Supporting Information

Photocatalytic hydro-fluorosulfonylation of alkenes with N-fluorosulfonyl aldimines

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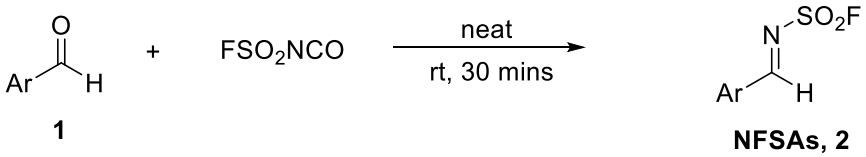
1. General information

NMR spectra were recorded with Bruker Avance III HD500 and Bruker Avance III HD400 spectrometer at 500 MHz or 400 MHz. All ^{1}H, ^{19}F and ^{13}C NMR spectra were recorded using $CDCl_3$ or DMSO-d_6 as solvent. Tetramethylsilane (TMS) signals or residual solvent signals were used [TMS $\delta = 0.00$ (^{1}H NMR), Chloroform-*d* $\delta = 77.16$ (^{13}C NMR), DMSO-d_6 $\delta = 2.50$ (^{1}H NMR), 39.52 (^{13}C NMR)] as internal standards. The following abbreviations were used to describe peak splitting patterns when appropriate: s = singlet, d = doublet, dd = double doublet, t = triplet, q = quartet, m = multiplet. High-resolution mass spectrometry (HRMS) was performed via electron ionization (EI) or electrospray ionization (ESI) sources or atmospheric pressure chemical ionization (APCI) source. The *m/z* ratios are reported in Daltons; high-resolution values are calculated to four decimal places from the molecular formula. All the reactions were monitored by thin layer chromatography (TLC), carried out on 0.25 mm silica gel plates using UV light as visualizing agent. Column chromatography was carried out on silica gel (230-400 mesh). The alkenes were synthesized according to procedures described in the literature.[1,2,3,4]

2. Experimental procedures and characterization data

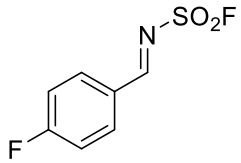
2.1 General procedure for the preparation of imidosulfonyl fluoride



1 **NFSAs, 2**

Following a modified literature procedure,[5] aldehyde **1** (12.5 mmol, 1.0 eq) was added to a 10 mL Schlenk tube equipped with a magnetic stir bar under nitrogen atmosphere. FSO_2NCO (FSI, 12.5 mmol, 1.0 eq) was then slowly added while stirring, and the mixture was stirred at room temperature for an additional 30 minutes. The solid product obtained can be used directly or recrystallized from hexane.

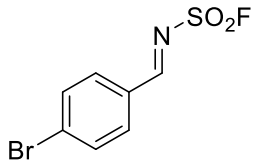
2.2 Characterization data of compounds **2a**-**2j**



(E)-(4-fluorobenzylidene)sulfamoyl fluoride **(2a)**

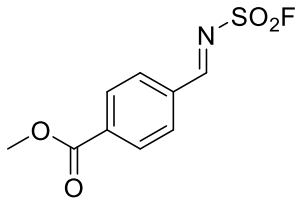
Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2a** as light yellow solid (94% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.08 (s, 1H), 8.23 - 7.94 (m, 2H), 7.29 (t, *J* = 8.5 Hz, 2H), **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 176.00 (d, *J* = 3.8 Hz), 169.48, 166.88, 135.15 (d, *J* =

10.3 Hz), 127.62, 117.46, 117.24, **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 43.81, -95.07 - -100.30 (m), **HRMS (ESI):** m/z calculated for [$C_7H_4F_2NO_2S$] [M-H]$^-$: 203.9936, found: 203.9938.



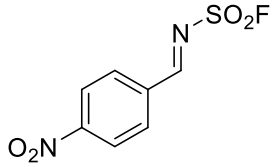
(E)-(4-bromobenzylidene)sulfamoyl fluoride **(2b)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2b** as yellow solid (95% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.06 (s, 1H), 7.88 (d, *J* = 8.5 Hz, 2H), 7.74 (d, *J* = 8.5 Hz, 2H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 176.49 (d, *J* = 3.8 Hz), 133.31, 133.20, 132.98, 132.50, 131.08, 129.93. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 43.78, **HRMS (ESI):** m/z calculated for [$C_7H_4ClFNO_2S$] [M-H]$^-$: 263.9136, found: 263.9138.



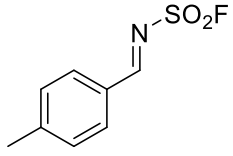
methyl (E)-4-((((fluorosulfonyl)imino)methyl)benzoate **(2c)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2c** as yellow solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.15 (s, 1H), 8.38 - 8.19 (m, 2H), 8.10 (d, *J* = 8.4 Hz, 2H), 3.98 (s, 3H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 176.62 (d, *J* = 4.0 Hz), 165.58, 137.05, 134.42, 132.02, 130.48, 130.20, 129.55, 52.86. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 43.48, **HRMS (ESI):** m/z calculated for [$C_9H_7FNO_4S$] [M-H]$^-$: 244.0085, found: 244.0088.



(E)-(4-nitrobenzylidene)sulfamoyl fluoride **(2d)**

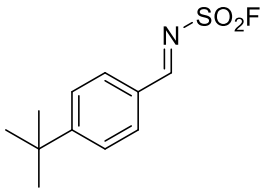
Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2d** as brown solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 10.17 (s, 1H), 8.44 - 8.35 (m, 2H), 8.14 - 8.00 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 190.35 (d, *J* = 2.5 Hz), 151.15, 140.07, 130.50, 124.31. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 44.73, **HRMS (ESI):** m/z calculated for [$C_7H_4FN_2O_4S$] [M-H]$^-$: 230.9881, found: 230.9885.



(E)-(4-methylbenzylidene)sulfamoyl fluoride **(2e)**

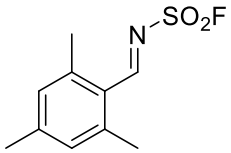
Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2e** as light yellow solid (95% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.04 (s, 1H), 7.91 (d, *J* = 8.2 Hz,

2H), 7.39 (d, *J* = 8.1 Hz, 2H), 2.50 (s, 3H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 177.33 (d, *J* = 3.3 Hz), 149.29, 132.56, 130.48, 128.66, 22.29. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 43.92, **HRMS (ESI):** m/z calculated for [$C_8H_7FNO_2S$] [M-H]$^-$: 200.0187, found: 200.0190.



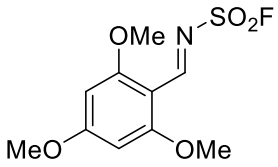
(E)-(4-(tert-butyl)benzylidene)sulfamoyl fluoride **(2f)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2f** as light yellow solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.07 (s, 1H), 7.96 (d, *J* = 8.5 Hz, 2H), 7.61 (d, *J* = 8.5 Hz, 2H), 1.37 (s, 9H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 177.28 (d, *J* = 3.6 Hz), 162.04, 132.47, 128.59, 126.78, 35.79, 30.87. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 43.97, **HRMS (ESI):** m/z calculated for [$C_{11}H_{13}FNO_2S$] [M-H]$^-$: 242.0657, found: 242.0660.



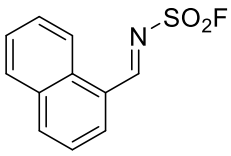
(E)-(2,4,6-trimethylbenzylidene)sulfamoyl fluoride **(2g)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2g** as light yellow solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.51 (s, 1H), 7.02 (s, 2H), 2.62 (s, 6H), 2.38 (s, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 175.73 (d, *J* = 3.4 Hz), 147.80, 145.17, 131.26, 125.10, 22.08, 21.86. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 44.23, **HRMS (ESI):** m/z calculated for [$C_{10}H_{11}FNO_2S$] [M-H]$^-$: 228.0500, found: 228.0505.



(E)-(2,4,6-trimethoxybenzylidene)sulfamoyl fluoride **(2h)**

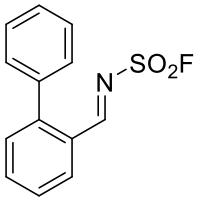
Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2h** as light yellow solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.43 (s, 1H), 6.08 (s, 2H), 3.93 (s, 9H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 170.14, 169.87, 165.70, 103.91, 90.62, 56.39, 55.95.**^{19}F NMR (376 MHz, Chloroform-*d*)** δ 44.92, **HRMS (ESI):** m/z calculated for [$C_{10}H_{11}FNO_5S$] [M-H]$^-$: 276.0347, found: 276.0350.



(E)-(naphthalen-1-ylmethylene)sulfamoyl fluoride **(2i)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2i** as light yellow solid (96% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.22 (s, 1H), 8.43 (s, 1H), 8.14 - 7.86 (m, 4H), 7.79 - 7.58 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 177.32 (d, *J* = 3.7 Hz), 138.64, 137.46, 132.52,

130.77, 130.01, 129.85, 128.88, 128.29, 127.80, 123.77. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 44.01, **HRMS (ESI):** m/z calculated for $[C_{11}H_7FNO_2S]$ $[M-H]^-$: 236.0187, found: 236.0190.

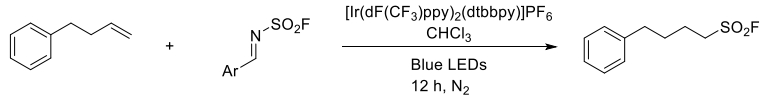


(E)-([1,1'-biphenyl]-2-ylmethylene)sulfamoyl fluoride **(2j)**

Following the **General procedure for the preparation of imidosulfonyl fluoride**, recrystallization using n-hexane yielded **2j** as light yellow solid (91% yield). **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 9.08 (s, 1H), 8.30 (dd, *J* = 8.0, 1.4 Hz, 1H), 7.97 – 7.87 (m, 1H), 7.72 – 7.61 (m, 2H), 7.60 – 7.51 (m, 3H), 7.49 (dd, *J* = 7.6, 1.9 Hz, 2H).**^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 179.18 (d, *J* = 3.6 Hz), 148.76, 137.64, 137.23, 131.69, 130.70, 129.57, 129.17, 128.99, 128.65. **^{19}F NMR (376 MHz, DMSO-*d*$_6$)** δ 45.22, **HRMS (ESI):** m/z calculated for $[C_{13}H_9FNO_2S]$ $[M-H]^-$: 262.0344, found: 262.0349.

2.3 Optimization of reaction conditions and general procedure

Table S1 Investigating the effect of **NFSAs**

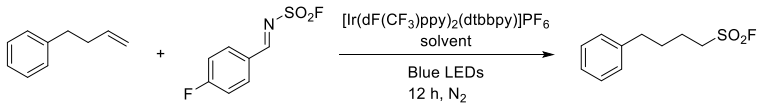


3a **NFSAs, 2** **4a**

Entry[a]	NFSAs	Yield(%)[b]
1	**2a**	**23(20)[c]**
2	**2b**	20
3	**2c**	16
4	**2d**	15
5	**2e**	14
6	**2f**	15
7	**2g**	18
8	**2h**	14
9	**2i**	20
10	**2j**	17

[a]General conditions: **3a** (1.0 equiv), **2** (3.0 equiv), $[Ir(dF(CF_3)ppy)_2(dtbbpy)]PF_6$ (1 mol %), $CHCl_3$ (3 mL), and nitrogen atmosphere, 30 W blue LEDs, 12 h. [b]Determined by ^{19}F NMR analysis using $PhCF_3$ as the internal standard. [c]Isolated yield.

Table S2 Investigating the effect of solvents

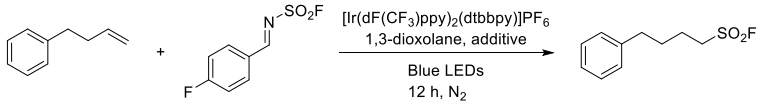


3a **2a** **4a**

Entry[a]	solvents	Yield(%)[b]
1	$CHCl_3$	23(20)[c]
2	DCM	10
3	MeCN	N.D.
4	DMF	N.D.
5	DMSO	N.D.
6	MeOH	N.D.
7	DCE	10
8	CCl_4	trace
9	Et_2O	N.D.
10	**1,3-dioxolane**	**40**
11	Acetone	12
12	THF	20
13	EA	trace

[a]General conditions: **3a** (1.0 equiv), **2a** (3.0 equiv), $[Ir(dF(CF_3)ppy)_2(dtbbpy)]PF_6$ (1 mol %), solvent (3 mL), and nitrogen atmosphere, 30 W blue LEDs, 12 h. [b]Determined by ^{19}F NMR analysis using $PhCF_3$ as the internal standard. [c]Isolated yield.

Table S3 Investigating the effect of additives



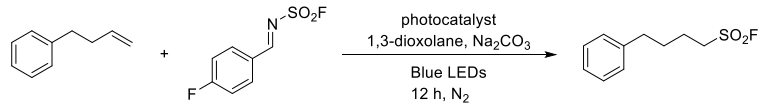
3a **2a** **4a**

Entry[a]	additives	Yield(%)[d]
1	$MgSO_4$	15
2[b]	5 Å MS	18
3	BnSH	19
4	Ph_3SiH	39
5	Et_3SiH	38
6	$(TMS)_3SiH$	32
7[c]	Ph_3SiH	27
8[c]	$Ph(Me)_2SiH$	28
9[c]	$(i\text{-}Pr)_3SiH$	35
10[c]	$(MeO)_3SiH$	38

11[c]	CH_3Cl_2SiH	19
12	**Na_2CO_3**	**60(58)[e]**
13	$NaHCO_3$	50
14	CH_3COONa	50
15	K_2CO_3	40
16	K_3PO_4	13
17	CS_2CO_3	25
18	NaOH	13
19	^{t}BuOK	N.D.
20	TMG	15
21	DBU	N.D.
22	Pyridine	N.D.
23	Et_3N	8
24	DMAP	5

[a]General conditions: **3a** (1.0 equiv), **2a** (3.0 equiv), additive (1.0 equiv), $[Ir(dF(CF_3)ppy)_2(dtbbpy)]PF_6$ (1 mol %), 1,3-dioxolane (3 mL), and nitrogen atmosphere, 30 W blue LEDs, 12 h. [b]100 mg 5 Å MS was used. [c]1.0 equiv. additive was used. [d]Determined by ^{19}F NMR analysis using $PhCF_3$ as the internal standard. [e]Isolated yield.

Table S4 Investigating the effect of NFSA loading

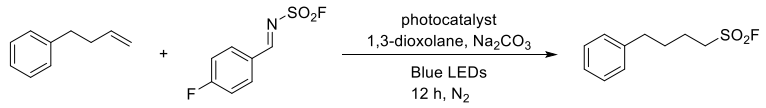


3a **2a** **4a**

Entry[a]	**2a** loading	Yield (%)[b]
1	**3.0 e.q.**	**60(58)[c]**
2	2.5 e.q.	52
3	2.0 e.q.	50
4	1.5 e.q.	44
5	1.0 e.q.	34

[a]General conditions: **3a** (1.0 equiv), **2a**, Na_2CO_3 (1.0 equiv), $[Ir(dF(CF_3)ppy)_2(dtbbpy)]PF_6$ (1 mol %), 1,3-dioxolane (3 mL), and nitrogen atmosphere, 30 W blue LEDs, 12 h. [b]Determined by ^{19}F NMR analysis using $PhCF_3$ as the internal standard. [c]Isolated yield.

Table S5 Investigating the effect of photocatalyst

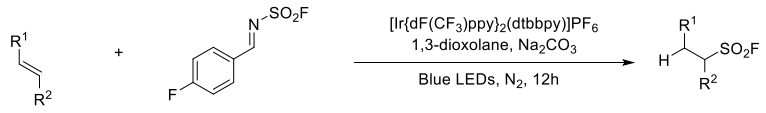


3a 2a 4a

Entry[a]	Photocatalyst	Photocatalyst loading	Yield(%)[b]
1	**[Ir{dF(CF$_3$)ppy}$_2$(dtbbpy)]PF$_6$**	**1%**	**60(58)[e]**
2	[Ir{dF(CF$_3$)$_2$ppy}$_2$(bpy)]PF$_6$	1%	44
3	[Ir(ppy)$_2$(dtbbpy)]PF$_6$	1%	10
4	[Ir{dF(CF$_3$)ppy}$_2$(OMe)$_2$]PF$_6$	1%	36
5	[Ir{dF(CF$_3$)ppy}$_2$(Me)$_2$]PF$_6$	1%	50
6	[Ir{dF(ppy)}$_2$(dtbbpy)]PF$_6$	1%	24
7	4CzIPN	5 mol%	39
8	Mes-Acr$^+$BF4$^-$	5 mol%	Trace
9	Thioxanthone	5 mol%	44
10	Eosin B	5 mol%	Trace
11	Eosin Y	5 mol%	Trace
12	Ru(bpy)$_3$Cl$_2$	1 mol%	44
13	[Ir{dF(CF$_3$)ppy}$_2$(dtbbpy)]PF$_6$	0.5%	55
14	[Ir{dF(CF$_3$)ppy}$_2$(dtbbpy)]PF$_6$	2.5%	48
15	[Ir{dF(CF$_3$)ppy}$_2$(dtbbpy)]PF$_6$	5%	40

[a]General conditions: **3a** (1.0 equiv), **2a** (3.0 equiv), photocatalyst, 1,3-dioxolane (3 mL), and nitrogen atmosphere, 30 W blue LEDs, 12 h. [b]Determined by ^{19}F NMR analysis using PhCF$_3$ as the internal standard. [c]Isolated yield.

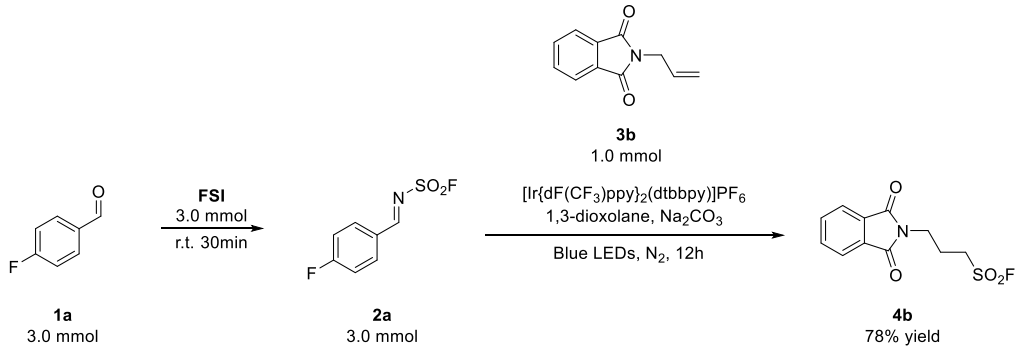
General procedure for hydro-fluorosulfonylation of alkenes



3 2a 4

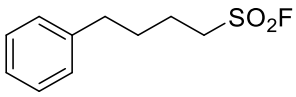
To a 10 mL Schenk tube equipped with a magnetic stirring bar, Na_2CO_3 (0.1 mmol, 1.0 equiv.), [Ir{dF(CF$_3$)ppy}$_2$(dtbbpy)]PF$_6$ (1.1 mg, 0.001 mmol, 1 mol%), alkenes (0.10 mmol, 1.0 equiv.), (*E*)-(4-fluorobenzylidene)sulfamoyl fluoride **(2a)** (0.3 mmol, 3.0 equiv.) and 1,3-dioxolane (3 mL) were added, and the tube was backfilled with nitrogen. The Schlenk tube was stirred at room temperature under irradiation of 30 W blue LEDs for 12 h. The solvent was removed under reduced pressure, and then the residue was purified by flash column chromatography (PE/EA= 15:1-5:1) to afford the desired product **4**.

2.4 Experimental procedure for scale-up reactions



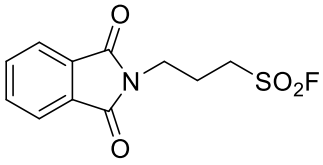
The scale-up reaction was prepared by one-pot method. To a flame-dried round-bottom-flask equipped with a magnetic stirring bar, **1a (**3.0 mmol, 3.0 equiv.**)** and **FSI (**3.0 mmol, 3.0 equiv.**)** were added into the reaction bottle. The reaction bottle was backfilled with nitrogen and reacted for 30 min at room temperature (pay attention to exhaust during the reaction). After the end of the reaction, added **3b** (1.0 mmol, 1.0 equiv.), $[Ir\{dF(CF_3)ppy\}_2(dtbbpy)]PF_6$ (11.2 mg, 0.01 mmol, 1 mol%), Na_2CO_3 (1 mmol, 1.0 equiv.) and 1,3-dioxolane (30 mL). to the reaction bottle and backfill nitrogen again. The reaction mixture was then irradiated with 30 W blue LEDs for 12 h. After the reaction, the solution was purified by flash column chromatography or on silica gel to give the product **4b** in 80% yield.

2.5 Characterization data of compounds **4a**-**4al**



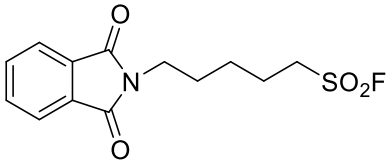
4-phenylbutane-1-sulfonyl fluoride **(4a)**[6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4a** as colorless oil (58% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.30 (t, *J* = 7.4 Hz, 2H), 7.21 (t, *J* = 7.3 Hz, 1H), 7.16 (d, *J* = 7.1 Hz, 2H), 3.42 - 3.30 (m, 2H), 2.68 (t, *J* = 7.5 Hz, 2H), 2.03 - 1.92 (m, 2H), 1.87 - 1.77 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 140.71, 128.60, 128.34, 126.30, 50.76 (d, *J* = 16.3 Hz), 35.06, 29.50, 22.96.**^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.57. **HRMS (ESI):** m/z calculated for $[C_{10}H_{12}FO_2S]$ $[M-H]^-$: 215.0548, found: 215.0551.



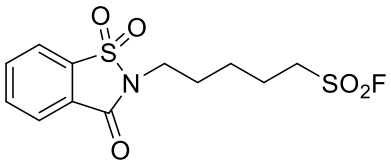
3-(1,3-dioxoisoindolin-2-yl)propane-1-sulfonyl fluoride **(4b)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4b** as yellow solid (74% yield). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.87 (s, 2H), 7.77 (d, *J* = 3.0 Hz, 2H), 3.88 (t, *J* = 6.3 Hz, 2H), 3.47 (s, 2H), 2.35 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.17, 134.42, 131.75, 123.61, 48.72 (d, *J* = 18.2 Hz), 35.78, 23.27. **^{19}F NMR (376 MHz, $CDCl_3$)** δ 53.34 (t, *J* = 4.4 Hz). **HRMS (ESI):** m/z calculated for $[C_{11}H_9FNO_4S]$ $[M-H]^-$: 270.0242, found: 270.0246.



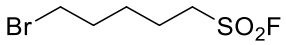
5-(1,3-dioxoisoindolin-2-yl)pentane-1-sulfonyl fluoride **(4c)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4c** as brown solid (68% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.85 (dd, *J* = 5.3, 3.1 Hz, 2H), 7.73 (dd, *J* = 5.4, 3.1 Hz, 2H), 3.72 (t, *J* = 7.0 Hz, 2H), 3.51 - 3.27 (m, 2H), 2.11 - 1.97 (m, 2H), 1.83 - 1.72 (m, 2H), 1.56 (q, *J* = 8.0 Hz, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 168.41, 134.08, 132.00, 123.31, 50.63 (d, *J* = 16.5 Hz), 37.21, 27.88, 25.11, 22.99. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.43. **HRMS (ESI):** m/z calculated for [$C_{13}H_{14}FNO_4SNa^+$] [M+Na$^+$]: 322.0520, found: 322.0518.



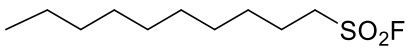
5-(1,1-dioxido-3-oxobenzo[d]isothiazol-2(3H)-yl)pentane-1-sulfonyl fluoride **(4d)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4d** as brown solid (61% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.20 - 7.77 (m, 4H), 3.81 (t, *J* = 7.1 Hz, 2H), 3.48 - 3.29 (m, 2H), 2.15 - 1.87 (m, 4H), 1.63 (p, *J* = 7.8 Hz, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 159.06, 137.62, 134.89, 134.45, 127.26, 125.23, 120.99, 50.58 (d, *J* = 16.5 Hz), 38.62, 27.60, 24.98, 22.92. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.51. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}FNO_5S_2Na^+$] [M+Na$^+$]: 358.0190, found: 358.0188.



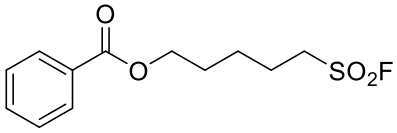
5-bromopentane-1-sulfonyl fluoride **(4e)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4e** as yellow oil (60% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 3.46 - 3.31 (m, 4H), 2.06 - 1.87 (m, 4H), 1.73 - 1.62 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 50.66 (d, *J* = 16.7 Hz), 32.55, 31.76, 26.43, 22.74. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.66. **HRMS (ESI):** m/z calculated for [$C_5H_9BrFO_2S$] [M-H]$^-$: 230.9496, found: 230.9500.



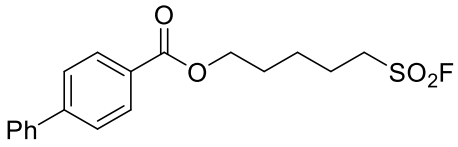
decane-1-sulfonyl fluoride **(4f)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4f** as yellow oil (57% yield).**^{1}H NMR (500 MHz, Chloroform-*d*)** δ 3.41 - 3.19 (m, 2H), 2.00 - 1.80 (m, 2H), 1.62 - 1.43 (m, 2H), 1.47 - 1.37 (m, 2H), 1.33 - 1.10 (m, 10H), 1.00 - 0.65 (m, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 49.90 (d, *J* = 16.8 Hz), 30.81, 28.69, 28.37, 28.16 (d, *J* = 4.8 Hz), 27.79, 26.85, 22.37, 21.63, 13.07.**^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.26. **HRMS (ESI):** m/z calculated for [$C_{10}H_{21}FO_2SNa^+$] [M+Na$^+$]: 247.1138, found: 247.1125.



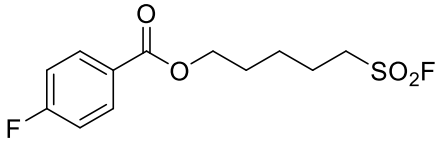
5-(fluorosulfonyl)pentyl benzoate **(4g)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4g** as brown oil (68% yield).**^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.06 - 8.00 (m, 2H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.45 (t, *J* = 7.7 Hz, 2H), 4.35 (t, *J* = 6.3 Hz, 2H), 3.53 - 3.28 (m, 2H), 2.14 - 1.99 (m, 2H), 1.90 - 1.80 (m, 2H), 1.74-1.63 (m, 2H)**.^{13}C NMR (101 MHz, Chloroform-*d*)** δ 166.56, 133.06, 130.14, 129.54, 128.43, 64.13, 50.72 (d, *J* = 16.6 Hz), 28.11, 24.62, 23.23. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.66. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}FO_4S$] [M-H]$^-$: 273.0602, found: 273.0606.



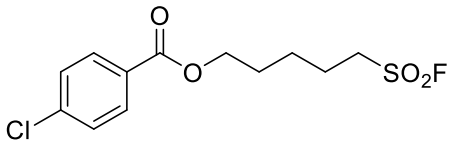
5-(fluorosulfonyl)pentyl [1,1'-biphenyl]-4-carboxylate **(4h)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4h** as brown oil (60% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.14 - 8.02 (m, 2H), 7.72 - 7.65 (m, 2H), 7.65 - 7.59 (m, 2H), 7.52 - 7.44 (m, 2H), 7.43 - 7.34 (m, 1H), 4.37 (t, *J* = 6.3 Hz, 2H), 3.45 - 3.31 (m, 2H), 2.11 - 2.01 (m, 2H), 1.94 - 1.80 (m, 2H), 1.75 - 1.58 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 166.45, 145.82, 139.96, 130.09, 128.97, 128.86, 128.22, 127.29, 127.12, 64.15, 50.74 (d, *J* = 16.5 Hz), 28.16, 24.65, 23.26. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.68. **HRMS (ESI):** m/z calculated for [$C_{18}H_{19}FO_4SNa^+$] [M+Na^+]: 373.0880, found: 373.0882.



5-(fluorosulfonyl)pentyl 4-fluorobenzoate **(4i)** [6]

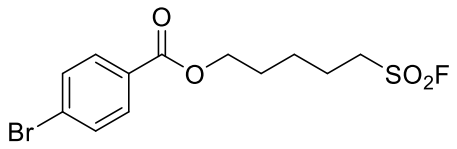
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4i** as brown oil (65% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.19 - 8.00 (m, 2H), 7.23 - 7.04 (m, 2H), 4.34 (t, *J* = 6.4 Hz, 2H), 3.47 - 3.32 (m, 2H), 2.10 - 1.99 (m, 2H), 1.89 - 1.80 (m, 2H), 1.71 - 1.64 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 165.83 (d, *J* = 254.1 Hz), 165.59, 132.10 (d, *J* = 9.3 Hz), 126.35 (d, *J* = 2.8 Hz), 115.60 (d, *J* = 22.0 Hz), 64.27, 50.62, 28.10, 24.60, 23.23. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.72, -105.51. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}O_4F_2SNa^+$] [M+Na^+]: 315.0473, found: 315.0472.



5-(fluorosulfonyl)pentyl 4-chlorobenzoate **(4j)**

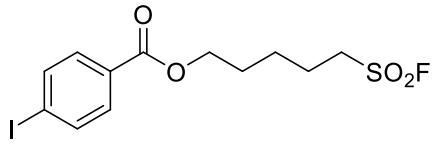
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4j** as light yellow oil (79% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.88 (d, *J* = 8.5 Hz, 2H), 7.34 (d, *J* = 8.6 Hz, 2H), 4.27 (t, *J* = 6.4 Hz, 2H), 3.52 - 3.27 (m, 2H), 2.11 - 1.88 (m, 2H), 1.85 - 1.74 (m, 2H), 1.68 - 1.56 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 165.67, 139.51, 130.95, 128.78, 128.59, 64.37, 50.69 (d, *J* = 16.6 Hz), 28.06, 24.56, 23.21.**^{19}F**

NMR (376 MHz, Chloroform-*d*) δ 53.80. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}O_4ClFSNa^+$] [$M+Na^+$]: 331.0178, found: 331.0180.



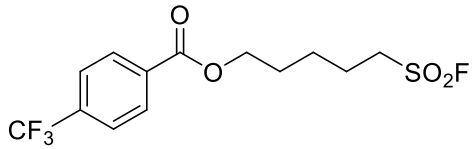
5-(fluorosulfonyl)pentyl 4-bromobenzoate **(4k)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4k** as yellow soild (73% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.92 - 7.68 (m, 2H), 7.62 - 7.45 (m, 2H), 4.27 (t, *J* = 6.4 Hz, 2H), 3.56 - 3.03 (m, 2H), 2.15 - 1.92 (m, 2H), 1.92 - 1.71 (m, 2H), 1.70 - 1.53 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 165.81, 131.79, 131.08, 129.03, 128.18, 64.40, 50.70 (d, *J* = 16.6 Hz), 28.06, 24.57, 23.21. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.78. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}O_4BrFSNa^+$] [$M+Na^+$]: 374.9672, found: 374.9675.



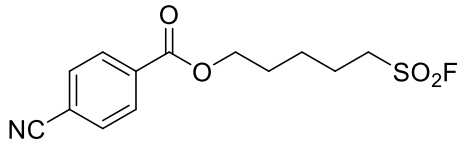
5-(fluorosulfonyl)pentyl 4-iodobenzoate **(4l)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4l** as yellow soild (92% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.77 - 7.69 (m, 2H), 7.68 - 7.61 (m, 2H), 4.25 (t, *J* = 6.3 Hz, 2H), 3.65 - 3.00 (m, 2H), 2.01 - 1.89 (m, 2H), 1.81 - 1.70 (m, 2H), 1.63 - 1.53 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-*d*)** δ 166.02, 137.79, 130.99, 129.62, 100.85, 64.41, 50.68 (d, *J* = 16.5 Hz), 28.04, 24.55, 23.21. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.77. **HRMS (ESI):** m/z calculated for [$C_{12}H_{14}O_4IFSNa^+$] [$M+Na^+$]: 422.9534, found: 422.9538.



5-(fluorosulfonyl)pentyl 4-(trifluoromethyl)benzoate **(4m)** [6]

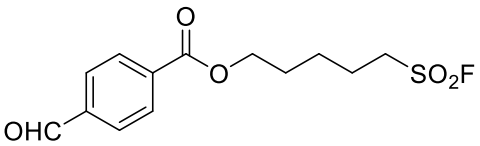
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4m** as yellow oil (62% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.32 - 8.09 (m, 2H), 7.93 - 7.57 (m, 2H), 4.39 (t, *J* = 6.4 Hz, 2H), 3.89 - 3.28 (m, 2H), 2.45 - 1.95 (m, 2H), 1.93 - 1.81 (m, 2H), 1.77 - 1.62 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 165.3, 134.6 (q, *J* = 32.7 Hz), 133.3, 130.0, 125.5 (q, *J* = 3.7 Hz), 123.6 (q, *J* = 272.9 Hz), 64.7, 50.7 (d, *J* = 16.5 Hz), 28.0, 24.6, 23.2. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.84, -63.14. **HRMS (ESI):** m/z calculated for [$C_{13}H_{14}F_4O_4SNa^+$] [$M+Na^+$]: 365.0441, found: 365.0442.



5-(fluorosulfonyl)pentyl 4-cyanobenzoate **(4n)** [6]

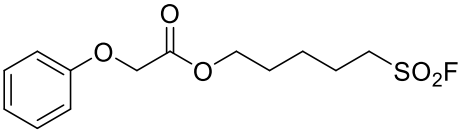
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4n** as yellow oil (45% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.31 - 8.07 (m, 2H), 7.93 - 7.69 (m, 2H), 4.39 (t, *J* = 6.4 Hz,

2H), 3.60 - 3.31 (m, 2H), 2.18 - 1.98 (m, 2H), 1.95 - 1.80 (m, 2H), 1.77 - 1.57 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 164.91, 133.91, 132.30, 130.08, 117.95, 116.53, 64.96, 50.66 (d, *J* = 16.5 Hz), 28.01, 24.52, 23.20. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.90. **HRMS (ESI):** m/z calculated for [$C_{13}H_{14}FO_4NSNa^+$] [M+Na^+]: 322.0520, found: 322.0519.



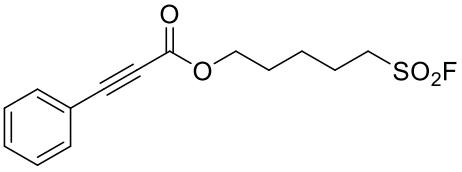
5-(fluorosulfonyl)pentyl 4-formylbenzoate **(4o)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4o** as yellow oil (64% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 10.11 (s, 1H), 8.19 (d, *J* = 8.2 Hz, 2H), 7.96 (d, *J* = 8.4 Hz, 2H), 4.40 (t, *J* = 6.4 Hz, 2H), 3.54 - 3.31 (m, 2H), 2.15 - 1.98 (m, 2H), 1.92-1.83 (m, 2H), 1.73 - 1.65 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 191.57, 165.51, 139.26, 135.06, 130.16, 129.55, 64.74, 50.69 (d, *J* = 16.5 Hz), 28.04, 24.56, 23.21. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.85. **HRMS (ESI):** m/z calculated for [$C_{13}H_{15}FO_5SNa^+$] [M+Na^+]: 325.0516, found: 325.0511.



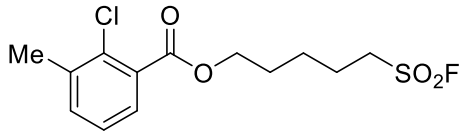
5-(fluorosulfonyl)pentyl 2-phenoxyacetate **(4p)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4p** as yellow oil (67% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.35 - 7.27 (m, 2H), 7.08 - 6.98 (m, 1H), 6.97 - 6.87 (m, 2H), 4.64 (d, *J* = 1.7 Hz, 2H), 4.22 (t, *J* = 6.3 Hz, 2H), 3.34 - 3.21 (m, 2H), 1.97 - 1.85 (m, 2H), 1.79 - 1.66 (m, 2H), 1.56 - 1.39 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 169.06, 157.81, 129.62, 121.81, 114.59, 65.31, 64.40, 50.59 (d, *J* = 16.6 Hz), 27.81, 24.29, 23.02. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.70. **HRMS (ESI):** m/z calculated for [$C_{13}H_{17}FO_5SNa^+$] [M+Na^+]: 327.0673, found: 327.0667.



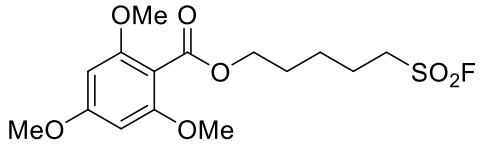
5-(fluorosulfonyl)pentyl 3-phenylpropiolate **(4q)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4q** as brown oil (31% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.58 - 7.48 (m, 2H), 7.43 - 7.35 (m, 1H), 7.34 - 7.27 (m, 2H), 4.18 (t, *J* = 6.3 Hz, 2H), 3.59 - 2.99 (m, 2H), 1.97 - 1.88 (m, 2H), 1.79 - 1.66 (m, 2H), 1.61 - 1.47 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 154.00, 133.01, 130.77, 128.63, 119.49, 86.63, 80.44, 65.17, 50.68 (d, *J* = 16.6 Hz), 27.81, 24.45, 23.15. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.62. **HRMS (ESI):** m/z calculated for [$C_{14}H_{15}O_4FSNa^+$] [M+Na^+]: 321.0567, found: 321.0577.



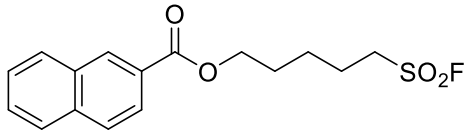
5-(fluorosulfonyl)pentyl 2-chloro-3-methylbenzoate **(4r)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4r** as brown oil (64% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.56 - 7.51 (m, 1H), 7.39 - 7.35 (m, 1H), 7.29 - 7.17 (m, 1H), 4.36 (t, *J* = 6.3 Hz, 2H), 3.52 - 3.35 (m, 2H), 2.43 (s, 3H), 2.09 - 1.97 (m, 2H), 1.88 - 1.80 (m, 2H), 1.71 - 1.63 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 166.62, 137.96, 133.68, 132.77, 131.34, 128.26, 126.21, 64.69, 50.71 (d, *J* = 16.5 Hz), 27.97, 24.61, 23.18, 20.66. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.61. **HRMS (ESI):** m/z calculated for [$C_{13}H_{16}FClO_4SNa^+$] [M+Na^+]: 345.0334, found: 345.0334.



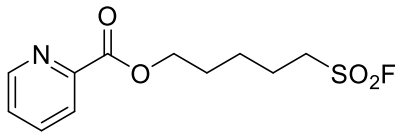
5-(fluorosulfonyl)pentyl 2,4,6-trimethoxybenzoate **(4s)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4s** as brown oil (48% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.51 (d, *J* = 8.9 Hz, 1H), 6.63 (d, *J* = 8.9 Hz, 1H), 4.24 (t, *J* = 6.3 Hz, 2H), 3.86 (s, 3H), 3.84 (s, 3H), 3.80 (s, 3H), 3.36 - 3.28 (m, 2H), 2.09 - 1.89 (m, 2H), 1.84 - 1.68 (m, 2H), 1.68 - 1.50 (m, 2H).**^{13}C NMR (126 MHz, Chloroform-*d*)** δ 164.56, 156.25, 153.66, 141.98, 125.83, 116.83, 105.93, 62.89, 60.74, 59.99, 55.08, 49.71 (d, *J* = 16.5 Hz), 27.08, 23.61, 22.19. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.70. **HRMS (ESI):** m/z calculated for [$C_{15}H_{21}FO_7SNa^+$] [M+Na^+]: 387.0884, found: 387.0884.



5-(fluorosulfonyl)pentyl 2-naphthoate **(4t)** [6]

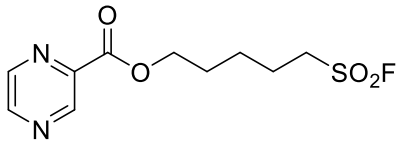
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4t** as yellow soild (62% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.59 (d, *J* = 1.7 Hz, 1H), 8.05 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.96 (dd, *J* = 7.9, 1.5 Hz, 1H), 7.89 (dd, *J* = 8.6, 1.9 Hz, 2H), 7.65 - 7.50 (m, 2H), 4.42 (t, *J* = 6.4 Hz, 2H), 3.65 - 3.20 (m, 2H), 2.14 - 2.00 (m, 2H), 1.97 - 1.84 (m, 2H), 1.77 - 1.66 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)**δ 166.73, 135.59, 132.51, 131.06, 129.37, 128.35, 128.25, 127.79, 127.36, 126.74, 125.14, 64.29, 50.75 (d, *J* = 16.6 Hz), 28.18, 24.69, 23.28. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.72. **HRMS (ESI):** m/z calculated for [$C_{16}H_{18}FO_4S^+$] [M+H^+]: 325.0904, found: 325.0908



5-(fluorosulfonyl)pentyl picolinate **(4u)** [6]

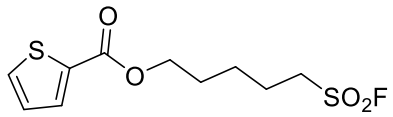
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4u** as colorless oil (62% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.77 (d, *J* = 4.3 Hz, 1H), 8.13 (d, *J* = 7.8 Hz, 1H), 8.05 - 7.79 (m, 1H), 7.50 (dd, *J* = 6.7, 4.9 Hz, 1H), 4.45 (t, *J* = 6.5 Hz, 2H), 3.54 - 3.30 (m, 2H), 2.09 - 2.01 (m, 2H), 1.97 -

1.86 (m, 2H), 1.70 - 1.65 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 165.24, 149.94, 147.95, 137.09, 127.03, 125.20, 65.08, 50.67 (d, *J* = 16.5 Hz), 27.99, 24.56, 23.19. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.54. **HRMS (ESI):** m/z calculated for [$C_{11}H_{14}FNO_4SNa^+$] [M+Na^+]: 298.0520, found: 298.0506.



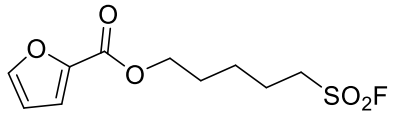
5-(fluorosulfonyl)pentyl pyrazine-2-carboxylate **(4v)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4v** as brown oil (63% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.31 (s, 1H), 8.92 - 8.66 (m, 2H), 4.48 (t, *J* = 6.5 Hz, 2H), 3.49 - 3.36 (m, 2H), 2.11 - 2.00 (m, 2H), 1.99 - 1.87 (m, 2H), 1.74 - 1.64 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 163.95, 147.78, 146.27, 144.47, 143.33, 65.47, 50.63 (d, *J* = 16.8 Hz), 27.91, 24.50, 23.15. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.67. **HRMS (ESI):** m/z calculated for [$C_{10}H_{14}FN_2O_4S^+$] [M+H^+]: 277.0653, found: 277.0655.



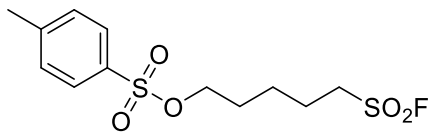
5-(fluorosulfonyl)pentyl thiophene-2-carboxylate **(4w)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4w** as brown oil (68% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.80 (dd, *J* = 3.7, 1.3 Hz, 1H), 7.57 (dd, *J* = 5.0, 1.3 Hz, 1H), 7.11 (dd, *J* = 5.0, 3.7 Hz, 1H), 4.33 (t, *J* = 6.3 Hz, 2H), 3.45 - 3.31 (m, 2H), 2.16 - 1.98 (m, 2H), 1.93 - 1.78 (m, 2H), 1.73 - 1.58 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 162.18, 133.59, 133.53, 132.50, 127.83, 64.29, 50.72 (d, *J* = 16.5 Hz), 28.07, 24.58, 23.20. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.67. **HRMS (ESI):** m/z calculated for [$C_{10}H_{13}FO_4S_2Na^+$] [M+Na^+]: 303.0131, found: 303.0141.



5-(fluorosulfonyl)pentyl furan-2-carboxylate **(4x)** [6]

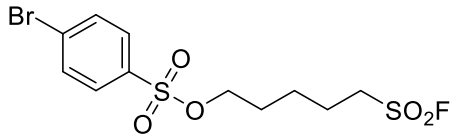
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4x** as brown oil (64% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.59 (d, *J* = 1.7 Hz, 1H), 7.19 (d, *J* = 3.5 Hz, 1H), 6.52 (dd, *J* = 3.6, 1.8 Hz, 1H), 4.34 (t, *J* = 6.3 Hz, 2H), 3.43 - 3.32 (m, 2H), 2.12 - 1.97 (m, 2H), 1.93 - 1.80 (m, 2H), 1.76 - 1.58 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 158.67, 146.42, 144.55, 118.08, 111.91, 64.10, 50.69 (d, *J* = 16.5 Hz), 28.01, 24.55, 23.17. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.62. **HRMS (ESI):** m/z calculated for [$C_{10}H_{13}FO_5SNa^+$] [M+Na^+]: 287.0360, found: 287.0351.



5-(fluorosulfonyl)pentyl 4-methylbenzenesulfonate **(4y)** [6]

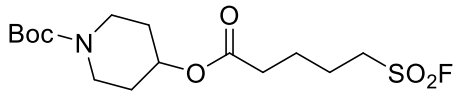
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4y** as brown oil (62% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.79 (d, *J* = 8.3 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 2H), 4.05 (t, *J* = 6.1 Hz, 2H), 3.43 - 3.24 (m, 2H), 2.46 (s, 3H), 1.97 - 1.86 (m, 2H), 1.77 - 1.68 (m, 2H), 1.55 (q, *J* = 8.3 Hz, 2H). **^{13}C**

NMR (101 MHz, Chloroform-*d*) δ 145.03, 132.90, 129.96, 127.87, 69.47, 50.55 (d, *J* = 16.7 Hz), 28.18, 23.93, 22.88, 21.65. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.69. **HRMS (ESI):** m/z calculated for [$C_{12}H_{17}FO_5S_2Na^+$] [M+Na^+]: 347.0394, found: 347.0385.



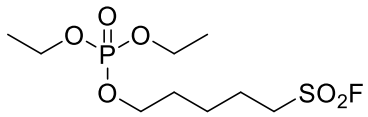
5-(fluorosulfonyl)pentyl 4-bromobenzenesulfonate **(4z)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4z** as brown soild (65% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.04 - 7.57 (m, 4H), 4.09 (t, *J* = 6.1 Hz, 2H), 3.53 - 3.04 (m, 2H), 2.04 - 1.88 (m, 2H), 1.84 - 1.71 (m, 2H), 1.65 - 1.48 (m, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*) **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 134.93, 132.72, 129.33, 129.21, 70.01, 50.54 (d, *J* = 16.7 Hz), 28.25, 23.95, 22.94. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.90. **HRMS (ESI):** m/z calculated for [$C_{11}H_{13}BrFO_5S_2$] [M-H]$^-$: 386.9377, found: 386.9383.



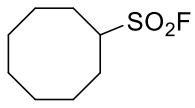
tert-butyl 4-((5-(fluorosulfonyl)pentanoyl)oxy)piperidine-1-carboxylate **(4aa)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4aa** as brown oil (68% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 4.99 - 4.88 (m, 1H), 3.73 (d, *J* = 12.7 Hz, 2H), 3.47 - 3.35 (m, 2H), 3.25 - 3.15 (m, 2H), 2.40 (t, *J* = 7.1 Hz, 2H), 2.09 - 1.96 (m, 2H), 1.94 - 1.83 (m, *J* = 7.5 Hz, 4H), 1.64 - 1.55 (m, 2H), 1.46 (s, 9H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 171.78, 154.72, 79.78, 70.28, 50.52 (d, *J* = 16.7 Hz), 33.47, 30.60, 29.70, 28.41, 23.10, 22.91. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.75. **HRMS (ESI):** m/z calculated for [$C_{15}H_{26}FNO_6SNa^+$] [M+Na^+]: 390.1357, found: 390.1356.



diethyl (5-(fluorosulfonyl)pentyl) phosphate **(4ab)** [6]

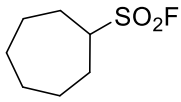
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ab** as brown oil (62% yield). **^{1}H NMR (400 MHz, Chloroform-d)** δ 4.24 - 3.94 (m, 6H), 3.44 - 3.32 (m, 2H), 2.07 - 1.93 (m, 2H), 1.85 - 1.70 (m, 2H), 1.69 - 1.56 (m, 2H), 1.40 - 1.31 (m, 6H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 66.63 (d, *J* = 5.9 Hz), 63.84 (d, *J* = 5.9 Hz), 50.71 (d, *J* = 16.5 Hz), 29.51 (d, *J* = 6.9 Hz), 24.07, 23.06, 16.16 (d, *J* = 6.6 Hz). **^{19}F NMR (376 MHz, Chloroform-d)** δ 53.67. **^{31}P NMR (162 MHz, Chloroform-*d*)** δ -0.92. **HRMS (ESI):** m/z calculated for [$C_9H_{21}FO_6PS^+$] [M+H^+]: 307.0775, found: 307.0774.



cyclooctanesulfonyl fluoride **(4ac)** [6]

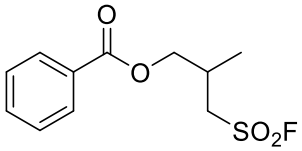
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ac** as brown oil (68% yield). **^{1}H NMR (400 MHz, Chloroform-d)** δ 3.61 - 3.38 (m, 1H), 2.39 - 2.22 (m, 2H), 2.05 - 1.77 (m, 4H),

1.72 - 1.52 (m, 8H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 62.23 (d, *J* = 10.3 Hz), 29.71, 26.61, 25.98, 24.66. **^{19}F NMR (376 MHz, Chloroform-d)** δ 41.08. **HRMS (ESI):** m/z calculated for [$C_8H_{14}FO_2S$] [M-H]$^-$: 193.0704, found: 193.0707.



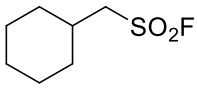
cycloheptanesulfonyl fluoride **(4ad)** [7]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ad** as colorless oil (57% yield). **^{1}H NMR (400 MHz, Chloroform-d)** δ 3.44 – 3.28 (m, 1H), 2.33 – 2.22 (m, 2H), 1.96 – 1.74 (m, 4H), 1.60 – 1.41 (m, 6H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 61.80 (d, *J* = 10.2 Hz), 27.12, 27.04, 24.31. **^{19}F NMR (376 MHz, Chloroform-d)** δ 41.47. **HRMS (ESI):** m/z calculated for [$C_7H_{12}FO_2S$] [M-H]$^-$: 179.0548, found: 179.0549.



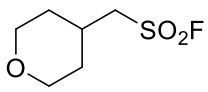
3-(fluorosulfonyl)-2-methylpropyl benzoate **(4ae)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ae** as yellow oil (63% yield).**^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.03 (d, *J* = 7.7 Hz, 2H), 7.60 (t, *J* = 7.4 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 4.43 – 4.22 (m, 2H), 3.73 – 3.57 (m, 1H), 3.47 – 3.25 (m, 1H), 2.85 – 2.63 (m, 1H), 1.32 (d, *J* = 6.9 Hz, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 166.1, 133.5, 129.6, 129.5, 128.6, 66.9, 54.2 (d, *J* = 15.8 Hz), 29.9, 16.4. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 59.02. **HRMS (ESI):** m/z calculated for [$C_{11}H_{13}O_4FSNa^+$] [M+Na^+]: 283.0411, found: 283.0413.



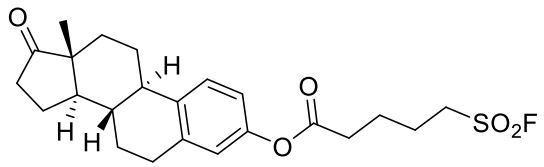
cyclohexylmethanesulfonyl fluoride **(4af)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4af** as colorless oil (47% yield). **^{1}H NMR (400 MHz, Chloroform-d)** δ 3.47 – 3.42 (m, 2H), 1.80 – 1.66 (m, 4H), 1.54 – 1.43 (m, 1H), 1.33 – 1.12 (m, 4H), 1.02 – 0.87 (m, 2H).**^{13}C NMR (101 MHz, Chloroform-d)** δ 68.82, 40.51, 29.57, 26.60, 25.85. **^{19}F NMR (376 MHz, Chloroform-d)** δ 53.45. **HRMS (ESI):** m/z calculated for [$C_7H_{12}FO_2S$] [M-H]$^-$: 179.0548, found: 179.0543.



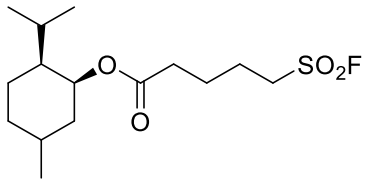
(tetrahydro-2H-pyran-4-yl)methanesulfonyl fluoride **(4ag)**

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ag** as colorless oil (59% yield). **^{1}H NMR (400 MHz, Chloroform-d)** δ 3.98 (m, 2H), 3.43 (m, 2H), 2.29 (d, J = 7.1 Hz, 2H), 2.03 (m, 1H), 1.69 (m, 2H), 1.38 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-d)** δ 67.64, 41.08,32.53,31.78. **^{19}F NMR (376 MHz, Chloroform-d)** δ 53.56. **HRMS (ESI):** m/z calculated for [$C_6H_{10}FO_3S$] [M-H]$^-$: 181.0340, found: 181.0343.



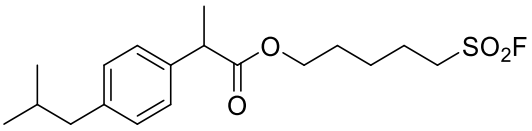
(8S,9R,13R)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 5-(fluorosulfonyl)pentanoate **(4ah)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ad** as yellow soild (52% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.30 - 7.27 (m, 1H), 6.87 - 6.83 (m, 1H), 6.80 (d, *J* = 2.5 Hz, 1H), 3.58 - 3.22 (m, 2H), 2.91 (dd, *J* = 8.6, 3.9 Hz, 2H), 2.64 (t, *J* = 7.1 Hz, 2H), 2.58 - 2.51 (m, 1H), 2.45 - 2.36 (m, 1H), 2.33 - 2.25 (m, 1H), 2.22 - 2.02 (m, 4H), 2.01 - 1.85 (m, 4H), 1.74 - 1.38 (m, 7H), 0.91 (s, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 171.31, 148.35, 138.15, 137.63, 126.49, 121.44, 118.60, 50.63, 50.47, 50.44, 47.95, 44.16, 38.00, 35.86, 33.33, 31.56, 29.41, 26.32, 25.76, 23.07, 22.93, 21.60, 13.84. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.82. **HRMS (ESI):** m/z calculated for [$C_{23}H_{29}FO_5SNa^+$] [M+Na^+]: 459.1612, found: 459.1611.



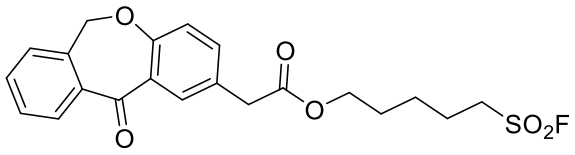
(1S,2S)-2-isopropyl-5-methylcyclohexyl 5-(fluorosulfonyl)pentanoate **(4ai)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ae** as brown oil (61% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** ^{1}H NMR (400 MHz, Chloroform-*d*) δ 4.76 - 4.58 (m, 1H), 3.45 - 3.32 (m, 2H), 2.37 (t, *J* = 7.1 Hz, 2H), 2.09 - 1.90 (m, 3H), 1.90 - 1.77 (m, 3H), 1.74 - 1.62 (m, 3H), 1.56 - 1.45 (m, 1H), 1.43 - 1.31 (m, 1H), 1.15 - 0.95 (m, 2H), 0.93 - 0.78 (m, 6H), 0.76 (d, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 172.05, 74.61, 50.56 (d, *J* = 16.8 Hz), 47.00, 40.94, 34.20, 33.60, 31.39, 26.38, 23.41, 23.24, 22.93, 22.00, 20.74, 16.28**. ^{19}F NMR (376 MHz, Chloroform-*d*)** δ 53.56. **HRMS (ESI):** m/z calculated for [$C_{15}H_{27}FO_4SNa^+$] [M+Na^+]: 345.1506, found: 345.1499.



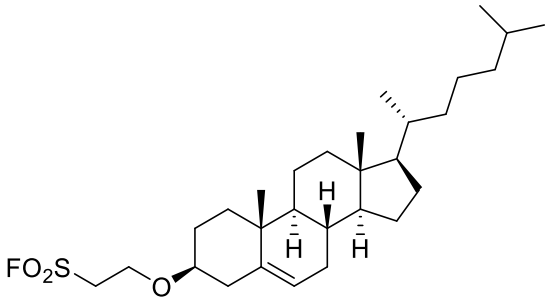
5-(fluorosulfonyl)pentyl 2-(4-isobutylphenyl)propanoate **(4aj)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4af** as brown oil (50% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.19 (dd, *J* = 8.1, 2.2 Hz, 2H), 7.14 - 7.06 (m, 2H), 4.17 - 3.95 (m, 2H), 3.68 (q, *J* = 7.0 Hz, 1H), 3.30 - 3.18 (m, 2H), 2.45 (dd, *J* = 7.2, 2.1 Hz, 2H), 1.93 - 1.76 (m, 3H), 1.72 - 1.55 (m, 2H), 1.52 - 1.46 (m, 3H), 1.45 - 1.35 (m, 2H), 0.90 (dd, *J* = 6.7, 2.1 Hz, 6H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 174.71, 140.66, 137.77, 129.35, 127.15, 63.69, 50.61 (d, *J* = 16.5 Hz), 45.16, 44.98, 30.21, 27.78, 24.28, 22.98, 22.37, 18.29. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.50. **HRMS (ESI):** m/z calculated for [$C_{18}H_{27}FO_4SNa^+$] [M+Na^+]: 381.1506, found: 381.1506.



4-(fluorosulfonyl)butyl 2-(11-oxo-6,11-dihydrodibenzo[b,e]oxepin-2-yl)acetate **(4ak)** [6]

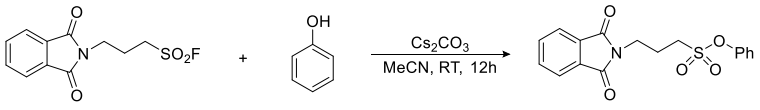
Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ag** as brown oil (64% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 8.12 (d, *J* = 2.4 Hz, 1H), 7.89 (dd, *J* = 7.7, 1.4 Hz, 1H), 7.60 - 7.52 (m, 1H), 7.51 - 7.45 (m, 1H), 7.41 (dd, *J* = 8.4, 2.4 Hz, 1H), 7.36 (dd, *J* = 7.4, 1.3 Hz, 1H), 7.03 (d, *J* = 8.4 Hz, 1H), 5.19 (s, 2H), 4.13 (t, *J* = 6.3 Hz, 2H), 3.64 (s, 2H), 3.47 - 3.33 (m, 2H), 2.16 - 1.87 (m, 2H), 1.76 - 1.64 (m, 2H), 1.60 - 1.48 (m, 2H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 189.82, 170.32, 159.49, 139.35, 135.29, 134.55, 131.84, 131.34, 128.45, 128.29, 126.84, 126.73, 124.18, 120.10, 72.63, 63.11, 49.63 (d, *J* = 16.5 Hz), 39.27, 28.68, 26.88, 23.43, 22.11. **^{19}F NMR (377 MHz, Chloroform-*d*)** δ 53.64. **HRMS (APCI):** m/z calculated for [$C_{21}H_{22}FO_6S^+$] [M+H$^+$]: 421.1116, found: 421.1115.



2-(((3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl)oxy)ethane-1-sulfonyl fluoride **(4al)** [6]

Following the **General procedure for hydro-fluorosulfonylation of alkenes** to afford the desired product **4ah** as white soild (54% yield). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 5.42 - 5.32 (m, 1H), 4.02 - 3.87 (m, 2H), 3.74 - 3.51 (m, 2H), 3.35 - 3.14 (m, 1H), 2.39 - 2.31 (m, 1H), 2.29 - 2.17 (m, 1H), 2.12 - 1.94 (m, 2H), 1.93 - 1.75 (m, 3H), 1.65 - 1.42 (m, 7H), 1.41 - 1.30 (m, 4H), 1.22 - 1.08 (m, 7H), 1.07 - 0.96 (m, 6H), 0.91 (d, *J* = 6.5 Hz, 3H), 0.86 (dd, *J* = 6.6, 1.9 Hz, 6H), 0.68 (s, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 140.21, 122.19, 80.14, 60.91, 56.75, 56.16, 51.65 (d, *J* = 15.4 Hz), 50.15, 42.33, 39.76, 39.53, 38.73, 37.04, 36.82, 36.20, 35.80, 31.90 (d, *J* = 6.5 Hz), 29.72, 28.24, 28.07 (d, *J* = 7.1 Hz), 24.30, 23.84, 22.84, 22.58, 21.08, 19.36, 18.73, 11.87. **^{19}F NMR (376 MHz, Chloroform-*d*)** δ 58.96. **HRMS (APCI):** m/z calculated for [$C_{29}H_{50}FO_3S^+$] [M+H$^+$]: 497.3459, found: 497.3456.

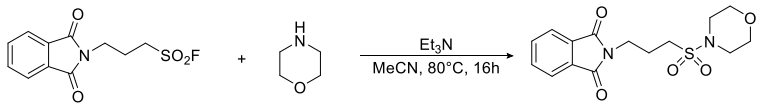
2.6 Experimental procedure for synthetic applications



4b **5** **6**

To a 10 mL round-bottomed flask equipped with a magnetic stir bar, **4b** (27.1 mg, 0.10 mmol, 1.0 eq.), phenol **5** (10.4 mg， 0.11 mmol， 1.1 eq) and Cs_2CO_3 (65.2 mg, 0.20 mmol, 2.0 eq.) in MeCN (1 mL) were added. Stir the reaction mixture for 12 hours at 25 ℃ under nitrogen. After completion of the reaction, purify the residue by silica gel column chromatography (PE/EA = 5:1) and product **6** was obtained in 76% yield (26.2 mg). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.91 - 7.81 (m, 2H), 7.79 - 7.70 (m, 2H), 7.37 (t, *J* = 7.7 Hz, 2H), 7.32 - 7.21 (m, 3H), 3.87 (t, *J* = 6.7 Hz, 2H), 3.57 - 3.06 (m,

2H), 2.41 - 2.34 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.18, 148.95, 134.30, 131.84, 130.01, 127.31, 123.51, 122.00, 48.13, 36.11, 23.33. **HRMS (ESI):** m/z calculated for $[C_{17}H_{14}NO_5S]$ $[M-H]^-$: 344.0598, found: 344.0560.

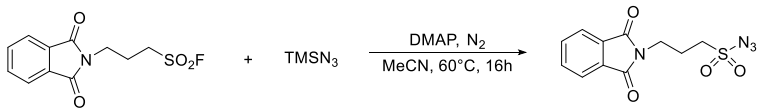


4b **7** **8**

To a 10 mL round-bottomed flask equipped with a magnetic stir bar, **4b** (27.1 mg, 0.10 mmol, 1.0 eq.), morpholine **7** (17.4 mg, 0.2 mmol, 2.0 eq.), triethylamine (28 μL, 0.2 mmol, 2.0 eq.), and MeCN (0.5 mL) were added. Stir the reaction mixture for 16 hours at 80°C under nitrogen. After completion of the reaction, purify the residue by silica gel column chromatography (PE/EA = 3:1) and the product **8** was obtained in 82% yield (27.7 mg). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.89 - 7.81 (m, 2H), 7.78 - 7.70 (m, 2H), 3.83 (t, *J* = 6.7 Hz, 2H), 3.78 - 3.69 (m, 4H), 3.31 - 3.21 (m, 4H), 3.12 - 2.92 (m, 2H), 2.25 - 2.17 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.27, 134.26, 131.89, 123.47, 66.59, 46.71, 45.83, 36.50, 22.82. **HRMS (ESI):** m/z calculated for $[C_{15}H_{17}N_2O_5S]$ $[M-H]^-$: 337.0864, found: 337.0868.

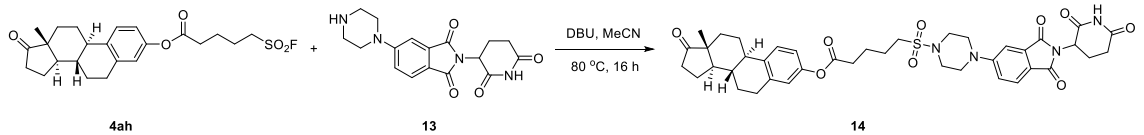
4b **9** **10**

To a 10 mL round-bottomed flask equipped with a magnetic stir bar, **4b** (27.1 mg, 0.10 mmol, 1.0 eq.), NH_3•H_2O **9** (143 μL, 2.0 mmol, 20.0 eq.), pyridine (31.7 mg, 0.4 mmol, 2.0 eq.), and MeCN (2 mL) were added. Stir the reaction mixture for 16 hours at 60°C under nitrogen. After completion of the reaction, purify the residue by silica gel column chromatography and the product **10** was obtained in 72% yield (19.3 mg). **^{1}H NMR (400 MHz, DMSO-*d6*)** δ 8.22 - 7.62 (m, 4H), 6.76 (s, 2H), 3.69 (t, *J* = 6.4 Hz, 2H), 3.10 - 2.94 (m, 2H), 2.13 - 1.90 (m, 2H). **^{13}C NMR (101 MHz, DMSO *d6*)** δ 168.46, 134.86, 132.14, 123.51, 52.59, 36.63, 23.60. **HRMS (ESI):** m/z calculated for $[C_{11}H_{11}N_2O_4S]$ $[M-H]^-$: 267.0445, found: 267.0449.



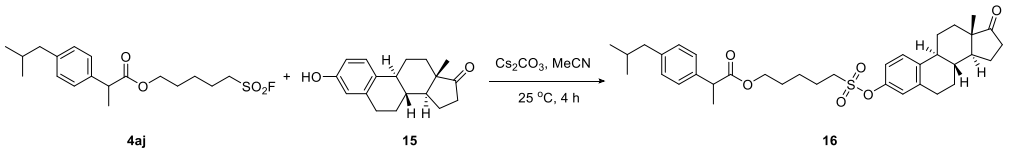
4b **11** **12**

Under nitrogen atmosphere, add **4b** (27.1 mg, 0.10 mmol, 1.0 eq.), DMAP (36.7 mg, 0.3 mmol, 1.5 eq.), $TMSN_3$ **11** (20 μL, 0.15 mmol, 1.5 eq.), and 2 mL MeCN to a 5 mL reaction tube equipped with a magnetic stir bar. After 15 minutes of reaction, add $TMSN_3$ (20 μL, 0.15 mmol, 1.5 eq.) to the mixture. Repeat this addition of $TMSN_3$ in the same amount after another 15 minutes. Continue the reaction for another 15 minutes and then add an equal amount of $TMSN_3$ again. Let the reaction proceed at room temperature for an additional 16 hours. Upon completion, remove the solvent under reduced pressure. Purify the product by column chromatography to obtain the **12** in 80% yield (23.5 mg). **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.85 (dd, *J* = 5.3, 3.1 Hz, 2H), 7.74 (dd, *J* = 5.4, 3.1 Hz, 2H), 3.86 (t, *J* = 6.6 Hz, 2H), 3.40 (dd, *J* = 9.0, 6.7 Hz, 2H), 2.47 - 2.03 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 168.20, 134.37, 131.79, 123.56, 53.58, 35.88, 23.20. **HRMS (ESI):** m/z calculated for $[C_{11}H_9N_4O_4S]$ $[M-H]^-$: 293.0350, found: 293.0351.



4ah **13** **14**

To a round-bottomed flask equipped with a magnetic stir bar, **4ah** (0.1 mmol), pomalidomide derivative **13** and DBU (0.2 mmol) and MeCN (1 mL) were added. Stir the reaction mixture for 16 hours at 80°C under nitrogen. After completion of the reaction, purify the residue by silica gel column chromatography (PE/EA = 1:1) and the product **14** was obtained in 46% yield (34.8 mg). **^{1}H NMR (400 MHz, DMSO-*d*$_6$)** δ 11.08 (s, 1H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.40 (s, 1H), 7.29 (t, *J* = 8.9 Hz, 2H), 6.89 - 6.74 (m, 2H), 5.08 (dd, *J* = 12.9, 5.4 Hz, 1H), 3.56 (t, *J* = 4.8 Hz, 4H), 3.16 (d, *J* = 7.5 Hz, 2H), 2.88 (t, *J* = 8.6 Hz, 1H), 2.82 (d, *J* = 5.2 Hz, 2H), 2.62 (t, *J* = 6.5 Hz, 2H), 2.56 (q, *J* = 4.6 Hz, 1H), 2.47 - 2.30 (m, 2H), 2.28 - 2.14 (m, 1H), 2.05 (dd, *J* = 19.3, 9.3 Hz, 2H), 1.91 (s, 2H), 1.69 - 1.17 (m, 16H), 0.83 (s, 3H). **^{13}C NMR (101 MHz, DMSO-*d*$_6$)** δ 220.0, 173.3, 172.2, 170.5, 167.9, 167.4, 155.3, 148.7, 138.2, 137.6, 134.3, 126.8, 125.4, 121.9, 119.5, 119.3, 118.9, 109.0, 60.2, 50.0, 49.3, 47.9, 47.5, 45.2, 44.0, 37.9, 35.8, 33.3, 31.8, 31.5, 29.3, 26.3, 25.8, 23.6, 22.5, 21.6, 21.2, 13.9. **HRMS (ESI):** m/z calculated for [$C_{40}H_{45}N_4O_9S$] [M-H]$^-$: 757.2913, found: 757.2919.

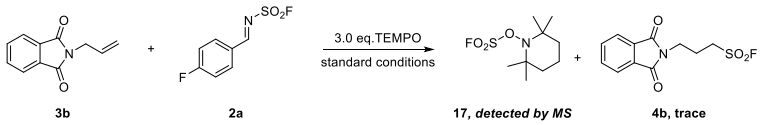


4aj **15** **16**

To a 10 mL round-bottomed flask equipped with a magnetic stir bar, **4aj** (0.1 mmol), estrone **15** (0.15 mmol) and Cs_2CO_3 (0.15 mmol) in MeCN (2 mL) were added. Stir the reaction mixture for 4 hours at 25°C under nitrogen. After completion of the reaction, purify the residue by silica gel column chromatography (PE/EA = 2:1) and product **16** was obtained in 85% yield (51.8 mg). **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 7.30 (d, *J* = 8.4 Hz, 1H), 7.19 (d, *J* = 7.7 Hz, 2H), 7.08 (d, *J* = 7.7 Hz, 2H), 7.01 (d, *J* = 11.0 Hz, 2H), 4.06 (dd, *J* = 12.9, 6.2 Hz, 2H), 3.68 (q, *J* = 7.2 Hz, 1H), 3.15 (t, *J* = 7.9 Hz, 2H), 2.93 (dd, *J* = 9.2, 4.2 Hz, 2H), 2.51 (dd, *J* = 18.8, 8.7 Hz, 1H), 2.44 (d, *J* = 7.3 Hz, 2H), 1.97 - 1.79 (m, 4H), 1.69 - 1.36 (m, 14H), 1.27 (s, 1H), 1.25 (d, *J* = 7.4 Hz, 3H), 0.91 (s, 3H), 0.89 (s, 3H), 0.88 (s, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 219.5, 173.7, 145.9, 139.5, 137.9, 137.8, 136.8, 128.3, 126.1, 125.9, 121.0, 118.0, 62.9, 49.4, 49.1, 46.9, 44.1, 44.0, 43.1, 36.9, 34.8, 30.5, 29.1, 28.4, 27.0, 25.2, 24.7, 23.5, 22.1, 21.4, 20.6, 17.3, 12.8. **HRMS (ESI):** m/z calculated for [$C_{36}H_{49}O_6S^+$][M+H$^+$]: 609.3244, found: 609.3247.

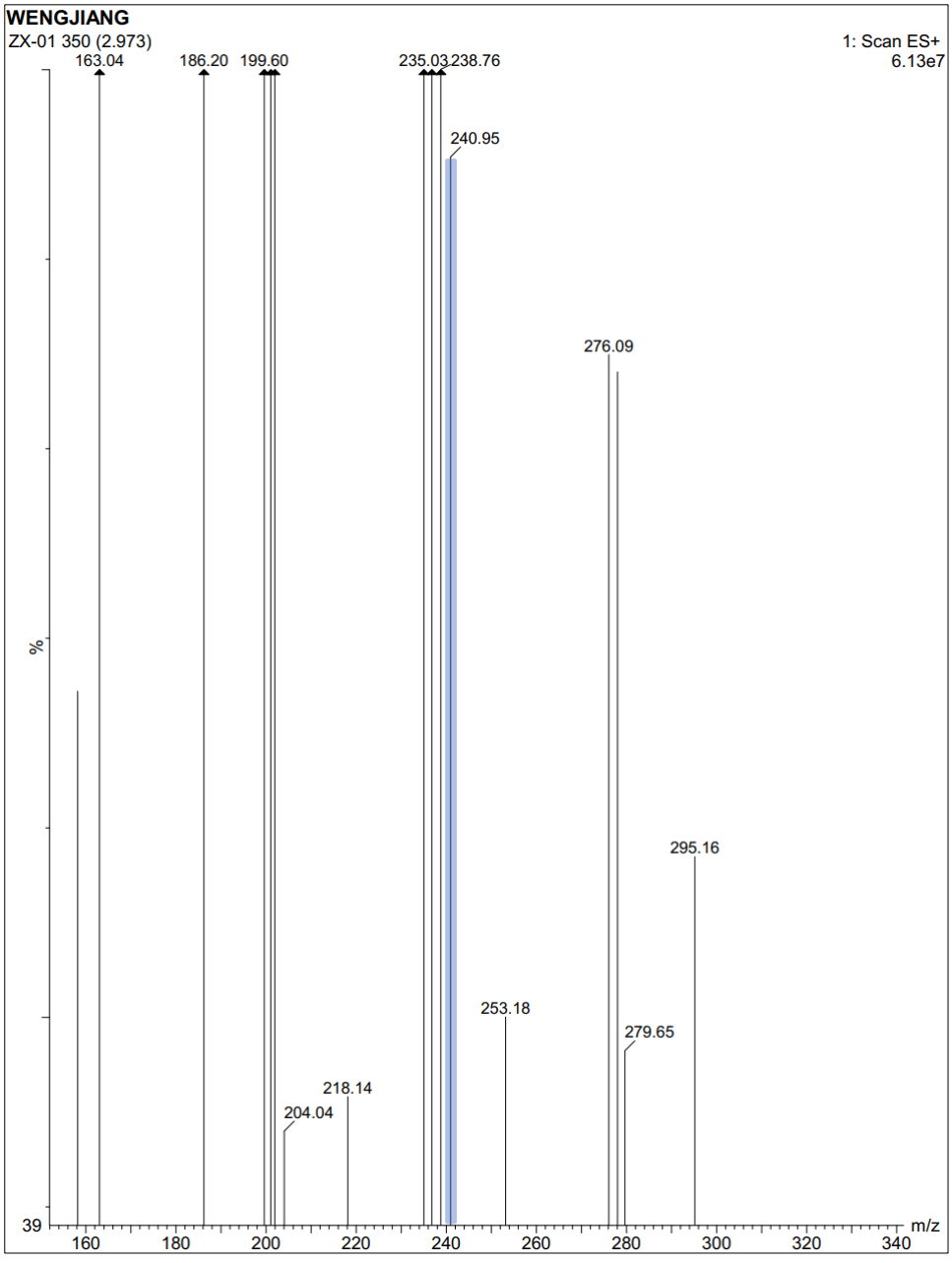
3. Mechanism studies

3.1 Radical trapping experiments with TEMPO

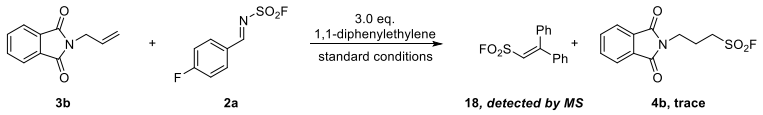


3b **2a** **17, *detected by MS*** **4b, trace**

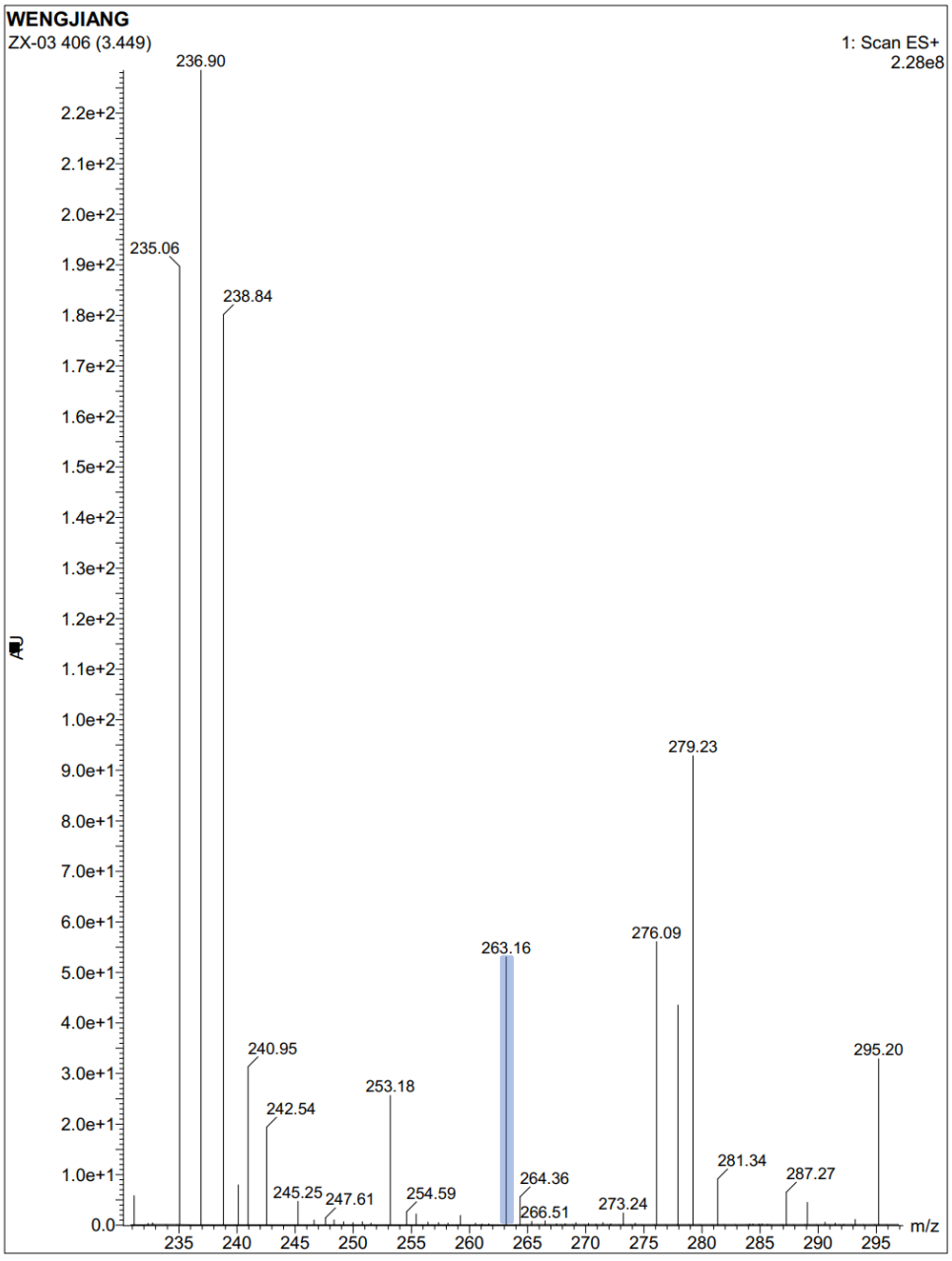
3b (0.1 mmol), **2a** (0.3 mmol), [Ir[dF(CF_3)ppy]$_2$(dtbbpy)]PF_6 (1 mmol%), Na_2CO_3 (0.1 mmol), TEMPO (0.3 mmol) and 1,3-dioxane (3 mL) were added to a 10 mL Schlenk tube equipped with a magnetic stirring bar. The tube was evacuated and backfilled with nitrogen. The reaction mixture was then irradiated with 30 W blue LEDs for 12 h. TLC and LC-MS analysis demonstrated that **17** is found. **MS (ESI):** m/z calculated for [$C_9H_{19}FNO_3S^+$] [M+H^+]: 240.11, found: 240.95.



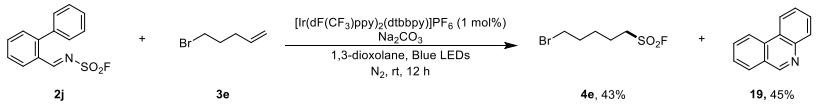
3.2 Radical trapping experiments with 1,1-diphenylethylene



3b (0.1 mmol), **2a** (0.3 mmol), [Ir[dF(CF_3)ppy]$_2$(dtbbpy)]PF_6 (1 mmol%), Na_2CO_3 (0.1 mmol), 1,1-diphenylethylene (0.3 mmol) and 1,3-dioxane (3 mL) were added to a 10 mL Schlenk tube equipped with a magnetic stirring bar. The tube was evacuated and backfilled with nitrogen. The reaction mixture was then irradiated with 30 W blue LEDs for 12 h. TLC and LC-MS analysis demonstrated that **18** is found. **MS (ESI):** m/z calculated for [$C_{14}H_{12}FO_2S^+$] [M+H$^+$]: 263.05, found: 263.16.



3.3 lminyl radical trapping experiment



3e (0.1 mmol), **2j** (0.3 mmol), [Ir[dF(CF$_3$)ppy]$_2$(dtbbpy)]PF$_6$ (1 mmol%), Na_2CO_3 (0.1 mmol) and 1,3-dioxane (3 mL) were added to a 10 mL Schlenk tube equipped with a magnetic stirring bar. The flask was backfilled with nitrogen. The reaction mixture was then irradiated with 30 W blue LEDs for 12 h. After the reaction, the solution was purified by flash column chromatography or on silica gel to give the product **4e** in 43% yield and **19**[8] in 45% yield. Compound **19**: **^{1}H NMR (400 MHz, Chloroform-*d*)** δ 9.30 (s, 1H), 8.65 – 8.56 (m, 2H), 8.20 (dd, J = 8.1, 1.4 Hz, 1H), 8.06 (dd, J = 8.0, 1.4 Hz, 1H), 7.91 – 7.84 (m, 1H), 7.80 – 7.66 (m, 3H). **^{13}C NMR (101 MHz, Chloroform-*d*)** δ 153.60, 144.49, 132.59, 131.04, 130.17, 128.80, 128.72, 127.52, 127.12, 126.42, 124.13, 122.24, 121.90. **HRMS (ESI):** m/z calculated for [$C_{13}H_{10}N^+$][M+H$^+$]: 180.0808, found: 180.0813.

3.4 Stern-Volmer quenching studies

Stern-Volmer luminescence quenching studies were performed using a Jasco FP-8300 spectrofluorometer using Starna® fluorescence quartz cuvettes (type: 29-F, chamber volume = 1.400 mL, H × W × D = 48 mm × 12.5 mm × 12.5 mm, path length = 10 mm). The following parameters were set: data interval = 0.5 nm, scan-speed = 500 nm/min, excitation wavelength λ_{ex} = 405 nm, measured luminescence wavelength λ = 471 nm. All samples used in the luminescence quenching-based screening studies were prepared in an argon-filled glovebox with degassed and dry MeCN. Stock solutions of potential quenchers and the photocatalyst (Ir[dF(CF$_3$)ppy]$_2$(dtbbpy))PF$_6$ (5×10^{-5} M) were initially prepared. Stern-Volmer luminescence quenching studies were performed using a stock solution of the photocatalyst and variable concentrations of the potential quenchers at rt under an argon atmosphere. The samples were prepared by dilution in the 1.4 mL quartz cuvettes inside the argon-filled glovebox. The solutions were irradiated at 405 nm and the luminescence was measured at 471 nm. The ratio of I_0/I was plotted as a function of the quencher concentration [Quencher] (I_0 = emission intensity of the photocatalyst in isolation at the specified wavelength 471 nm; I = observed emission intensity of the photocatalyst with added quencher).

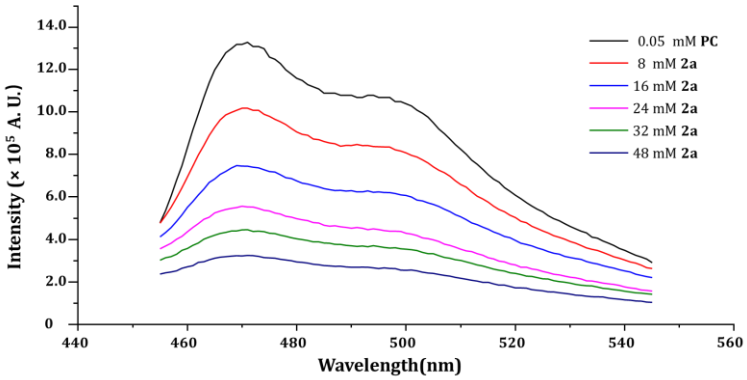


Figure S1. Emission spectra of (Ir[dF(CF$_3$)ppy]$_2$(dtbbpy))PF$_6$ (5×10^{-5} M) at different concentrations of **2a**

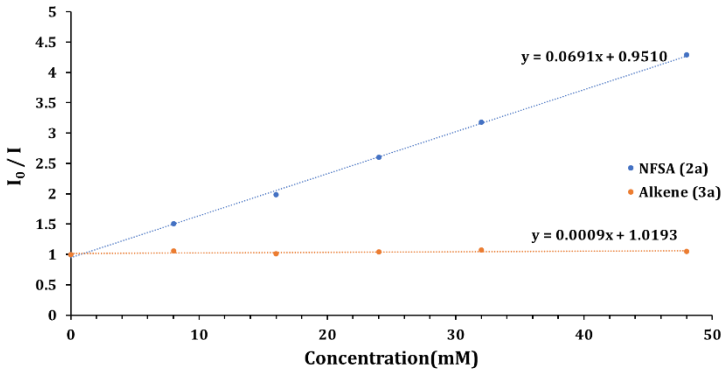


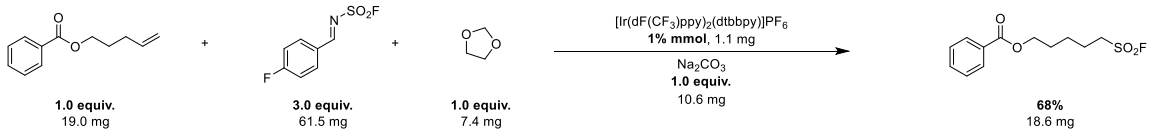
Figure S2. Stern-Volmer plot of (Ir[dF(CF_3)ppy]$_2$(dtbbpy))PF_6 ($5\times\cdot10^{-5}$ M) at different concentrations of **2a** and **3a**

4. Green metrics[9]

To give a clear calculation, compound **4g** has been chosen as a representative example.

entry	Work of different groups	*E*-Factor	AE	RME	PMI
1	**This work**	**4.35**	**58.4%**	**21.2%**	**5.35**
2	Wang[9]	6.24	35.2%	14.0%	7.24
3	Liao[10]	6.94	35.2%	12.6%	7.94
4	Glorius[11]	4.48	39.3%	18.5%	5.47
5	Weng[6]	4.82	50.5%	17.4%	5.82

Our method



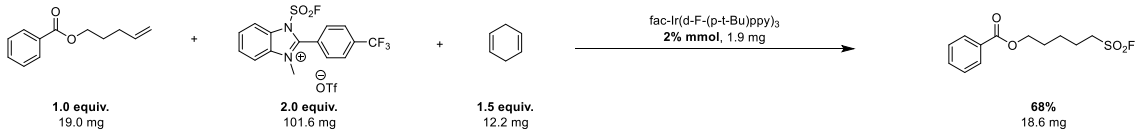
Total amounts of reactants = 99.6 mg
Amount of final product = 18.6 mg
Amount of waste: 99.6 mg – 18.6 mg = 81.0 mg
***E*-Factor** = Amount of waste/Amount of final product = 4.35

Molecular weight of product = 274.1
Sum of molecular weight of reagent = 469.1
AE = Molecular weight of product/Sum of molecular weight of reagent = 58.4%

Mass of product = 18.6 mg
Total mass of reagent = 87.9 mg
RME = Mass of product/Total mass of reagent = 21.2%

Total mass in process = 99.6 mg
Mass of product = 18.6 mg
PMI = Total mass in process/Mass of product = 5.35

Wang's work[10]



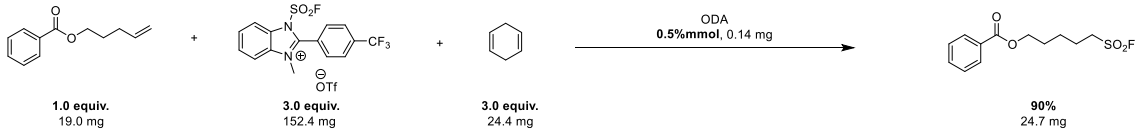
Total amounts of reactants = 134.7 mg
Amount of final product = 18.6 mg
Amount of waste: 134.7 mg – 18.6 mg = 116.1 mg
***E*-Factor** = Amount of waste/Amount of final product = 6.24

Molecular weight of product = 274.1
Sum of molecular weight of reagent = 778.2
AE = Molecular weight of product/Sum of molecular weight of reagent = 35.2%

Mass of product = 18.6 mg
Total mass of reagent = 132.8 mg
RME = Mass of product/Total mass of reagent = 14.0 %

Total mass in process = 134.7 mg
Mass of product = 18.6 mg
PMI = Total mass in process/Mass of product = 7.24

Liao's work[11]



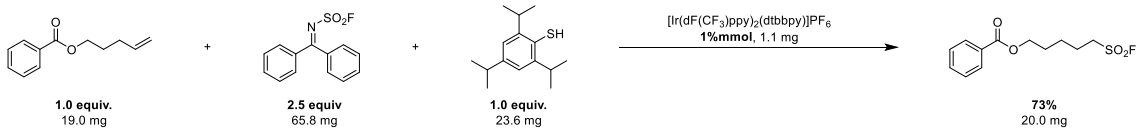
Total amounts of reactants = 195.9 mg
Amount of final product = 24.7 mg
Amount of waste: 195.9 mg – 24.7 mg = 171.2 mg
***E*-Factor** = Amount of waste/Amount of final product = 6.94

Molecular weight of product = 274.1
Sum of molecular weight of reagent = 778.2
AE = Molecular weight of product/Sum of molecular weight of reagent = 35.2%

Mass of product = 24.7 mg
Total mass of reagent = 195.8 mg
RME = Mass of product/Total mass of reagent = 12.6 %

Total mass in process = 195.9 mg
Mass of product = 24.7 mg
PMI = Total mass in process/Mass of product = 7.94

Glorius's work[12]



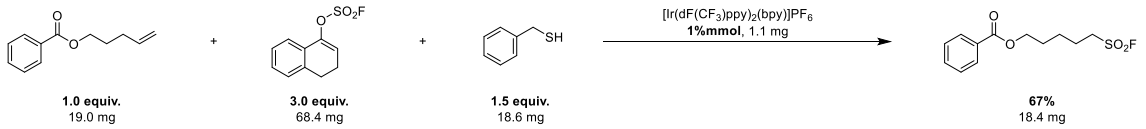
Total amounts of reactants = 109.5 mg
Amount of final product = 20.0 mg
Amount of waste: 109.5 mg – 20.0 mg = 89.5 mg
***E*-Factor** = Amount of waste/Amount of final product = 4.48

Molecular weight of product = 274.1
Sum of molecular weight of reagent = 689.6
AE = Molecular weight of product/Sum of molecular weight of reagent = 39.3%

Mass of product = 20.0 mg
Total mass of reagent = 108.4 mg
RME = Mass of product/Total mass of reagent = 18.5 %

Total mass in process = 109.5 mg
Mass of product = 20.0 mg
PMI = Total mass in process/Mass of product = 5.47

Weng's work[6]



Total amounts of reactants = 107.1 mg
Amount of final product = 18.4 mg
Amount of waste: 107.1 mg – 18.4 mg = 88.7 mg
***E*-Factor** = Amount of waste/Amount of final product = 4.82

Molecular weight of product = 274.1
Sum of molecular weight of reagent = 542.3
AE = Molecular weight of product/Sum of molecular weight of reagent = 50.5%

Mass of product = 18.4 mg
Total mass of reagent = 106.0 mg
RME = Mass of product/Total mass of reagent = 17.4 %

Total mass in process = 107.1 mg
Mass of product = 18.4 mg
PMI = Total mass in process/Mass of product = 5.82

5. Reference

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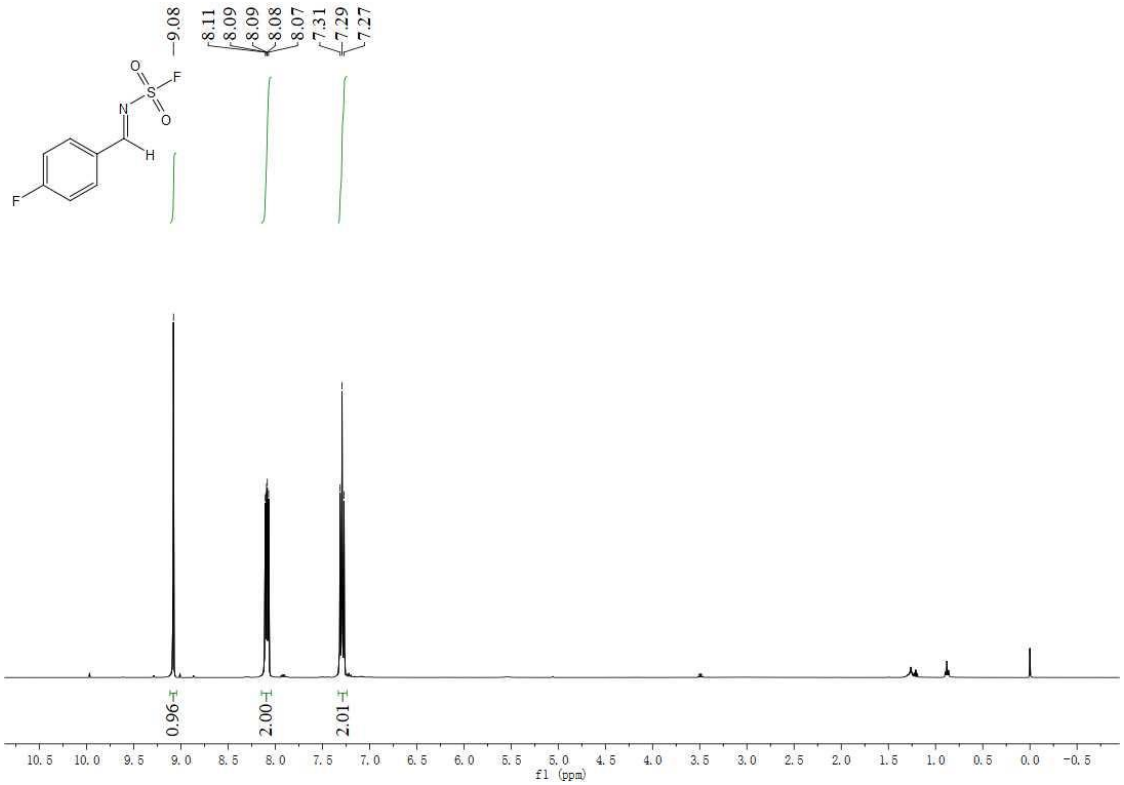
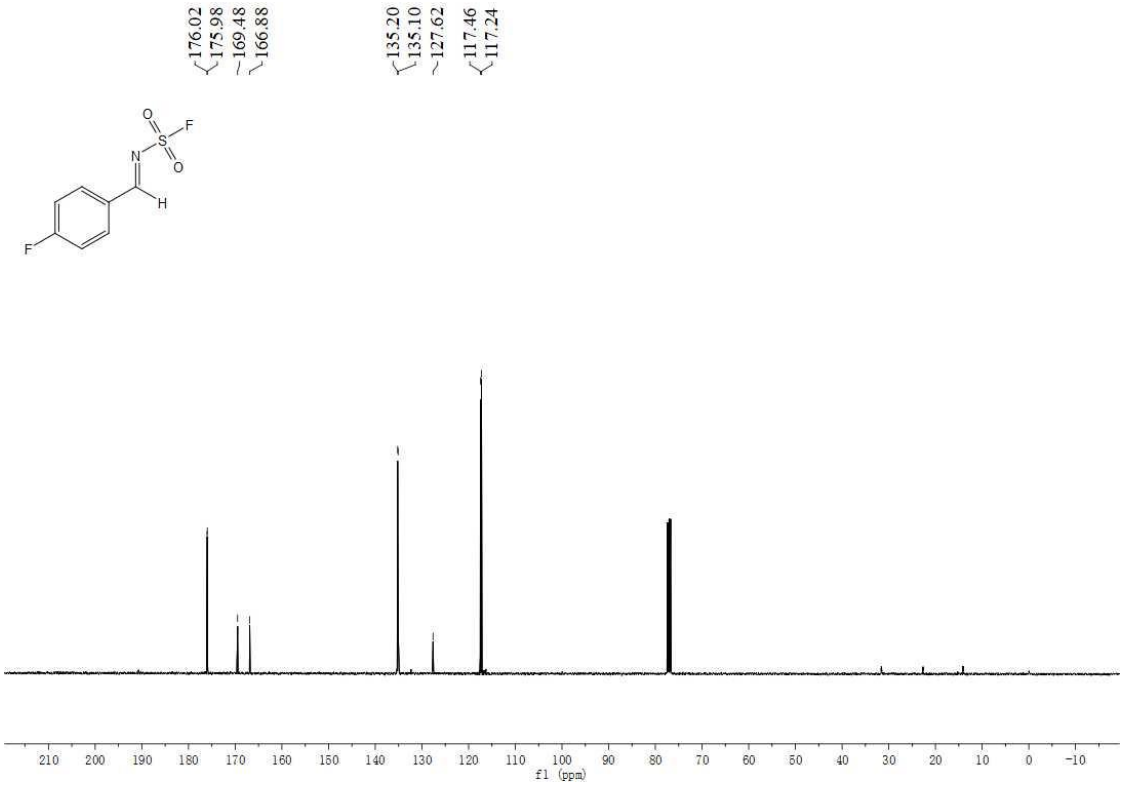
6. ^{1}H NMR, ^{13}C NMR, ^{19}F NMR and ^{31}P NMR spectra for compounds

(E)-(4-fluorobenzylidene)sulfamoyl fluoride **(2a)**

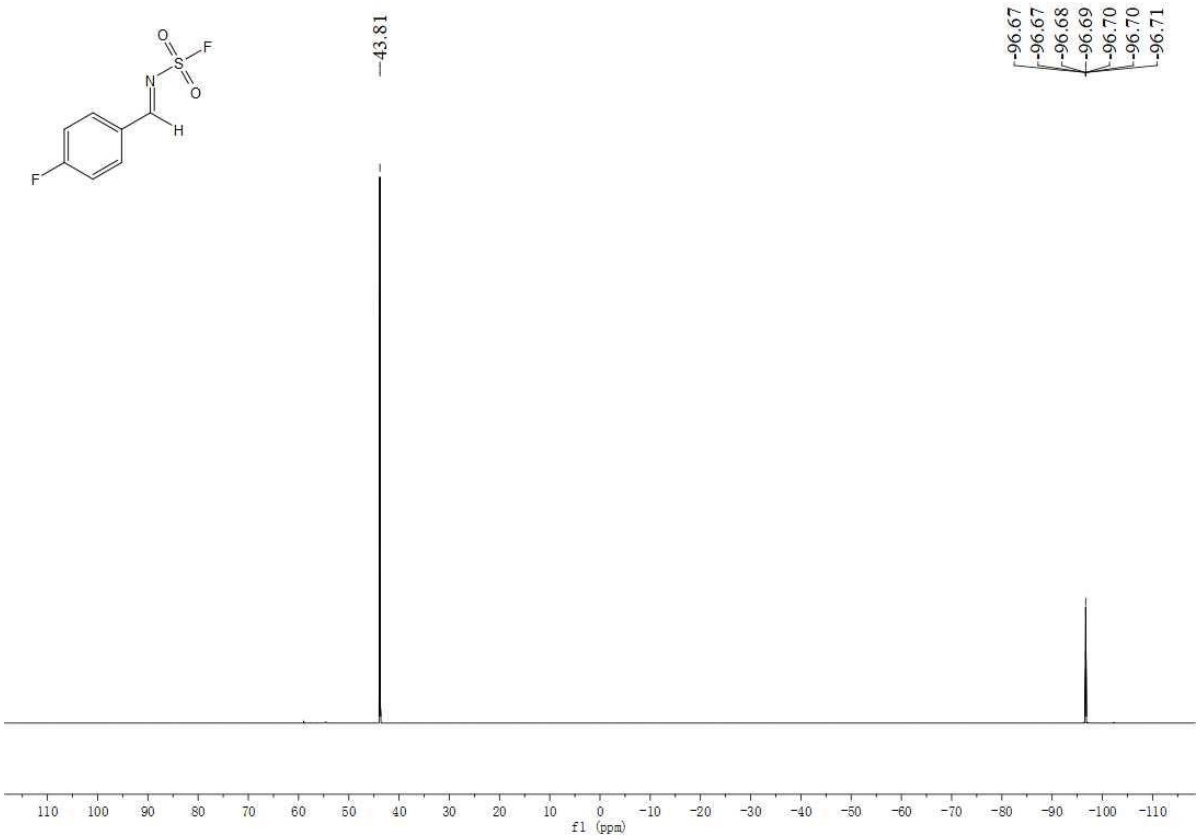
^{1}H NMR



^{13}C NMR



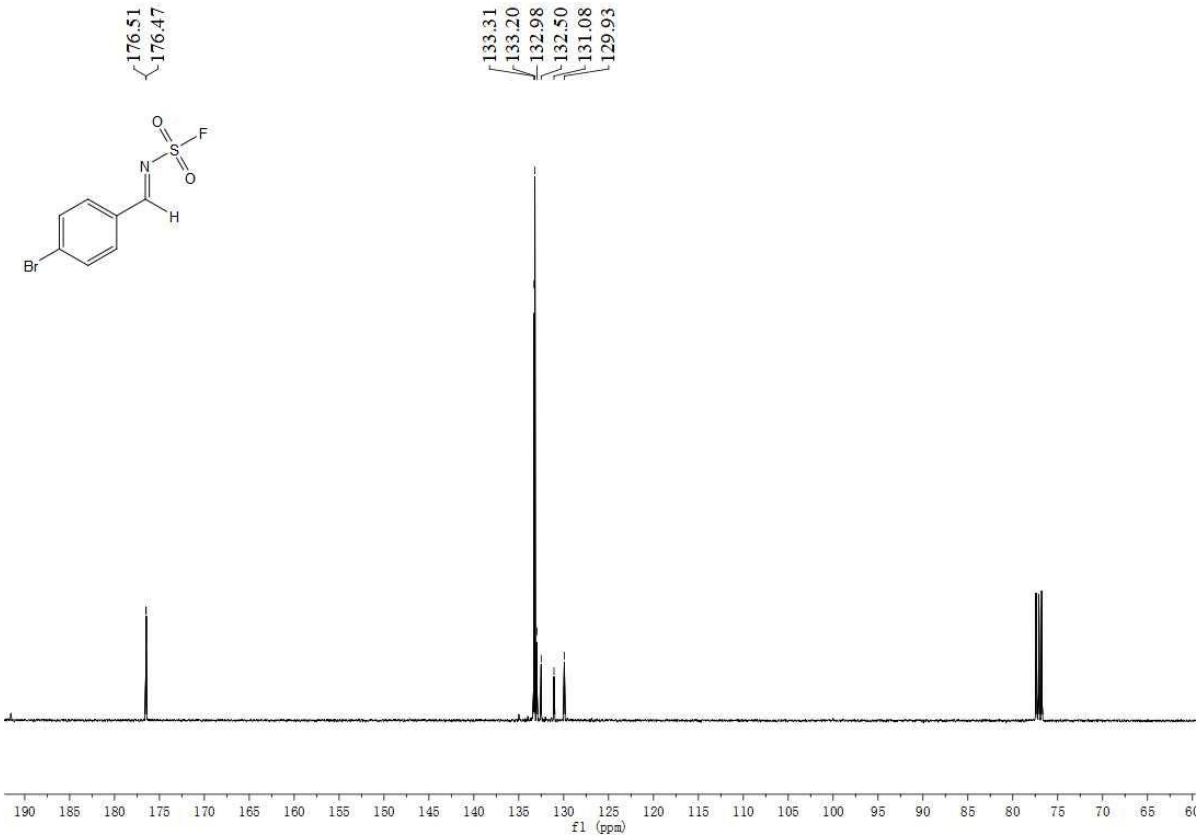
^{19}F NMR



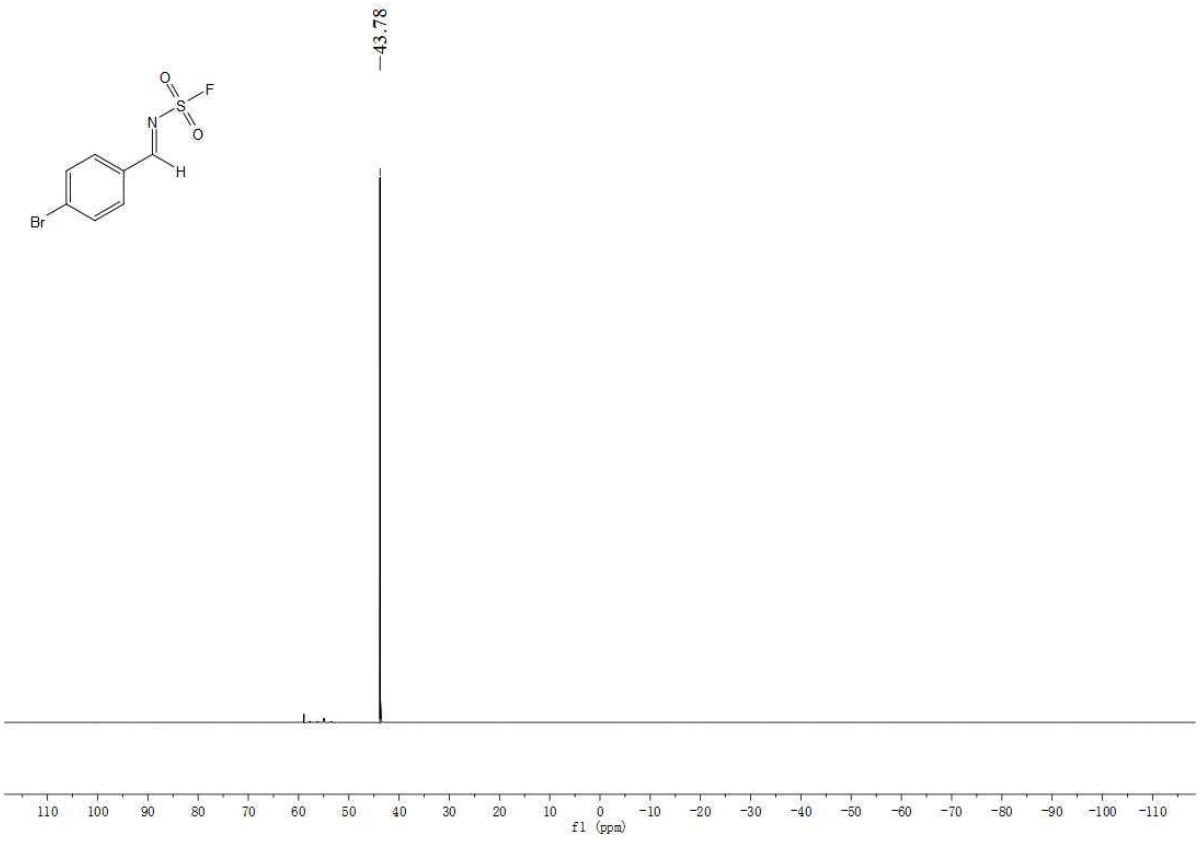
(E)-(4-bromobenzylidene)sulfamoyl fluoride **(2b)**

^{1}H NMR

^{13}C NMR

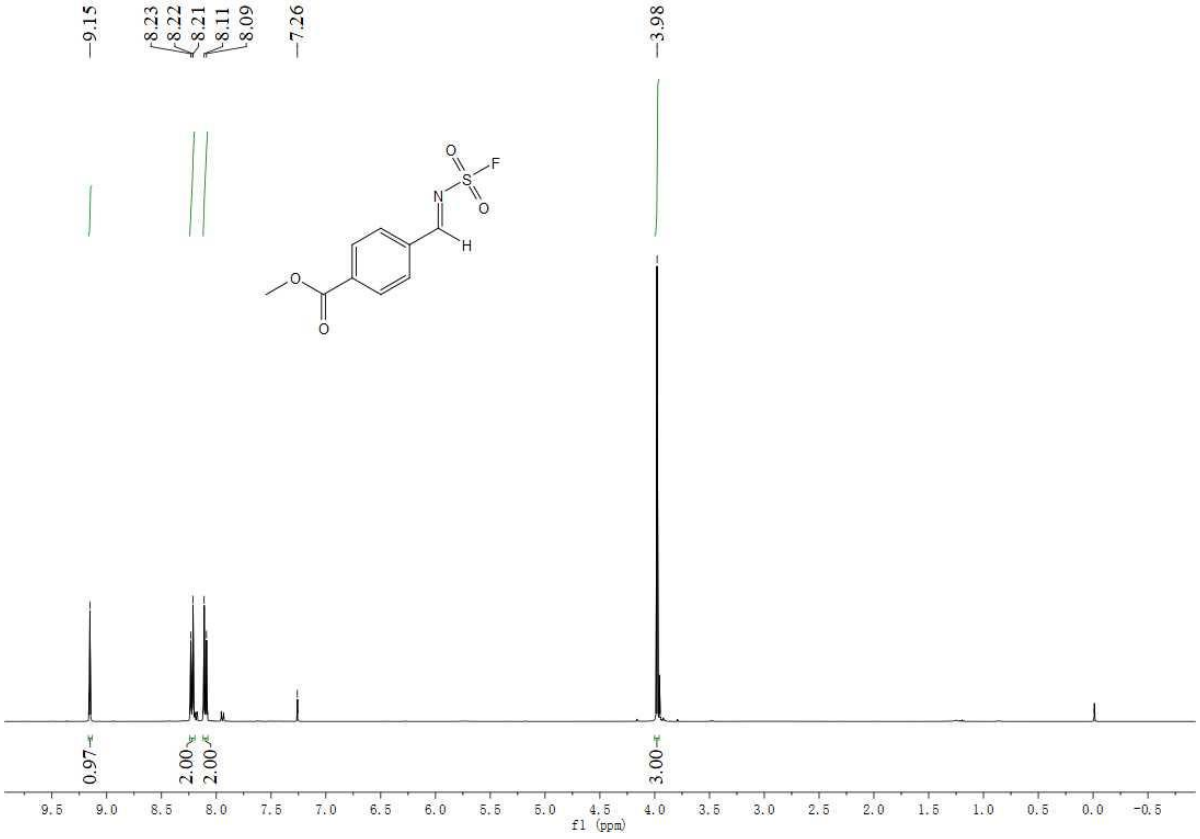


^{19}F NMR

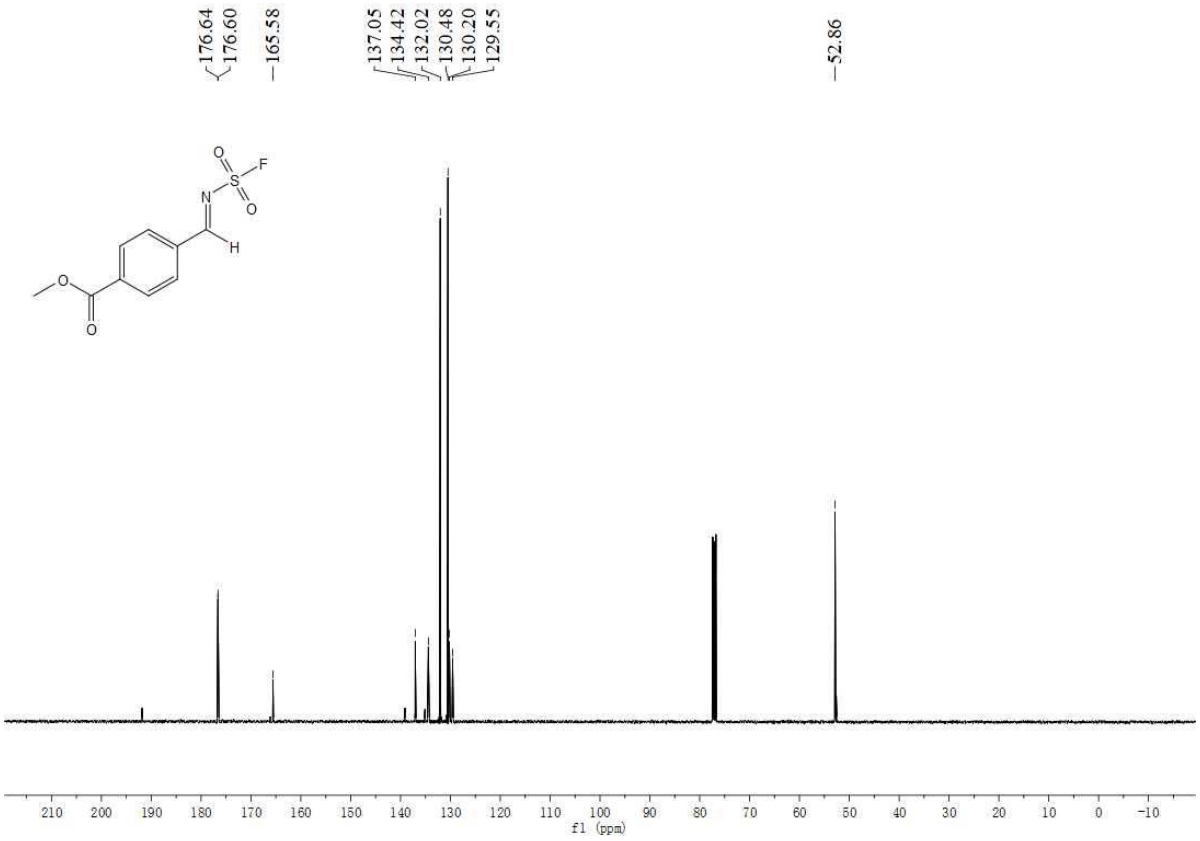


methyl (E)-4-(((fluorosulfonyl)imino)methyl)benzoate **(2c)**

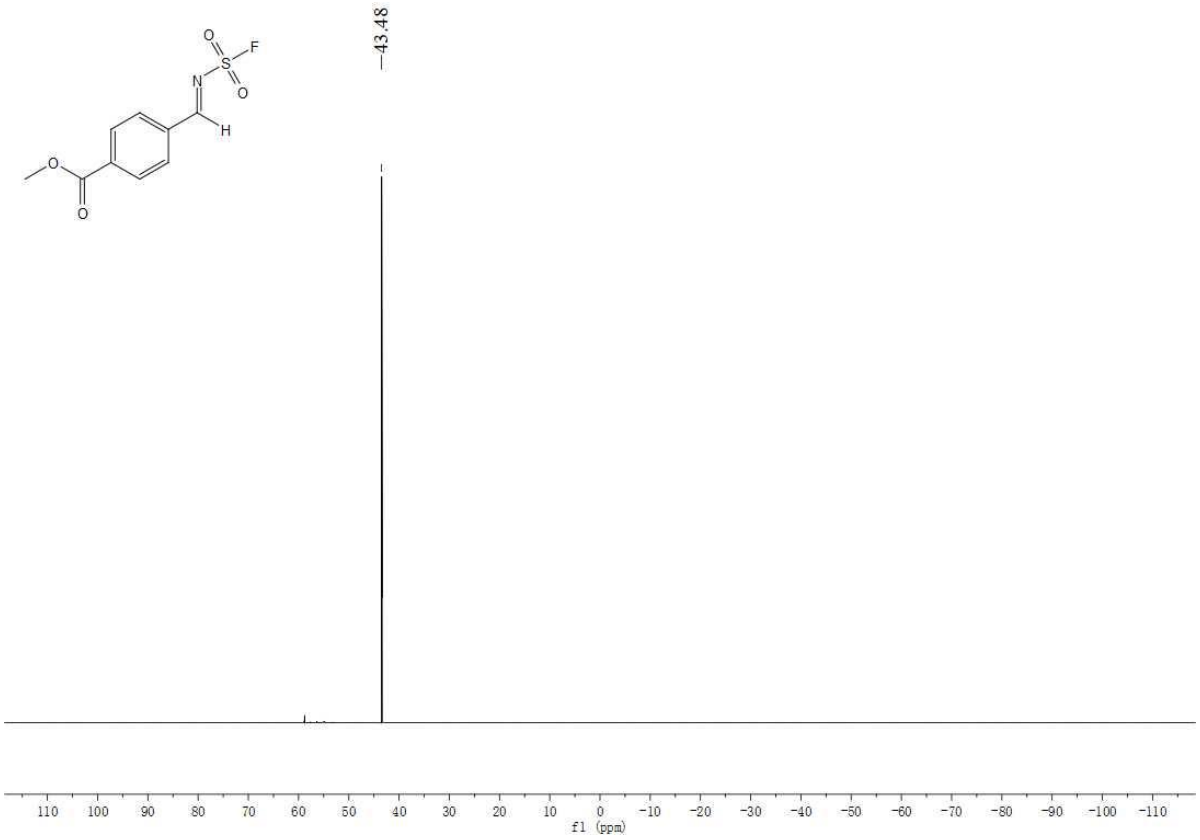
^{1}H NMR



^{13}C NMR

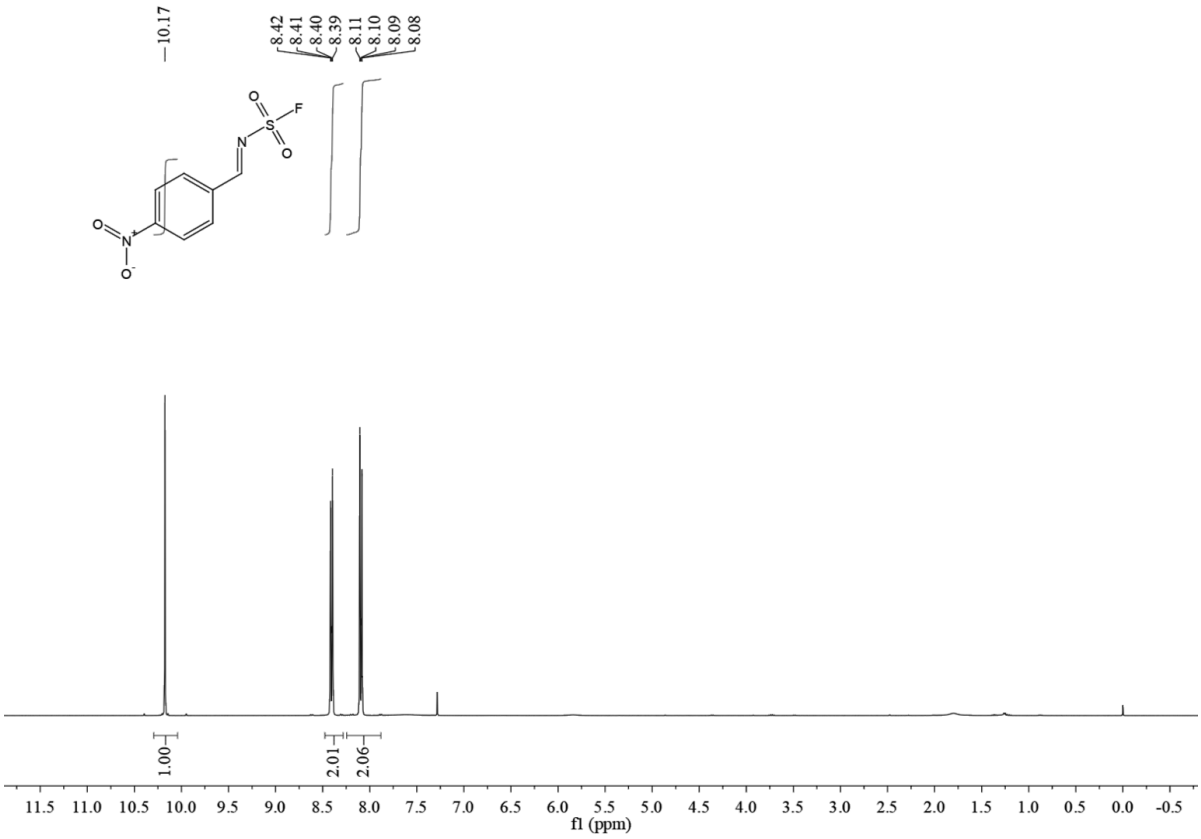


^{19}F NMR

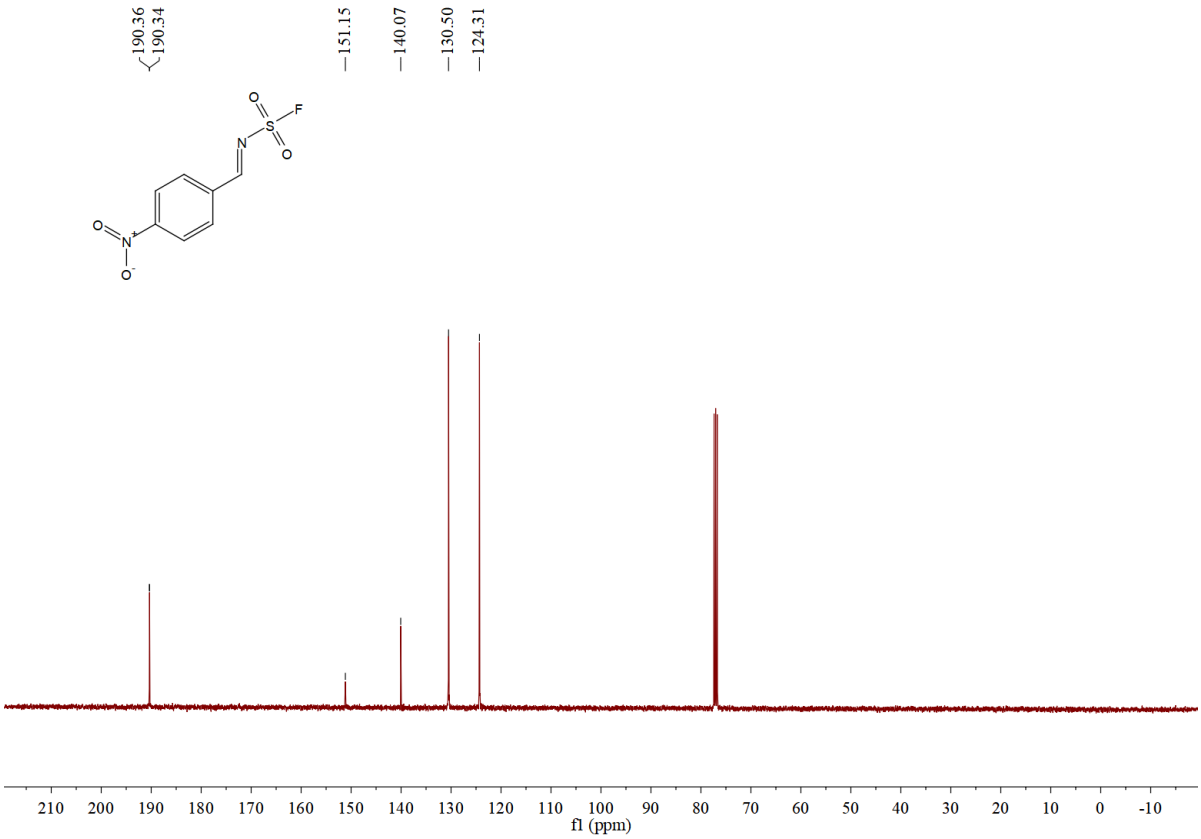


(E)-(4-nitrobenzylidene)sulfamoyl fluoride **(2d)**

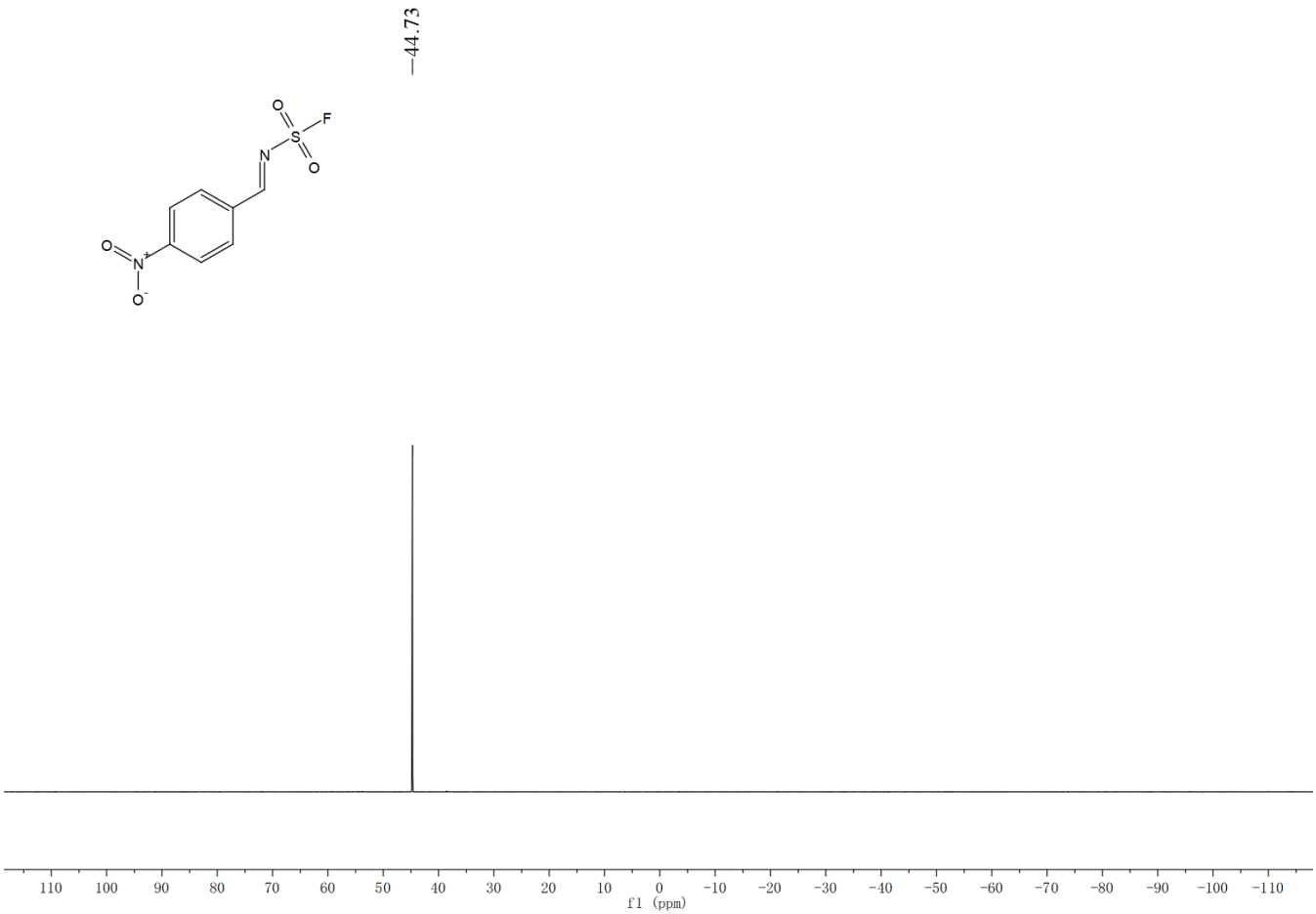
^{1}H NMR



^{13}C NMR

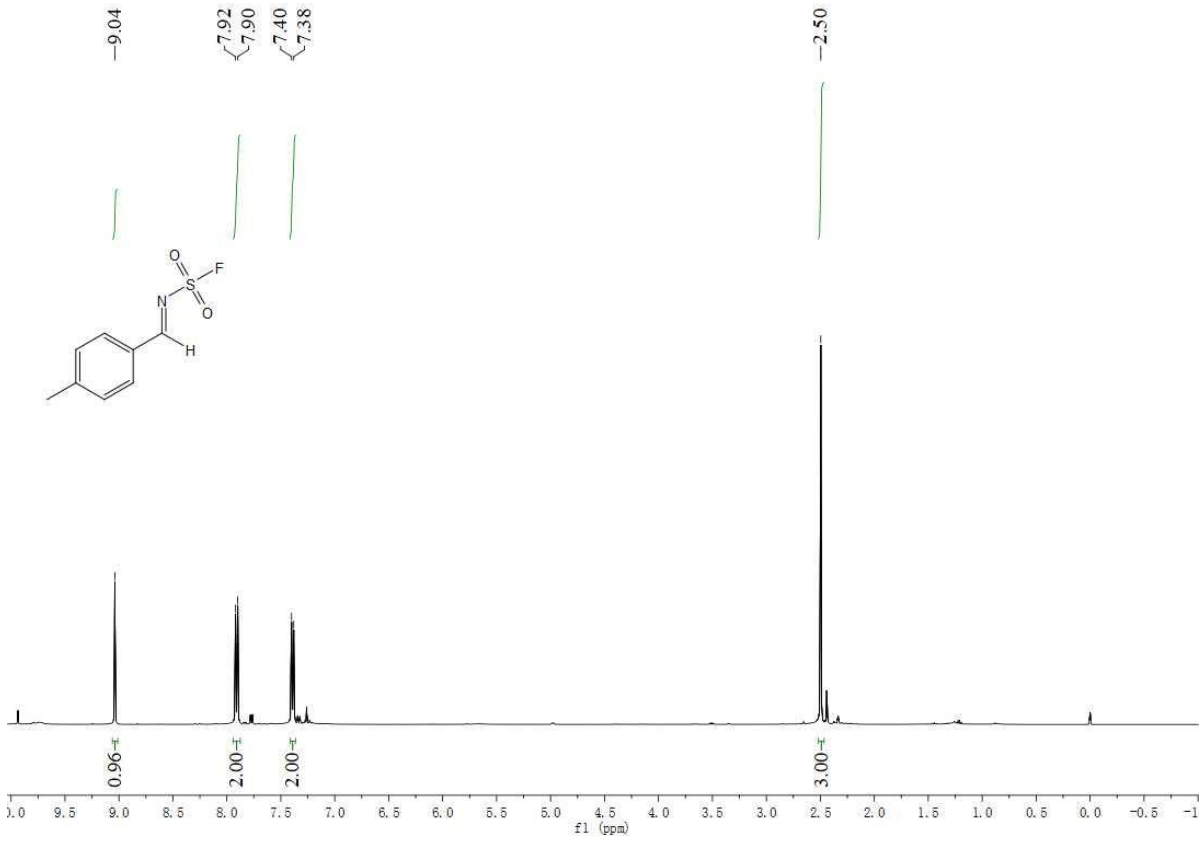


^{19}F NMR

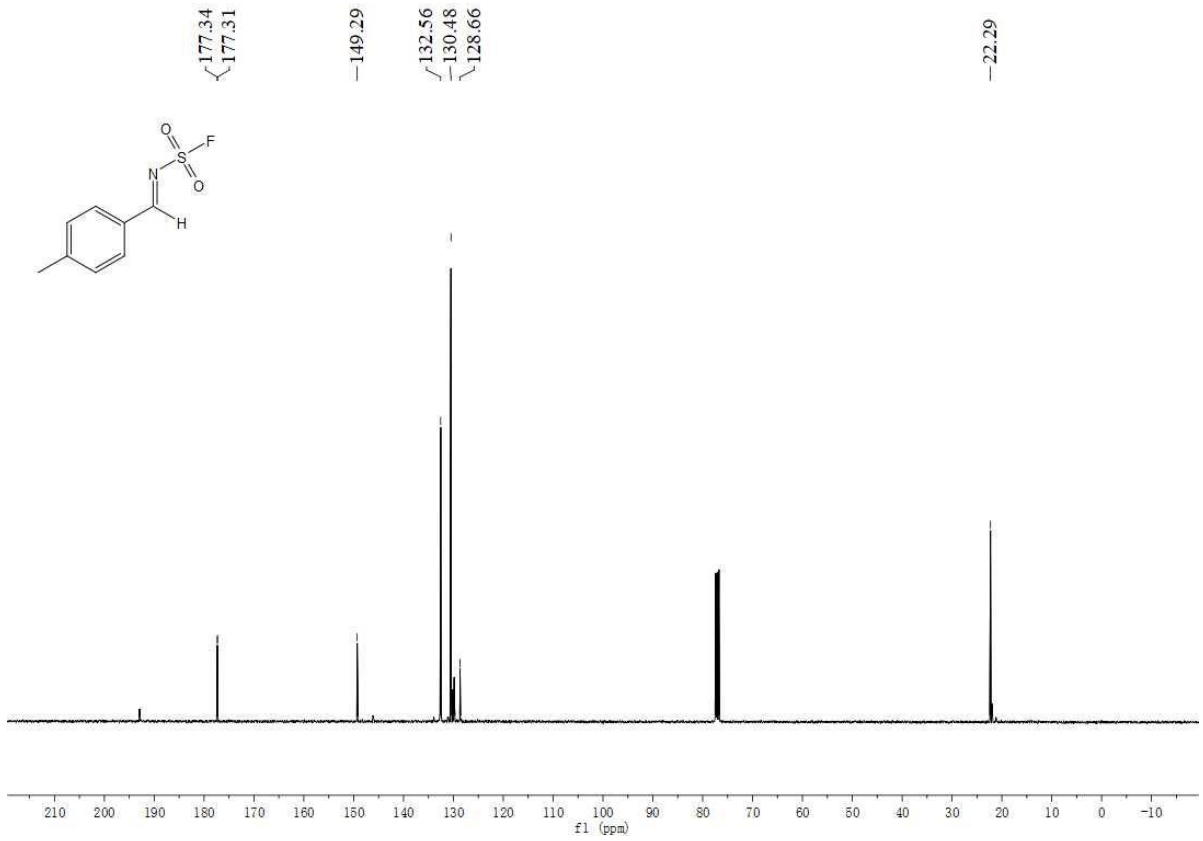


(E)-(4-methylbenzylidene)sulfamoyl fluoride **(2e)**

^{1}H NMR



^{13}C NMR



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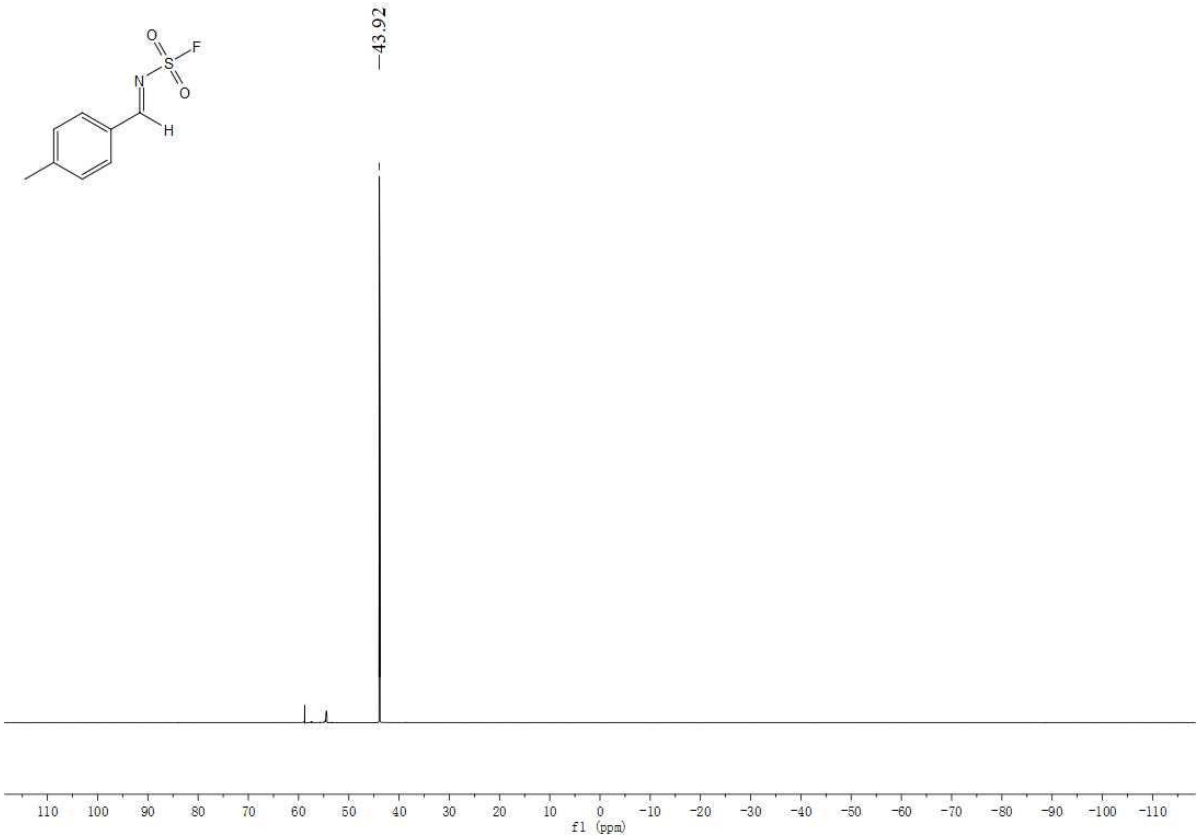
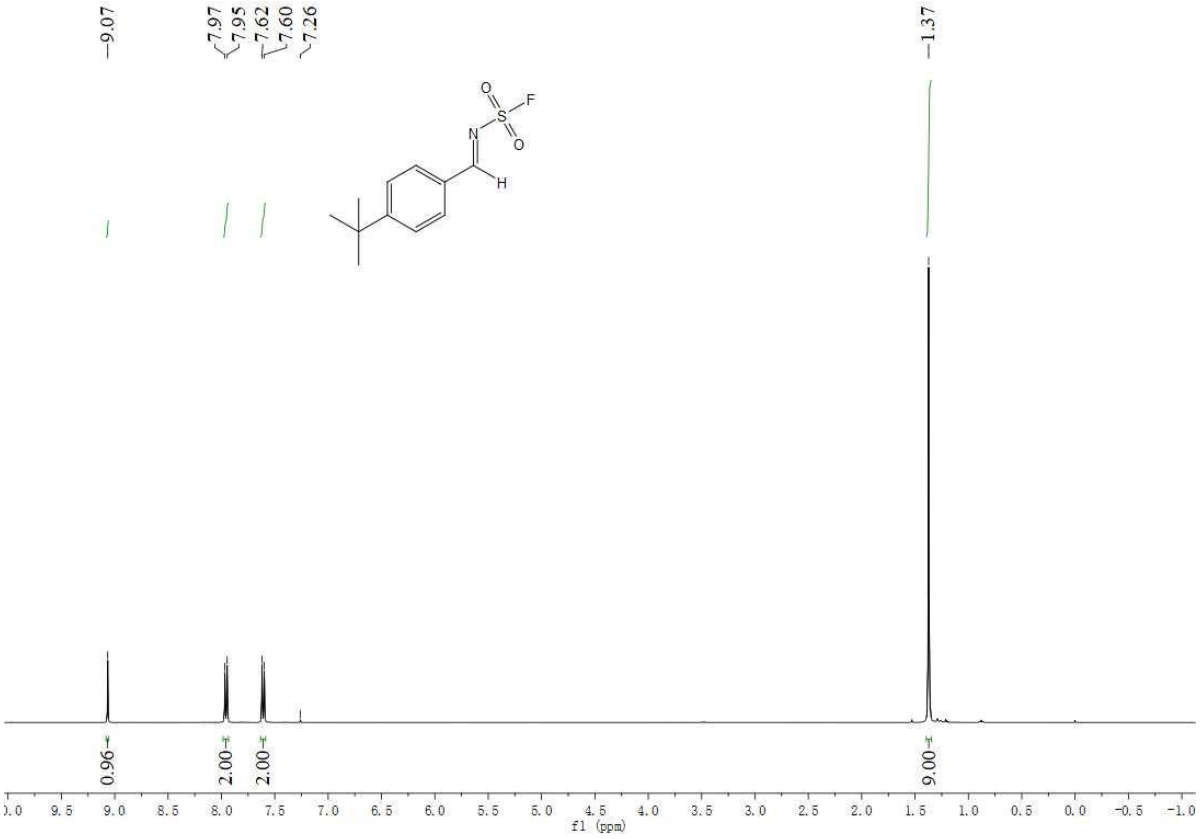
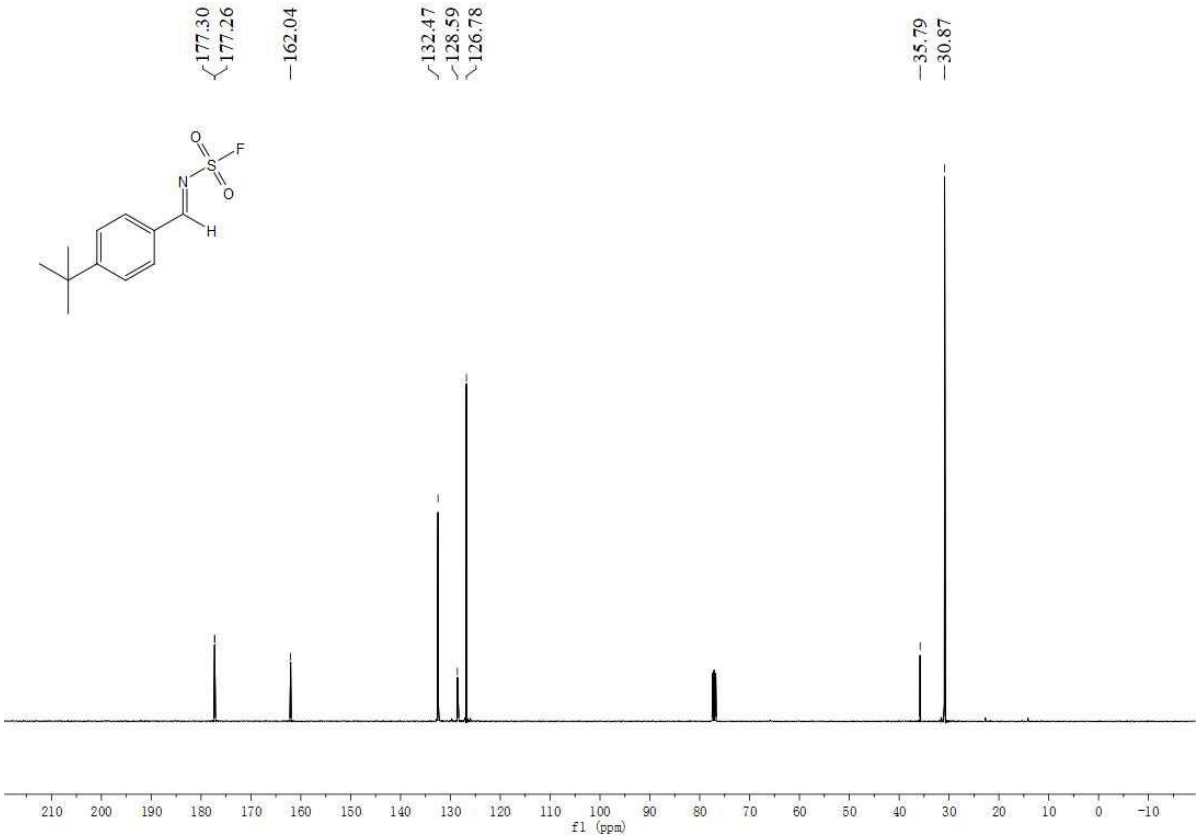


(E)-(4-(tert-butyl)benzylidene)sulfamoyl fluoride **(2f)**

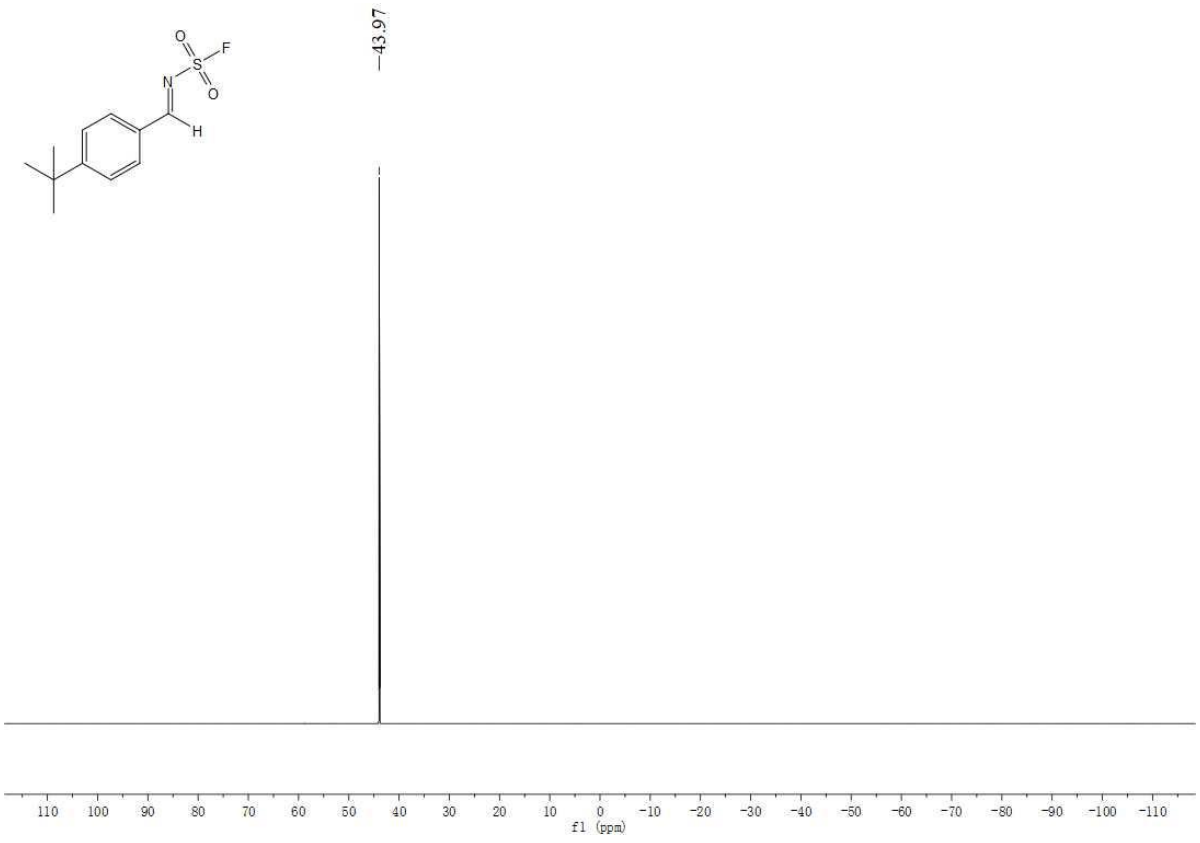
^{1}H NMR



^{13}C NMR

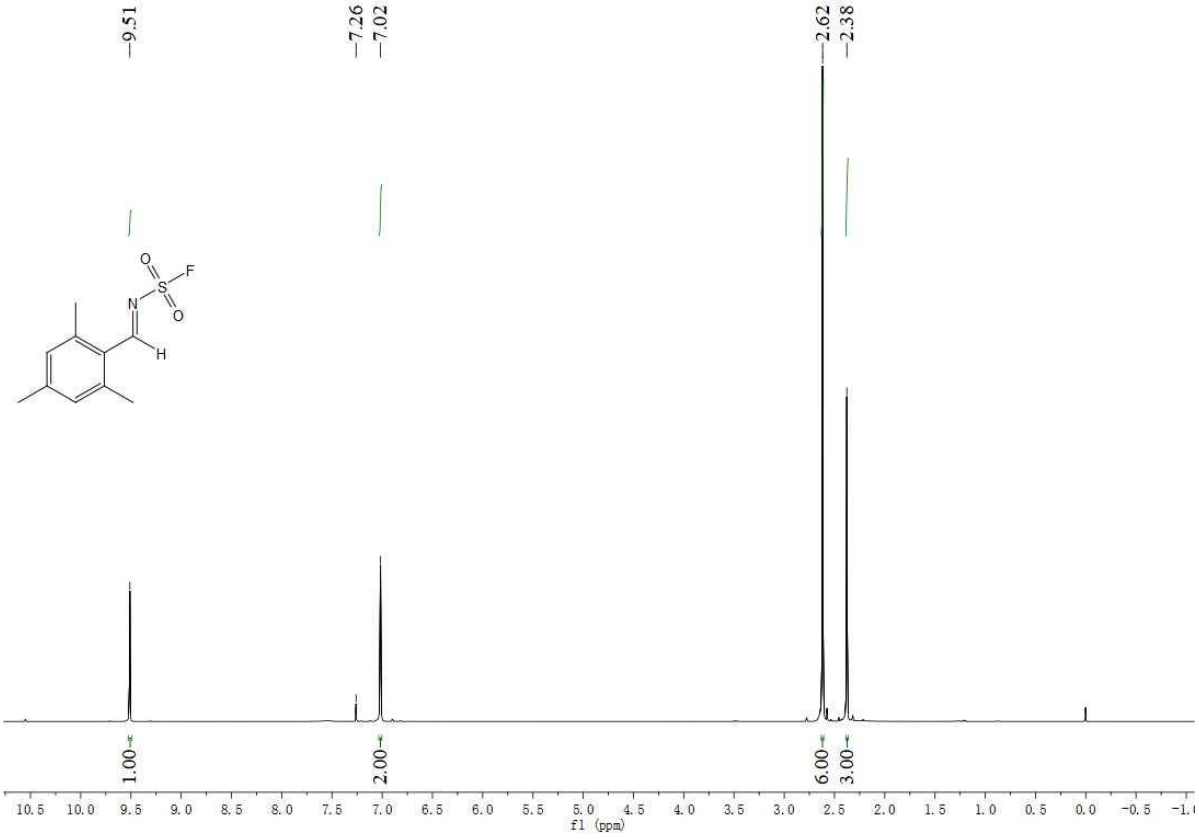


^{19}F NMR

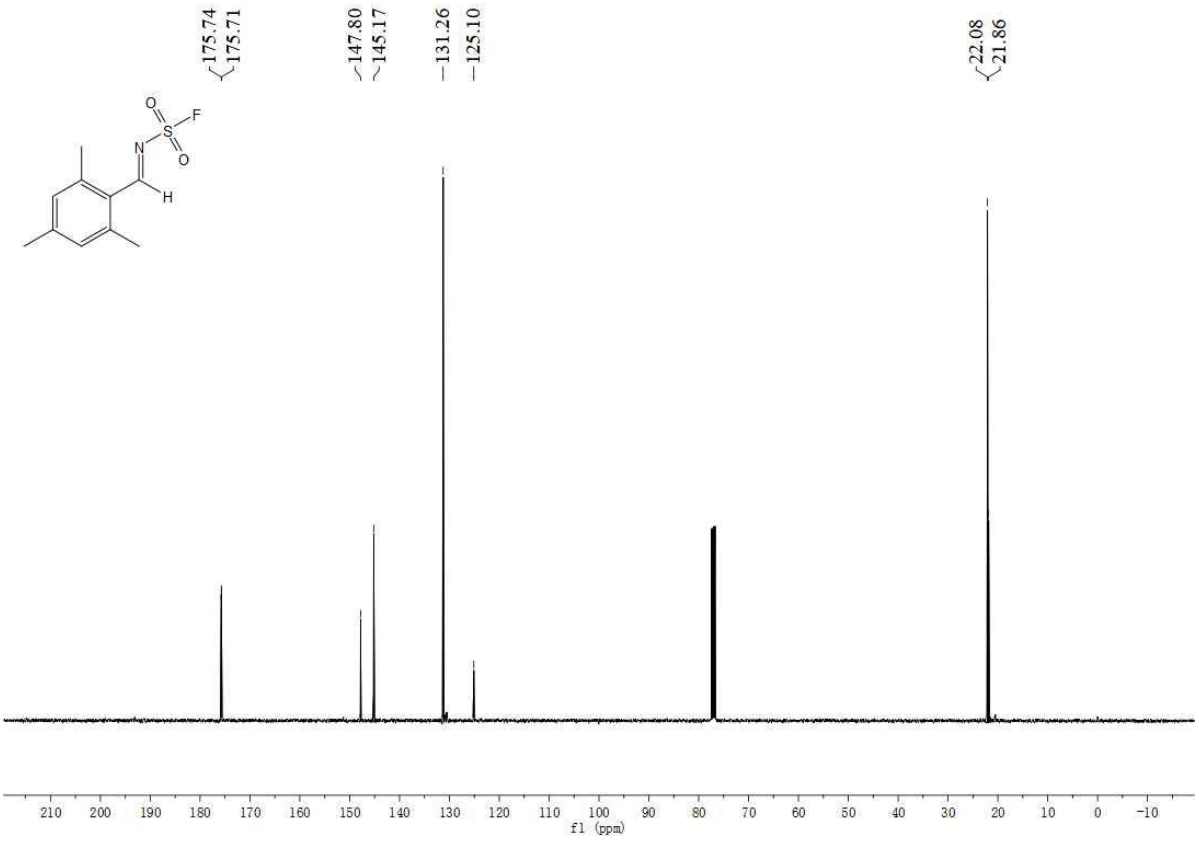


(E)-(2,4,6-trimethylbenzylidene)sulfamoyl fluoride **(2g)**

^{1}H NMR



^{13}C NMR



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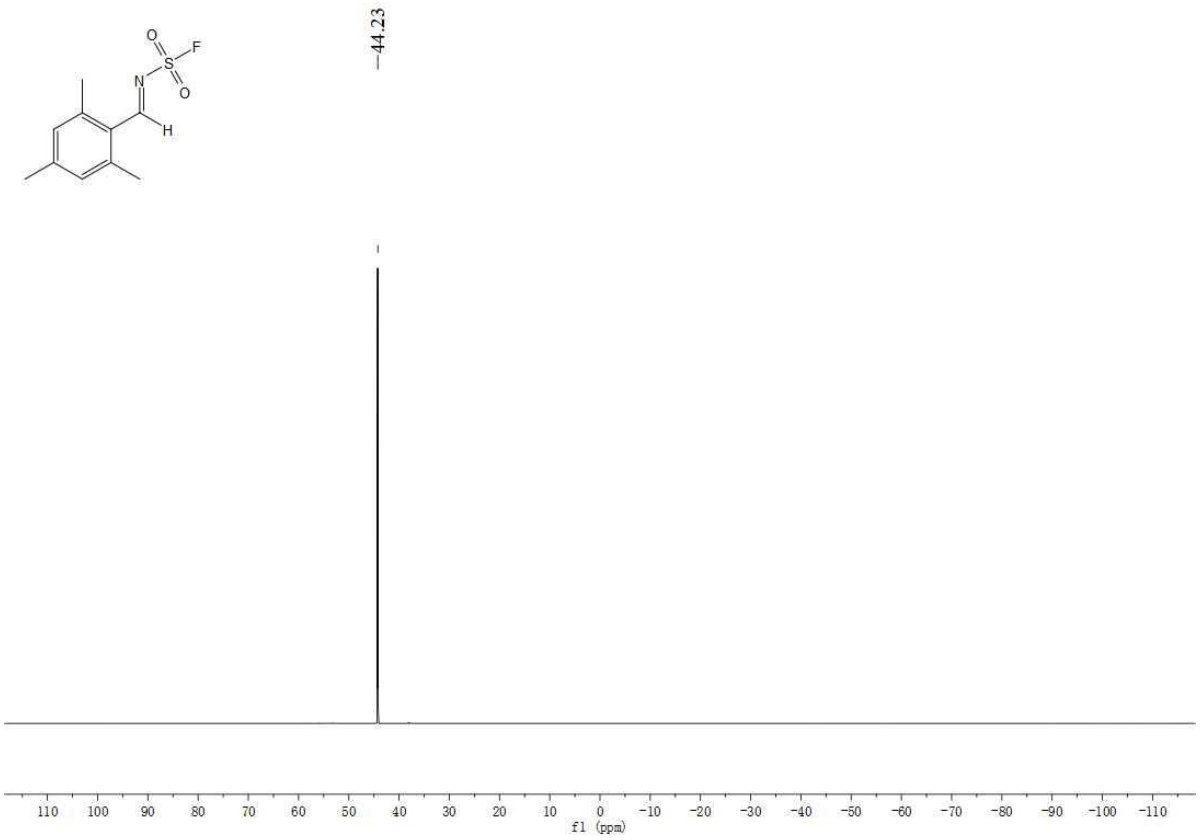
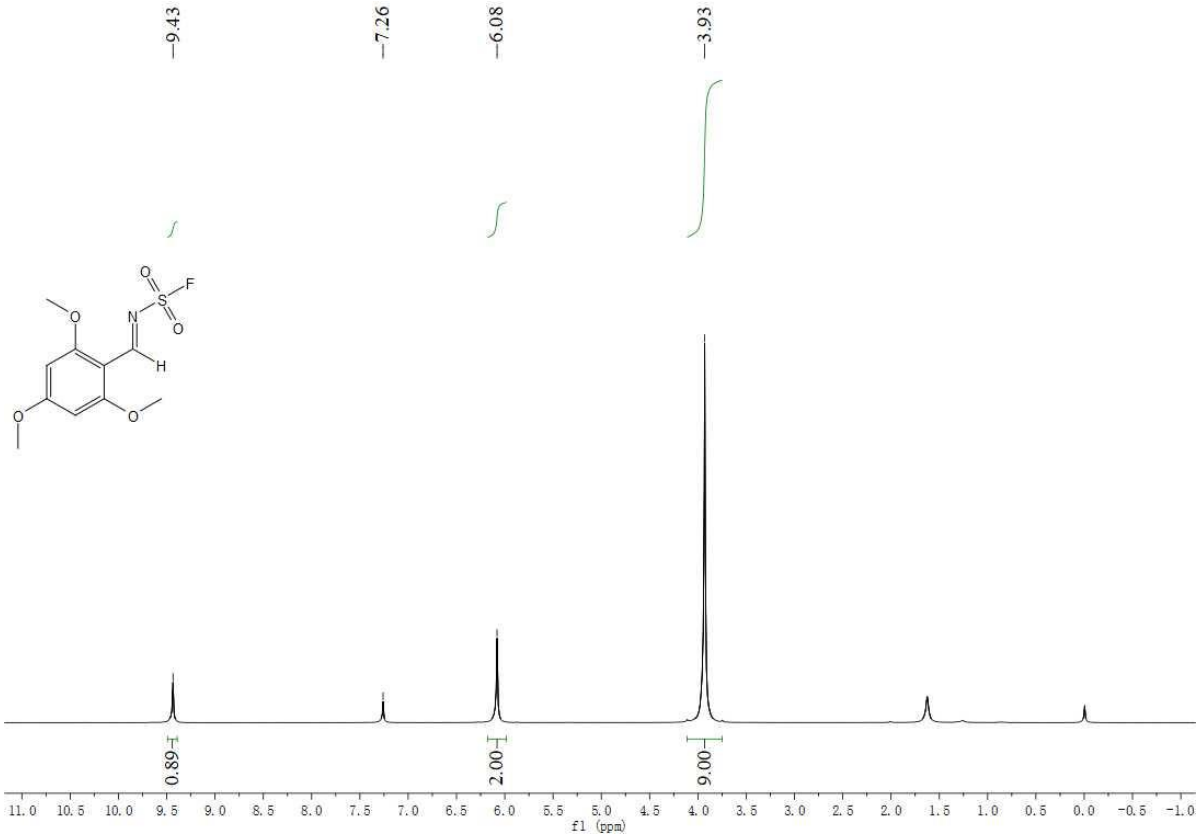


(E)-(2,4,6-trimethoxybenzylidene)sulfamoyl fluoride **(2h)**

^{1}H NMR



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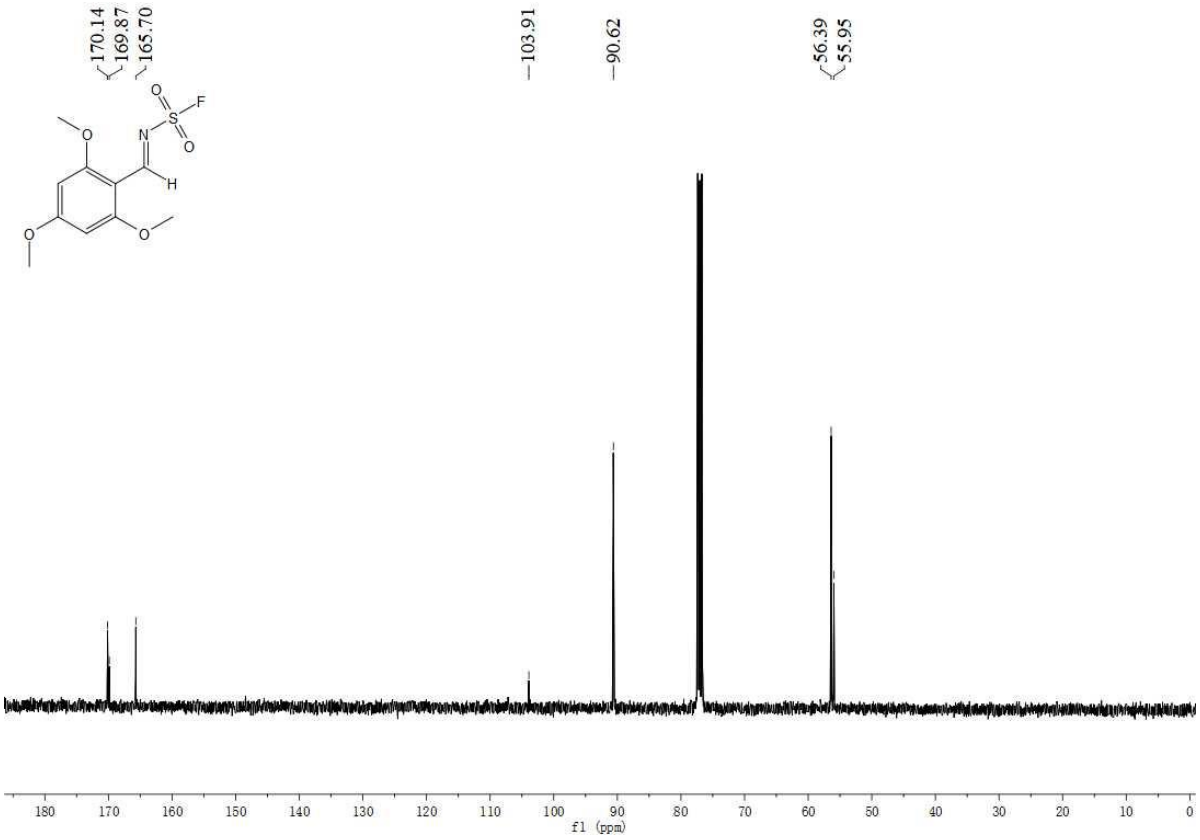
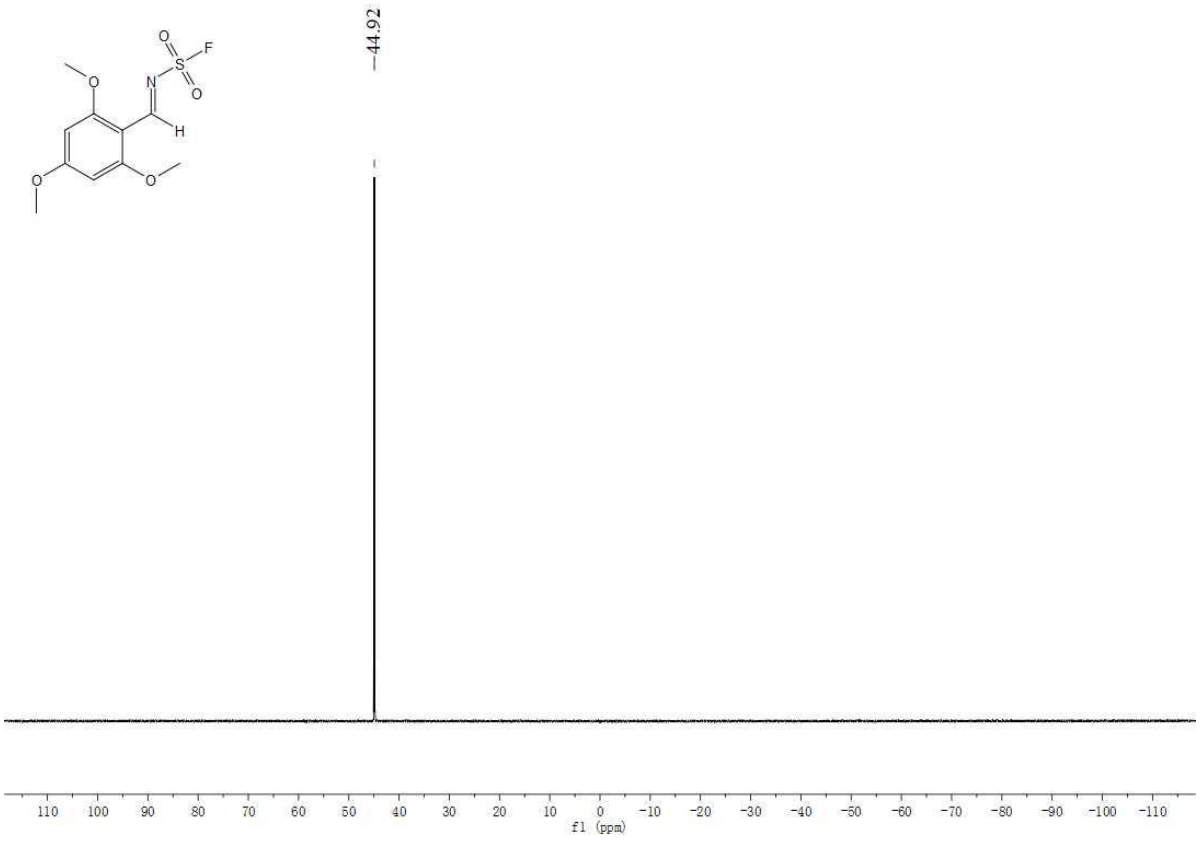
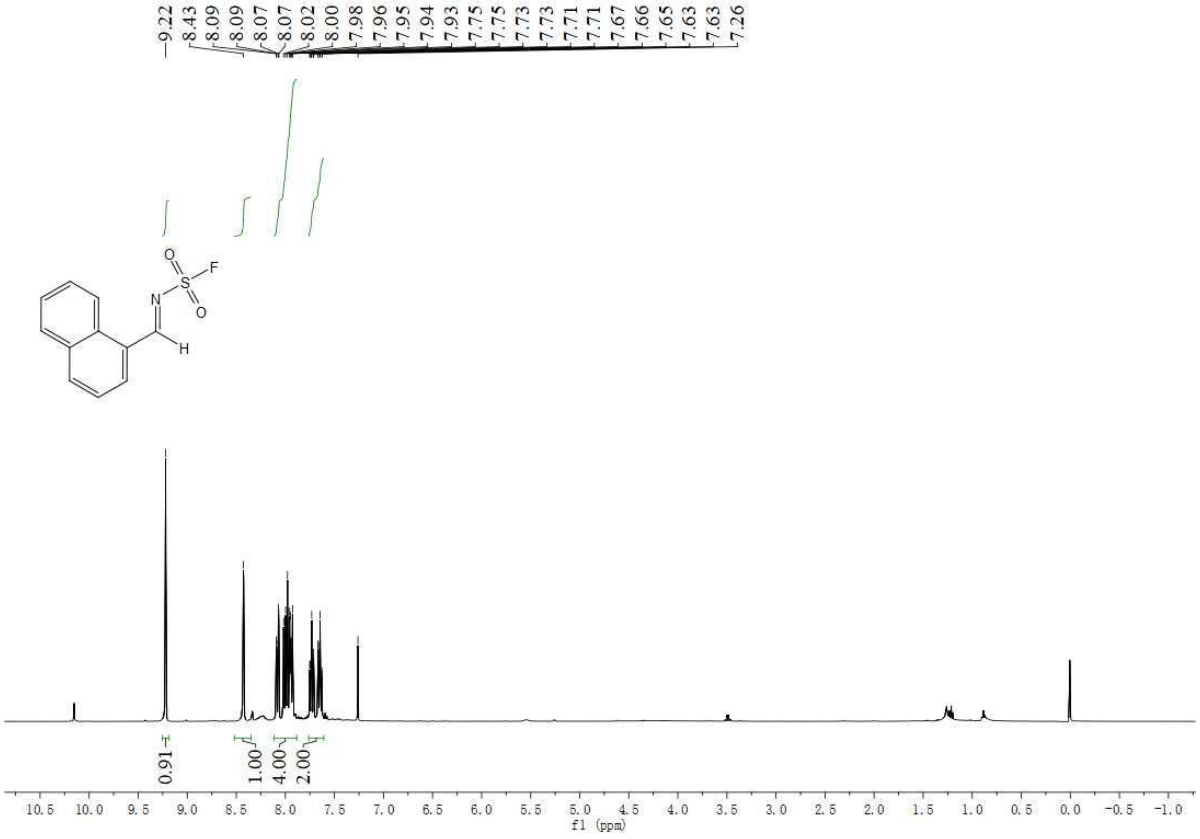


^{19}F NMR

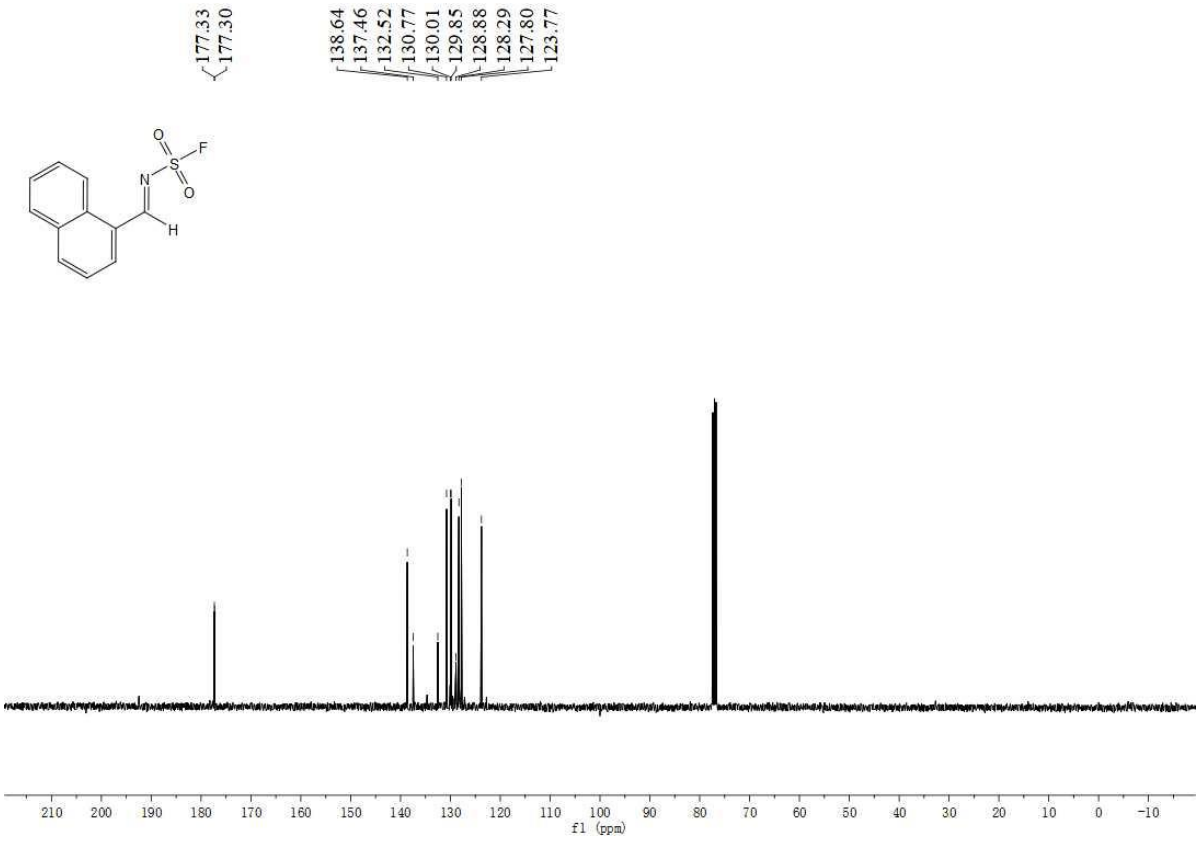


(E)-(naphthalen-1-ylmethylene)sulfamoyl fluoride **(2i)**

^{1}H NMR



^{13}C NMR



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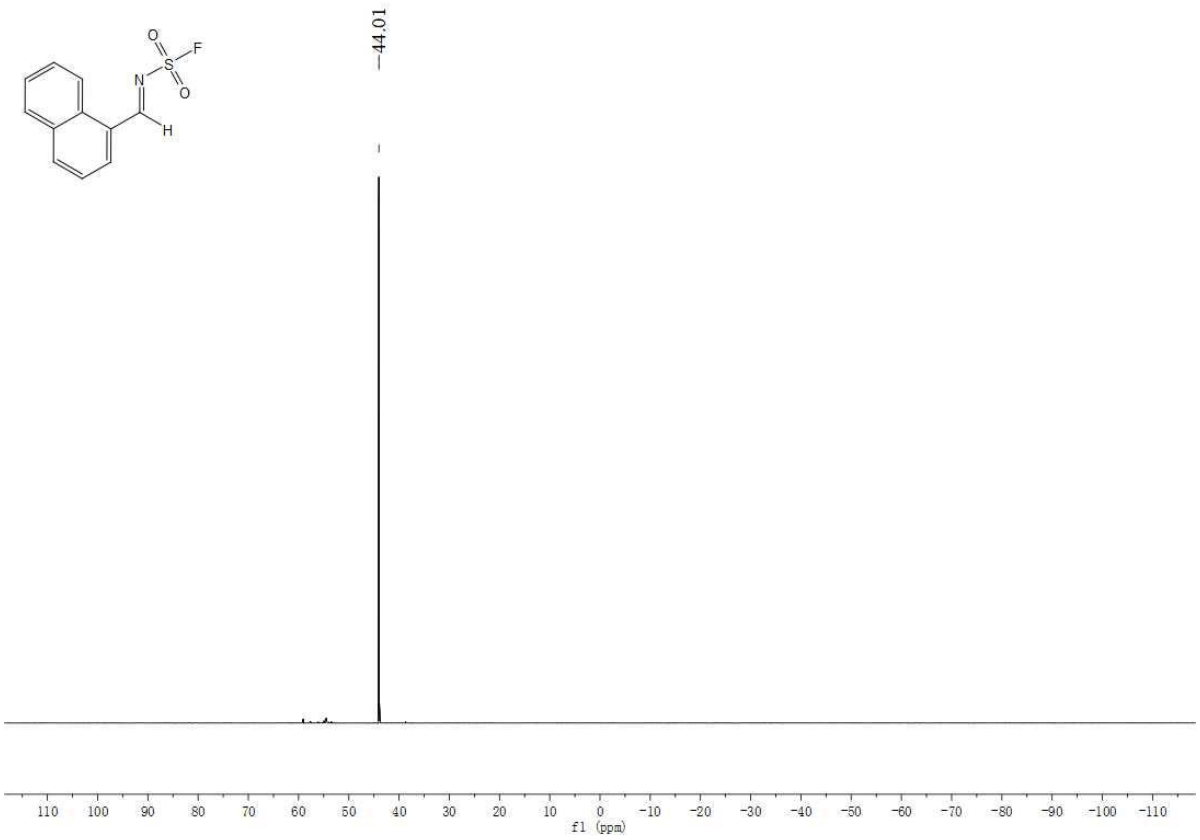
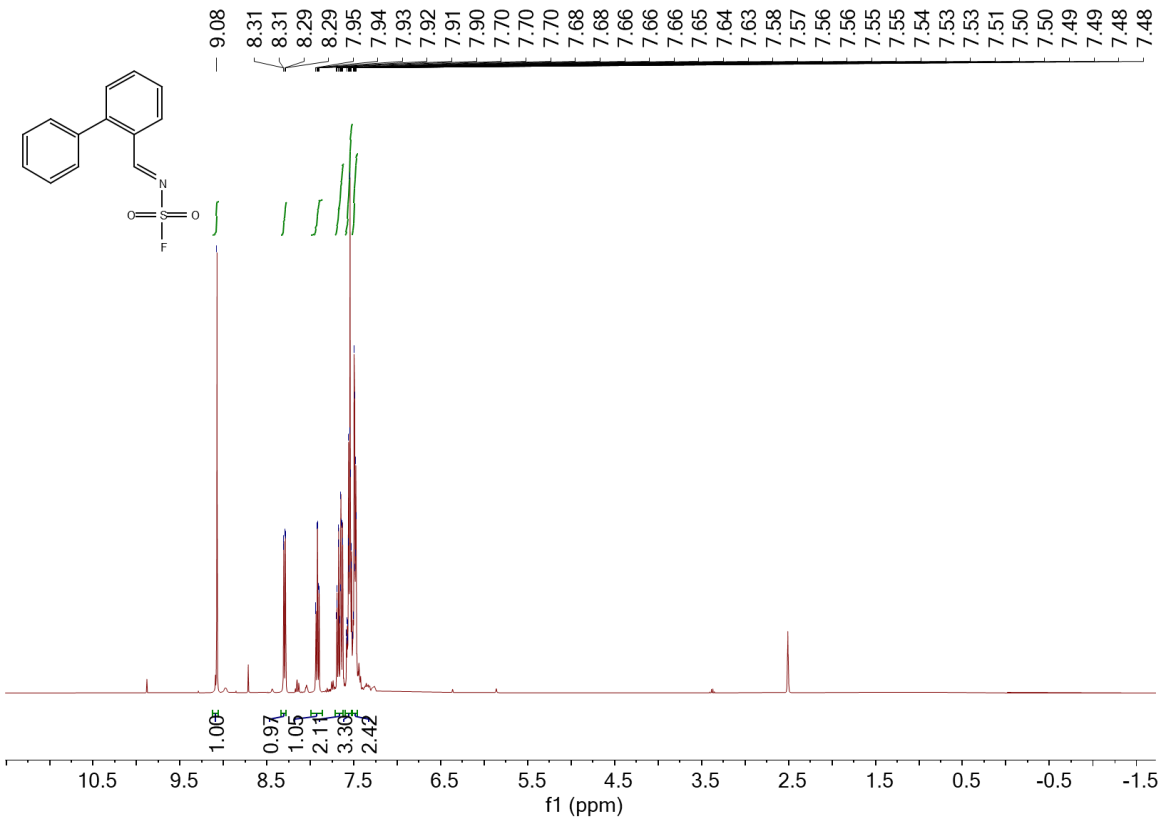


(E)-[1,1'-biphenyl]-2-yl((fluorosulfonyl)imino)methanide (**2j**)

^{1}H NMR



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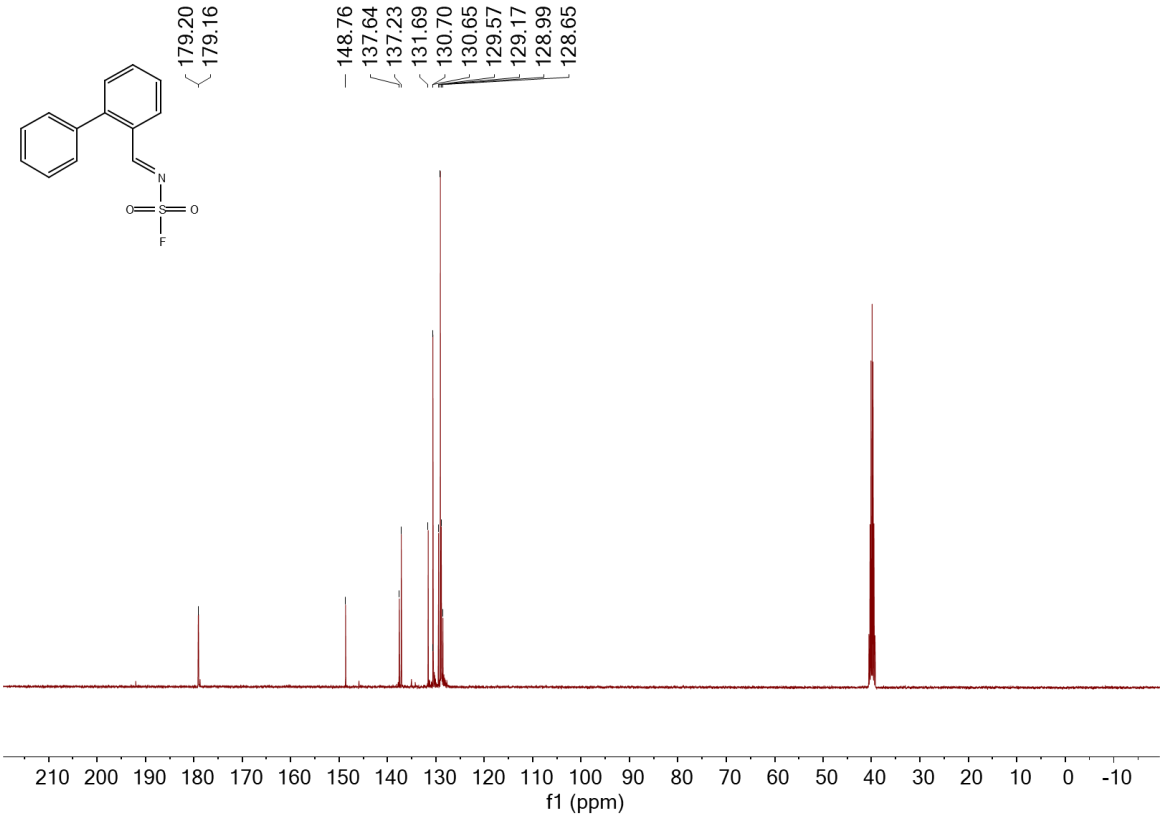

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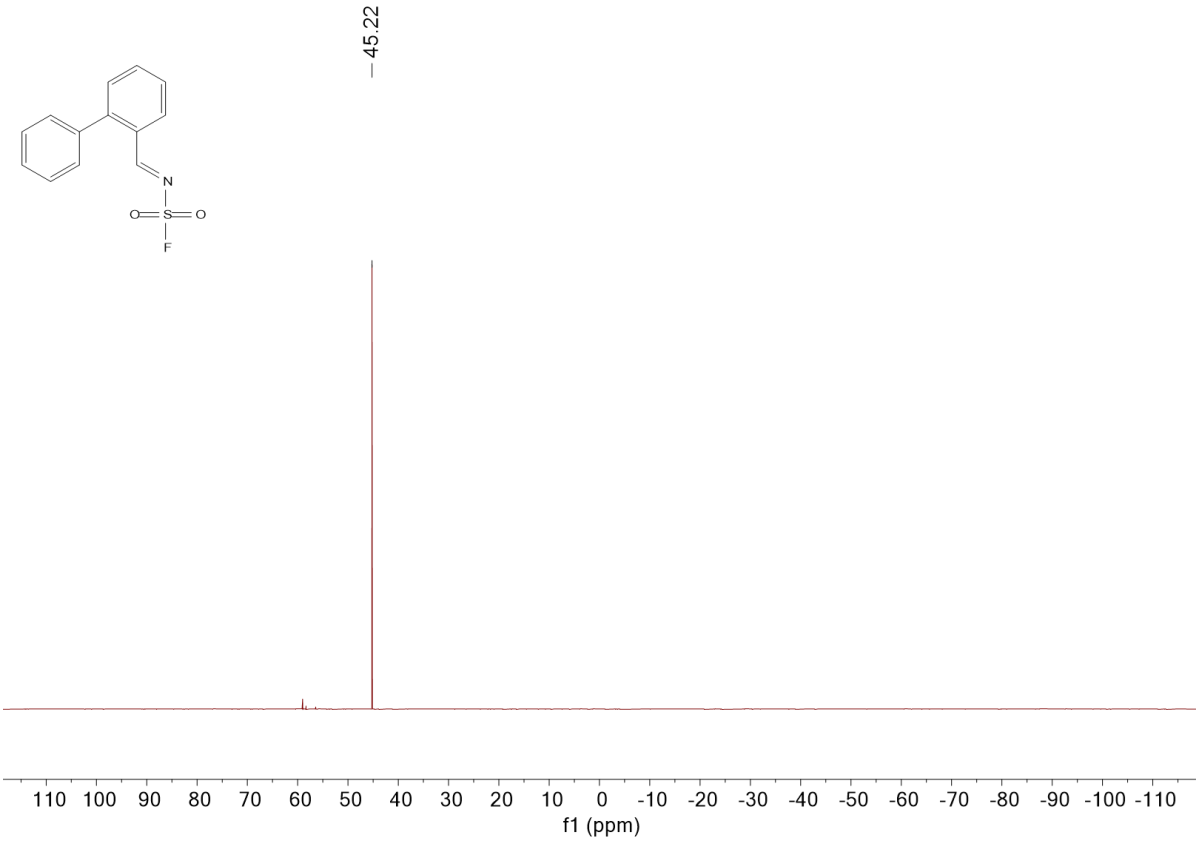
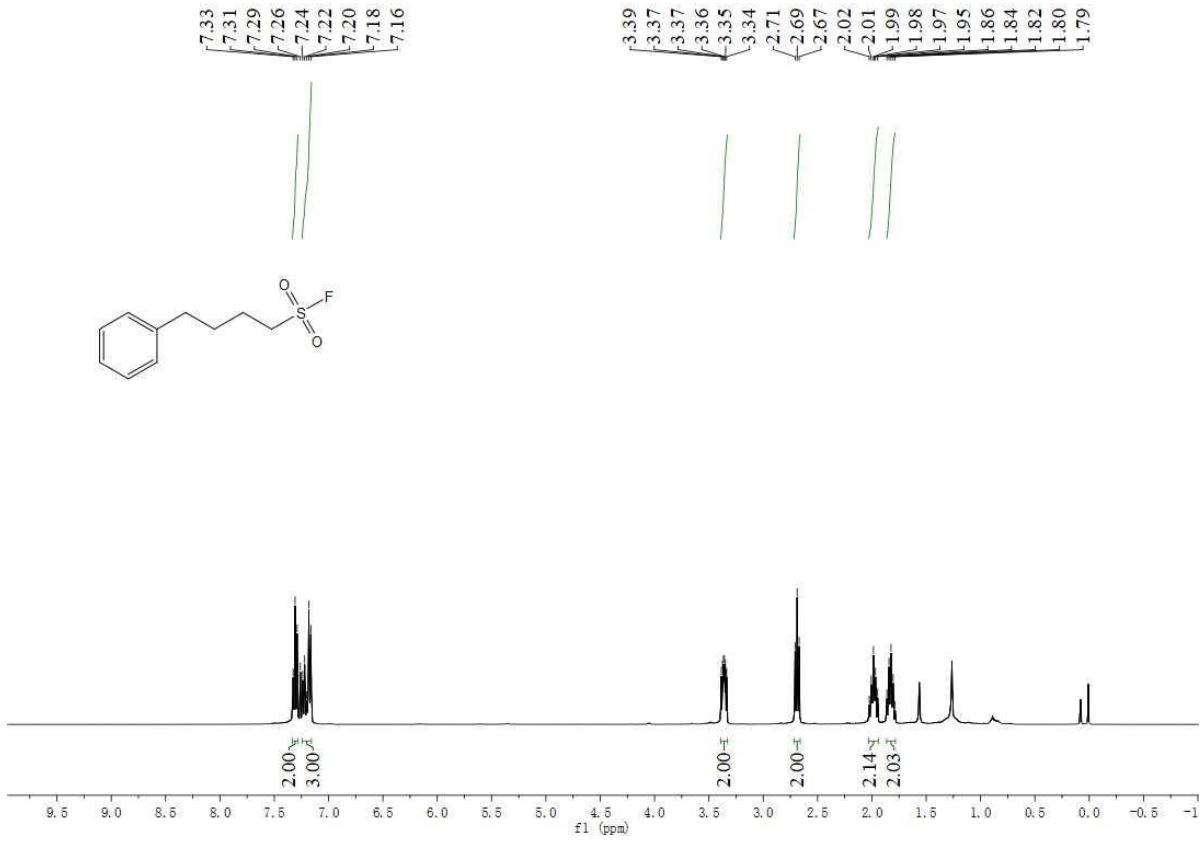


4-phenylbutane-1-sulfonyl fluoride (**4a**)

^{1}H NMR



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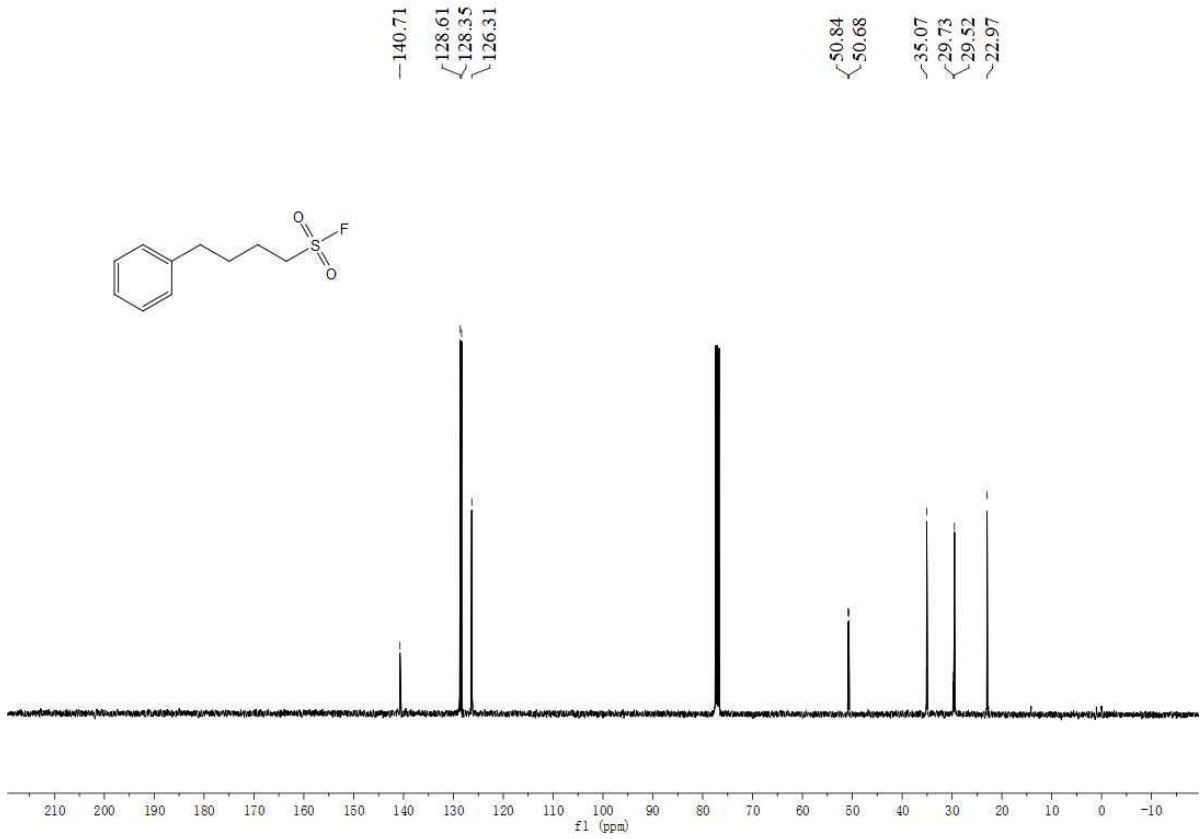
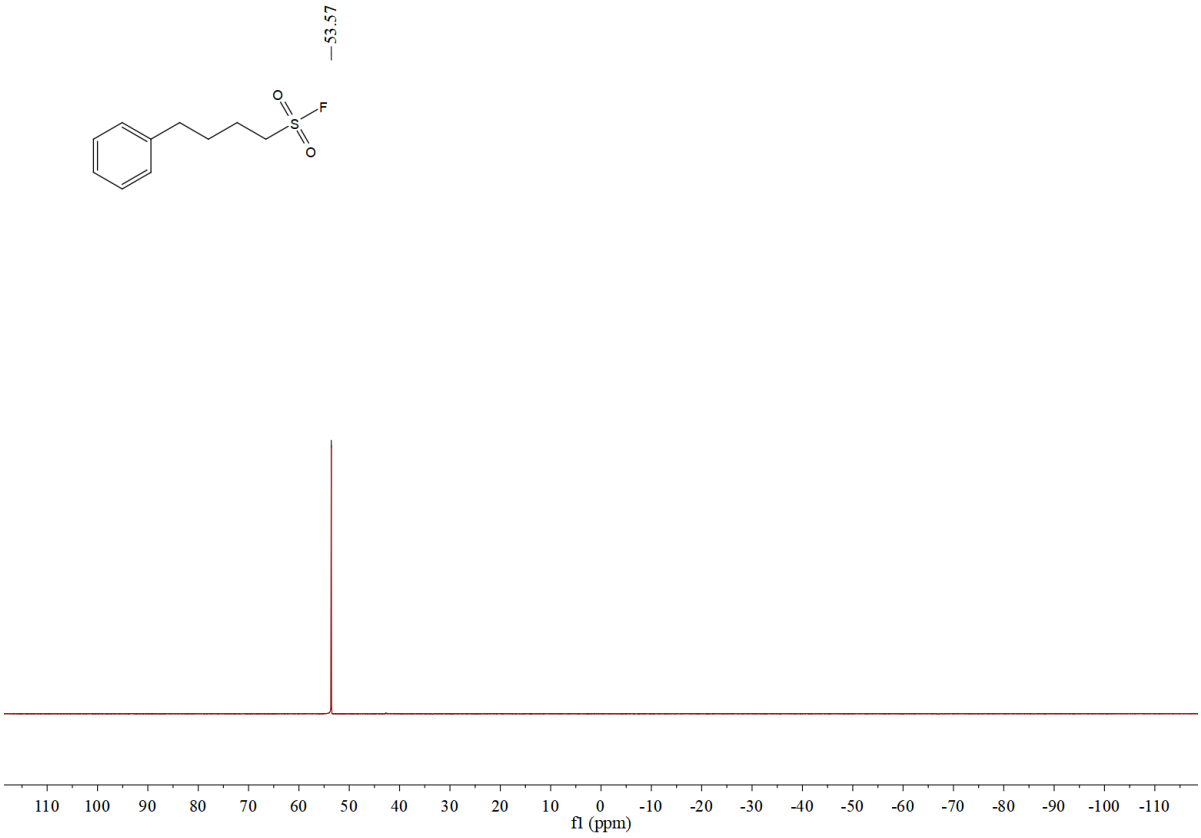
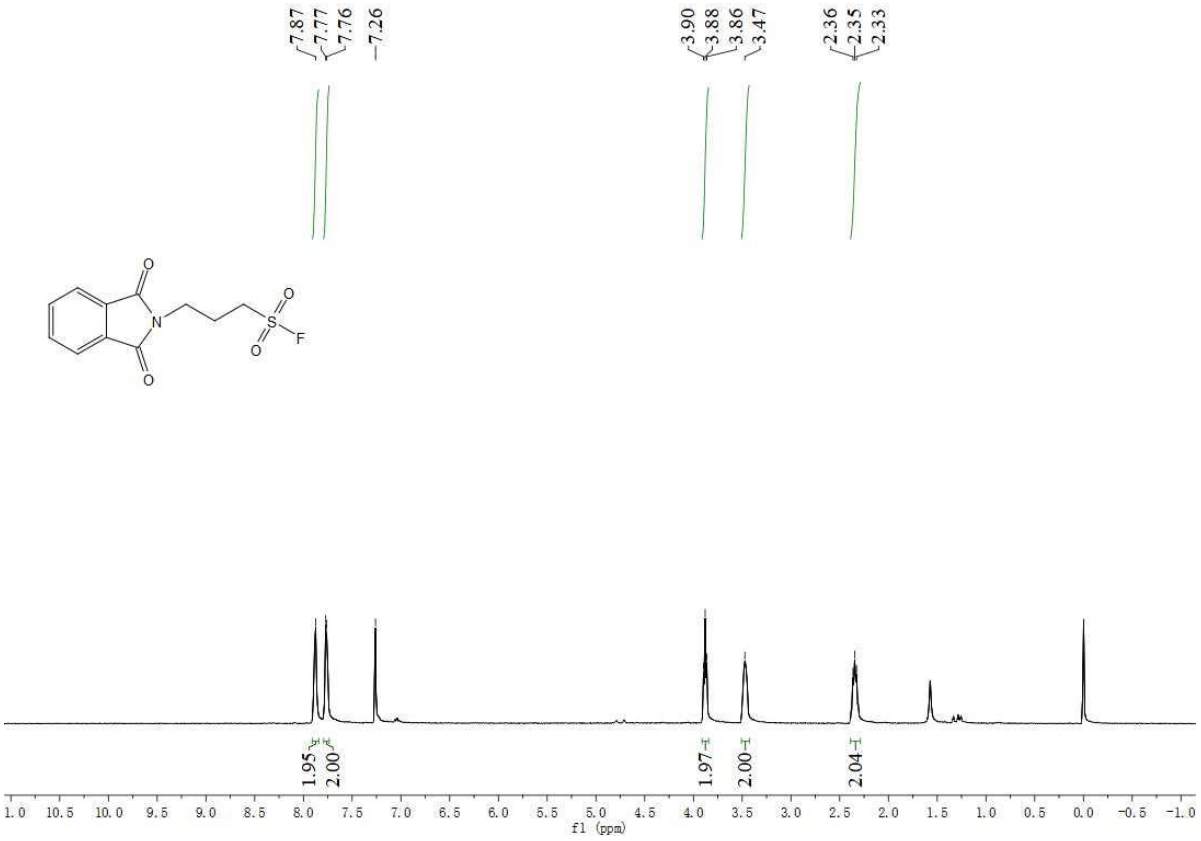


^{19}F NMR

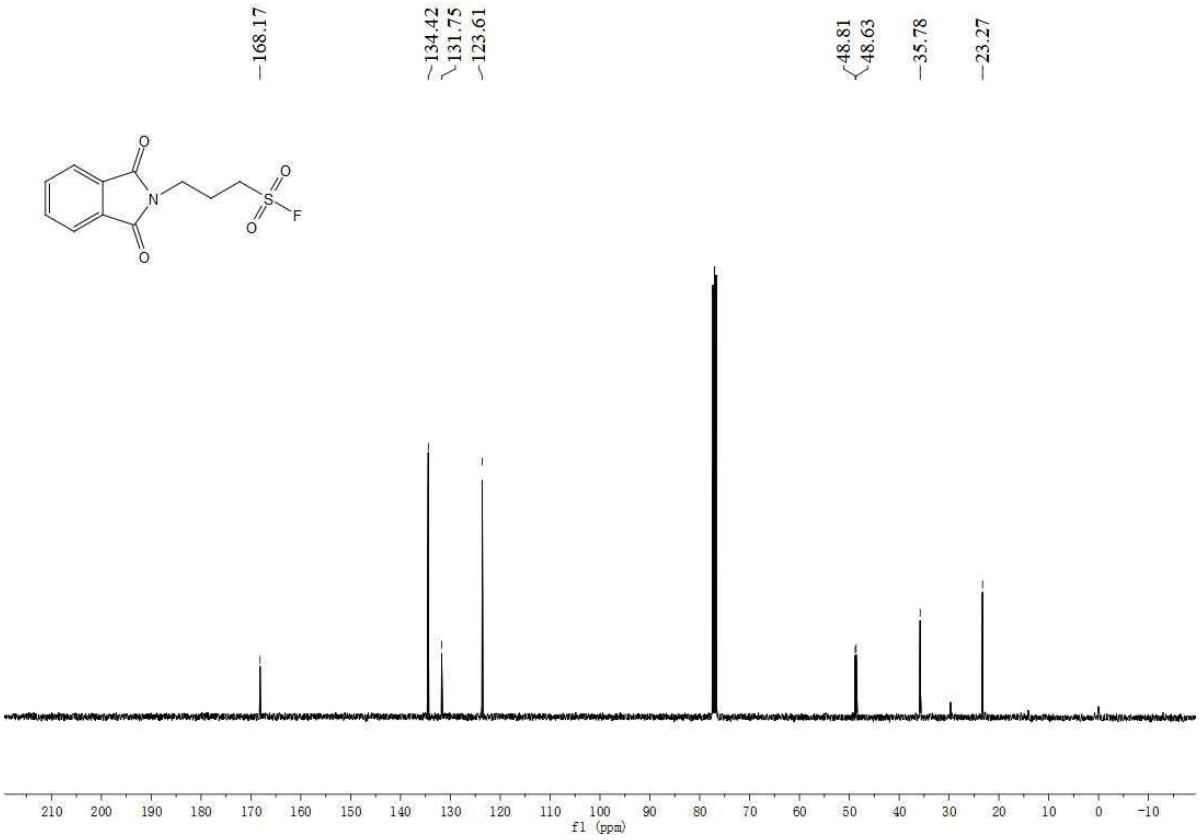


3-(1,3-dioxoisoindolin-2-yl)propane-1-sulfonyl fluoride **(4b)**

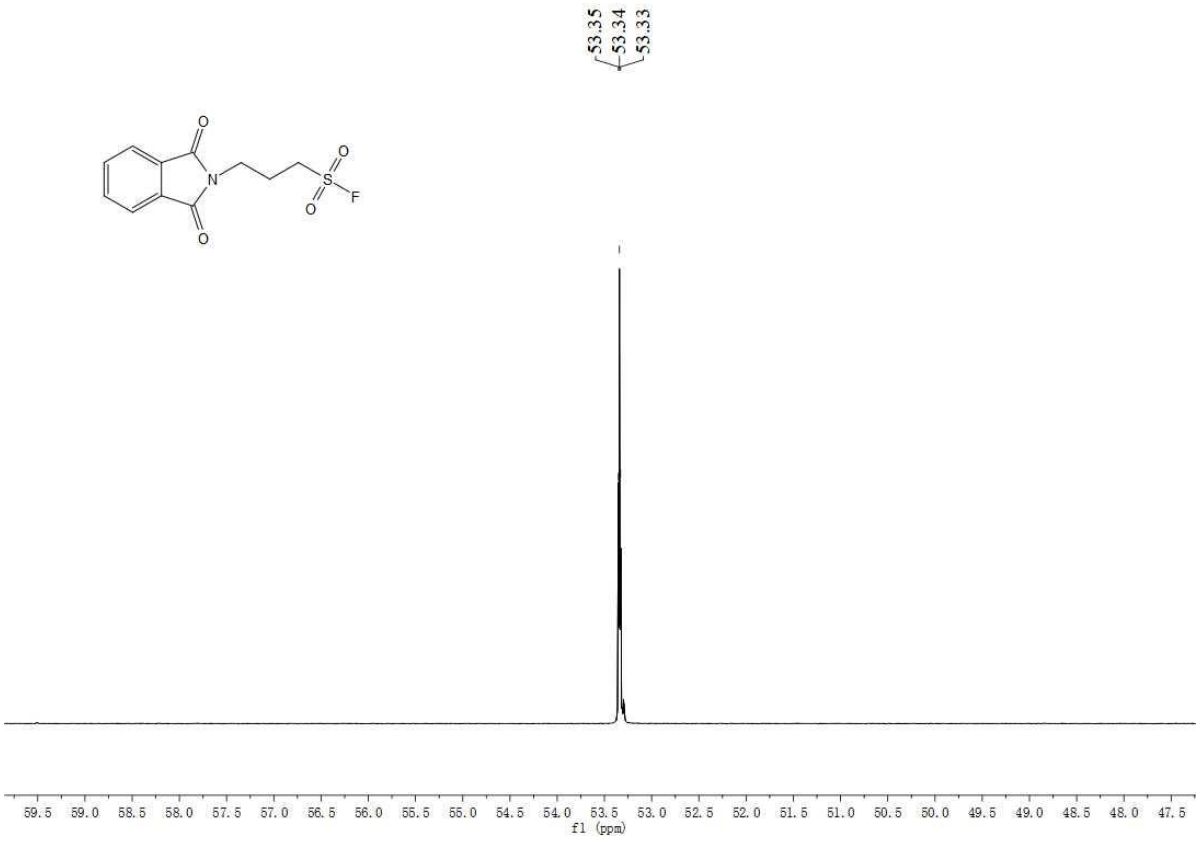
^{1}H NMR



^{13}C NMR

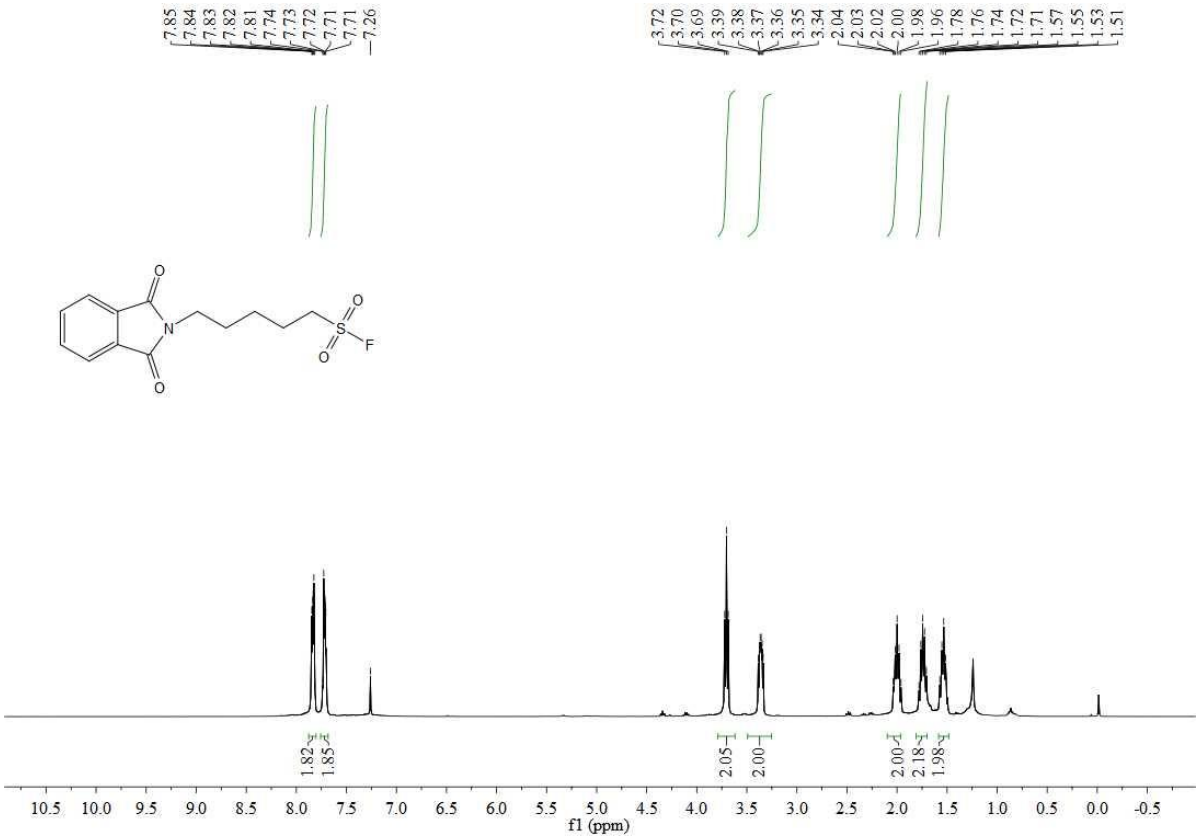


^{19}F NMR



5-(1,3-dioxoisoindolin-2-yl)pentane-1-sulfonyl fluoride **(4c)**

^{1}H NMR



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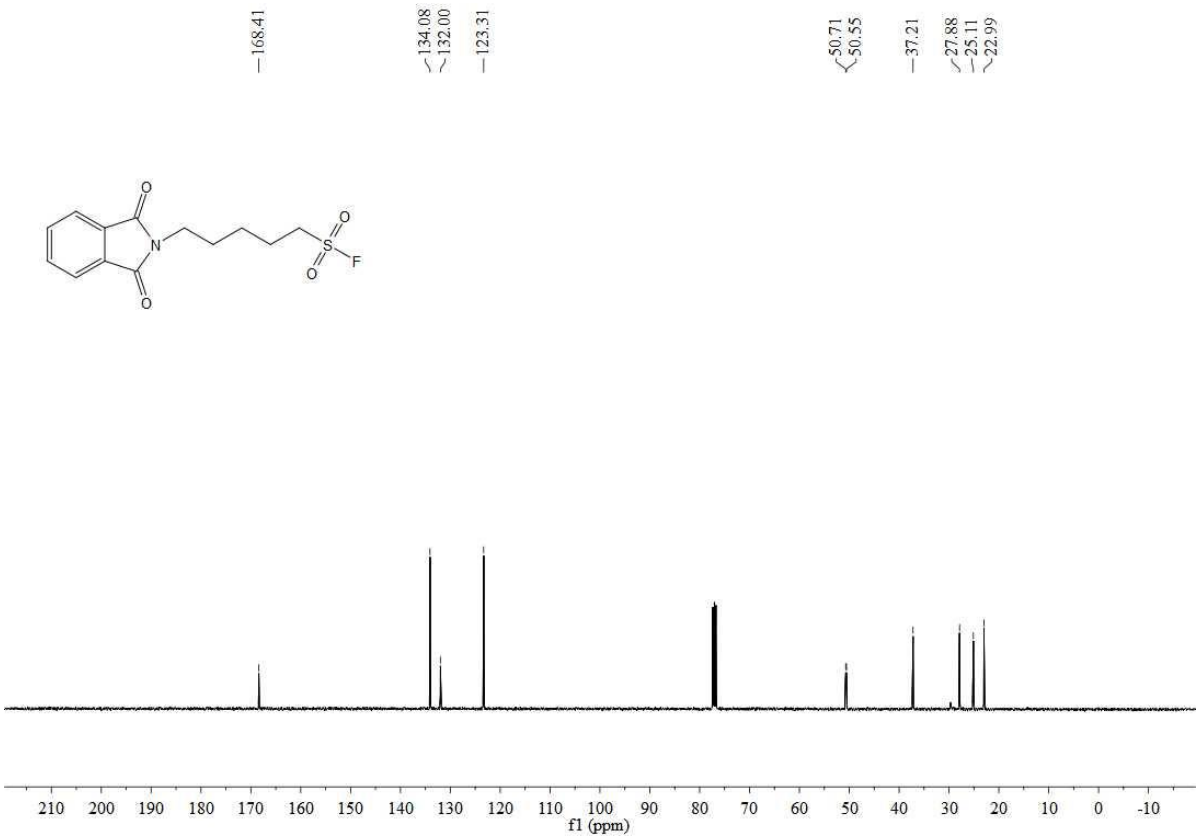
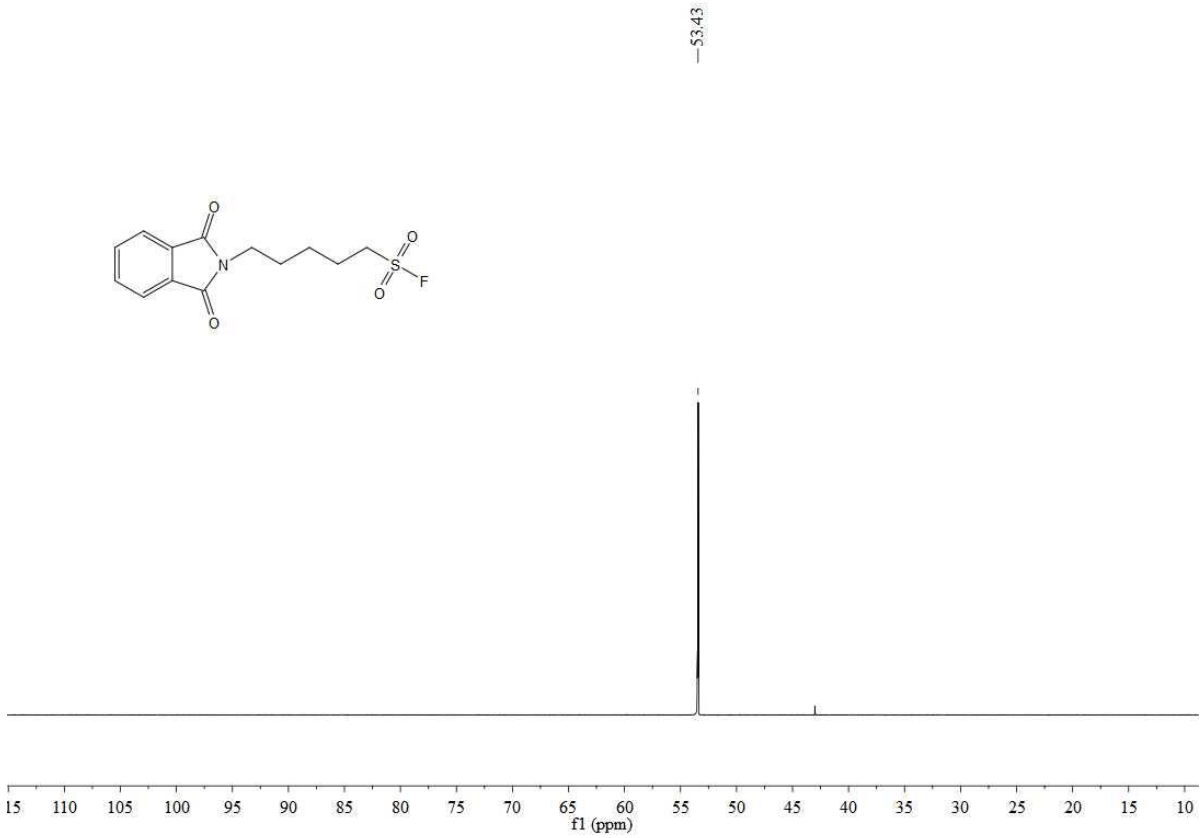
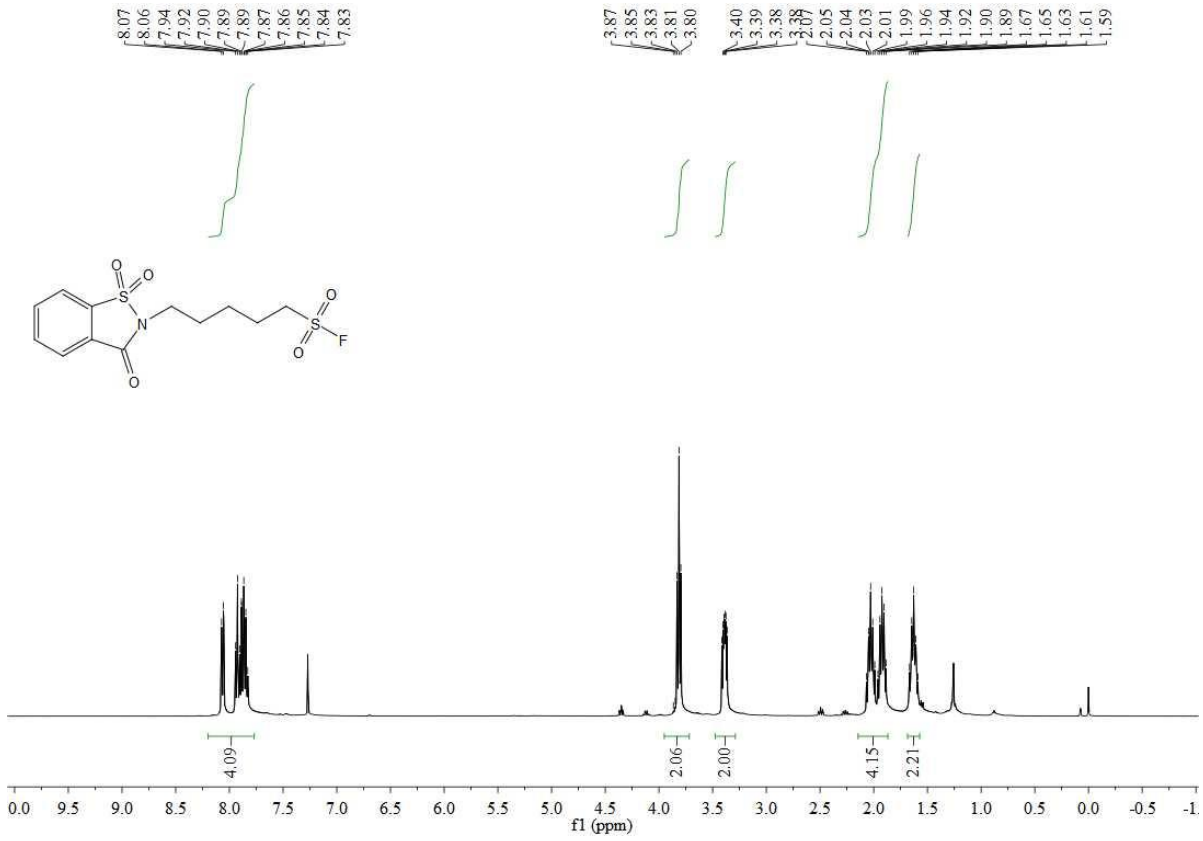


^{19}F NMR

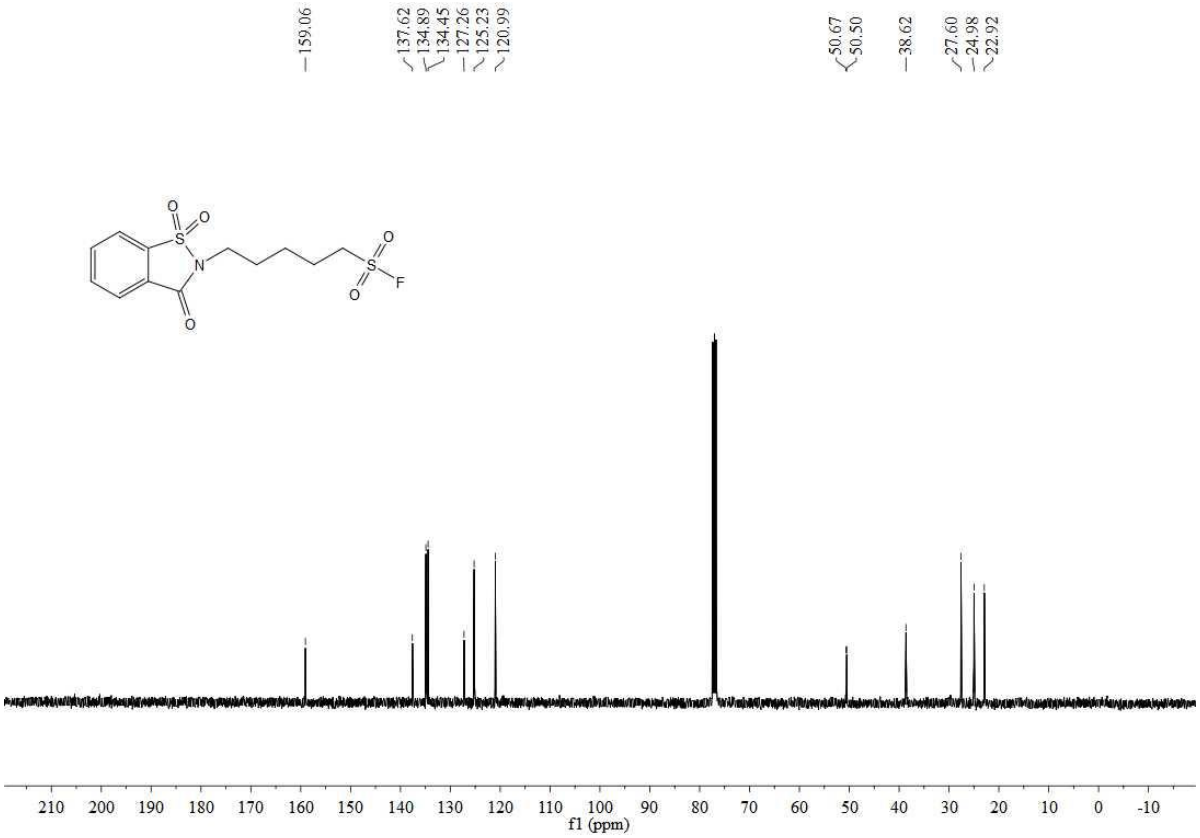


5-(1,1-dioxido-3-oxobenzo[d]isothiazol-2(3H)-yl)pentane-1-sulfonyl fluoride **(4d)**

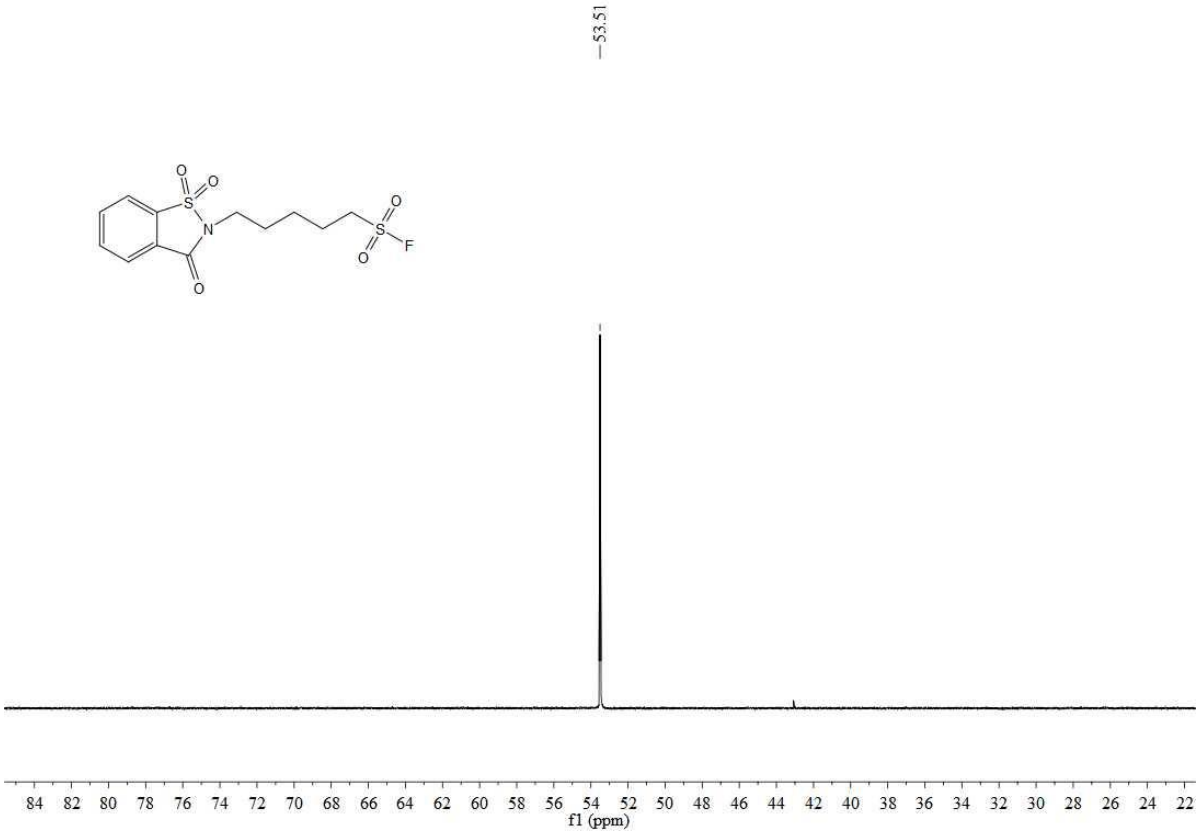
^{1}H NMR



^{13}C NMR

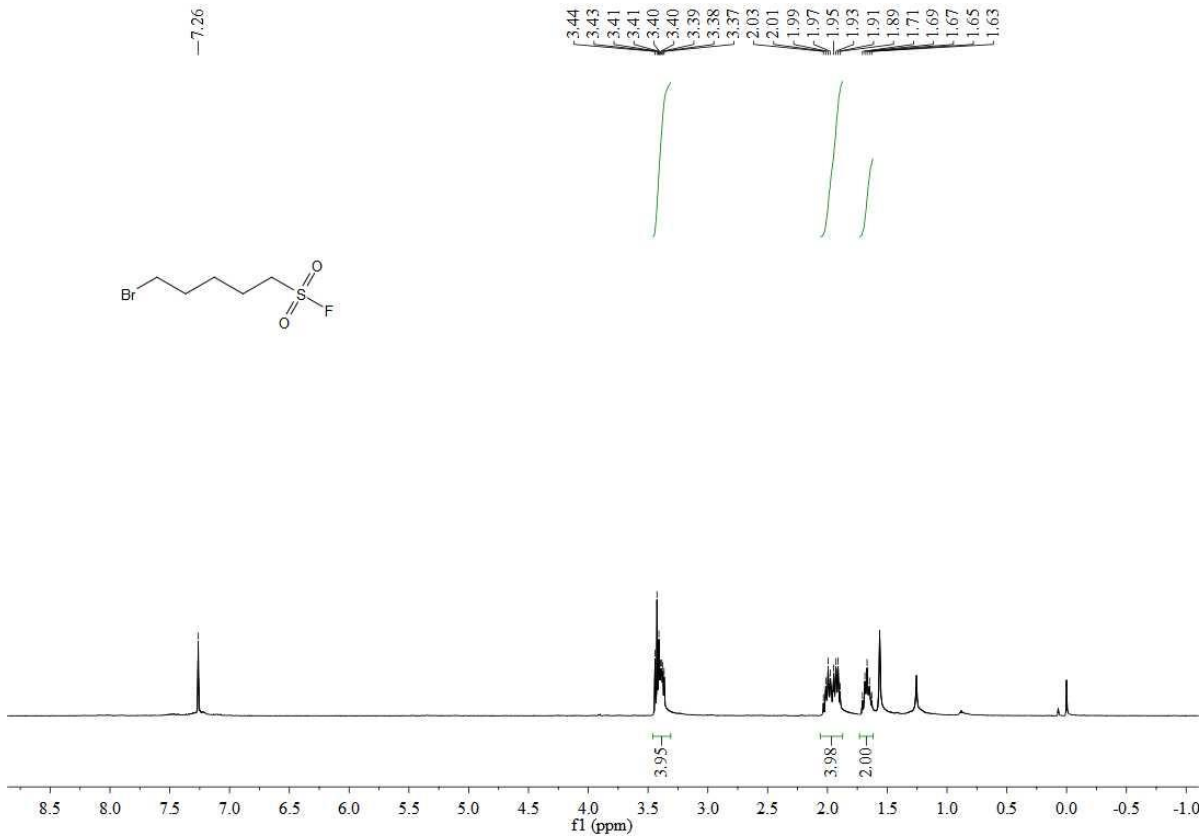


^{19}F NMR

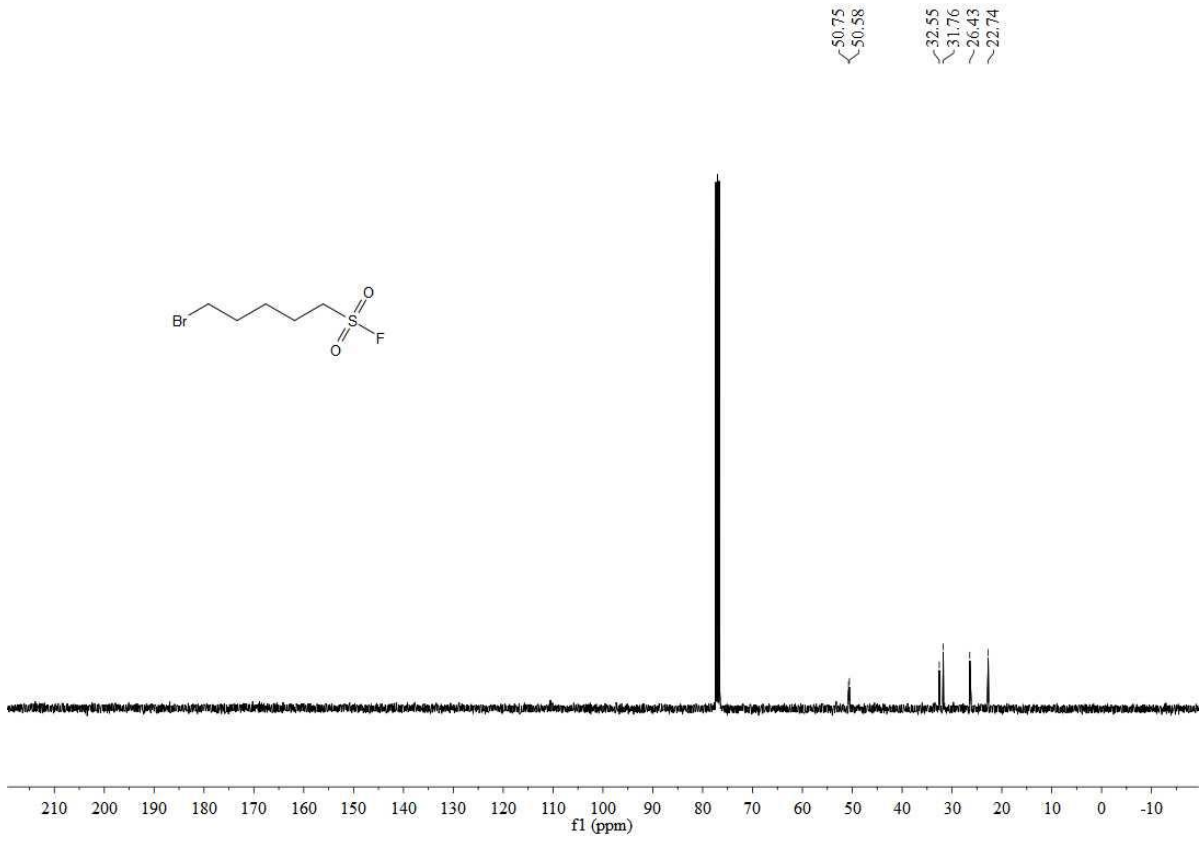


5-bromopentane-1-sulfonyl fluoride (**4e**)

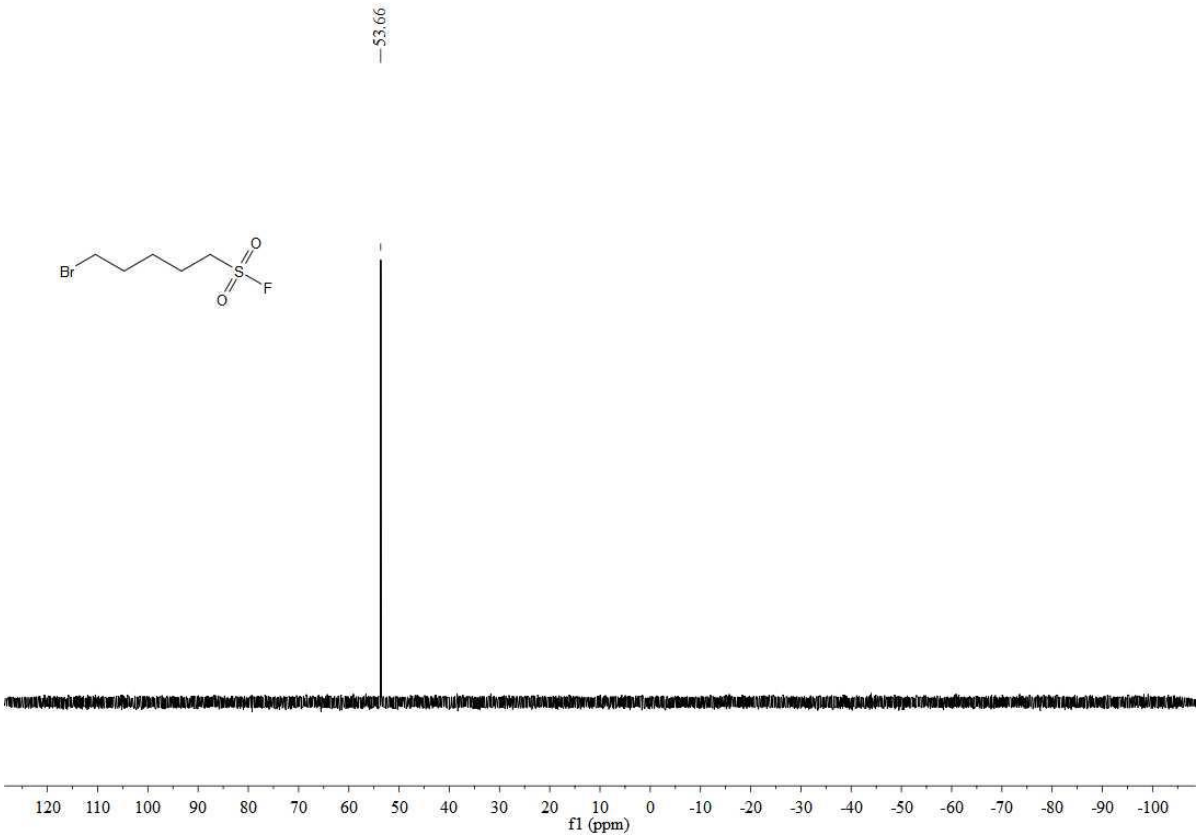
^{1}H NMR



^{13}C NMR

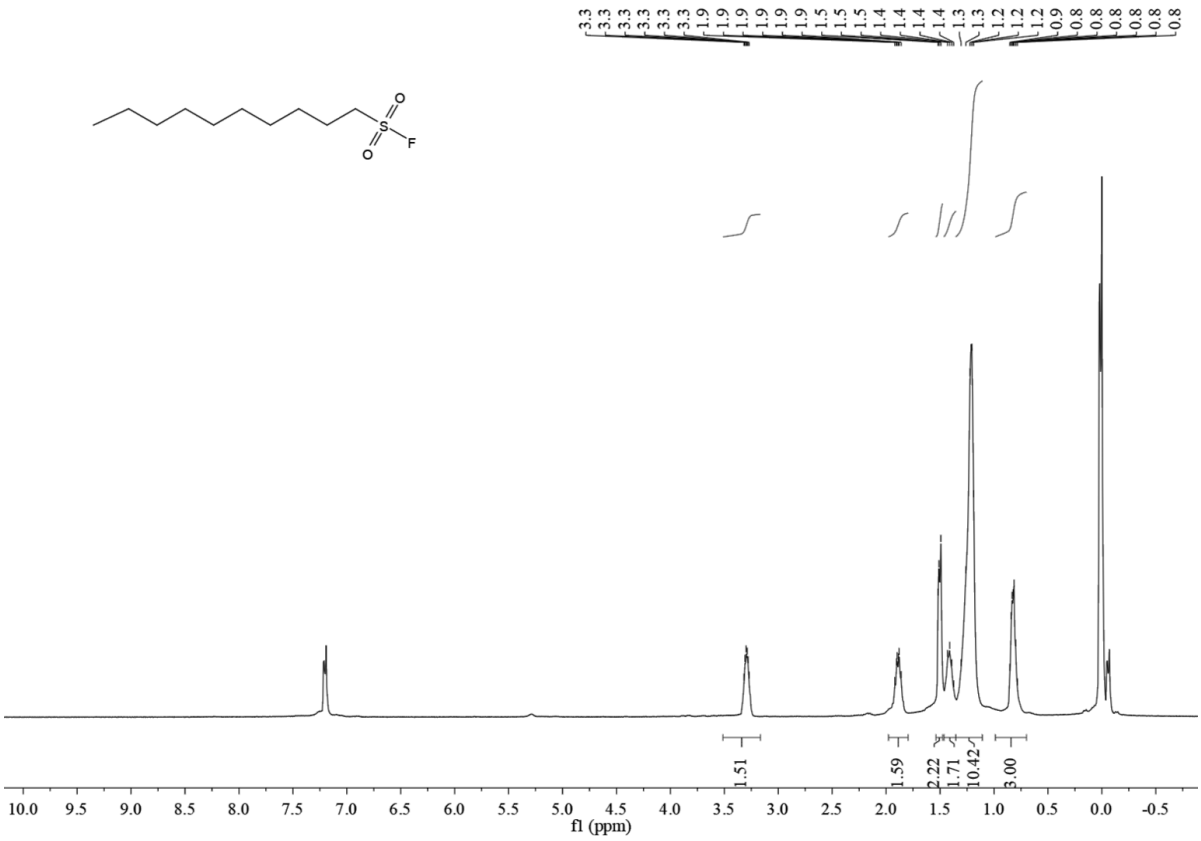


^{19}F NMR

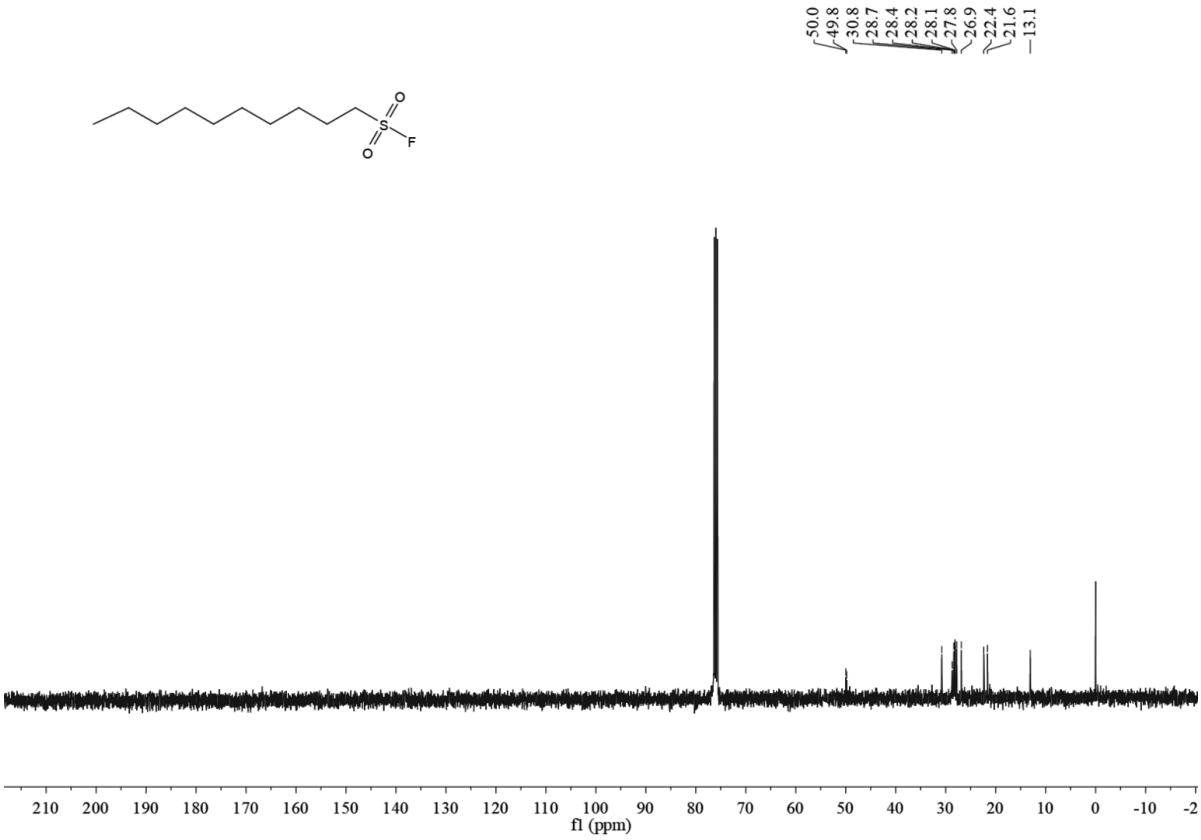


decane-1-sulfonyl fluoride **(4f)**

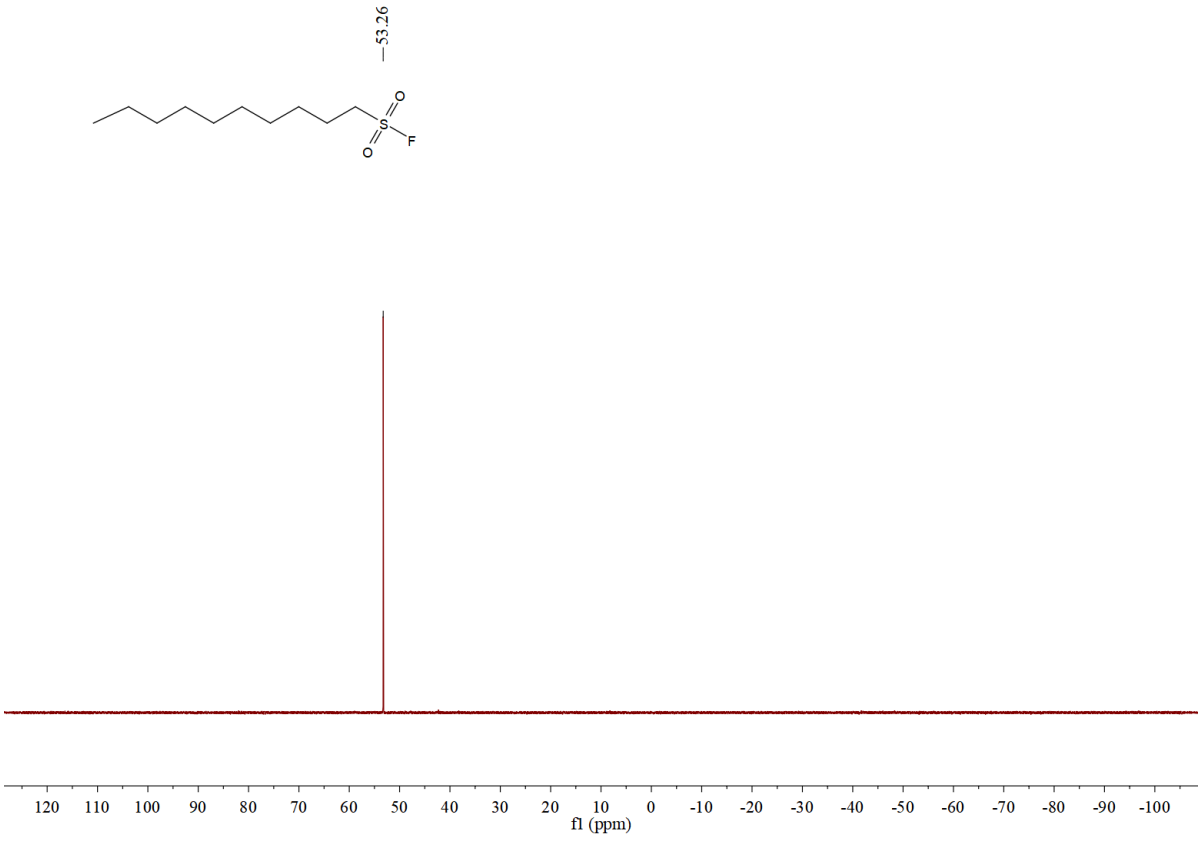
^{1}H NMR



^{13}C NMR

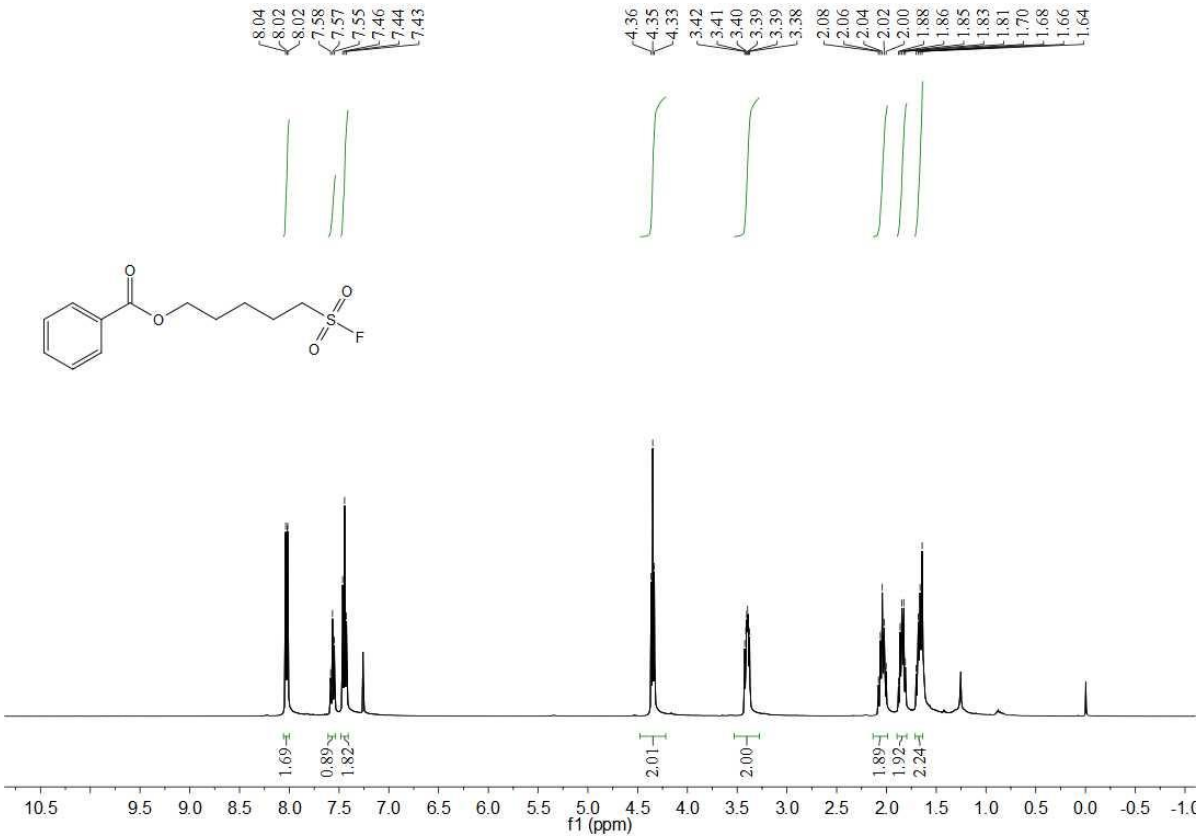


^{19}F NMR

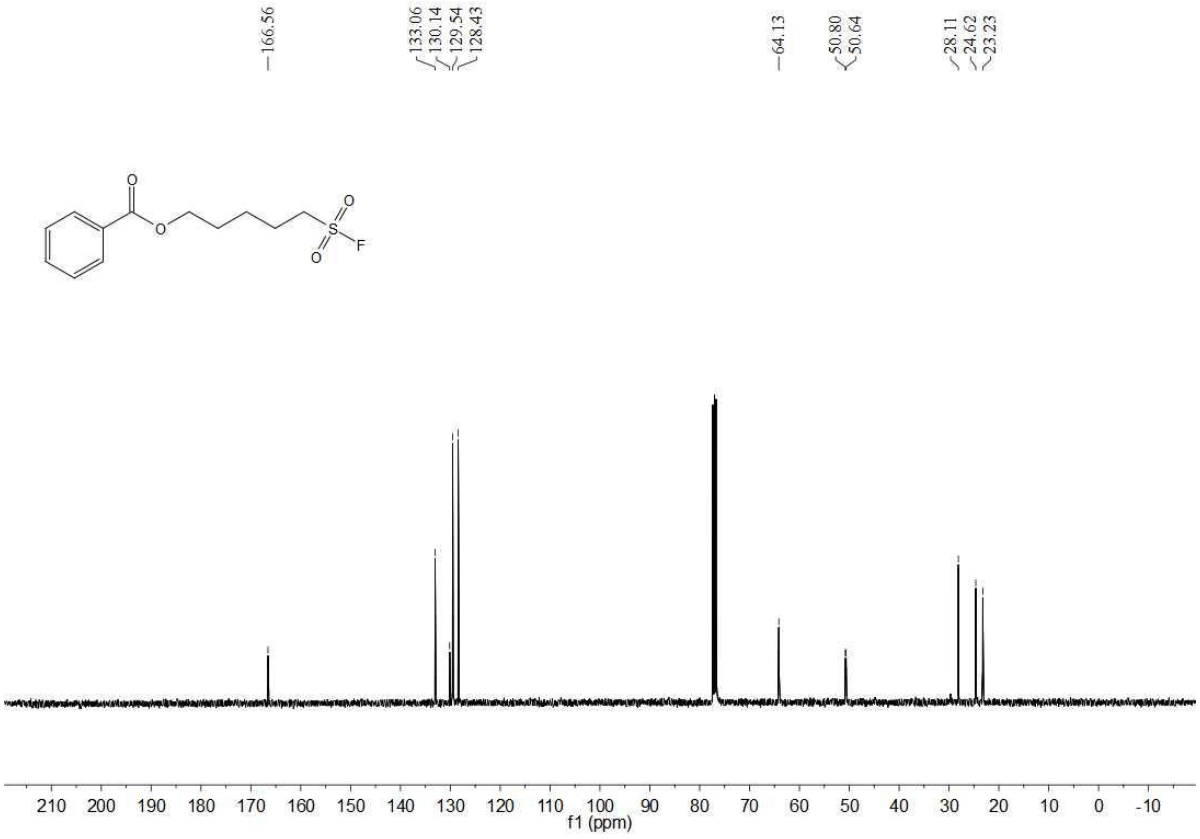


5-(fluorosulfonyl)pentyl benzoate **(4g)**

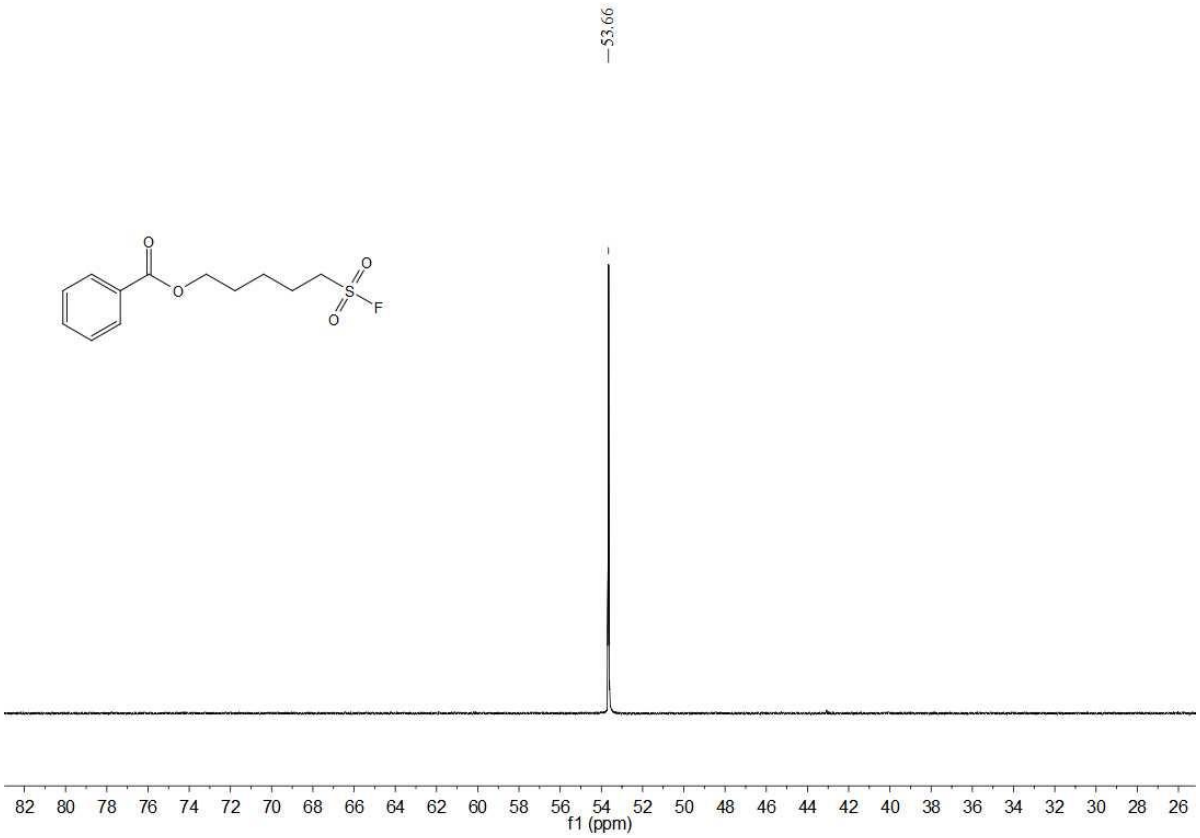
^{1}H NMR



^{13}C NMR

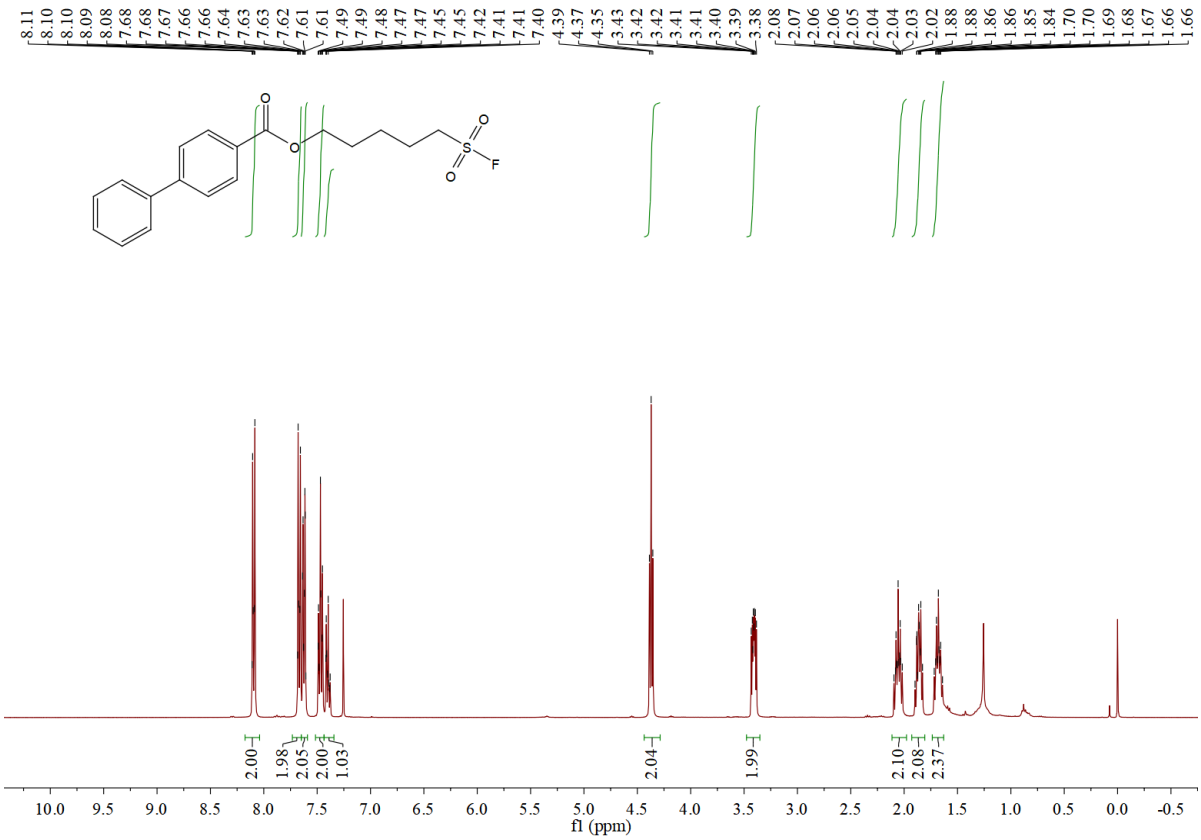


^{19}F NMR

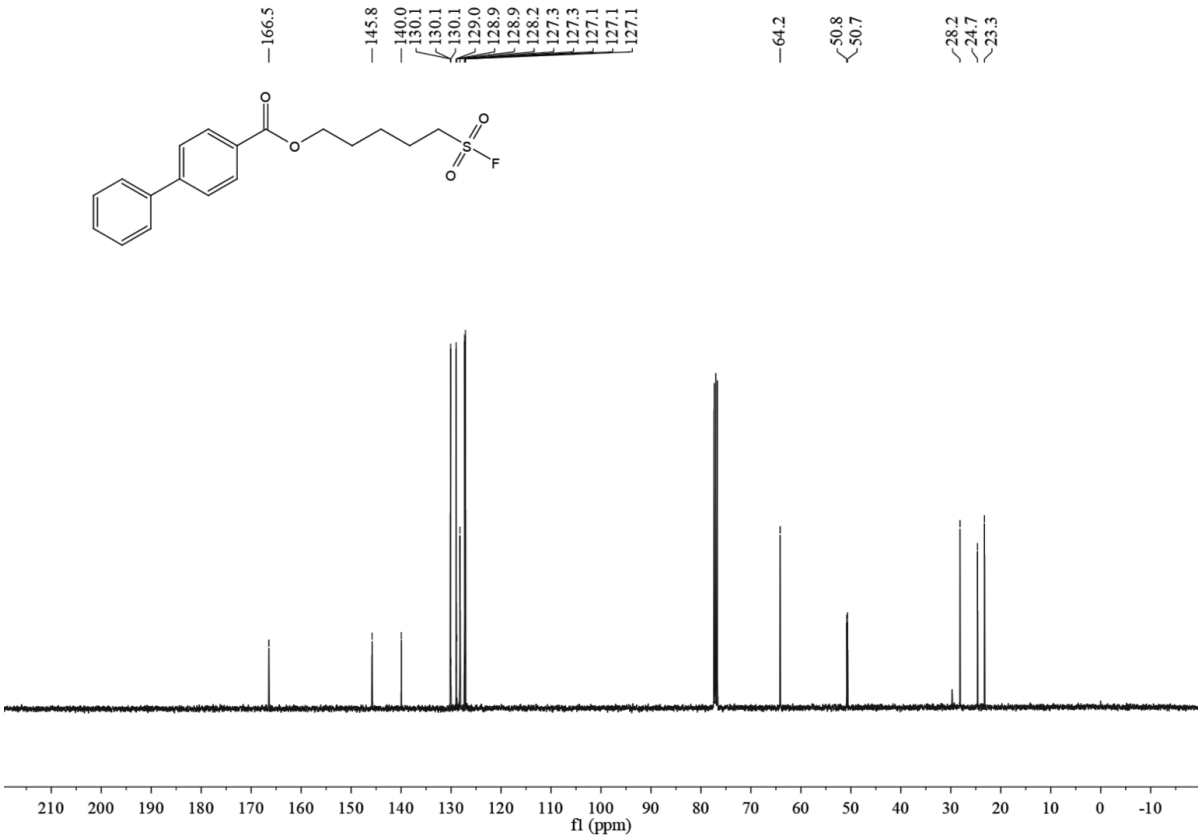


5-(fluorosulfonyl)pentyl [1,1'-biphenyl]-4-carboxylate **(4h)**

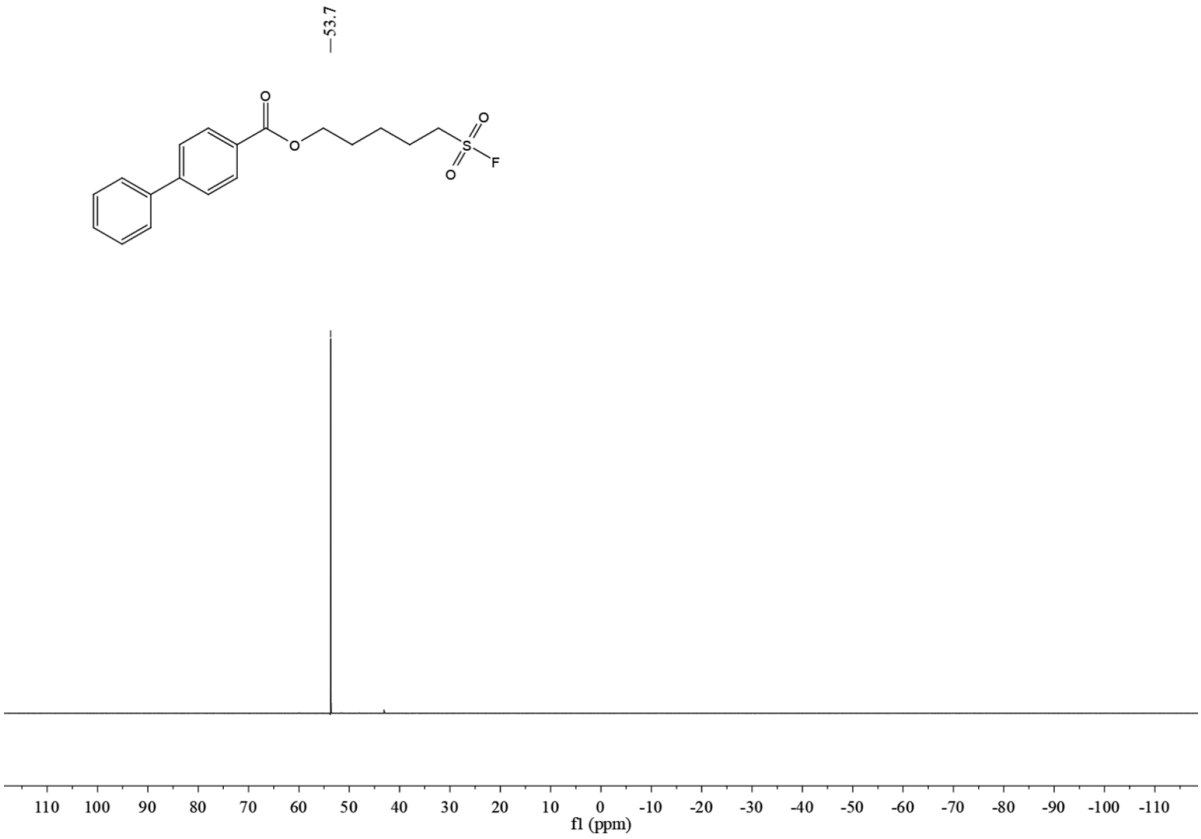
^{1}H NMR



^{13}C NMR

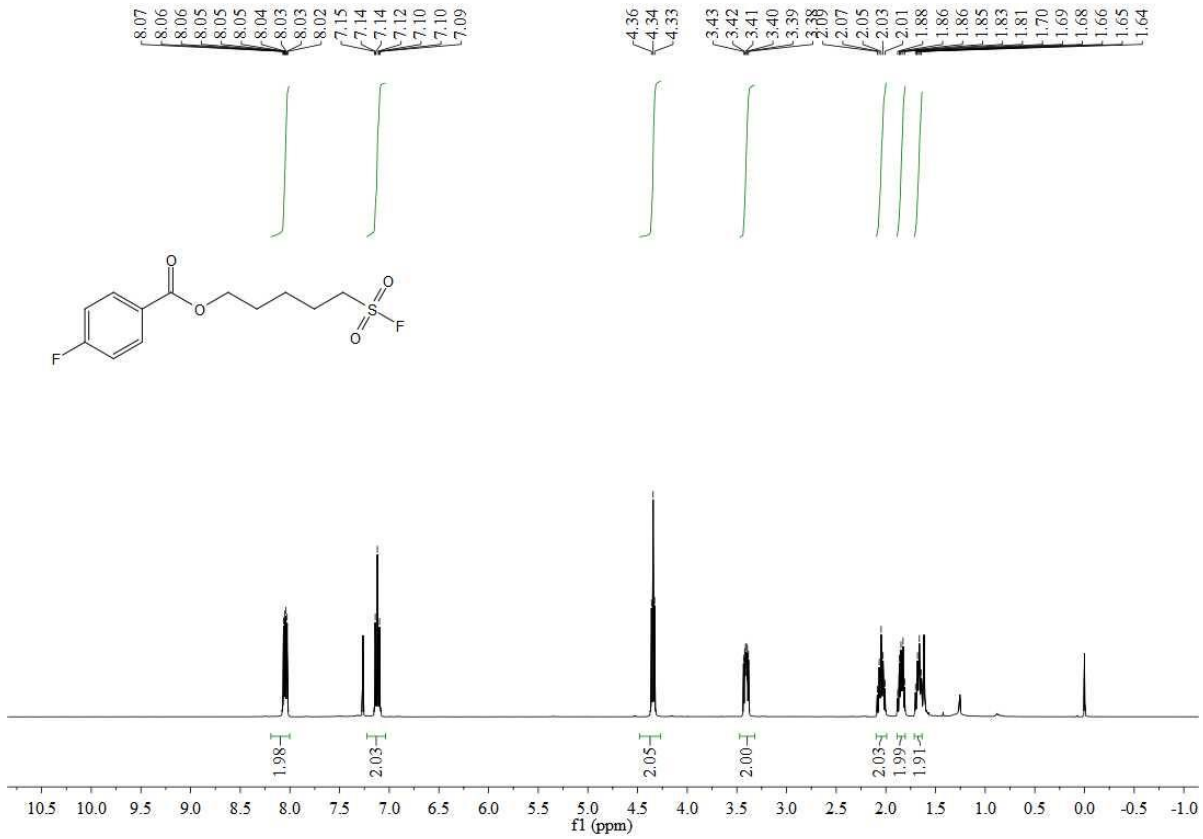


^{19}F NMR

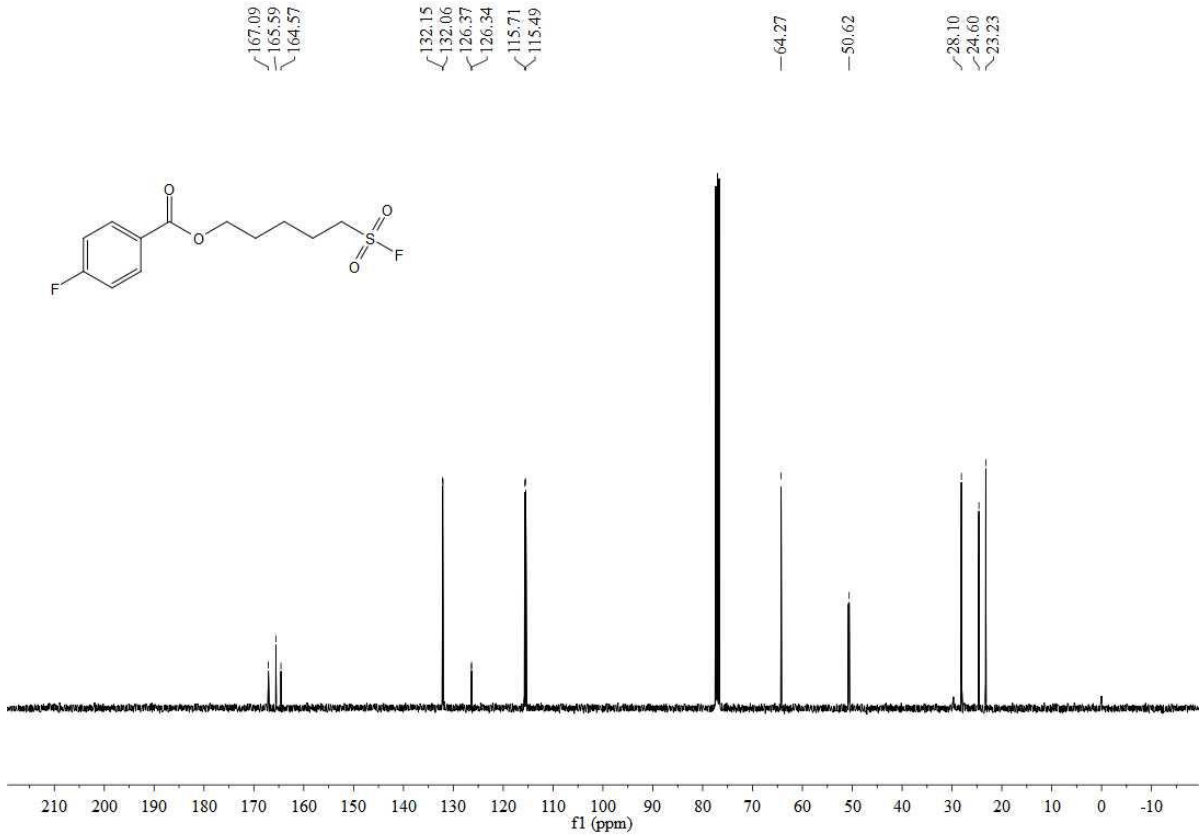


5-(fluorosulfonyl)pentyl 4-fluorobenzoate **(2i)**

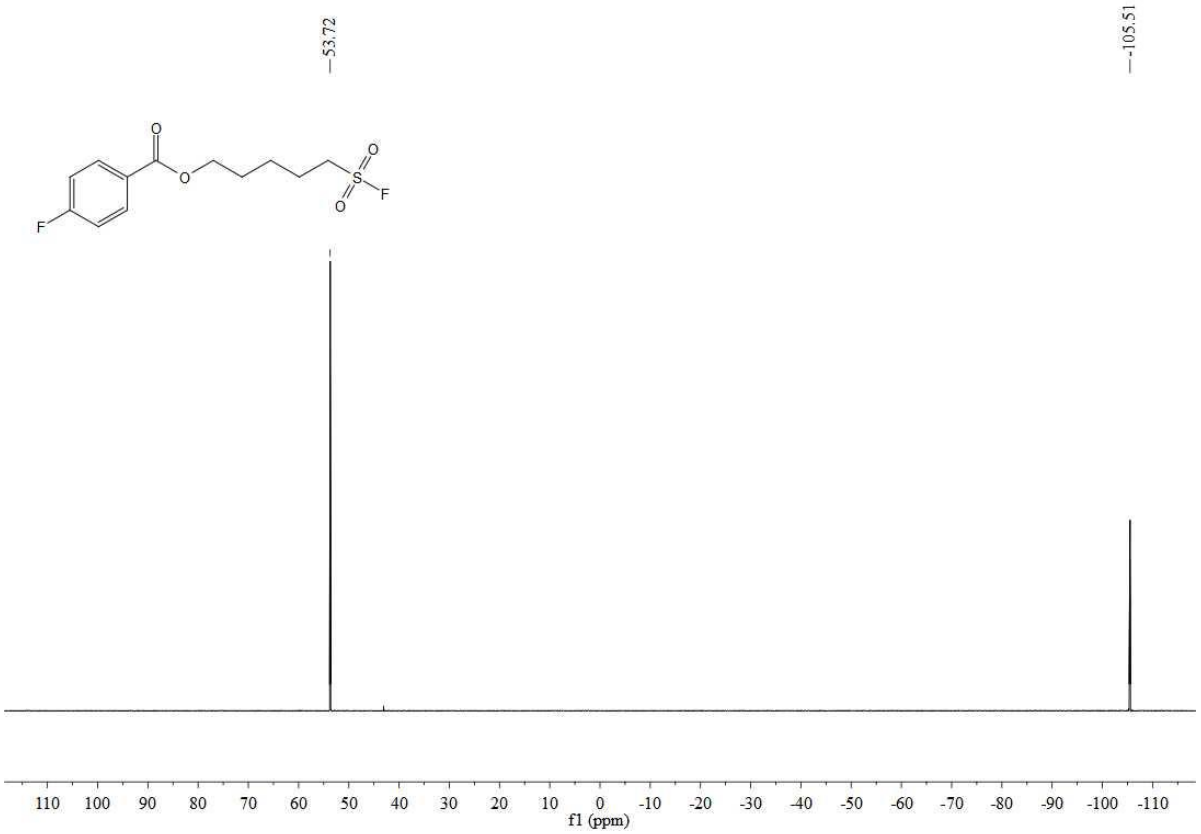
^{1}H NMR



^{13}C NMR

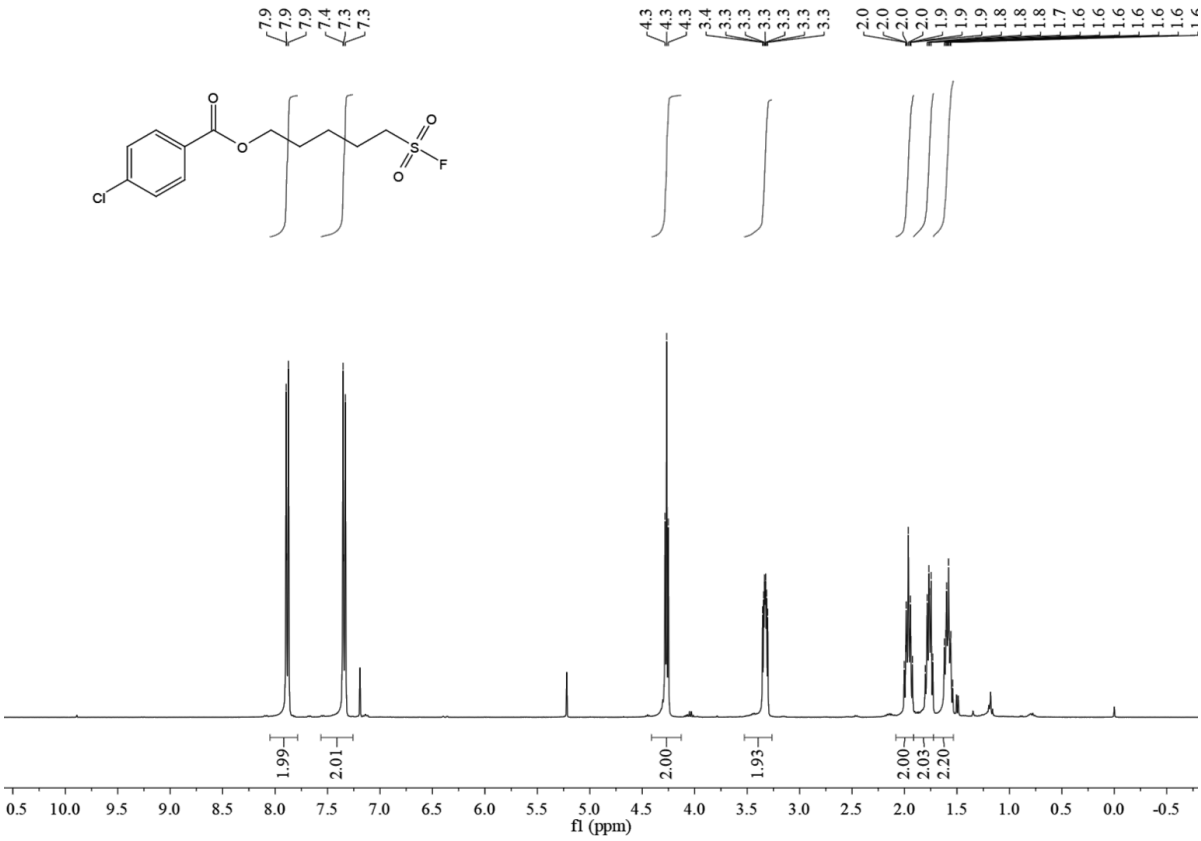


^{19}F NMR

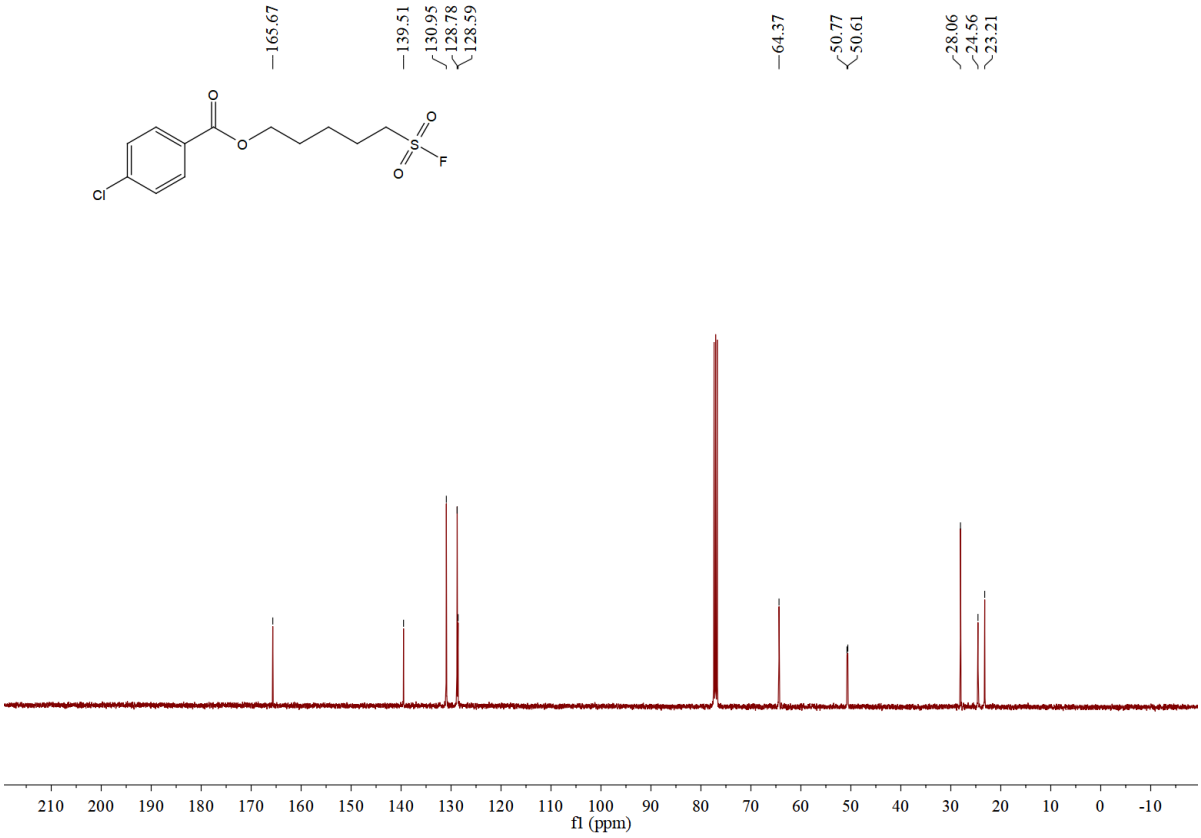


5-(fluorosulfonyl)pentyl 4-chlorobenzoate **(4j)**

^{1}H NMR



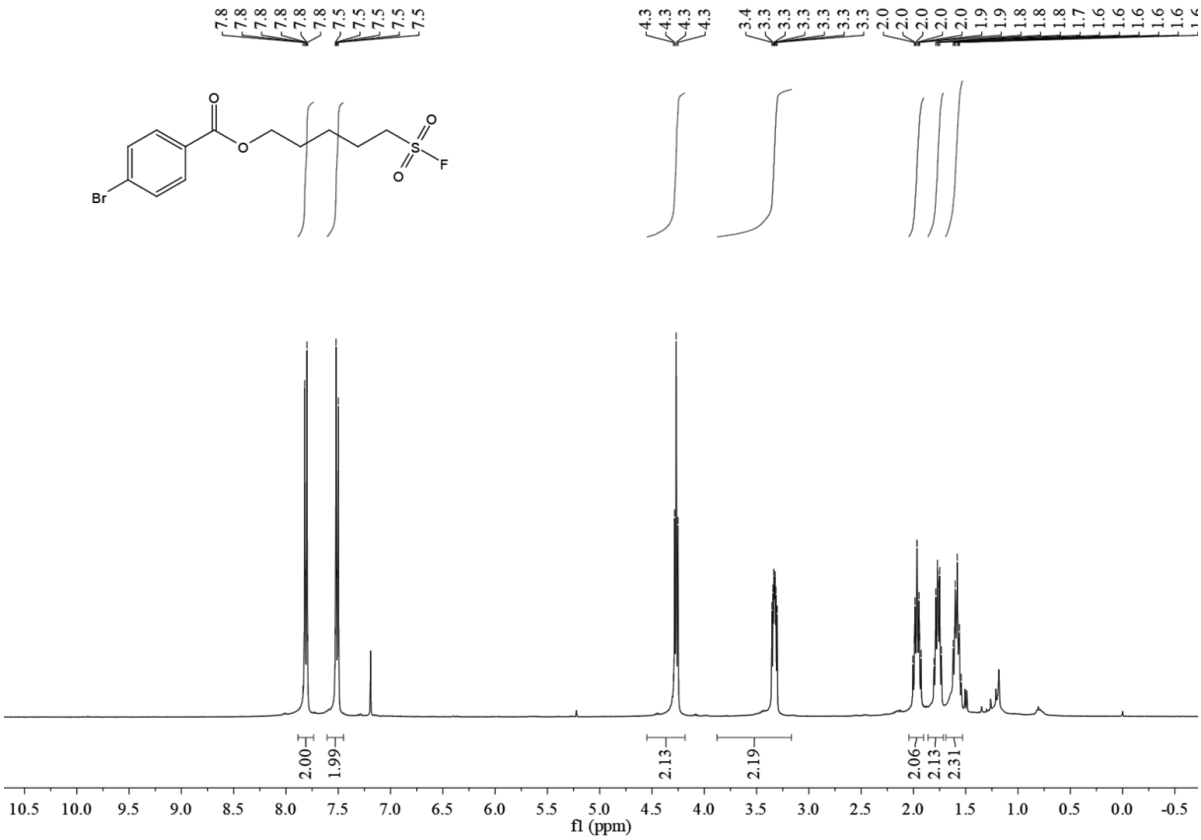
^{13}C NMR



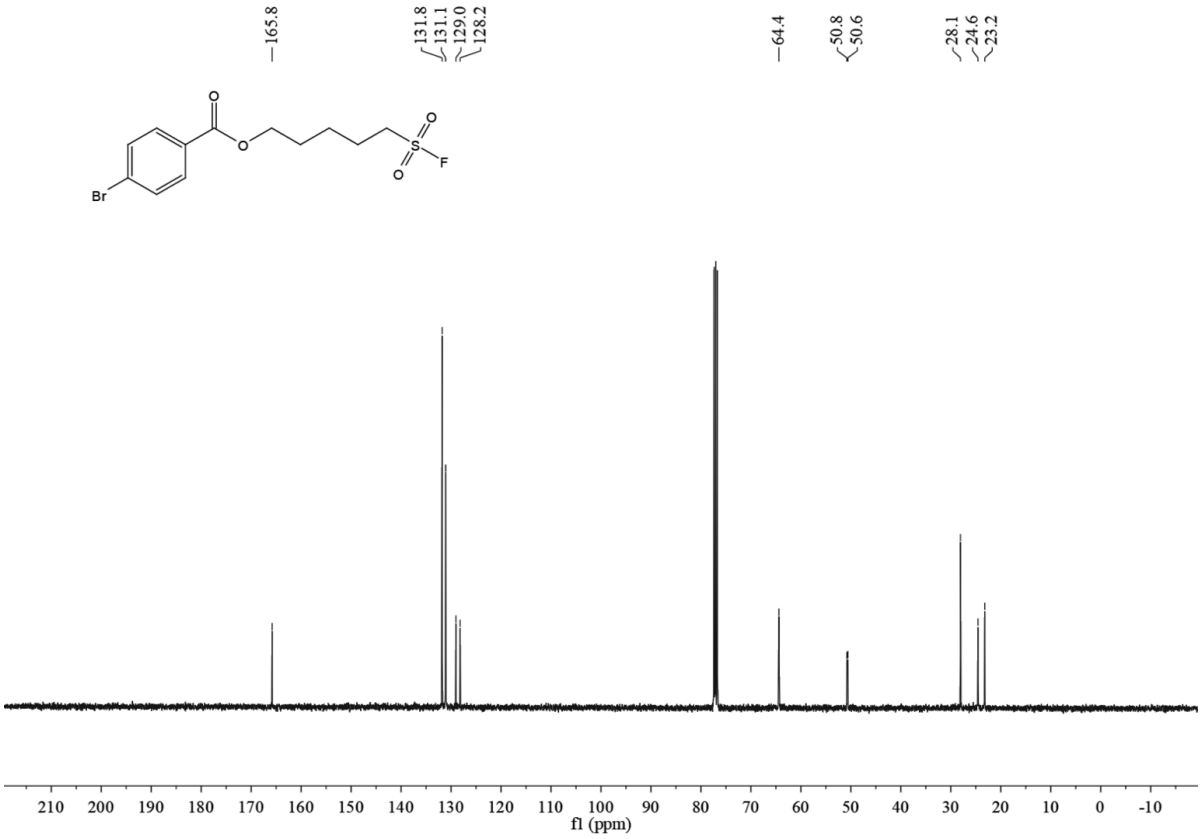
^{19}F NMR

5-(fluorosulfonyl)pentyl 4-bromobenzoate **(4k)**

^{1}H NMR



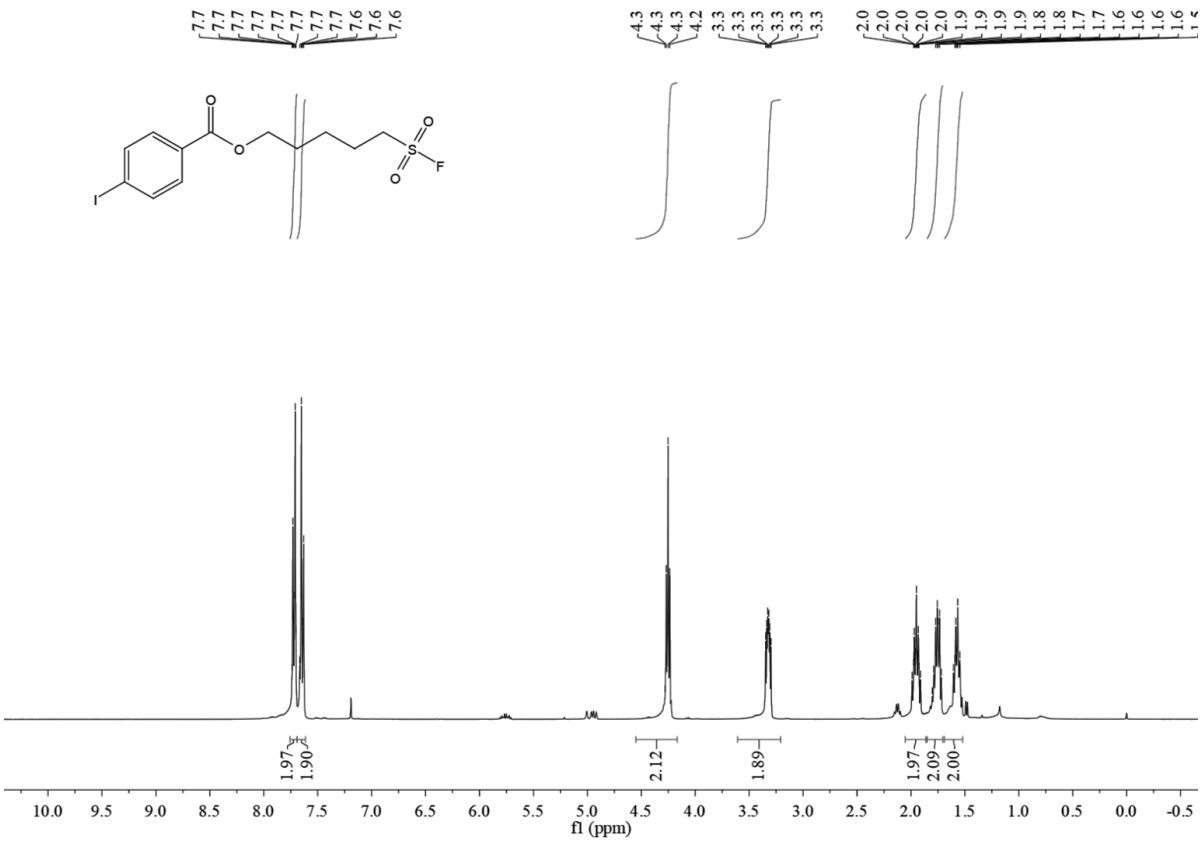
^{13}C NMR



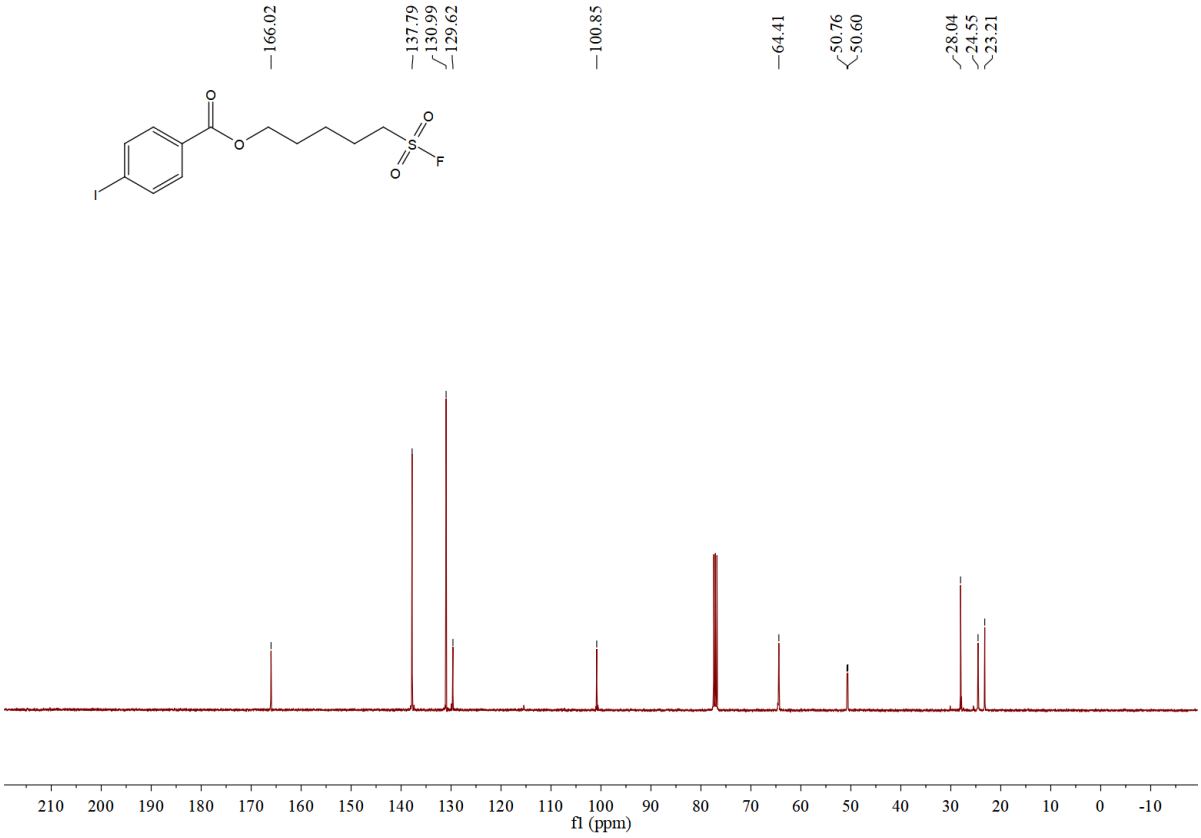
^{19}F NMR

5-(fluorosulfonyl)pentyl 4-iodobenzoate **(4l)**

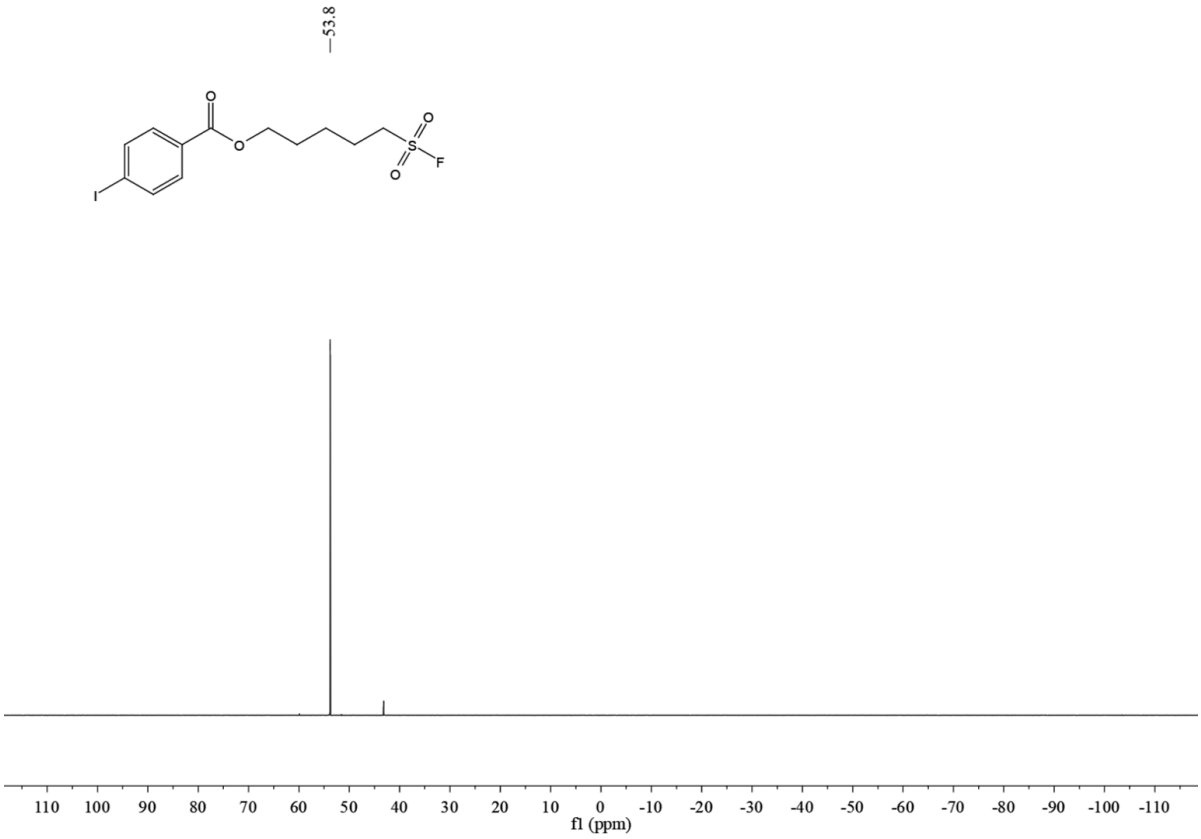
^{1}H NMR



^{13}C NMR

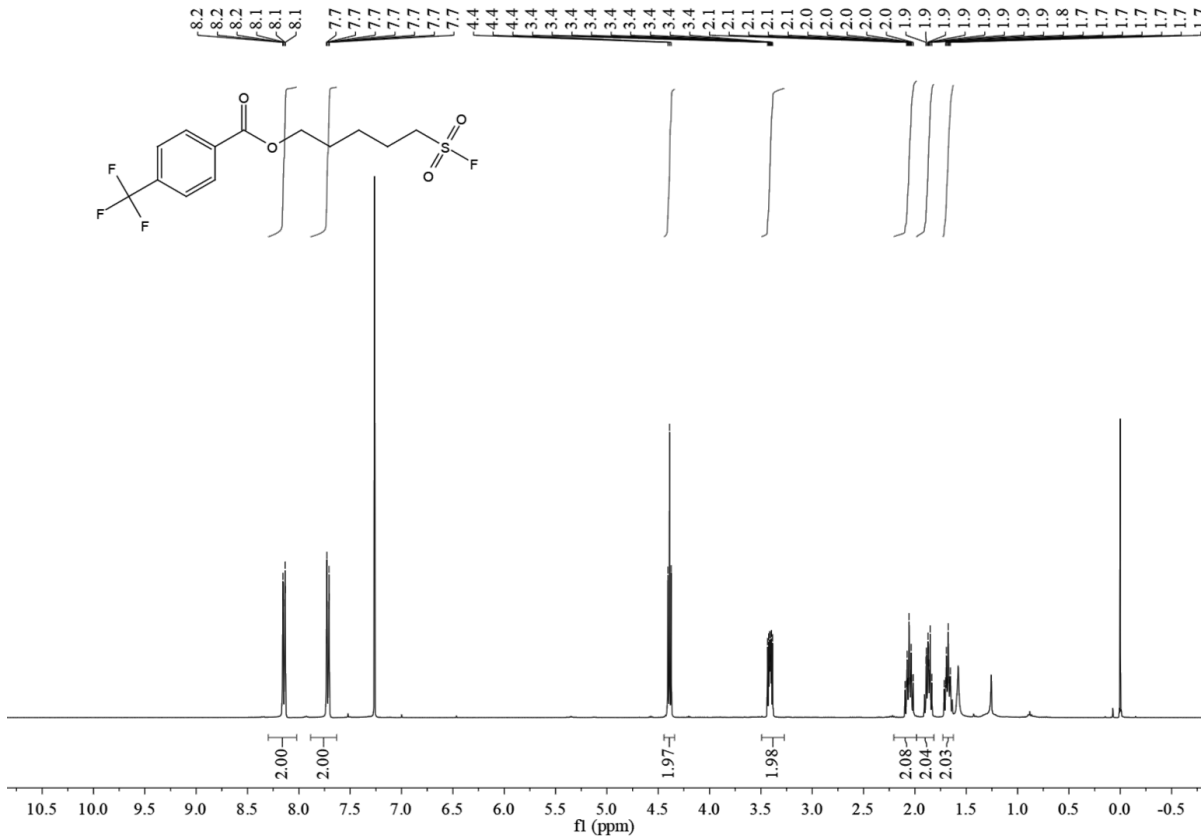


^{19}F NMR

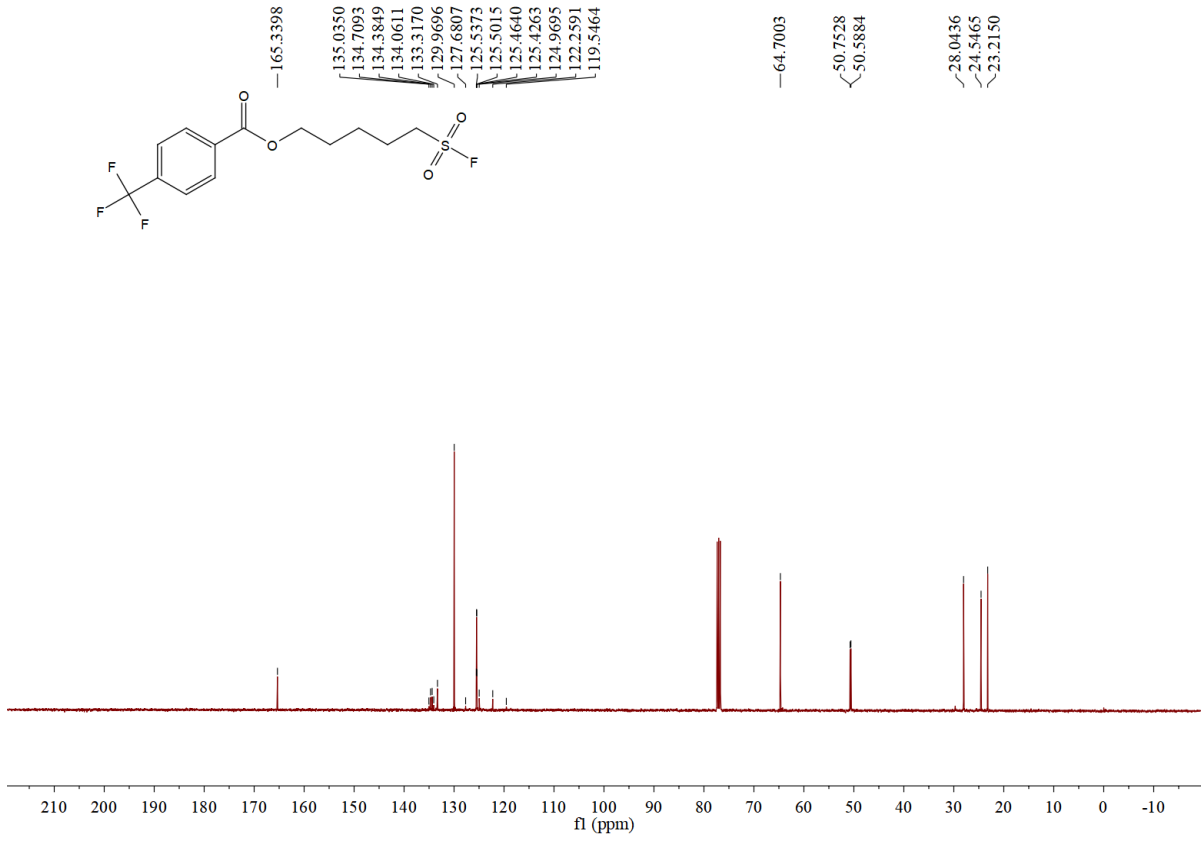


5-(fluorosulfonyl)pentyl 4-(trifluoromethyl)benzoate **(4m)**

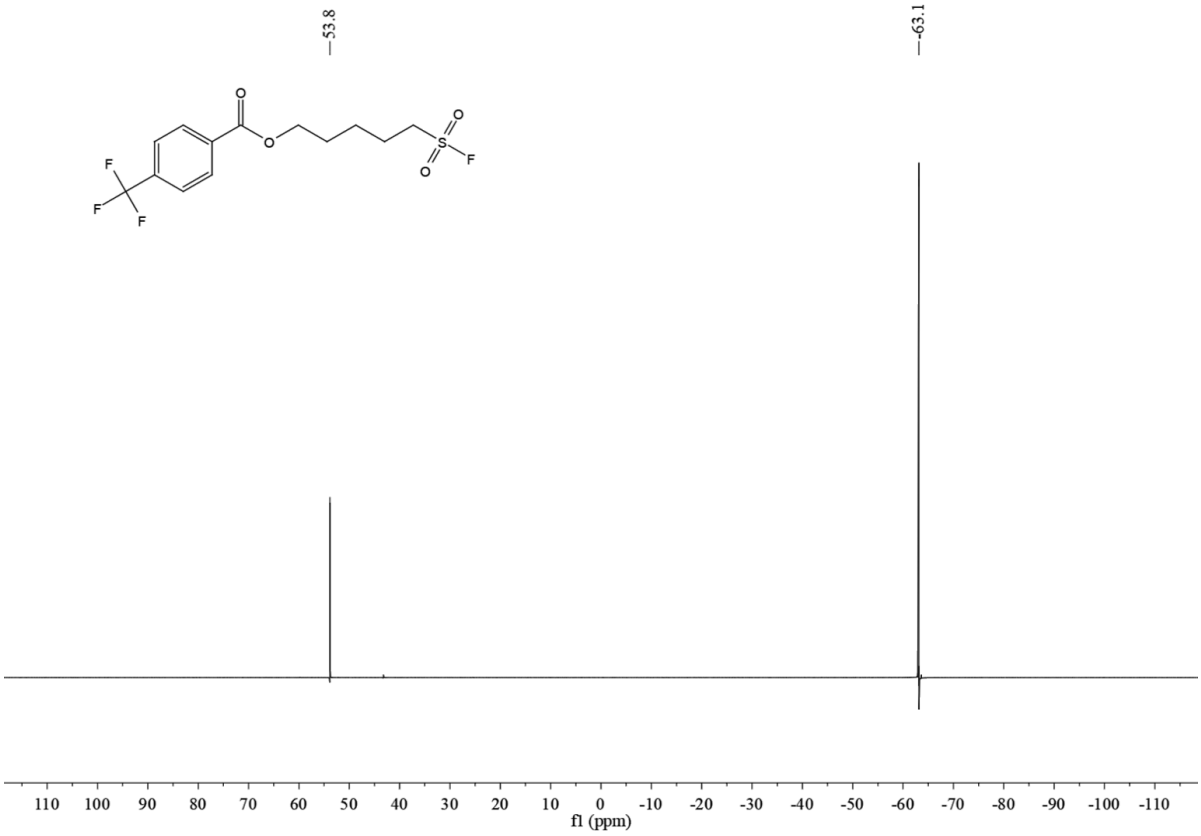
^{1}H NMR



^{13}C NMR

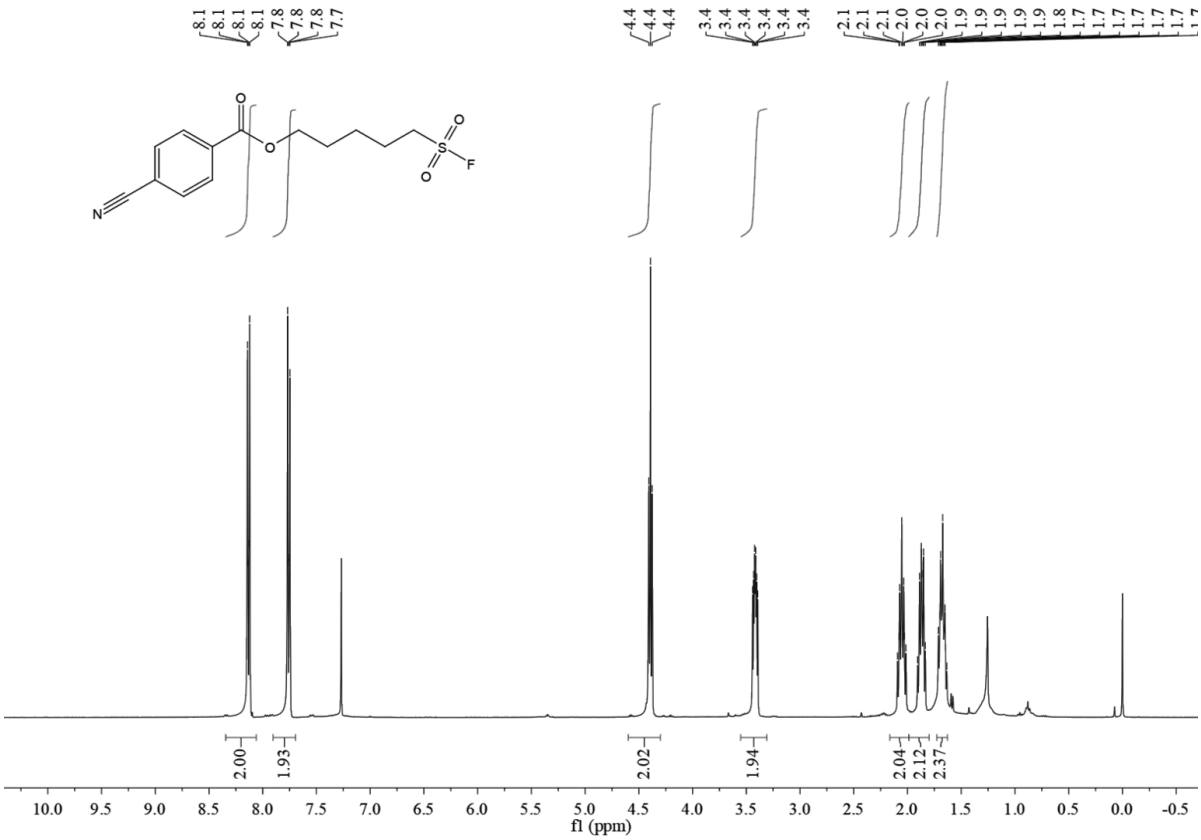


^{19}F NMR

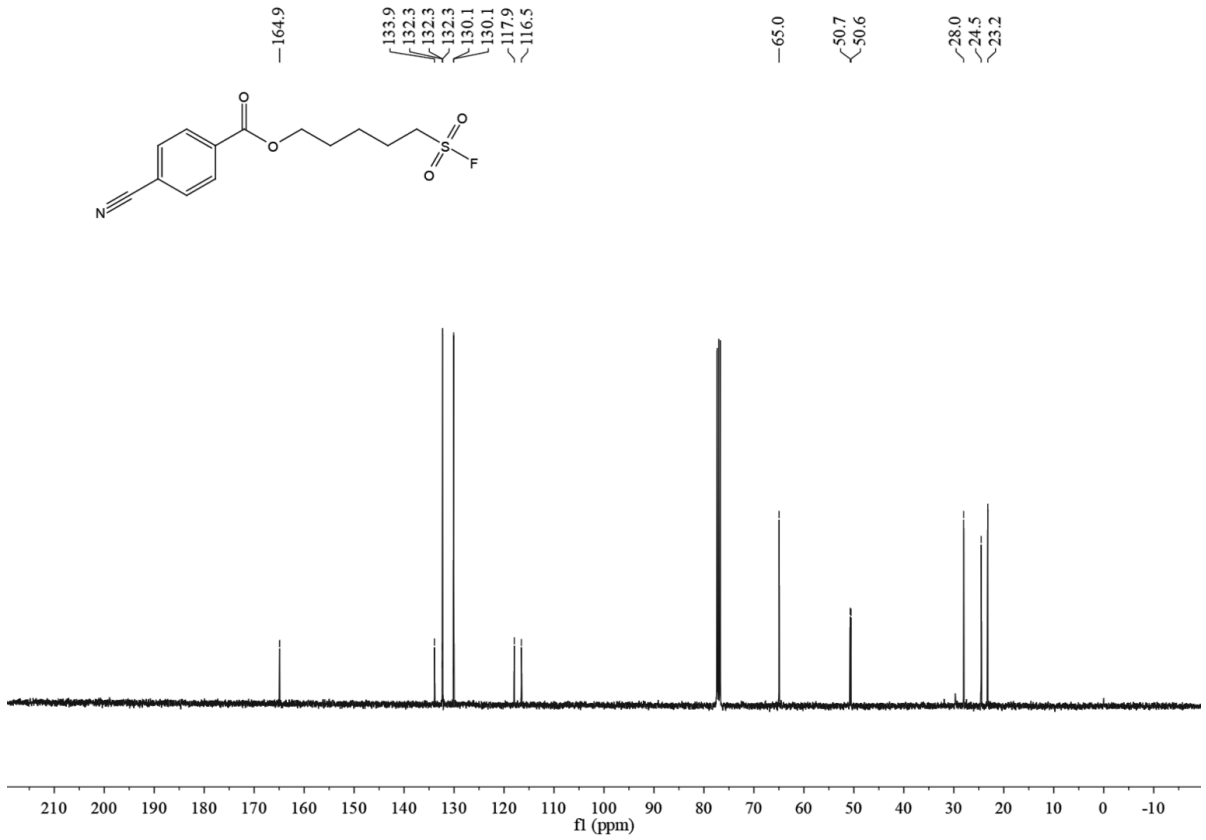


5-(fluorosulfonyl)pentyl 4-cyanobenzoate **(4n)**

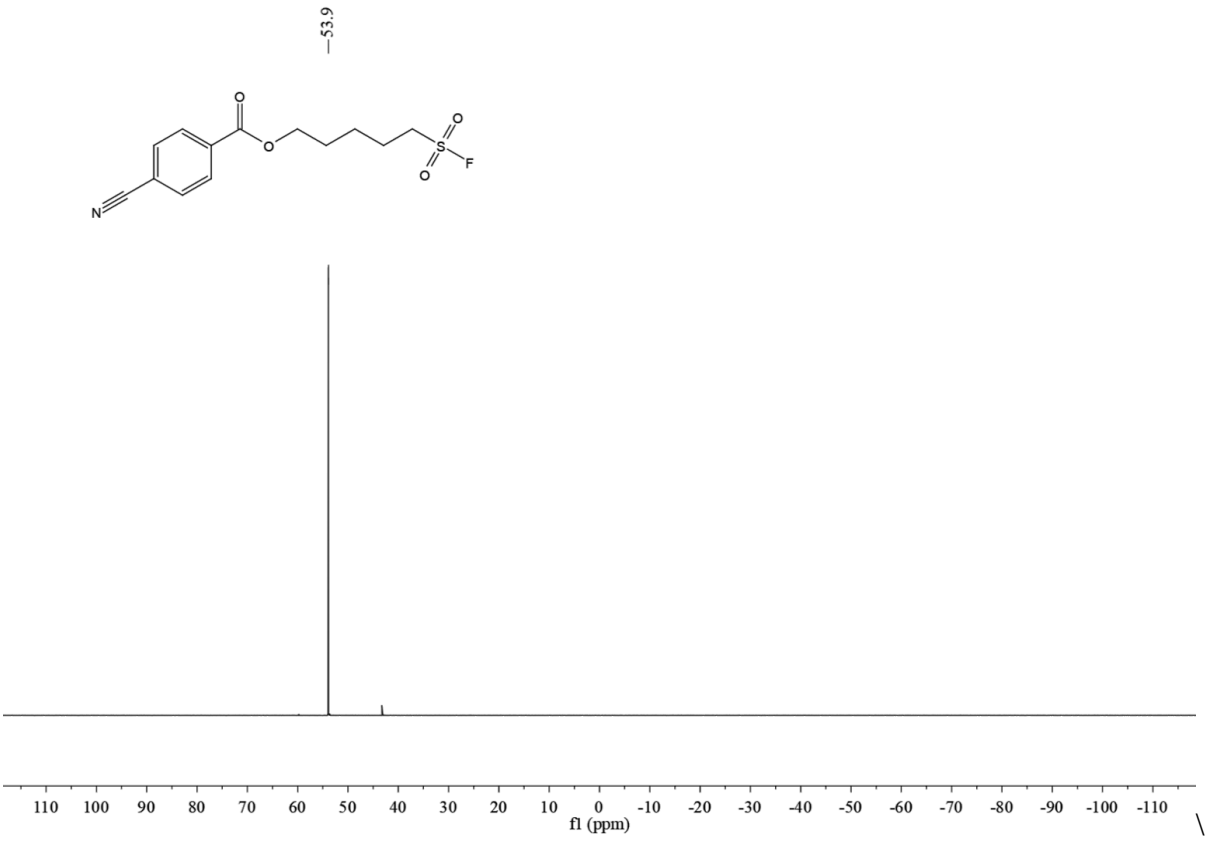
^{1}H NMR



^{13}C NMR

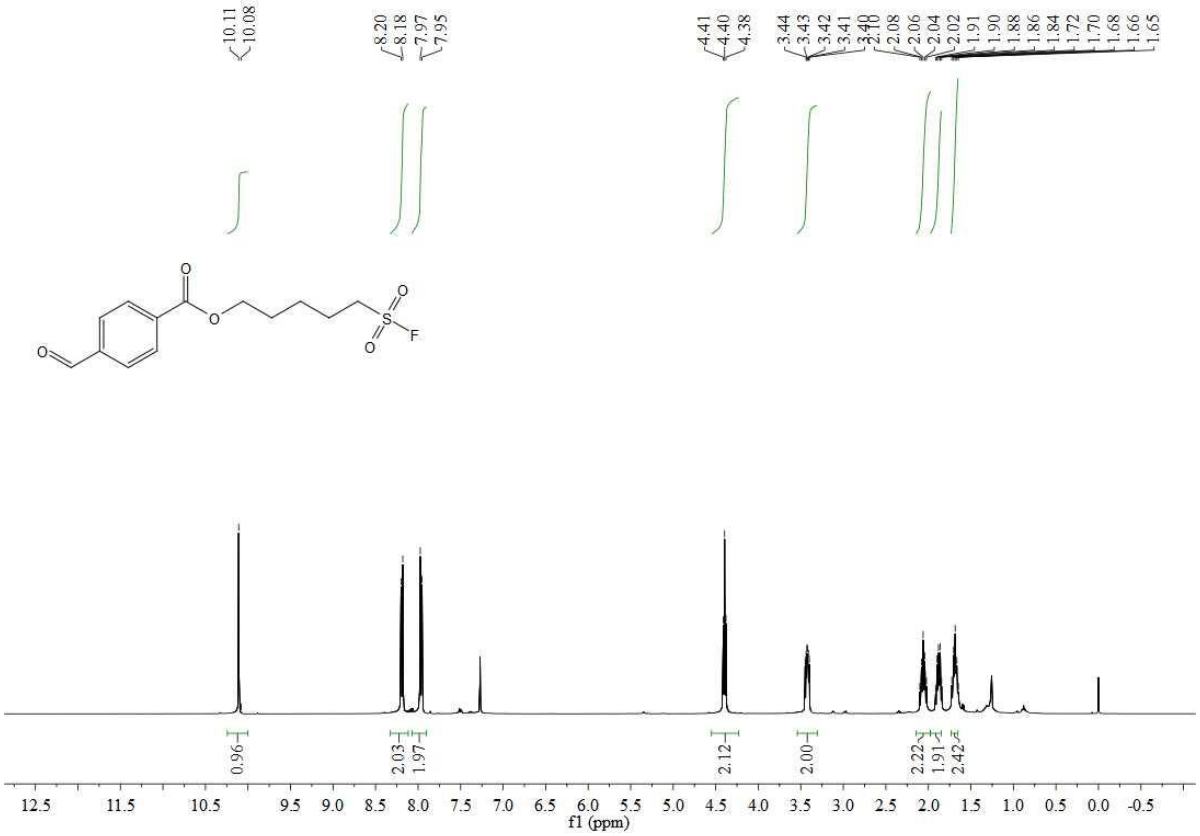


^{19}F NMR

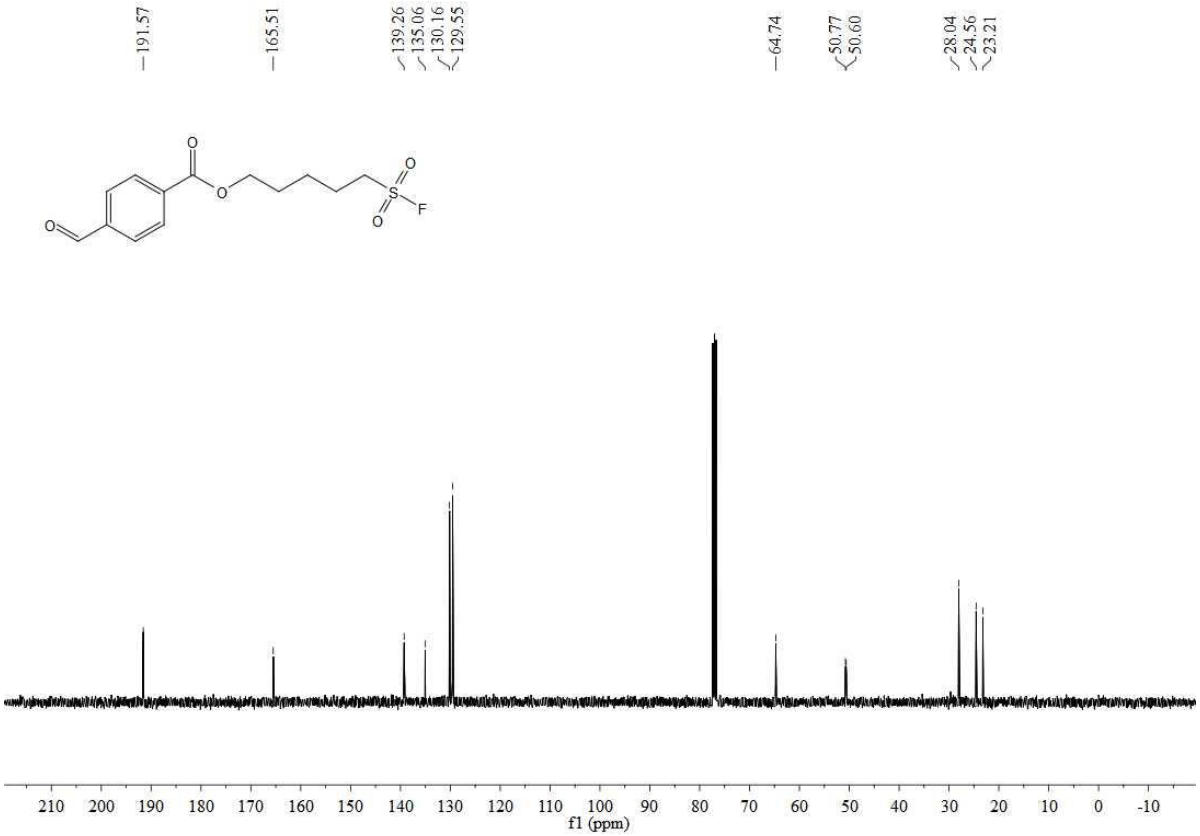


5-(fluorosulfonyl)pentyl 4-formylbenzoate (**4o**)

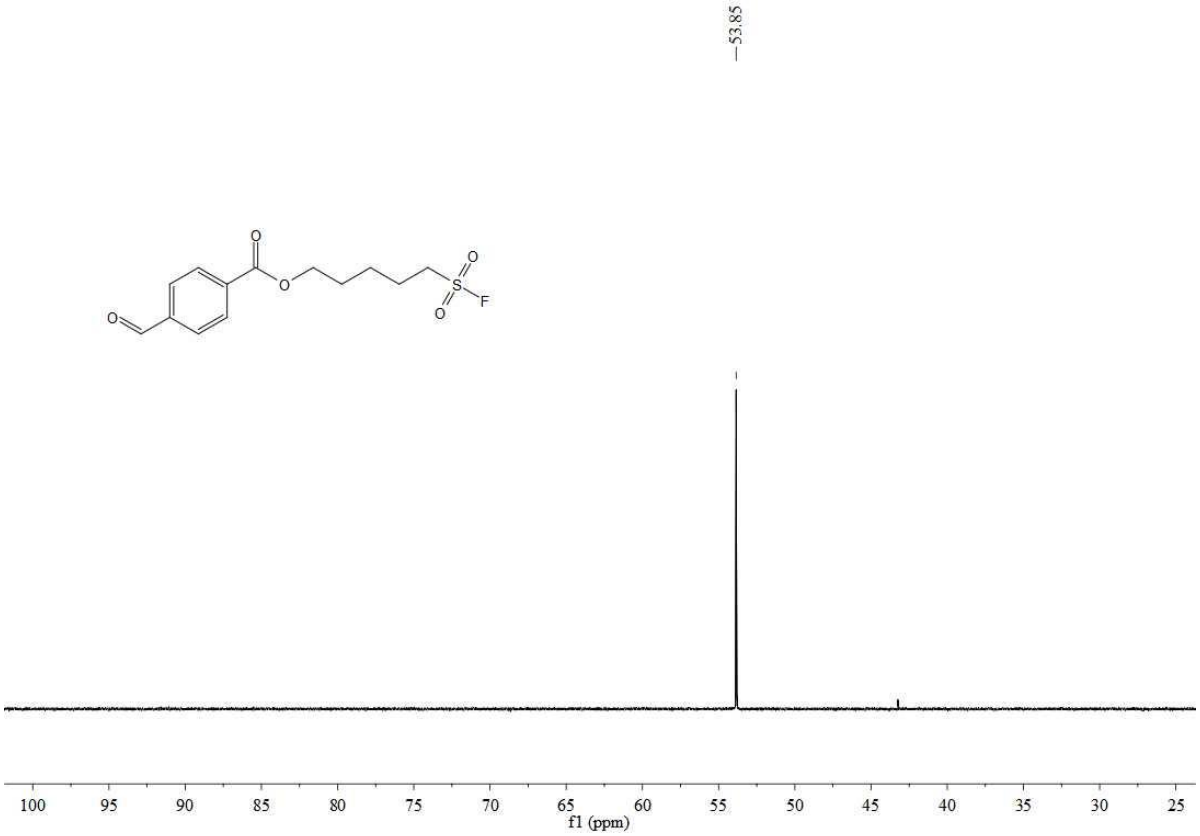
^{1}H NMR



\$^{13}$C NMR

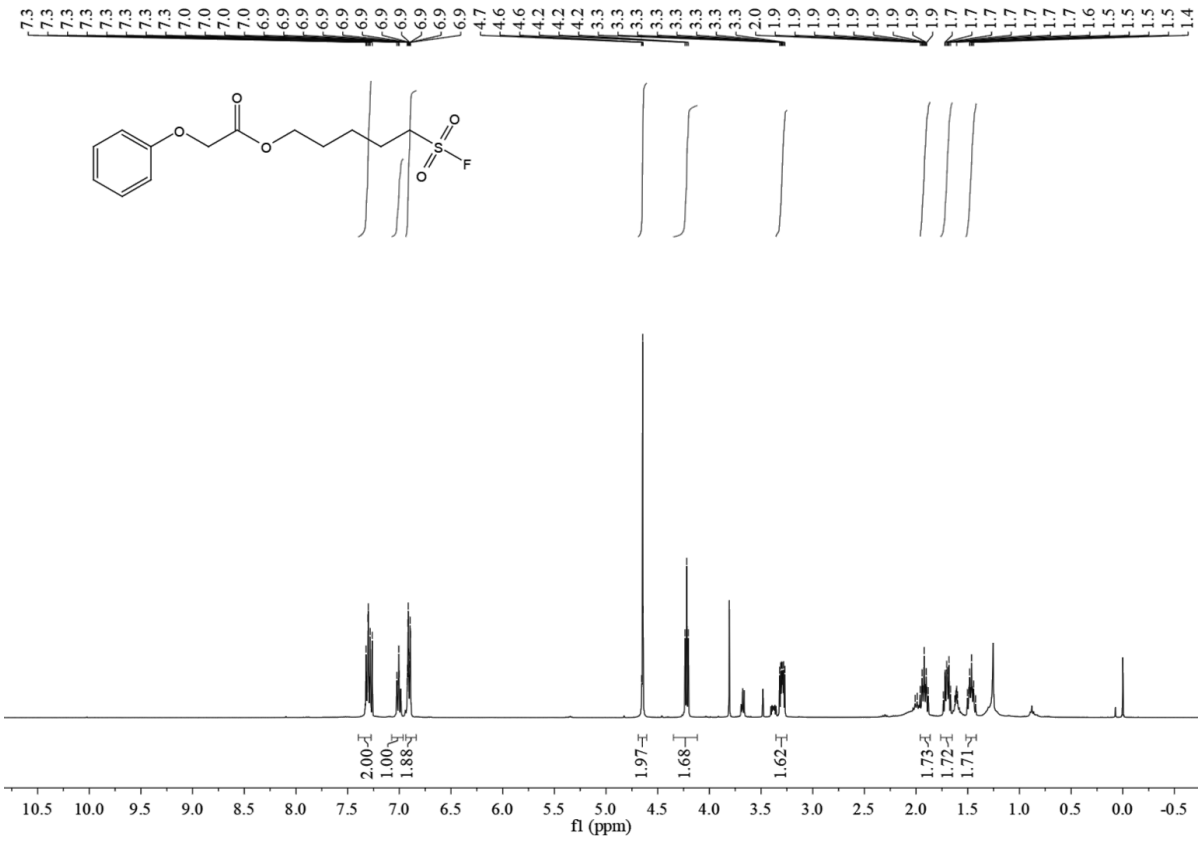


^{19}F NMR

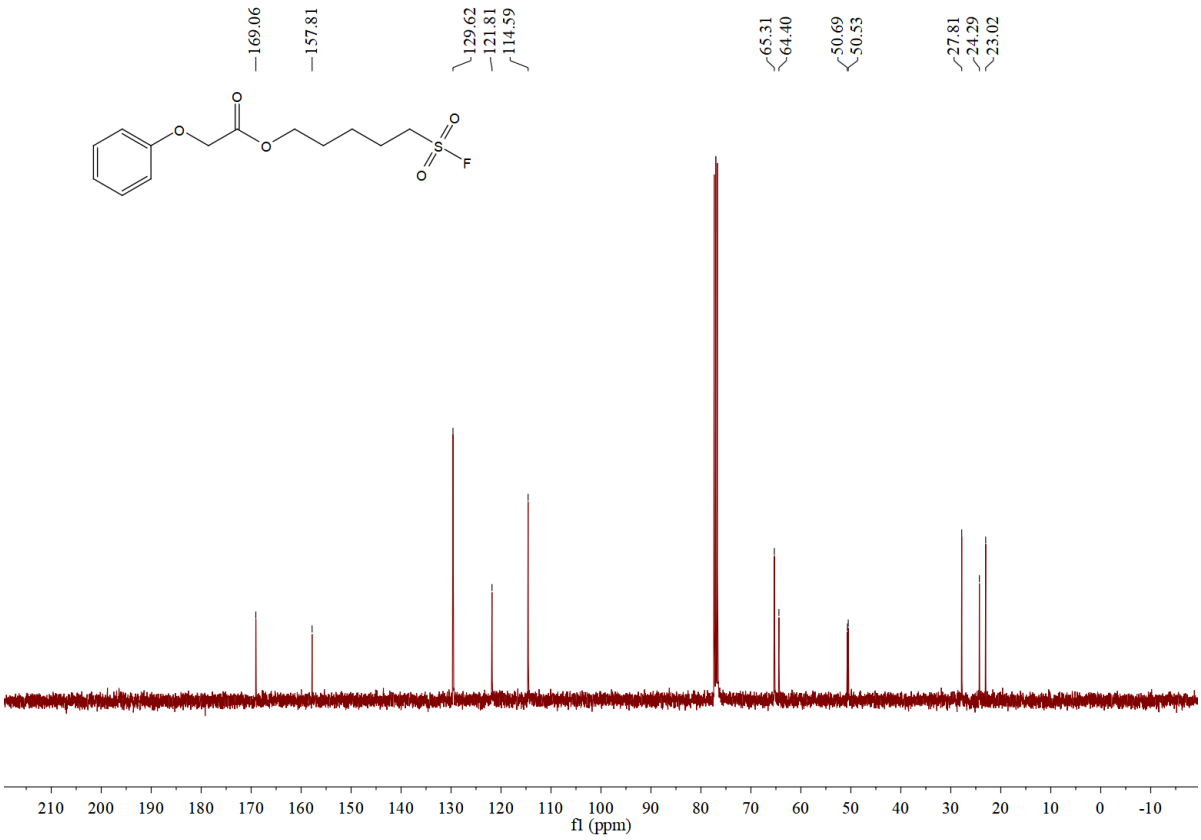


5-(fluorosulfonyl)pentyl 2-phenoxyacetate **(4p)**

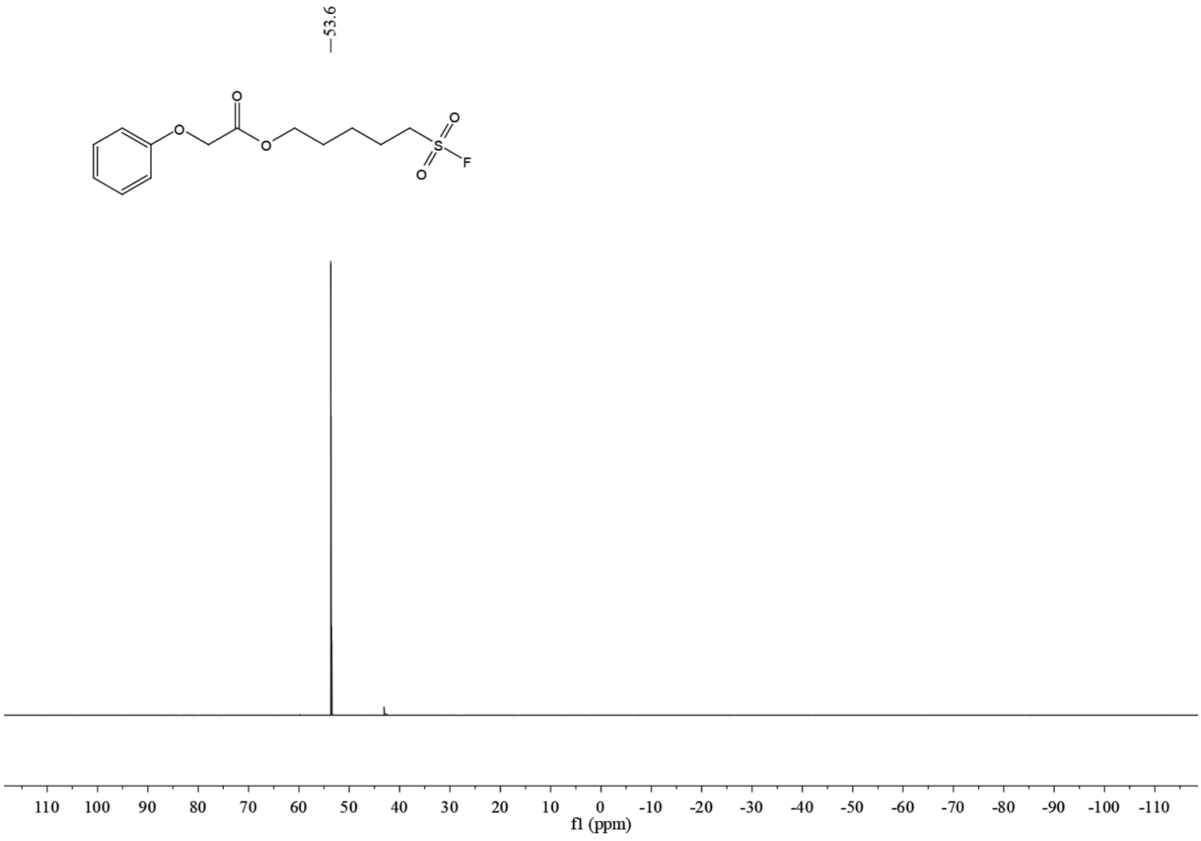
^{1}H NMR



^{13}C NMR

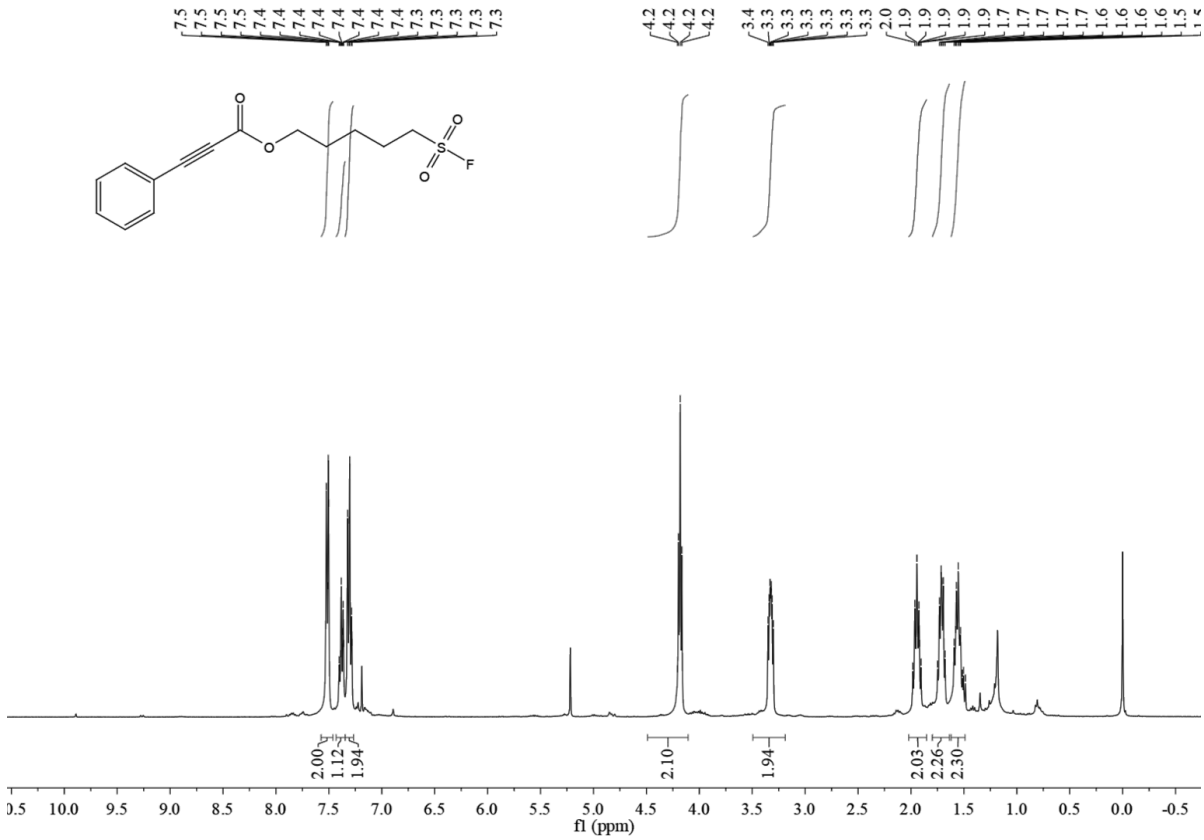


^{19}F NMR

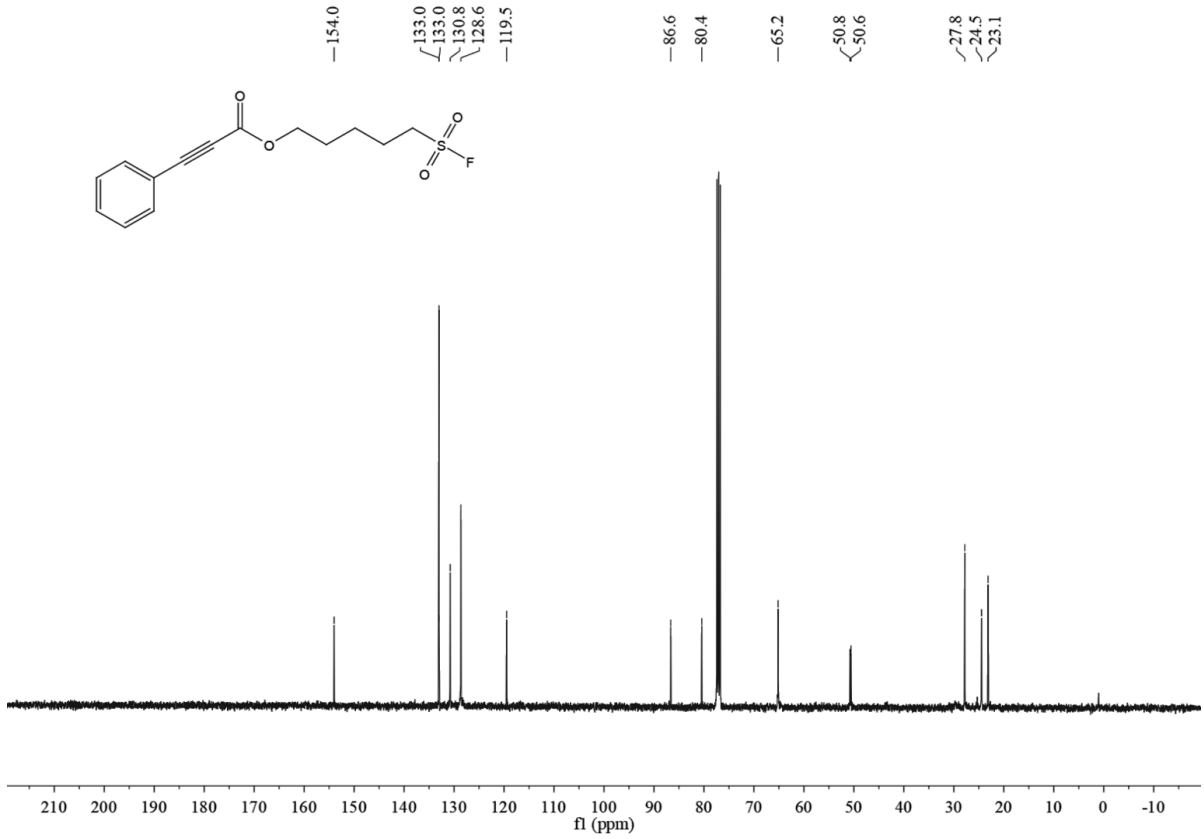


5-(fluorosulfonyl)pentyl 3-phenylpropiolate **(4q)**

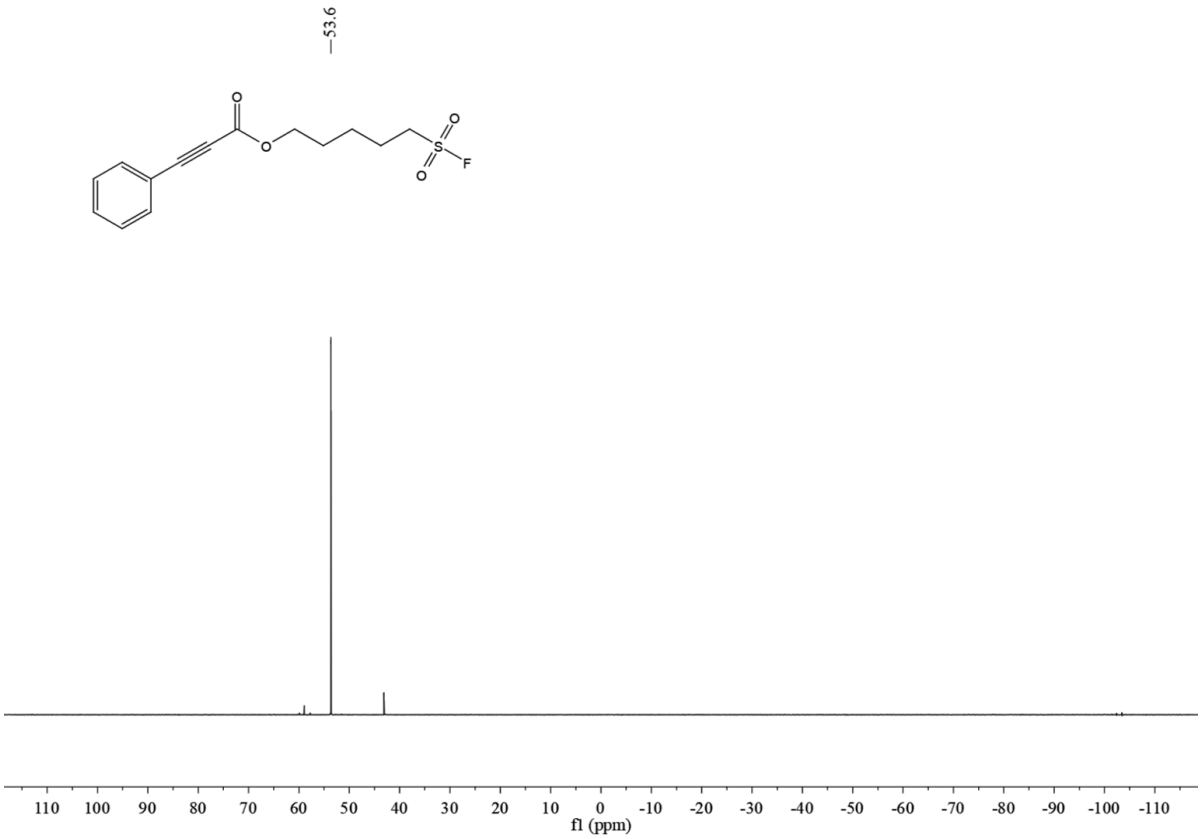
^{1}H NMR



^{13}C NMR

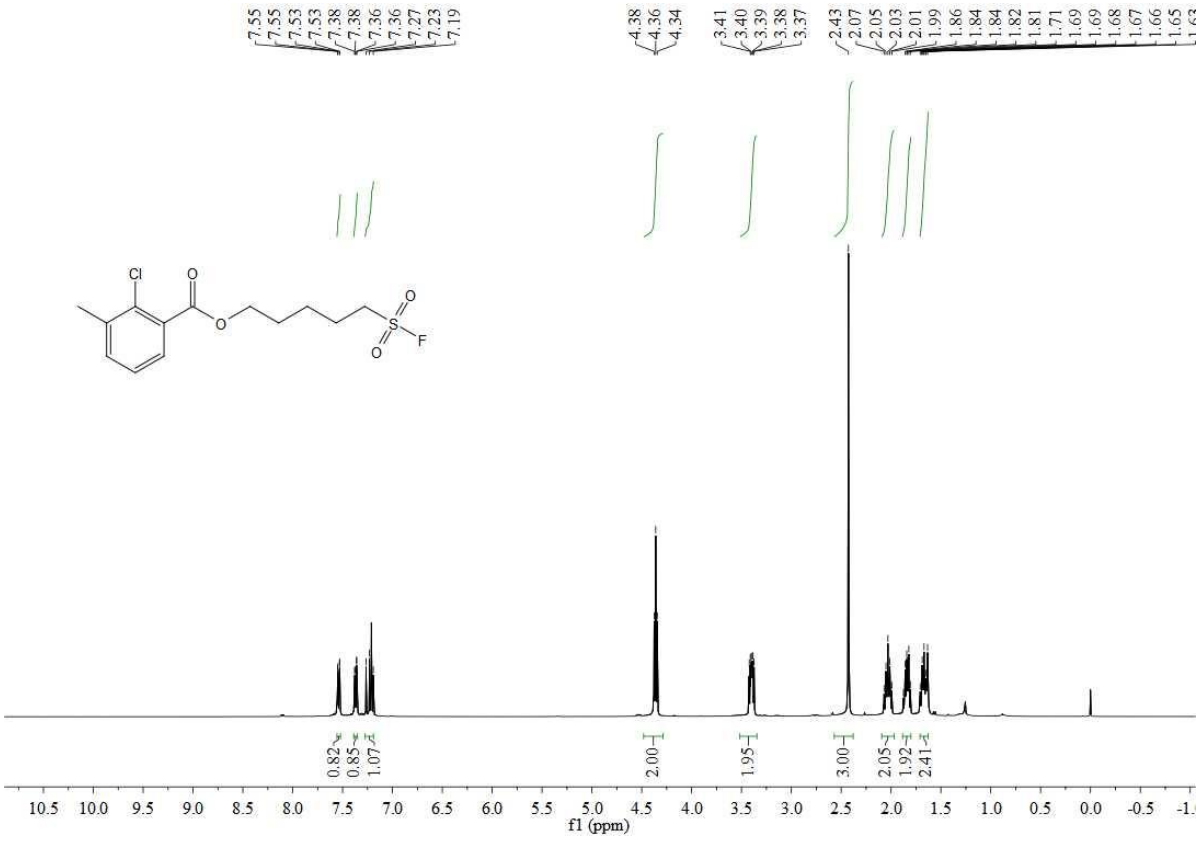


^{19}F NMR

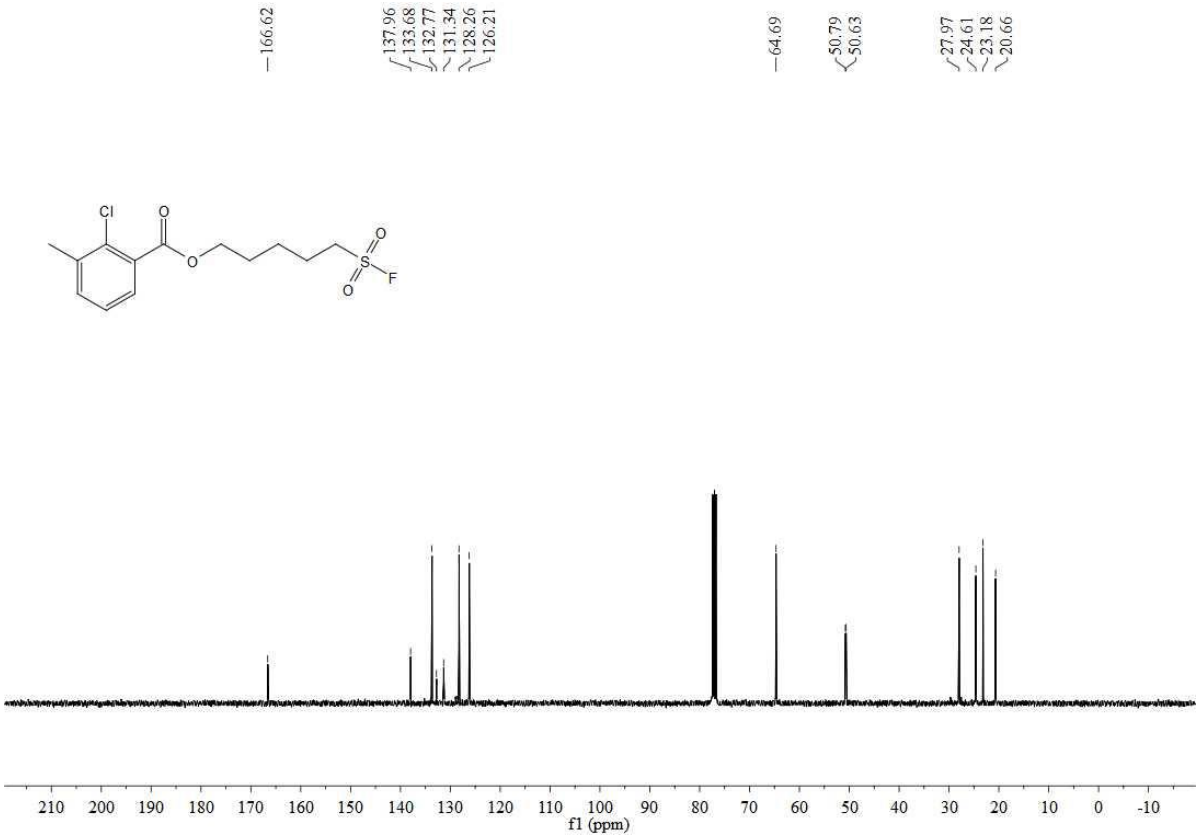


5-(fluorosulfonyl)pentyl 2-chloro-3-methylbenzoate **(4r)**

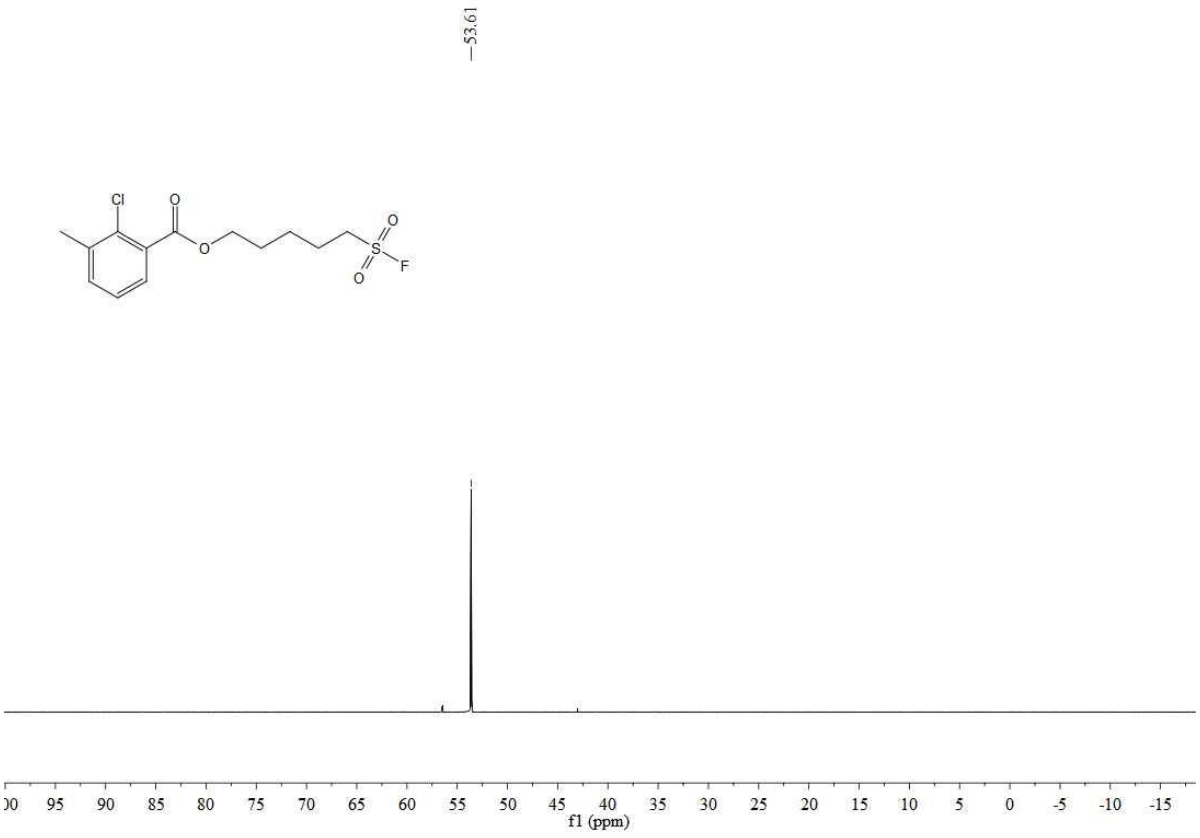
^{1}H NMR



^{13}C NMR

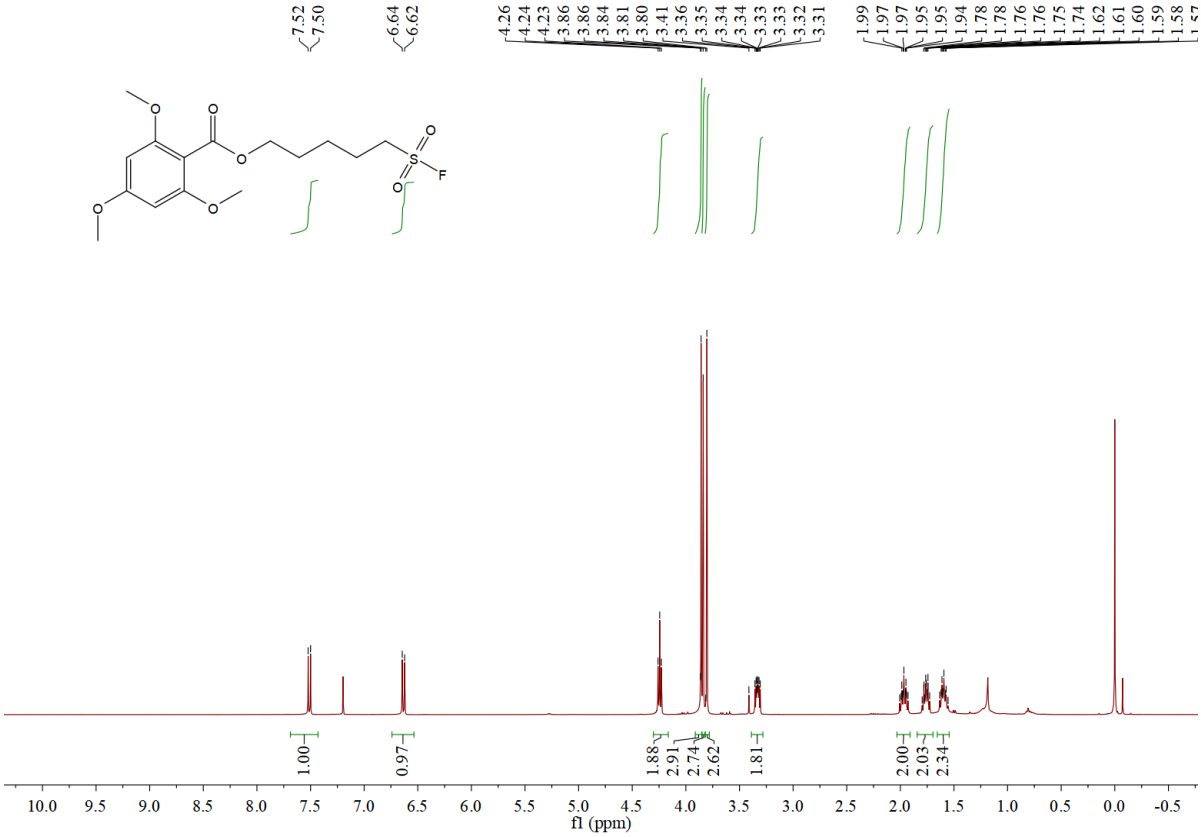


^{19}F NMR

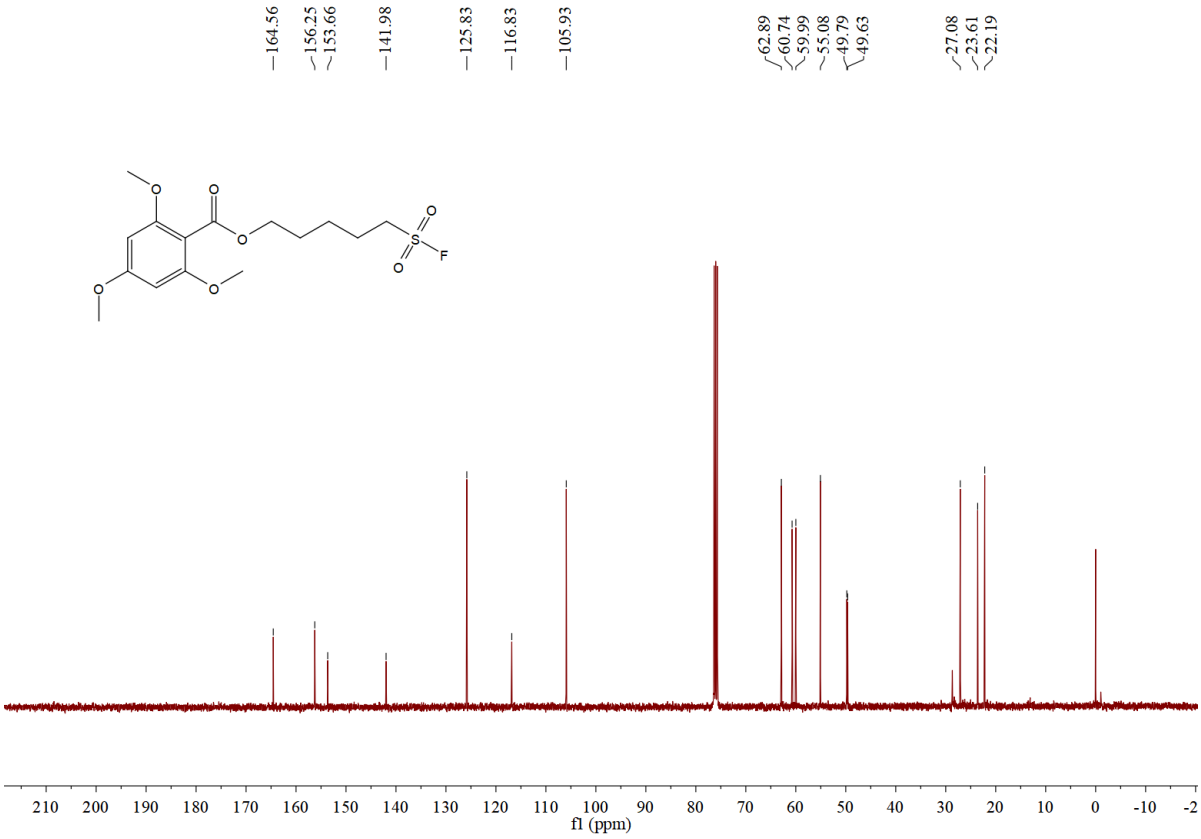


5-(fluorosulfonyl)pentyl 2,4,6-trimethoxybenzoate **(4s)**

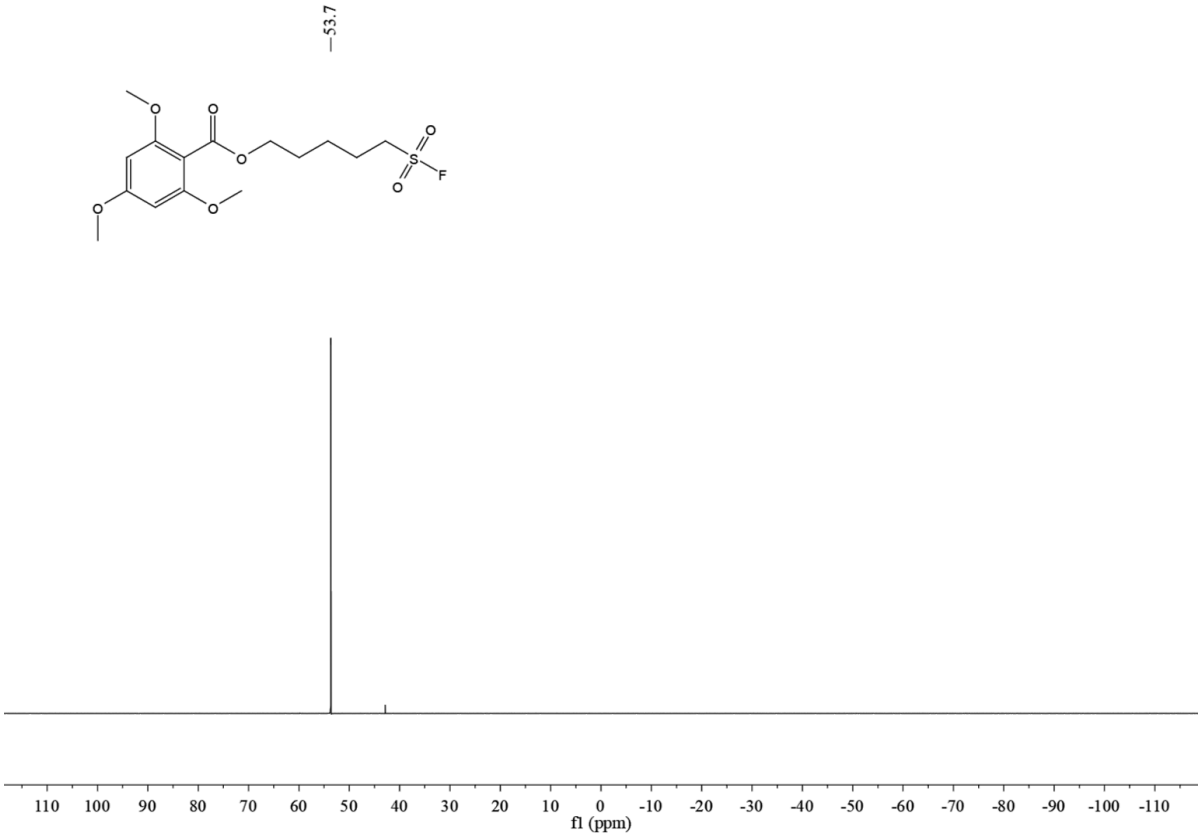
^{1}H NMR



^{13}C NMR

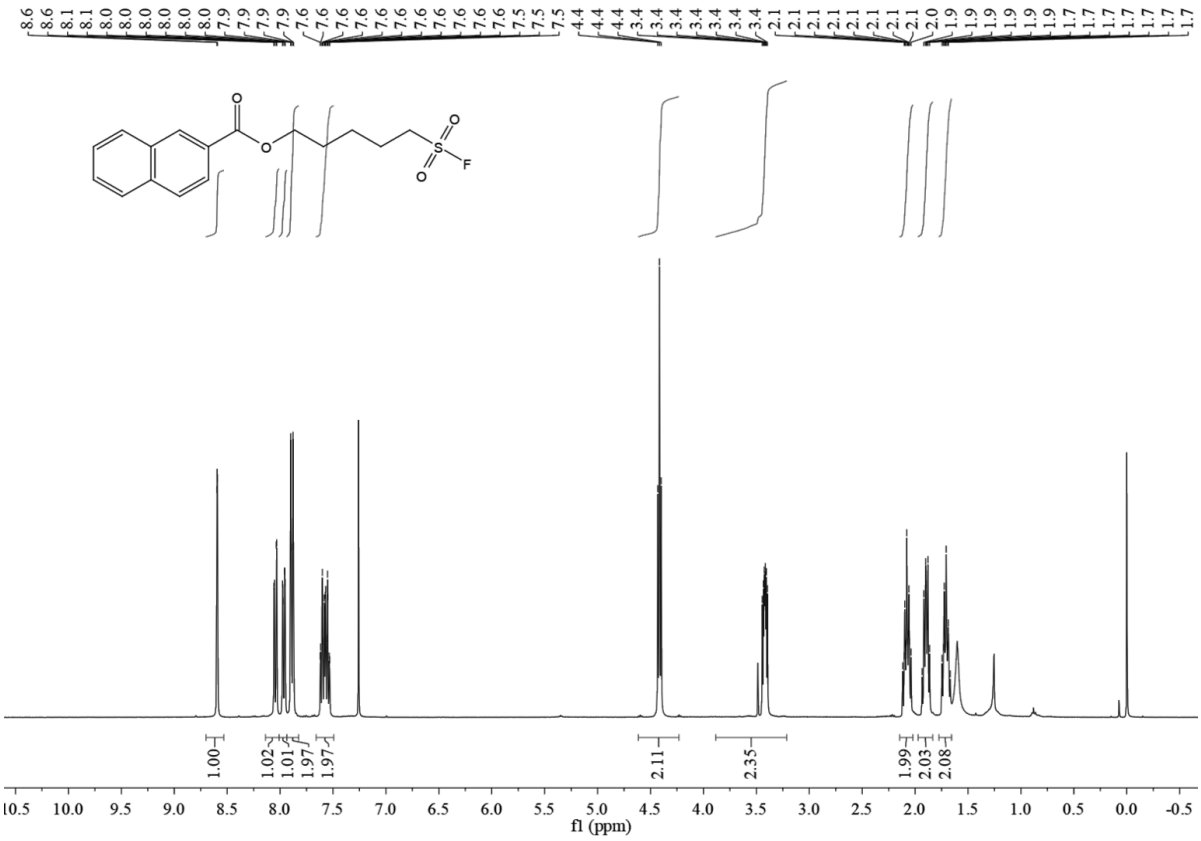


^{19}F NMR

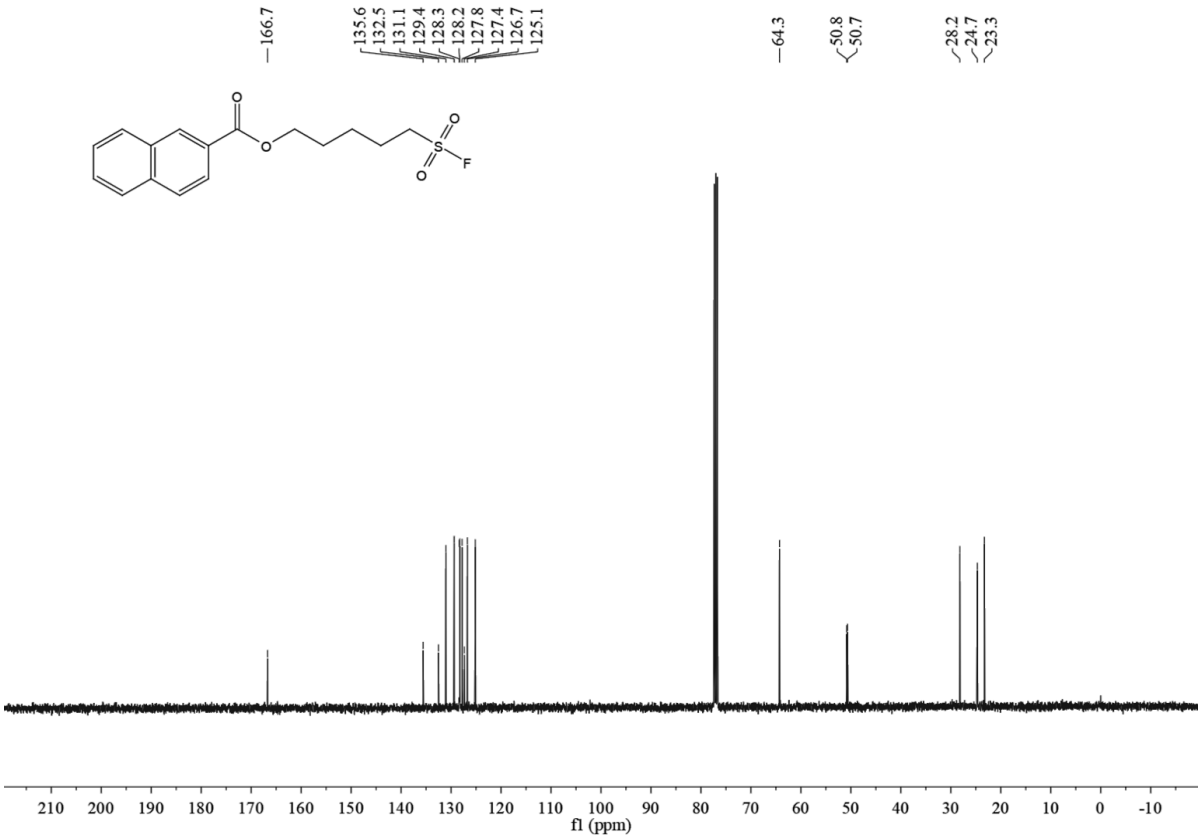


5-(fluorosulfonyl)pentyl 2-naphthoate **(4t)**

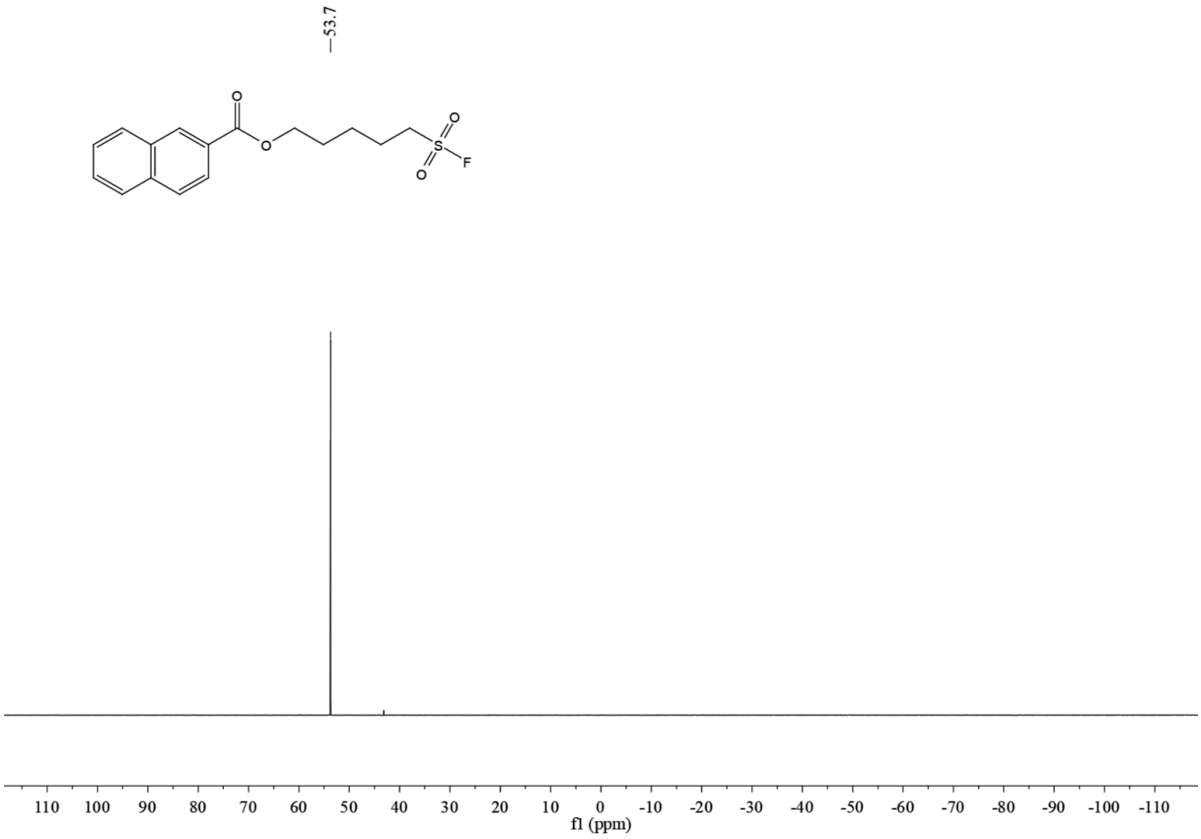
^{1}H NMR



^{13}C NMR

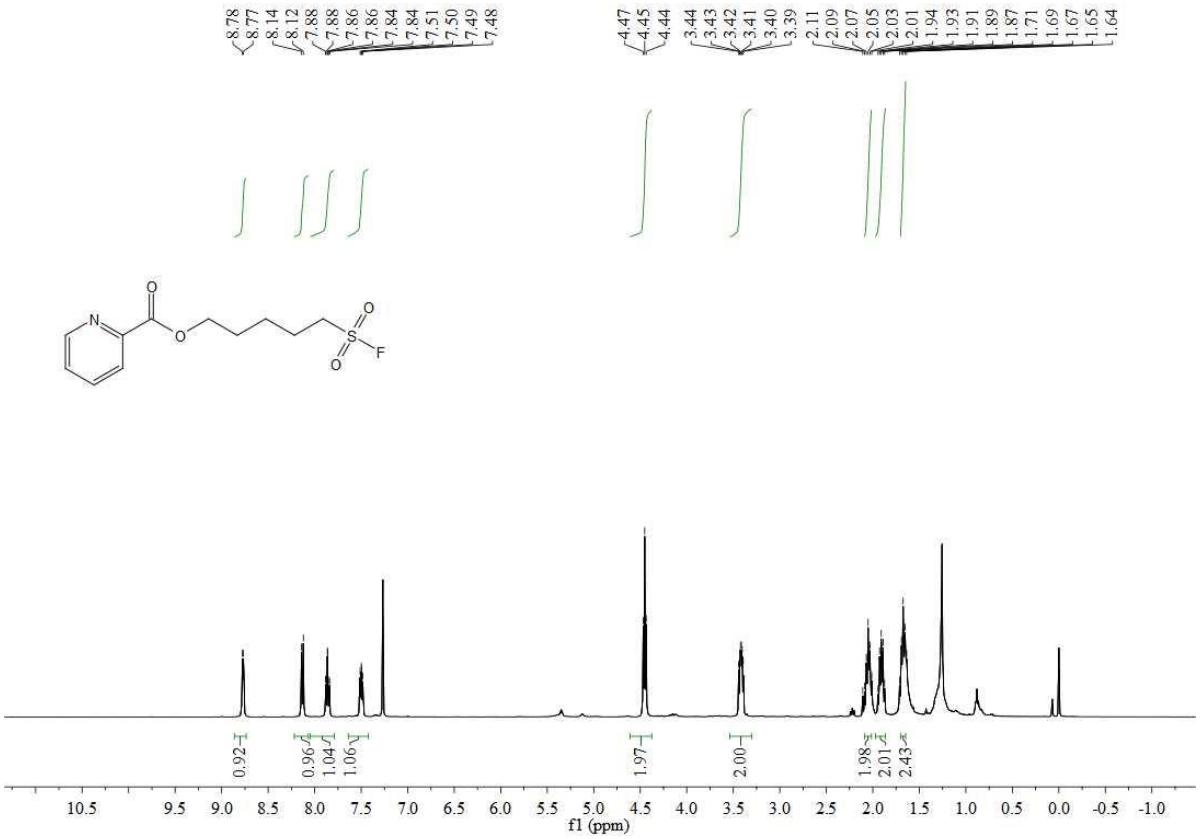


^{19}F NMR

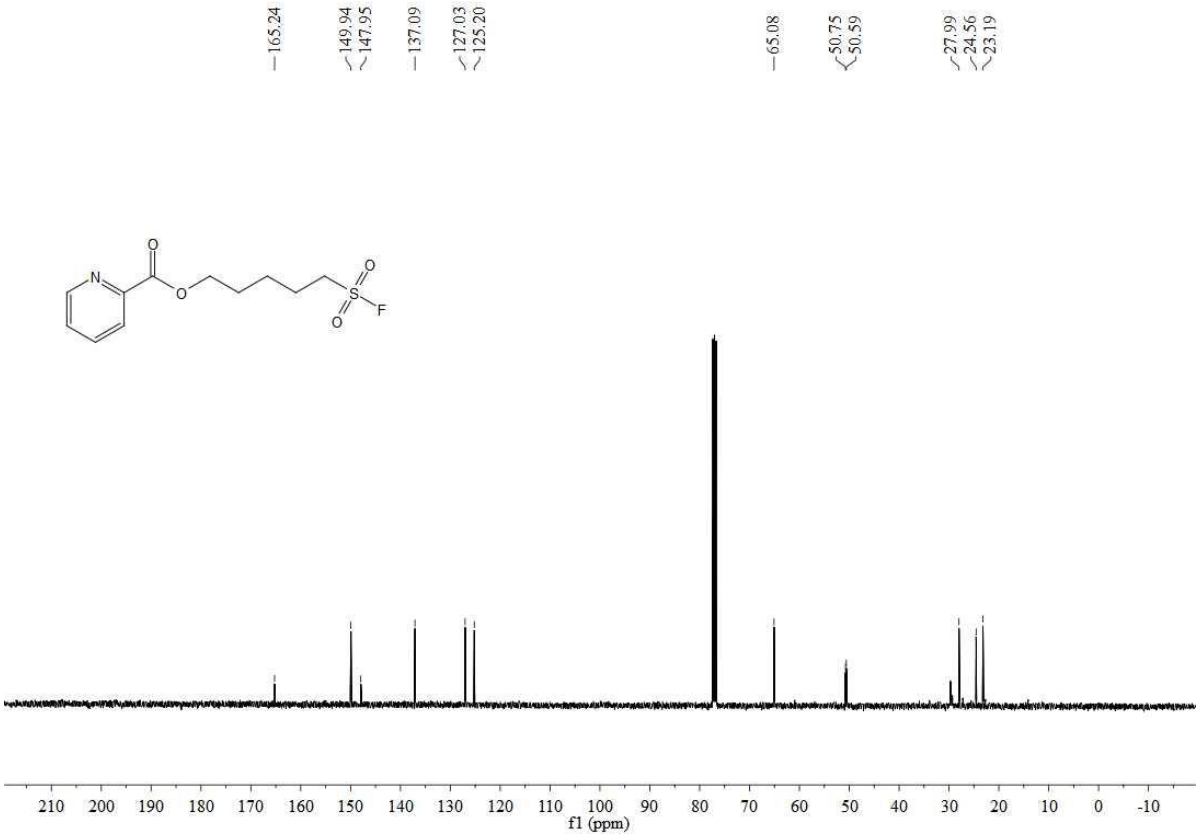


5-(fluorosulfonyl)pentyl picolinate **(4u)**

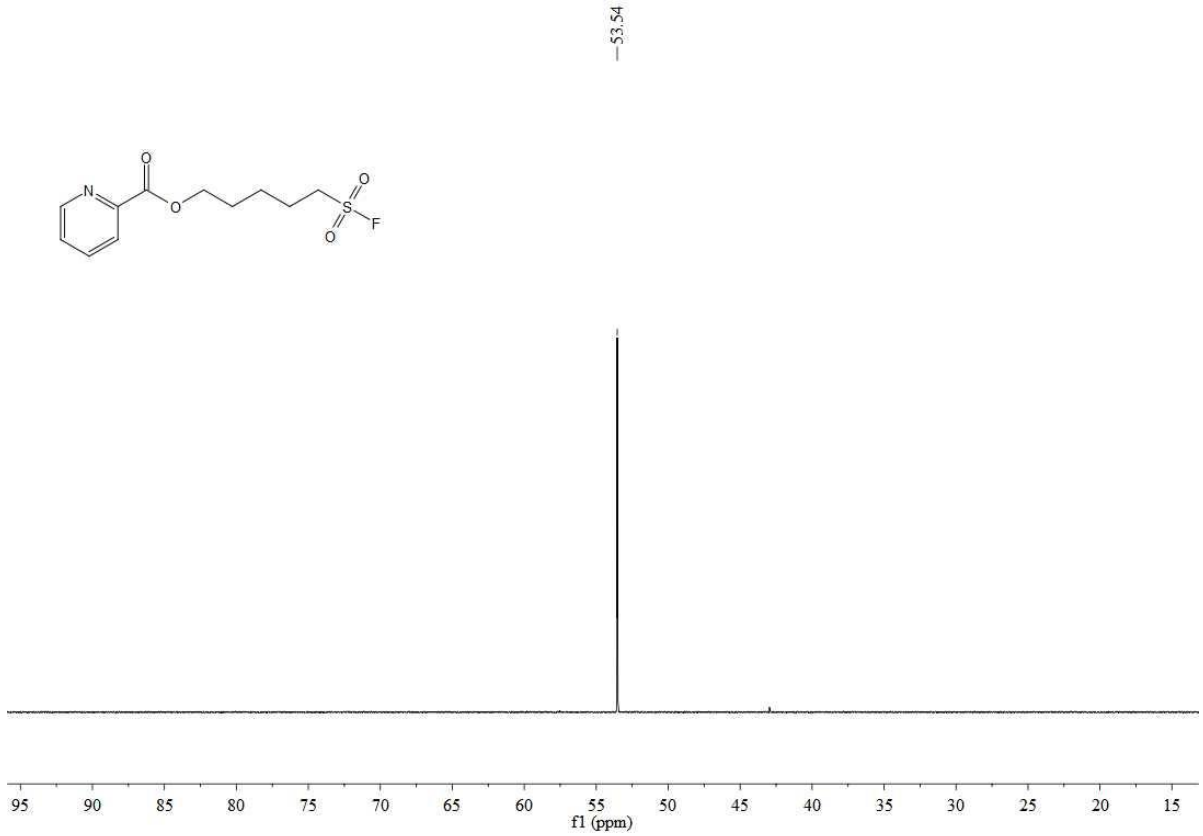
^{1}H NMR



^{13}C NMR

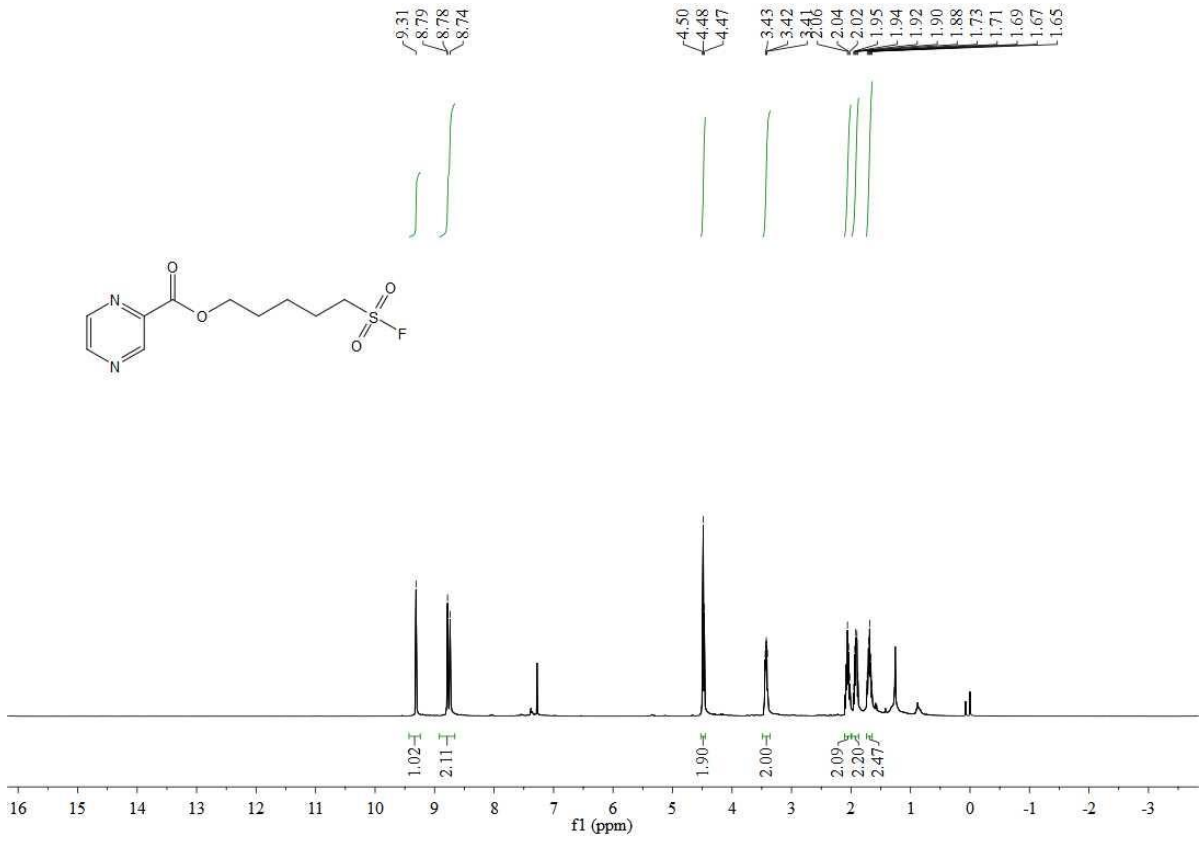


^{19}F NMR

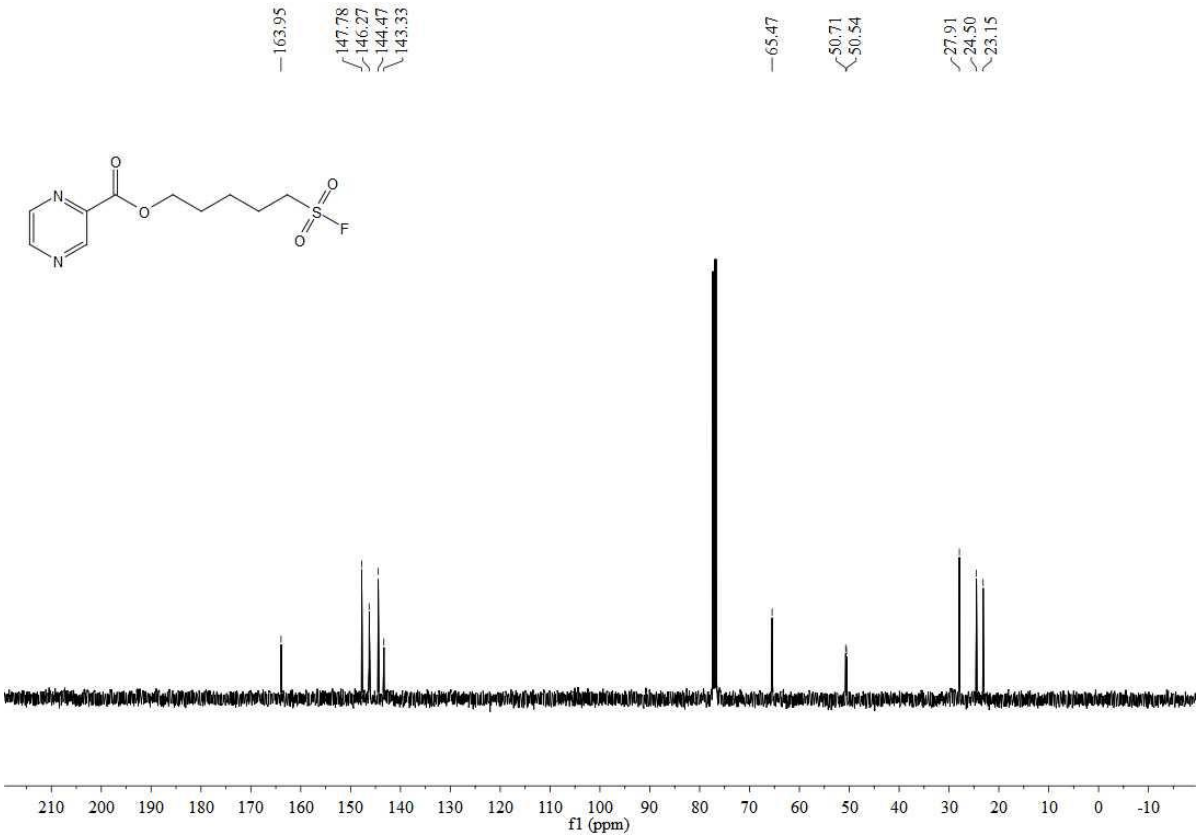


5-(fluorosulfonyl)pentyl pyrazine-2-carboxylate **(4v)**

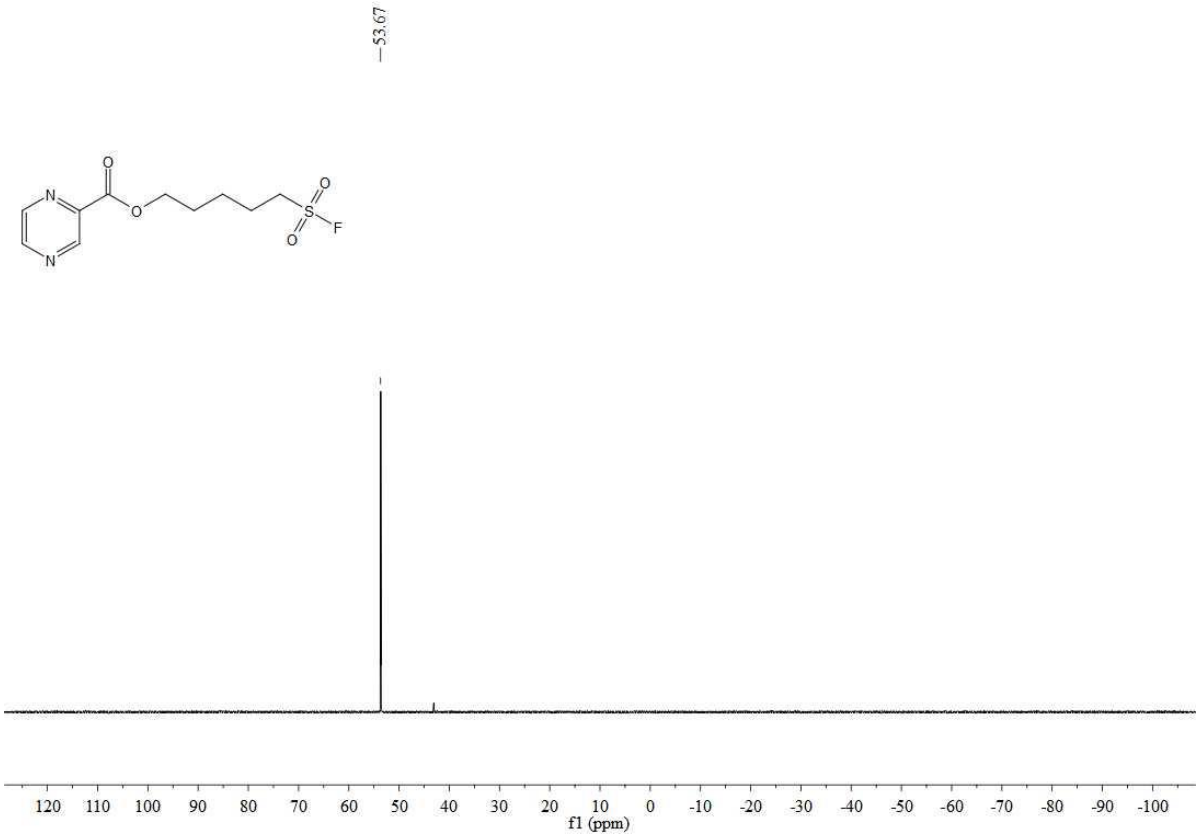
^{1}H NMR



^{13}C NMR

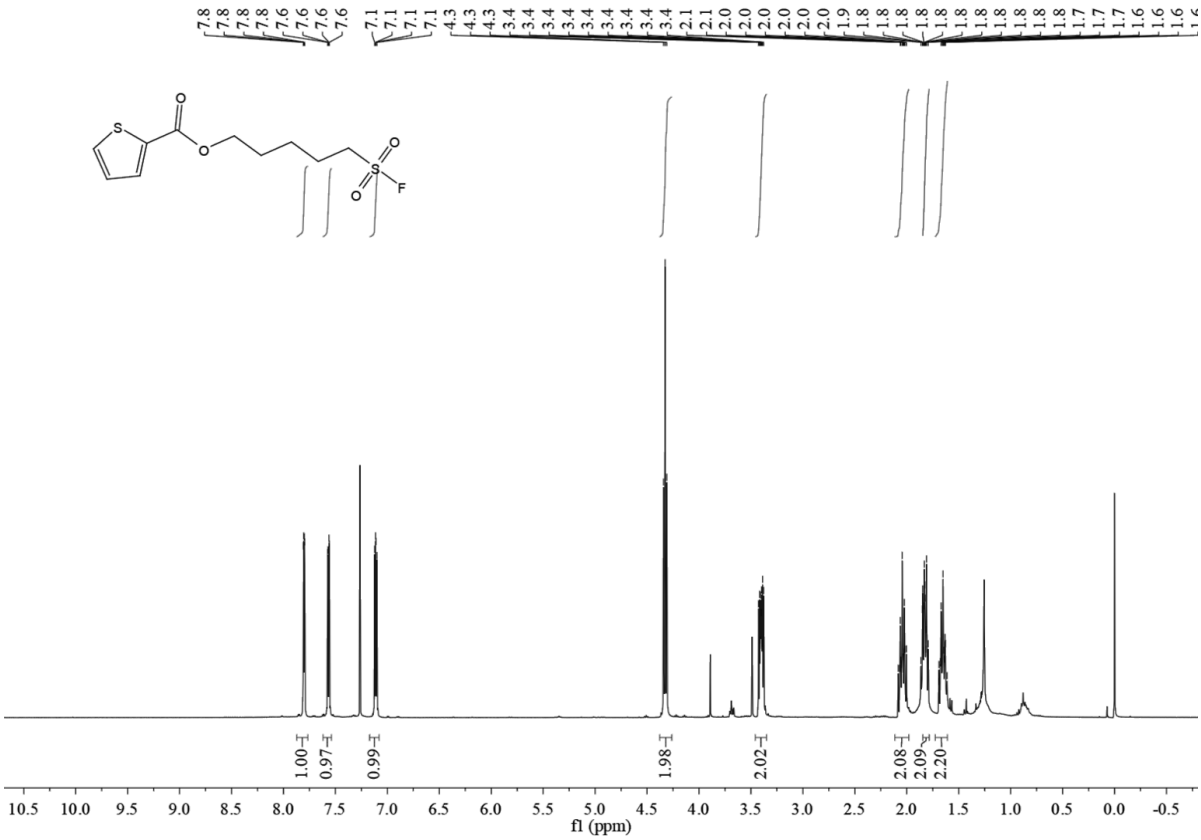


^{19}F NMR

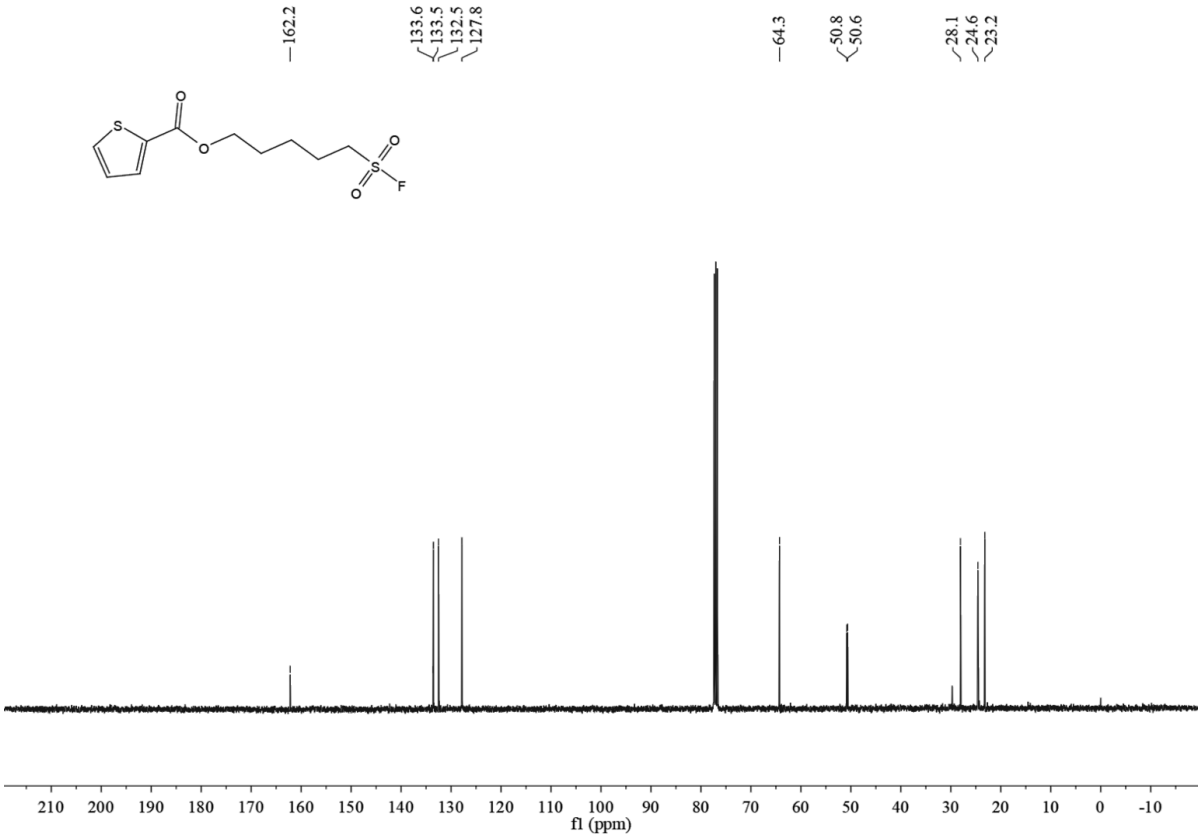


5-(fluorosulfonyl)pentyl thiophene-2-carboxylate **(4w)**

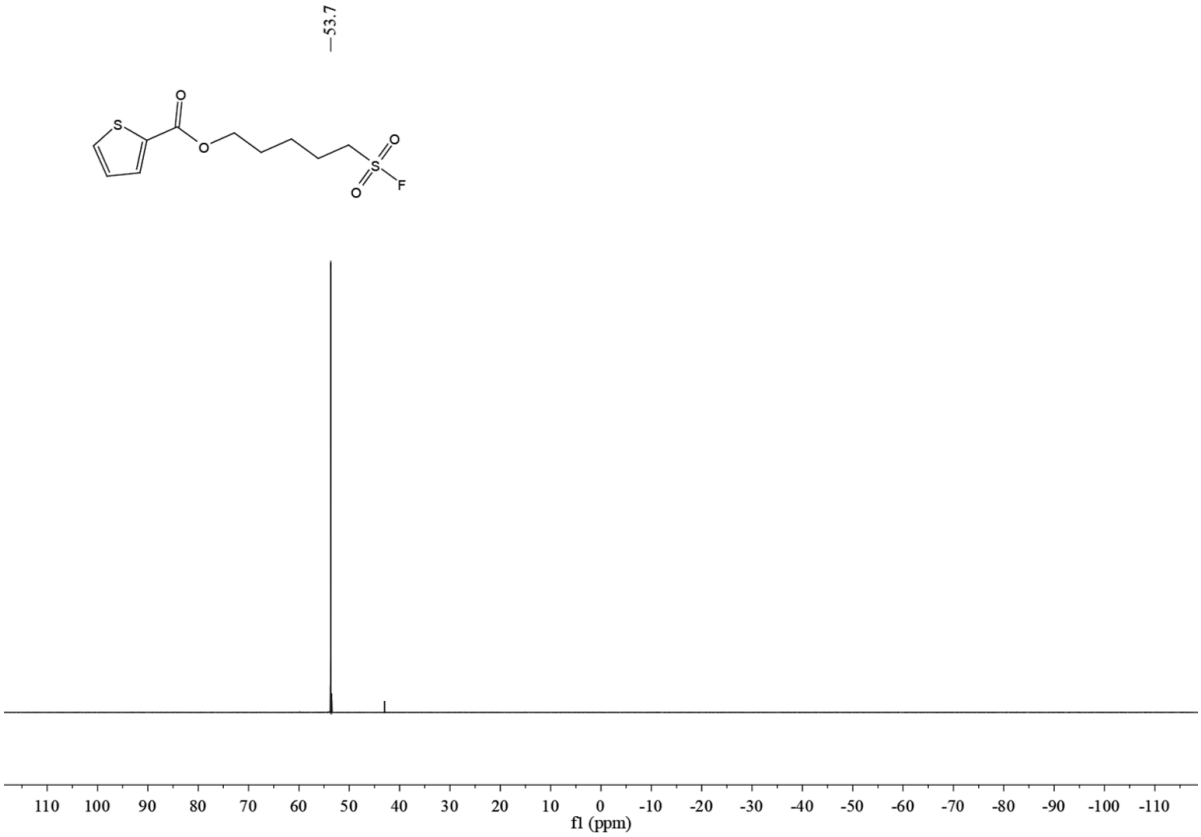
^{1}H NMR



^{13}C NMR

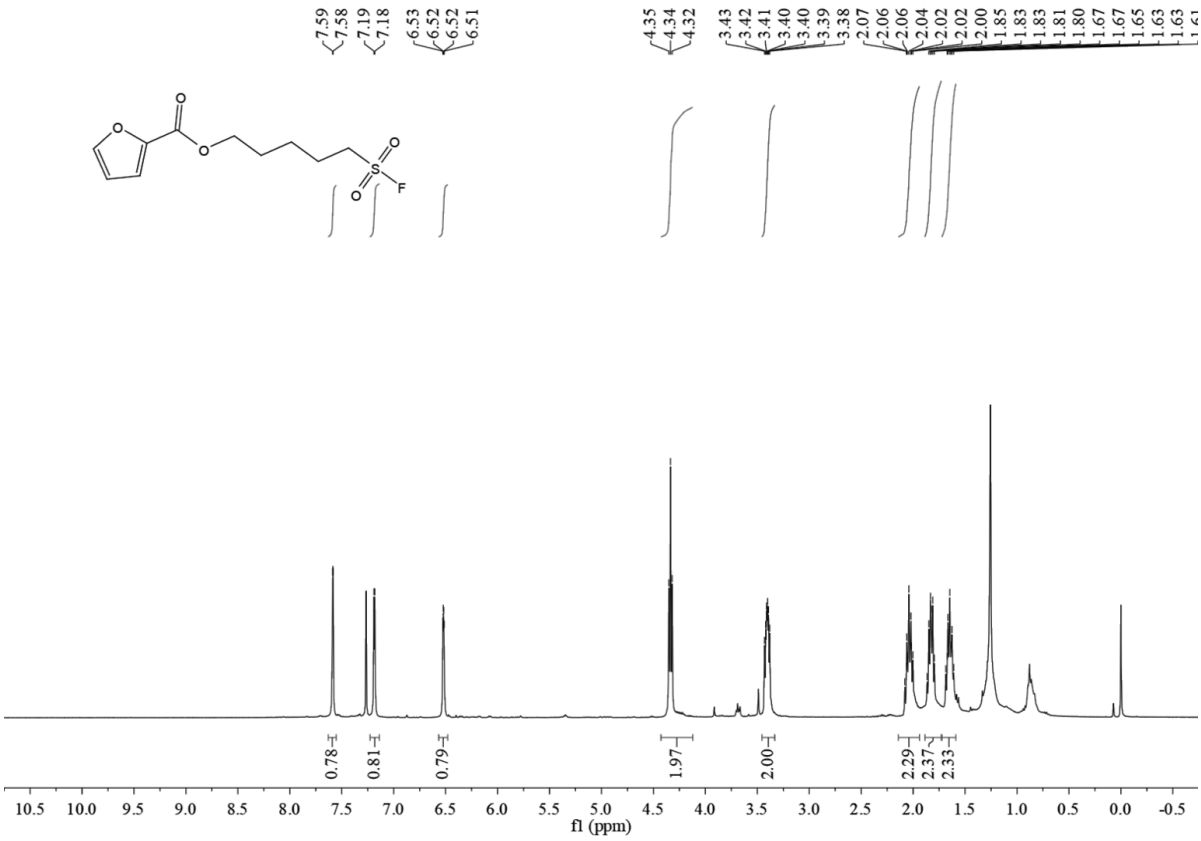


^{19}F NMR

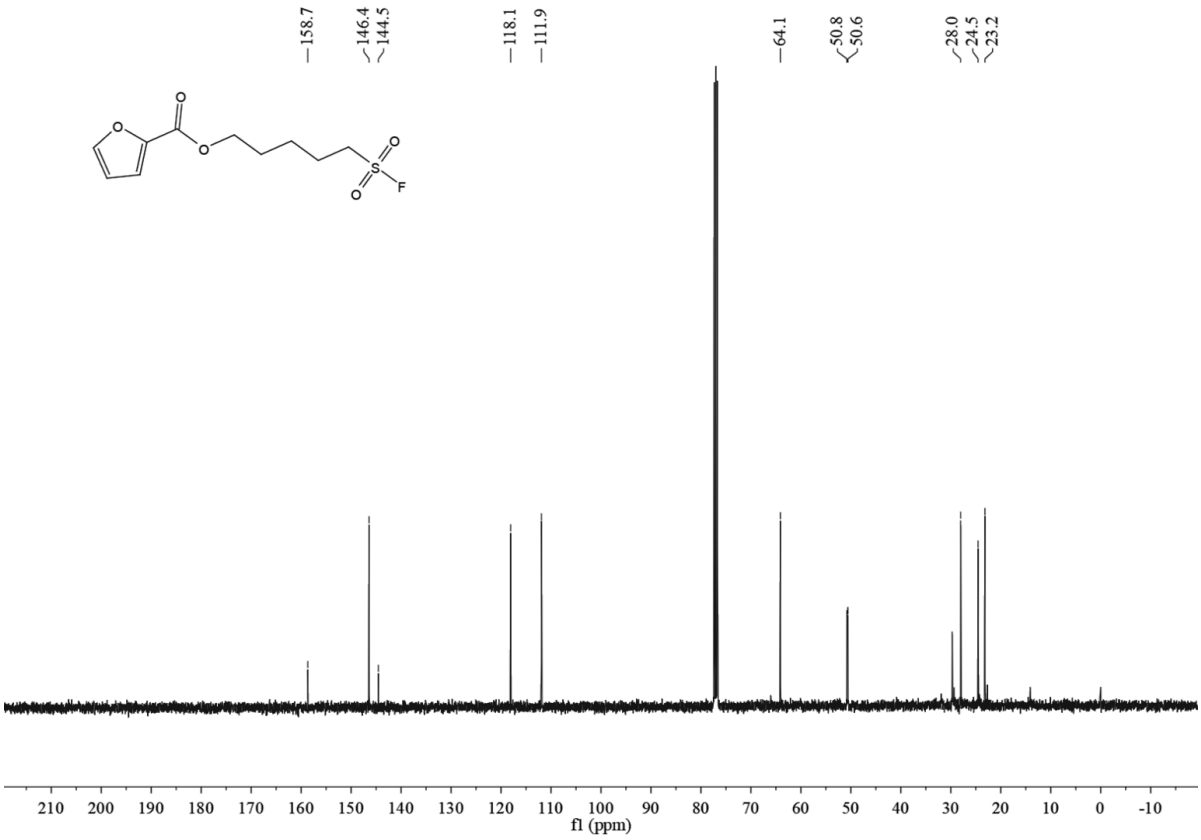


5-(fluorosulfonyl)pentyl furan-2-carboxylate (**4x**)

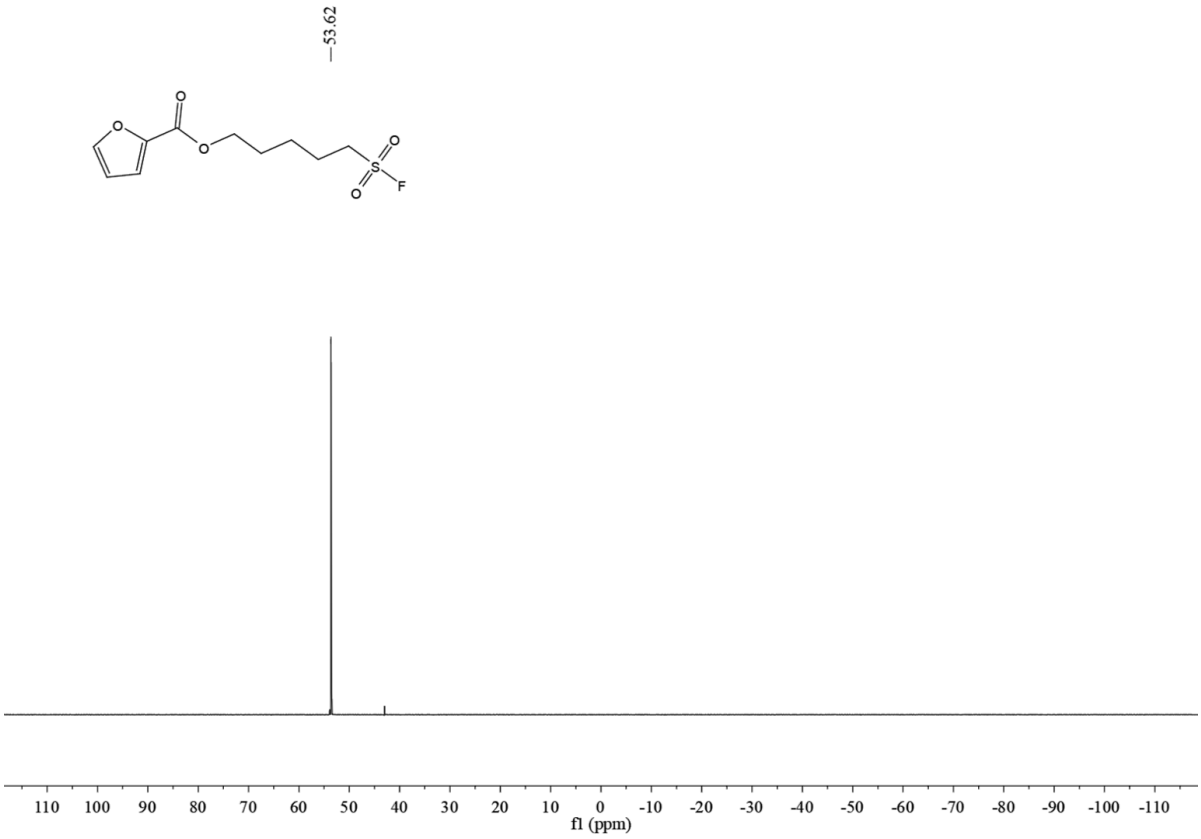
^{1}H NMR



^{13}C NMR

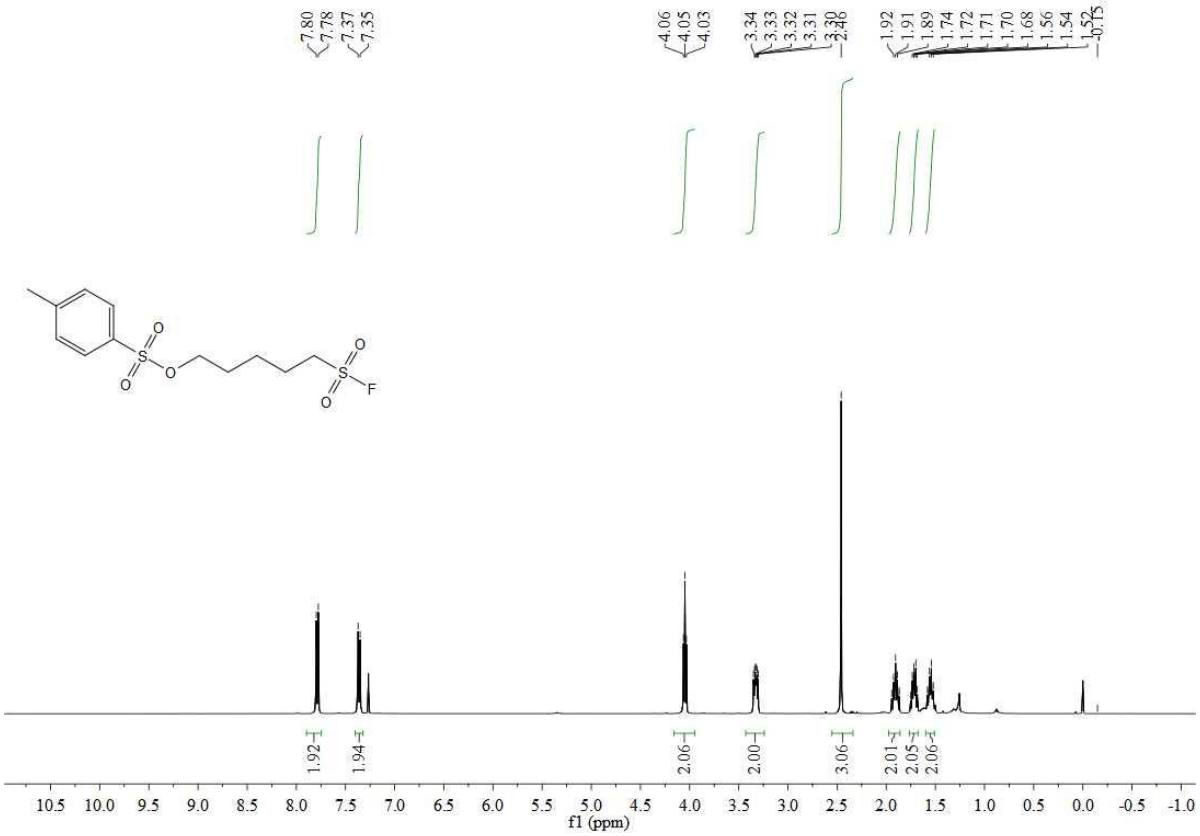


^{19}F NMR

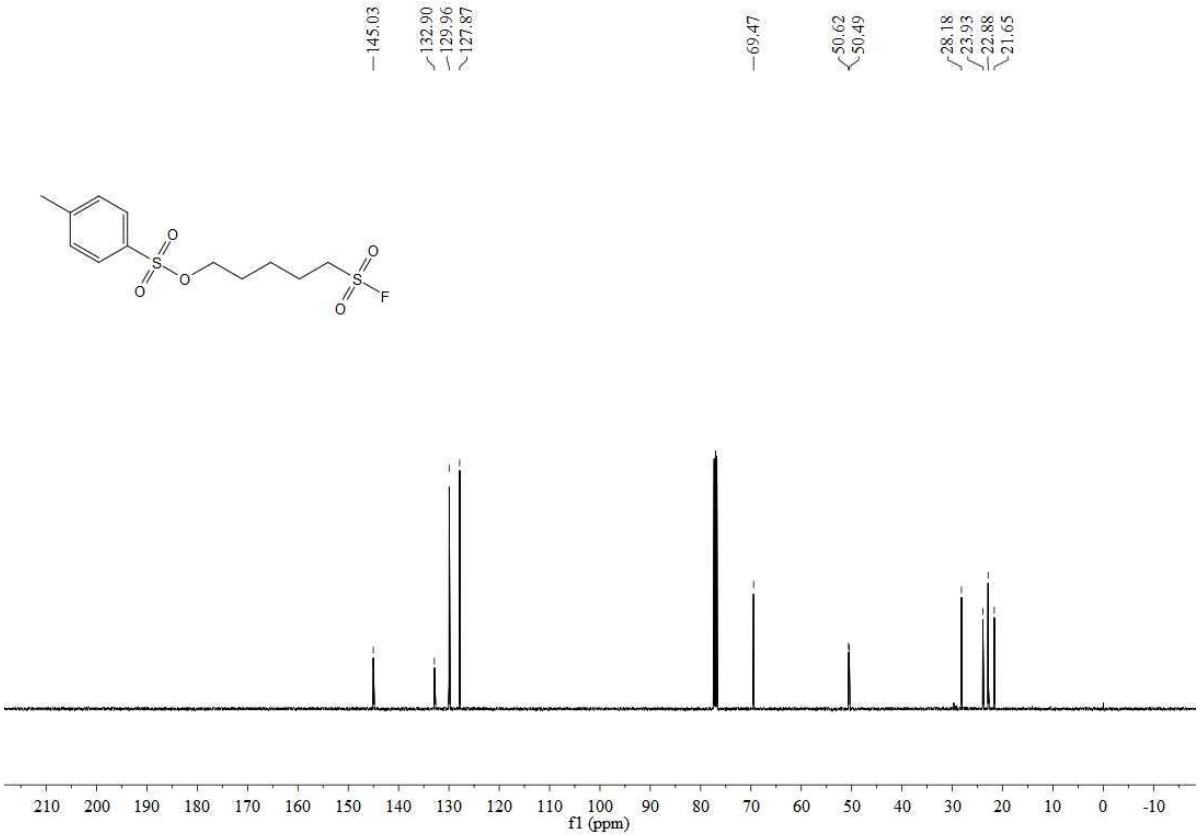


5-(fluorosulfonyl)pentyl 4-methylbenzenesulfonate **(4y)**

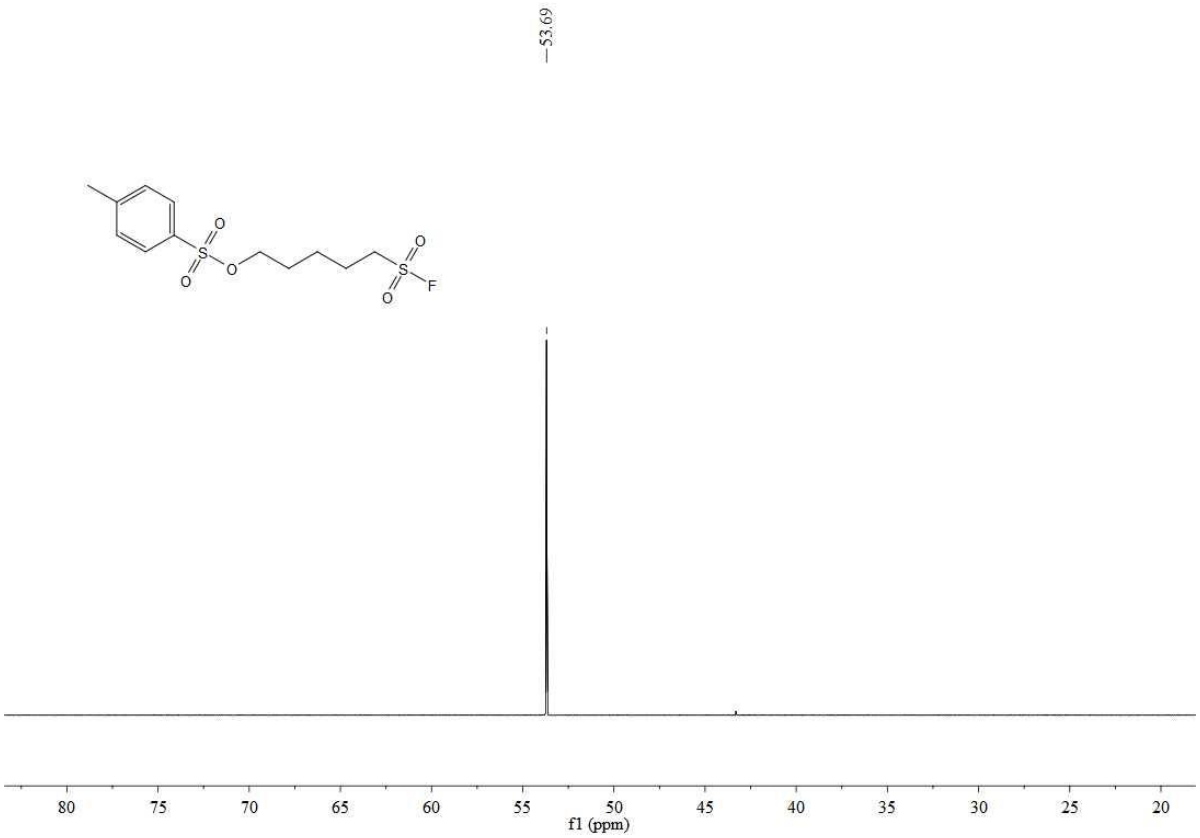
^{1}H NMR



^{13}C NMR

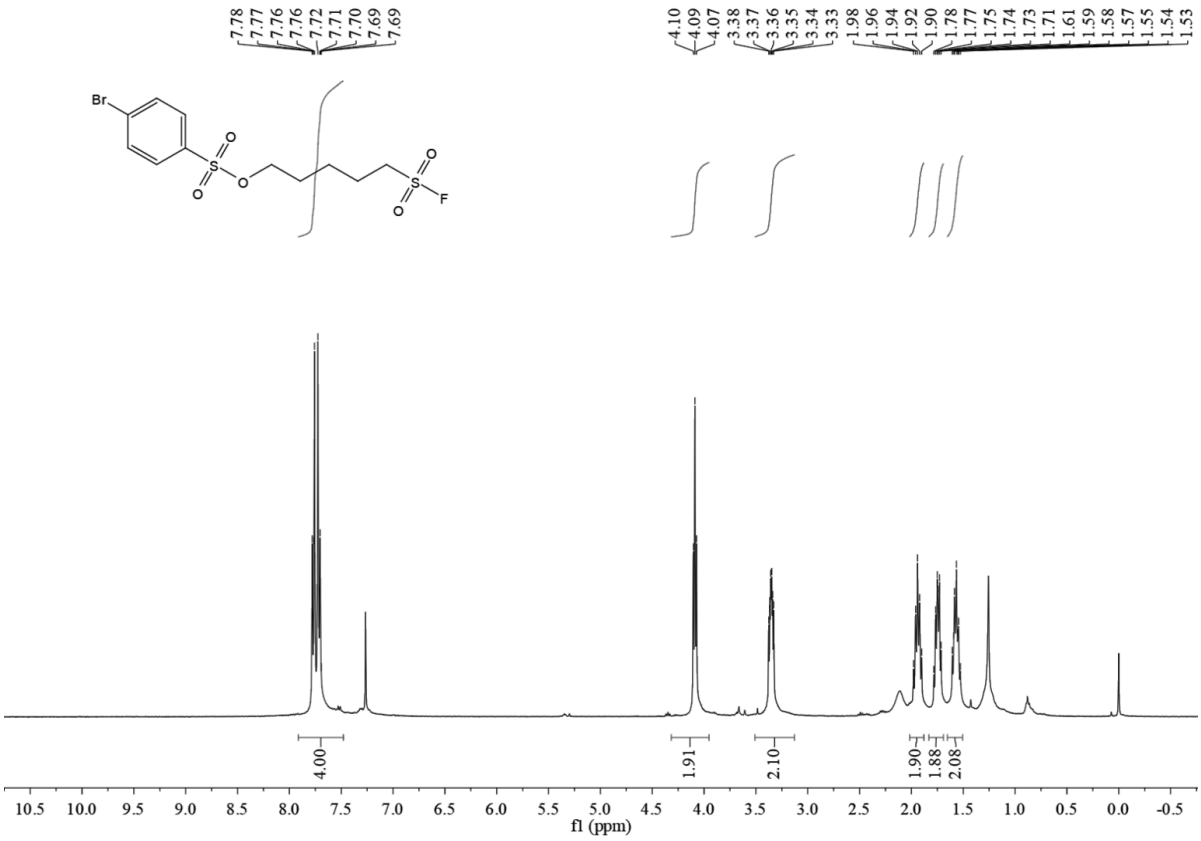


^{19}F NMR

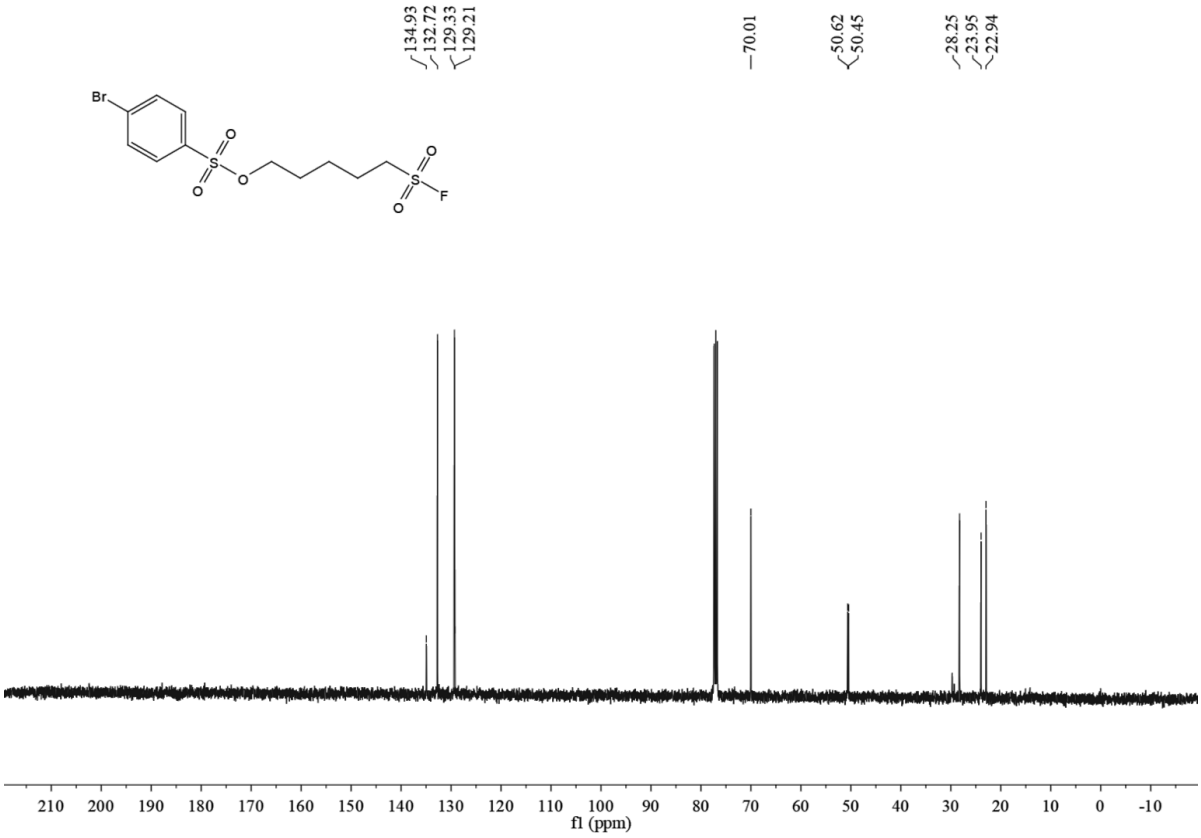


5-(fluorosulfonyl)pentyl 4-bromobenzenesulfonate **(4z)**

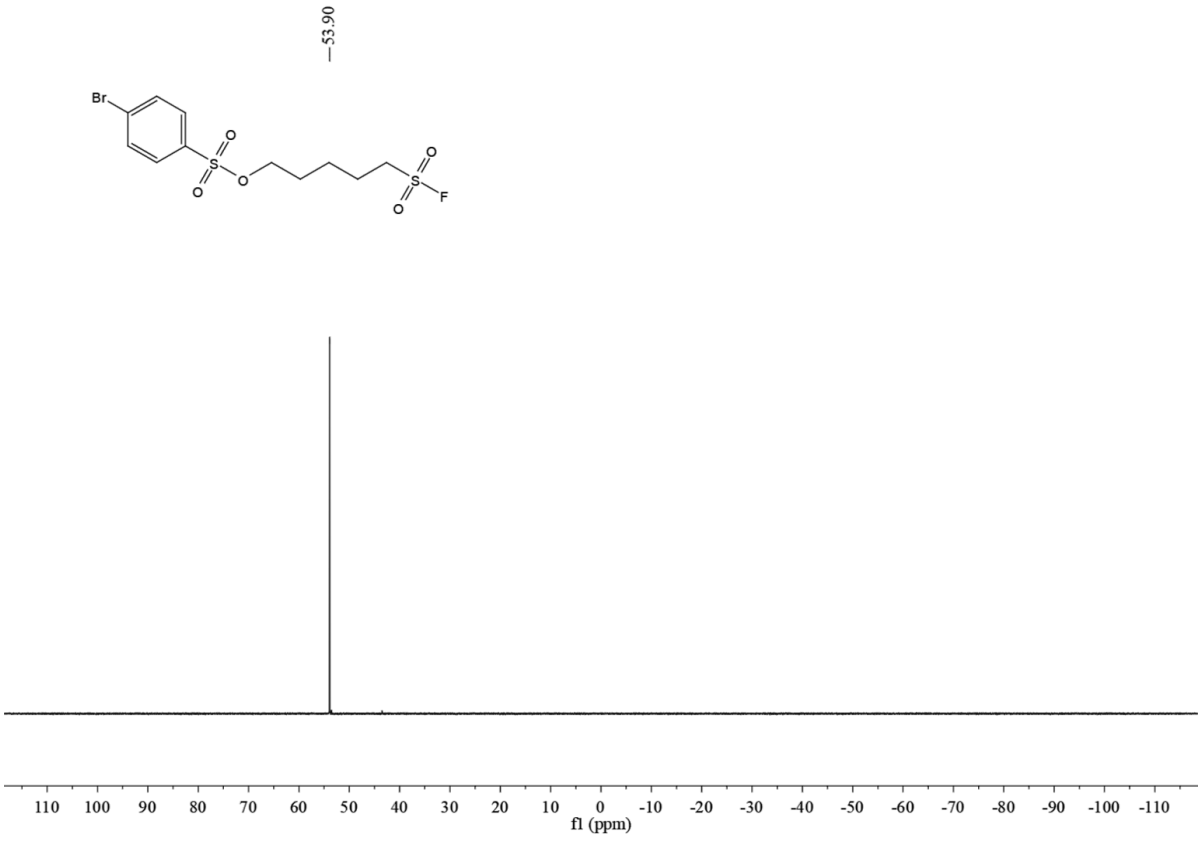
^{1}H NMR



^{13}C NMR

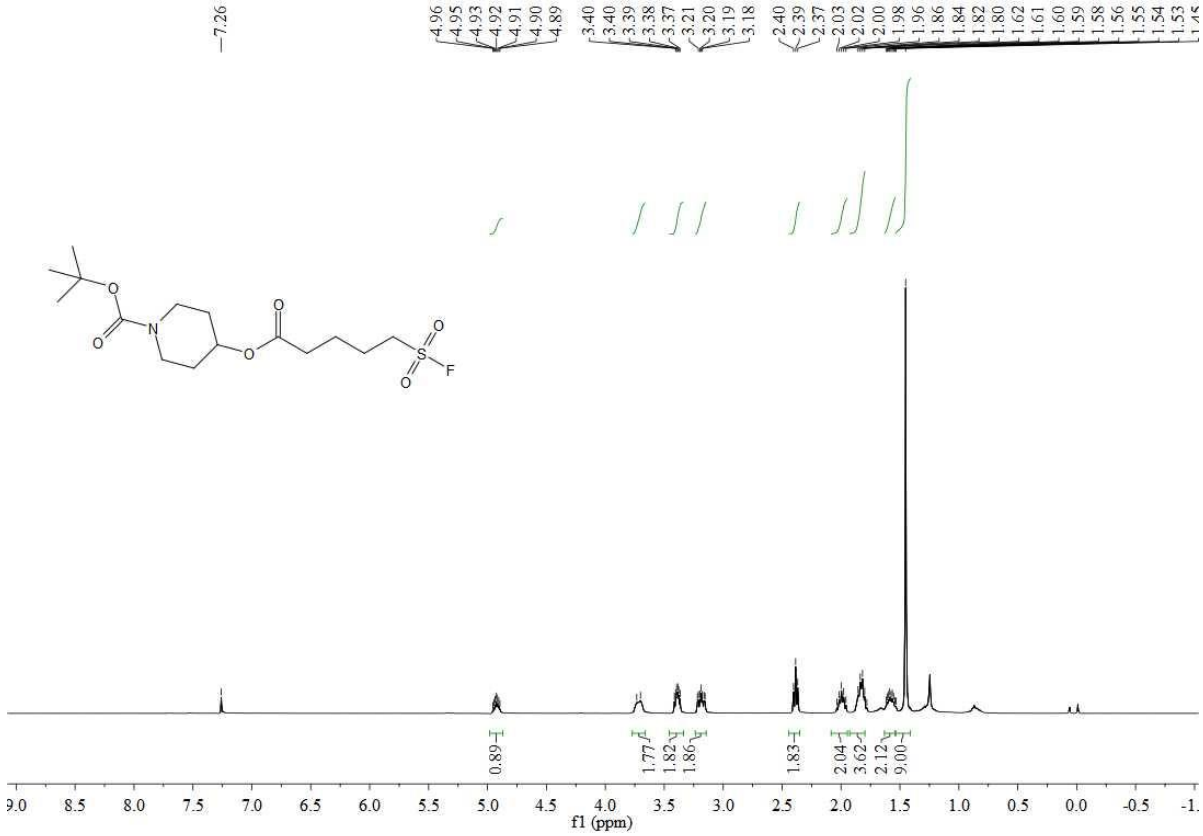


^{19}F NMR

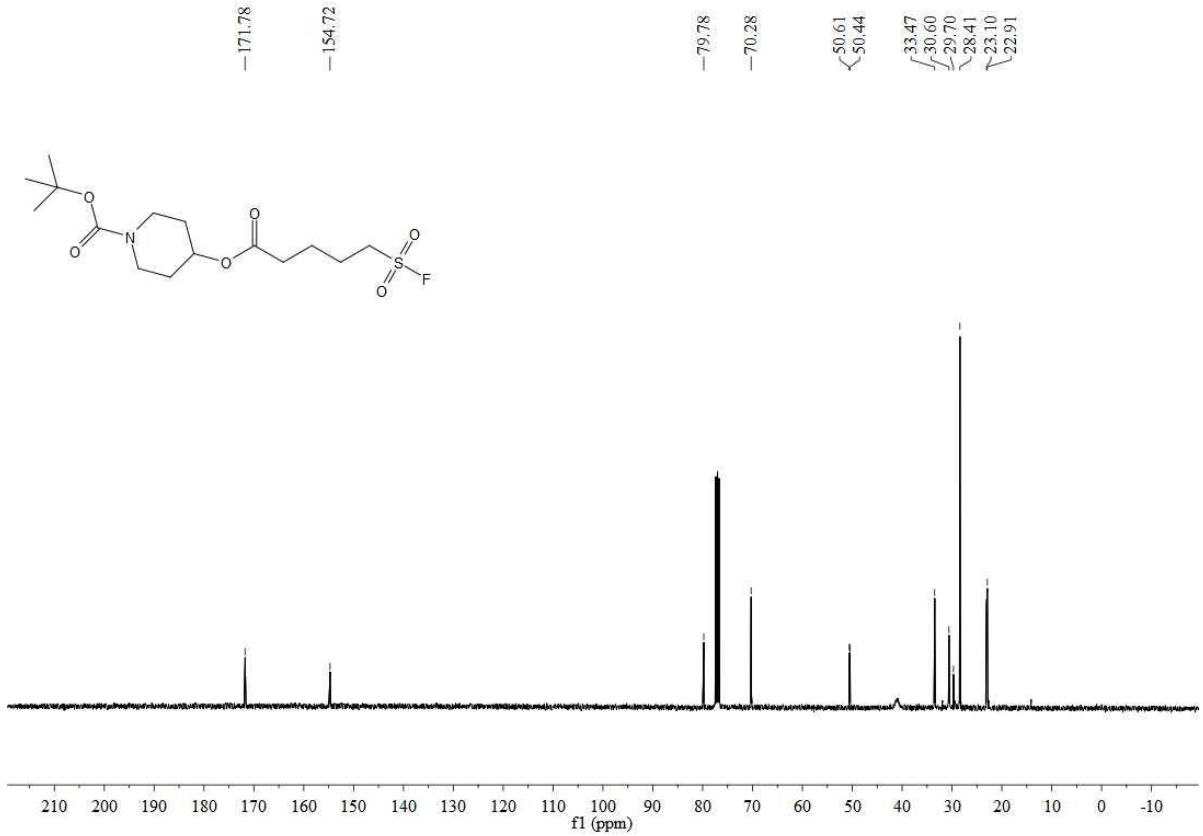


tert-butyl 4-((5-(fluorosulfonyl)pentanoyl)oxy)piperidine-1-carboxylate **(4aa)**

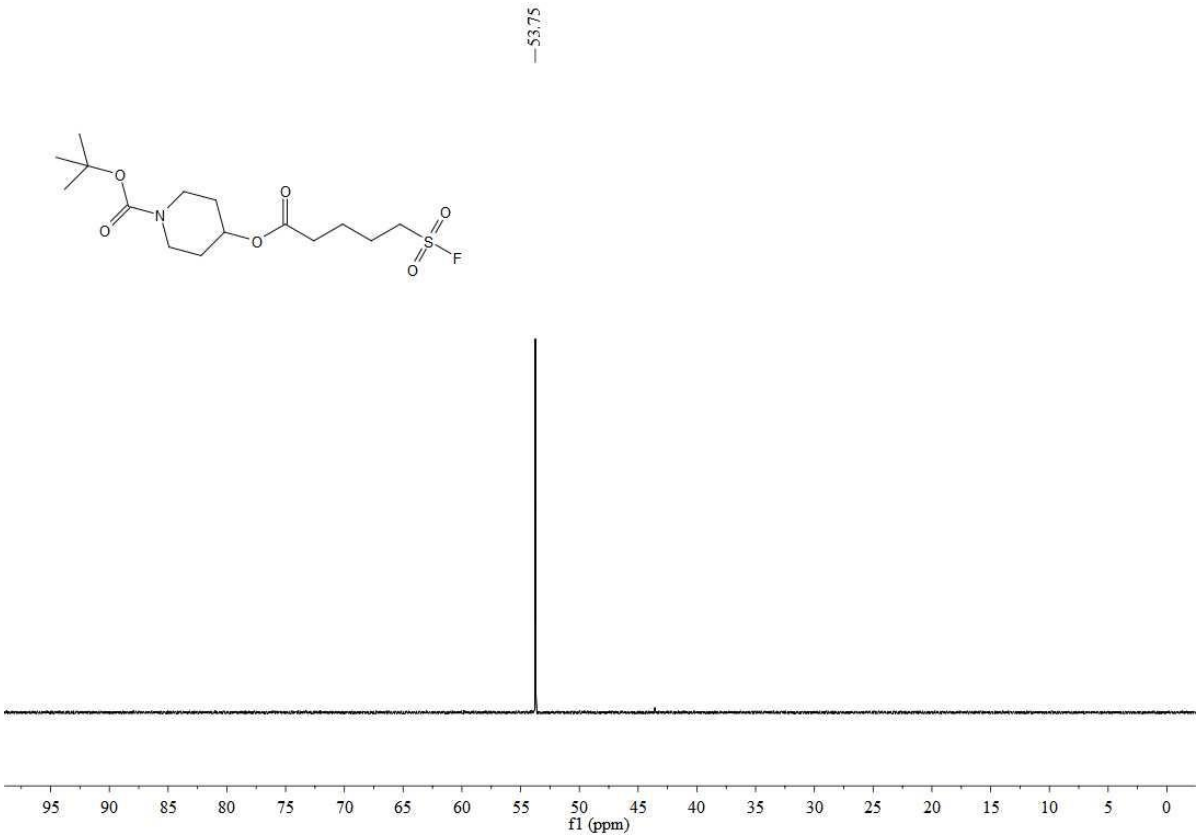
^{1}H NMR



^{13}C NMR

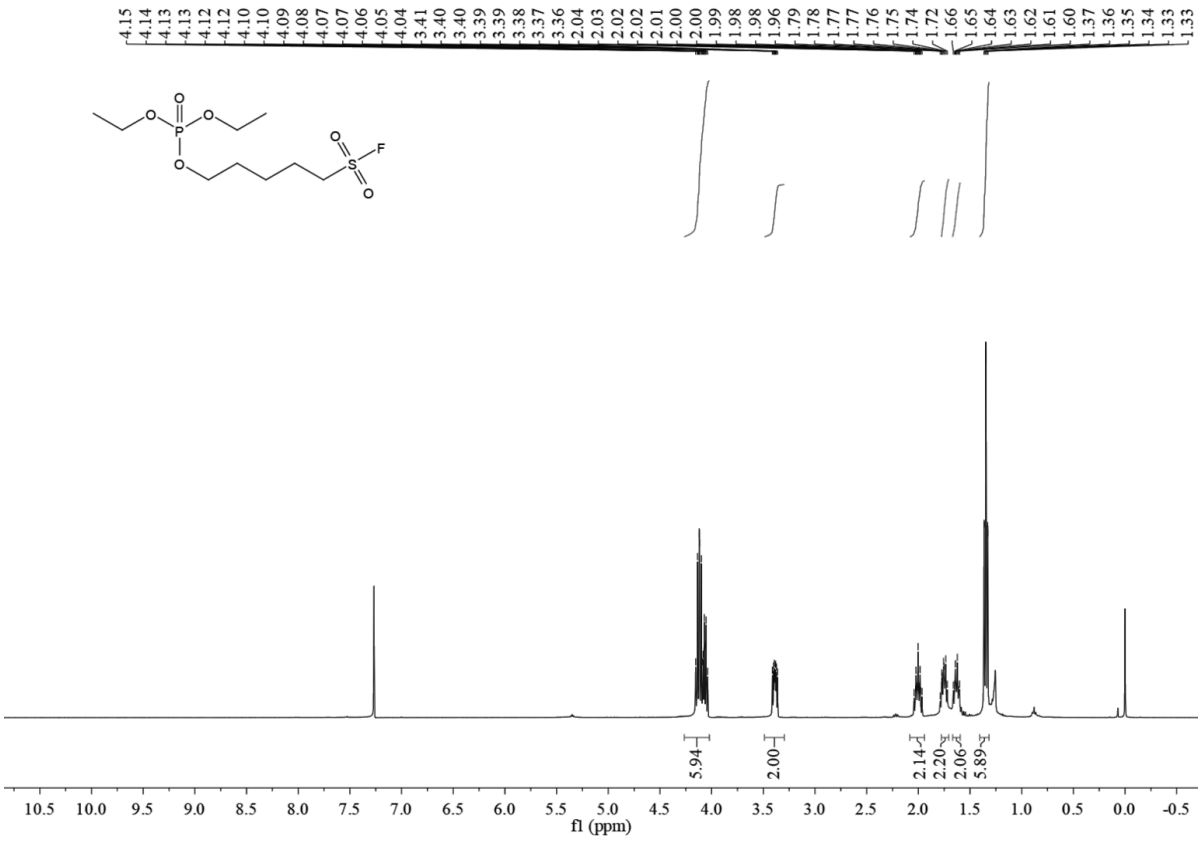


^{19}F NMR

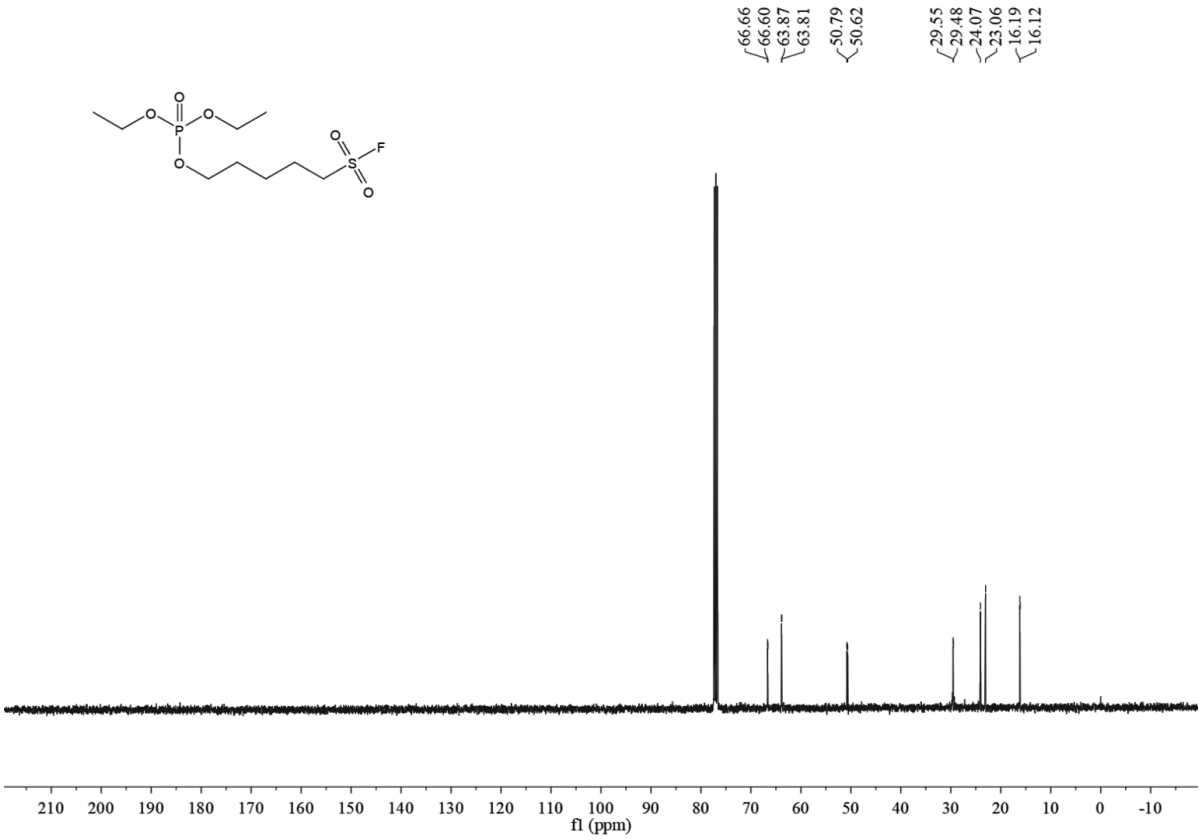


diethyl (5-(fluorosulfonyl)pentyl) phosphate **(4ab)**

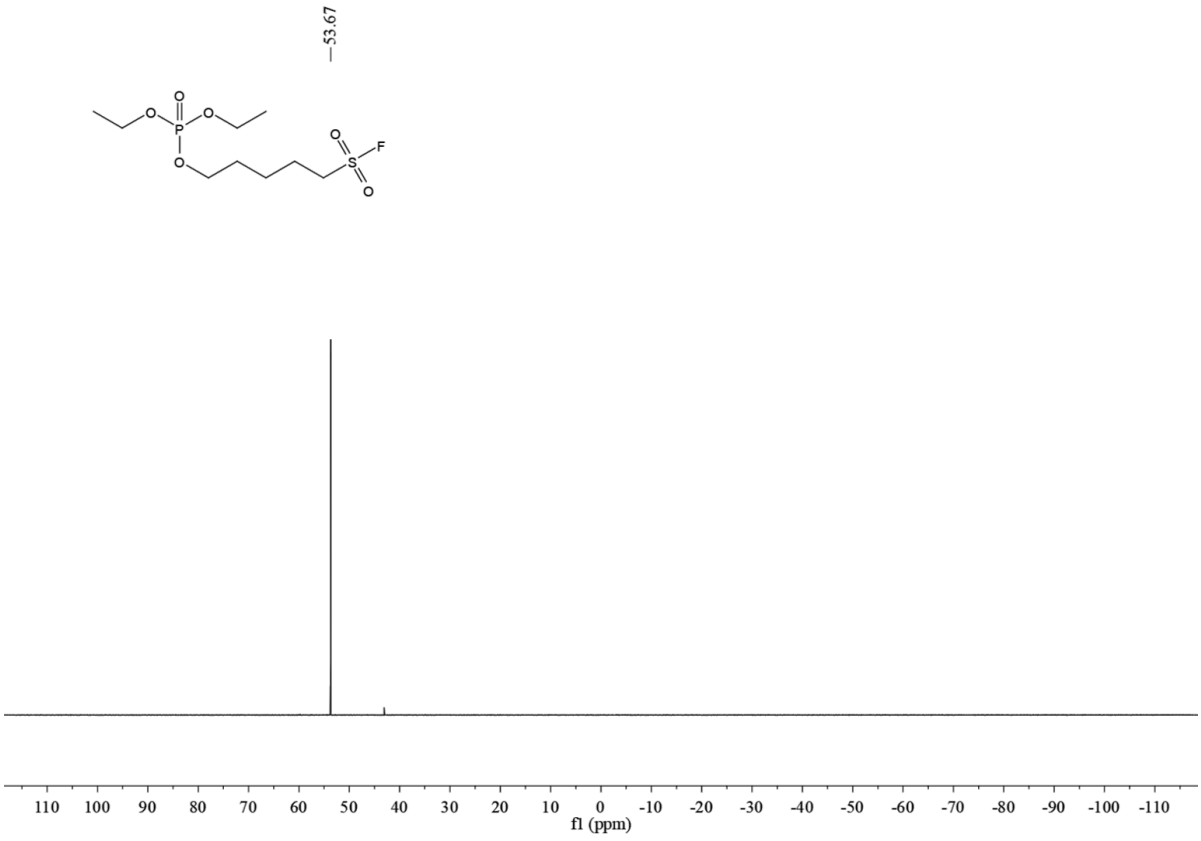
^{1}H NMR



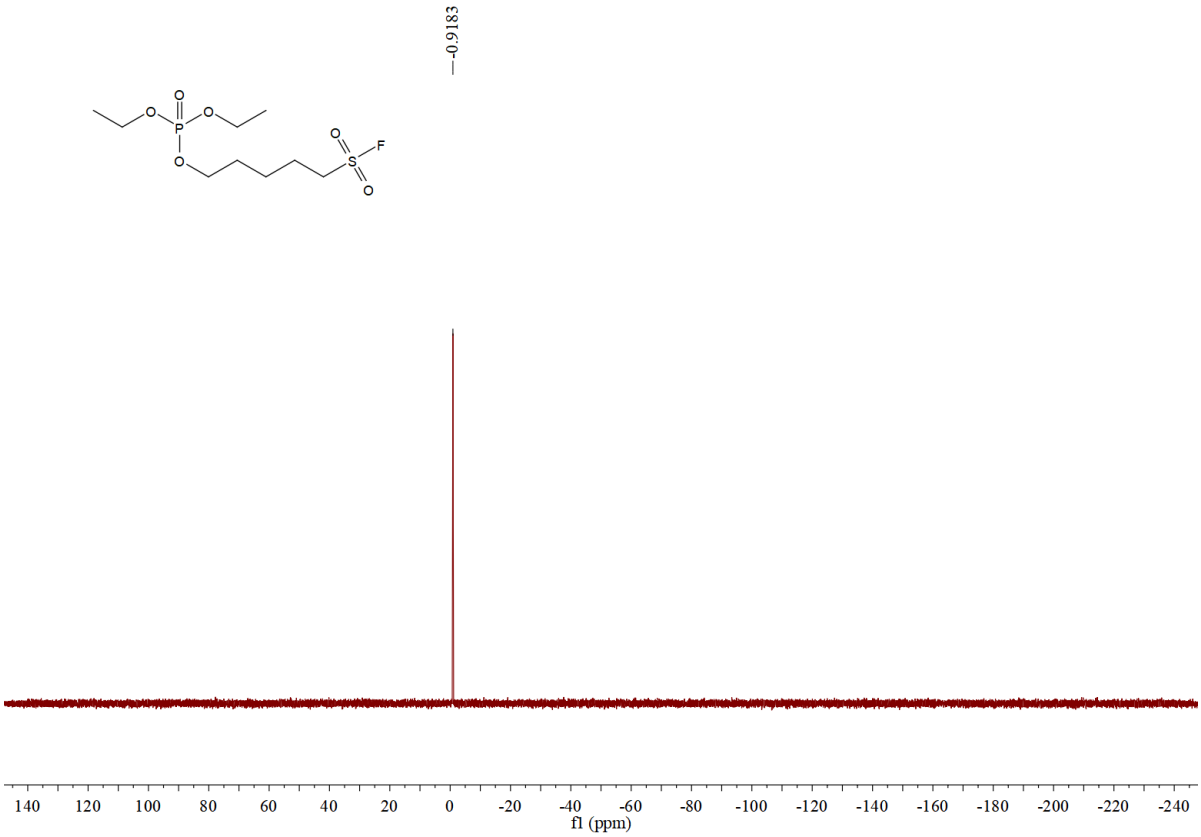
^{13}C NMR



^{19}F NMR

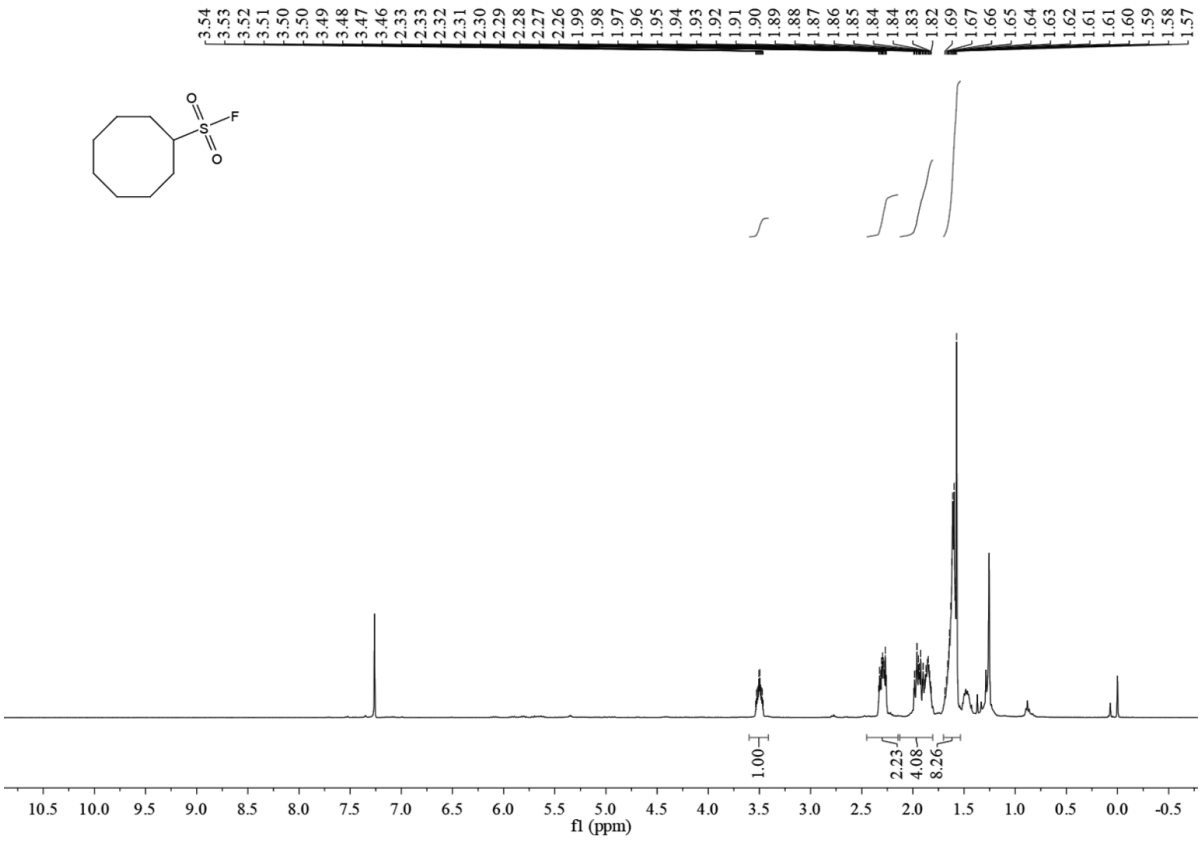


^{31}P NMR

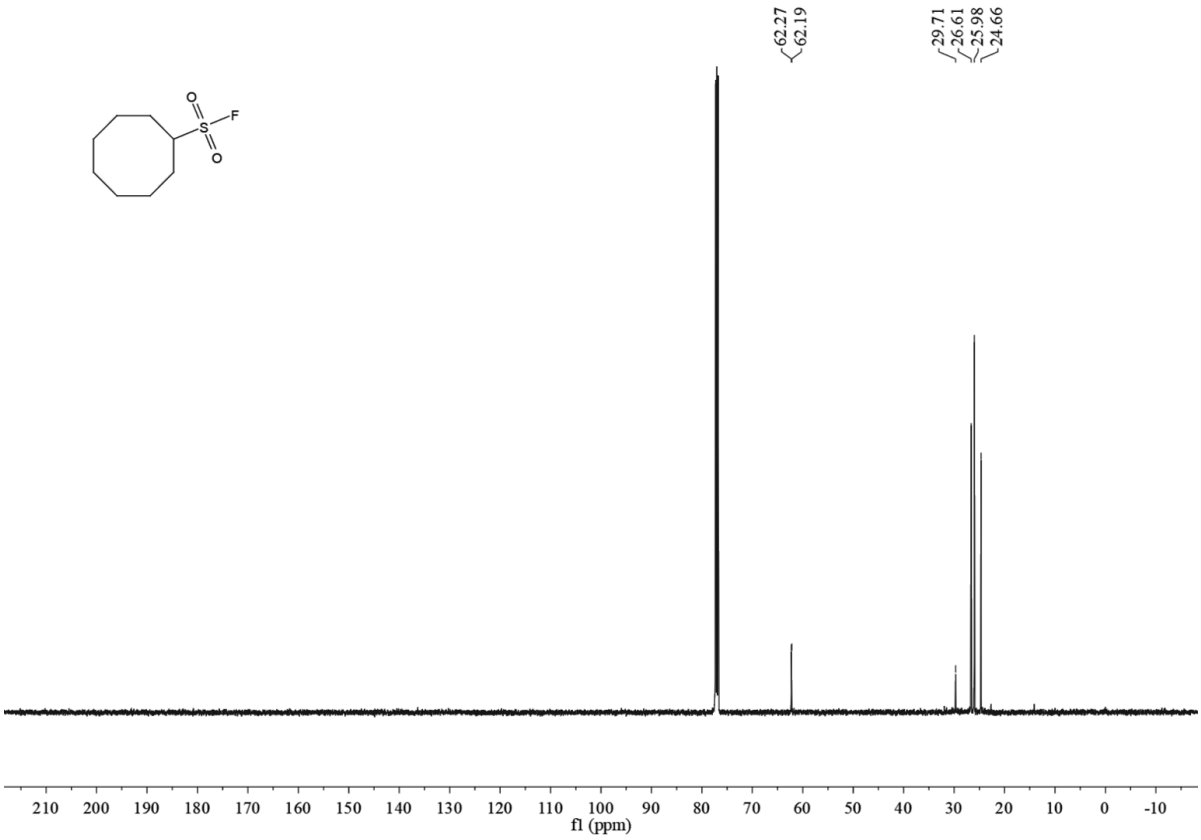


cyclooctanesulfonyl fluoride **(4ac)**

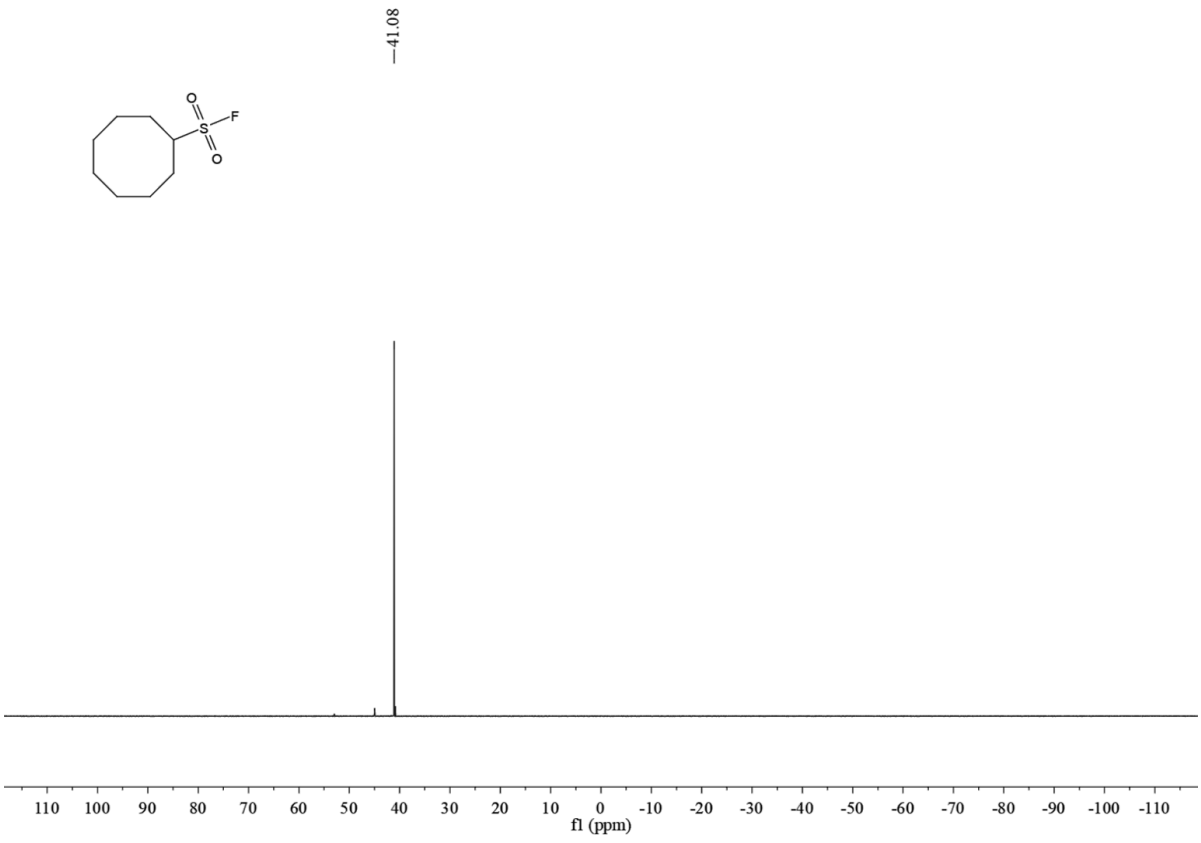
^{1}H NMR



^{13}C NMR

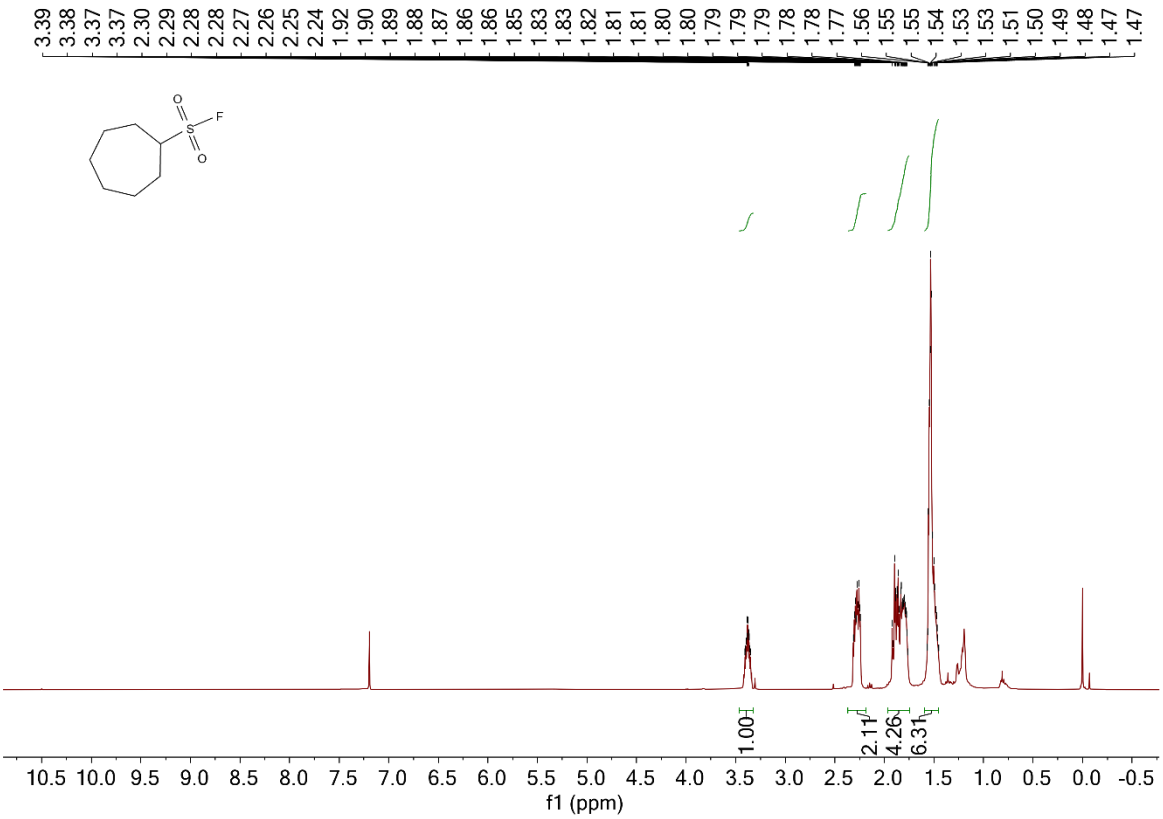


^{19}F NMR

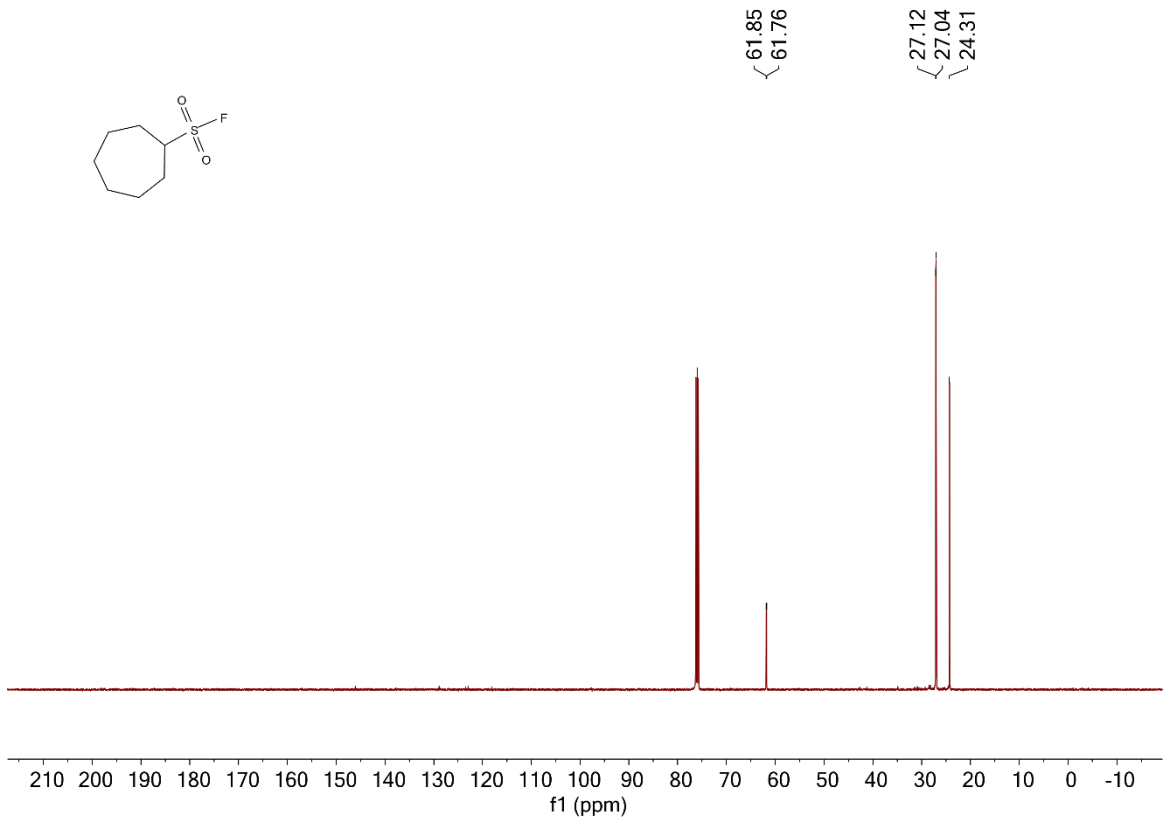


cycloheptanesulfonyl fluoride **(4ad)**

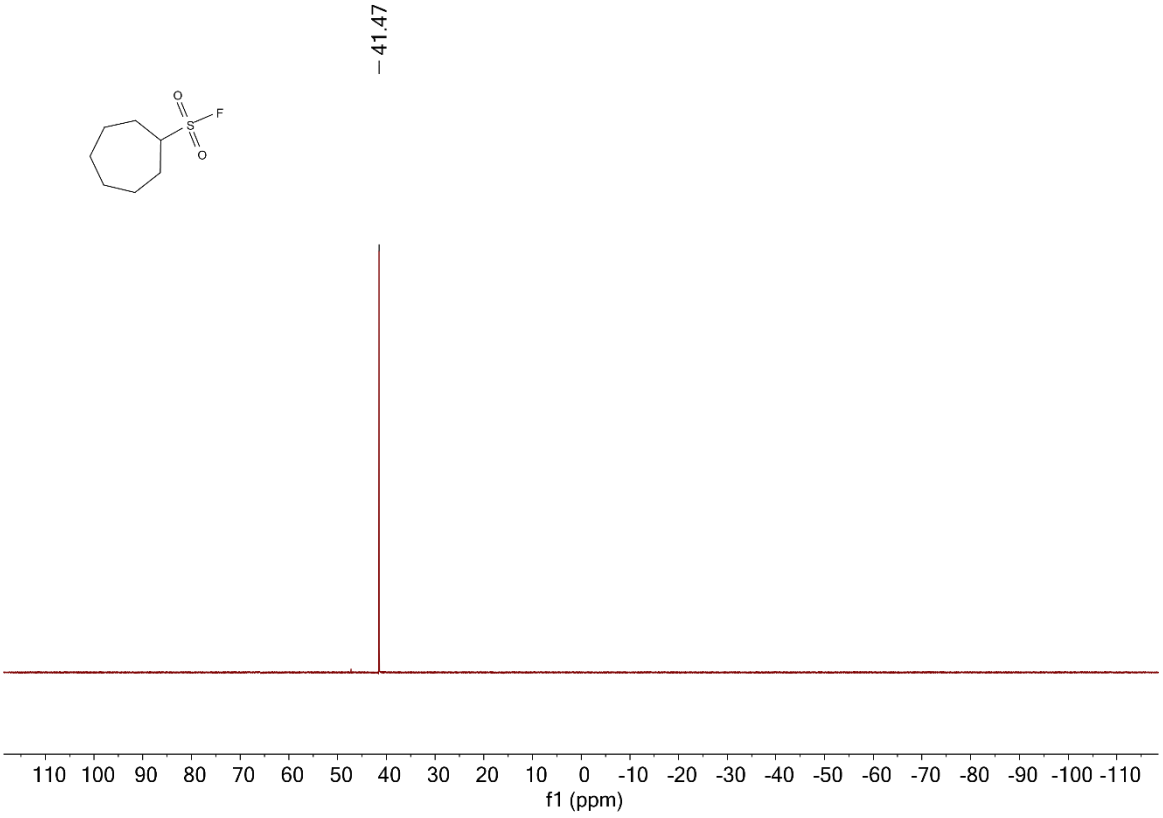
^{1}H NMR



^{13}C NMR

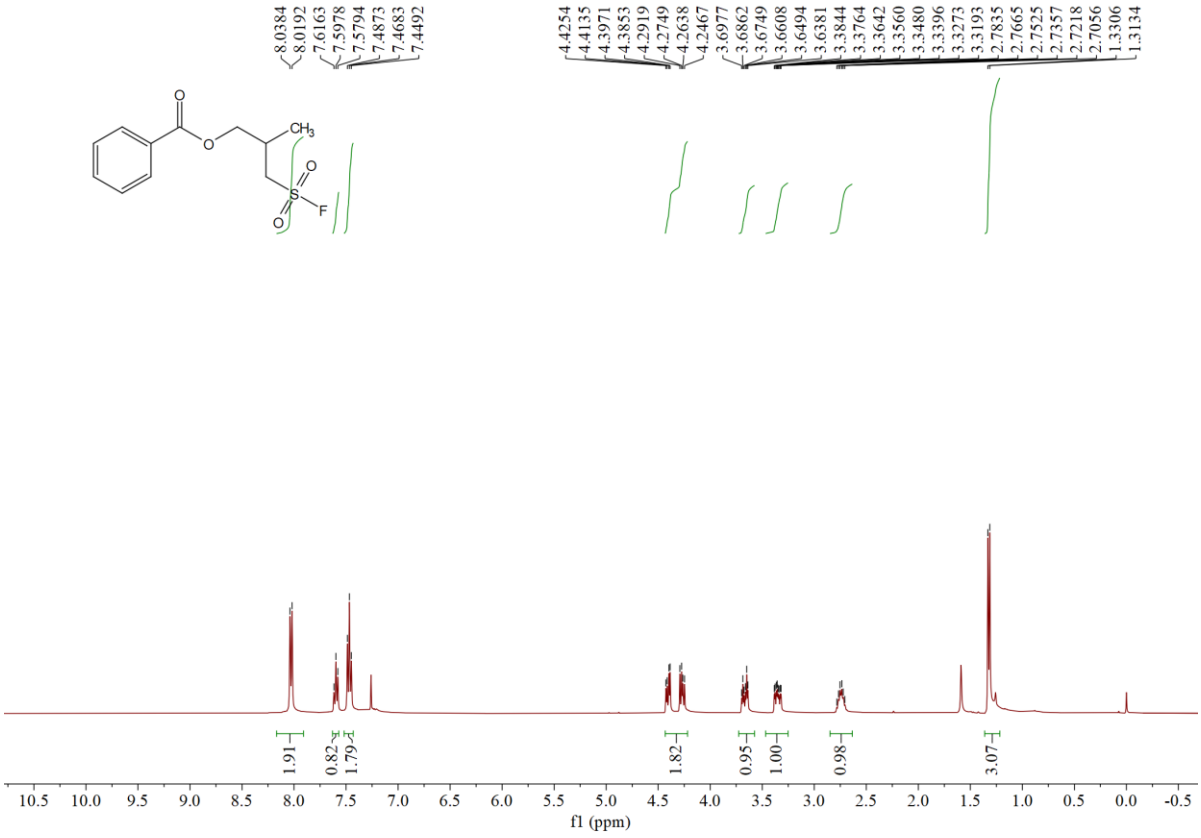


^{19}F NMR

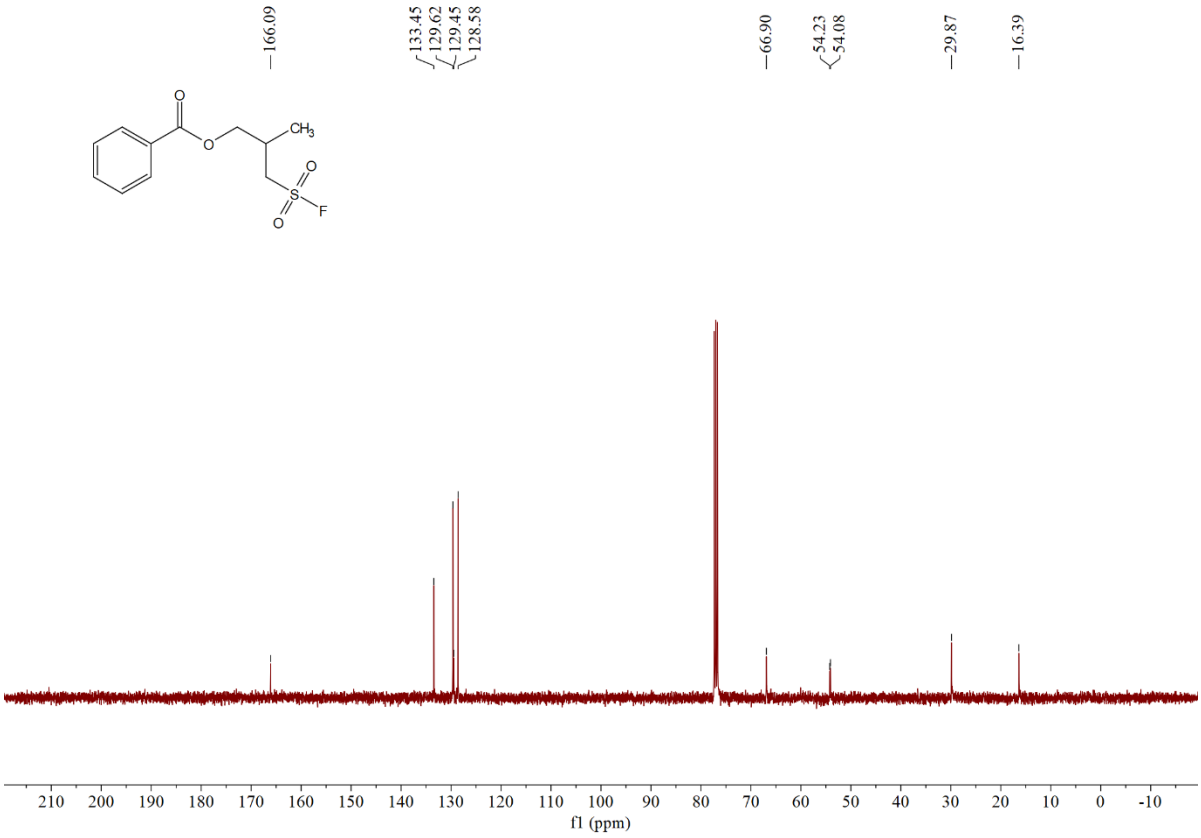


3-(fluorosulfonyl)-2-methylpropyl benzoate **(4ae)**

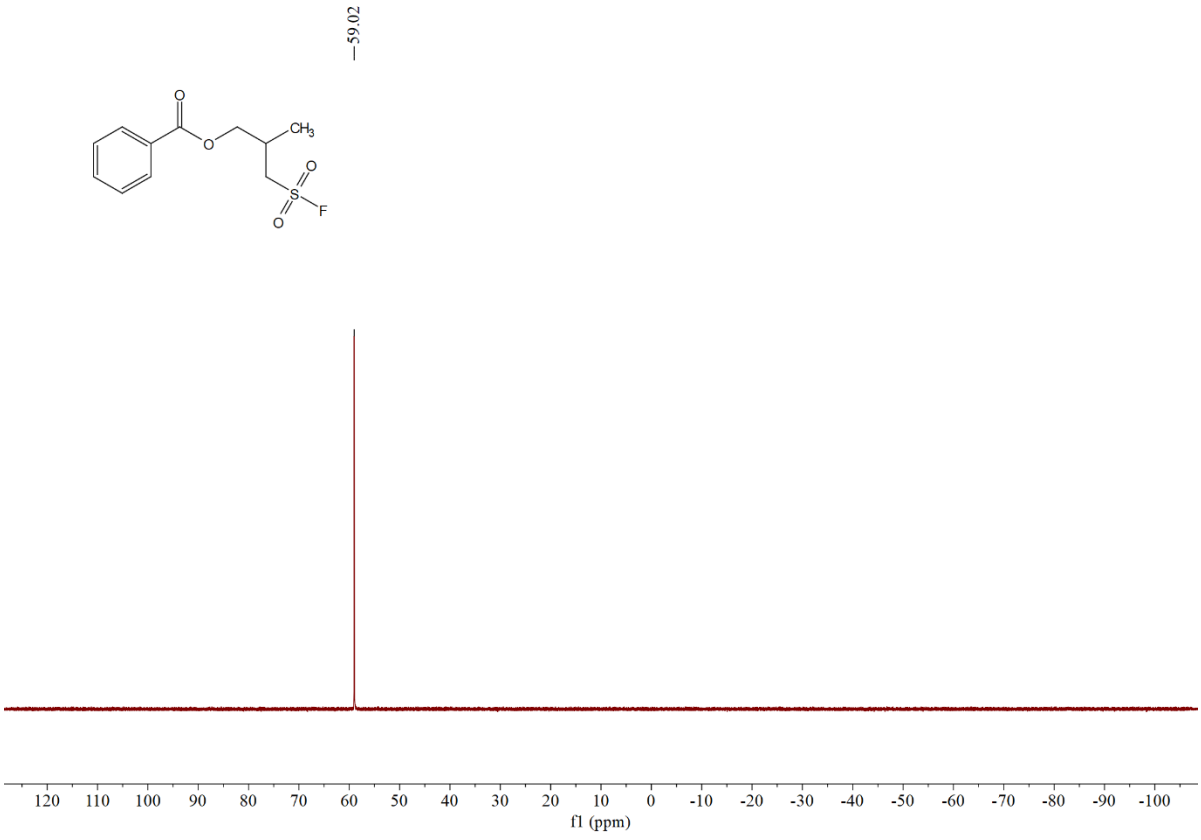
^{1}H NMR



^{13}C NMR

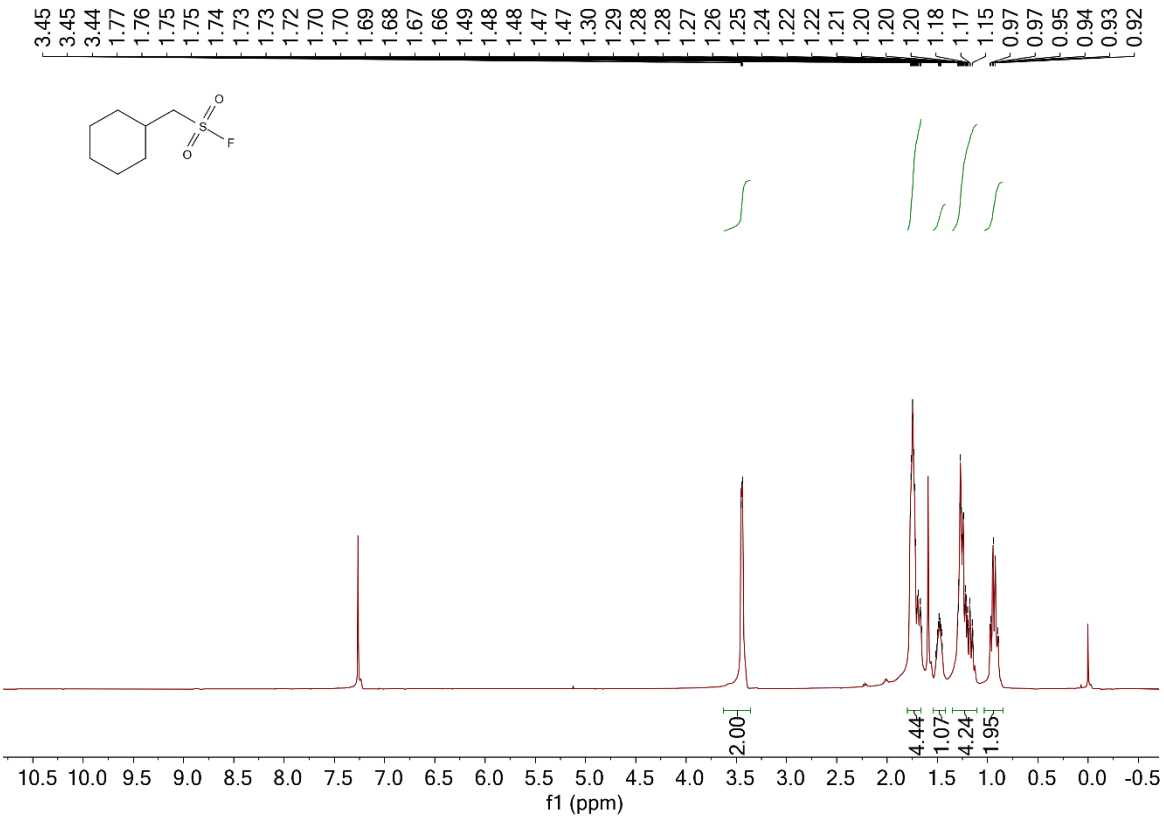


^{19}F NMR

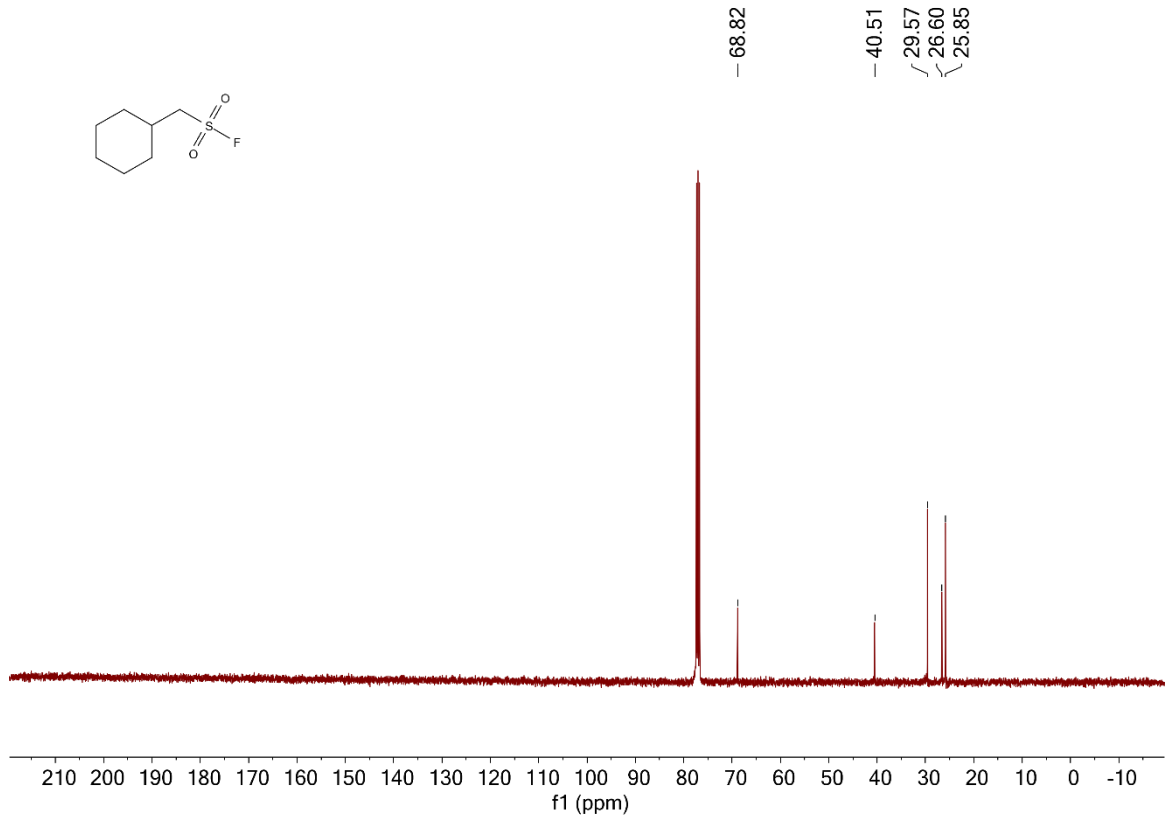


cyclohexylmethanesulfonyl fluoride **(4af)**

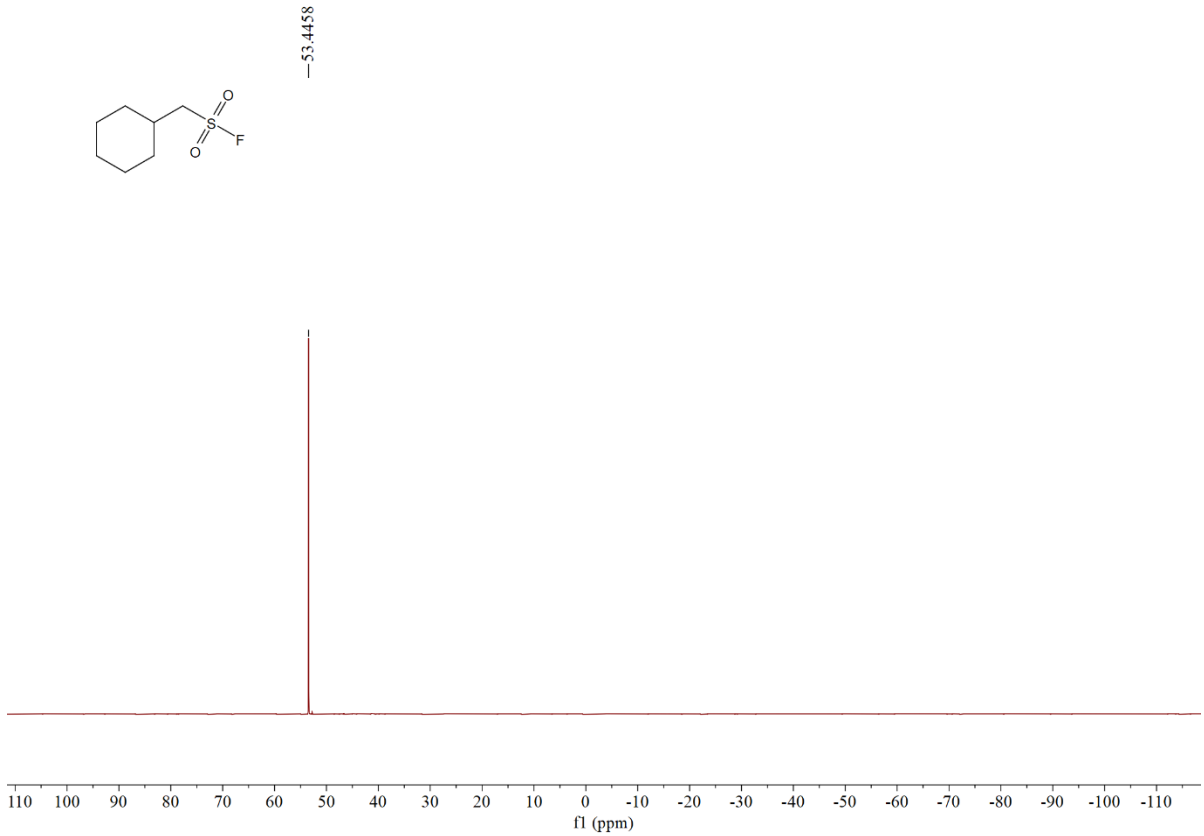
^{1}H NMR



^{13}C NMR

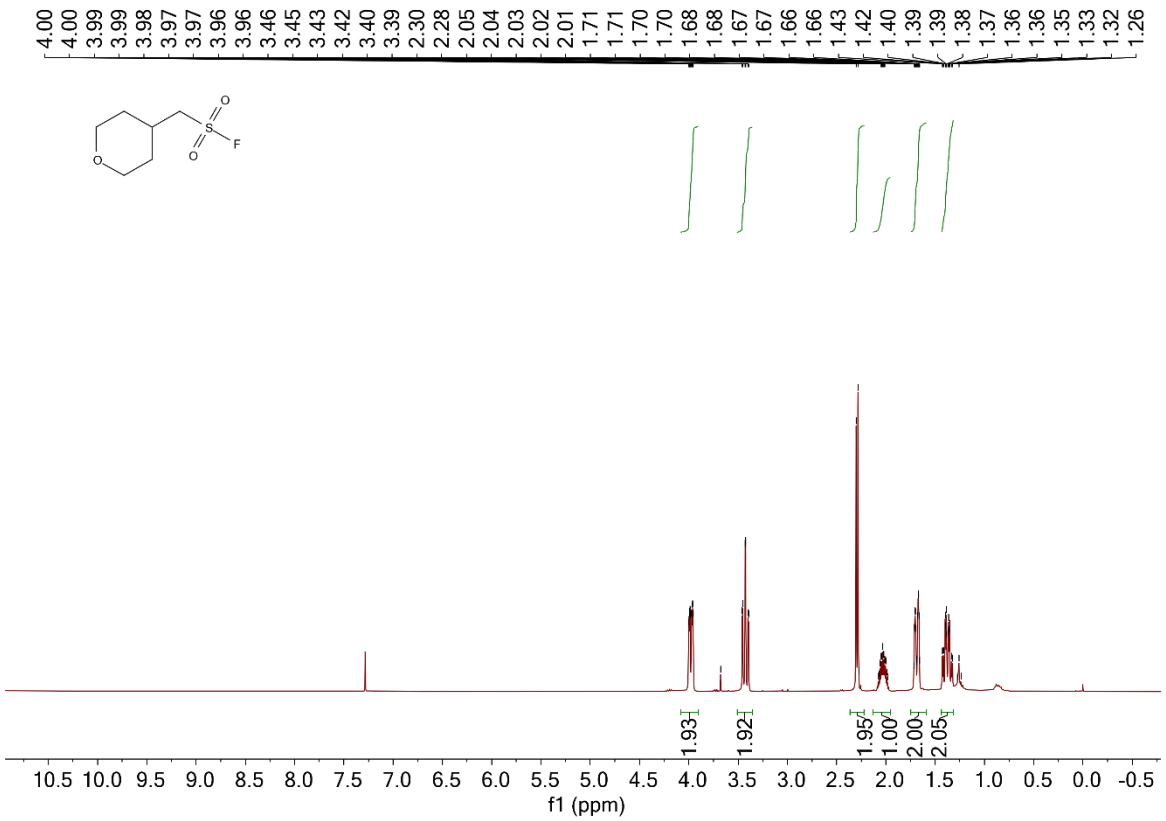


^{19}F NMR

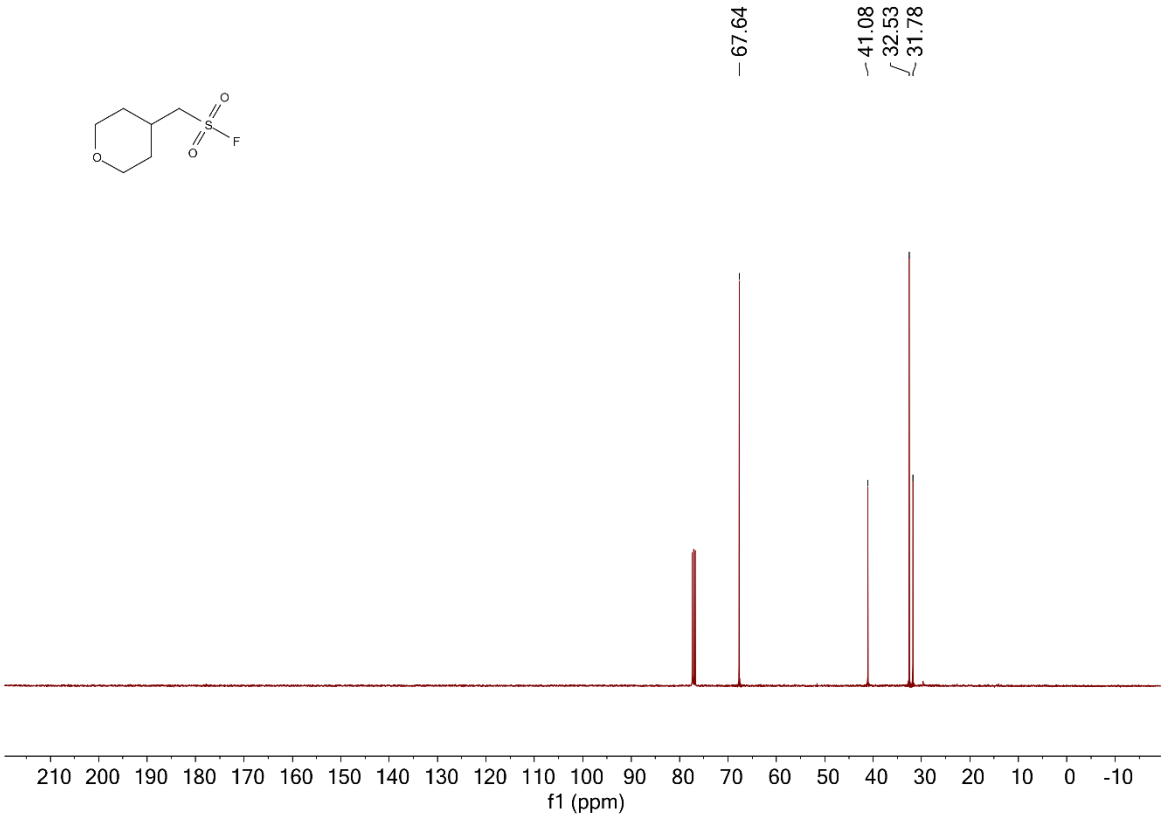


(tetrahydro-2H-pyran-4-yl)methanesulfonyl fluoride **(4ag)**

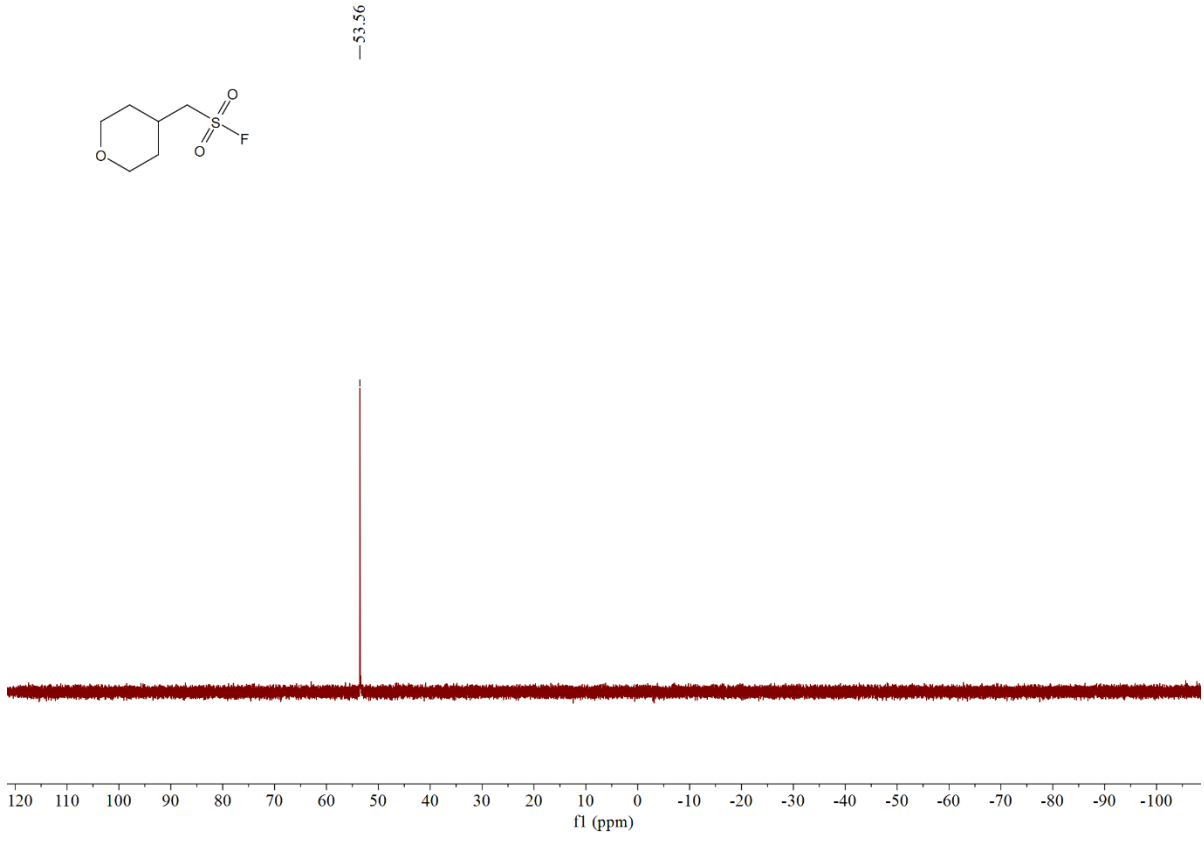
^{1}H NMR



^{13}C NMR

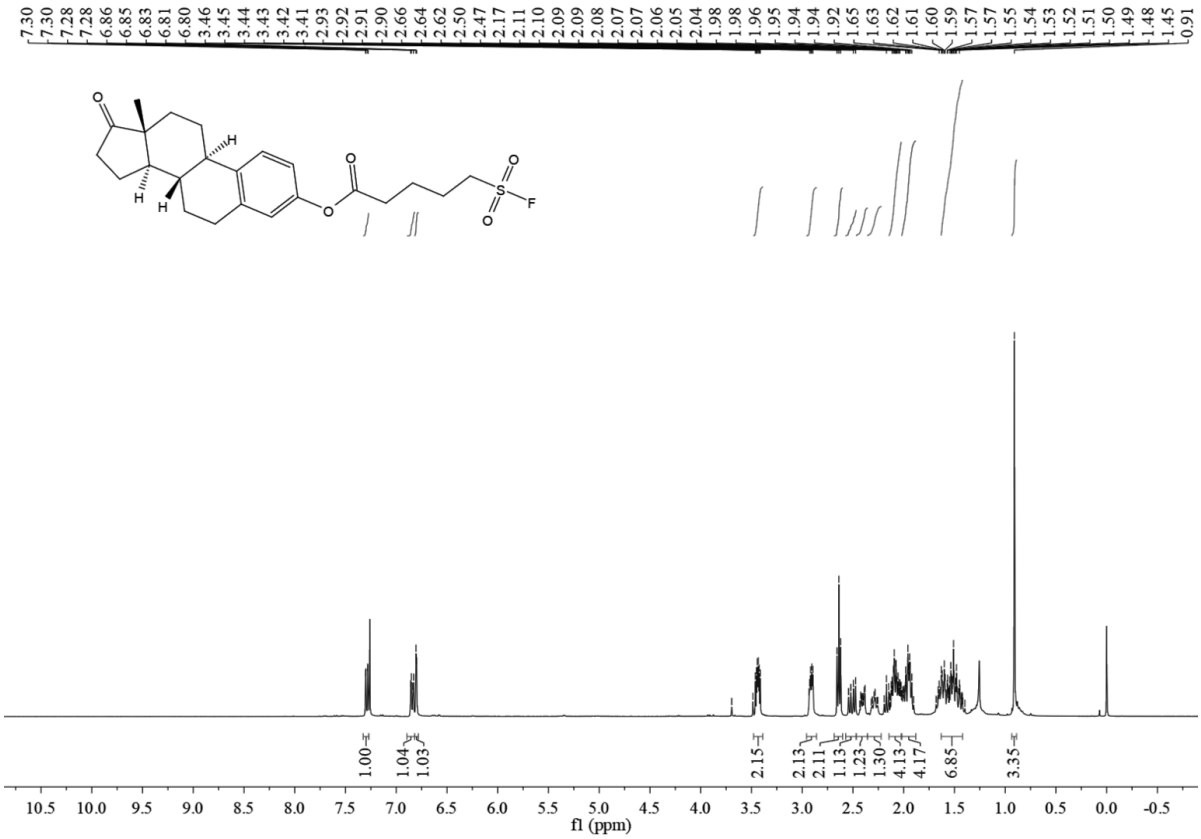


^{19}F NMR

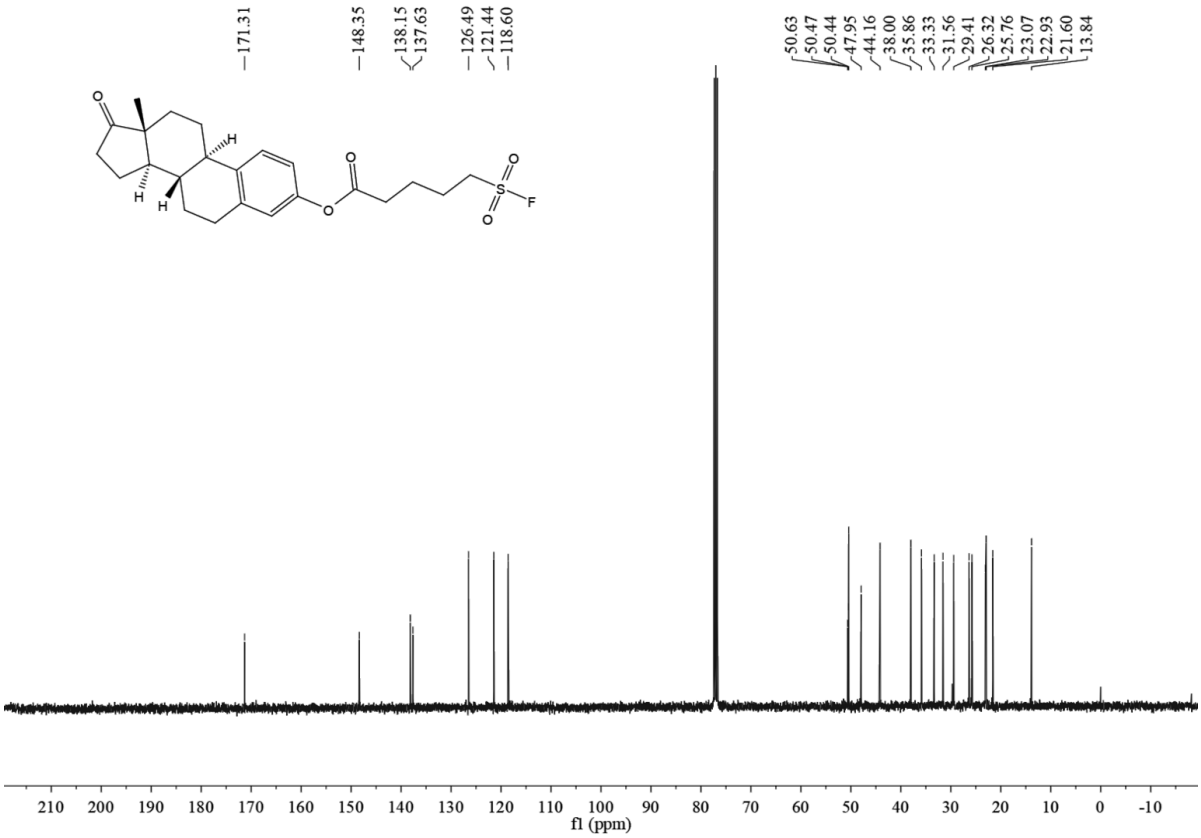


(8S,9R,13R)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 5-(fluorosulfonyl)pentanoate **(4ah)**

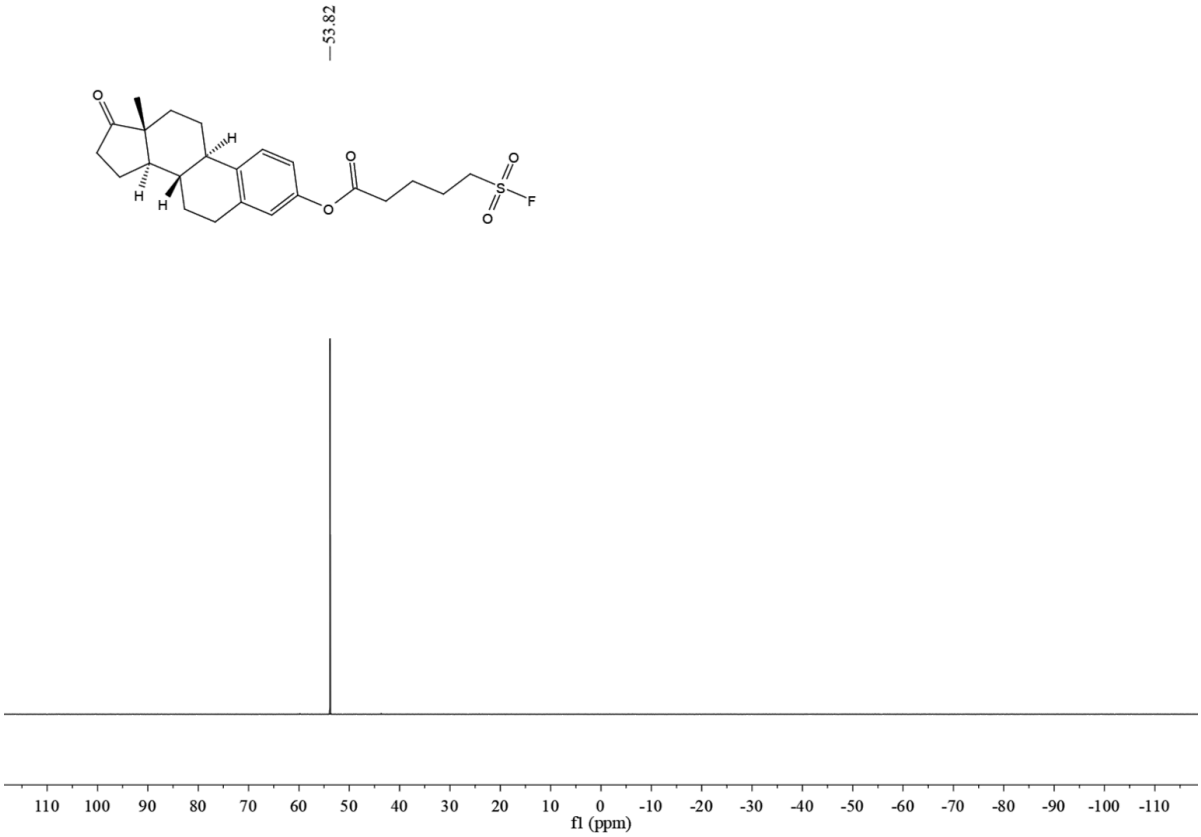
^{1}H NMR



^{13}C NMR

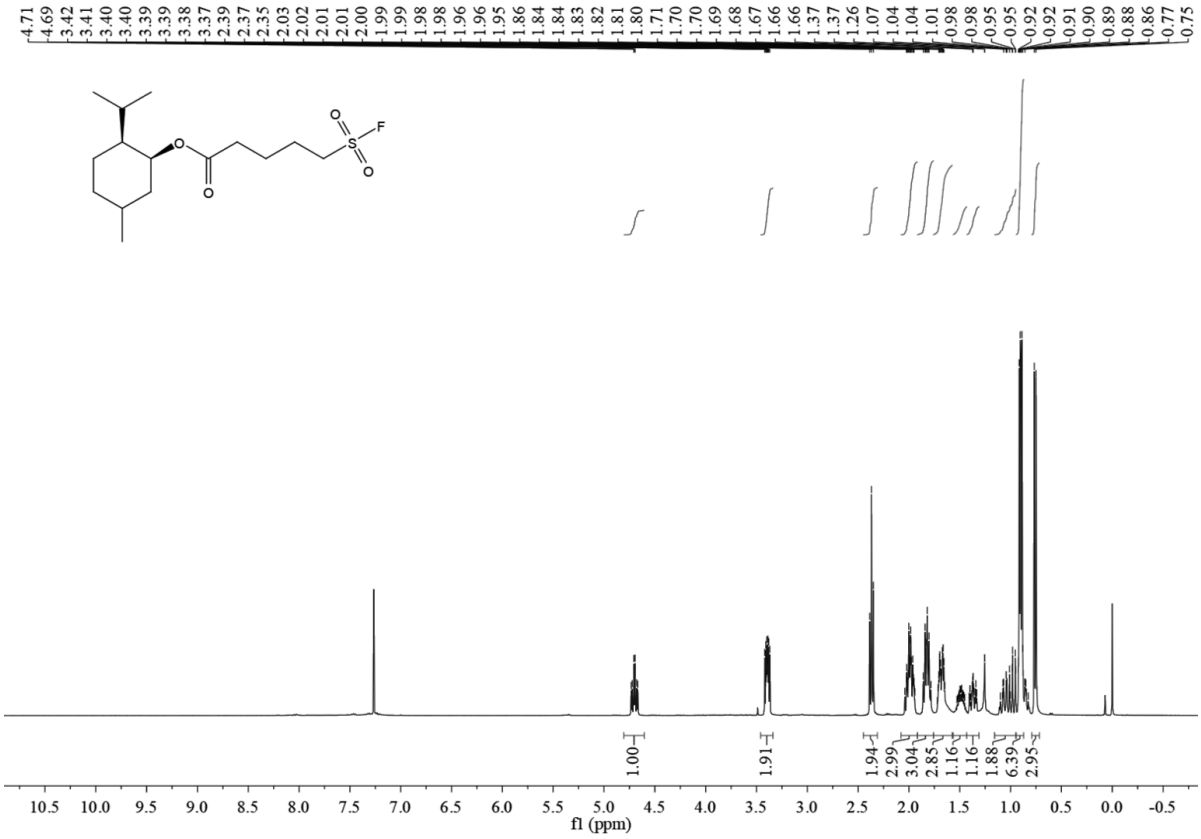


^{19}F NMR

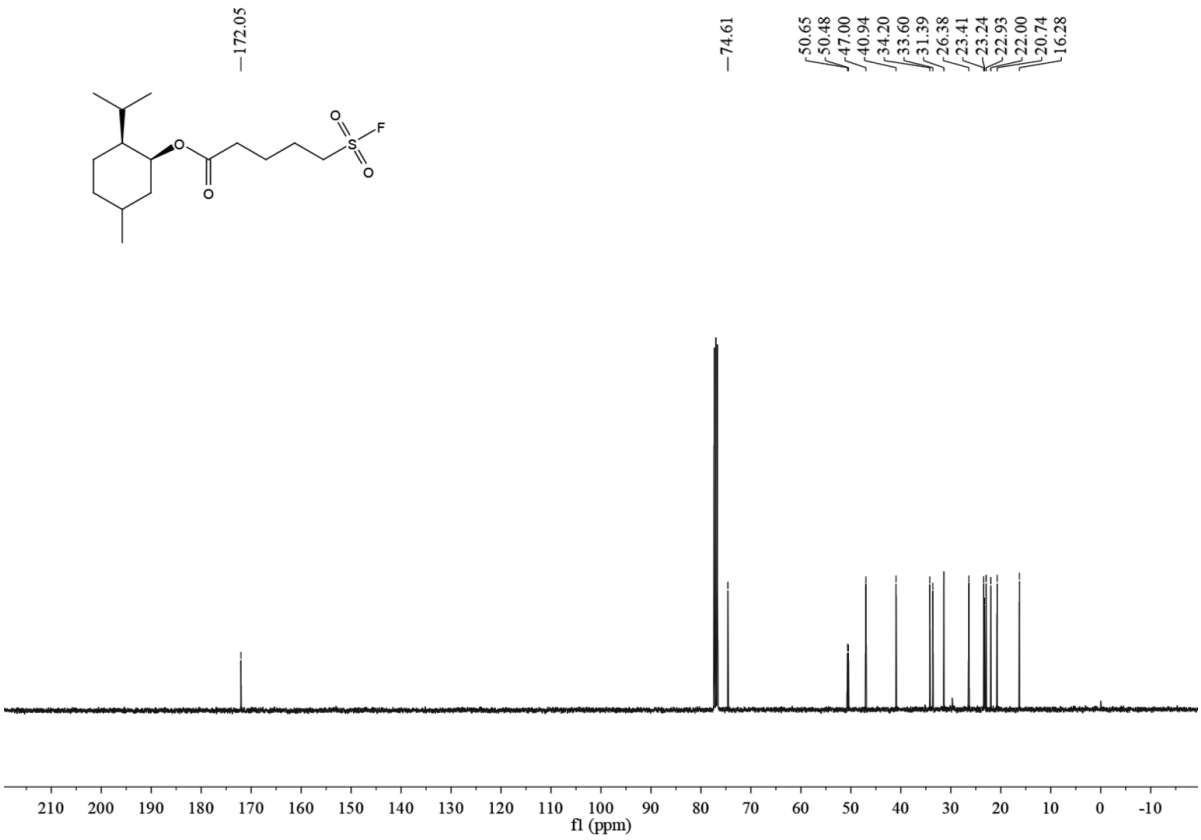


(1S,2S)-2-isopropyl-5-methylcyclohexyl 5-(fluorosulfonyl)pentanoate **(4ai)**

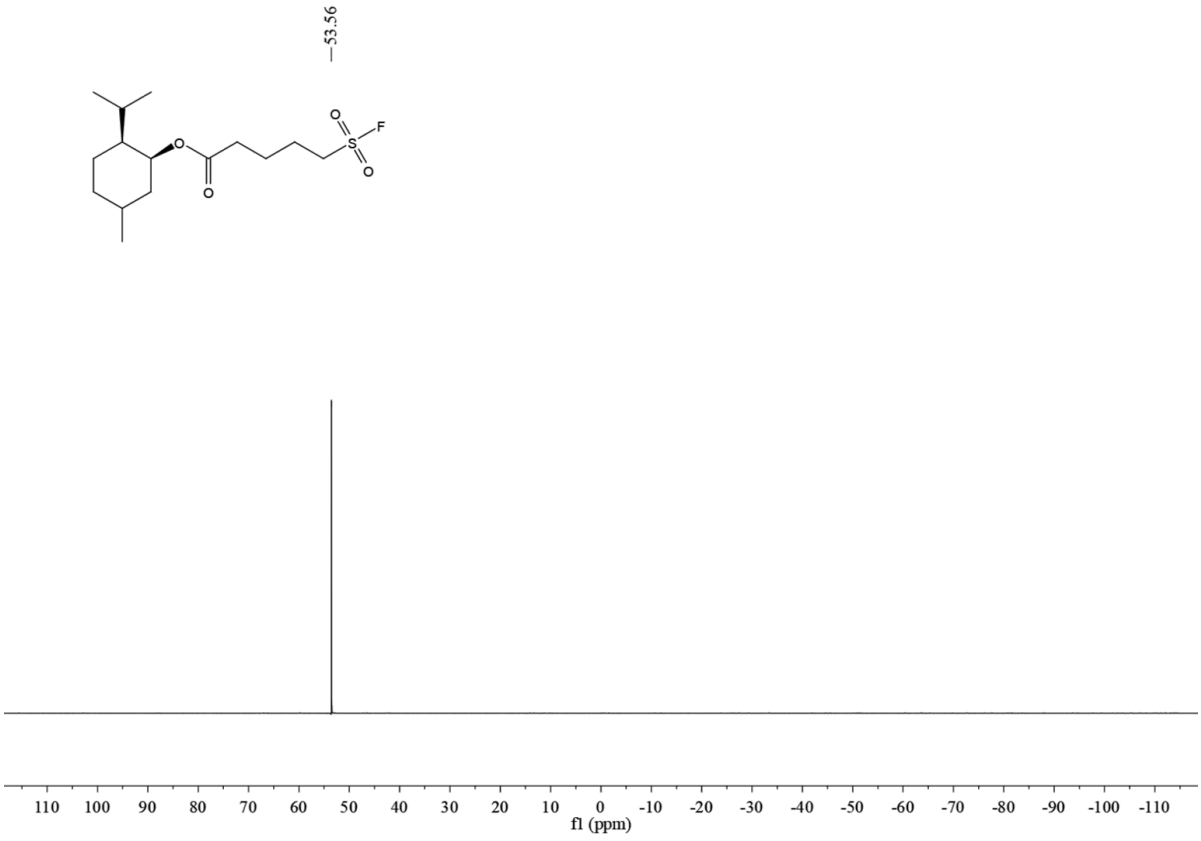
^{1}H NMR



^{13}C NMR

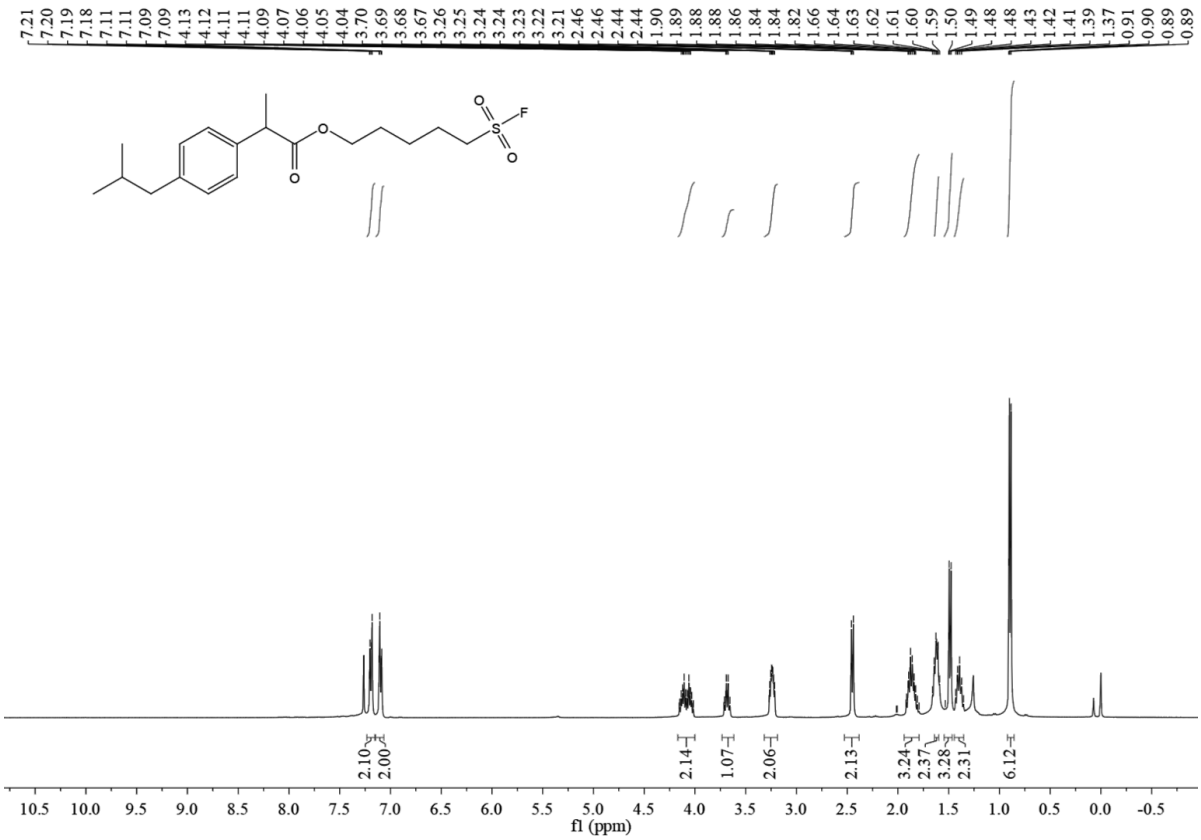


^{19}F NMR

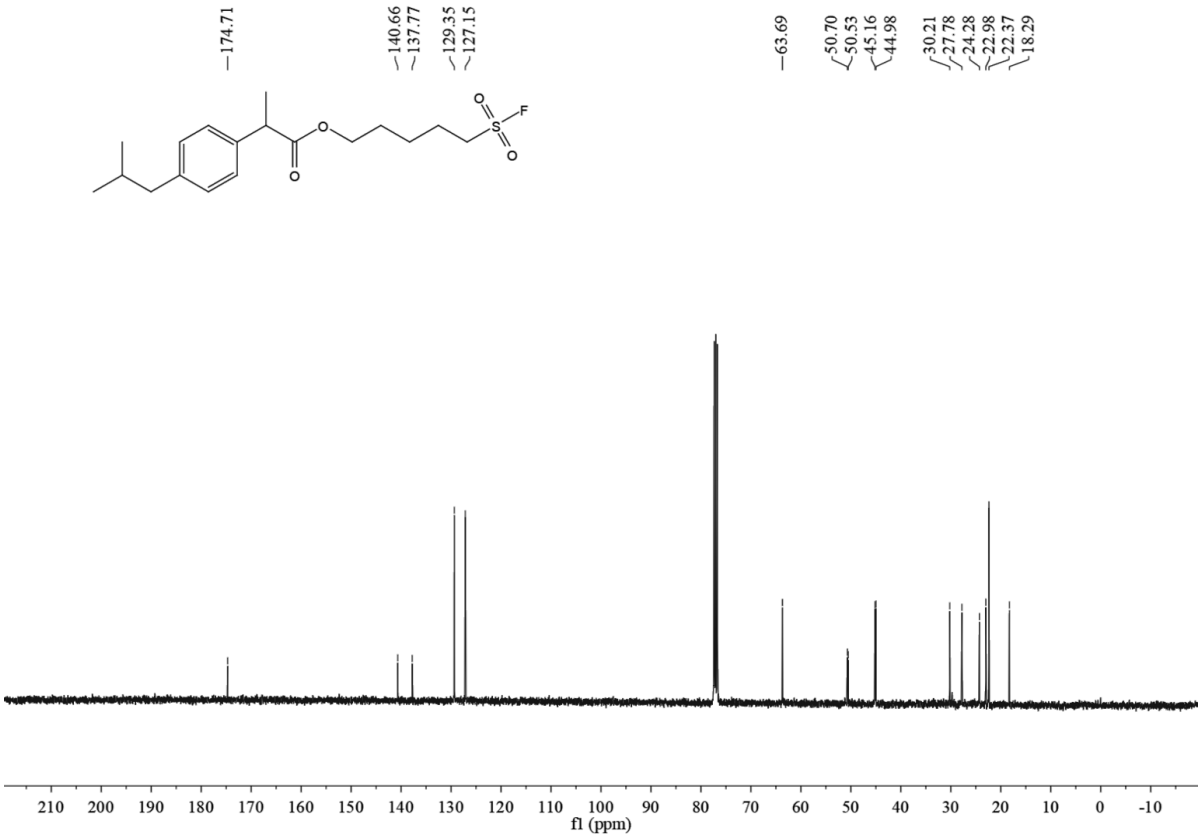


5-(fluorosulfonyl)pentyl 2-(4-isobutylphenyl)propanoate **(4aj)**

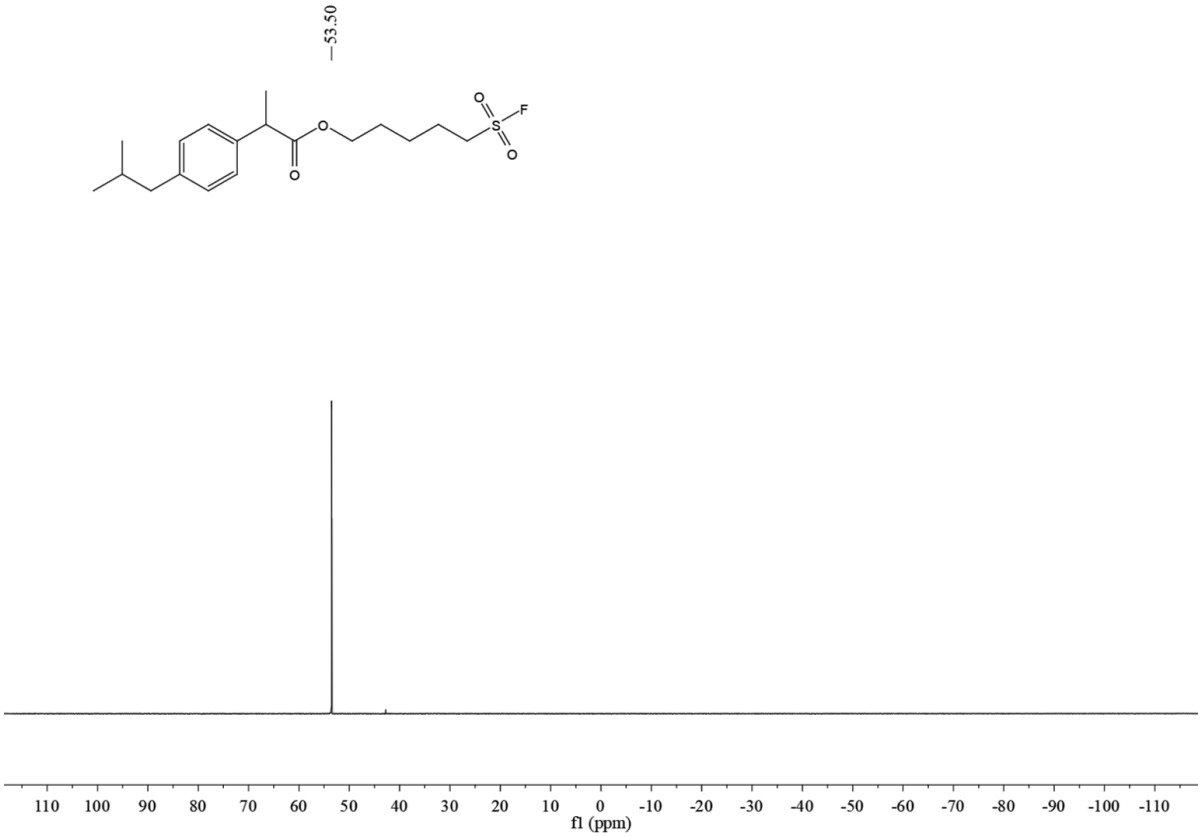
^{1}H NMR



^{13}C NMR

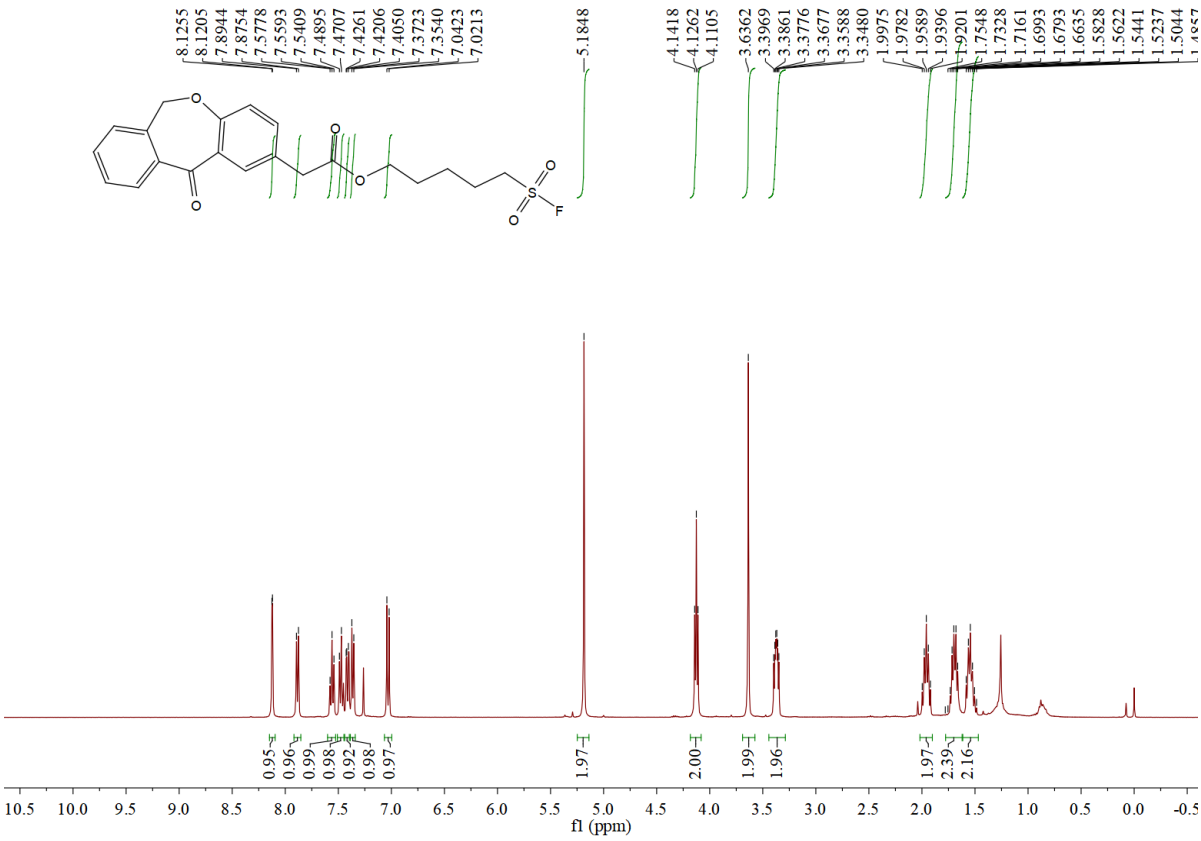


^{19}F NMR

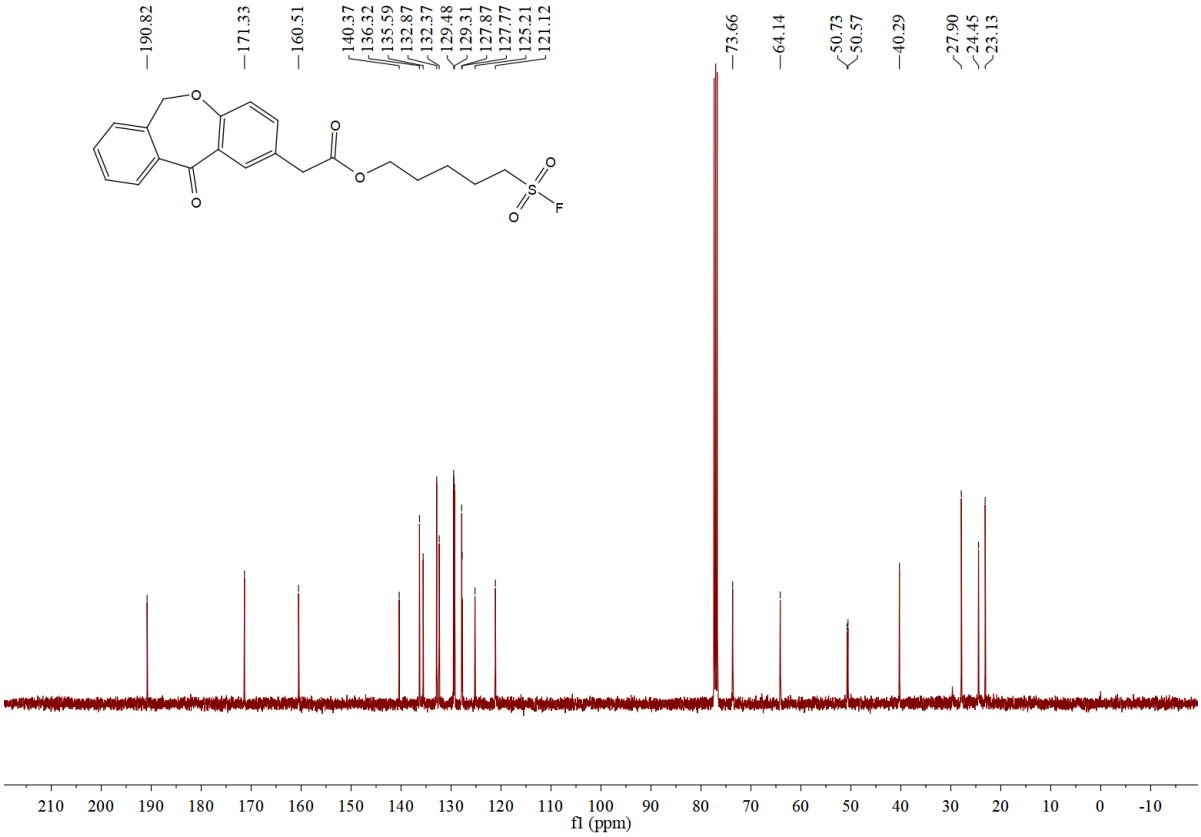


4-(fluorosulfonyl)butyl 2-(11-oxo-6,11-dihydrodibenzo[b,e]oxepin-2-yl)acetate **(4ak)**

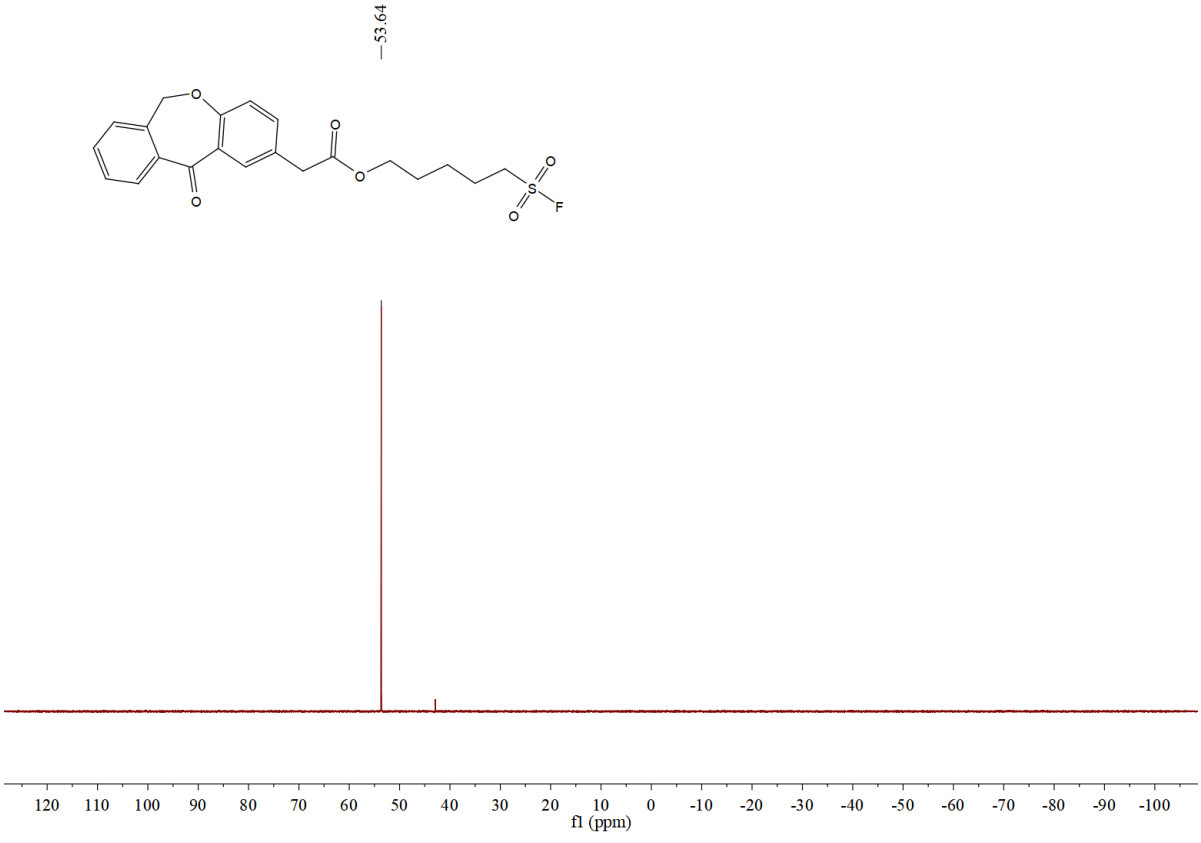
^{1}H NMR



^{13}C NMR

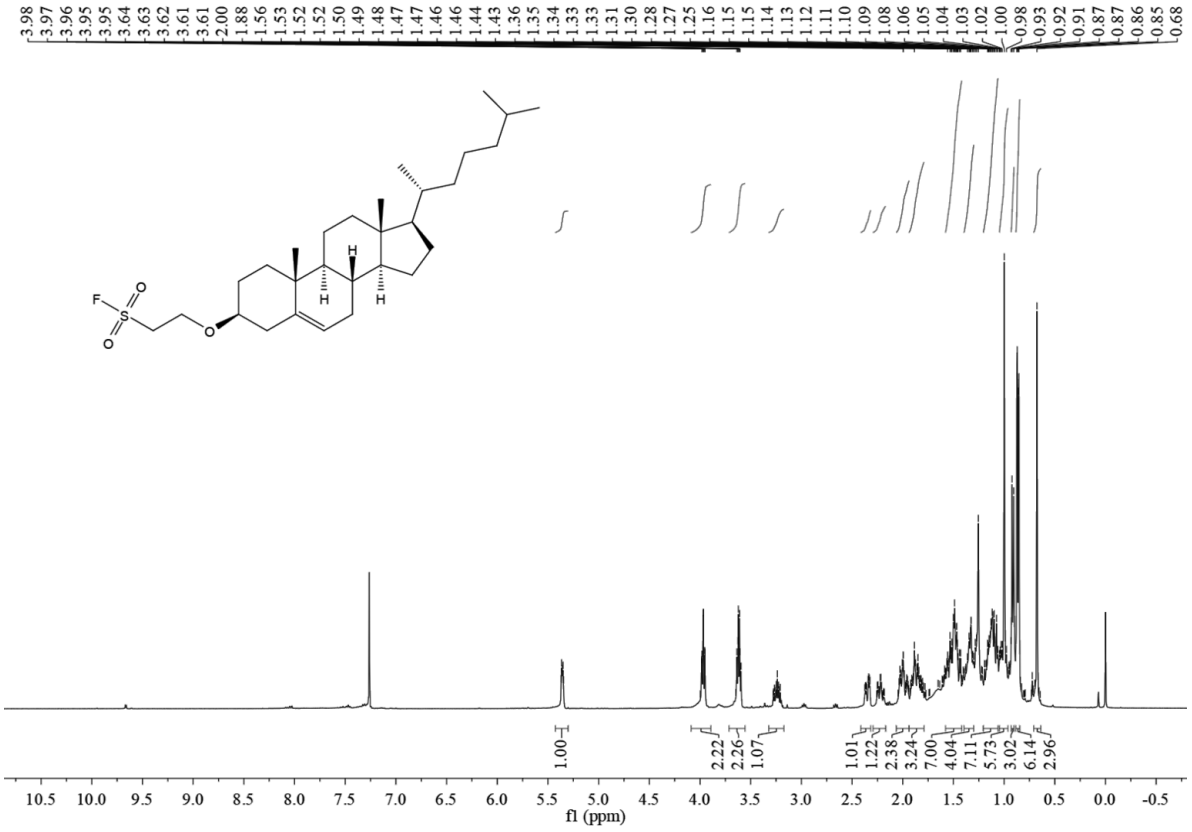


^{19}F NMR

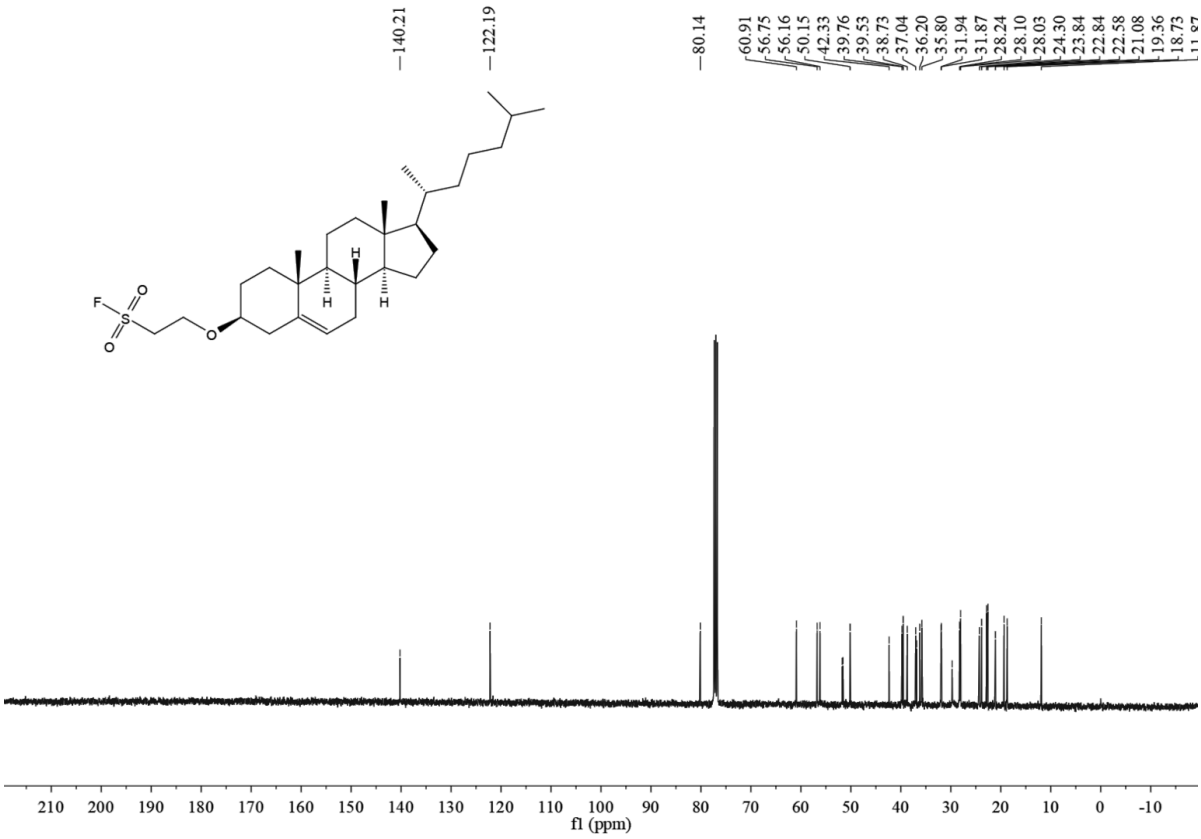


2-(((3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl)oxy)ethane-1-sulfonyl fluoride **(4al)**

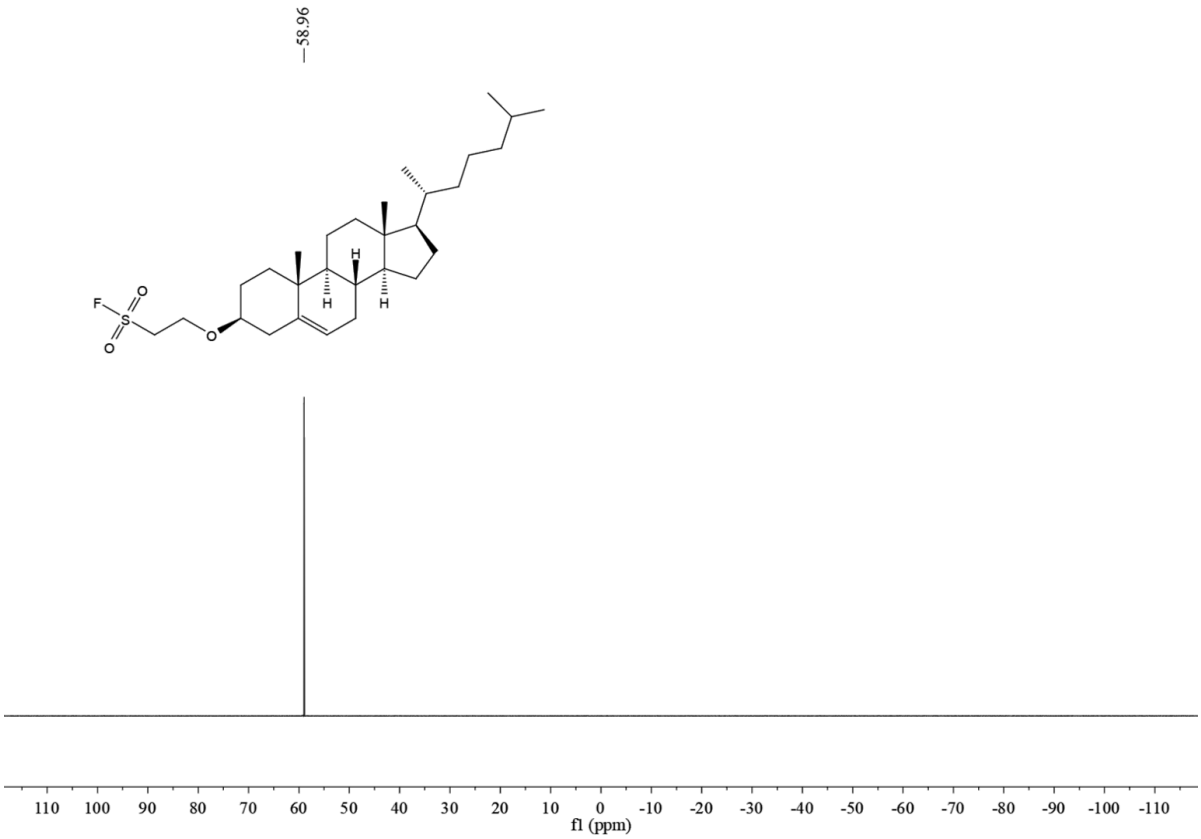
^{1}H NMR



^{13}C NMR

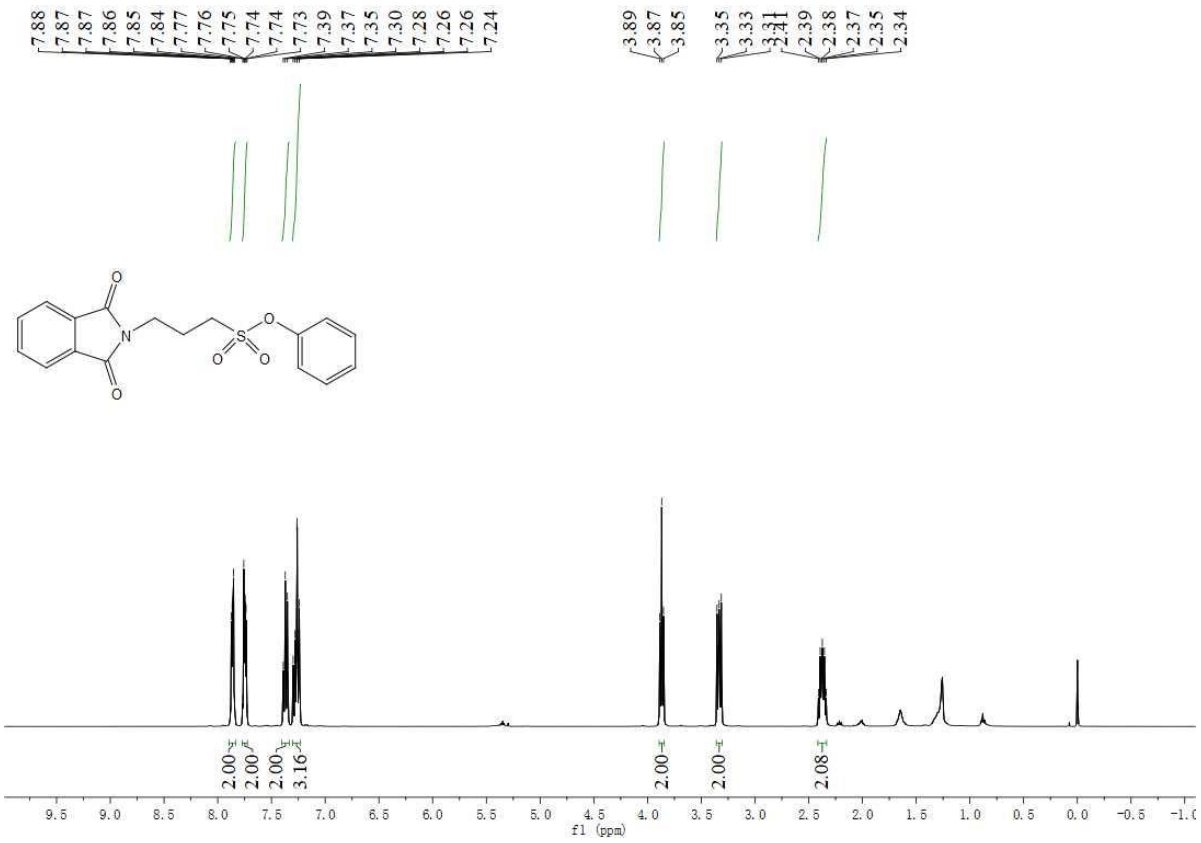


^{19}F NMR

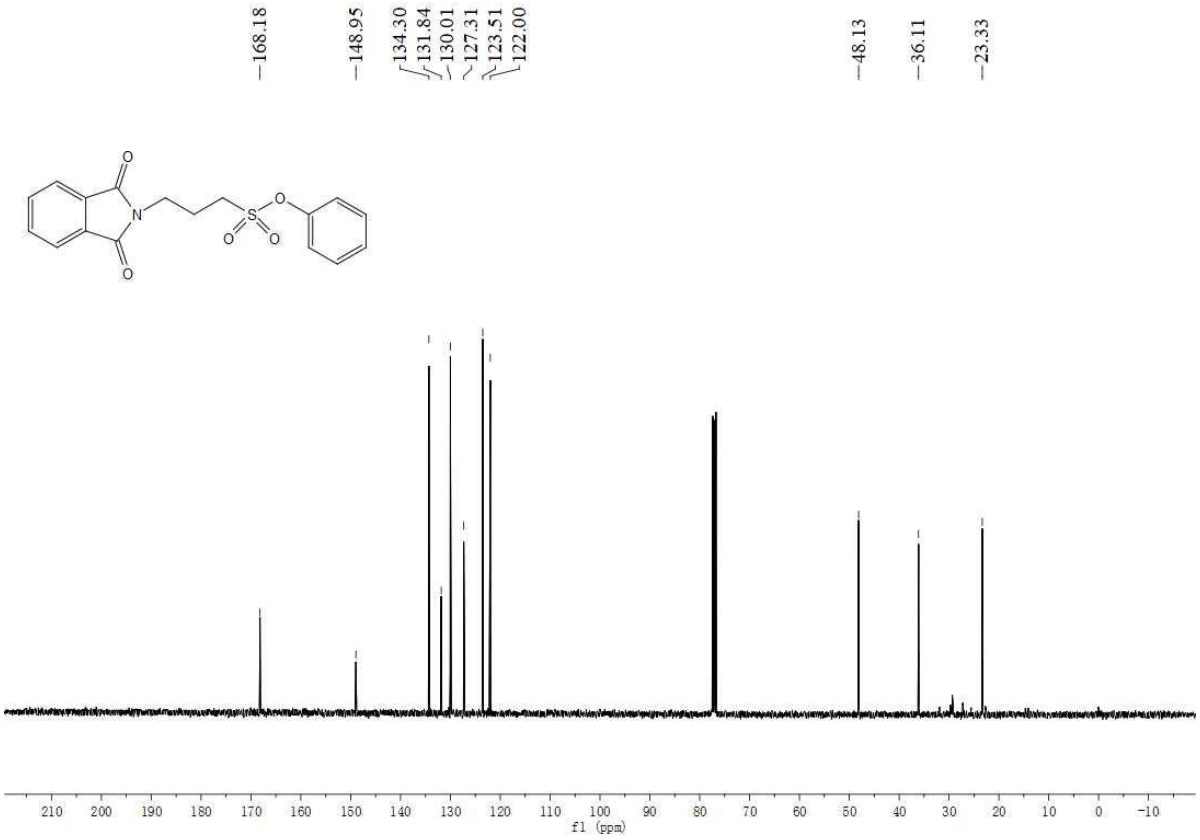


2-(3-(phenylsulfonyl)propyl)isoindoline-1,3-dione **(6)**

^{1}H NMR

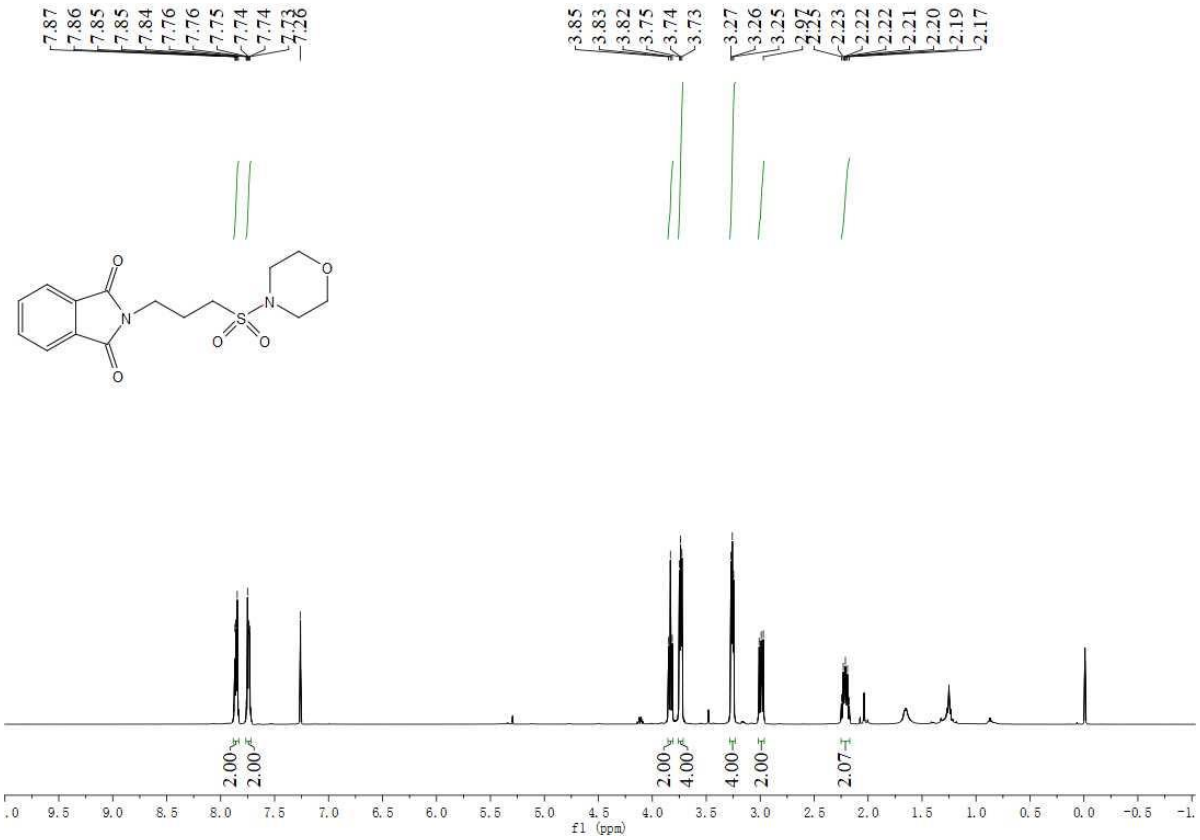


^{13}C NMR

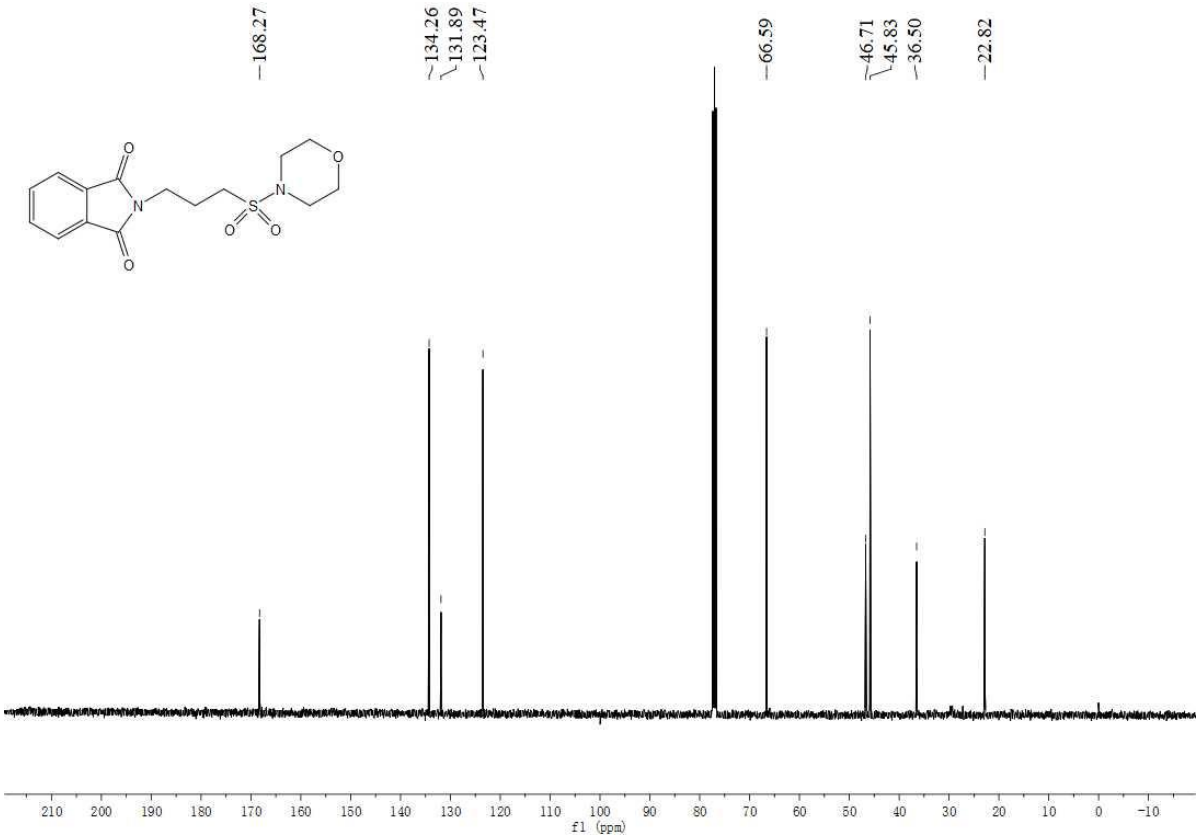


2-(3-(morpholinosulfonyl)propyl)isoindoline-1,3-dione **(8)**

^{1}H NMR

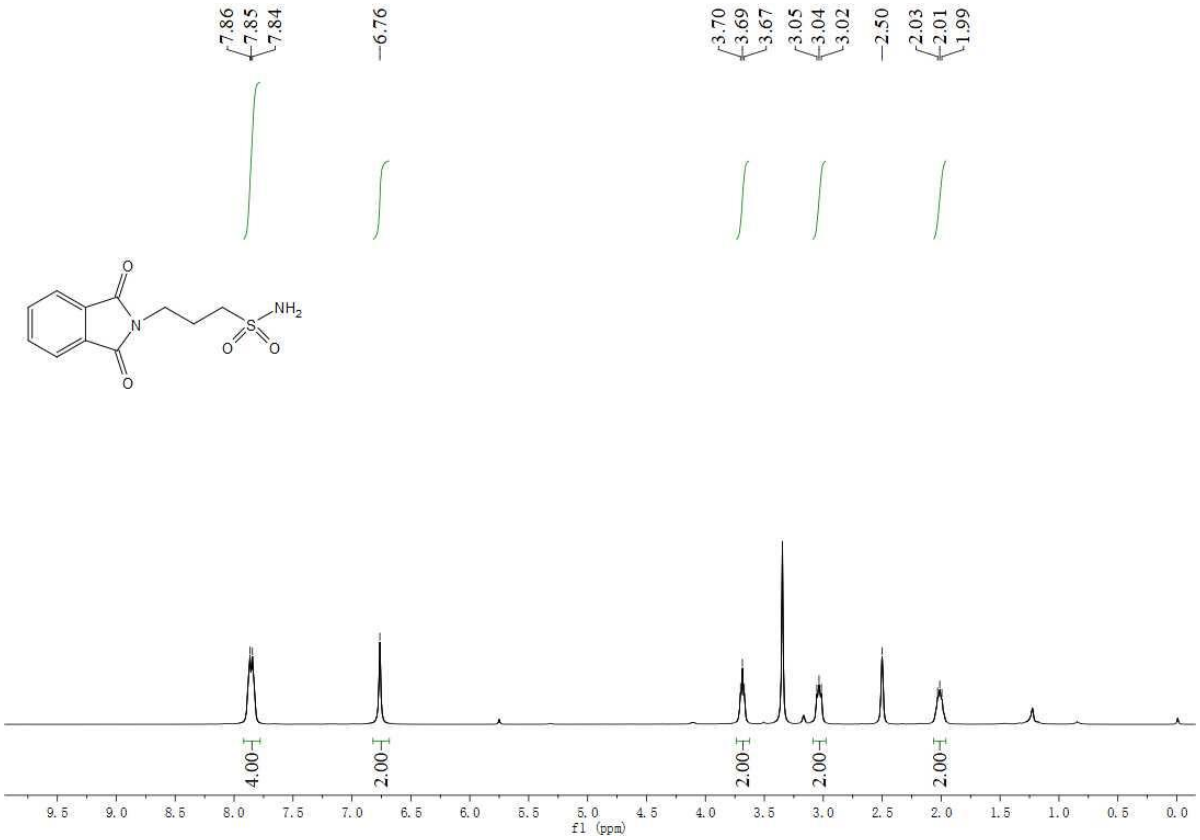


^{13}C NMR

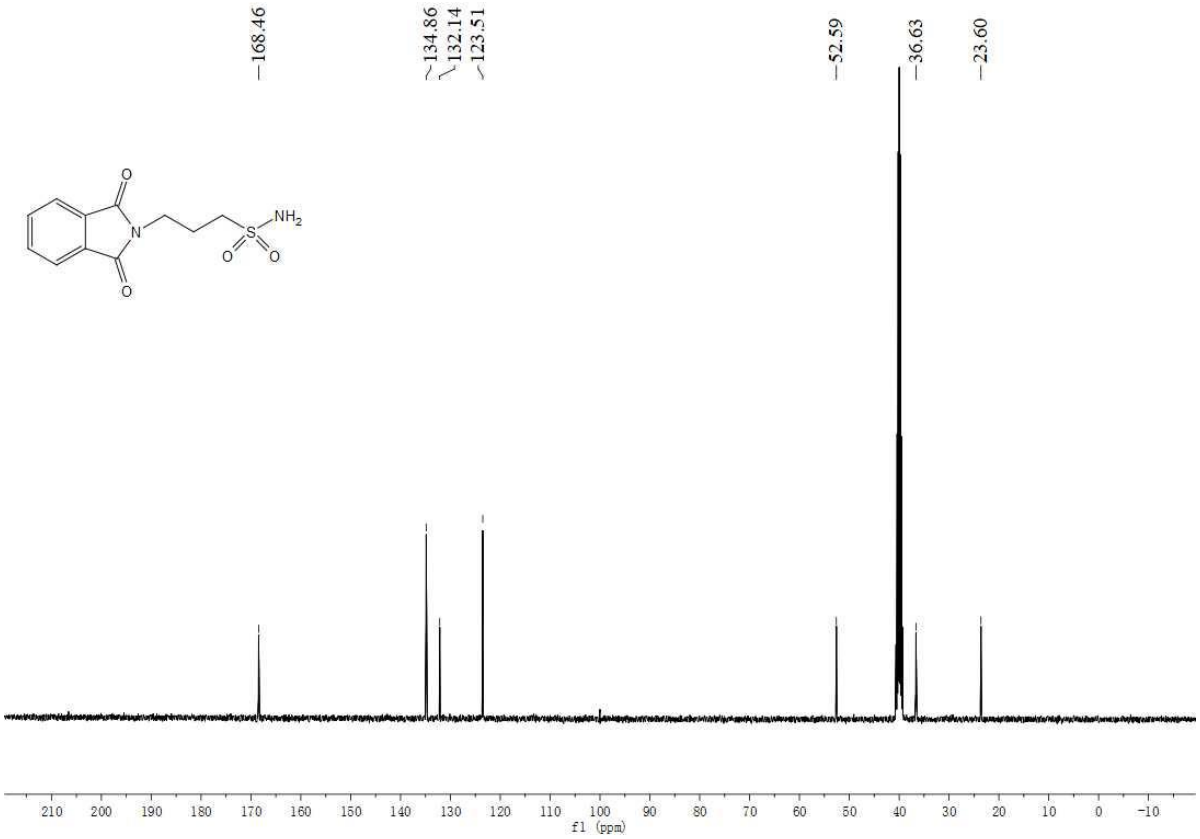


3-(1,3-dioxoisoindolin-2-yl)propane-1-sulfonamide **(10)**

^{1}H NMR

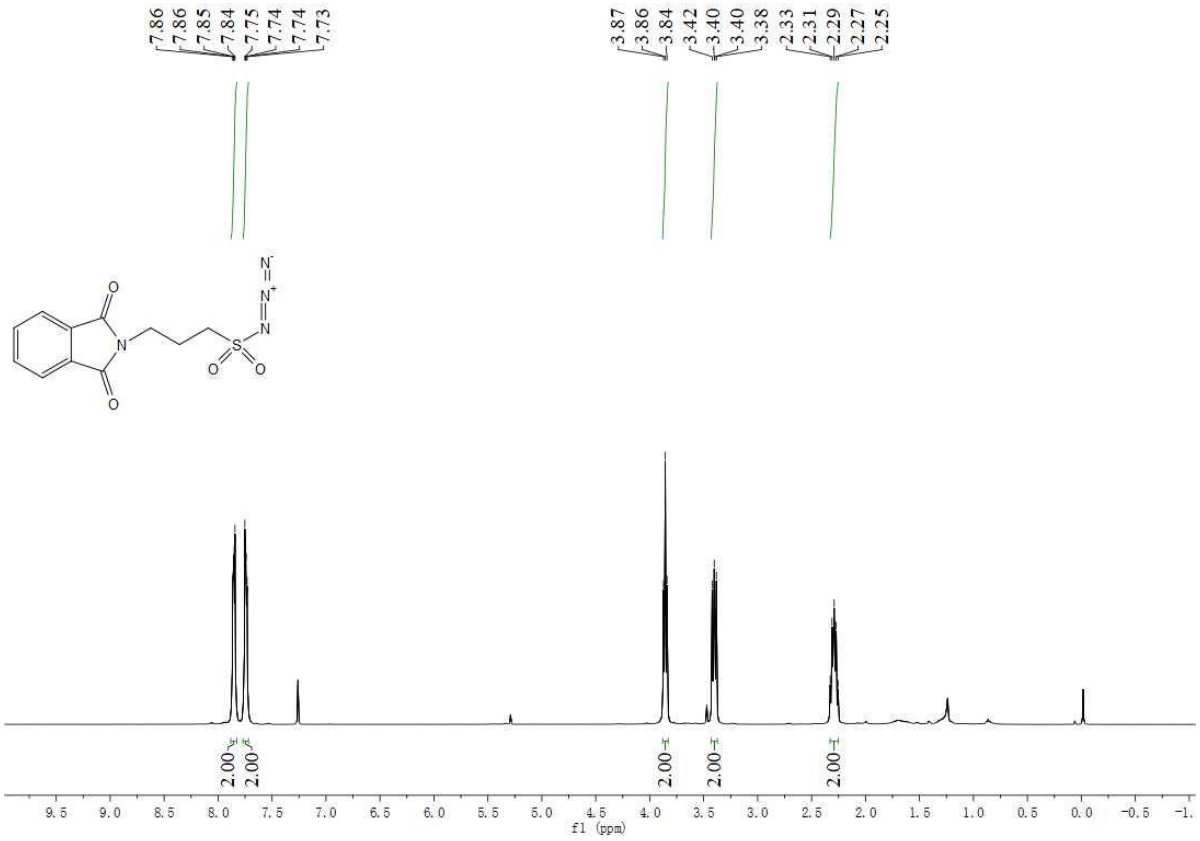


^{13}C NMR

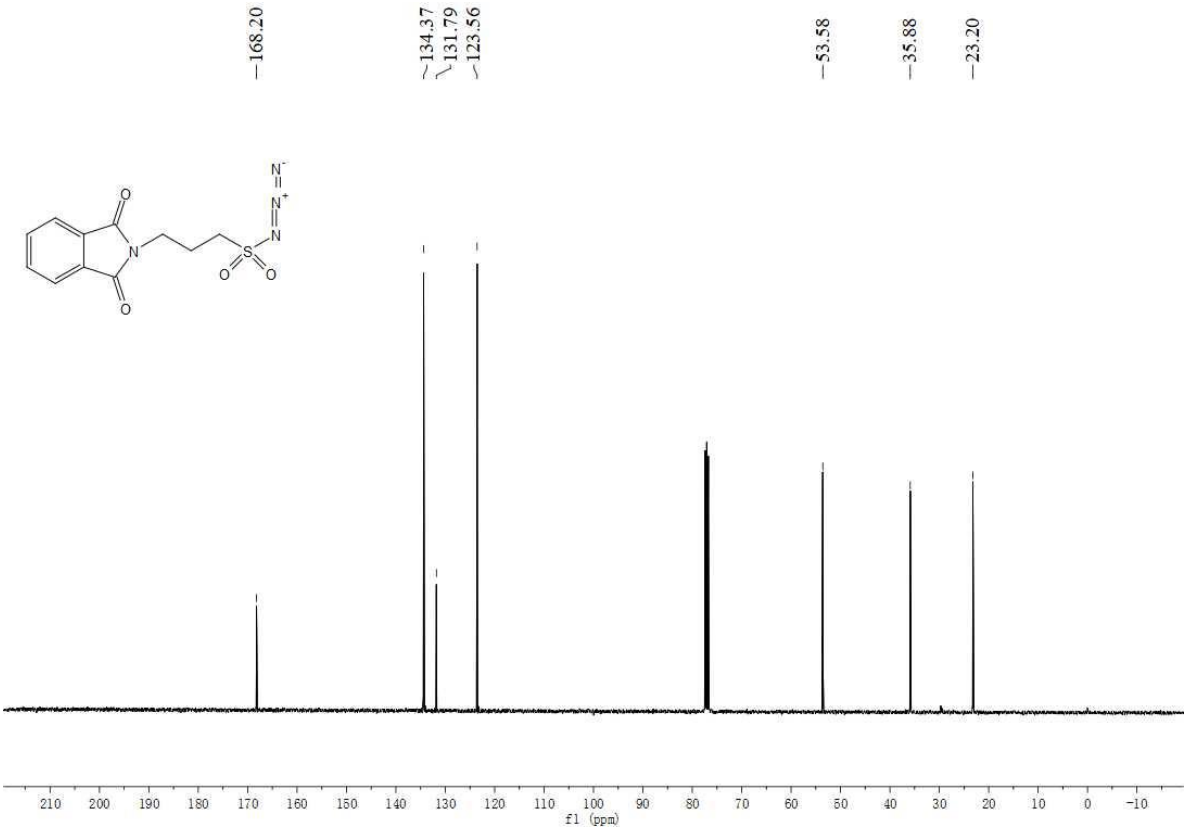


3-(1,3-dioxoisoindolin-2-yl)propane-1-sulfonyl azide **(12)**

^{1}H NMR

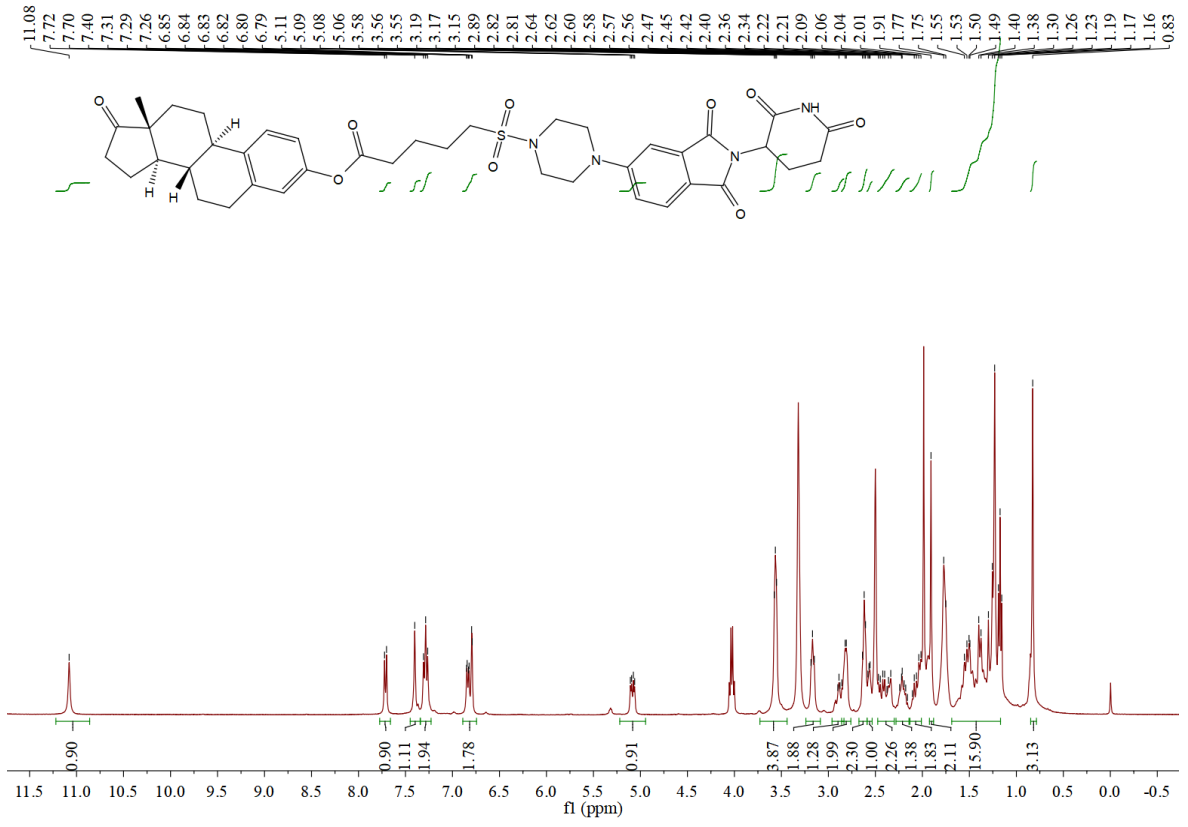


^{13}C NMR

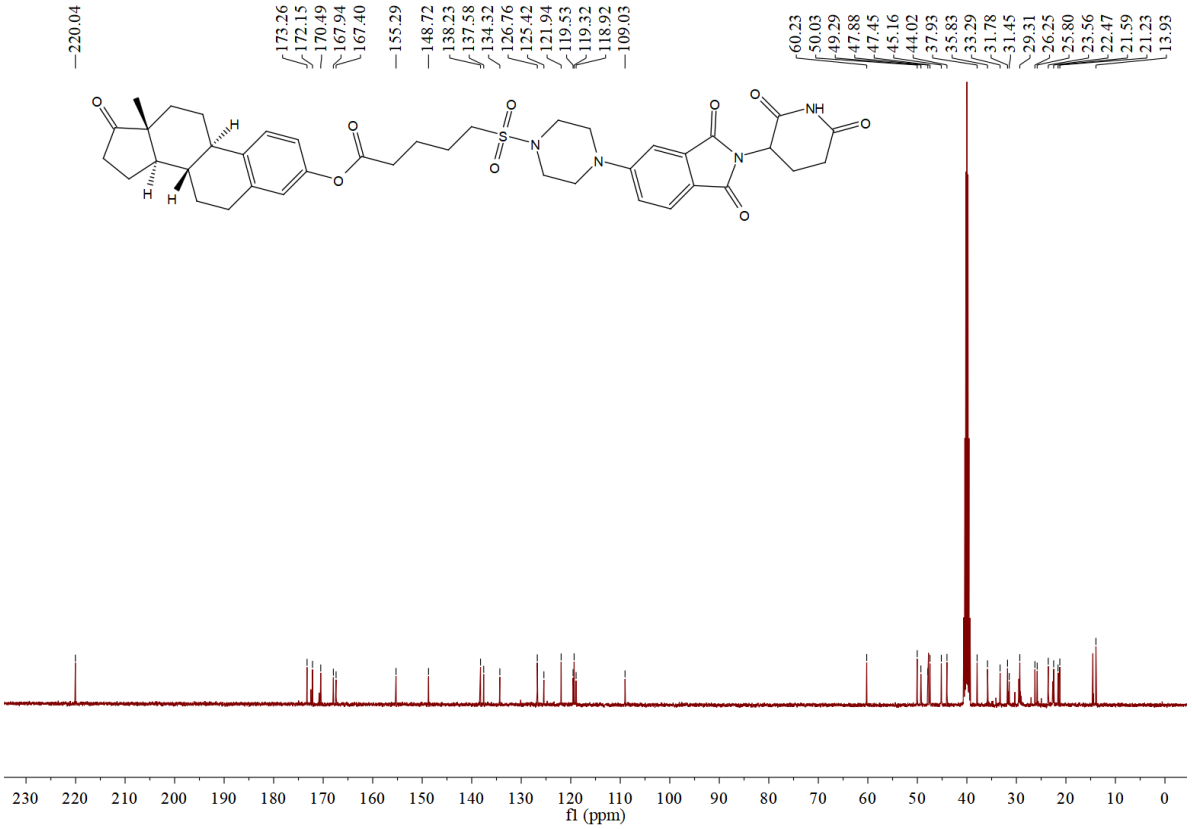


(8S,9R,13R,14R)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl 5-((4-(2-(2,6-dioxopiperidin-3-yl)-1,3-dioxoisoindolin-5-yl)piperazin-1-yl)sulfonyl)pentanoate **(14)**

^{1}H NMR

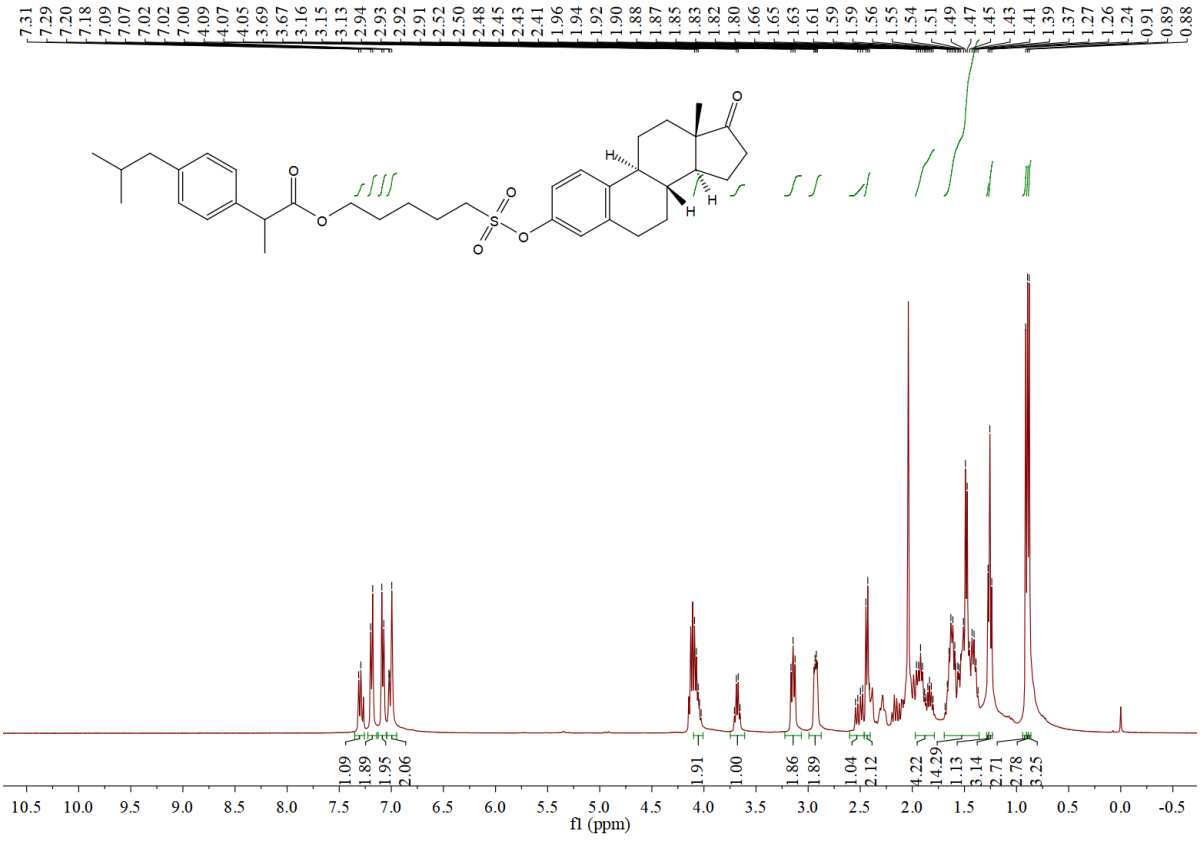


^{13}C NMR

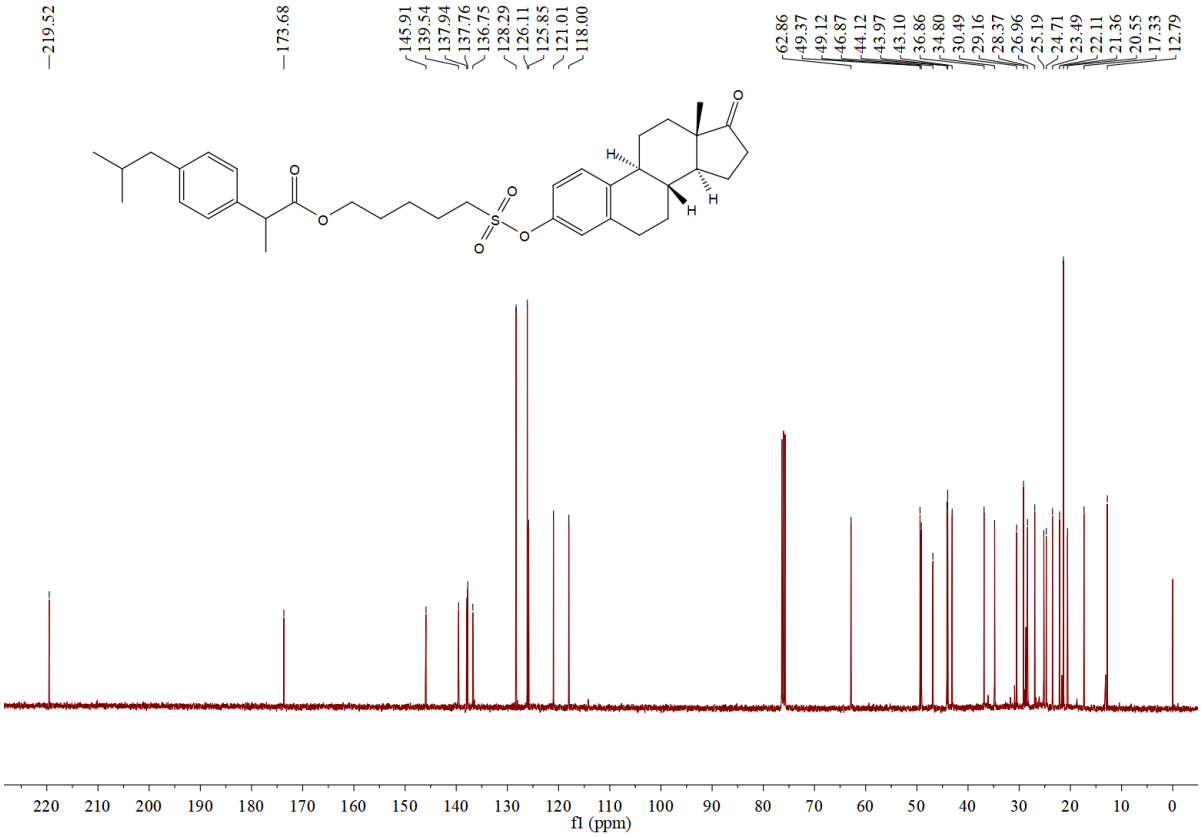


5-((((8R,9S,13S,14S)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl)oxy)sulfonyl)pentyl 2-(4-isobutylphenyl)propanoate **(16)**

^{1}H NMR

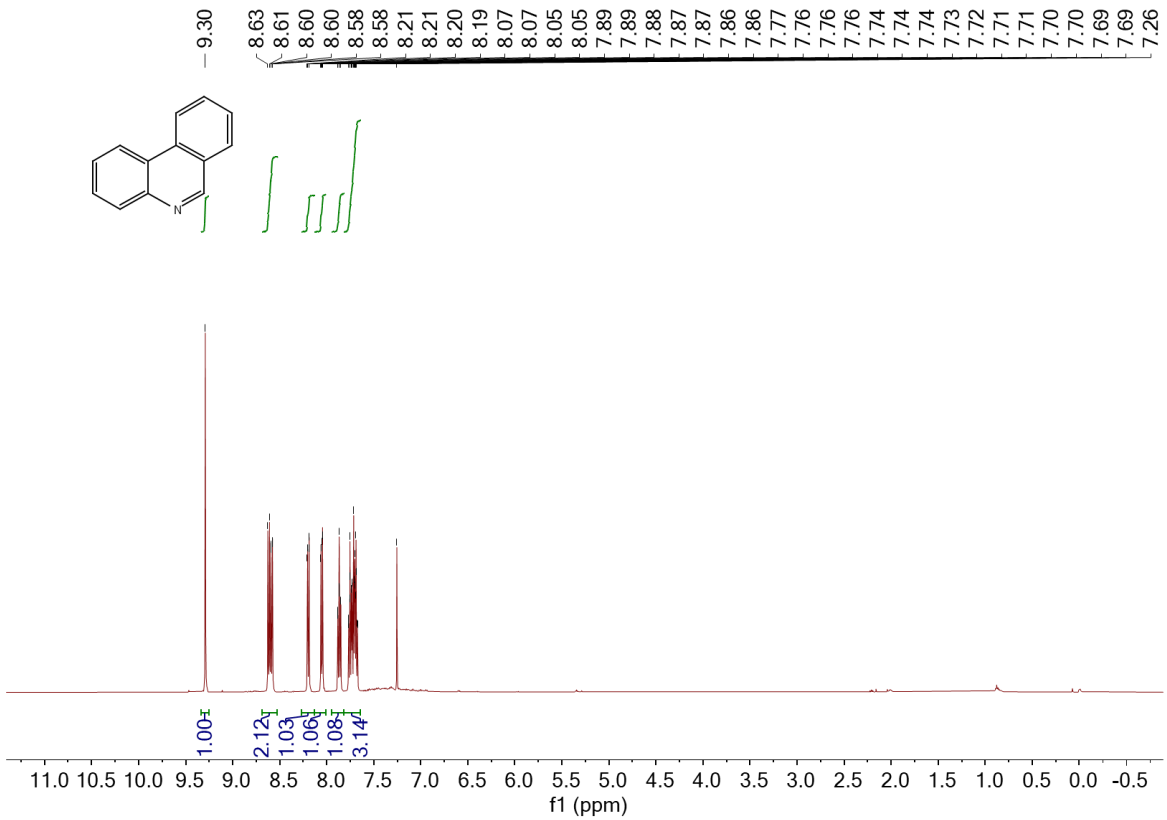


^{13}C NMR

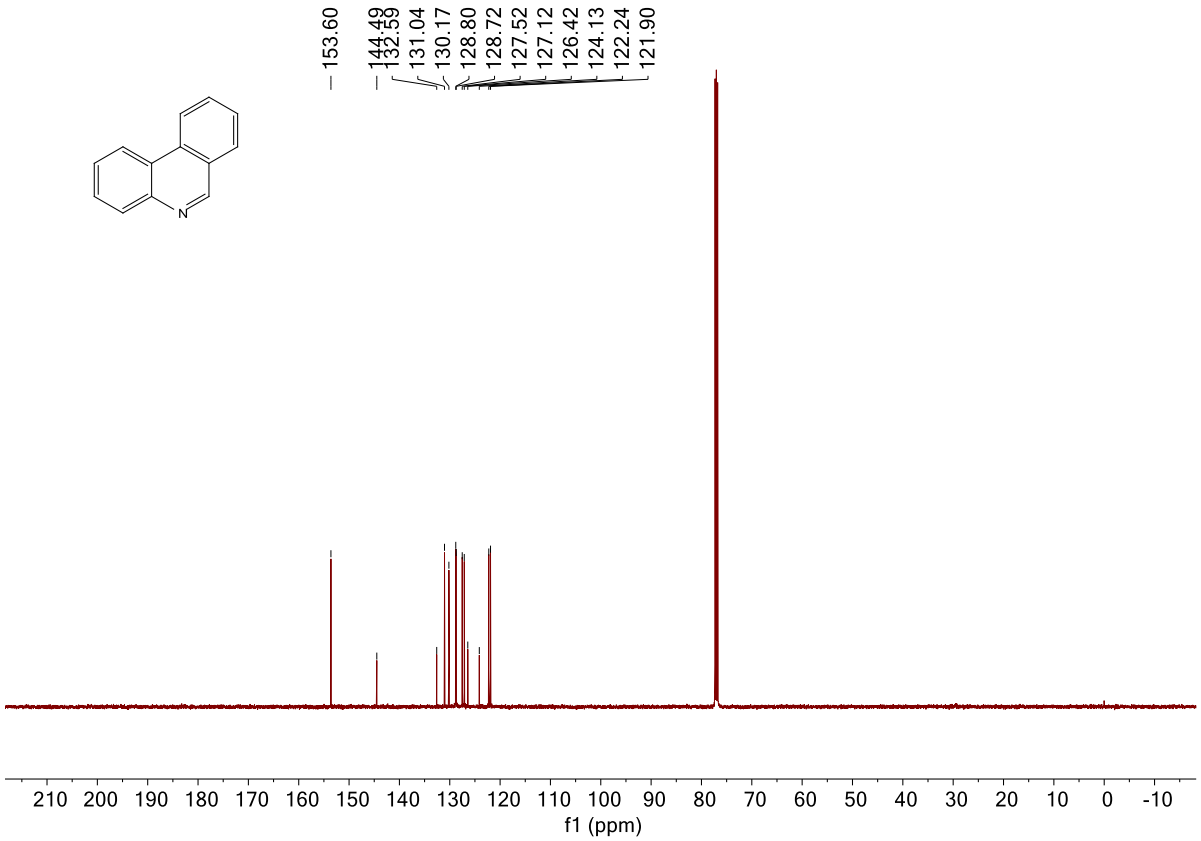


Phenanthridine **(19)**

^{1}H NMR



^{13}C NMR


153.60
144.49
132.59
131.04
130.17
128.80
128.72
127.52
127.12
126.42
124.13
122.24
121.90
N
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)