Supporting information

Transition-Metal-Free Aryl–Heteroatom Bond Formation via C–S Bond Cleavage

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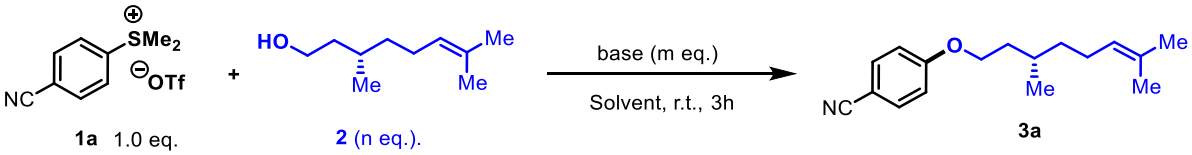
1. General Methods for Experiments

All reactions were carried out under a slightly positive pressure of dry argon by using standard Schlenk line techniques. Liquids and solutions were transferred with syringes. All solvents and chemical reagents were obtained from commercial sources such as Strem Chemicals, Adamas-beta, Sigma-Aldrich, J&K, Accela and TCI, which were used without further purification. ^{1}H and ^{13}C NMR spectra were recorded with tetramethylsilane as an internal reference. Low and high-resolution mass spectra were recorded on EI-TOF (electrospray ionization-time of flight) or ESI-TOF. Normal-phase column chromatography was performed with silica gel 60 (230–400 mesh) from Merck and thin-layer chromatography was carried out on 0.25 mm Merck silica gel plates (60F-254).

2. Optimization for Reaction Conditions

Table S1. Screening of Etherification Conditions

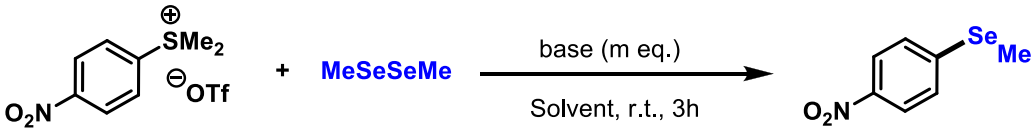


Entry	Base	n	m	solvent	NMR Yield
1	KO^tBu	1.5	1.5	DMF	74%
2	Na_2CO_3	1.5	1.5	DMF	trace
4	K_2CO_3	1.5	1.5	DMF	12%
5	$KHCO_3$	1.5	1.5	DMF	trace
6	K_3PO_4	1.5	1.5	DMF	45%
7	Cs_2CO_3	1.5	1.5	DMF	88%
8	Cs_2CO_3	1.5	1.5	THF	45%
9	Cs_2CO_3	1.5	1.5	DMSO	46%
10	Cs_2CO_3	1.5	1.5	DCM	50%
11	Cs_2CO_3	1.5	1.5	NMP	25%
12	Cs_2CO_3	1.5	1.5	MeCN	78%
13	Cs_2CO_3	1.1	1.1	DMF	53%
14[a]	Cs_2CO_3	1.5	1.5	DMF	80%
15[b]	Cs_2CO_3	1.5	1.5	DMF	79%

[a] performed in darkness

[b] add 2.0 eq. TEMPO

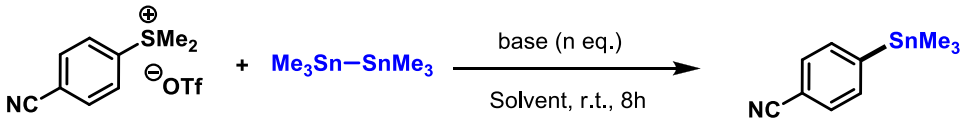
Table S2. Screening of Selenation Conditions



1b (1.0 eq.). (n eq.). **6a**

Entry	Base	n	m	solvent	NMR Yield
1	KO^{t}Bu	1.5	1.5	DMF	0%
2	NaH	1.5	1.5	DMF	trace
4	KHMDS	1.5	1.5	DMF+THF	trace
5	$NaBH_4$	1.5	3.0	THF+H_2O+DMF	75%
6	KBH_4	1.5	3.0	THF+H_2O+DMF	98%
7	KBH_4	1.0	2.0	THF+H_2O+DMF	96%
8	KBH_4	0.6	1.2	THF+H_2O+DMF	48%

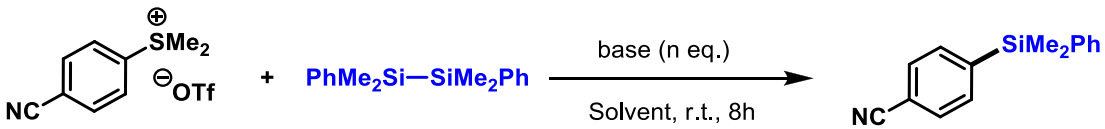
Table S3. Screening of Stannylation Conditions



1a (1.0 eq.). (n eq.). **7a**

Entry	Base	n	solvent	NMR Yield
1	KO^{t}Bu	2.0	DMF	0%
2	KF	2.0	DMF	21%
3	KOAc	2.0	DMF	0%
4	NaOEt	2.0	DMF	0%
5	TBAF	2.0	DMF	28%
6	CsF	2.0	DMF	66%
7	CsF	2.0	DMSO	39%
9	CsF	2.0	NMP	trace
10	CsF	1.5	DMF	65%

Table S4. Screening of Silylation Conditions



1a (1.0 eq.). (n eq.). **8a**

Entry	Base	n	solvent	NMR Yield
1	KF	2.0	DMF	12%
2	CsF	2.0	DMF	44%
3	NaOMe	2.0	DMF	0%
4	TBAF	2.0	DMF	28%
5	CsF	2.0	THF	29%
6	CsF	2.0	DMSO	17%
7	CsF	2.0	CH_3CN	18%
8	CsF	2.0	NMP	26%
9	CsF	1.5	DMF	55%
10	CsF	1.1	DMF	33%

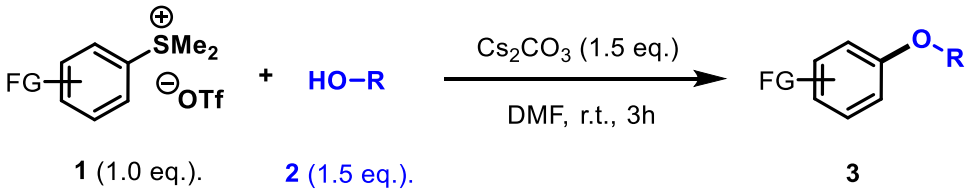
3. Details of Experiments

3.1 General Procedure for Preparation of Arylsulfonium Salts

K_2CO_3 (15 mmol), thiolphenol (10 mmol), iodomethane (15 mmol) and acetone (50 mL) were added into a flask. The mixture was stirred at room temperature overnight. After the completion of the reaction as indicated by TLC, the mixture was concentrated under a reduced pressure. H_2O (40 mL) was added to the residue and the resulting mixture was extracted with EA. The combined organic layer was dried over Na_2SO_4, concentrated under a reduced pressure. The residue was purified by silica gel column chromatography to give arylmethylthioether.

To a stirred solution of arylmethylthioether (10 mmol dissolved in 10 ml 1,2-dichloroethane) in a 200 mL flask was added dropwise methyl trifluoromethanesulfonate (1.35 mL, 12.0 mmol) at 25°C for 8 h. Solvent was then removed in vacuum and the residue was washed with Et_2O, dried under vacuum to give arylsulfonium salts solid.

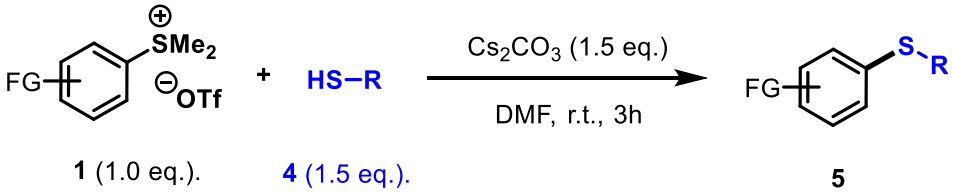
3.2 General Procedure for the Reactions of Arylsulfonium Salts with Alcohols



Alcohol (0.3 mmol), cesium carbonate (0.3 mmol, for **2i-n**: 0.6 mmol) and DMF (1 ml) were added into a 10 ml flask; drop the arylsulfonium salt DMF solution (0.2 mmol in 1 ml DMF) into the

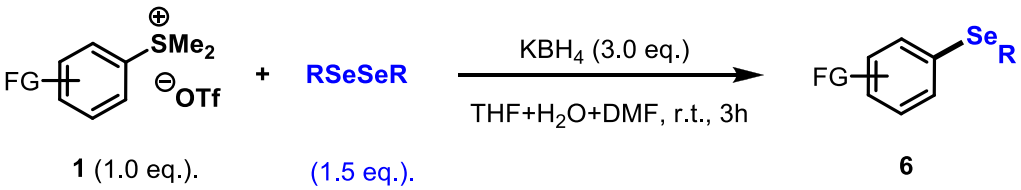
flask, stirred at room temperature for 3 h. The resulting mixture was extracted with ethyl acetate, the combined organic layer was dried over Na_2SO_4, then concentrated under a reduced pressure. The residue was purified on column chromatography or preparative TLC (silica gel) to give the product.

3.3 General Procedure for the Reactions of Arylsulfonium Salts with Thiols



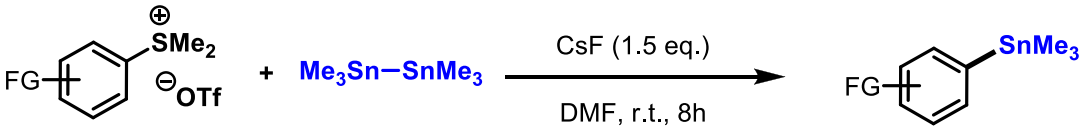
Add thiol (0.3 mmol), cesium carbonate (0.3 mmol, for **4g**, **4h, 4l**: 0.6 mmol) and DMF (1 ml) into a 10 ml flask; drop the arylsulfonium salt DMF solution (0.2 mmol in 1 ml DMF) into the flask, stirred at room temperature for 3 h. The resulting mixture was extracted with ethyl acetate, the combined organic layer was dried over Na_2SO_4, then concentrated under a reduced pressure. The residue was purified on column chromatography or preparative TLC (silica gel) to give the product.

3.4 General Procedure for the Selenation Reaction of Arylsulfonium Salts



KBH_4 aqueous solution (0.6 mmol in 0.5 ml H_2O) was added dropwise into selenide solution (0.3 mmol dissolved in 0.5 ml THF) in a 10 ml flask, stirred at room temperature for 10 min. Then, arylsulfonium salt solution (0.2 mmol dissolved in 1 ml DMF) was added into the flask, stirred at room temperature for 3 h. The resulting mixture was extracted with ethyl acetate, the combined organic layer was dried over Na_2SO_4, then concentrated under a reduced pressure. The residue was purified on column chromatography or preparative TLC (silica gel) to give the product.

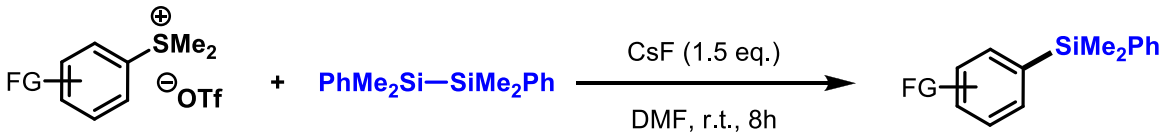
3.5 General Procedure for the Stannylation Reaction of Arylsulfonium Salts



1 (1.0 eq.). (1.5 eq.). **7**

Stannide (0.3 mmol), cesium fluoride (0.3 mmol), DMF (1 ml) were added into a Schlenck with argon protected at room temperature. Arylsulfonium salt (0.2 mmol) was dissolved in 1 ml DMF and added dropwise into the Schlenk. The mixture was stirred at room temperature for 8h. The resulting mixture was extracted with ethyl acetate, the combined organic layer was dried over Na_2SO_4, then concentrated under a reduced pressure. The residue was purified on column chromatography or preparative TLC (silica gel) to give the product.

3.6 General Procedure for the Silylation Reaction of Arylsulfonium Salts

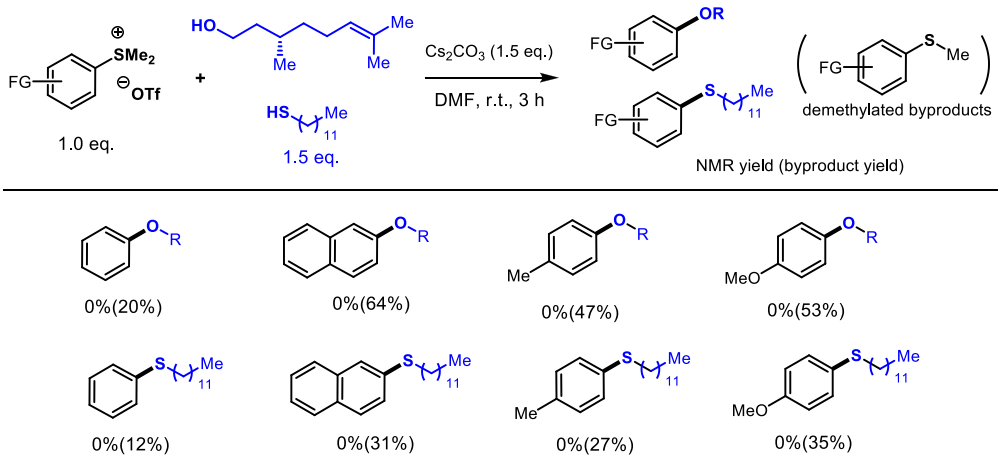


1 (1.0 eq.). (1.5 eq.). **8**

In a 10 ml Schlenck tube, silane (0.3 mmol) and cesium fluoride (0.3 mmol) were dissolved in 1 ml DMF with argon protected at room temperature. Arylsulfonium salt solution (0.2 mmol dissolved in 1 ml DMF) was added dropwise into the Schlenk. The mixture was stirred at room temperature for 8 h. The resulting mixture was extracted with ethyl acetate, the combined organic layer was dried over Na_2SO_4, then concentrated under a reduced pressure. The residue was purified on column chromatography or preparative TLC (silica gel) to give the product.

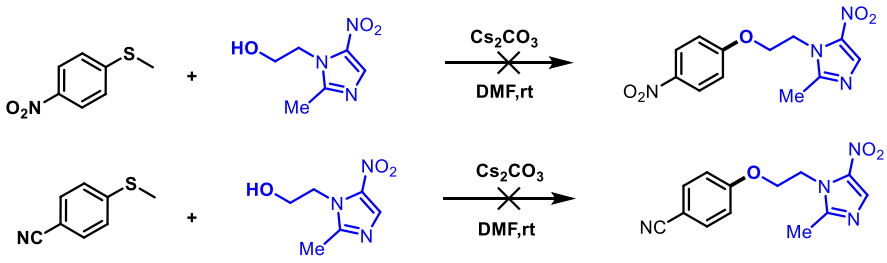
3.7 Reactions of Arylsulfoiniums Bearing Electron-neutral and Electron-donating Groups

We have examined more etherification and thioetherification reactions with some arylsulfoinium substrates bearing electron-neutral and electron-donating groups as shown below. But these substrates showed little or no reactivity toward alcohol/thiol. Instead, demethylated byproducts were detected.

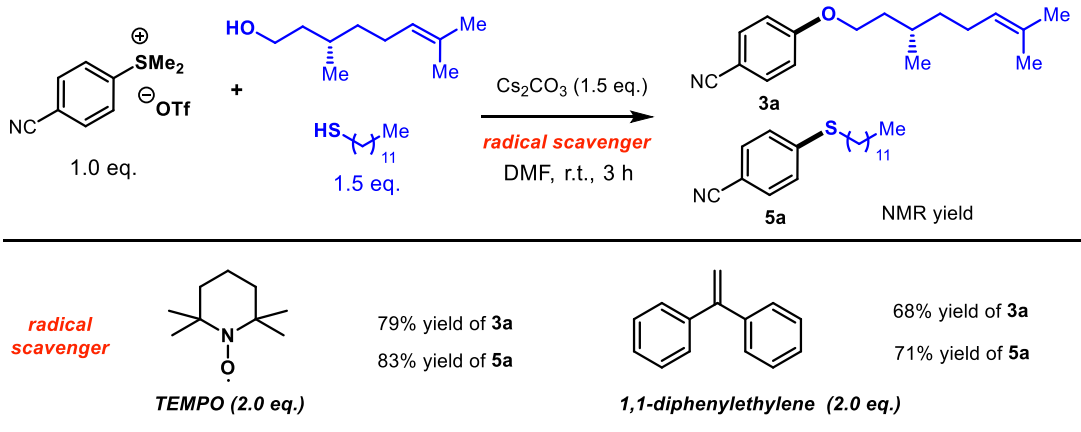


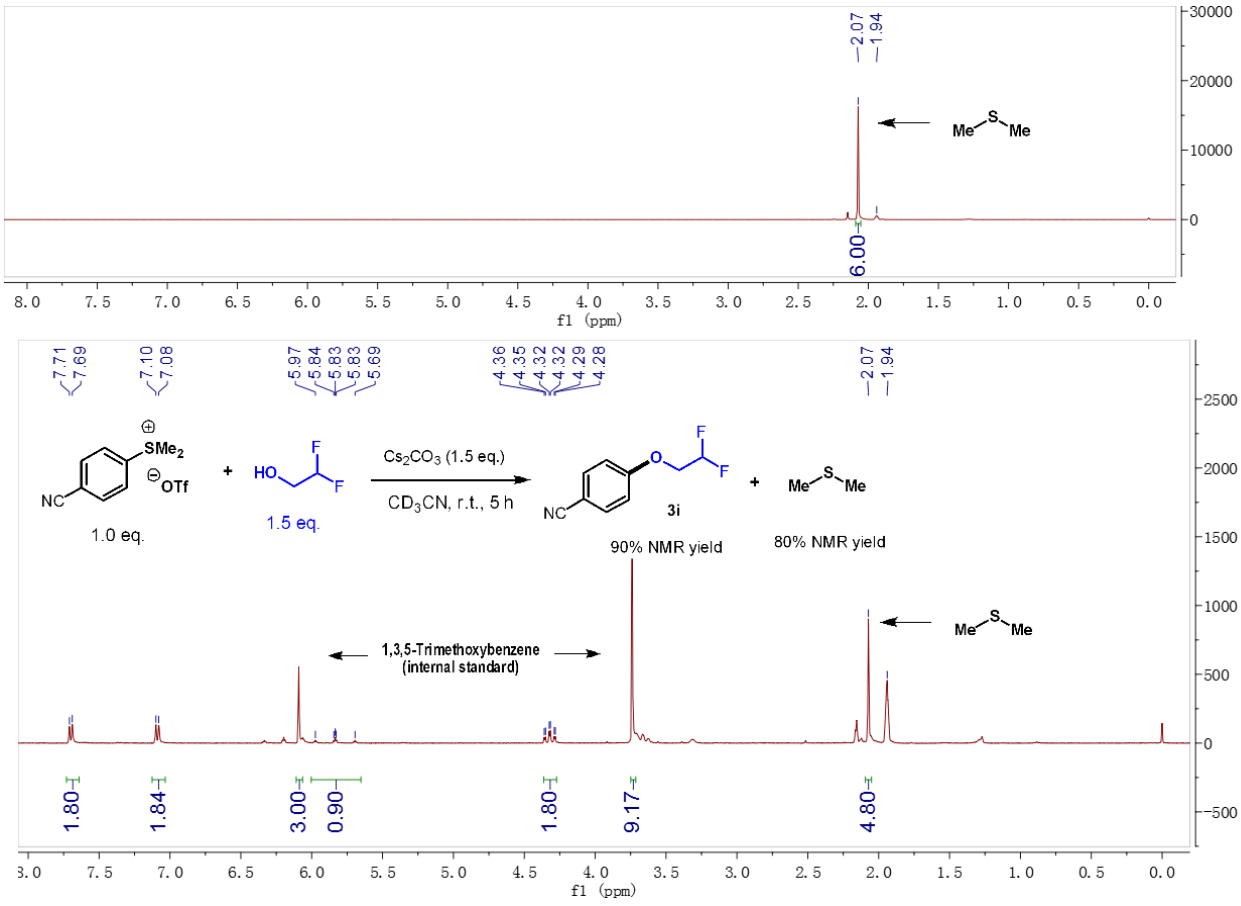
4. Mechanistic Studies

Additional control experiment was performed with *p*-CN and *p*-NO_2-substituted thioethers as substrates in our reaction conditions. However, no etherification product was obtained. We think the "real" arylation reagents were aryl dimethylsulfonium salts but not arylmethylthioethers.

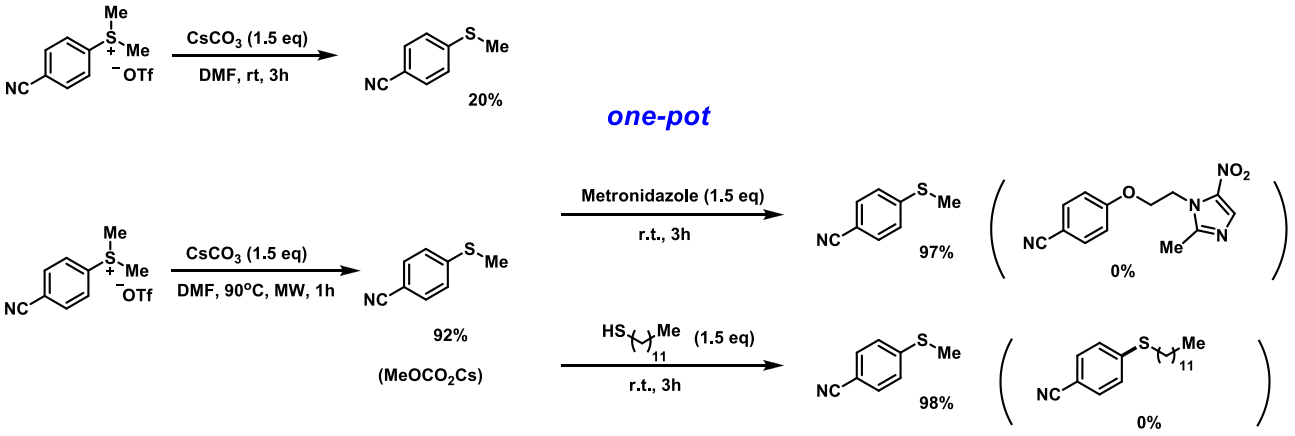


We found that when the reactions of arylsulfonium salt **1a** with β-citronellol and 1-dodecanethiol were performed in the presence of TEMPO or 1,1-diphenylethylene as radical scavengers, the yields of **3a** and **5a** hardly changed, thus excluding radical involvement. (ref: Org. Lett. 2018, 20, 4749) In addition, co-product dimethyl sulfide was detected in 80% yield after the etherification of sulfonium salt based on ^{1}H-NMR.



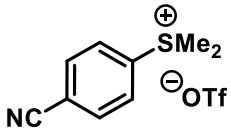


As shown below, treatment of **1a** with Cs_2CO_3 in the absence of nucleophiles at room temperature in 3 hours provided ArSMe in 20% NNR yield. But when this transformation performed in microwave condition at 90°C, ArSMe was obtained in 92% NMR yield. Then metronidazole or 1-dodecanethiol was added and the subsequent reaction performed in one-pot manner in the standard conditions. No S_NAr product was detected. Based on these results, we consider that ArSMe should be a byproduct of this aromatic nucleophilic substitution reaction, and $MeOCO_2Cs$ could not promote the reaction of ArSMe with NuH.



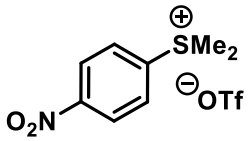
5. Characterization of Products

4-cyanophenyldimethylsulfonium trifluoromethanesulfonate salt (1a)



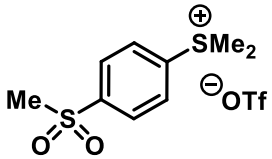
White solid. **m.p.** 96.5-101.2°C; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.22 (d, J = 8.9 Hz, 2H), 8.08 (d, J = 8.9 Hz, 2H), 3.35 (s, 6H). **^{13}C NMR** (126 MHz, CD_3OD) δ 152.34, 134.25, 132.40, 126.46, 121.73 (q, J = 316.75 Hz), 29.01. **^{19}F NMR** (471 MHz, CD_3OD) δ -79.95. All spectral data match those previously reported.[1]

4-nitrophenyldimethylsulfonium trifluoromethanesulfonate salt (1b)



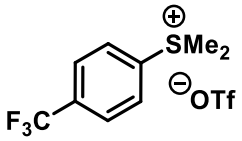
Yellow solid. **m.p.** 83.2-85.1°C; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.56 – 8.49 (d, J = 4.7 Hz, 2H), 8.33 (d, J = 4.7 Hz, 2H), 3.43 – 3.37 (s, 6H). **^{13}C NMR** (126 MHz, CD_3OD) δ 152.34, 134.25, 132.40, 126.46, 125.52, 122.99, 121.72 (q, J = 316.75 Hz), 120.45, 117.92, 29.01. **^{19}F NMR** (471 MHz, CD_3OD) δ -80.01. All spectral data match those previously reported.[2]

dimethyl(4-(methylsulfonyl)phenyl)sulfonium trifluoromethanesulfonate salt (1c)



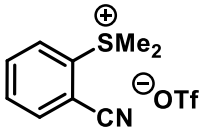
Yellow solid. **m.p.** 100.2-101.9°C; IR υ_{max}/cm^{-1} (film): 3430, 2925, 1579, 1297, 1149, 1095, 1081, 958, 777, 567, 526, 462; **^{1}H NMR** (400 MHz, DMSO-d6) δ 8.33 (d, J = 8.4 Hz, 2H), 8.25 (d, J = 8.5 Hz, 2H), 3.35 (s, 3H), 3.32 (s, 6H). **^{13}C NMR** (151 MHz, DMSO-d6) δ 144.98, 132.89, 131.03, 128.52, 120.68 (q, J = 322.69 Hz), 42.95, 28.02. **^{19}F NMR** (471 MHz, DMSO-d6) δ -77.74. **HRMS** (ESI) m/z [M^{+}] calcd for $C_9H_{13}O_2S_2$, 217.0351. found, 217.0346.

dimethyl(4-(trifluoromethyl)phenyl)sulfonium sulfoniumtrifluoromethanesulfonate salt (1d)



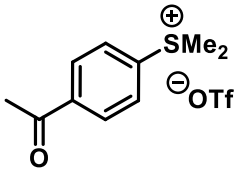
White solid. **m.p.** 162.3-164.8°C; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.26 (d, J = 8.5 Hz, 2H), 8.04 (d, J = 8.5 Hz, 2H), 3.36 (s, 6H). **^{13}C NMR** (126 MHz, CD_3OD) δ 136.47 (q, J = 33.39 Hz), 131.78, 128.74, 124.33 (q, J = 325.71 Hz), 121.98 (q, J = 372.08 Hz), 29.00. **^{19}F NMR** (471 MHz, CD_3OD) δ -64.86, -79.97. All spectral data match those previously reported.[3]

(2-cyanophenyl)dimethylsulfonium trifluoromethanesulfonate salt (1e)



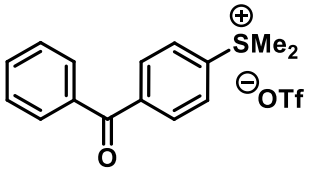
White solid. **m.p.** 143.2-147.1°C; IR υ_{max}/cm^{-1} (film): 3444, 3027, 2237, 1477, 1430, 1257, 1161, 1030, 779, 640, 516; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.27 (d, J = 8.1 Hz, 1H), 8.05 – 7.97 (m, 2H), 7.90 (t, J = 7.7 Hz, 1H), 3.35 (s, 6H). **^{13}C NMR** (126 MHz, CD_3OD) δ 136.69, 136.35, 135.83, 130.75, 130.03, 121.73 (q, J = 319.16 Hz), 116.82, 115.67, 29.10. **^{19}F NMR** (471 MHz, CD_3OD) δ -79.95. **HRMS** (ESI) m/z [M^{+}] calcd for $C_9H_{10}NS$, 164.0528. found, 164.0532.

(4-acetylphenyl)dimethylsulfonium trifluoromethanesulfonate salt (1f)



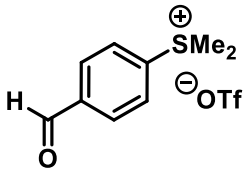
White solid. **m.p.** 103.5-105.6°C; **^{1}H NMR** (400 MHz, DMSO-d6) δ 8.21 (s, 4H), 2.66 (s, 3H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 197.40, 140.30, 131.50, 130.18, 129.55, 120.69 (q, J = 322.81 Hz), 28.00, 27.07. **^{19}F NMR** (471 MHz, DMSO-d6) δ -77.76. All spectral data match those previously reported.[3]

(4-benzoylphenyl)dimethylsulfonium trifluoromethanesulfonate salt (1g)



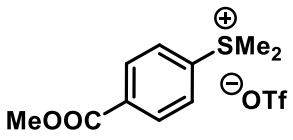
Yellow solid. **m.p.** 97.2-99.4°C; IR υ_{max}/cm^{-1} (film): 3431, 3039, 1664, 1597, 1276, 1257, 1161, 1143, 1032, 638; **^{1}H NMR** (400 MHz, DMSO-d6) δ 8.25 (d, J = 8.4 Hz, 2H), 7.99 (d, J = 8.4 Hz, 2H), 7.77 (d, J = 7.2 Hz, 3H), 7.61 (d, J = 7.7 Hz, 2H), 3.36 (s, 6H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 194.68, 141.41, 135.89, 133.57, 130.64, 130.03, 129.84, 128.82, 120.69 (q, J = 322.81 Hz), 28.05. **^{19}F NMR** (471 MHz, DMSO-d6) δ -77.73. **HRMS** (ESI) m/z [M^{+}] calcd for $C_{15}H_{15}OS$, 243.0838. found, 243.0831.

(4-formylphenyl)dimethylsulfonium trifluoromethanesulfonate salt (1f)



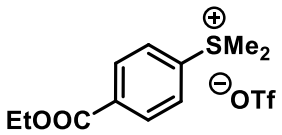
Brown oil. **^{1}H NMR** (400 MHz, DMSO-d6) δ 9.64 – 9.59 (m, 1H), 7.75 (t, J = 7.8 Hz, 2H), 7.72 – 7.63 (m, 2H), 2.80 (s, 6H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 192.46, 139.09, 132.80, 130.56, 130.54, 120.67 (q, J = 322.81 Hz), 27.97. **^{19}F NMR** (471 MHz, DMSO-d6) δ -77.75. All spectral data match those previously reported.[1]

(4-(methoxycarbonyl)phenyl)dimethylsulfonium trifluoromethanesulfonate salt (1i)



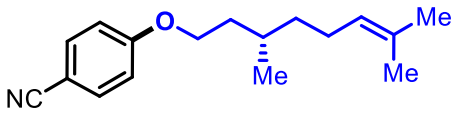
White solid. **m.p.** 109.1-112.1°C; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.30 (d, J = 8.7 Hz, 2H), 8.14 (d, J = 8.9 Hz, 2H), 3.97 (s, 3H), 3.33 (s, 6H). **^{13}C NMR** (126 MHz, CD_3OD) δ 166.53, 136.53, 132.70, 132.49, 132.22, 130.95, 121.79 (q, J = 319.16 Hz), 53.33, 28.98. **^{19}F NMR** (471 MHz, CD_3OD) δ -80.05. All spectral data match those previously reported.[3]

(4-(ethoxycarbonyl)phenyl)dimethylsulfonium trifluoromethanesulfonate salt (1j)



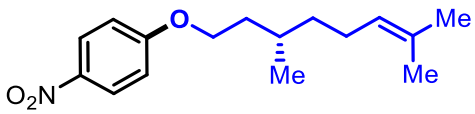
White solid. **m.p.** 93.1-99.6°C; IR υ_{max}/cm^{-1} (film): 3438, 3024, 1730, 1271, 1248, 1155, 1028, 854, 762, 686, 640, 573, 518, 493; **^{1}H NMR** (400 MHz, CD_3OD) δ 8.29 (dd, J = 8.4, 1.6 Hz, 2H), 8.17 – 8.12 (m, 2H), 4.42 (qd, J = 7.1, 1.4 Hz, 2H), 3.34 (s, 6H), 1.44 – 1.37 (m, 3H). **^{13}C NMR** (126 MHz, CD_3OD) δ 166.03, 136.79, 132.42, 132.11, 130.94, 121.78 (q, J = 319.16 Hz), 63.07, 28.99, 14.46. **^{19}F NMR** (471 MHz, CD_3OD) δ -79.98. **HRMS** (ESI) m/z [M^+] calcd for $C_{11}H_{15}O_2S$, 211.0787. found, 211.0788.

(S)-4-((3,7-dimethyloct-6-en-1-yl)oxy)benzonitrile (3a)



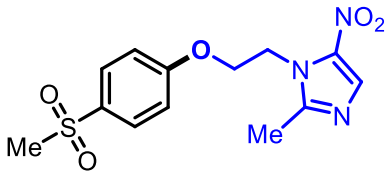
Colorless oil (42.2 mg, 82% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 15:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.8 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 5.09 (t, *J* = 6.5 Hz, 1H), 4.03 (t, *J* = 6.3 Hz, 2H), 2.09 – 1.94 (m, 2H), 1.89 – 1.79 (m, 1H), 1.69 – 1.59 (m, 7H), 1.46 – 1.14 (m, 3H), 0.95 (d, *J* = 6.4 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 162.57, 134.08, 131.59, 124.62, 119.45, 115.33, 103.81, 66.86, 37.17, 35.94, 29.58, 25.84, 25.54, 19.63, 17.80. All spectral data match those previously reported.[4]

(S)-1-((3,7-dimethyloct-6-en-1-yl)oxy)-4-nitrobenzene (3b)



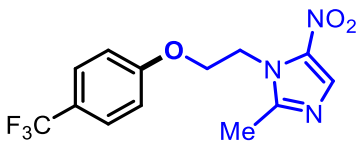
Colorless oil (43.3 mg, 78% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 15:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 9.3 Hz, 2H), 6.94 (d, *J* = 9.3 Hz, 2H), 5.09 (t, *J* = 7.1 Hz, 1H), 4.08 (ddd, *J* = 9.1, 6.6, 3.2 Hz, 2H), 2.01 (dq, *J* = 14.7, 7.2 Hz, 2H), 1.93 – 1.81 (m, 1H), 1.68 (s, 3H), 1.66 – 1.62 (m, 1H), 1.61 (s, 3H), 1.44 – 1.16 (m, 3H), 0.96 (d, *J* = 6.5 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 164.35, 141.43, 131.65, 126.06, 124.57, 114.54, 67.33, 37.17, 35.93, 29.55, 25.88, 25.55, 19.64, 17.83. All spectral data match those previously reported.[5]

2-methyl-1-(2-(4-(methylsulfonyl)phenoxy)ethyl)-5-nitro-1H-imidazole (3c)



Colorless solid (47.5 mg, 73% yield). **m.p.** 157.2-163.1°C; The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 20:1). IR ν_{max}/cm^{-1} (film): 3423, 2922, 1593, 1533, 1506, 1363, 1333, 1255, 1188, 1107, 1051, 906, 854, 750, 658; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.86 (d, *J* = 9.0 Hz, 2H), 6.95 (d, *J* = 9.0 Hz, 2H), 4.78 (t, *J* = 4.6 Hz, 2H), 4.42 (t, *J* = 4.6 Hz, 2H), 3.01 (s, 3H), 2.67 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 161.74, 151.48, 133.82, 132.50, 129.94, 114.98, 67.16, 45.95, 44.92, 14.55. **HRMS** (ESI) m/z [$(M+H)^+$] calcd for $C_{13}H_{16}N_3O_5S$, 326.0805. found, 326.0809.

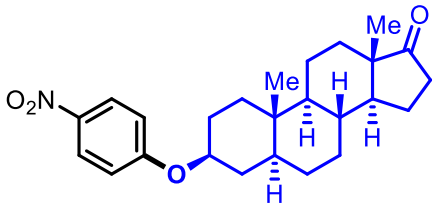
2-methyl-5-nitro-1-(2-(4-(trifluoromethyl)phenoxy)ethyl)-1H-imidazole (3d)



Colorless solid (38.5 mg, 61% yield). **m.p.** 142.7-148.2°C; The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 20:1). IR ν_{max}/cm^{-1} (film): 3364, 2923, 2852, 1614, 1531, 1481, 1430, 1372, 1329, 1314, 1255, 1165, 1127, 1112, 1054, 849, 824, 740,

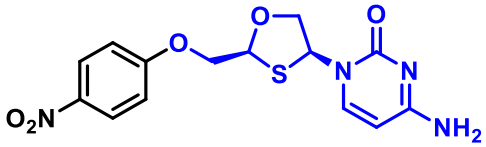
641, 600; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.98 (s, 1H), 7.53 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.5 Hz, 2H), 4.75 (t, *J* = 4.8 Hz, 2H), 4.37 (t, *J* = 4.8 Hz, 2H), 2.63 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.08, 151.66, 133.37, 127.15, 127.12, 123.60 (q, J = 133.56 Hz), 114.30, 66.86, 45.83, 29.71, 14.70.. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -61.67 (m, 3F). **HRMS** (ESI): m/z [$(M+H)^+$] calcd for $C_{13}H_{13}F_3N_3O_3$, 316.0904. found, 316.0908.

(3S,5S,8R,9S,10S,13S,14S)-10,13-dimethyl-3-(4-nitrophenoxy)hexadecahydro-17H-cyclopenta[a]phenanthren-17-one (3e)



Colorless solid (40.3 mg, 49% yield). **m.p.** 212.3-221.5ºC; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). IR ν_{max}/cm^{-1} (film): 3463, 2921, 2852, 1738, 1588, 1507, 1494, 1328, 1260, 1111, 1015, 848, 754; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.17 (d, *J* = 9.3 Hz, 2H), 6.91 (d, *J* = 9.3 Hz, 2H), 4.39 – 4.24 (m, 1H), 2.41 (q, *J* = 7.5 Hz, 1H), 2.06 (dd, *J* = 19.2, 9.1 Hz, 1H), 1.99 – 1.90 (m, 2H), 1.87 – 1.82 (m, 2H), 1.77 (dd, *J* = 4.8, 2.5 Hz, 1H), 1.64 (dd, *J* = 12.5, 2.9 Hz, 4H), 1.57 – 1.44 (m, 2H), 1.42 – 1.33 (m, 3H), 1.30 – 1.20 (m, 3H), 1.11 (dd, *J* = 13.7, 3.8 Hz, 1H), 1.00 (dd, *J* = 12.7, 5.2 Hz, 1H), 0.90 (s, 3H), 0.87 (s, 3H), 0.75 (td, *J* = 12.0, 11.6, 4.0 Hz, 1H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 221.24, 163.18, 141.04, 125.99, 115.24, 54.43, 51.39, 47.81, 44.77, 36.71, 35.88, 35.86, 35.04, 33.97, 31.54, 30.85, 28.34, 27.62, 21.79, 20.54, 13.85, 12.35. **HRMS** (EI): m/z [M^+] calcd for $C_{25}H_{33}NO_4$, 411.2404. found, 411.2397.

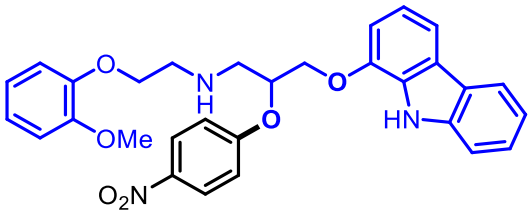
4-amino-1-((2S,4S)-2-((4-nitrophenoxy)methyl)-1,3-oxathiolan-4-yl)pyrimidin-2(1H)-one (3f)



Colorless oil (52.5 mg, 75% yield). The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). IR ν_{max}/cm^{-1} (film): 3461, 3361, 2921, 2850, 1631, 1469, 1332, 1217, 1126, 1091, 974, 939, 839, 667, 598; **^{1}H NMR** (400 MHz, DMSO-d6) δ

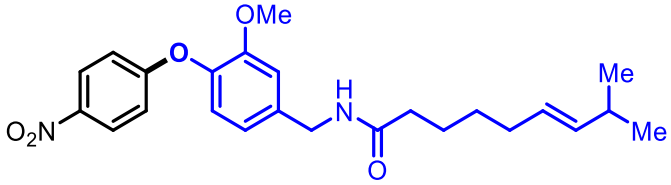
8.22 (d, *J* = 9.3 Hz, 2H), 7.72 (d, *J* = 7.5 Hz, 1H), 7.31 – 7.19 (m, 4H), 6.29 (t, *J* = 5.7 Hz, 1H), 5.74 (d, *J* = 7.5 Hz, 1H), 5.54 (t, *J* = 4.7 Hz, 1H), 4.58 – 4.48 (m, 2H), 3.46 (dd, *J* = 11.5, 5.4 Hz, 1H), 3.14 (dd, *J* = 11.5, 5.9 Hz, 1H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 166.08, 163.68, 155.08, 141.66, 141.15, 126.35, 115.72, 94.82, 87.47, 81.67, 70.29, 36.09. **HRMS** (ESI): m/z [(M+Na)$^+$] calcd for $C_{14}H_{14}N_4NaO_5S$, 373.0577. found, 373.0573.

3-((9H-carbazol-1-yl)oxy)-N-(2-(2-methoxyphenoxy)ethyl)-2-(4-nitrophenoxy)propan-1-amine (3g)



Colorless oil (50.6 mg, 48% yield). The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). IR ν_{max}/cm^{-1} (film): 3514, 3313, 2968, 2233, 1606, 1510, 1302, 1261, 1174, 1018, 839, 706, 550; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.33 (d, *J* = 7.8 Hz, 1H), 8.21 (s, 1H), 8.00 (d, *J* = 9.4 Hz, 2H), 7.46 – 7.37 (m, 2H), 7.33 (t, *J* = 8.0 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.08 (d, *J* = 8.0 Hz, 1H), 6.96 (td, *J* = 7.5, 2.3 Hz, 1H), 6.91 – 6.83 (m, 3H), 6.81 (d, *J* = 9.5 Hz, 2H), 6.68 (d, *J* = 8.0 Hz, 1H), 4.64 (s, 1H), 4.29 (dddd, *J* = 41.1, 19.9, 9.7, 4.9 Hz, 4H), 4.07 – 3.97 (m, 3H), 3.93 (s, 1H), 3.86 – 3.78 (m, 1H), 3.77 (s, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 154.86, 153.21, 149.35, 147.63, 141.16, 138.91, 137.78, 126.84, 126.15, 125.40, 122.82, 122.42, 122.30, 121.08, 119.88, 113.79, 112.76, 111.81, 111.63, 110.41, 104.38, 101.32, 69.70, 68.71, 65.87, 57.24, 55.73, 51.56. **HRMS** (ESI): m/z [(M+H)$^+$] calcd for $C_{30}H_{30}N_3O_6$, 528.2129. found, 528.2116.

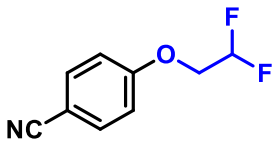
(E)-N-(3-methoxy-4-(4-nitrophenoxy)benzyl)-8-methylnon-6-enamide (3h)



Colorless oil (70.8 mg, 83% yield). The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 20:1). IR ν_{max}/cm^{-1} (film): 3281, 2956, 2927, 2854,

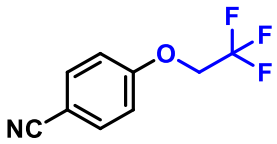
1646, 1588, 1504, 1488, 1343, 1287, 1272, 1238, 1158, 1121, 1038, 846, 747, 637, 492; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 10.4 Hz, 2H), 7.05 (d, *J* = 8.1 Hz, 1H), 6.97 (s, 1H), 6.94 – 6.88 (m, 3H), 5.83 (s, 1H), 5.42 – 5.26 (m, 2H), 4.47 (d, *J* = 5.9 Hz, 2H), 3.76 (s, 3H), 2.24 (dt, *J* = 13.1, 7.1 Hz, 3H), 2.00 (q, *J* = 6.9 Hz, 2H), 1.76 – 1.59 (m, 4H), 1.47 – 1.35 (m, 2H), 0.90 (dd, *J* = 37.7, 6.7 Hz, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 173.04, 163.49, 151.66, 142.38, 141.76, 138.16, 137.63, 126.40, 125.78, 122.59, 120.37, 115.78, 112.56, 55.88, 43.25, 36.66, 32.22, 30.96, 29.29, 25.26, 22.65. **HRMS** (ESI): m/z [$(M+H)^+$] calcd for $C_{24}H_{31}N_2O_5$, 427.2227. found, 427.2235.

4-(2,2-difluoroethoxy)benzonitrile (3i)



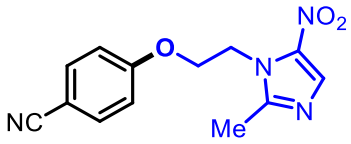
Colorless solid (31.1 mg, 85% yield). **m.p.** 42.7-47.2°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.62 (d, *J* = 7.3 Hz, 2H), 6.98 (d, *J* = 7.4 Hz, 2H), 6.11 (t, *J* = 54.9 Hz, 1H), 4.23 (td, *J* = 12.9, 2.5 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.77, 134.19, 118.72, 115.31, 115.06, 113.14, 111.21, 105.56, 67.42, 67.18, 66.94. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -125.23, -125.26, -125.29, -125.35, -125.37, -125.40. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -125.26 (t, J = 12.8 Hz, 1F), -125.37 (t, J = 12.8 Hz, 1F). All spectral data match those previously reported.[4]

4-(2,2,2-trifluoroethoxy)benzonitrile (3j)



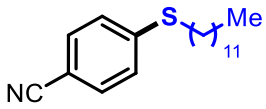
Colorless solid (26.5 mg, 66% yield). **m.p.** 59.1-63.1°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 15:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.63 (d, *J* = 7.9 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 4.41 (q, *J* = 7.9 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.20, 134.19, 126.15, 123.94, 121.73, 119.52, 118.50, 115.47, 106.09, 65.93, 65.64, 65.35, 65.06. **^{19}F NMR** (471 MHz, $CDCl_3$) δ -73.77 (t, J = 7.2 Hz, 3F). All spectral data match those previously reported.[6]

4-(2-(2-methyl-5-nitro-1H-imidazol-1-yl)ethoxy)benzonitrile (3k)



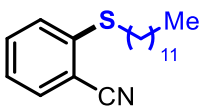
Colorless solid (1.2 g, 88% yield). **m.p.** 148.2-151.5°C; The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.96 (s, 1H), 7.57 (d, J = 9.0 Hz, 2H), 6.88 (d, J = 8.9 Hz, 2H), 4.74 (t, J = 4.8 Hz, 2H), 4.38 (t, J = 4.8 Hz, 2H), 2.62 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.95, 151.64, 138.52, 134.29, 133.41, 118.81, 115.16, 105.39, 67.07, 45.80, 14.77. All spectral data match those previously reported.[4]

4-(dodecylthio)benzonitrile (5a)



Colorless solid (27.7 mg, 85% yield). **m.p.** 48.5-52.2°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.51 (d, *J* = 8.7 Hz, 2H), 7.28 (d, *J* = 8.7 Hz, 2H), 2.96 (t, *J* = 1.2, 0.1 Hz, 2H), 1.69 (p, *J* = 7.3 Hz, 2H), 1.44 (p, *J* = 7.0 Hz, 2H), 1.28 (t, *J* = 7.1 Hz, 16H), 0.88 (t, *J* = 6.7 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 145.33, 132.17, 126.66, 118.95, 107.89, 31.91, 29.62, 29.55, 29.46, 29.33, 29.11, 28.87, 28.57, 22.68, 14.11. All spectral data match those previously reported.[7]

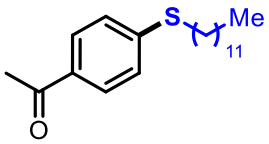
2-(dodecylthio)benzonitrile (5b)



Colorless solid (23.1 mg, 71% yield). **m.p.** 54.3-61.2°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 (dd, *J* = 7.7, 1.1 Hz, 1H), 7.49 (dd, *J* = 7.8, 1.4 Hz, 1H), 7.40 (d, *J* = 8.4 Hz, 1H), 7.23 (td, *J* = 7.6, 1.1 Hz, 1H), 3.01 (d, *J* = 8.7 Hz, 2H), 1.68 (p, *J* = 7.3 Hz, 2H), 1.48 – 1.38 (m, 2H), 1.25 (s, 16H), 0.88 (t, *J* = 6.9 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 142.30, 133.64, 132.71, 128.66,

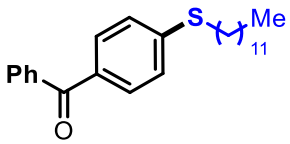
125.68, 117.18, 113.37, 33.57, 31.91, 29.62, 29.62, 29.56, 29.45, 29.34, 29.12, 28.82, 28.76, 22.69, 14.11. All spectral data match those previously reported.[8]

(4-(dodecylthio)phenyl)(phenyl)methanone (5c)



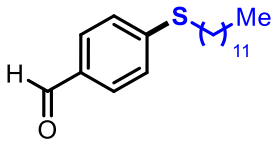
White solid (19.8 mg, 55% yield). **m.p.** 67.4-71.1°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 8:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 8.7 Hz, 2H), 7.29 (d, *J* = 8.7 Hz, 2H), 2.98 (t, *J* = 7.4 Hz, 2H), 2.56 (s, 3H), 1.69 (p, *J* = 7.4 Hz, 2H), 1.44 (p, *J* = 7.0 Hz, 2H), 1.35 – 1.19 (m, 16H), 0.88 (t, *J* = 8.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 197.15, 145.02, 133.73, 128.73, 126.26, 32.00, 31.91, 29.63, 29.62, 29.56, 29.48, 29.34, 29.15, 28.90, 28.76, 26.41, 22.69, 14.11. All spectral data match those previously reported.[7]

(4-(dodecylthio)phenyl)(phenyl)methanone (5d)



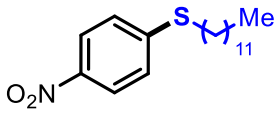
White solid (28.6 mg, 59% yield). **m.p.** 67.4-71.1°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 15:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 – 7.75 (m, 2H), 7.73 (d, *J* = 8.6 Hz, 2H), 7.60 – 7.55 (m, 1H), 7.48 (dd, *J* = 8.1, 7.0 Hz, 2H), 7.32 (d, *J* = 8.6 Hz, 2H), 3.00 (t, *J* = 5.7 Hz, 2H), 1.71 (p, *J* = 7.4 Hz, 2H), 1.46 (p, *J* = 7.1 Hz, 2H), 1.28 (d, *J* = 14.3 Hz, 16H), 0.88 (t, *J* = 8.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 195.82, 144.40, 137.86, 133.90, 132.18, 130.64, 129.83, 128.25, 126.15, 32.10, 31.91, 29.64, 29.63, 29.57, 29.50, 29.34, 29.16, 28.92, 28.81, 22.69, 14.12. All spectral data match those previously reported.[9]

4-(ethylthio)benzaldehyde (5e)



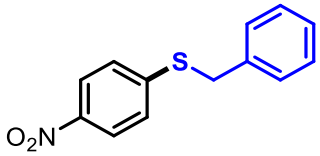
Colorless solid (27.3 mg, 82% yield). **m.p.** 34.1-35.7°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 8:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 9.91 (s, 1H), 7.75 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.3 Hz, 2H), 3.03 – 2.97 (m, 2H), 1.74 – 1.65 (m, 2H), 1.50 – 1.40 (m, 2H), 1.25 (s, 16H), 0.87 (t, *J* = 6.6 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 191.32, 147.31, 133.26, 130.14, 126.45, 32.05, 31.97, 29.77, 29.76, 29.70, 29.61, 29.47, 29.27, 29.04, 28.79, 22.82, 14.25. All spectral data match those previously reported.[7]

dodecyl(4-nitrophenyl)sulfane (5f)



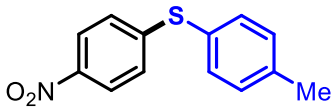
Colorless solid (32.2 mg, 88% yield). **m.p.** 48.4-51.3°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.10 (d, *J* = 9.0 Hz, 2H), 7.30 (d, *J* = 9.0 Hz, 2H), 3.04 – 2.96 (m, 2H), 1.76 – 1.65 (m, 2H), 1.50 – 1.40 (m, 2H), 1.25 (s, 16H), 0.87 (t, *J* = 6.7 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 148.16, 144.72, 125.86, 123.84, 31.85, 29.57, 29.50, 29.41, 29.29, 29.06, 28.82, 28.41, 22.64, 14.07. All spectral data match those previously reported.[7]

benzyl(4-nitrophenyl)sulfane (5g)



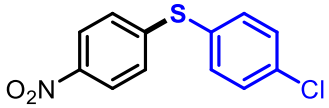
Colorless oil (34.8 mg, 71% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.8 Hz, 2H), 7.38 (d, *J* = 7.2 Hz, 2H), 7.36 – 7.28 (m, 5H), 4.25 (s, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 147.35, 145.42, 135.60, 128.98, 128.84, 127.95, 126.84, 124.07, 37.22. All spectral data match those previously reported.[10]

(4-nitrophenyl)(p-tolyl)sulfane (5h)



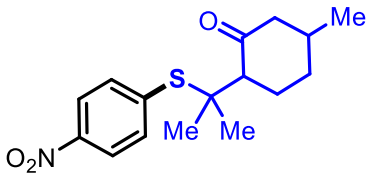
White solid (38.3 mg, 78% yield). **m.p.** 77.9-80.7°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 9.1 Hz, 2H), 7.44 (d, *J* = 8.1 Hz, 2H), 7.27 (d, *J* = 8.2 Hz, 2H), 7.13 (d, *J* = 9.1 Hz, 2H), 2.42 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 149.32, 145.16, 140.23, 135.07, 130.85, 126.52, 126.15, 123.97, 21.34. All spectral data match those previously reported.[11]

(4-chlorophenyl)(4-nitrophenyl)sulfane (5i)



White solid (37.7 mg, 71% yield). **m.p.** 85.1-89.8°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.08 (d, *J* = 9.1 Hz, 2H), 7.45 (q, *J* = 8.6 Hz, 4H), 7.21 – 7.15 (m, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 147.59, 145.66, 136.08, 135.84, 130.29, 129.20, 127.00, 124.17. All spectral data match those previously reported.[12]

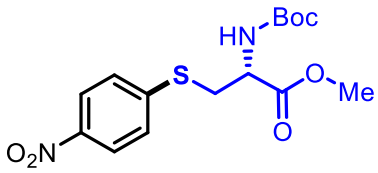
5-methyl-2-(2-((4-nitrophenyl)thio)propan-2-yl)cyclohexan-1-one (5j)



White solid (36.8 mg, 60% yield). **m.p.** 113-120.5°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). IR ν_{max}/cm^{-1} (film): 3429, 1593, 1573, 1508, 1475, 1336, 1072, 852, 808, 738, 505; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.9 Hz, 2H), 7.65 (d, *J* = 8.9 Hz, 2H), 2.67 (dq, *J* = 13.2, 3.4 Hz, 1H), 2.40 – 2.27 (m, 2H), 2.01 – 1.87 (m, 3H), 1.70 – 1.57 (m, 2H), 1.44 (d, *J* = 14.8 Hz, 6H), 1.02 (d, *J* = 6.1 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 209.97, 148.01, 141.36, 137.48, 123.38, 57.98, 52.93, 52.26, 36.75,

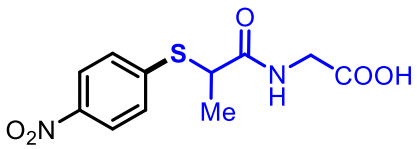
34.54, 29.78, 28.20, 24.67, 22.19. **HRMS** (EI): m/z [M^+] calcd for $C_{16}H_{21}O_3N_1S_1$, 307.1237. found, 307.1244.

methyl N-(tert-butoxycarbonyl)-S-(4-nitrophenyl)-L-cysteinate (5k)



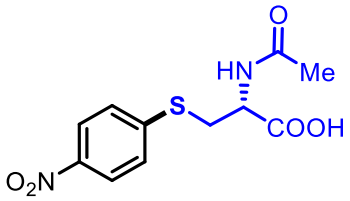
Colorless oil (45 mg, 63% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 5:1). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 8.12 (d, *J* = 8.8 Hz, 2H), 7.43 (d, *J* = 8.8 Hz, 2H), 5.34 (d, *J* = 6.7 Hz, 1H), 4.65 (q, *J* = 4.9 Hz, 1H), 3.70 (s, 3H), 3.57 (dd, *J* = 14.0, 4.8 Hz, 1H), 3.44 (dd, *J* = 14.0, 4.8 Hz, 1H), 1.41 (s, 9H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 170.68, 155.04, 145.77, 127.76, 124.13, 80.68, 53.32, 52.95, 35.17, 28.37. All spectral data match those previously reported.[13]

(2-((4-nitrophenyl)thio)propanoyl)glycine (5l)



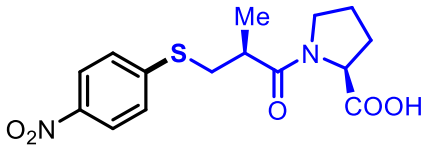
White solid (27.3 mg, 78% yield). **m.p.** 147-155°C; The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). IR ν_{max}/cm^{-1} (film): 2924, 2854, 1658, 1631, 1464, 1377, 1219, 773; **^{1}H NMR** (300 MHz, DMSO-d6) δ 12.61 (s, 1H), 8.61 (t, *J* = 5.9 Hz, 1H), 8.13 (d, *J* = 9.1 Hz, 2H), 7.55 (d, *J* = 9.1 Hz, 2H), 4.29 (q, *J* = 7.0 Hz, 1H), 3.79 (dd, *J* = 5.9, 2.2 Hz, 2H), 1.46 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 170.96, 170.91, 145.75, 144.95, 127.72, 123.87, 43.80, 40.91, 18.05. **HRMS** (ESI): m/z calcd for $C_{11}H_{11}N_2O_5S$ [$(M-H)^-$], 283.0394. found, 283.0387.

N-acetyl-S-(4-nitrophenyl)-L-cysteine (5m)



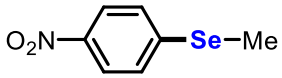
Colorless oil (29.5 mg, 52% yield). The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). **^{1}H NMR** (500 MHz, DMSO-d6) δ 8.42 (d, *J* = 8.0 Hz, 1H), 8.14 (d, *J* = 9.1 Hz, 1H), 7.54 (d, *J* = 9.1 Hz, 1H), 4.46 (td, *J* = 8.4, 4.9 Hz, 1H), 3.54 (dd, *J* = 13.6, 5.0 Hz, 1H), 3.32 (dd, *J* = 13.7, 8.5 Hz, 1H), 1.83 (s, 2H). **^{13}C NMR** (126 MHz, DMSO-d6) δ 171.57, 169.54, 146.62, 144.70, 126.64, 123.97, 51.17, 32.75, 22.31. All spectral data match those previously reported.[14]

((S)-2-methyl-3-((4-nitrophenyl)thio)propanoyl)-L-proline (5n)



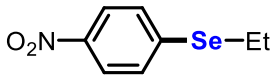
Colorless oil (50.7 mg, 75% yield). The product was purified by flash column chromatography on silica gel (eluent: dichloromethane/methanol= 10:1). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.14 (d, *J* = 9.0 Hz, 2H), 7.36 (d, *J* = 9.0 Hz, 2H), 4.57 (dd, *J* = 7.8, 3.0 Hz, 1H), 3.57 – 3.53 (m, 1H), 3.43 (dd, *J* = 13.2, 9.0 Hz, 2H), 3.11 (dd, *J* = 13.2, 5.2 Hz, 1H), 2.93 (ddd, *J* = 9.0, 6.9, 5.3 Hz, 1H), 2.40 – 2.32 (m, 1H), 2.08 – 1.98 (m, 3H), 1.34 (d, *J* = 6.9 Hz, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 175.83, 172.60, 146.65, 145.54, 126.70, 124.25, 59.88, 47.85, 38.27, 35.29, 27.71, 24.94, 17.71. All spectral data match those previously reported. [15]

methyl(4-nitrophenyl)selane (6a)



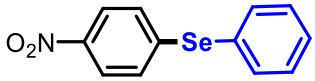
Yellow oil (38 mg, 88% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.9 Hz, 2H), 7.46 (d, *J* = 8.9 Hz, 2H), 2.44 (s, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 147.68, 145.22, 130.53, 125.68, 8.61. All spectral data match those previously reported.[16]

ethyl(4-nitrophenyl)selane (6b)



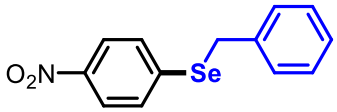
Yellow oil (36.3 mg, 79% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 9.0 Hz, 2H), 7.51 (d, *J* = 9.0 Hz, 2H), 3.06 (q, *J* = 7.5 Hz, 2H), 1.51 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 147.89, 144.12, 131.91, 125.71, 22.61, 16.82. All spectral data match those previously reported.[17]

(4-nitrophenyl)(phenyl)selane (6c)



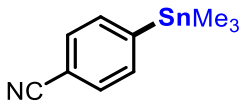
Yellow solid (24 mg, 43% yield). **m.p.** 54.1-59.2°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.9 Hz, 2H), 7.63 (d, *J* = 7.5 Hz, 2H), 7.42 (d, *J* = 7.3 Hz, 3H), 7.36 (d, *J* = 9.0 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 146.35, 144.06, 136.02, 130.19, 129.87, 129.52, 127.37, 124.11. All spectral data match those previously reported.[18]

benzyl(4-nitrophenyl)selane (6d)



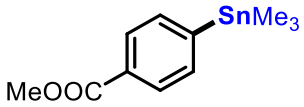
Yellow solid (39 mg, 67% yield). **m.p.** 95.4-96.8°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.09 – 8.05 (m, 2H), 7.52 (d, *J* = 8.9 Hz, 2H), 7.30 (d, *J* = 4.4 Hz, 4H), 7.26 – 7.23 (m, 1H), 4.25 (s, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 196.98, 138.11, 137.74, 137.67, 137.45, 134.29, 134.16, 132.58, 132.55, 130.23, 130.20, 129.53, 129.18, 128.41, 128.09. All spectral data match those previously reported.[19]

4-(trimethylstannyl)benzonitrile (7a)



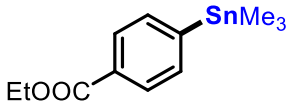
Colorless oil (26 mg, 55% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 20:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.59 (d, *J* = 2.7 Hz, 4H), 0.33 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 150.26, 136.30, 130.85, 119.12, 111.84, -9.49. All spectral data match those previously reported.[20]

methyl 4-(trimethylstannyl)benzoate (7b)



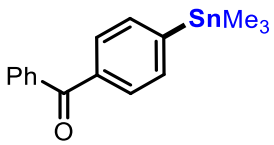
Yellow oil (47.2 mg, 79% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.0 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 2H), 3.91 (s, 3H), 0.32 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 167.84, 150.04, 136.18, 130.22, 128.91, 52.44, -9.14. All spectral data match those previously reported.[20]

ethyl 4-(trimethylstannyl)benzoate (7c)



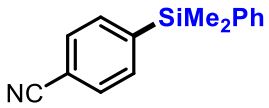
Yellow oil (25 mg, 40% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.1 Hz, 2H), 7.57 (d, *J* = 8.1 Hz, 2H), 4.37 (q, *J* = 7.1 Hz, 2H), 1.39 (t, *J* = 7.1 Hz, 3H), 0.32 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.95, 149.45, 135.73, 130.18, 128.48, 60.86, 14.34, -9.55. All spectral data match those previously reported.[20]

phenyl(4-(trimethylstannyl)phenyl)methanone (7d)



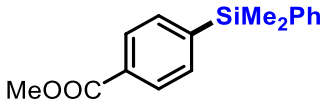
Colorless oil (42 mg, 61% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 15:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.1 Hz, 2H), 7.74 (d, *J* = 8.0 Hz, 2H), 7.64 – 7.55 (m, 3H), 7.48 (t, *J* = 7.6 Hz, 2H), 0.34 (s, 9H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 196.96, 137.70, 137.26, 135.65, 132.33, 130.06, 129.07, 128.27, 128.23, -9.51. All spectral data match those previously reported.[21]

4-(dimethyl(phenyl)silyl)benzonitrile (8a)



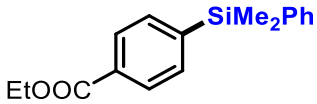
Colorless oil (20.4 mg, 43% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 (s, 4H), 7.49 (dd, *J* = 7.5, 1.8 Hz, 2H), 7.42 – 7.34 (m, 3H), 0.58 (s, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 145.52, 136.59, 134.73, 134.22, 131.16, 129.77, 128.21, 119.10, 112.81, -2.60. All spectral data match those previously reported.[22]

methyl 4-(dimethyl(phenyl)silyl)benzoate (8b)



Colorless oil (24.3 mg, 45% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.3 Hz, 2H), 7.60 (d, *J* = 8.3 Hz, 2H), 7.51 (dd, *J* = 7.5, 1.9 Hz, 2H), 7.41 – 7.33 (m, 3H), 3.92 (s, 3H), 0.58 (s, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 167.24, 144.68, 137.34, 134.16, 134.14, 130.58, 129.37, 128.55, 127.94, 52.12, -2.56. All spectral data match those previously reported.[22]

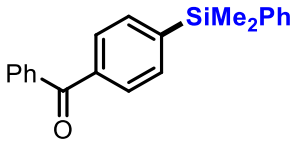
ethyl 4-(dimethyl(phenyl)silyl)benzoate (8c)



Colorless oil (21.6 mg, 38% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). **^{1}H NMR** (300 MHz, $CDCl_3$) δ 8.01 (d, *J* = 7.9 Hz, 2H), 7.60 (d, *J* = 7.9 Hz, 2H), 7.54 – 7.48 (m, 2H), 7.37 (d, *J* = 5.9 Hz, 3H), 4.38 (q, *J* = 7.1

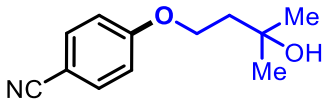
Hz, 2H), 1.39 (t, *J* = 7.1 Hz, 3H), 0.58 (s, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 166.88, 144.63, 137.52, 134.27, 134.26, 131.08, 129.48, 128.65, 128.06, 61.07, 14.47, -2.43. All spectral data match those previously reported.[23]

(4-(dimethyl(phenyl)silyl)phenyl)(phenyl)methanone (8d)



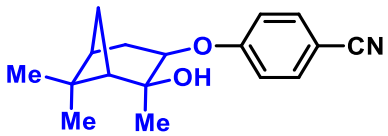
Colorless oil (23.4 mg, 37% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 10:1). IR ν_{max}/cm^{-1} (film): 3462, 3066, 2956, 2922, 1658, 1597, 1446, 1386, 1317, 1278, 1251, 1112, 939, 922, 833, 816, 777, 731, 770, 665, 482; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.83 – 7.80 (m, 3H), 7.77 – 7.74 (m, 2H), 7.66 – 7.62 (m, 2H), 7.57 – 7.52 (m, 2H), 7.50 – 7.47 (m, 3H), 7.40 – 7.37 (m, 2H), 0.60 (s, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 196.73, 137.86, 137.49, 137.41, 137.19, 134.04, 133.91, 132.30, 129.95, 129.27, 128.92, 128.16, 127.84, -2.66. **HRMS** (EI): m/z [M^+] calcd for $C_{21}H_{20}OSi$, 316.1278. found, 316.1267.

4-(3-hydroxy-3-methylbutoxy)benzonitrile (3l)



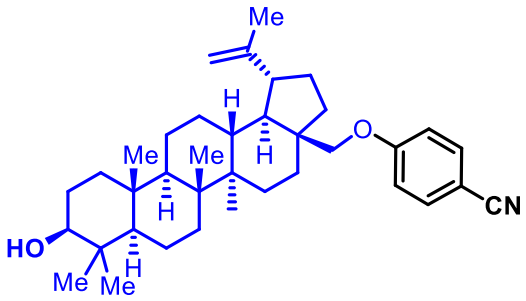
White oil (34.8 mg, 85% yield). The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 5:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.58 (d, *J* = 9.0 Hz, 2H), 6.96 (d, *J* = 9.0 Hz, 2H), 4.22 (t, *J* = 6.5 Hz, 2H), 2.01 (t, *J* = 6.5 Hz, 2H), 1.32 (s, 6H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 162.11, 134.16, 119.31, 115.36, 104.26, 70.33, 65.47, 41.74, 29.96. All spectral data match those previously reported.[24]

4-(((1S,2S,5S)-2-hydroxy-2,6,6-trimethylbicyclo[3.1.1]heptan-3-yl)oxy)benzonitrile (3m)



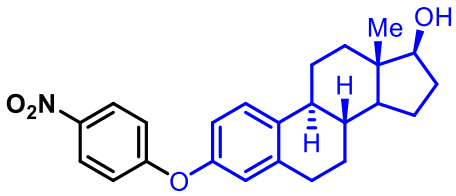
White solid (50.4 mg, 93% yield). **m.p.** 87.2-91.5°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 3:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 9.0 Hz, 2H), 7.03 (d, *J* = 9.0 Hz, 2H), 4.64 (dd, *J* = 9.1, 5.3 Hz, 1H), 2.61 (tdd, *J* = 8.0, 4.6, 2.2 Hz, 1H), 2.30 (ddt, *J* = 10.5, 6.0, 3.0 Hz, 1H), 2.10 (t, *J* = 5.8 Hz, 1H), 2.04 (dq, *J* = 5.6, 2.6 Hz, 1H), 1.79 (ddd, *J* = 14.0, 5.3, 2.5 Hz, 1H), 1.63 (d, *J* = 10.5 Hz, 1H), 1.36 (d, *J* = 9.9 Hz, 6H), 1.05 (s, 3H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 160.89, 134.27, 119.09, 116.74, 104.88, 76.31, 73.95, 53.96, 40.53, 38.67, 35.24, 30.67, 28.35, 27.96, 24.59. All spectral data match those previously reported.[4]

4-(((1R,3aS,5aR,5bR,7aR,9S,11aR,11bR,13aR,13bR)-3a-(hydroxymethyl)-5a,5b,8,8,11a-pentamethyl-1-(prop-1-en-2-yl)icosahydro-1H-cyclopenta[a]chrysen-9-yl)oxy)benzonitrile (3n)



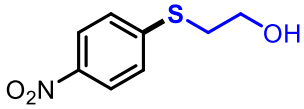
White solid (65.2 mg, 60% yield). **m.p.** 98-115°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 5:1). IR ν_{max}/cm^{-1} (film): 3483, 2927, 1670, 1606, 1510, 1460, 1259, 1219, 1018, 669; **^{1}H NMR** (600 MHz, $CDCl_3$) δ 7.58 (d, J = 8.8 Hz, 2H), 6.97 (d, J = 8.8 Hz, 2H), 4.71 (s, 1H), 4.61 (s, 1H), 4.10 (d, J = 8.7 Hz, 1H), 3.67 (d, J = 8.8 Hz, 1H), 3.19 (dd, J = 11.5, 4.6 Hz, 1H), 2.46 (td, J = 10.8, 5.7 Hz, 1H), 2.08 (d, J = 13.3 Hz, 1H), 2.01 – 1.90 (m, 2H), 1.70 (s, 3H), 1.01 (d, J = 3.8 Hz, 6H), 0.96 (s, 3H), 0.83 (s, 4H), 0.75 (s, 3H), 0.68 (d, J = 10.9 Hz, 1H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 165.00, 151.92, 135.88, 121.23, 117.08, 111.89, 105.54, 80.84, 68.66, 57.16, 52.24, 50.67, 49.91, 48.93, 44.63, 42.80, 40.76, 40.60, 39.73, 39.05, 36.39, 36.06, 31.59, 29.87, 29.27, 29.00, 27.09, 22.70, 20.98, 20.16, 18.00, 17.96, 17.26, 16.74. **HRMS** (EI): m/z [M^+] calcd for $C_{37}H_{53}O_2N$, 543.4071. found, 543.4075.

(8R,9S,13S,17S)-13-methyl-3-(4-nitrophenoxy)-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-17-ol (3o)



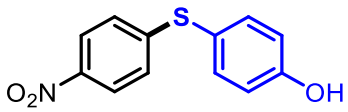
Colorless solid (64.5 mg, 82% yield). **m.p.** 200.4-215.4°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 5:1). IR ν_{max}/cm^{-1} (film): 3600, 3467, 2927, 2864, 1589, 1508, 1487, 1344, 1251, 1163, 1112, 922, 850, 752; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 9.2 Hz, 2H), 7.33 (d, *J* = 8.3 Hz, 1H), 7.00 (d, *J* = 9.2 Hz, 2H), 6.85 (dd, *J* = 8.5, 2.6 Hz, 1H), 6.80 (s, 1H), 3.75 (t, *J* = 8.7 Hz, 1H), 2.98 – 2.82 (m, 3H), 2.39 – 2.22 (m, 2H), 2.19 – 2.08 (m, 1H), 2.01 – 1.87 (m, 2H), 1.76 – 1.17 (m, 11H), 0.81 (s, 3H). **^{13}C NMR** (151 MHz, $CDCl_3$) δ 165.65, 154.21, 144.27, 141.13, 139.60, 129.07, 127.78, 122.43, 119.56, 118.76, 83.72, 51.98, 46.04, 45.14, 40.46, 38.57, 32.49, 31.50, 28.93, 28.14, 25.05, 12.98. **HRMS** (EI): m/z [M^+] calcd for $C_{24}H_{27}O_4N$, 393.1935. found, 393.1927.

2-((4-nitrophenyl)thio)ethan-1-ol (5o)



Yellow solid (31.8 mg, 80% yield). **m.p.** 79.8-88.4°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 5:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.9 Hz, 2H), 7.40 (d, *J* = 8.9 Hz, 2H), 3.89 (t, *J* = 6.0 Hz, 2H), 3.25 (t, *J* = 6.1 Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 146.41, 145.54, 127.00, 124.19, 60.66, 35.25. All spectral data match those previously reported.[25]

4-((4-nitrophenyl)thio)phenol (5p)



White solid (37 mg, 75% yield). **m.p.** 147.5-155.7°C; The product was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate= 8:1). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 9.0 Hz, 2H), 7.44 (d, *J* = 8.6 Hz, 2H), 7.09 (d, *J* = 9.0 Hz, 2H), 6.94 (d, *J* = 8.7

Hz, 2H). **^{13}C NMR** (126 MHz, $CDCl_3$) δ 157.41, 150.08, 144.99, 137.41, 125.60, 123.99, 120.31, 117.22. All spectral data match those previously reported.[25]

6. Reference

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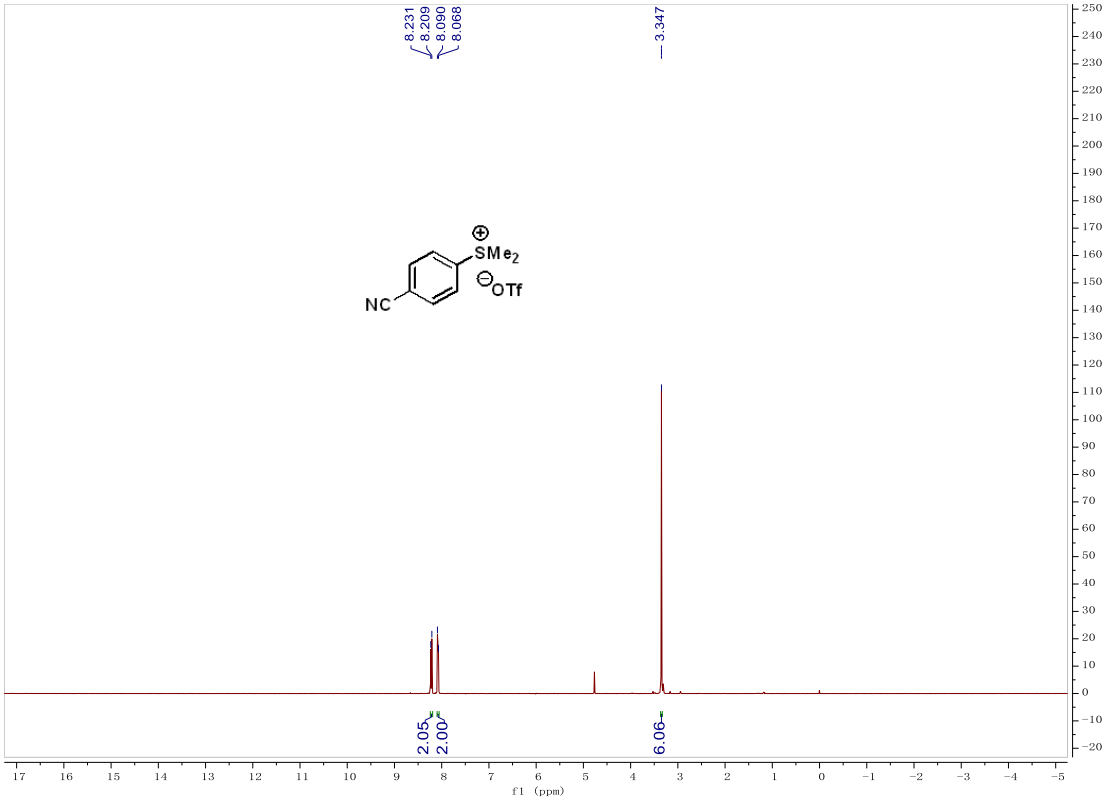
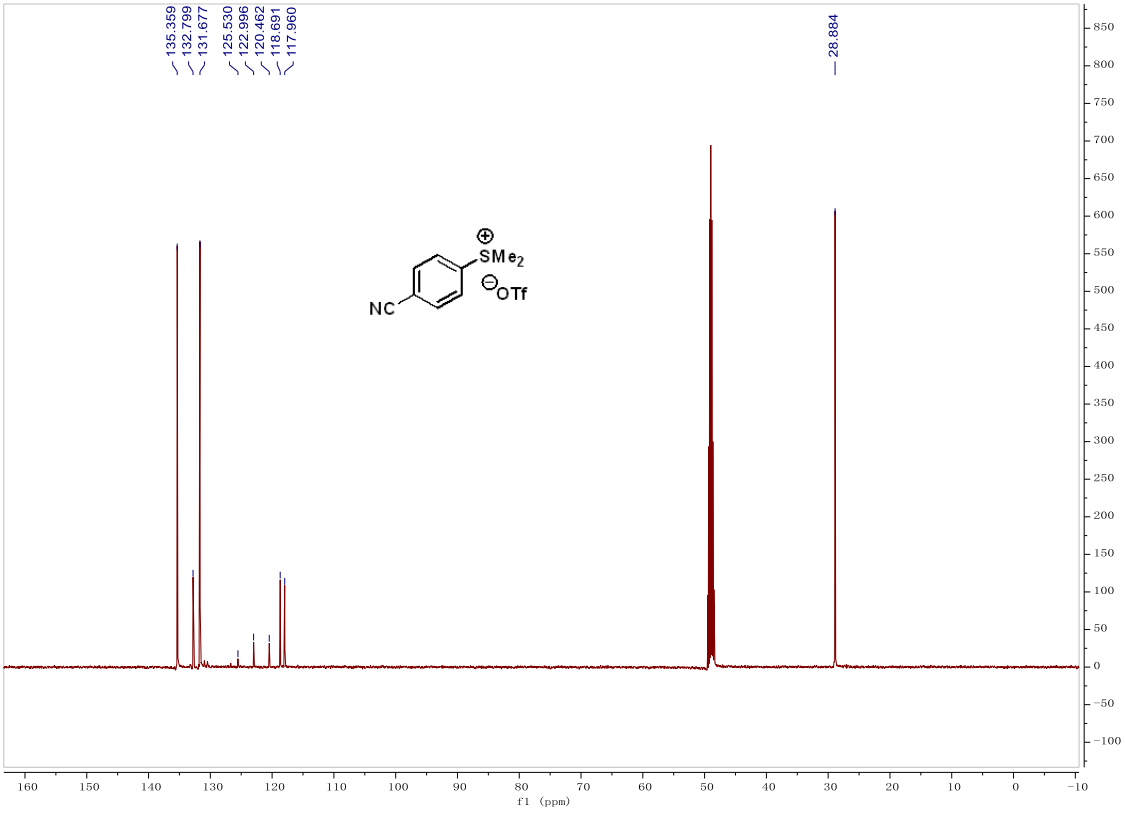
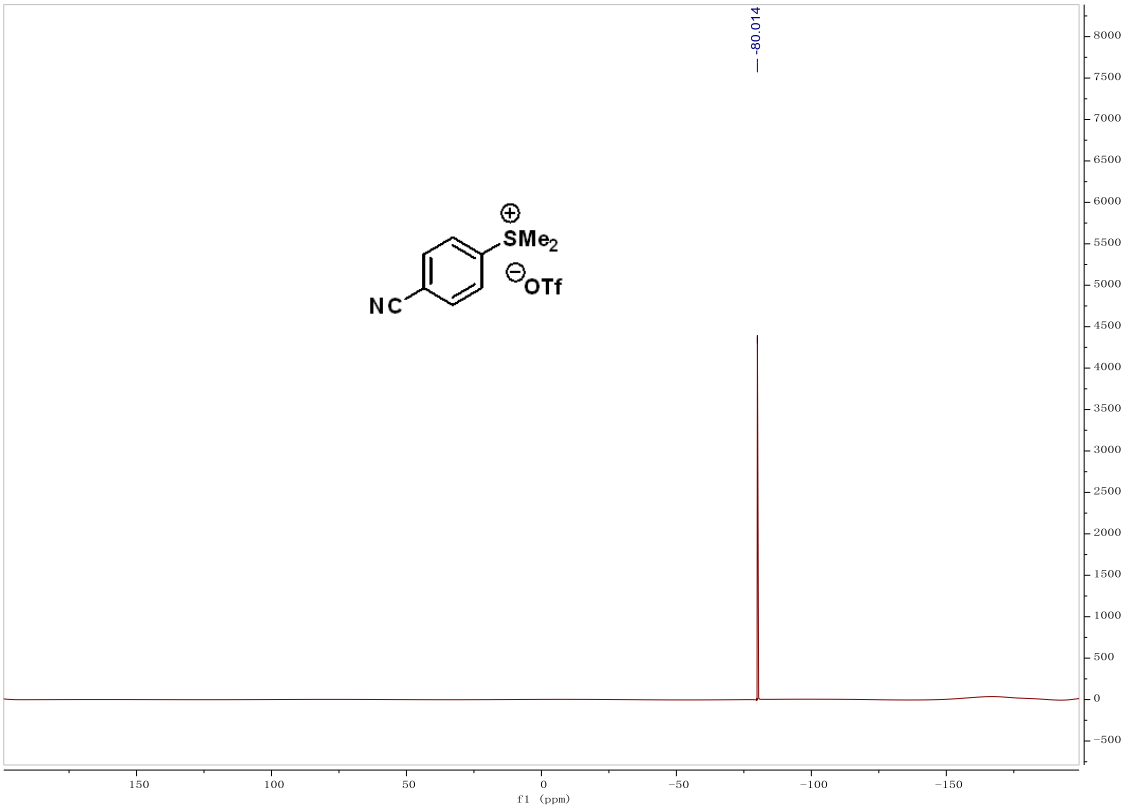
7. Copies of NMR spectra data

^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1a



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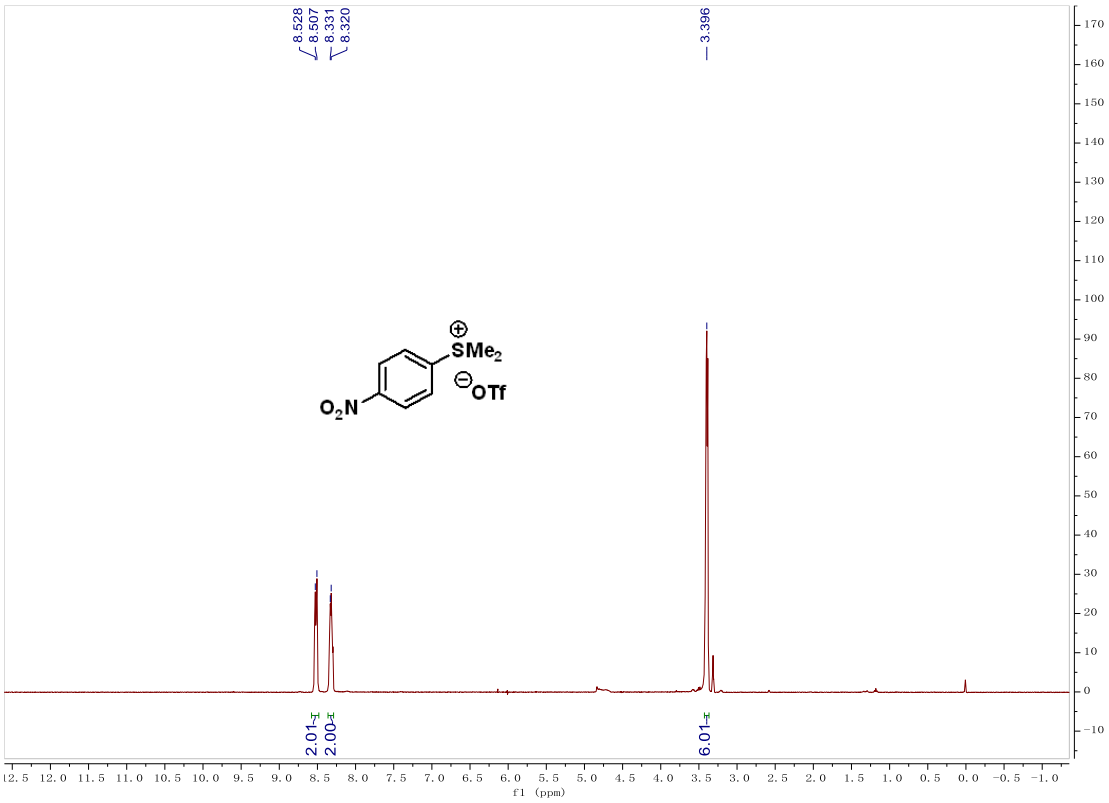
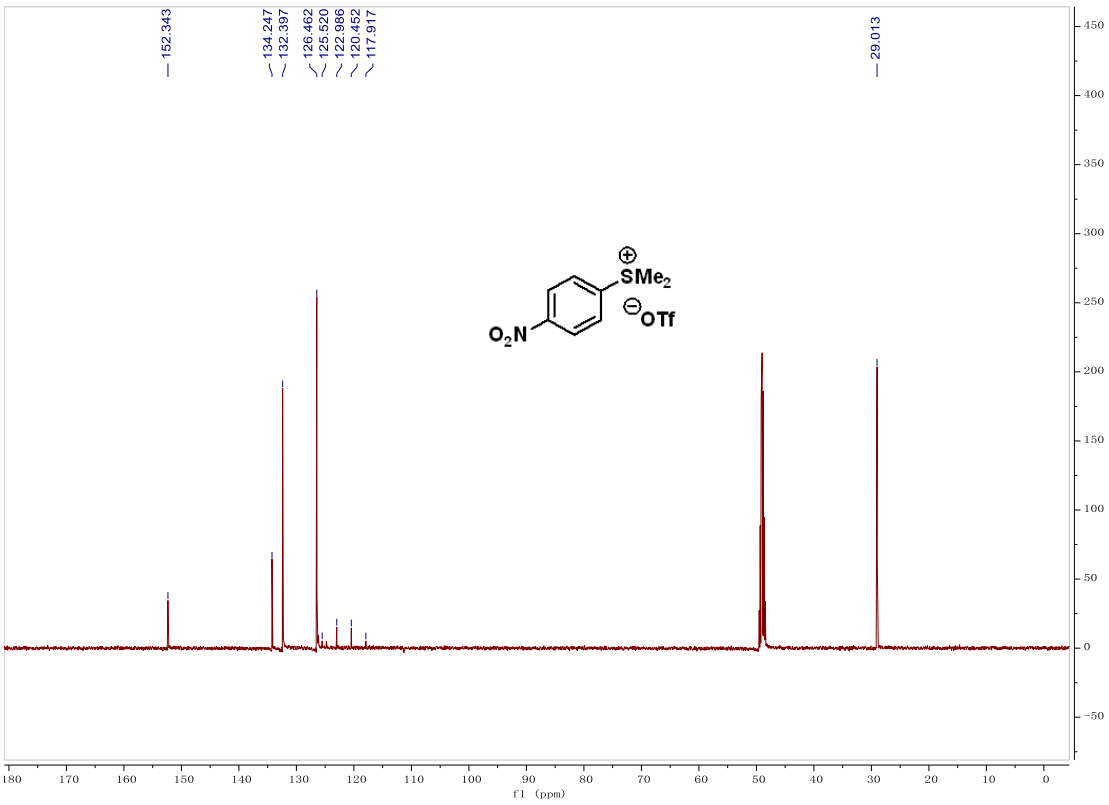
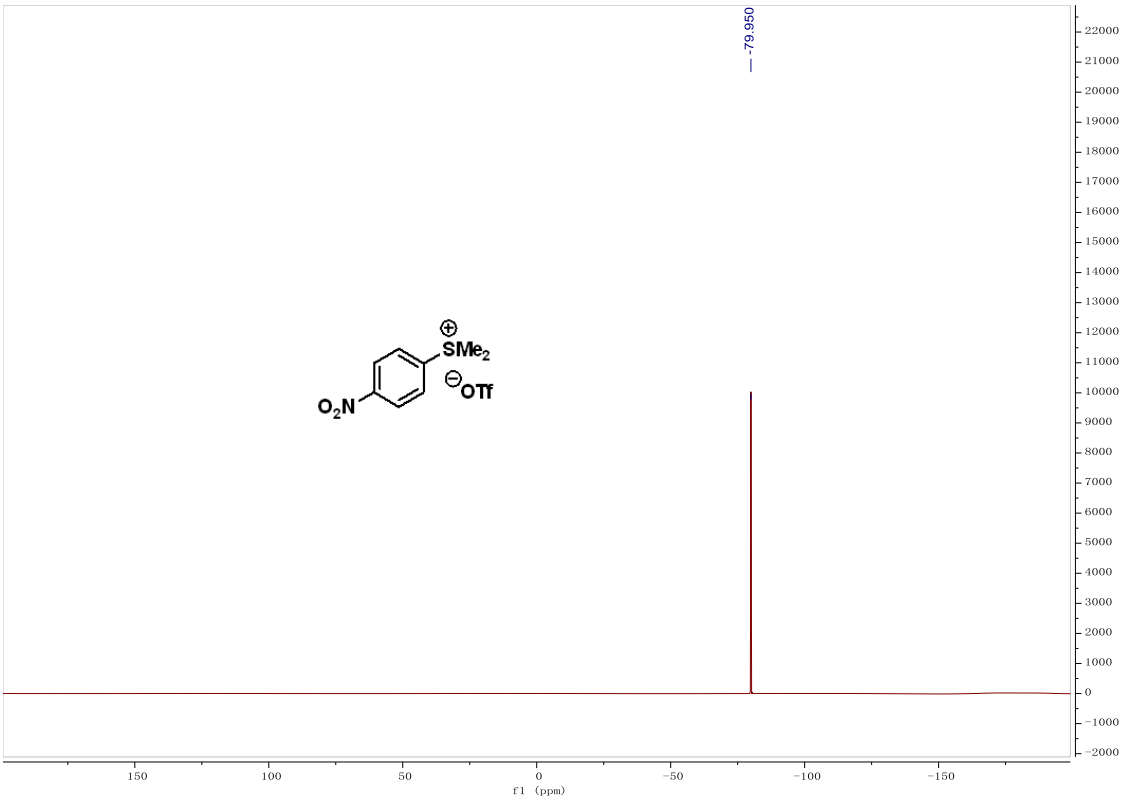
f1 (ppm)

^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1b



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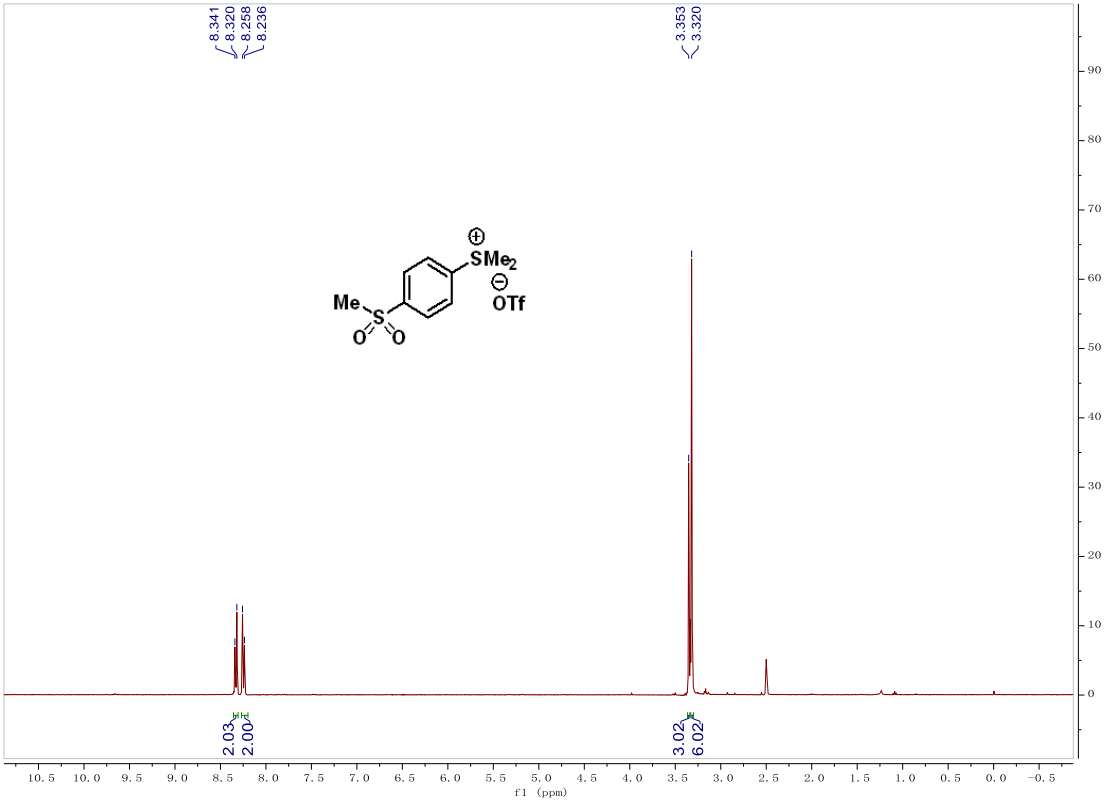
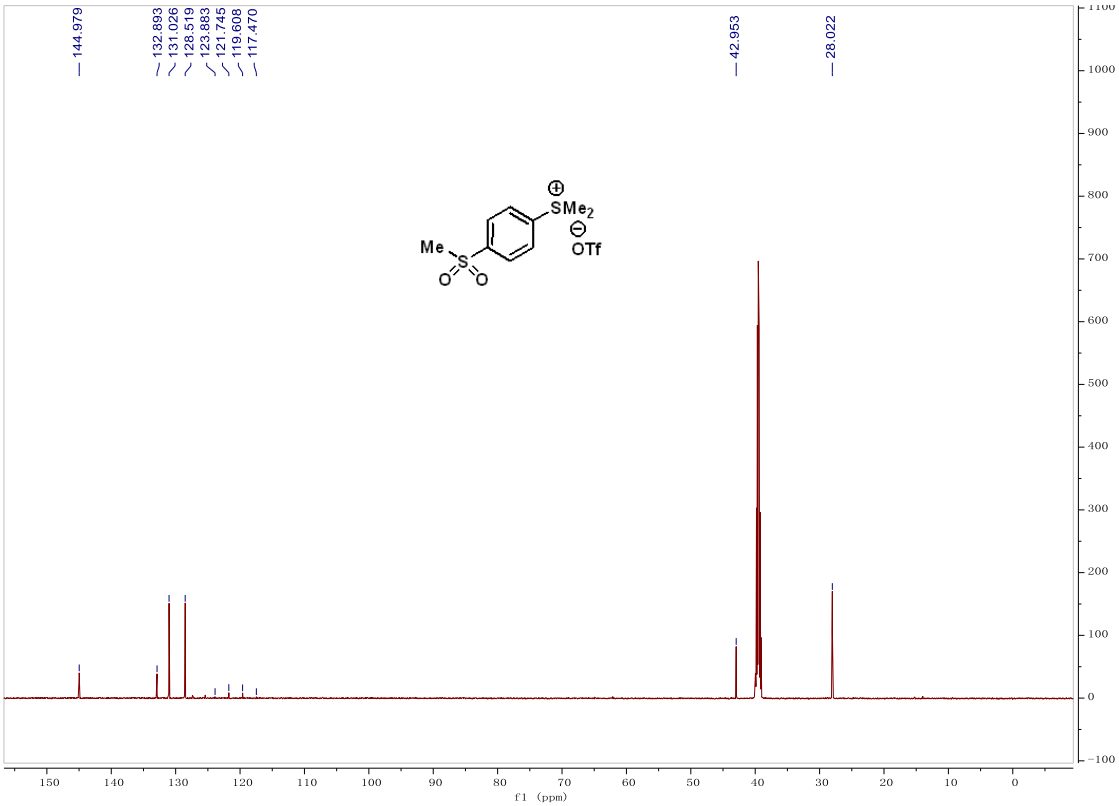
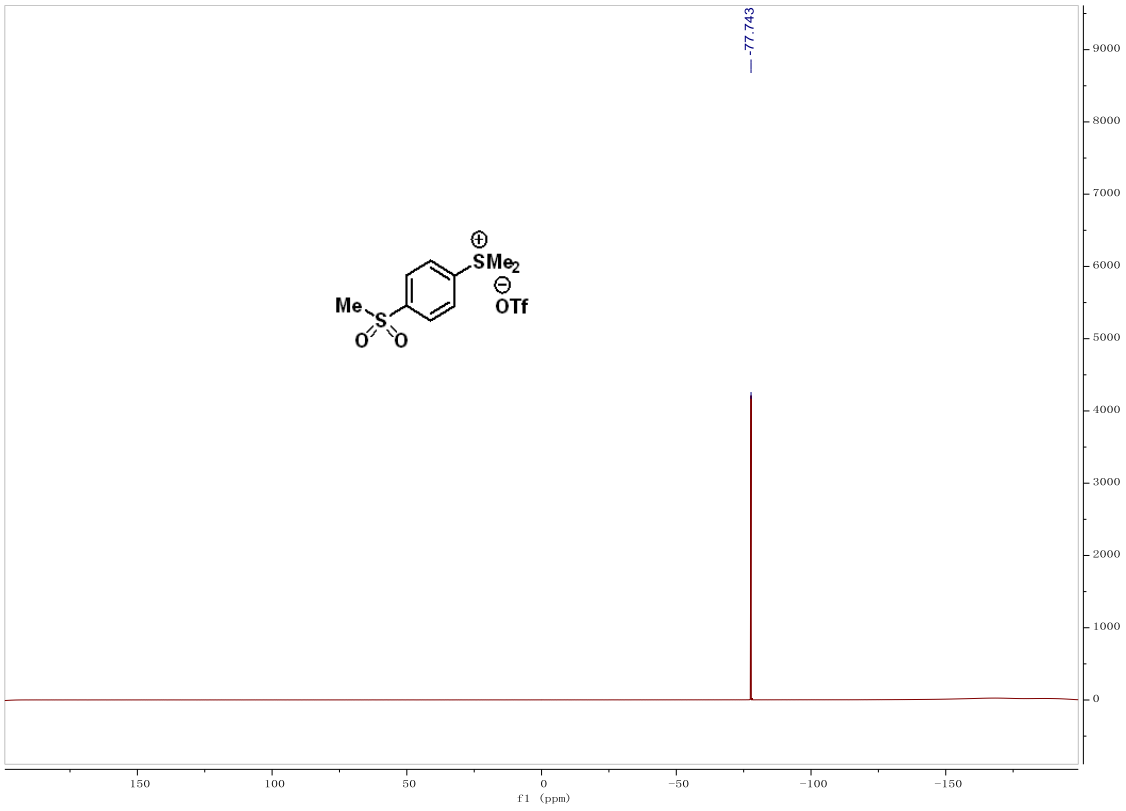
f1 (ppm)

^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1c



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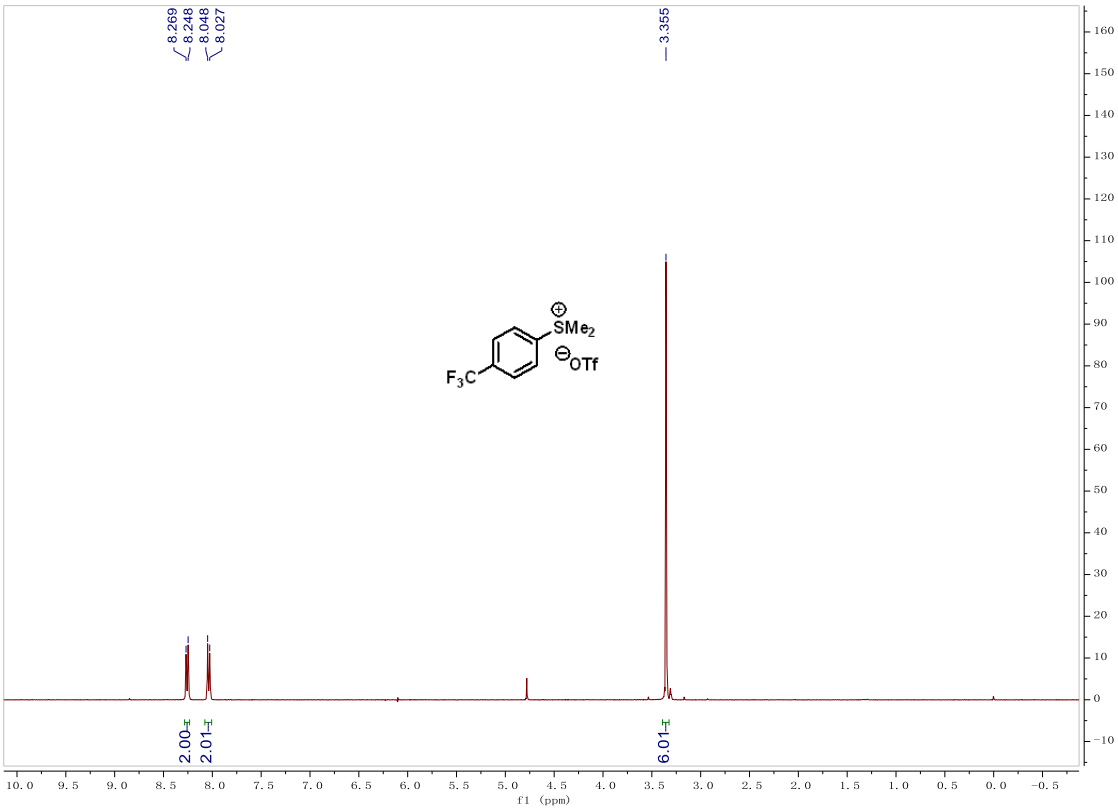
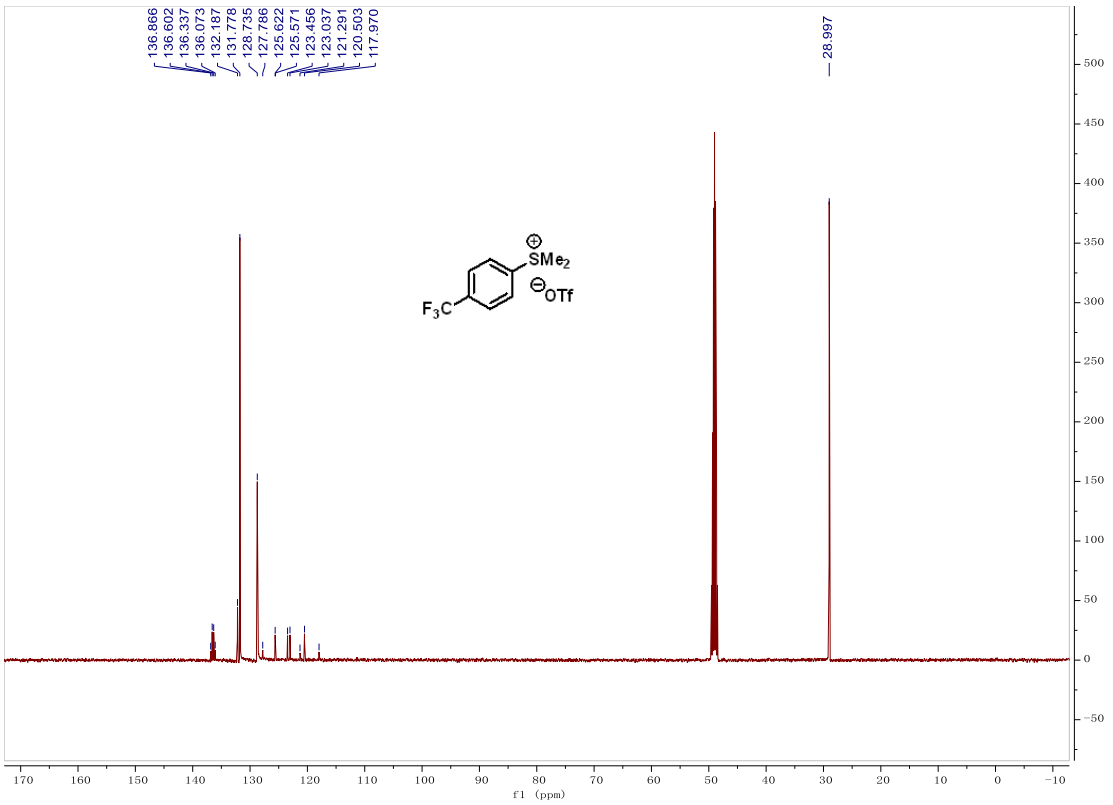
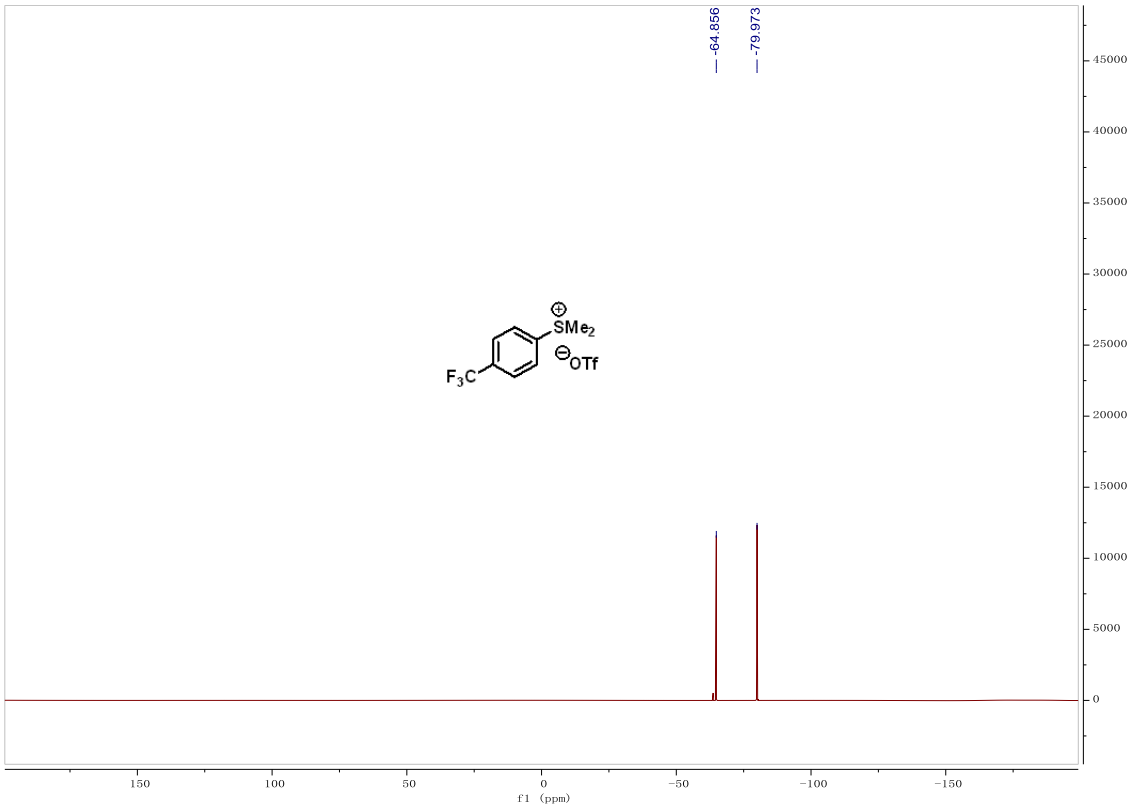
f1 (ppm)

^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1d



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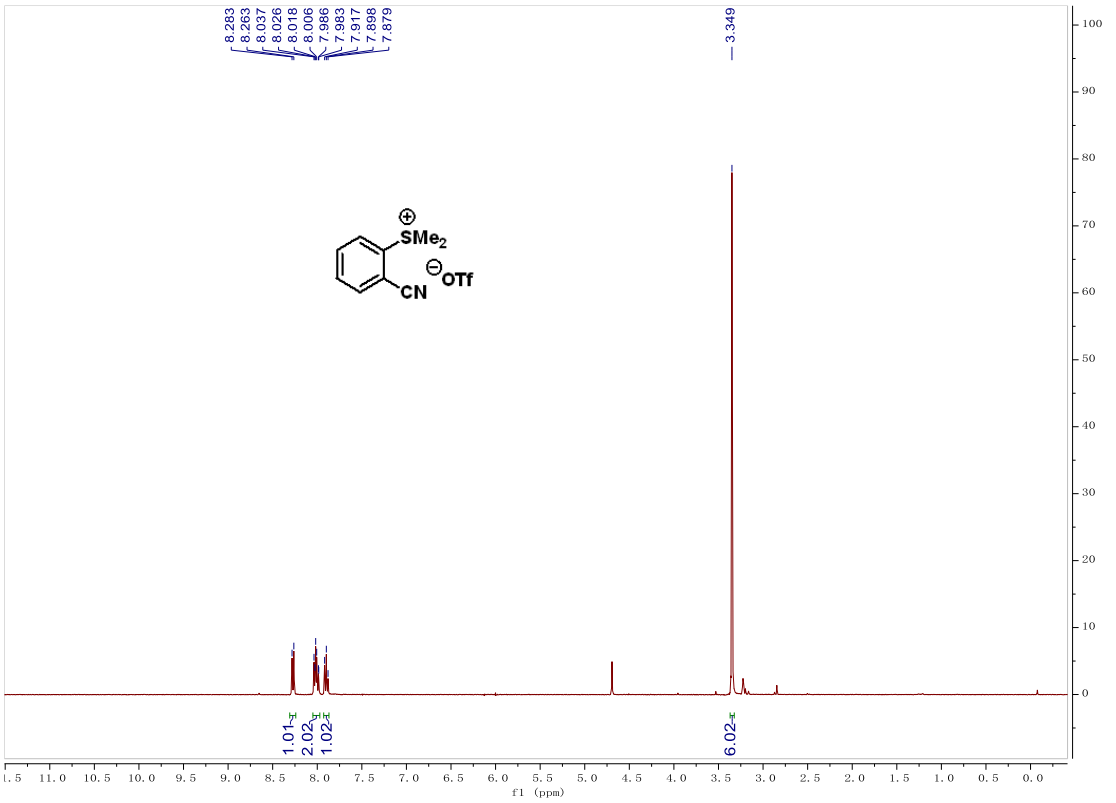
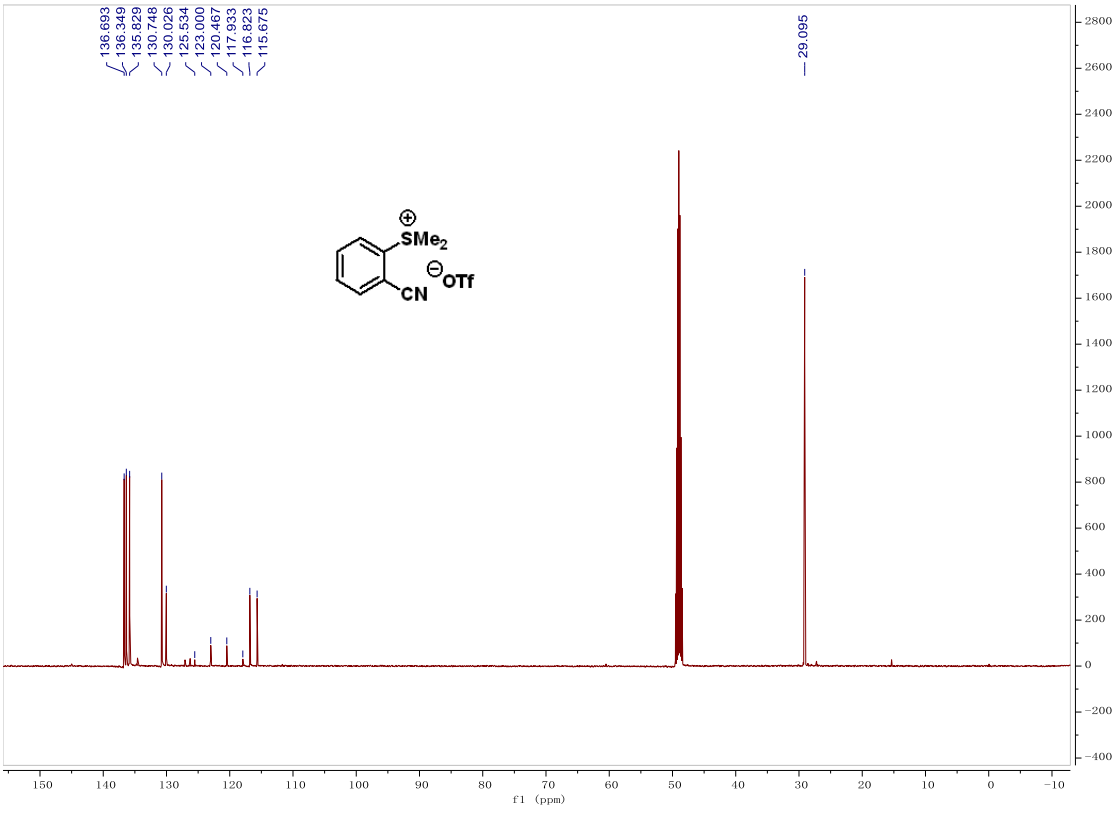
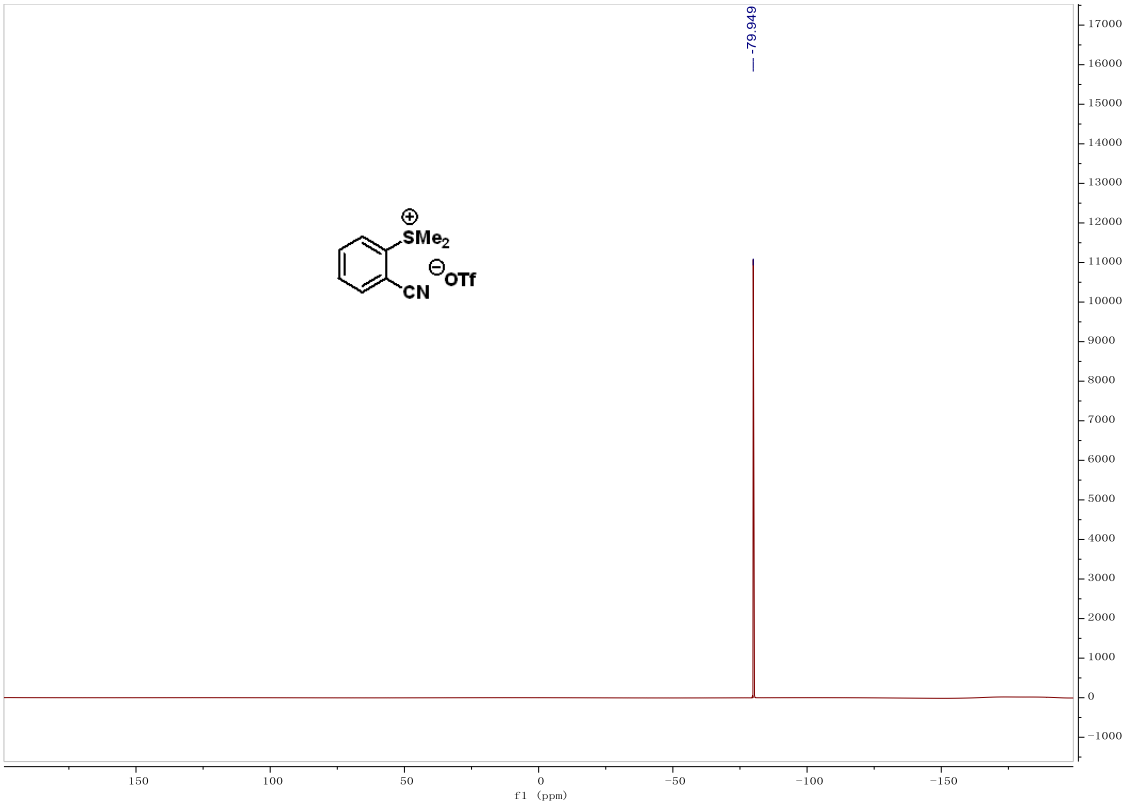
SMe2
OTf
F3C

^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1e



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8000
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6000
5000
4000
3000
2000
1000
0
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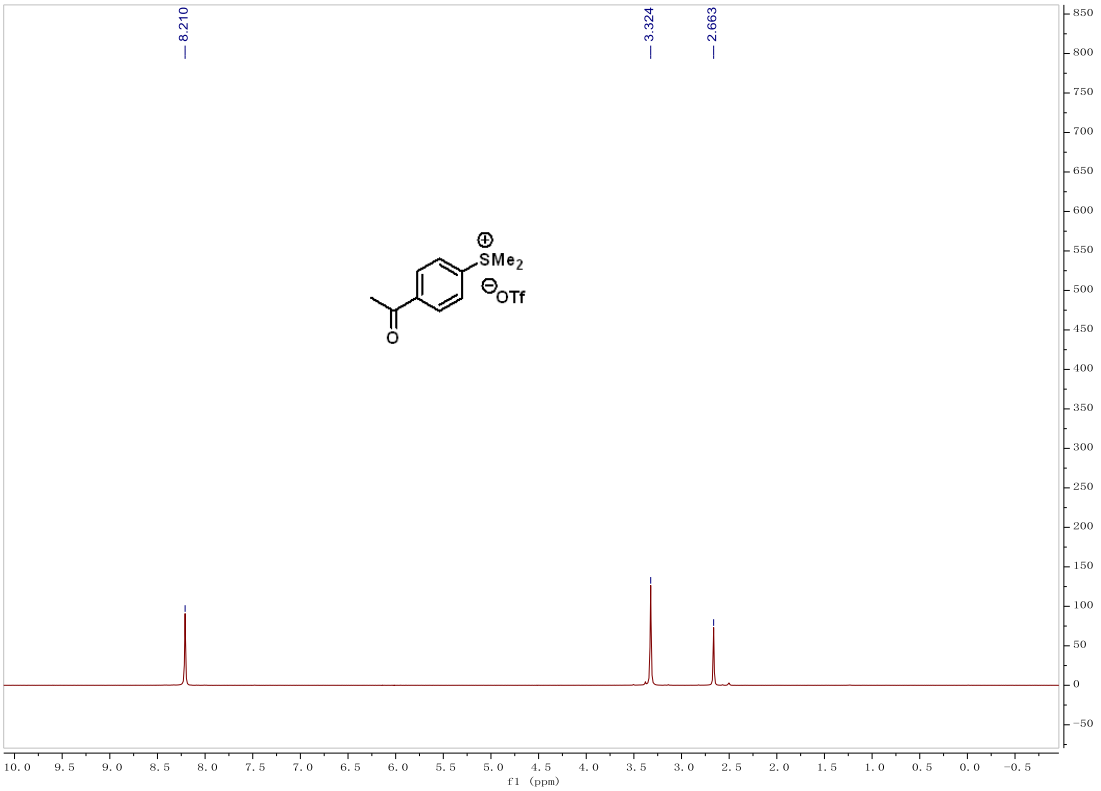
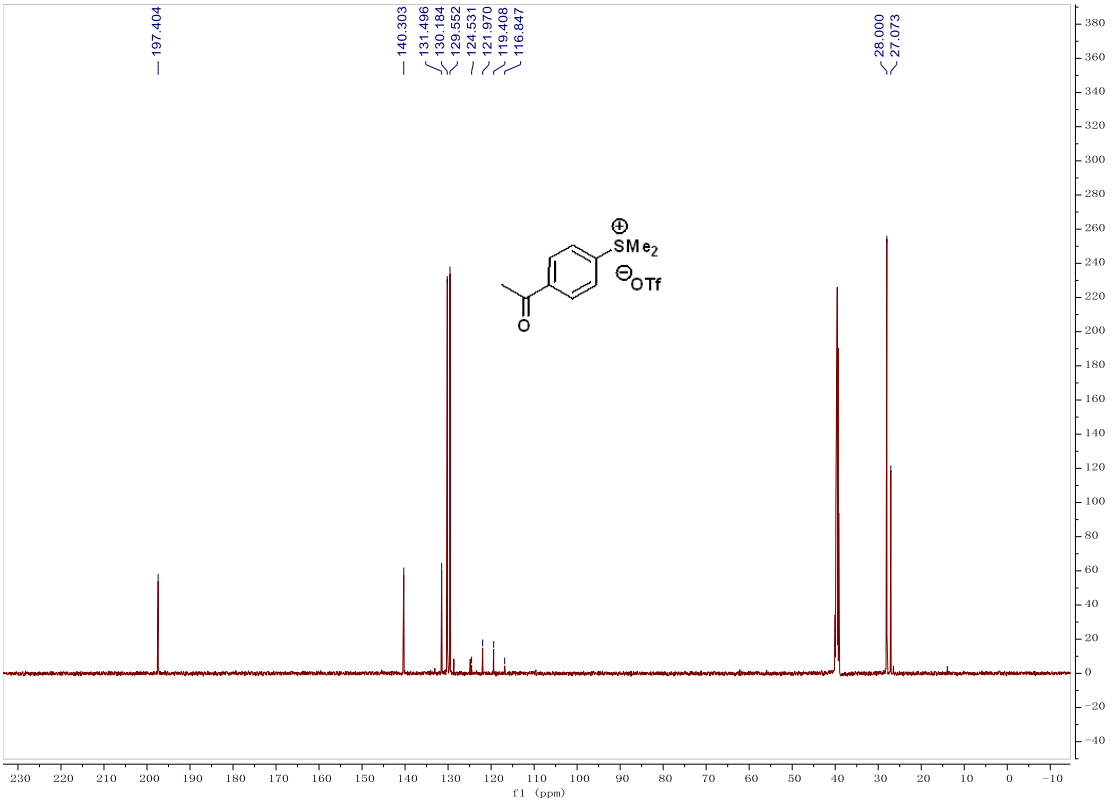
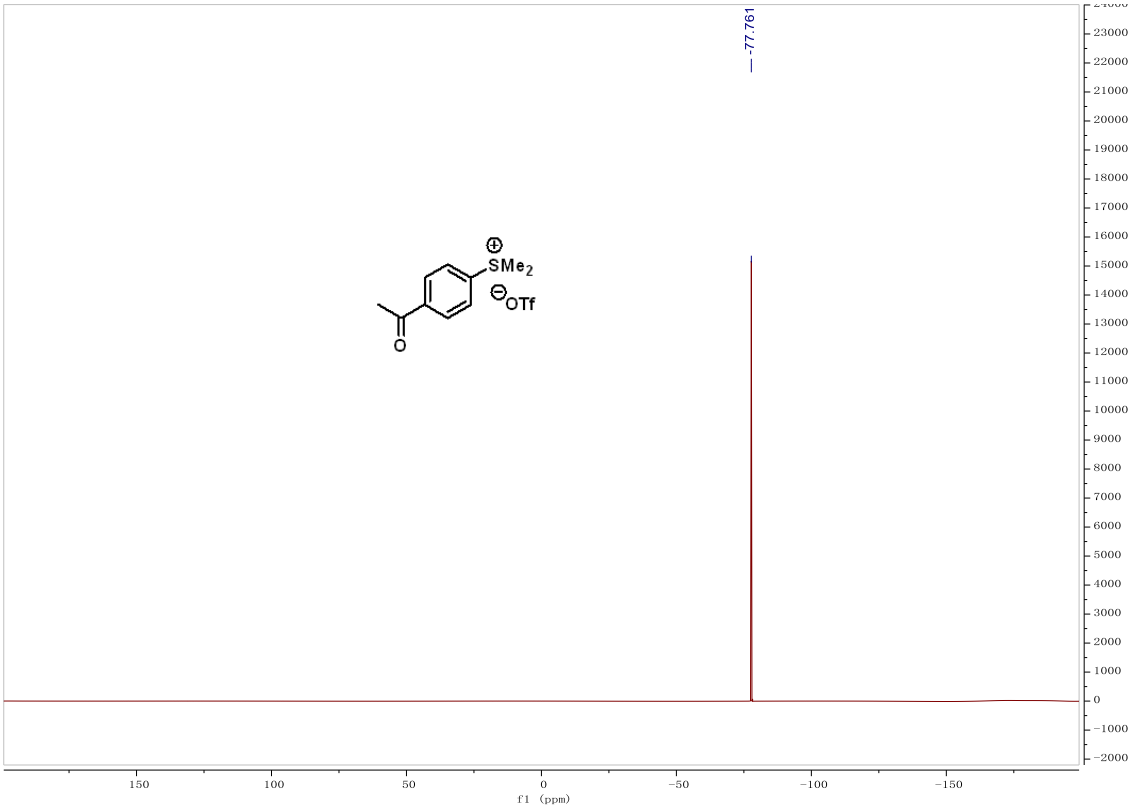
150
100
50
0
-50
-100
-150
f1 (ppm)

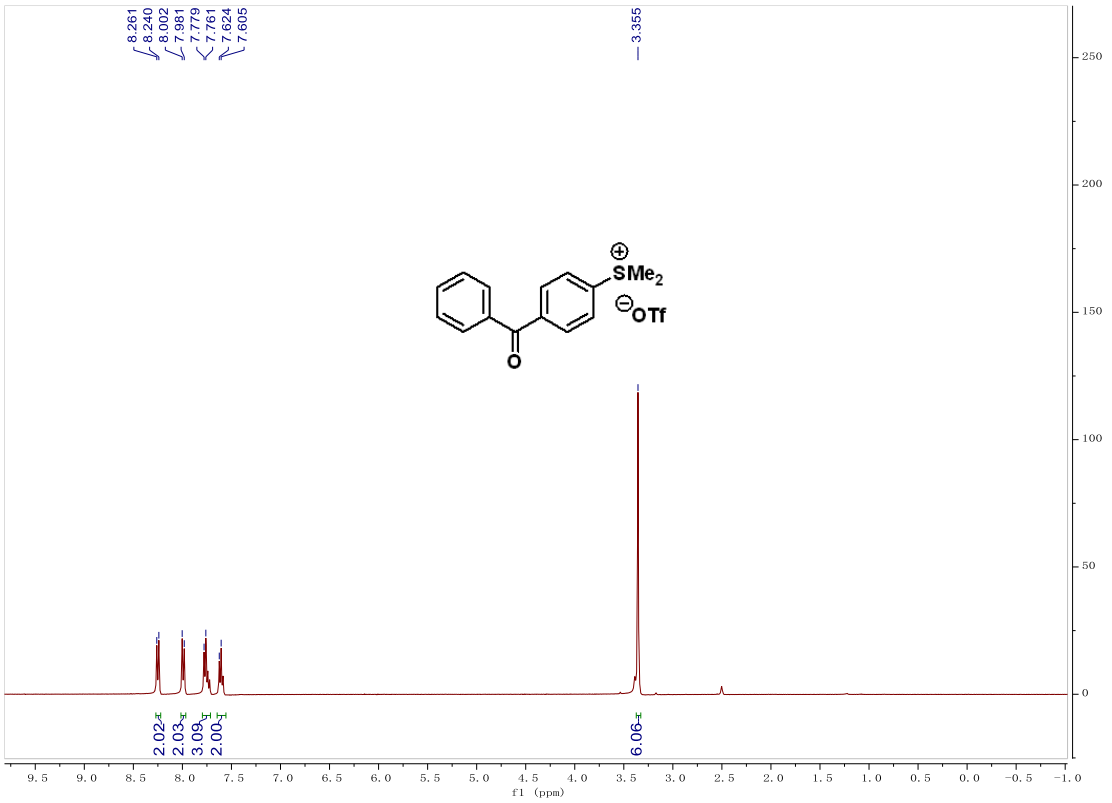
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1f

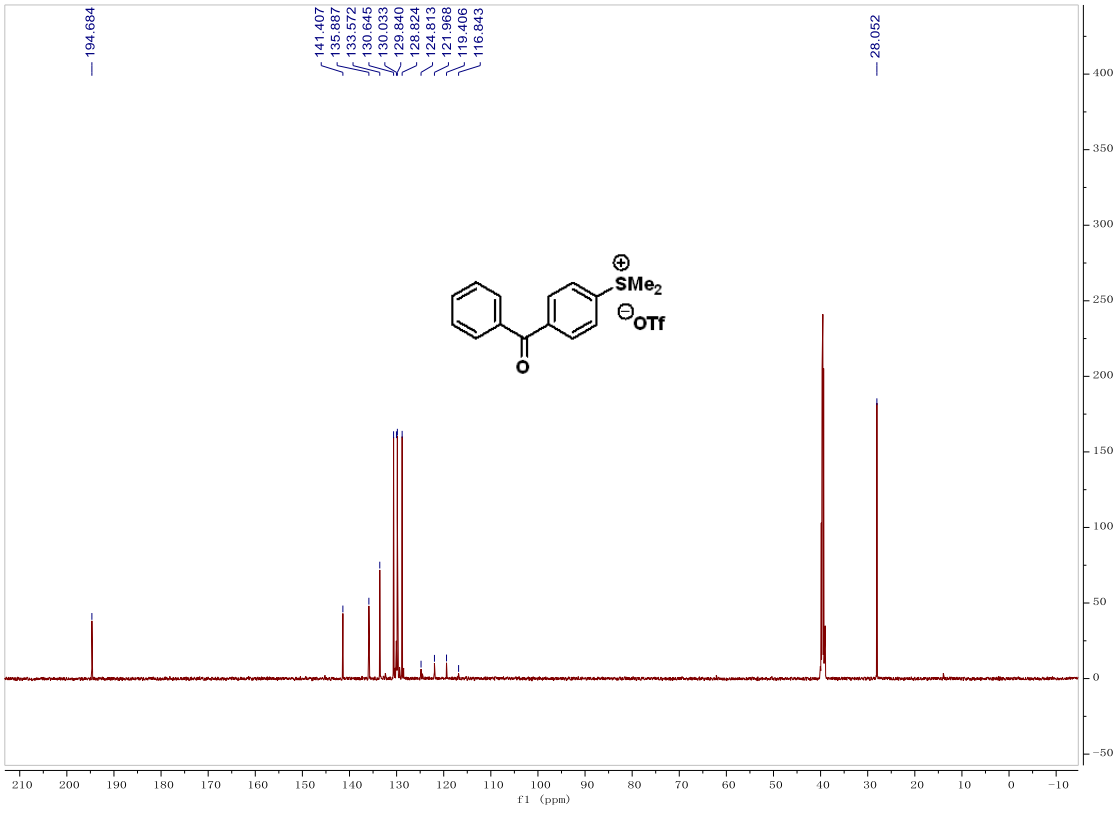


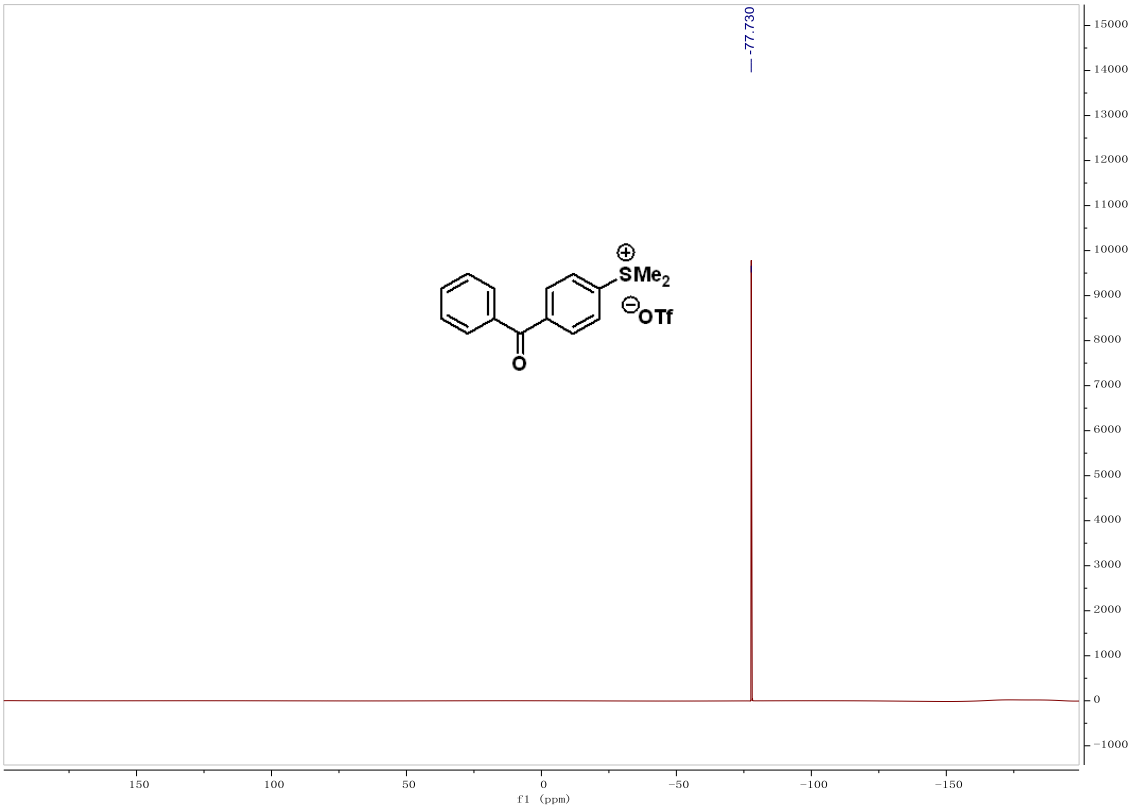



-77.761
SMe2
OTf
O
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
150
100
50
0
-50
-100
-150
f1 (ppm)

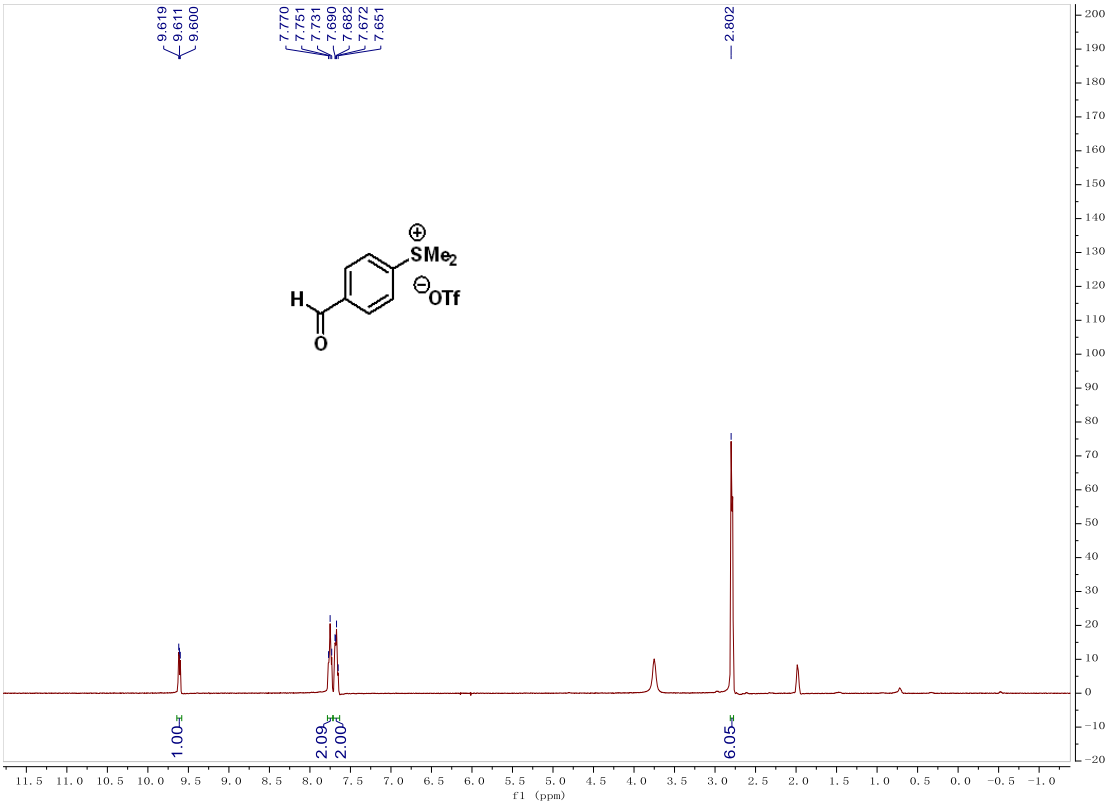
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1g

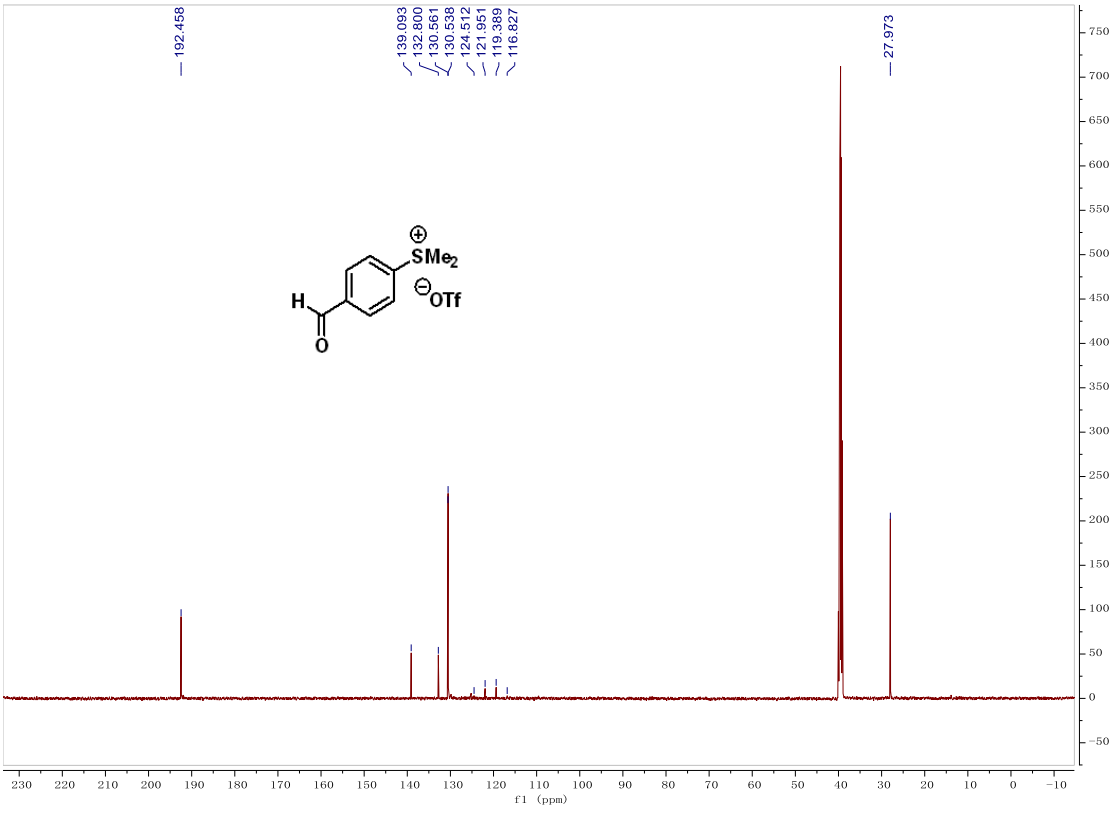


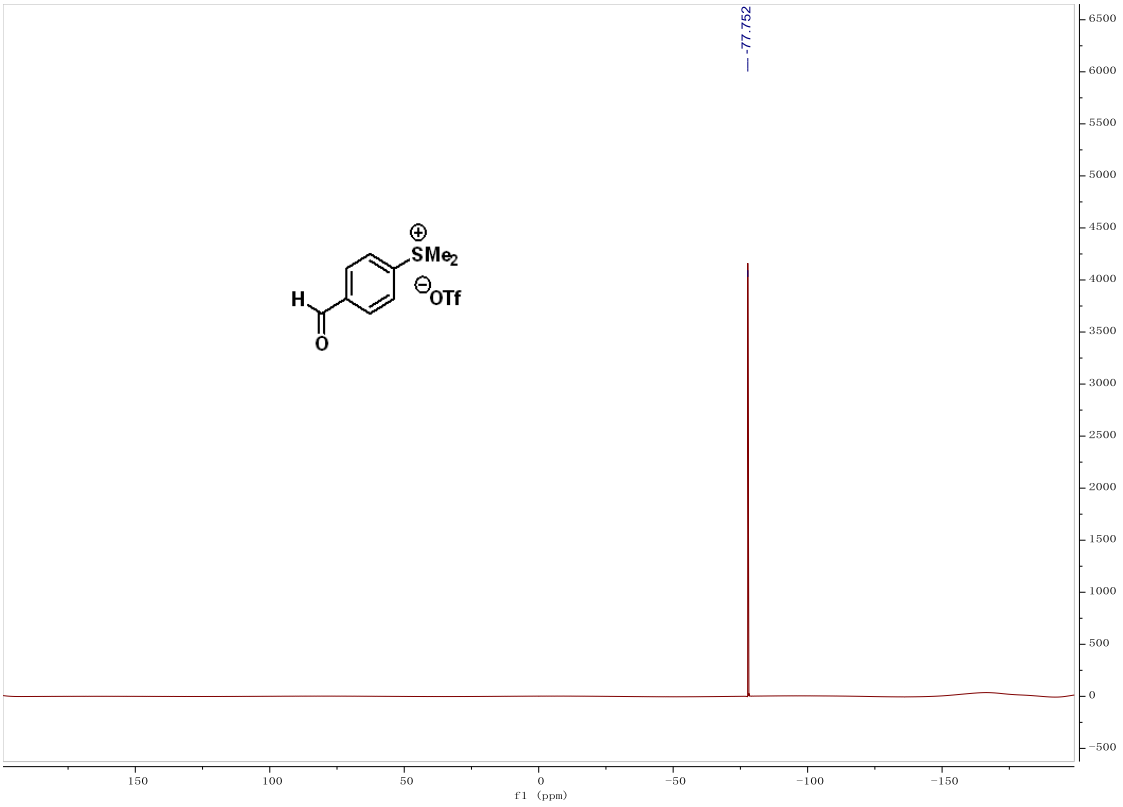



-77.730
SMe2
OTf
O
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
150
100
50
0
-50
-100
-150
f1 (ppm)

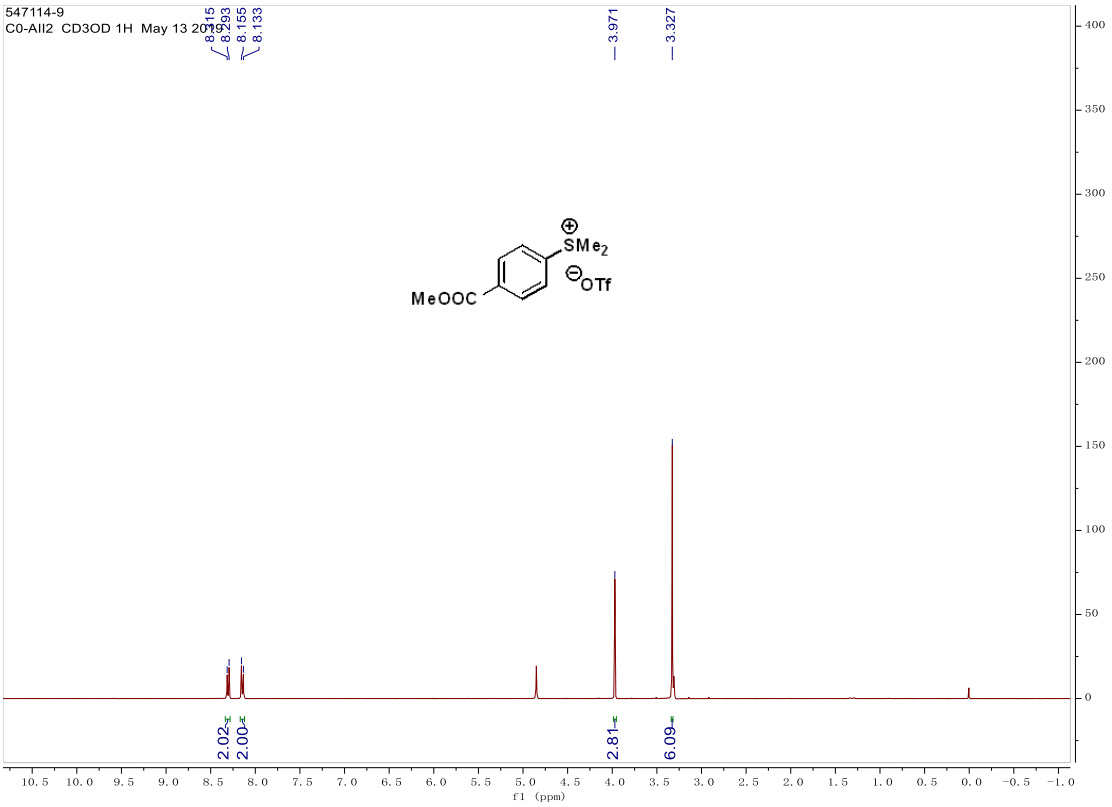
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1h

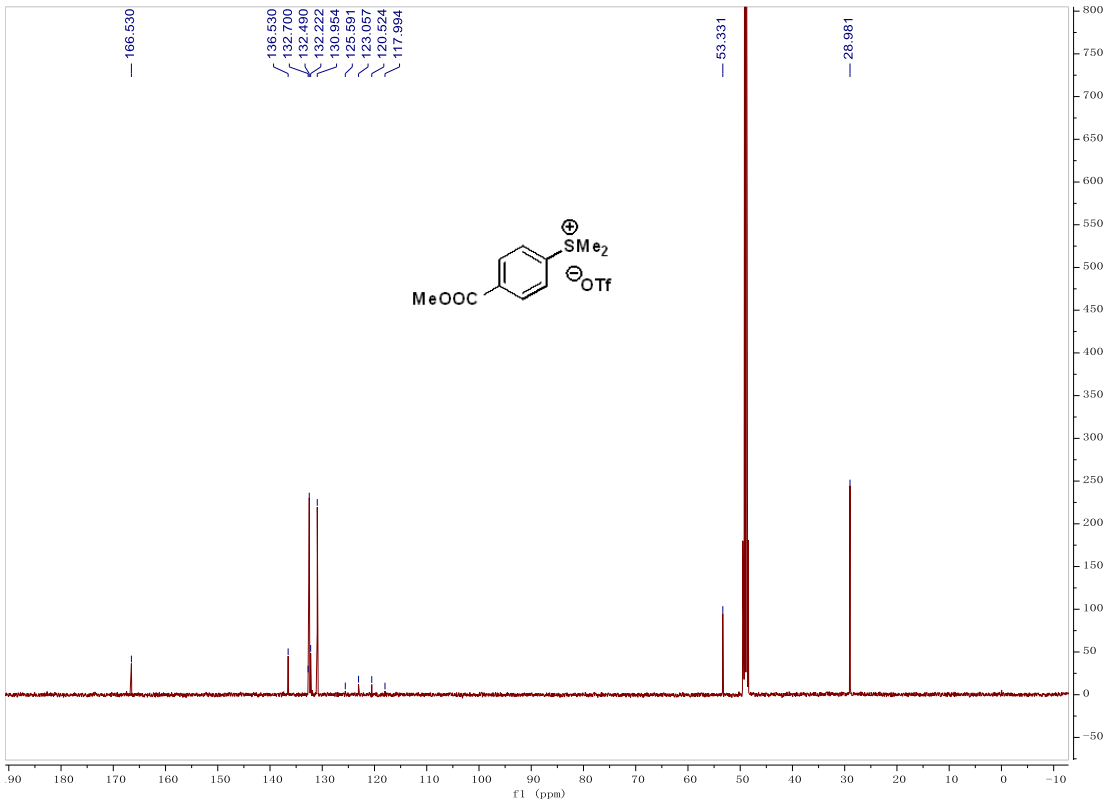


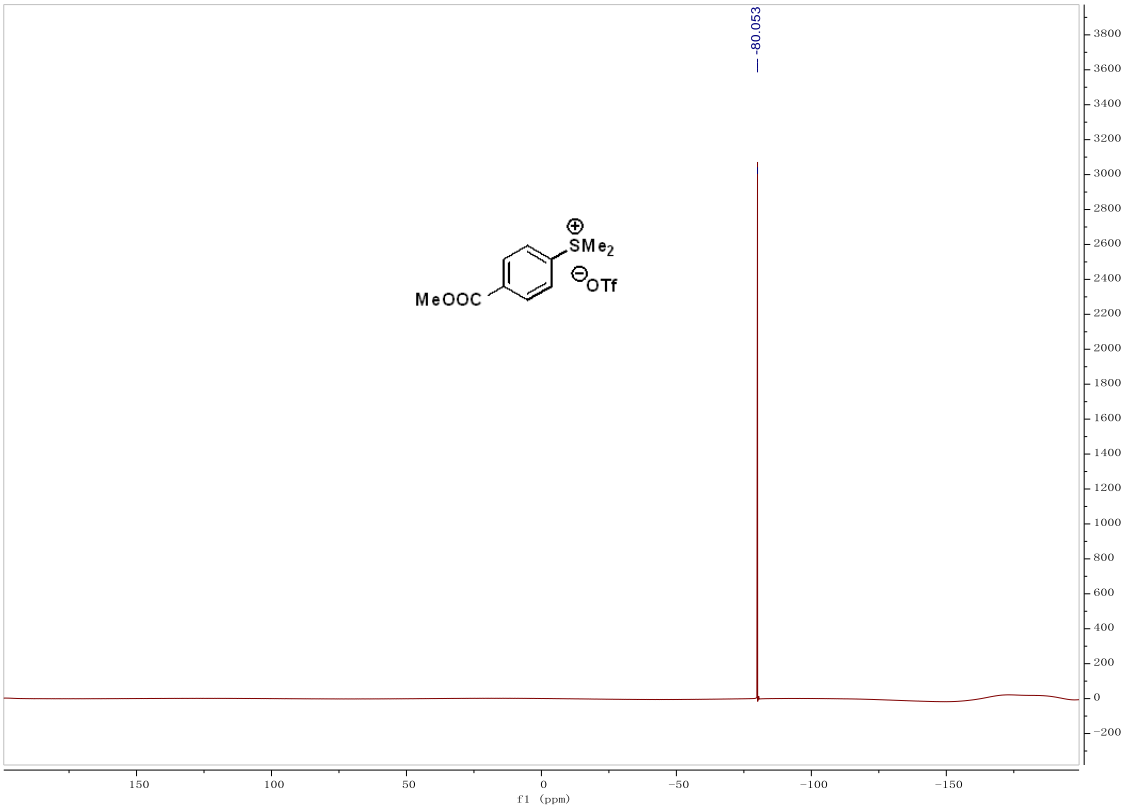



-77.752
SMe2
OTf
H
O
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
150
100
50
0
−50
−100
−150
f1 (ppm)

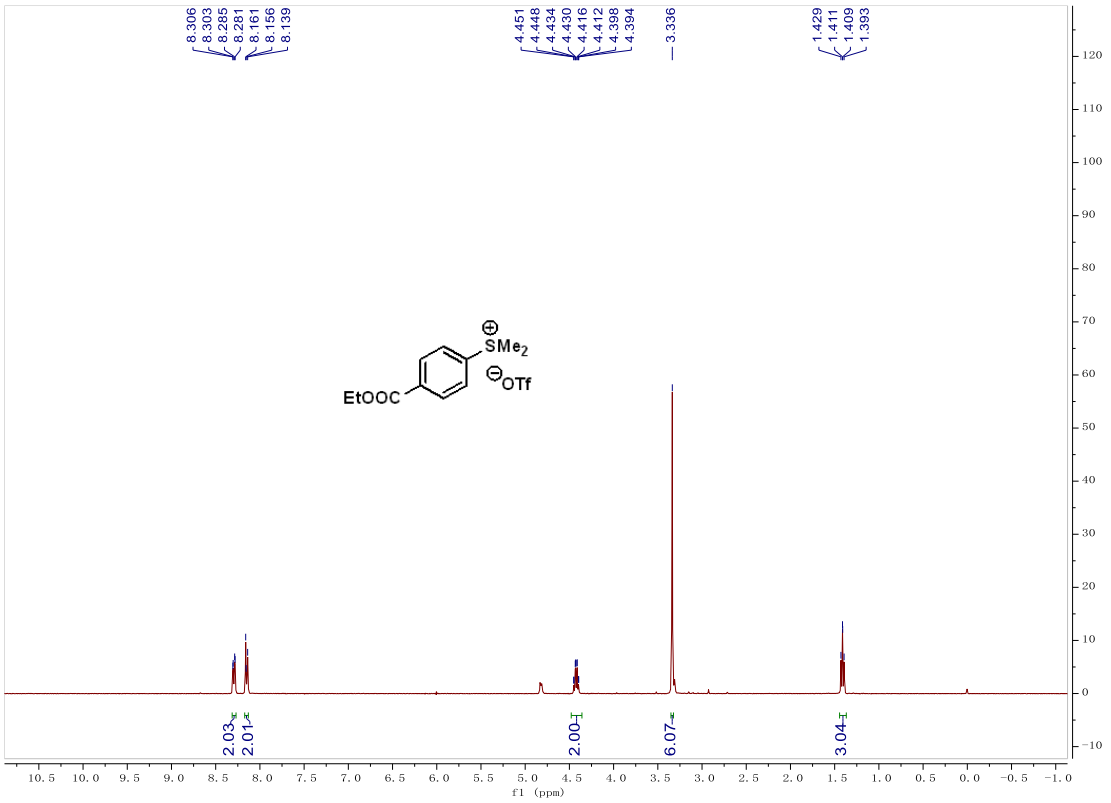
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1i

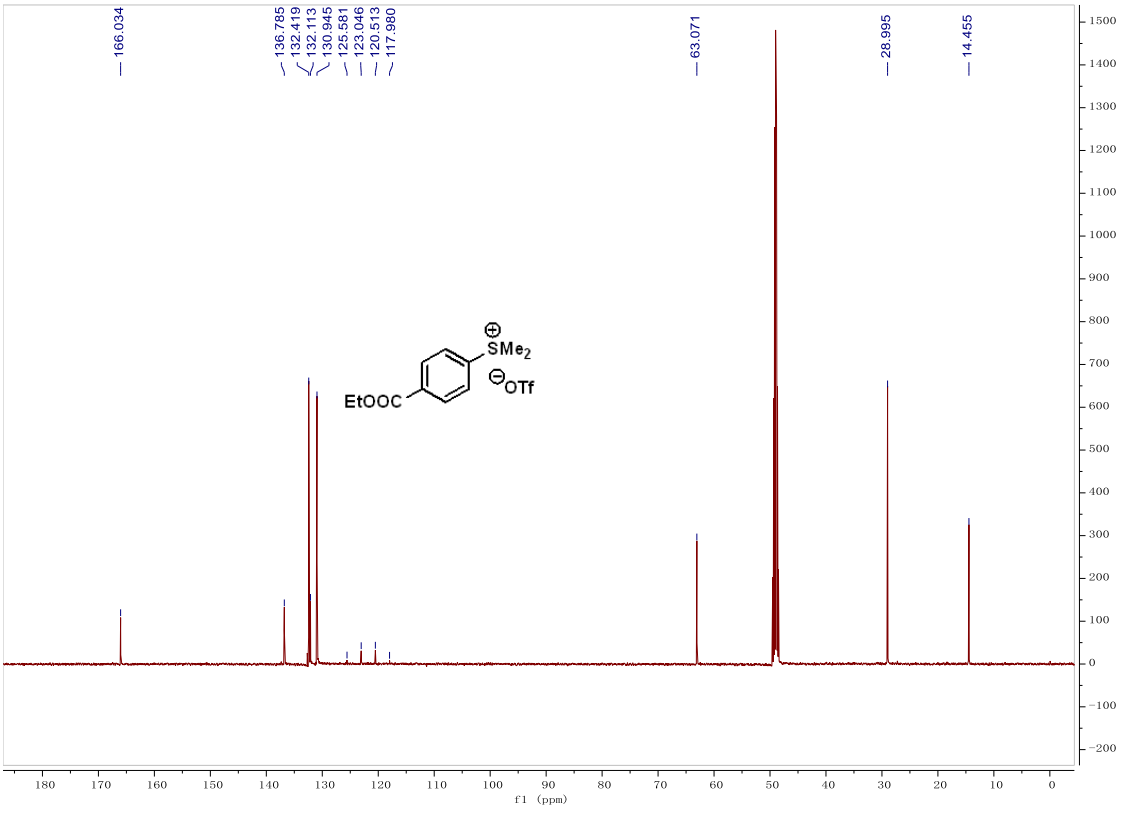


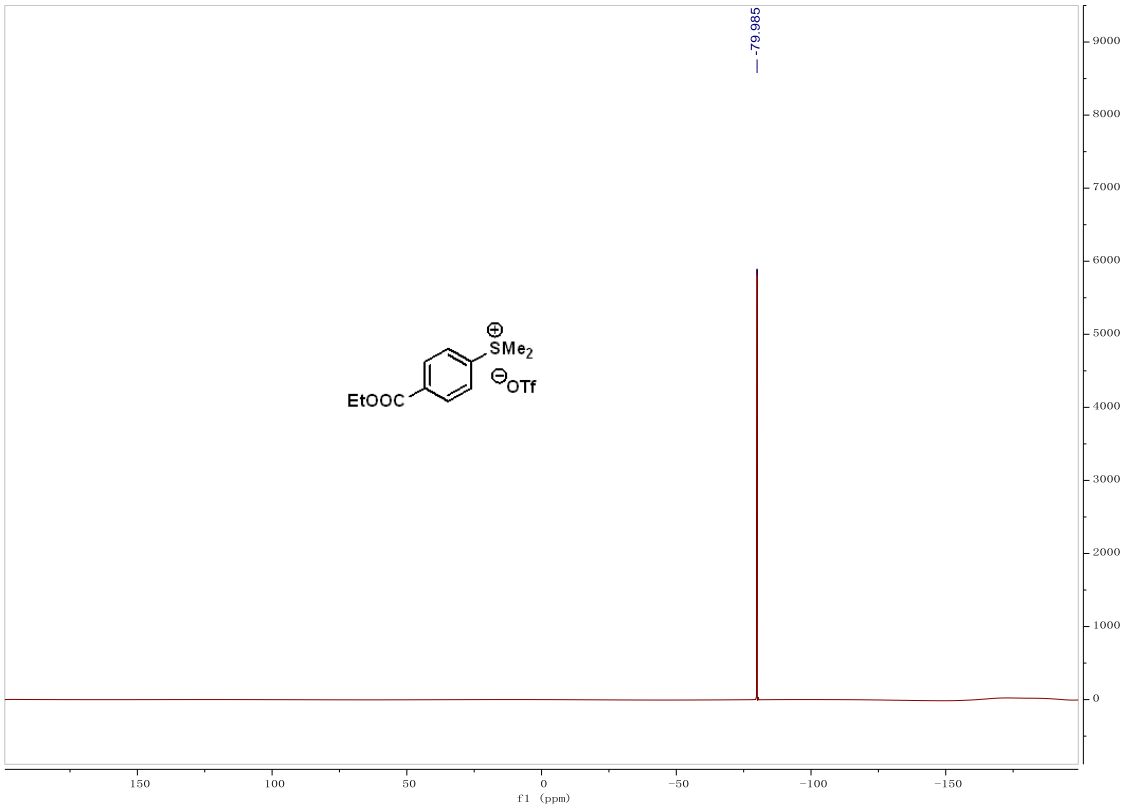



-80.053
SMe2
OTf
MeOOC
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
150
100
50
0
−50
−100
−150
f1 (ppm)

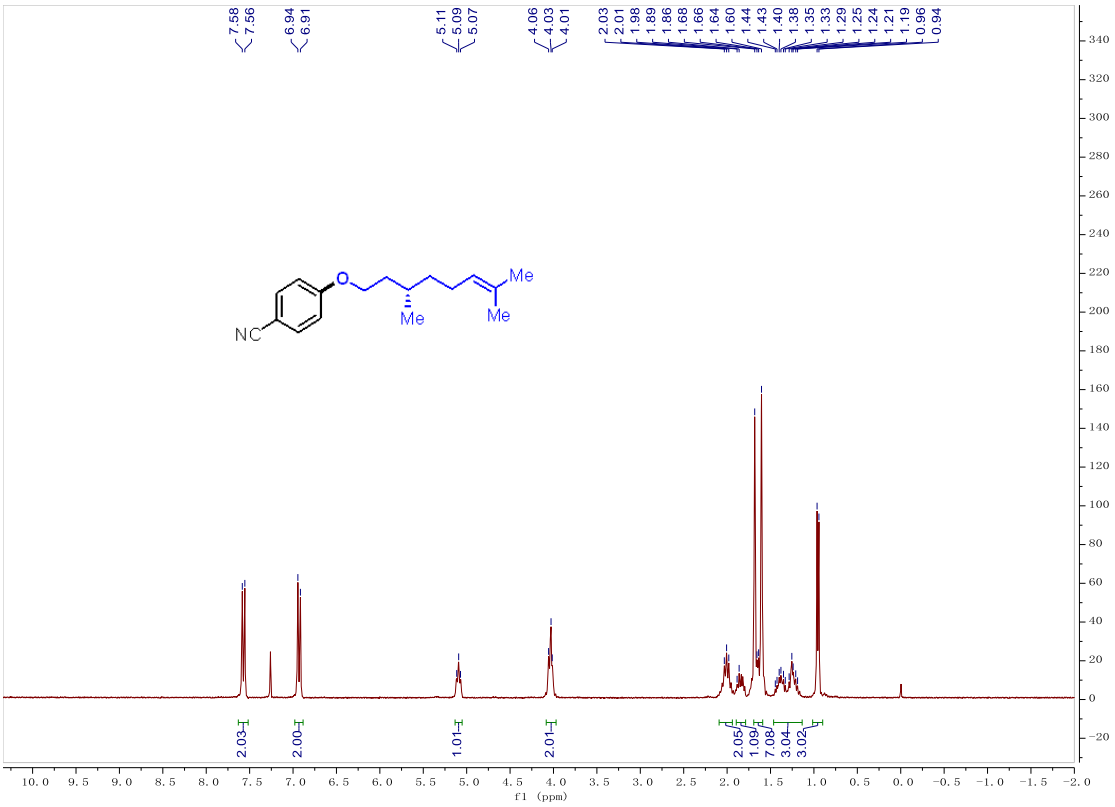
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 1j

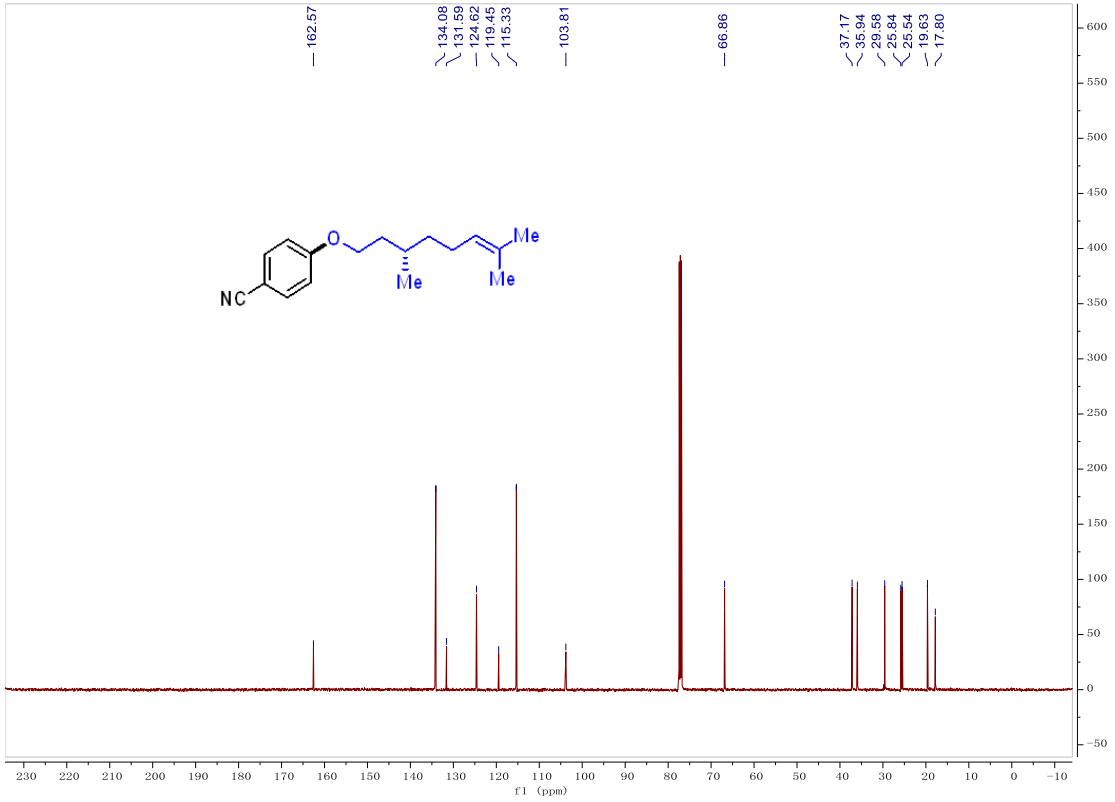




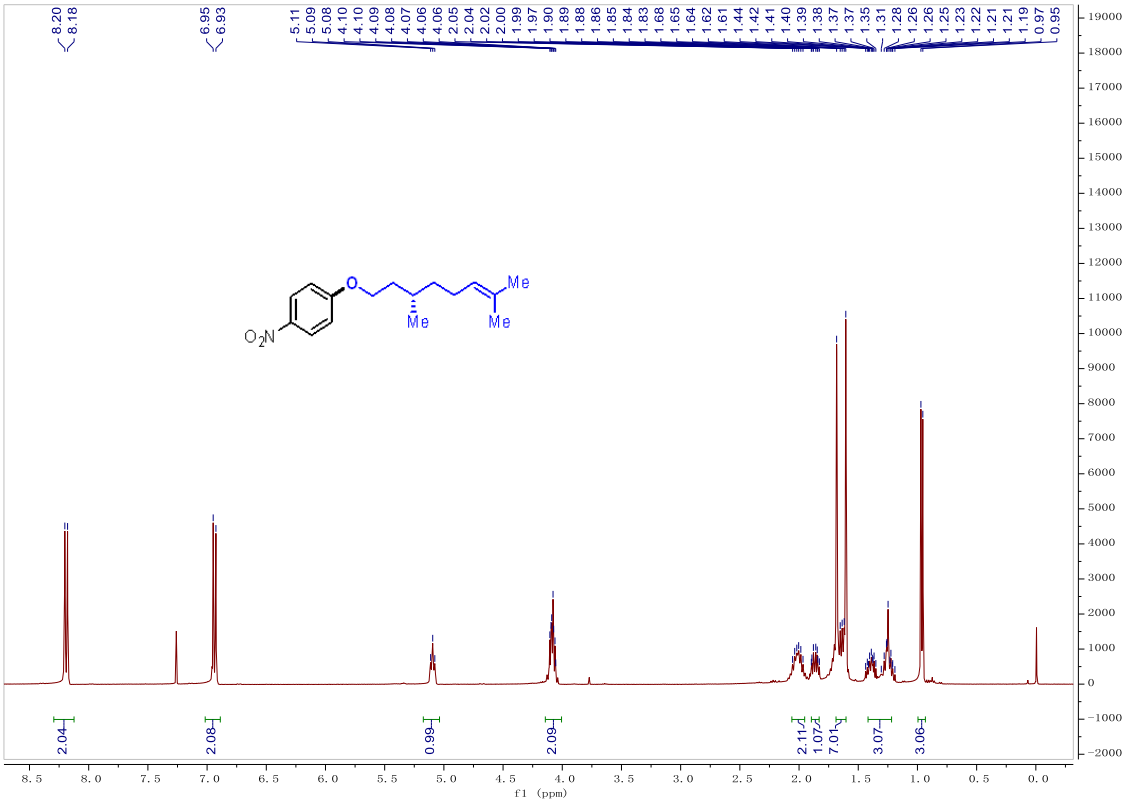

-79.985
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
150
100
50
0
−50
−100
−150
f1 (ppm)
SMe2
OTf
EtOOC

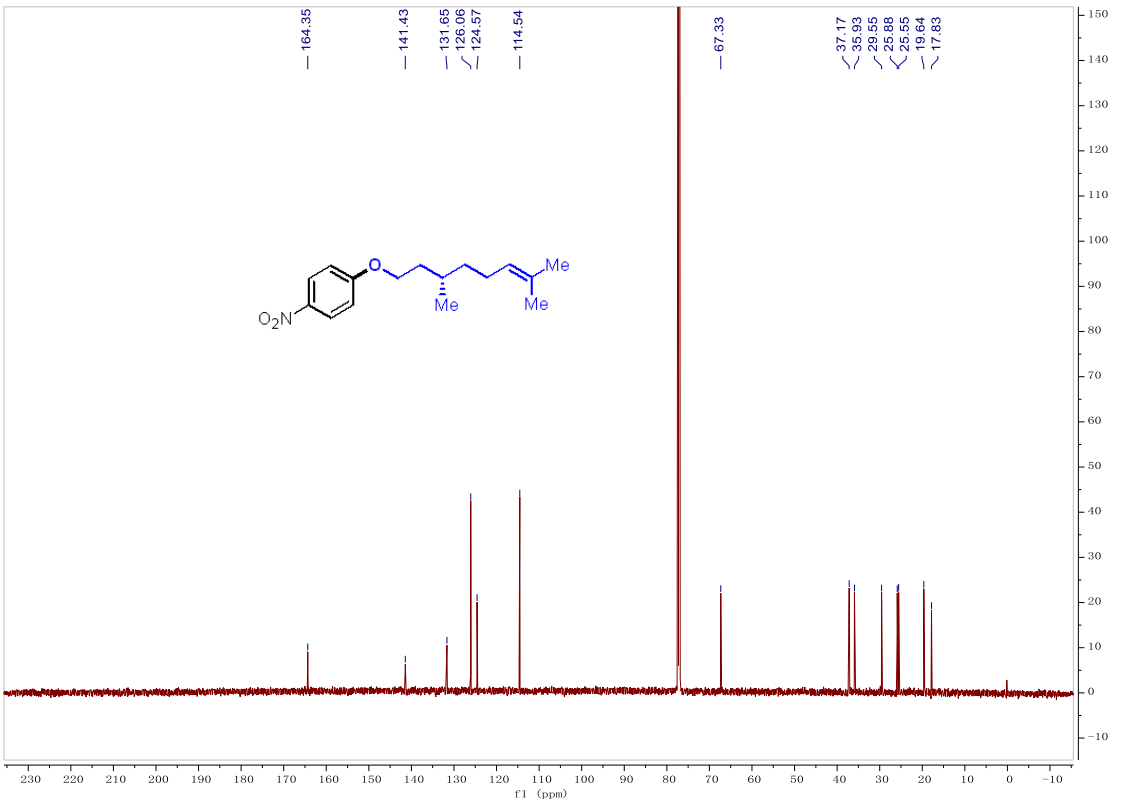
^{1}H and ^{13}C NMR spectra of compound 3a



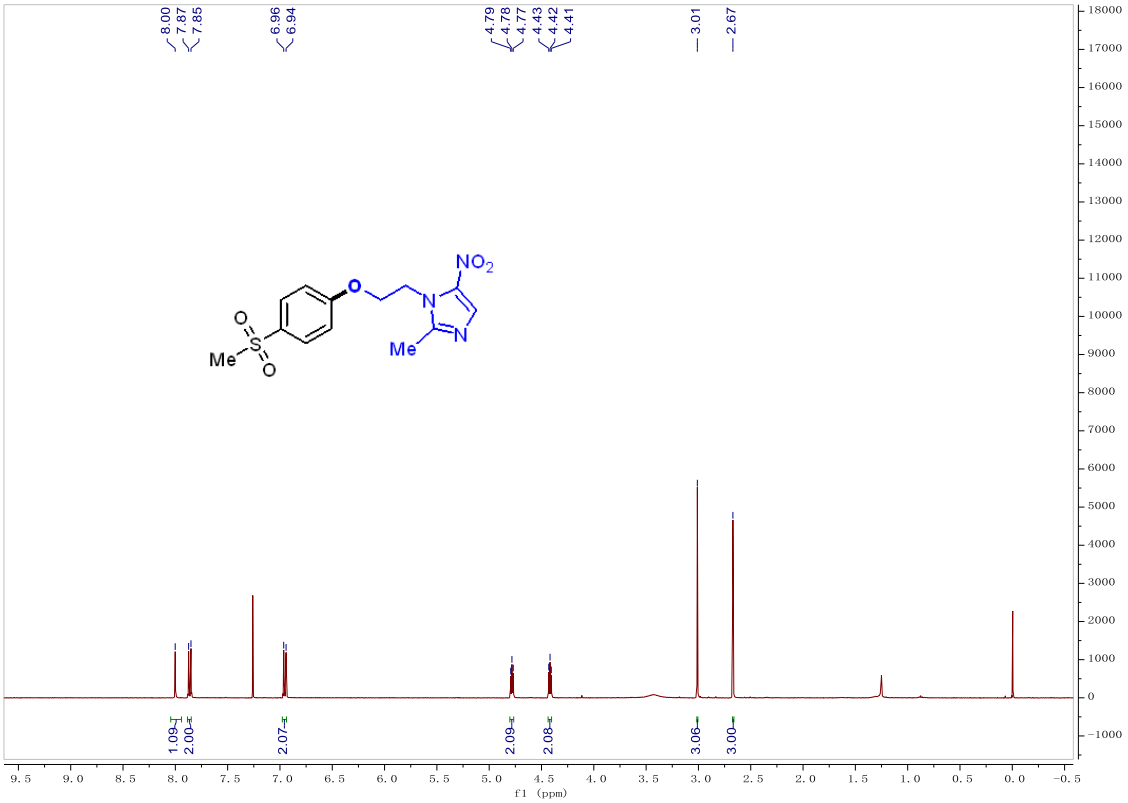


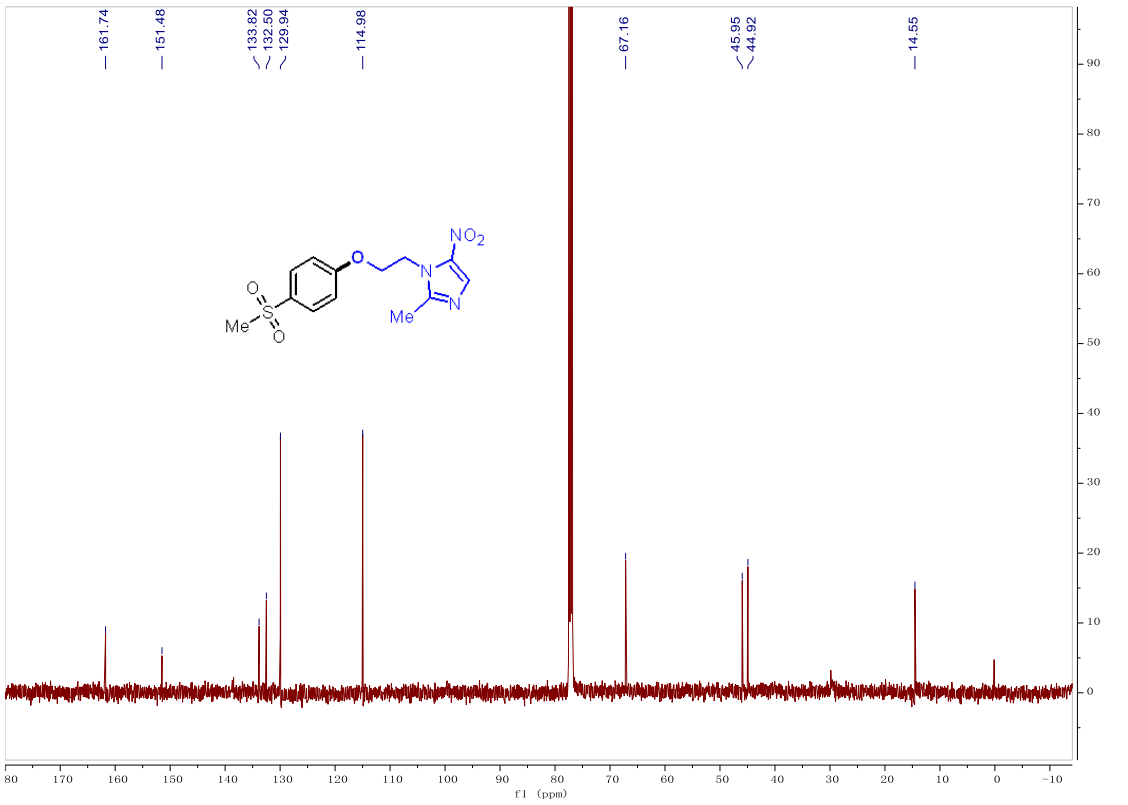
^{1}H and ^{13}C NMR spectra of compound 3b



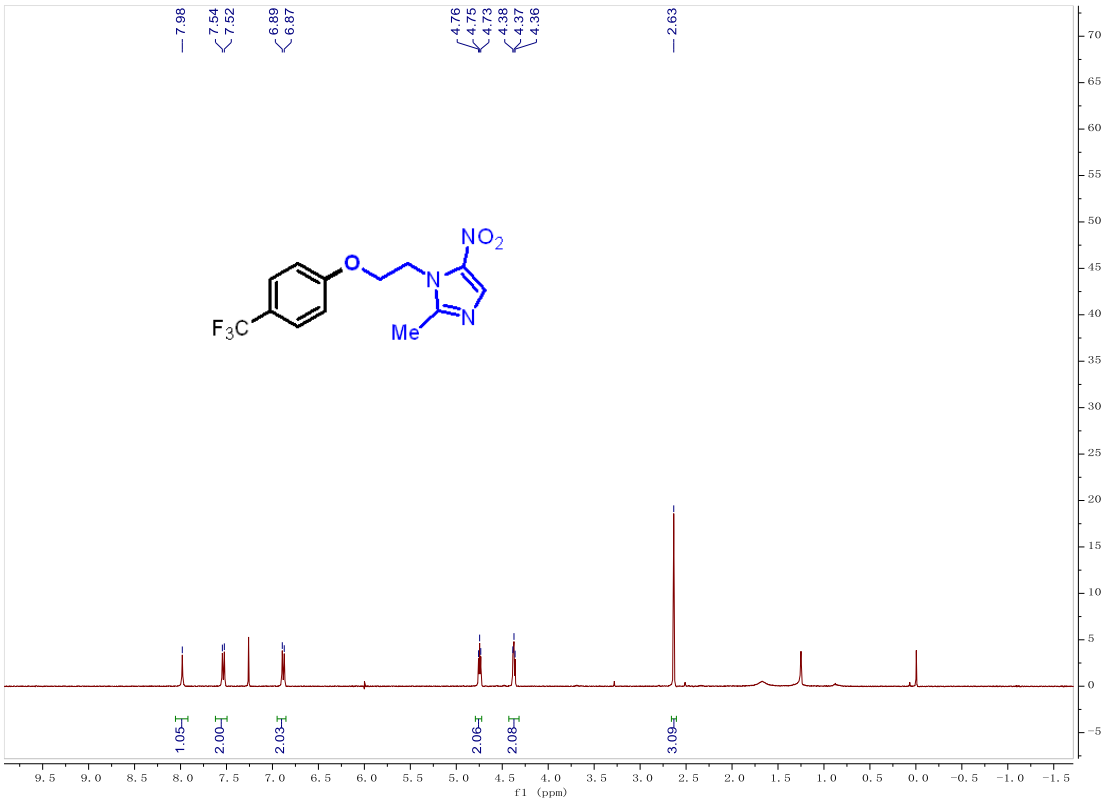


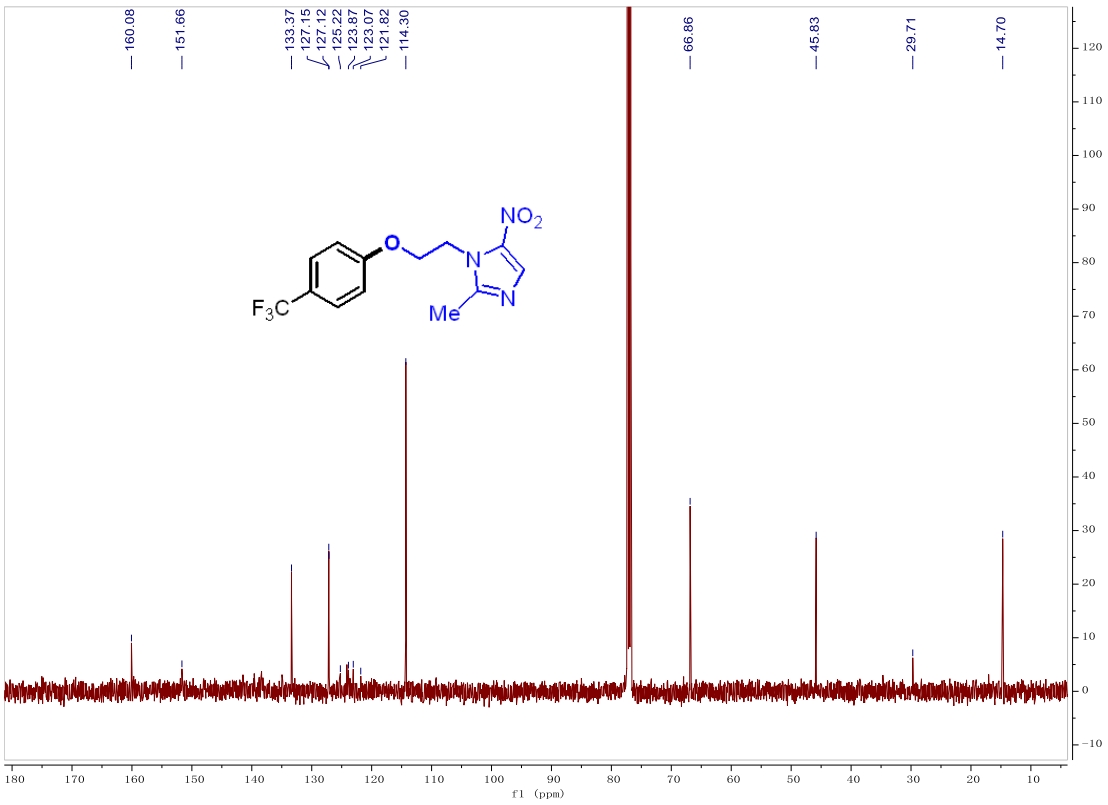
^{1}H and ^{13}C NMR spectra of compound 3c

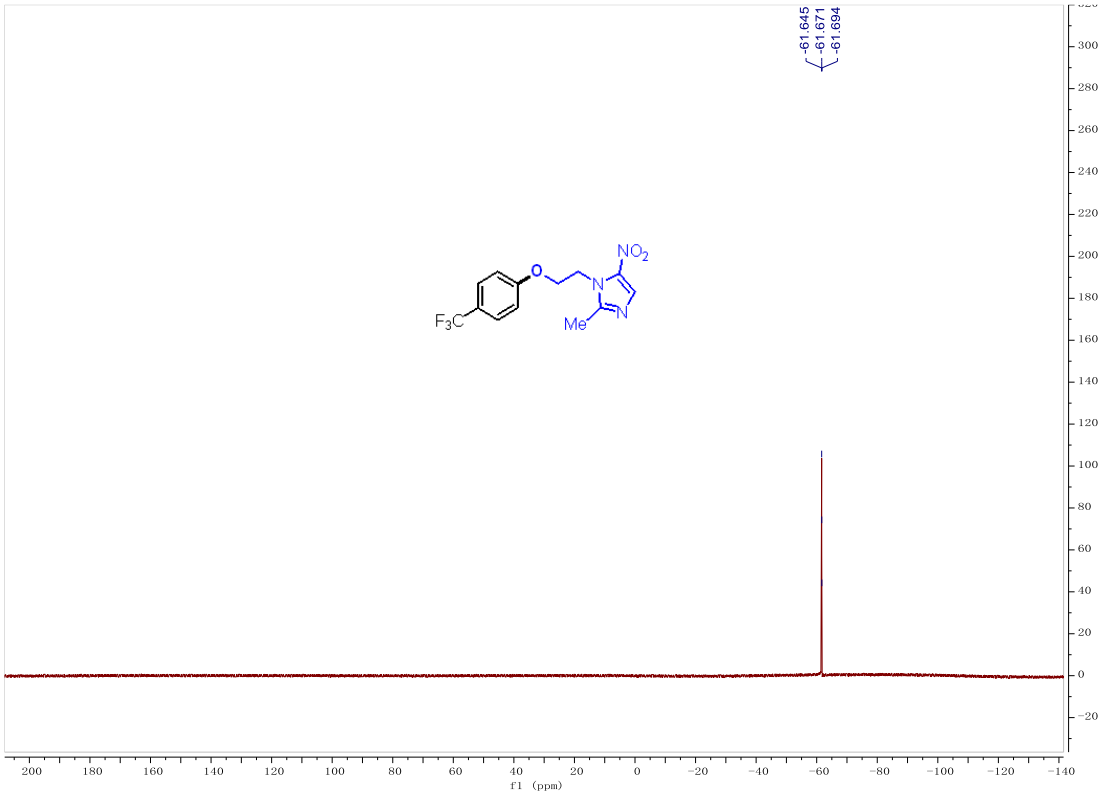




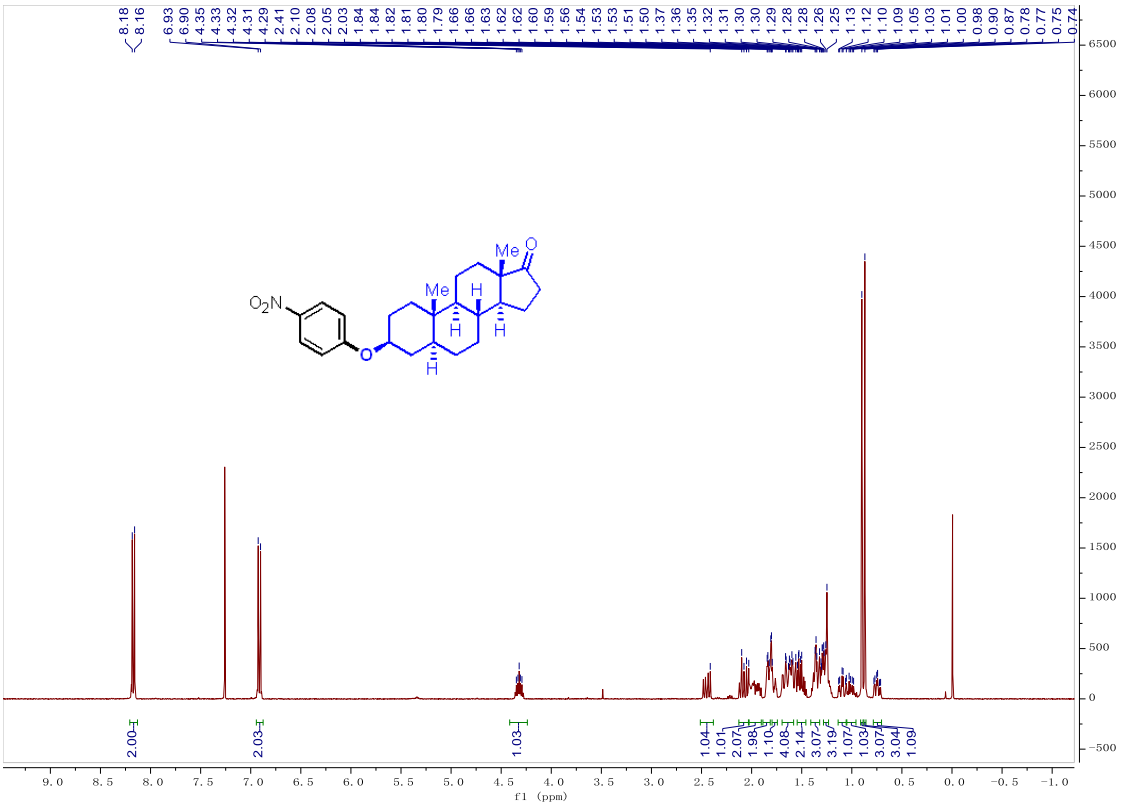
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 3d

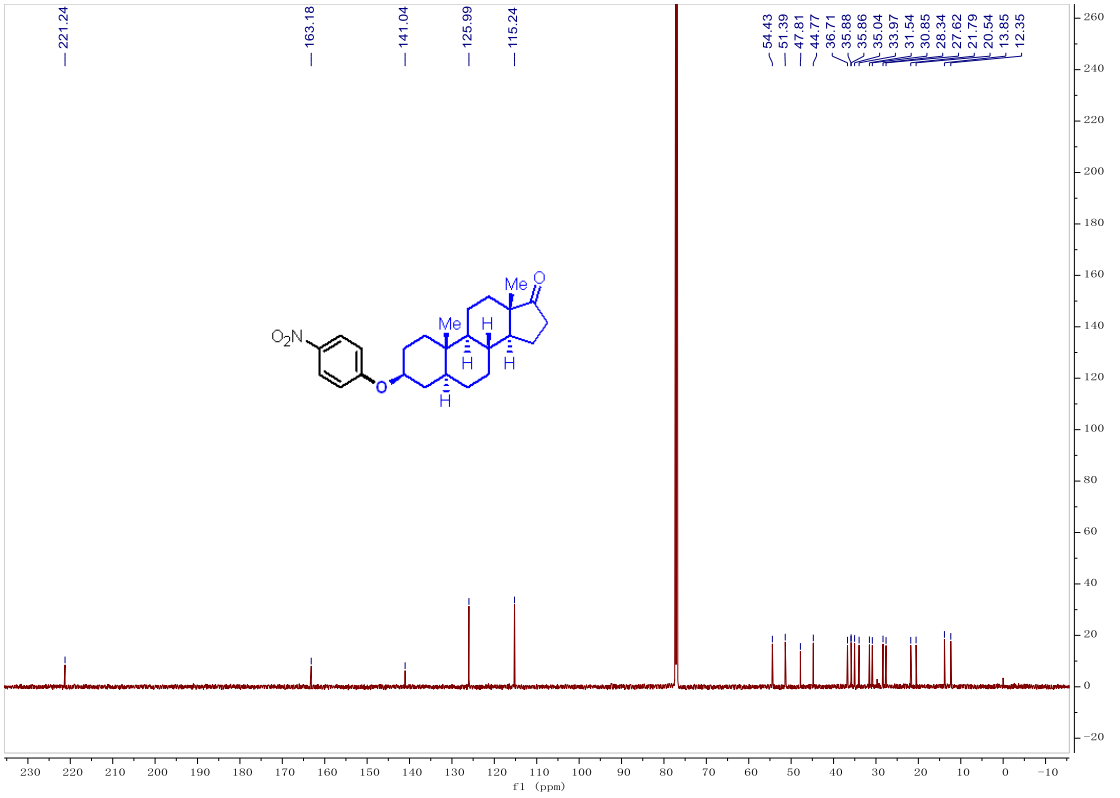




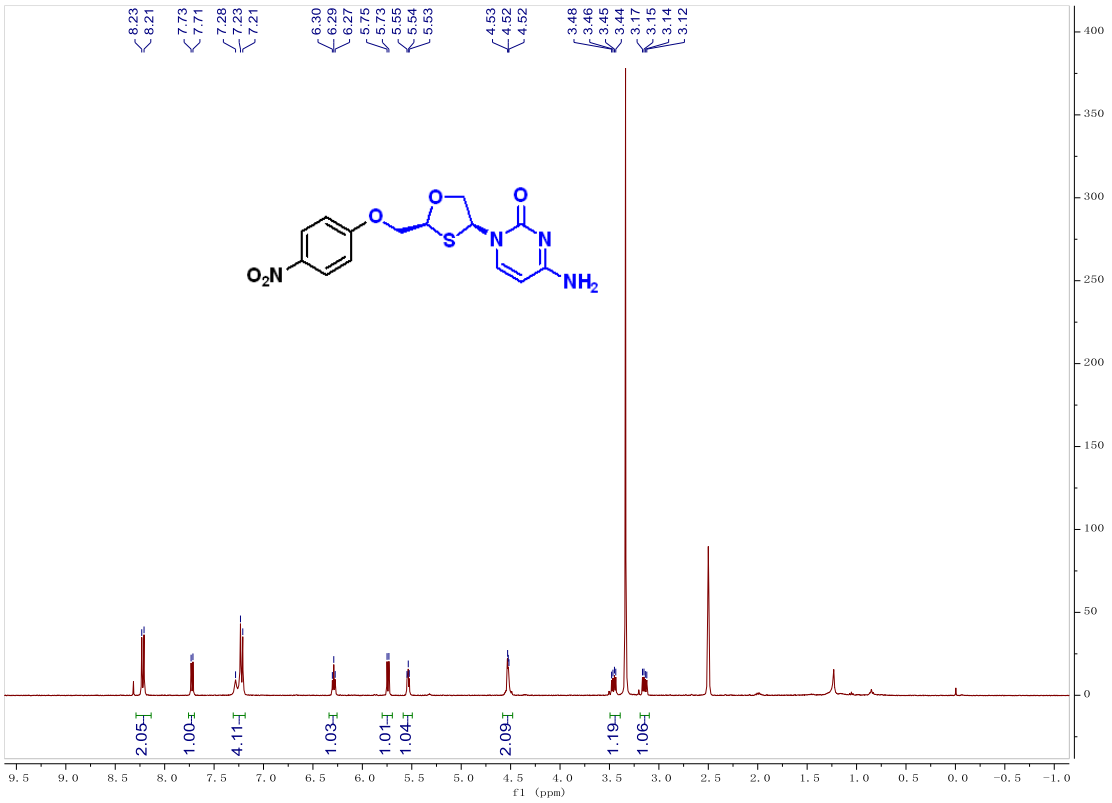

-61.645
-61.671
-61.694
NO2
O
N
N
Me
F3C
f1 (ppm)

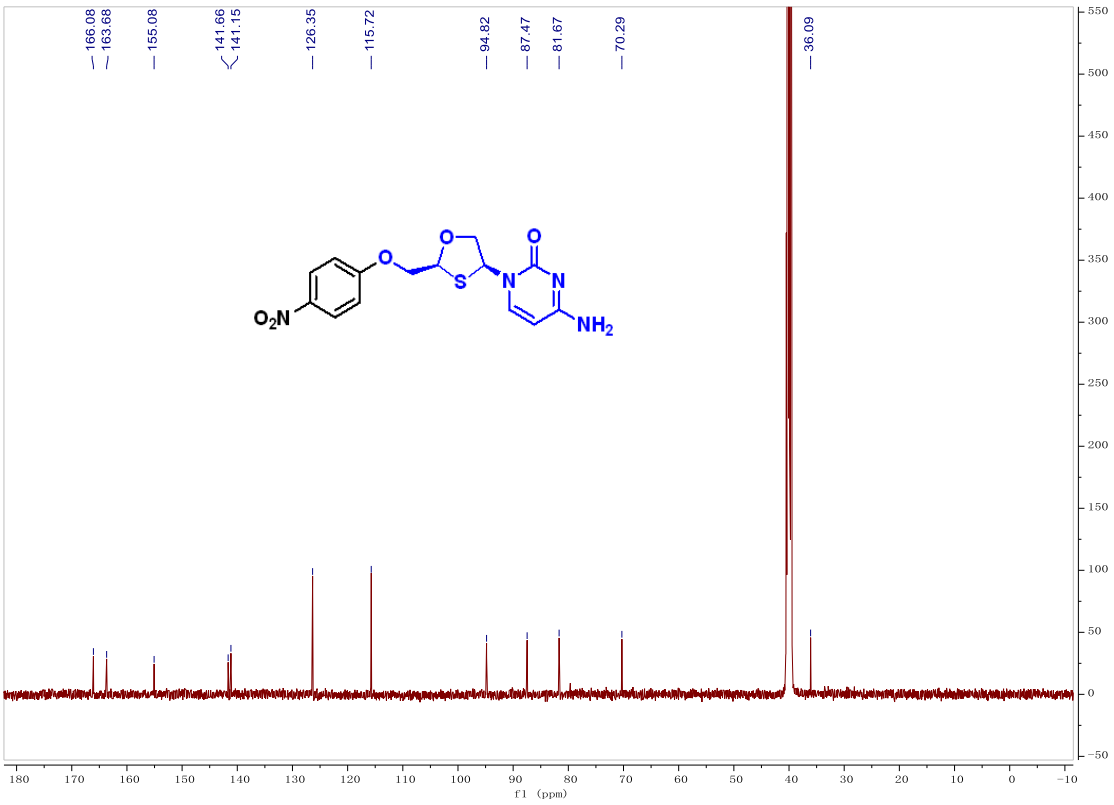
^{1}H and ^{13}C NMR spectra of compound 3e



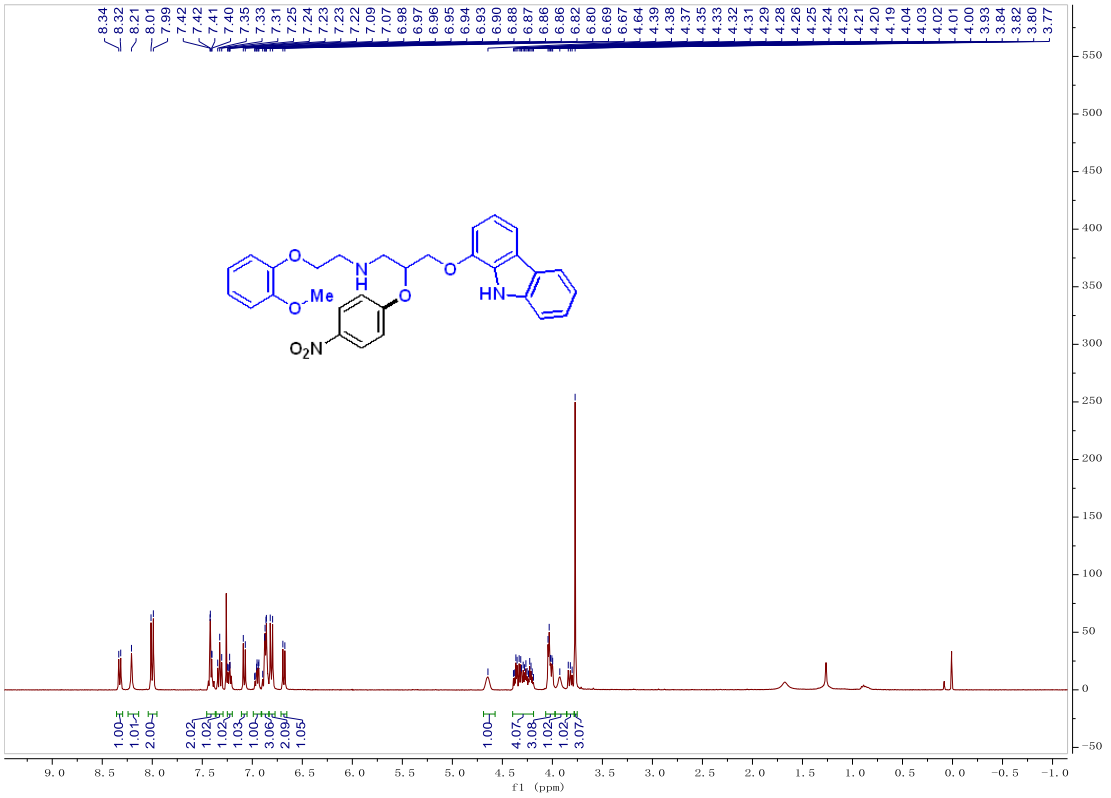


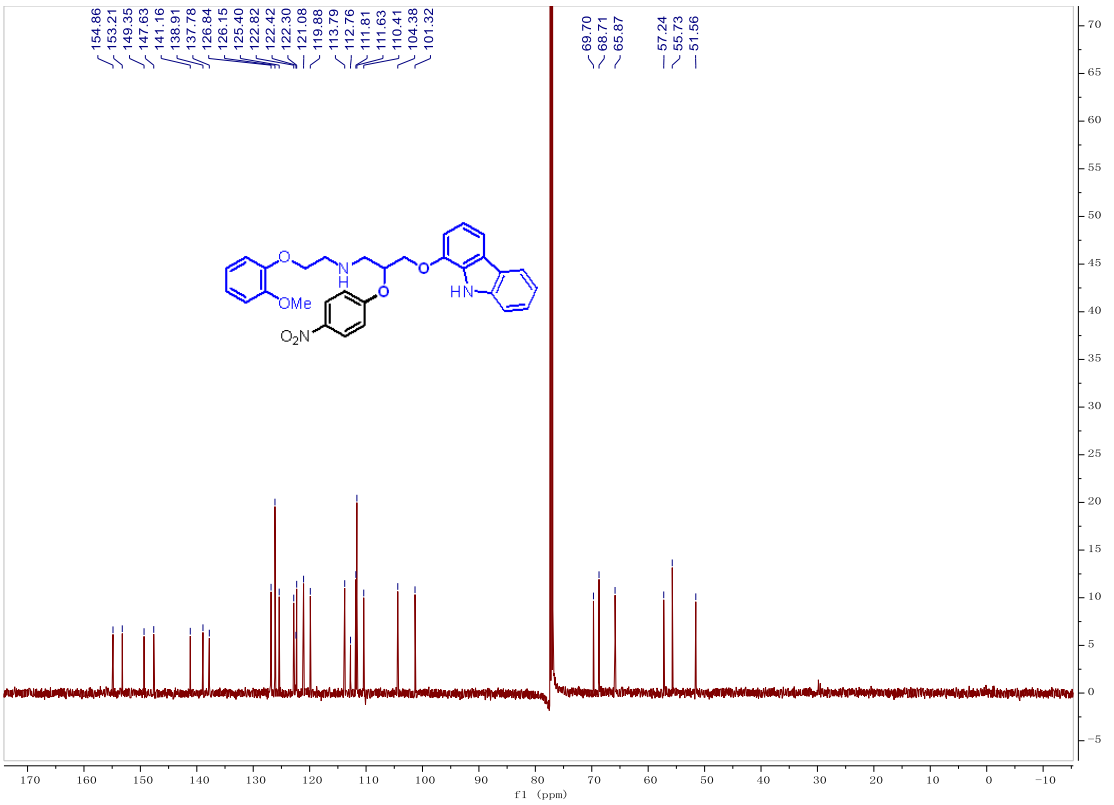
^{1}H and ^{13}C NMR spectra of compound 3f



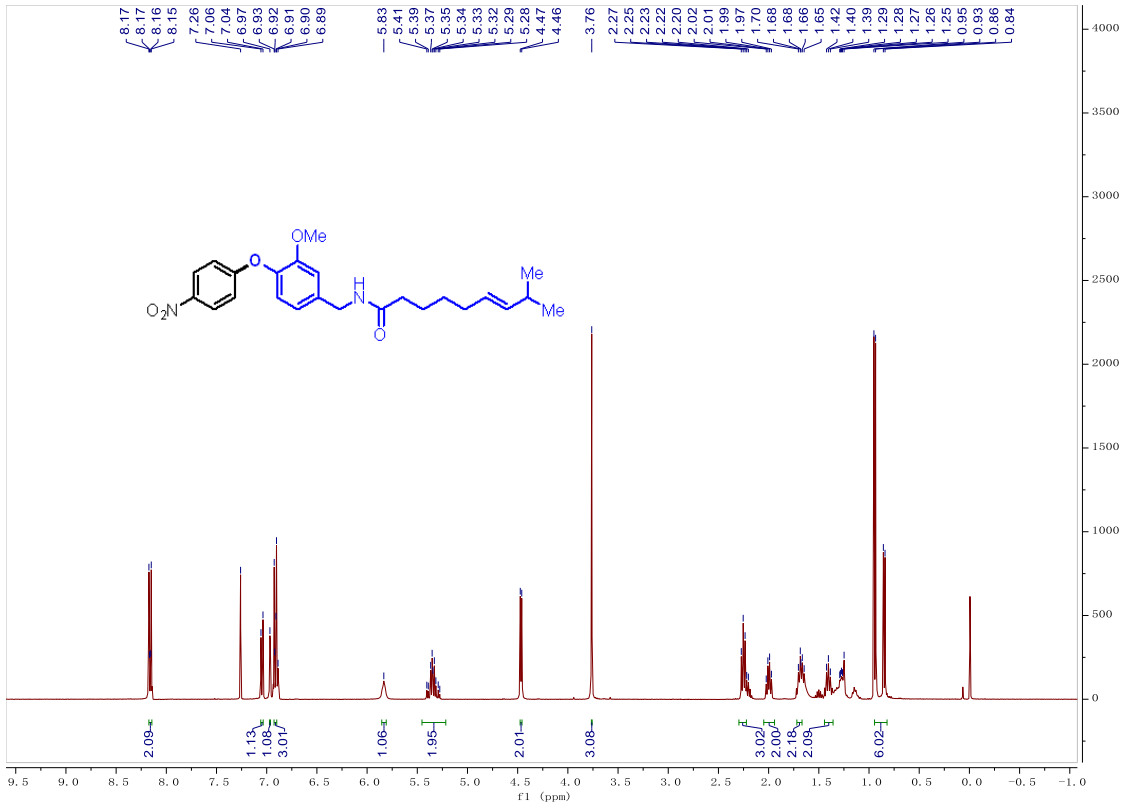


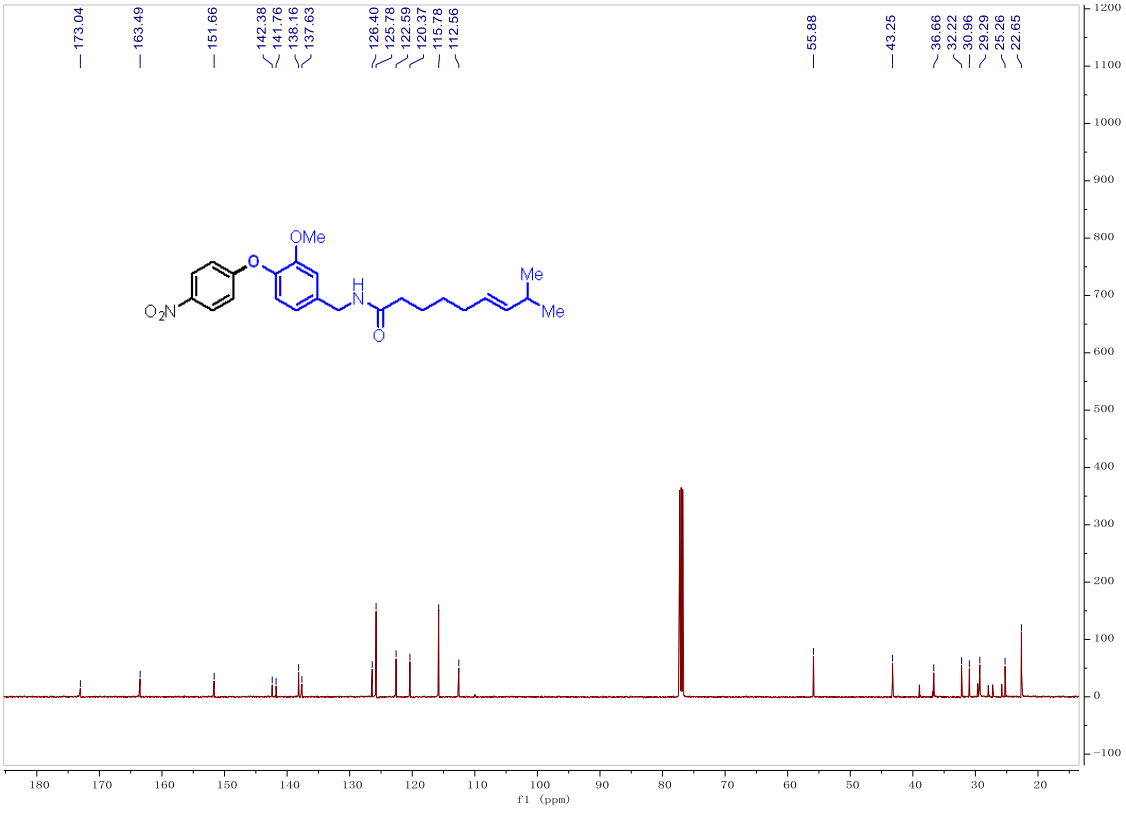
^{1}H and ^{13}C NMR spectra of compound 3g



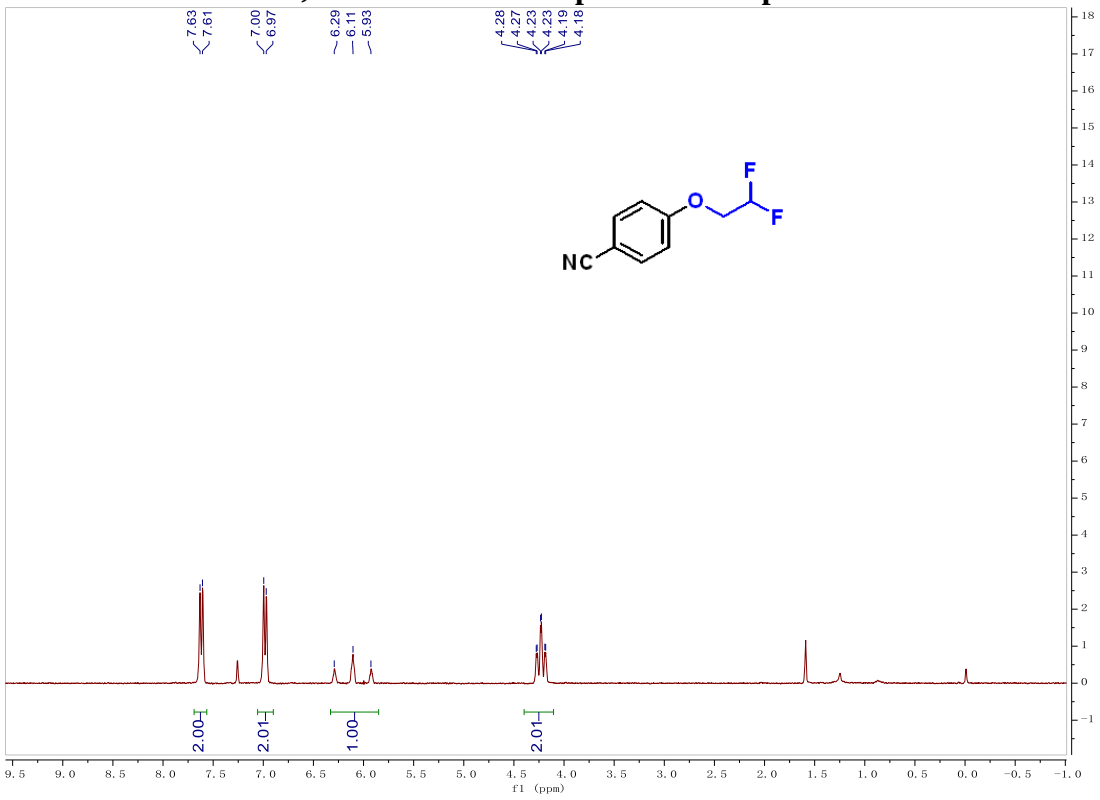


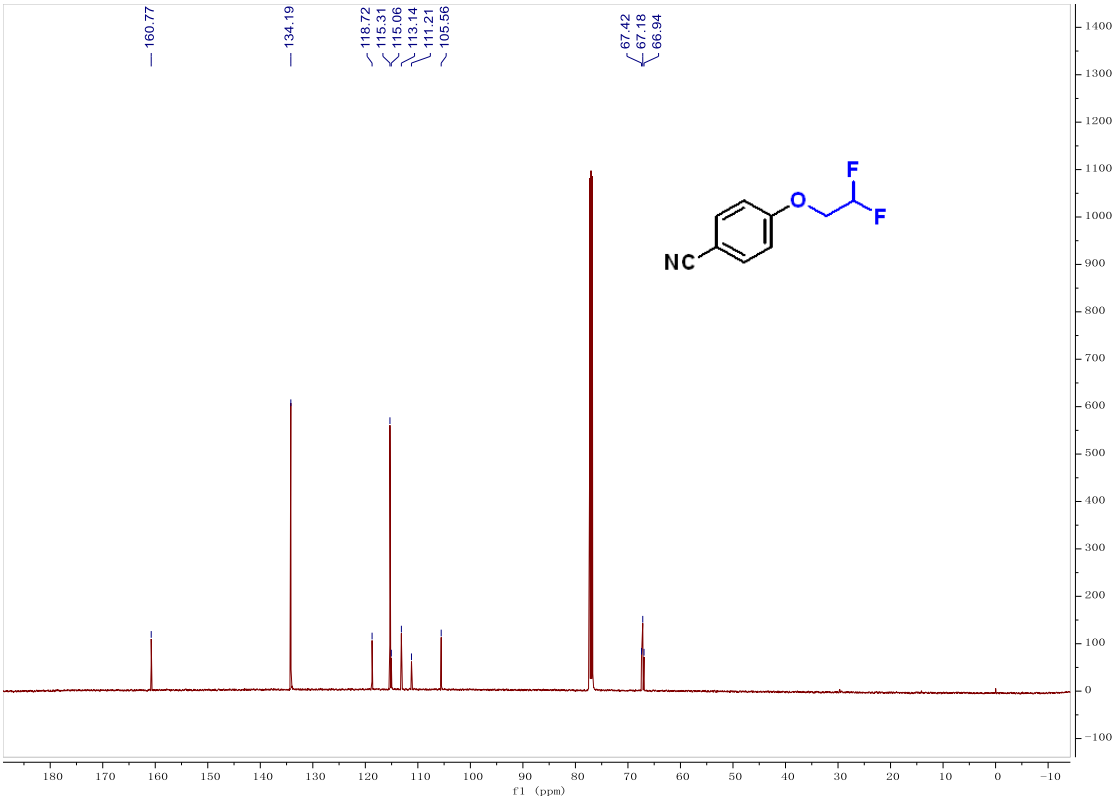
^{1}H and ^{13}C NMR spectra of compound 3h

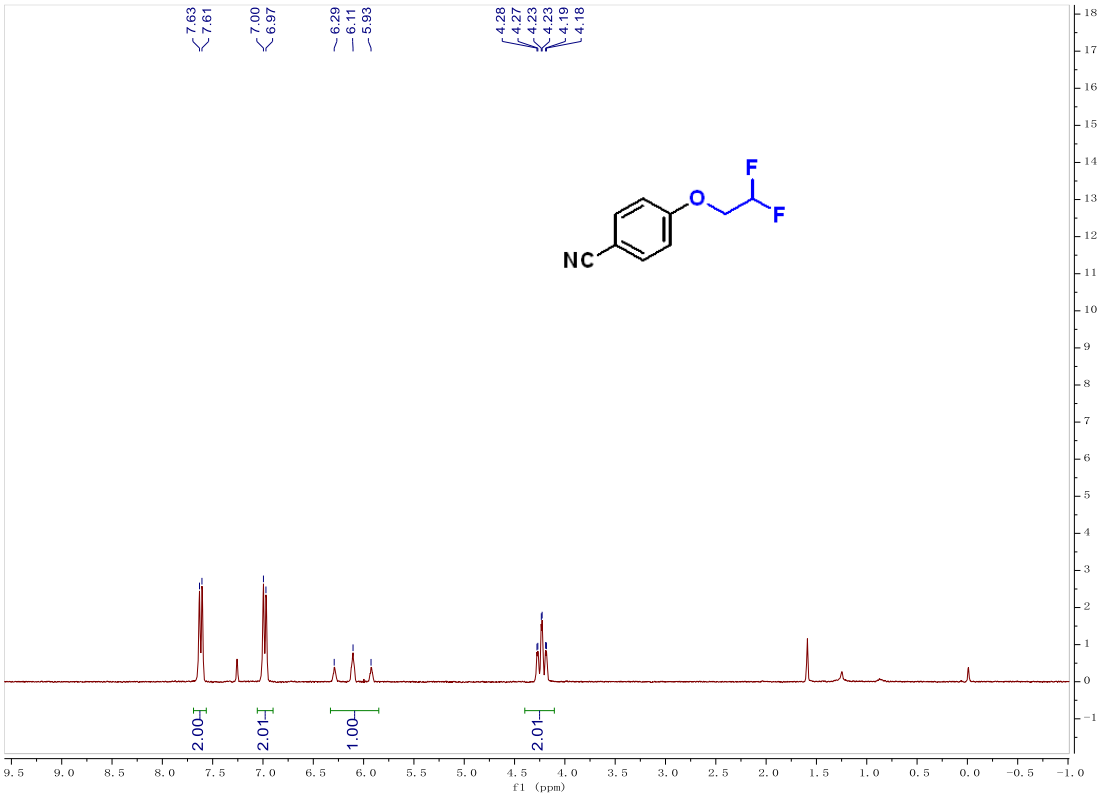




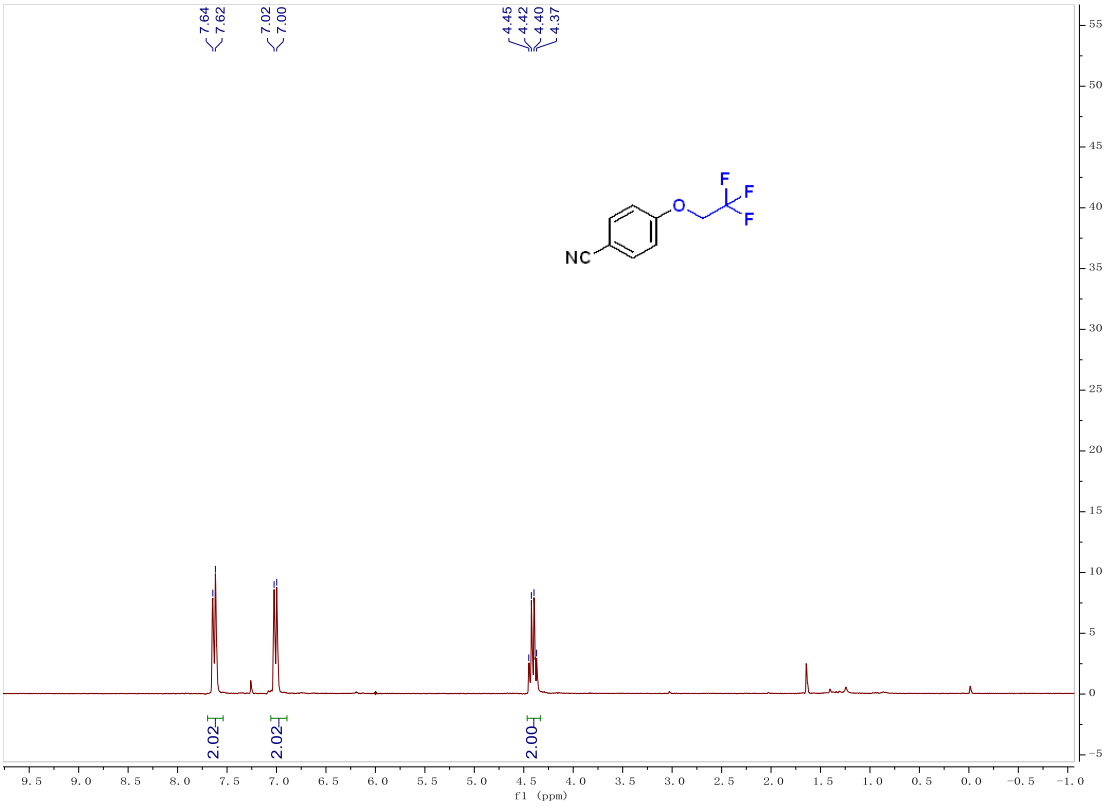
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 3i

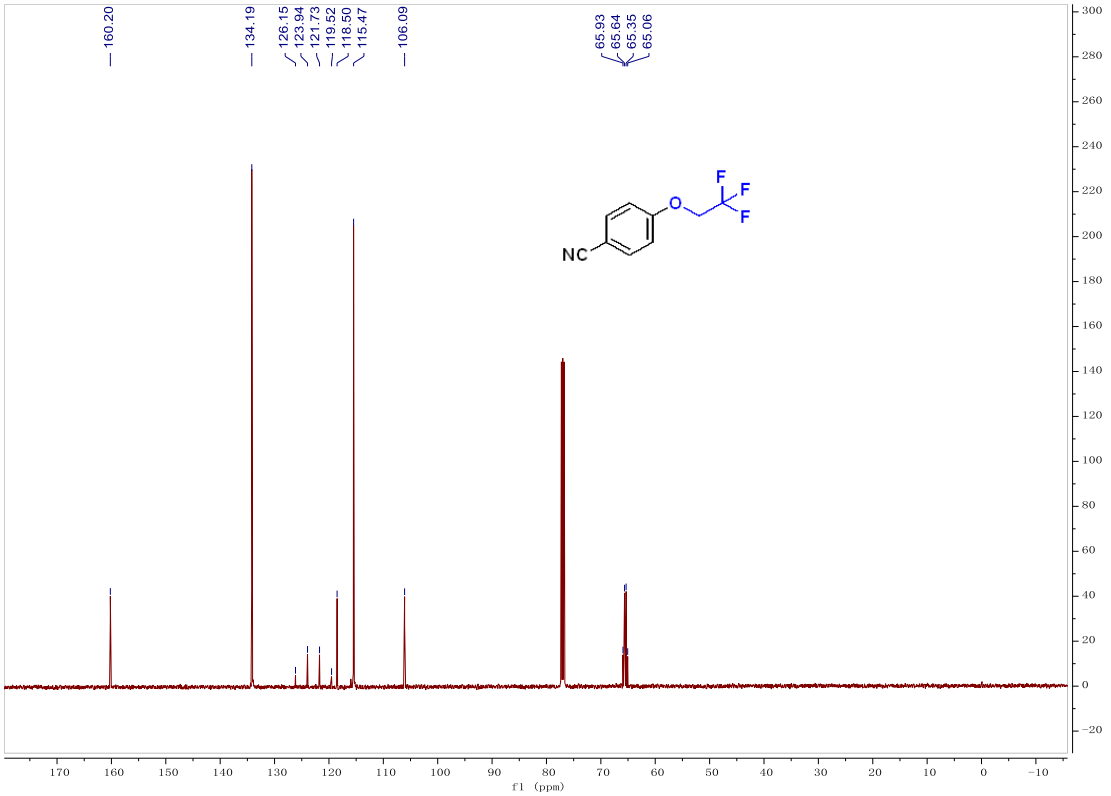


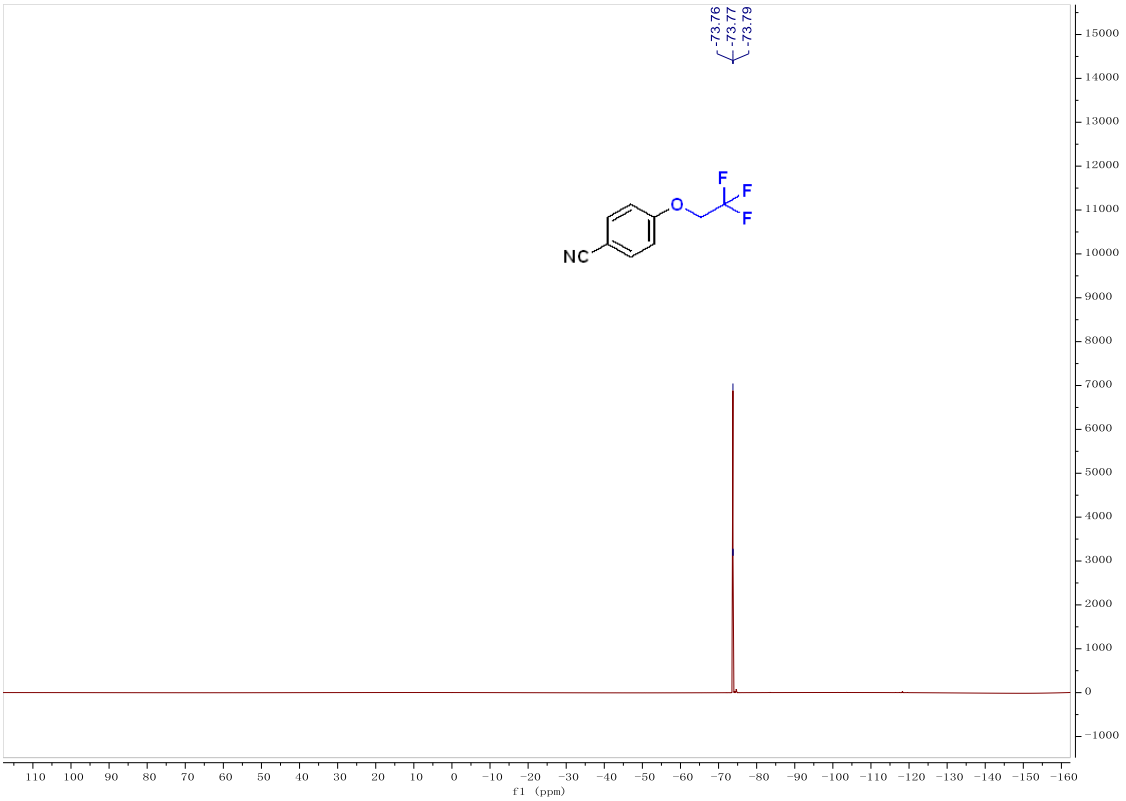



7.63
7.61
7.00
6.97
6.29
6.11
5.93
4.28
4.27
4.23
4.23
4.19
4.18
F
O
F
NC
2.00
2.01
1.00
2.01
f1 (ppm)

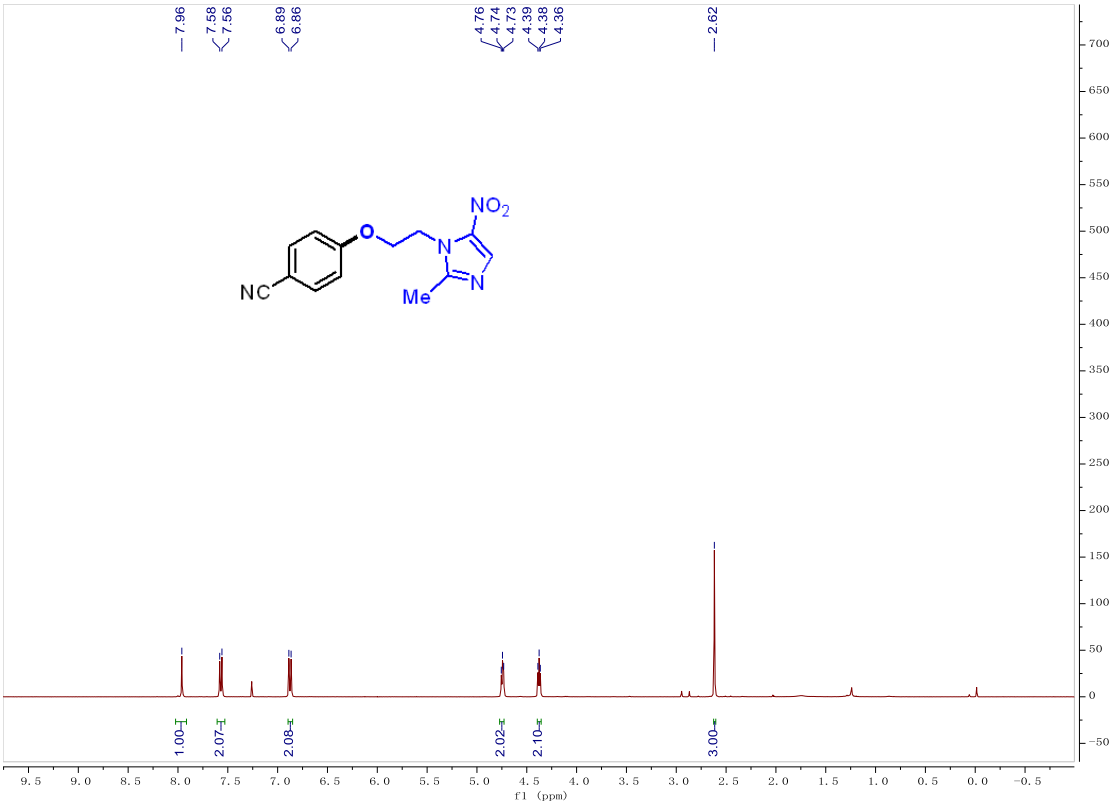
^{1}H, ^{13}C and ^{19}F NMR spectra of compound 3j

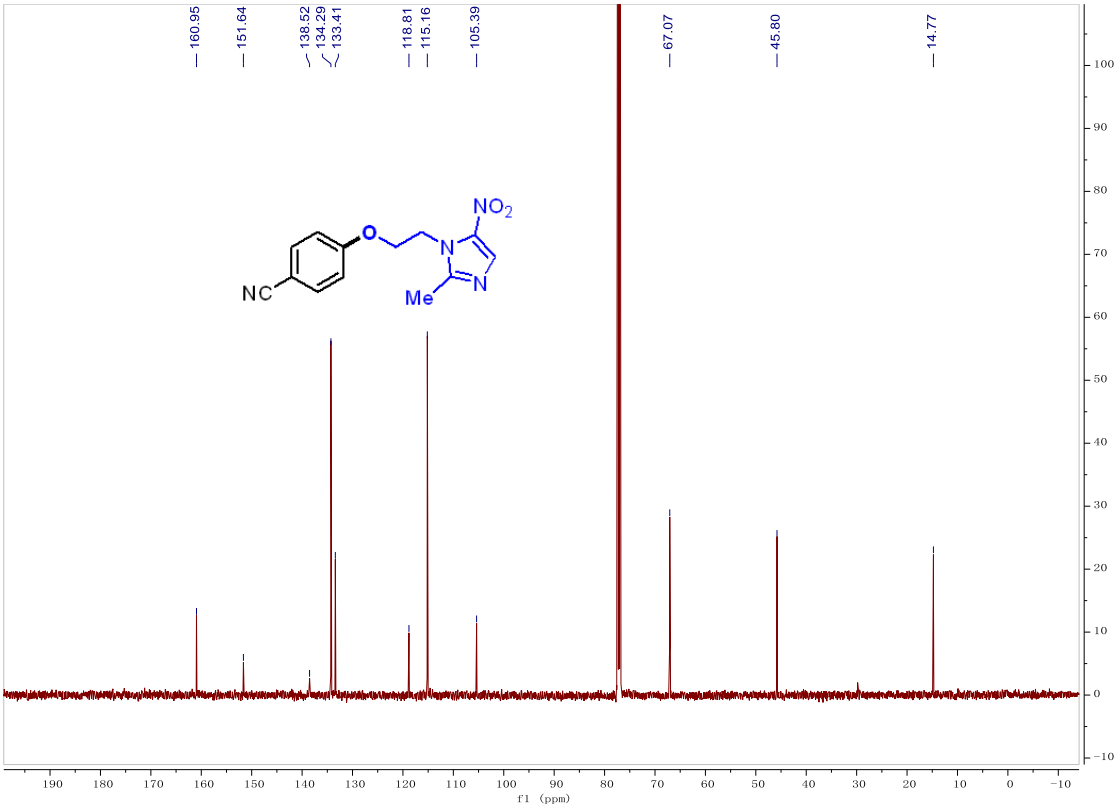




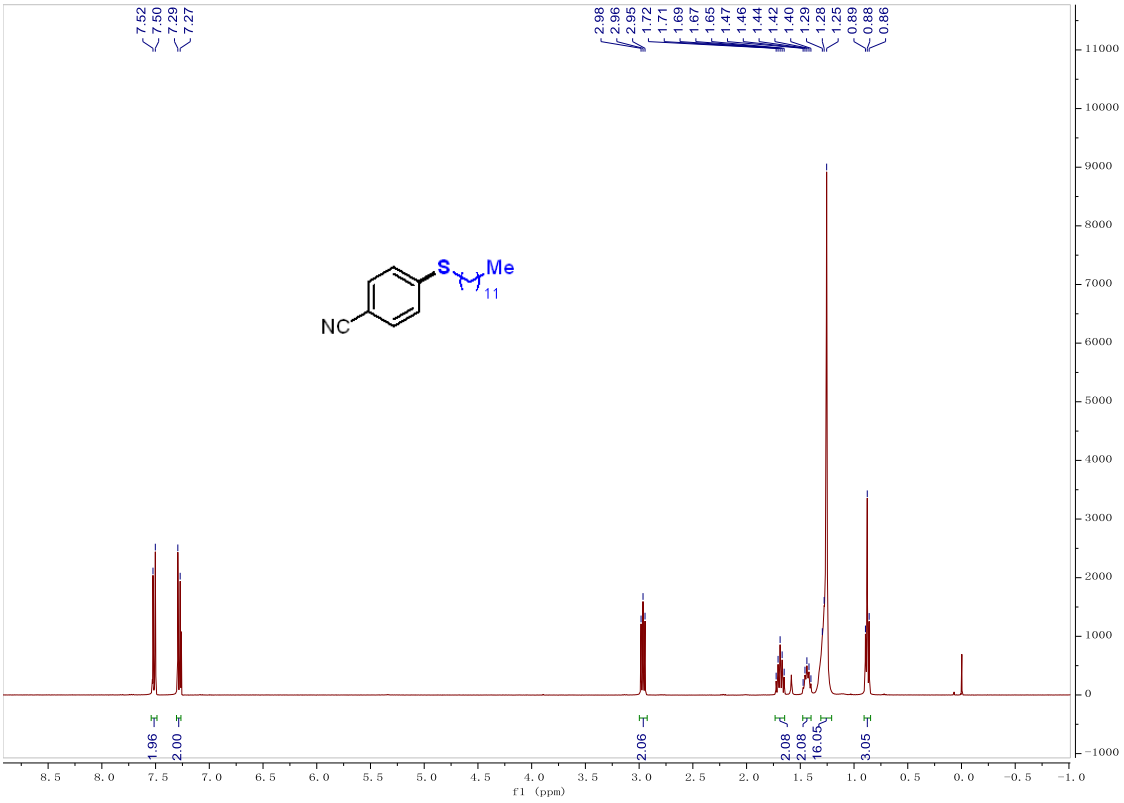

-73.76
-73.77
-73.79
F
F
F
O
NC
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 −90 −100 −110 −120 −130 −140 −150 −160
f1 (ppm)

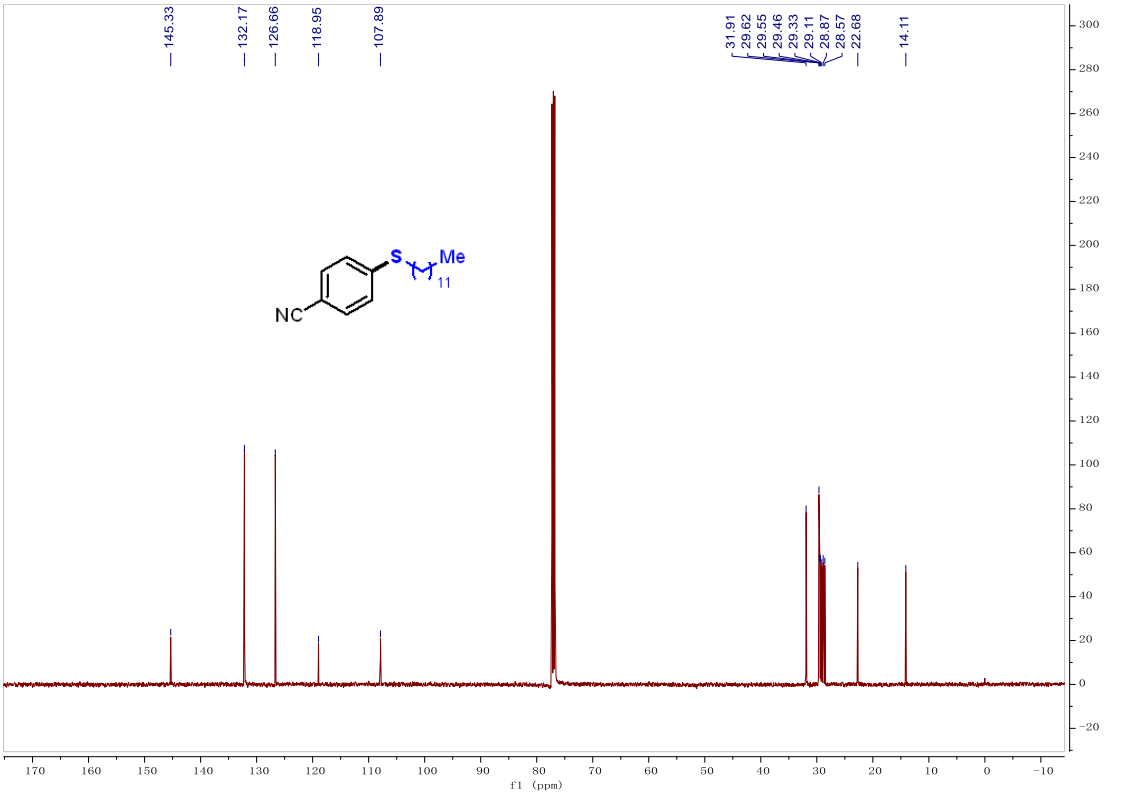
^{1}H and ^{13}C NMR spectra of compound 3k



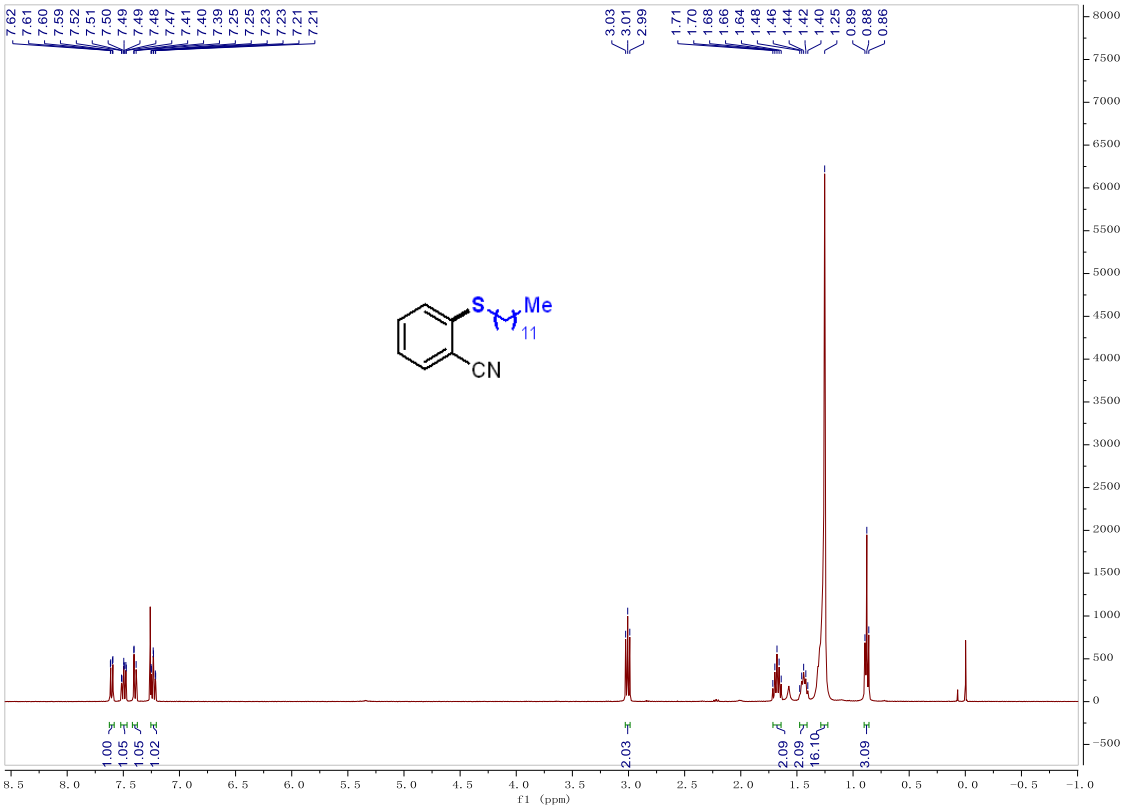


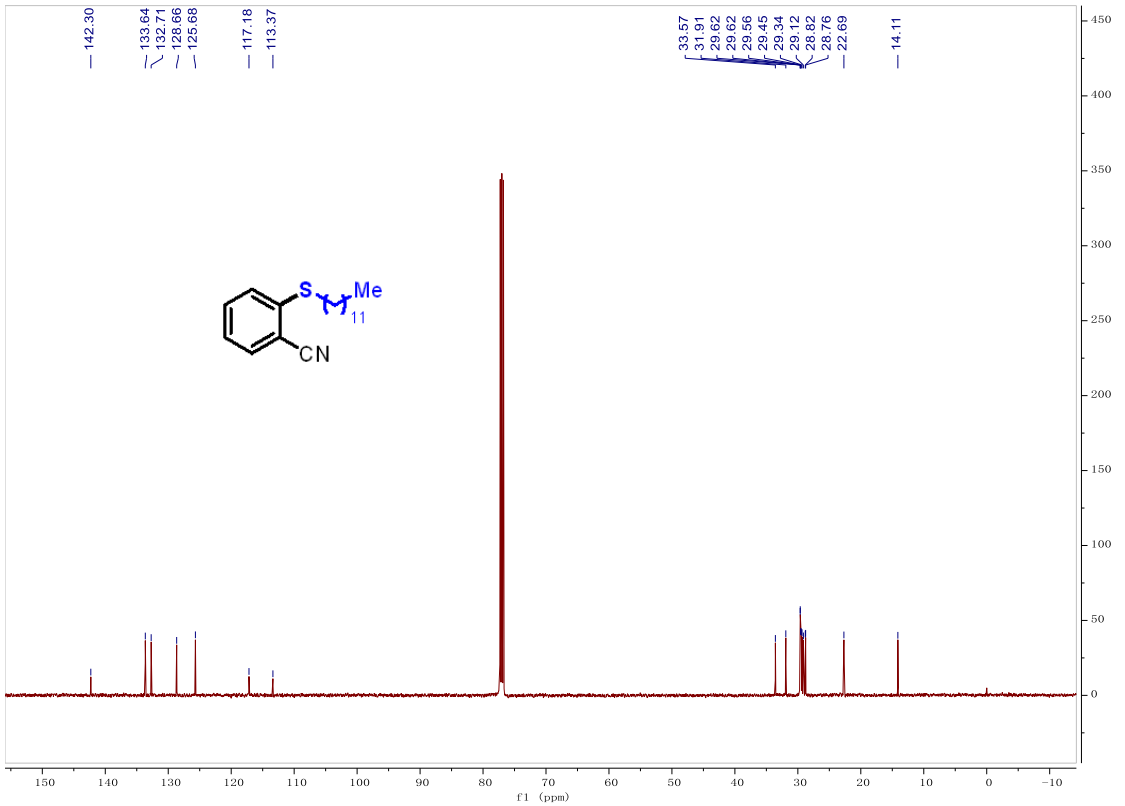
^{1}H and ^{13}C NMR spectra of compound 5a



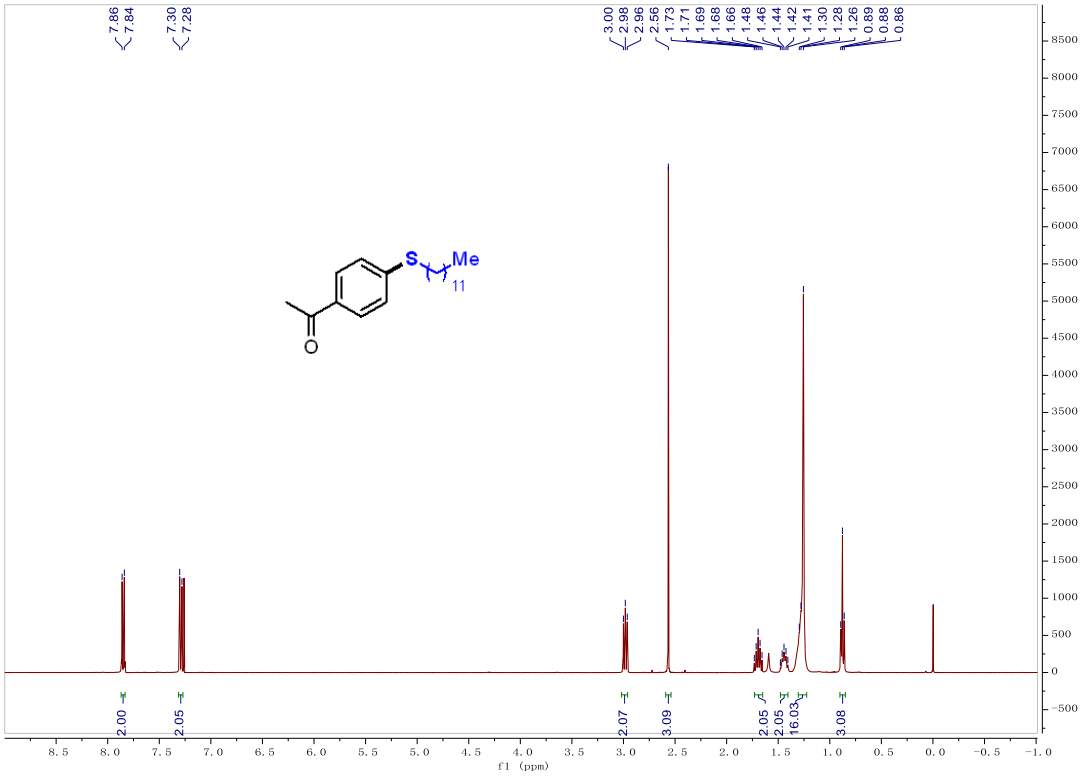


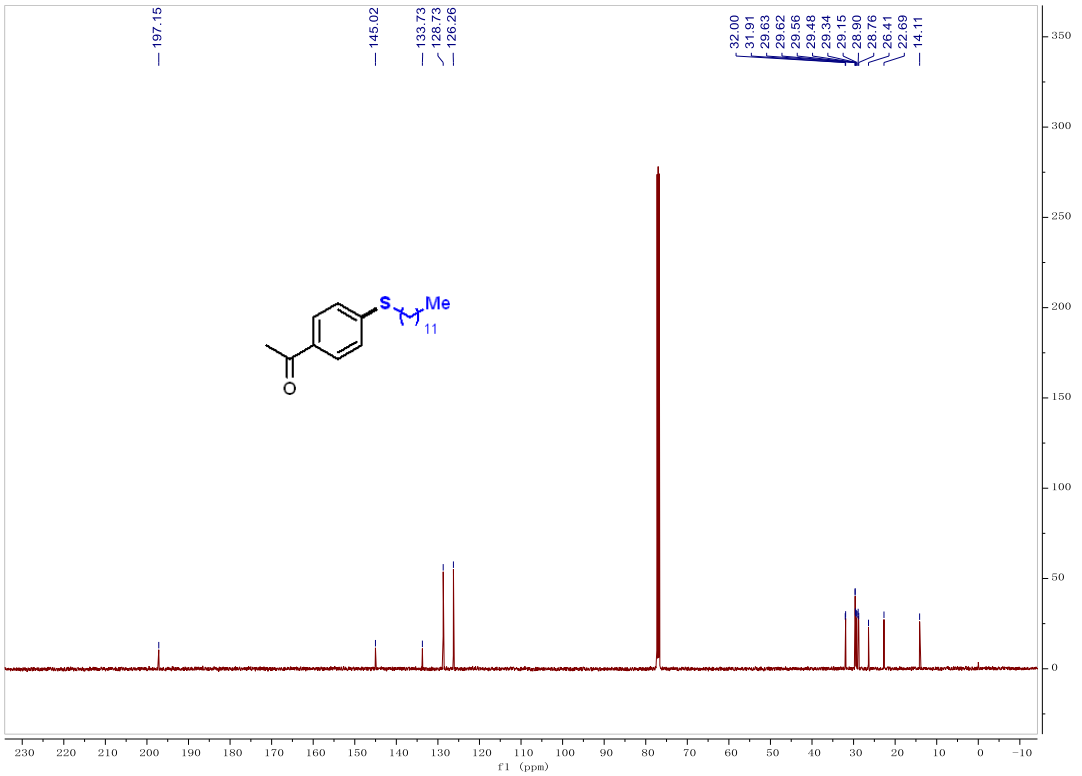
^{1}H and ^{13}C NMR spectra of compound 5b



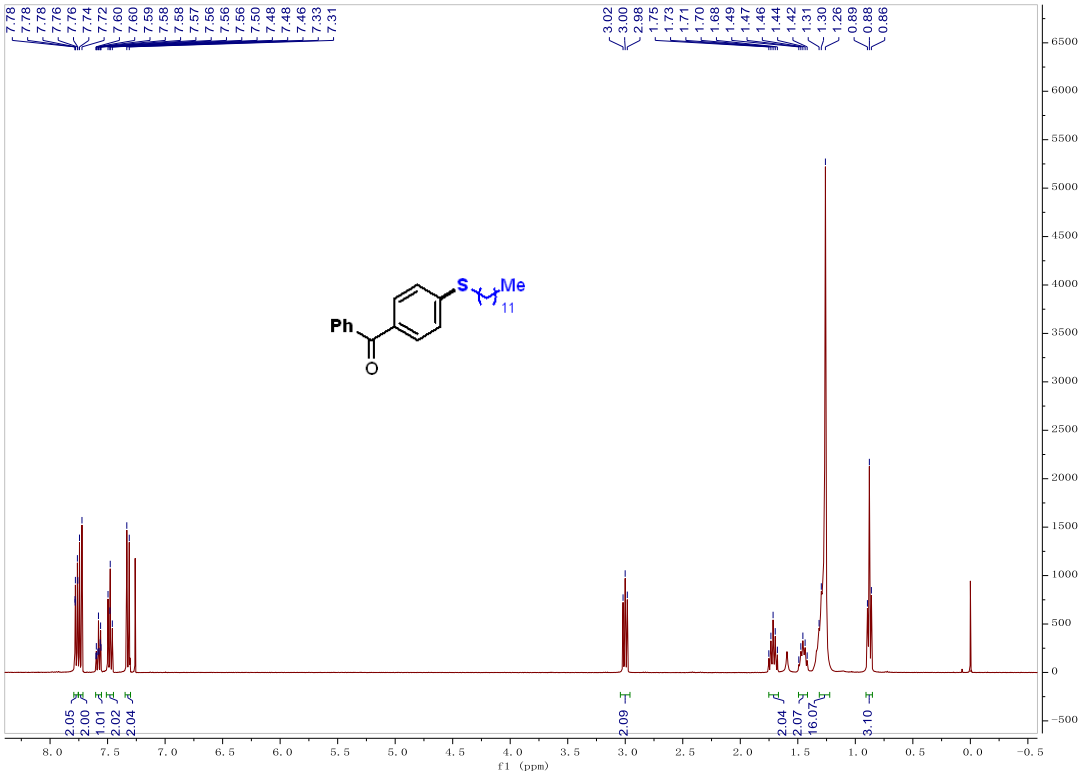


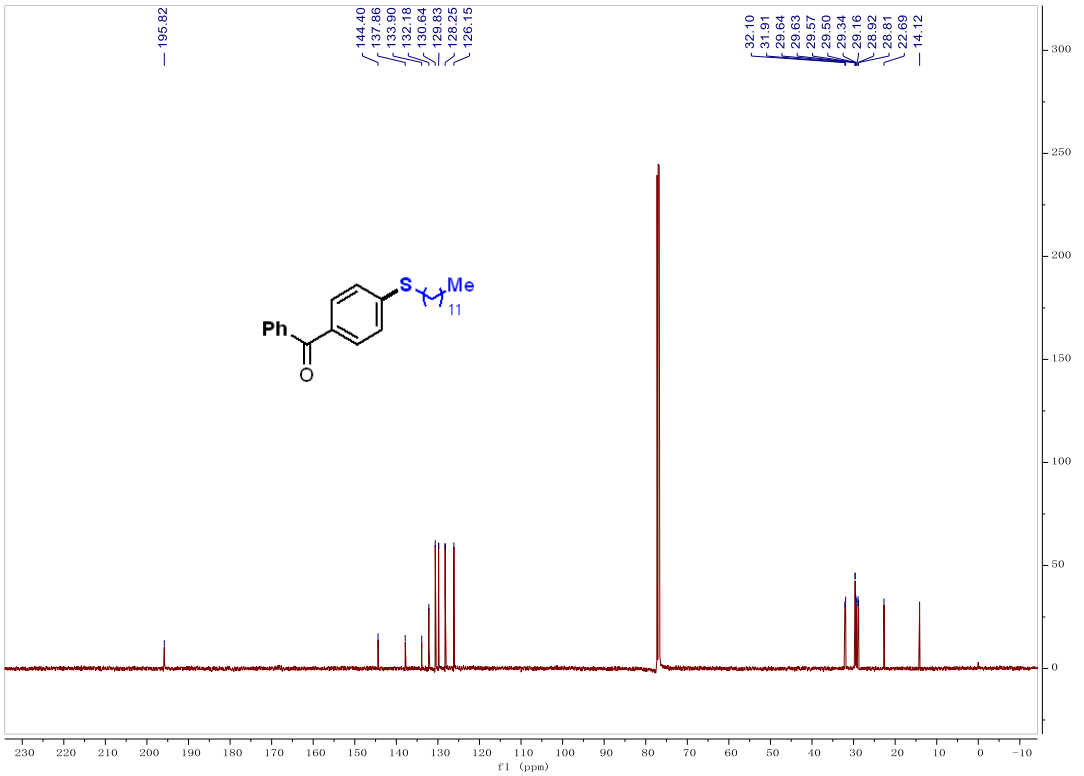
^{1}H and ^{13}C NMR spectra of compound 5c



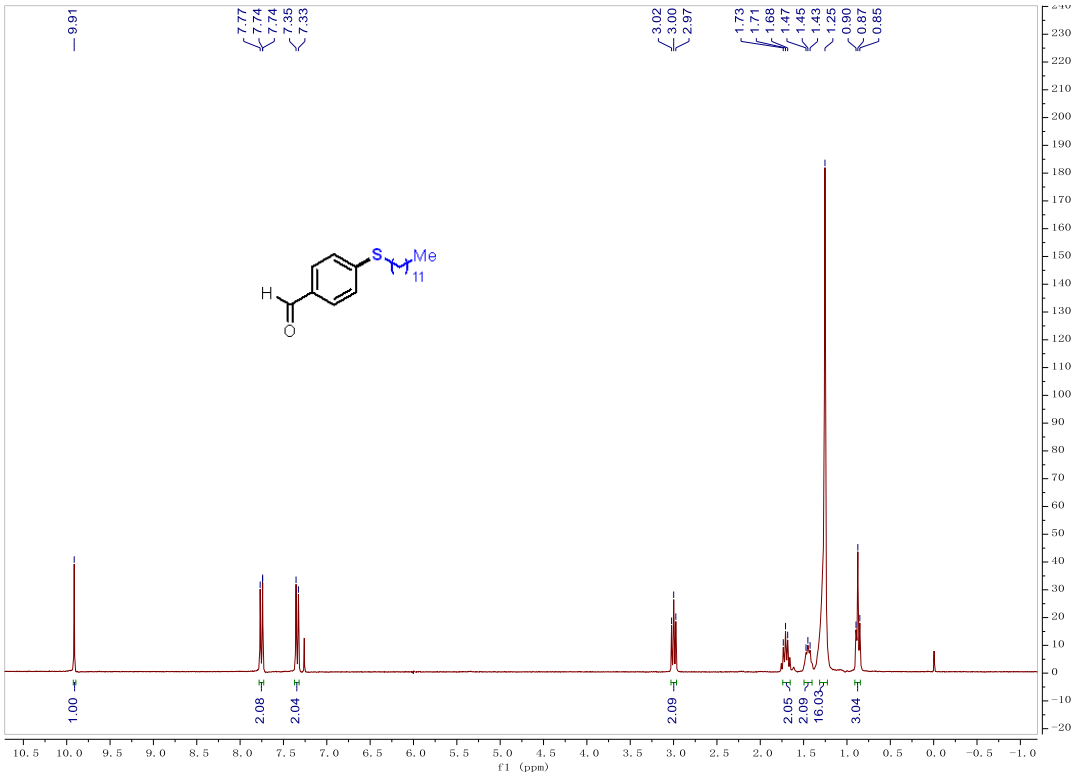


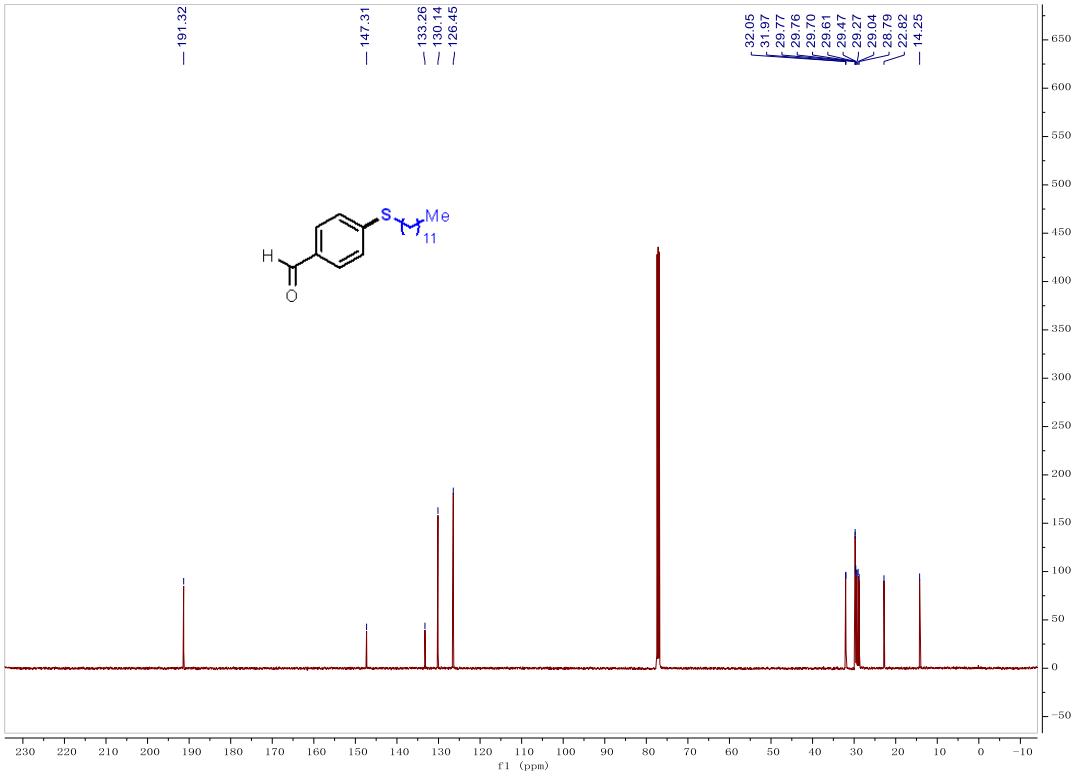
^{1}H and ^{13}C NMR spectra of compound 5d



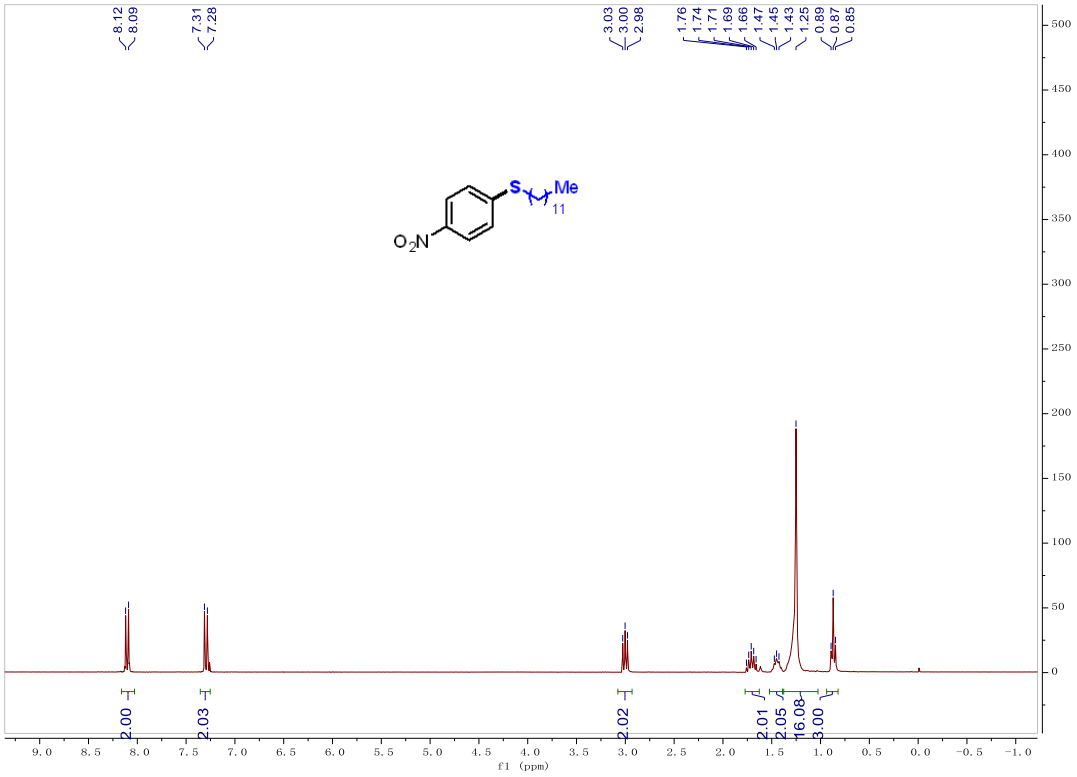


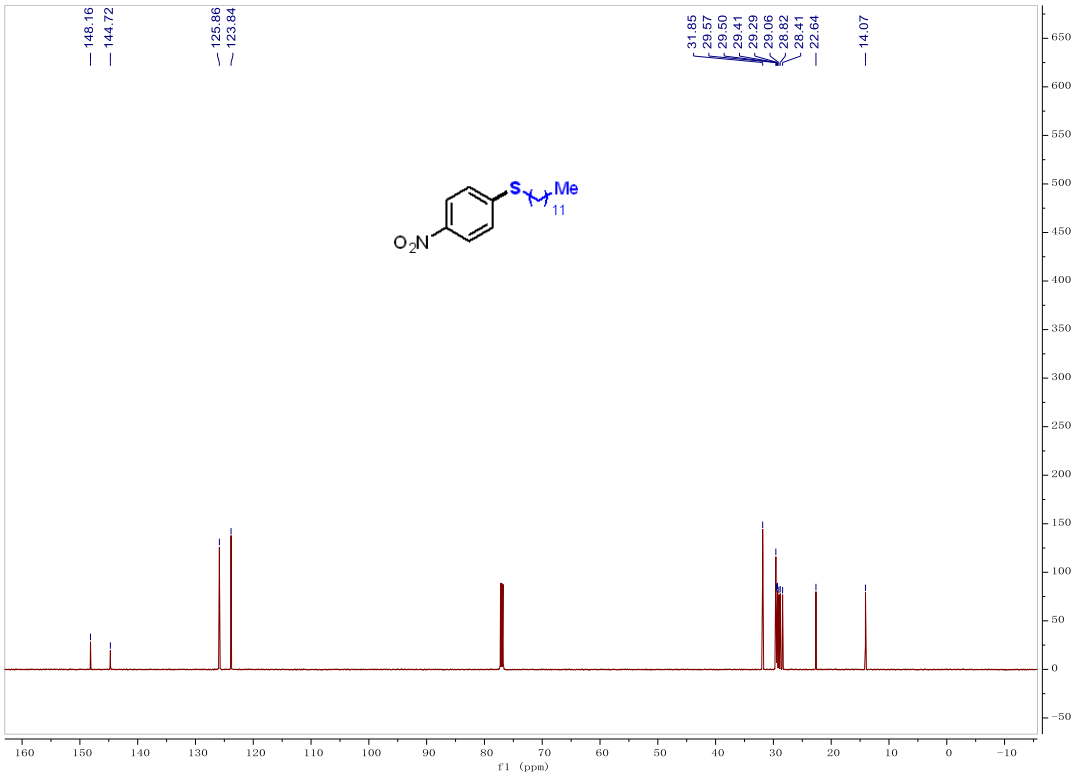
^{1}H and ^{13}C NMR spectra of compound 5e



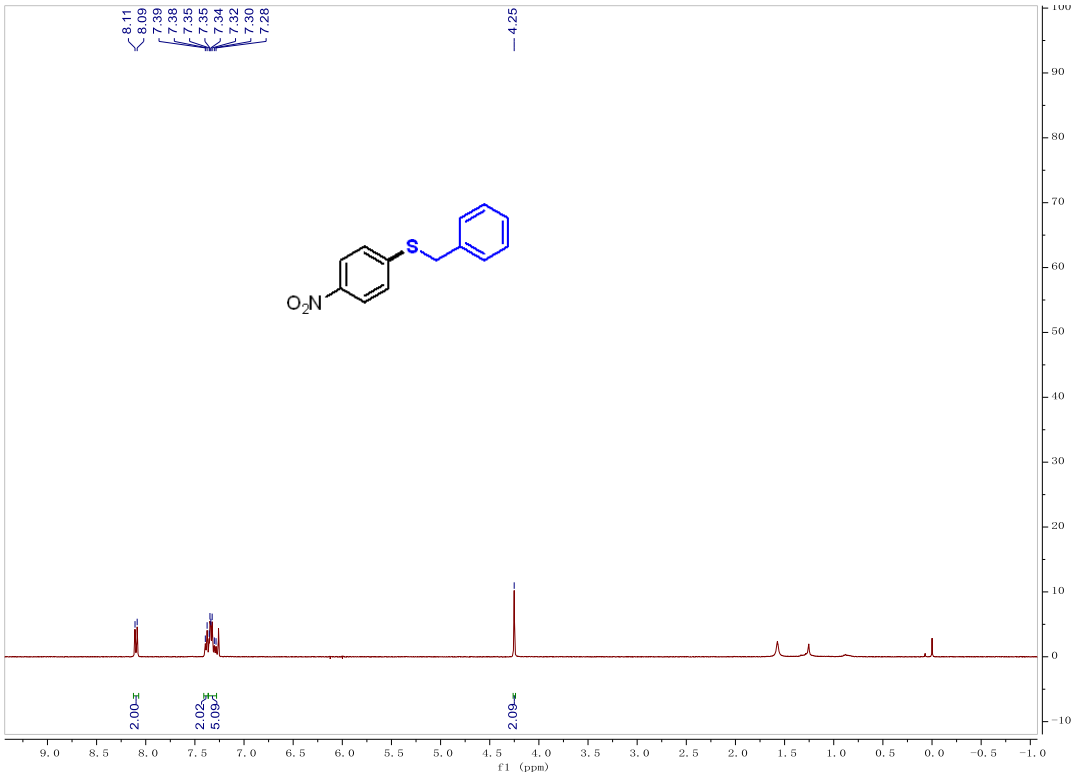


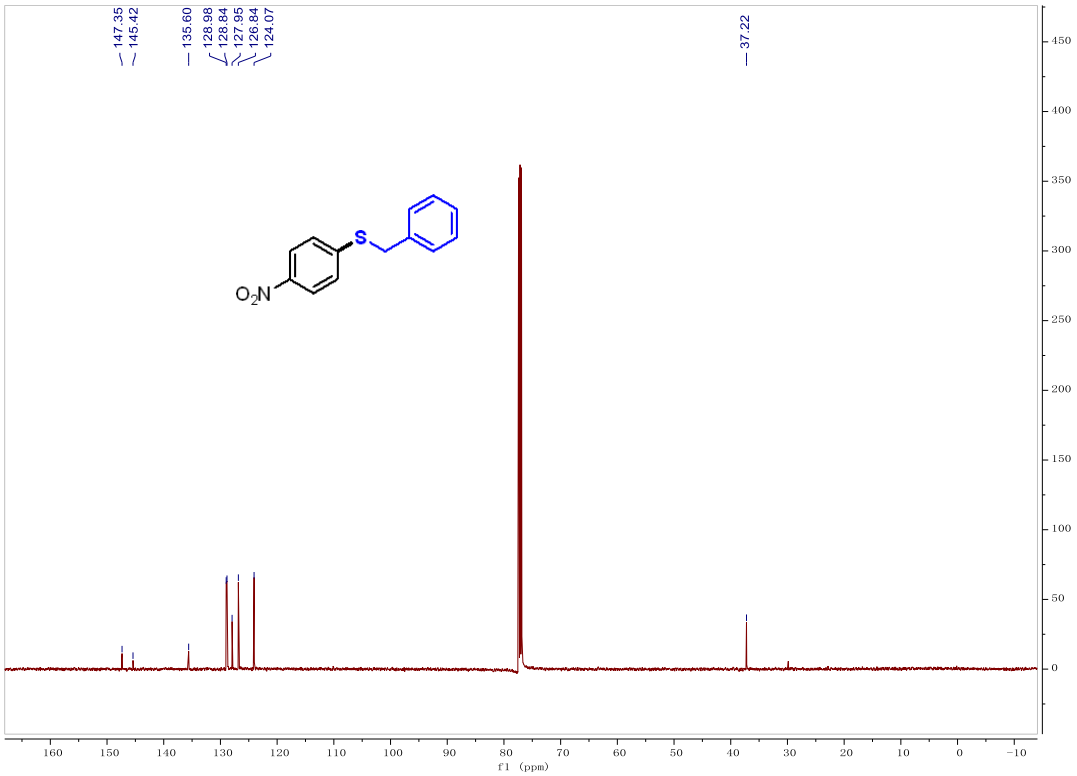
^{1}H and ^{13}C NMR spectra of compound 5f



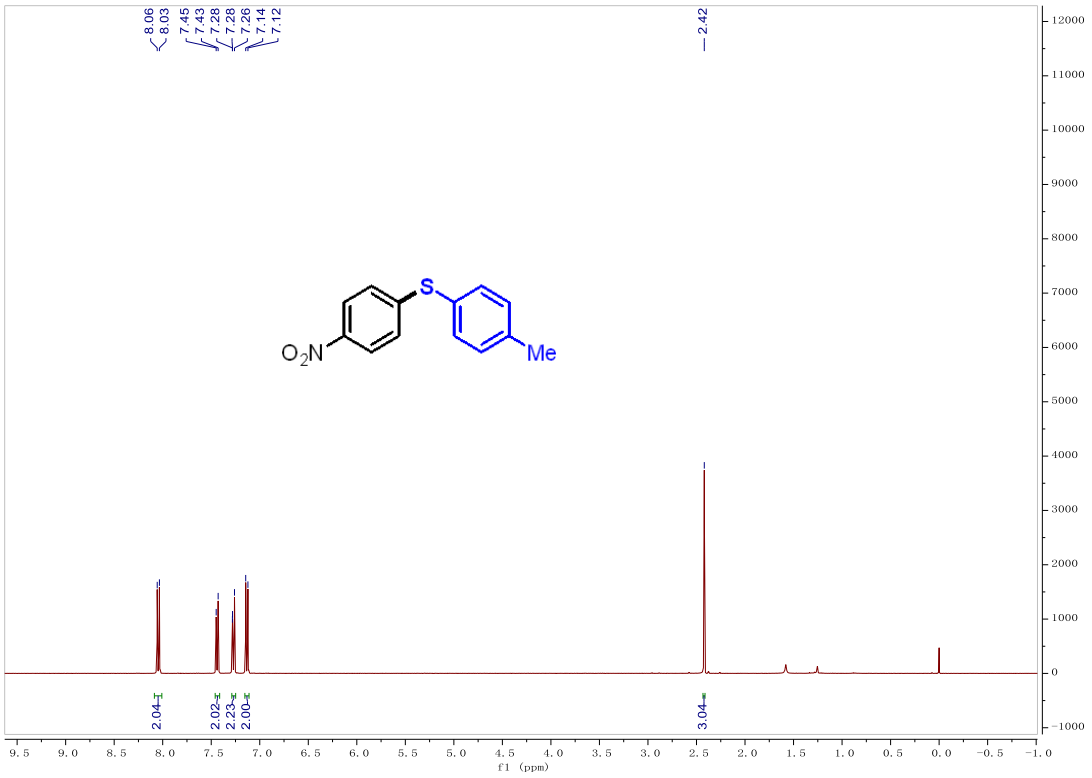


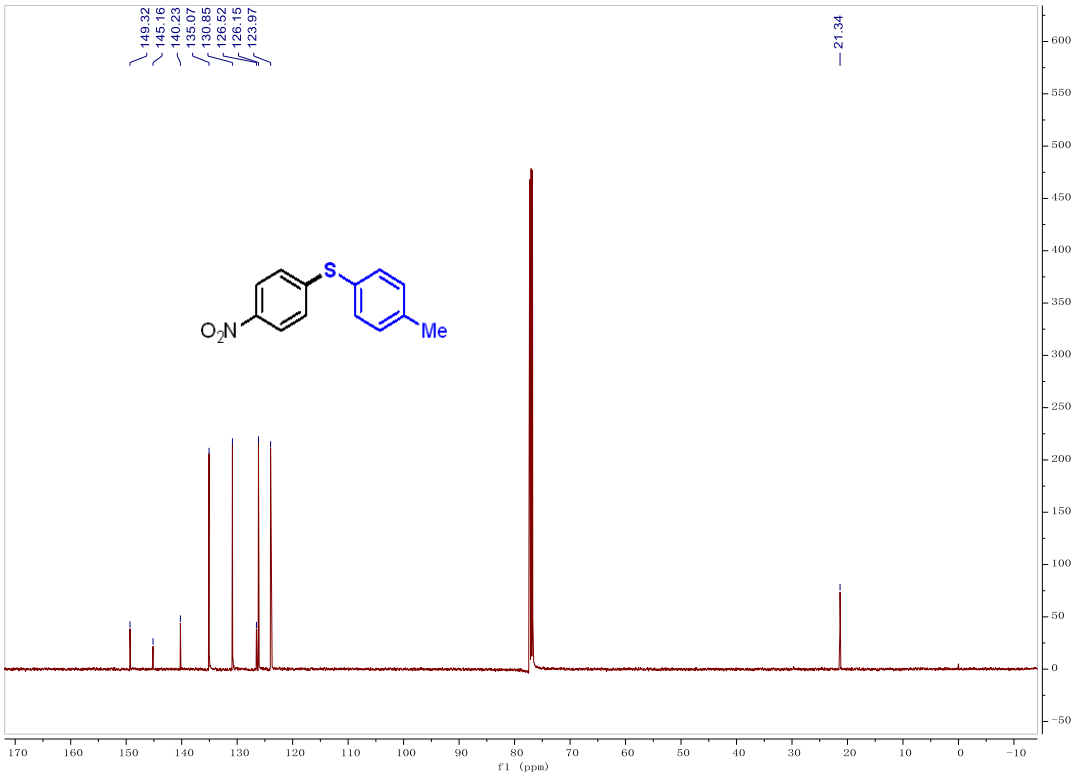
^{1}H and ^{13}C NMR spectra of compound 5g



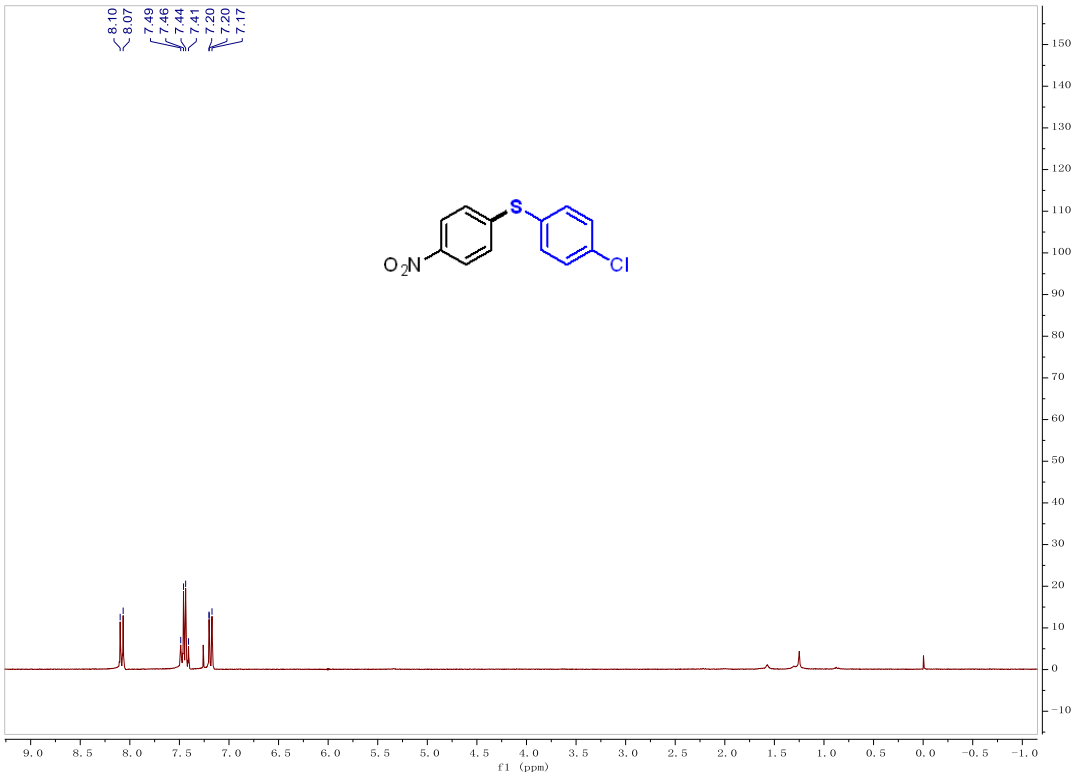


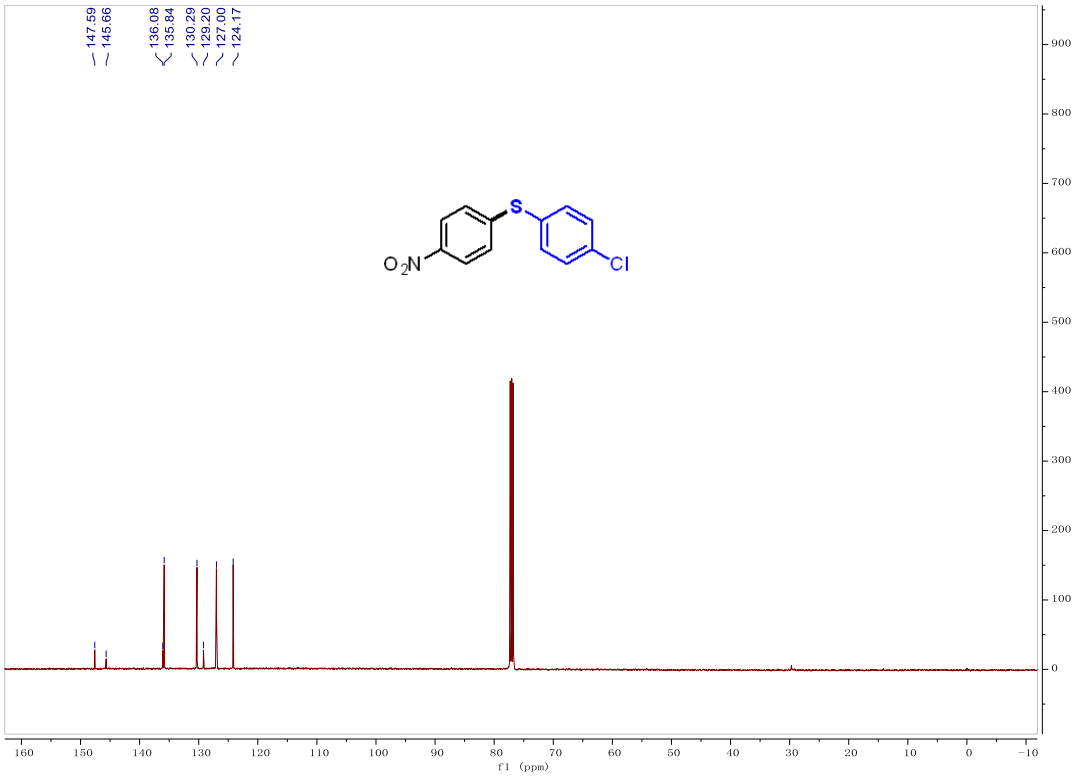
^{1}H and ^{13}C NMR spectra of compound 5h



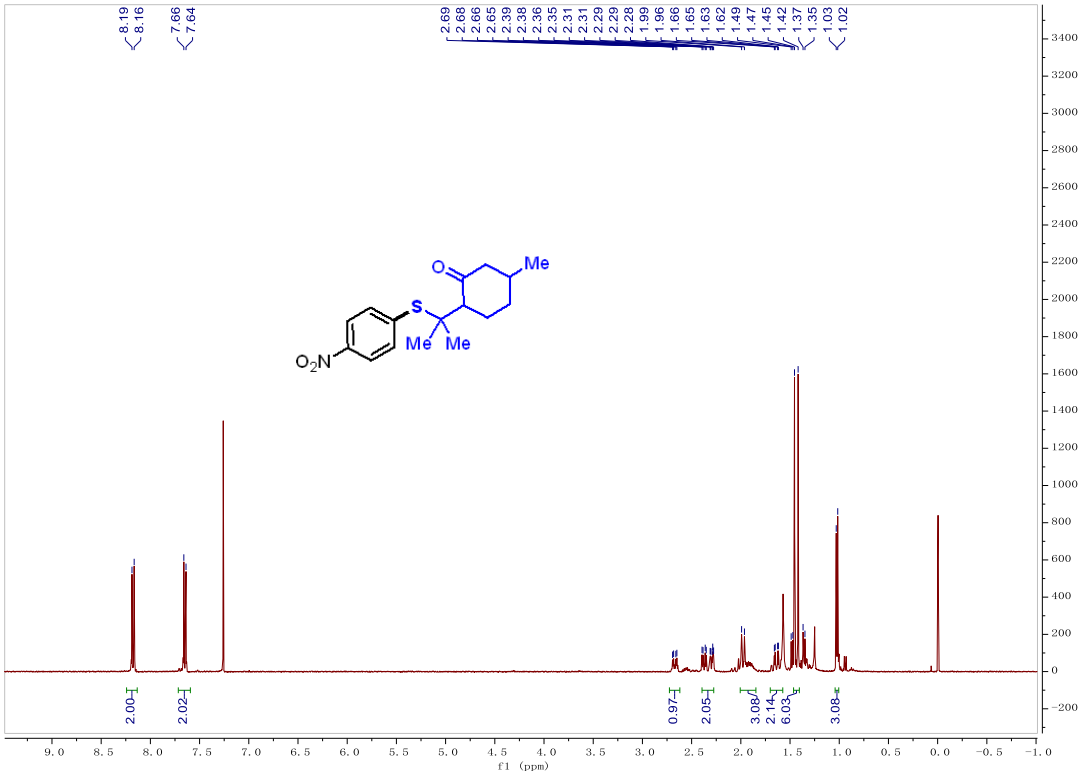


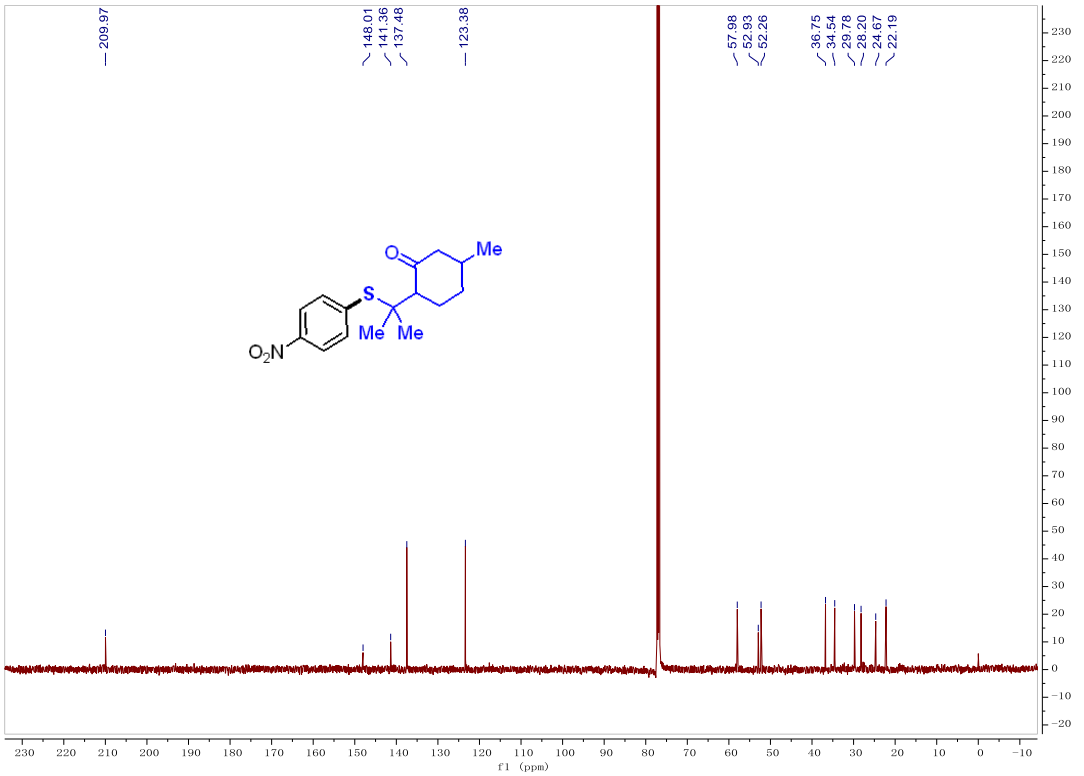
^{1}H and ^{13}C NMR spectra of compound 5i



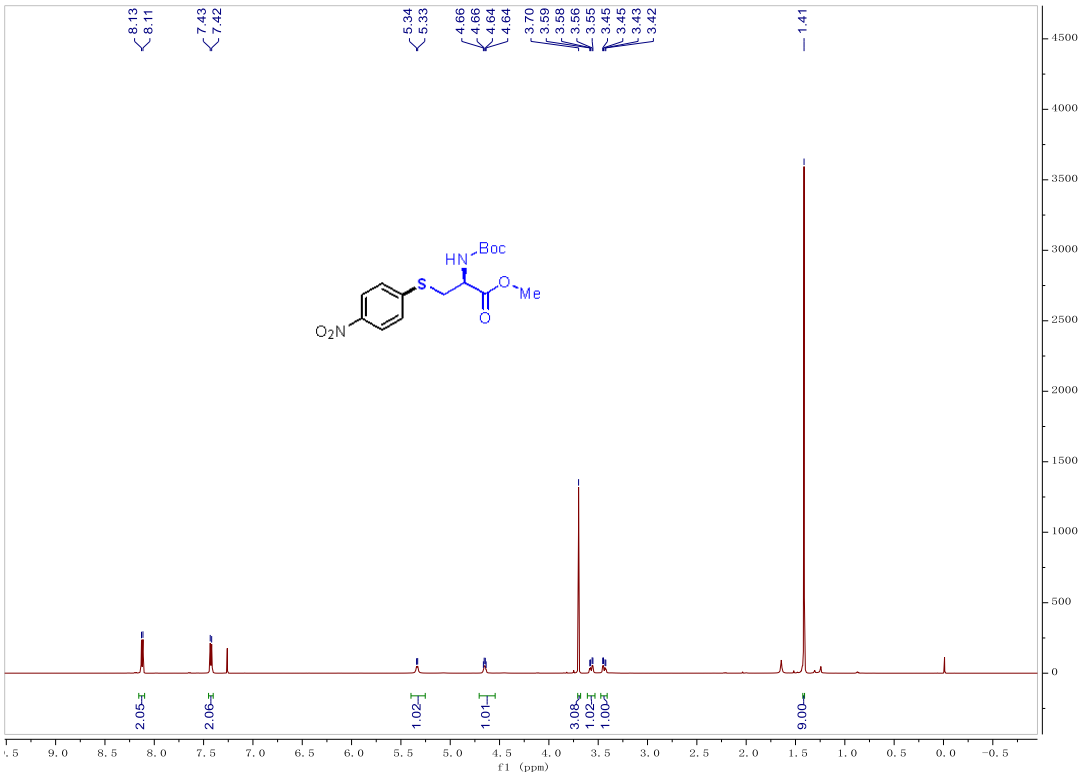


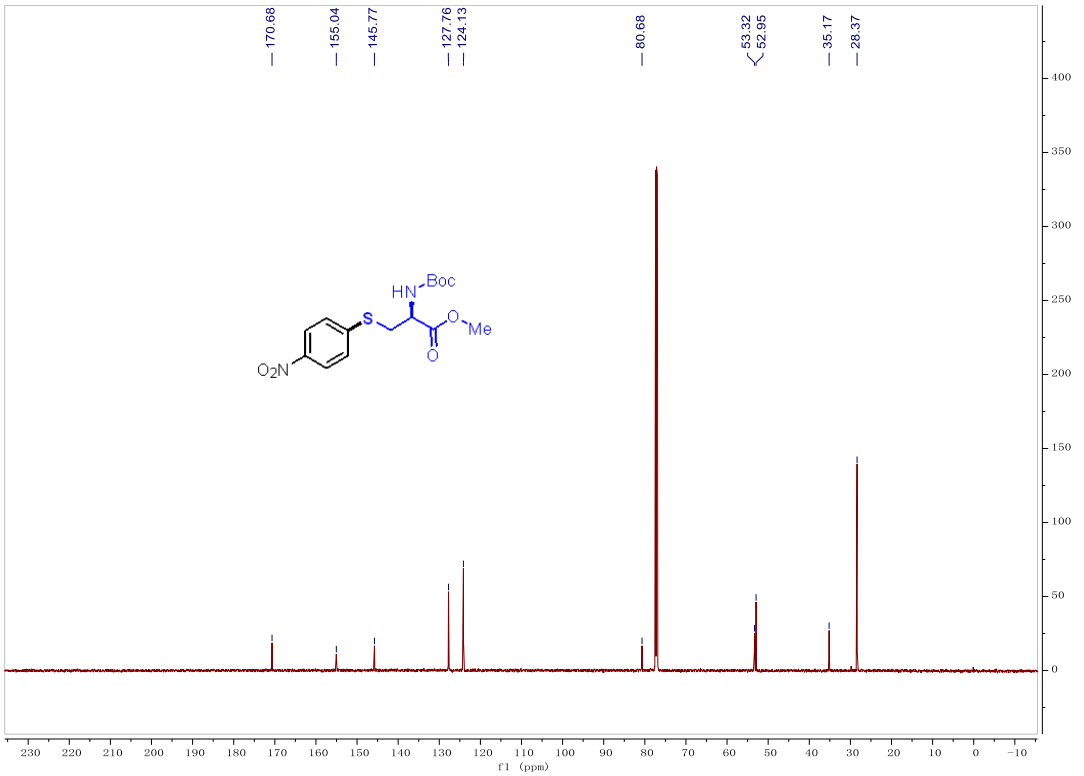
^{1}H and ^{13}C NMR spectra of compound 5j



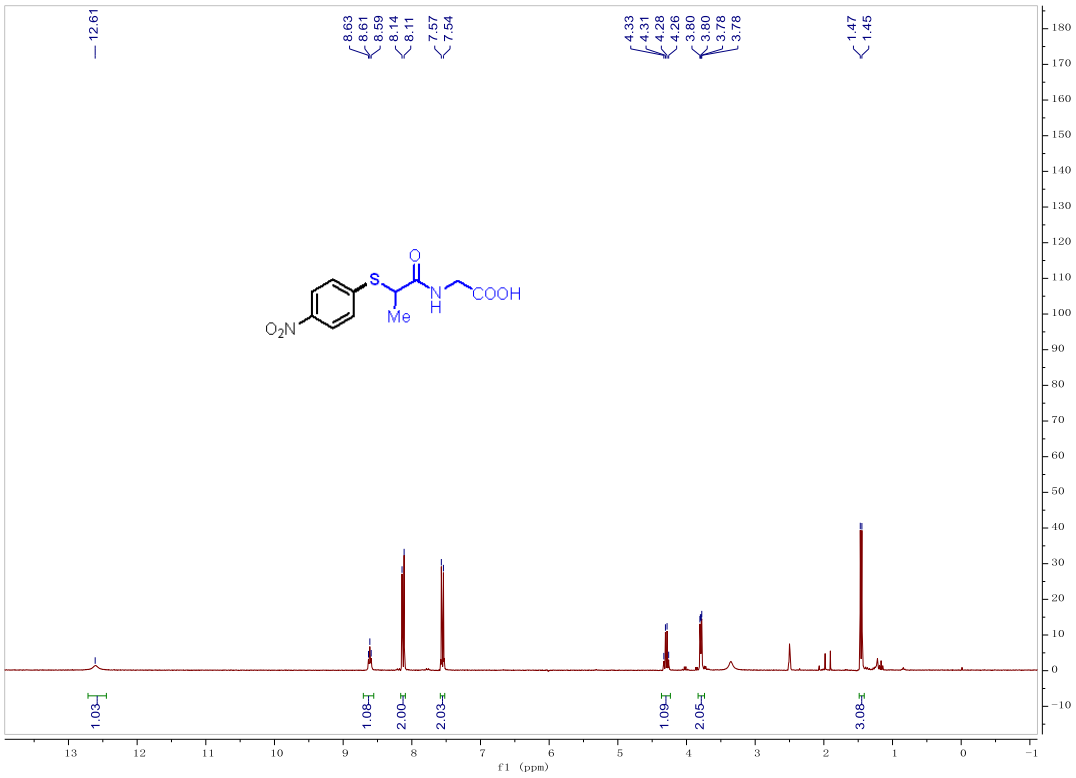


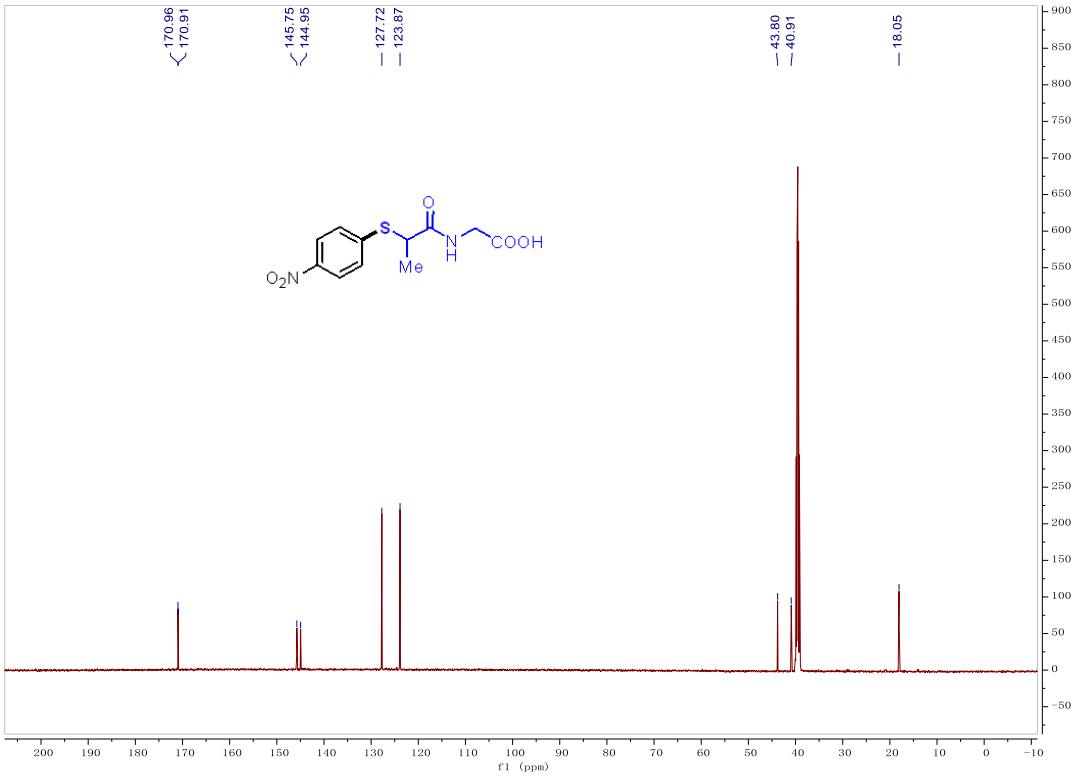
^{1}H and ^{13}C NMR spectra of compound 5k



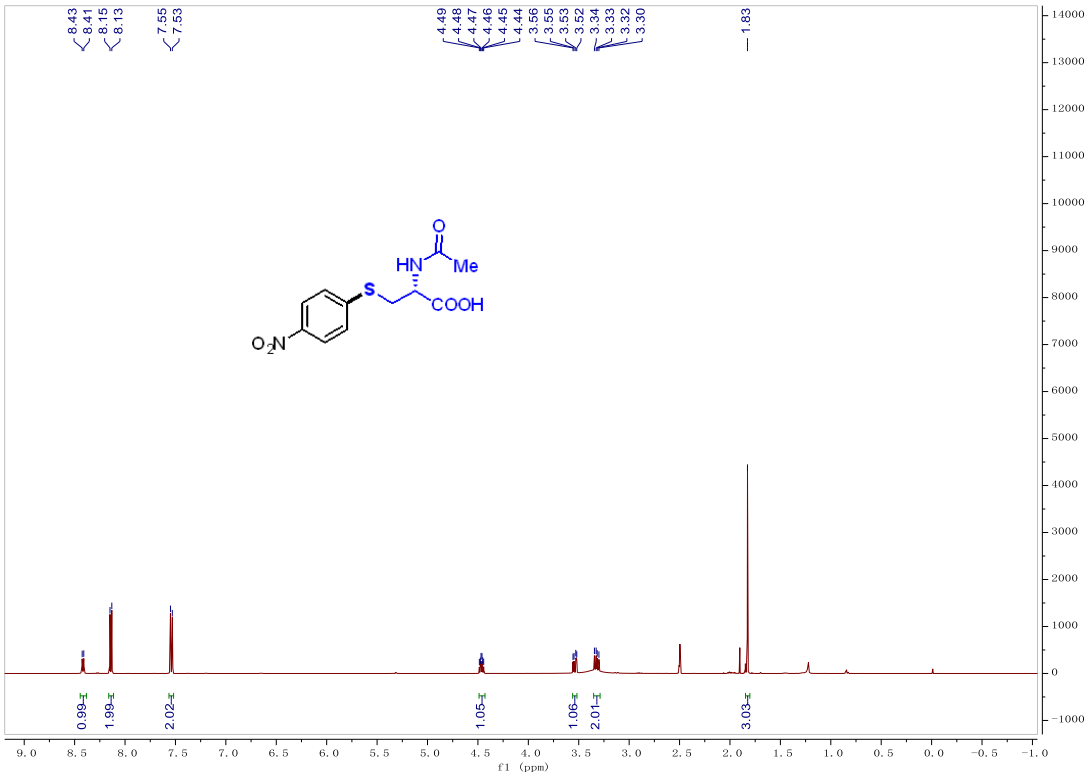


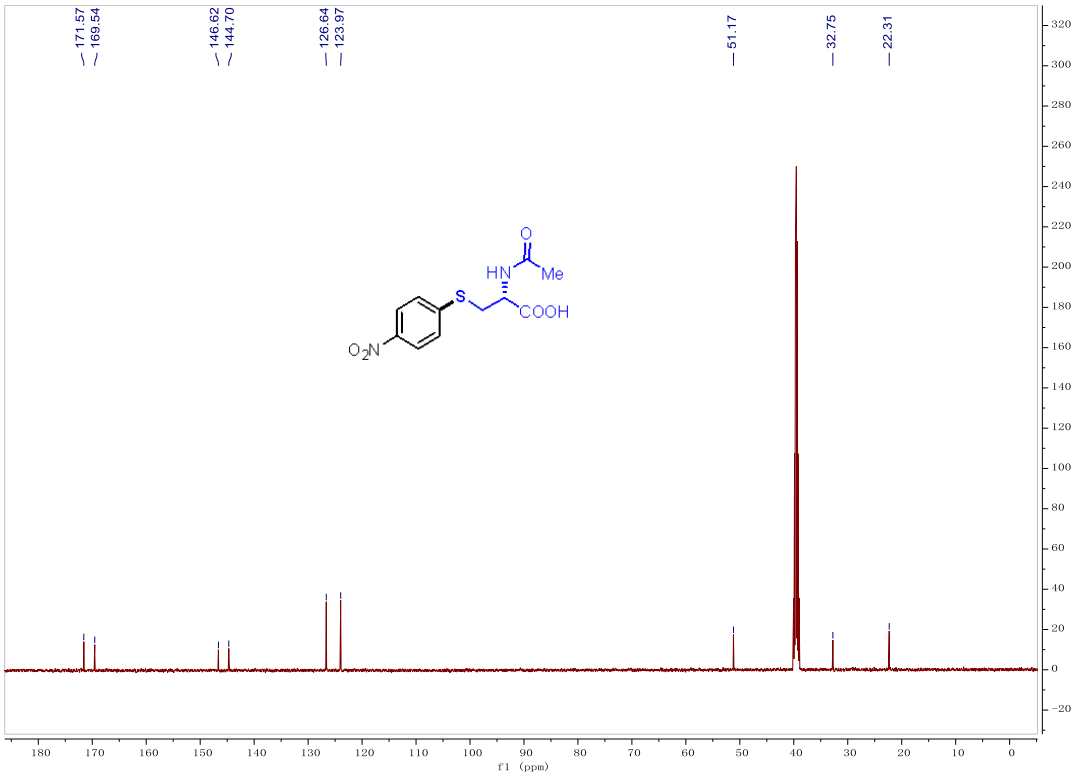
^{1}H and ^{13}C NMR spectra of compound 5l



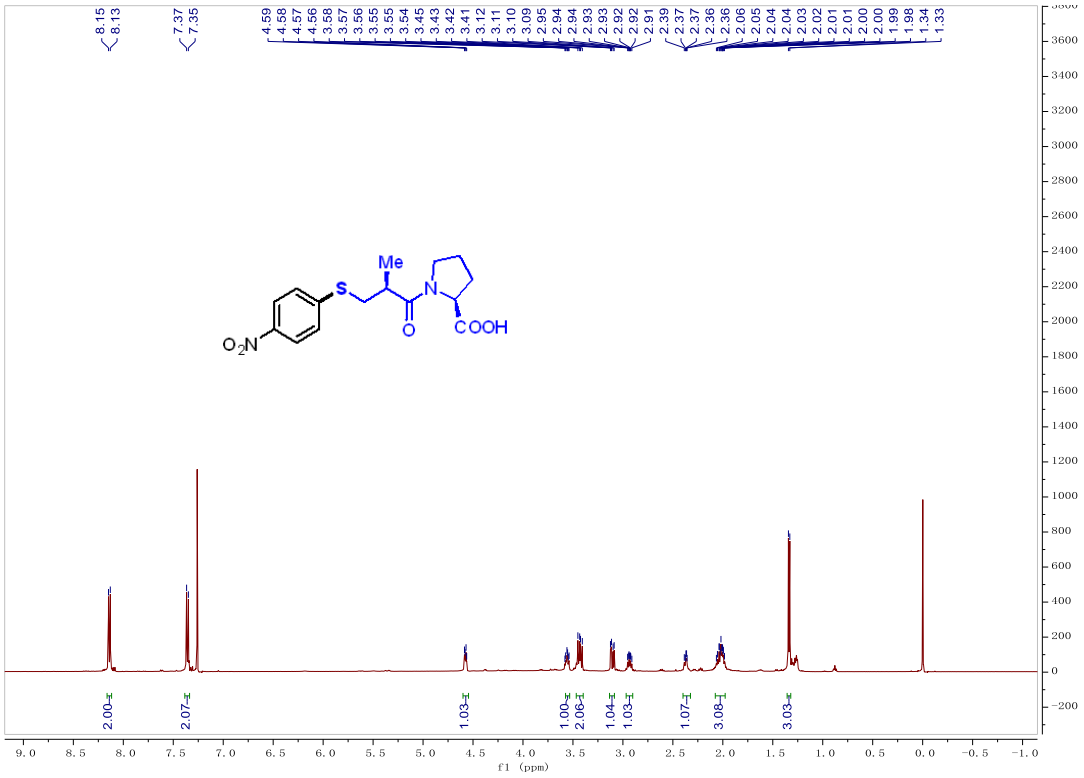


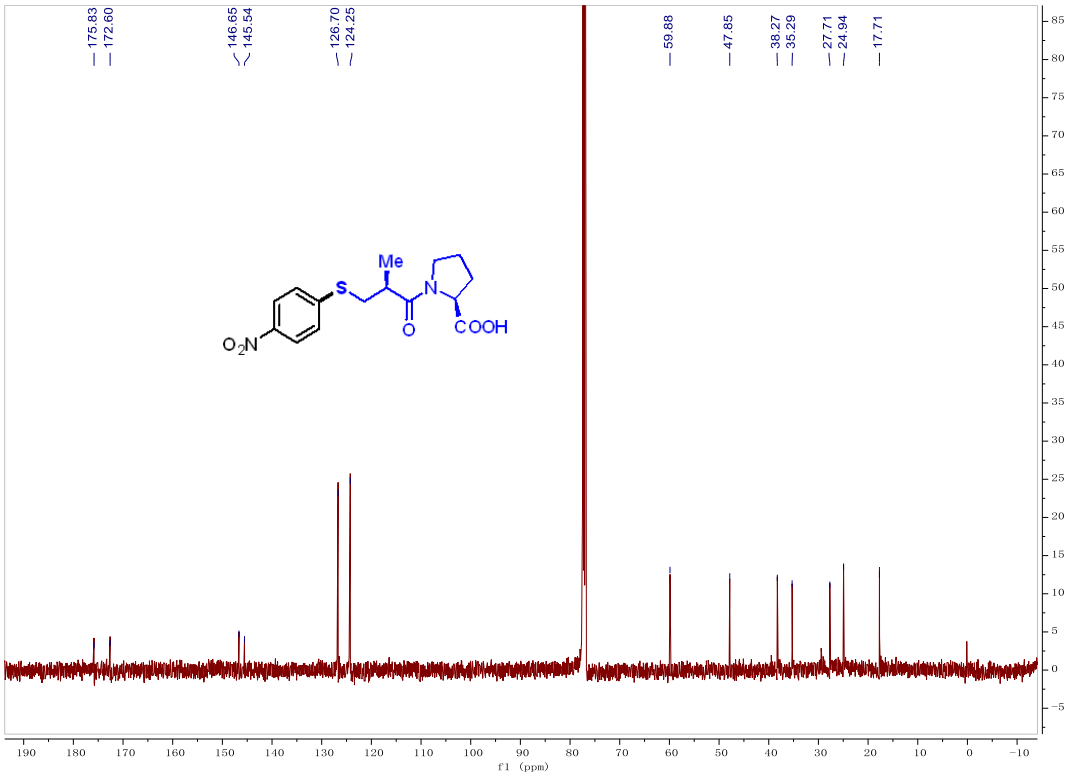
^{1}H and ^{13}C NMR spectra of compound 5m



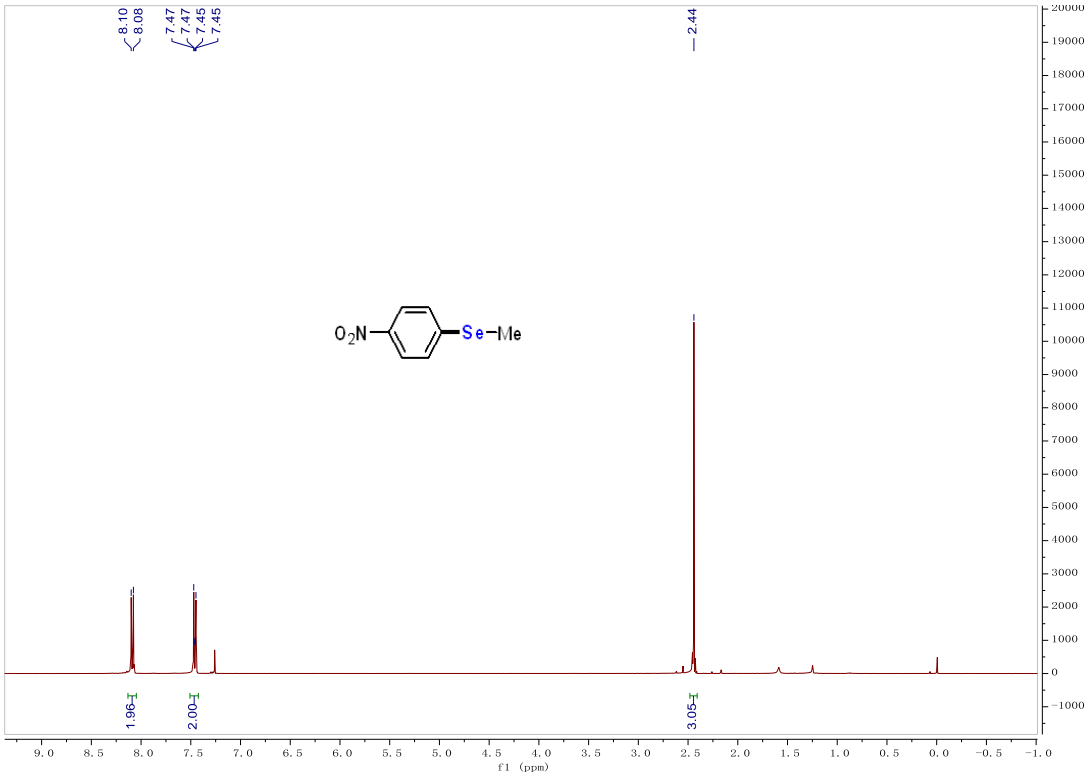


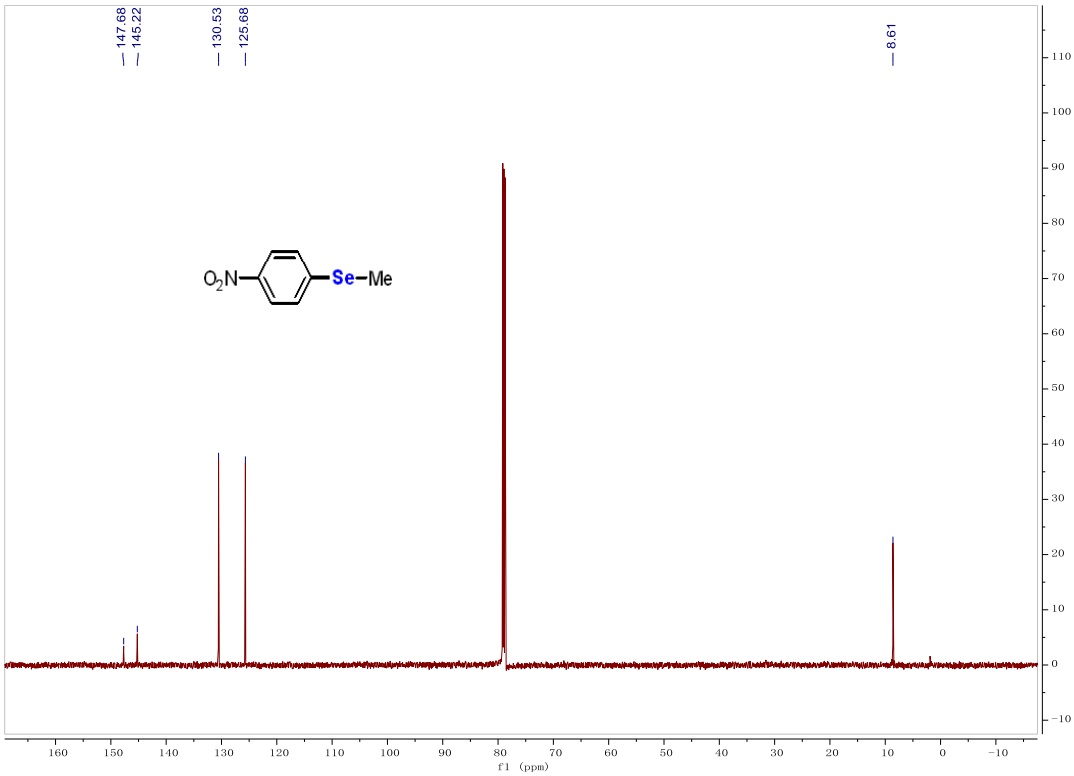
^{1}H and ^{13}C NMR spectra of compound 5n



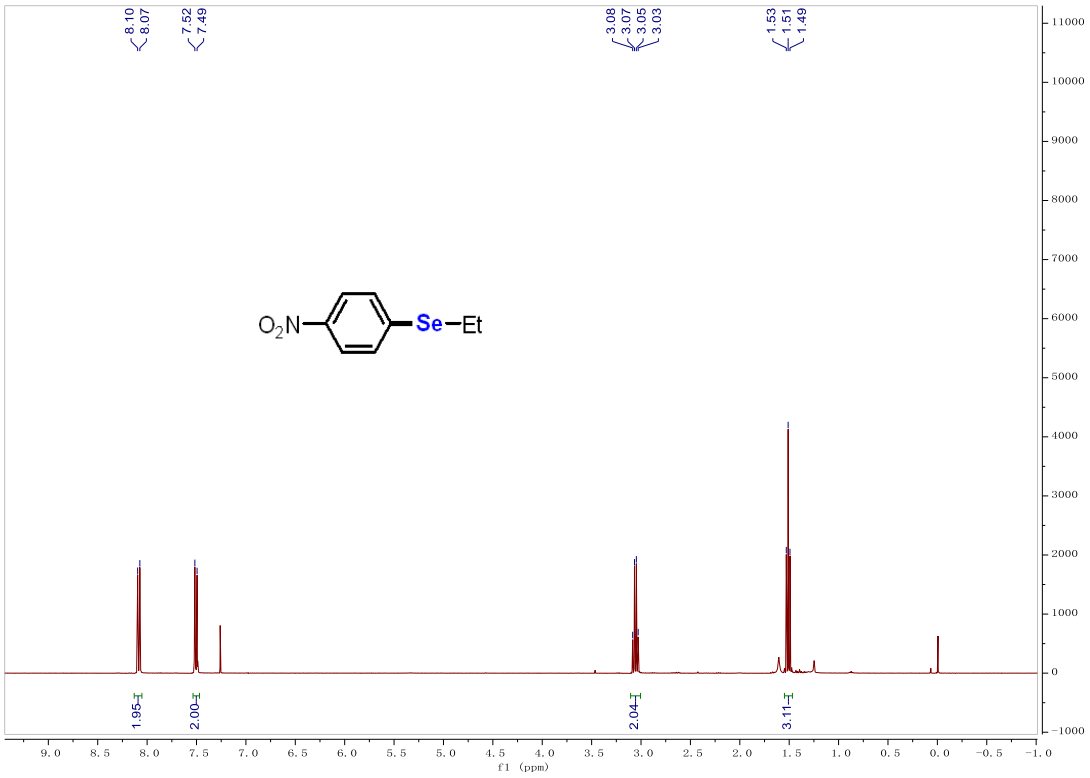


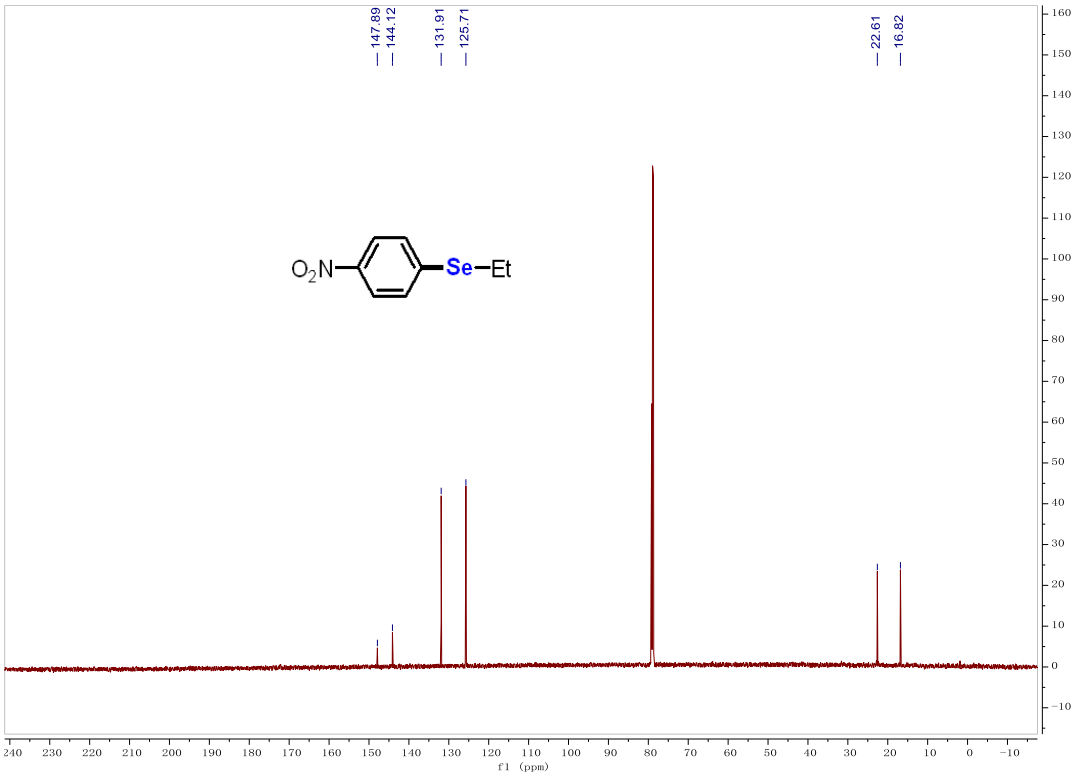
^{1}H and ^{13}C NMR spectra of compound 6a



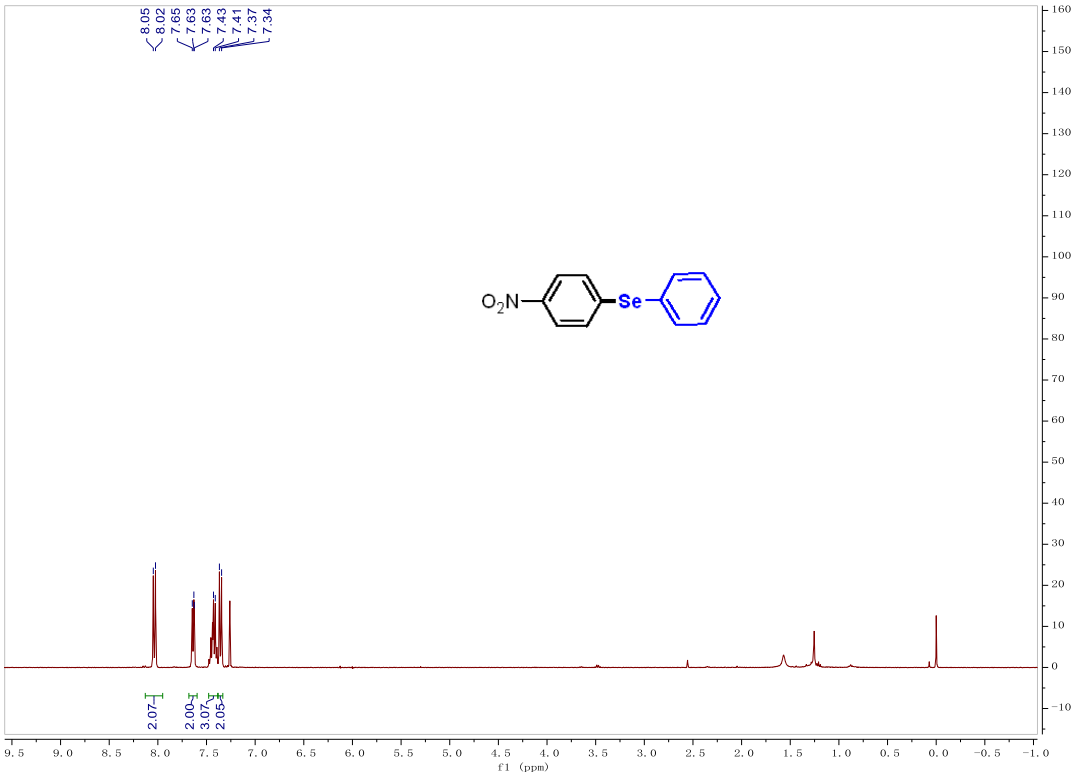


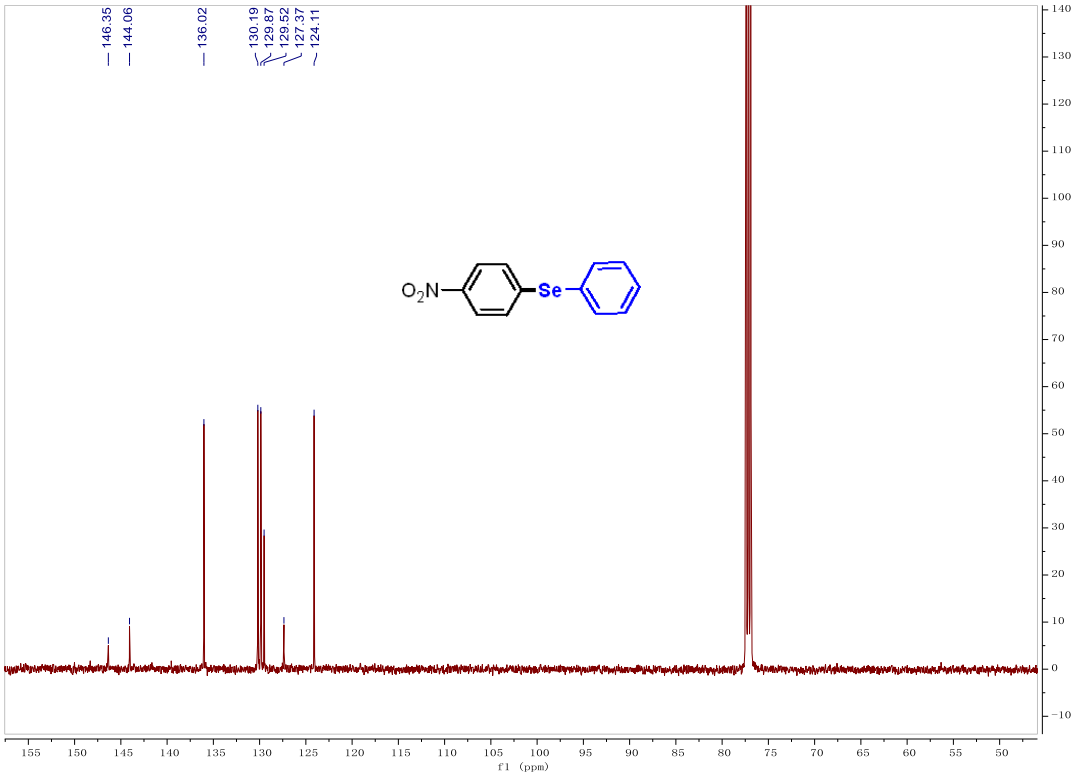
^{1}H and ^{13}C NMR spectra of compound 6b



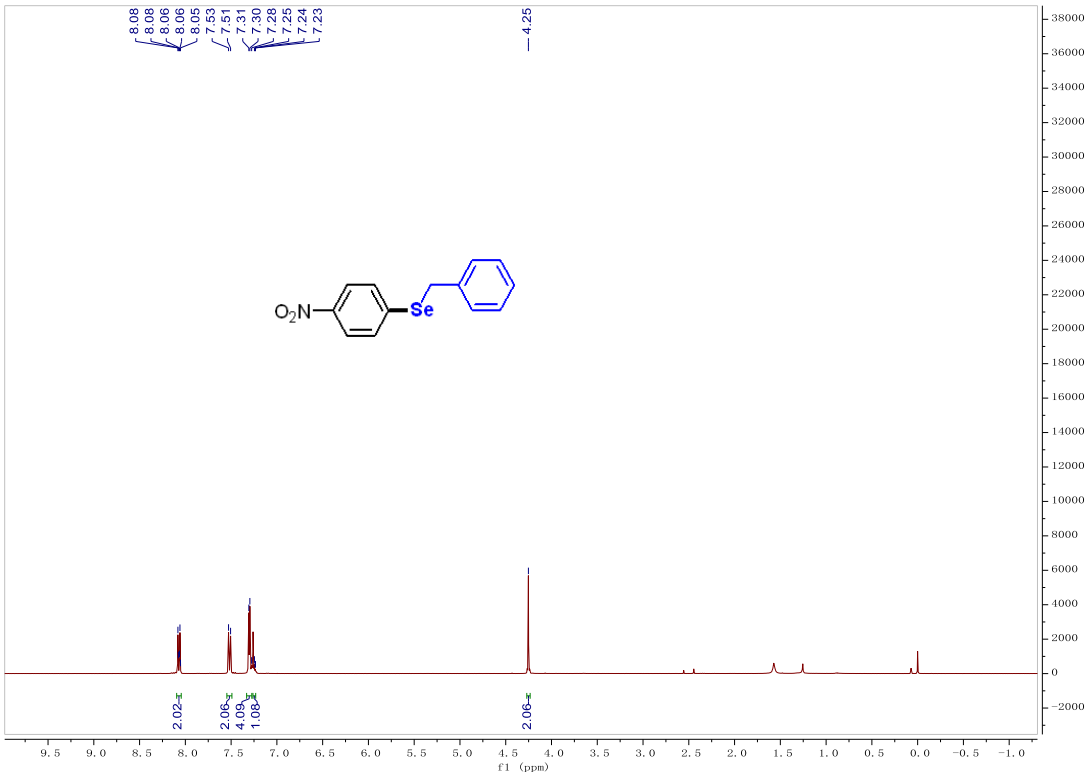


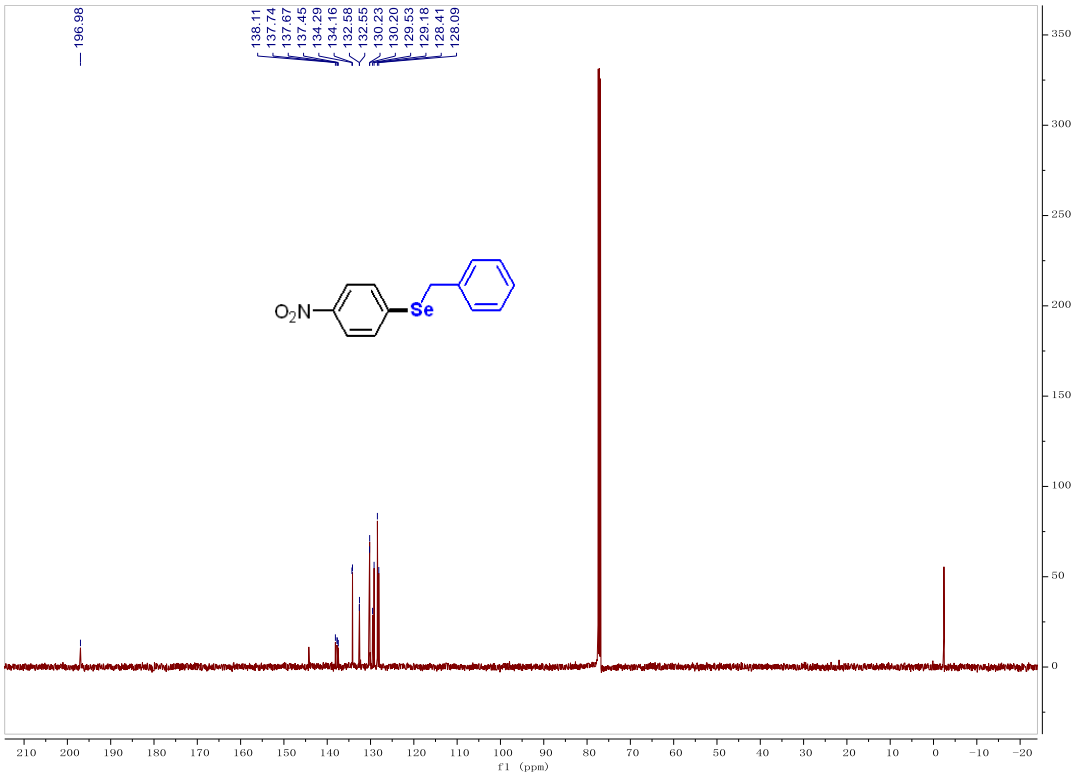
^{1}H and ^{13}C NMR spectra of compound 6c



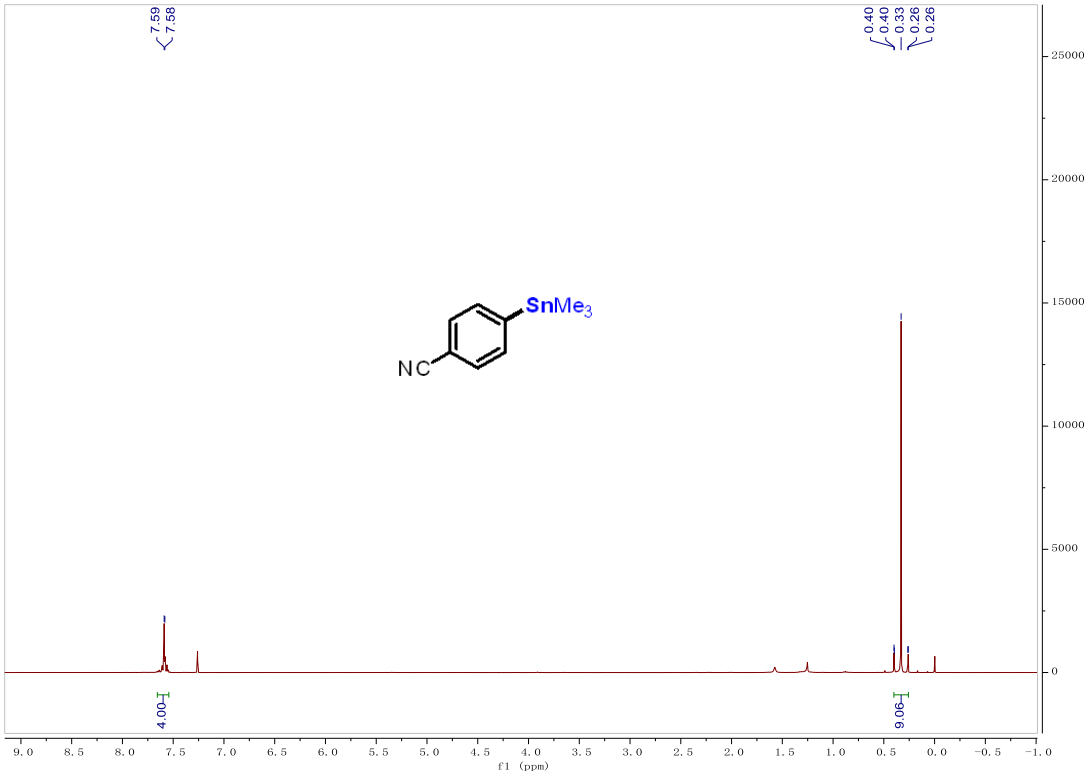


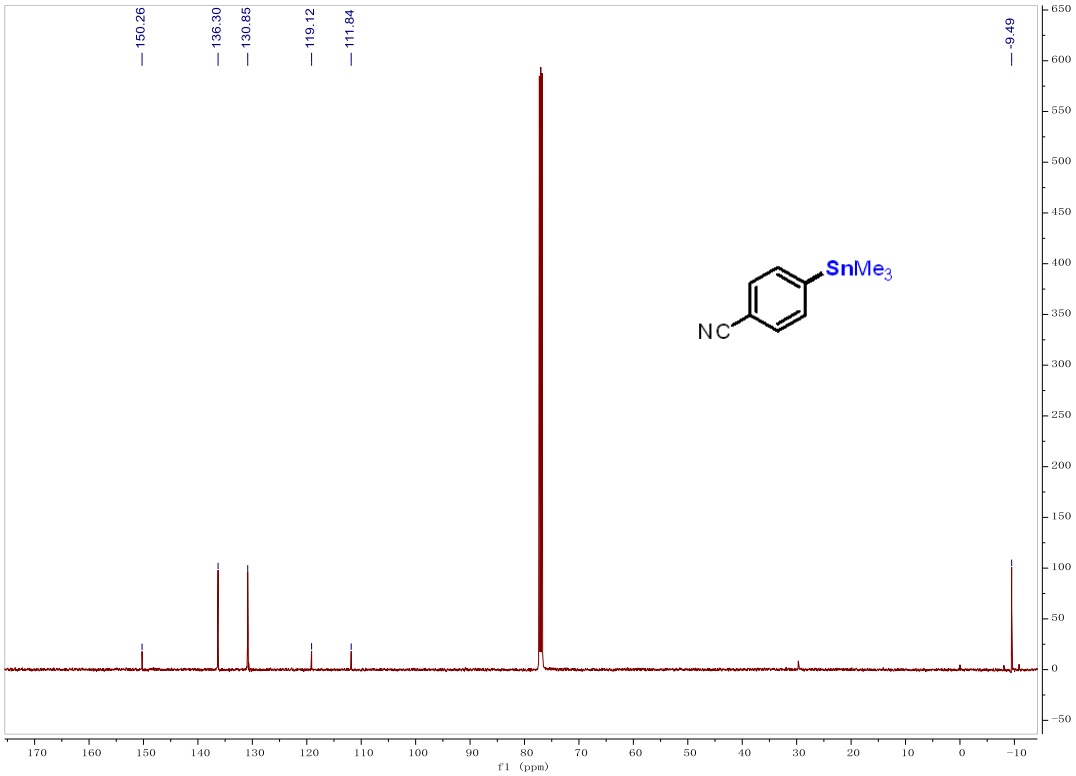
^{1}H and ^{13}C NMR spectra of compound 6d



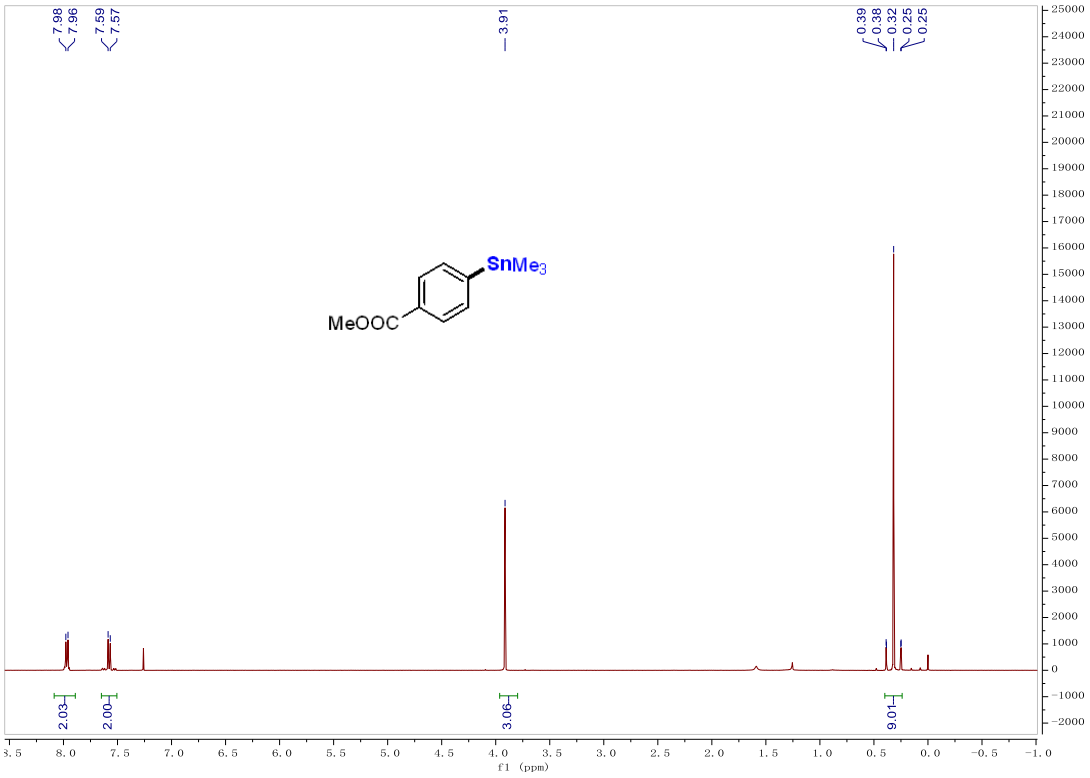


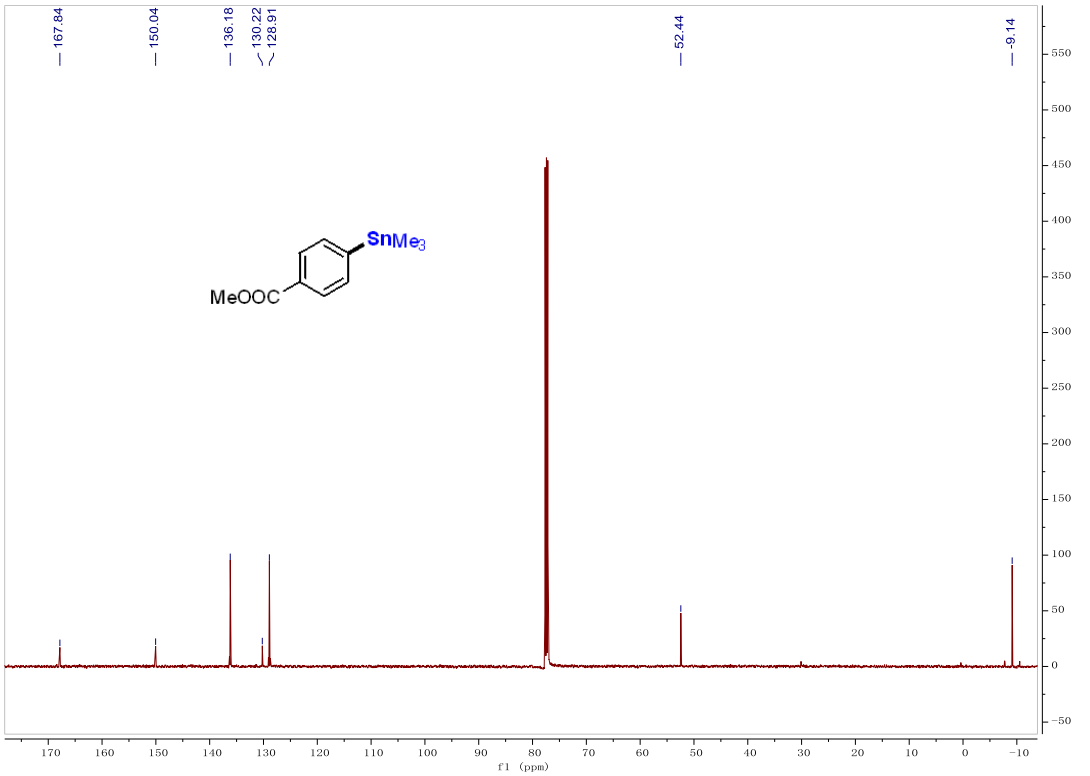
^{1}H and ^{13}C NMR spectra of compound 7a



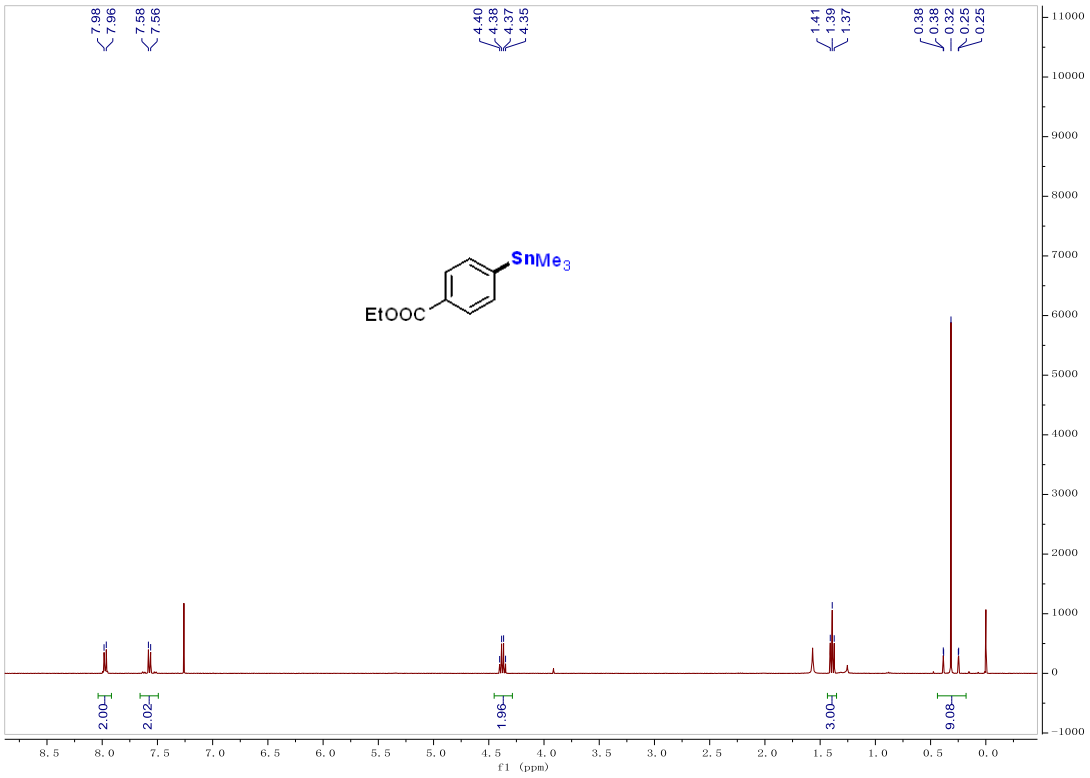


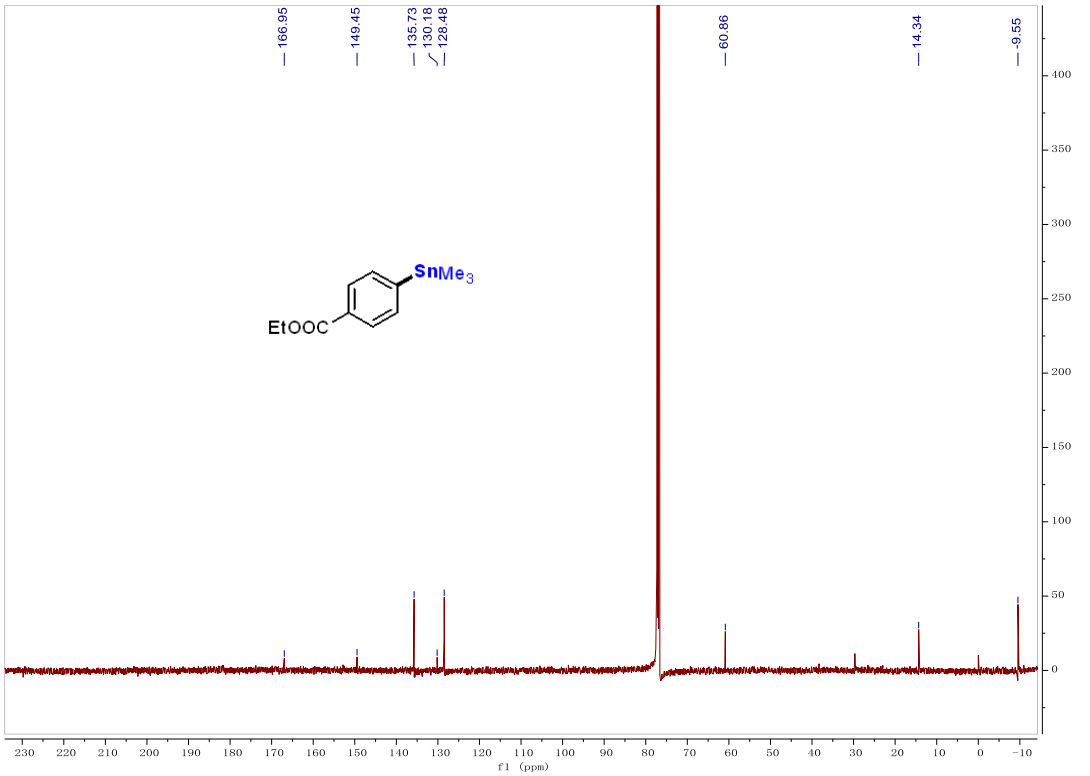
^{1}H and ^{13}C NMR spectra of compound 7b



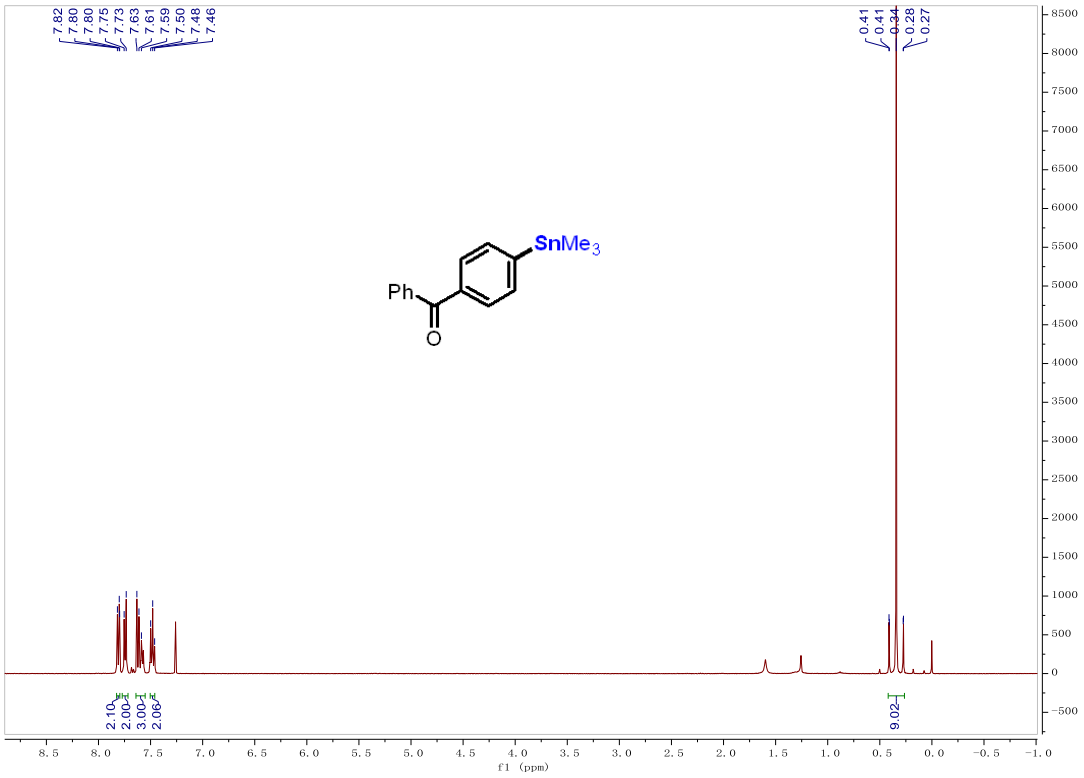


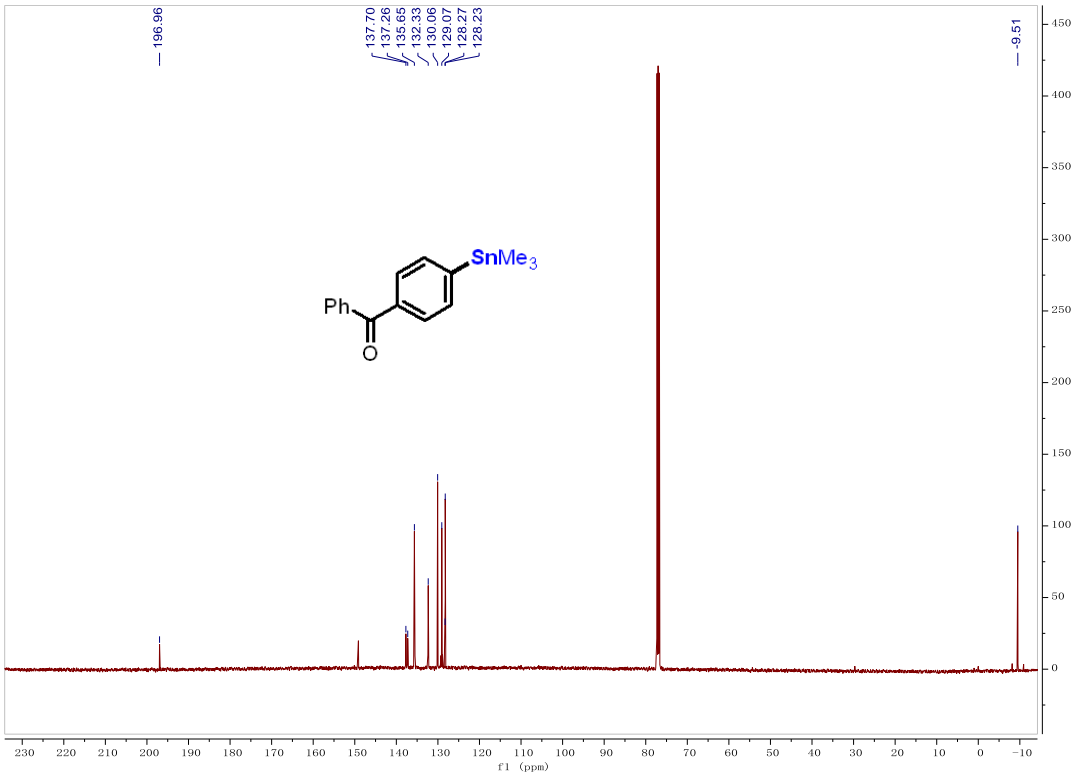
^{1}H and ^{13}C NMR spectra of compound 7c



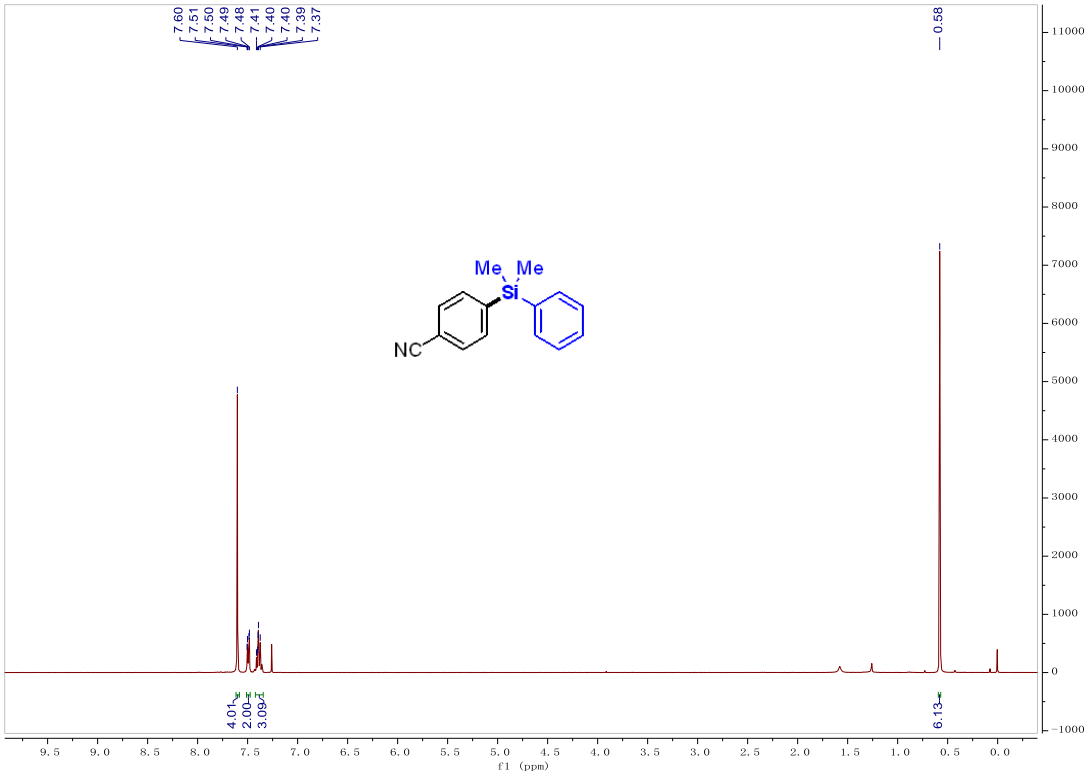


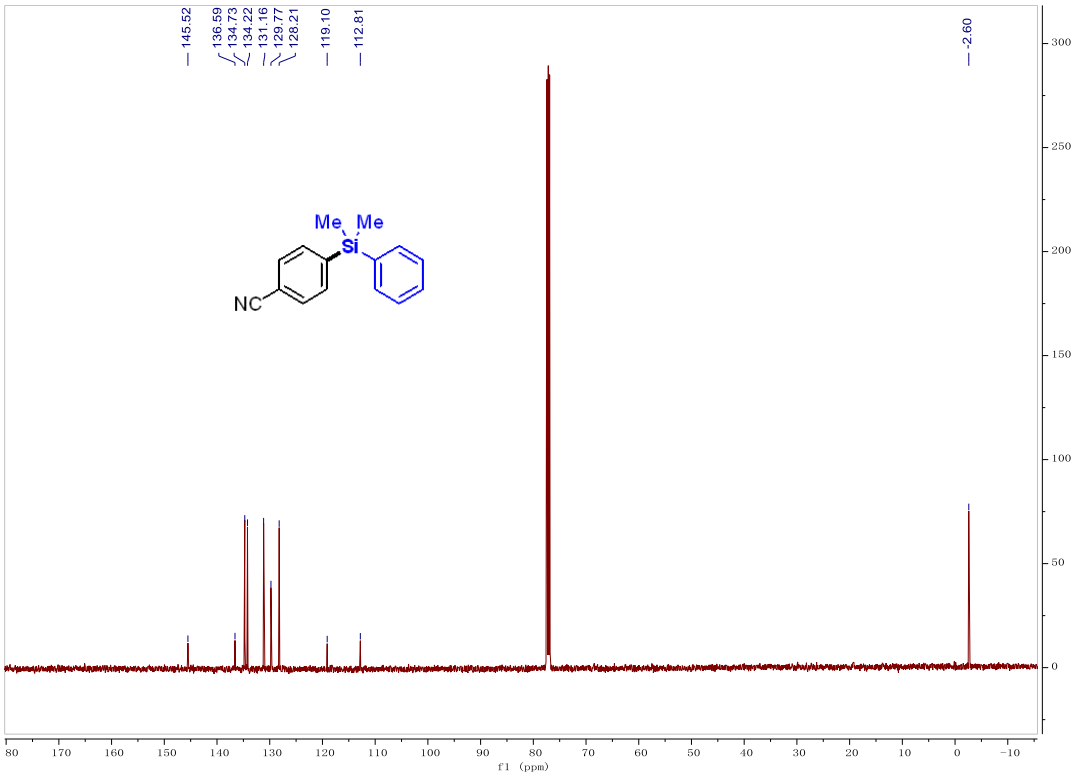
^{1}H and ^{13}C NMR spectra of compound 7d



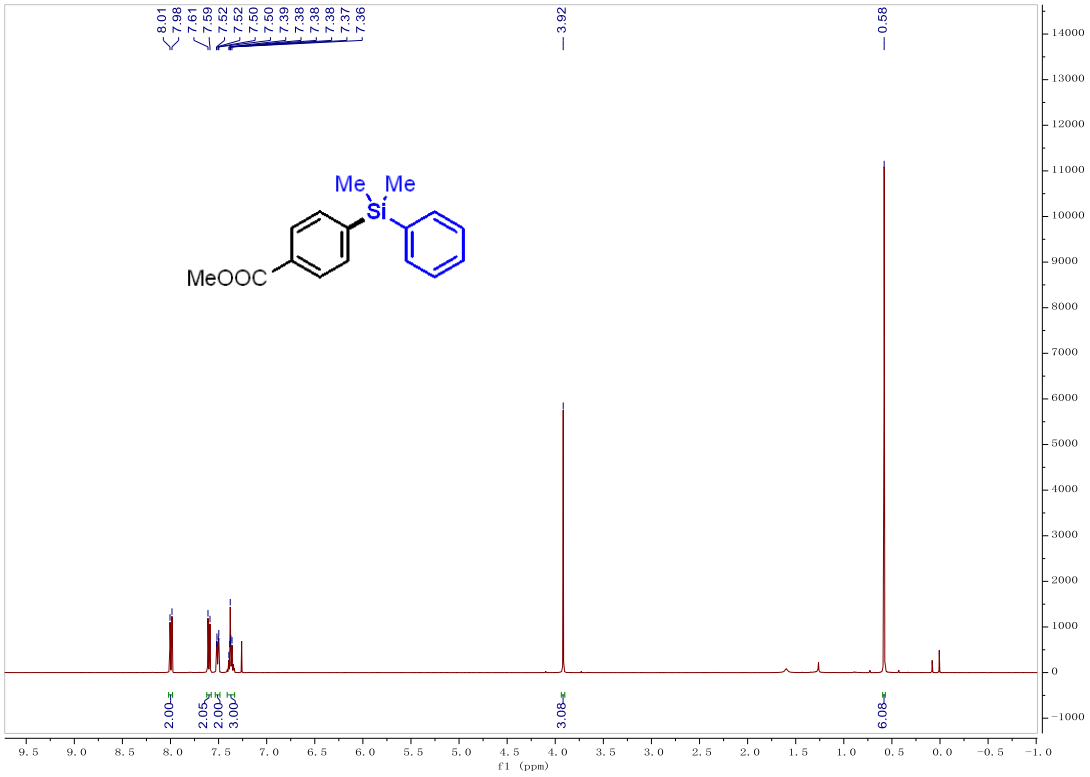


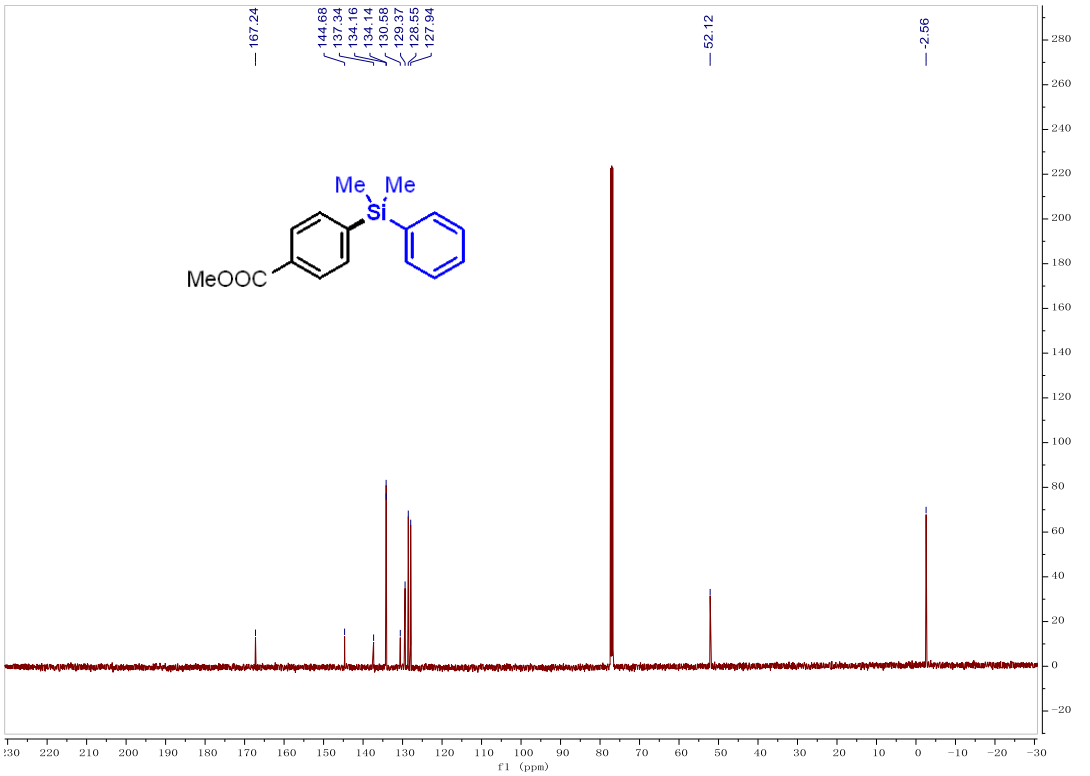
^{1}H and ^{13}C NMR spectra of compound 8a



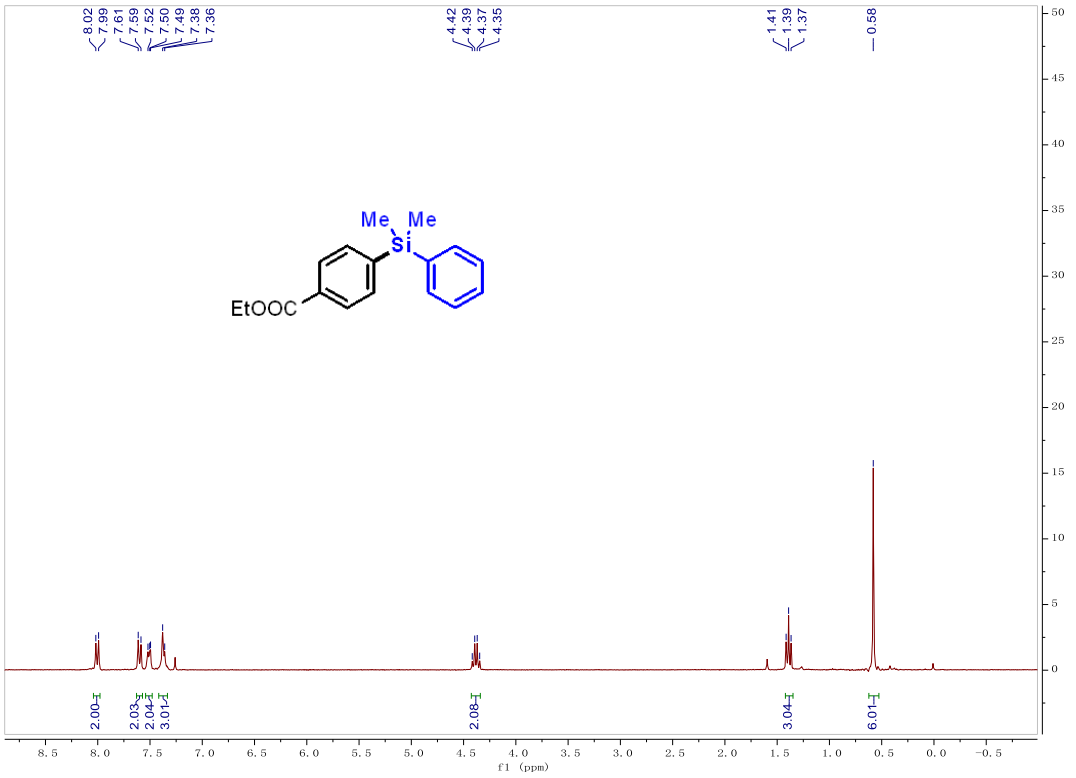


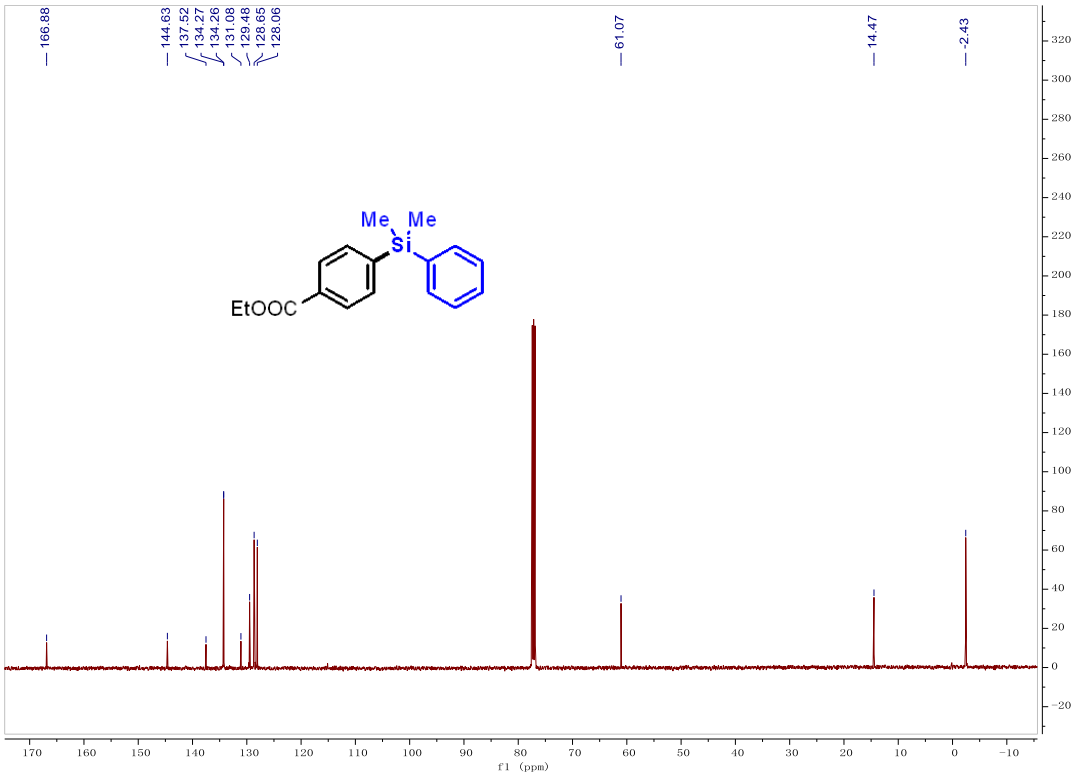
^{1}H and ^{13}C NMR spectra of compound 8b



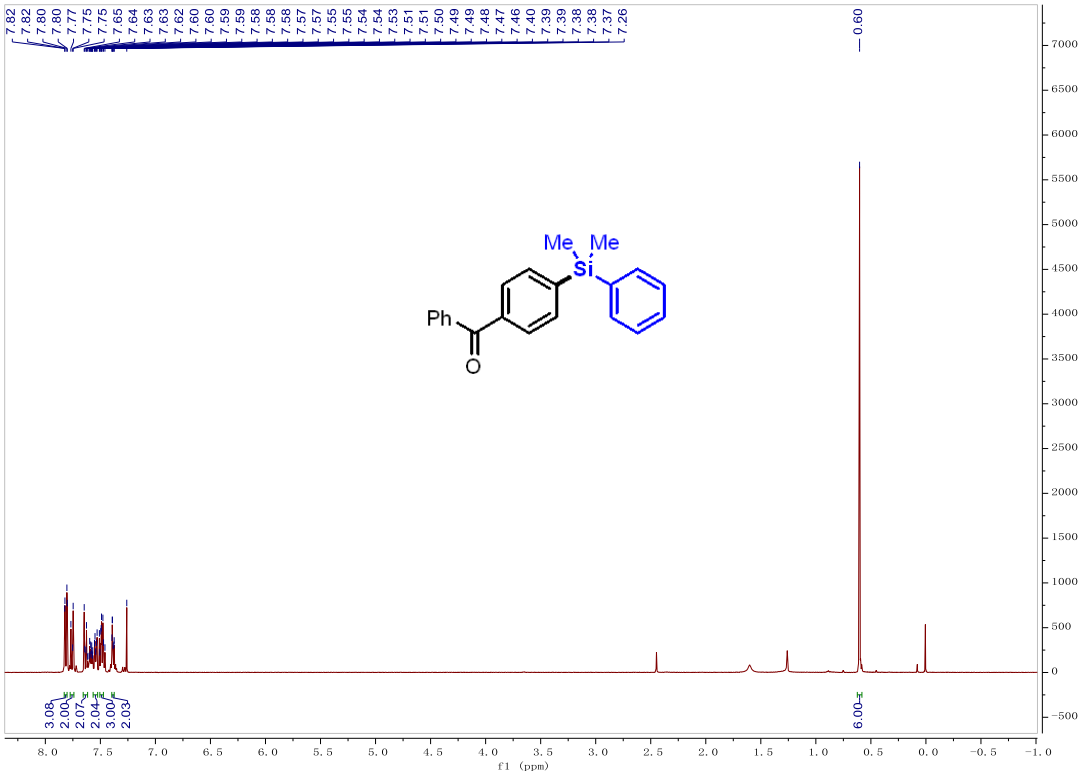


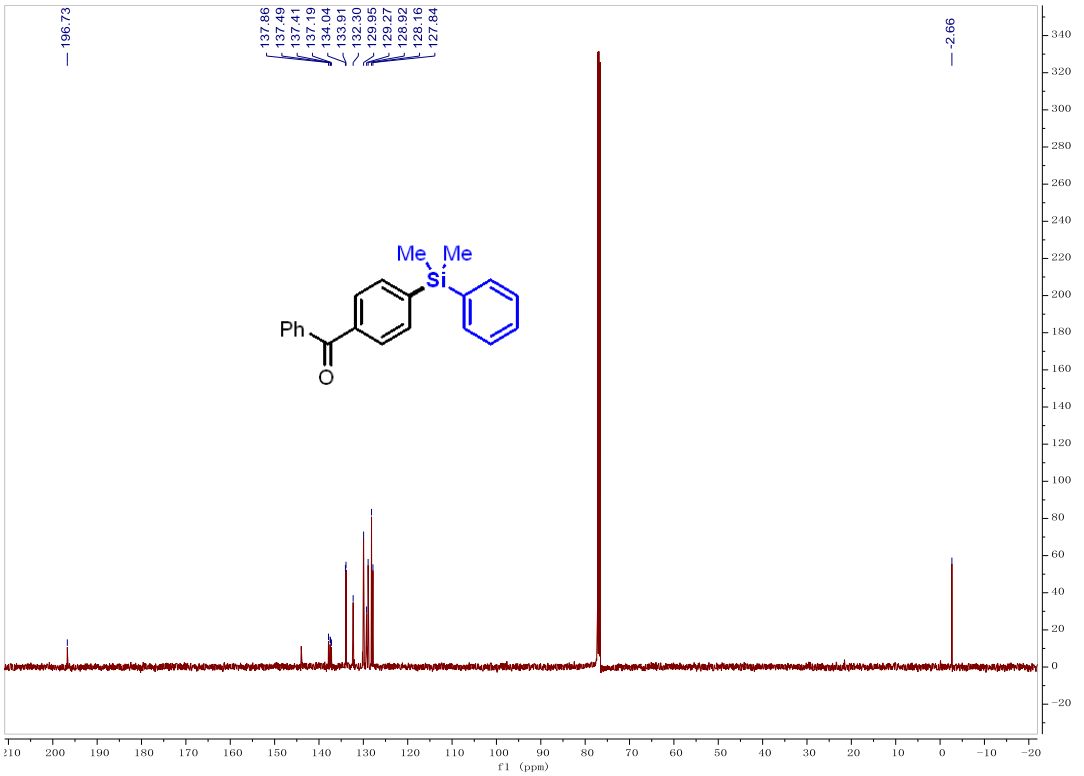
^{1}H and ^{13}C NMR spectra of compound 8c



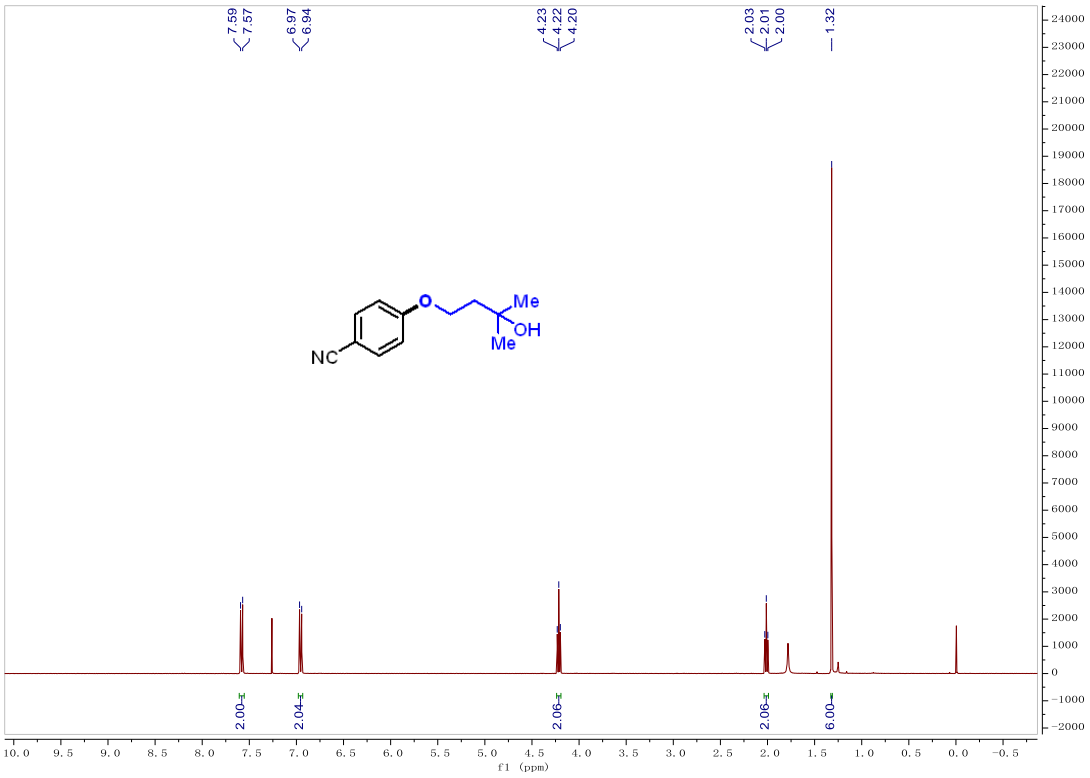


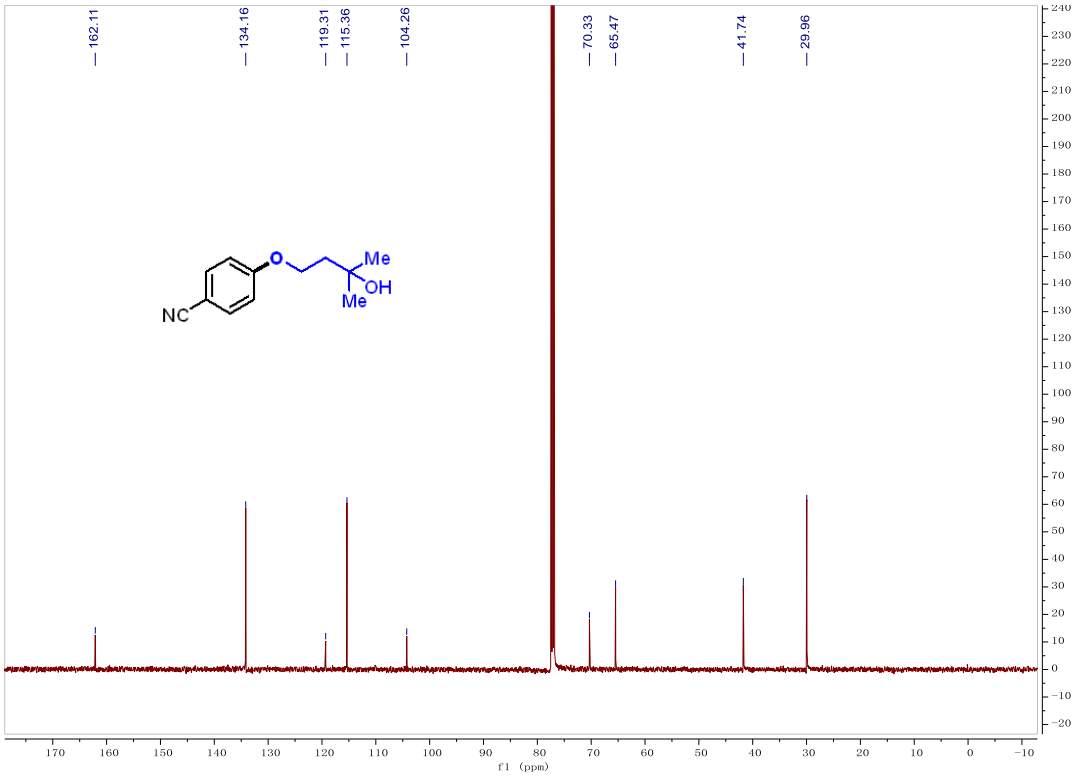
^{1}H and ^{13}C NMR spectra of compound 8d



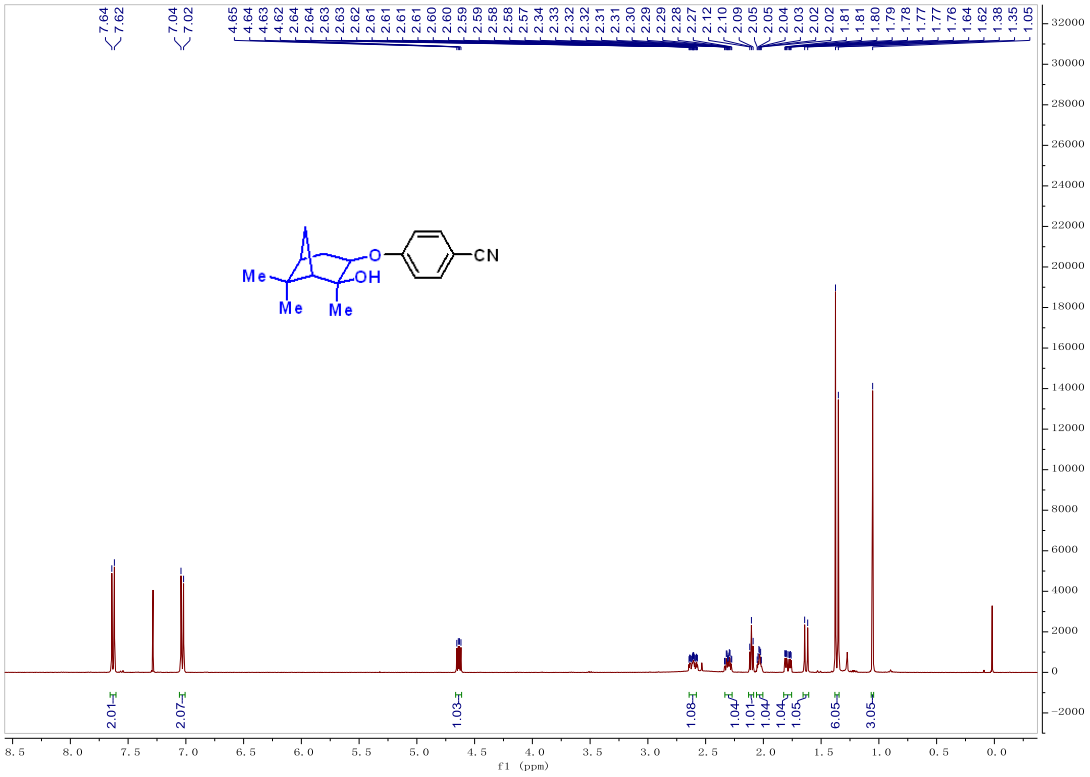


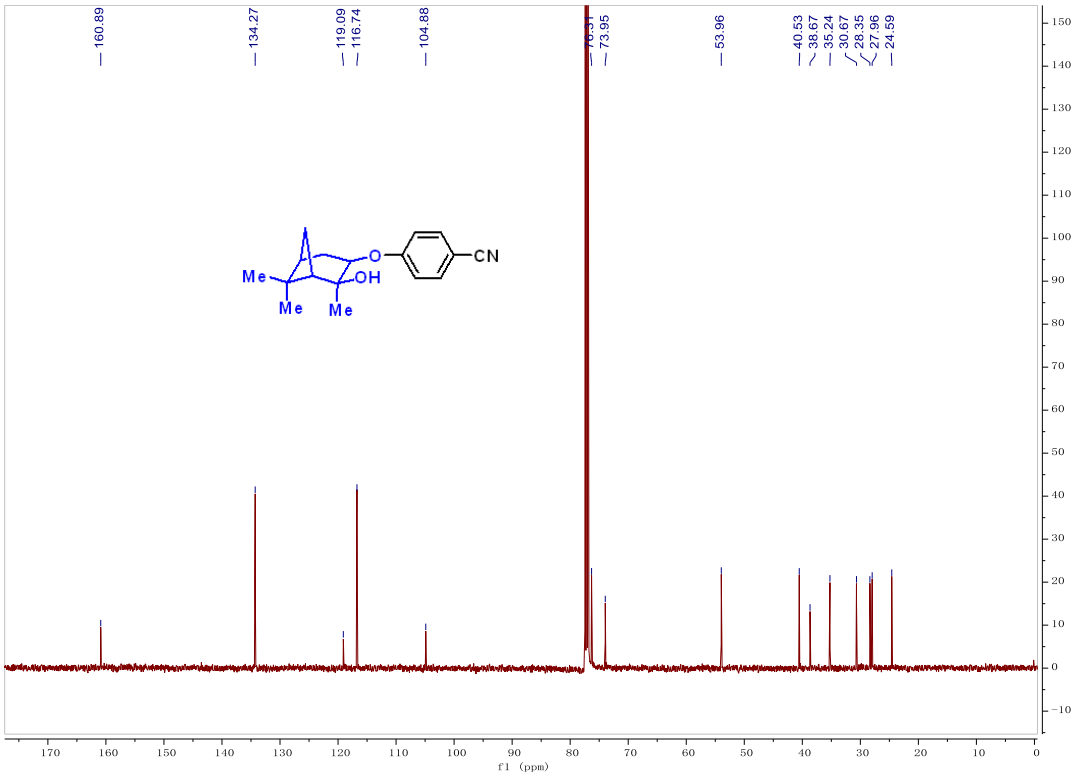
^{1}H and ^{13}C NMR spectra of compound 3l



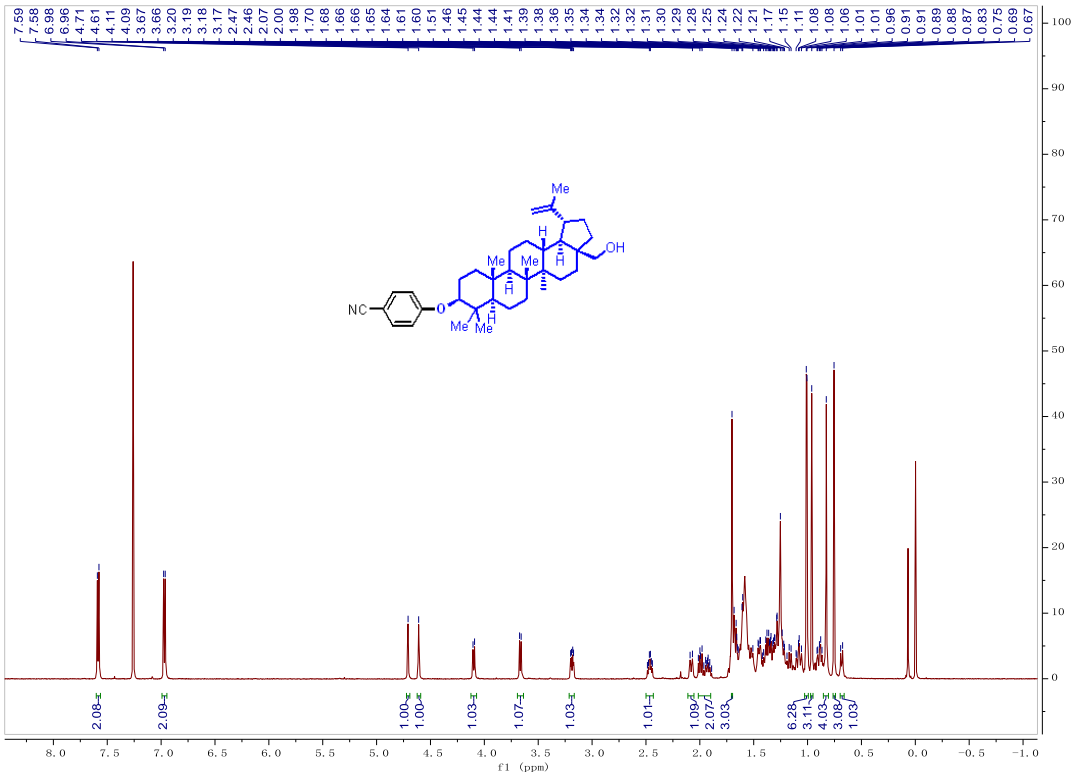


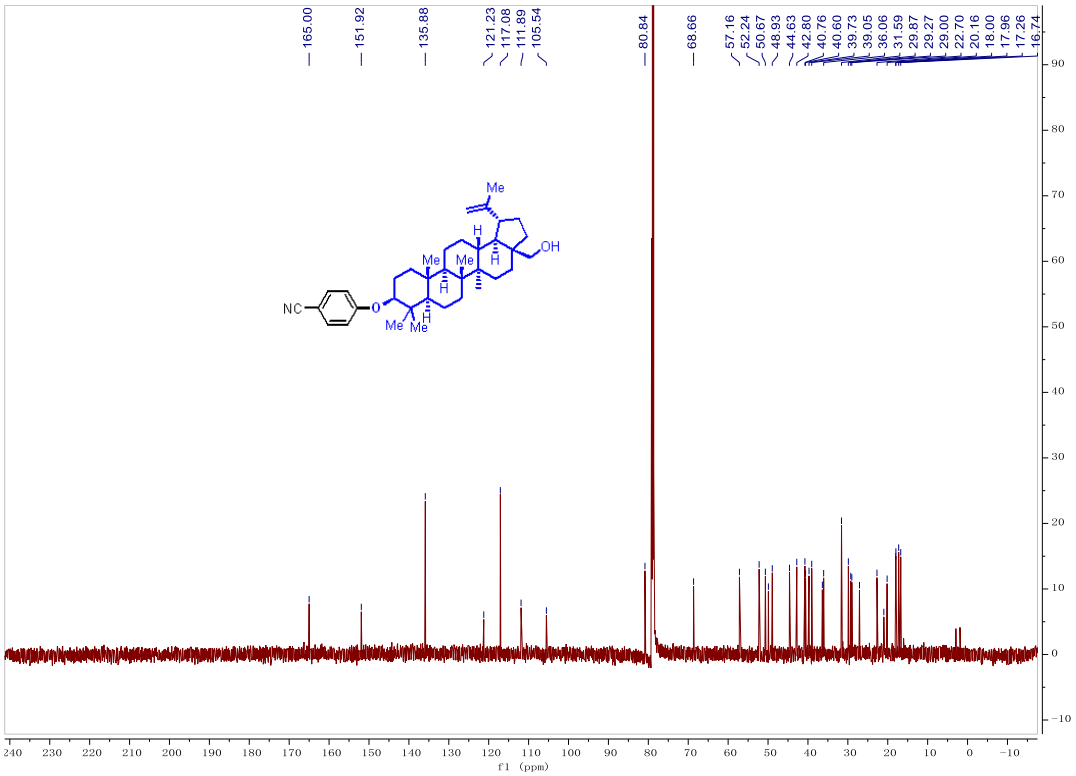
^{1}H and ^{13}C NMR spectra of compound 3m



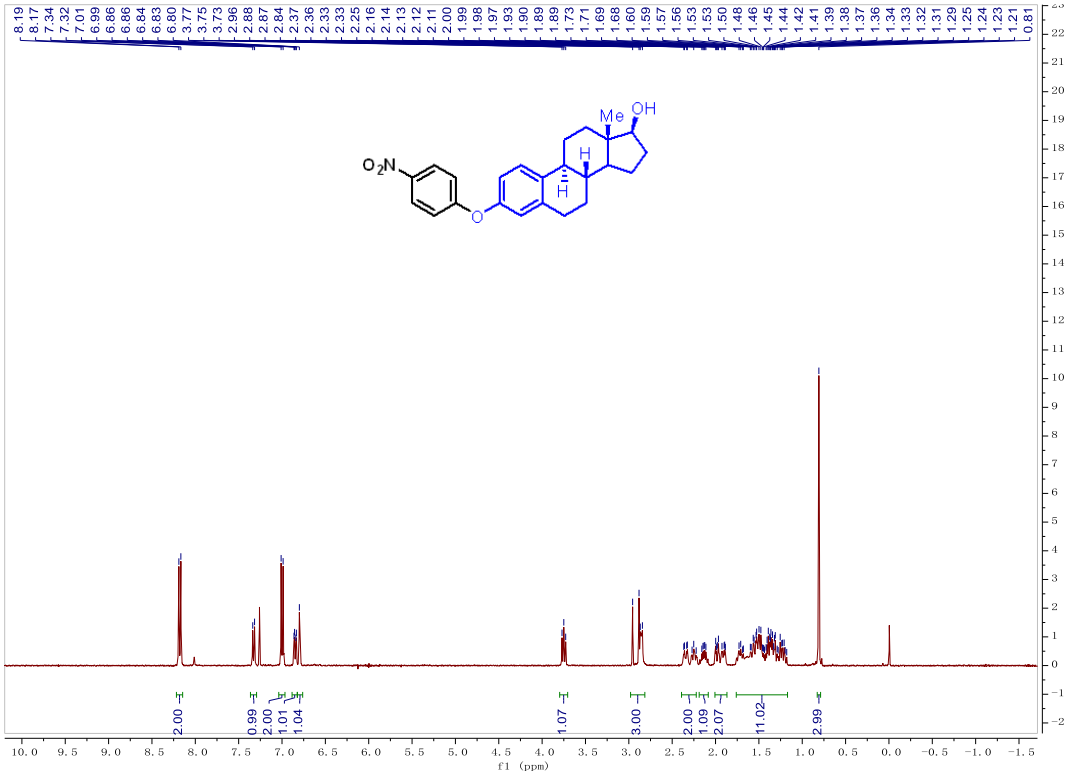


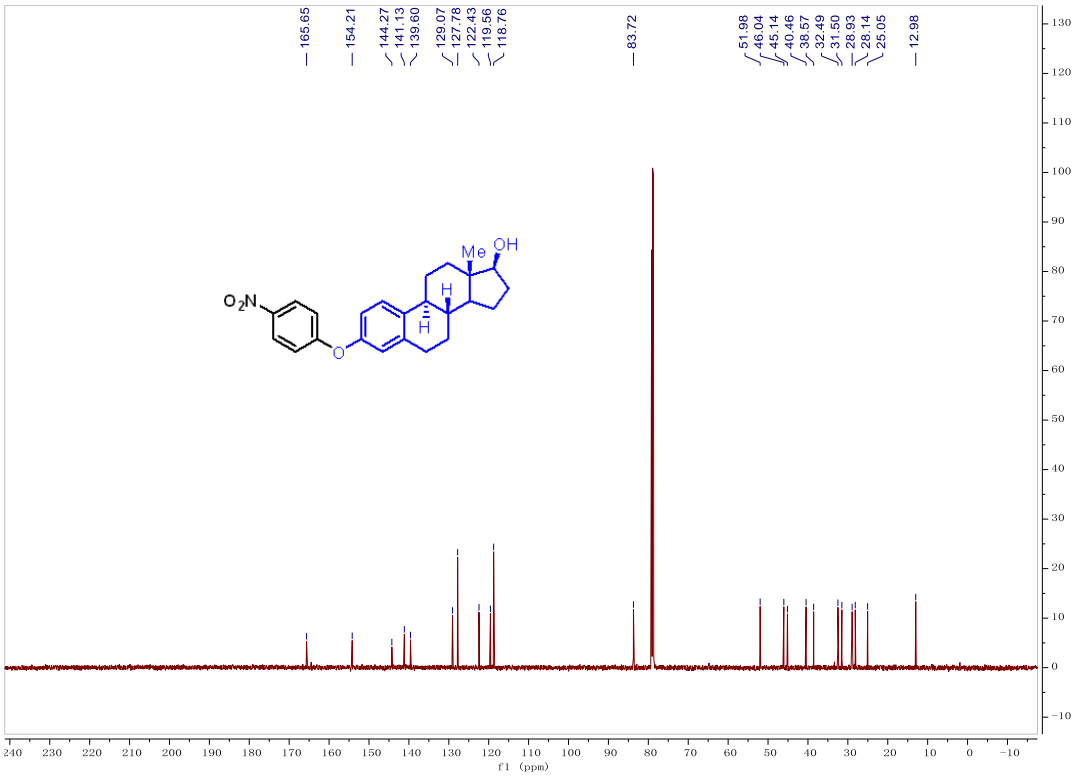
^{1}H and ^{13}C NMR spectra of compound 3n



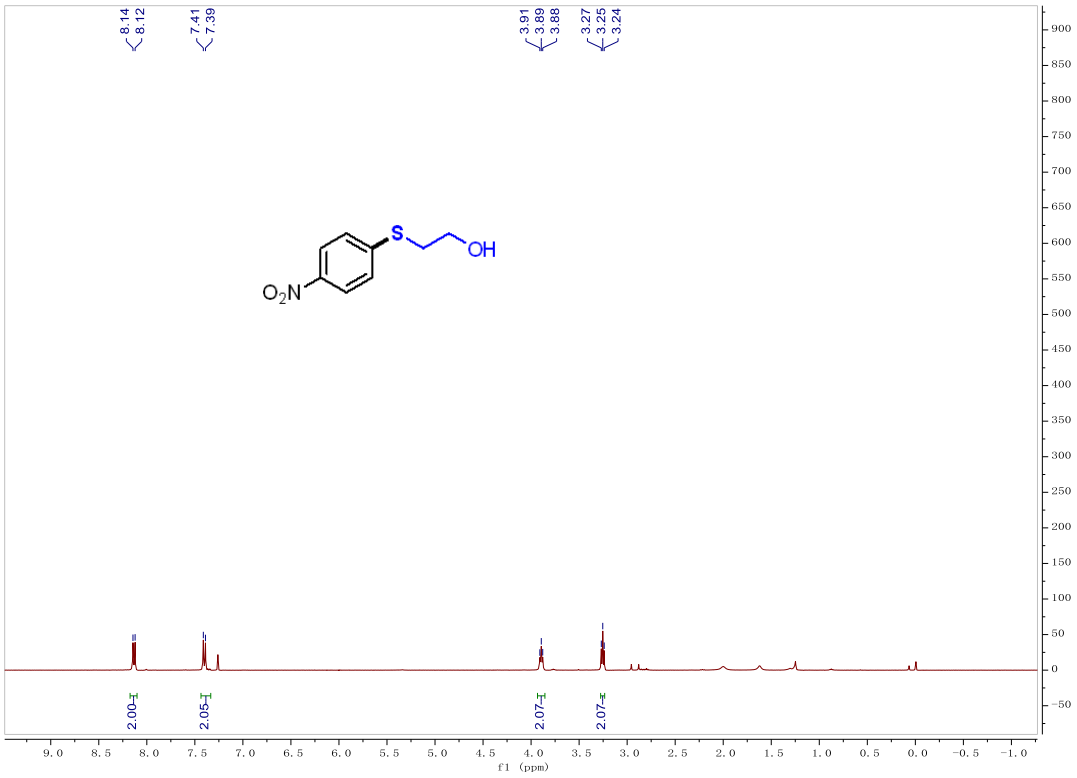


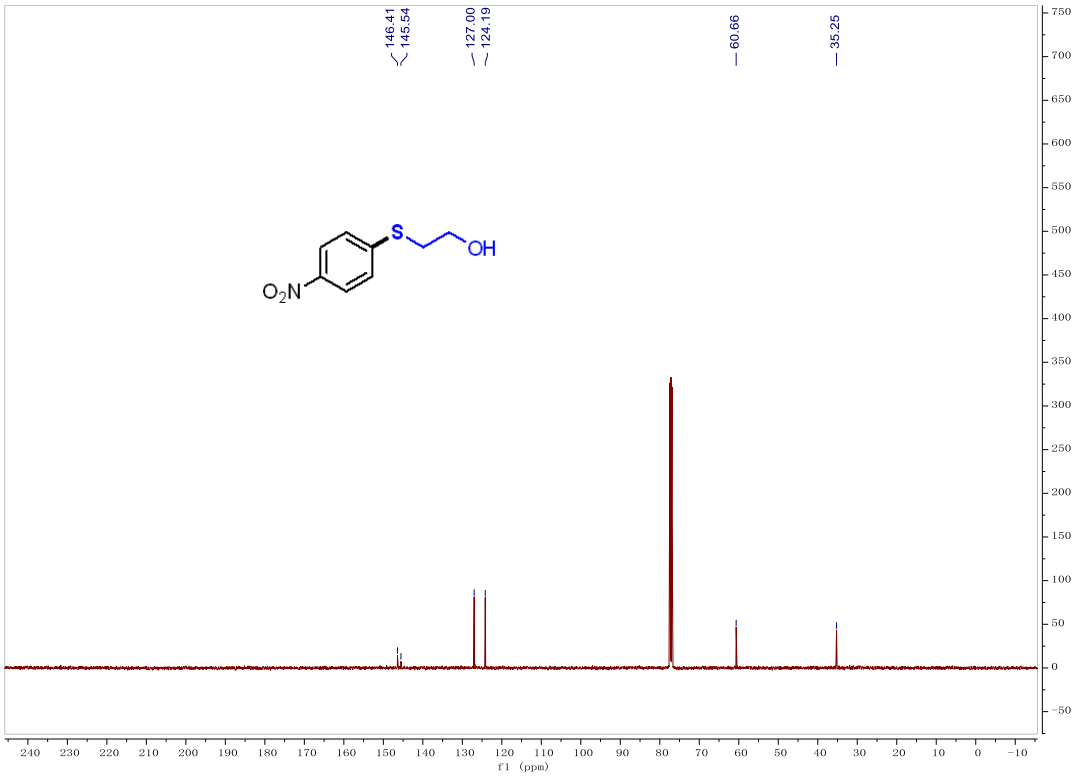
^{1}H and ^{13}C NMR spectra of compound 3o





^{1}H and ^{13}C NMR spectra of compound 5o





^{1}H and ^{13}C NMR spectra of compound 5p