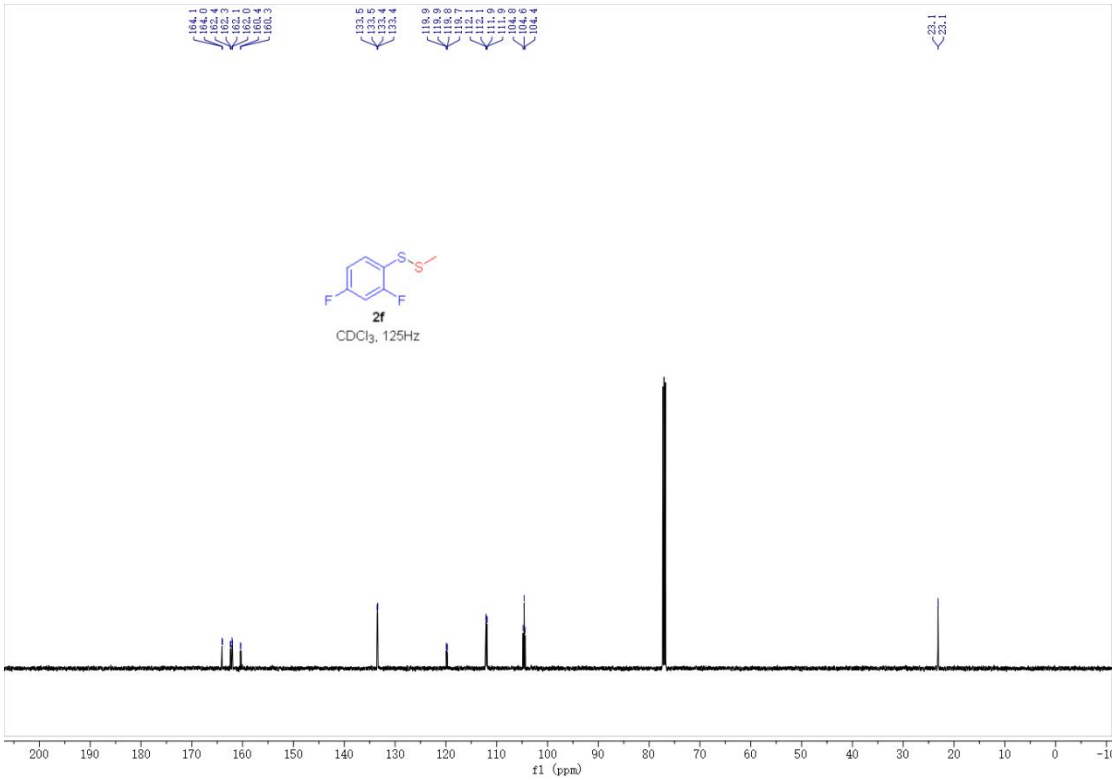

138.4
130.3
128.8
128.6
125.7
123.1
22.9
Br
S
S
2d
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

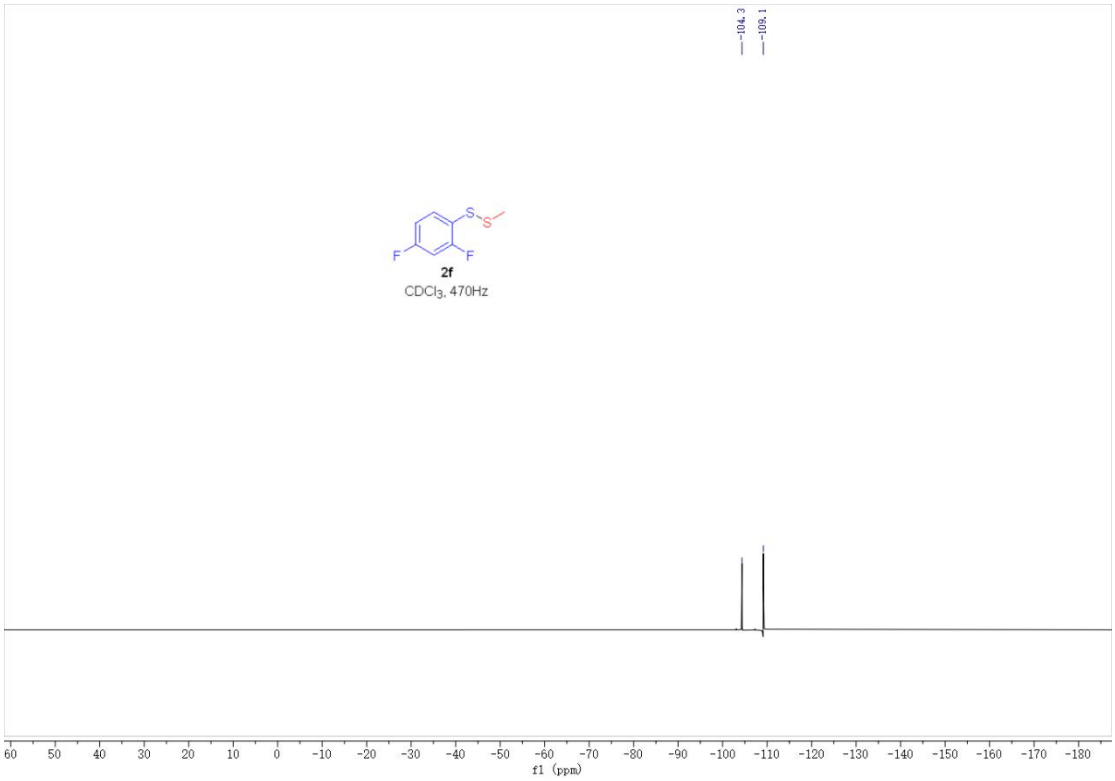

7.892
7.670
7.667
7.664
7.655
7.650
7.648
7.268
7.258
7.253
7.241
7.227
7.224
7.168
7.153
7.138
7.078
7.061
7.058
7.042
2.456
2e
CDCl3, 500Hz
1.00
1.04
1.00
0.99
3.03
f1 (ppm)

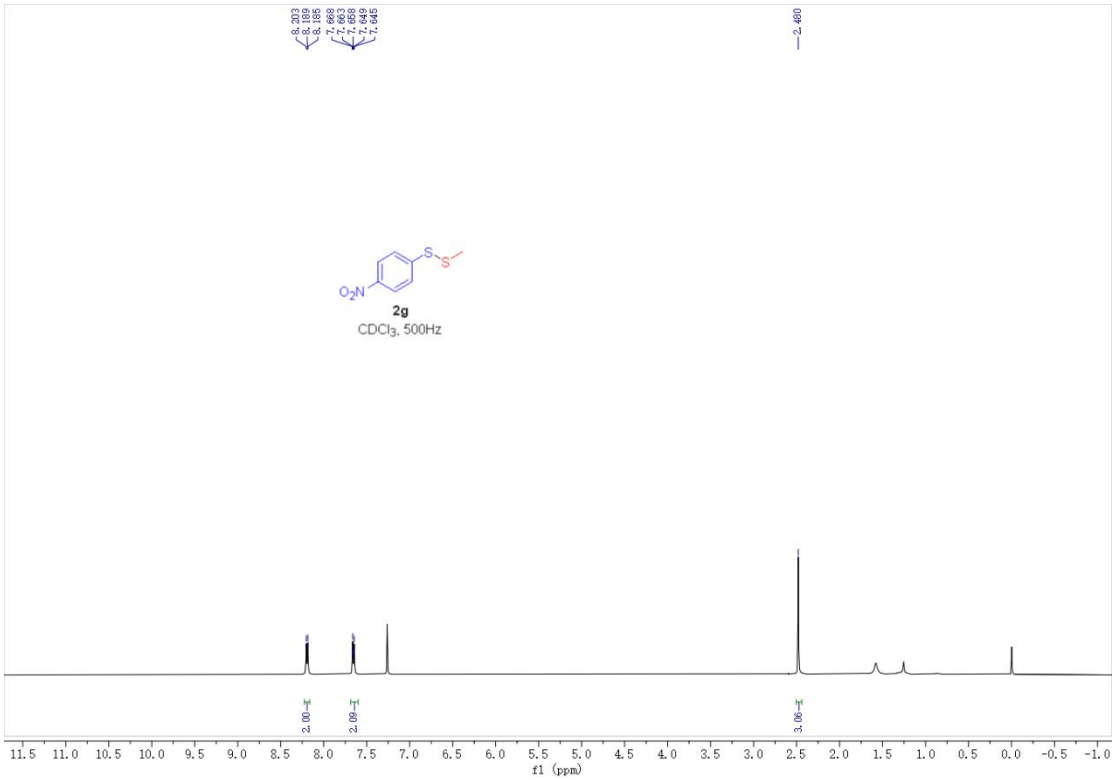

161.6
159.7
130.7
129.3
129.2
124.7
124.4
124.2
124.1
115.9
115.7
23.1
23.0
2e
CDCl3, 125Hz
f1 (ppm)

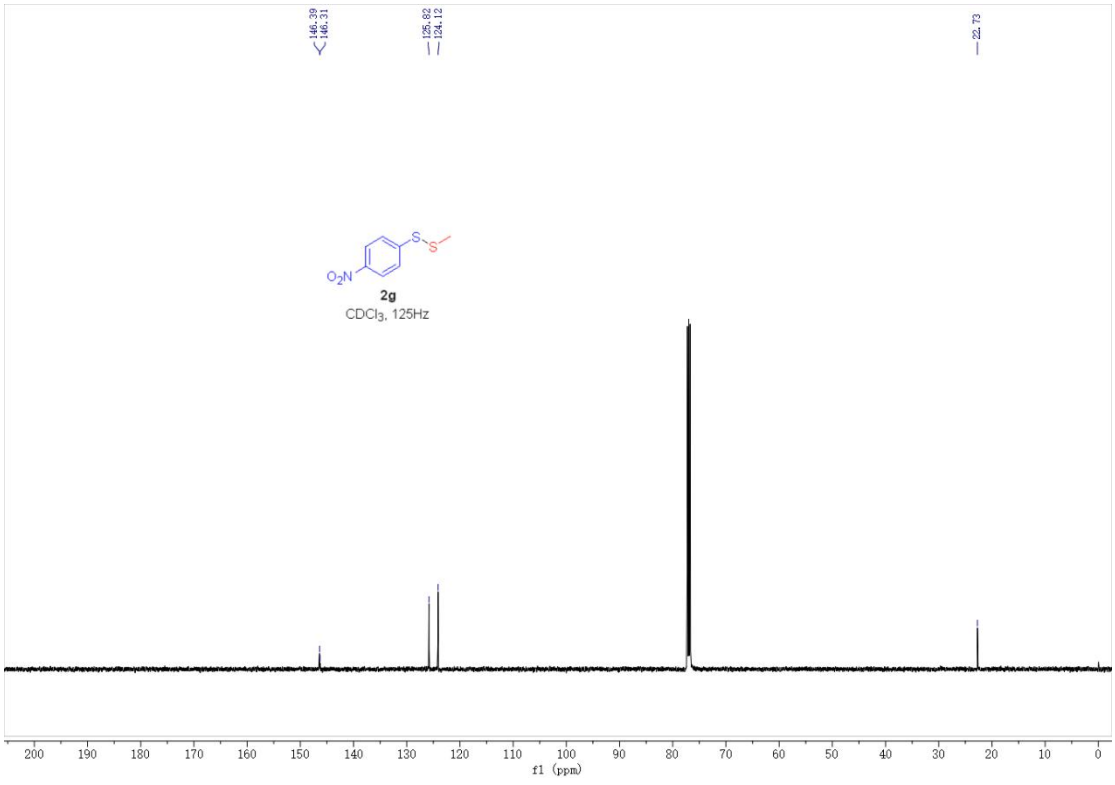

-110.4
2e
CDCl3, 470Hz
f1 (ppm)

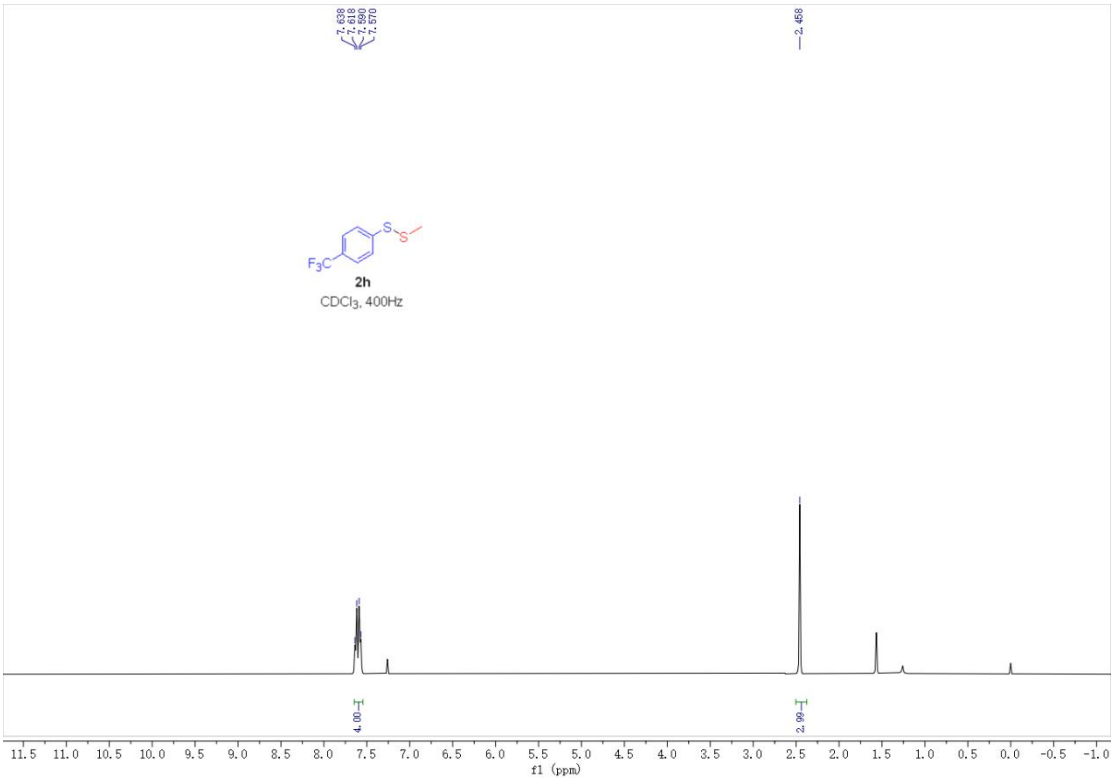

2.476
2f
CDCl3, 500Hz
1.00
2.04
2.99
f1 (ppm)

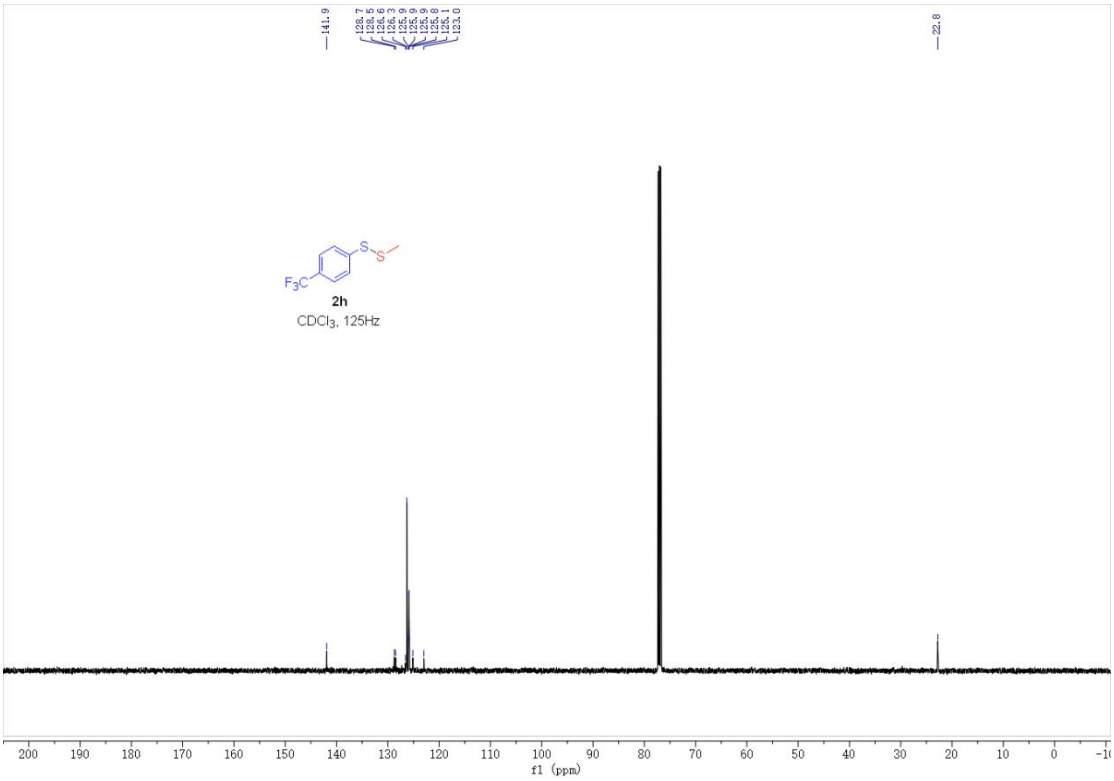

164.1
164.0
162.4
162.3
162.1
162.0
160.4
160.3
133.5
133.5
133.4
133.4
119.9
119.8
119.8
119.7
112.1
112.1
111.9
111.9
104.8
104.6
104.4
23.1
23.1
2f
CDCl3, 125Hz
f1 (ppm)

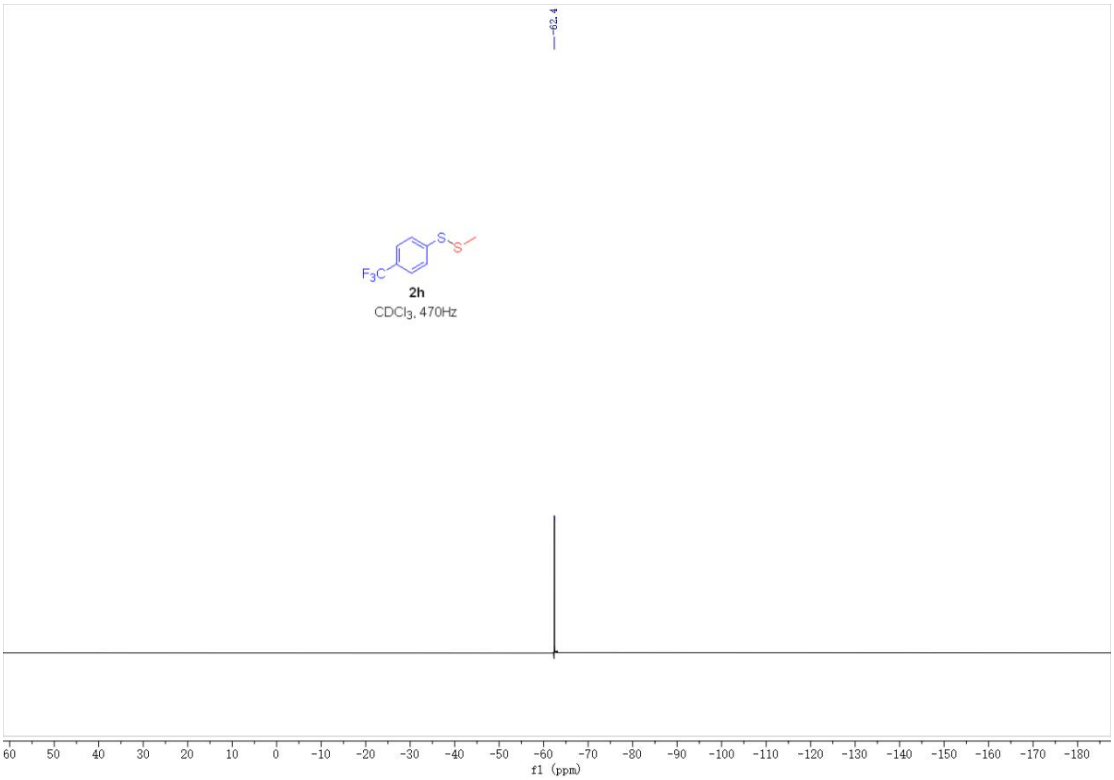

-104.3
-109.1
2f
CDCl3, 470Hz
f1 (ppm)

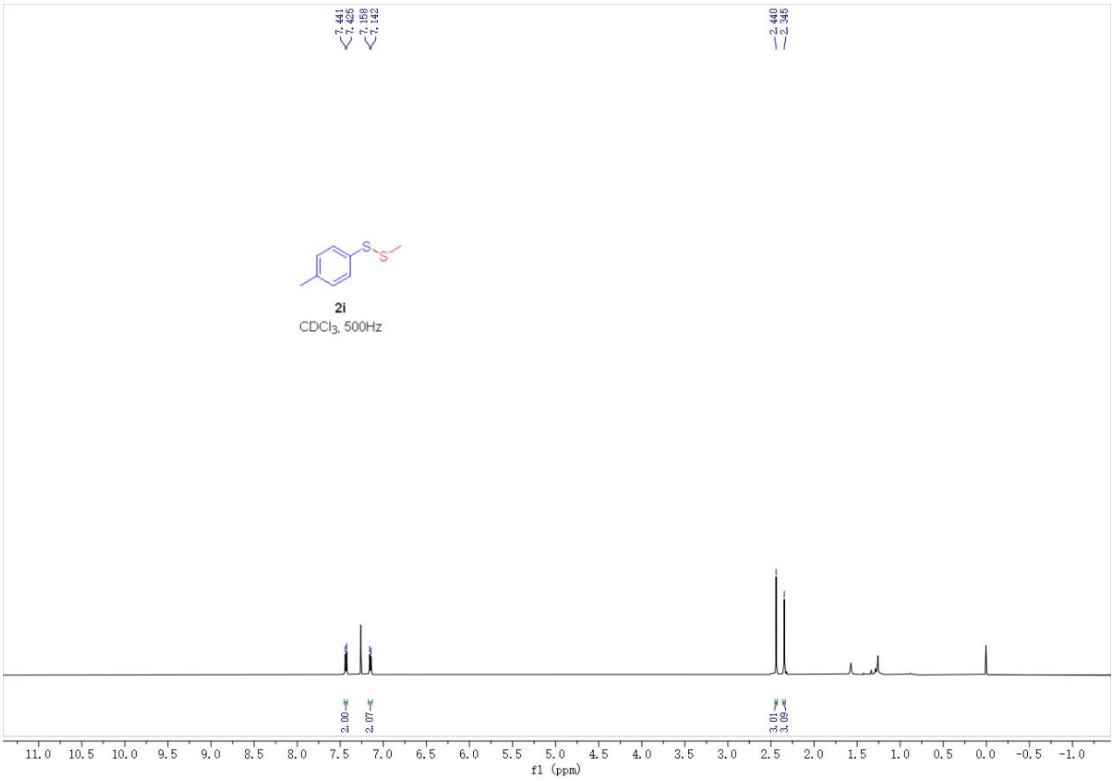

8.203
8.189
8.185
7.668
7.663
7.658
7.649
7.645
2.460
2g
CDCl3, 500Hz
2.00
2.09
3.06
f1 (ppm)

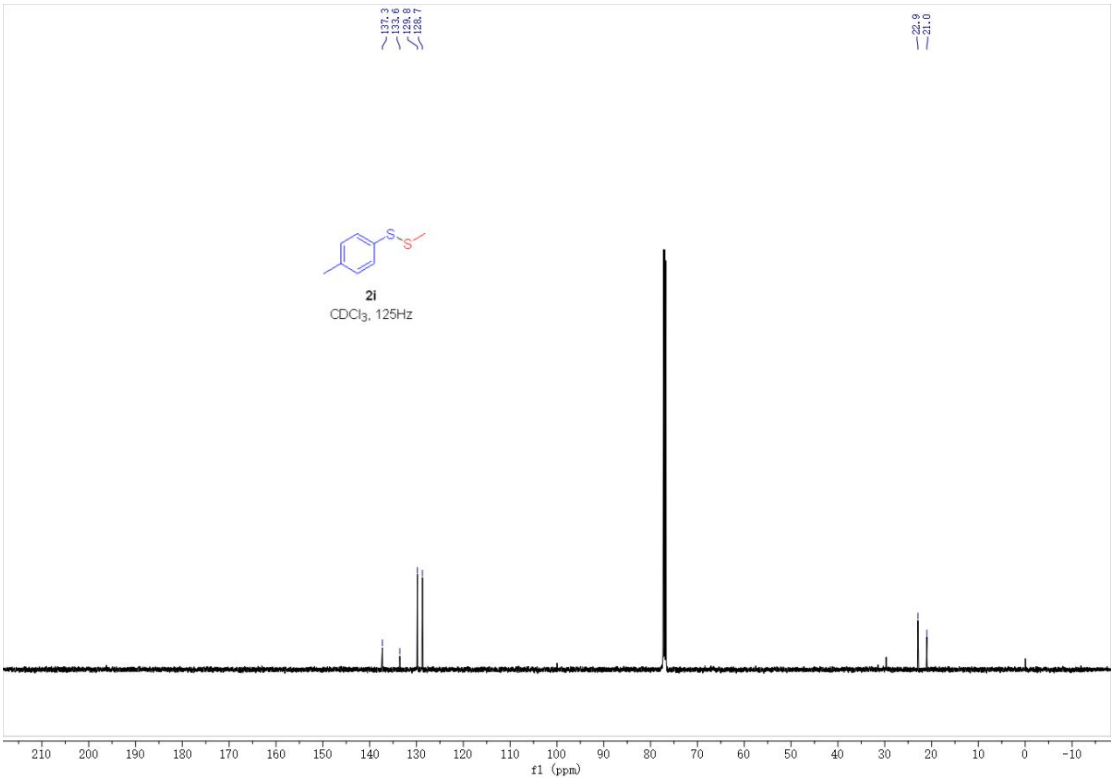

146.39
146.31
125.82
124.12
22.73
2g
CDCl3, 125Hz
f1 (ppm)

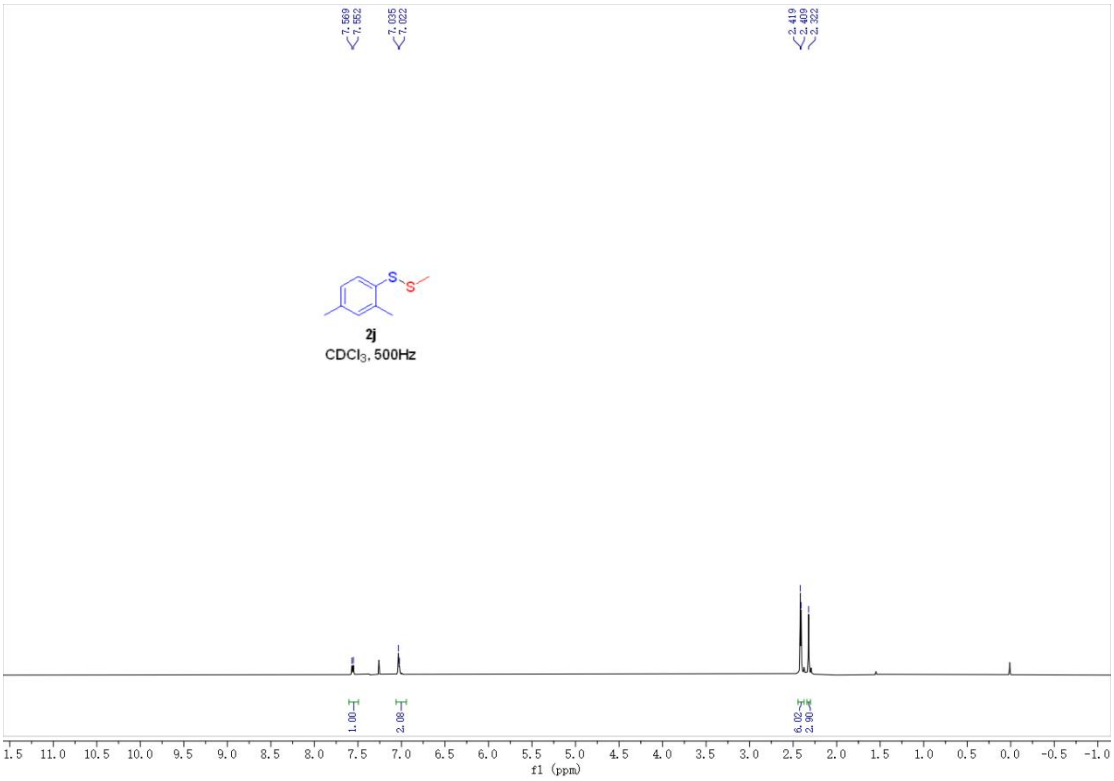

7.638
7.618
7.590
7.570
2.468
S
S
F3C
2h
CDCl3, 400Hz
4.00
2.99
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

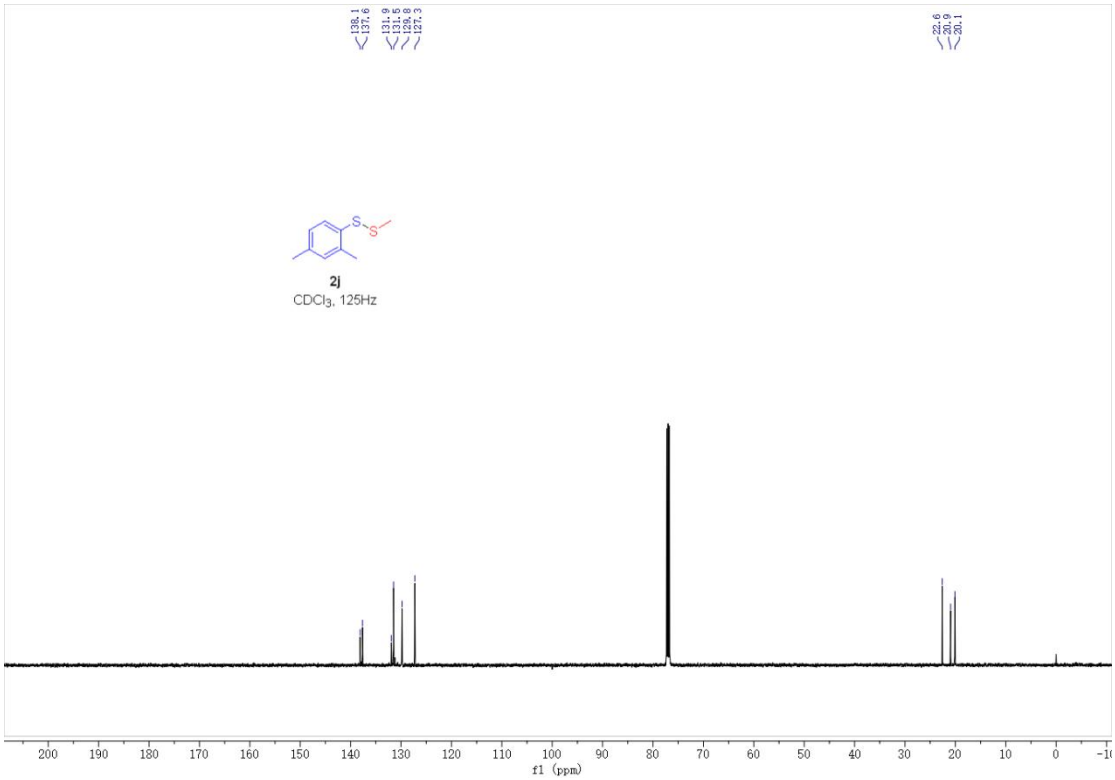

141.9
128.7
128.5
126.6
126.3
125.9
125.9
125.9
125.8
125.1
123.0
22.8
S
S
F3C
2h
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

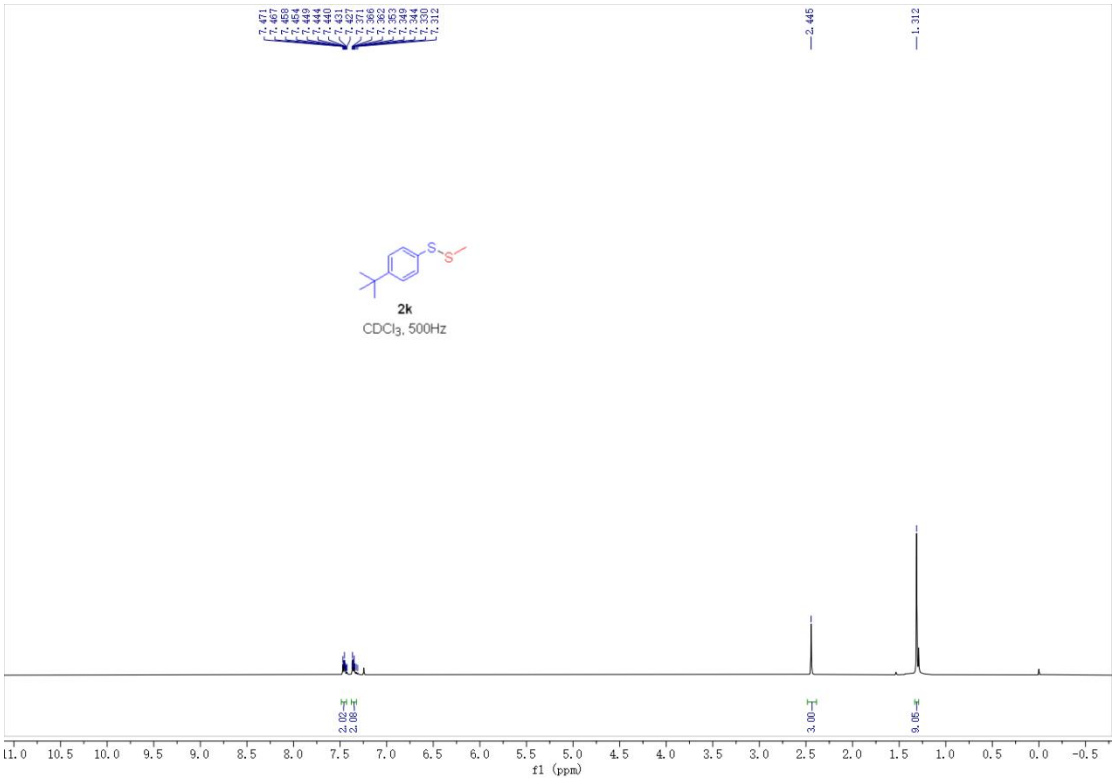

-62.4
2h
CDCl3, 470Hz
60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180
f1 (ppm)

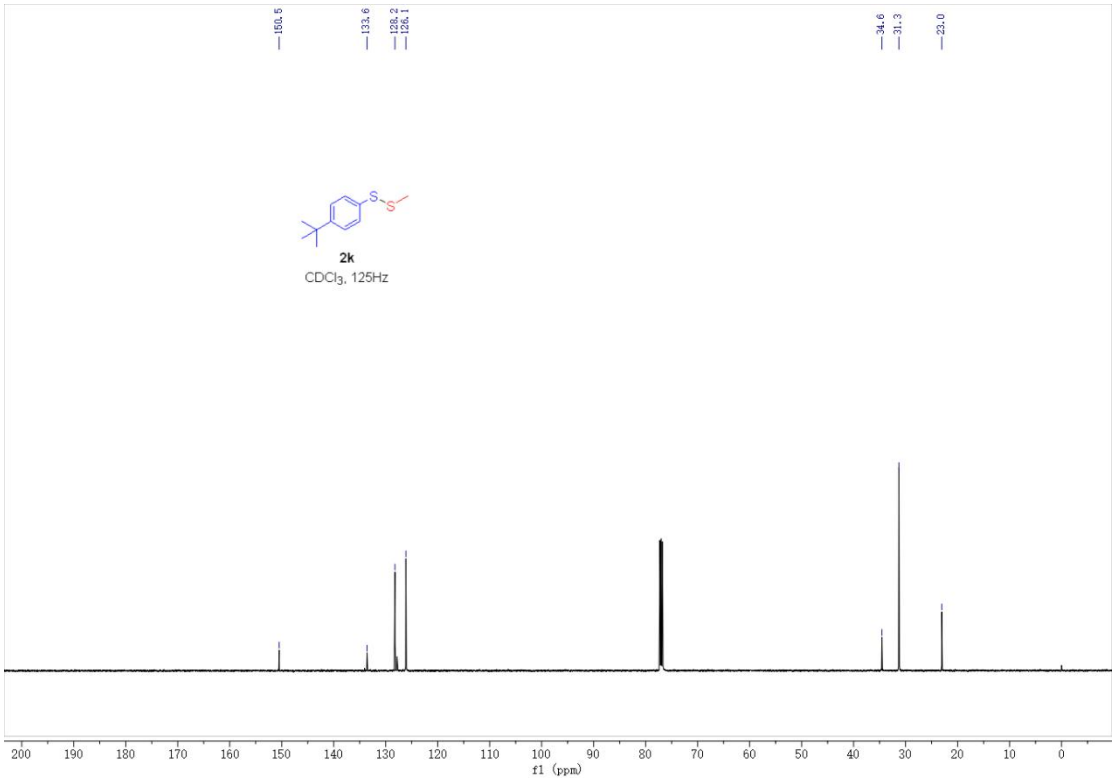

7.441
7.435
7.158
7.142
2.440
2.436
2i
CDCl3, 500Hz
2.00
2.07
3.01
3.09
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

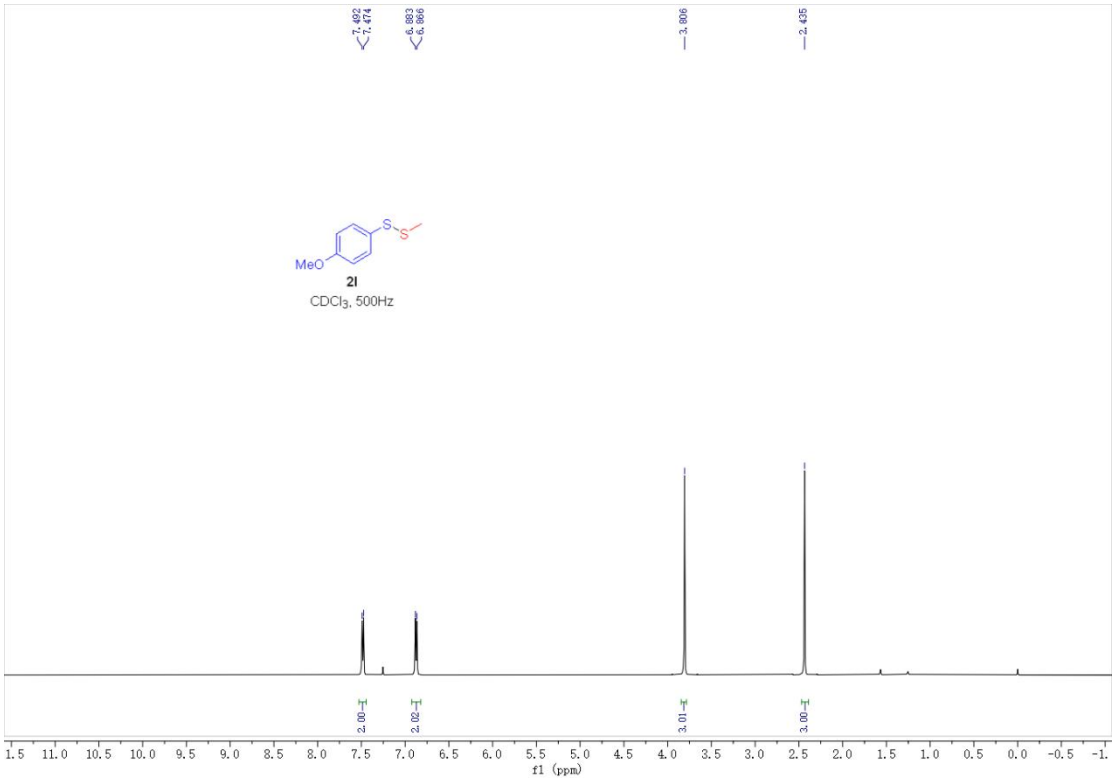

137.3
133.6
130.9
128.7
21.9
21.0
2i
CDCl3, 125Hz
f1 (ppm)

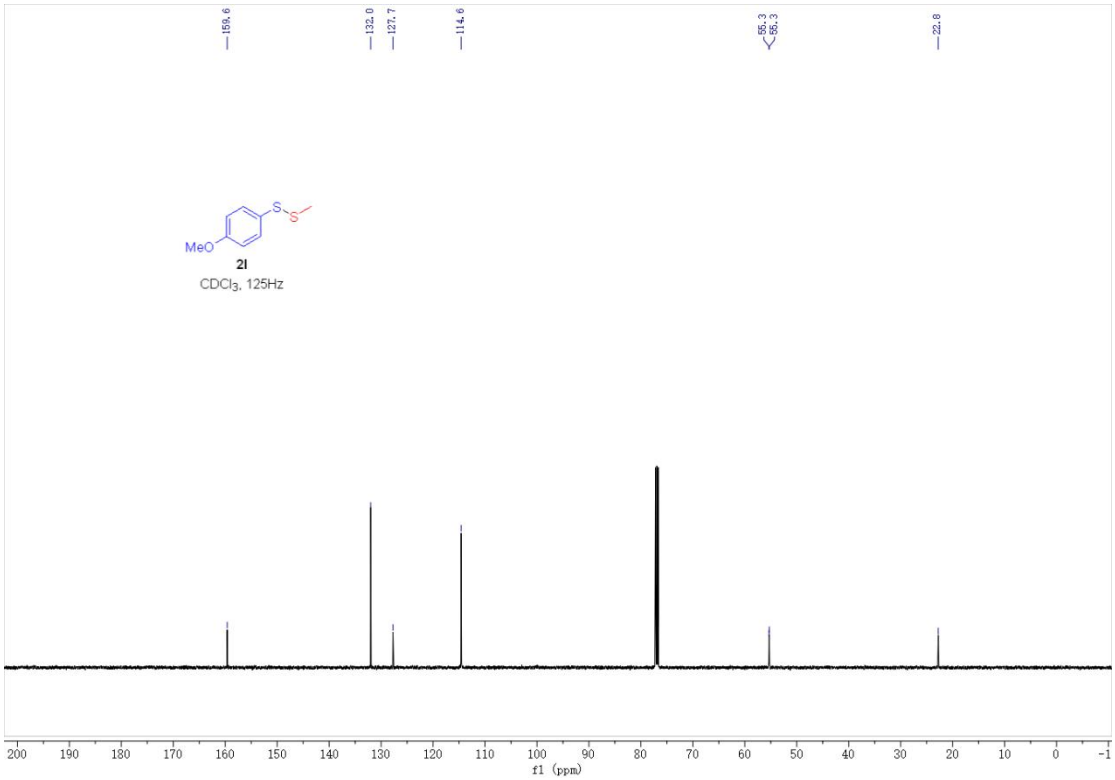

7.569
7.552
7.035
7.022
2.419
2.409
2.322
2j
CDCl3, 500Hz
1.00
2.08
6.02
2.90
f1 (ppm)

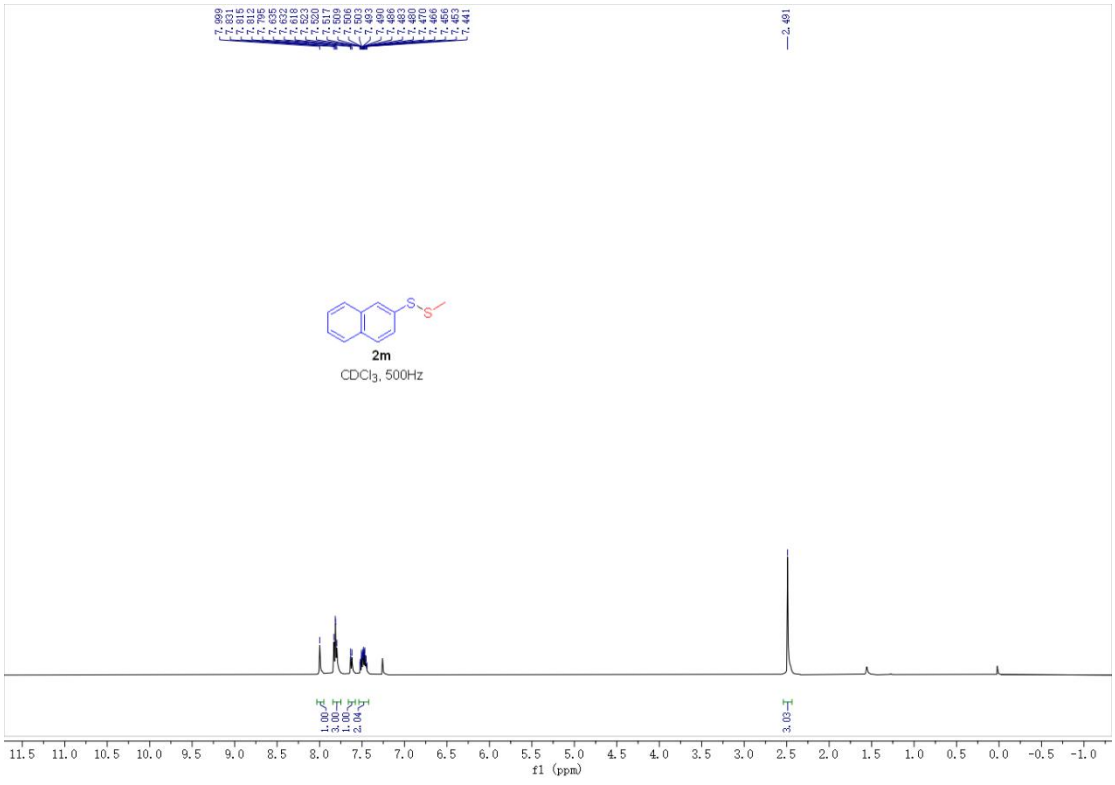

138.1
137.6
131.9
131.5
128.8
127.3
22.6
20.9
20.1
2j
CDCl3, 125Hz
f1 (ppm)

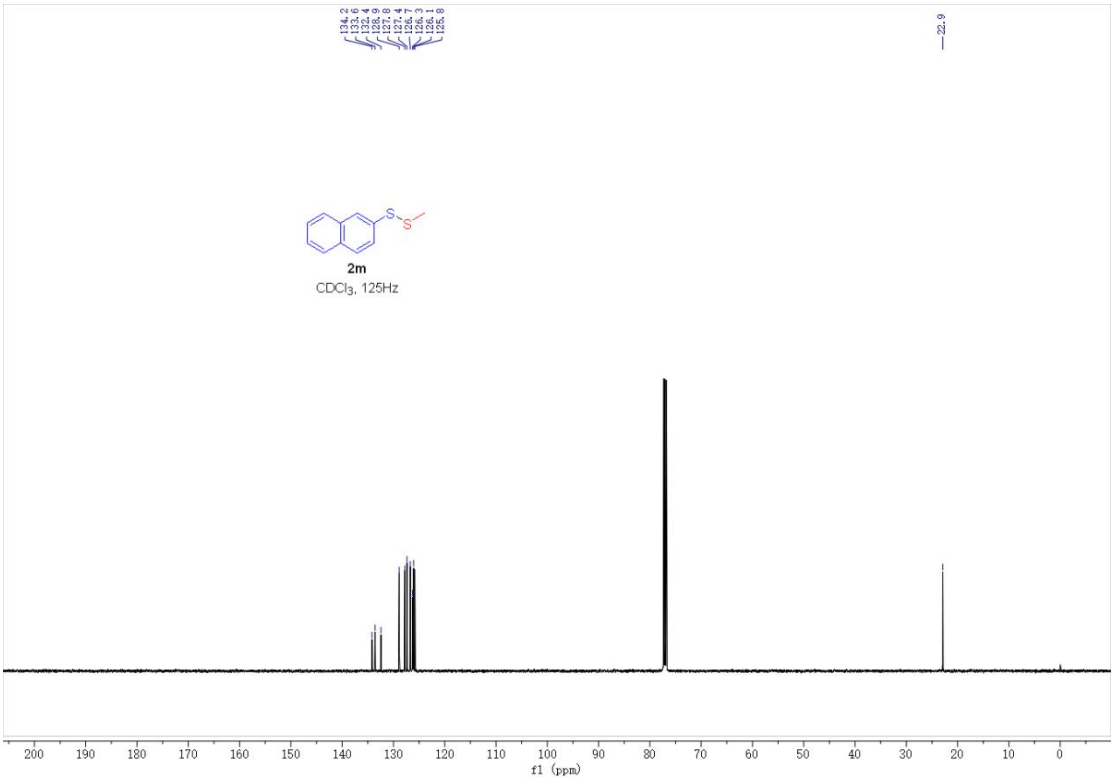

7.471
7.467
7.459
7.454
7.449
7.444
7.440
7.437
7.431
7.427
7.371
7.366
7.362
7.353
7.349
7.344
7.330
7.312
2.445
1.312
2k
CDCl3, 500Hz
2.02
2.08
3.00
9.05
f1 (ppm)

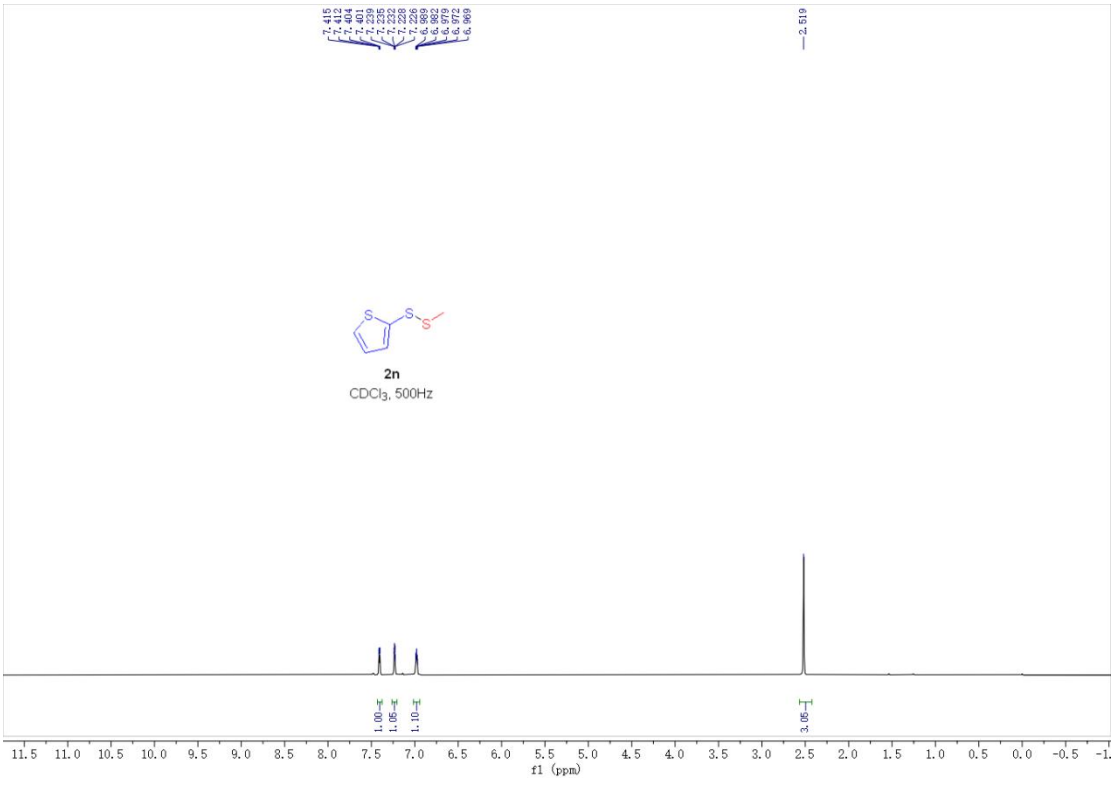

150.5
133.6
128.2
126.1
34.6
31.3
23.0
2k
CDCl3, 125Hz
f1 (ppm)

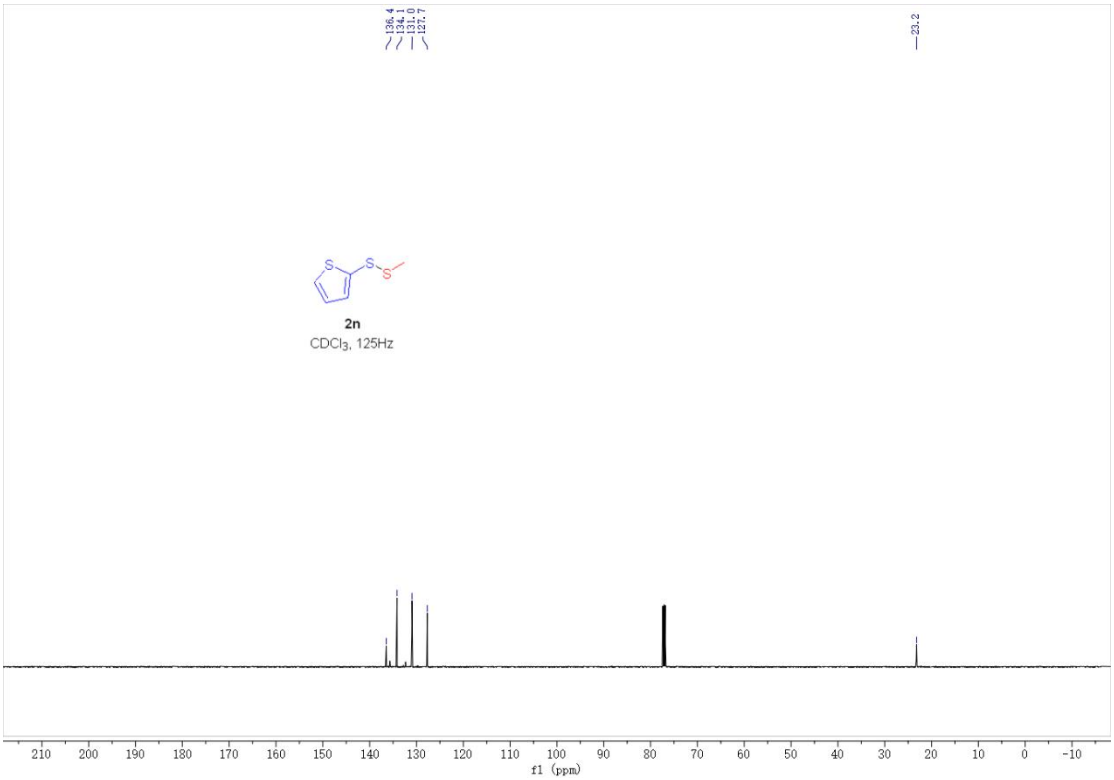

7.492
7.474
6.893
6.886
3.806
2.435
MeO
2l
CDCl3, 500Hz
2.00
2.02
3.01
3.00
f1 (ppm)

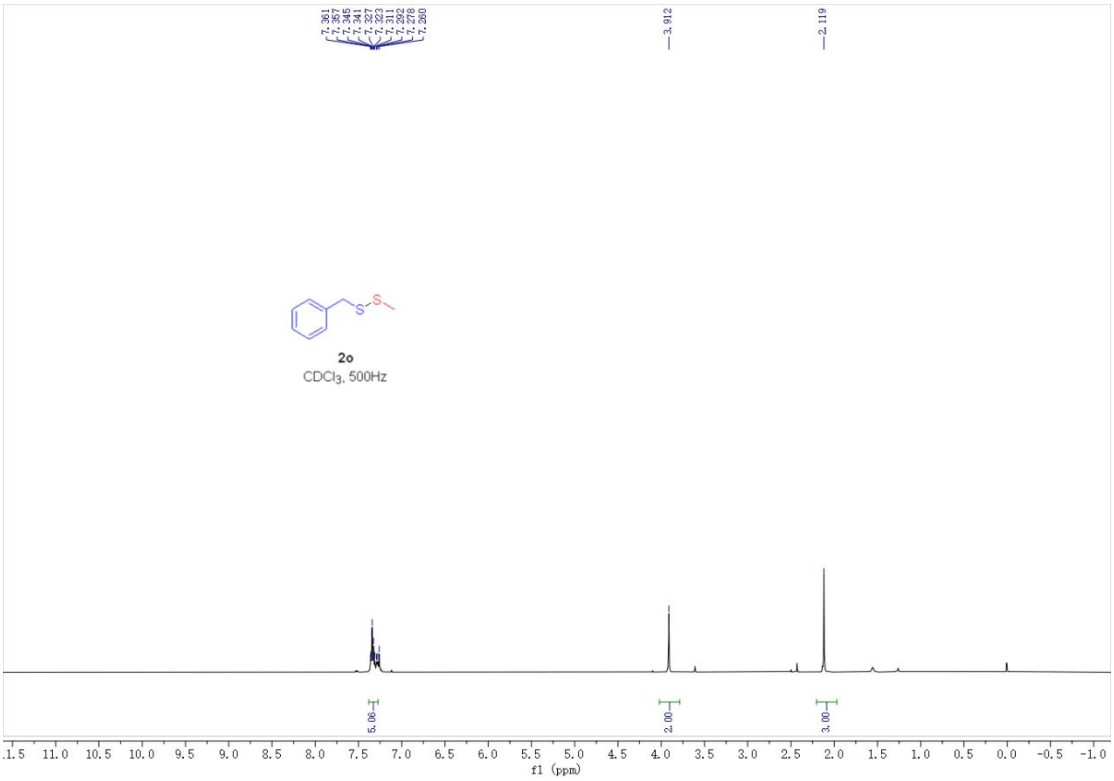

159.6
132.0
127.7
114.6
55.3
55.3
22.8
MeO
S
S
2l
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -1
f1 (ppm)

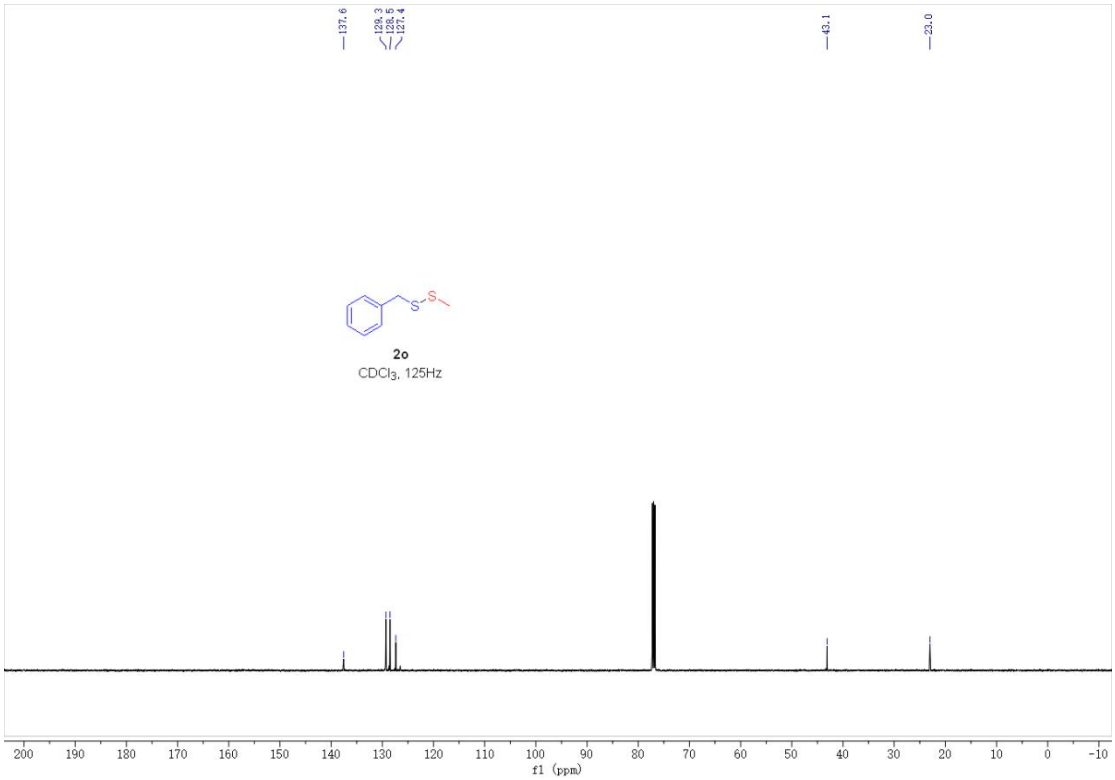

7.899
7.831
7.815
7.812
7.795
7.635
7.632
7.618
7.523
7.520
7.517
7.509
7.506
7.503
7.493
7.490
7.486
7.483
7.480
7.470
7.466
7.456
7.453
7.441
2.491
S
S
2m
CDCl3, 500Hz
1.00
1.00
1.00
2.04
3.03
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

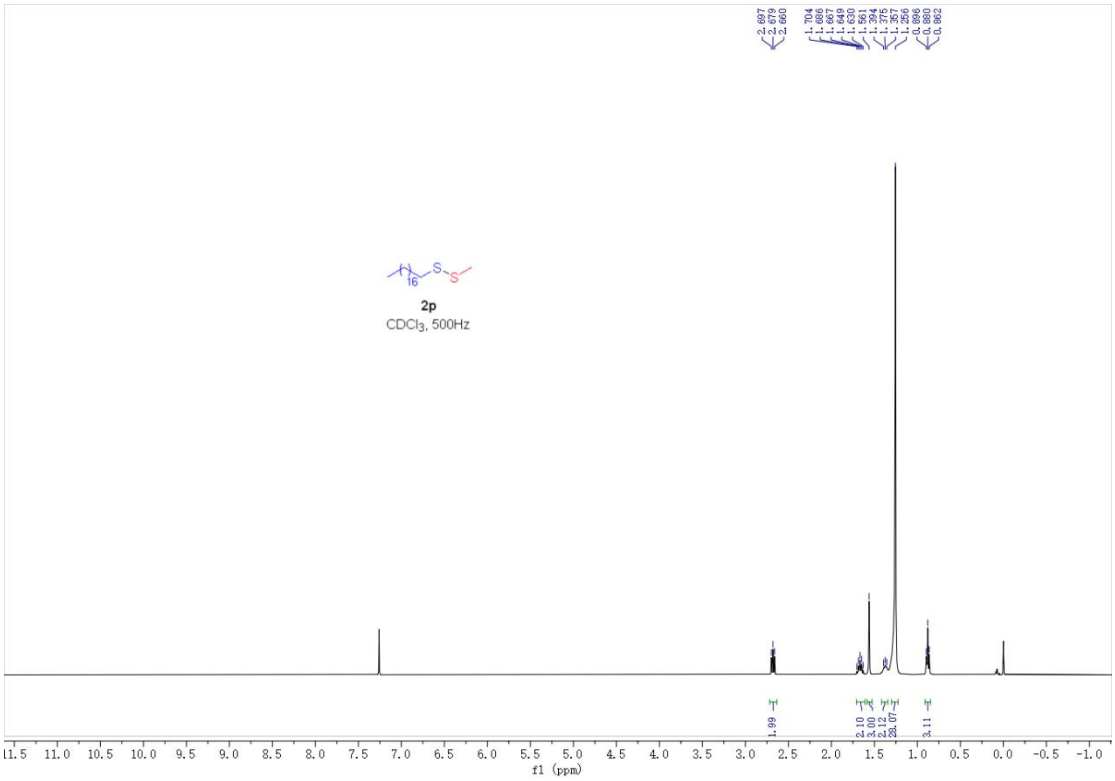

134.2
133.6
132.4
128.9
127.8
127.4
126.7
126.3
126.1
125.8
22.9
2m
CDCl3, 125Hz
f1 (ppm)

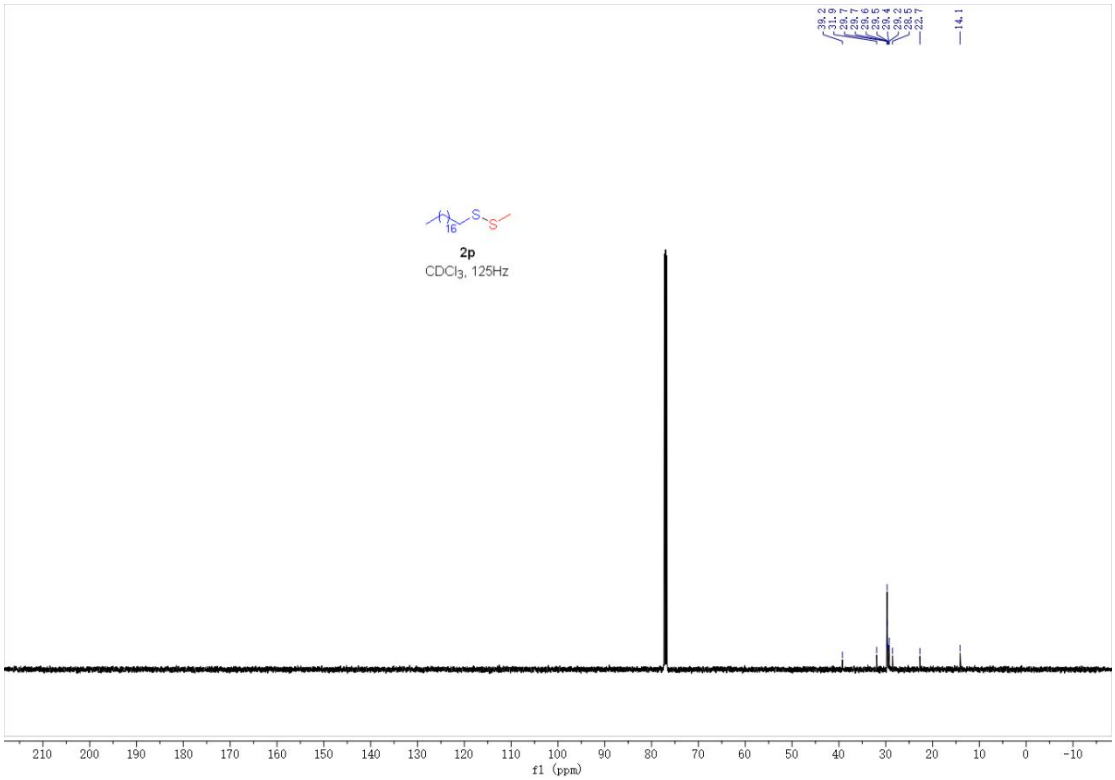

7.415
7.412
7.404
7.401
7.239
7.235
7.232
7.228
7.226
6.989
6.982
6.979
6.972
6.969
2.519
2n
CDCl3, 500Hz
1.00
1.05
1.10
3.05
f1 (ppm)

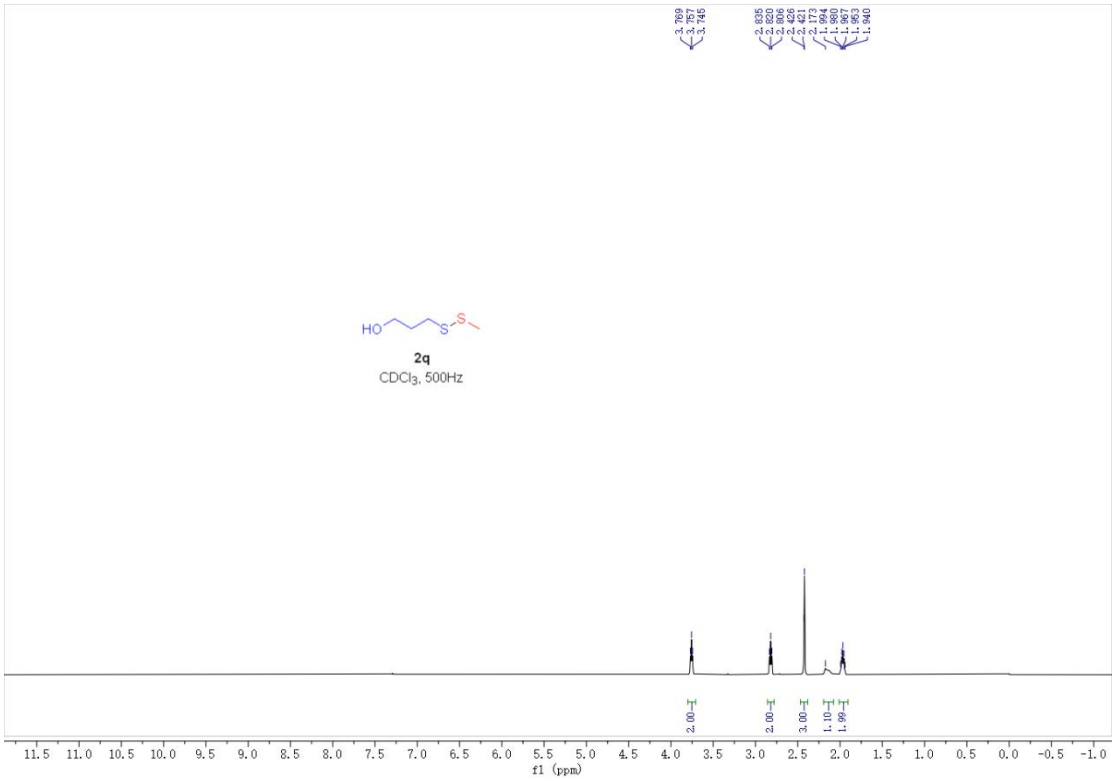

136.4
134.1
131.0
127.7
23.2
2n
CDCl3, 125Hz
f1 (ppm)

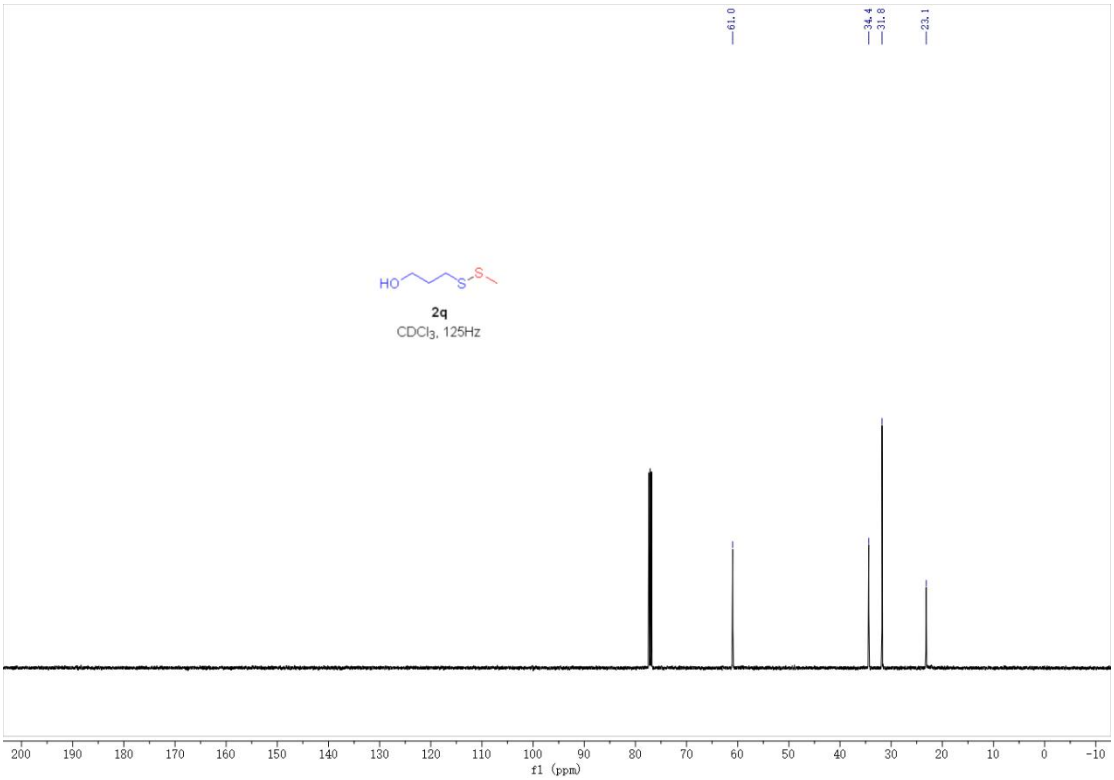

7.361
7.357
7.345
7.341
7.327
7.323
7.311
7.292
7.278
7.280
3.912
2.119
2o
CDCl3, 500Hz
5.06
2.00
3.00
f1 (ppm)

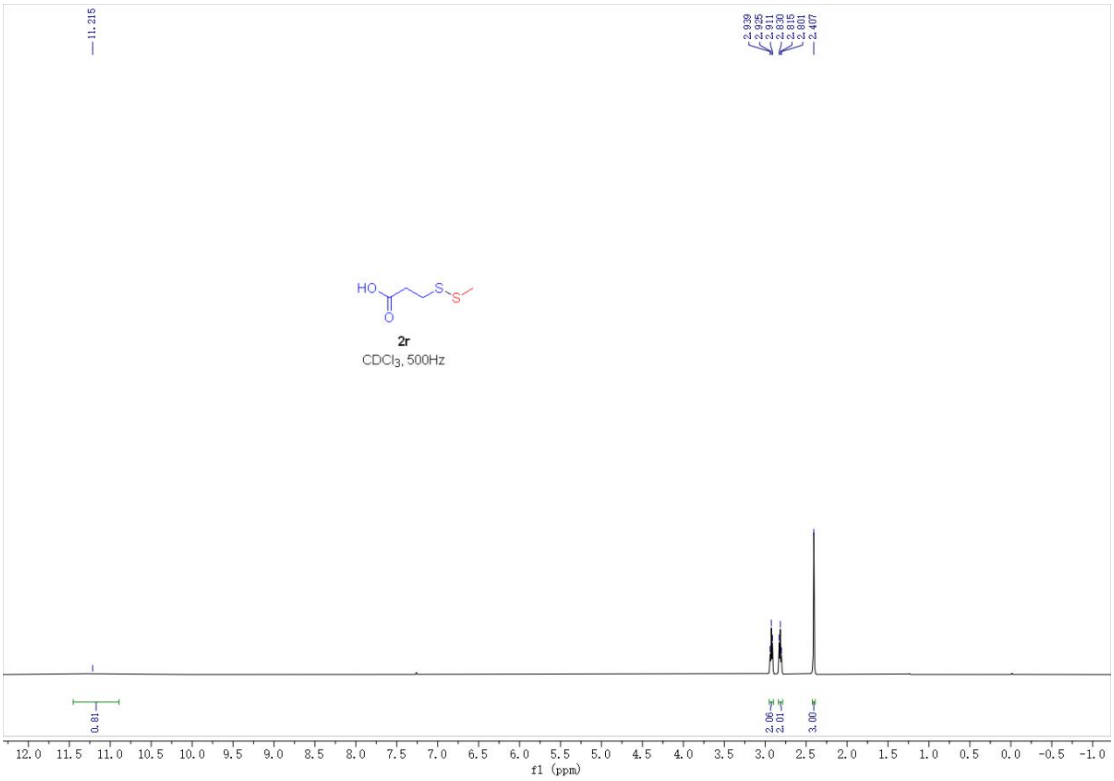

137.6
129.3
128.5
127.4
43.1
23.0
2o
CDCl3, 125Hz
f1 (ppm)

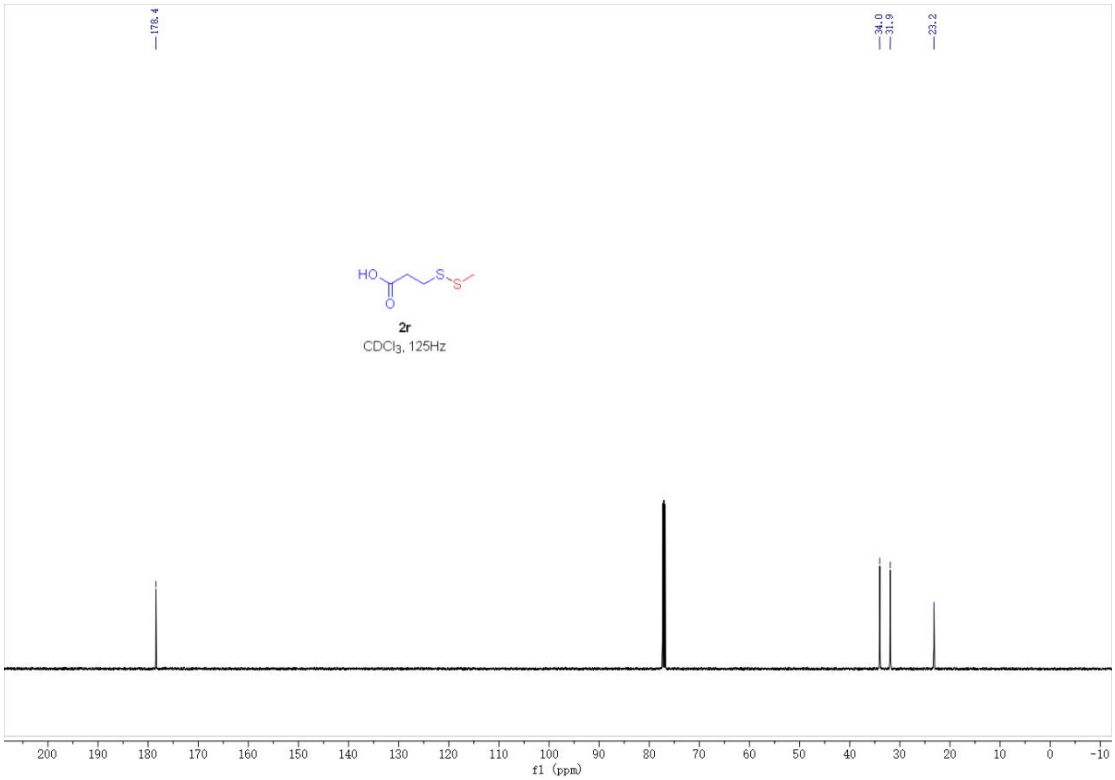

2p
CDCl3, 500Hz
1.99
2.10
2.09
2.17
28.07
3.11
f1 (ppm)

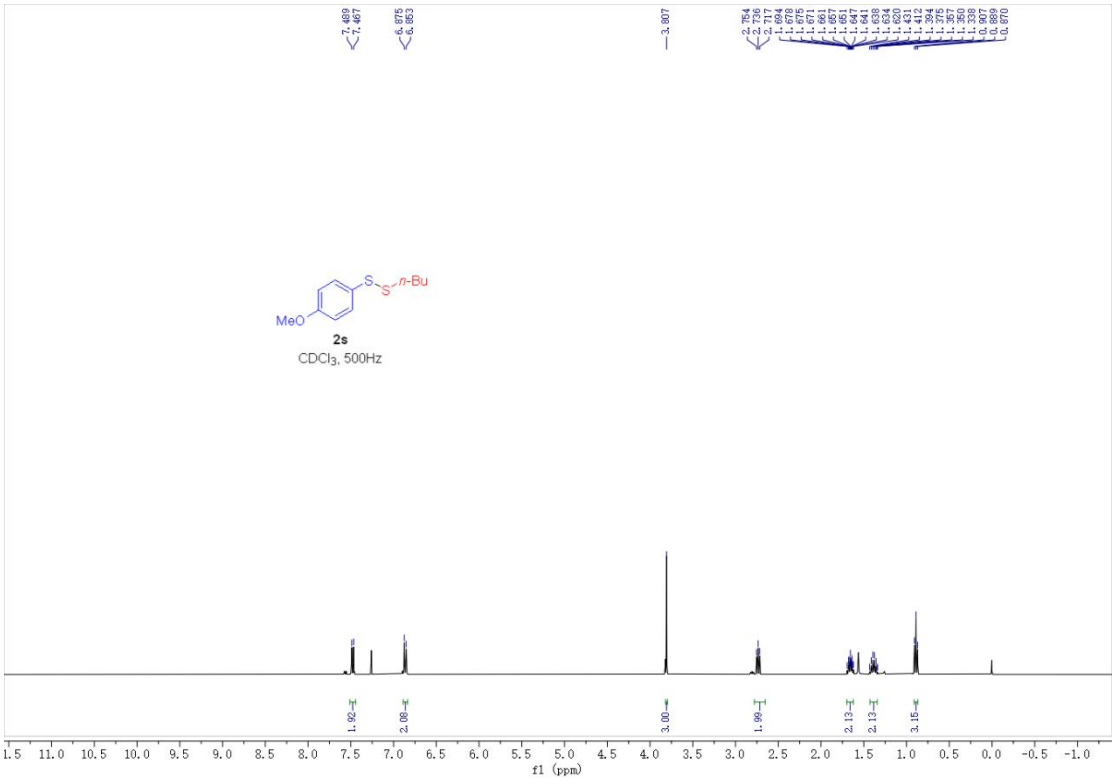

39.2
31.9
29.7
29.6
29.5
29.4
29.2
28.5
22.7
14.1
16
S
S
2p
CDCl3, 125Hz
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

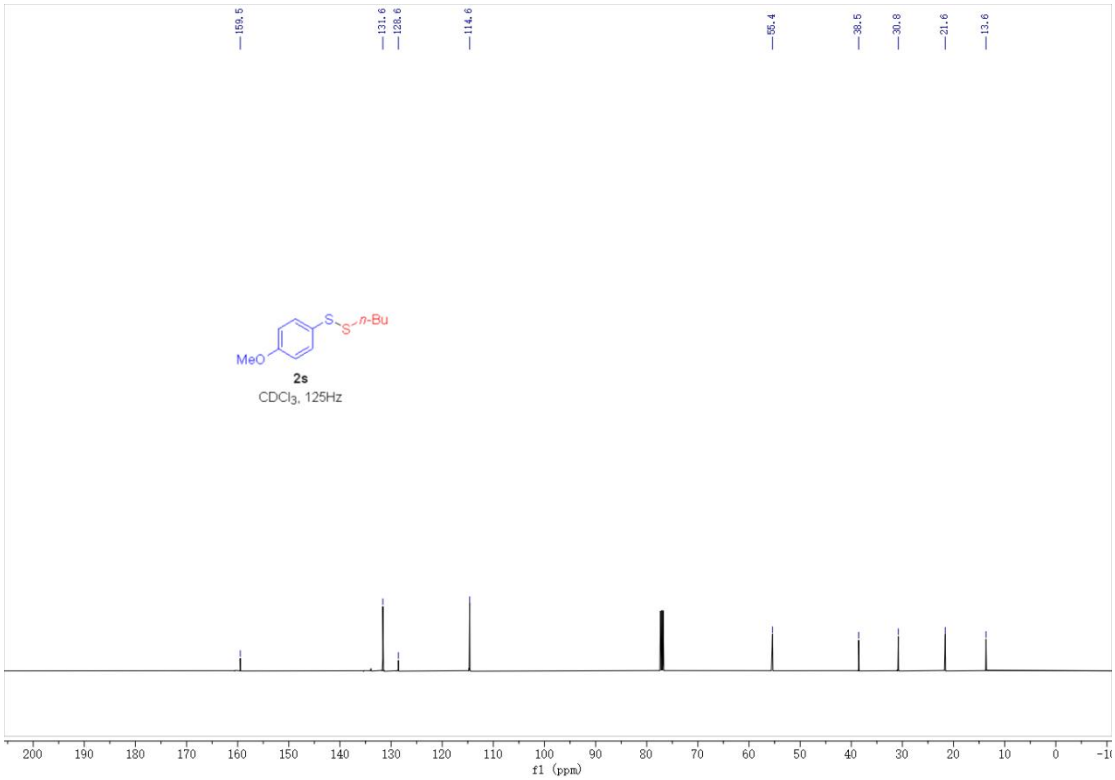

3.769
3.757
3.746
2.805
2.800
2.796
2.426
2.421
2.417
1.994
1.980
1.967
1.955
1.940
HO
S
S
2q
CDCl3, 500Hz
2.00
2.00
3.00
1.10
1.99
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

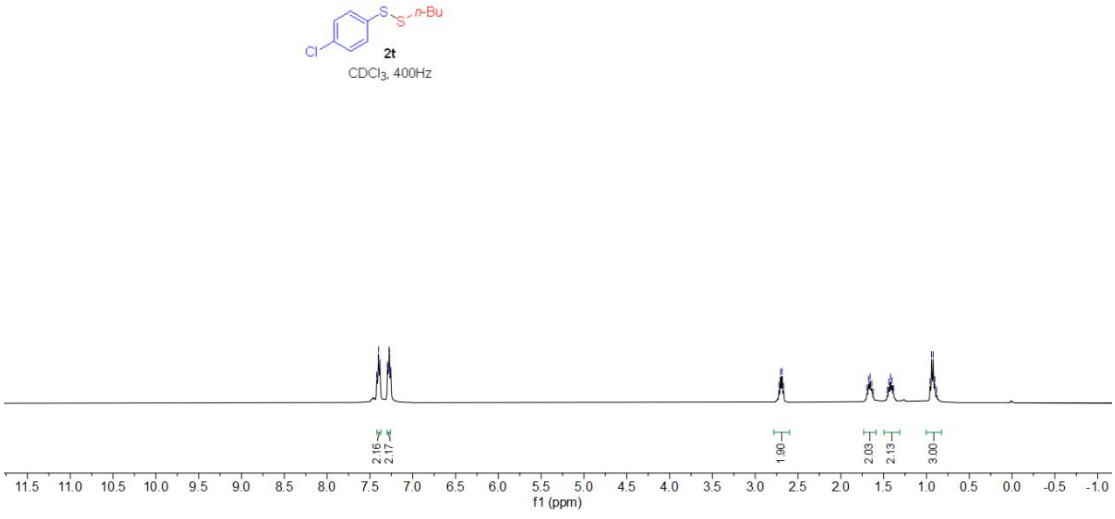

61.0
34.4
31.8
23.1
HO
S
S
2q
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

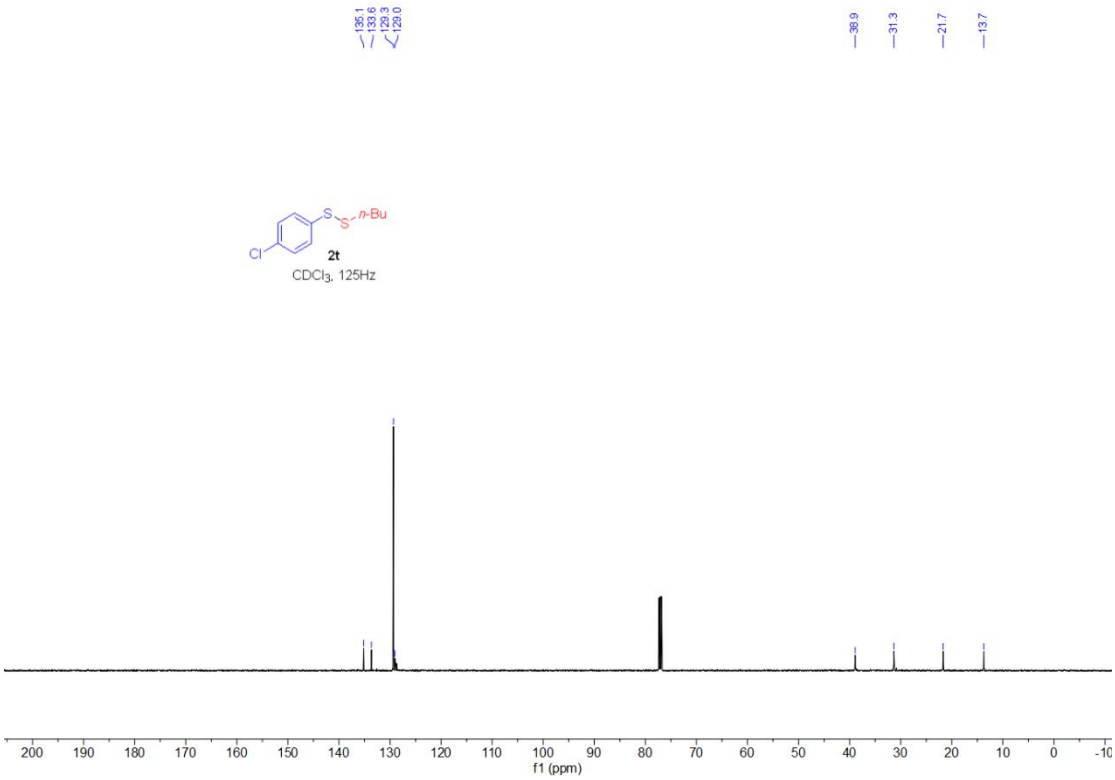

11.215
2.939
2.925
2.911
2.830
2.815
2.801
2.407
HO
O
S
S
2r
CDCl3, 500Hz
0.81
2.06
2.01
3.00
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

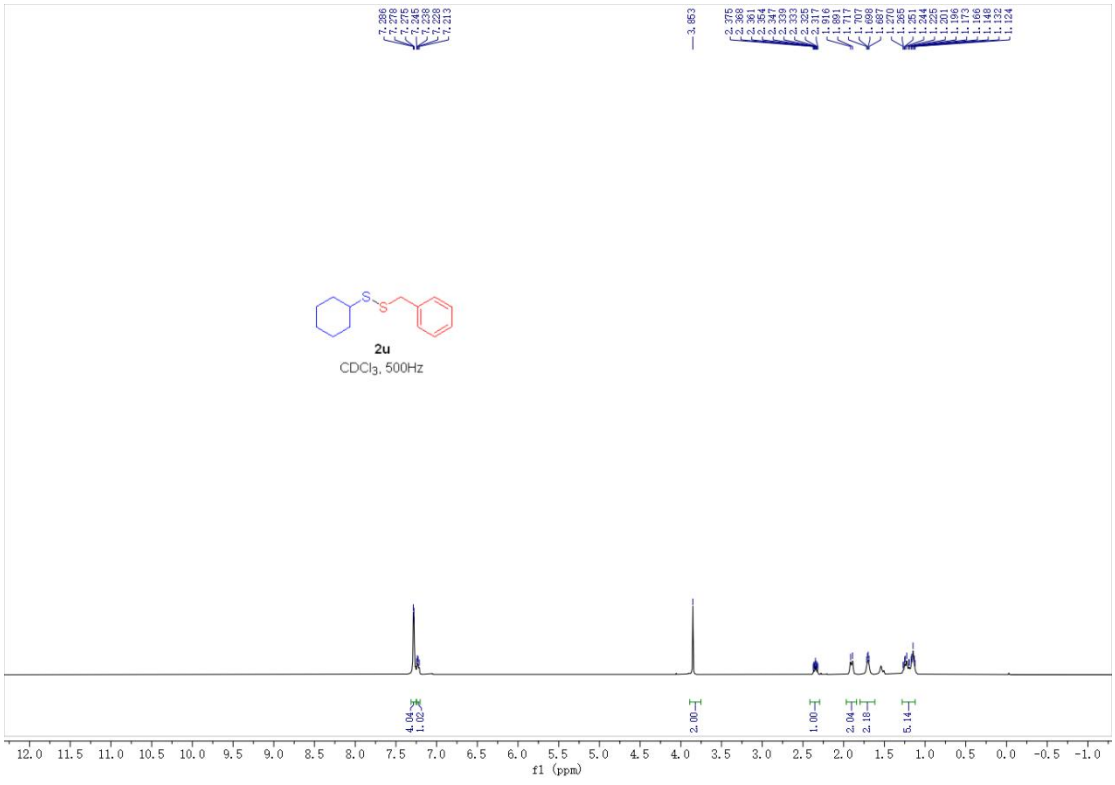

178.4
34.0
31.9
23.2
HO
O
S
S
2r
CDCl3, 125Hz
f1 (ppm)

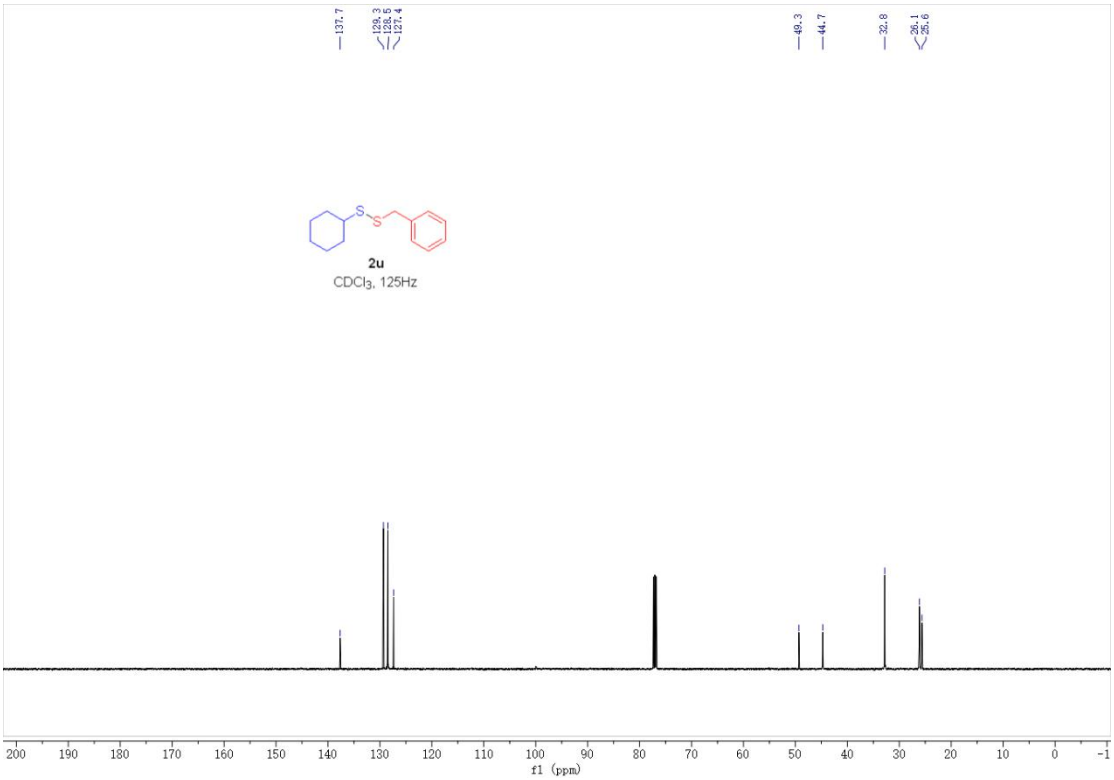

7.489
7.467
6.875
6.853
3.807
n-Bu
MeO
2s
CDCl3, 500Hz
1.92
2.08
3.00
1.99
2.13
2.13
3.15
f1 (ppm)

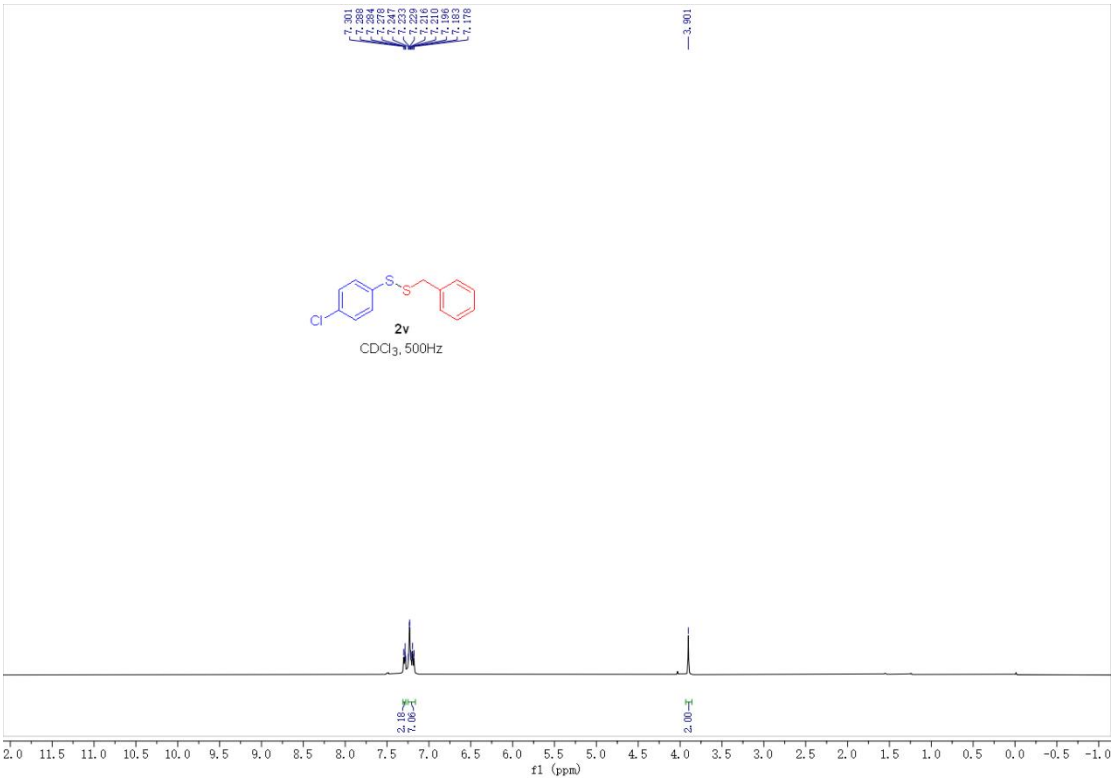

159.5
131.6
128.6
114.6
55.4
39.5
30.8
21.6
13.6
MeO
S
S
n-Bu
2s
CDCl3, 125Hz
f1 (ppm)
7.421
7.416
7.403
7.399
7.388
7.382
7.295
7.289
7.277
7.273
7.261
7.255
2.722
2.704
2.696
2.688
1.695
1.676
1.658
1.640
1.620
1.457
1.439
1.421
1.402
1.391
1.384
0.958
0.940
0.922
0.903
0.881

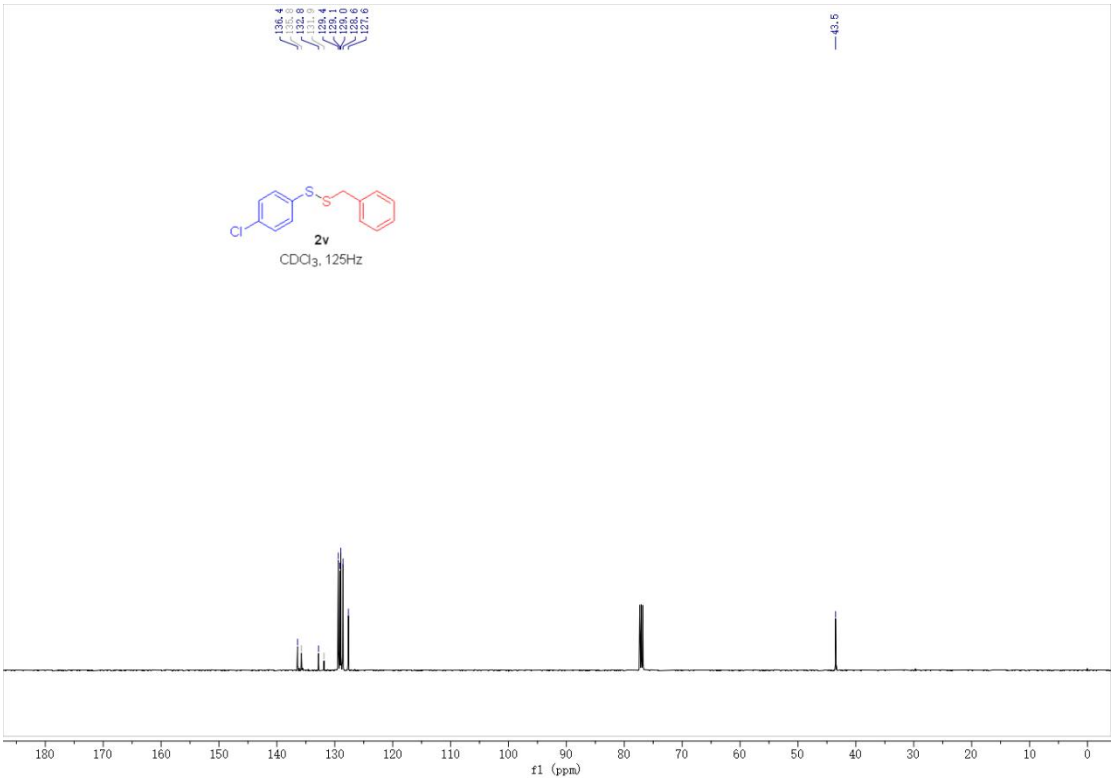

Cl
S
S
n-Bu
2t
CDCl3, 400Hz
2.16
2.17
1.90
2.03
2.13
3.00
f1 (ppm)

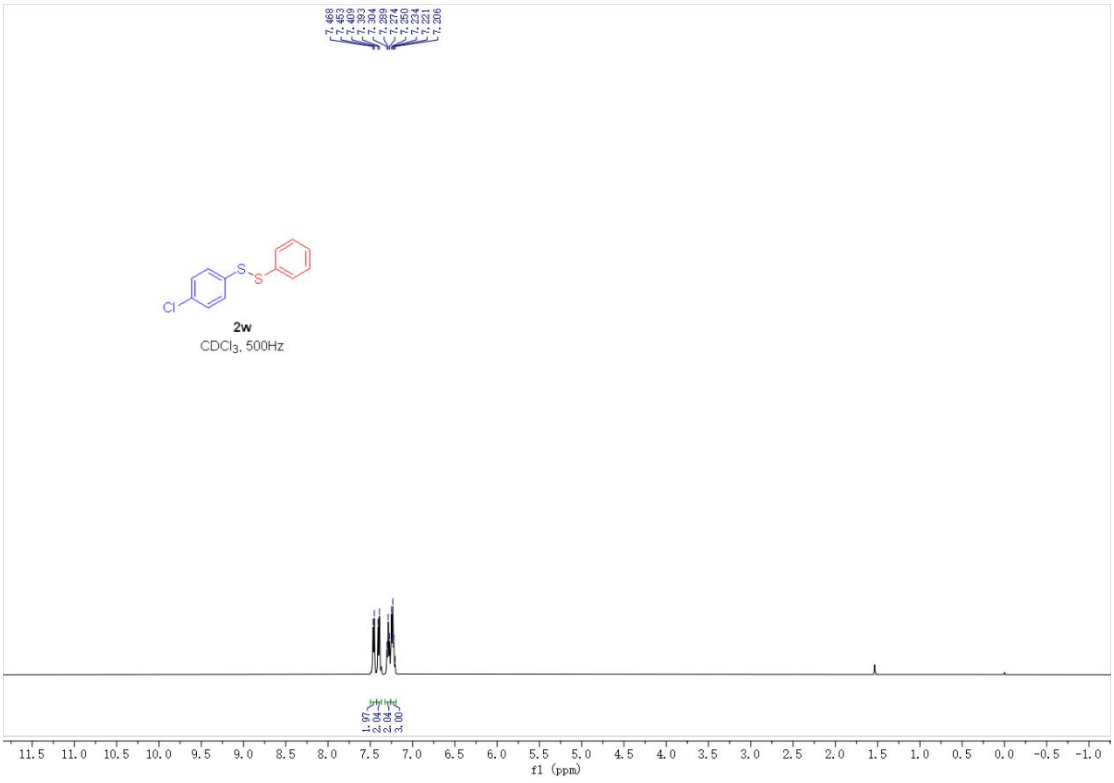

135.1
133.6
129.3
129.0
38.9
31.3
21.7
13.7
S
S
n-Bu
Cl
2t
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

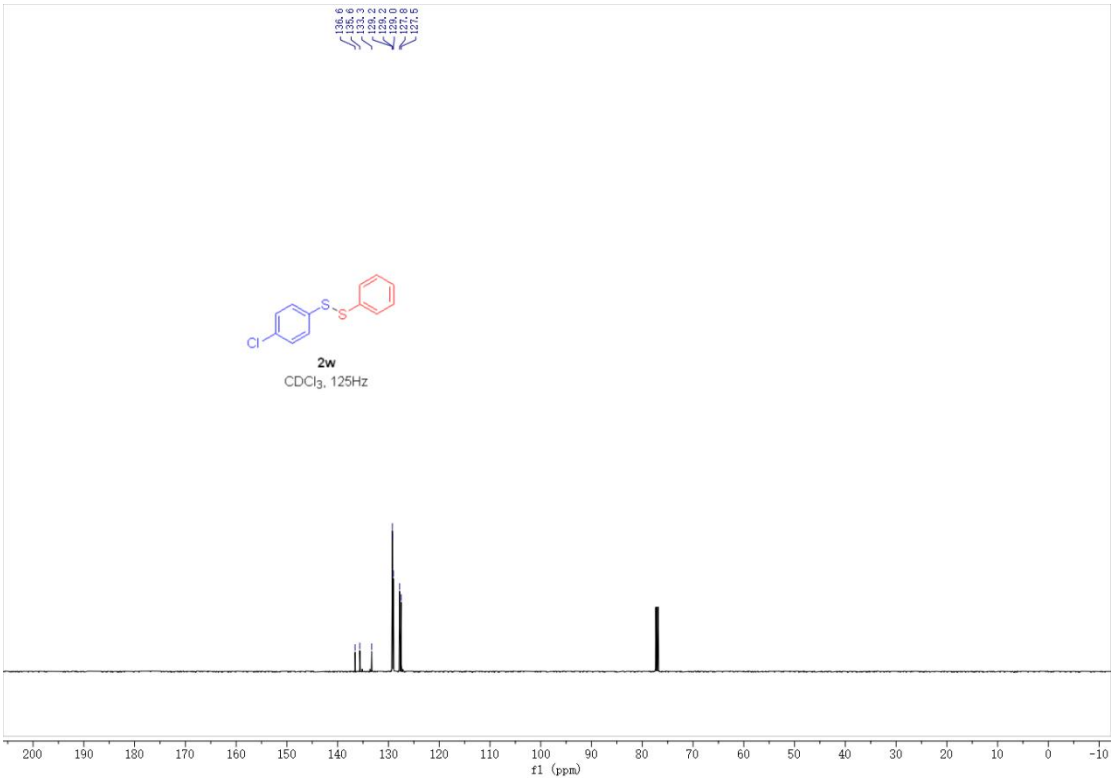

7.286
7.278
7.275
7.245
7.238
7.218
7.213
3.853
2.375
2.368
2.361
2.354
2.347
2.339
2.333
2.325
2.317
1.891
1.717
1.707
1.698
1.687
1.270
1.265
1.251
1.244
1.225
1.201
1.196
1.173
1.166
1.148
1.132
1.124
S
S
2u
CDCl3, 500Hz
4.04
1.02
2.00
1.00
2.04
2.18
5.14
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 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 -0.5 -1.0
f1 (ppm)


137.7
129.3
128.5
127.4
49.3
44.7
32.8
26.1
25.6
2u
CDCl3, 125Hz
f1 (ppm)


7.301
7.288
7.284
7.278
7.277
7.233
7.229
7.216
7.210
7.196
7.183
7.178
3.901
2v
CDCl3, 500Hz
2.18
7.06
2.00
f1 (ppm)

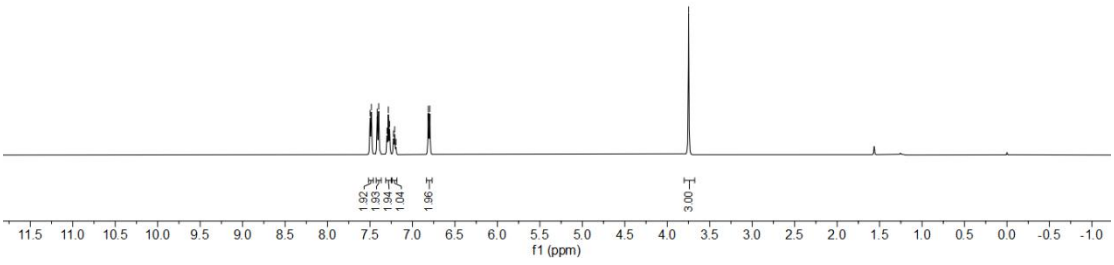

136.4
132.8
131.9
129.4
129.1
129.0
128.6
127.6
43.5
2v
CDCl3, 125Hz
f1 (ppm)

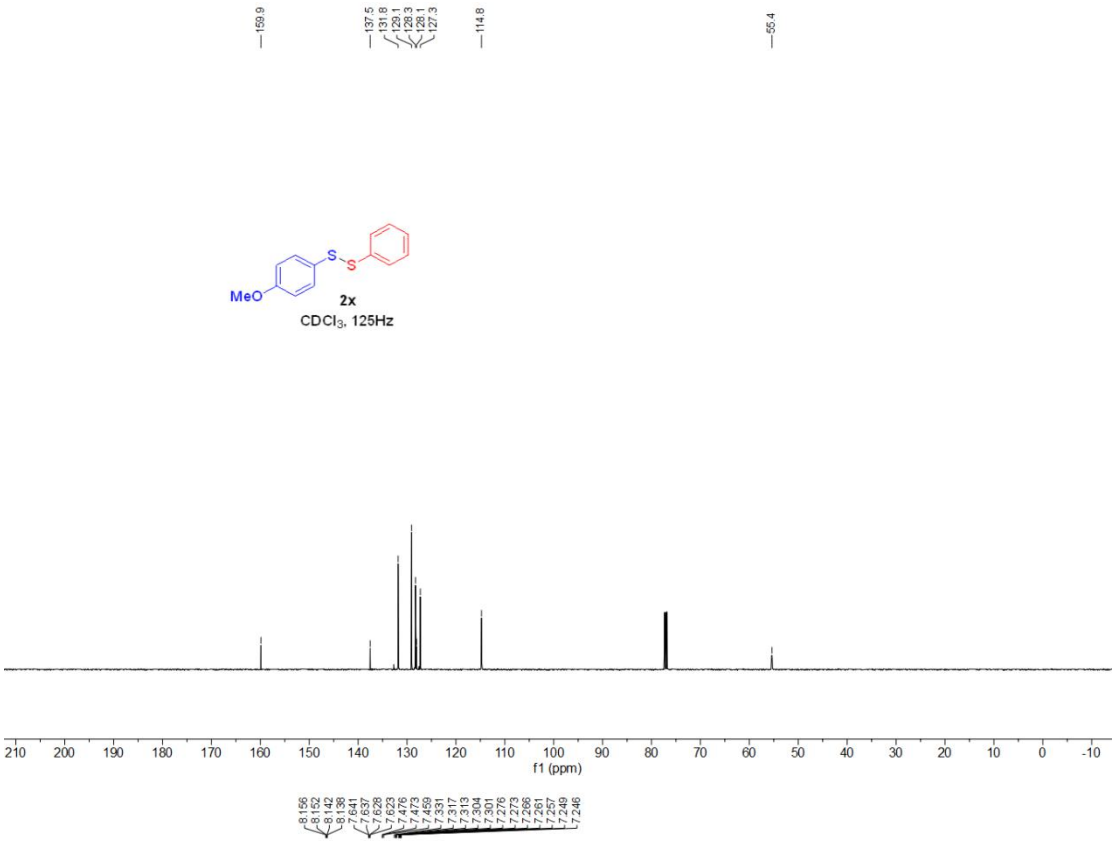

7.468
7.463
7.459
7.393
7.304
7.289
7.274
7.250
7.234
7.221
7.306
1.97
1.04
2.04
3.00
2w
CDCl3, 500Hz
f1 (ppm)

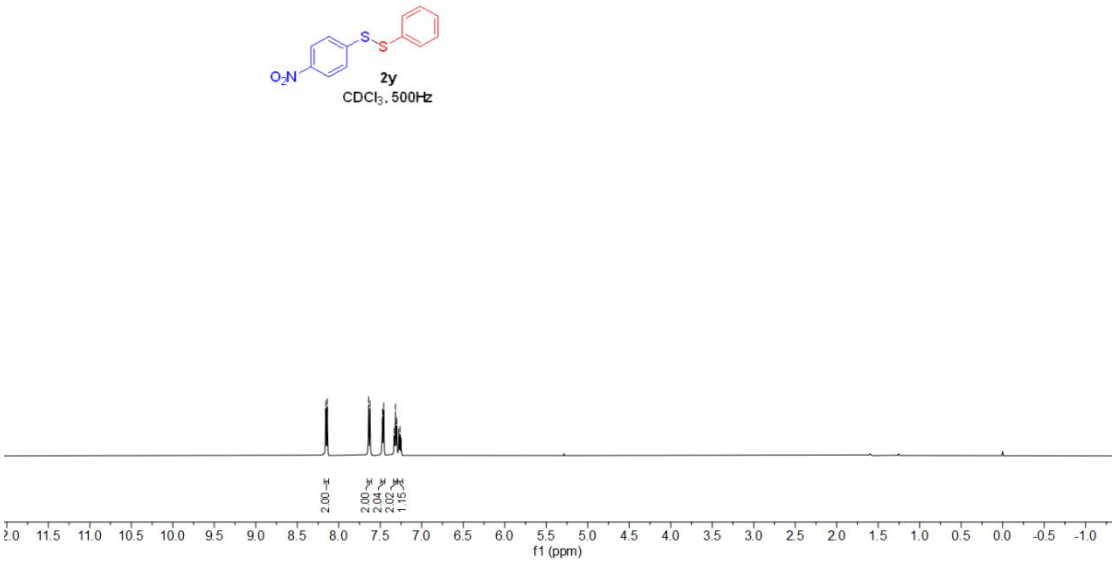

136.6
135.6
133.3
129.2
129.2
129.0
128.8
127.5
Cl
S
S
2w
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

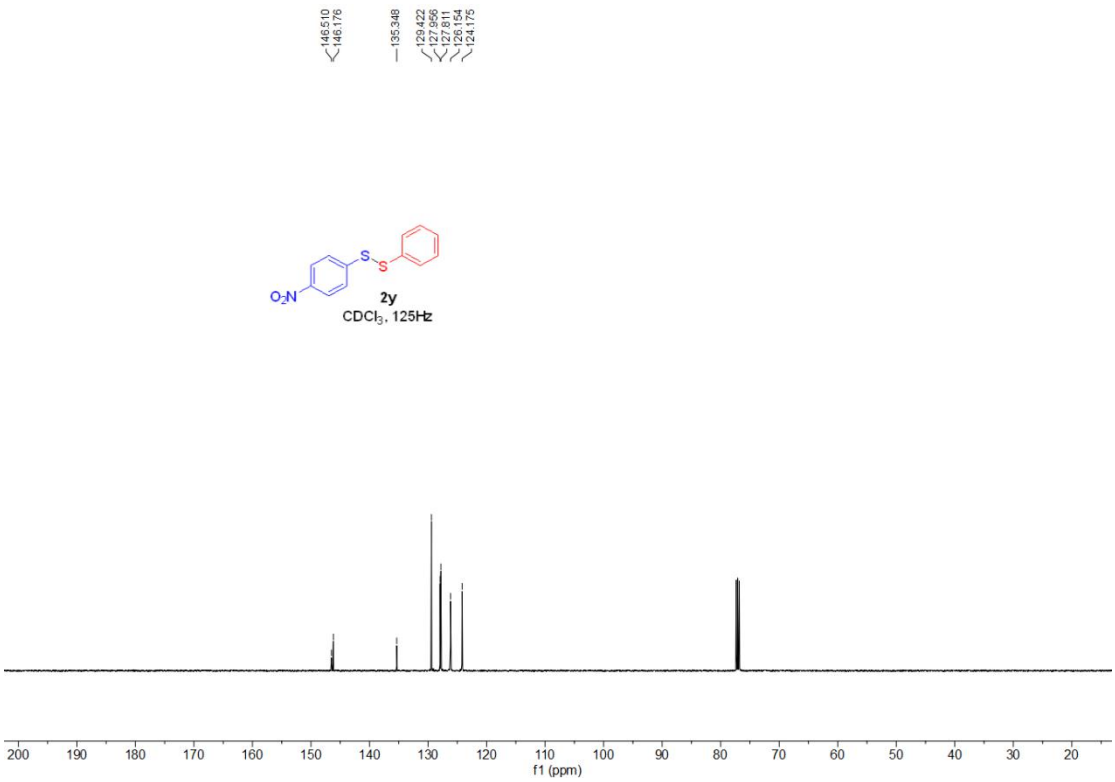

7.499
7.484
7.416
7.412
7.398
7.300
7.285
7.270
7.224
7.210
7.195
6.814
6.811
6.796
3.748

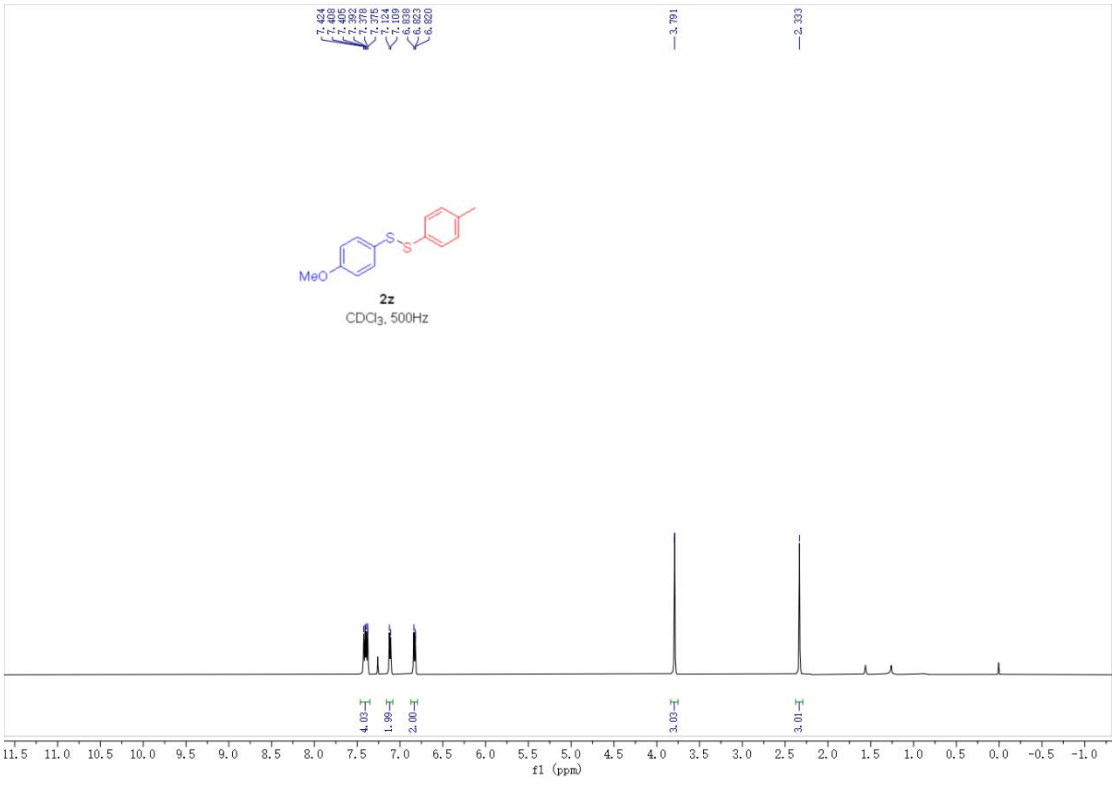

MeO
S
S
2x
CDCl3, 500Hz

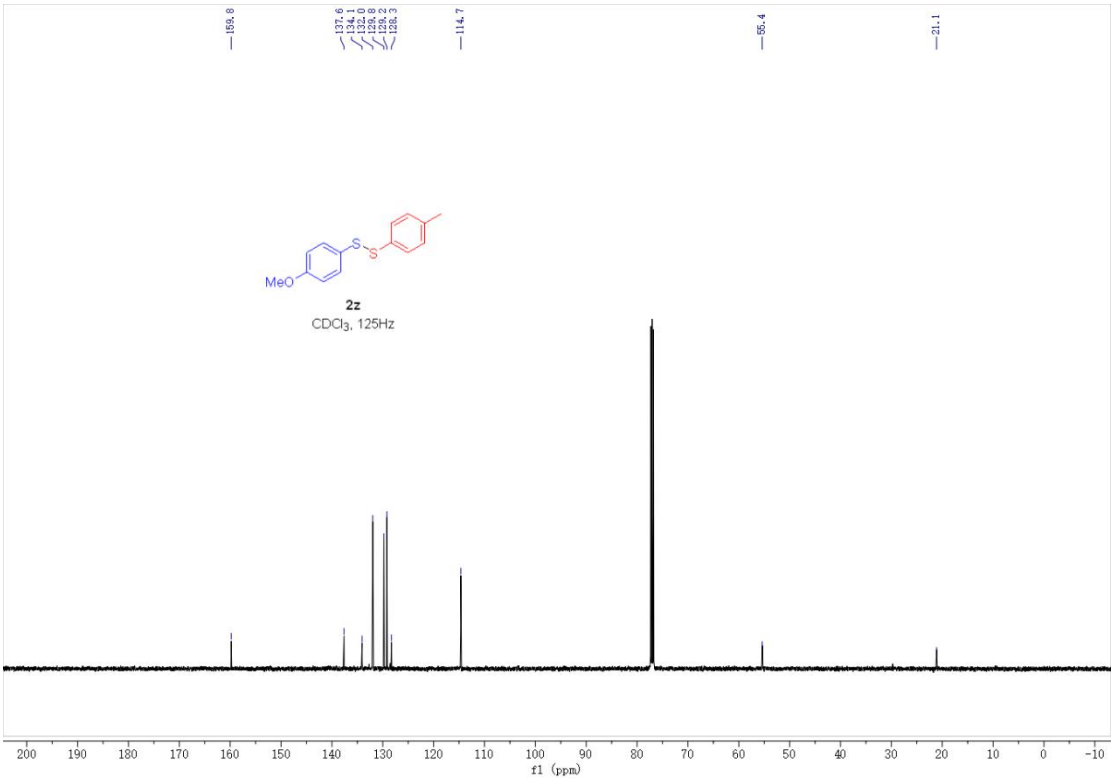

1.92
1.93
1.94
1.04
1.96
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

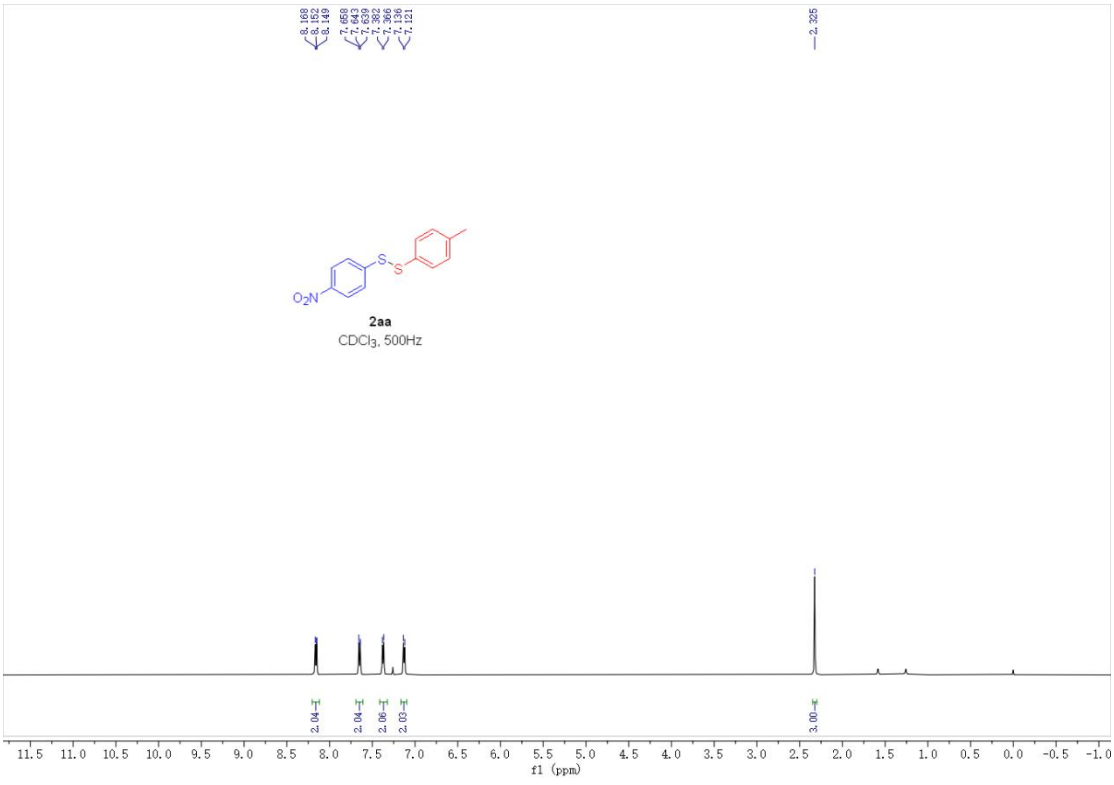

159.9
137.5
131.8
129.1
128.3
128.1
127.3
114.8
55.4
MeO
S
S
2x
CDCl3, 125Hz
f1 (ppm)
8.156
8.152
8.142
8.138
7.641
7.637
7.628
7.623
7.476
7.473
7.459
7.331
7.317
7.313
7.304
7.301
7.276
7.273
7.266
7.261
7.257
7.249
7.246

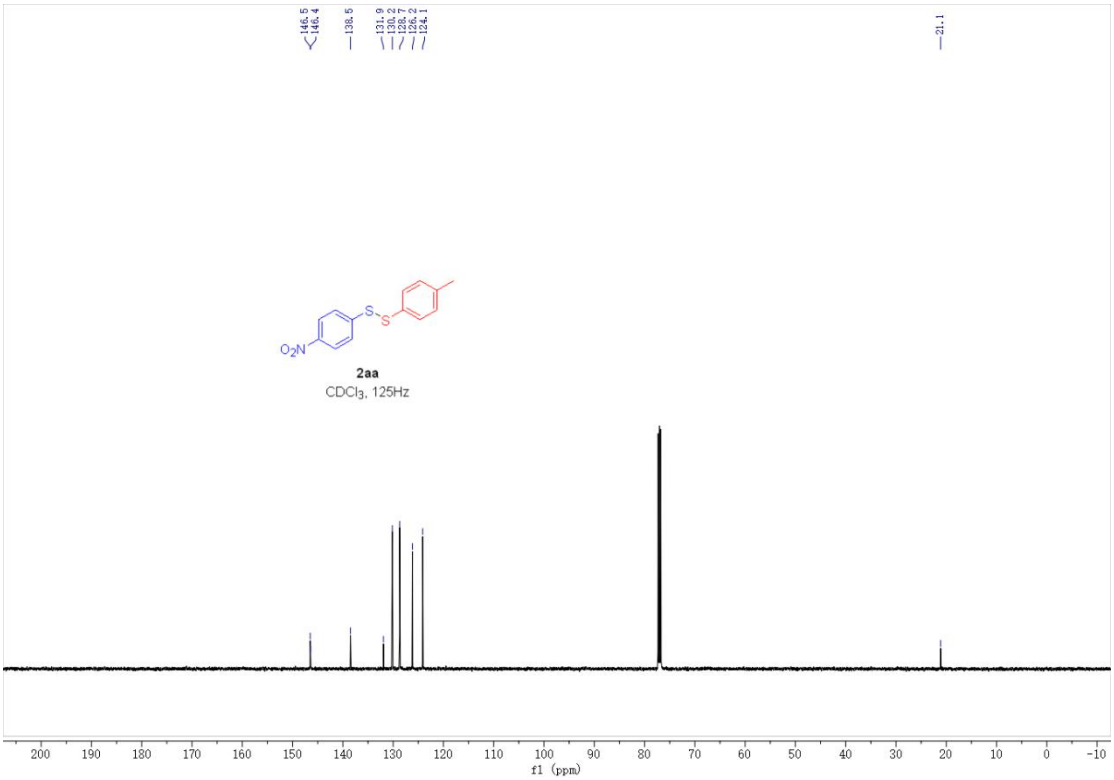

O2N
S
S
2y
CDCl3, 500Hz
2.00
2.00
2.04
2.02
1.15
f1 (ppm)

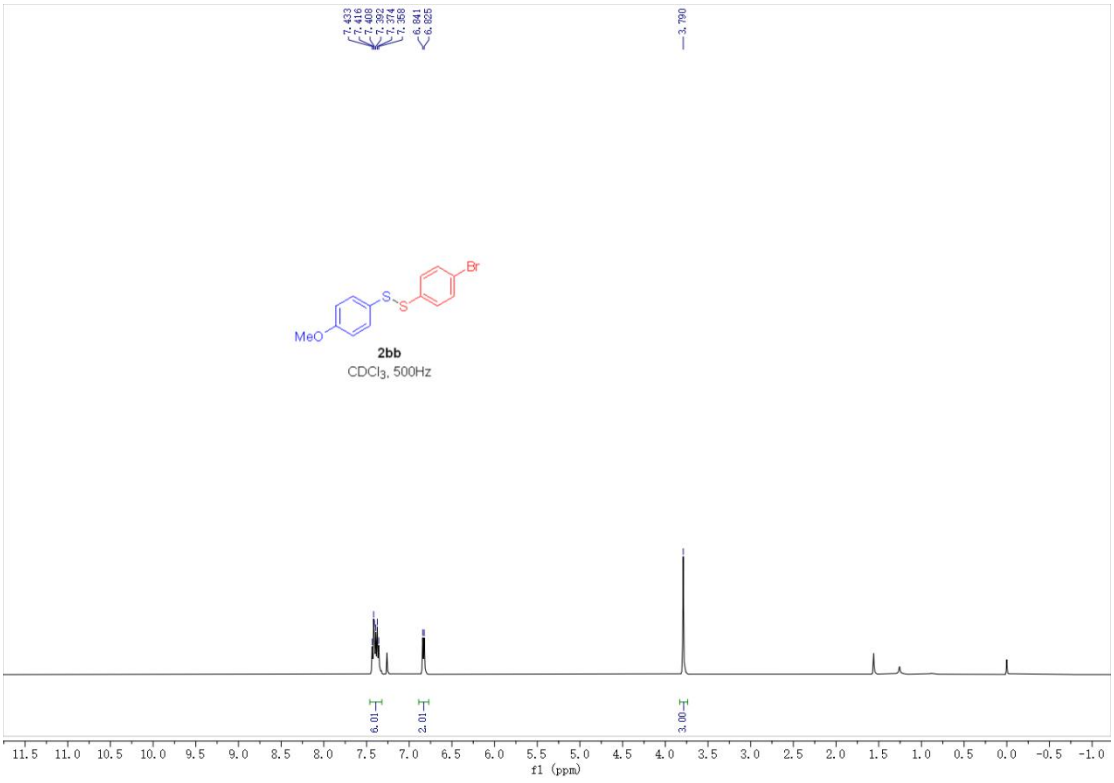

146.510
146.176
135.348
129.422
127.956
127.811
126.154
124.175
O2N
S
S
2y
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20
f1 (ppm)

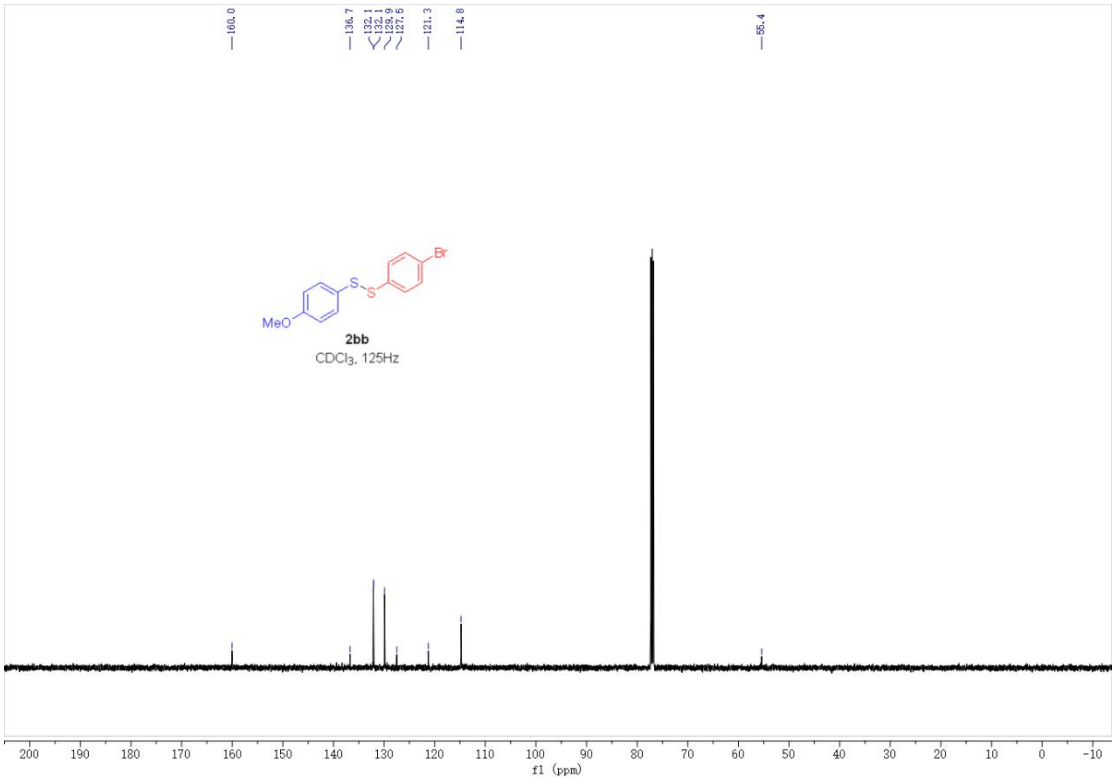

7.424
7.408
7.406
7.392
7.376
7.375
7.124
7.109
6.838
6.823
6.820
3.791
2.333
MeO
S
S
2z
CDCl3, 500Hz
4.03
1.99
2.00
3.03
3.01
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

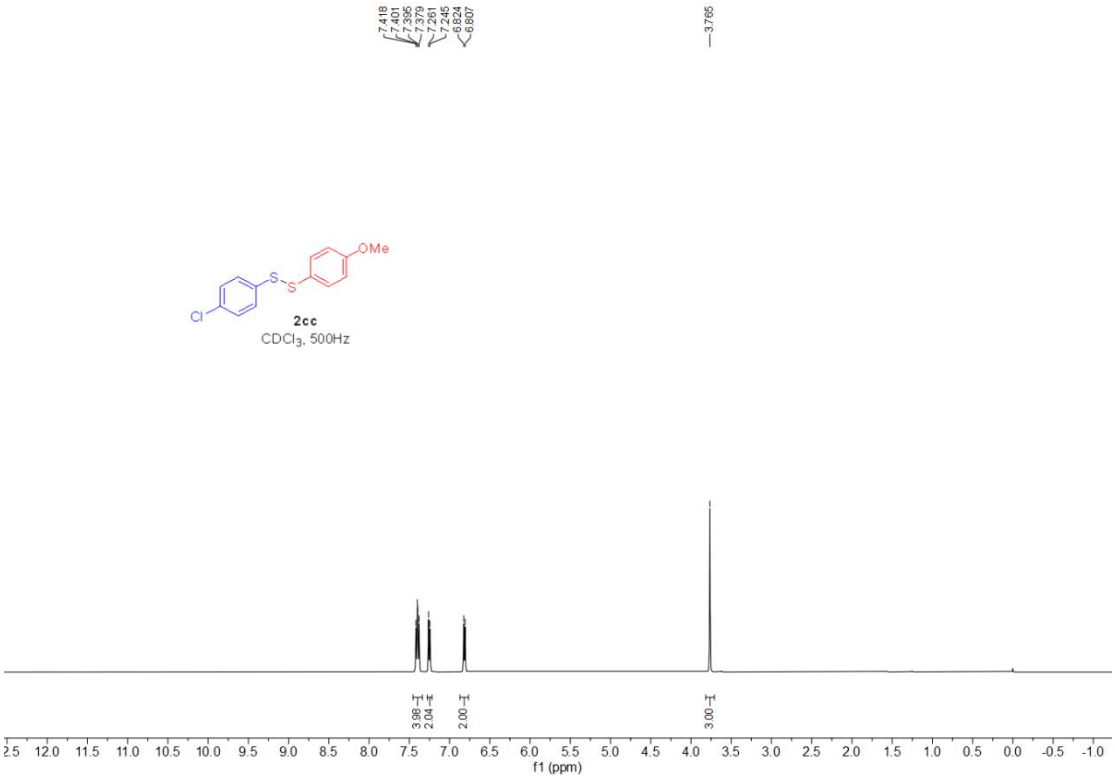

159.8
137.6
134.1
132.1
129.8
129.2
128.3
114.7
55.4
21.1
MeO
S
S
2z
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

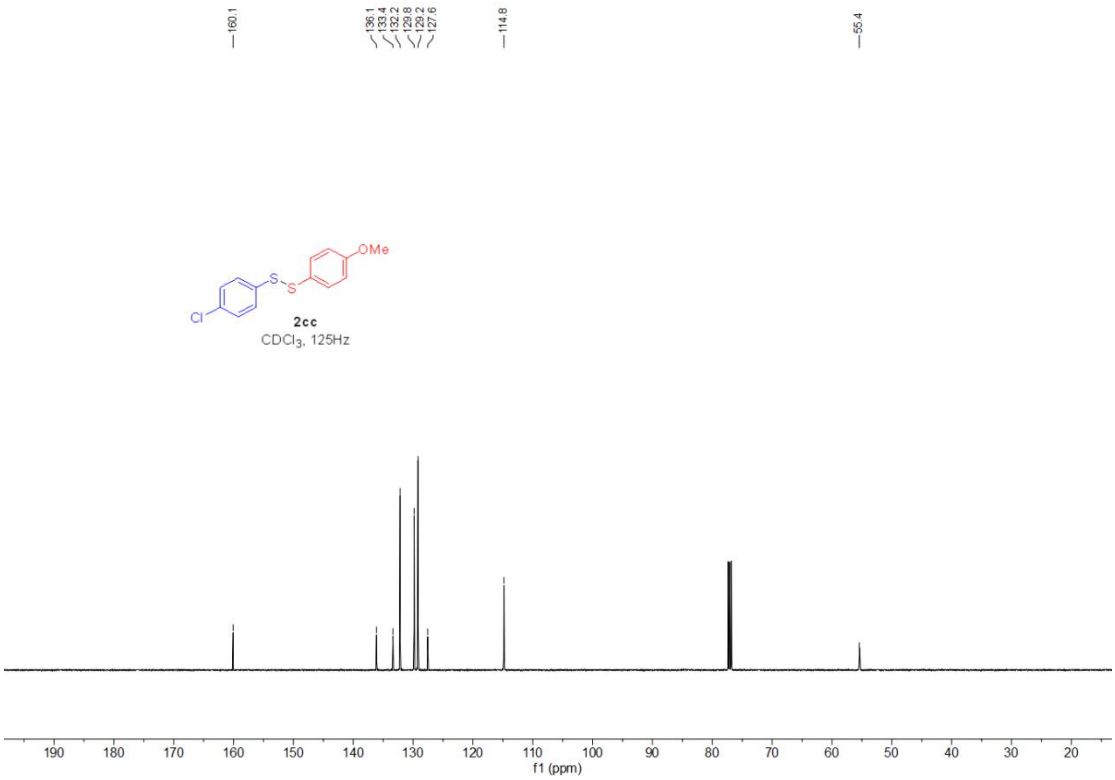

8.168
8.152
8.149
7.658
7.643
7.639
7.382
7.366
7.136
7.121
2.325
O2N
S
S
2aa
CDCl3, 500Hz
2.04
2.04
2.06
2.03
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

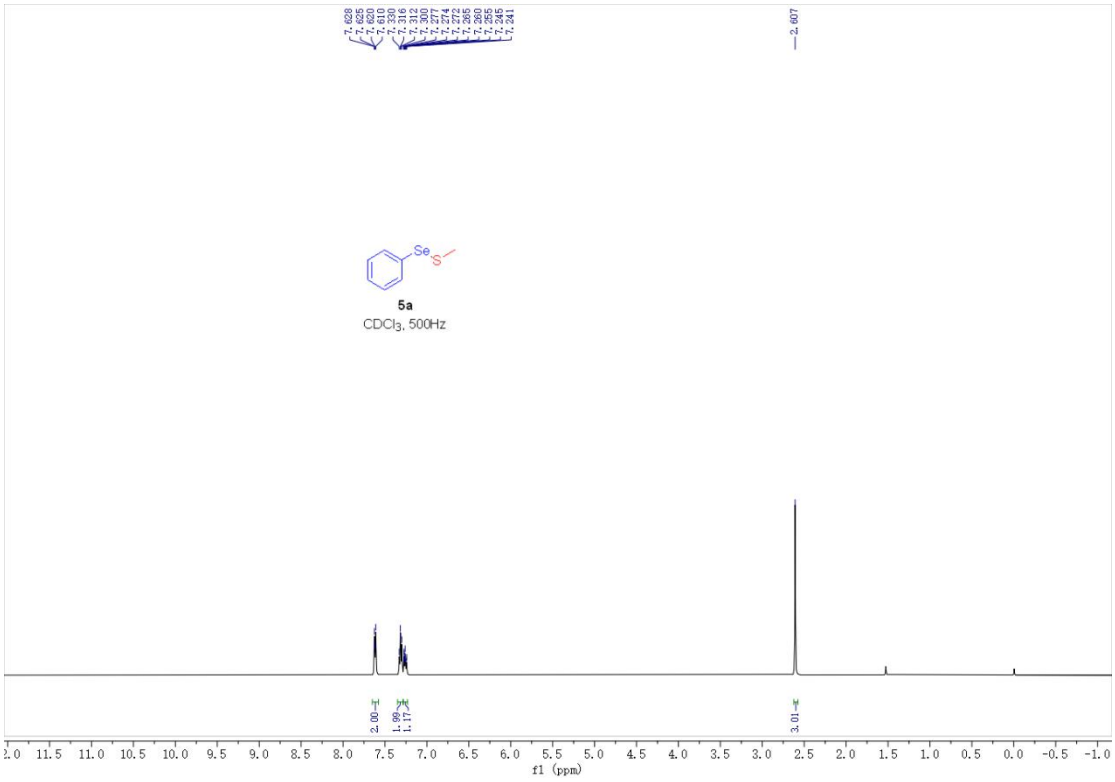

146.5
146.4
138.5
131.9
130.2
128.7
126.2
124.1
21.1
O2N
S
S
2aa
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

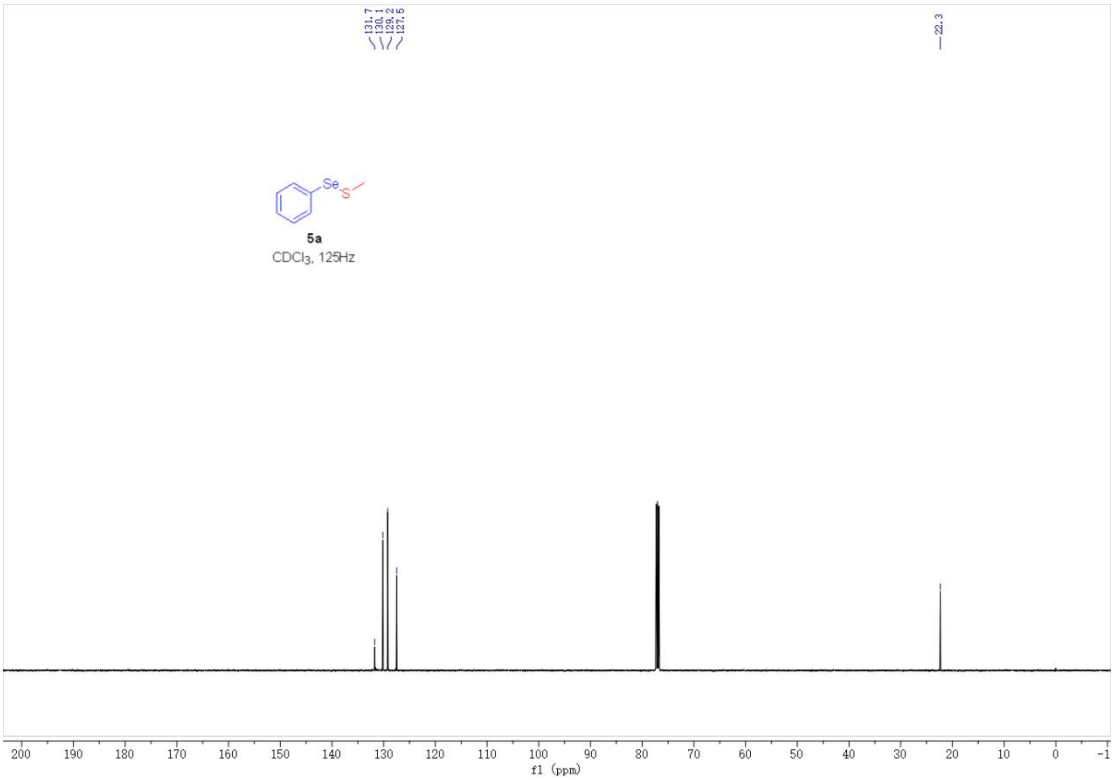

7.433
7.416
7.408
7.392
7.374
7.358
6.841
6.825
3.790
Br
MeO
S
S
2bb
CDCl3, 500Hz
6.01
2.01
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

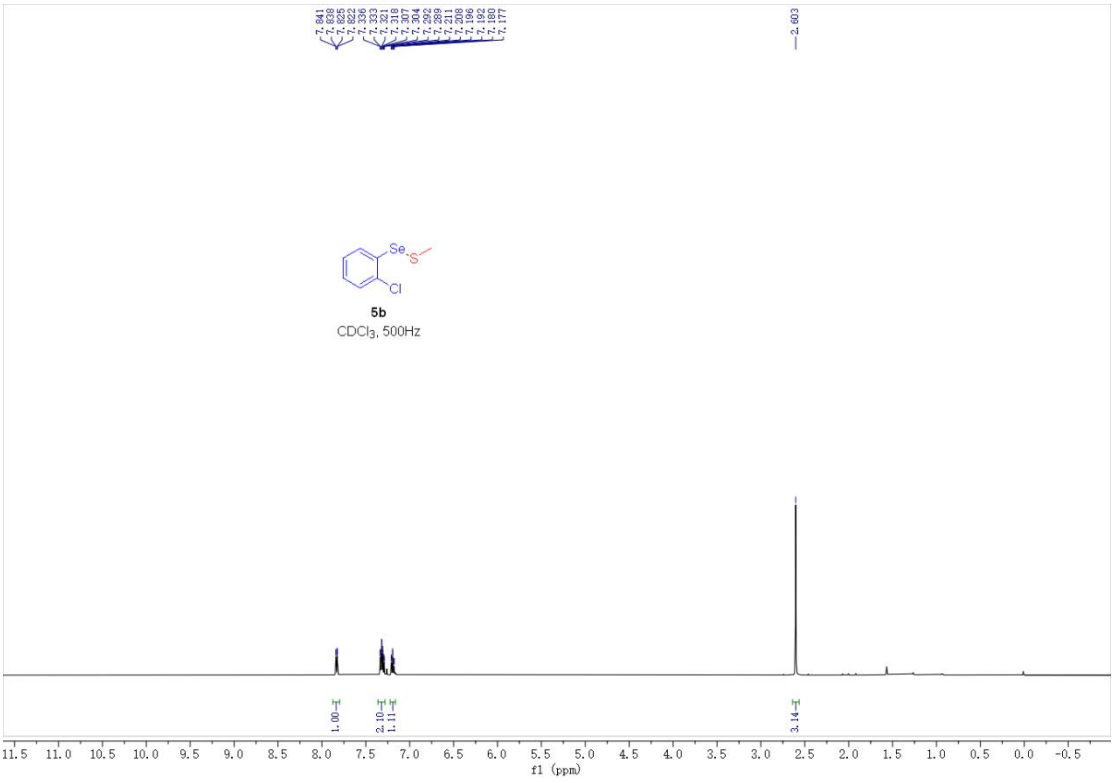

160.0
136.7
132.1
132.1
129.9
127.5
121.3
114.8
55.4
Br
S
S
MeO
2bb
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

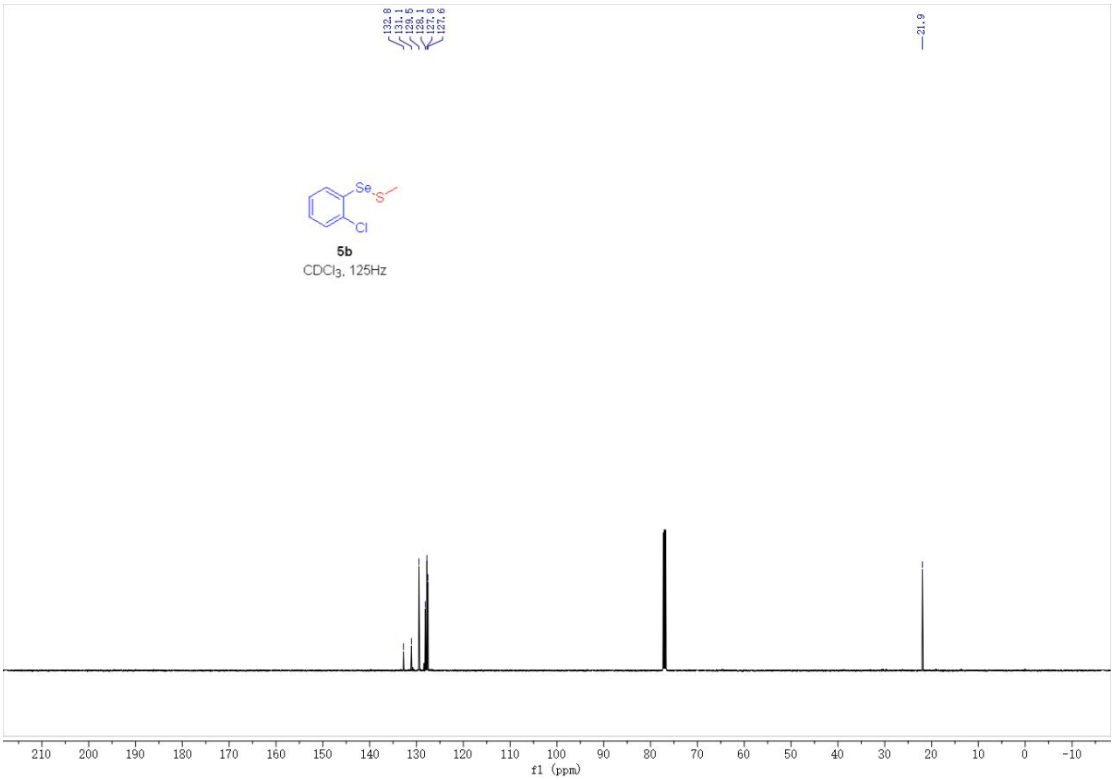

7.418
7.401
7.395
7.379
7.261
7.245
6.824
6.807
3.765
OMe
S
S
Cl
2cc
CDCl3, 500Hz
3.98
2.04
2.00
3.00
2.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

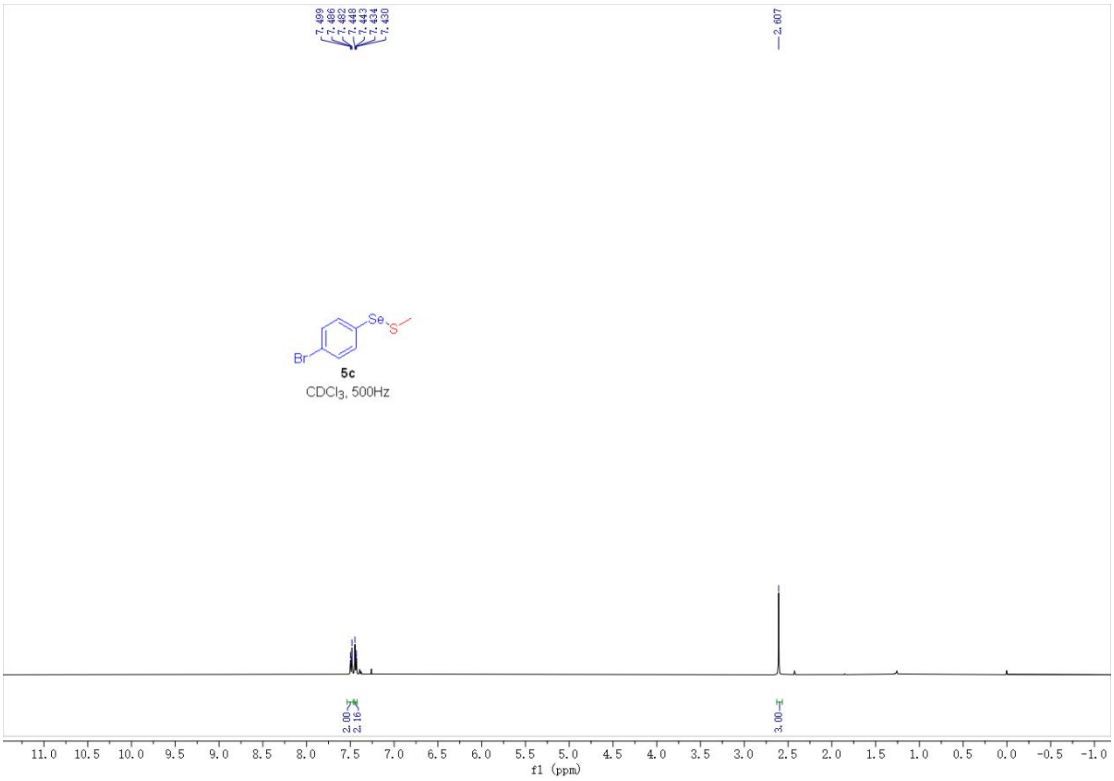

160.1
136.1
133.4
132.2
129.8
129.2
127.6
114.8
55.4
OMe
S
S
Cl
2cc
CDCl3, 125Hz
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20
f1 (ppm)

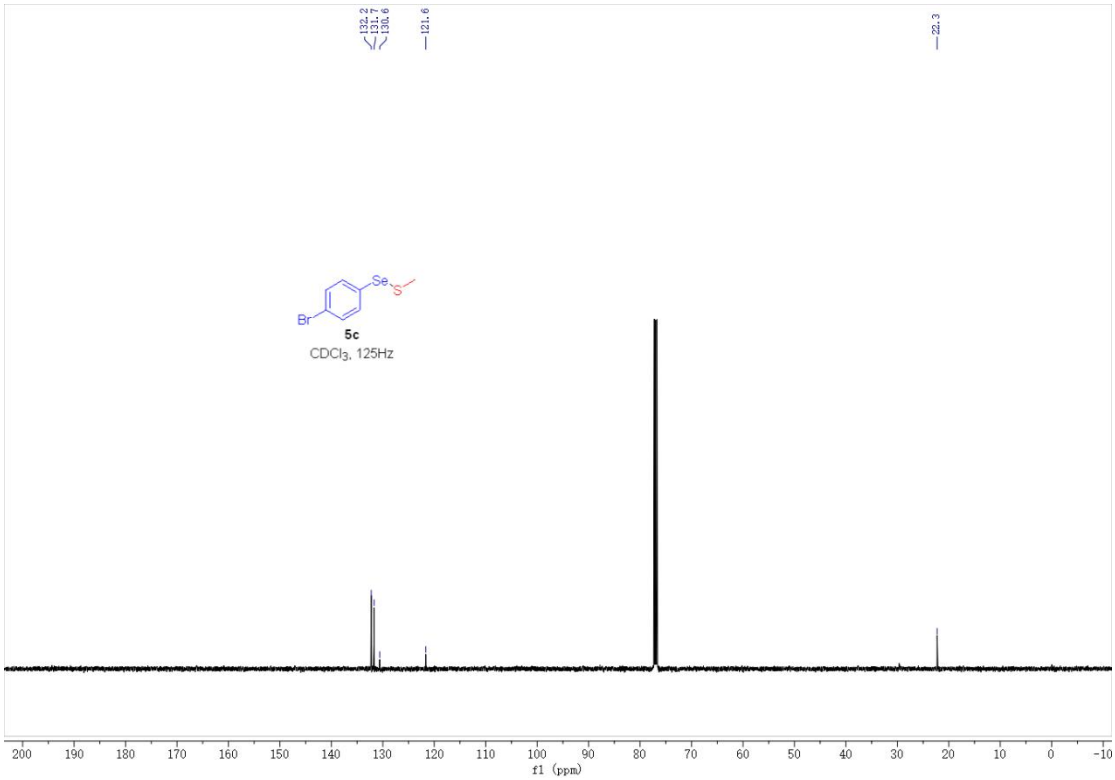

7.628
7.625
7.620
7.618
7.316
7.312
7.300
7.277
7.274
7.272
7.266
7.260
7.255
7.245
7.241
2.607
Se
S
5a
CDCl3, 500Hz
2.00
1.99
1.17
3.01
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

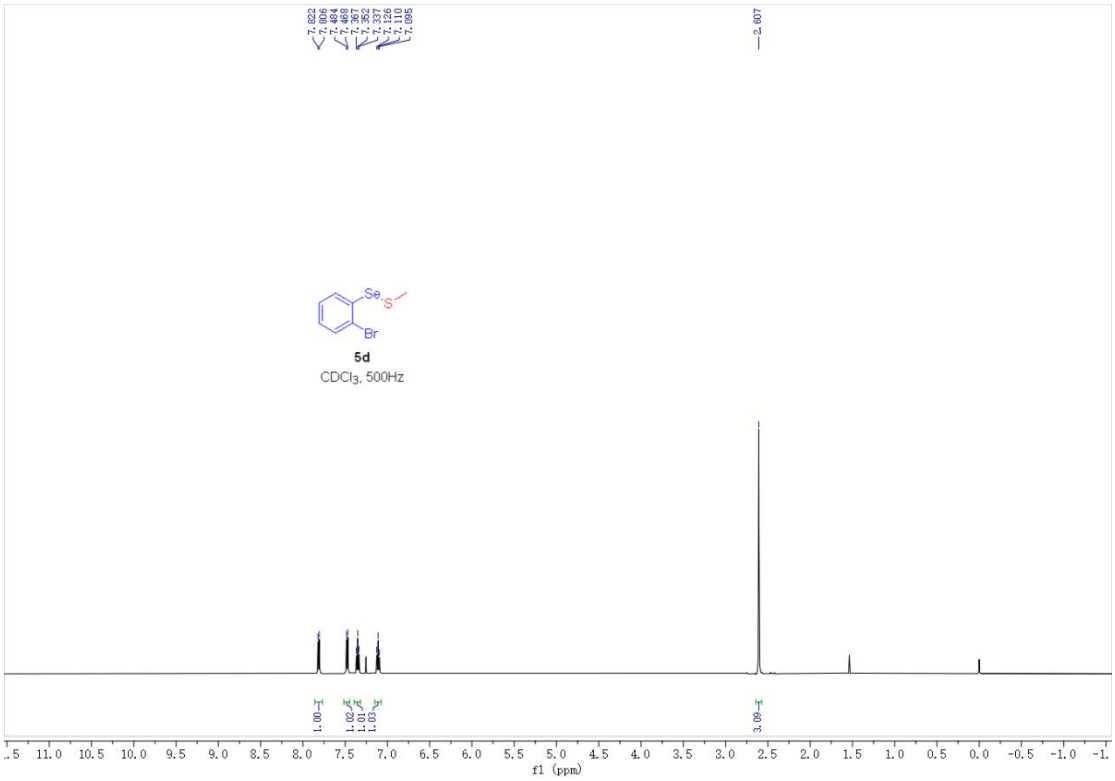

131.7
130.1
128.2
127.5
22.3
5a
CDCl3, 125Hz
f1 (ppm)

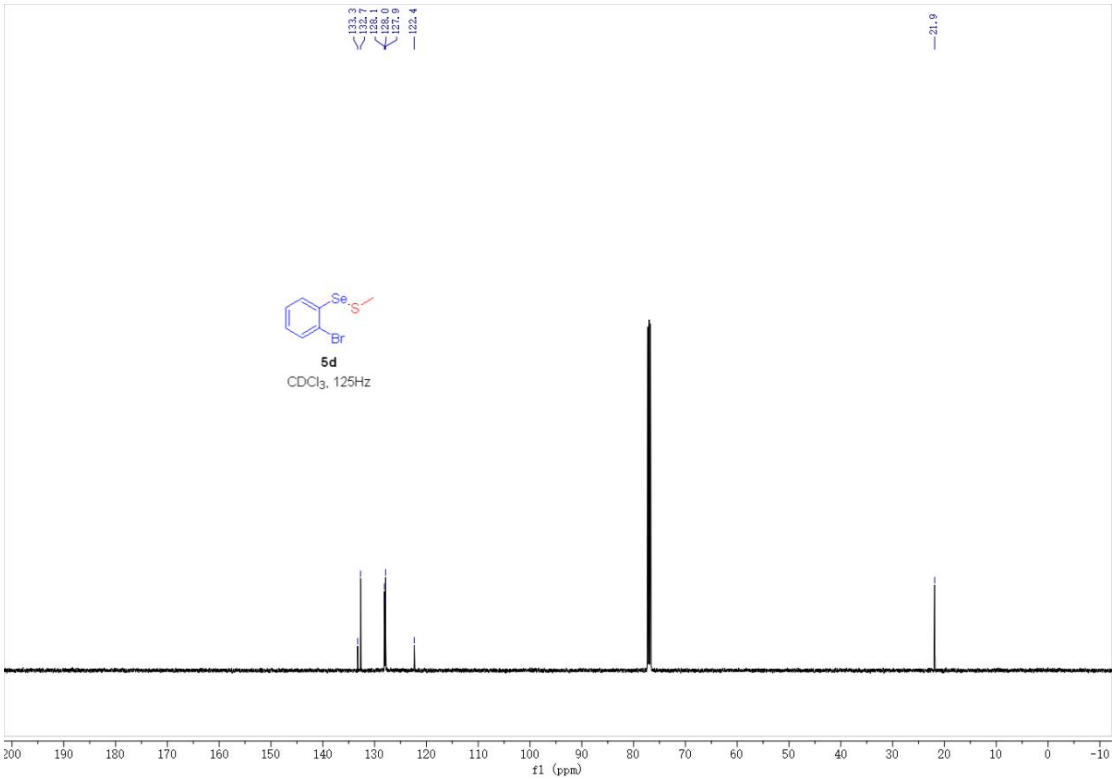

7.841
7.838
7.825
7.822
7.336
7.333
7.321
7.318
7.307
7.304
7.292
7.289
7.211
7.208
7.196
7.192
7.179
7.177
2.603
5b
CDCl3, 500Hz
1.00
2.10
1.11
3.14
f1 (ppm)

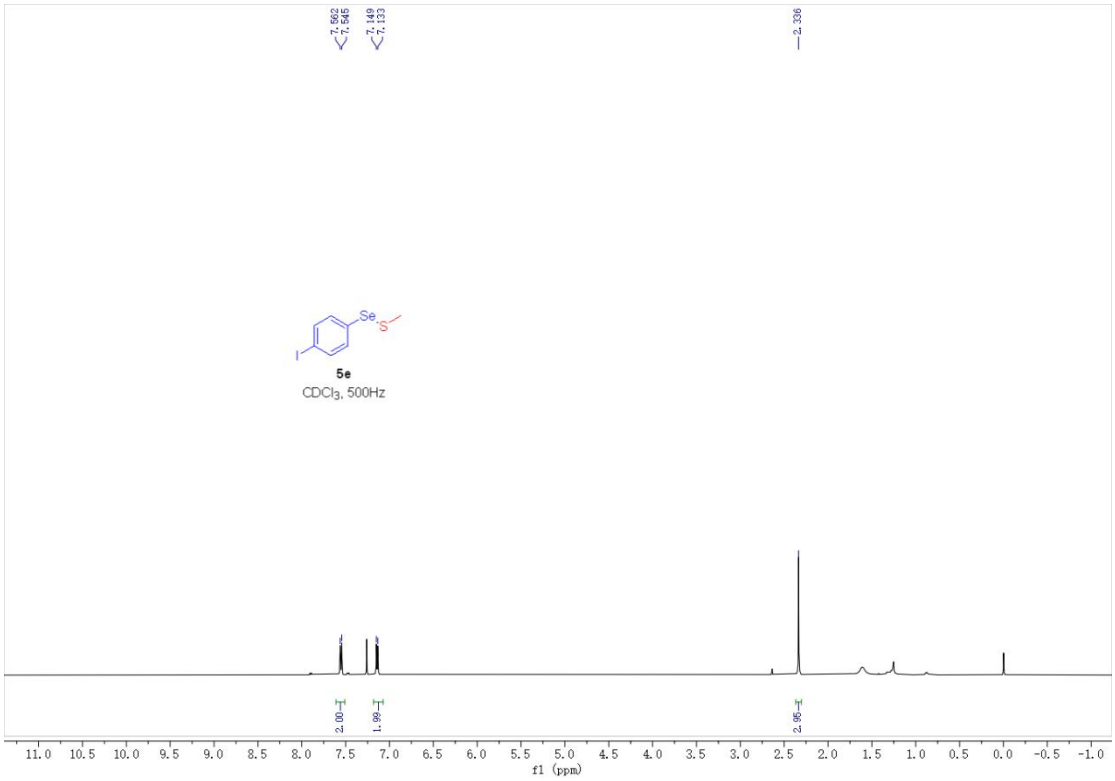

132.8
131.1
128.5
128.1
127.8
127.6
21.9
Se
S
Cl
5b
CDCl3, 125Hz
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

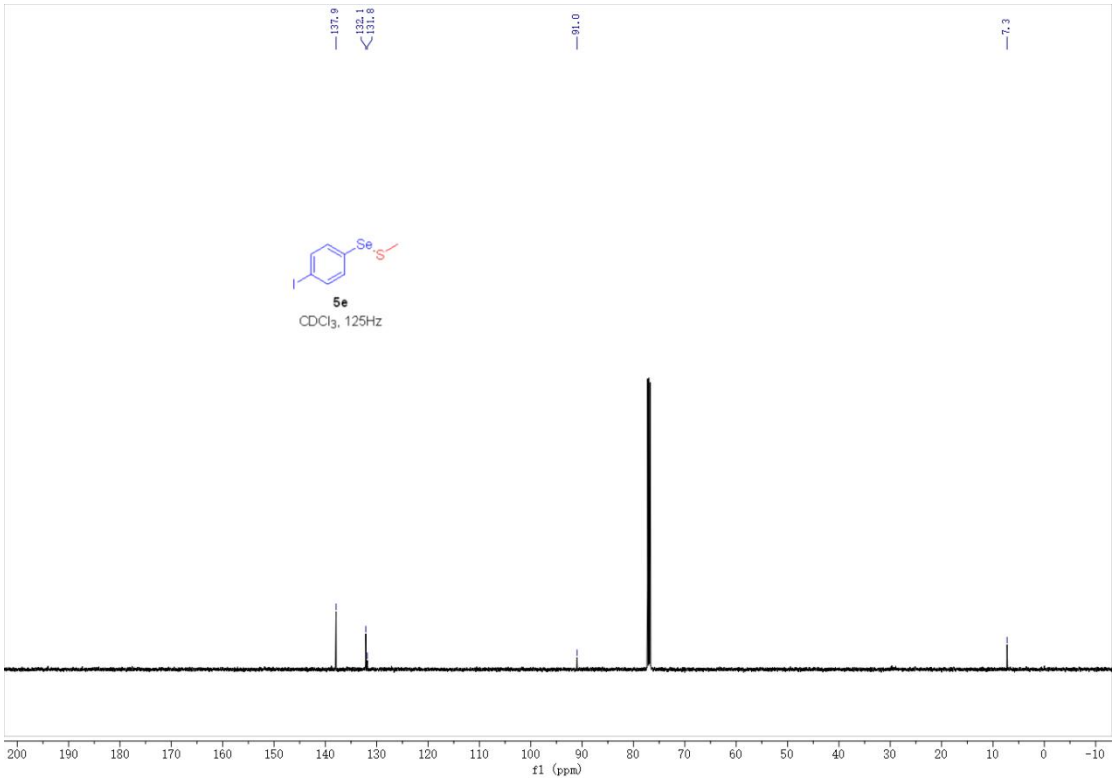

7.499
7.486
7.482
7.448
7.443
7.434
7.430
2.407
Se
S
Br
5c
CDCl3, 500Hz
2.00
2.16
3.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

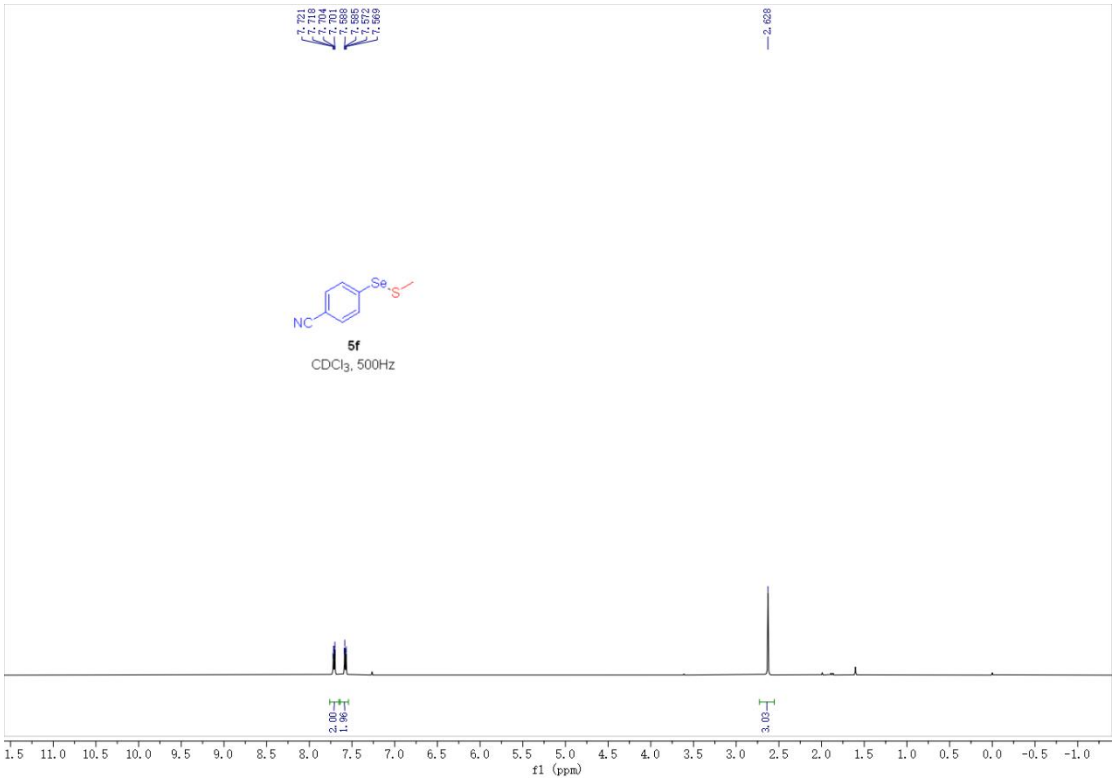

132.2
131.7
130.6
121.6
22.3
Se
S
Br
5c
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

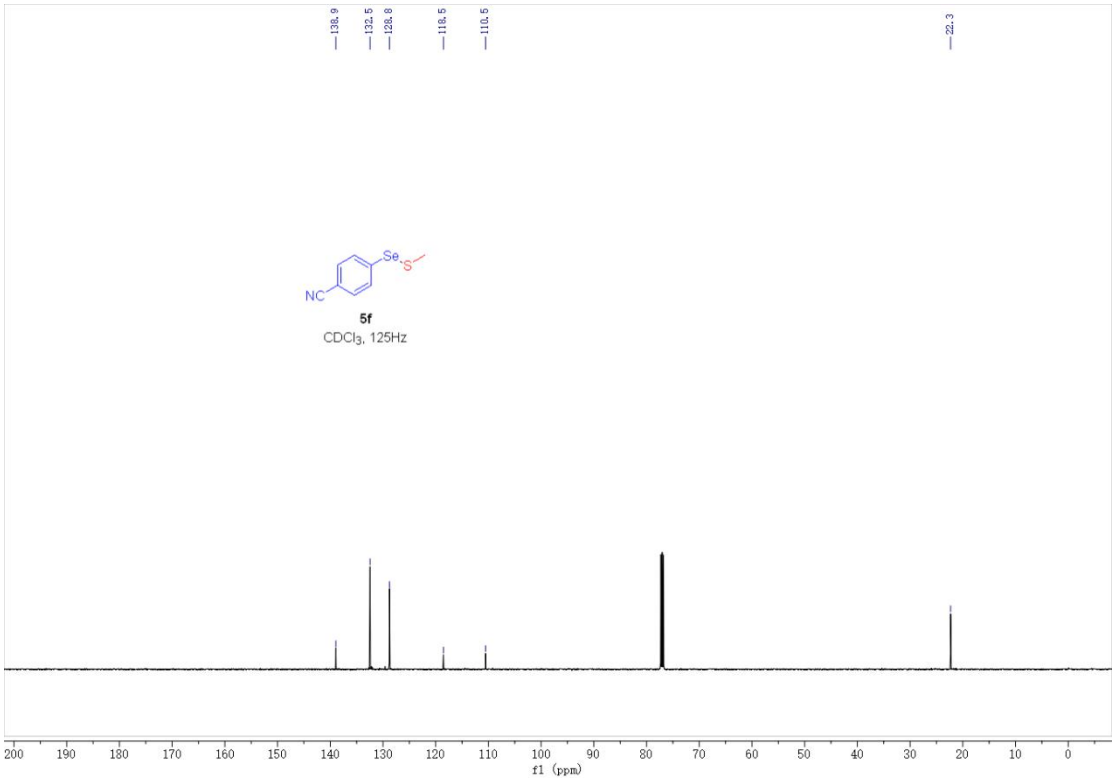

7.622
7.606
7.484
7.468
7.367
7.352
7.337
7.126
7.110
7.095
2.607
Se
S
Br
5d
CDCl3, 500Hz
1.00
1.02
1.01
1.03
3.09
..5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.
f1 (ppm)

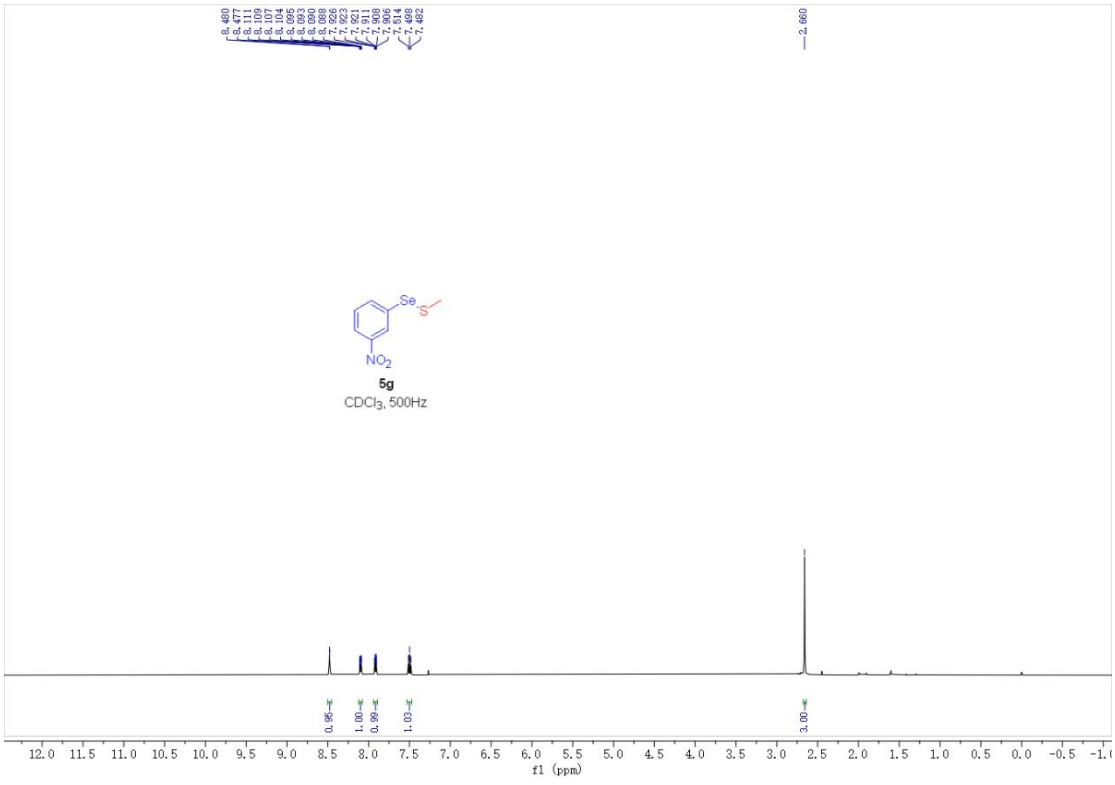

133.3
132.7
128.1
128.0
127.9
122.4
21.9
Se
S
Br
5d
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

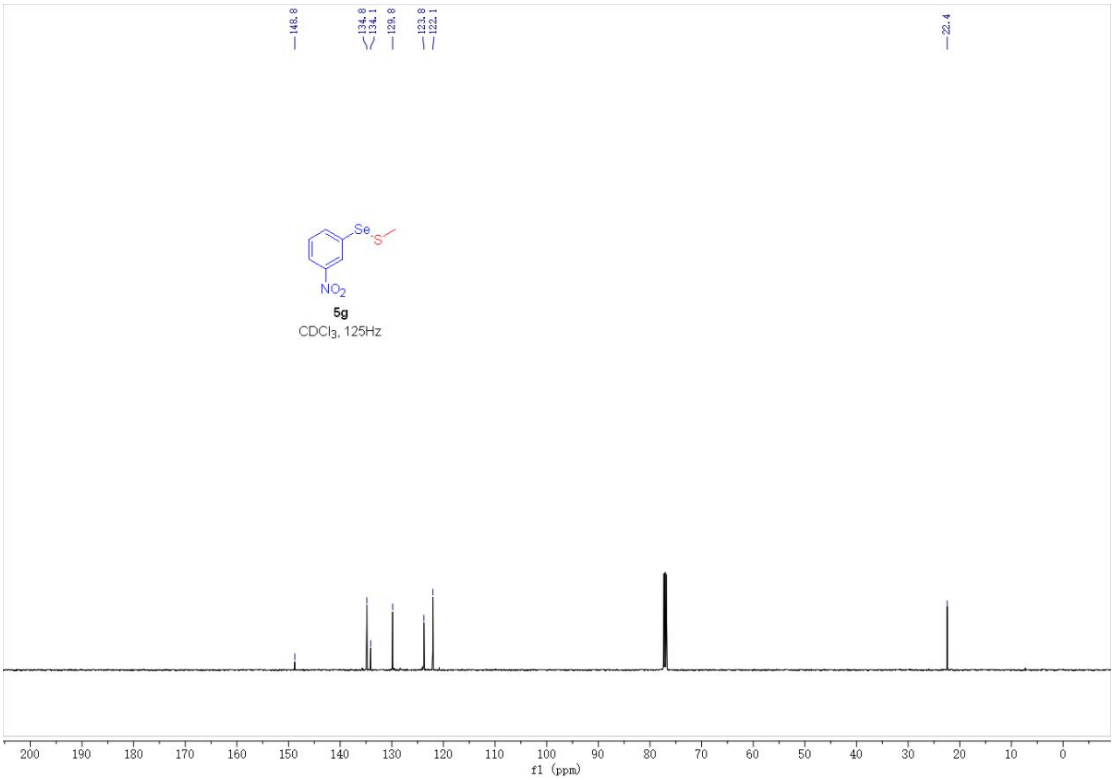

7.562
7.545
7.149
7.133
2.336
Se
S
I
5e
CDCl3, 500Hz
2.00
1.99
2.95
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

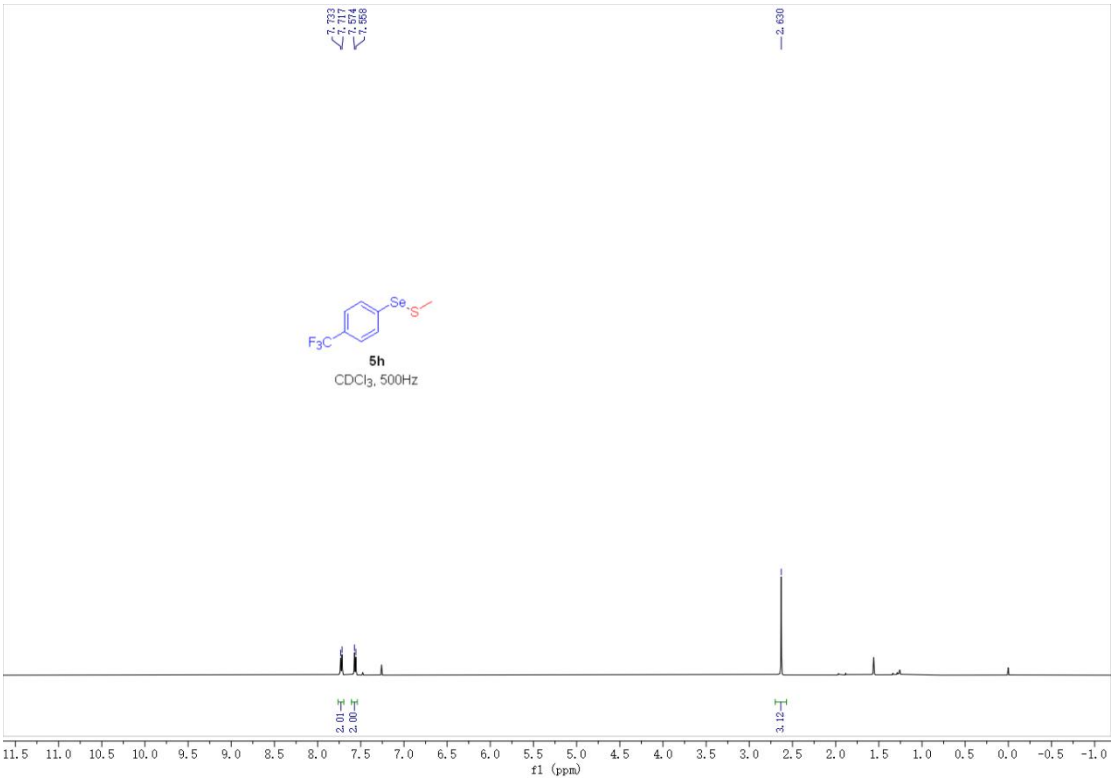

137.9
132.1
131.8
91.0
7.3
Se
S
I
5e
CDCl3, 125Hz
f1 (ppm)

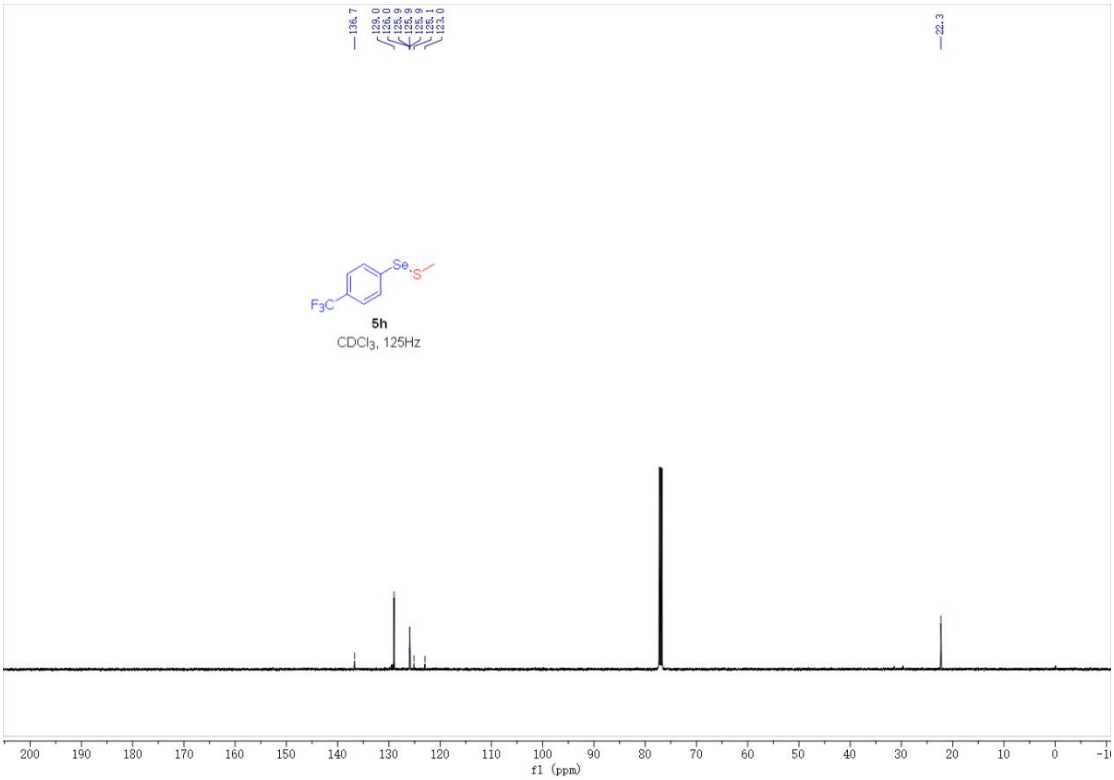

7.721
7.719
7.704
7.701
7.588
7.585
7.572
7.569
2.628
Se
S
NC
5f
CDCl3, 500Hz
2.00
1.96
3.03
f1 (ppm)

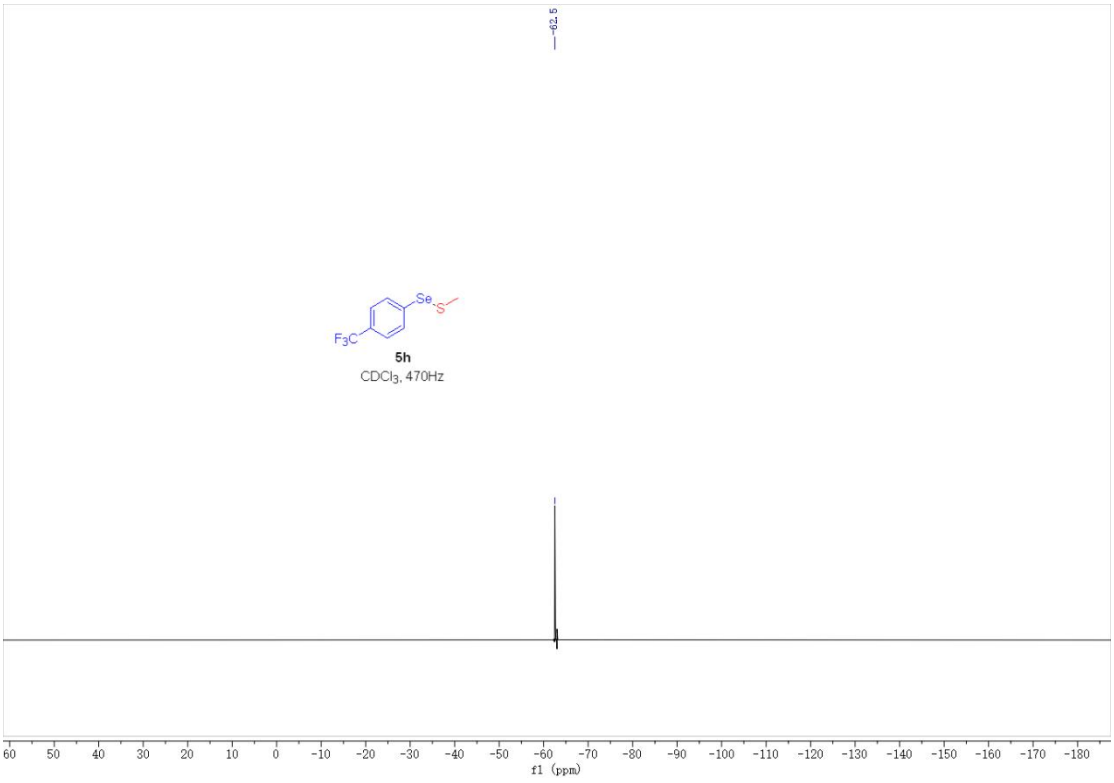

138.9
132.5
128.8
118.5
110.5
22.3
Se
S
NC
5f
CDCl3, 125Hz
f1 (ppm)

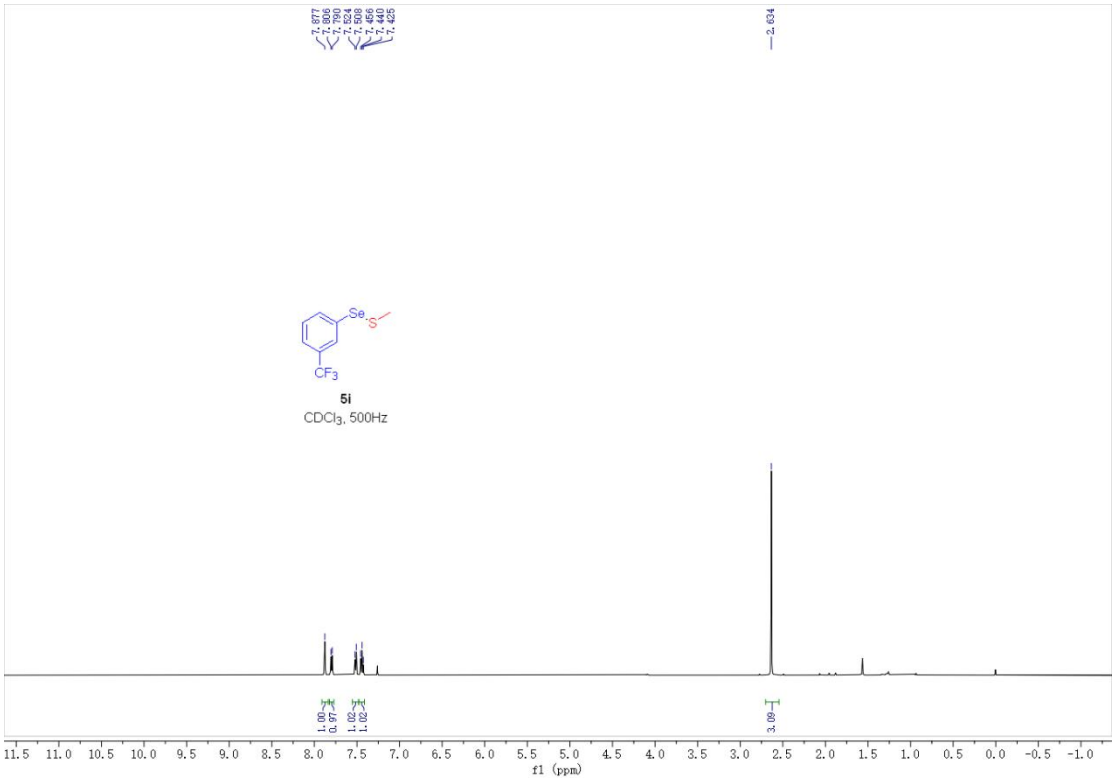

2.660
Se
S
NO2
5g
CDCl3, 500Hz
0.95
1.00
0.99
1.03
3.00
f1 (ppm)

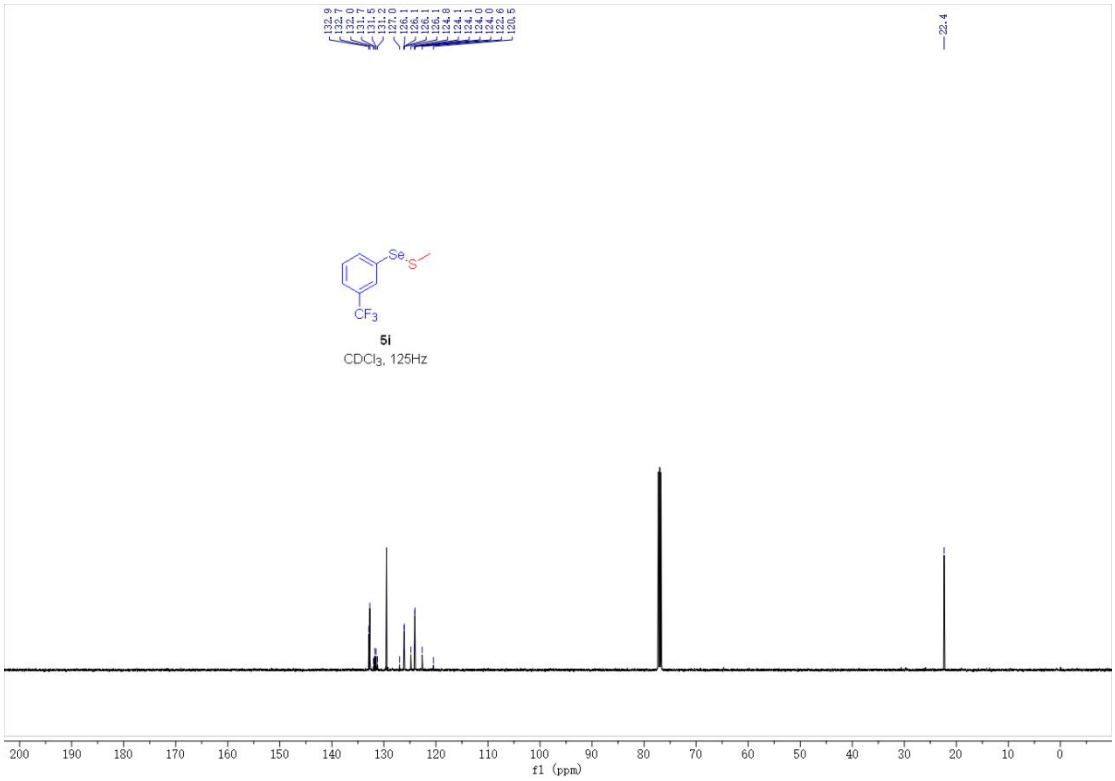

148.8
134.8
134.1
129.8
123.8
122.1
22.4
Se
S
NO2
5g
CDCl3, 125Hz
f1 (ppm)

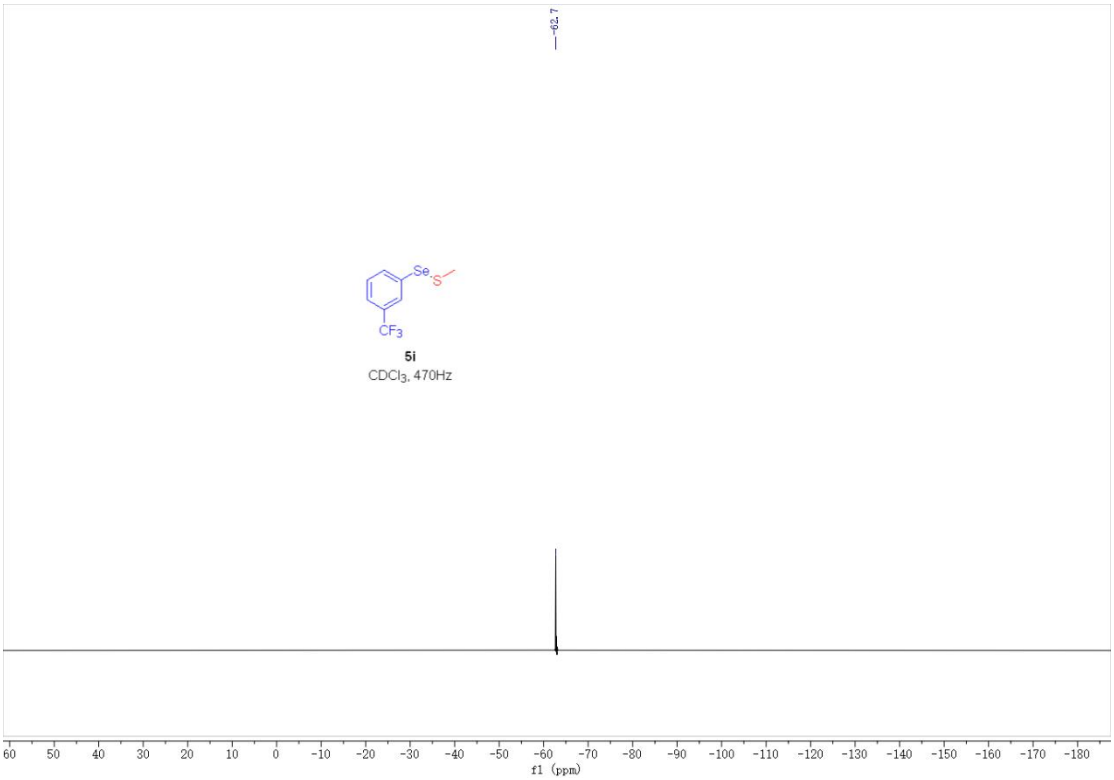

7.733
7.717
7.674
7.658
2.630
Se
S
F3C
5h
CDCl3, 500Hz
2.01
2.00
3.12
f1 (ppm)

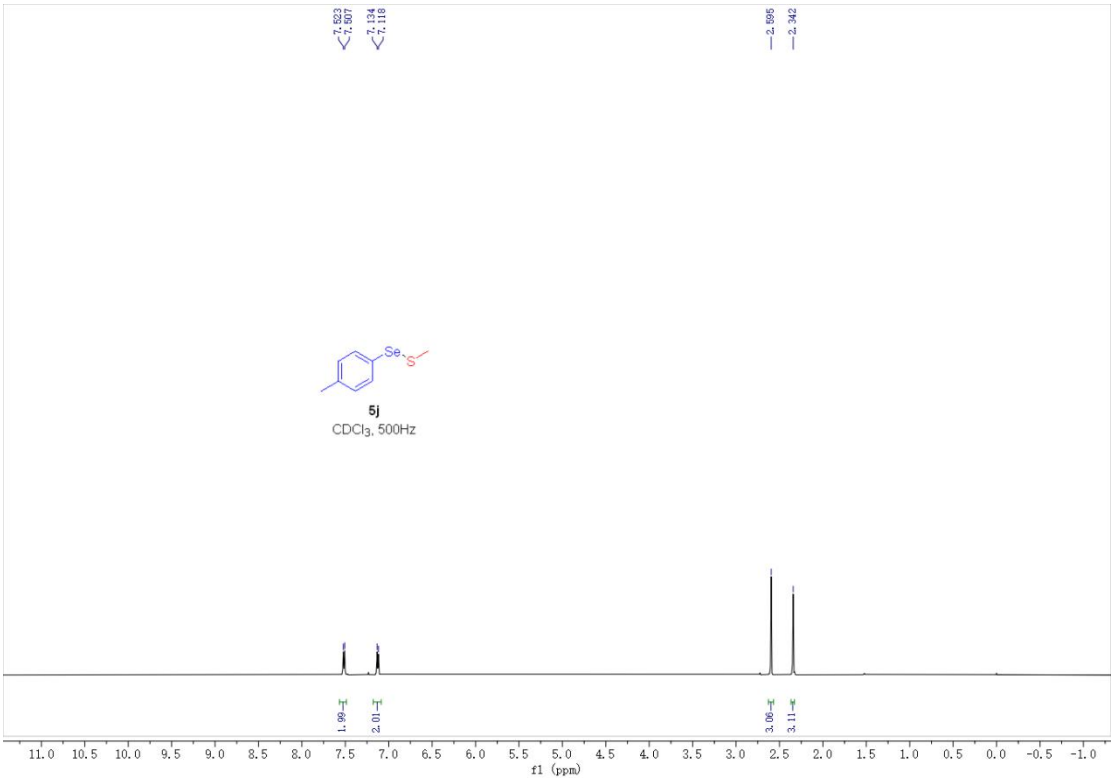

136.7
129.0
126.0
125.9
125.9
125.8
125.1
123.0
22.3
Se
S
F3C
5h
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

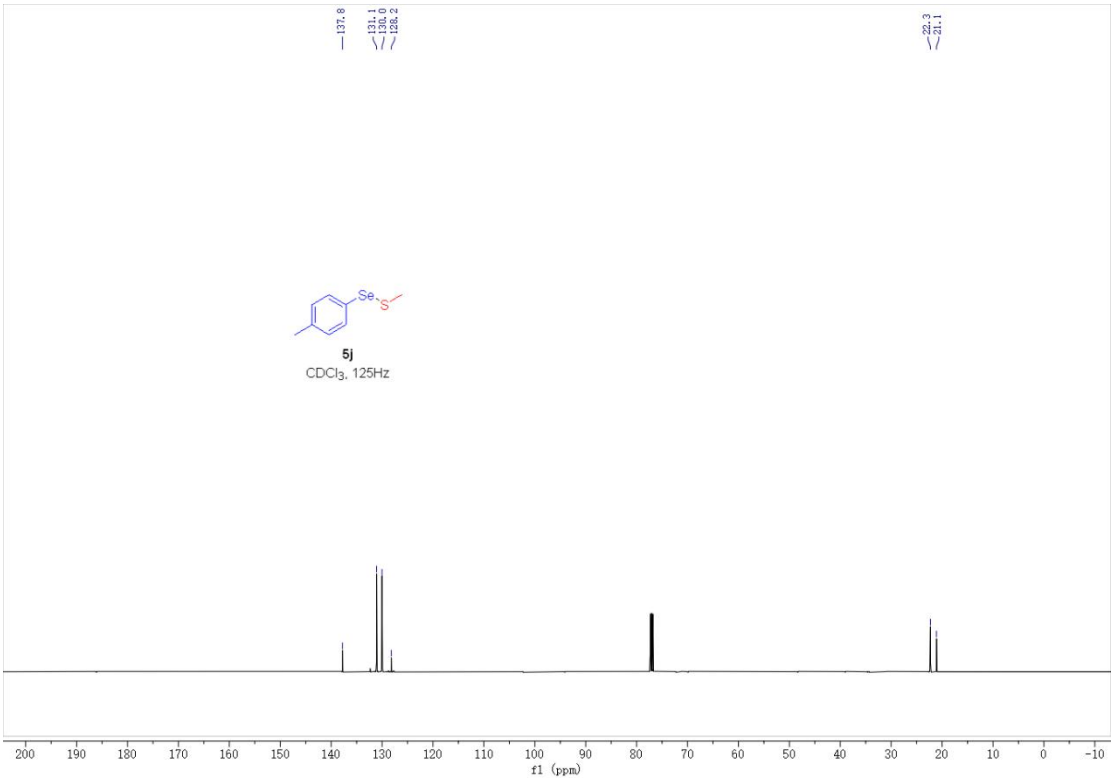

-62.5
Se
S
F3C
5h
CDCl3, 470Hz
60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180
f1 (ppm)

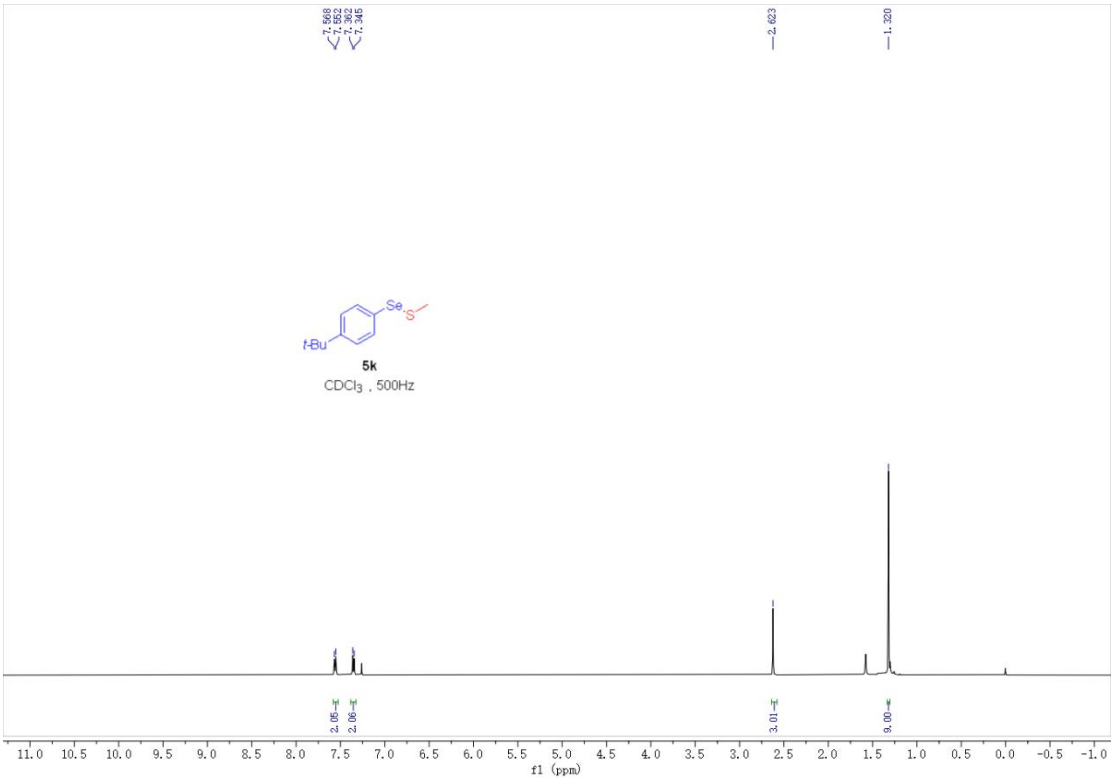

7.877
7.806
7.790
7.524
7.508
7.456
7.440
7.425
2.634
Se
S
CF3
5i
CDCl3, 500Hz
1.00
0.97
1.02
1.02
3.09
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

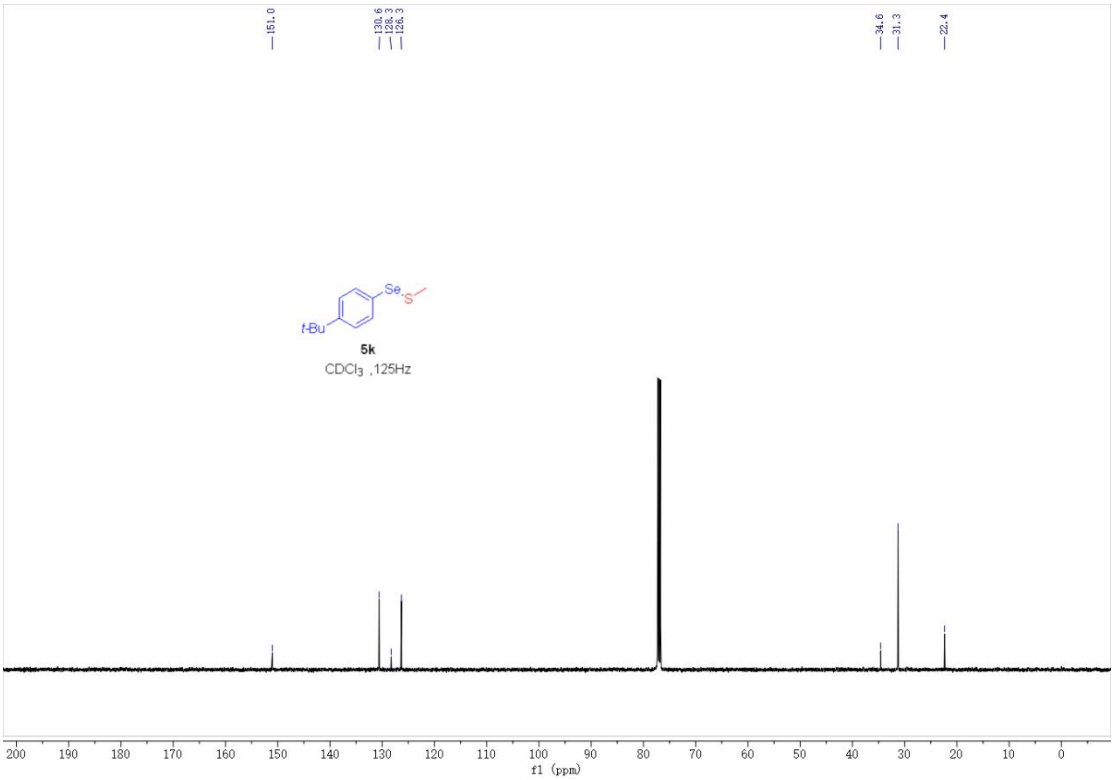

132.9
132.7
132.0
131.7
131.5
131.2
131.0
126.1
126.1
126.1
124.8
124.1
124.1
124.0
124.0
122.6
120.5
22.4
Se
S
CF3
5i
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

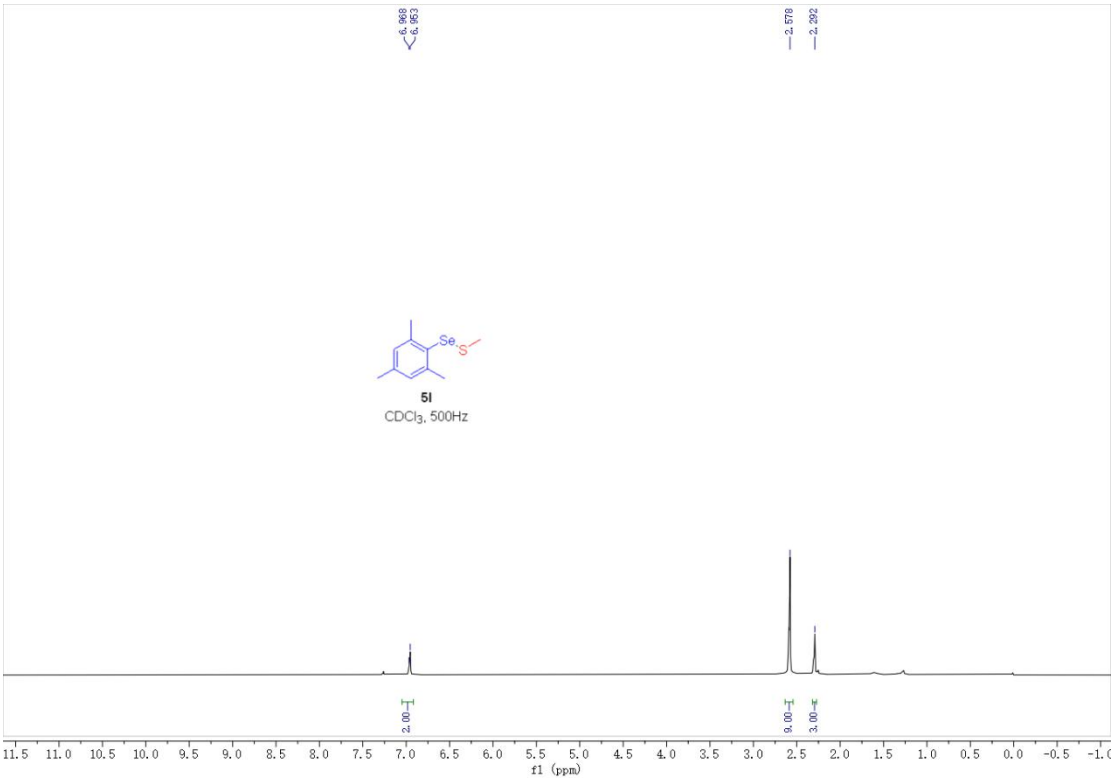

-62.7
Se
S
CF3
5i
CDCl3, 470Hz
60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180
f1 (ppm)

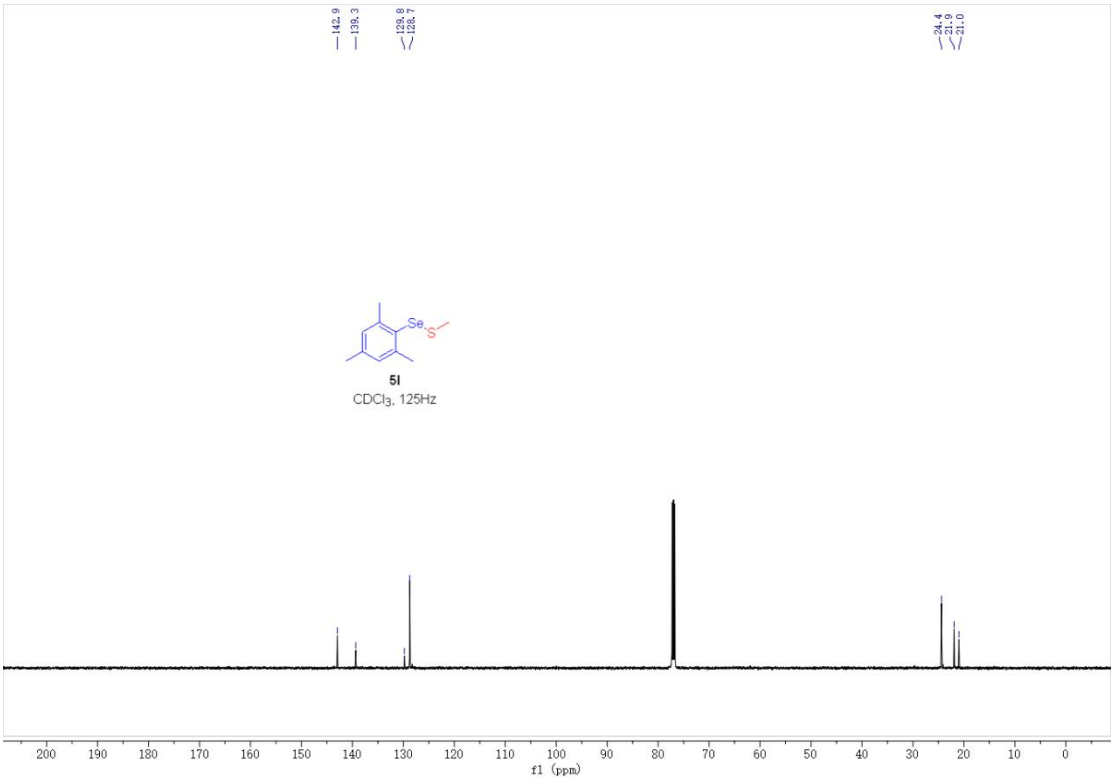

7.623
7.607
7.134
7.118
2.595
2.342
Se
S
5j
CDCl3, 500Hz
1.99
2.01
3.06
3.11
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

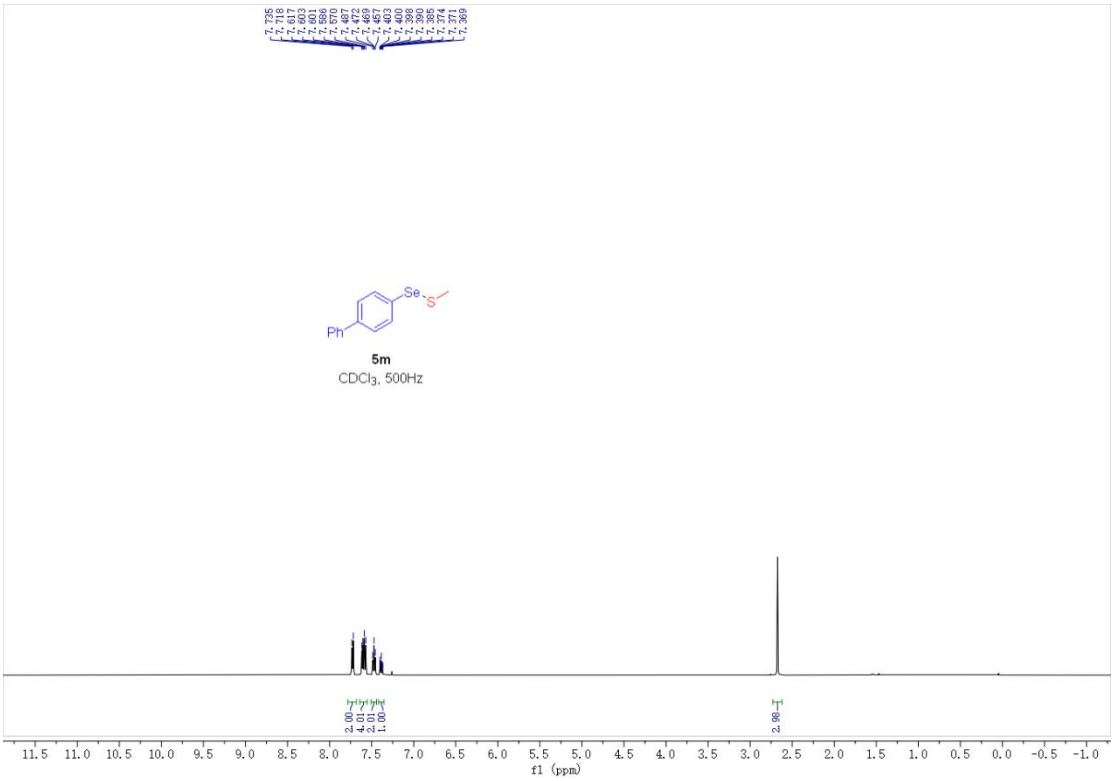

137.8
131.1
130.0
128.2
22.3
21.1
Se
S
5j
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

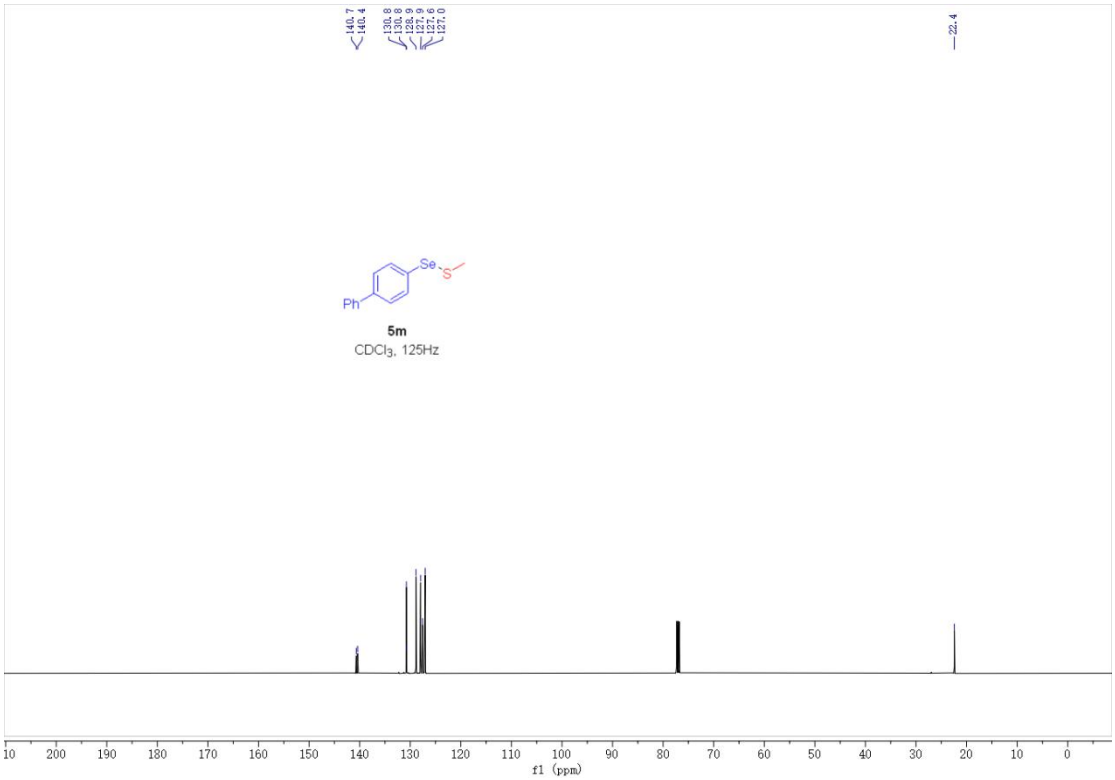

7.668
7.662
7.362
7.345
2.623
1.320
Se
S
t-Bu
5k
CDCl3 , 500Hz
2.05
2.06
3.01
9.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

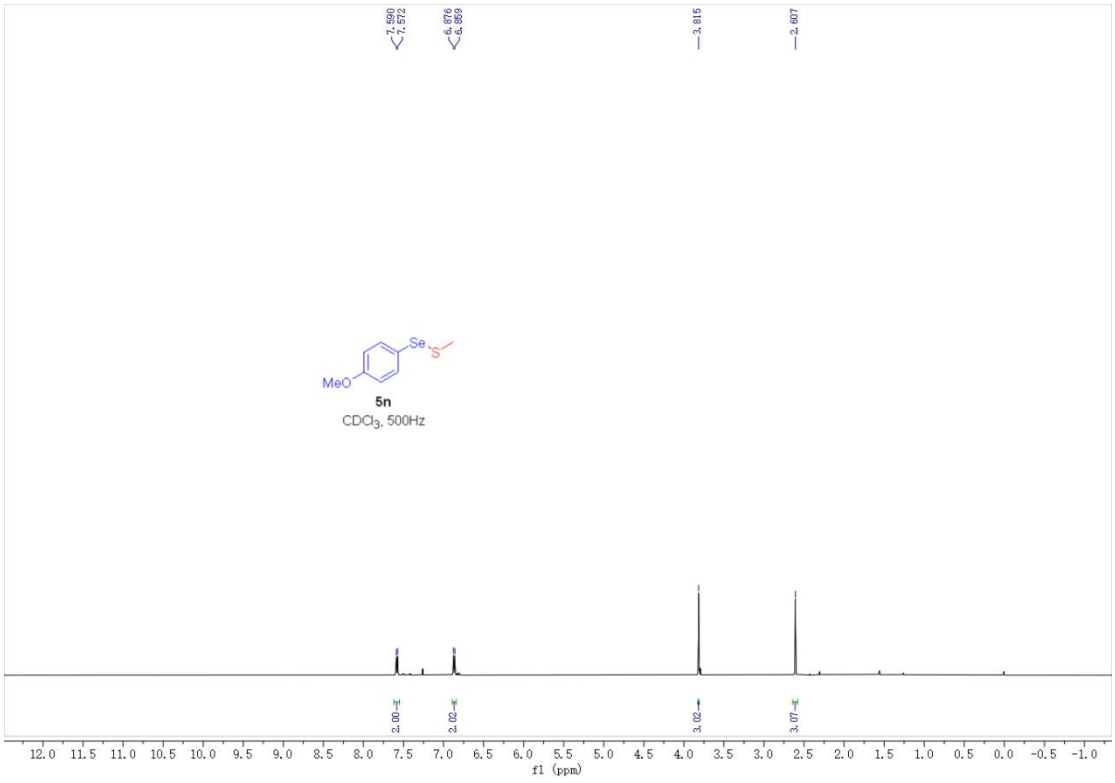

151.0
130.6
128.3
126.3
34.6
31.3
22.4
Se
S
t-Bu
5k
CDCl3 ,125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

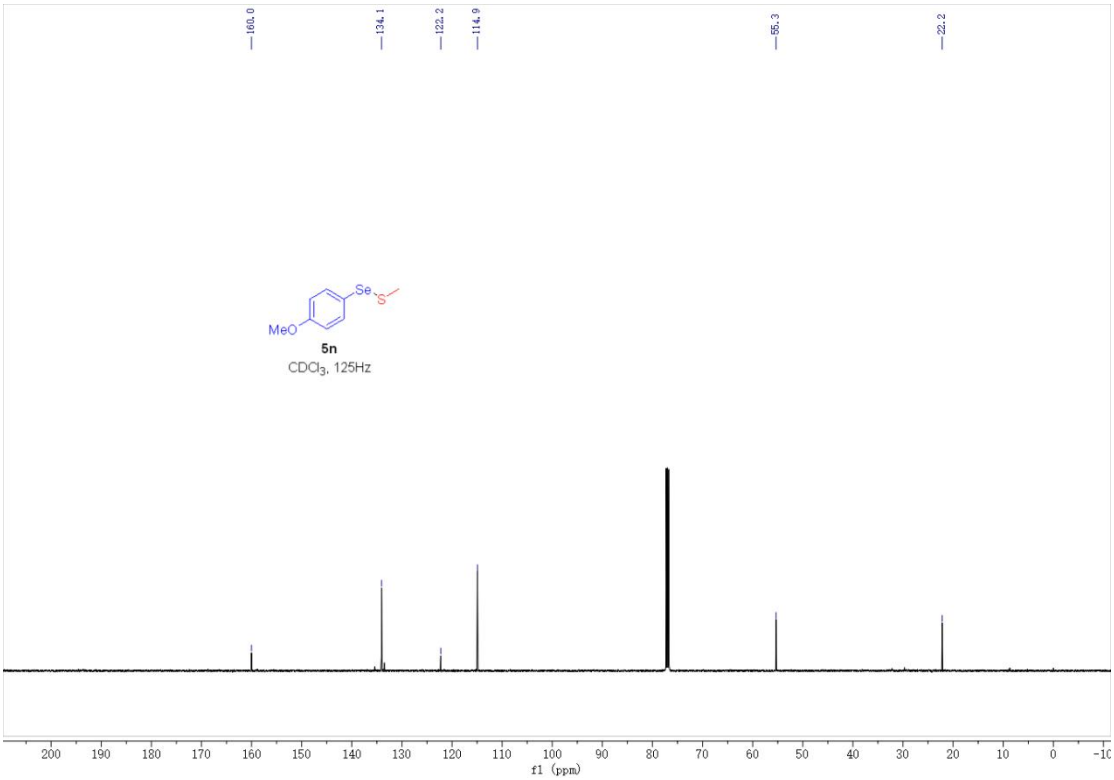

6.968
6.953
2.578
2.292
Se
S
5l
CDCl3, 500Hz
2.00
9.00
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

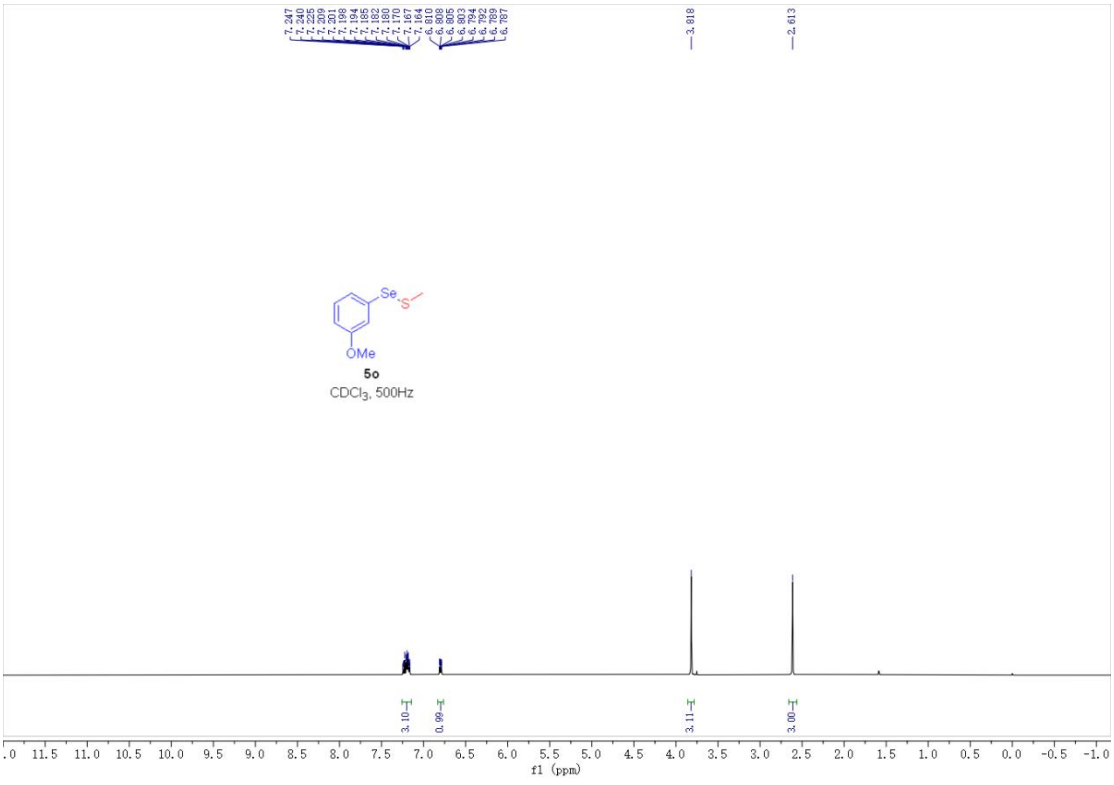

142.9
139.3
129.8
128.7
24.4
21.9
21.0
5l
CDCl3, 125Hz
f1 (ppm)

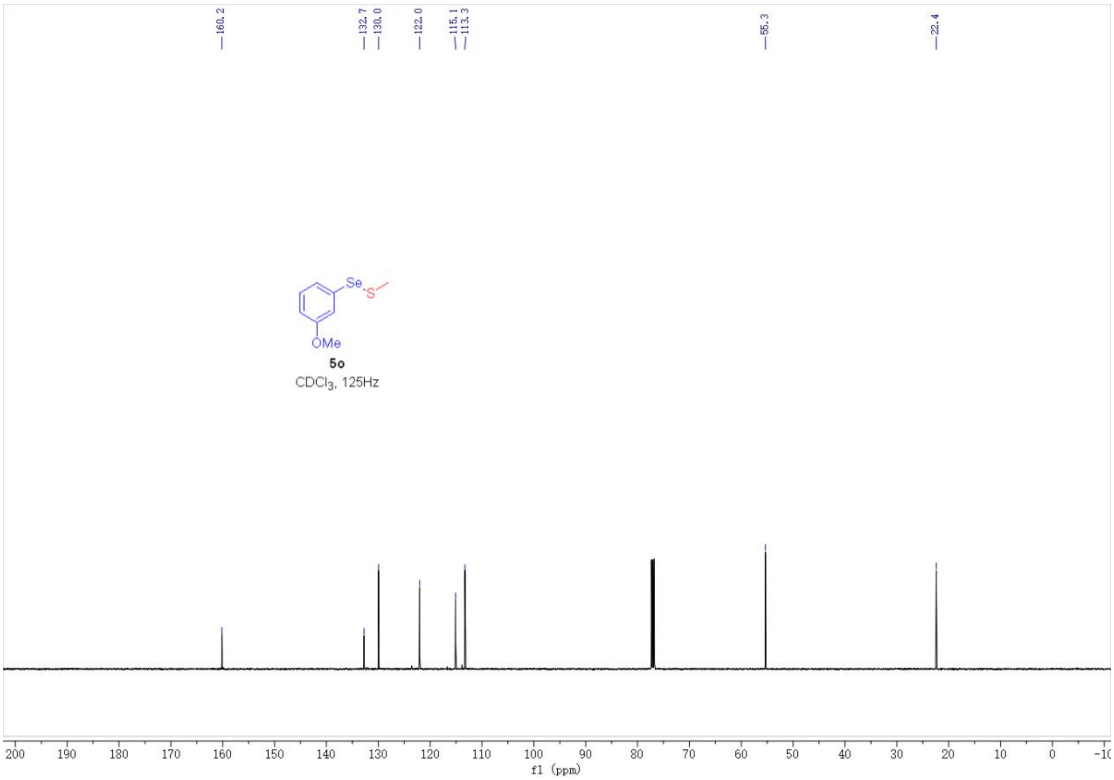

5m
CDCl3, 500Hz
f1 (ppm)

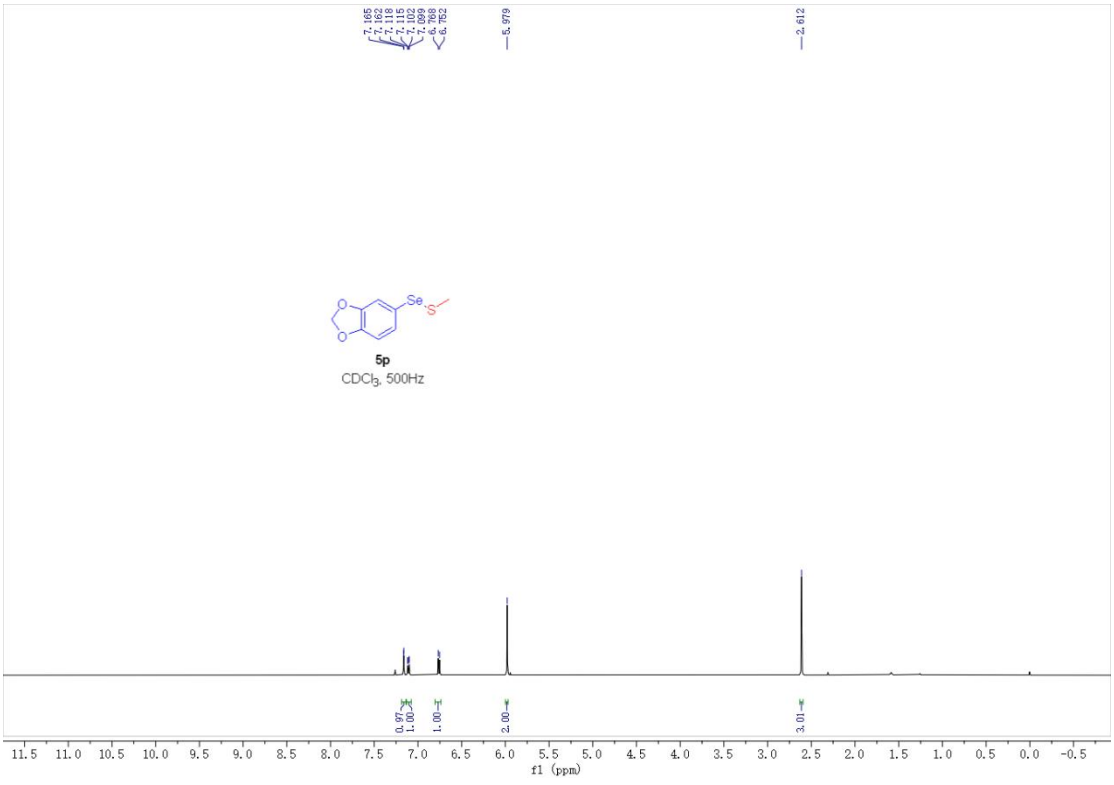

140.7
140.4
130.8
130.8
128.9
127.8
127.6
127.0
22.4
Se
S
Ph
5m
CDCl3, 125Hz
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

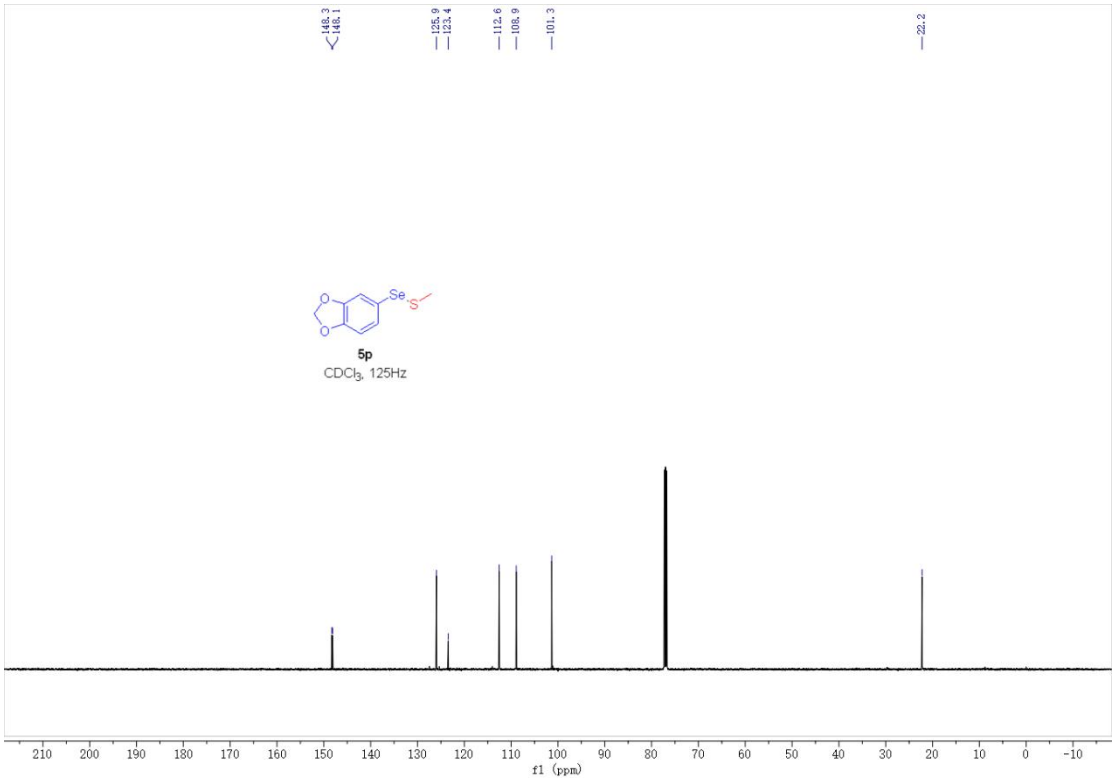

7.590
7.572
6.876
6.869
3.815
2.607
Se
S
MeO
5n
CDCl3, 500Hz
2.00
2.02
3.02
3.07
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

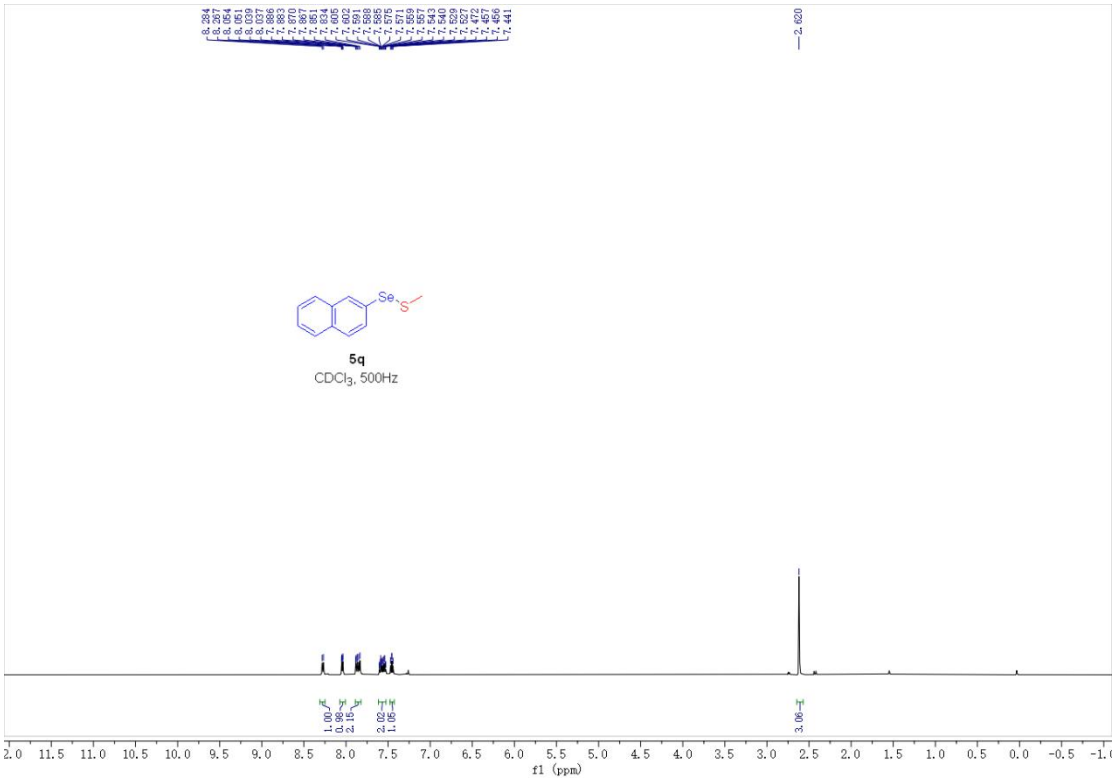

160.0
134.1
122.2
114.9
55.3
22.2
MeO
Se
S
5n
CDCl3, 125Hz
f1 (ppm)

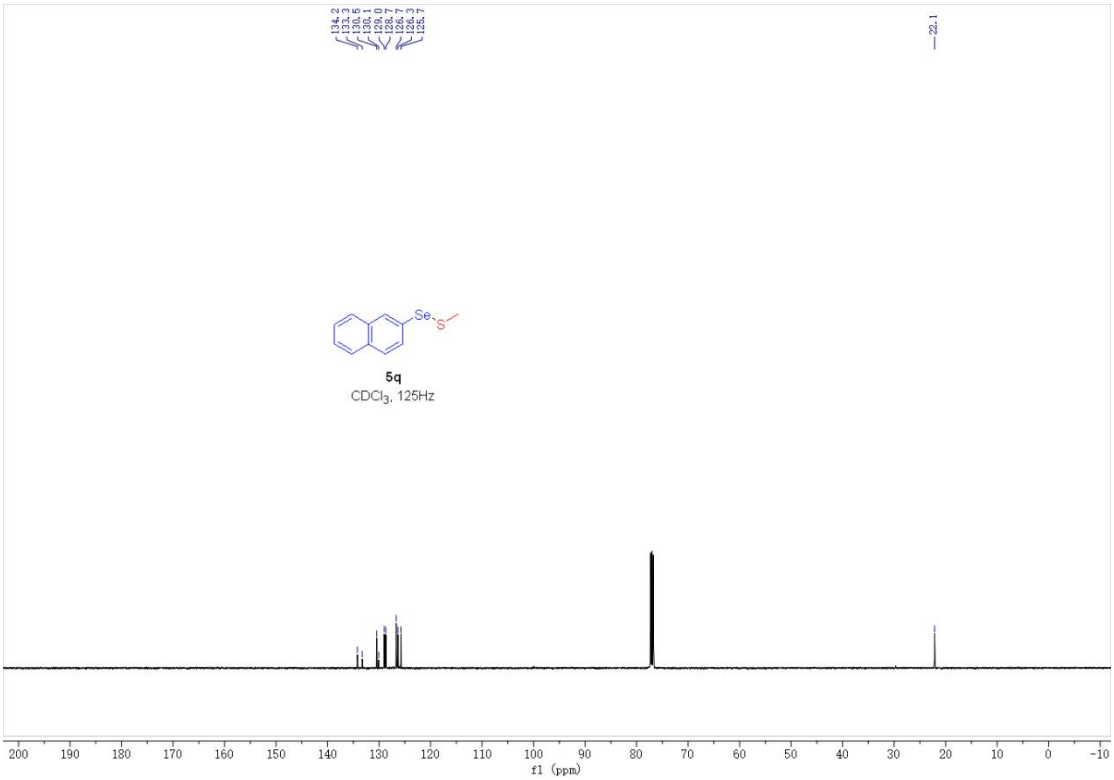

7.247
7.240
7.226
7.209
7.201
7.198
7.194
7.185
7.182
7.180
7.170
7.167
7.164
6.810
6.808
6.805
6.803
6.794
6.792
6.789
6.787
3.818
2.613
OMe
Se
S
5o
CDCl3, 500Hz
3.10
0.99
3.11
3.00
f1 (ppm)

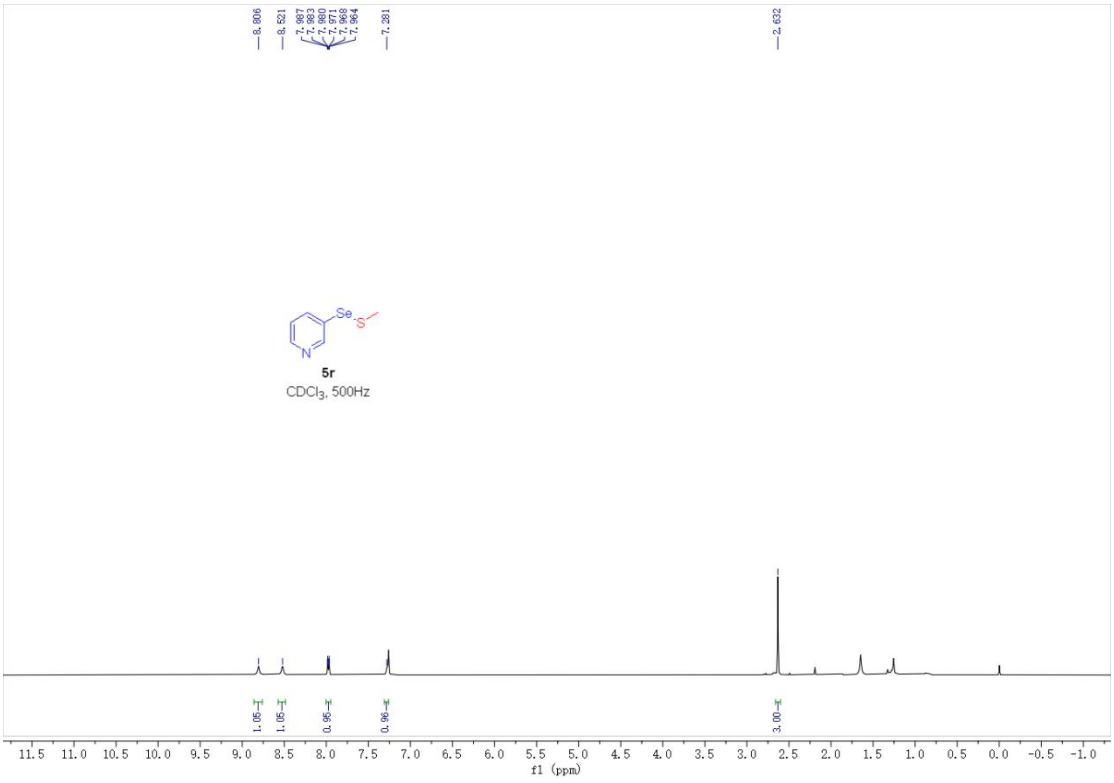

160.2
132.7
130.0
122.0
115.1
113.3
55.3
22.4
Se
S
OMe
5o
CDCl3, 125Hz
f1 (ppm)

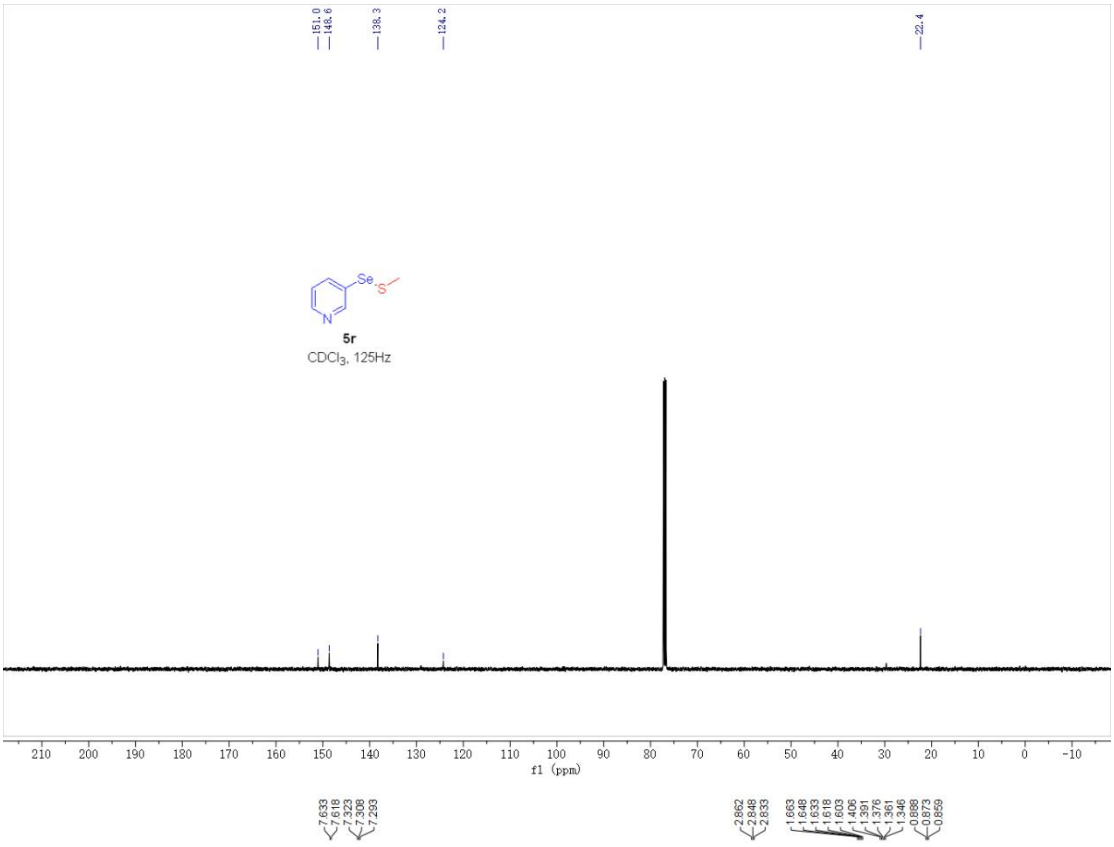

7.165
7.152
7.118
7.115
7.102
7.099
6.888
6.752
5.979
2.612
Se
S
5p
CDCl3, 500Hz
0.97
1.00
1.00
2.00
3.01
f1 (ppm)

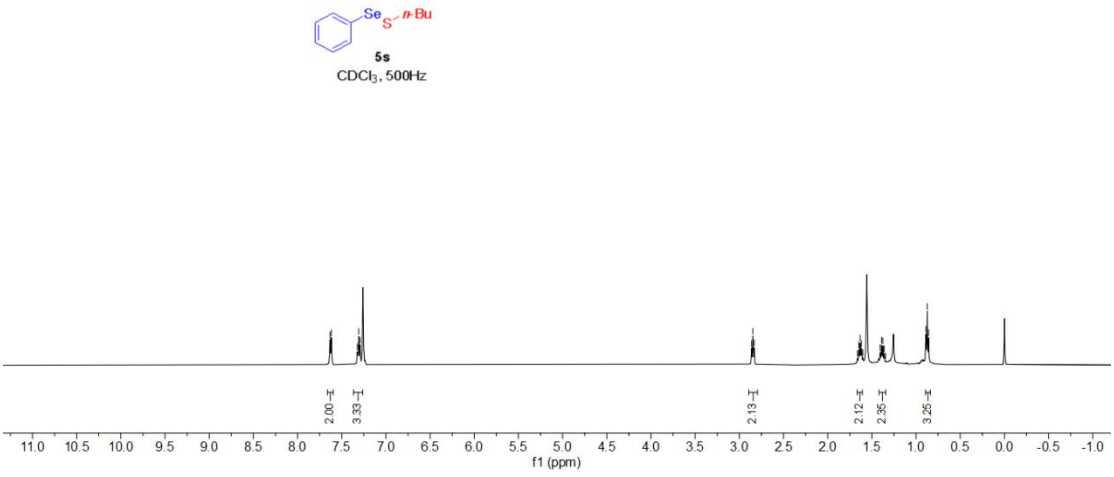

148.3
148.1
125.9
123.4
112.6
108.9
101.3
22.2
Se
S
5p
CDCl3, 125Hz
f1 (ppm)

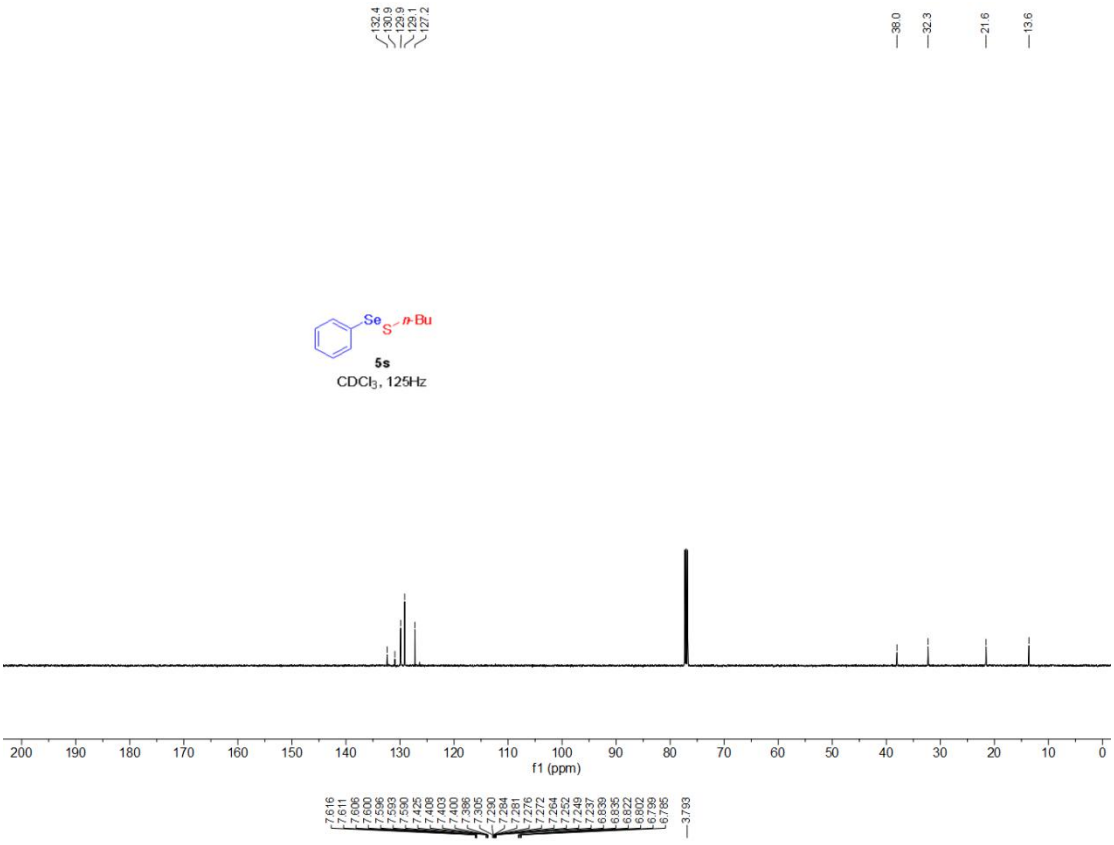

8.284
8.267
8.054
8.051
8.039
8.037
7.886
7.883
7.870
7.867
7.851
7.834
7.605
7.602
7.591
7.588
7.575
7.571
7.559
7.557
7.543
7.540
7.529
7.527
7.472
7.457
7.456
7.441
2.620
Se
S
5q
CDCl3, 500Hz
1.00
0.98
2.15
2.02
1.05
3.06
f1 (ppm)

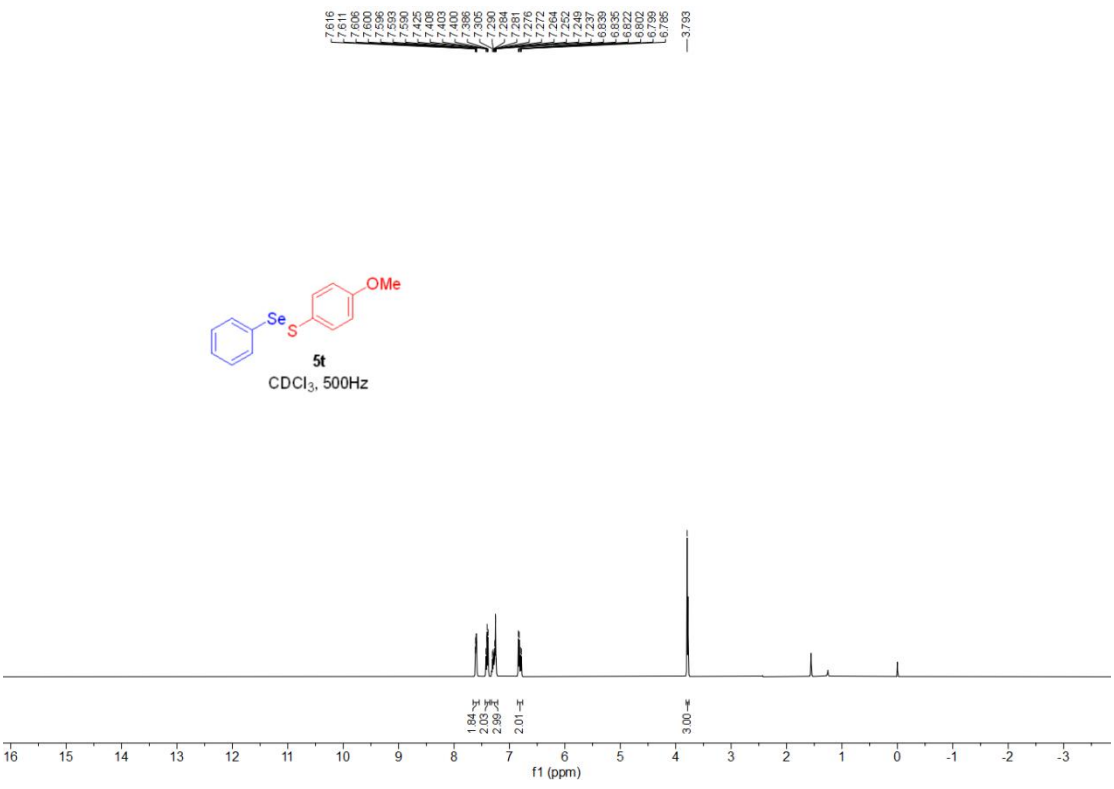

134.2
133.3
130.5
130.1
129.0
128.7
126.7
126.3
125.7
22.1
Se
S
5q
CDCl3, 125Hz
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

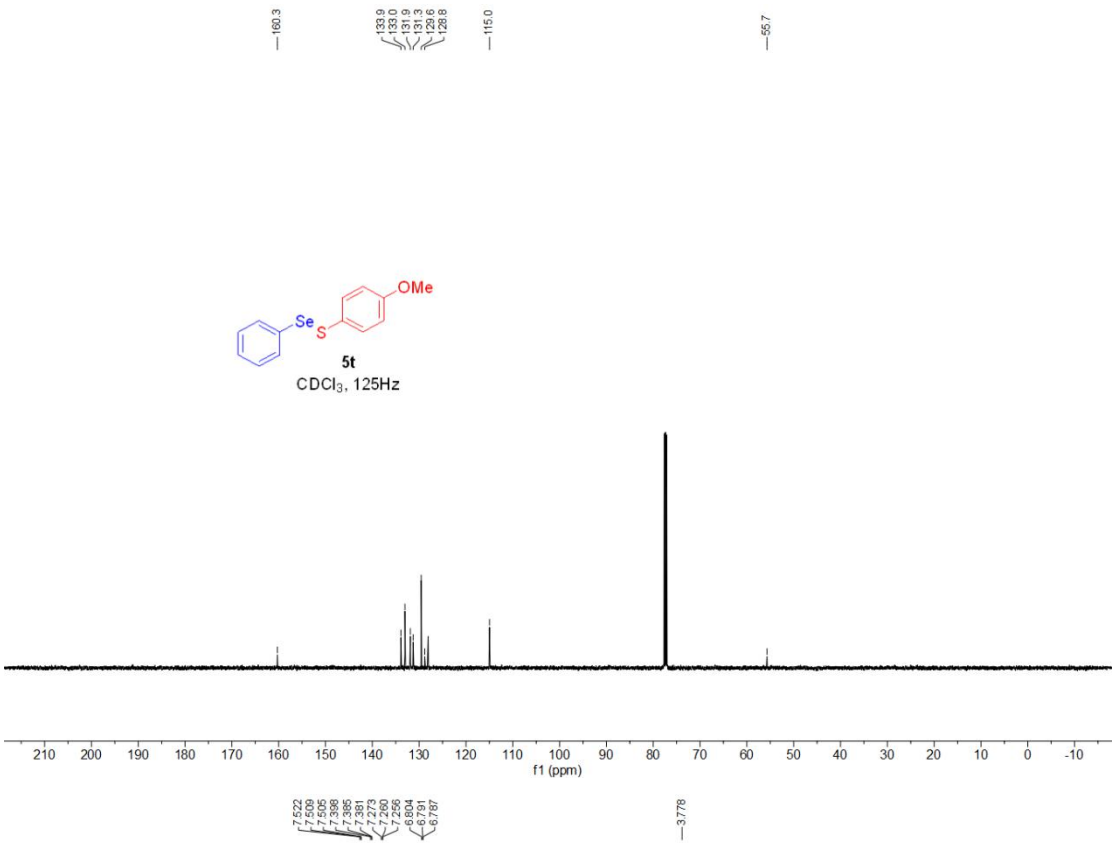

8.606
8.521
7.887
7.883
7.880
7.971
7.968
7.964
7.281
2.632
Se
S
N
5r
CDCl3, 500Hz
1.05
1.05
0.98
0.96
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

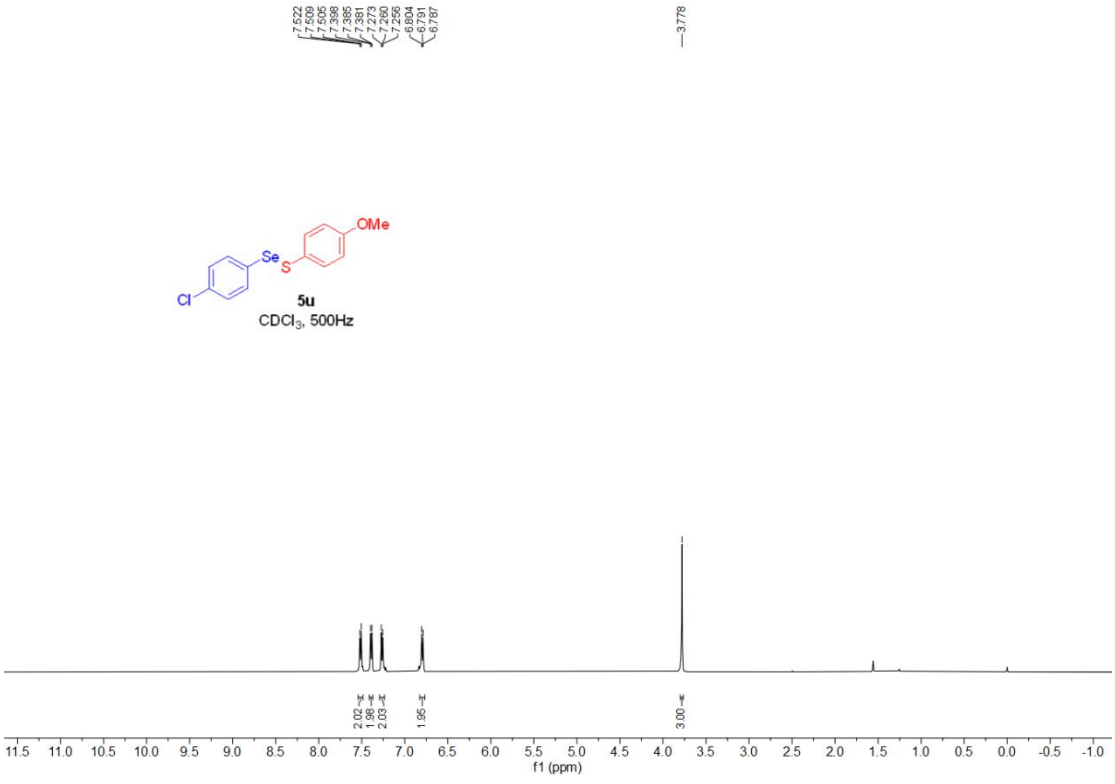

151.0
148.6
138.3
124.2
22.4
Se
S
N
5r
CDCl3, 125Hz
f1 (ppm)
7.633
7.618
7.323
7.308
7.293
2.862
2.848
2.833
1.663
1.648
1.633
1.618
1.603
1.406
1.391
1.376
1.361
1.346
0.888
0.873
0.859

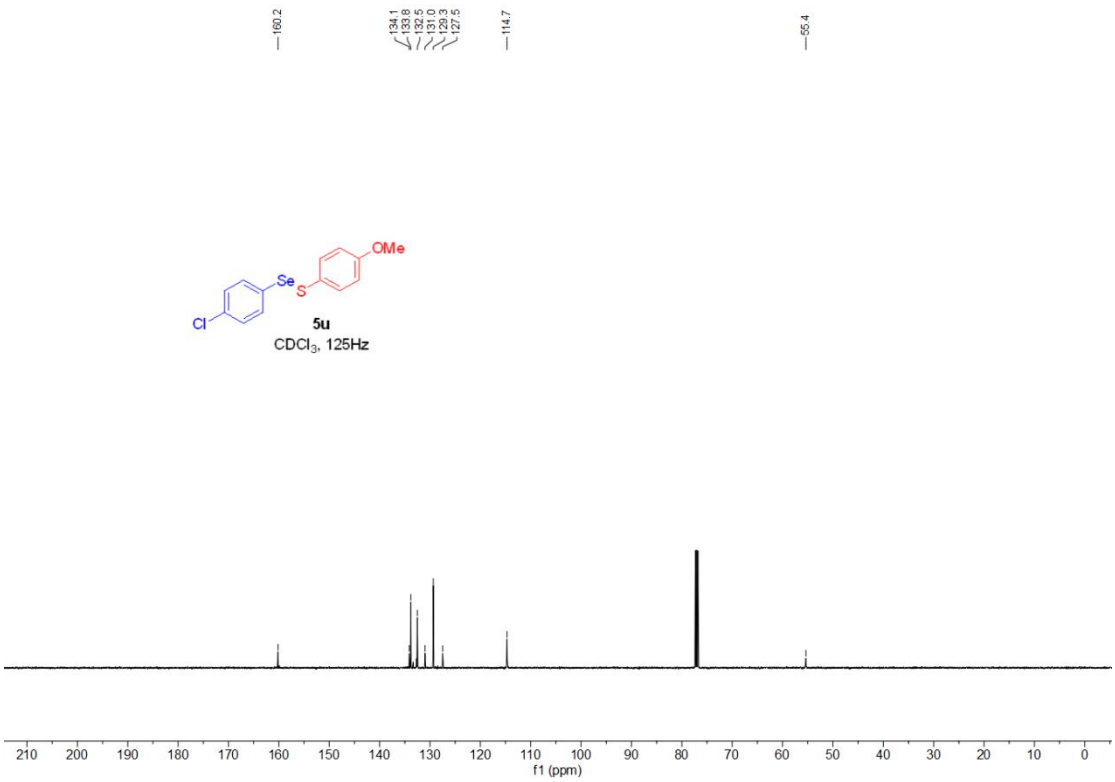

Se
S
n-Bu
5s
CDCl3, 500Hz
2.00
3.33
2.13
2.12
2.35
3.25
f1 (ppm)


132.4
130.9
129.9
129.1
127.2
38.0
32.3
21.6
13.6
Se
S
n-Bu
5s
CDCl3, 125Hz
f1 (ppm)


7.616
7.611
7.606
7.600
7.596
7.593
7.590
7.425
7.408
7.403
7.400
7.386
7.305
7.280
7.264
7.261
7.276
7.272
7.264
7.252
7.249
6.837
6.839
6.835
6.822
6.802
6.799
6.785
3.793
OMe
Se
S
5t
CDCl3, 500Hz
1.84
2.03
2.99
2.01
3.00
f1 (ppm)


160.3
133.9
133.0
131.9
131.3
129.6
128.8
115.0
55.7
OMe
Se
S
5t
CDCl3, 125Hz
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.522
7.509
7.505
7.398
7.385
7.381
7.273
7.260
7.256
6.804
6.791
6.787
3.778
OMe
Se
S
Cl
5u
CDCl3, 500Hz
2.02
1.98
2.03
1.95
3.00
11.5 11.0 10.5 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 -0.5 -1.0
f1 (ppm)


160.2
134.1
133.8
132.5
131.0
129.3
127.5
114.7
55.4
OMe
Se
S
Cl
5u
CDCl3, 125Hz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)