Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supporting Information

Cu-Mediated Arylselenylation of Aryl Halides with Trifluoromethyl Aryl Selenonium Ylides

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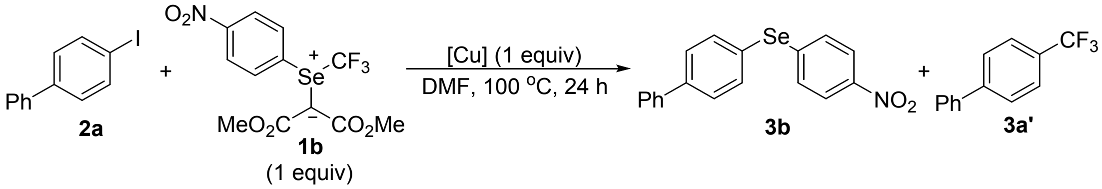
Table of contents

1. General information

All reactions were carried out under a nitrogen atmosphere unless otherwise stated. The NMR spectra were recorded in $CDCl_3$ or CD_3COCD_3 on a 500 MHz (for ^{1}H), 471 MHz (for ^{19}F), and 126 MHz (for ^{13}C) spectrometer. All chemical shifts were reported in ppm relative to TMS (0 ppm for ^{1}H NMR) and $PhOCF_3$ (58.0 ppm for ^{19}F NMR) as an internal or external standard, respectively. The coupling constants were reported in Hertz (Hz). The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, and m = multiplet. The HPLC experiments were carried out on a Wufeng LC-100 II instrument (column: Shodex, C18, 5 μm, 4.6 × 250 mm), and the HPLC yields of the products were determined by using the corresponding pure compounds as the external standards. Melting points were measured and uncorrected. MS experiments were performed on a TOF-Q ESI or EI instrument. Trifluoromethyl aryl selenium ylides (**1a-b**[1] and **1f-j**[1]), dimethyl 2-(phenylselanyl)malonate (**4**),[2] and aryl trifluoromethyl selenoethers[3] (starting materials for the synthesis of **1**) were synthesized according to the literatures. Solvents were purified according to the literature.[4] Other reagents used in the reactions were all purchased from the commercial sources and used without further purification.

2. Screening the optimal reaction conditions for 1b and 2a

Table S1. Reaction of **2a** with **1b** in the presence of different Cu-catalysts.[a]

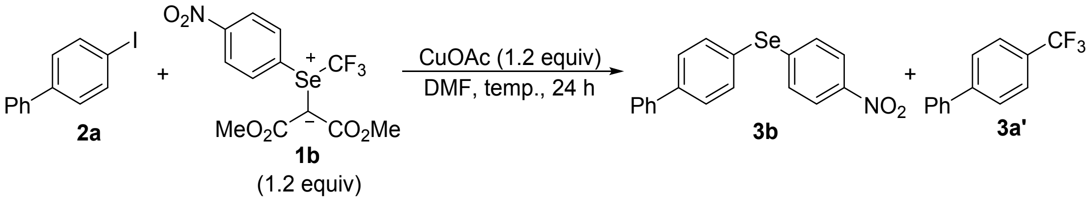


Entry	Catalyst	Yield (**3b**, %) [b]	Yield (**3a'**, %) [b]
1	CuI	8	4
2	CuCl	27	10
3	CuBr	16	7
4	**CuOAc**	**54**	**6**
5	CuSCN	5	0
6	CuCN	18	3
7	CuOTf	40	6

8	Cu(OAc)$_2$	45	0
9	CuSO$_4$	36	0
10	Cu(acac)$_2$	44	2
11	Cu	48	3

[a] Reaction conditions: a mixture of **2a** (0.2 mmol), **1b** (0.2 mmol), and catalysts (0.2 mmol) in DMF (2 mL) was reacted at 100 °C for 24 h. [b] Yields were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, t_R = 15.24 min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a'**, t_R = 8.54 min) as external standards, respectively.

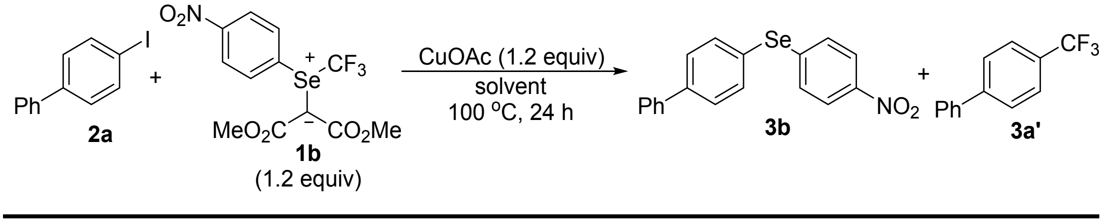
Table S2. CuOAc-Catalyzed reaction of **2a** with **1b** at different temperature.[a]



Entry	Temp. (°C)	Yield (**3b**, %)[b]	Yield (**3a'**, %)[b]
1	r.t.	0	1
2	60	trace	8
3	80	38	6
4	**100**	**56**	**6**

[a] Reaction condition: a mixture of **2a** (0.2 mmol), **1b** (0.24 mmol), and CuOAc (0.24 mmol) in DMF (2 mL) was reacted at different temperature for 24 h. [b] Yields were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, t_R = 15.24 min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a'**, t_R = 8.54 min) as external standards, respectively.

Table S3. CuOAc-Catalyzed reaction of **2a** with **1b** in different solvents.[a]

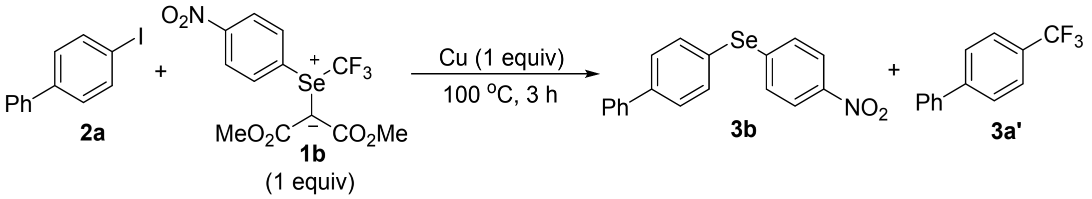


Entry	Solvent	Yield (**3b**, %)[b]	Yield (**3a'**, %)[b]

1	**DMSO**	**64**	**2**
2	1,4-dioxane	trace	2
3	toluene	11	0
4	CH_3CN	60	2
5	DCE	16	0
6	DMF	56	6
7	NMP	52	8

[a] Reaction condition: a mixture of **2a** (0.2 mmol), **1b** (0.24 mmol), and CuOAc (0.24 mmol) in solvent (2 mL) was stirred at 100 °C for 24 h. [b] Yields were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, t_R = 15.24 min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a**', t_R = 8.54 min) as external standards, respectively.

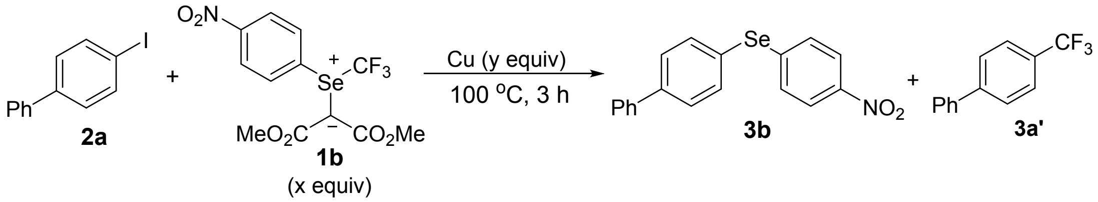
Table S4. The Cu-catalyzed reaction of **2a** with **1b** in different solvent.[a]



Entry	Solvent	Yield (**3b**, %)[b]	Yield (**3a’**, %)[b]
1	DMSO	42	3
2	CH_3CN	15	6
3	**DMF**	**54**	**3**

[a] Reaction condition: a mixture of **2a** (0.2 mmol), **1b** (0.2 mmol), and Cu (0.2 mmol) in solvent (2 mL) was reacted at 100 °C for 3 h. [b] Yields were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, t_R = 15.24 min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a**', t_R = 8.54 min) as external standards, respectively.

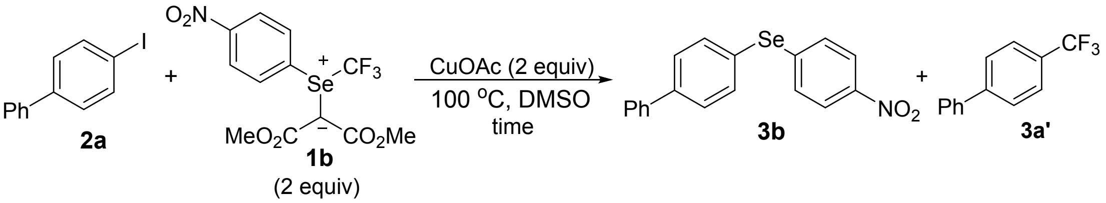
Table S5. The effects of molar ratios of **2a**, **1a** and Cu on the reaction.[a]



Entry	**[2a]**:[**1b**]:[Cu]	Yield (**3b**, %)[b]	Yield (**3a’**, %)[b]
1	1:1.2:1.2	49	3
2	1:1.2:2	56	3
3	1:1.5:1.5	60	12
4	1:2:2	84, 81[c]	6
5[d]	1:2:2	84	7
6	1:2:3	62	9
7	1:2:2.5	59	7
8	1:2:1.5	56	7
9	2:1:2	48	7
10[e]	1:2:2	14	9
11[f]	1:2:2	68	10
12[g]	1:2:2	0	trace
13[h]	**1:2:2**	**92**	**4**
14	1:2.5:2.5	72	7
15	1:3.5:2	58	10

[a] Reaction condition: a mixture of **2a** (0.2 mmol), **1b** (x equiv), and Cu (y equiv) in DMF (2 mL) was reacted at 100 °C for 3 h. [b] Yields were determined by HPLC ($\lambda = 253$ nm, $H_2O/CH_3OH = 15:85$ (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, $t_R = 15.24$ min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a**’, $t_R = 8.54$ min) as external standards, respectively. [c] Isolated yield. [d] 6 h. [e] CuOAc. [f] CuOAc, 24 h. [g] CuSCN. [h] CuOAc, DMSO, 24 h.

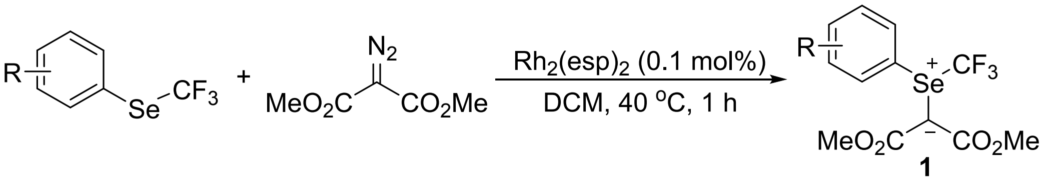
Table S6. Reaction of **2a**, **1b** and CuOAc with different times.[a]



Entry	Time (h)	Yield (**3b**, %)[b]	Yield (**3a'**, %)[b]
1	3	29	4
2	6	46	4
3	12	51	4
4	16	69	4
5	**20**	**94, 94**[c]	**5**
6	24	92	4
7	36	93	5

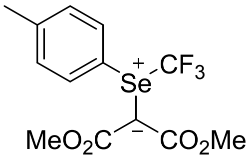
[a] Reaction condition: a mixture of **2a** (0.2 mmol), **1b** (0.4 mmol), and CuOAc (0.4 mmol) in DMSO (2 mL) was reacted at 100 °C for 3-36 h. [b] Yields were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (**3b**, t_R = 15.24 min) and 4-(trifluoromethyl)-1,1'-biphenyl (**3a'**, t_R = 8.54 min) as external standards, respectively. [c] Isolated yield.

3. Typical procedures for the synthesis of trifluoromethyl aryl selenium ylide 1



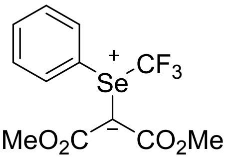
Procedure A: In a nitrogen-filled glovebox, an oven-dried flask was charged with *p*-tolyl(trifluoromethyl)selane (1.20 g, 5.0 mmol), $Rh_2(esp)_2$ (3.8 mg, 0.005 mmol), and CH_2Cl_2 (40 mL) with stirring. A solution of diazomalonate (0.948 g, 6.0 mmol) in CH_2Cl_2 (10 mL) was added slowly at room temperature during a period of 30 min. The mixture was heated at 40 °C for 1 h, cooled to room temperature, and concentrated to dryness under the reduced pressure. The residue was purified by column chromatography on silica gel using a mixture of petroleum ether and ethyl acetate (1:1 (v/v)) as eluents to give 0.846 g of **1c** as a white solid (91%).

Dimethyl 2-(p-tolyl(trifluoromethyl)-λ^4-selanylidene)malonate (**1c**)



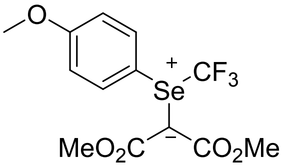
M.p.: 102-103 ºC. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.51 (d, *J* = 8.1 Hz, 2H), 7.36 (d, *J* = 8.1 Hz, 2H), 3.70 (s, 6H), 2.43 (s, 3H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -45.3 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 166.1, 143.5, 131.3, 128.7, 123.6, 120.5 (q, *J* = 357.3 Hz), 64.9, 51.4, 21.4. IR (KBr): 3077, 3023, 2959, 2851, 1744, 1690, 1649, 1587, 1488, 1440, 1322, 1231, 1210, 1170, 1075, 1056, 1040, 940, 808, 758, 741 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_{14}F_3O_4Se$ ([M + H]$^+$): 371.0004; Found: 370.9998.

Dimethyl 2-(phenyl(trifluoromethyl)-λ^4-selanylidene)malonate (**1a**)



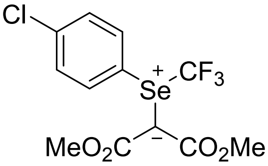
Light yellow solid (0.801 g, 90%), a mixture of petroleum ether and ethyl acetate (1:1 (v/v)) as eluents for column chromatography. M.p.: 78-80 ºC. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.67-7.58 (m, 5H), 3.73 (s, 6H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -44.9 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 166.1, 132.5, 130.6, 128.7, 127.0, 120.5 (q, *J* = 357.6 Hz), 64.8, 51.5. IR (KBr): 3090, 3074, 3018, 2960, 2850, 1748, 1697, 1648, 1479, 1440, 1325, 1233, 1205, 1169, 1074, 1055, 999, 941, 759, 741, 685 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{12}H_{12}F_3O_4Se$ ([M + H]$^+$): 356.9847; Found: 356.9857.

Dimethyl 2-((4-methoxyphenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1d**)[1]



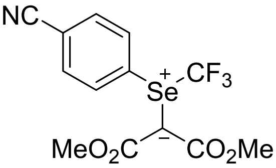
Light yellow oil (0.924 g, 96%), a mixture of petroleum ether and ethyl acetate (1:1 (v/v)) as eluents for column chromatography. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.58 (d, *J* = 8.9 Hz, 2H), 7.05 (d, *J* = 8.9 Hz, 2H), 3.86 (s, 3H), 3.70 (s, 6H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -45.8 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 166.2, 163.1, 131.0, 120.5 (q, *J* = 357.7 Hz), 117.1, 116.1, 65.4, 55.7, 51.4.

Dimethyl 2-((4-chlorophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1e**)



White solid (0.317 g, 68%), a mixture of petroleum ether and ethyl acetate (1:1 (v/v)) as eluents for column chromatography. M.p.: 113-115 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.60-7.55 (m, 4H), 3.71 (s, 6H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -44.7 (s, 3F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.0, 139.5, 130.9, 130.2, 125.1, 120.5 (q, J = 357.6 Hz), 65.1, 51.6. IR (KBr): 3098, 3083, 3013, 2994, 2950, 2911, 2843, 1684, 1630, 1439, 1394, 1336, 1239, 1197, 1186, 1161, 1100, 1076, 1005, 813, 764, 737 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{12}H_{11}ClF_3O_4Se$ ([M + H]$^+$): 390.9458; Found: 390.9452.

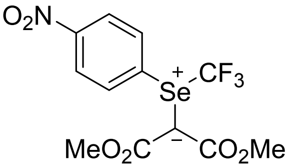
Dimethyl 2-((4-cyanophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1g**)



White solid (0.537 g, 94%), a mixture of petroleum ether and ethyl acetate (1:1 (v/v)) as eluents for column chromatography. M.p.: 125-127 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (d, J = 8.4 Hz, 2H), 7.77 (d, J = 8.4 Hz, 2H), 3.72 (s, 6H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -43.6 (s, 3F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.9, 133.8, 130.2, 127.7, 125.7, 121.8, 120.5 (q, J = 357.5 Hz), 65.0, 51.6. IR (KBr): 3093, 3071, 2949, 2849, 2236, 1678, 1633, 1440, 1326, 1244, 1196, 1187, 1163, 1083, 1053, 1009, 957, 825, 761, 738 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_{11}F_3O_4Se$ ([M + H]$^+$): 381.9800; Found: 381.9802.

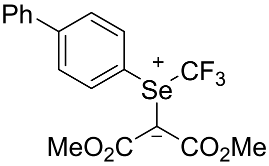
Procedure B: In a nitrogen-filled glovebox, an oven-dried flask was charged with aryl trifluoromethylselenoether (1 equiv), $Rh_2(esp)_2$ (0.1 mol%), and CH_2Cl_2 with stirring. A solution of diazomalonate (1.2 equiv) in CH_2Cl_2 was added slowly at room temperature during a period of 30 min. The mixture was heated at 40 °C for 1 h, cooled to room temperature, and concentrated to dryness under the reduced pressure. The residue was purified by crystallization from layering a solution of the crude product in dichloromethane with diethyl ether to afford the desired product (**1b**, **1f**, and **1h**-**j**).

Dimethyl 2-((4-nitrophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1b**)[1]



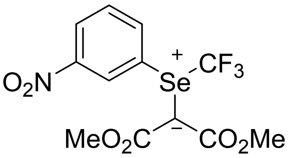
Yellow solid (3.2 g, 80%). M.p.: 113-115 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.42 (d, *J* = 8.7 Hz, 2H), 7.85 (d, *J* = 8.7 Hz, 2H), 3.74 (s, 6H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -43.5 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 165.7, 150.3, 133.7, 130.0, 125.3, 120.5 (q, *J* = 358.5 Hz), 65.4, 51.8.

Dimethyl 2-([1,1'-biphenyl]-4-yl(trifluoromethyl)-λ^4-selanylidene)malonate (**1f**)[1]



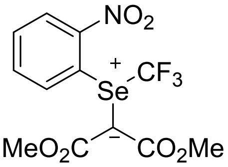
White solid (0.450 g, 52%). M.p.: 122-124 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.77 (d, *J* = 8.3 Hz, 2H), 7.70 (d, *J* = 8.3 Hz, 2H), 7.58 (d, *J* = 7.5 Hz, 2H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.43 (t, *J* = 7.2 Hz, 1H), 3.73 (s, 6H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -44.9 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 166.1, 145.7, 138.9, 129.3, 129.2, 129.1, 128.7, 127.3, 125.4, 120.5 (q, *J* = 357.0 Hz), 64.9, 51.5.

Dimethyl 2-((3-nitrophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1h**)[1]



Grey solid (0.442 g, 73%). M.p.: 127-129 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.50-8.47 (m, 2H), 7.99 (d, *J* = 8.1 Hz, 1H), 7.82 (t, *J* = 8.1 Hz, 1H), 3.74 (s, 6H). ^{19}F NMR (471 MHz, CDCl$_3$) δ -43.7 (s, 3F). ^{13}C NMR (126 MHz, CDCl$_3$) δ 165.8, 149.1, 134.4, 131.5, 128.9, 127.2, 124.2, 120.5 (q, *J* = 358.8 Hz), 65.4, 51.8.

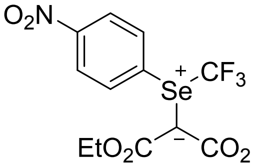
Dimethyl 2-((2-nitrophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1i**)[1]



Yellow solid (0.777 g, 53%). M.p.: 116-118 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.52

(dd, *J* = 7.8, 1.3 Hz, 1H), 7.97 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.91 (td, *J* = 7.8, 1.5 Hz, 1H), 7.86 (td, *J* = 7.9, 1.5 Hz, 1H), 3.70 (s, 6H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -42.7 (s, 3F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.1, 146.3, 135.7, 133.8, 132.3, 126.7, 122.9, 120.5 (q, *J* = 357.2 Hz), 65.2, 51.6.

Diethyl 2-((4-nitrophenyl)(trifluoromethyl)-λ^4-selanylidene)malonate (**1j**)

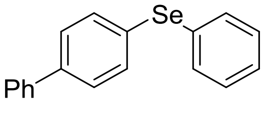


Yellow solid (0.483 g, 23%). M.p.: 123-125 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.41 (d, *J* = 8.6 Hz, 2H), 7.86 (d, *J* = 8.6 Hz, 2H), 4.18 (q, *J* = 7.1 Hz, 4H), 1.23 (t, *J* = 7.1 Hz, 6H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -43.6 (s, 3F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.4, 150.2, 134.0, 130.0, 125.2, 120.5 (q, *J* = 358.9 Hz), 65.6, 60.7, 14.4. IR (KBr): 3098, 2982, 2953, 1677, 1638, 1601, 1526, 1478, 1398, 1373, 1347, 1320, 1233, 1203, 1182, 1088, 1070, 1050, 1007, 849, 764, 739, 708 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{12}H_{11}F_3NO_6Se$ ($[M + H]^+$): 430.0011; Found: 430.0007.

4. General procedure for the synthesis of diaryl selenides 3

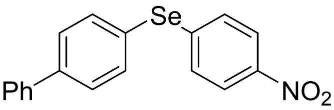
In a nitrogen-filled glovebox, a sealed tube was charged with aryl halides (**2**, 0.2 mmol), trifluoromethyl aryl selenium ylide (**1**, 0.4 mmol), CuOAc (48.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100, 120 or 140 °C for 20 h, cooled to room temperature, and diluted with ethyl acetate (60 mL). The organic solution was washed by water (20 × 3 mL), dried over anhydrous Na_2SO_4, and concentrated to dryness under reduced pressure. The residue was purified by column chromatography on silica gel using petroleum ether or a mixture of petroleum ether and ethyl acetate as eluents to give the title compound (**3**).

[1,1'-Biphenyl]-4-yl(phenyl)selane (**3a**)[5]



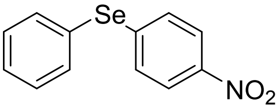
White solid (41.5 mg from 100 °C, 67%; 44.6 mg from 120 °C, 72%), petroleum ether as eluent for column chromatography. M.p.: 64-66 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59 (d, *J* = 7.8 H, 2H), 7.56-7.51 (m, 6H), 7.45 (t, *J* = 7.4 Hz, 2H), 7.37 (m, 1H), 7.33-7.30 (m, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 140.4, 140.3, 133.3, 133.1, 131.1, 130.3, 129.4, 128.9, 128.0, 127.5, 127.5, 127.0.

[1, 1'-Biphenyl]-4-yl(4-nitrophenyl)selane (**3b**)



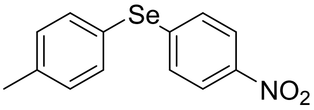
Yellow solid (67.0 mg from **1b**, 94%; 39.1 mg from 4-PhC_6H_4Br (140 °C), 55%; 59.7 mg from **1j**, 84%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 95-97 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.06 (d, J = 9.0 Hz, 2H), 7.70 (d, J = 8.4 Hz, 2H), 7.64-7.61 (m, 4H), 7.48 (t, J = 7.5 Hz, 2H), 7.43-7.39 (m, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.3, 143.8, 142.4, 139.9, 136.2, 129.9, 129.0, 128.7, 128.0, 127.1, 126.1, 124.0. IR (KBr): 3059, 2924, 1574, 1512, 1474, 1343, 1176, 1107, 1060, 1003, 850, 762, 734, 692 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{18}H_{14}NO_2Se$ ($[M + H]^+$): 356.0184; Found: 356.0178.

(4-Nitrophenyl)(phenyl)selane (**3c**)[6]



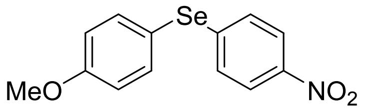
Yellow solid (54.2 mg from C_6H_5I, 97%; 39.0 mg from C_6H_5Br (140 °C), 70%), a mixture of petroleum ether and ethyl acetate (80:1 (v/v)) as eluents for column chromatography. M.p.: 56-58 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.03 (d, J = 8.8 Hz, 2H), 7.64 (d, J = 6.8 Hz, 2H), 7.47-7.40 (m, 3H), 7.36 (d, J = 9.0 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.2, 144.0, 135.9, 130.1, 129.7, 129.4, 127.2, 124.0.

(4-Nitrophenyl)(*p*-tolyl)selane (**3d**)[7]



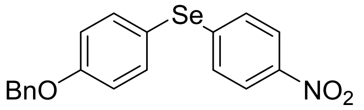
Yellow solid (49.9 mg from 4-$CH_3C_6H_4I$, 85%; 34.0 mg from 4-$CH_3C_6H_4Br$ (140 °C), 58%), a mixture of petroleum ether and ethyl acetate (80:1 (v/v)) as eluents for column chromatography. M.p.: 82-84 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.01 (d, J = 8.9 Hz, 2H), 7.53 (d, J = 7.8 Hz, 2H), 7.32 (d, J = 8.9 Hz, 2H), 7.23 (d, J = 7.9, 2H), 2.41 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.0, 144.8, 139.8, 136.2, 130.9, 129.2, 123.9, 123.3, 21.3.

(4-Methoxyphenyl)(4-nitrophenyl)selane (**3e**)[6]



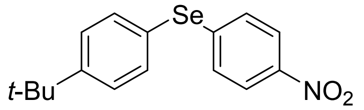
Yellow solid (48.0 mg, 78%; 23.0 mg from 4-$MeOC_6H_4Br$ (140 °C, 20 h), 37%; 32.2 mg from 4-$MeOC_6H_4Br$ (140 °C, 48 h), 52%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 88-90 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.01 (d, *J* = 9.0 Hz, 2H), 7.58 (d, *J* = 8.8 Hz, 2H), 7.28 (d, *J* = 9.0 Hz, 2H), 6.95 (d, *J* = 8.9, 2H), 3.86 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.9, 145.9, 145.4, 138.2, 128.7, 123.9, 116.8, 115.8, 55.4.

(4-(Benzyloxy)phenyl)(4-nitrophenyl)selane (**3f**)



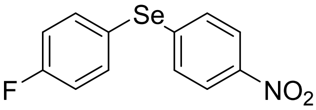
Yellow solid (48.4 mg, 63%; 47.7 mg from 4-$BnOC_6H_4Br$ (140 °C), 62%), a mixture of petroleum ether and ethyl acetate (20:1 (v/v)) as eluents for column chromatography. M.p.: 107-109 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.02 (d, *J* = 8.9 Hz, 2H), 7.58 (d, *J* = 8.7 Hz, 2H), 7.46 (d, *J* = 7.1 Hz, 2H), 7.42 (d, *J* = 7.2 Hz, 2H), 7.36 (t, *J* = 7.0, 1H), 7.29 (d, *J* = 9.0 Hz, 2H), 7.03 (d, *J* = 8.5 Hz, 2H), 5.12 (s, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.1, 146.0, 145.3, 138.2, 136.4, 128.8, 128.7, 128.2, 127.5, 123.9, 117.3, 116.7, 70.2. IR (KBr): 3084, 3063, 3028, 2929, 2876, 2848, 1588, 1573, 1510, 1492, 1359, 1345, 1281, 1242, 1176, 1108, 1079, 1059, 1012, 915, 840, 811, 751, 736, 700, 654 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{19}H_{19}N_2O_3Se$ ($[M + NH_4]^+$): 403.0555; Found: 403.0554.

(4-(*Tert*-butyl)phenyl)(4-nitrophenyl)selane (**3g**)



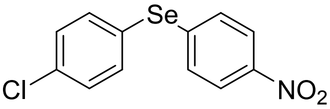
Yellow solid (63.5 mg, 95%; 40.5 mg from 4-*t*-BuC_6H_4Br (140 °C), 60%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 66-68 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.9 Hz, 2H), 7.56 (d, *J* = 8.6 Hz, 2H), 7.43 (d, *J* = 8.5 Hz, 2H), 7.35 (d, *J* = 8.8, 2H), 1.36 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 152.9, 146.1, 144.4, 135.8, 129.5, 127.2, 123.9, 123.6, 34.8, 31.2. IR (KBr): 3100, 3061, 3027, 2952, 2901, 2867, 1595, 1575, 1509, 1474, 1398, 1341, 1323, 1176, 1113, 1075, 1061, 1009, 853, 838, 827, 739, 678 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{16}H_{18}NO_2Se$ ($[M + H]^+$): 336.0497; Found: 336.0483.

(4-Fluorophenyl)(4-nitrophenyl)selane (**3h**)[8]



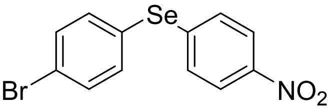
Yellow solid (41.3 mg, 70%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 71-73 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (d, *J* = 9.0 Hz, 2H), 7.64 (m, 2H), 7.32 (d, *J* = 8.9 Hz, 2H), 7.12 (t, *J* = 8.7 Hz, 2H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -110.7 (m, 1F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.6 (d, *J* = 250.5 Hz), 146.3, 143.8, 138.3 (d, *J* = 8.3 Hz), 129.4, 124.0, 121.8 (d, *J* = 3.5), 117.4 (d, *J* = 21.8 Hz).

(4-Chlorophenyl)(4-nitrophenyl)selane (**3i**)[9]



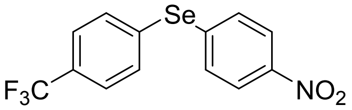
Yellow solid (52.3 mg, 84%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 82-84 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.7 Hz, 2H), 7.56 (d, *J* = 8.5 Hz, 2H), 7.38-7.35(m, 4H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.4, 143.1, 137.1, 135.9, 130.3, 129.9, 125.5, 124.1.

(4-Bromophenyl)(4-nitrophenyl)selane (**3j**)



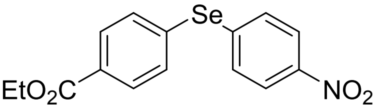
Yellow solid (39.6 mg, 56%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 97-99 °C. ^{1}H NMR (500 MHz, acetone-d_6) δ 8.14 (d, *J* = 8.7 Hz, 2H), 7.65 (d, *J* = 8.6 Hz, 2H), 7.62 (d, *J* = 8.6 Hz, 2H), 7.57 (d, *J* = 8.7 Hz, 2H). ^{13}C NMR (126 MHz, acetone-d_6) δ 146.7, 142.4, 137.3, 133.2, 130.5, 126.7, 124.1, 123.4. IR (KBr): 3088, 3019, 2920, 2840, 1912, 1817, 1645, 1574, 1509, 1466, 1341, 1321, 1177, 1109, 1064, 1005, 851, 842, 808, 738, 709, 678 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{12}H_9BrNO_2Se$ ([M + H]$^+$): 357.8976; Found: 357.8973.

(4-Nitrophenyl)(4-(trifluoromethyl)phenyl)selane (**3k**)



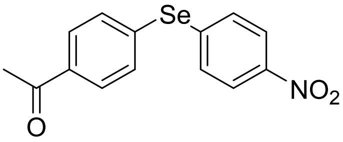
Yellow solid (49.6 mg, 71%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 81-83 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 9.0 Hz, 2H), 7.68 (d, *J* = 8.2 Hz, 2H), 7.62 (d, *J* = 8.2 Hz, 2H), 7.48 (d, *J* = 8.9 Hz, 2H). ^{19}F NMR (471 MHz, $CDCl_3$) δ -62.9 (s, 3F). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.9, 141.2, 134.7, 133.2, 131.5, 131.0 (q, *J* = 32.8 Hz), 126.7 (q, *J* = 3.7 Hz), 124.3, 123.8 (q, *J* = 272.2 Hz). IR (KBr): 3097, 3068, 2962, 2920, 2850, 1595, 1577, 1508, 1475, 1398, 1341, 1324, 1168, 1123, 1100, 1081, 1065, 1056, 1016, 1009, 958, 852, 835, 817, 737, 690 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_9F_3NO_2Se$ ([M + H]$^+$): 347.9745; Found: 347.9751.

Ethyl 4-((4-nitrophenyl)selanyl)benzoate (**3l**)



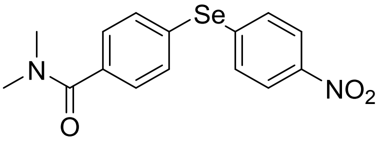
Yellow solid (57.9 mg, 82%; 36.1 mg from 4-$EtO_2CC_6H_5Br$ (140 °C), 60%), a mixture of petroleum ether and ethyl acetate (2:1 (v/v)) as eluents for column chromatography. M.p.: 111-113 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.9 Hz, 2H), 8.01 (d, *J* = 8.2 Hz, 2H), 7.61 (d, *J* = 8.3 Hz, 2H), 7.46 (d, *J* = 8.9 Hz, 2H), 4.39 (q, *J* = 7.2 Hz, 2H), 1.40 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.9, 146.8, 141.6, 134.3, 134.2, 131.4, 130.8, 130.8, 124.2, 61.3, 14.3. IR (KBr): 3090, 3059, 3038, 2979, 2925, 2909, 2850, 1945, 1817, 1702, 1589, 1575, 1517, 1488, 1474, 1400, 1369, 1349, 1287, 1274, 1184, 1106, 1058, 1011, 852, 760, 739, 688, 683 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{15}H_{14}NO_4Se$ ([M + H]$^+$): 352.0083; Found: 352.0078.

1-(4-((4-Nitrophenyl)selanyl)phenyl)ethan-1-one (**3m**)



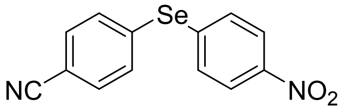
Yellow solid (21.0 mg from CuOAc/DMF/20 h, 33%; 31.2 mg from Cu/DMF/3 h, 49%), a mixture of petroleum ether and ethyl acetate (10:1 (v/v)) as eluents for column chromatography. M.p.: 125-127 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.10 (d, *J* = 8.9 Hz, 2H), 7.92 (d, *J* = 8.4 Hz, 2H), 7.63 (d, *J* = 8.3 Hz, 2H), 7.50 (d, *J* = 8.8 Hz, 2H), 2.62 (s, 3H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 197.1, 147.0, 141.1, 137.1, 135.1, 134.1, 131.8, 129.5, 124.2, 26.6. IR (KBr): 3085, 3053, 3003, 2958, 2920, 2849, 1681, 1572, 1514, 1477, 1394, 1344, 1319, 1267, 1181, 1105, 1060, 1008, 957, 852, 827, 737, 682 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{14}H_{12}NO_3Se$ ([M + H]$^+$): 321.9977; Found: 321.9983.

N,*N*-Dimethyl-4-((4-nitrophenyl)selanyl)benzamide (**3n**)



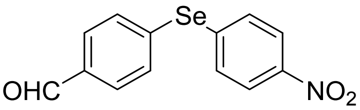
Yellow solid (42.3 mg, 61%), a mixture of petroleum ether and ethyl acetate (2:1 (v/v)) as eluents for column chromatography. M.p.: 97-99 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.04 (d, *J* = 8.9 Hz, 2H), 7.62 (d, *J* = 8.1 Hz, 2H), 7.43-7.39 (m, 4H), 3.12 (s, 3H), 3.00 (s, 3H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 170.6, 146.5, 142.6, 137.1, 135.3, 135.2, 130.5, 129.4, 128.6, 39.5, 35.4. IR (KBr): 3077, 3043, 2921, 2850, 1790, 1630, 1593, 1574, 1517, 1472, 1404, 1343, 1264, 1085, 1068, 1009, 851, 828, 736 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{15}H_{15}N_2O_3Se$ ([M + H]$^+$): 351.0242; Found: 351.0250.

4-((4-Nitrophenyl)selanyl)benzonitrile (**3o**)



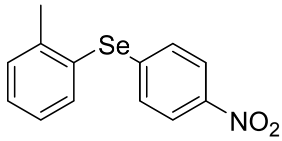
Yellow solid (27.2 mg from 4-NCC$_6$H$_4$I, 45%; 32.0 mg from 4-NCC$_6$H$_4$Br (140 °C), 53%), a mixture of petroleum ether and ethyl acetate (10:1 (v/v)) as eluents for column chromatography. M.p.: 134-136 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.14 (d, *J* = 8.6 Hz, 2H), 7.62-7.55 (m, 6H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 147.4, 139.4, 136.1, 133.7, 133.0, 132.8, 124.5, 118.1, 112.2. IR (KBr): 3091, 3052, 3023, 2922, 2850, 2230, 1921, 1798, 1729, 1655, 1596, 1585, 1574, 1510, 1481, 1346, 1177, 1104, 1059, 1011, 851, 826, 737, 681, 547 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_{12}N_3O_2Se$ ([M + NH_4]$^+$): 322.0089; Found: 322.0082.

4-((4-Nitrophenyl)selanyl)benzaldehyde (**3p**)



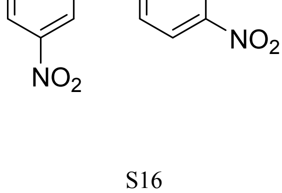
Yellow solid (53.9 mg, 88%), a mixture of petroleum ether and ethyl acetate (10:1 (v/v)) as eluents for column chromatography. M.p.: 135-137 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 10.02 (s, 1H), 8.13 (d, J = 8.8 Hz, 2H), 7.84 (d, J = 8.1 Hz, 2H), 7.66 (d, J = 8.1 Hz, 2H), 7.56 (d, J = 8.8 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 191.1, 147.2, 140.2, 137.5, 136.0, 133.8, 132.4, 130.6, 124.3. IR (KBr): 3090, 3054, 2832, 2736, 1696, 1587, 1564, 1508, 1474, 1384, 1346, 1208, 1168, 1104, 1058, 1010, 852, 836, 737, 680 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_{10}NO_3Se$ ([M + H]$^+$): 307.9820; Found: 307.9822.

(4-Nitrophenyl)(*o*-tolyl)selane (**3q**)



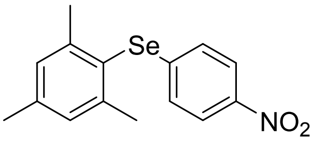
Yellow solid (50.0 mg, 85%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 61-63 °C. ^1H NMR (500 MHz, $CDCl_3$) δ 8.03 (d, J = 8.8 Hz, 2H), 7.65 (d, J = 7.5 Hz, 1H), 7.40-7.38 (m, 2H), 7.28 (d, J = 8.6 Hz, 2H), 7.21 (m, 1H), 2.42 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 146.1, 143.8, 142.4, 137.4, 131.0, 130.2, 129.2, 127.9, 127.4, 124.0, 22.8. IR (KBr): 3087, 3064, 2999, 2957, 2924, 2854, 1594, 1571, 1506, 1475, 1359, 1341, 1317, 1184, 1109, 1064, 1033, 1101, 851, 836, 750, 737, 677 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{13}H_{12}NO_2Se$ ([M + H]$^+$): 294.0028; Found: 294.0032.

(3-Nitrophenyl)(4-nitrophenyl)selane (**3r**)



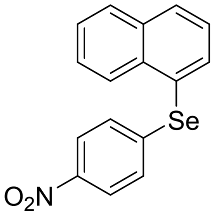
Yellow solid (49.7 mg, 77%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 120-122 °C. ^{1}H NMR (500 MHz, acetone-d$_6$) δ 8.44 (s, 1H), 8.31 (d, *J* = 8.2 Hz, 1H), 8.17 (d, *J* = 8.7 Hz, 2H), 8.07 (d, *J* = 7.8 Hz, 1H), 7.76 (t, *J* = 7.9 Hz, 1H), 7.70 (d, *J* = 8.6 Hz, 2H). ^{13}C NMR (126 MHz, acetone-d$_6$) δ 148.9, 147.2, 140.7, 140.6, 131.8, 131.2, 130.2, 128.9, 124.3, 123.7. IR (KBr): 3093, 3019, 3075, 2919, 2850, 1648, 1596, 1576, 1525, 1476, 1345, 1184, 1109, 1058, 870, 852, 835, 802, 729, 670 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{12}H_9N_2O_4Se$ ([M + H]$^+$): 324.9722; Found: 324.9724.

Mesityl(4-nitrophenyl)selane (**3s**)[10]



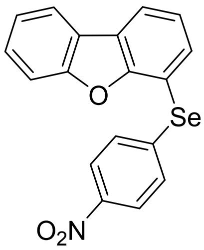
Yellow solid (53.9 mg, 84%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 89-91 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.98 (d, *J* = 8.9 Hz, 2H), 7.14 (d, *J* = 8.9 Hz, 2H), 7.06 (s, 2H), 2.42 (s, 6 H), 2.35 (s, 3H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 145.7, 144.8, 143.7, 140.3, 129.4, 127.7, 125.1, 124.0, 24.1, 21.1.

Naphthalen-1-yl(4-nitrophenyl)selane (**3t**)[11]



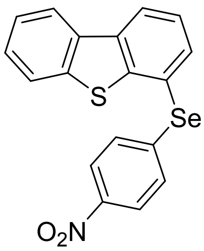
Yellow solid (51.7 mg, 79%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 82-84 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.27 (d, *J* = 8.0 Hz, 1H), 8.02 (d, *J* = 7.6 Hz, 2H), 7.96 (d, *J* = 8.7 Hz, 2H), 7.92 (d, *J* = 7.6 Hz, 1H), 7.58-7.49 (m, 3H), 7.23 (d, *J* = 8.7 Hz, 2H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 146.1, 143.9, 136.8, 134.6, 134.5, 131.2, 129.1, 128.9, 127.7, 126.8, 126.2, 126.0, 123.9.

4-((4-Nitrophenyl)selanyl)dibenzo[b,d]furan (**3u**)



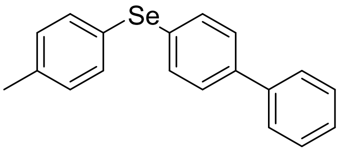
Yellow solid (57.6 mg, 78%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 143-145 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 (d, *J* = 7.6 Hz, 1H), 8.02-7.98 (m, 3H), 7.71 (d, *J* = 7.5 Hz, 1H), 7.58 (d, *J* = 8.2 Hz, 1H), 7.49 (t, *J* = 7.3 Hz, 1H), 7.41-7.38 (m, 4H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.7, 156.0, 146.4, 142.2, 134.7, 129.9, 127.9, 125.2, 124.1, 124.0, 124.0, 123.3, 122.5, 121.1, 112.0, 109.5. IR (KBr): 3101, 3054, 3019, 2835, 1787, 1664, 1593, 1575, 1503, 1475, 1466, 1447, 1408, 1341, 1318, 1260, 1220, 1183, 1142, 1108, 1066, 1031, 1010, 850, 844, 750, 737 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{18}H_{12}NO_3Se$ ([M + H]$^+$): 369.9977; Found: 369.9977.

4-((4-Nitrophenyl)selanyl)dibenzo[b,d]thiophene (**3v**)



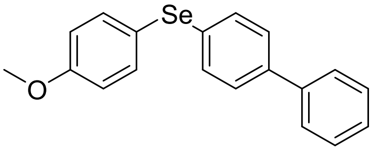
Yellow solid (59.9 mg, 78%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 154-156 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.28 (d, *J* = 7.9 Hz, 1H), 8.17 (m, 1H), 8.00 (d, *J* = 8.6 Hz, 2H), 7.83-7.81 (m, 2H), 7.54-7.48 (m, 3H) 7.33 (d, *J* = 8.8 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 147.3, 146.4, 141.9, 139.3, 136.5, 136.0, 135.2, 129.5, 127.4, 125.7, 124.8, 124.1, 123.1, 122.9, 122.2, 120.3. IR (KBr): 3090, 3060, 2918, 2849, 1642, 1594, 1575, 1509, 1382, 1343, 1246, 1102, 1063, 1045, 1028, 1008, 851, 836, 797, 756, 738, 679 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{18}H_{12}NO_2SSe$ ([M + H]$^+$): 385.9748; Found: 385.9755.

[1,1'-Biphenyl]-4-yl(*p*-tolyl)selane (**3w**)[9]



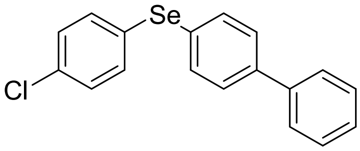
White solid (30.6 mg from 100 °C, 47%; 41.8 mg from 120 °C, 65%), petroleum ether as eluent for column chromatography. M.p.: 98-100 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (d, *J* = 8.0 H, 2H), 7.49-7.43 (m, 8H), 7.36 (t, *J* = 6.9 Hz, 1H), 7.15 (d, *J* = 7.6 Hz, 2H), 2.37 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 140.5, 139.9, 137.8, 134.0, 132.4, 131.3, 130.3, 128.8, 127.9, 127.4, 127.0, 126.9, 21.2.

[1,1'-Biphenyl]-4-yl(4-methoxyphenyl)selane (**3x**)[9]



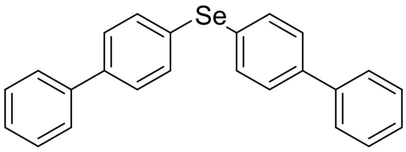
White solid (17.2 mg from 100 °C, 25%; 37.1 mg from 120 °C, 54%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 75-77 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57-7.55 (m, 4H), 7.47-7.40 (m, 6H), 7.34 (t, *J* = 7.3 Hz, 1H), 6.89 (d, *J* = 8.7 Hz, 2H), 3.83 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.9, 140.5, 139.5, 136.6, 132.4, 131.3, 128.8, 127.8, 127.3, 126.9, 112.0, 115.2, 55.3.

[1,1'-Biphenyl]-4-yl(4-chlorophenyl)selane (**3y**)[9]



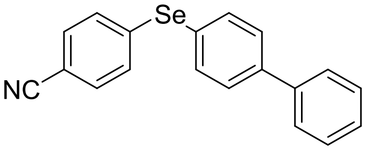
White solid (55.7 mg, 81%), petroleum ether as eluent for column chromatography. M.p.: 119-121 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 7.8 Hz, 2H), 7.58-7.54 (m, 4H), 7.50-7.45 (m, 4H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.29 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 140.7, 140.3, 134.2, 133.6, 133.6, 129.7, 129.6, 128.9, 128.2, 127.6, 127.0.

Di([1,1'-biphenyl]-4-yl)selane (**3z**)[12]



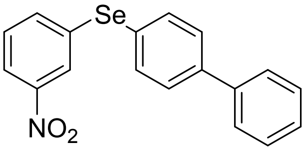
White solid (47.4 mg from 100 °C, 61%; 51.3 mg from 120 °C, 66%), petroleum ether as eluent for column chromatography. M.p.: 177-179 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.61 (d, *J* = 7.6 Hz, 8H), 7.55 (d, *J* = 7.8 Hz, 4H), 7.47 (t, *J* = 7.3 Hz, 4H), 7.38 (t, *J* = 7.3 Hz, 2H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 140.4, 140.4, 133.4, 130.2, 128.9, 128.1, 127.5, 127.0.

4-([1,1'-Biphenyl]-4-ylselanyl)benzonitrile (**3aa**)



White solid (63.6 mg, 95%), a mixture of petroleum ether and ethyl acetate (20:1 (v/v)) as eluents for column chromatography. M.p.: 131-133 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.67 (d, *J* = 8.2 Hz, 2H), 7.61 (d, *J* = 7.5 Hz, 4H), 7.49-7.46 (m, 4H). 7.41-7.39 (m, 3H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 142.1, 140.9, 139.9, 136.0, 132.4, 130.4, 129.0, 128.6, 127.9, 127.1, 126.4, 118.8, 109.8. IR (KBr): 3052, 3028, 2924, 2853, 2227, 1587, 1552, 1481, 1474, 1445, 1391, 1181, 1063, 1016, 1004, 833, 812, 763, 715, 695 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{19}H_{14}NSe$ ([M + H]$^+$): 336.0286; Found: 336.0285.

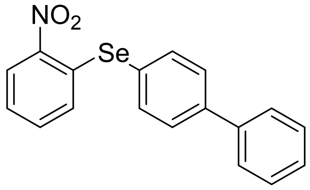
[1,1'-Biphenyl]-4-yl(3-nitrophenyl)selane (**3ab**)



Yellow solid (47.4 mg, 67%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 95-97 °C. ^{1}H NMR (500 MHz, CDCl$_3$) δ 8.27 (m, 1H), 8.07 (dd, *J* = 8.2, 1.0 Hz, 1H), 7.70 (d, *J* = 7.7 Hz, 1H), 7.65 (d, *J* = 8.2 Hz, 2H), 7.61-7.58 (m, 4H), 7.47 (t, *J* = 7.5 Hz, 2H), 7.43-7.37 (m, 2H). ^{13}C NMR (126 MHz, CDCl$_3$) δ 148.7, 141.8, 140.0, 137.1, 135.1, 134.8, 129.9, 128.9, 128.6, 127.9, 127.4, 127.1, 125.9, 121.7. IR (KBr): 3098, 3049, 2919, 2855, 1522, 1477, 1346, 1004, 868, 836, 802, 763, 758, 729, 695 cm^{-1}. HRMS-ESI (m/z) calcd for

$C_{18}H_{14}NO_2Se$ ([M + H]$^+$): 356.0184; Found: 356.0188.

[1,1'-Biphenyl]-4-yl(2-nitrophenyl)selane (**3ac**)



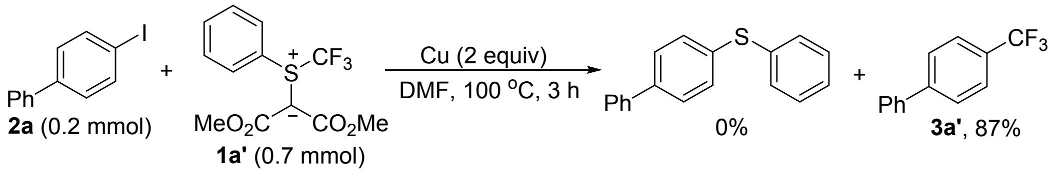
Yellow solid (27.7 mg, 39%), a mixture of petroleum ether and ethyl acetate (40:1 (v/v)) as eluents for column chromatography. M.p.: 121-123 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.34 (dd, *J* = 8.2, 0.9 Hz, 1H), 7.78 (d, *J* = 8.1 Hz, 2H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.66 (d, *J* = 7.5 Hz, 2H), 7.50 (t, *J* = 7.4 Hz, 2H), 7.41 (t, *J* = 7.4 Hz, 1H), 7.34 (t, *J* = 7.6 Hz, 1H), 7.29 (t, *J* = 7.4 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 145.7, 142.8, 140.0, 137.8, 136.0, 133.7, 130.3, 129.0, 128.7, 128.0, 127.2, 127.0, 126.1, 125.8. IR (KBr): 3055, 3023, 2963, 2921, 2852, 1732, 1633, 1589, 1568, 1508, 1474, 1448, 1331, 1307, 1169, 1097, 1035, 1006, 875, 851, 830, 758, 724, 693 cm^{-1}. HRMS-ESI (m/z) calcd for $C_{18}H_{14}NO_2Se$ ([M + H]$^+$): 356.0184; Found: 356.0189.

5. Control experiments

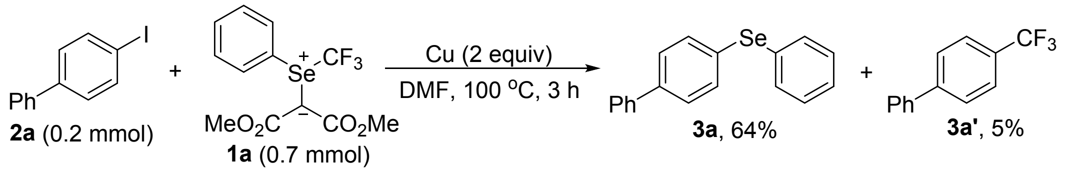
5.1. Cu-Mediated reactions of 2a with trifluoromethyl aryl sulfonium ylide and trifluoromethyl aryl selenium ylides under the same conditions.

In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), **1a’** or **1a** or **1b** (0.4 mmol), Cu (25.6 mg, 0.4 mmol), and DMSO or DMF (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yields of **3a’** and 4-PhC_6H_4SPh or **3a** or **3b** were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using 4-(trifluoromethyl)-1,1'-biphenyl (t_R = 8.54 min) and [1,1'-biphenyl]-4-yl(phenyl)sulfane (t_R = 17.04 min) or [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) or [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (t_R = 15.24 min) as external standards, respectively.

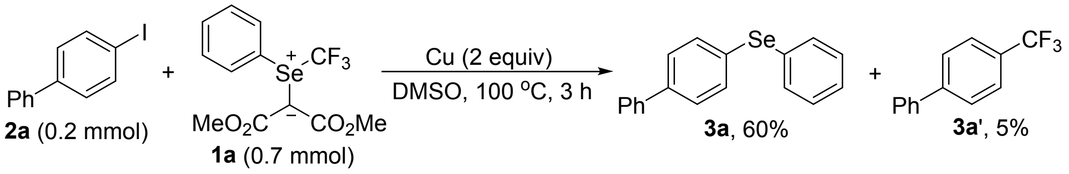
1)



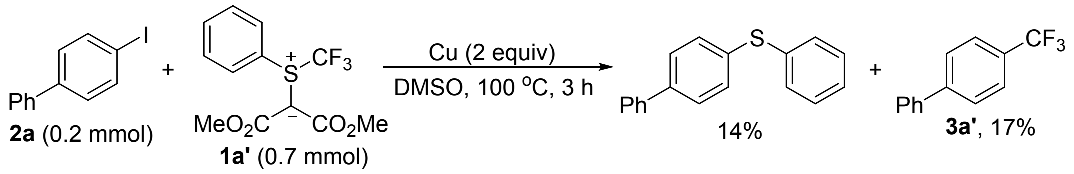
2)



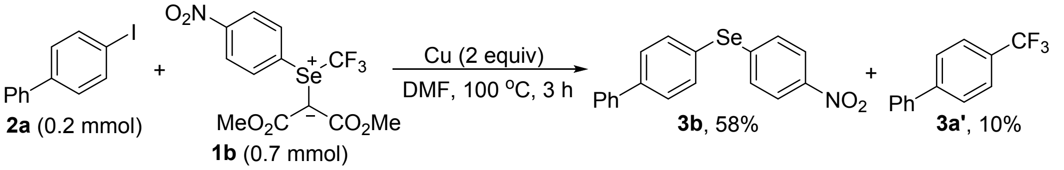
3)



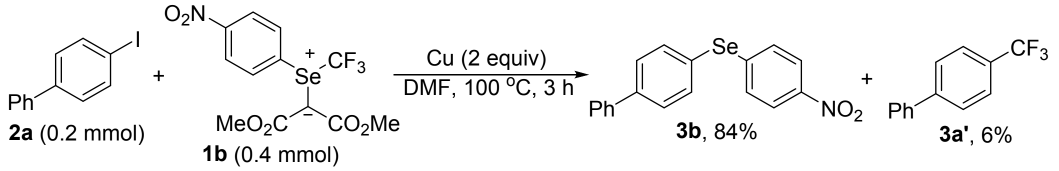
4)



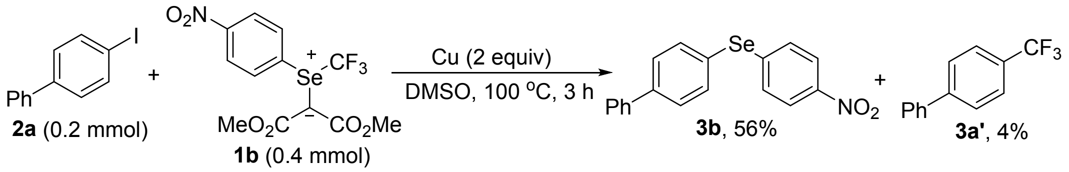
5)



6)



7)

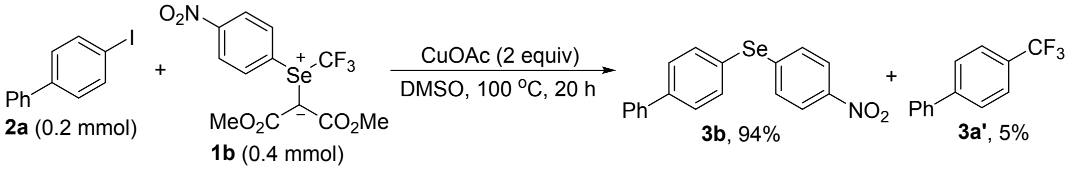


5.2. CuOAc-Mediated reactions of 2a with trifluoromethyl aryl sulfonium ylide and trifluoromethyl aryl selenium ylides under the same conditions.

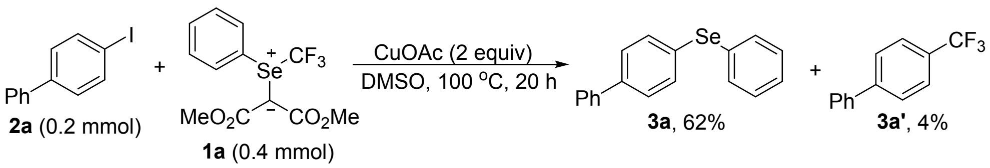
In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), **1b** or **1a** or **1a'** (0.4 mmol), CuOAc (48.8 mg, 0.4 mmol), and DMSO or DMF (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yields of **3a'** and **3b** or **3a** or 4-PhC_6H_4SPh were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using 4-

(trifluoromethyl)-1,1'-biphenyl (t_R = 8.54 min) and [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (t_R = 15.24 min) or [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) or [1,1'-biphenyl]-4-yl(phenyl)sulfane (t_R = 17.04 min) as external standards, respectively.

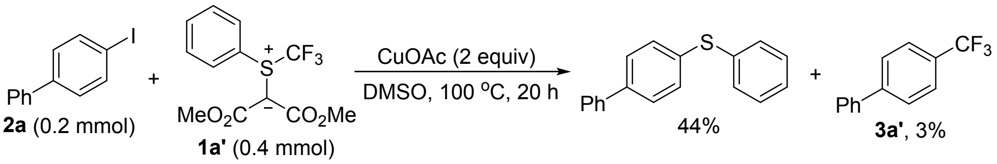
8)



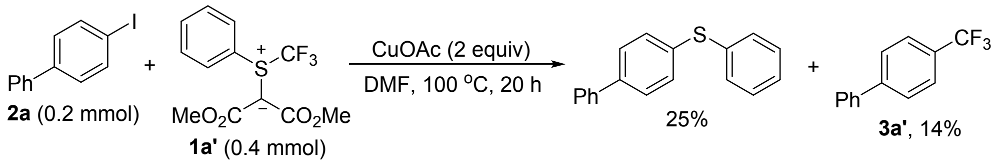
9)



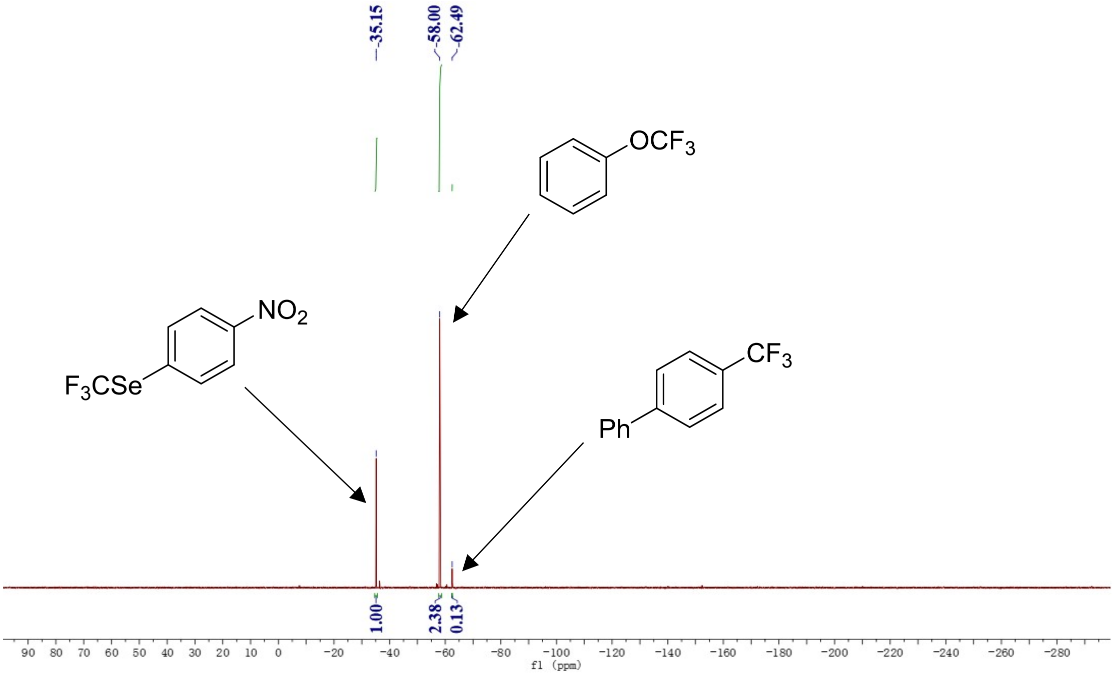
10)



11)



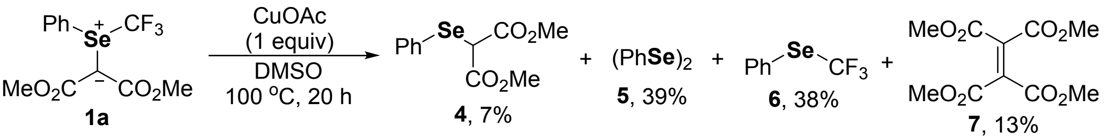
The ^{19}F NMR spectrum of the reaction mixture (equation 8)



29.9 mg of PhOCF$_3$ was added to the reaction mixture as an internal standard. The yield of 4-(trifluoromethyl)-1,1'-biphenyl was calculated to be 5% and that of (4-

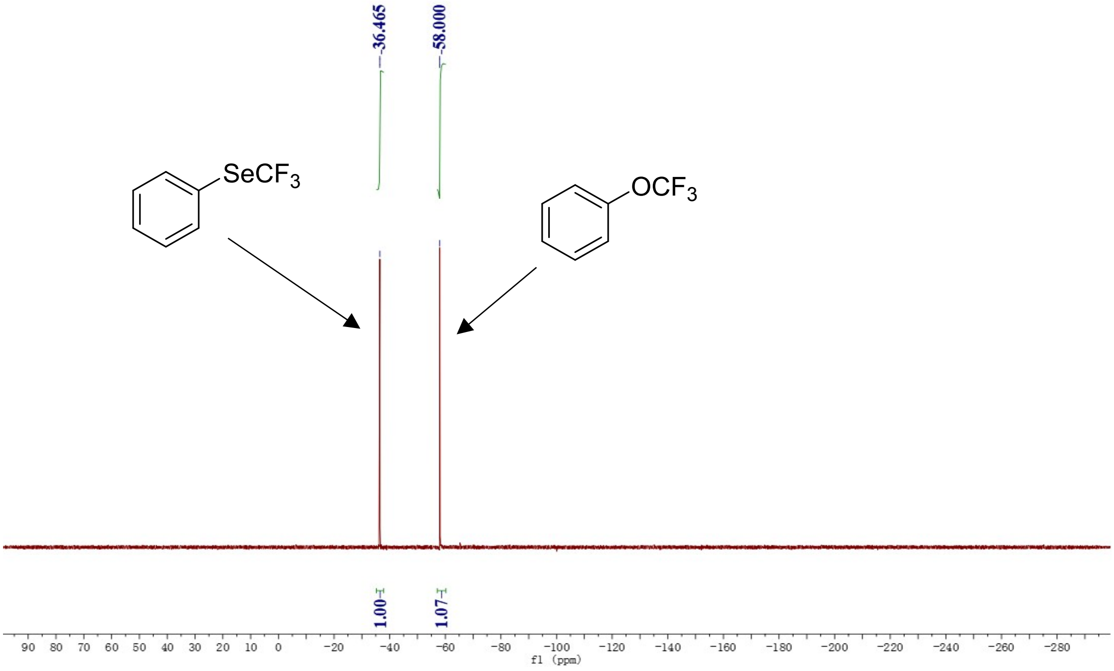
nitrophenyl)(trifluoromethyl)selane was found to be 19% based on $PhOCF_3$ added.

5.3. CuOAc-Mediated decomposition of 1a in the absence of aryl halide.

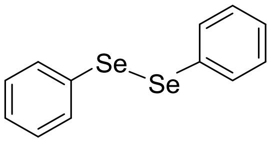


In a nitrogen-filled glovebox, a sealed tube was charged with dimethyl 2-(phenyl(trifluoromethyl)-λ^4-selanylidene)malonate (**1a**, 71.2 mg, 0.2 mmol), CuOAc (24.4 mg, 0.2 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. 13.2 mg of $PhOCF_3$ was added as an internal standard and the yield of $PhSeCF_3$ (**6**) was measured by ^{19}F NMR spectroscopy (38%). The reaction mixture was then diluted by ethyl acetate (60 mL). The organic solution was washed with water (20 × 3 mL), dried over anhydrous Na_2SO_4, and concentrated to dryness under reduced pressure. The residue was purified by column chromatography on silica gel using petroleum ether and a mixture of petroleum ether and ethyl acetate (40:1 to 10:1 (v/v)) as eluents to give 12.3 mg of **5** (39%), 4.0 mg of **4** (7%), and 3.5 mg of **7** (13%), respectively.

The ^{19}F NMR spectrum of the reaction mixture (after addition of 13.2 mg $PhOCF_3$ and before workup)

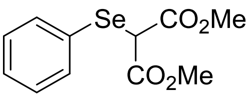


1,2-Diphenyldiselane (**5**)[13]



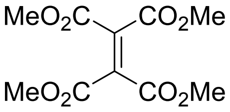
Yellow solid, petroleum ether for column chromatography. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.64 (d, *J* = 7.6 Hz, 4H), 7.31-7.27 (m, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 131.5, 130.9, 129.2, 127.7.

Dimethyl 2-(phenylselanyl)malonate (**4**)[2]



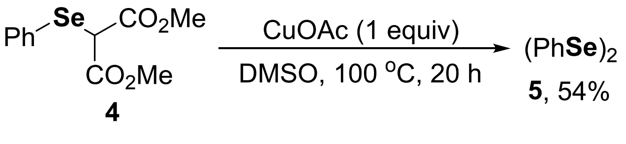
Yellow oil, a mixture of petroleum ether and ethyl acetate (20:1 (v/v)) as eluents for column chromatography. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 (d, *J* = 7.2 Hz, 2H), 7.36 (t, *J* = 7.2 Hz, 1H), 7.32 (t, *J* = 7.1 Hz, 2H), 4.50 (s, 1H), 3.72 (s, 6H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.6, 135.7, 129.3, 129.2, 127.4, 53.1, 45.8.

Tetramethyl ethene-1,1,2,2-tetracarboxylate (**7**)[14]



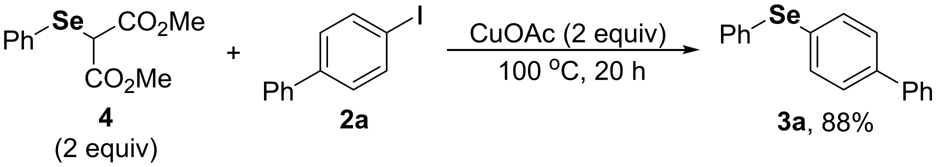
Light yellow solid, a mixture of petroleum ether and ethyl acetate (10:1 (v/v)) as eluents for column chromatography. ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.87 (s, 12 H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 162.6, 135.4, 53.4.

5.4. CuOAc-Mediated decomposition of 4 in the absence of aryl halide.

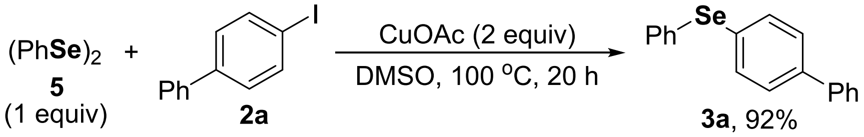


In a nitrogen-filled glovebox, a sealed tube was charged with dimethyl 2-(phenylselanyl)malonate (**4**,[2] 57.6 mg, 0.2 mmol), CuOAc (24.4 mg, 0.2 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h, cooled to room temperature, and diluted with ethyl acetate (60 mL). The organic solution was washed with water (20 × 3 mL), dried over anhydrous Na_2SO_4, and concentrated to dryness under reduced pressure. The residue was purified by column chromatography on silica gel using petroleum ether as eluent to give 17.1 mg of **5** (54%).

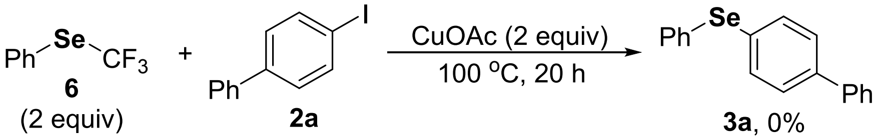
5.5. CuOAc-Mediated reactions of 4, 5 and 6 with 2a under the standard conditions.



In a nitrogen-filled glovebox, a sealed tube was charged with dimethyl 2-(phenylselanyl)malonate (**4**,[2] 115.2 mg, 0.4 mmol), 4-iodo-1,1'-biphenyl (**2a**, 55.6 mg, 0.2 mmol), CuOAc (48.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3a** was determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) as an external standard (88%).

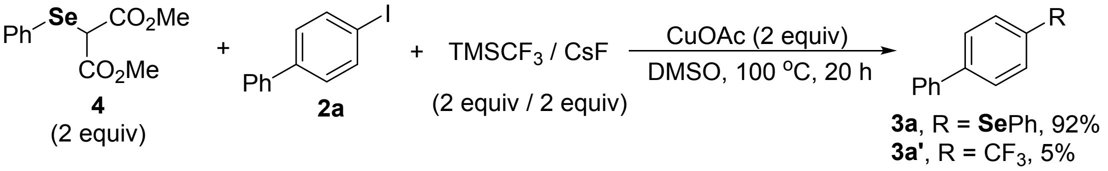


In a nitrogen-filled glovebox, a sealed tube was charged with 1,2-diphenyldiselane (**5**, 62.8 mg, 0.2 mmol), 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), CuOAc (48.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3a** was determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) as an external standard (92%).

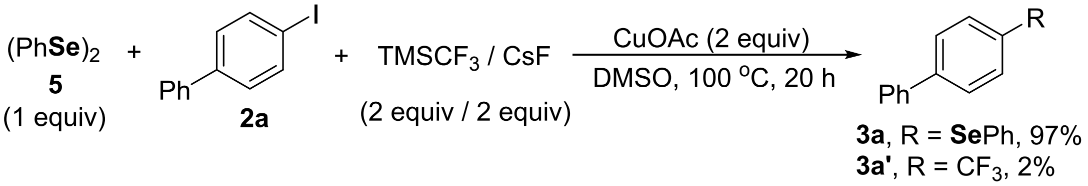


In a nitrogen-filled glovebox, a sealed tube was charged with phenyl(trifluoromethyl)selane (**6**,[3] 90.4 mg, 0.4 mmol), 4-iodo-1,1'-biphenyl (**2a**, 55.6 mg, 0.2 mmol), CuOAc (48.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3a** was determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) as an external standard (0%).

5.6. CuOAc-Mediated competitive aryl selenylation and trifluoromethylation.

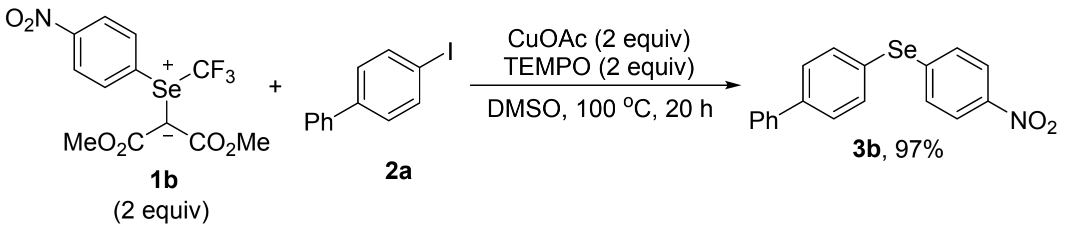


In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), (phenylselanyl)malonate (**4**, 115.0 mg, 0.4 mmol) CuOAc (48.8 mg, 0.4 mmol), TMSCF$_3$ (56.8 mg, 0.4 mmol), CsF (60.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yields of **3a’** (5%) and **3a** (92%) were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using 4-(trifluoromethyl)-1,1'-biphenyl (t_R = 8.54 min) and [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) as external standards, respectively.



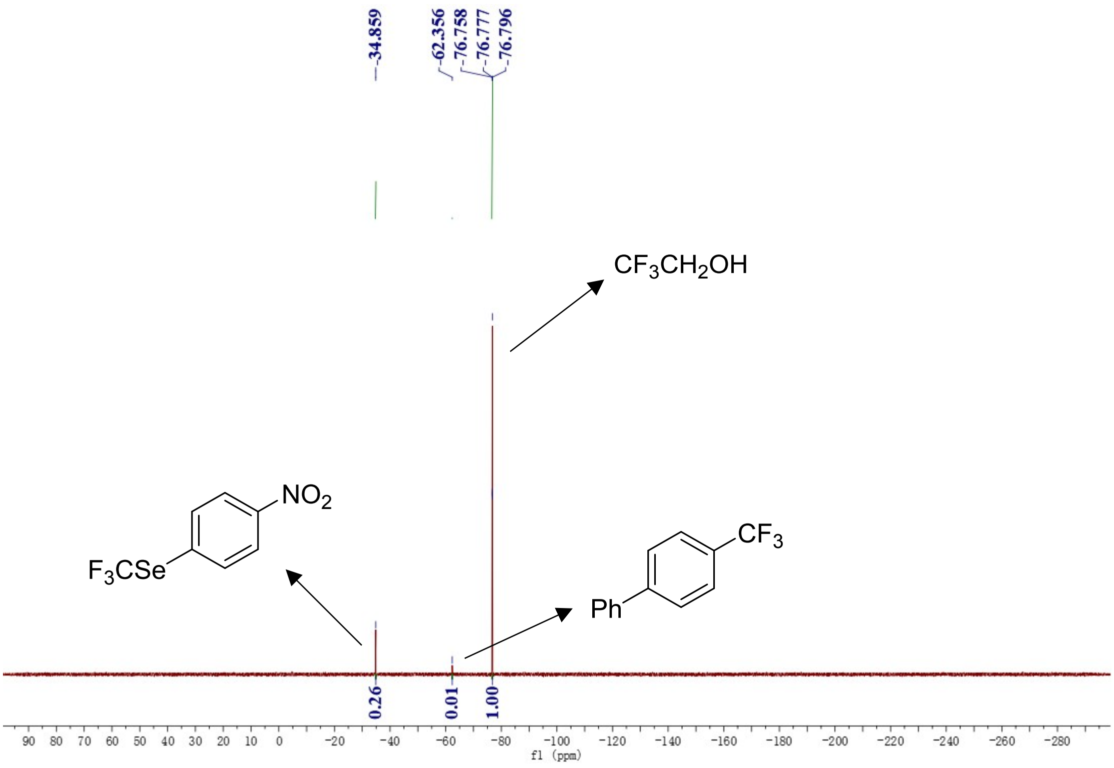
In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), 1,2-diphenyldiselane (**5**, 62.8 mg, 0.2 mmol), CuOAc (48.8 mg, 0.4 mmol), TMSCF$_3$ (56.8 mg, 0.4 mmol), CsF (60.8 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yields of **3a’** (2%) and **3a** (97%) were determined by HPLC (λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) using 4-(trifluoromethyl)-1,1'-biphenyl (t_R = 8.54 min) and [1,1'-biphenyl]-4-yl(phenyl)selane (t_R = 18.78 min) as external standards, respectively.

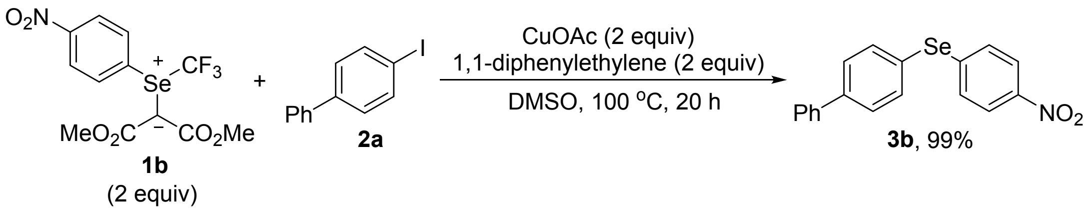
5.7. Cu-Mediated arylselenylation of 2a by 1b in the presence of radical traps.



In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), **1b** (160.4 mg, 0.4 mmol), CuOAc (48.8 mg, 0.4 mmol), 2,2,6,6-tetramethylpiperidine 1-oxyl (TEMPO, 62.5 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3b** (97%) was determined by HPLC using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (t_R = 15.24 min, λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) as an external standard.

The ^{19}F NMR spectrum of the reaction mixture (after addition of 21.3 mg CF_3CH_2OH as an internal standard)

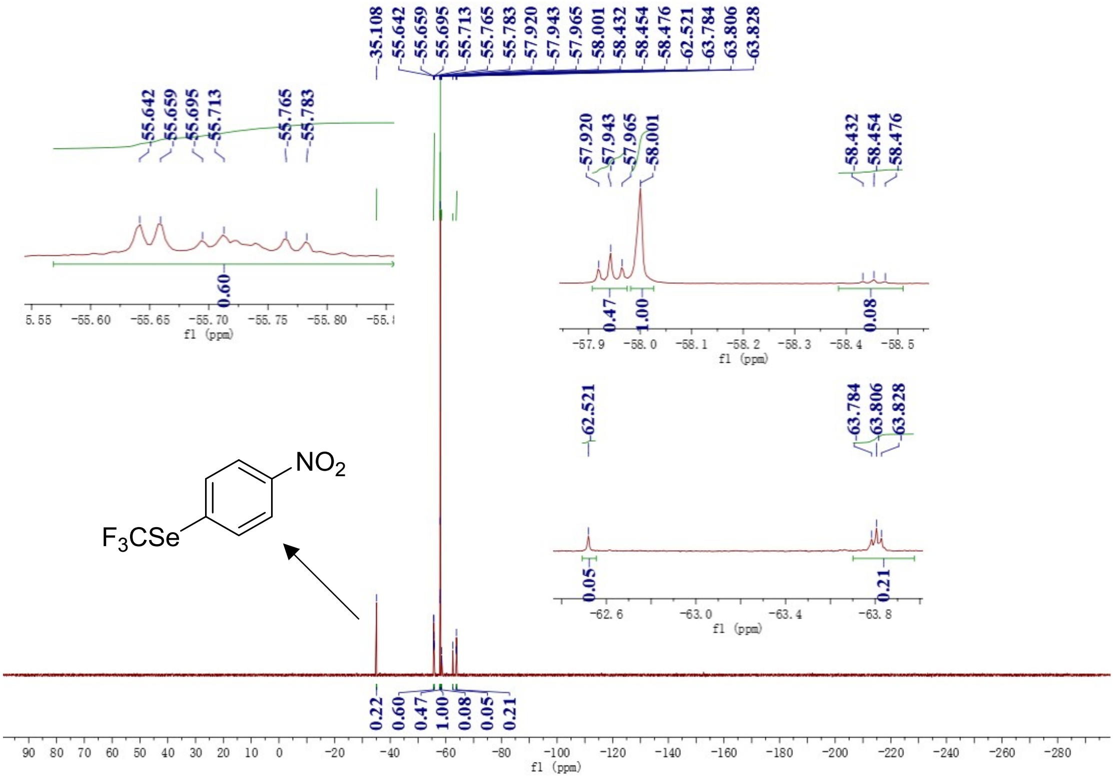


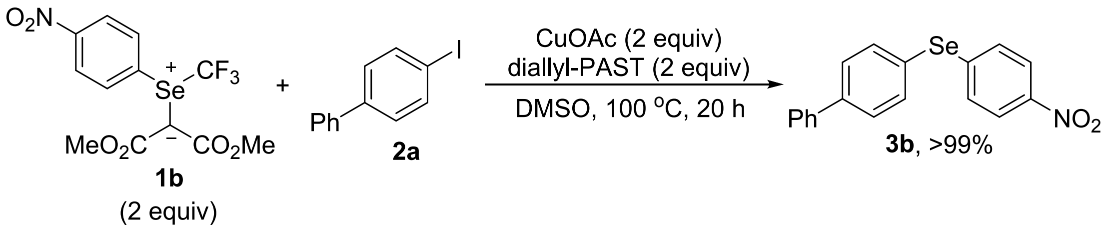


In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), **1b** (160.4 mg, 0.4 mmol), CuOAc (48.8 mg, 0.4 mmol), 1,1-diphenylethylene (72.1 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3b** (99%) was determined by HPLC using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (t_R = 15.24

min, λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) as an external standard.

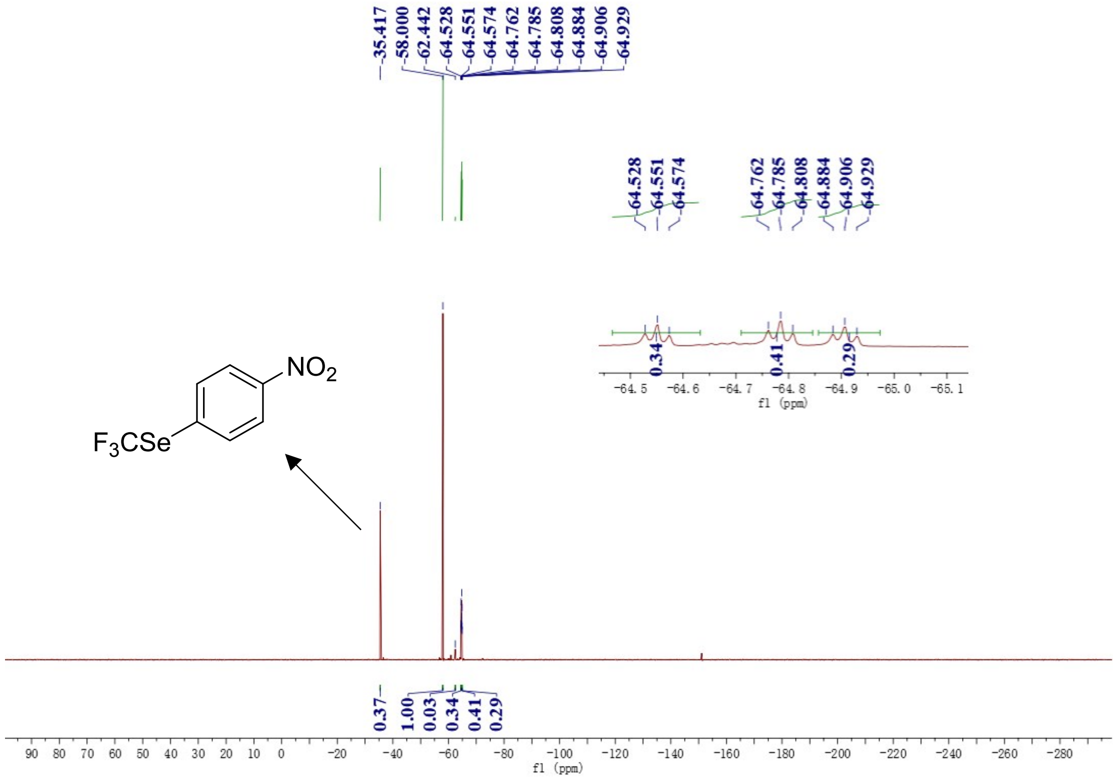
The ^{19}F NMR spectrum of the reaction mixture (after addition of 29.3 mg $PhOCF_3$ as an internal standard)





In a nitrogen-filled glovebox, a sealed tube was charged with 4-iodo-1,1'-biphenyl (**2a**, 56.0 mg, 0.2 mmol), **1b** (160.4 mg, 0.4 mmol), CuOAc (48.8 mg, 0.4 mmol), N,N-diallyl-4-methylbenzenesulfonamide (diallyl-PAST, 100.5 mg, 0.4 mmol), and DMSO (2 mL) with stirring. The mixture was reacted at 100 °C for 20 h and cooled to room temperature. The yield of **3b** (>99%) was determined by HPLC using [1,1'-biphenyl]-4-yl(4-nitrophenyl)selane (t_R = 15.24 min, λ = 253 nm, H_2O/CH_3OH = 15:85 (v/v)) as an external standard.

The ^{19}F NMR spectrum of the reaction mixture (after addition of 32.0 mg $PhOCF_3$ as an internal standard)



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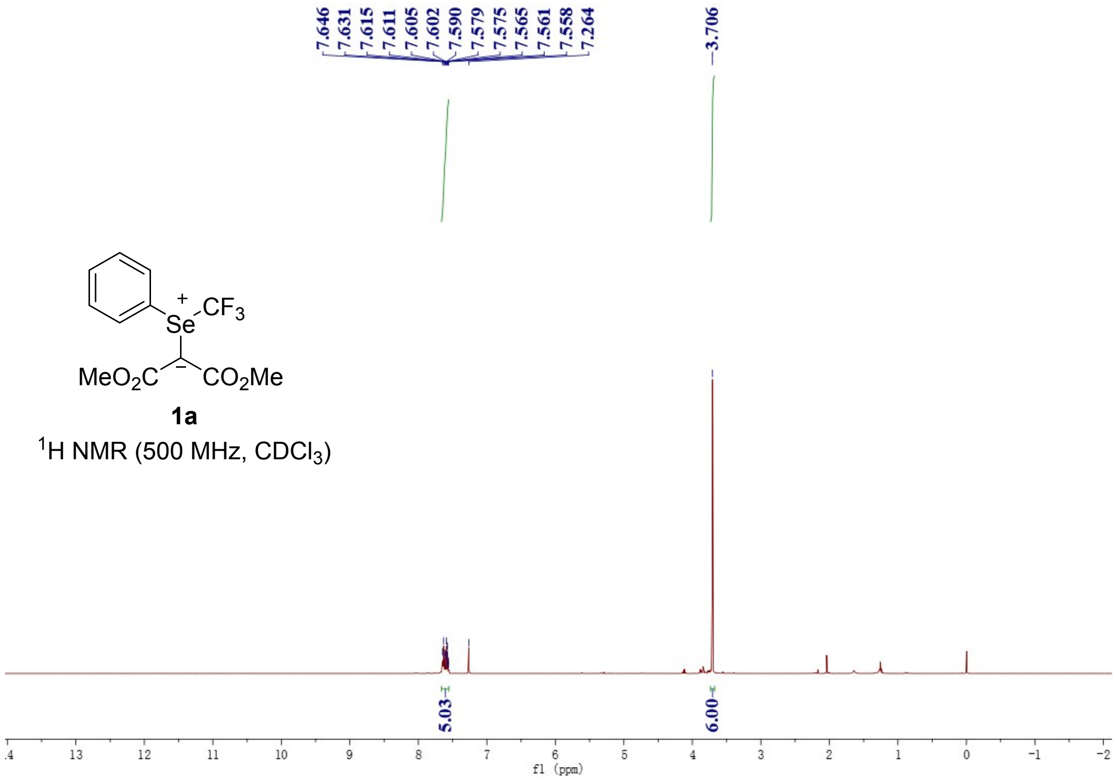
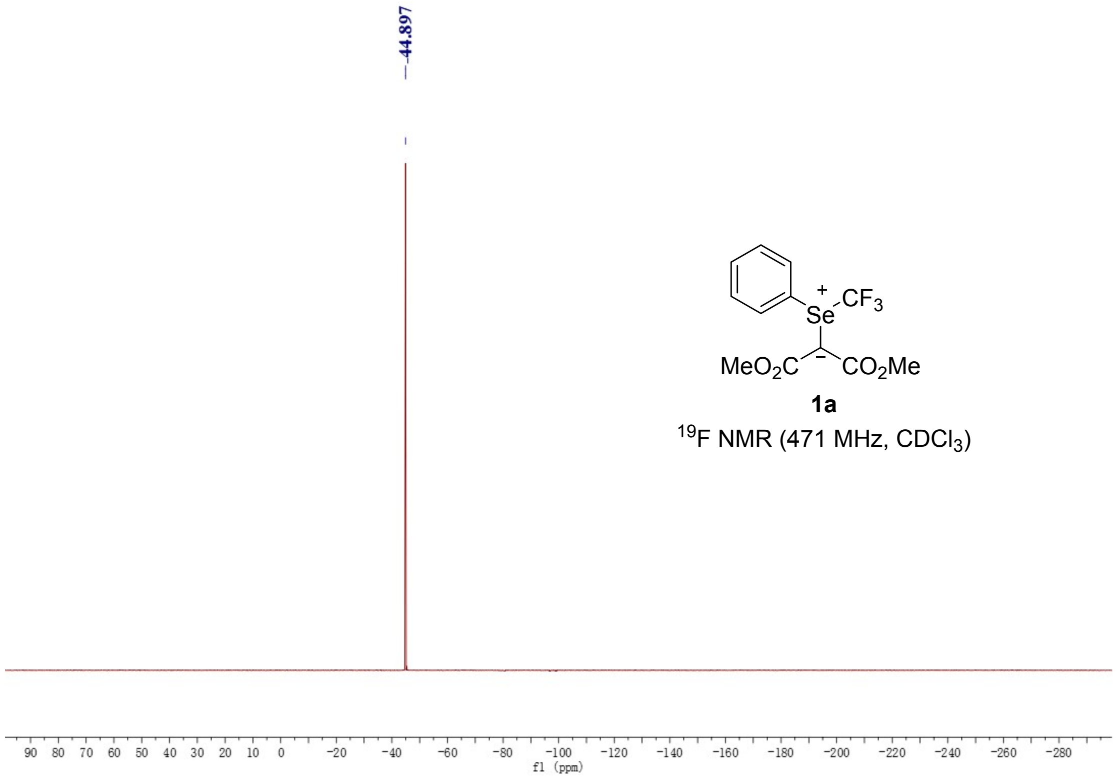
6. The NMR spectra of 1, 3, 4, 5, 6 and 7



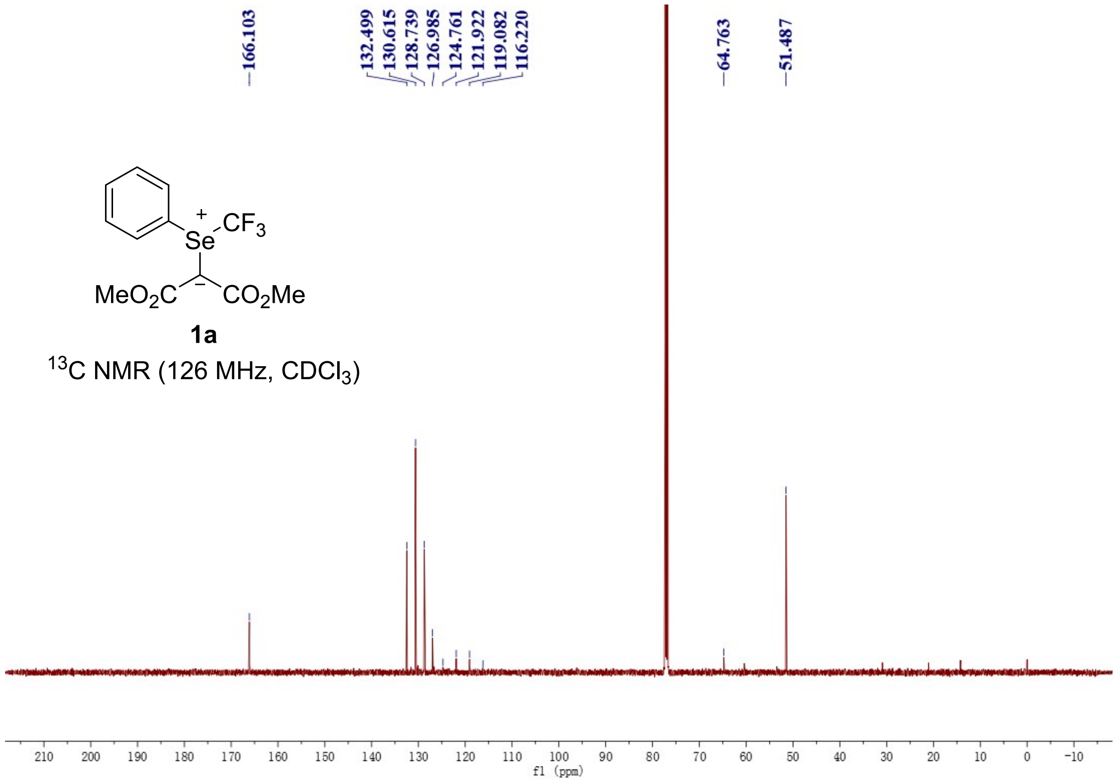
1a

^{1}H NMR (500 MHz, CDCl$_3$)



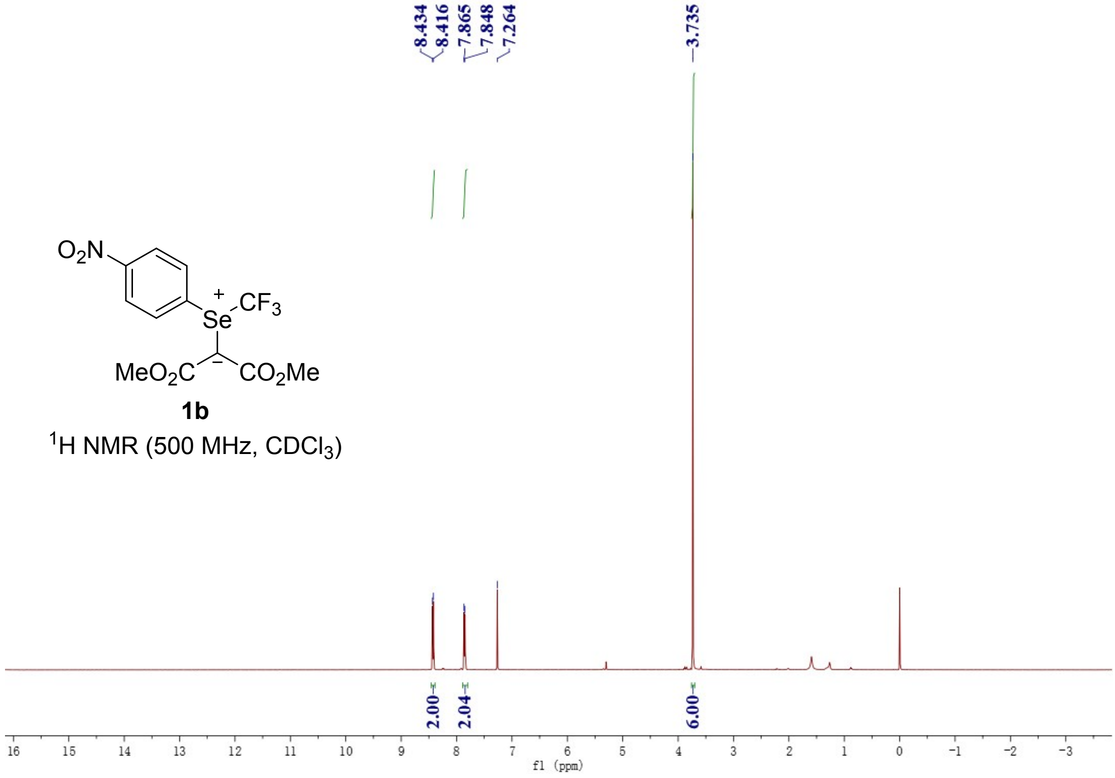
1a

^{19}F NMR (471 MHz, CDCl$_3$)



1a

^{13}C NMR (126 MHz, $CDCl_3$)



1b

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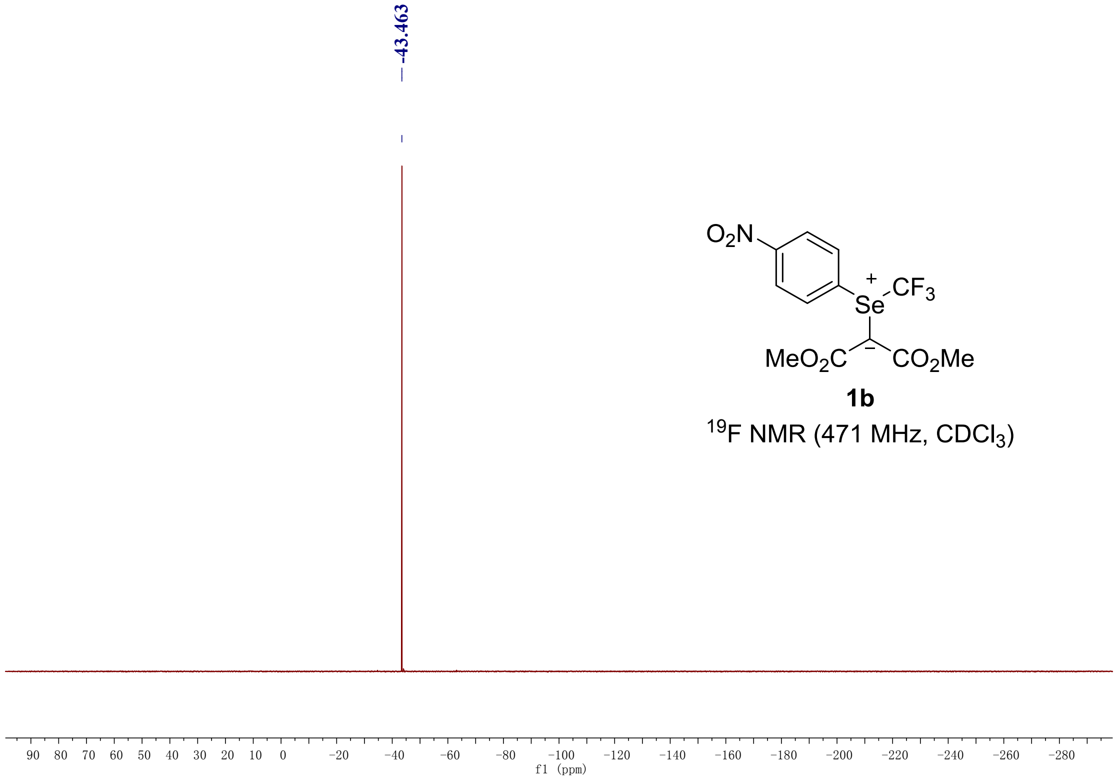

1b

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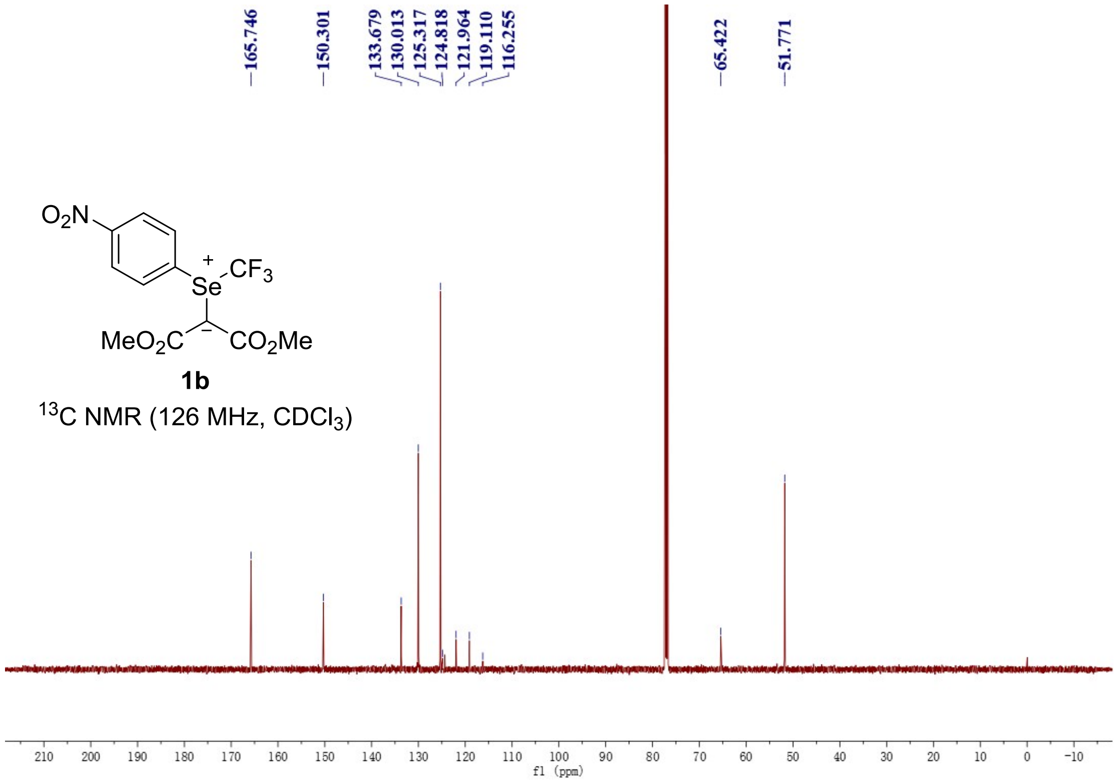

1b

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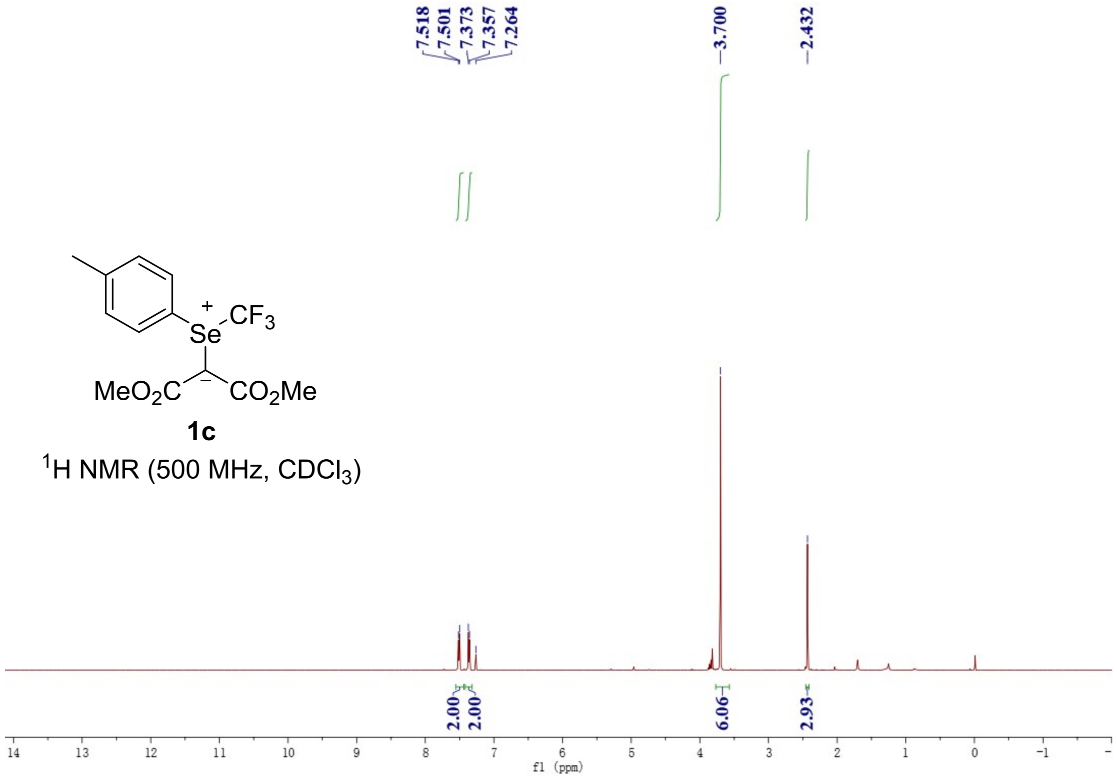

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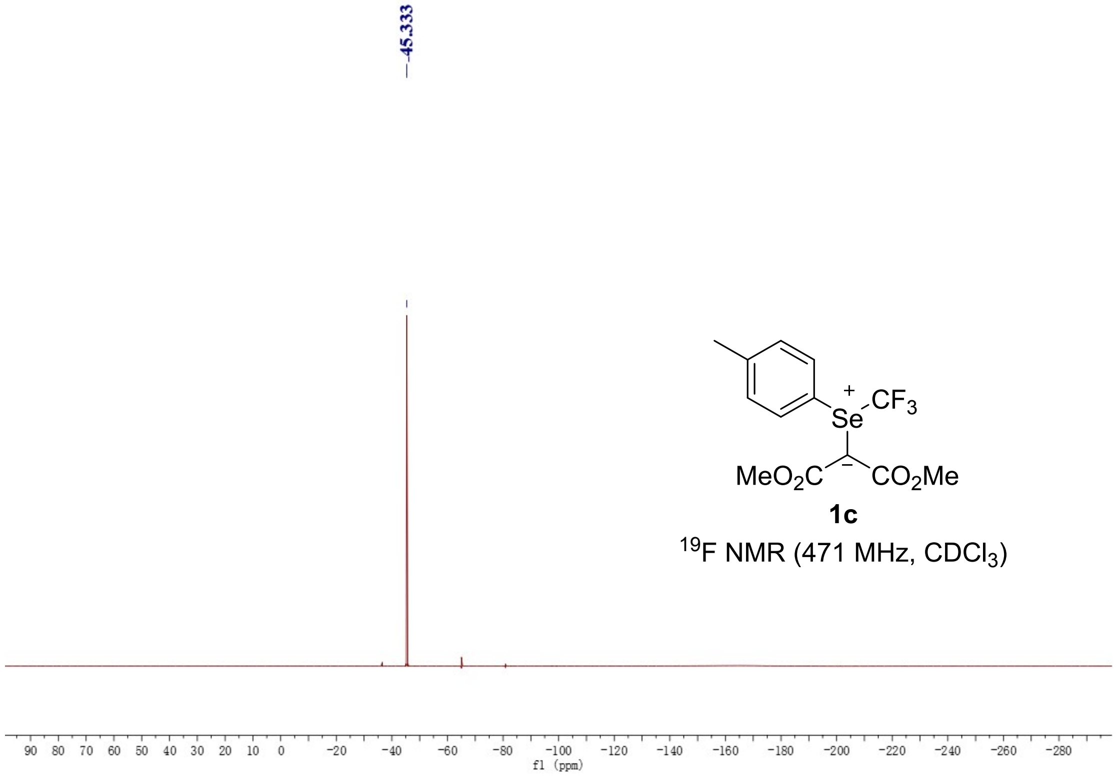

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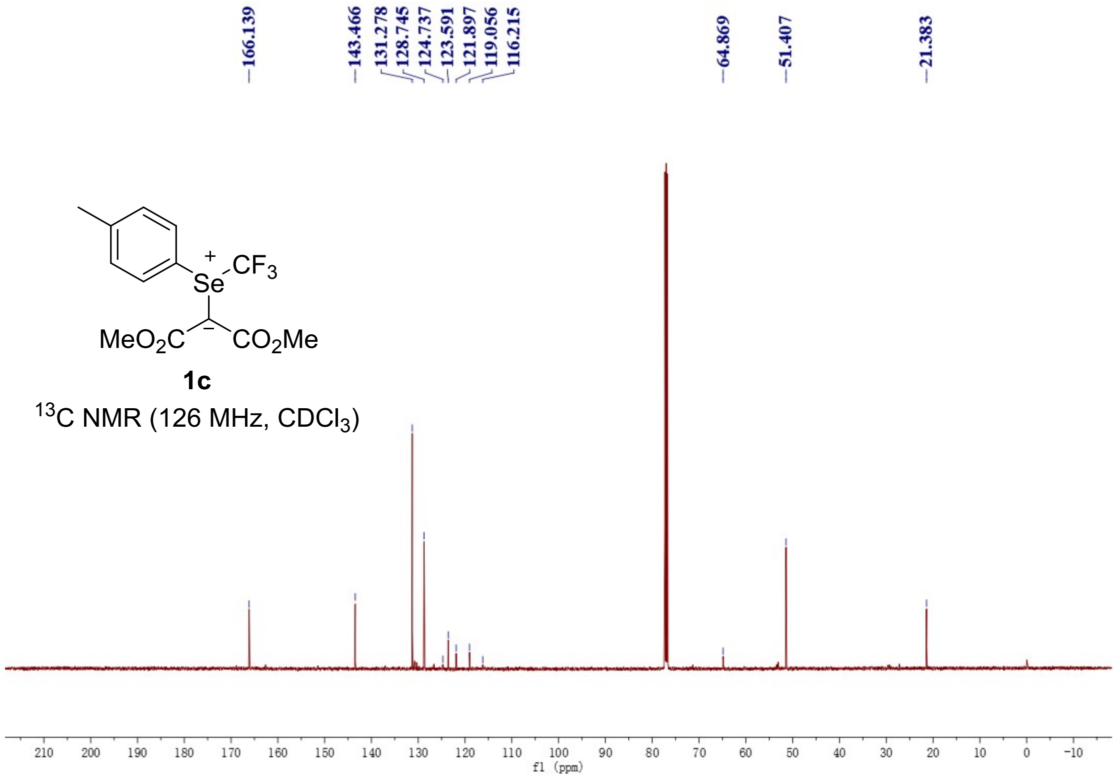

1c

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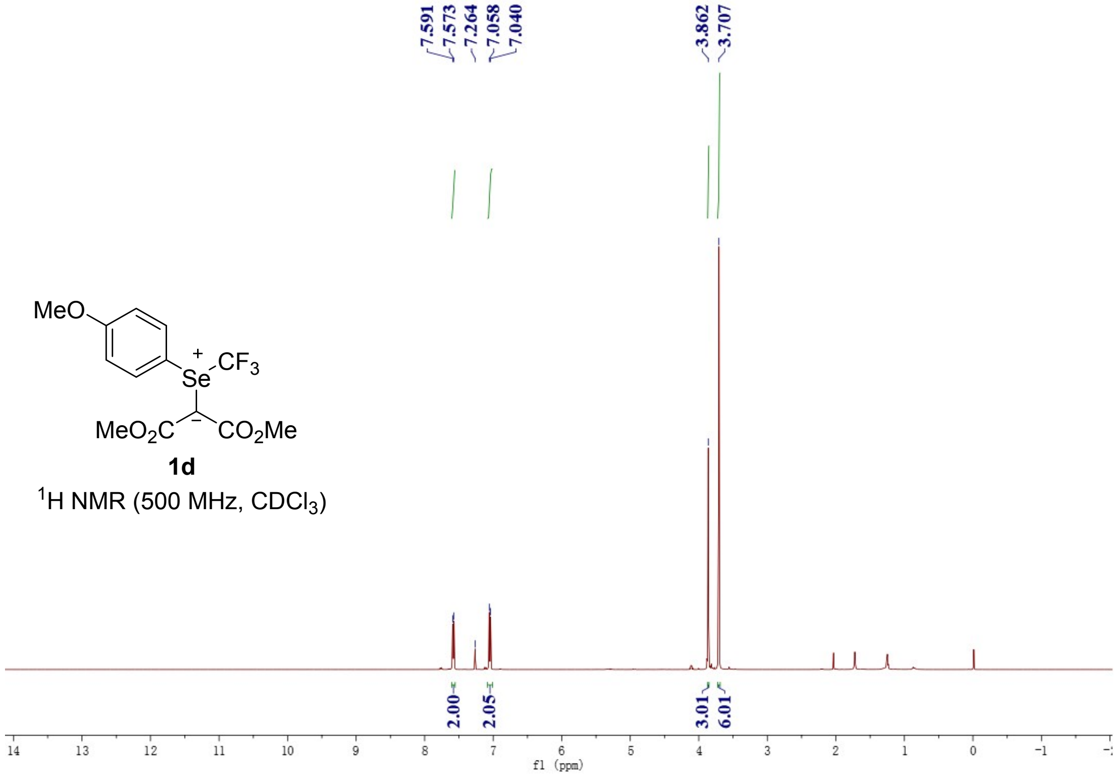

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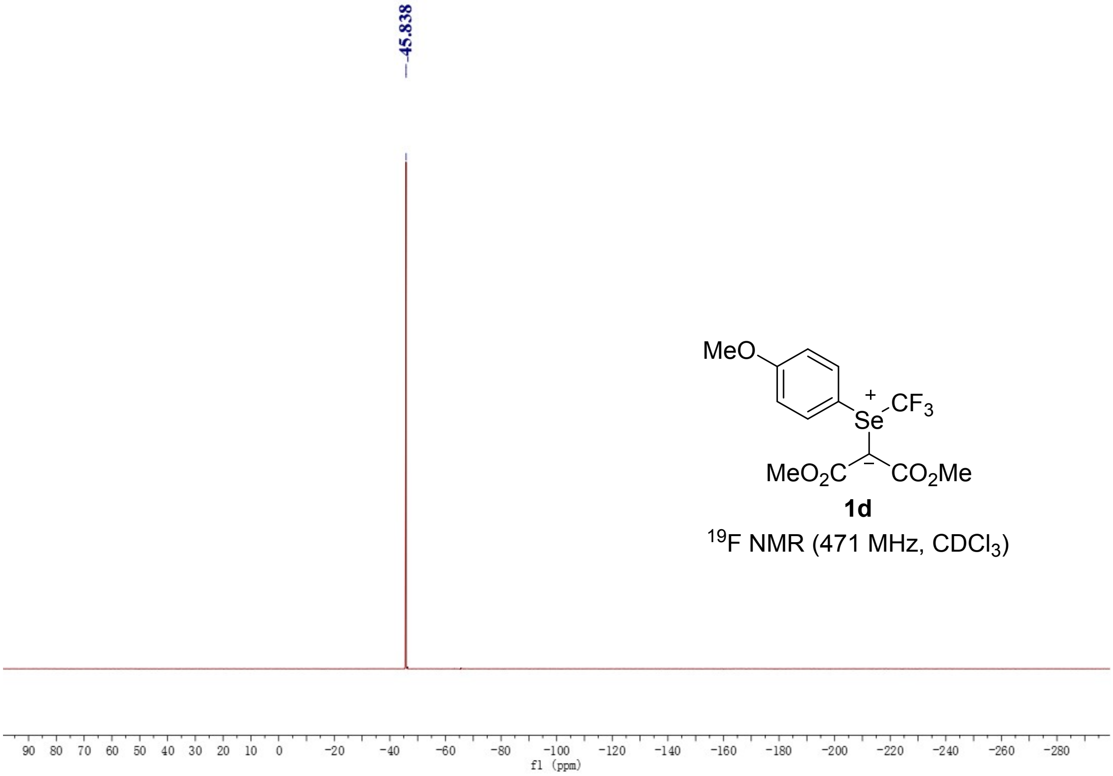

1d

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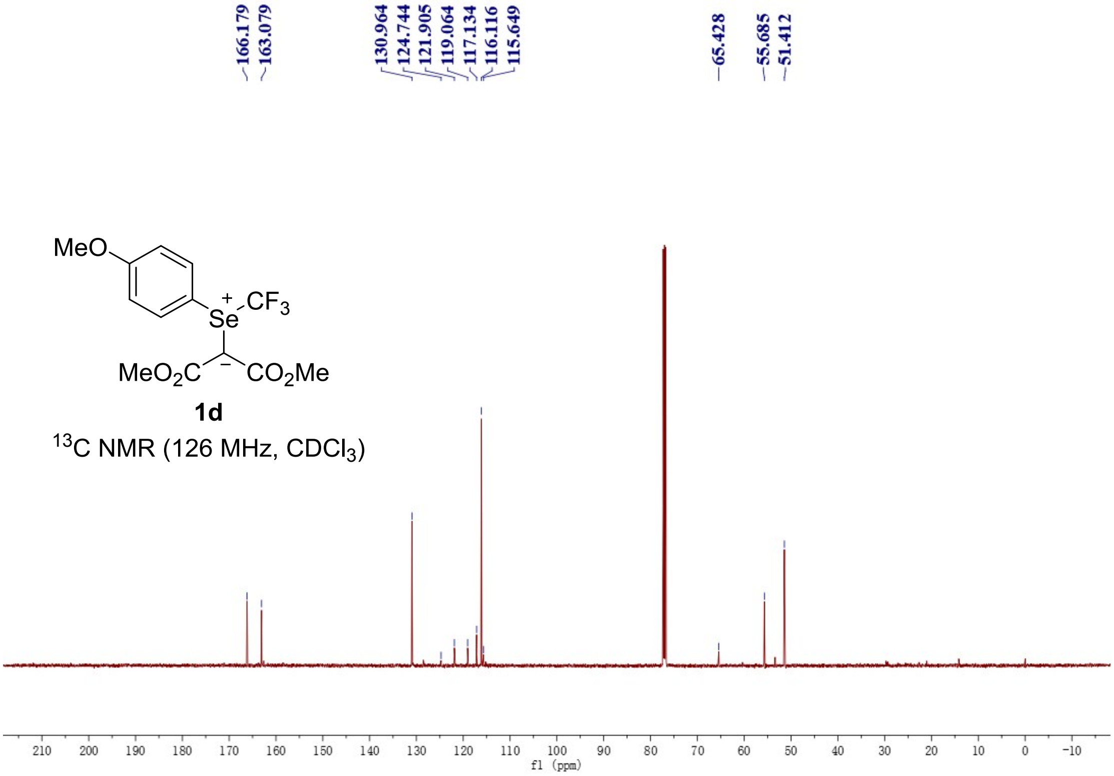

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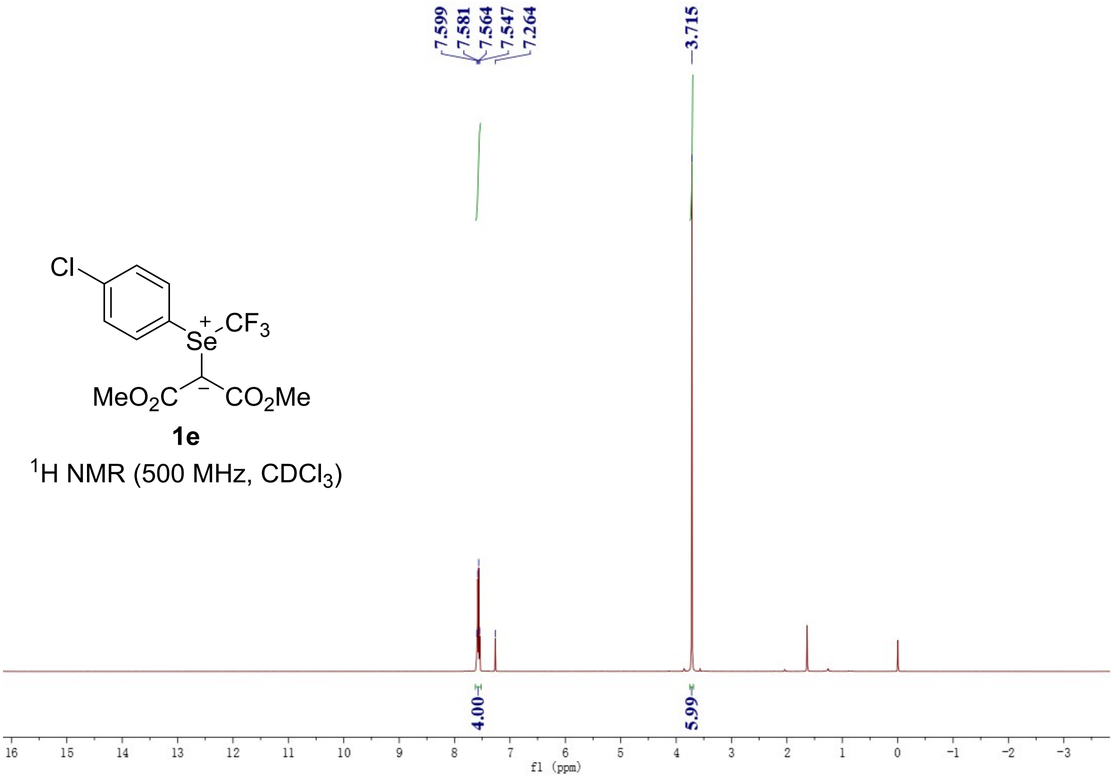

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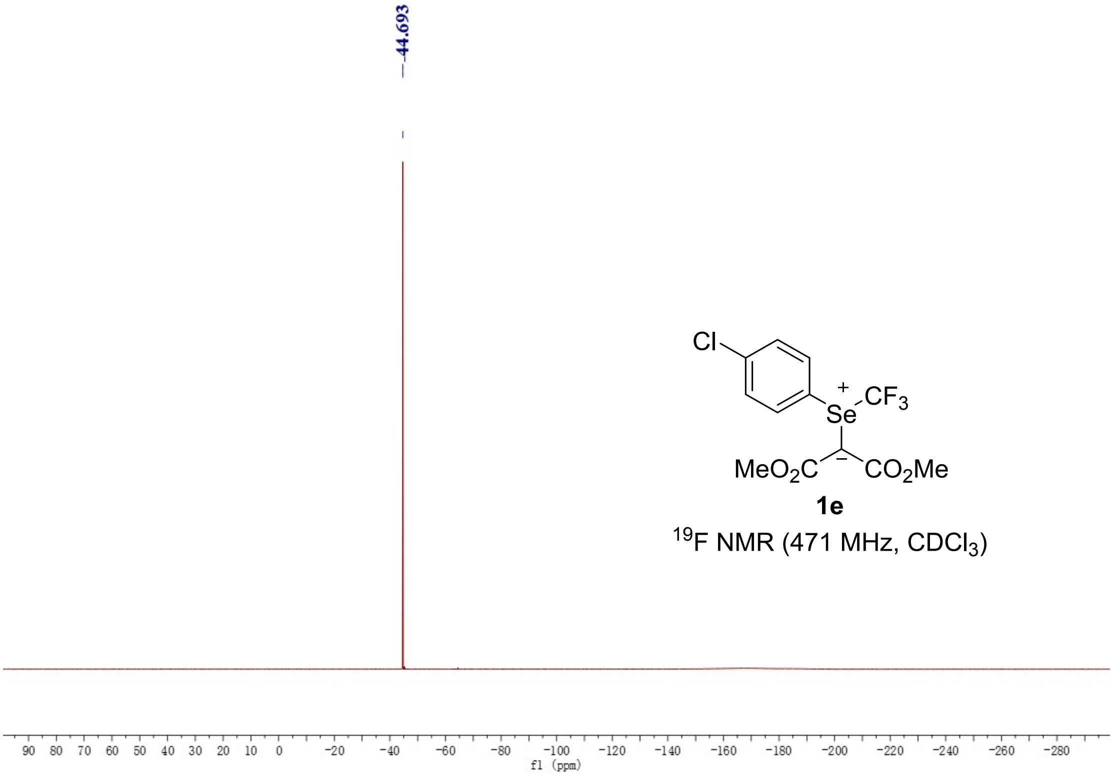

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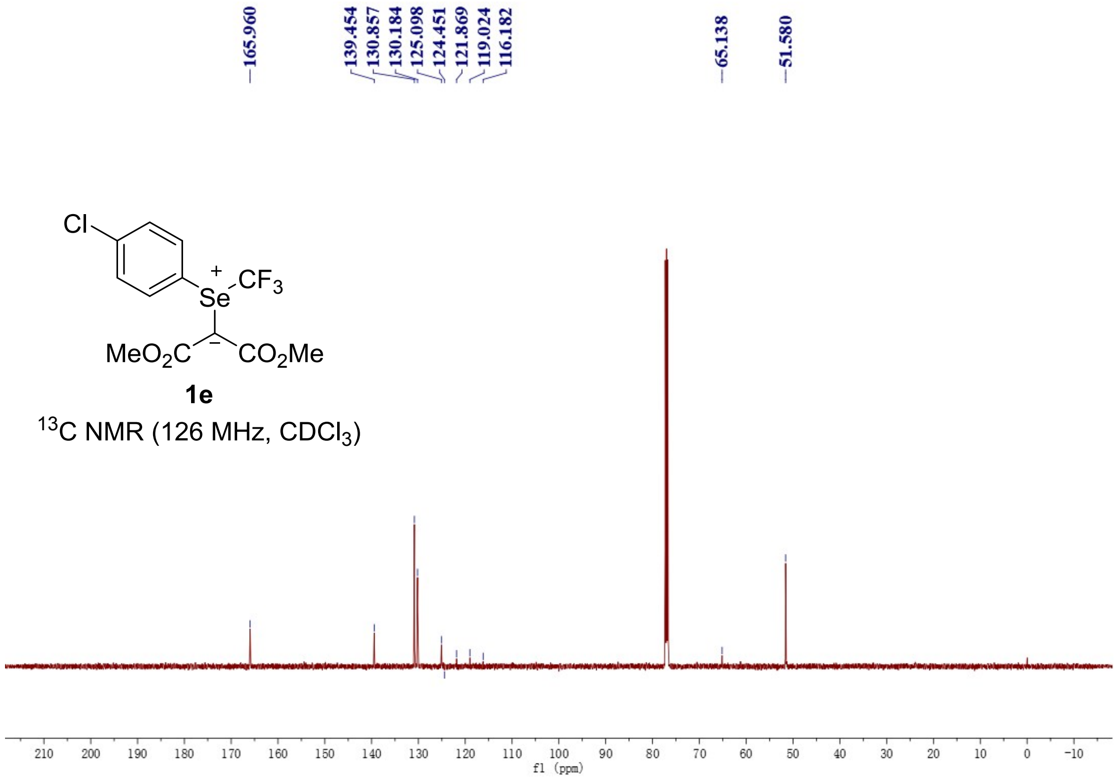

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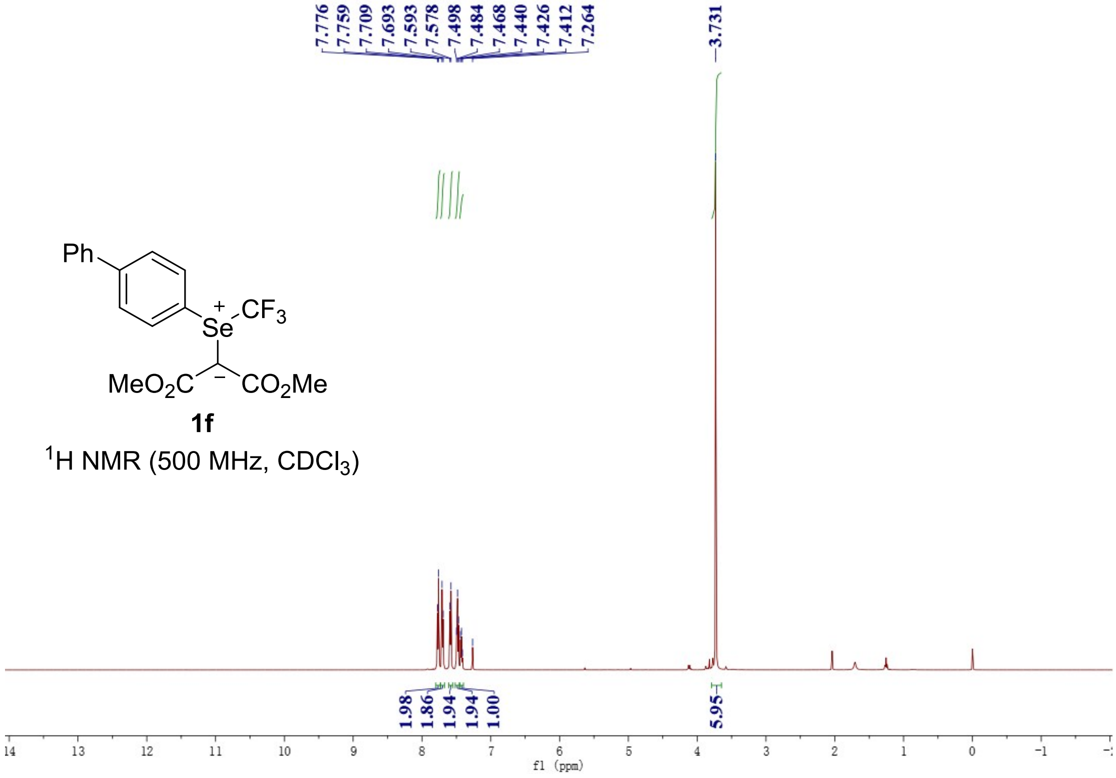

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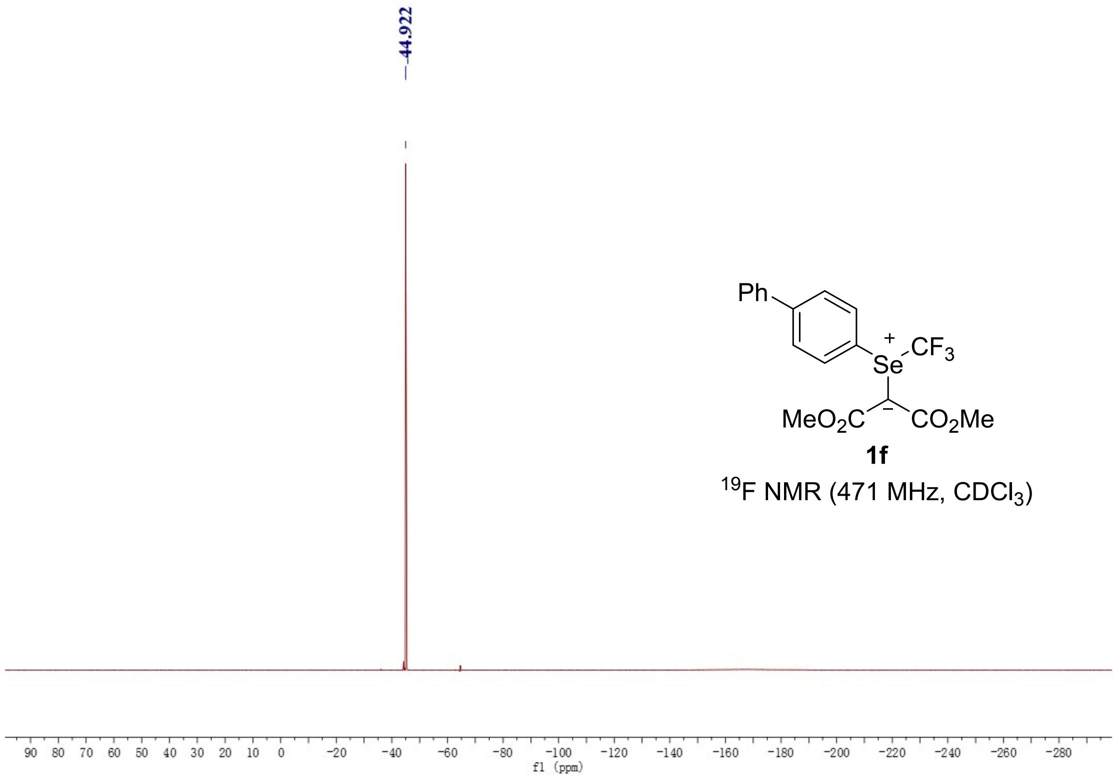

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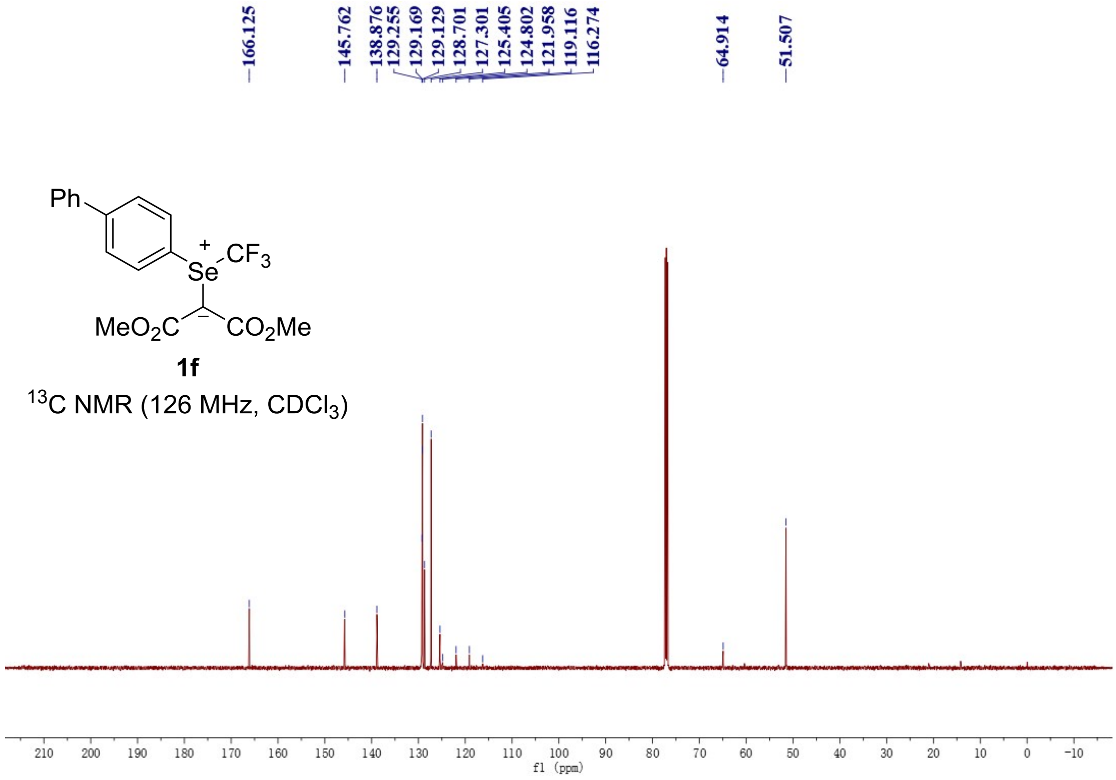

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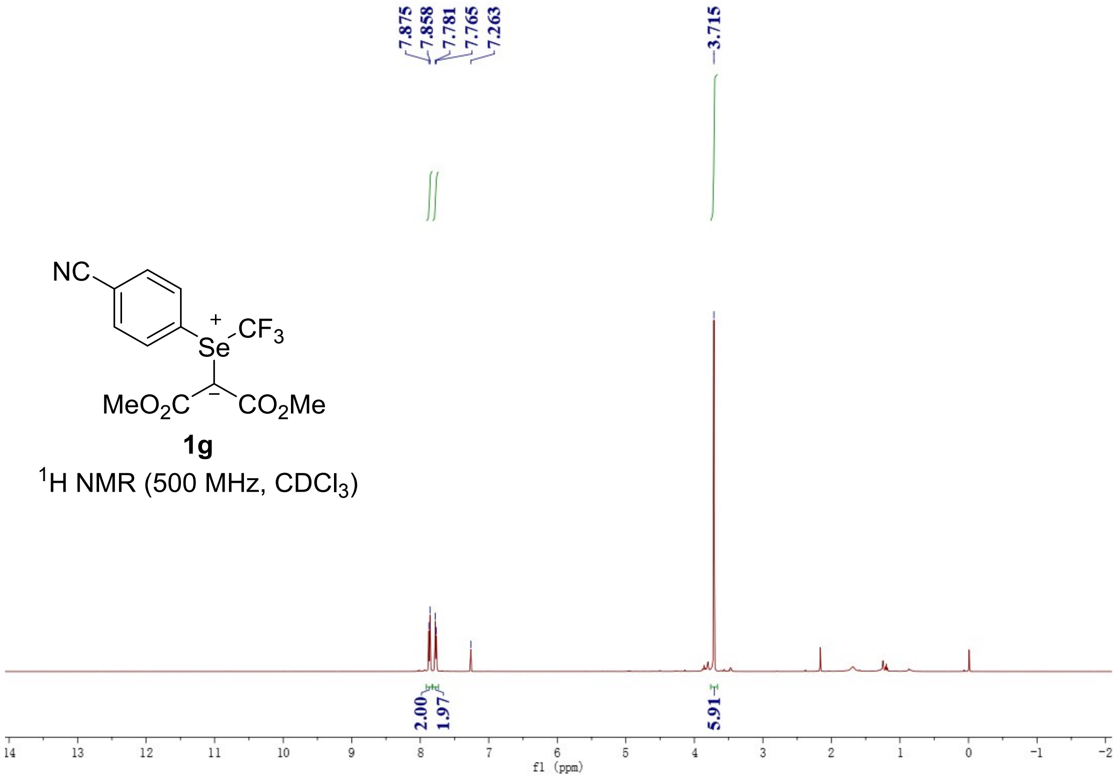
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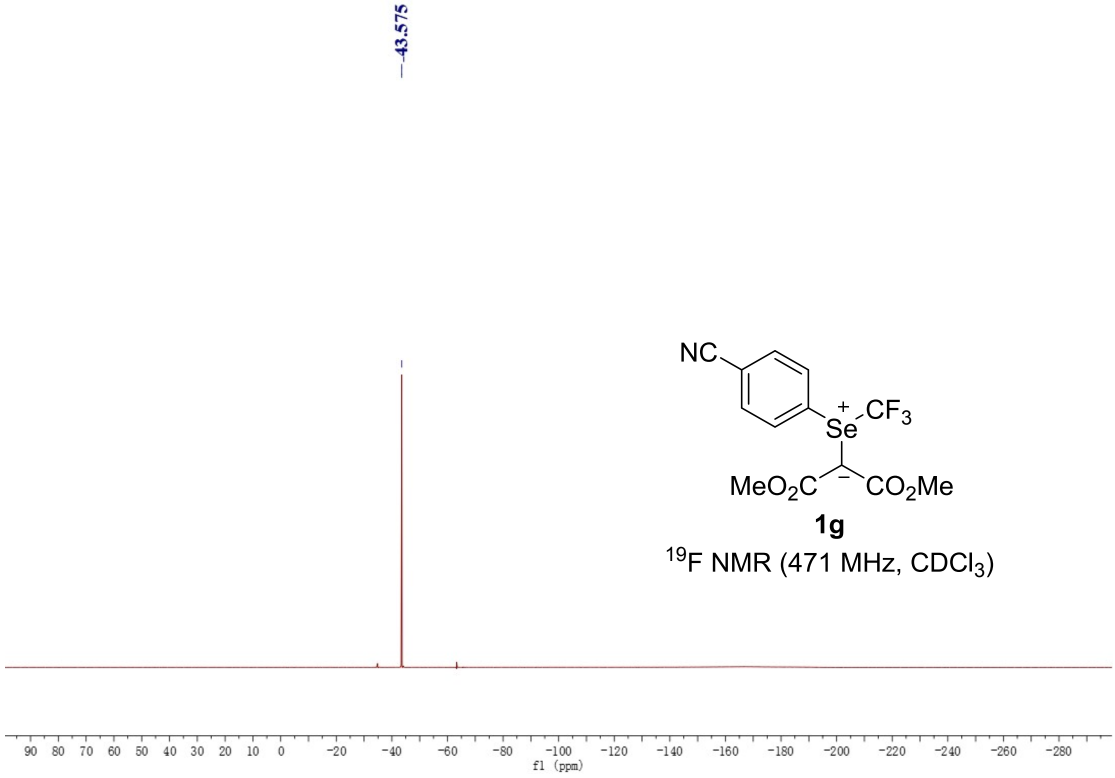
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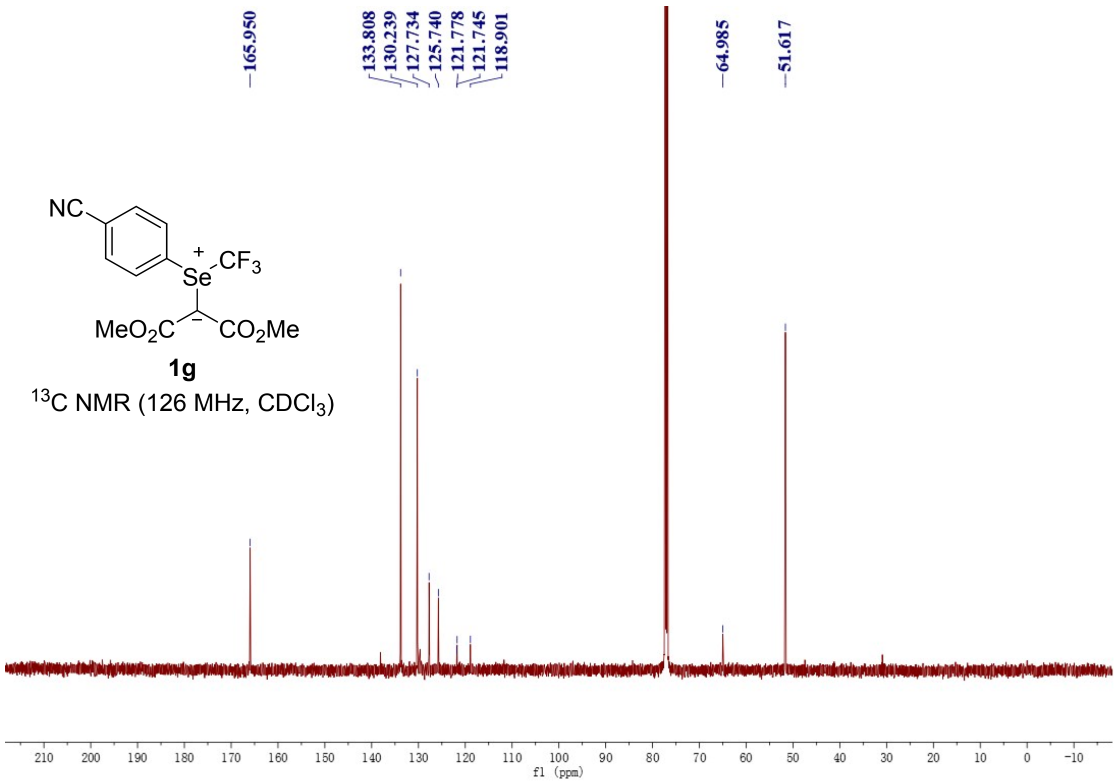

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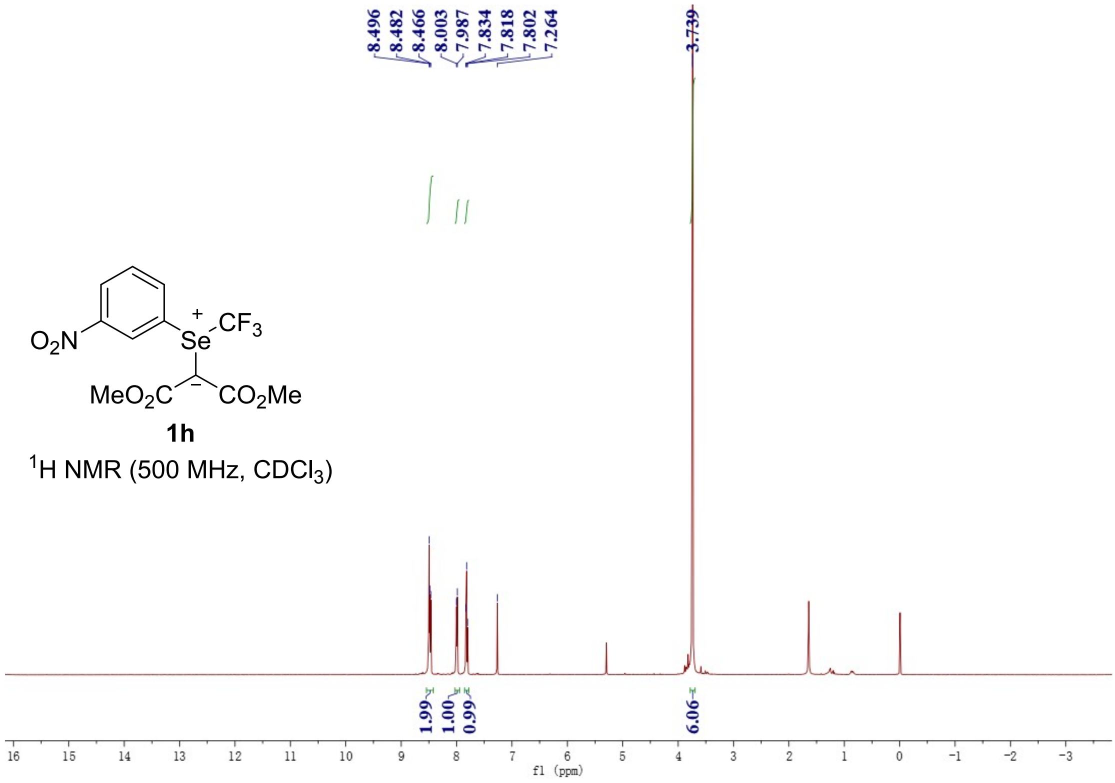

1h

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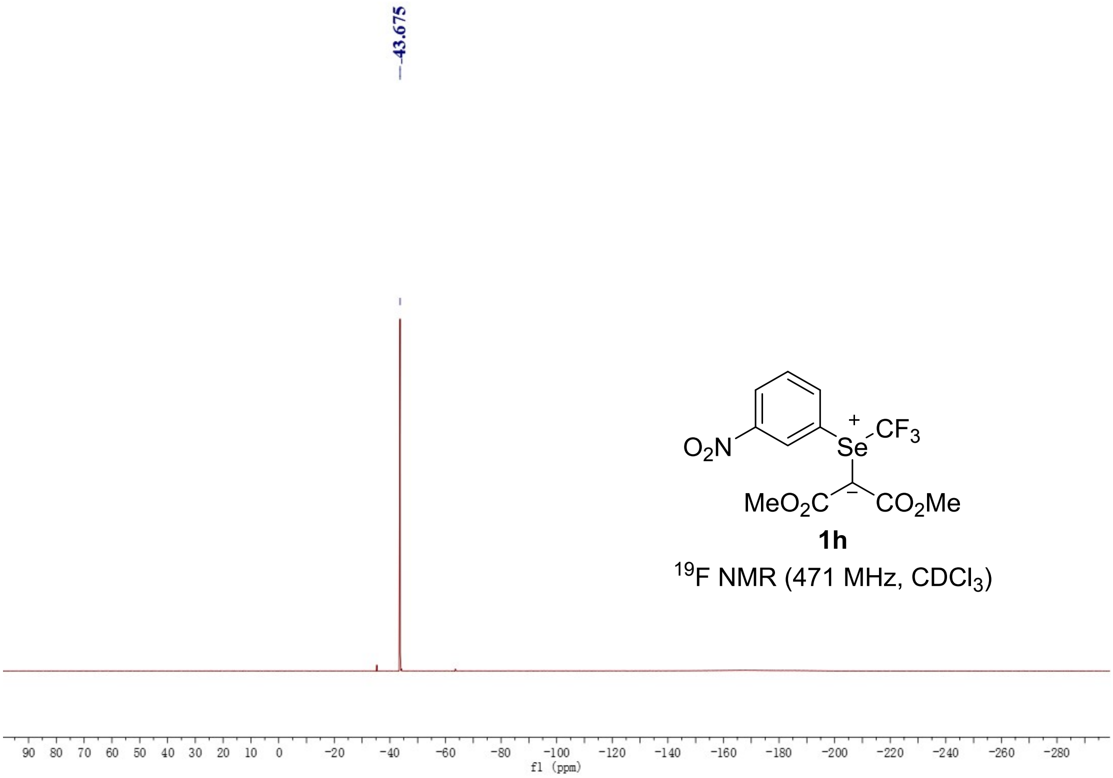

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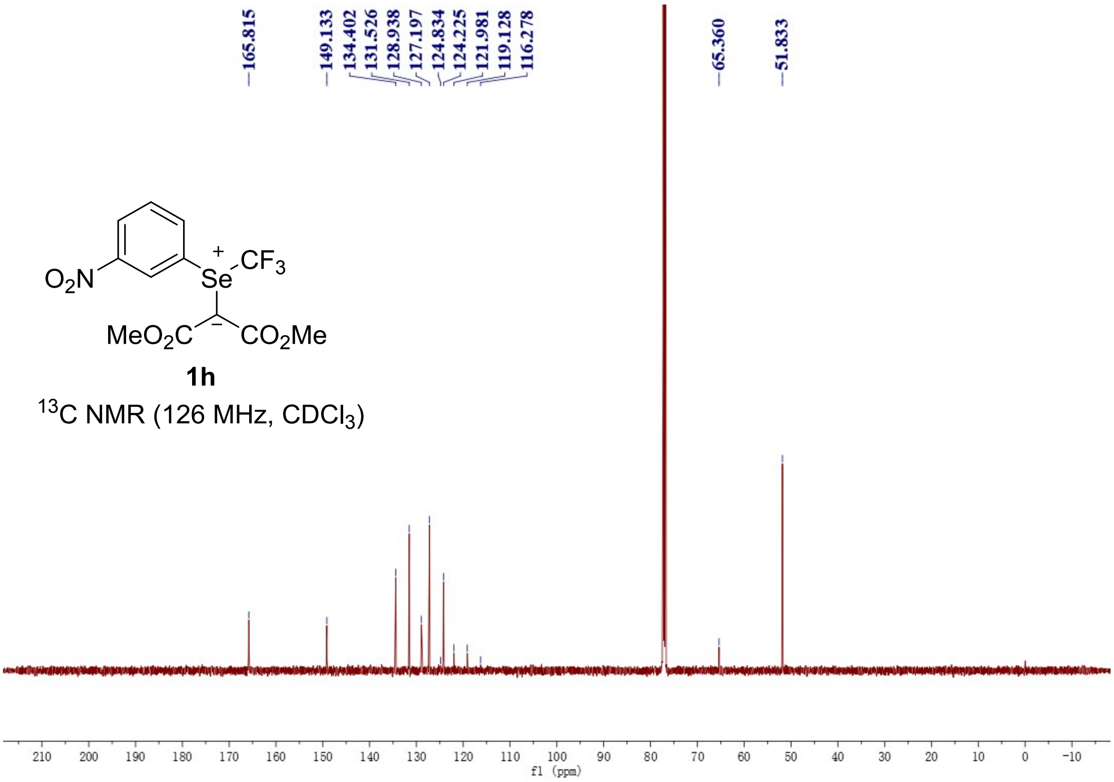

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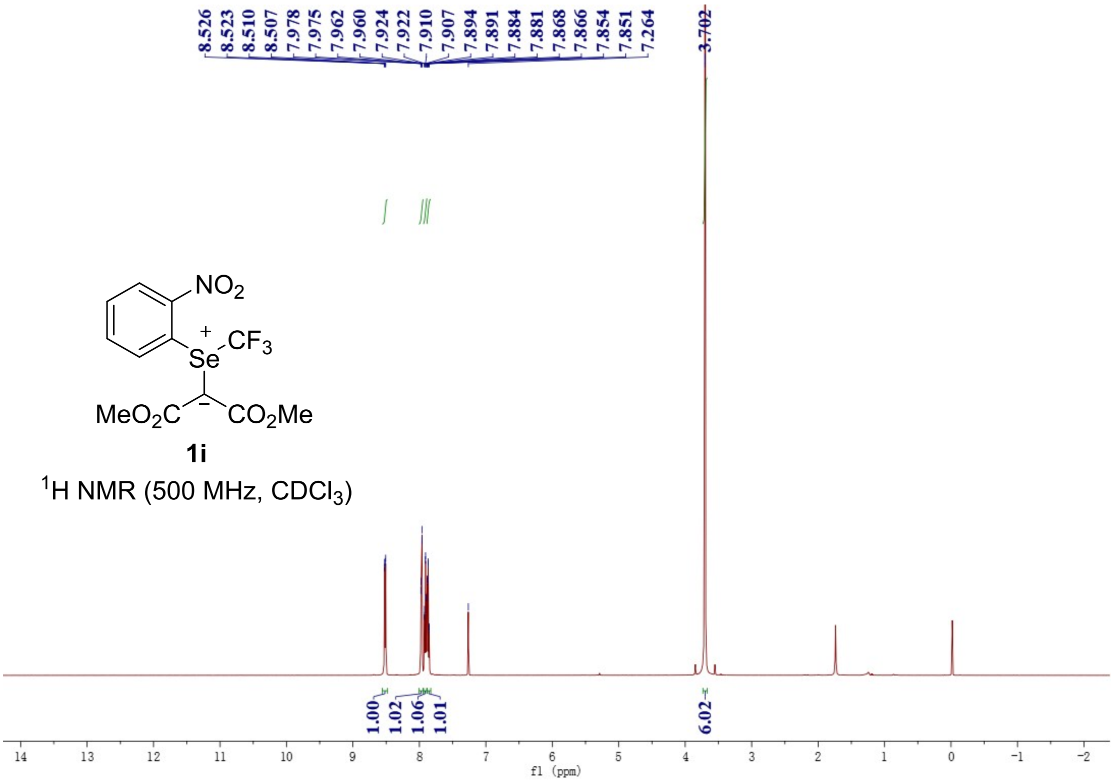

1i

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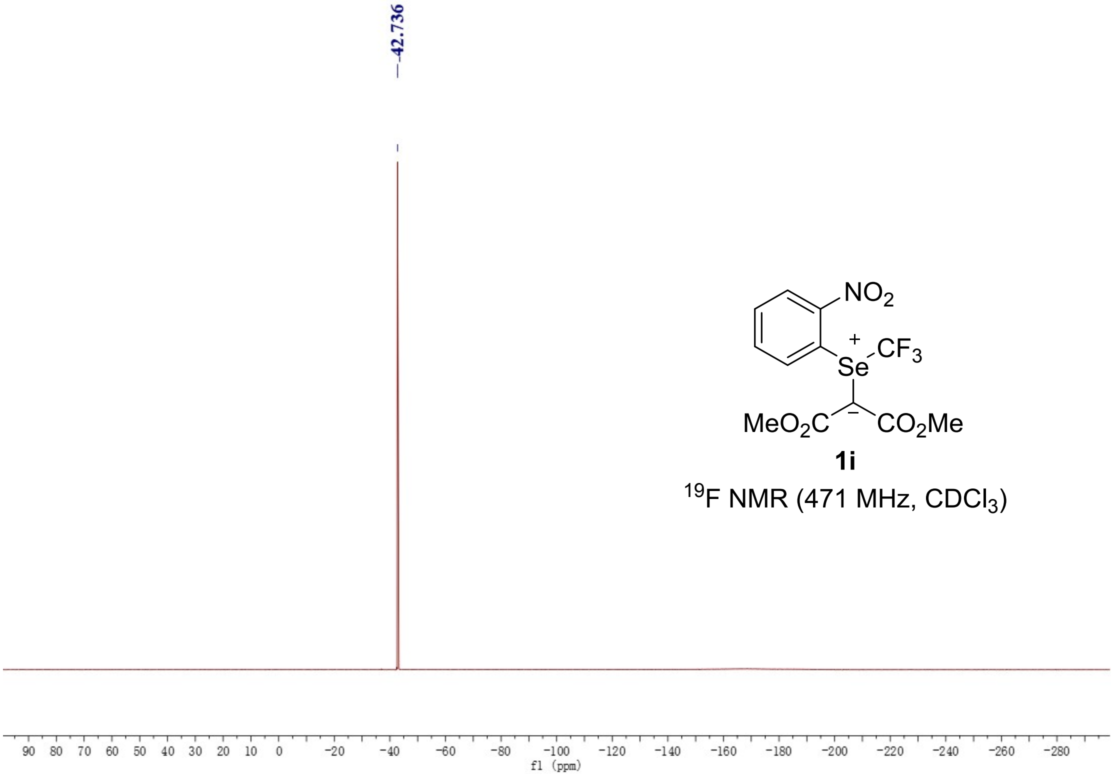

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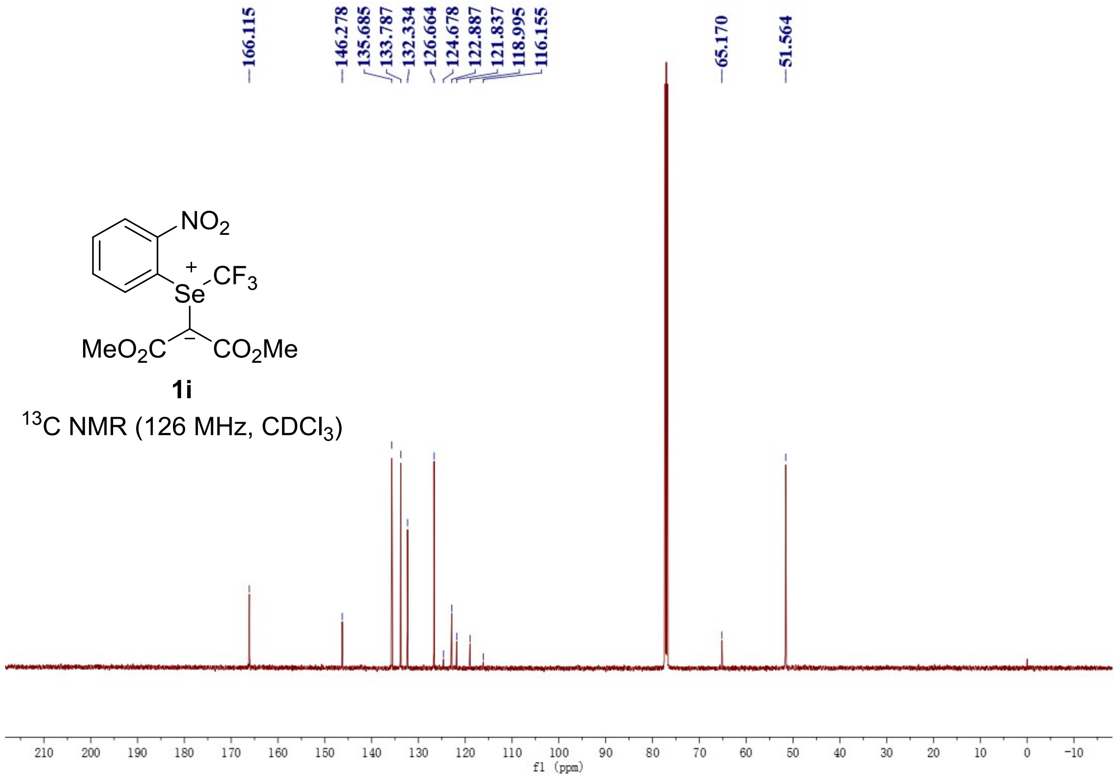
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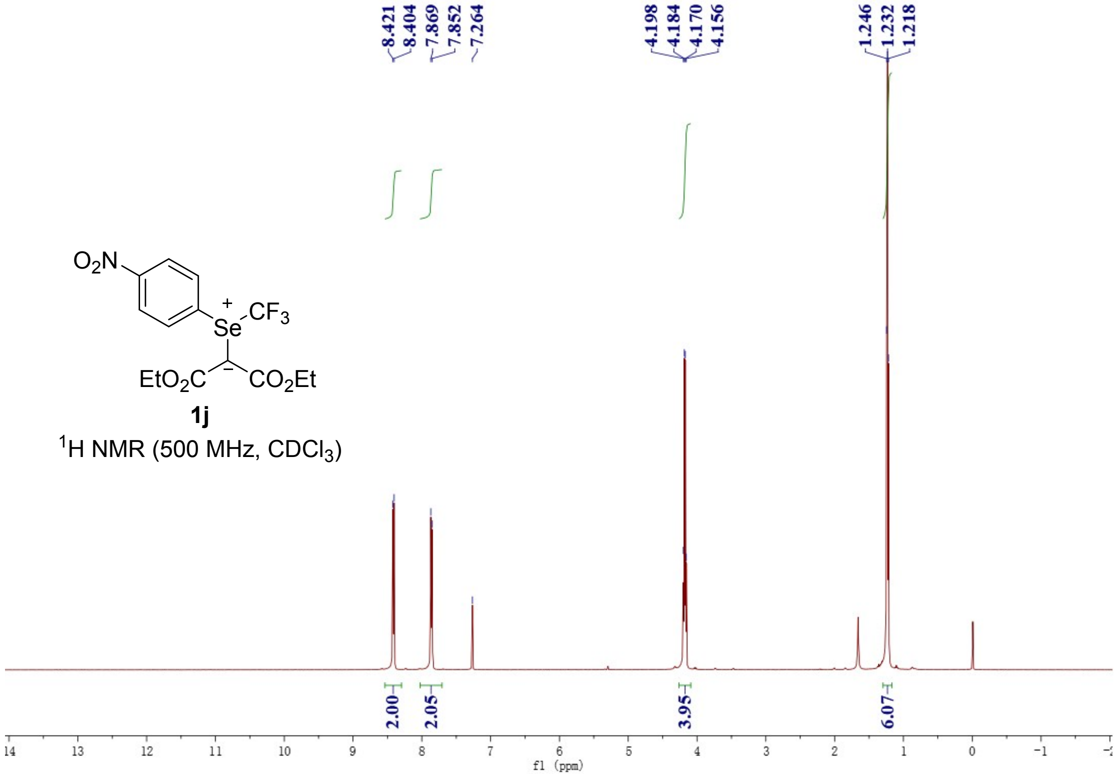
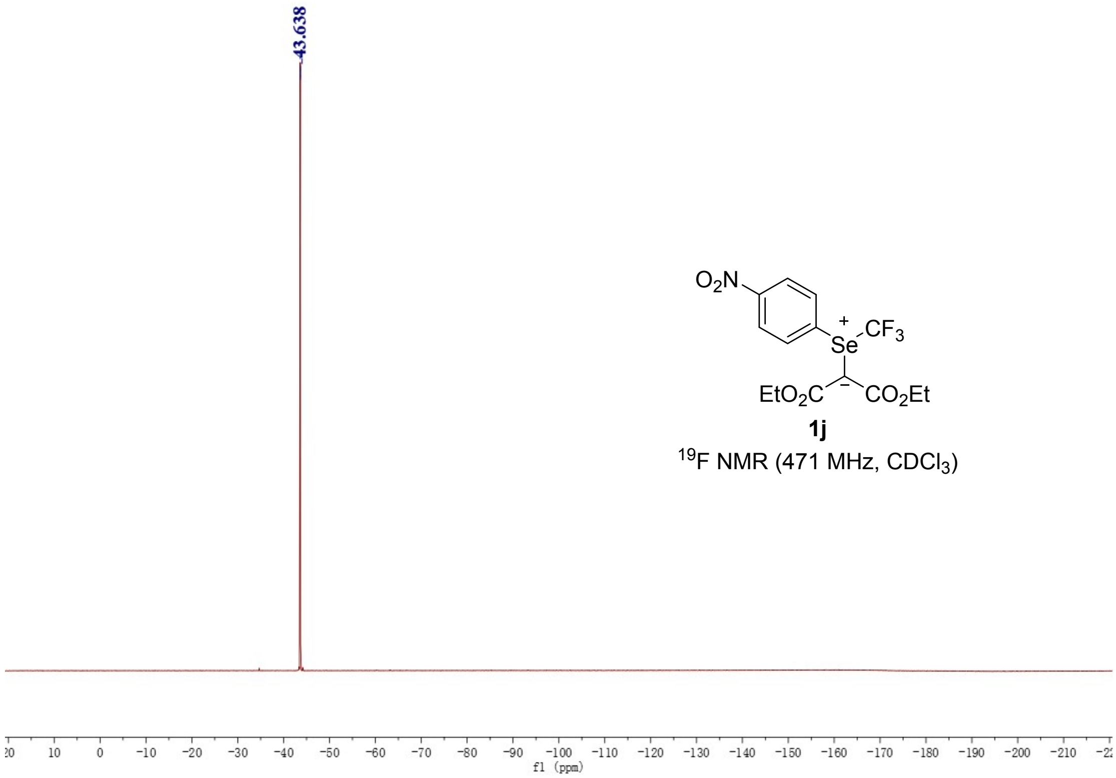
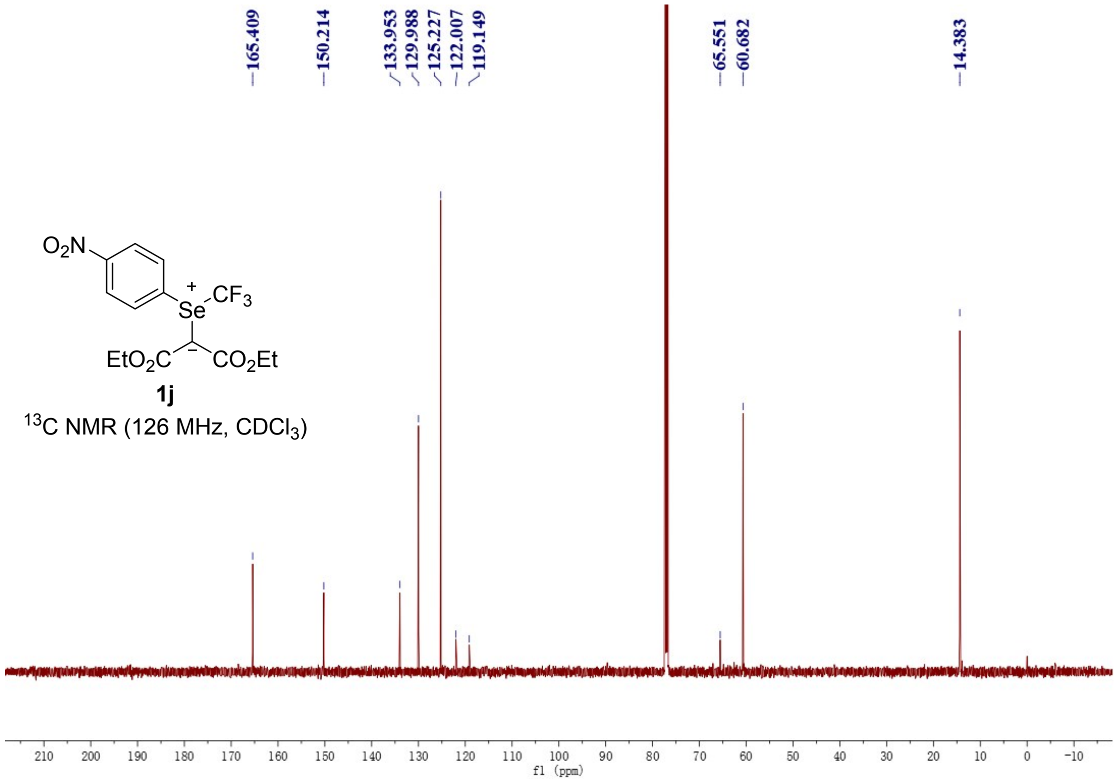
132.334
126.664
124.678
122.887
121.837
118.995
116.155
65.170
51.564
NO2
CF3
Se
MeO2C
CO2Me
1i
13C NMR (126 MHz, CDCl3)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


8.421
8.404
7.869
7.852
7.264
4.198
4.184
4.170
4.156
1.246
1.232
1.218
O2N
CF3
Se
EtO2C
CO2Et
1j
1H NMR (500 MHz, CDCl3)
2.00
2.05
3.95
6.07
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1
f1 (ppm)



1j

^{19}F NMR (471 MHz, $CDCl_3$)



1j

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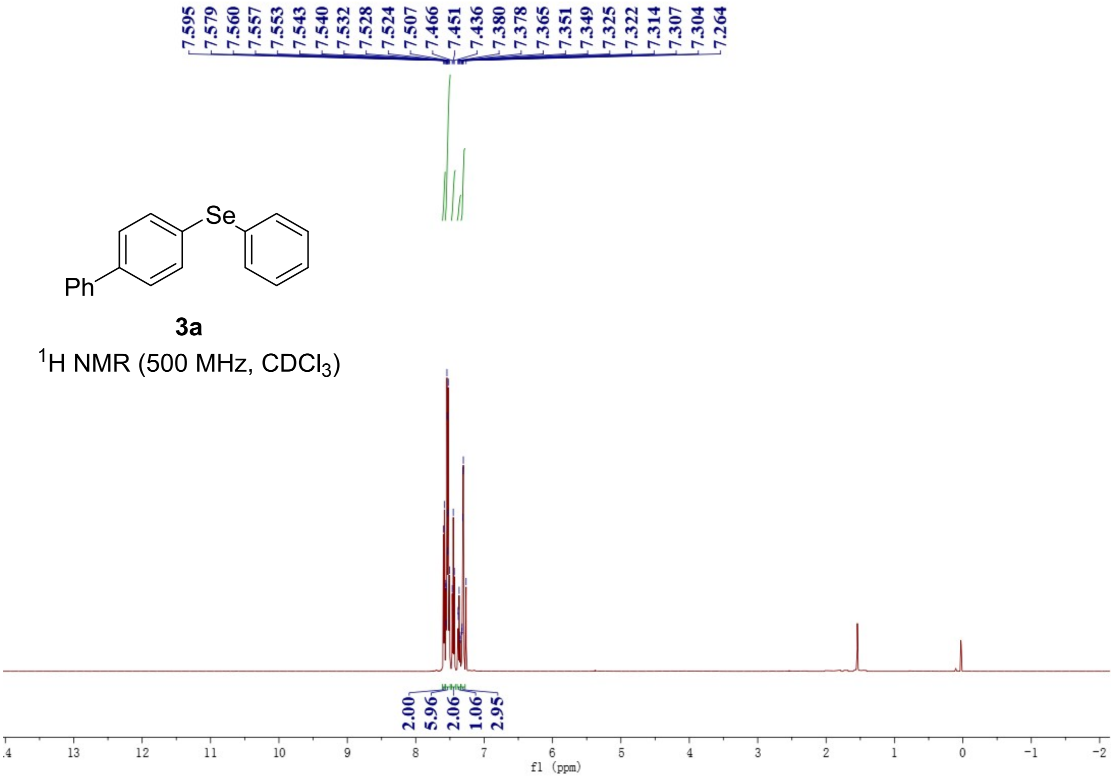

3a

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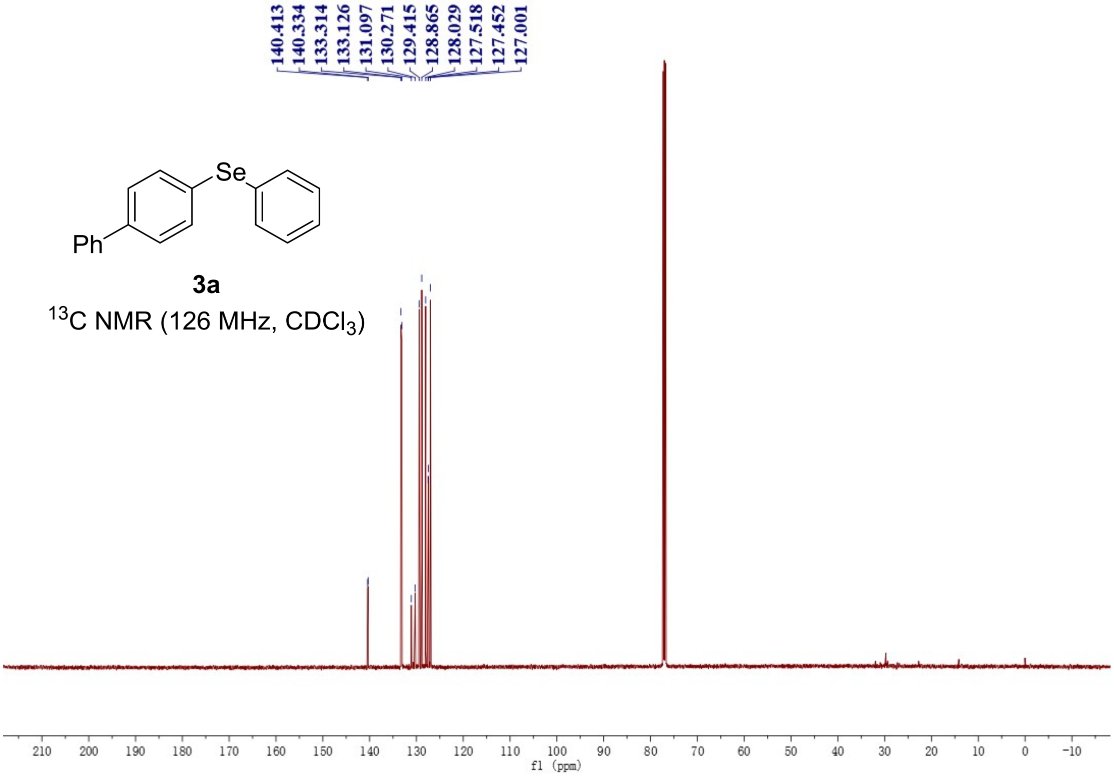

3a

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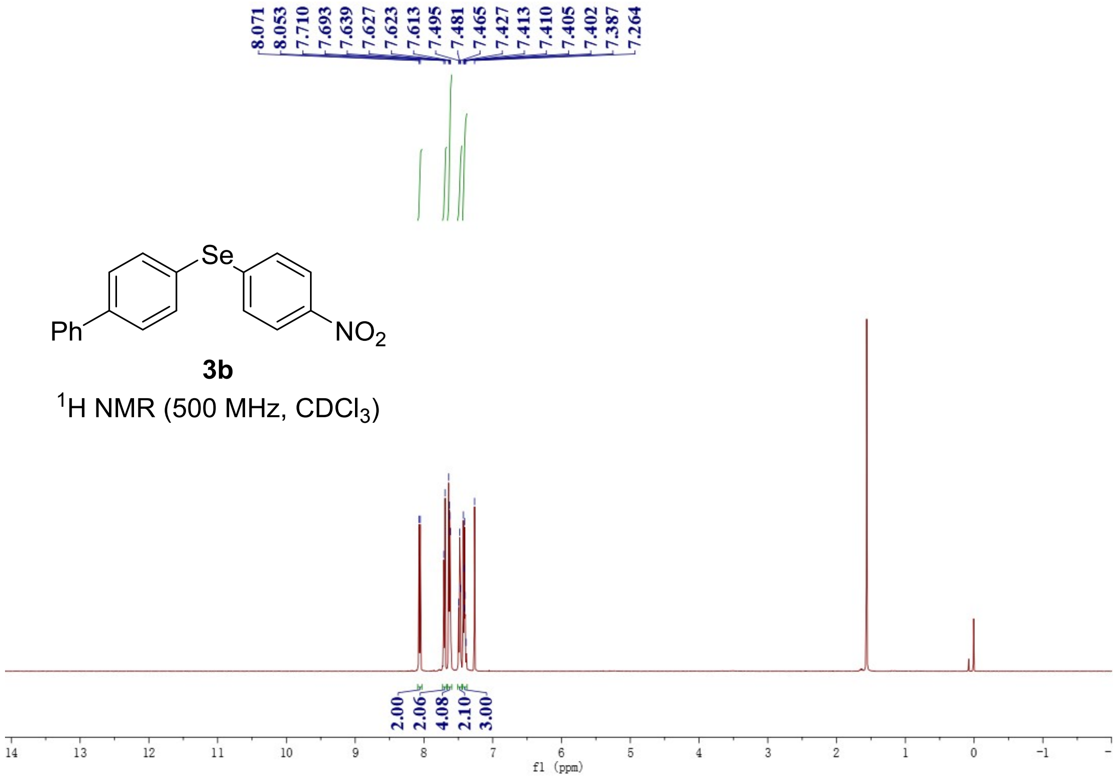

3b

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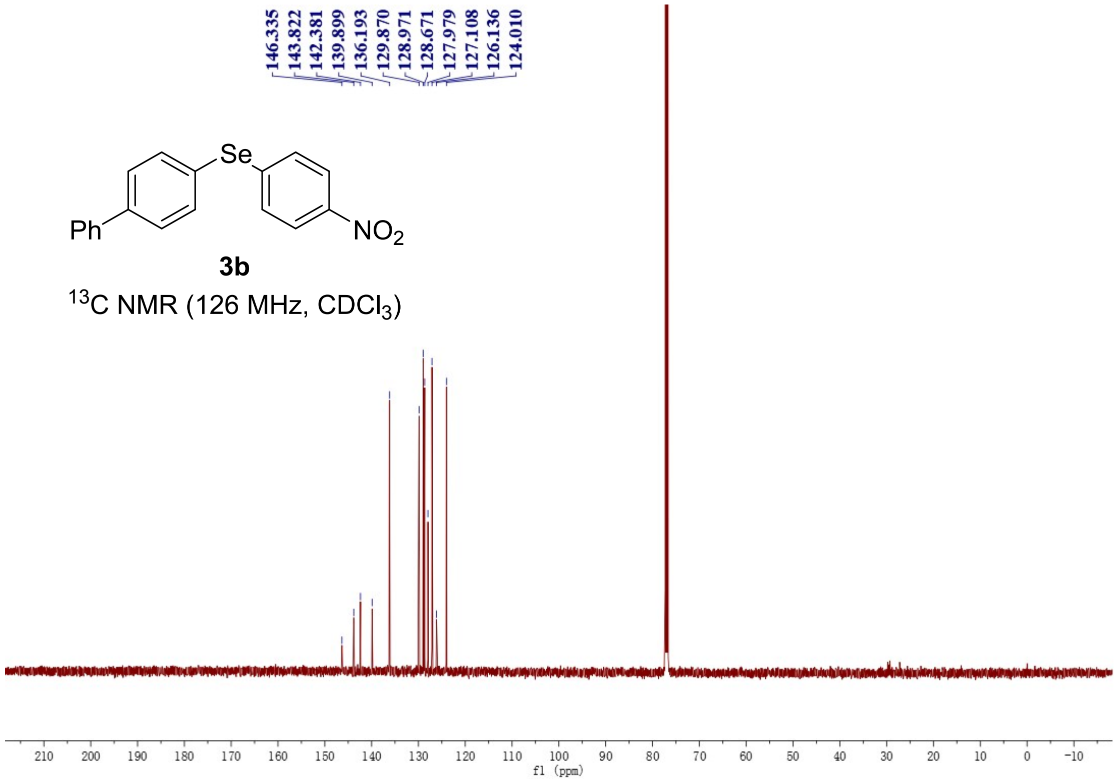

3b

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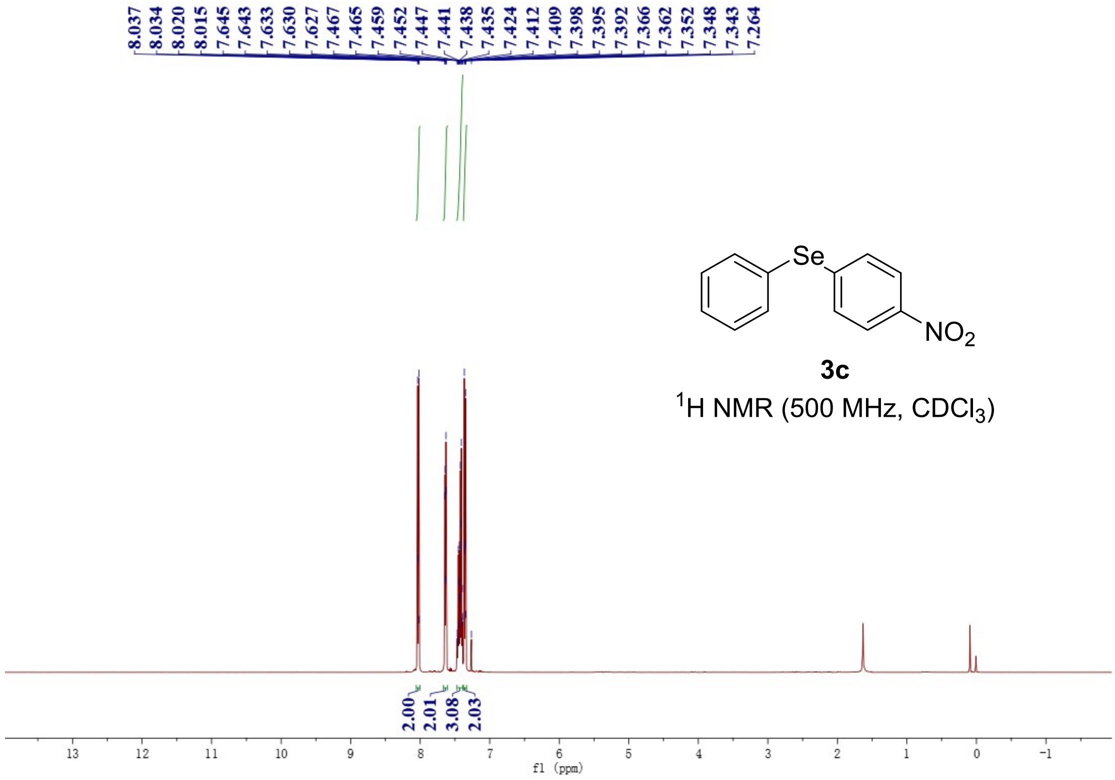
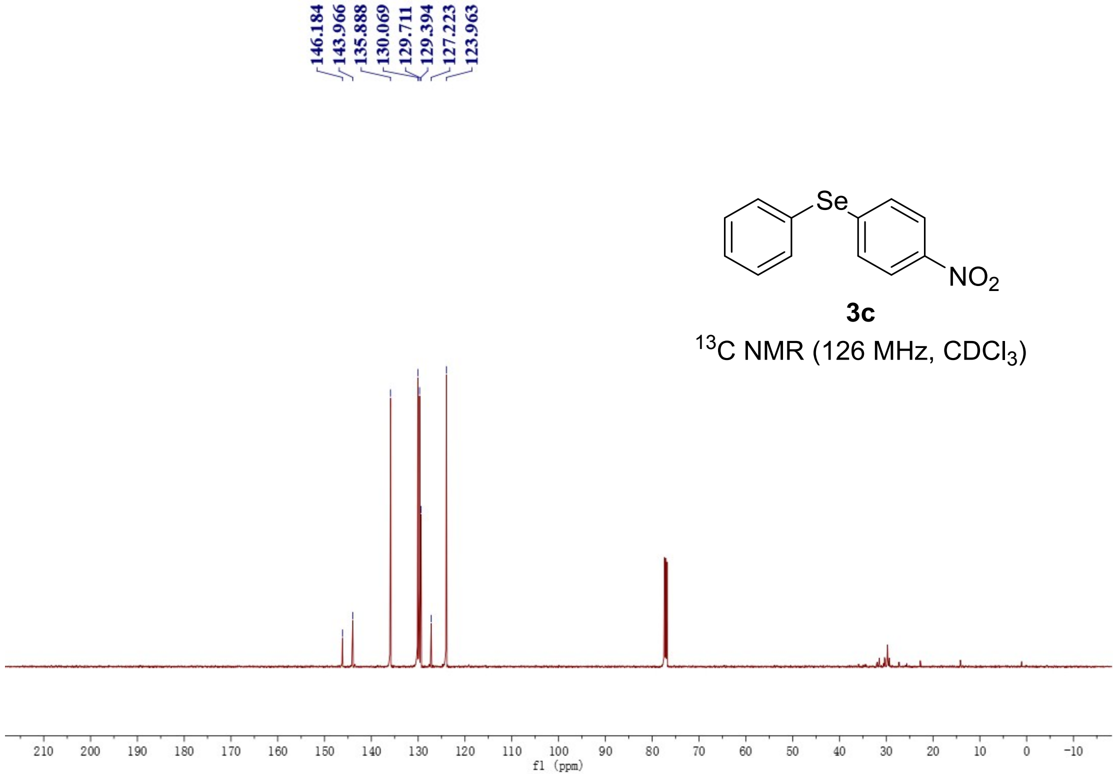


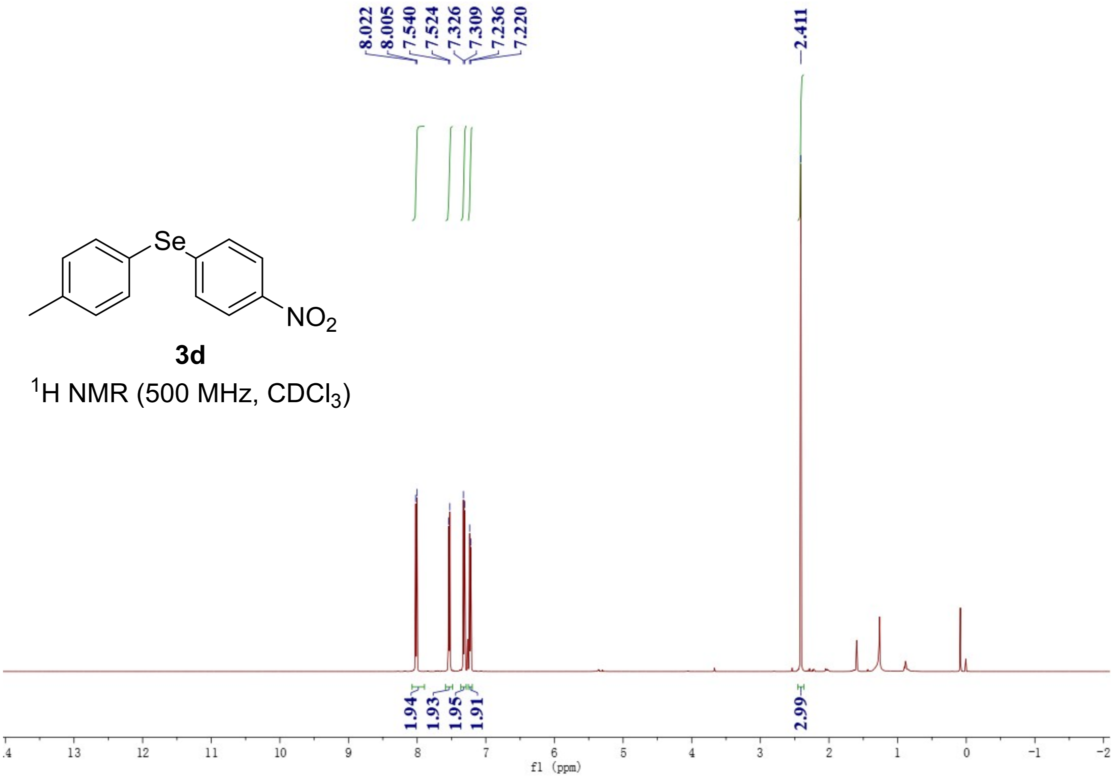
3c

^{1}H NMR (500 MHz, CDCl$_3$)



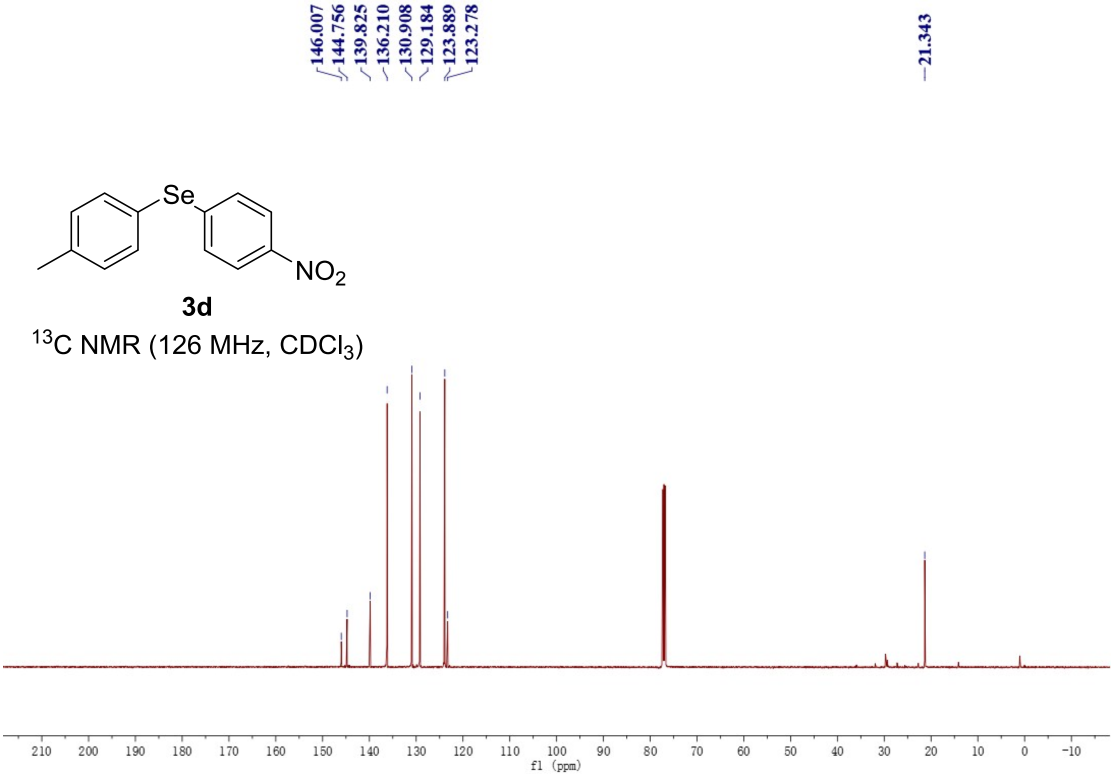
3c

^{13}C NMR (126 MHz, CDCl$_3$)



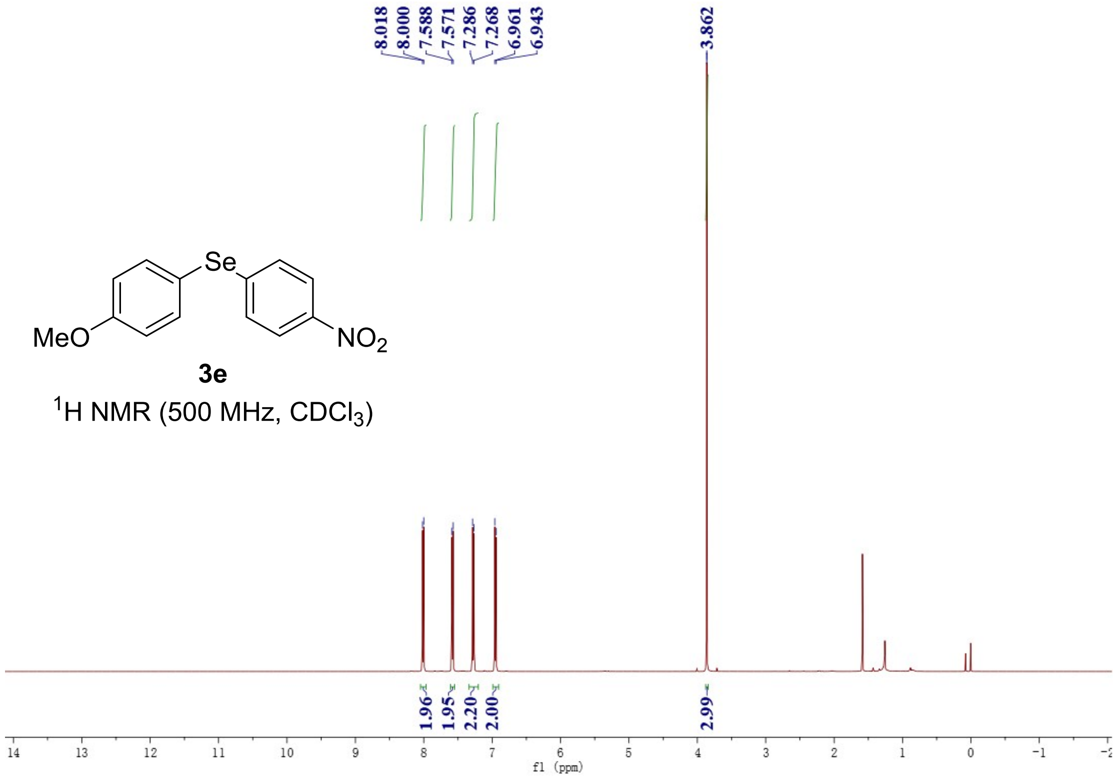
3d

^{1}H NMR (500 MHz, CDCl$_3$)



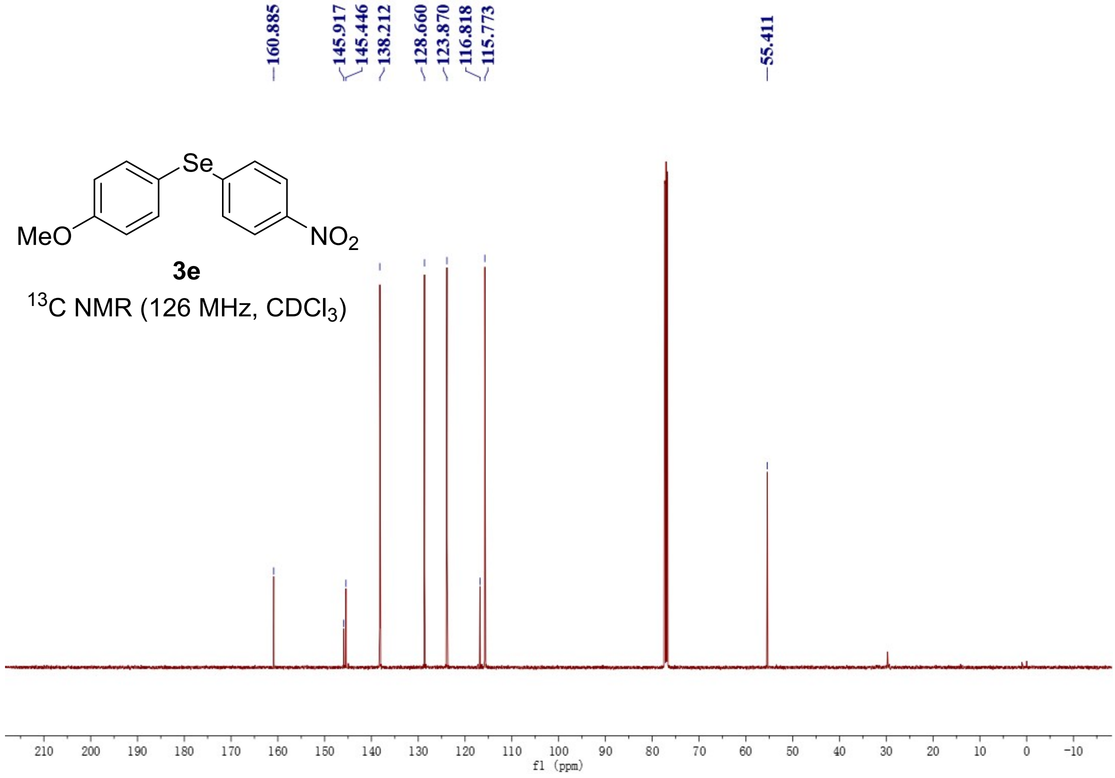
3d

^{13}C NMR (126 MHz, CDCl$_3$)



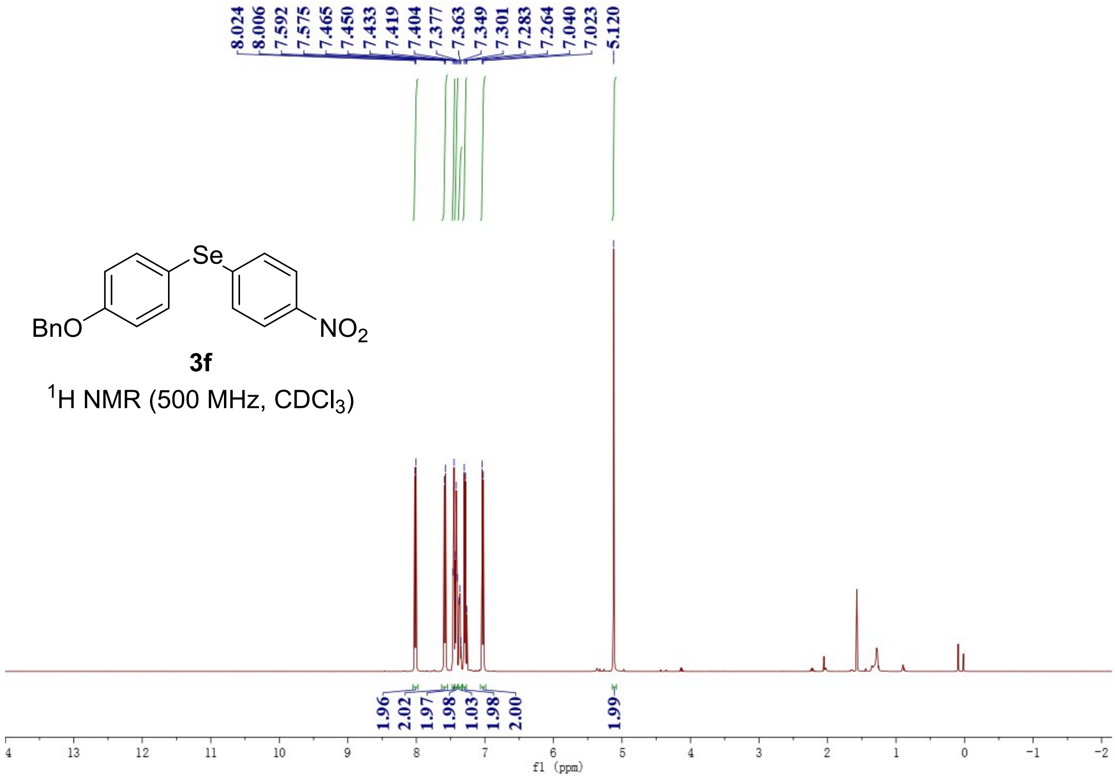
3e

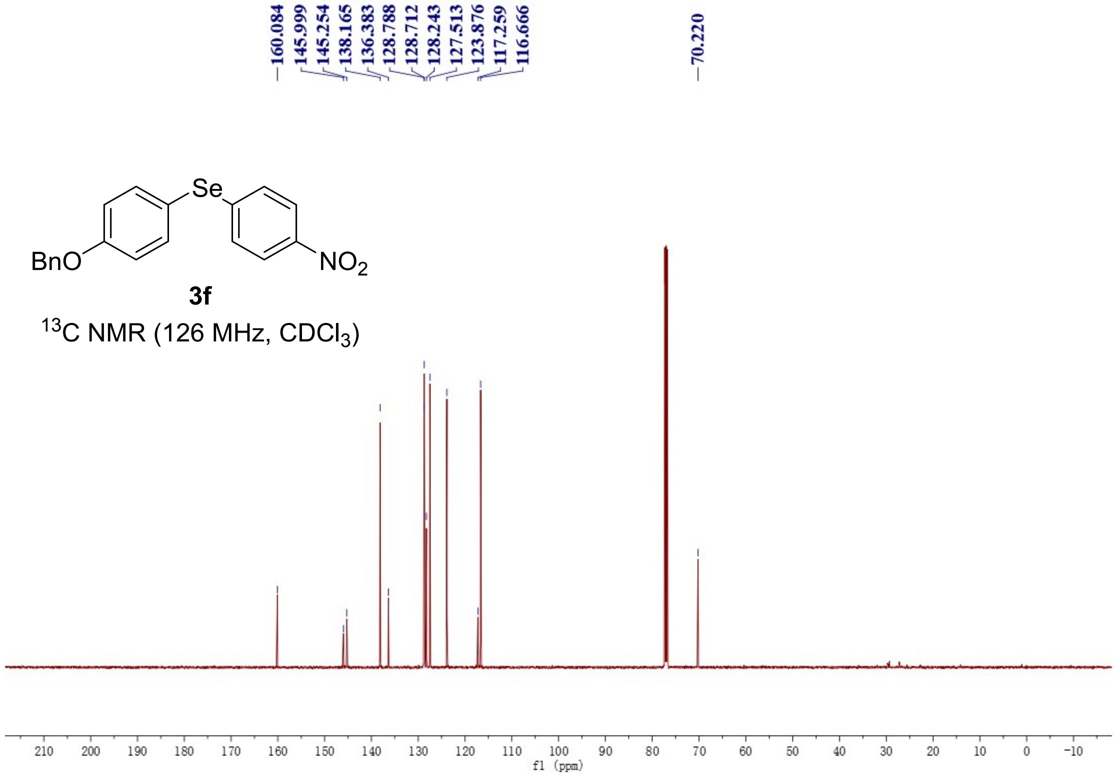
^1H NMR (500 MHz, $CDCl_3$)

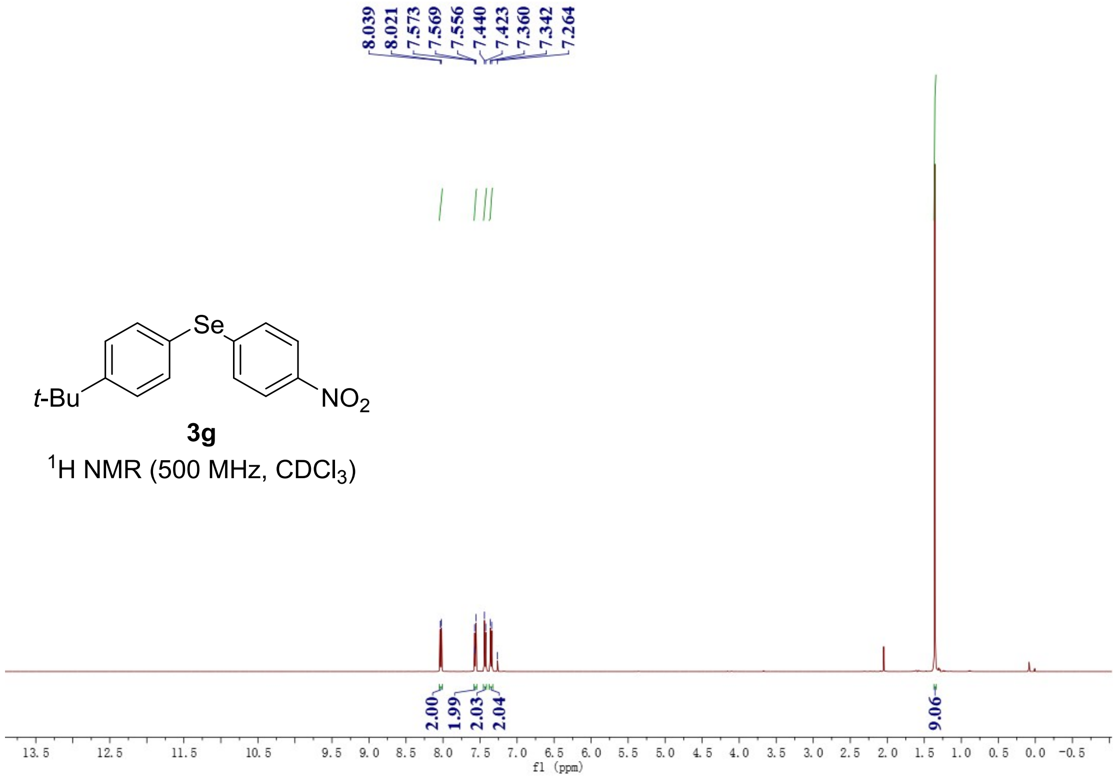


3e

^{13}C NMR (126 MHz, $CDCl_3$)

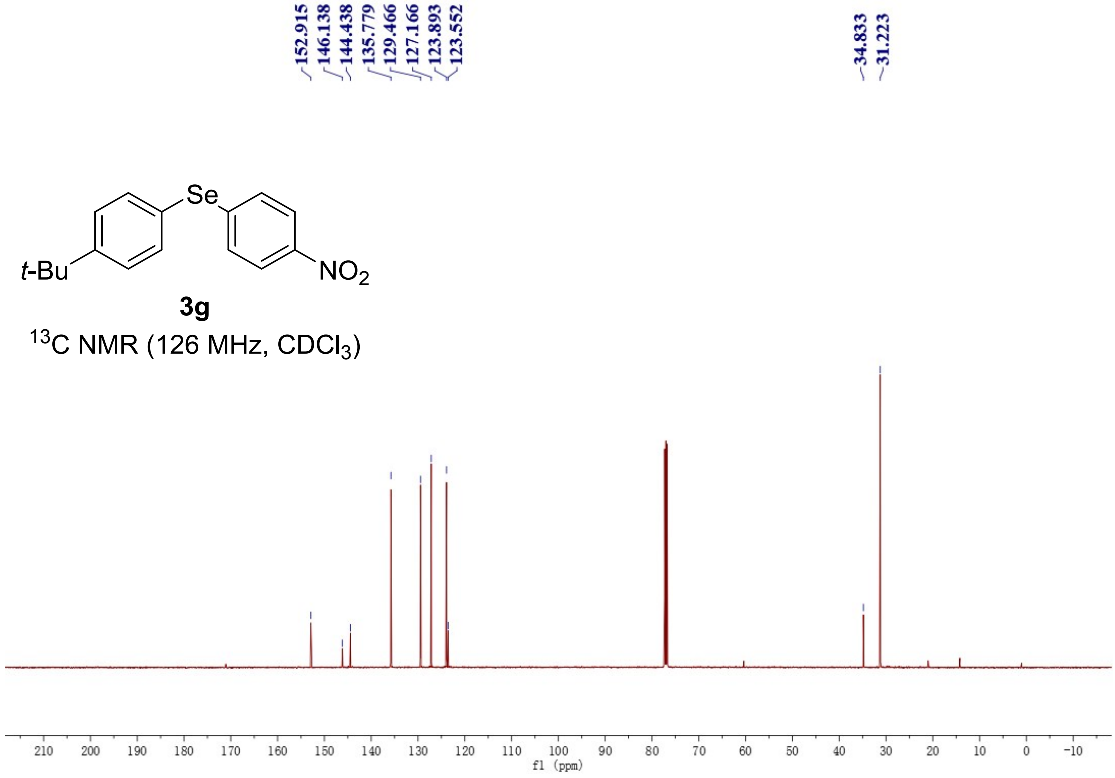

8.024
8.006
7.592
7.575
7.465
7.450
7.433
7.419
7.404
7.377
7.363
7.349
7.301
7.283
7.264
7.040
7.023
5.120
Se
BnO
NO2
3f
1H NMR (500 MHz, CDCl3)
1.96
2.02
1.97
1.98
1.03
1.98
2.00
1.99
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
f1 (ppm)


160.084
145.999
145.254
138.165
136.383
128.788
128.712
128.243
127.513
123.876
117.259
116.666
70.220
Se
BnO
NO2
3f
13C NMR (126 MHz, CDCl3)
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)



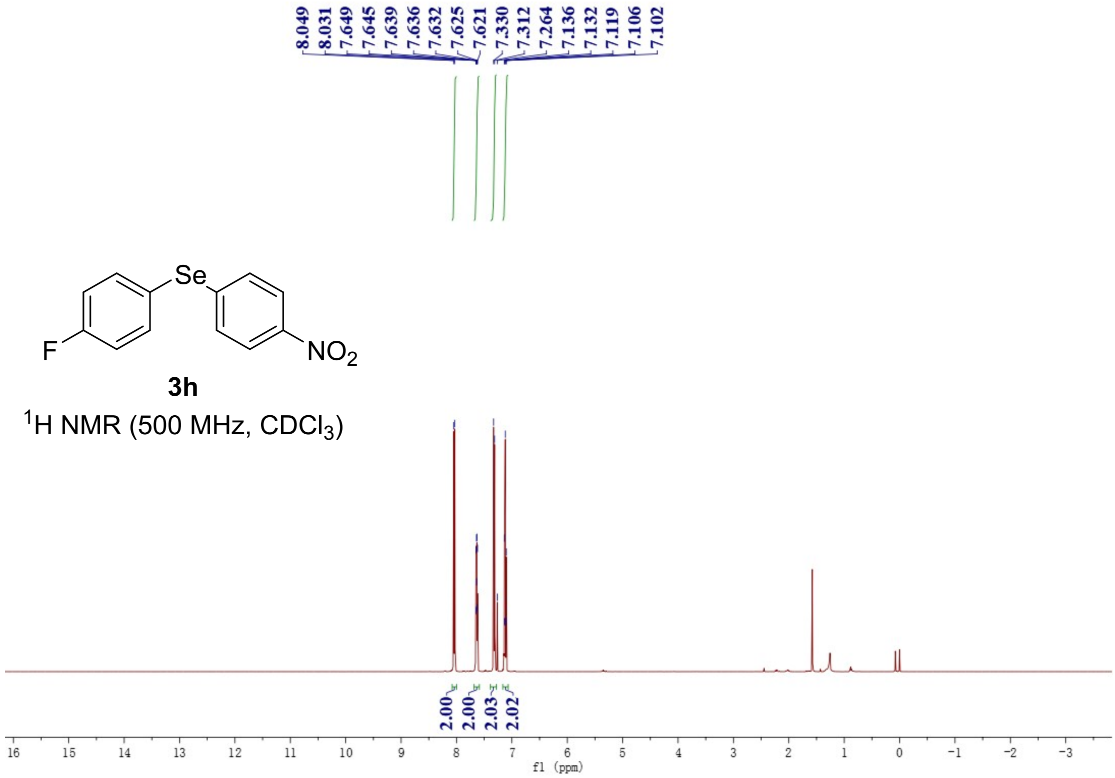
3g

^{1}H NMR (500 MHz, $CDCl_3$)



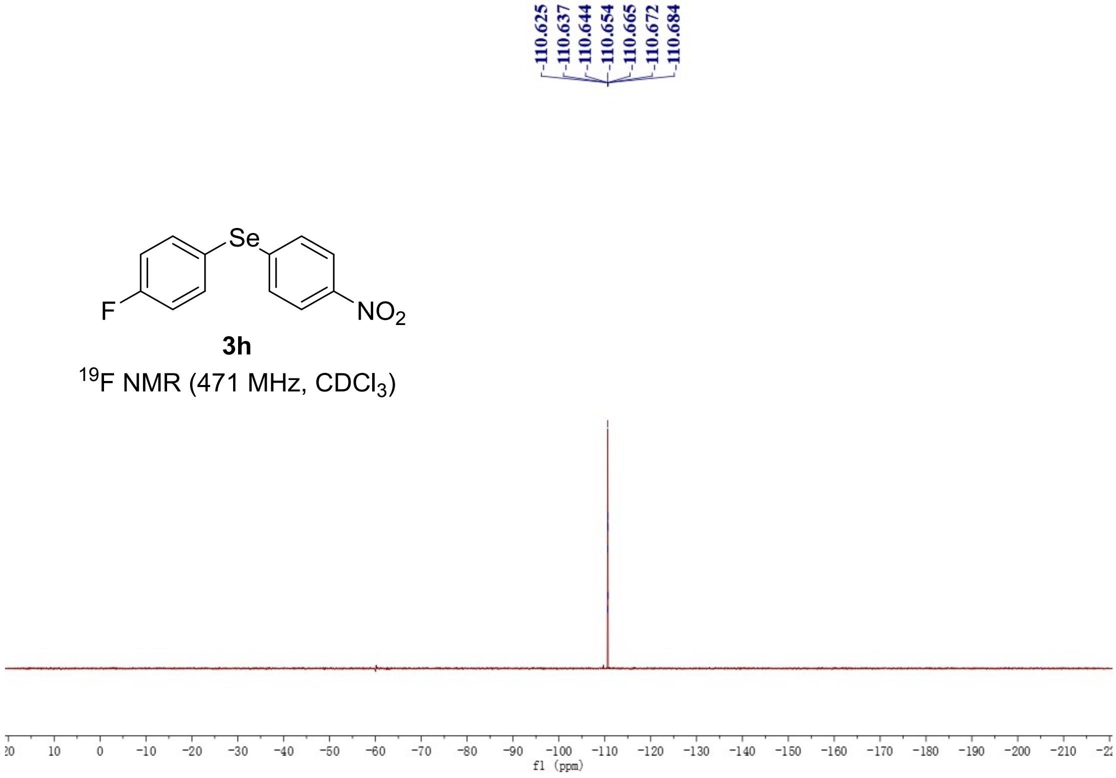
3g

^{13}C NMR (126 MHz, $CDCl_3$)



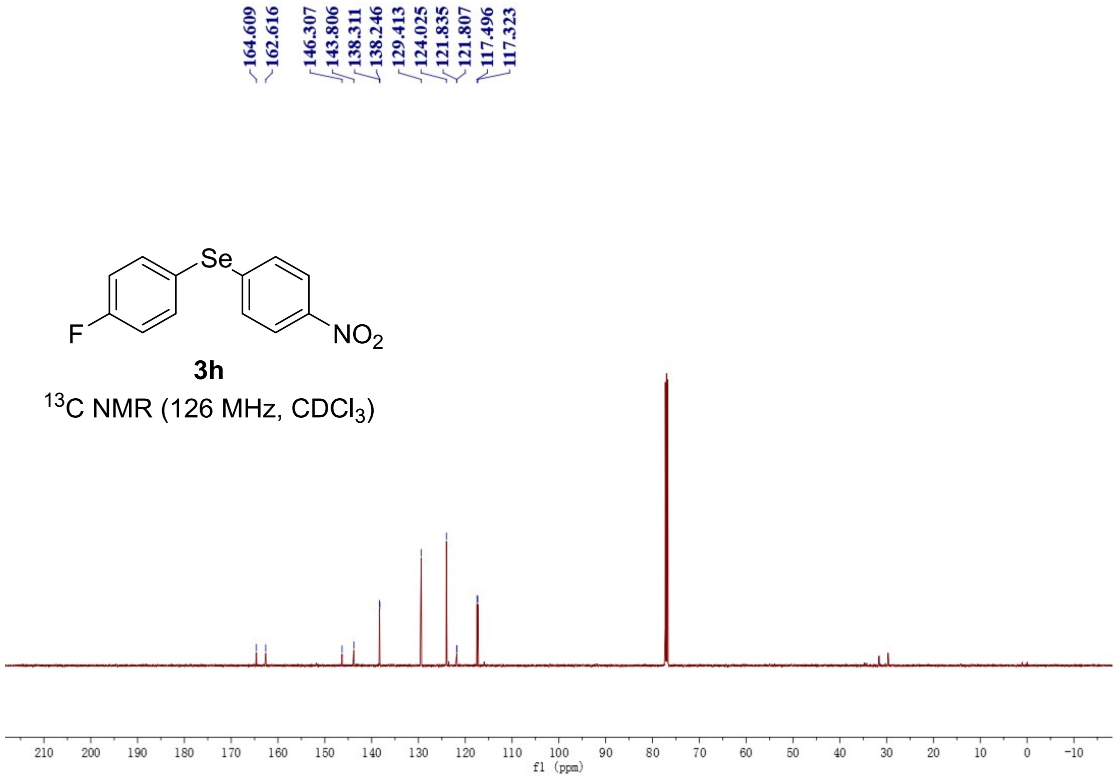
3h

^{1}H NMR (500 MHz, CDCl$_3$)



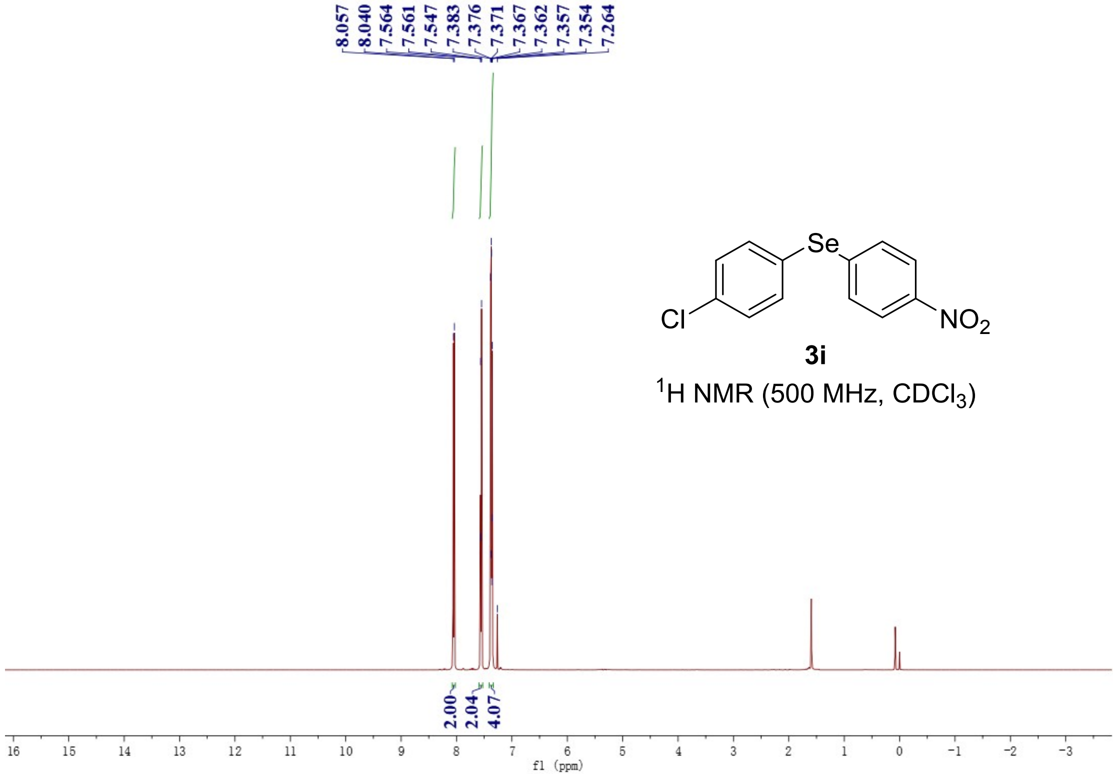
3h

^{19}F NMR (471 MHz, CDCl$_3$)



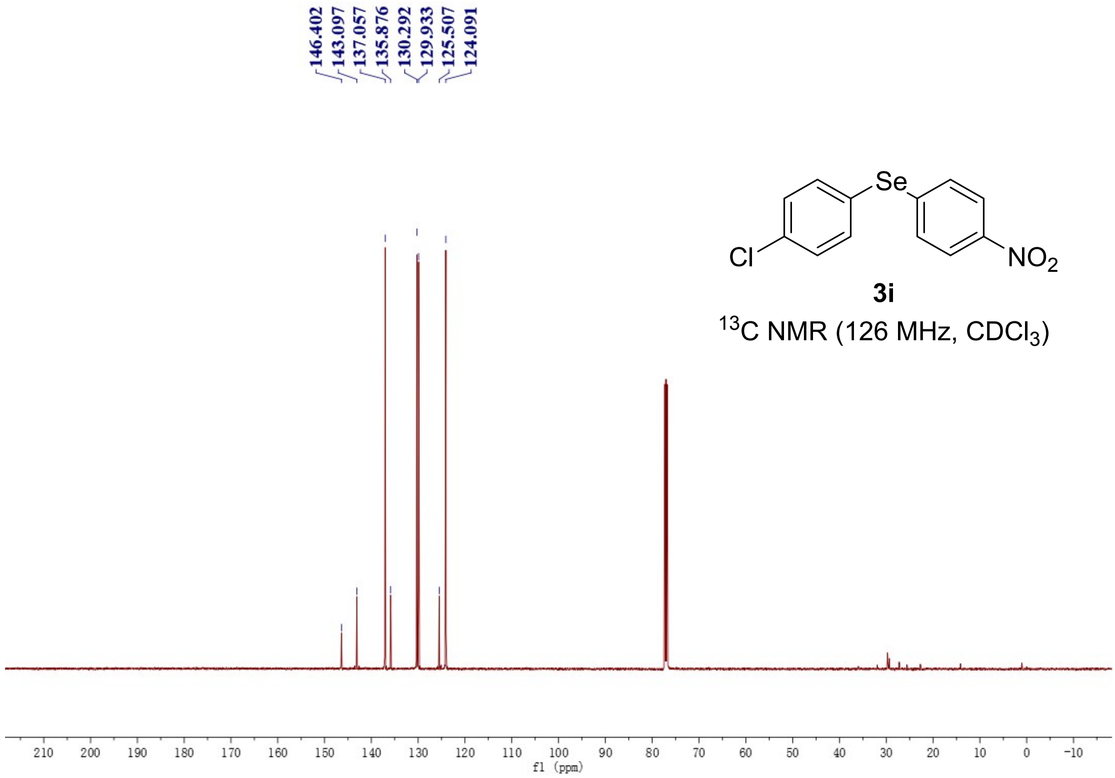
3h

^{13}C NMR (126 MHz, CDCl$_3$)



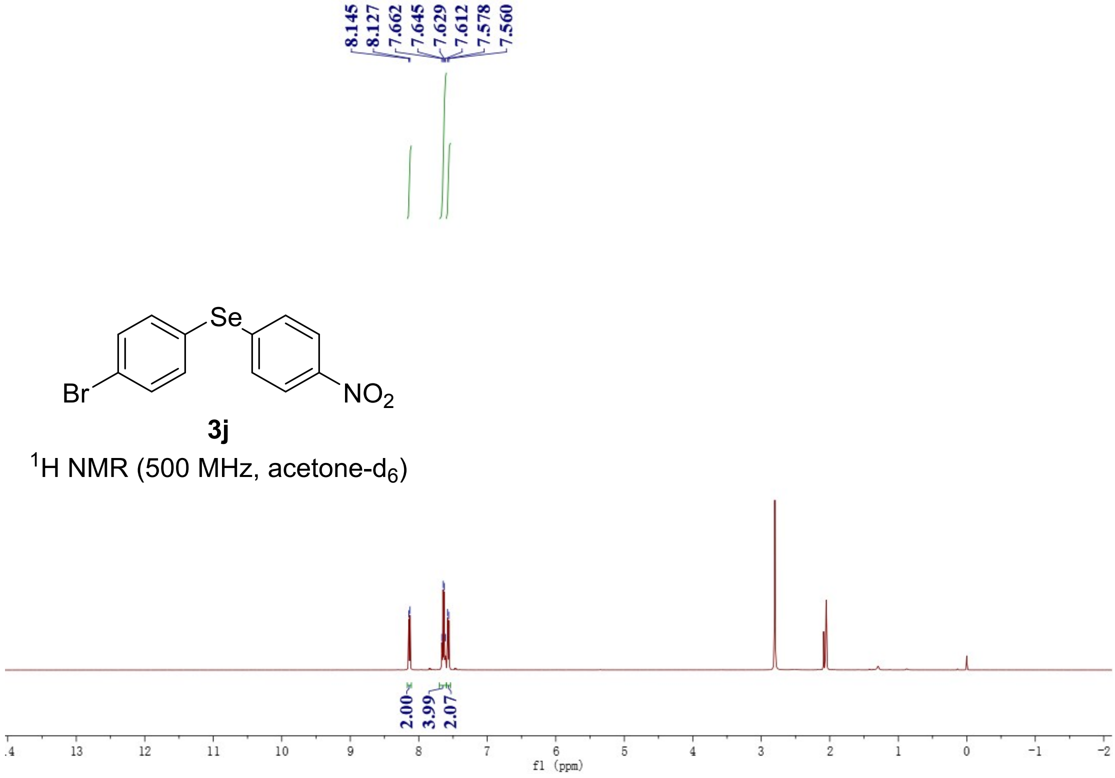
3i

^{1}H NMR (500 MHz, CDCl$_3$)



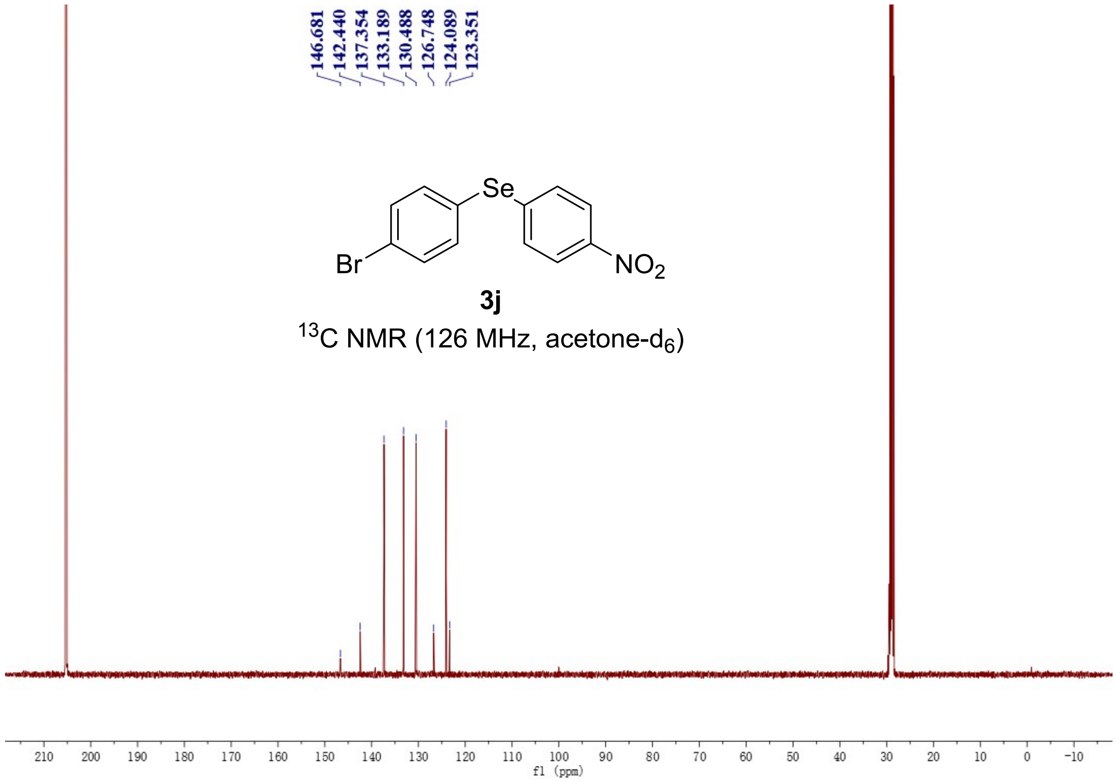
3i

^{13}C NMR (126 MHz, $CDCl_3$)



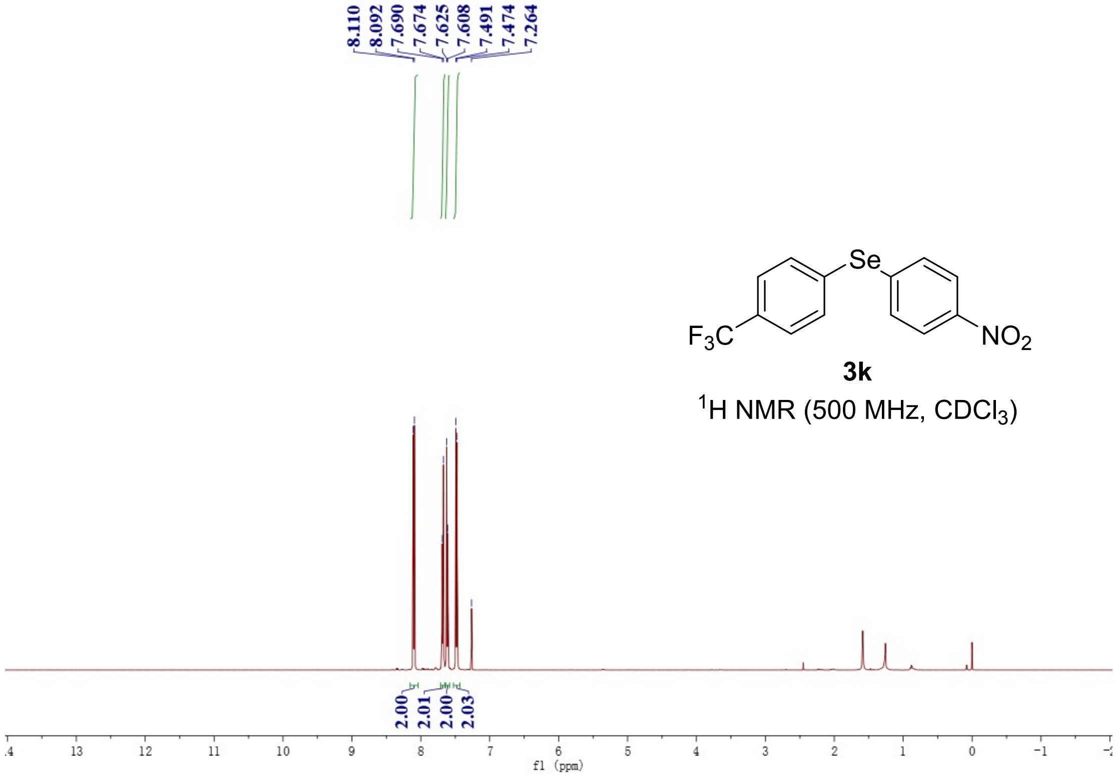
3j

^{1}H NMR (500 MHz, acetone-d_6)



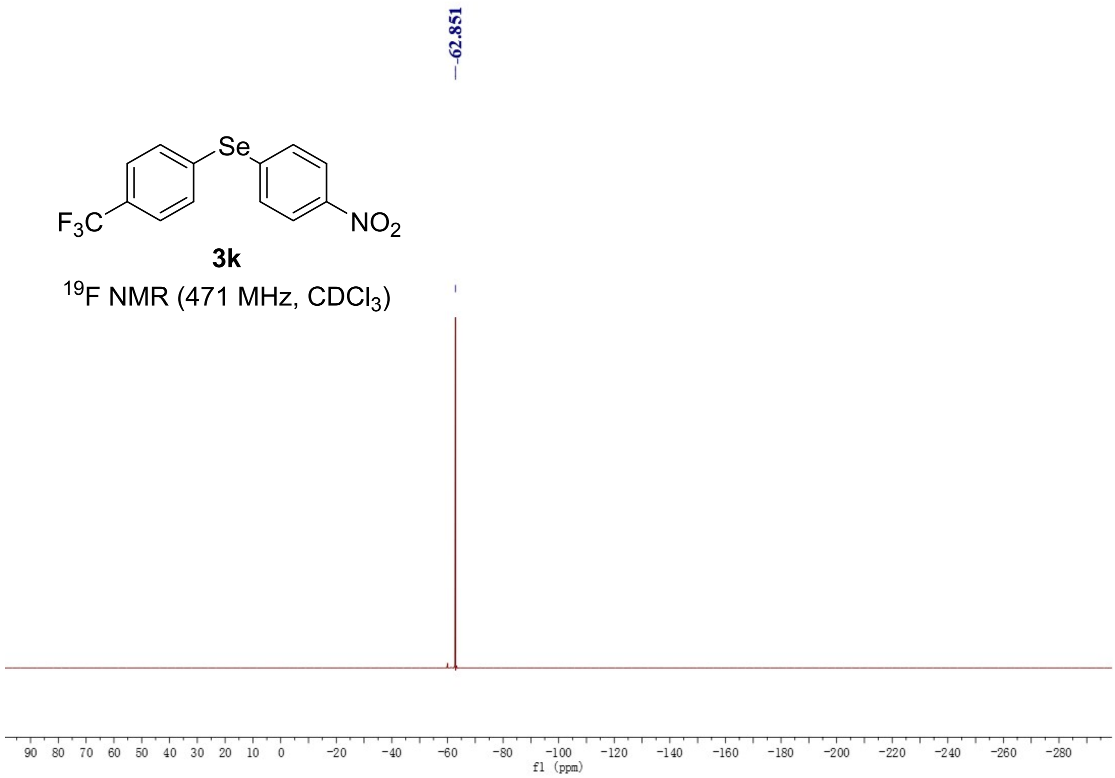
3j

^{13}C NMR (126 MHz, acetone-d_6)



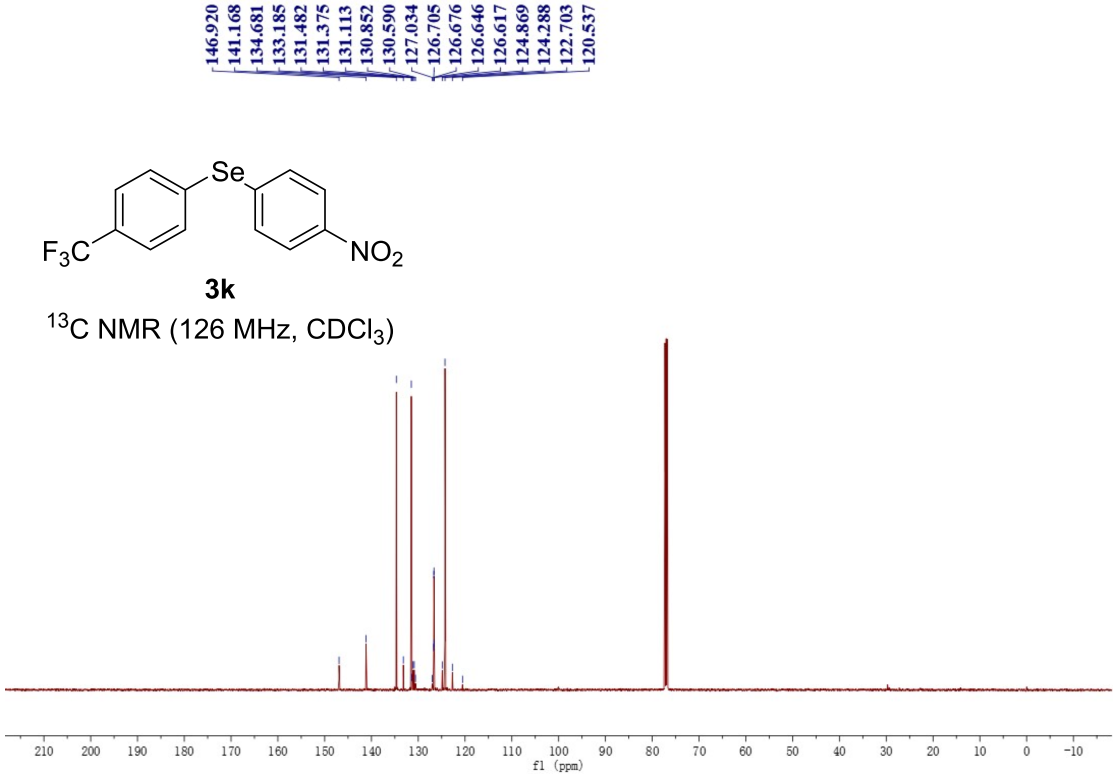
3k

^{1}H NMR (500 MHz, CDCl$_3$)



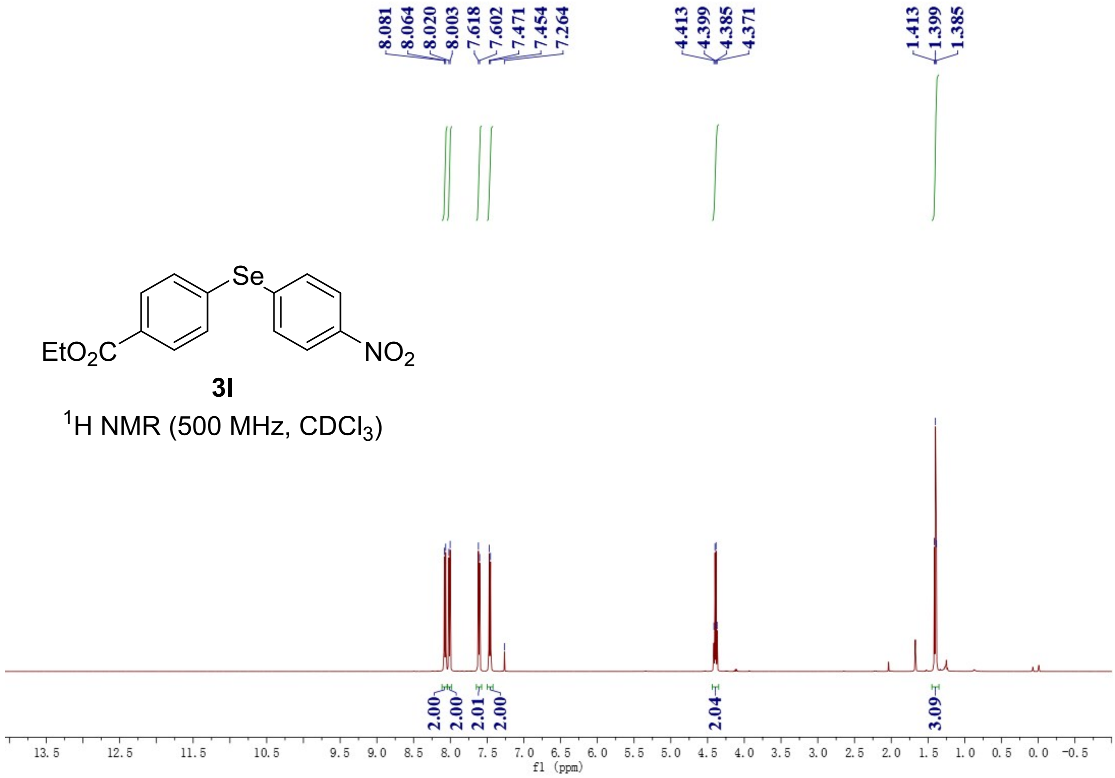
3k

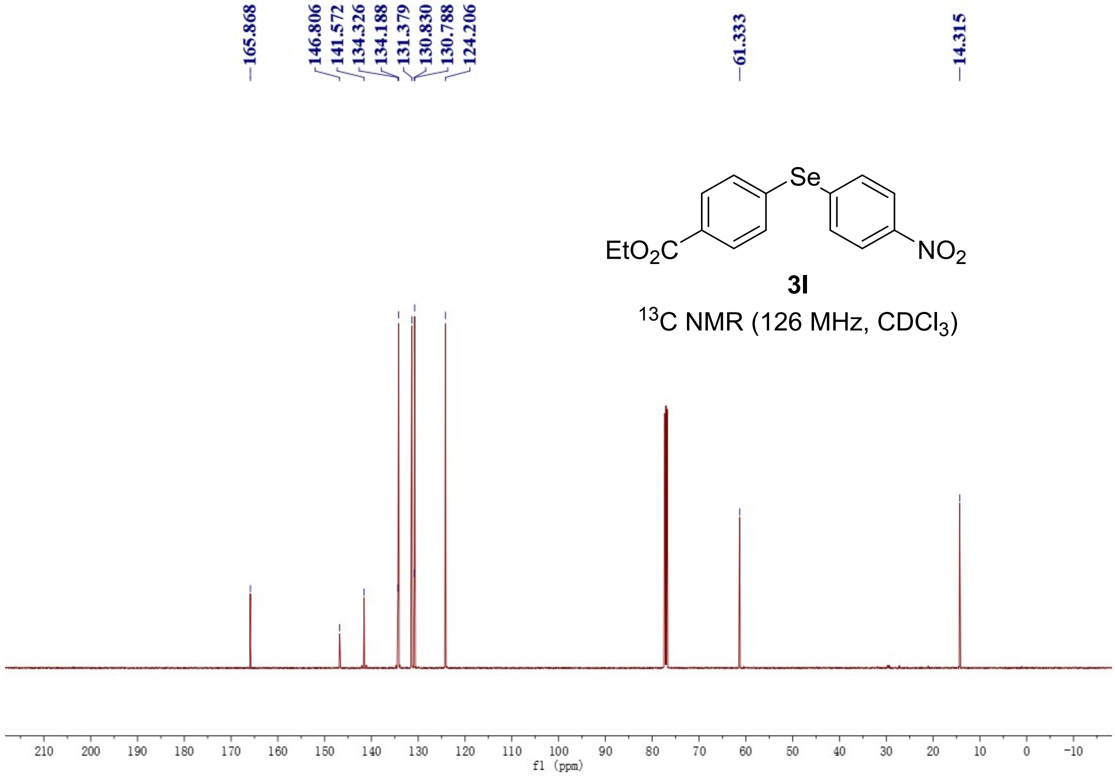
^{19}F NMR (471 MHz, $CDCl_3$)

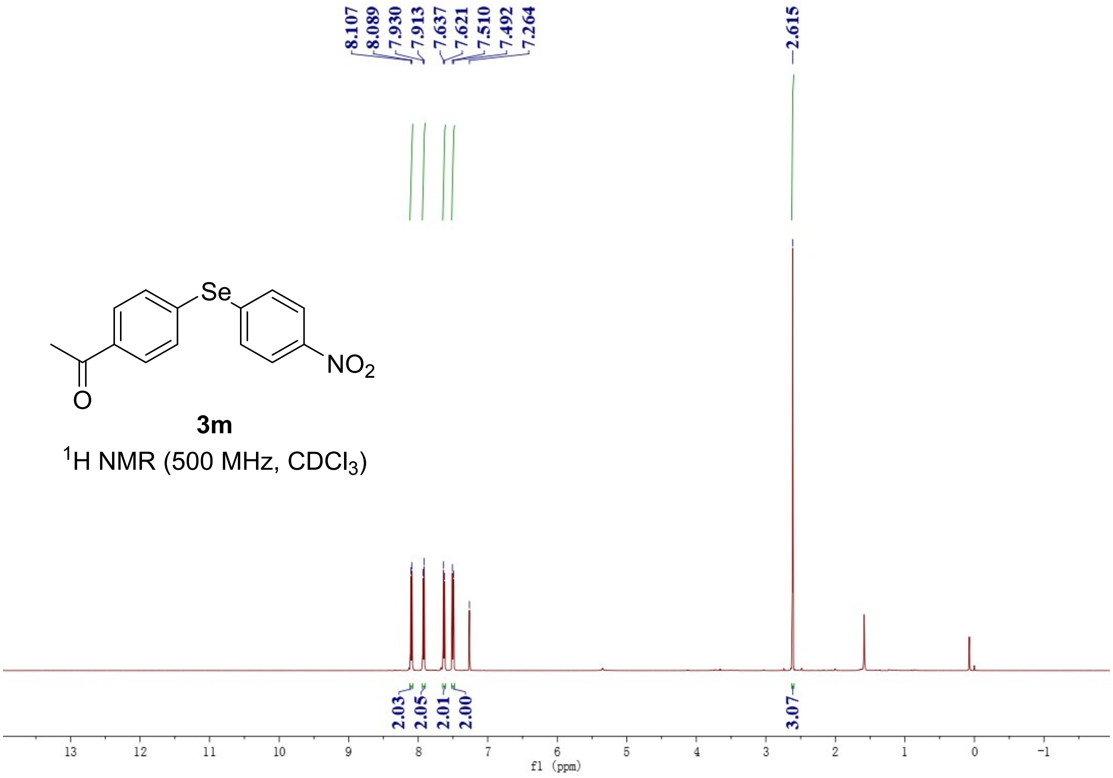


3k

^{13}C NMR (126 MHz, $CDCl_3$)

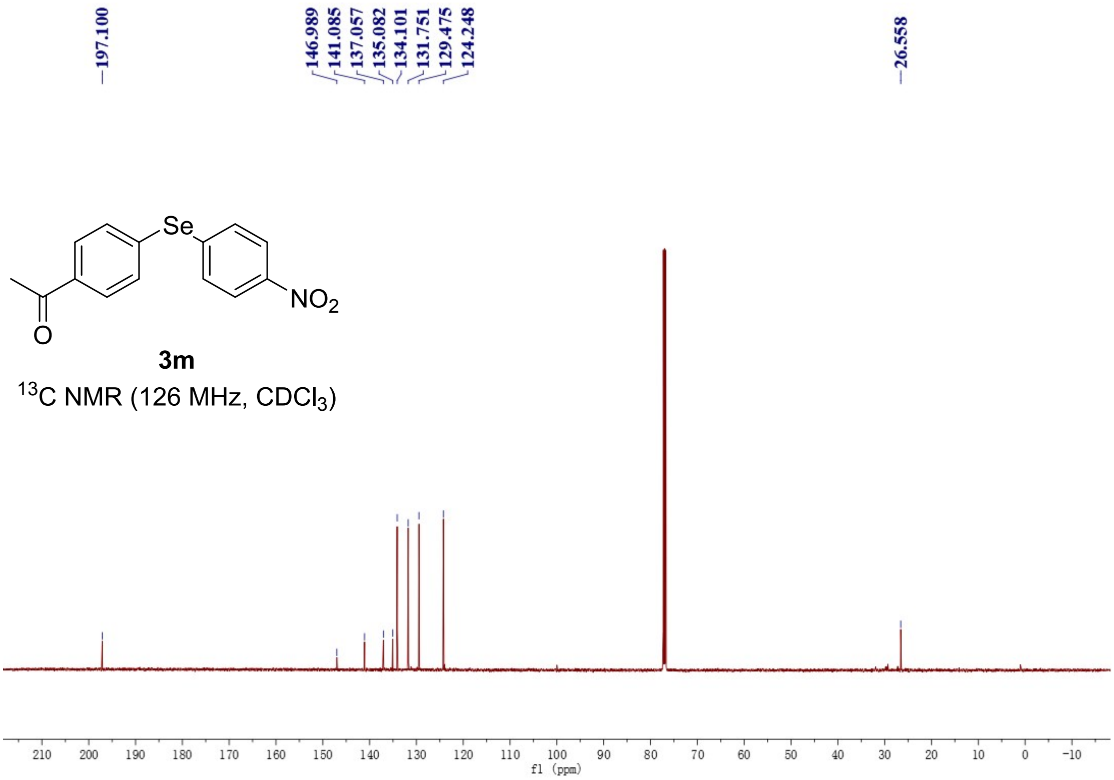

8.081
8.064
8.020
8.003
7.618
7.602
7.471
7.454
7.264
4.413
4.399
4.385
4.371
1.413
1.399
1.385
Se
EtO$_2$C
NO$_2$
3l
^{1}H NMR (500 MHz, CDCl$_3$)
2.00
2.00
2.01
2.00
2.04
3.09
13.5
12.5
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


165.868
146.806
141.572
134.326
134.188
131.379
130.830
130.788
124.206
61.333
14.315
Se
EtO$_2$C
NO$_2$
3l
^{13}C NMR (126 MHz, CDCl$_3$)
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)



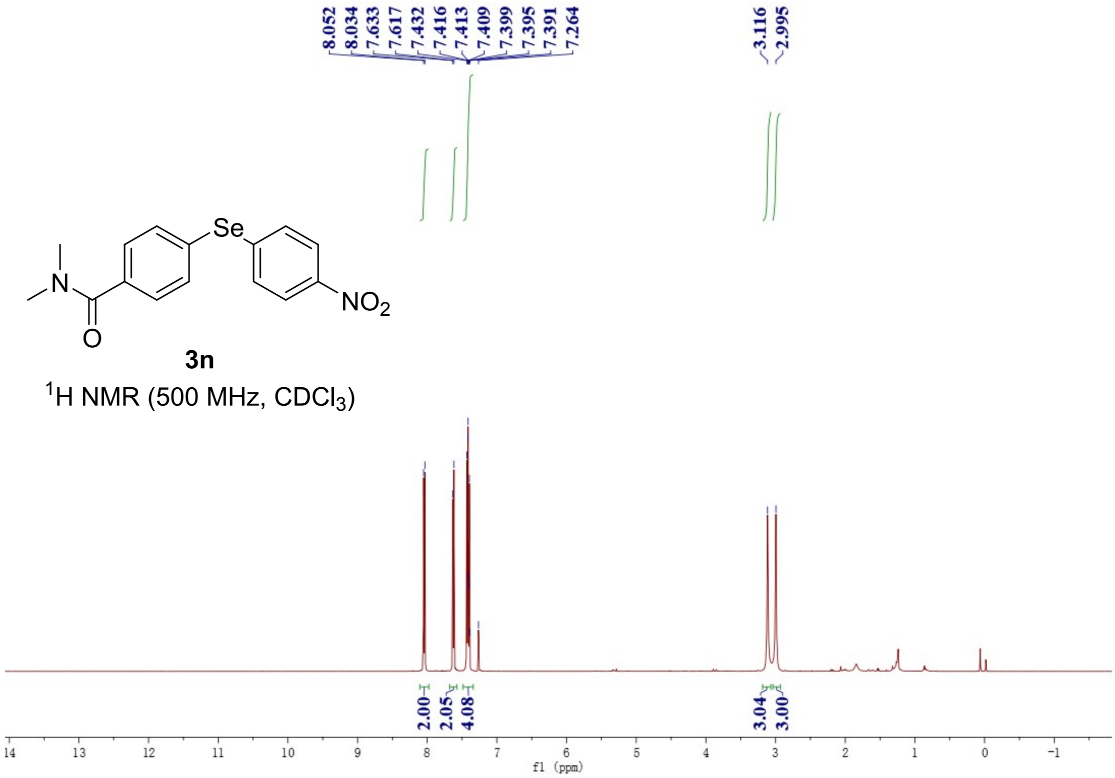
3m

^{1}H NMR (500 MHz, $CDCl_3$)



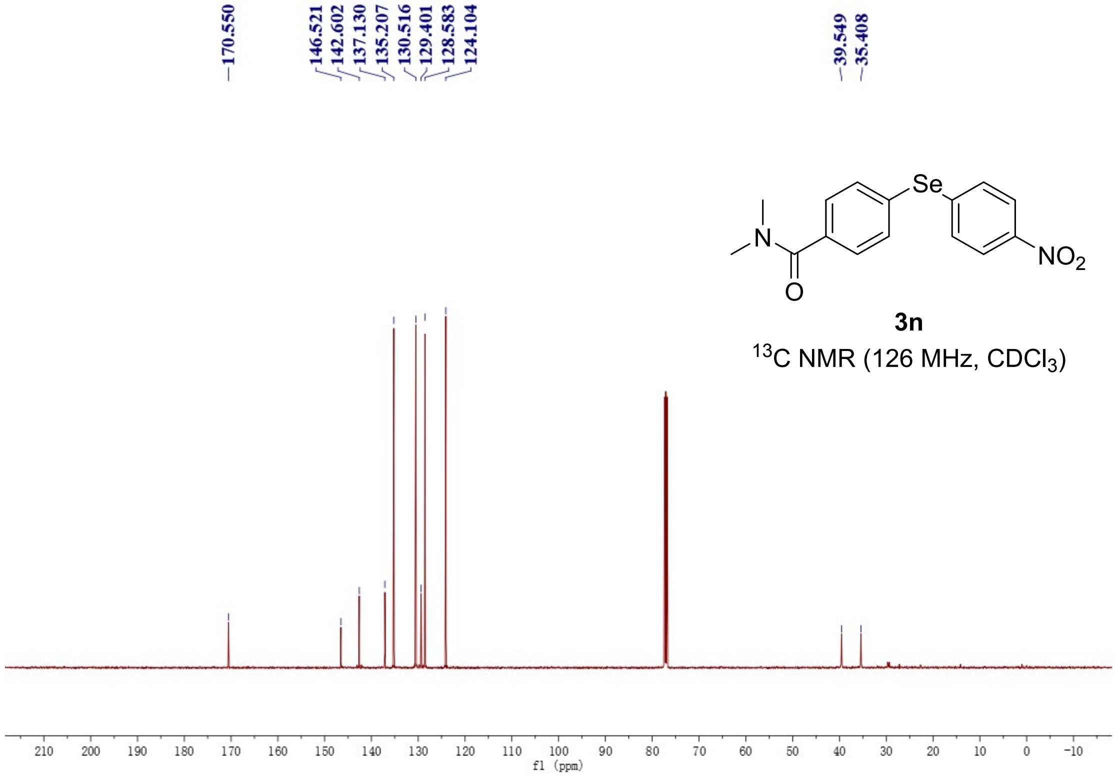
3m

^{13}C NMR (126 MHz, $CDCl_3$)



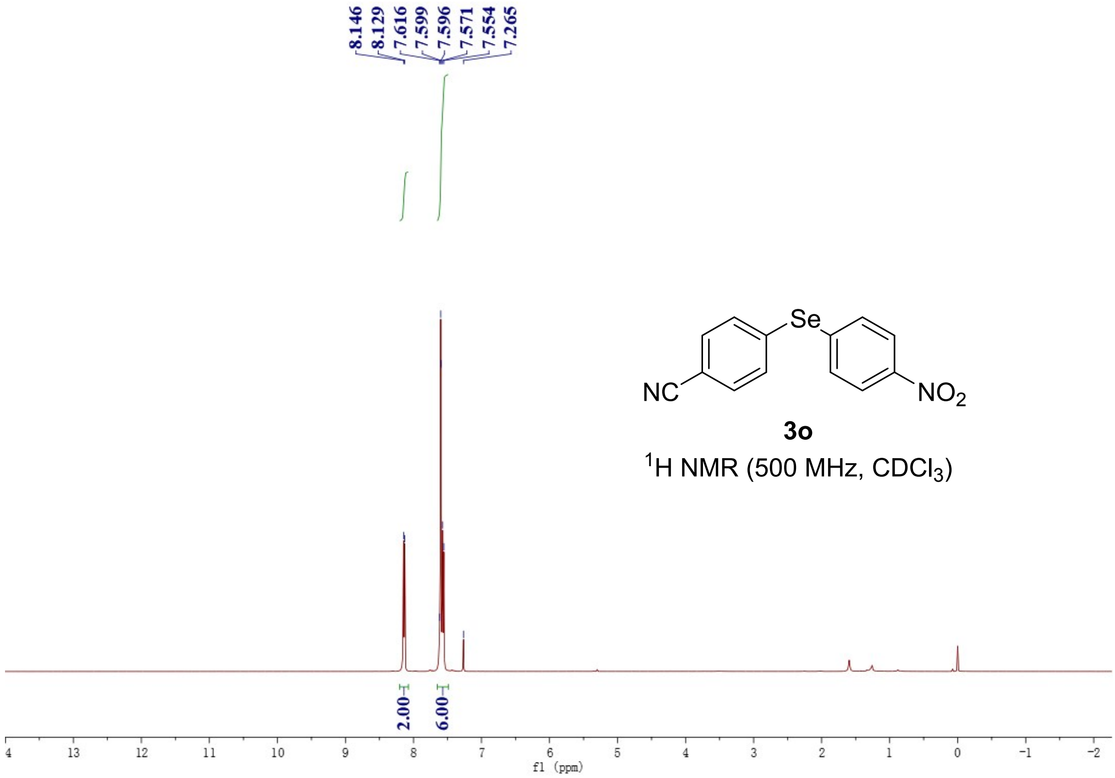
3n

^{1}H NMR (500 MHz, CDCl$_3$)



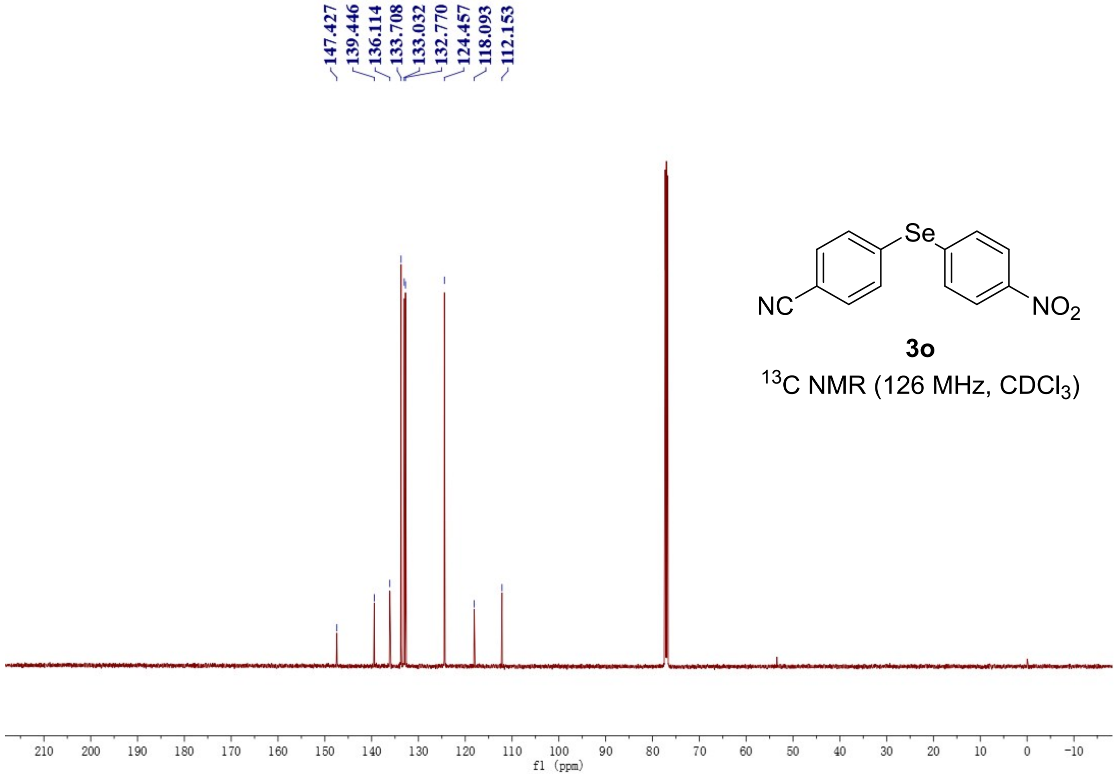
3n

^{13}C NMR (126 MHz, CDCl$_3$)



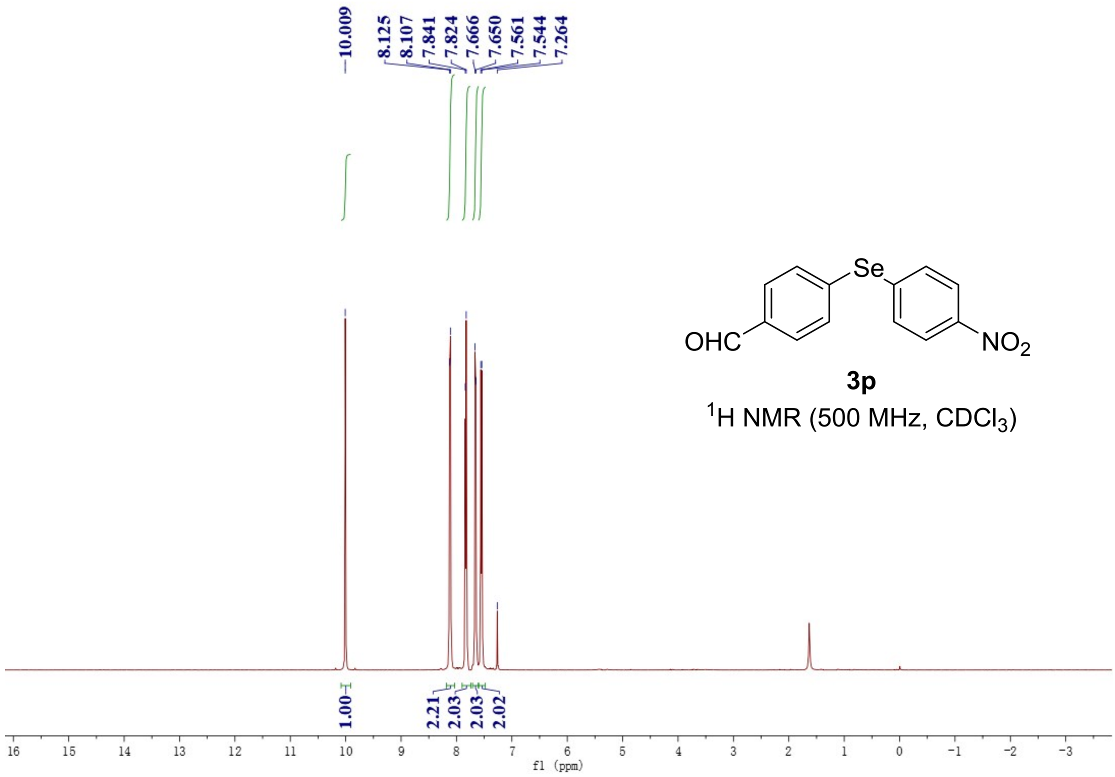
3o

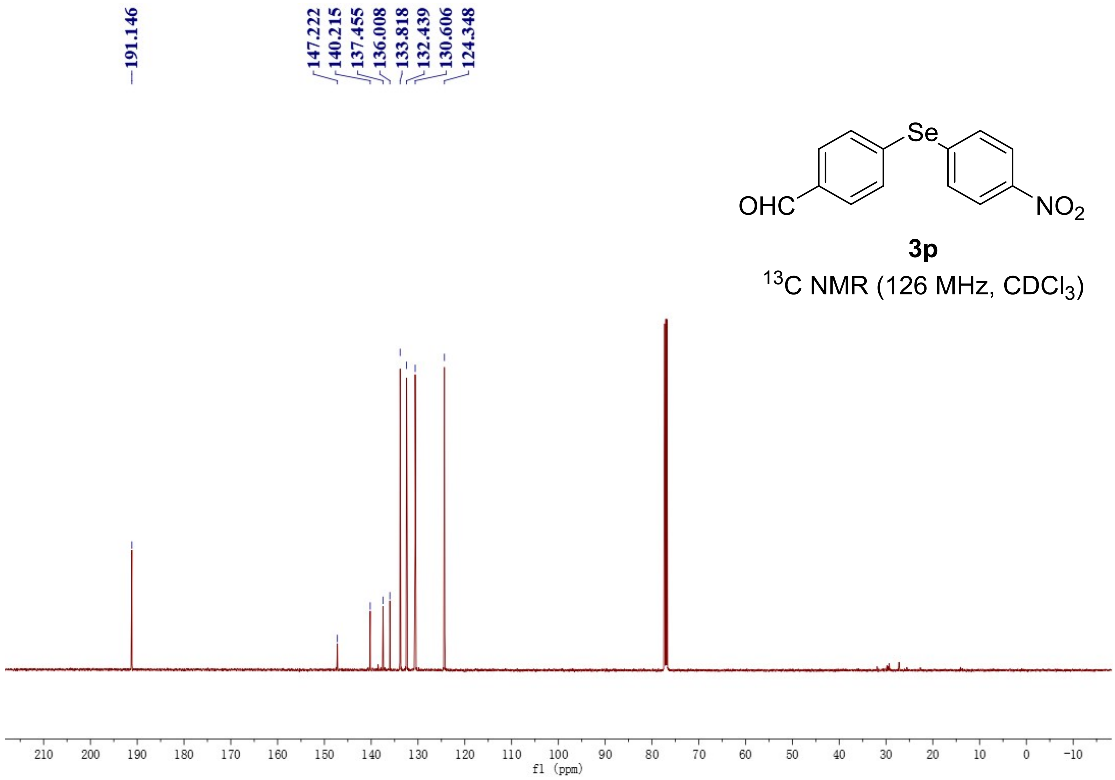
^{1}H NMR (500 MHz, $CDCl_3$)

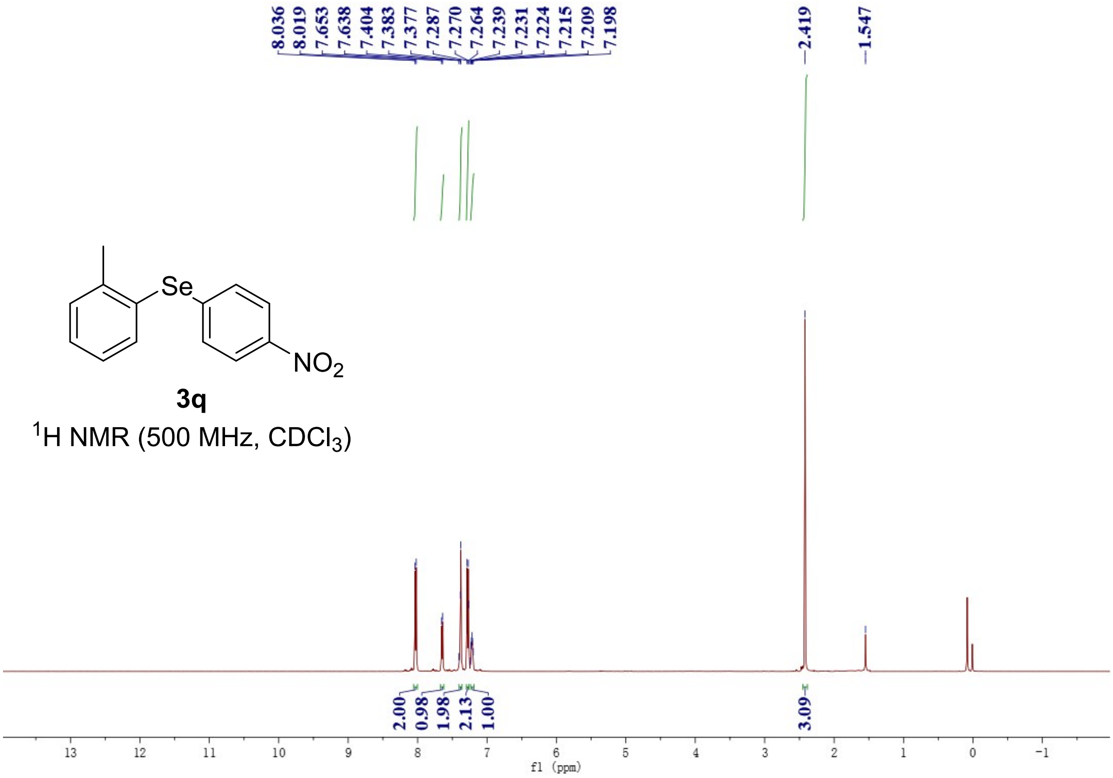


3o

^{13}C NMR (126 MHz, $CDCl_3$)

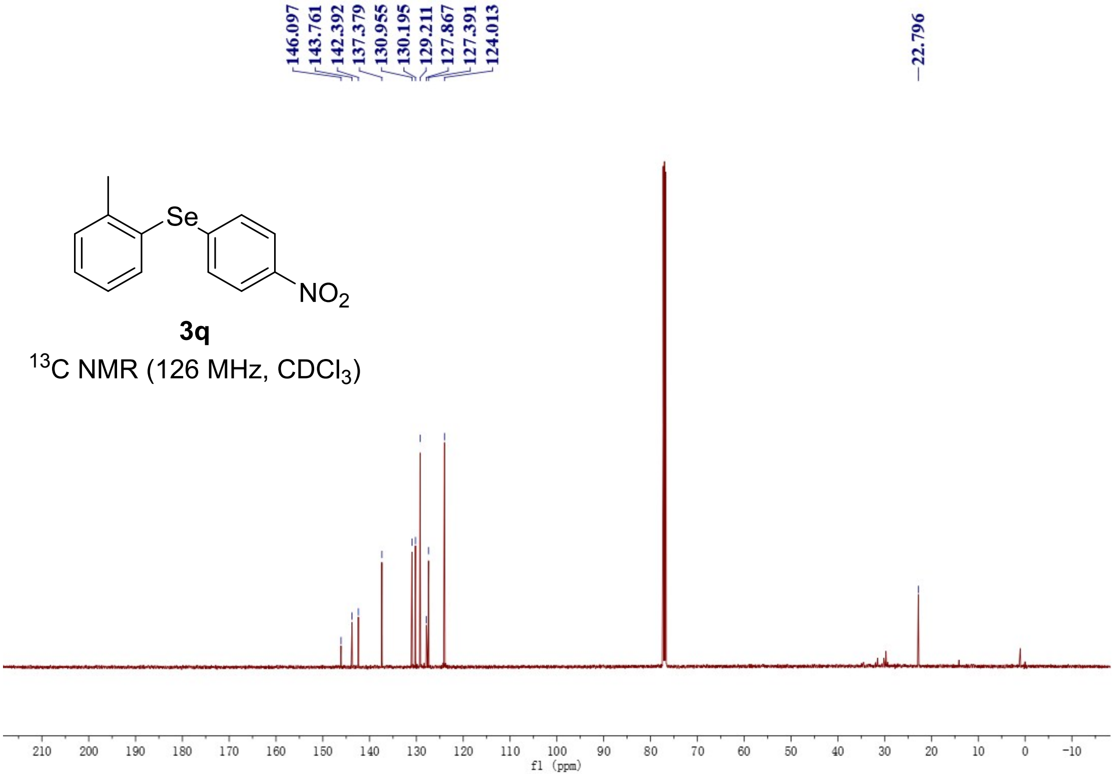

10.009
8.125
8.107
7.841
7.824
7.666
7.650
7.561
7.544
7.264
Se
OHC
NO$_2$
3p
^{1}H NMR (500 MHz, CDCl$_3$)
1.00
2.21
2.03
2.03
2.02
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)


191.146
147.222
140.215
137.455
136.008
133.818
132.439
130.606
124.348
Se
OHC
NO$_2$
3p
^{13}C NMR (126 MHz, CDCl$_3$)
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)



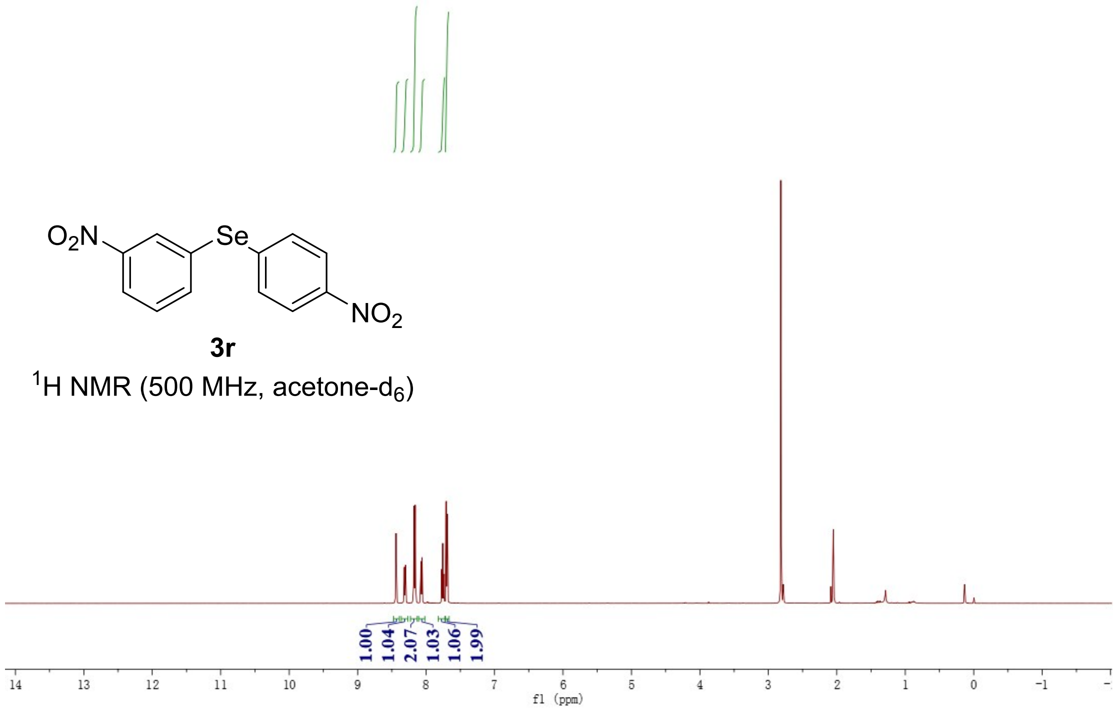
3q

^{1}H NMR (500 MHz, $CDCl_3$)



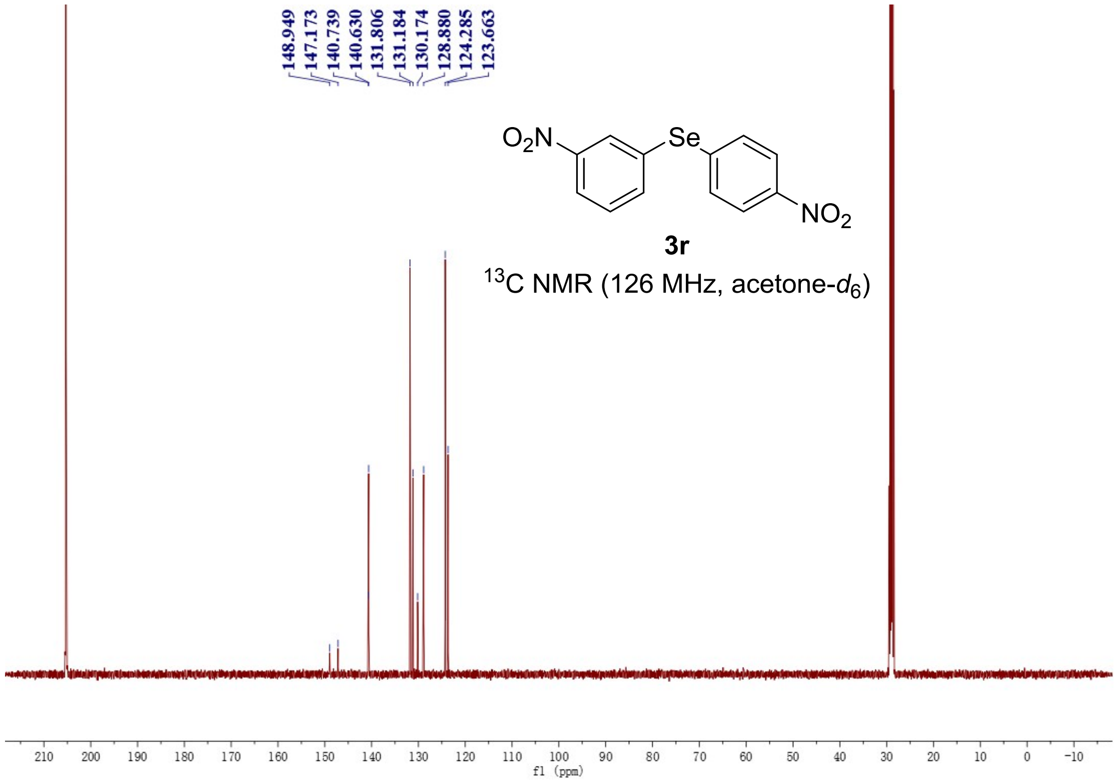
3q

^{13}C NMR (126 MHz, $CDCl_3$)



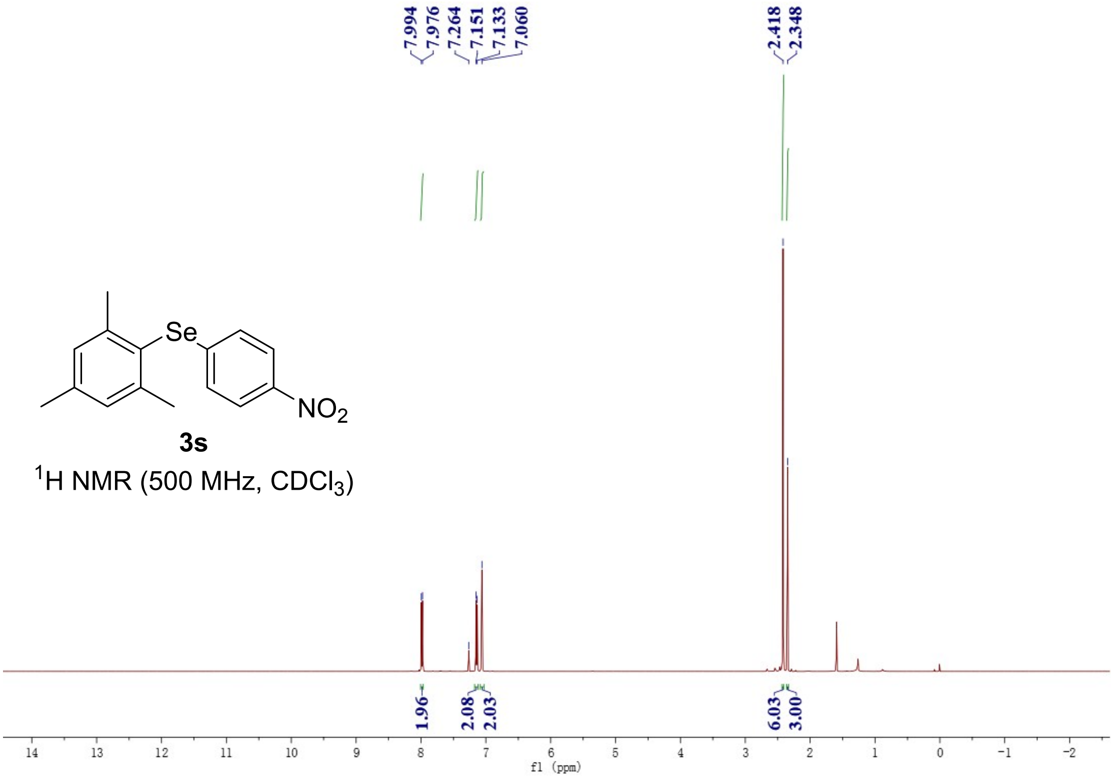
3r

^{1}H NMR (500 MHz, acetone-d_6)



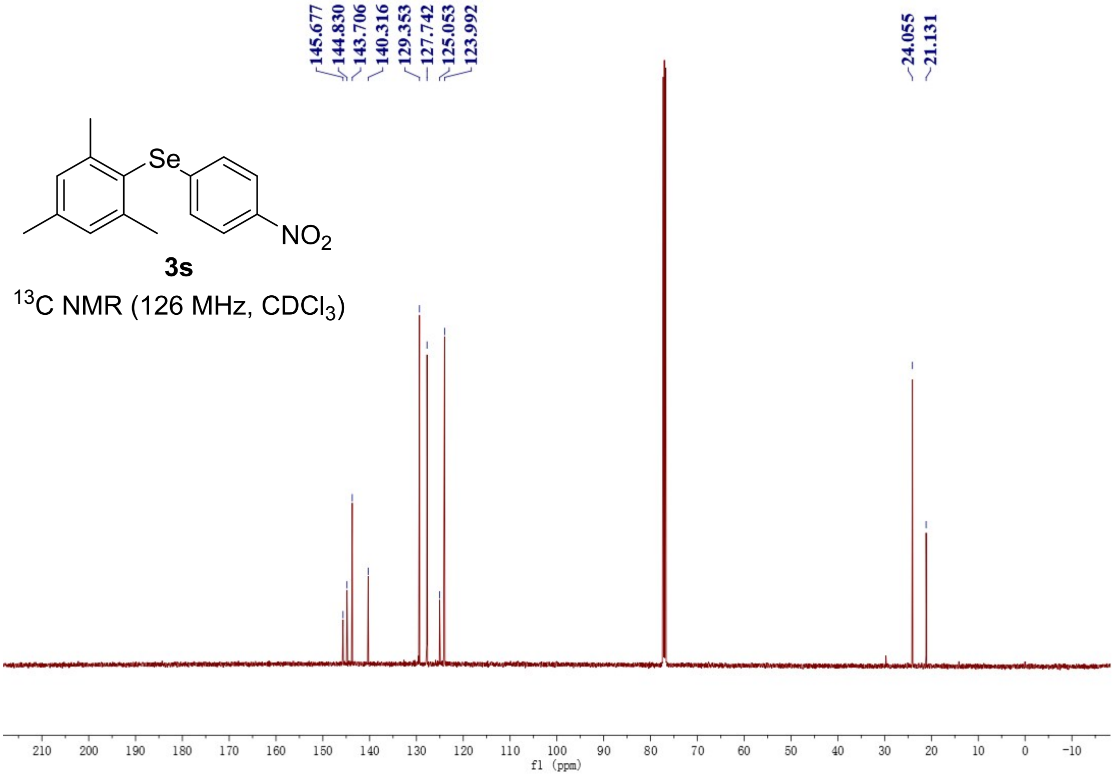
3r

^{13}C NMR (126 MHz, acetone-d_6)



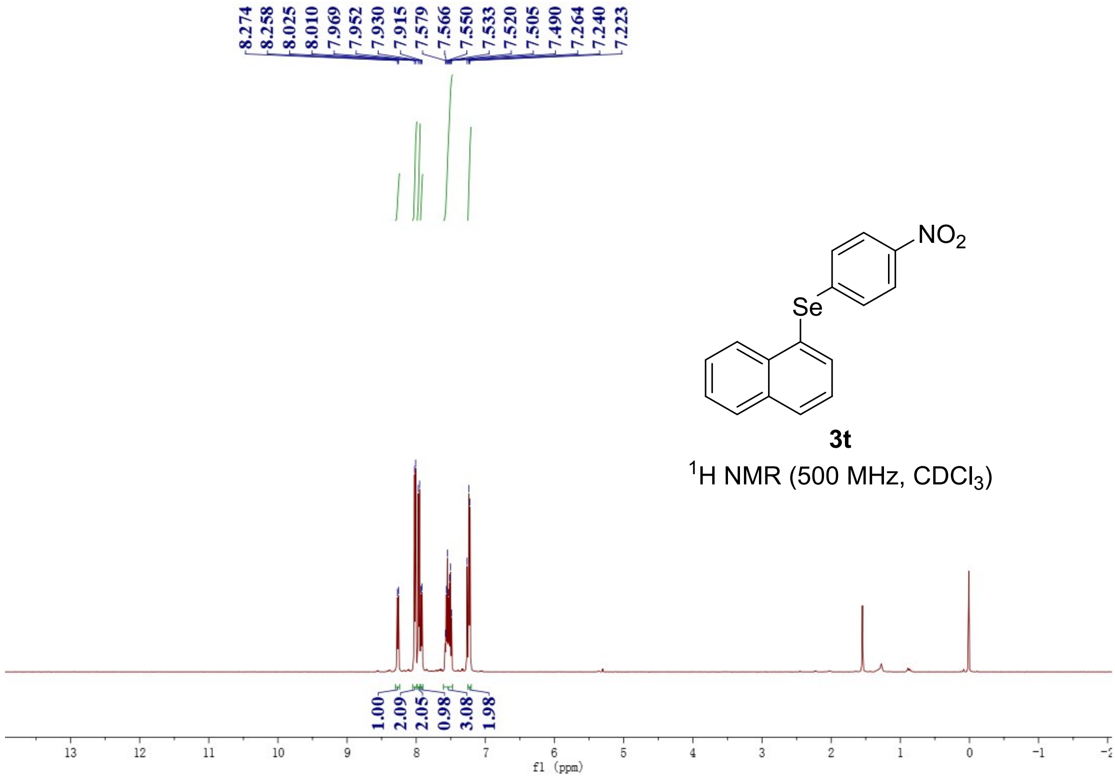
3s

^{1}H NMR (500 MHz, $CDCl_3$)



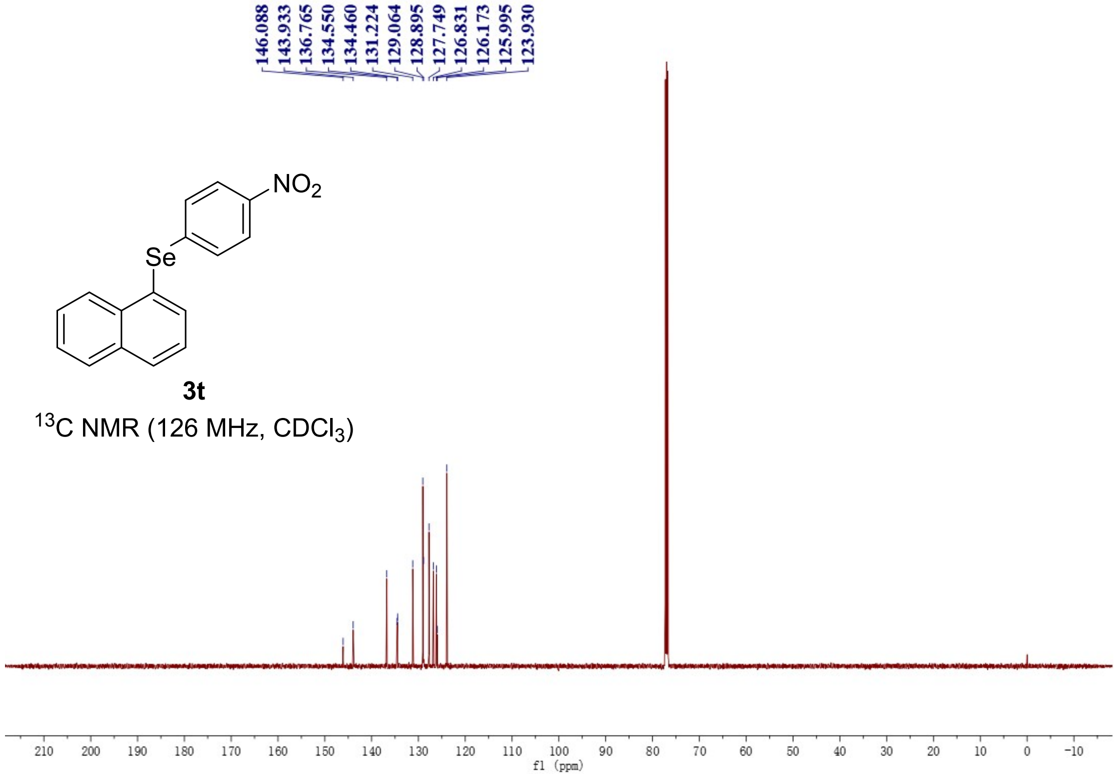
3s

^{13}C NMR (126 MHz, $CDCl_3$)



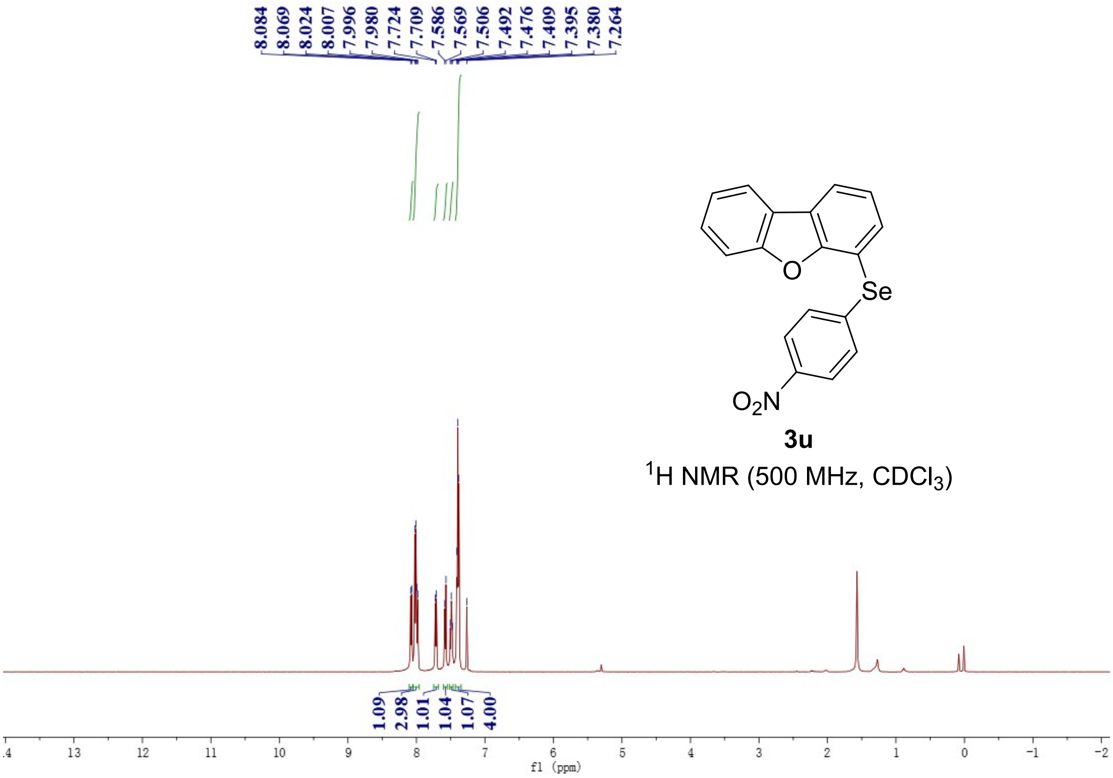
3t

^{1}H NMR (500 MHz, $CDCl_3$)



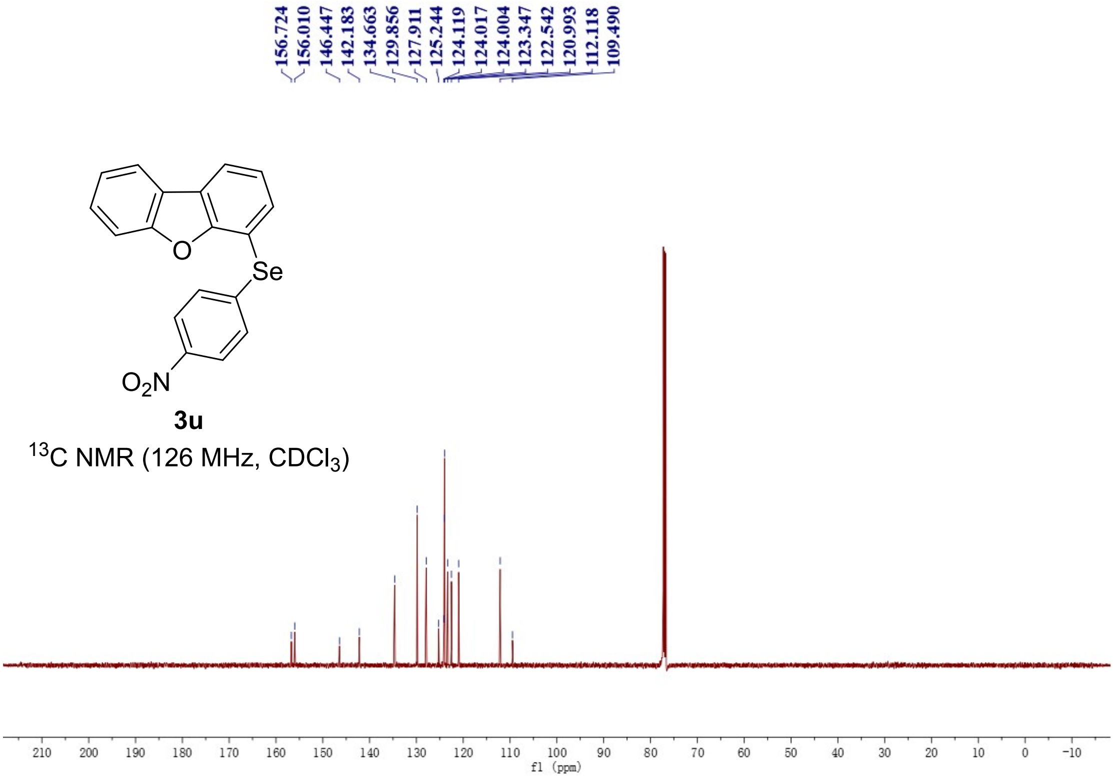
3t

^{13}C NMR (126 MHz, $CDCl_3$)



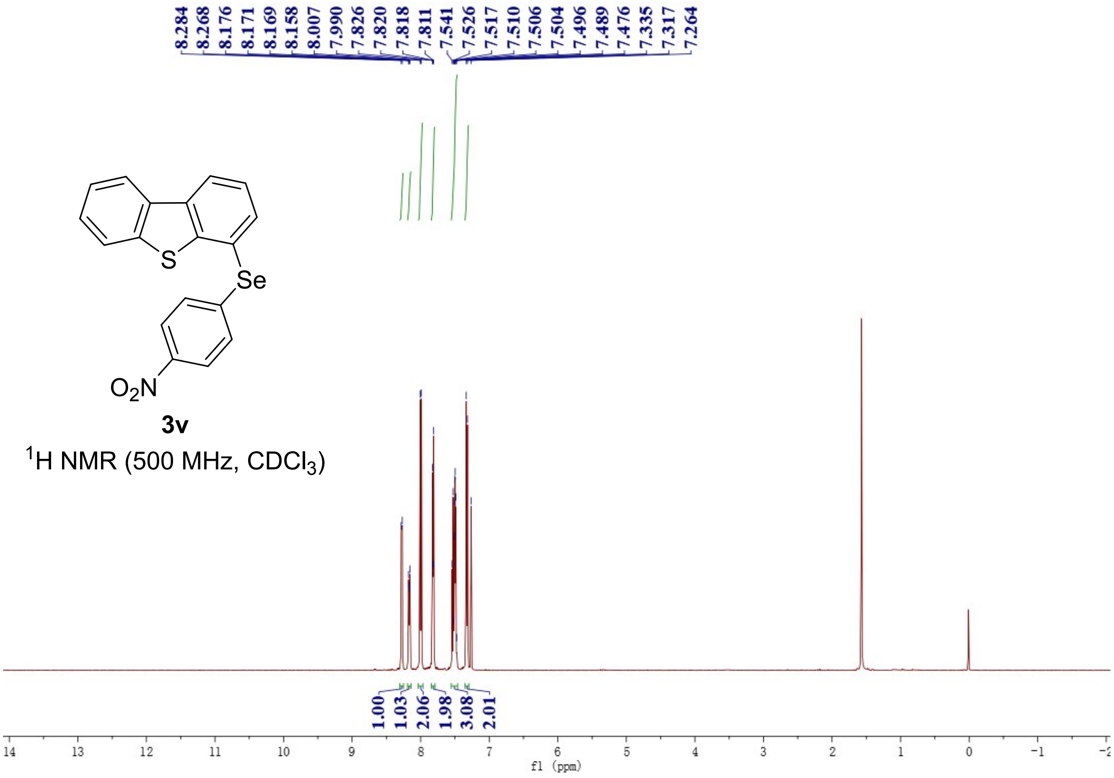
3u

^{1}H NMR (500 MHz, CDCl$_3$)



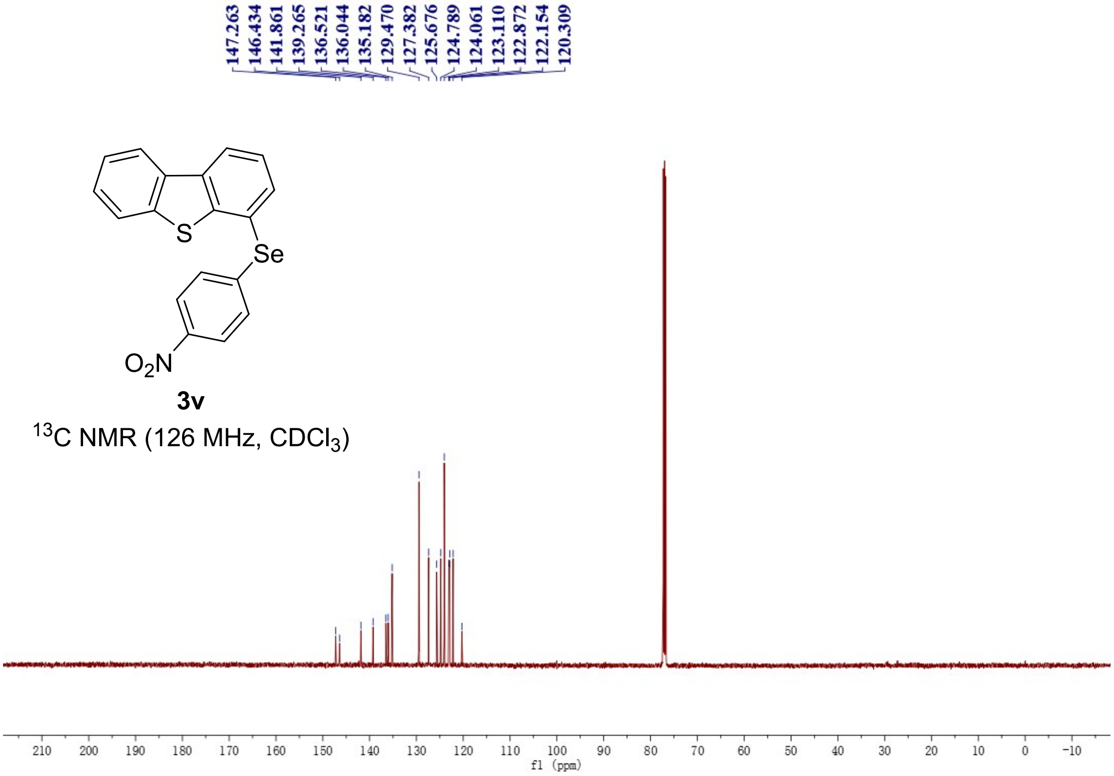
3u

^{13}C NMR (126 MHz, CDCl$_3$)



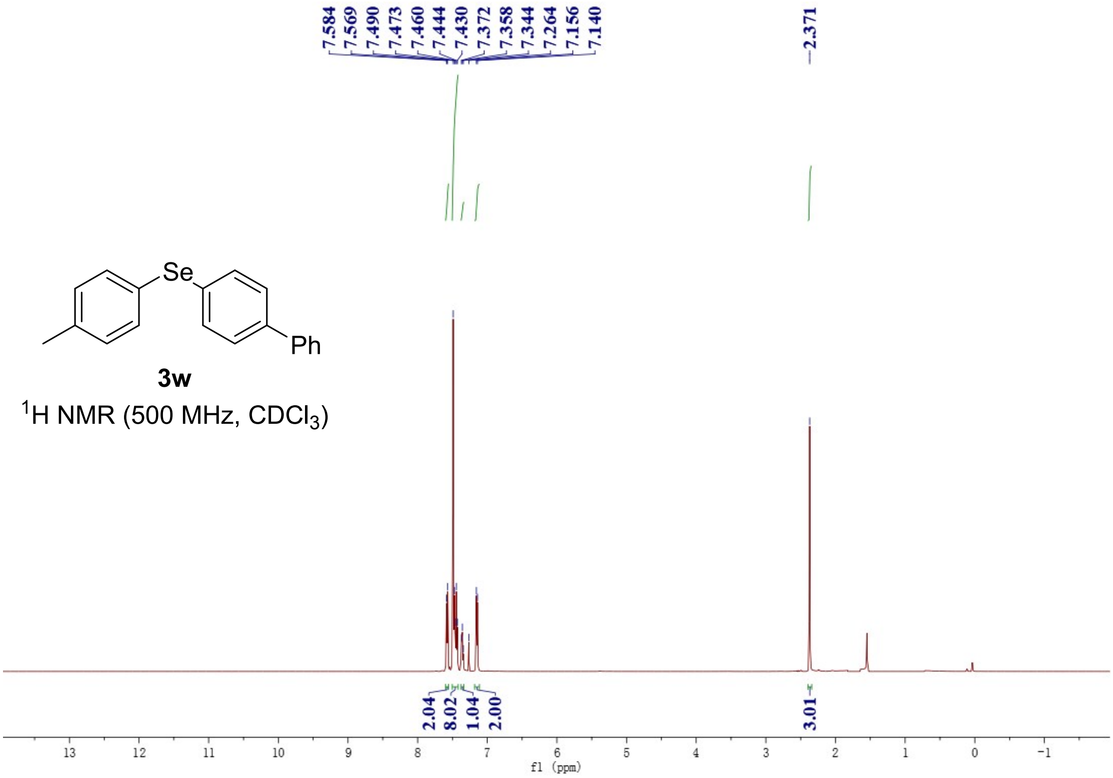
3v

^{1}H NMR (500 MHz, CDCl$_3$)



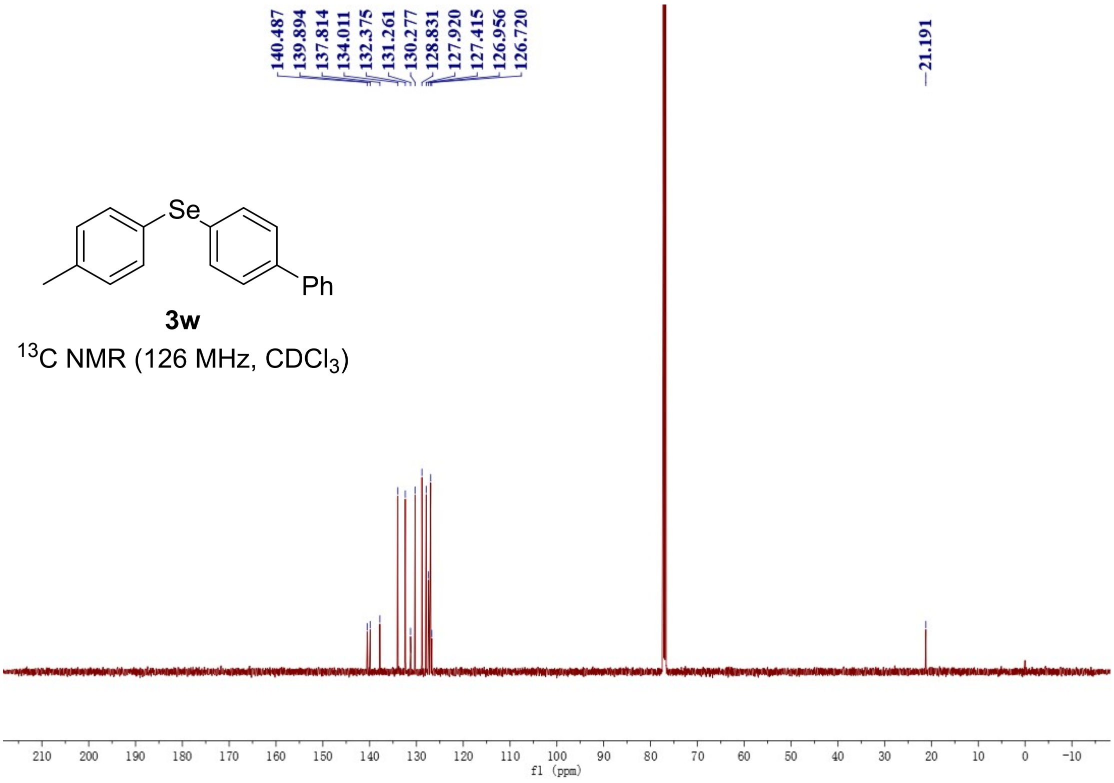
3v

^{13}C NMR (126 MHz, CDCl$_3$)



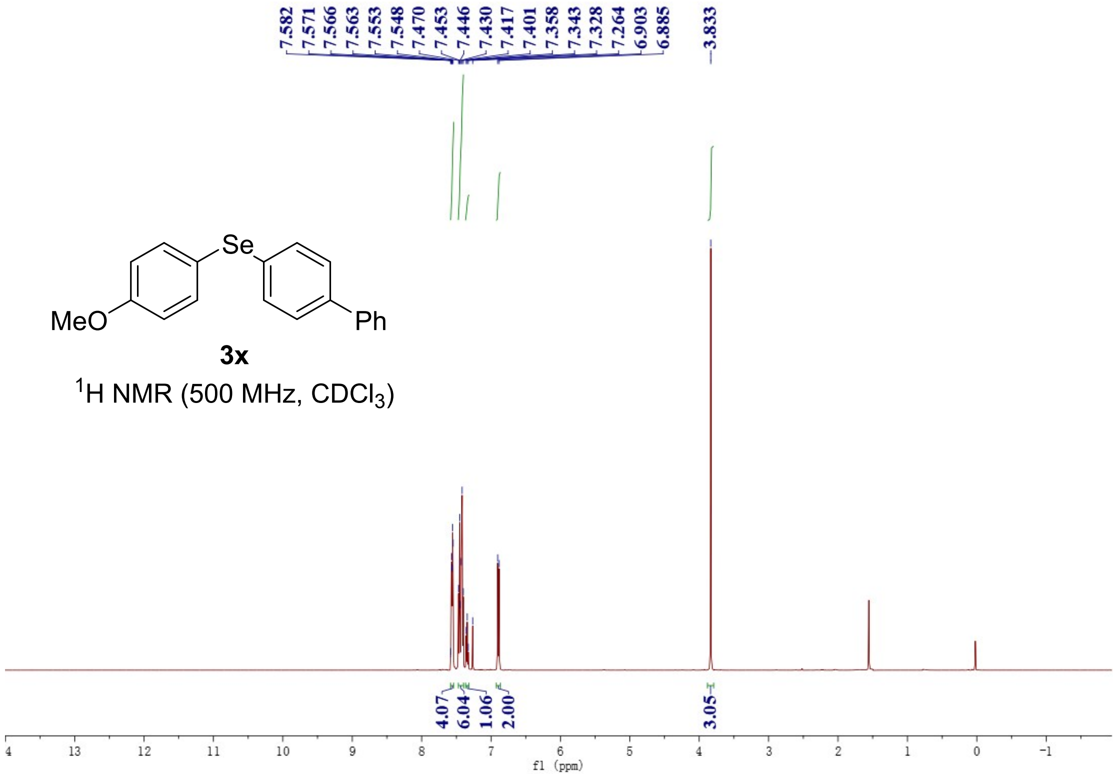
3w

^{1}H NMR (500 MHz, CDCl$_3$)



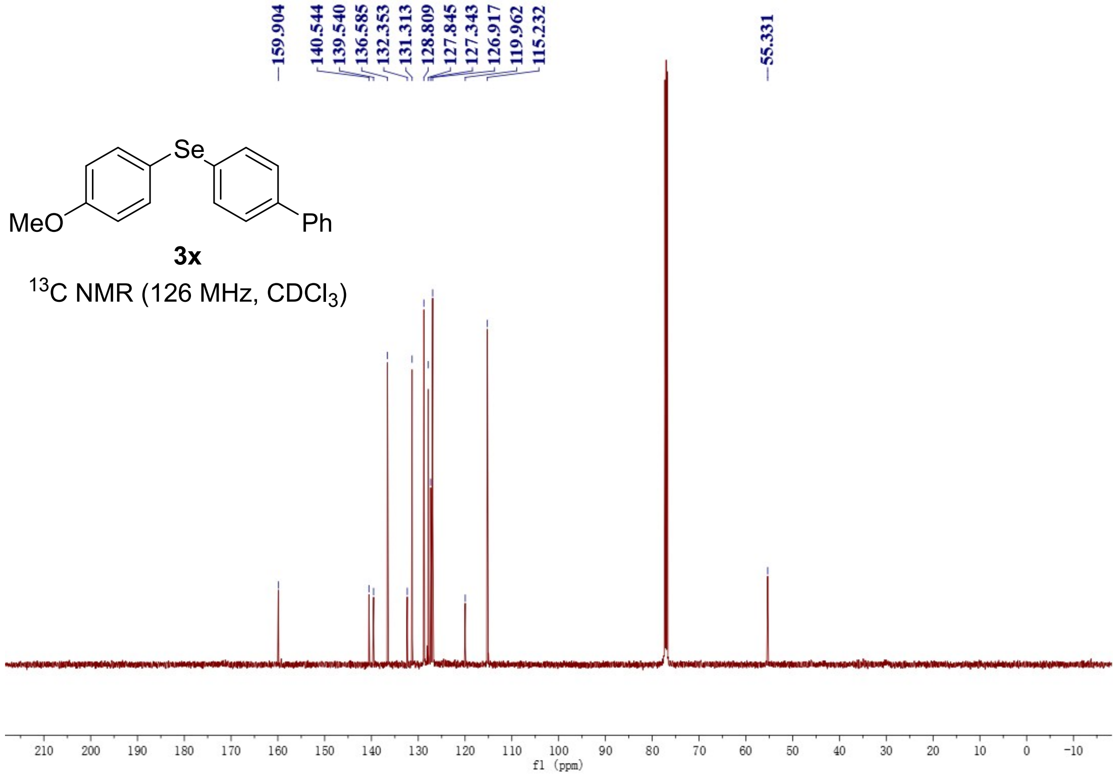
3w

^{13}C NMR (126 MHz, CDCl$_3$)



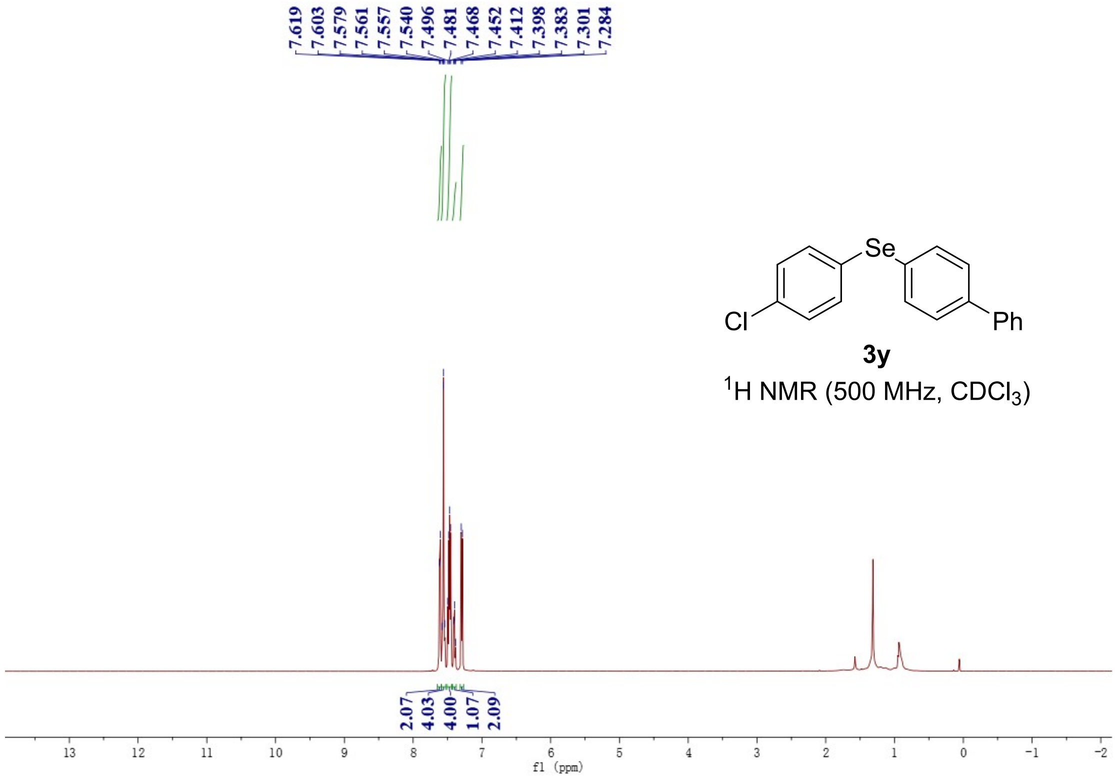
3x

^{1}H NMR (500 MHz, $CDCl_3$)



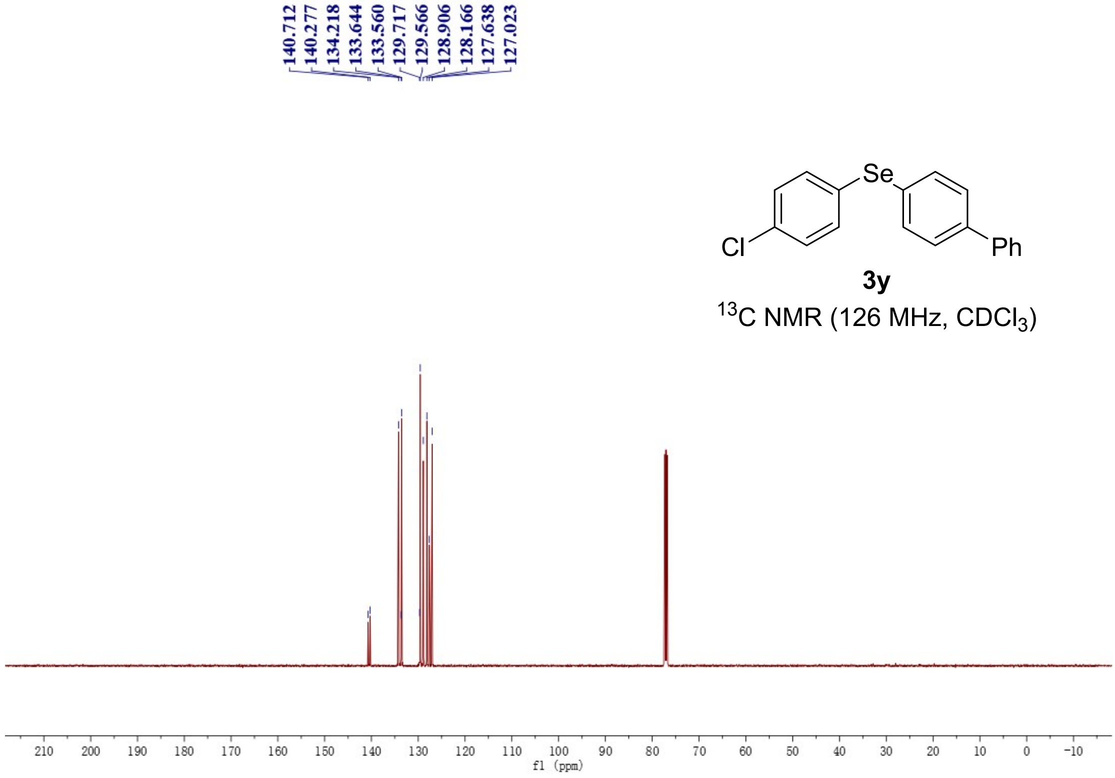
3x

^{13}C NMR (126 MHz, $CDCl_3$)



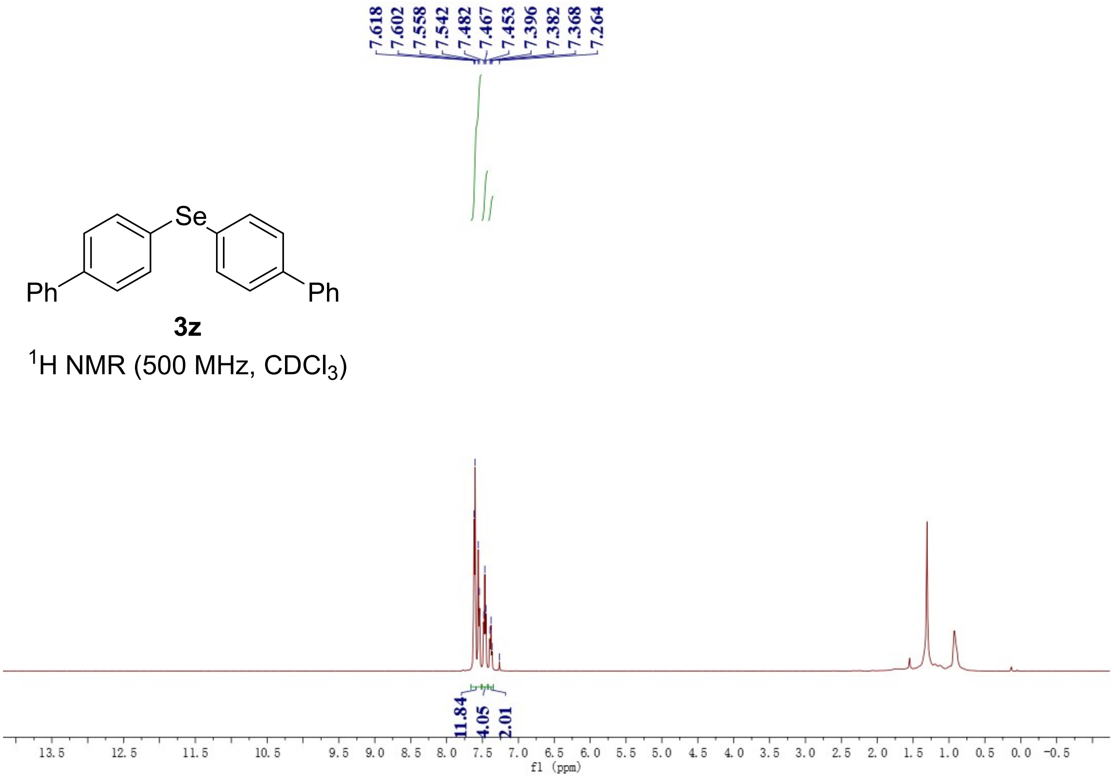
3y

^{1}H NMR (500 MHz, $CDCl_3$)



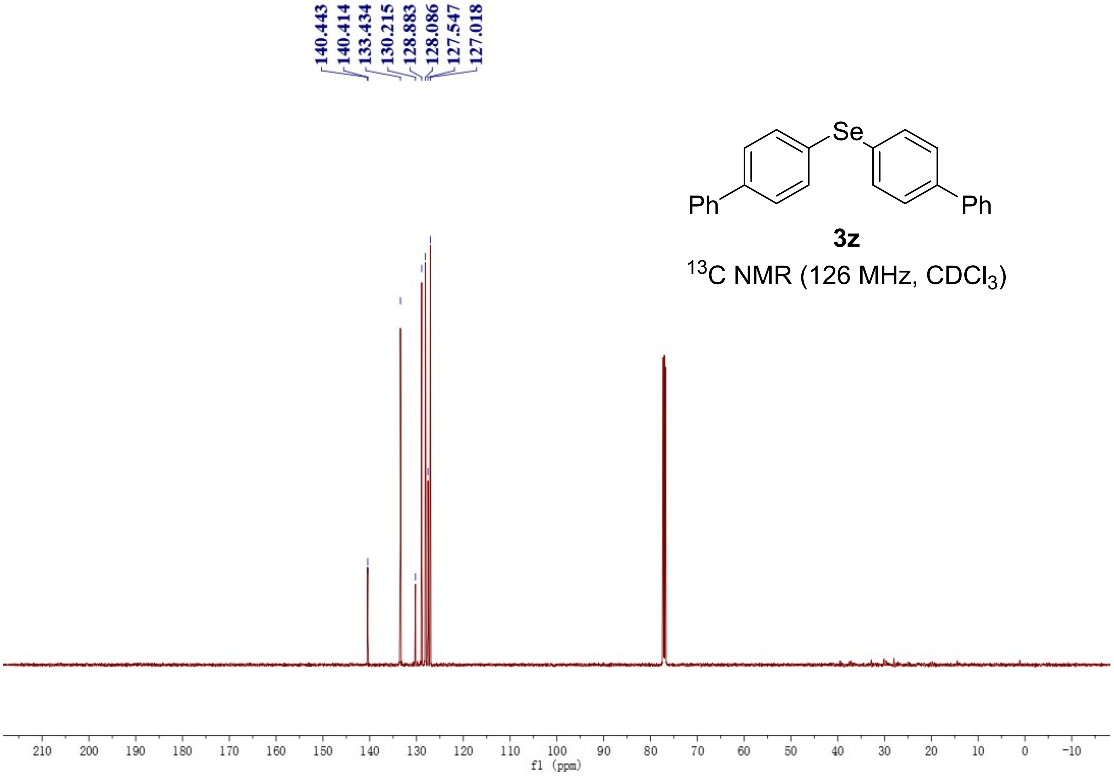
3y

^{13}C NMR (126 MHz, $CDCl_3$)



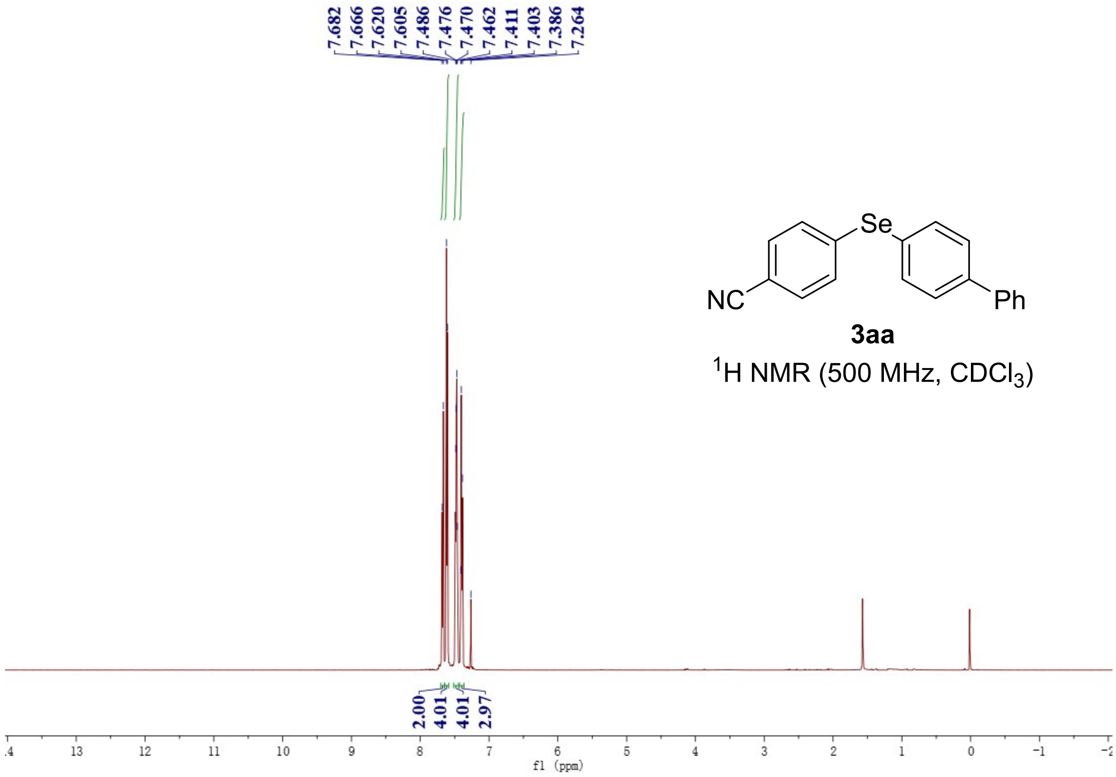
3z

^{1}H NMR (500 MHz, $CDCl_3$)



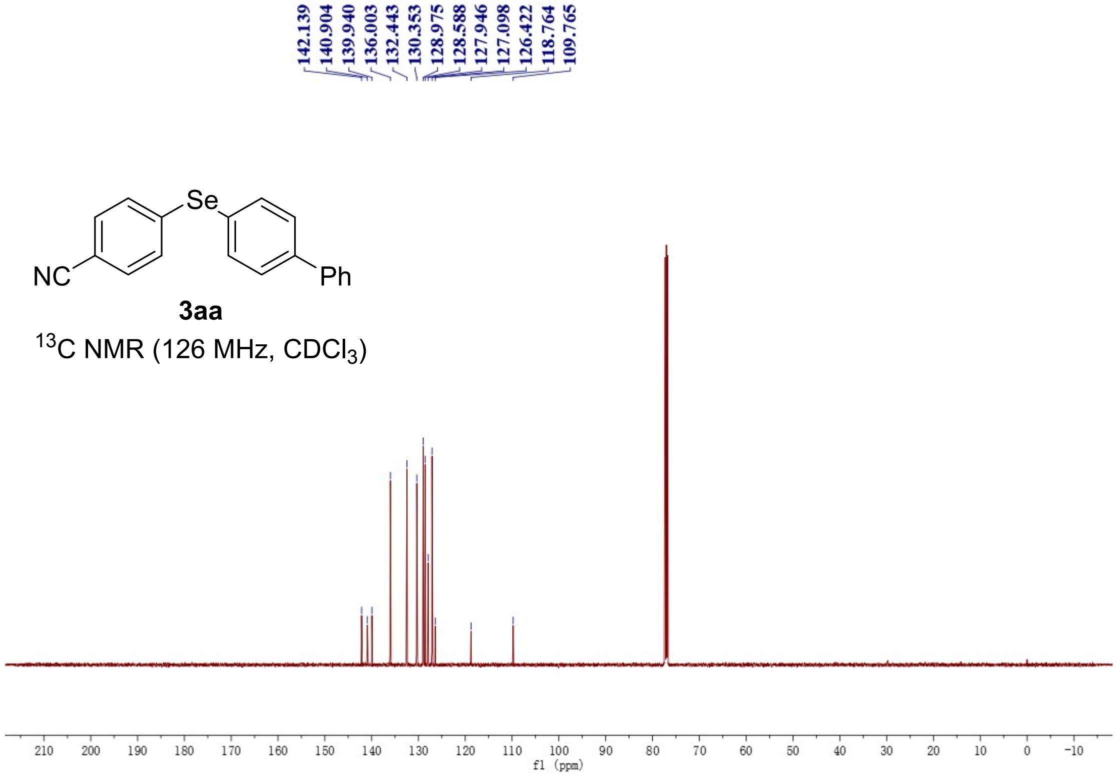
3z

^{13}C NMR (126 MHz, $CDCl_3$)



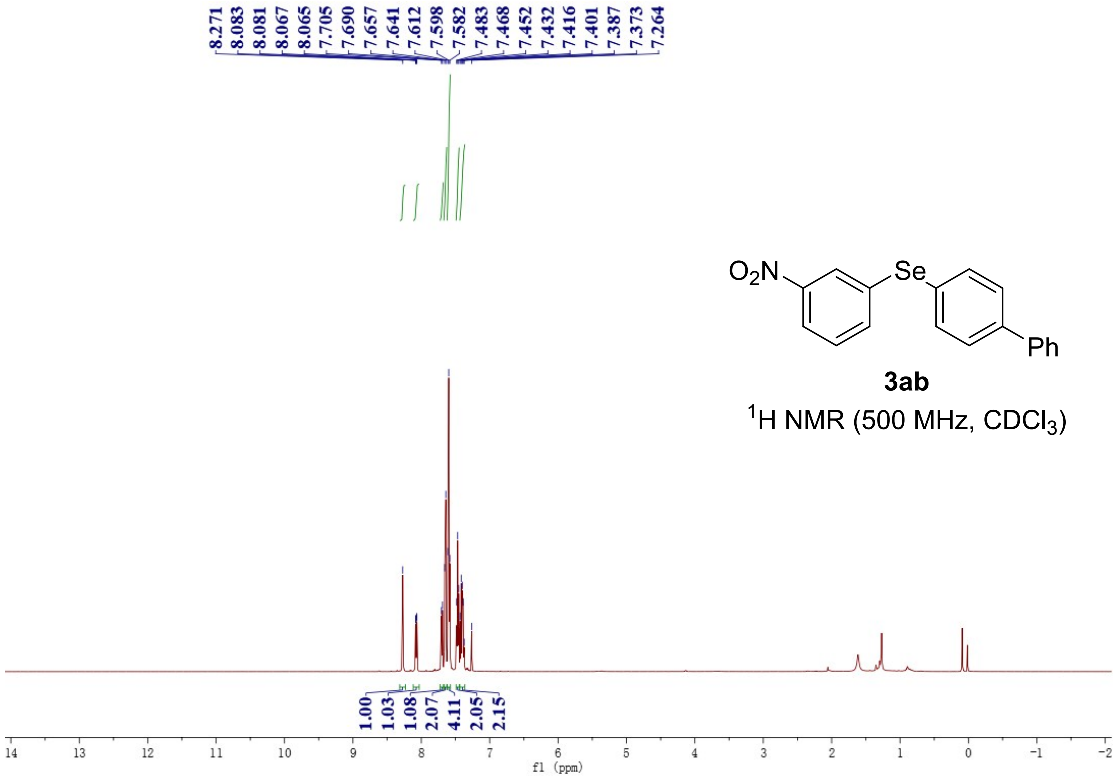
3aa

^{1}H NMR (500 MHz, CDCl$_3$)



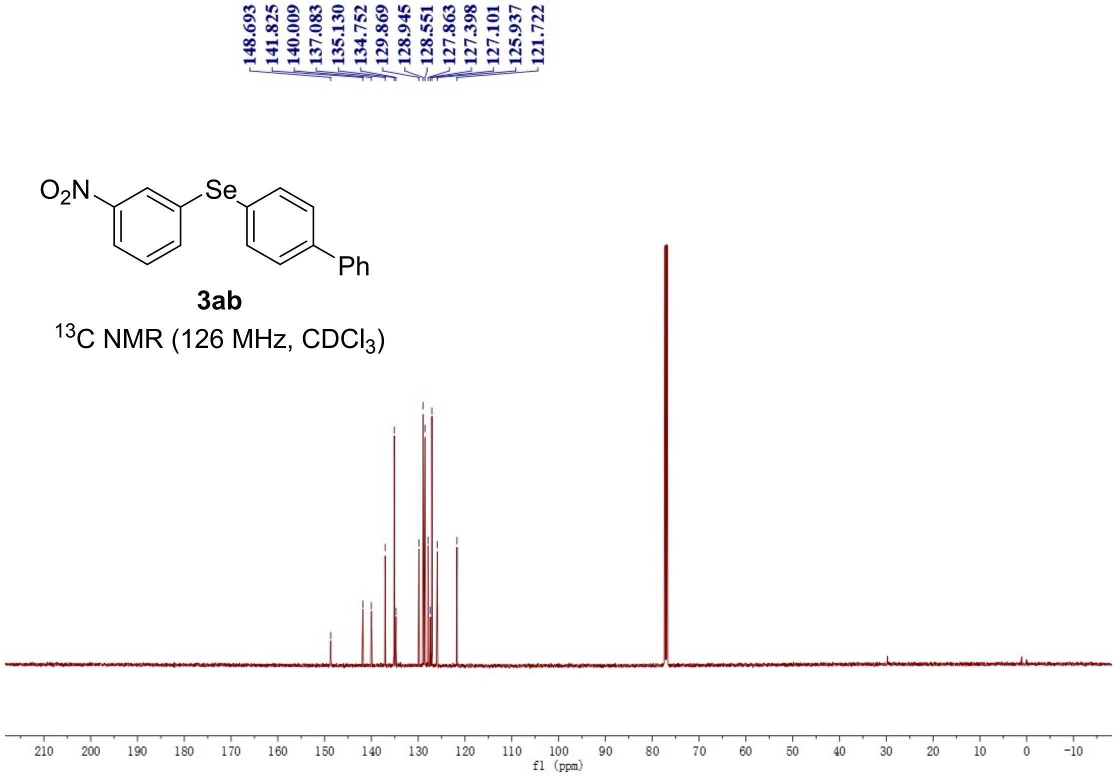
3aa

^{13}C NMR (126 MHz, CDCl$_3$)



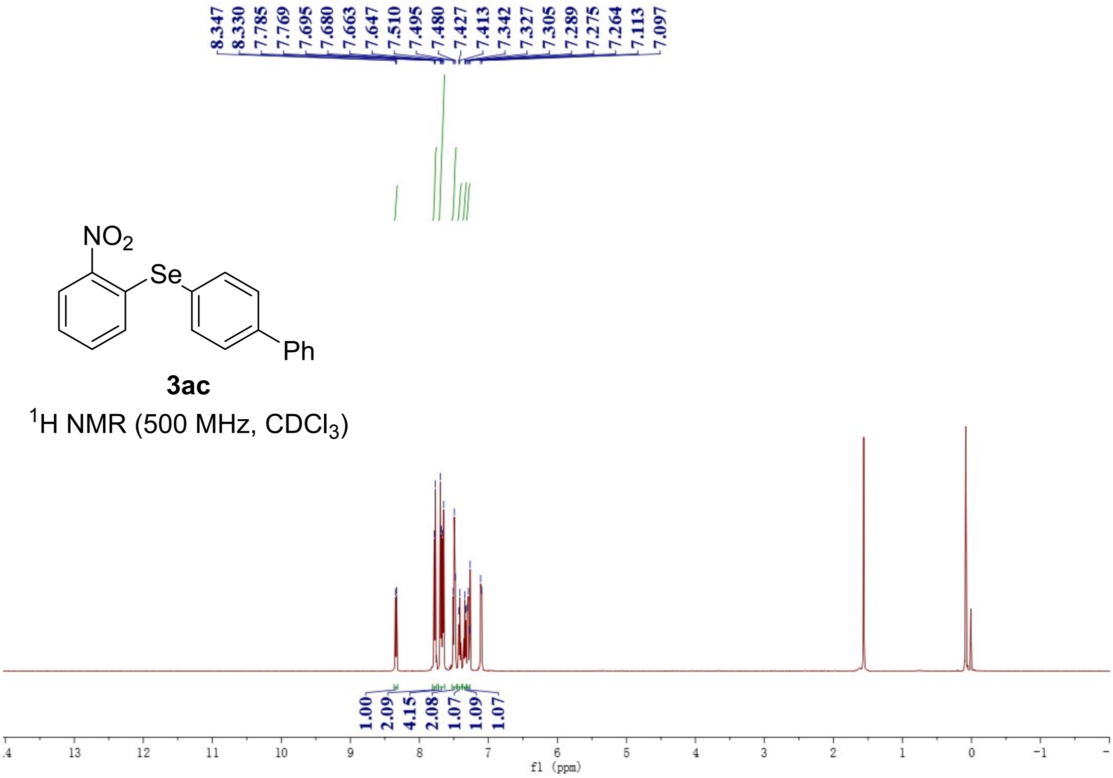
3ab

^{1}H NMR (500 MHz, CDCl$_3$)



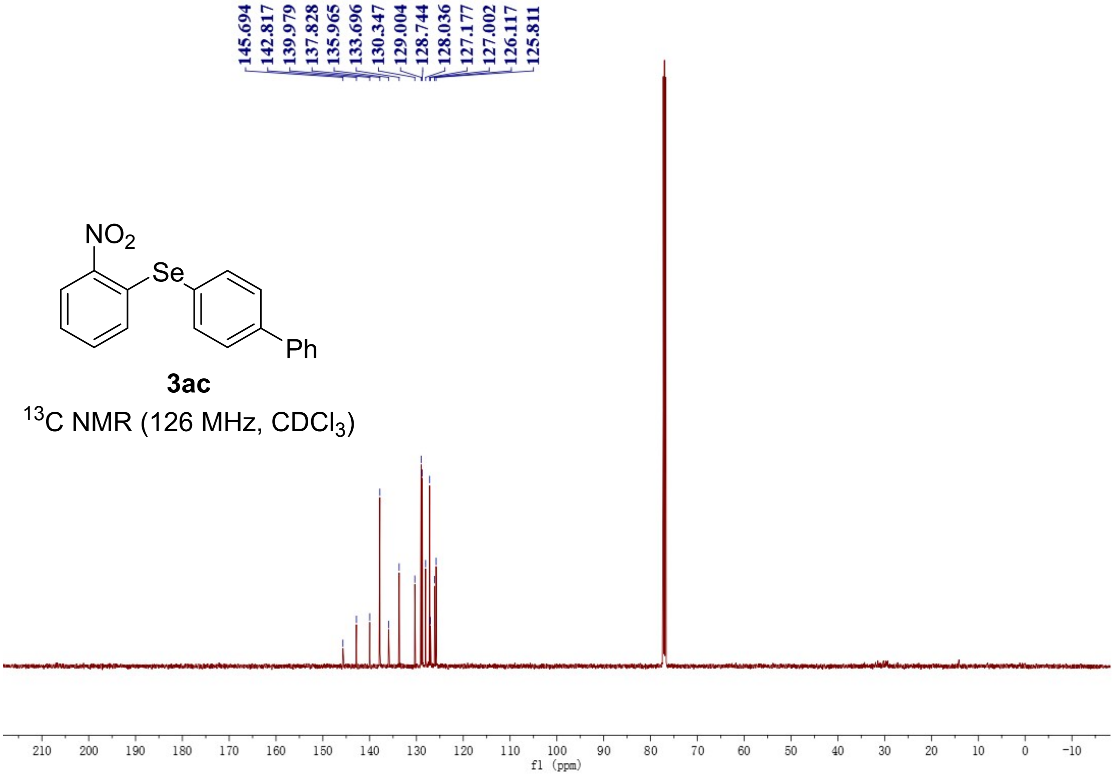
3ab

^{13}C NMR (126 MHz, CDCl$_3$)



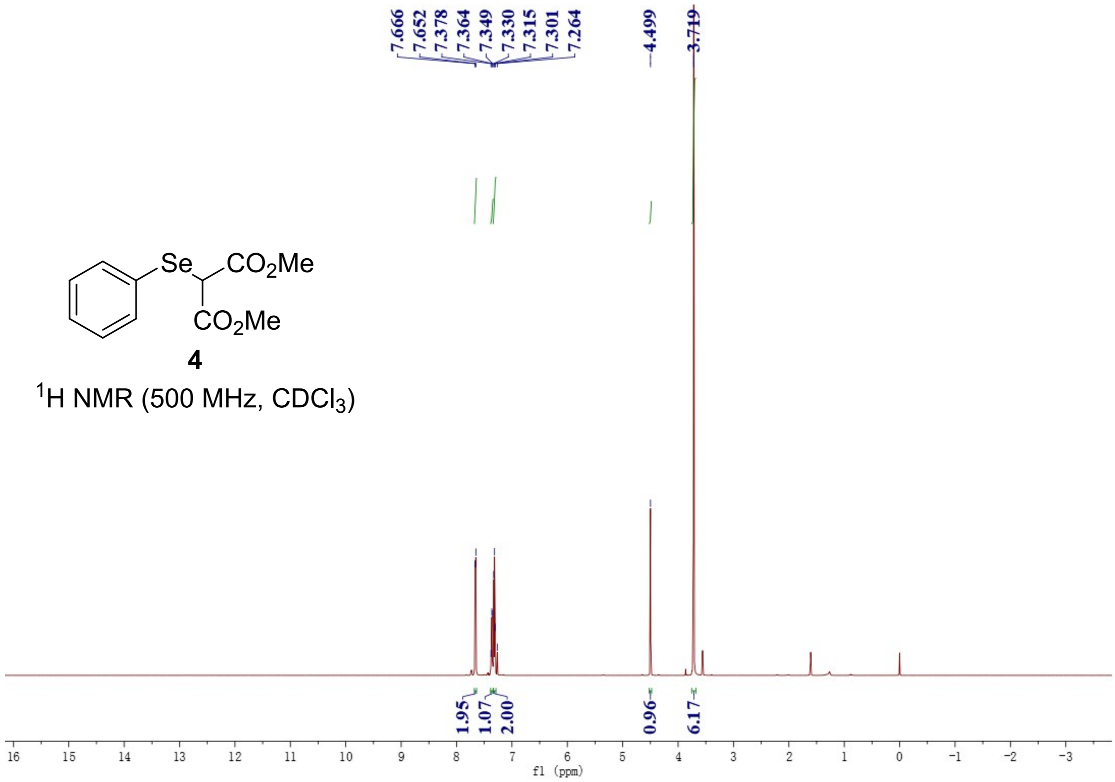
3ac

^{1}H NMR (500 MHz, $CDCl_3$)



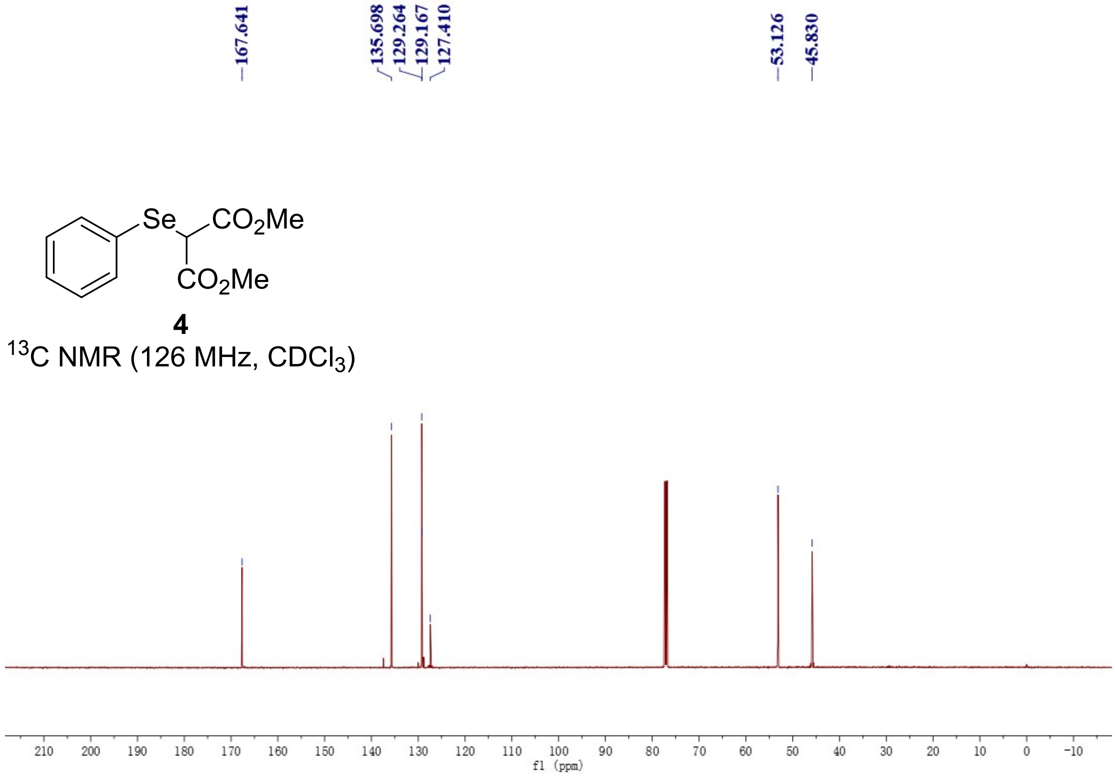
3ac

^{13}C NMR (126 MHz, $CDCl_3$)



4

^{1}H NMR (500 MHz, CDCl$_3$)



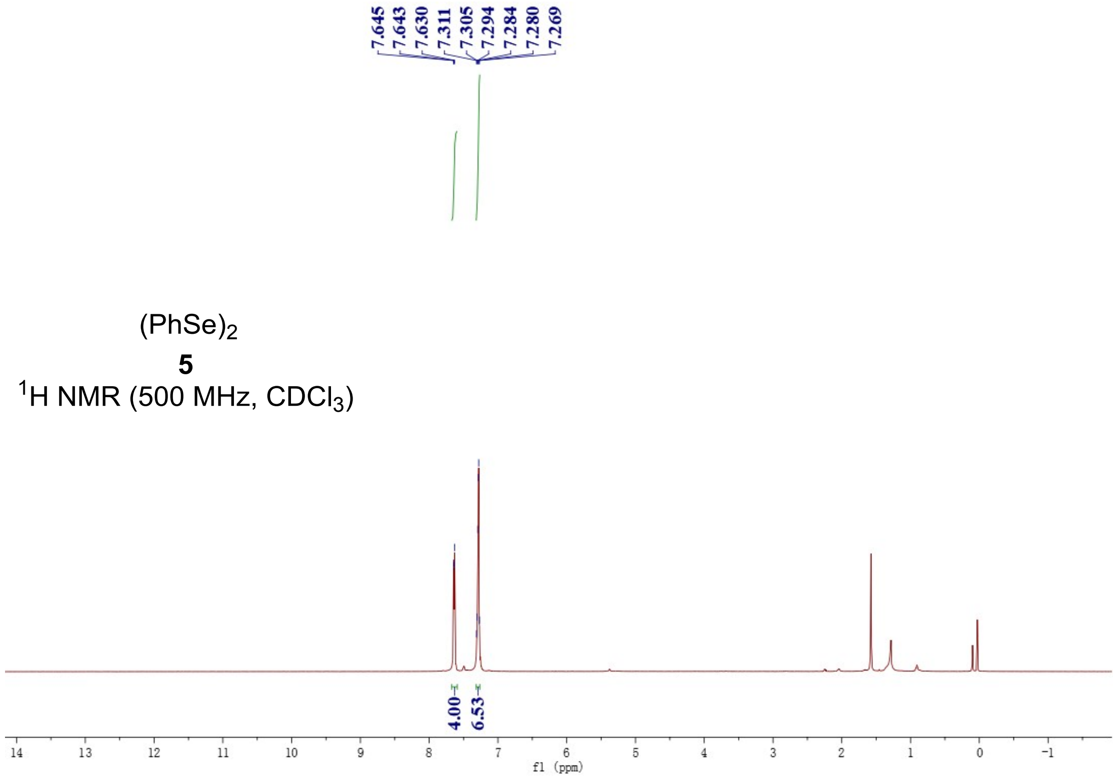
4

^{13}C NMR (126 MHz, CDCl$_3$)

(PhSe)$_2$

5

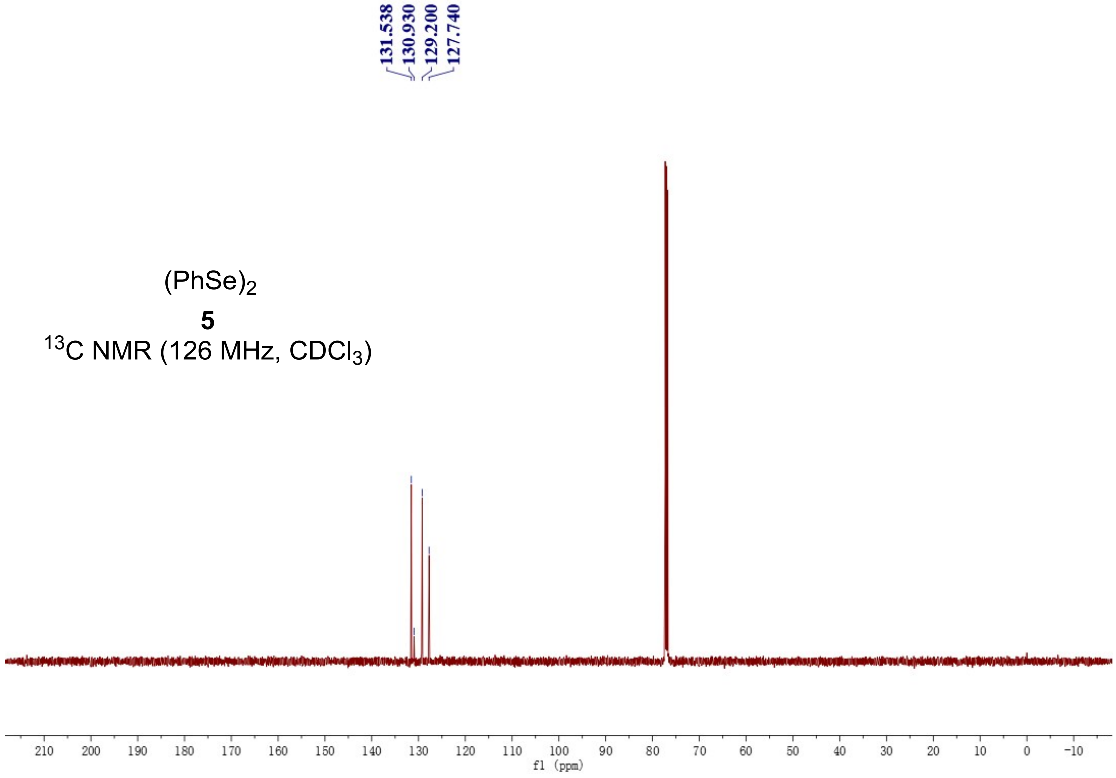
^{1}H NMR (500 MHz, CDCl$_3$)

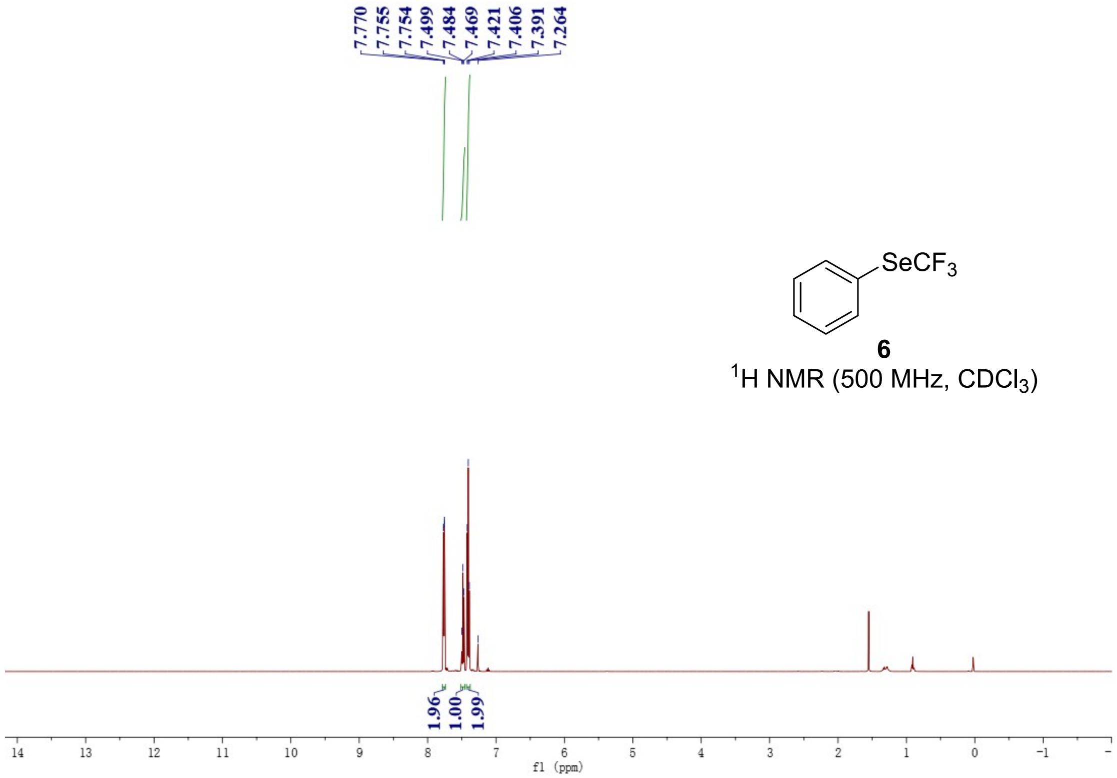


(PhSe)$_2$

5

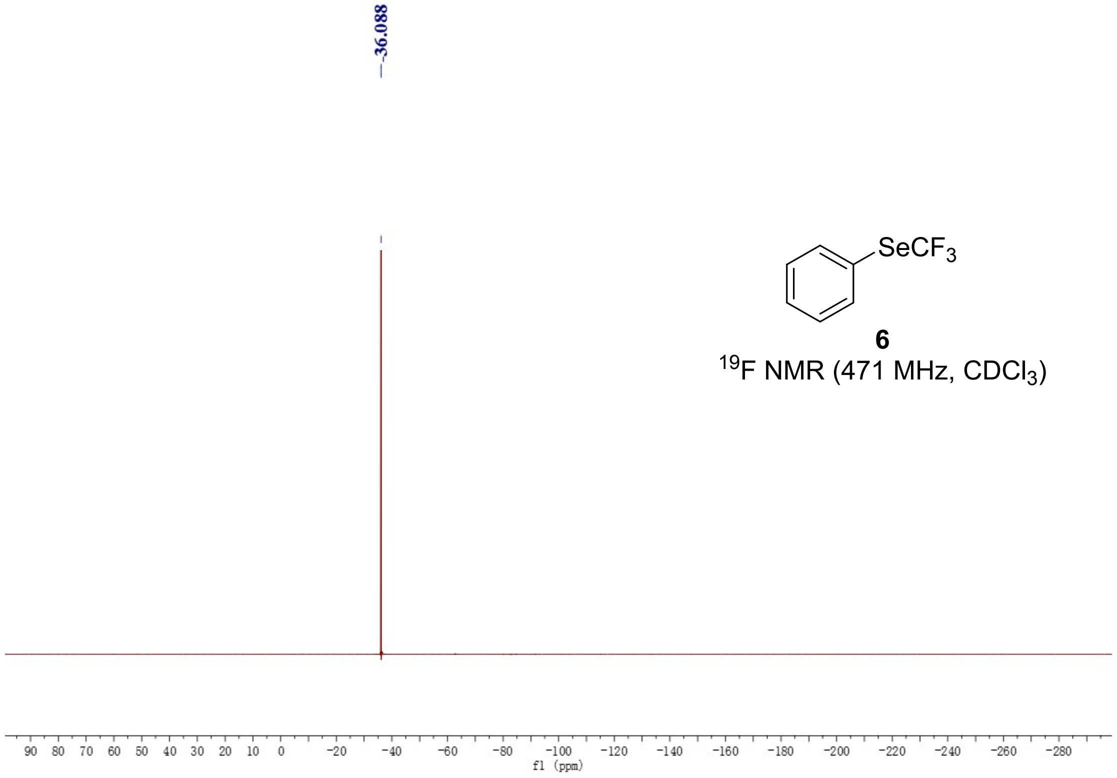
^{13}C NMR (126 MHz, CDCl$_3$)





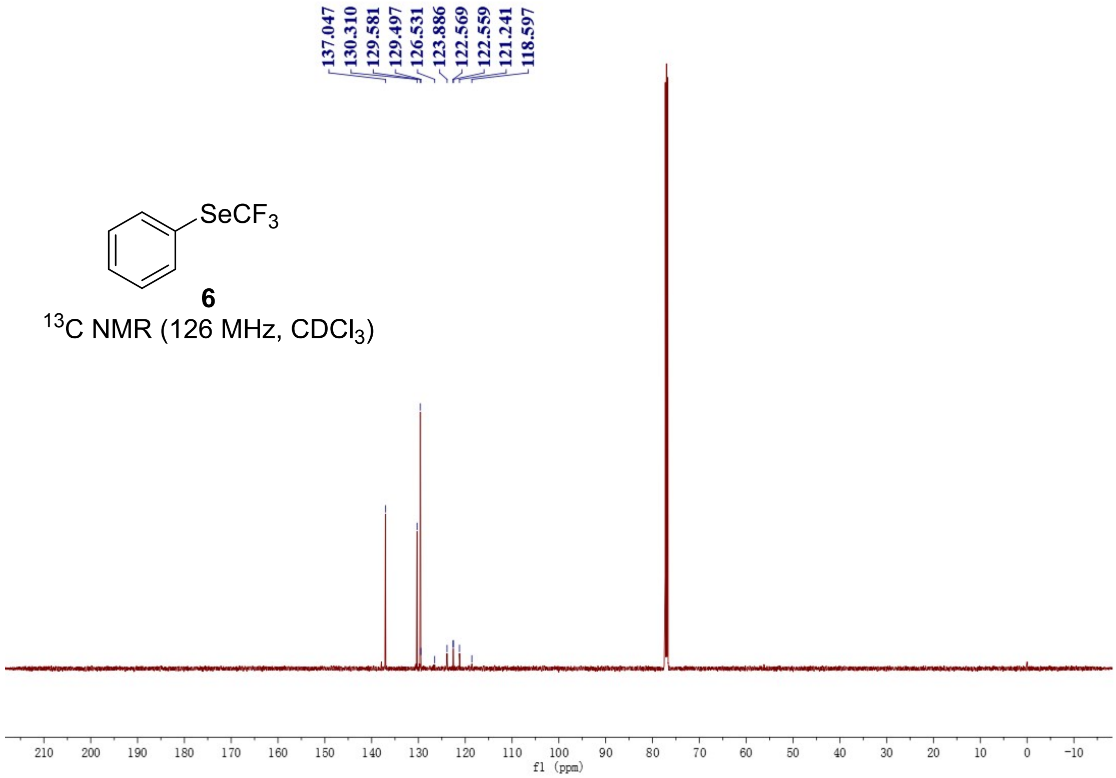
6

^{1}H NMR (500 MHz, CDCl$_3$)



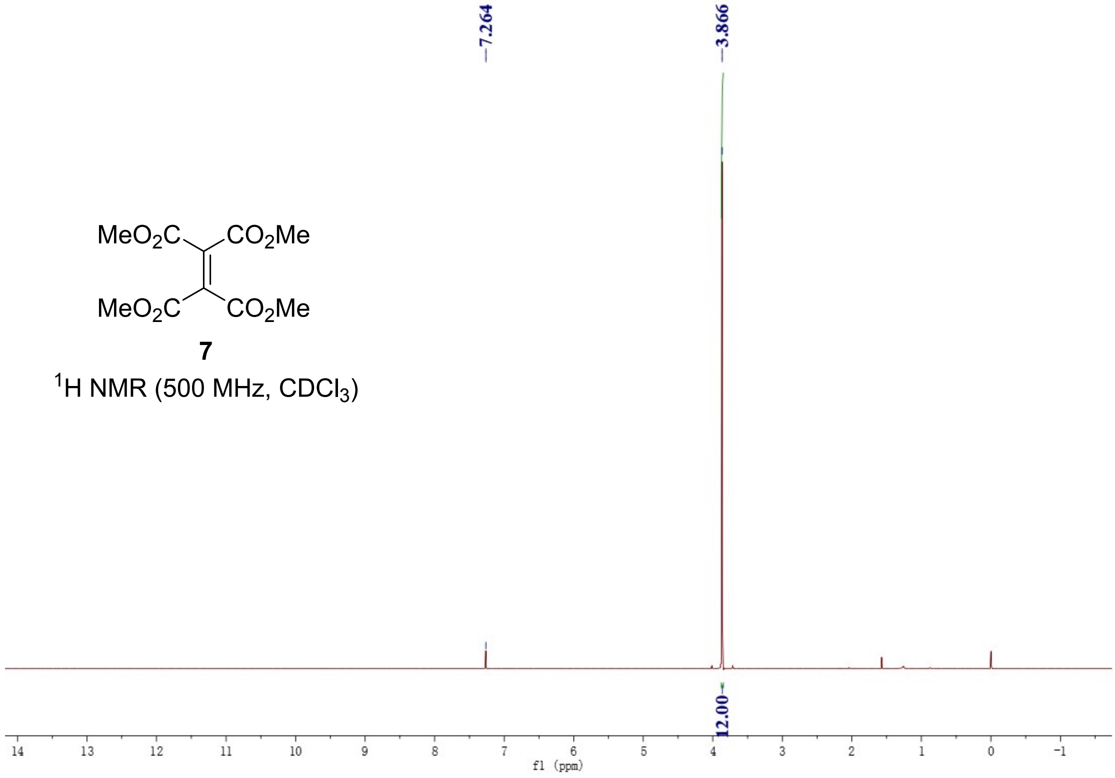
6

^{19}F NMR (471 MHz, CDCl$_3$)



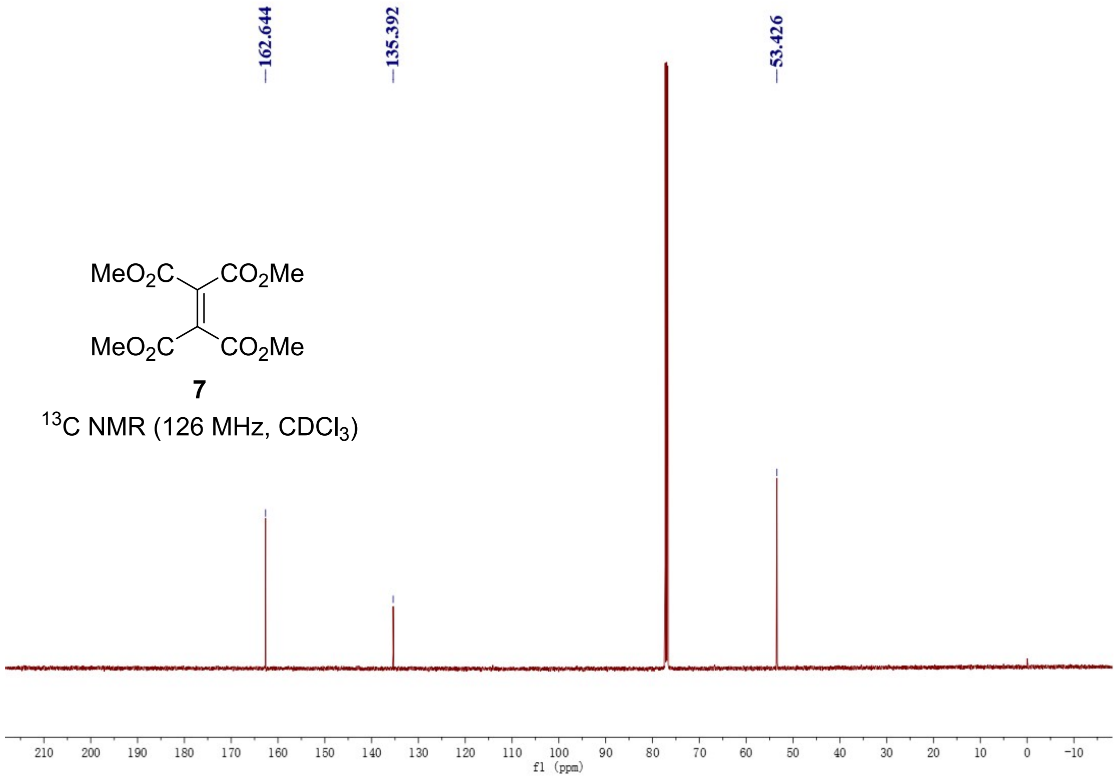
6

^{13}C NMR (126 MHz, CDCl$_3$)



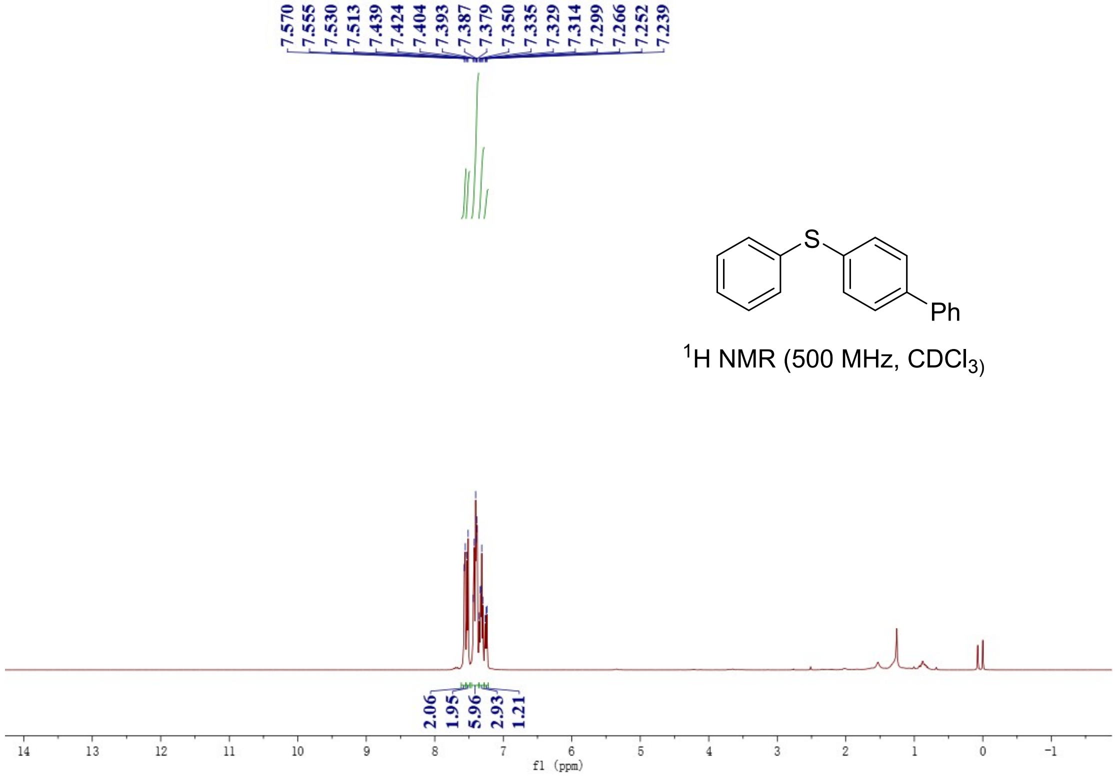
7

^{1}H NMR (500 MHz, CDCl$_3$)

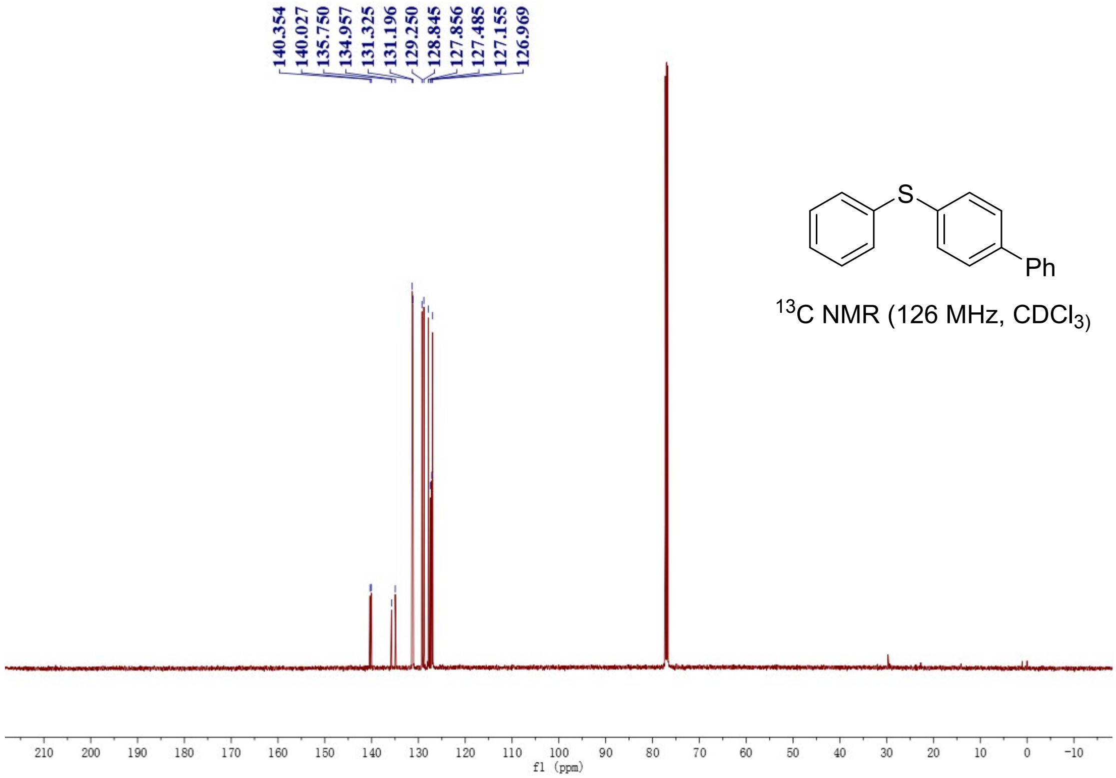


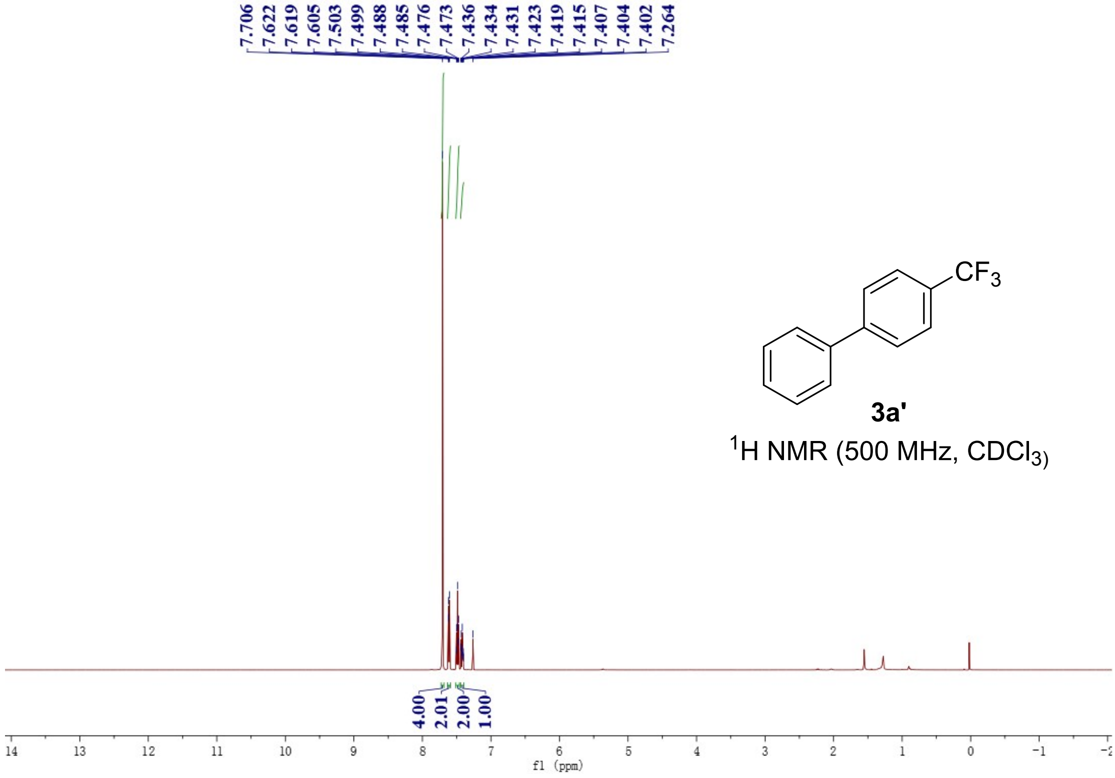
7

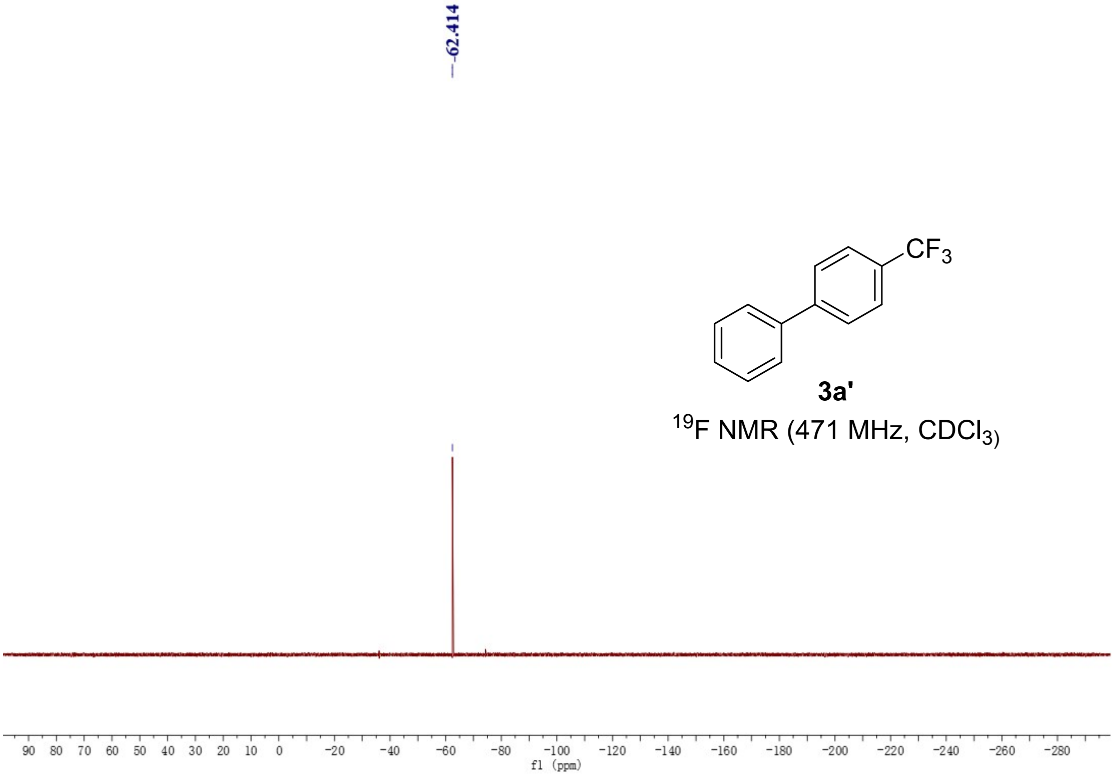
^{13}C NMR (126 MHz, CDCl$_3$)



^{1}H NMR (500 MHz, CDCl$_3$)

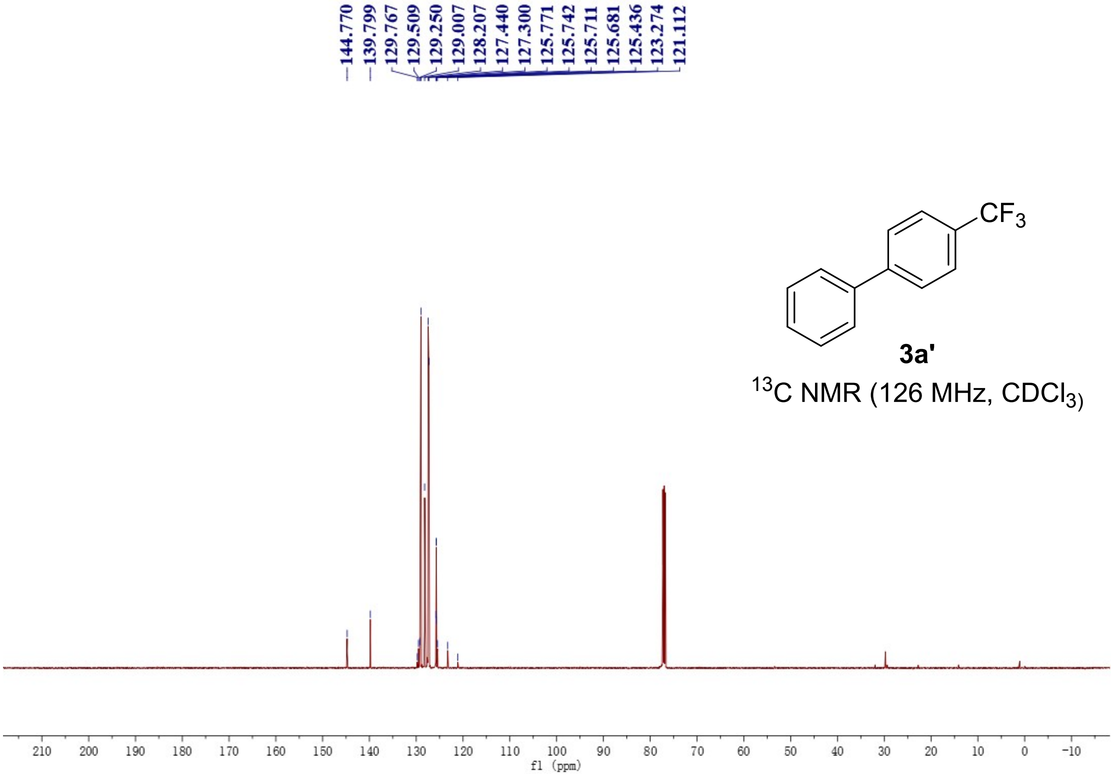

140.354
140.027
135.750
134.957
131.325
131.196
129.250
128.845
127.856
127.485
127.155
126.969
S
Ph
^{13}C NMR (126 MHz, CDCl$_3$)
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.706
7.622
7.619
7.605
7.503
7.499
7.488
7.485
7.476
7.473
7.436
7.434
7.431
7.423
7.419
7.415
7.407
7.404
7.402
7.264
CF$_3$
3a'
^{1}H NMR (500 MHz, CDCl$_3$)
4.00
2.01
2.00
1.00
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2
f1 (ppm)



3a'

^{19}F NMR (471 MHz, $CDCl_3$)



3a'

^{13}C NMR (126 MHz, $CDCl_3$)