Pd-Catalyzed Thiophene Directed Regioselective Functionalization of Arenes: A Direct Approach to Multiply-Substituted Benzyl Amines

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Supporting information

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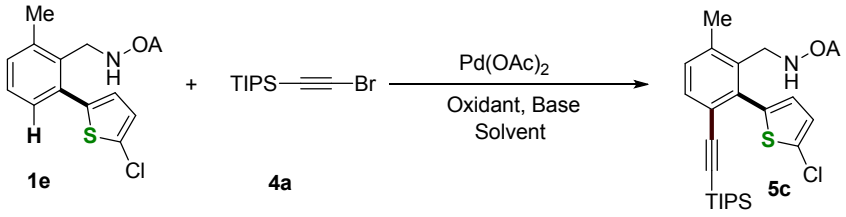
1. Reagents: Unless otherwise noted, all reagents were purchased from commercial suppliers and used without further purification. Column chromatography purifications were performed using 300–400 mesh silica gel.

2. Instruments: NMR spectra were obtained on Bruker DRX–400 instrument. Multiplicities are recorded as: s = singlet, d = doublet, t = triplet, br = broad, m = multiplet. The ^{1}H NMR (400 MHz) chemical shifts were measured relative to $CDCl_3$, $(CD_3)_2CO$, TMS or DMSO-d_6 as the internal reference ($CDCl_3$: δ = 7.26 ppm; $(CD_3)_2CO$: δ = 2.50 ppm; TMS: δ = 0.00 ppm; DMSO-d_6: δ = 2.50 ppm). The ^{13}C NMR (100 MHz) chemical shifts were given using $CDCl_3$, $(CD_3)_2CO$ or DMSO-d_6 as the internal standard ($CDCl_3$: δ = 77.16 ppm; $(CD_3)_2CO$: δ = 29.84 ppm; DMSO-d_6: δ = 39.52 ppm). HRMS analyses were carried out using a Bruker MicrOTOF-Q II instrument.

3. Optimization of reaction conditions

Table 3-1 Optimization of the reaction conditions for the C-H alkynylation [a, b]

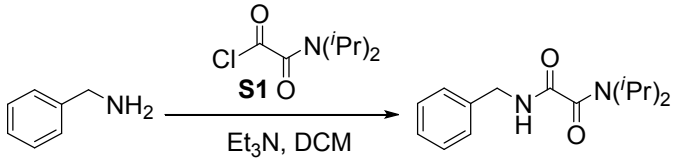


Entry	Oxidant	Base	Solvent	Yield/%
1	-	CsOAc	HFIP	trace
2	-	CsOAc	toluene	64
3	-	CsOAc	DCE	trace
4	-	KOAc	toluene	58
5	-	NaOAc	toluene	32
6	-	K_2CO_3	toluene	30
7	Ag_2O	CsOAc	toluene	60
8	AgOAc	CsOAc	toluene	86 (81)[c]
9	AgOAc	-	toluene	trace
10[d]	AgOAc	CsOAc	toluene	0

[a] Reactions were carried out using **1e** (0.05 mmol), **4** (0.1 mmol), $Pd(OAc)_2$ (5.0 mol %), Oxidant (0.05 mmol), Base (0.1 mmol), Solvent (0.2 mL) at 100 °C for 12 h in a 15 mL sealed tube. [b] Yield is determined by LC using acetophenone as internal standard. [c] Isolated yield.[d] Without $Pd(OAc)_2$.

4. General procedure for the synthesis of products

4.1 Preparation of oxalamide substrates



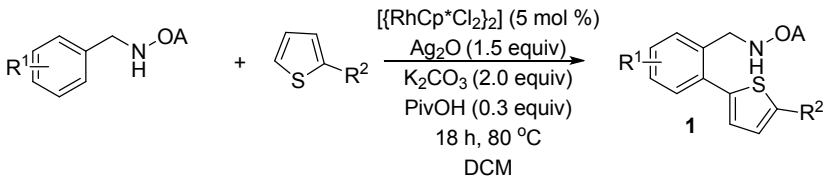
Preparation of N, N-Diisopropyloxamoyl chloride S1[1]

A solution of Diisopropylamine (7.01 mL, 50 mmol, 1.0 equiv) in CH_2Cl_2 (50 mL) was added dropwise to a solution of oxalyl chloride (6.44 ml, 75 mmol, 1.5 equiv) in CH_2Cl_2 (100 mL) at 0 °C, after stirring for 5 min, triethylamine (7.30 mL, 52.5 mmol, 1.05 equiv) was added dropwise. The solution was warmed to room temperature and stirred for 6 hours. The excess of oxalyl chloride and the solvent were removed under reduce pressure and CH_2Cl_2 (30 mL) was added and evaporated. This operation was performed twice to give **S1** as a pale yellow solid. The crude product was used in the next step without any purification.

General procedures for the preparation of oxalamide substrates [2]

A solution of benzylamine (20 mmol, 1.0 eq) in CH_2Cl_2 (40 mL) was added dropwise to a solution of N,N-Diisopropyloxamoyl chloride **S1** (25 mmol, 1.25 equiv) in CH_2Cl_2 (50 mL) at 0 °C, after stirring for 5 min, triethylamine (2.92 ml, 21 mmol, 1.05 equiv) was added dropwise and then the mixture was stirred for 6 hrs at room temperature before quenched by water (50 mL). The organic layer was separated and the aqueous layer was extracted with CH_2Cl_2 (20 mL × 2). The combined organic phase was washed with brine (30 mL), and then dried over anhydrous Na_2SO_4. Evaporation and column chromatography on silica gel afforded corresponding amide substrates as white solid.

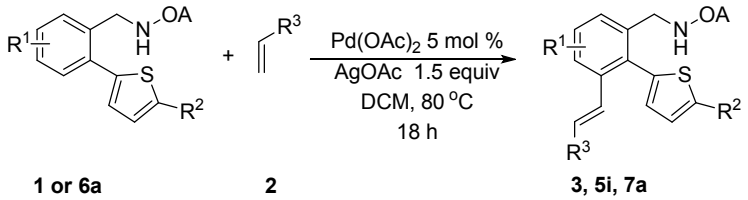
4.2 General procedure for the synthesis of products (1a-1i) [3]



A mixture of benzylamine derivatives (1 mmol, 1.0 equiv), thiophene derivatives (1.5 mmol, 1.5 equiv), [{RhCp*Cl_2}$_2$] (31 mg, 0.05 equiv), Ag_2O (347 mg, 1.5 equiv), K_2CO_3 (276 mg, 2.0 equiv), PivOH (30 mg, 0.3 equiv), and DCM (4 mL) in a 15 mL glass vial was heated at 80 °C for 18 hours. The reaction mixture was cooled to rt, filtered through diatomite and washed with 5-10 mL of CH_2Cl_2 then concentrated in vacuo. The resulting residue was purified by column

chromatography with the solvent of PE/EA= 5:1 (PE = petroleum ether, EA = ethyl acetate) on silica gel to give the heterocyclic product **1**.

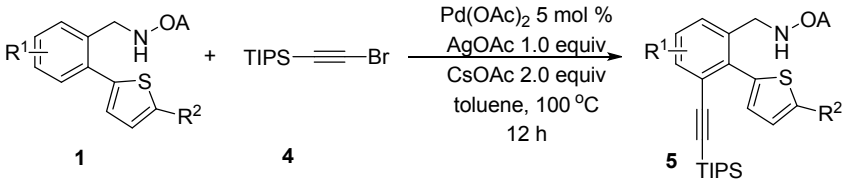
4.3 General procedure for the synthesis of products (3a-3j, 5i and 7a)



1 or 6a **2** **3, 5i, 7a**

A mixture of product **1** or **6a** (0.2 mmol, 1.0 equiv), olefin **2** (0.4 mmol, 2.0 equiv), $Pd(OAc)_2$ (2.2 mg, 0.05 equiv), AgOAc (49.8 mg, 1.5 equiv), DCM (0.8 mL) in a 15 mL glass vial was heated at 80 °C for 18 hours. The reaction mixture was cooled to rt, filtered through diatomite and washed with 5-10 mL of CH_2Cl_2 then concentrated in vacuo. The resulting residue was purified by column chromatography with the solvent of PE/EA= 3:1 on silica gel to give the alkenyl product **3**, **5i** or **7a**.

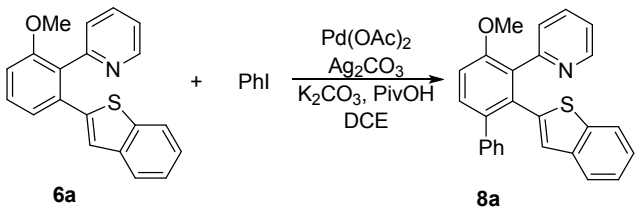
4.4 General procedure for the synthesis of products (5a-5h)



1 **4** **5**

A mixture of product **1** (0.2 mmol, 1.0 equiv), **4** (0.4 mmol, 2.0 equiv), $Pd(OAc)_2$ (2.2 mg, 0.05 equiv), AgOAc (24.9 mg, 1.0 equiv), CsOAc (76.8 mg, 2.0 equiv), toluene (0.8 mL) in a 15 mL glass vial was heated at 100 °C for 12 hours. The reaction mixture was cooled to rt, filtered through diatomite and washed with 5-10 mL of CH_2Cl_2 then concentrated in vacuo. The resulting residue was purified by column chromatography with the solvent of PE/EA= 10:1 on silica gel to give the alkynyl product **5**.

4.5 General procedure for the synthesis of products (8a)

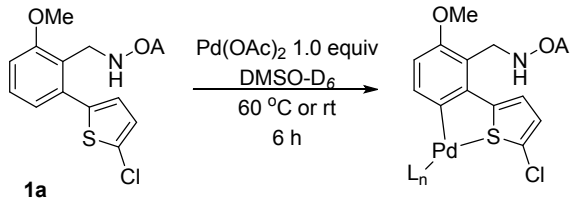


6a **8a**

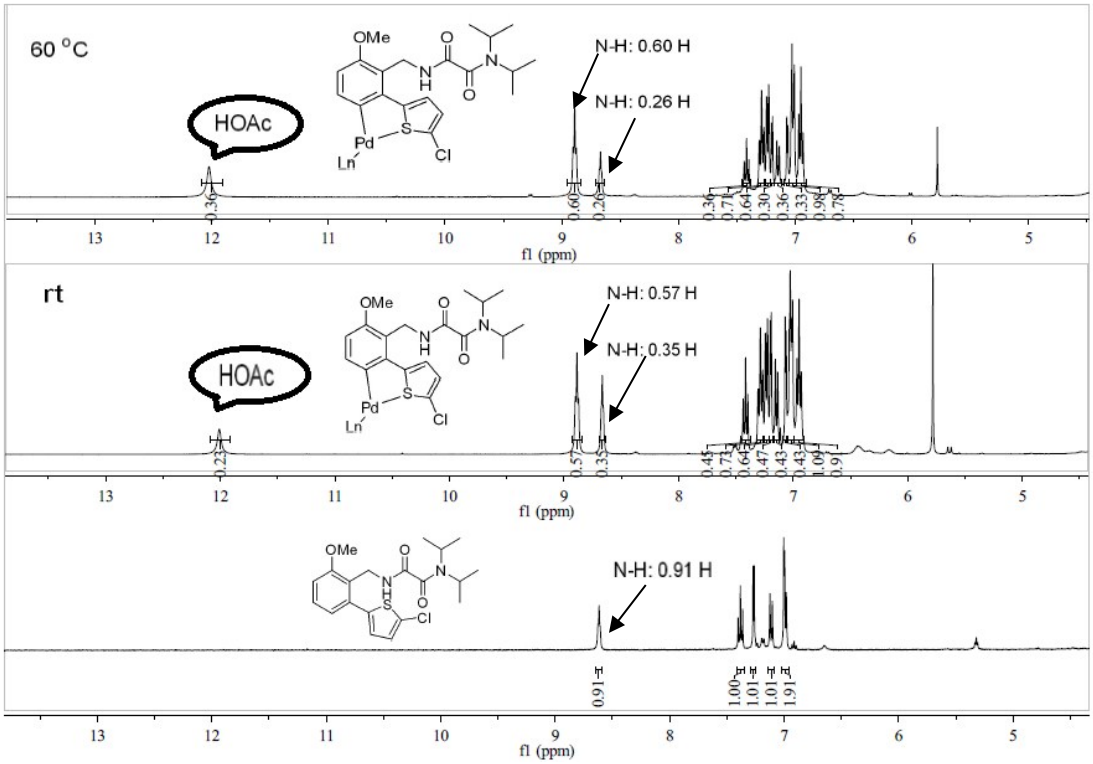
A mixture of product **6a** (0.2 mmol, 1.0 equiv), iodobenzene (0.4 mmol, 2.0 equiv), $Pd(OAc)_2$ (2.2 mg, 0.05 equiv), Ag_2CO_3 (82.5 mg, 1.5 equiv), K_2CO_3 (55.2 mg, 2.0 equiv), PivOH (6.0 mg, 0.3 equiv), DCE (0.8 mL) in a 15 mL glass vial was heated at 110 °C for 12 hours. The

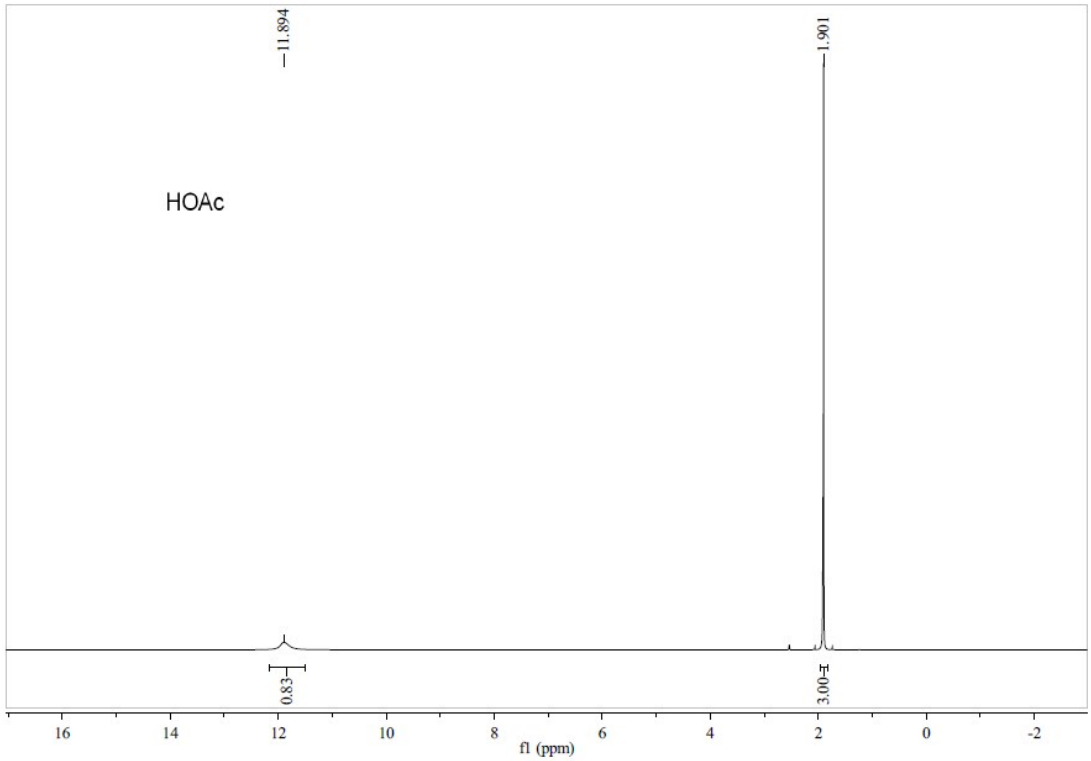
reaction mixture was cooled to rt, filtered through diatomite and washed with 5-10 mL of CH_2Cl_2 then concentrated in vacuo. The resulting residue was purified by column chromatography with the solvent of PE/EA= 3:1 on silica gel to give the alkenyl product **8a**.

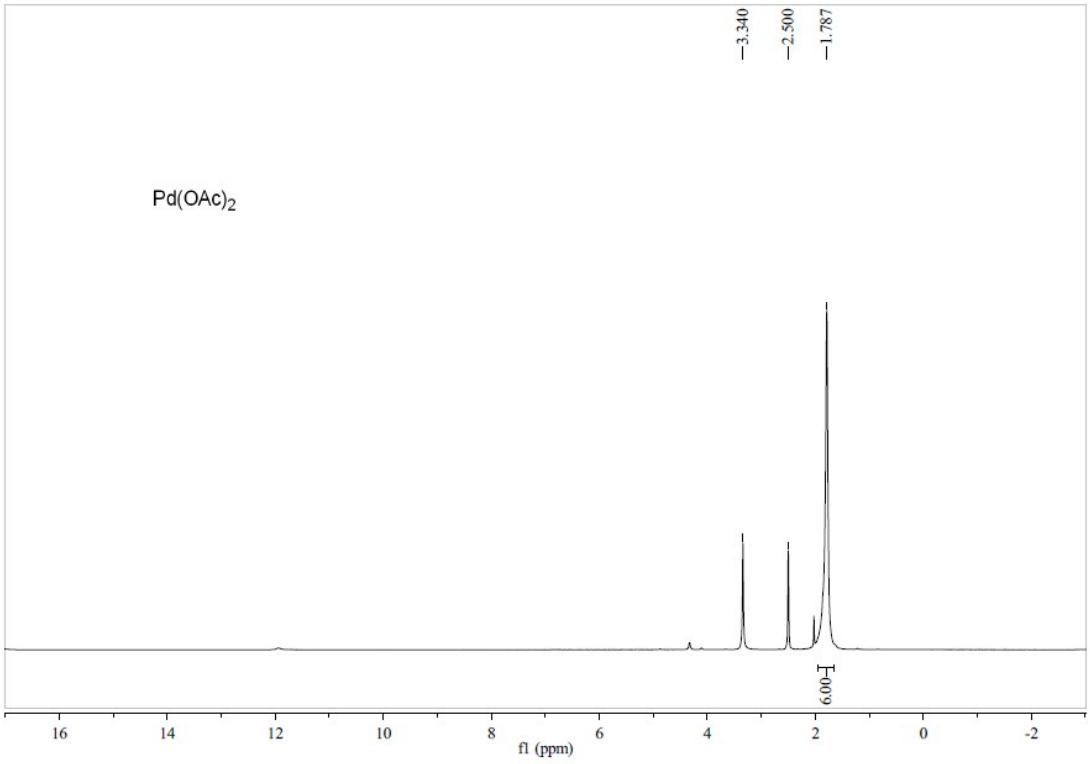
5. Investigate thiophene directed C-H functionalization

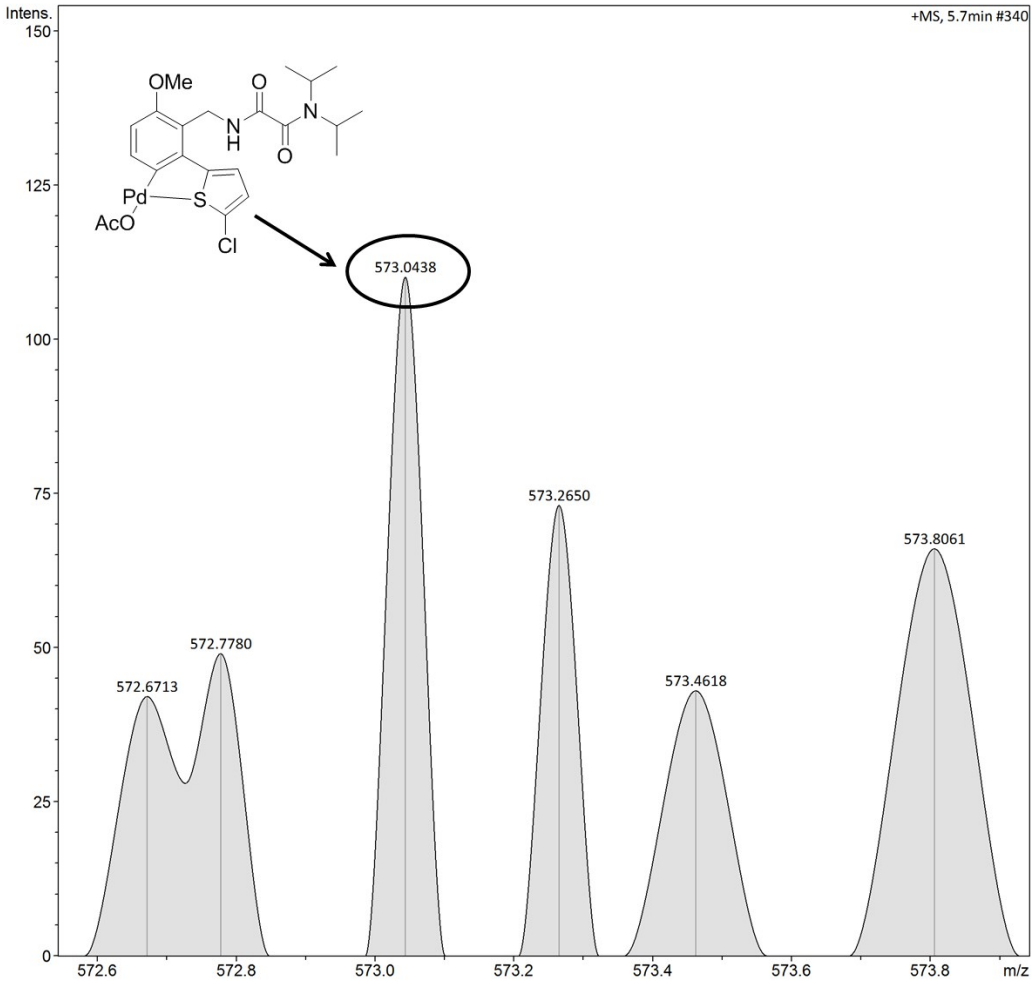


A mixture of **1a** (1.0 mmol, 1.0 equiv), $Pd(OAc)_2$ (1.0 mmol, 1.0 equiv), DIMETHYL SULFOXIDE-D_6 (2.0 mL) in a 15 mL glass vial (sealed with PTFE cap) were heated at 60 °C and at room temperature for 6 hrs respectively. The reaction mixture was cooled to room temperature, and concentrated in vacuo. Then the mixtures were monitored by proton NMR, and desired results were observed.




11.894
1.901
HOAc
0.83
3.00
16
14
12
10
8
6
4
2
0
-2
f1 (ppm)


3.340
2.500
1.787
Pd(OAc)2
6.00
16
14
12
10
8
6
4
2
0
-2
f1 (ppm)



6. **The OPV(organic photovoltaic) device fabrication procedure and measurement**

A mixture of zincAcetate Dihydrate (0.25 g), 2-Aminoethanol (125 μL), and 2-methoxyethanol (5 mL) were stirred at room temperature for 8 h, the ZnO precursor was obtained. Spin coating ZnO precursor on the Indium tin oxide (ITO) 5000 rpm (40 s), the temperature was heated to 320 ^{o}C at the speed of 20 ^{o}C/min in the air, then the obtained film thickness is about 40 nm. Spin coating *ortho* dichlorobenzene (*o*-DCB) solvent of P3HT:PC61BM (1 : 1, w/w) (40 mg/mL) 800 rpm (30 s) in the glove box, then annealing at 150 ^{o}C for 10 min in the glove box, the film thickness is about 150 nm. The organic molecules $\mathbf{3j_{di}}$ was dissolved in isopropanol. The solution concentration is 20 mg/mL, and was Spin coatted on the active layer as the hole transport layer (HTL) 2000 rpm (40 s), then annealing at 150 ^{o}C for 10 min. The device is placed in a vacuum environment (10-5 Torr), and vacuum depositing 10 nm Ag. The battery was obtained, and the structure is ITO/ZnO/P3HT:PC61BM/HTL/Ag. Current density-voltage (J-V) measurement was carried out under AM. 1.5 G.

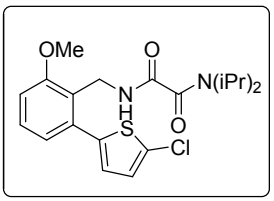
7. References

[1] T.-S. Mei, X. Wang, J.-Q. Yu, *J. Am. Chem. Soc.* **2009**, *131*, 10806.

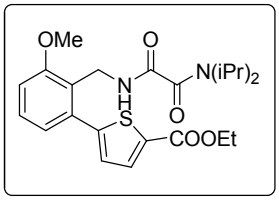
[2] G. Xu, S. R. Gilbertson, *Org. Lett*. **2005**, *7*, 4605.

[3] J. Hu, G. Li, C. Yuan, Z.-B. Huang, D.-Q. Shi, Y. Zhao, *Org. Lett*. **2016**, *18*, 5998.

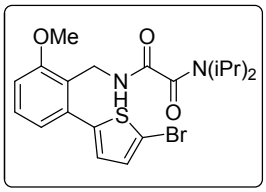
8. Data of all the compounds



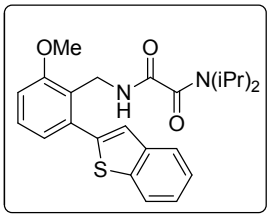
N*^{1}*-(2-(5-chlorothiophen-2-yl)-6-methoxybenzyl)-N*^{2}*,N*^{2}*-diisopropylo-xalamide(1a) [3]: Yellow liquid. 338.5 mg, yield 83%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.27 (m, 1H), 6.98-6.96 (m, 2H), 6.93-6.88 (m, 2H), 6.86 (d, *J* = 3.8 Hz, 1H), 4.77-4.66 (m, 1H), 4.55 (d, *J* = 5.4 Hz, 2H), 3.89 (s, 3H), 3.53-3.46 (m, 1H), 1.40 (d, *J* = 6.8 Hz, 6H), 1.23 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 162.0, 158.3, 139.3, 134.8, 129.5, 128.4, 126.1, 126.0, 123.2, 122.9, 110.0, 59.9, 55.4, 49.1, 46.0, 35.9, 20.4, 19.6, 13.7. HRMS Calcd for $C_{20}H_{26}ClN_2O_3S$ $[M+H]^+$: 409.1353; Found: 409.1343.



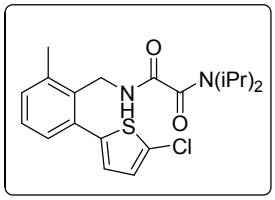
Ethyl 5-(2-((2-(diisopropylamino)-2-oxoacetamido)methyl)-3-methoxyphenyl)thiophene-2-carboxylate(1b) [3]: Yellow liquid. 325.5 mg, yield 73%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 3.8 Hz, 1H), 7.31 (t, *J* = 8.0 Hz, 1H), 7.07 (d, *J* = 3.8 Hz, 1H), 7.03-7.00 (m, 2H), 6.95 (d, *J* = 8.3 Hz, 1H), 4.70-4.63 (m, 1H), 4.53 (d, *J* = 5.4 Hz, 2H), 4.35 (q, *J* = 7.1 Hz, 2H), 3.90 (s, 3H), 3.52-3.45 (m, 1H), 1.40-1.36 (m, 9H), 1.21 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 162.0, 161.7, 158.3, 147.7, 134.6, 133.5, 133.1, 128.5, 127.4, 123.1, 122.8, 110.4, 60.7, 55.4, 49.2, 46.0, 35.9, 20.4, 19.6, 13.9. HRMS Calcd for $C_{23}H_{31}N_2O_5S$ $[M+H]^+$: 447.1954; Found: 447.1944.



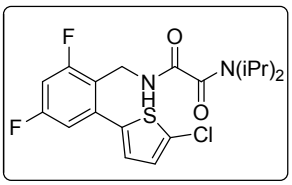
N*^{1}*-(2-(5-bromothiophen-2-yl)-6-methoxybenzyl)-N*^{2}*,N*^{2}*-diisopropylox-alamide(1c) [3]: Yellow liquid. 321 mg, yield 71%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31-7.27 (m, 1H), 7.04 (d, *J* = 3.8 Hz, 1H), 6.97 (d, *J* = 7.6 Hz, 2H), 6.92 (d, *J* = 8.3 Hz, 1H), 6.85 (d, *J* = 3.8 Hz, 1H), 4.72-4.66 (m, 1H), 4.54 (d, *J* = 5.4 Hz, 2H), 3.89 (s, 3H), 3.53-3.46 (m, 1H), 1.41 (d, *J* = 6.8 Hz, 6H), 1.23 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 162.0, 158.3, 142.2, 134.7, 129.8, 128.4, 127.0, 123.1, 122.9, 111.8, 110.1, 55.4, 49.1, 46.0, 35.9, 20.4, 19.6. HRMS Calcd for $C_{20}H_{26}BrN_2O_3S$ $[M+H]^+$: 453.0848; Found: 453.0839.



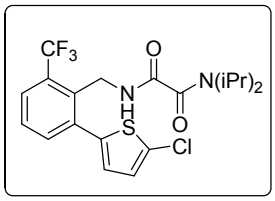
N*^{1}*-(2-(benzo[b]thiophen-2-yl)-6-methoxybenzyl)-N*^{2}*,N*^{2}*-diisopropylox-alamide(1d) [3]: Yellow liquid. 297 mg, yield 70%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82-7.77 (m, 2H), 7.39-7.29 (m, 4H), 7.12-7.10 (m, 1H), 6.99 (br, 1H), 6.95 (d, *J* = 8.2 Hz, 1H), 4.63 (d, *J* = 5.4 Hz, 3H), 3.91 (s, 3H), 3.52-3.45 (m, 1H), 1.40 (d, *J* = 6.8 Hz, 6H), 1.19 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.9, 162.0, 158.2, 140.9, 139.8, 139.6, 135.7, 128.4, 124.0, 123.8, 123.4, 123.3, 123.1, 121.5, 110.1, 55.4, 49.1, 45.9, 35.9, 20.4, 19.6. HRMS Calcd for $C_{24}H_{29}N_2O_3S$ $[M+H]^+$: 425.1899; Found: 425.1894.



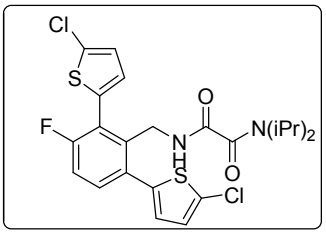
N^1-(2-(5-chlorothiophen-2-yl)-6-methylbenzyl)-N^2,N^2-diisopropyloxalamide(1e) [3]: Yellow liquid. 313.5 mg, yield 80%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.19 (m, 3H), 6.88 (d, *J* = 3.7 Hz, 1H), 6.78 (d, *J* = 3.8 Hz, 1H), 6.74 (br, 1H), 4.76-4.69 (m, 1H), 4.49 (d, *J* = 5.0 Hz, 2H), 3.53-3.47 (m, 1H), 2.42 (s, 3H), 1.40 (d, *J* = 6.8 Hz, 6H), 1.24 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3, 162.1, 140.1, 138.2, 134.3, 132.9, 130.7, 129.4, 128.8, 127.5, 125.9, 125.7, 49.2, 46.1, 38.3, 20.4, 19.6, 19.3. HRMS Calcd for $C_{20}H_{26}ClN_2O_2S$ $[M+H]^+$: 393.1404; Found: 393.1395.



N^1-(2-(5-chlorothiophen-2-yl)-4,6-difluorobenzyl)-N^2,N^2-diisopropyloxalamide(1f) [3]: Yellow liquid. 215.5 mg, yield 52%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 (br, 1H), 6.93-6.90 (m, 3H), 6.88-6.83 (m, 1H), 4.69-4.62 (m, 1H), 4.53-4.51 (m, 2H), 3.51-3.44 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.21 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1 (d, *J* = 12.8 Hz), 162.6 (d, *J* = 13.0 Hz) 162.2, 162.0, 160.6 (d, *J* = 12.8 Hz), 160.1 (d, *J* = 14.0 Hz), 136.8, 136.7, 136.6, 130.8, 126.8, 126.3, 118.5 (dd, *J* = 15.7, 4.0 Hz), 113.4 (dd, *J* = 22.1, 3.5 Hz), 103.8, 103.6, 103.3, 49.2, 46.0, 34.3 (d, *J* = 4.1 Hz), 20.4, 19.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ -109.5 (d, *J* = 8.8 Hz), -110.2 (d, *J* = 8.7 Hz). HRMS Calcd for $C_{19}H_{22}ClF_2N_2O_2S$ $[M+H]^+$: 415.1059; Found: 415.1065.

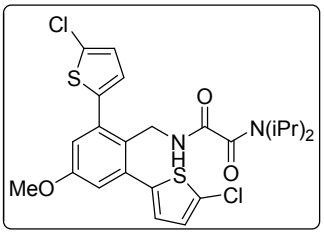


N^1-(2-(5-chlorothiophen-2-yl)-6-(trifluoromethyl)benzyl)-N^2,N^2-diisopropyloxalamide(1g) [3]: Yellow liquid. 298 mg, yield 78%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.2 Hz, 1H), 7.55 (d, *J* = 7.0 Hz, 1H), 7.44 (t, *J* = 7.8 Hz, 1H), 7.15 (s, 1H), 6.90–6.86 (m, 2H), 4.64–4.54 (m, 3H), 3.44 (dt, *J* = 13.6, 6.8 Hz, 1H), 1.30 (d, *J* = 6.8 Hz, 6H), 1.19 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3, 161.6, 137.7, 136.8, 135.0, 133.2, 130.5, 130.4, 130.2, 127.7, 126.8, 126.20 (q, *J* = 6.0 Hz), 124.9, 122.2, 49.2, 45.9, 37.4 (d, *J* = 1.7 Hz), 20.3, 19.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -58.80. HRMS Calcd for $C_{20}H_{23}ClF_3N_2O_2S$ $[M+H]^+$: 447.1121; Found: 447.1113.

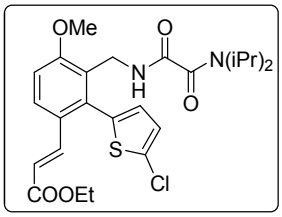


N^1-(2,6-bis(5-chlorothiophen-2-yl)-3-fluorobenzyl)-N^2, N^2-diisopropyloxalamide(1h) [3]: White solid. 261 mg, yield 51%, PE/EA= 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41-7.38 (m, 1H), 7.16–7.11 (m, 1H), 6.97 (br, 1H), 6.93 (d, *J* = 3.8 Hz, 1H), 6.90-6.84 (m, 3H), 4.61–4.53 (m, 1H), 4.41 (d, *J* = 5.0 Hz, 2H), 3.50-3.43 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.20 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.9, 161.3, 158.9, 138.2, 137.0, 133.11 (d, *J* = 8.7 Hz), 131.1, 130.7 (d, *J* = 4.0 Hz), 130.6, 130.0, 128.0, 126.5, 126.3, 126.1, 126.0 (d, *J* = 8.0 Hz), 122.8 (d, *J* = 16.0 Hz), 118.1 (d, *J* = 21.0 Hz), 115.0 (d, *J* = 23.0 Hz), 49.1, 46.1, 38.7 (d, *J* = 2.4 Hz), 20.4, 19.5. ^{19}F NMR (376 MHz,

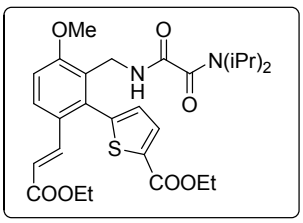
$CDCl_3$) δ -108.73. HRMS Calcd for $C_{23}H_{24}Cl_2FN_2O_2S_2$ [M+ H]$^+$: 513.0640; Found: 513.0639.



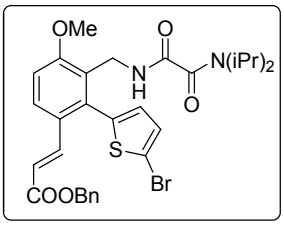
N^1-(2,6-bis(5-chlorothiophen-2-yl)-4-methoxybenzyl)-N^2,N^2-diisopropyloxalamide(1i) [3]: White solid. 304 mg, yield 58%, PE/EA = 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.93 (s, 2H), 6.89-6.87 (m, 4H), 6.73 (br, 1H), 4.61-4.55 (m, 1H), 4.41 (d, *J* = 4.7 Hz, 2H), 3.83 (s, 3H), 3.52-3.45 (m, 1H), 1.39 (d, *J* = 6.8 Hz, 6H), 1.22 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3, 161.5, 158.0, 139.1, 136.4, 129.9, 126.1, 126.0, 125.3, 116.8, 55.1, 49.2, 46.0, 38.5, 20.4, 19.6. HRMS Calcd for $C_{24}H_{26}Cl_2N_2O_3S_2Na$[M+ Na]$^+$: 547.0660; Found: 547.0668.



(E)-ethyl 3-(2-(5-chlorothiophen-2-yl)-3-((2-(diisopropylamin-o)-2-oxoacetamido)methyl)-4-methoxyphenyl)acrylate(3a): White solid. 87.0 mg, yield 86%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (t, *J* = 8.0 Hz, 1H), 7.15–7.10 (m, 2H), 7.02 (s, 1H), 6.97 (d, *J* = 8.2 Hz, 1H), 6.85 (d, *J* = 7.6 Hz, 1H), 6.13 (d, *J* = 15.9 Hz, 1H), 4.64–4.58 (m, 1H), 4.34 (d, *J* = 5.6 Hz, 2H), 4.17–4.10 (m, 2H), 3.89 (s, 3H), 3.47–3.40 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.24 (t, *J* = 7.1 Hz, 3H), 1.16 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 162.6, 161.8, 158.1, 141.3, 135.2, 133.8, 131.9, 130.1, 128.5, 125.0, 123.6, 123.3, 118.7, 111.2, 60.0, 55.3, 49.0, 45.9, 35.6, 20.4, 19.6, 13.8. HRMS Calcd for $C_{25}H_{32}ClN_2O_5S$ [M+ H]$^+$: 507.1720; Found: 507.1700.

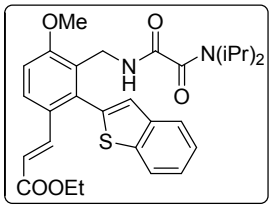


(E)-ethyl 5-(2-((2-(diisopropylamino)-2-oxoacetamido)methyl)-6-(3-ethoxy-3-oxoprop-1-en-1-yl)-3-methoxyphenyl)thiophene-2-carboxylate(3b): White solid. 75.1 mg, yield 69%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (s, 1H), 7.34 (t, *J* = 8.0 Hz, 1H), 7.18 (d, *J* = 16.0 Hz, 1H), 7.01 (d, *J* = 8.1 Hz, 2H), 6.88 (d, *J* = 7.6 Hz, 1H), 6.28 (d, *J* = 15.9 Hz, 1H), 4.64-4.57 (m, 1H), 4.39–4.32 (m, 4H), 4.20–4.13 (m, 2H), 3.93 (s, 3H), 3.49-3.42 (m, 1H), 1.37 (d, *J* = 6.7 Hz, 6H), 1.28-1.24 (m, 6H), 1.16 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.4, 162.4, 161.7, 161.2, 158.1, 148.4, 135.4, 134.8, 133.4, 132.2, 130.2, 128.5, 124.7, 123.2, 119.1, 111.3, 61.0, 60.0, 55.3, 49.0, 45.9, 35.5, 20.3, 19.6, 13.9, 13.8. HRMS Calcd for $C_{28}H_{37}N_2O_7S$ [M+ H]$^+$: 545.2321; Found: 545.2316.

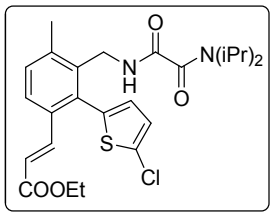


(E)-benzyl 3-(2-(5-bromothiophen-2-yl)-3-((2-(diisopropylamino)-2-oxoacetamido)methyl)-4-methoxyphenyl)acrylate(3c): White solid. 91.8 mg, yield 75%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39–7.33 (m, 5H), 7.29 (d, *J* = 5.1 Hz, 2H), 7.22 (d, *J* = 15.9 Hz, 1H), 7.01 (d, *J* = 8.1 Hz, 2H), 6.89 (d, *J* = 7.2 Hz, 1H), 6.23 (d, *J* = 15.9 Hz, 1H), 5.18 (s, 2H), 4.69-4.62 (m, 1H), 4.37 (d, *J* = 5.6 Hz, 2H), 3.94 (s, 3H), 3.52-3.45 (m, 1H), 1.41 (d, *J* = 6.8 Hz, 6H), 1.21 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 162.5,

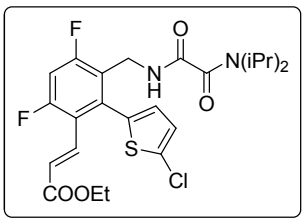
161.8, 158.1, 144.4, 135.7, 135.5, 134.8, 131.9, 128.5, 128.1, 127.7, 127.6, 127.1, 124.9, 123.6, 118.2, 112.7, 111.2, 65.8, 55.3, 49.0, 45.9, 35.6, 20.4, 19.6. HRMS Calcd for $C_{30}H_{34}BrN_2O_5S$ $[M+H]^+$: 613.1372; Found: 613.1385.



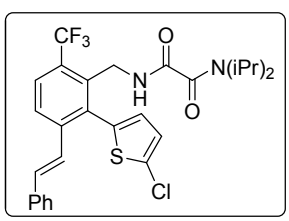
(E)-ethyl 3-(2-(benzo[b]thiophen-2-yl)-3-((2-(diisopropylamino)-2-oxoacetamido)methyl)-4-methoxyphenyl)acrylate(3d): White solid. 82.5 mg, yield 79%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.1 Hz, 1H), 7.81 (d, *J* = 7.9 Hz, 1H), 7.60 (d, *J* = 16.3 Hz, 1H), 7.47 (t, *J* = 7.3 Hz, 1H), 7.41–7.33 (m, 2H), 7.01-6.94 (m, 3H), 6.32 (d, *J* = 16.3 Hz, 1H), 4.57-4.50 (m, 1H), 4.37 (d, *J* = 5.4 Hz, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.90 (s, 3H), 3.46-3.39 (m, 1H), 1.36 (d, *J* = 6.8 Hz, 6H), 1.28 (t, *J* = 7.1 Hz, 3H), 1.13 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.7, 162.7, 161.8, 158.1, 144.3, 139.0, 137.1, 135.9, 133.9, 128.6, 128.2, 124.8, 124.6, 124.4, 123.0, 122.4, 121.9, 119.0, 111.1, 60.0, 55.3, 49.0, 45.8, 35.7, 20.3, 19.6, 13.8. HRMS Calcd for $C_{29}H_{35}N_2O_5S$ $[M+H]^+$: 523.2267; Found: 523.2256.



(E)-ethyl 3-(2-(5-chlorothiophen-2-yl)-3-((2-(diisopropylamno-2-oxoacetamido)methyl)-4-methylphenyl)acrylate(3e): White solid. 75.5 mg, yield 77%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29–7.23 (m, 2H), 7.14-7.09 (m, 3H), 6.79 (s, 1H), 6.14 (d, *J* = 15.9 Hz, 1H), 4.68-4.61 (m, 1H), 4.33 (d, *J* = 1.3 Hz, 2H), 4.15 (q, *J* = 7.1 Hz, 2H), 3.49-3.42 (m, 1H), 2.41 (s, 3H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.19 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 162.1, 162.0, 142.1, 138.4, 135.0, 134.4, 133.8, 131.8, 131.4, 130.0, 129.4, 127.5, 123.3, 118.9, 60.0, 49.1, 46.0, 38.1, 20.4, 19.5, 19.2, 13.8. HRMS Calcd for $C_{25}H_{32}ClN_2O_4S$ $[M+H]^+$: 491.1771; Found: 491.1773.

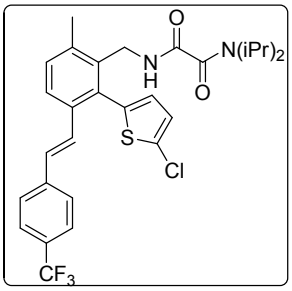


(E)-ethyl 3-(2-(5-chlorothiophen-2-yl)-3-((2-(diisopropylamino)-2-oxoacetamido)methyl)-4,6-difluorophenyl)acrylate(3f): White solid. 73.7 mg, yield 72%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.26 m, 1H), 7.14 (s, 1H), 7.07 (d, *J* = 15.9 Hz, 1H), 6.95-6.90 (m, 1H), 6.84–6.81 (m, 1H), 6.17 (d, *J* = 15.9 Hz, 1H), 4.62-4.55 (m, 1H), 4.33 (d, *J* = 5.0 Hz, 2H), 4.16 (q, *J* = 7.1 Hz, 2H), 3.45-3.39 (m, 1H), 1.30 (d, *J* = 6.8 Hz, 6H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.15 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.1, 162.0, 161.8, 138.0, 134.3, 134.2, 131.2, 123.5, 119.9, 114.7 (d, J_{C-F} = 4.0 Hz), 114.4 (d, J_{C-F} = 3.0 Hz), 105.2, 105.0, 104.7, 60.2, 49.0, 46.0, 34.01 (d, J_{C-F} = 3.1 Hz), 20.3, 19.4, 13.7. ^{19}F NMR (376 MHz, $CDCl_3$) δ -108.75 (d, *J* = 7.9 Hz), -109.33 (d, *J* = 8.0 Hz), -112.87 (d, *J* = 8.1 Hz), -116.21 (d, *J* = 7.9 Hz). HRMS Calcd for $C_{24}H_{28}ClF_2N_2O_4S$ $[M+H]^+$: 513.1426; Found: 513.1430.

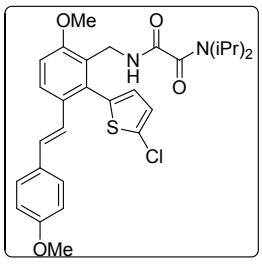


(E)-N^1-(2-(5-chlorothiophen-2-yl)-3-styryl-6-(trifluoromethyl)benzy-

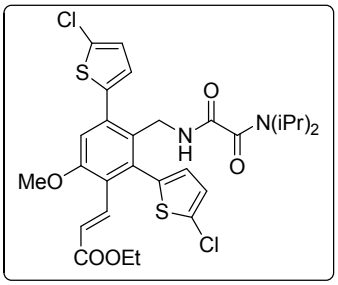
l)-N²,N²-diisopropyloxalamide(3g): White solid. 61.4 mg, yield 56%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.3 Hz, 1H), 7.62–7.55 (m, 2H), 7.33-7.31 (m, 5H), 7.28-7.26 (m, 1H), 7.07 (s, 1H), 6.93 (d, *J* = 16.2 Hz, 1H), 6.51 (d, *J* = 16.2 Hz, 1H), 4.86-4.79 (m, 1H), 4.64 (s, 2H), 3.50-3.44 (m, 1H), 1.34 (d, *J* = 6.1 Hz, 6H), 1.22 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.4, 161.0, 136.8, 136.07 (d, *J* = 7.6 Hz), 135.3, 135.1, 133.0, 130.7, 130.2, 128.2, 127.8, 127.5, 126.9 (q, *J* = 5.7 Hz), 126.0, 123.4, 119.4, 53.0, 48.9, 46.1, 37.0, 20.4, 19.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -58.64. HRMS Calcd for $C_{28}H_{29}ClF_3N_2O_2S$ [M+ H]$^+$: 549.1590; Found: 549.1585.



(E)-N¹-(2-(5-chlorothiophen-2-yl)-6-methyl-3-(4-(trifluoro-methyl)styryl)benzyl)-N²,N²-diisopropyloxalamide(3h): White solid. 85.4 mg, yield 76%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 8.3 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 2H), 7.33–7.27 (m, 2H), 7.24 (s, 1H), 7.19-7.17 (m, 1H), 6.85 (d, *J* = 16.3 Hz, 1H), 6.76 (s, 1H), 6.63 (d, *J* = 16.3 Hz, 1H), 4.75-4.68 (m, 1H), 4.40 (d, *J* = 5.2 Hz, 2H), 3.45-3.39 (m, 1H), 2.45 (s, 3H), 1.28 (d, *J* = 6.5 Hz, 6H), 1.17 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8, 139.8, 138.3, 137.3, 135.6, 134.8, 132.2, 131.5, 129.6, 128.3, 127.5, 126.1, 125.1 (q, *J* = 3.6 Hz), 123.2, 122.3, 49.0, 46.1, 38.1, 20.4, 19.4, 19.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.57. HRMS Calcd for $C_{29}H_{31}ClF_3N_2O_2S$ [M+ H]$^+$: 563.1747; Found: 563.1739.

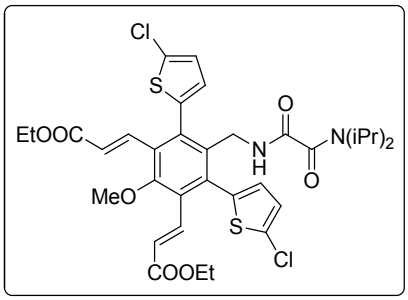


(E)-N¹-(2-(5-chlorothiophen-2-yl)-6-methoxy-3-(4-methoxystyryl)benzyl)-N²,N²-diisopropyloxalamide(3i): White solid. 77.8 mg, yield 72%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.33 (m, 1H), 7.28-7.23 (m, 3H), 7.05 (s, 1H), 7.00 (d, *J* = 7.7 Hz, 1H), 6.97-6.95 (m, 1H), 6.83-6.79 (m, 3H), 6.46 (d, *J* = 16.3 Hz, 1H), 4.72-4.66 (m, 1H), 4.44 (d, *J* = 5.5 Hz, 2H), 3.94 (s, 3H), 3.79 (s, 3H), 3.47-3.41 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.15 (d, *J* = 6.6 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.1, 162.3, 159.4, 158.7, 136.9, 134.7, 133.8, 129.9, 129.8, 129.7, 128.9, 127.8, 125.7, 124.5, 123.8, 118.8, 114.2, 111.2, 55.9, 55.4, 49.6, 46.5, 36.3, 22.8, 20.9, 20.2.. HRMS Calcd for $C_{29}H_{34}ClN_2O_4S$ [M+ H]$^+$: 541.1928; Found: 541.1935.

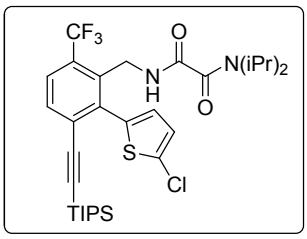


(E)-ethyl 3-(2,4-bis(5-chlorothiophen-2-yl)-3-((2-(diisopropyla-mino)-2-oxoacetamido)methyl)-6-methoxyphe-nyl)acrylate (3j$_{mono}$): White solid. 34.8 mg, yield 28%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (d, *J* = 15.9 Hz, 1H), 7.13 (s, 1H), 6.99 (d, *J* = 2.7 Hz, 1H), 6.91-6.88 (m, 2H), 6.82 (d, *J* = 2.7 Hz, 1H), 6.78 (s, 1H), 6.17 (d, *J* = 15.9 Hz, 1H), 4.60-4.53 (m, 1H), 4.30 (s, 2H), 4.18 (q, *J* = 7.1 Hz, 2H), 3.82 (s, 3H), 3.48-3.41 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 7H), 1.27 (t, *J* = 7.2 Hz, 3H), 1.18 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.3, 161.8, 161.3, 157.9,

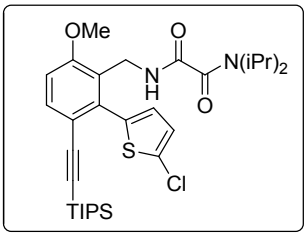
140.8, 138.8, 136.4, 134. 8, 134.0, 133.6, 130.4, 130.0, 126.9, 126.2, 126.1, 123.3, 119.3, 117.8, 117.6, 60.1, 55.1, 49.0, 46.0, 38.0, 29.2, 20.4, 19.5, 13.8. HRMS Calcd for $C_{29}H_{33}Cl_2N_2O_5S_2$ [M+ H]$^+$: 623.1208; Found: 623.1198.



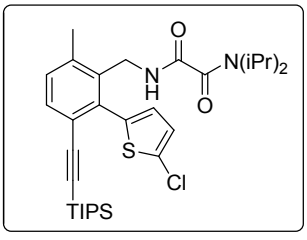
(2E,2'E)-diethyl 3,3'-(4,6-bis(5-chlorothiophen-2-yl)-5-((2-(diisopropylamino)-2-oxoacetamido)met-hyl)-2-meth-oxy-1,3-phenylene)diacrylate(3j$_{(o+o')di}$): White solid. 89.3 mg, yield 62%, PE/EA = 3:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 (d, *J* = 16.0 Hz, 2H), 7.13 (s, 2H), 6.90 (s, 2H), 6.78 (s, 1H), 6.18 (d, *J* = 15.9 Hz, 2H), 4.61-4.54 (m, 1H), 4.21–4.15 (m, 6H), 3.81 (s, 3H), 3.44-3.37 (m, 1H), 1.31 (d, *J* = 6.8 Hz, 6H), 1.27 (t, *J* = 7.1 Hz, 6H), 1.15 (d, *J* = 6.7 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.2, 161.3, 161.1, 157.9, 140.3, 134.6, 134.1, 133.7, 130.6, 128.7, 123.4, 119.6, 118.7, 60.1, 55.2, 48.8, 46.0, 37.7, 20.4, 19.4, 13.8. HRMS Calcd for $C_{34}H_{39}Cl_2N_2O_7S_2$ [M+ H]$^+$: 721.1576; Found: 721.1563.



N^1-(2-(5-chlorothiophen-2-yl)-6-(trifluoromethyl)-3-((triisopropylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5a): Yellow solid. 90.1 mg, yield 72%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J* = 7.2 Hz, 1H), 7.54 (d, *J* = 6.9 Hz, 1H), 7.46 (t, *J* = 7.8 Hz, 1H), 6.99 (s, 1H), 6.91 (s, 1H), 4.75-4.65 (m, 3H), 3.50-3.43 (m, 1H), 1.37 (d, *J* = 6.8 Hz, 6H), 1.20 (d, *J* = 6.7 Hz, 6H), 0.94–0.86 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.7, 161.1, 141.0, 135.4, 135.3, 135.1, 130.2, 129.9, 129.1, 128.1, 127.6, 126.6 (q, *J* = 5.7 Hz), 121.6, 99.0, 94.2, 48.9, 46.1, 36.8, 20.4, 19.5, 17.9, 10.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ -58.62. HRMS Calcd for $C_{31}H_{43}ClF_3N_2O_2SSi$ [M+ H]$^+$: 627.2455; Found: 627.2425.

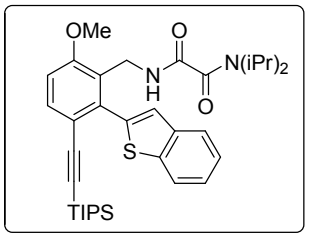


N^1-(2-(5-chlorothiophen-2-yl)-6-methoxy-3-((triisopropylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5b): Yellow solid. 78.8 mg, yield 67%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29-7.25 (m, 1H), 6.97-6.91 (m, 4H), 4.68-4.62 (m, 1H), 4.50 (d, *J* = 5.7 Hz, 2H), 3.87 (s, 3H), 3.50-3.43 (m, 1H), 1.38 (d, *J* = 6.8 Hz, 6H), 1.19 (d, *J* = 6.7 Hz, 6H), 0.92–0.85 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8, 161.8, 157.9, 142.9, 133.1, 128.3, 128.1, 124.9, 123.4, 120.9, 110.7, 99.6, 93.0, 55.3, 49.0, 45.9, 35.5, 20.4, 19.6, 17.9, 10.6. HRMS Calcd for $C_{31}H_{46}ClN_2O_3SSi$ [M+ H]$^+$: 589.2687; Found: 589.2684.

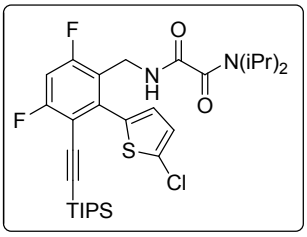


N^1-(2-(5-chlorothiophen-2-yl)-6-methyl-3-((triisopropylsillyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5c): Yellow solid. 92.7 mg, yield 81%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22–7.18 (m, 2H), 7.18–7.12 (m, 1H), 6.94 (s, 1H), 6.72 (s, 1H), 4.68–4.60 (m,

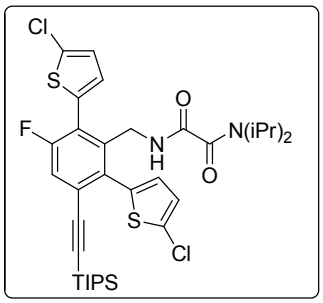
1H), 4.47 (d, *J* = 5.3 Hz, 2H), 3.50-3.42 (m, 1H), 2.38 (s, 3H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.20 (d, *J* = 6.7 Hz, 6H), 0.93–0.86 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3, 162.0, 143.8, 137.8, 134.2, 132.6, 131.2, 129.1, 128.1, 128.0, 127.3, 127.2, 120.8, 99.6, 93.2, 59.9, 49.1, 46.0, 38.0, 20.4, 19.5, 19.1, 18.2, 17.9, 10.6. HRMS Calcd for $C_{31}H_{46}ClN_2O_2SSi$ [M+ H]$^+$: 573.2738; Found: 573.2731.



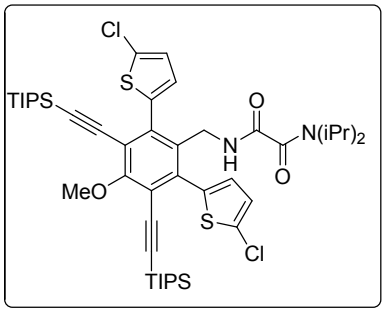
N^1-(2-(benzo[b]thiophen-2-yl)-6-methoxy-3-((triisopropylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5d): Yellow solid. 93.0 mg, yield 77%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.7 Hz, 1H), 7.79 (d, *J* = 7.9 Hz, 1H), 7.48–7.44 (m, 1H), 7.40–7.36 (m, 1H), 7.32 (t, *J* = 8.0 Hz, 1H), 7.07 (d, *J* = 7.7 Hz, 1H), 6.96 (d, *J* = 8.4 Hz, 2H), 4.57-4.52 (m, 3H), 3.90 (s, 3H), 3.47-3.40 (m, 1H), 1.37 (d, *J* = 6.8 Hz, 6H), 1.13 (d, *J* = 6.6 Hz, 6H), 1.02–0.98 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.9, 161.9, 158.0, 145.3, 139.1, 138.1, 134.3, 128.0, 124.7, 124.6, 124.5, 123.2, 122.9, 121.6, 117.8, 110.7, 99.3, 95.3, 55.3, 48.9, 45.8, 35.8, 20.4, 19.6, 18.1, 10.7. HRMS Calcd for $C_{35}H_{49}N_2O_3SSi$ [M+ H]$^+$: 605.3233; Found: 605.3227.



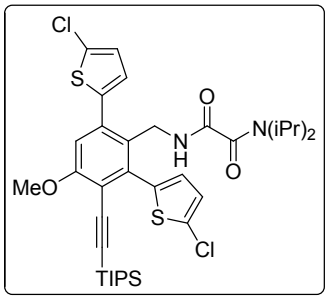
N^1-(2-(5-chlorothiophen-2-yl)-4,6-difluoro-3-((triisopropylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5e): Yellow solid. 99.8 mg, yield 84%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.05 (s, 1H), 6.97 (s, 1H), 6.95-6.92 (m, 1H), 6.90-6.85 (m, 1H), 4.70-4.63 (m, 1H), 4.50 (d, *J* = 5.6 Hz, 2H), 3.49-3.42 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.19 (d, *J* = 6.7 Hz, 6H), 0,98–0.91 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.0, 161.7, 129.6, 128.3, 121.5, 114.4 (d, $J_{C\text{-}F}$ = 3.0Hz), 114.2 (d, $J_{C\text{-}F}$ = 3.0Hz), 104.5, 104.2, 103.9, 98.9, 94.4, 49.0, 46.1, 34.0 (d, $J_{C\text{-}F}$ = 3.0 Hz), 20.4, 19.5, 17.9, 10.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -110.44 (d, *J* = 8.5 Hz), -111.24 (d, *J* = 8.5 Hz). HRMS Calcd for $C_{30}H_{42}ClF_2N_2O_2SSi$ [M+ H]$^+$: 595.2393; Found: 595.2381.



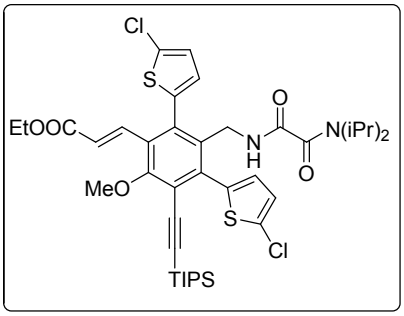
N^1-(2,6-bis(5-chlorothiophen-2-yl)-3-fluoro-5-((triisopropylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5f$_{(o+o')di}$): Yellow solid. 76.1 mg, yield 55%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43–7.37 (m, 1H), 7.16-7.11 (m, 1H), 6.99 (d, *J* = 20.5 Hz, 1H), 6.95–6.89 (m, 1H), 6.88–6.86 (m, 1H), 6.83-6.80 (m, 1H), 4.65-4.40 (m, 3H), 3.49-3.42 (m, 1H), 1.36 (d, *J* = 6.7 Hz, 6H), 1.19 (d, *J* = 6.6 Hz, 6H), 0.98–0.91 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.6, 161.1, 141.6, 138.7, 138.1, 133.64 (d, $J_{C\text{-}F}$ = 8.9 Hz), 131.1, 130.5, 130.1, 128.9, 128.0 (d, $J_{C\text{-}F}$ = 7.0 Hz), 126.04 (d, $J_{C\text{-}F}$ = 7.2 Hz), 126.0, 121.5, 114.8, 114.6, 99.2, 94.0, 59.9, 49.0 (d, *J* = 8.2 Hz), 46.1, 38.2, 20.4, 19.5, 18.0, 13.7, 10.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ -108.24. HRMS Calcd for $C_{34}H_{44}Cl_2FN_2O_2S_2Si$ [M+ H]$^+$: 693.1975; Found: 693.1977.



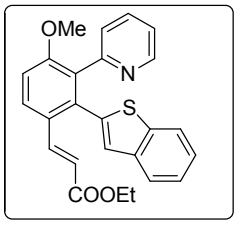
N^1-(2,6-bis(5-chlorothiophen-2-yl)-4-methoxy-3,5-bis((triiso propylsilyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5g): Yellow solid. 118.5 mg, yield 67%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95 (d, *J* = 2.9 Hz, 4H), 6.66 (s, 1H), 4.44–4.37 (m, 3H), 3.77 (s, 3H), 3.45-3.38 (m, 1H), 1.35 (d, *J* = 6.8 Hz, 6H), 1.19 (d, *J* = 6.7 Hz, 6H), 0.99–0.91 (m, 42H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.2, 161.5, 157.9, 142.4, 134.7, 128.6, 128.2, 127.9, 121.3, 118.0, 99.4, 93.9, 54.9, 49.0, 45.9, 37.6, 20.4, 19.6, 18.1, 10.6. HRMS Calcd for $C_{46}H_{67}Cl_2N_2O_3S_2Si_2$[M+ H]$^+$: 885.3509; Found: 885.3012.



N^1-(2,6-bis(5-chlorothiophen-2-yl)-4-methoxy-3-((triisopropylsi lyl)ethynyl)benzyl)-N^2,N^2-diisopropyloxalamide(5h):Yellow solid. 85.9 mg, yield 61%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95–6.94 (m, 2H), 6.91 (d, *J* = 2.8 Hz, 1H), 6.88 (d, *J* = 3.8 Hz, 1H), 6.84 (d, *J* = 3.8 Hz, 1H), 6.69 (s, 1H), 4.57-4.50 (m, 1H), 4.40 (d, *J* = 5.1 Hz, 2H), 3.80 (s, 3H), 3.49-3.42 (m, 1H), 1.37 (d, *J* = 6.8 Hz, 6H), 1.20 (d, *J* = 6.7 Hz, 6H), 0.97–0.91 (m, 21H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.2, 161.4, 157.9, 142.5, 139.1, 136.0, 135.0, 129.8, 128.6, 127.9, 126.9, 126.0, 126.0, 121.2, 117.8, 117.2, 99.3, 93.9, 55.0, 49.1, 46.0, 38.0, 20.4, 19.6, 18.0, 10.6. HRMS Calcd for $C_{35}H_{47}Cl_2N_2O_3S_2Si$ [M+ H]$^+$: 705.2174; Found: 705.2180.

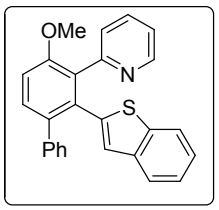


(E)-ethyl 3-(2,4-bis(5-chlorothiophen-2-yl)-3-((2-(diisopro-pylamino)-2-oxoacetamido)methyl)-6-methoxy-5-((triisop ropylsilyl)ethynyl)phenyl)acrylate(5i): Yellow solid. 97.8 mg, yield 61%, PE/EA = 10:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28-4.24 (m, 1H), 7.19 (d, *J* = 12.1 Hz, 2H), 6.96 (d, *J* = 2.6 Hz, 1H), 6.82 (d, *J* = 2.6 Hz, 1H), 6.21 (d, *J* = 15.8 Hz, 1H), 5.66 (s, 1H), 4.19-4.14 (m, 3H), 3.87-3.79 (m, 4H), 3.70-3.65 (m, 1H), 3.45-3.38 (m, 1H), 1.42 (d, *J* = 6.8 Hz, 6H), 1.27 (t, *J* = 6.8 Hz, 3H), 1.18 (d, *J* = 6.6 Hz, 6H), 1.10–0.97 (m, 7H), 0.95–0.84 (m, 14H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.1, 166.2, 162.9, 162.3, 158.6, 144.7, 140.9, 137.5, 137.0, 136.0, 134.9, 134.0, 133.5, 130.7, 129.4, 128.1, 125.7, 123.5, 119.0, 116.1, 113.9, 60.0, 55.3, 50.2, 45.4, 43.6, 22.0, 19.9, 16.8, 16.6, 13.8, 12.3. HRMS Calcd for $C_{40}H_{53}Cl_2N_2O_5S_2Si$[M+ H]$^+$: 803.2542; Found: 803.2549.



(E)-ethyl 3-(2-(benzo[b]thiophen-2-yl)-4-methoxy-3-(pyridin-2-yl)phenyl)acrylate(7a): White solid. 53.1 mg, yield 64%, PE/EA = 5:1. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (d, *J* = 4.8 Hz, 1H), 7.93 (d, *J* = 8.1 Hz, 1H), 7.70 (d, *J* = 7.9 Hz, 1H), 7.64 (d, *J* = 16.3 Hz, 1H), 7.45 (t, *J* = 8.0 Hz,

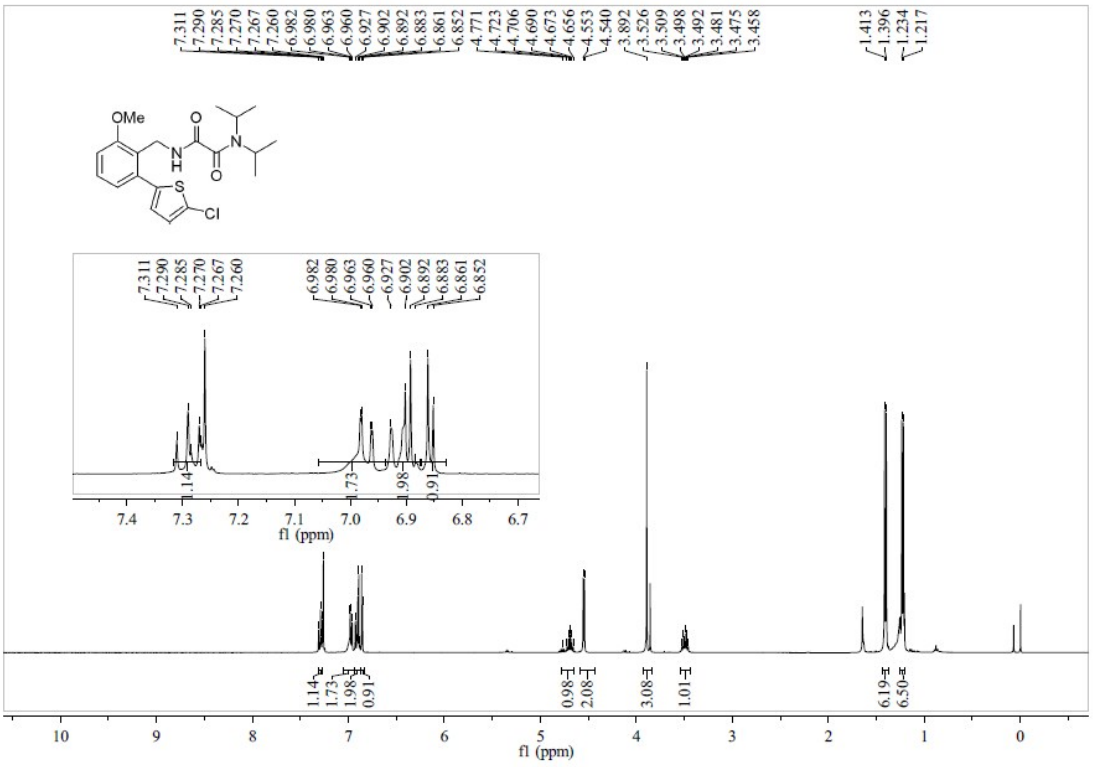
2H), 7.37 (t, *J* = 7.1 Hz, 1H), 7.32-7.28 (m, 1H), 7.22 (d, *J* = 7.8 Hz, 1H), 7.09 (t, *J* = 8.6 Hz, 2H), 7.03–7.00 (m, 1H), 6.26 (d, *J* = 16.3 Hz, 1H), 4.24 (q, *J* = 7.1 Hz, 2H), 3.81 (s, 3H), 1.32 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.9, 156.9, 154.8, 148.4, 146.3, 139.4, 136.7, 134.9, 133.4, 130.2, 128.9, 127.3, 125.6, 124.3, 124.1, 123.6, 122.2, 121.8, 121.3, 118.6, 111.6, 59.9, 55.5, 13.9. HRMS Calcd for $C_{15}H_{22}NO_3S$[M+ H]$^+$: 416.1320; Found: 416.1310.



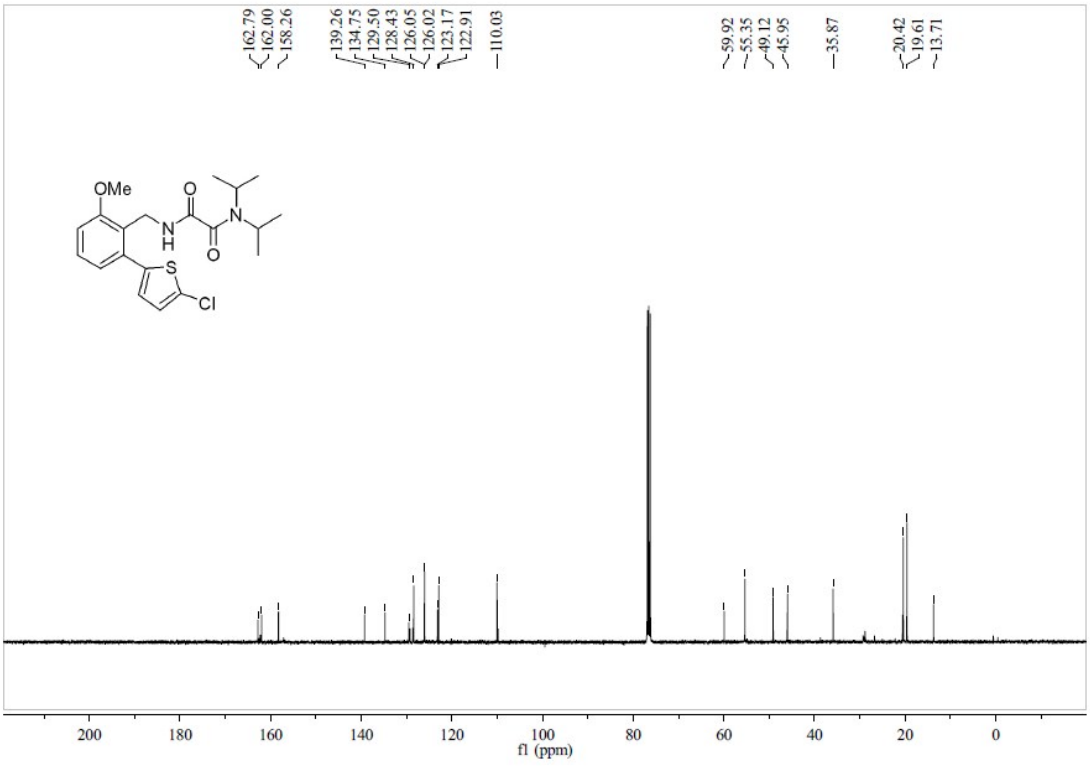
2-(2-(benzo[b]thiophen-2-yl)-4-methoxy-[1,1'-biphenyl]-3-yl)pyridine(8a). White solid. 67.6 mg, yield 86%, PE/EA = 5:1. ^{1}H NMR (400 MHz, DMSO) δ 8.34 (d, *J* = 4.4 Hz, 1H), 7.85–7.83 (m, 1H), 7.61-7.57 (m, 1H), 7.50–7.47 (m, 1H), 7.37–7.28 (m, 6H), 7.26–7.24 (m, 2H), 7.14–7.10 (m, 2H), 7.04 (d, *J* = 7.8 Hz, 1H), 6.86 (d, *J* = 7.4 Hz, 1H), 3.69 (s, 3H); ^{13}C NMR (101 MHz, DMSO) δ 174.3, 156.6, 139.1, 138.6, 138.5, 134.4, 134.3, 133.6, 129.9, 129.6, 129.0, 128.3, 127.2, 126.1, 124.5, 124.4, 124.2, 122.5, 122.2, 121.8, 111.5, 55.6. HRMS Calcd for $C_{26}H_{20}NOS$ [M+ H]$^+$: 394.1266; Found: 394.127.

9. ^{1}H NMR and ^{13}C NMR and ^{19}F NMR Spectra of compounds.

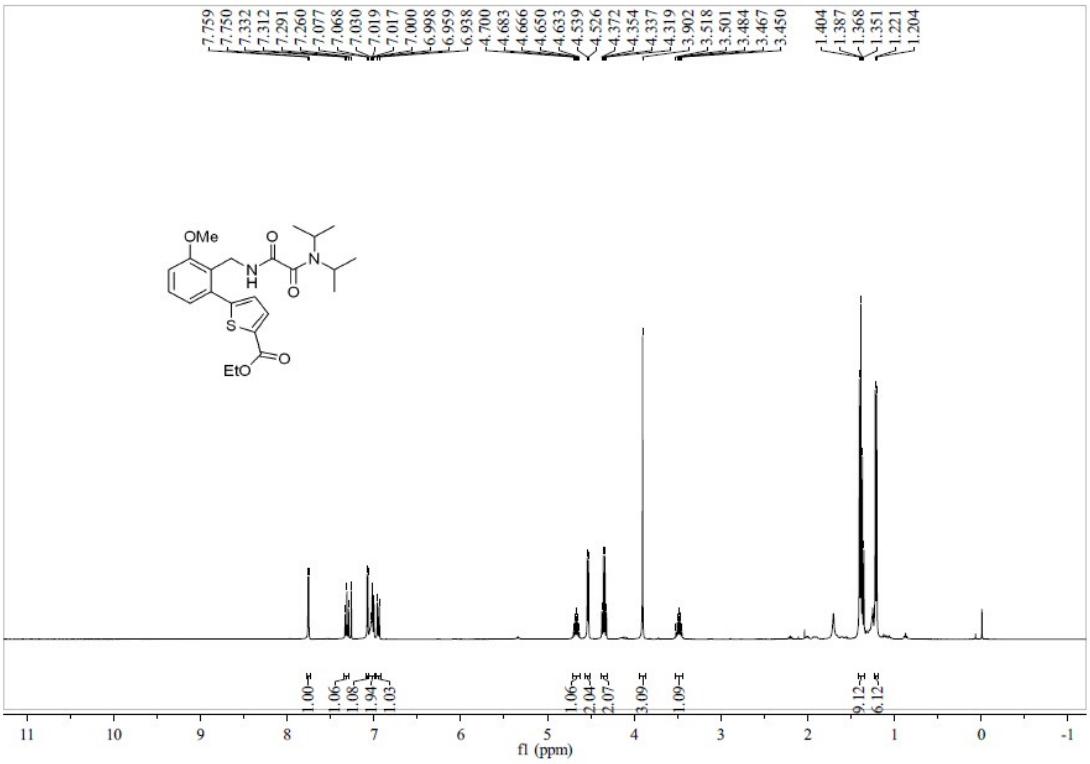
^{1}H NMR of compound **(1a)**[3]



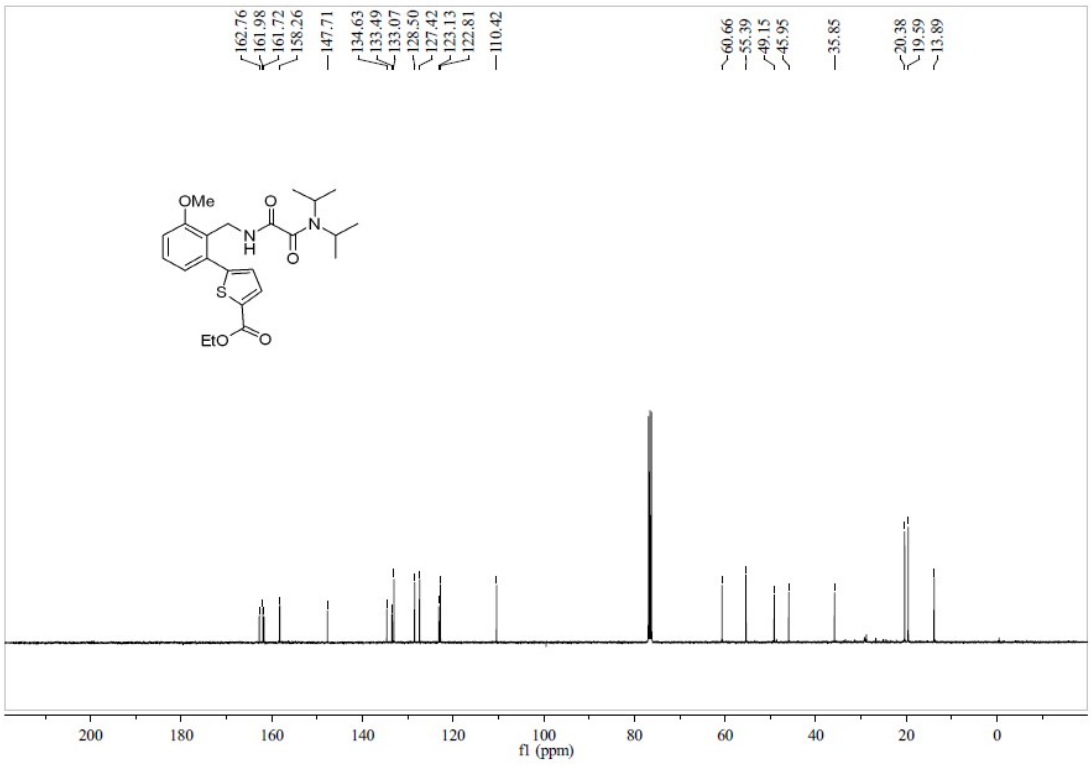
^{13}C NMR of compound **(1a)** [3]



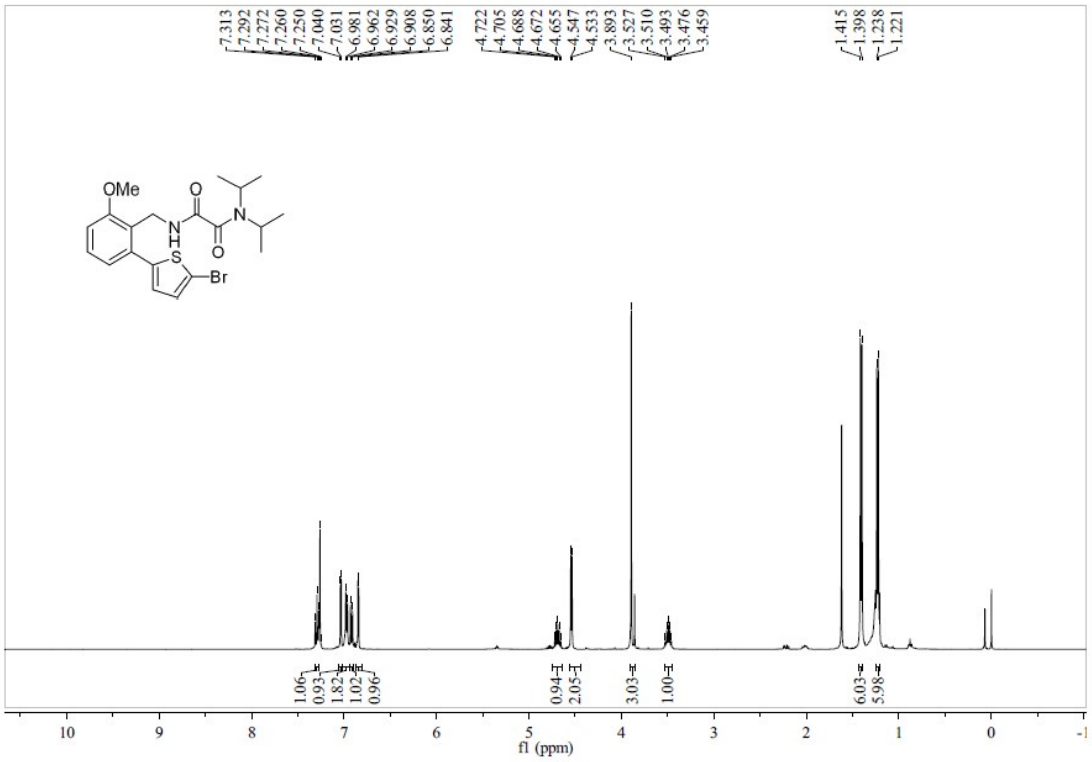
^{1}H NMR of compound **(1b)** [3]



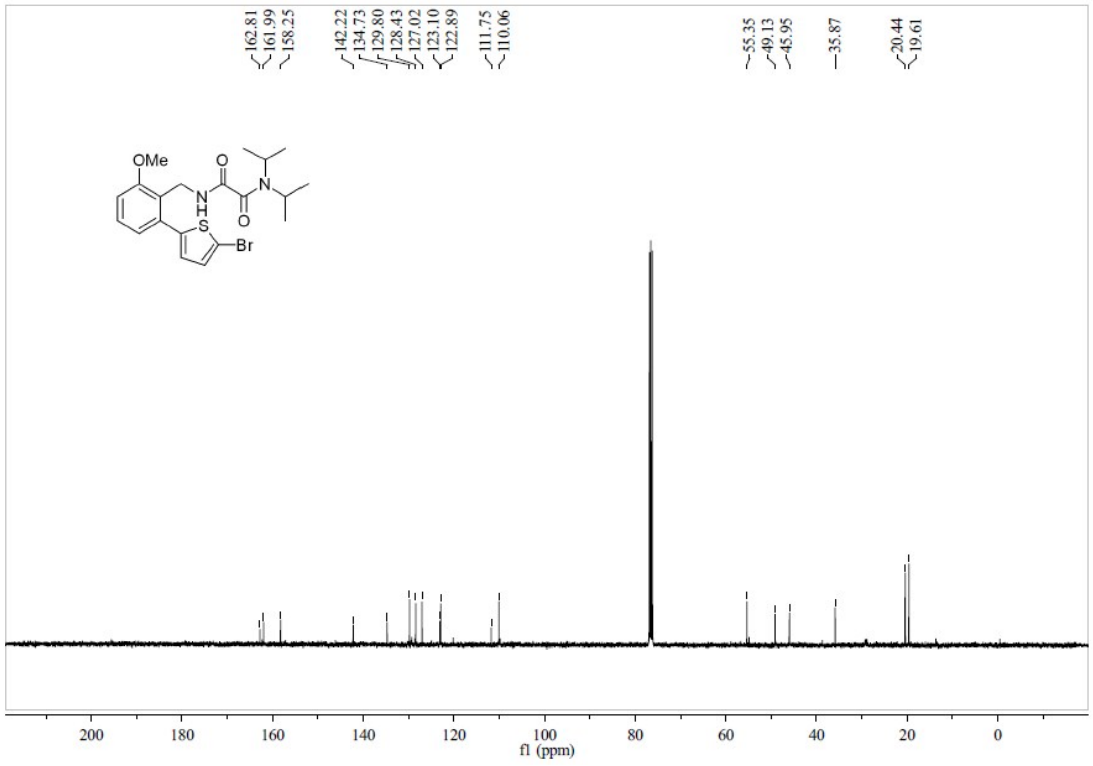
^{13}C NMR of compound **(1b)** [3]



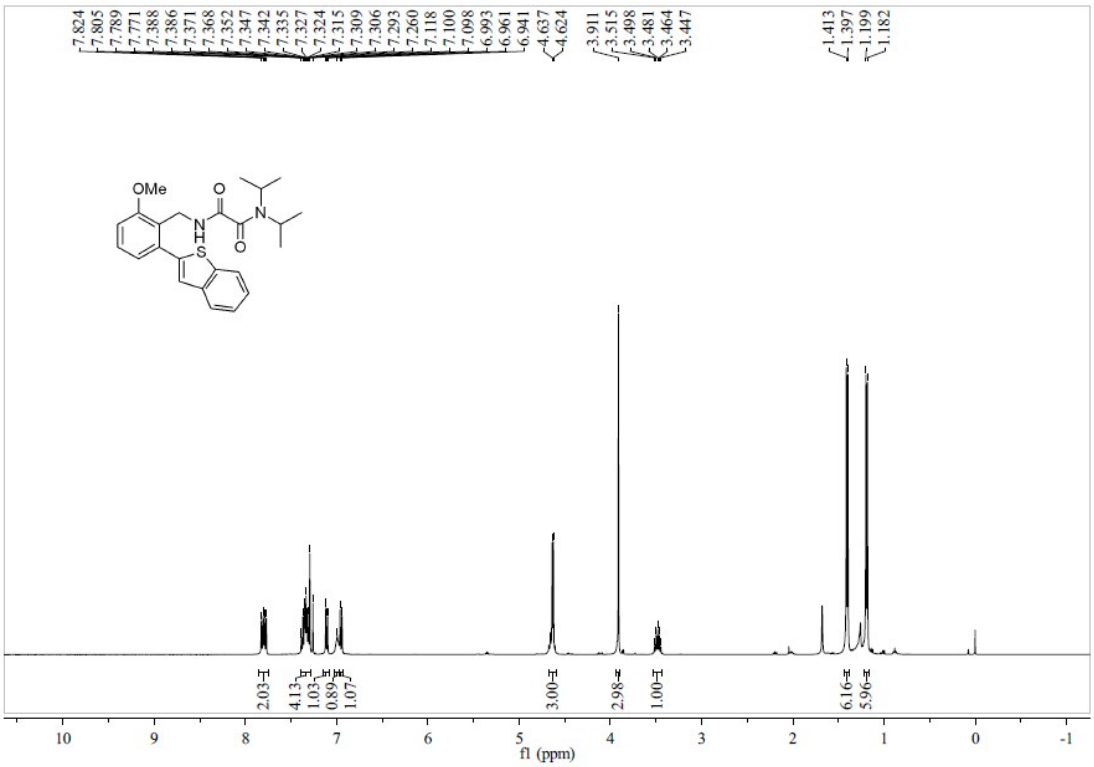
^{1}H NMR of compound **(1c)** [3]



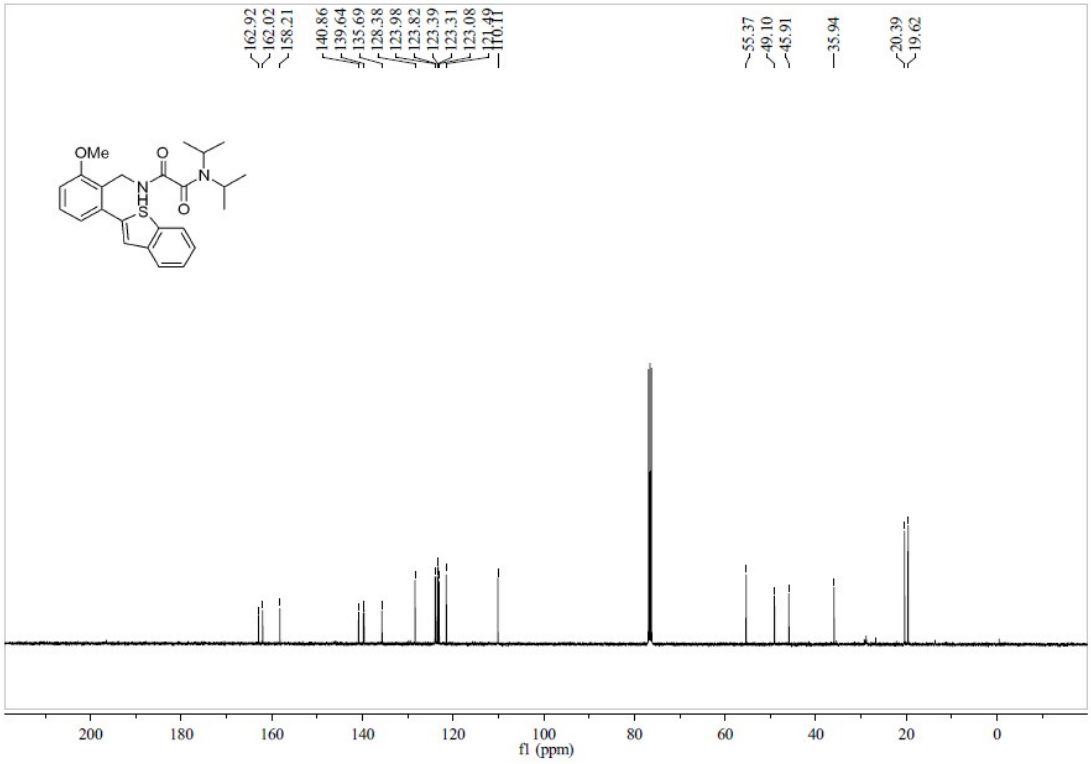
^{13}C NMR of compound **(1c)** [3]



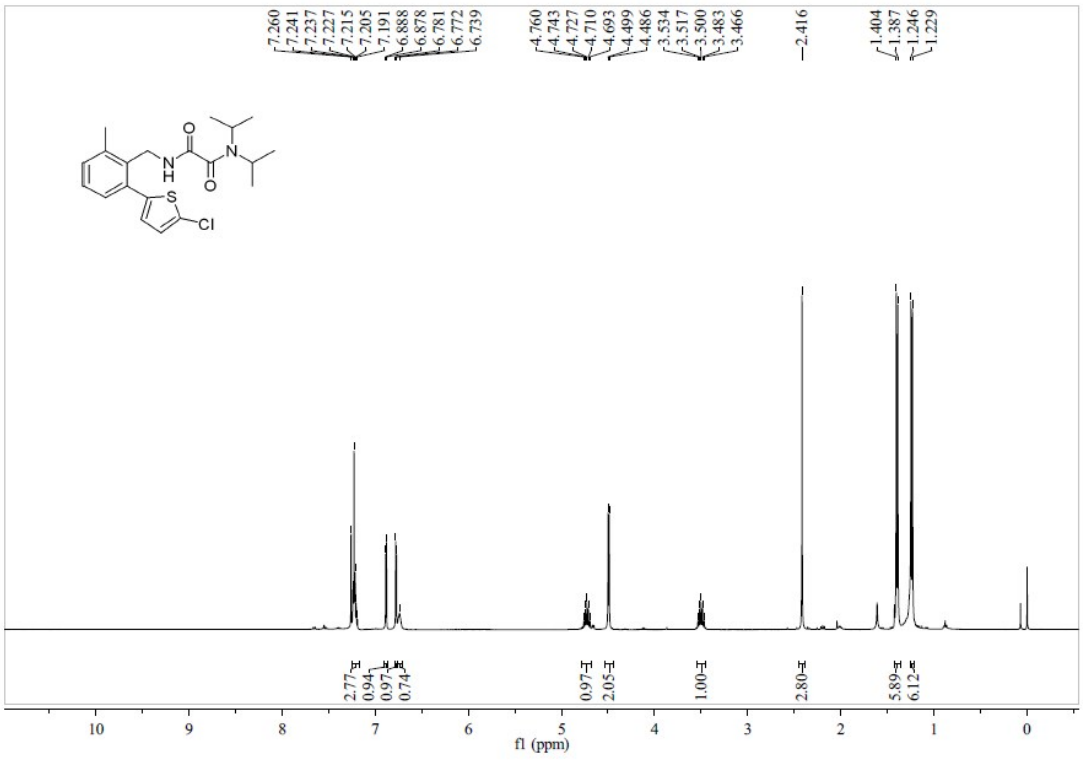
^{1}H NMR of compound **(1d)** [3]



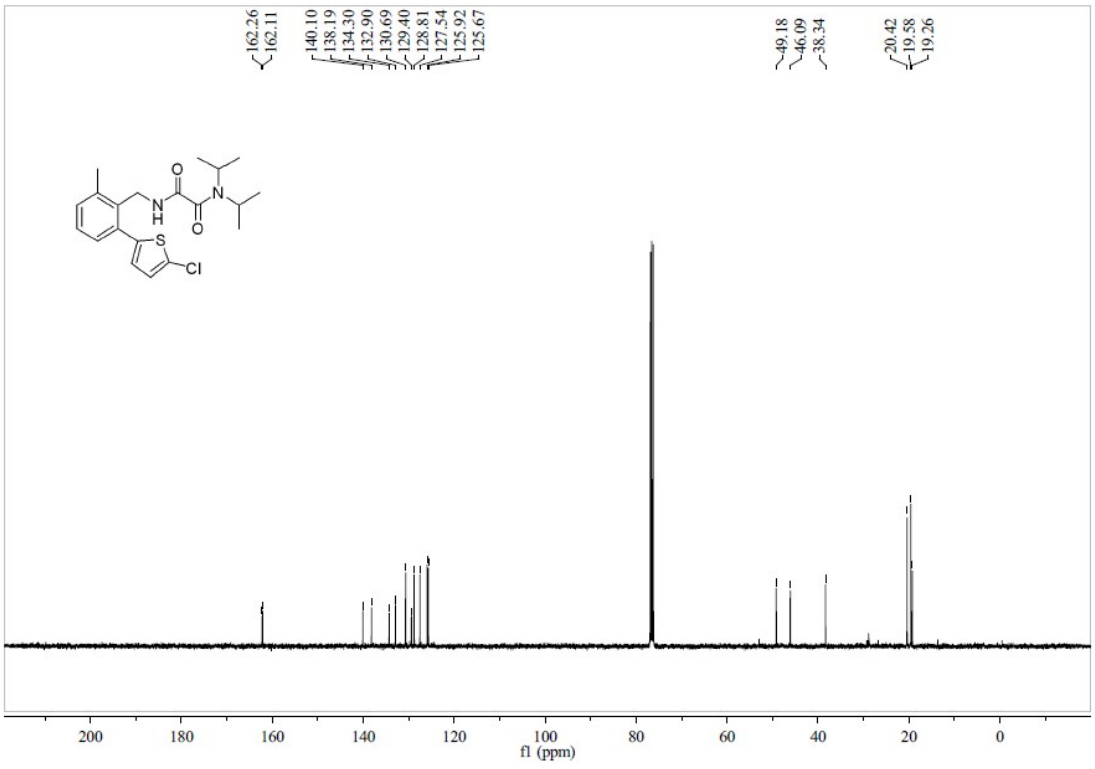
^{13}C NMR of compound **(1d)** [3]



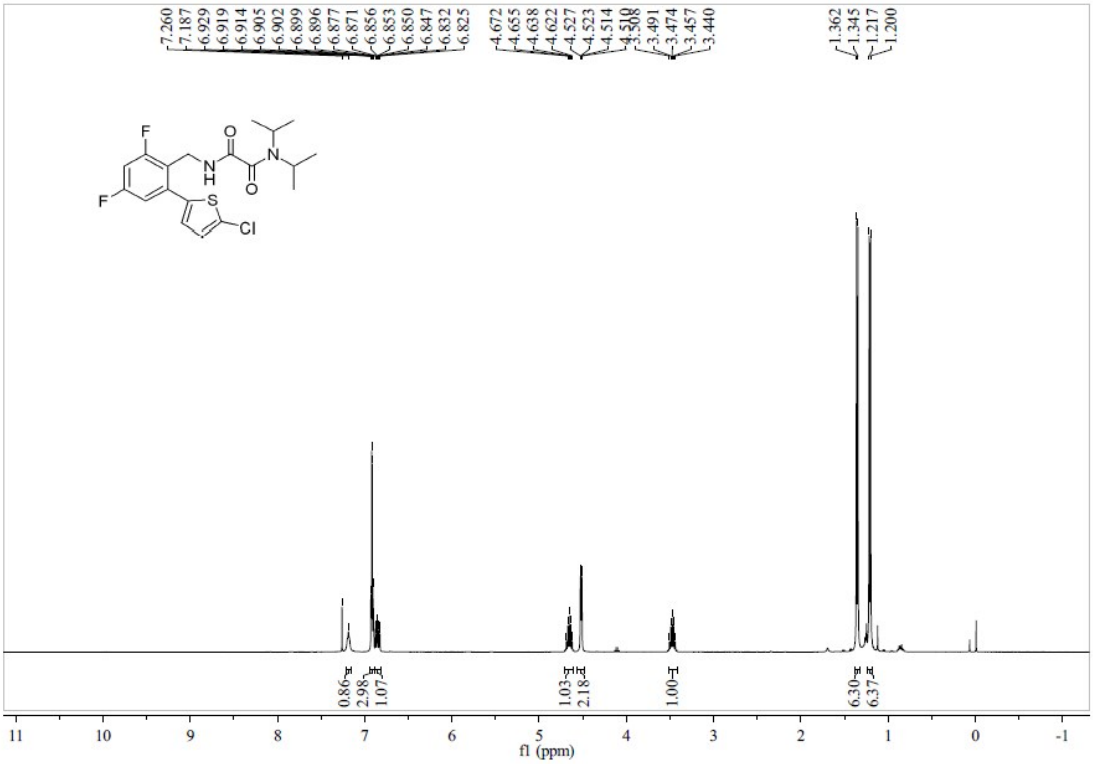
^{1}H NMR of compound **(1e)** [3]



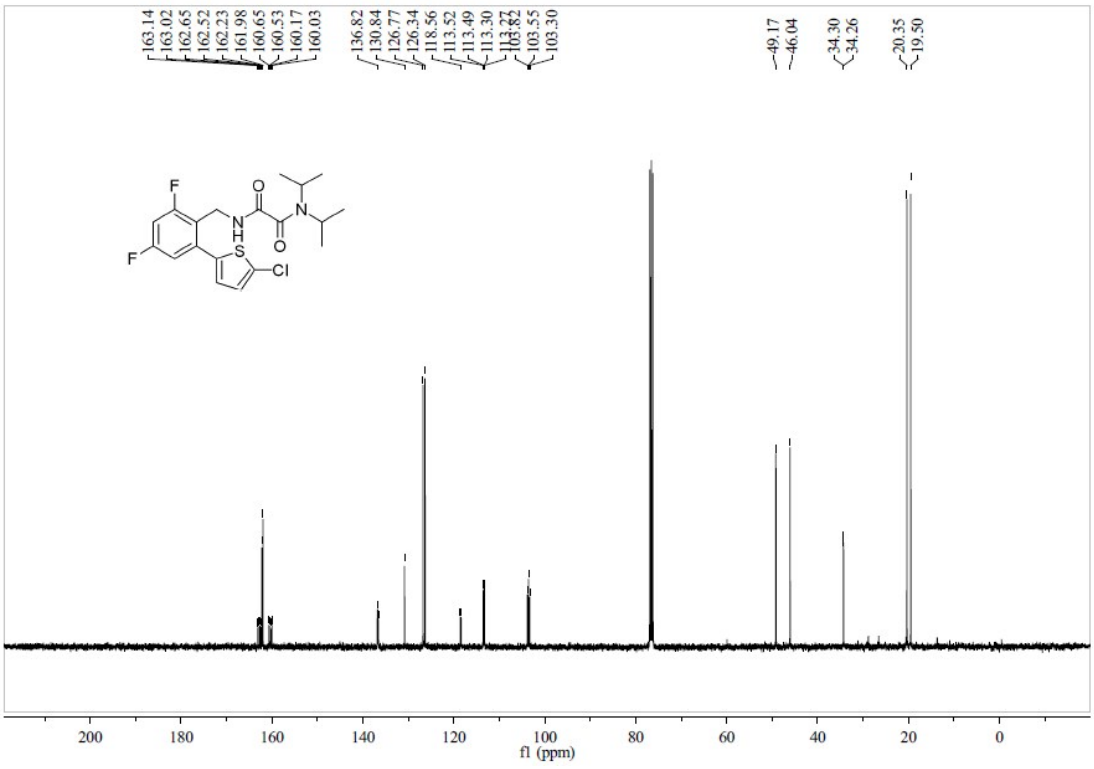
^{13}C NMR of compound **(1e)** [3]



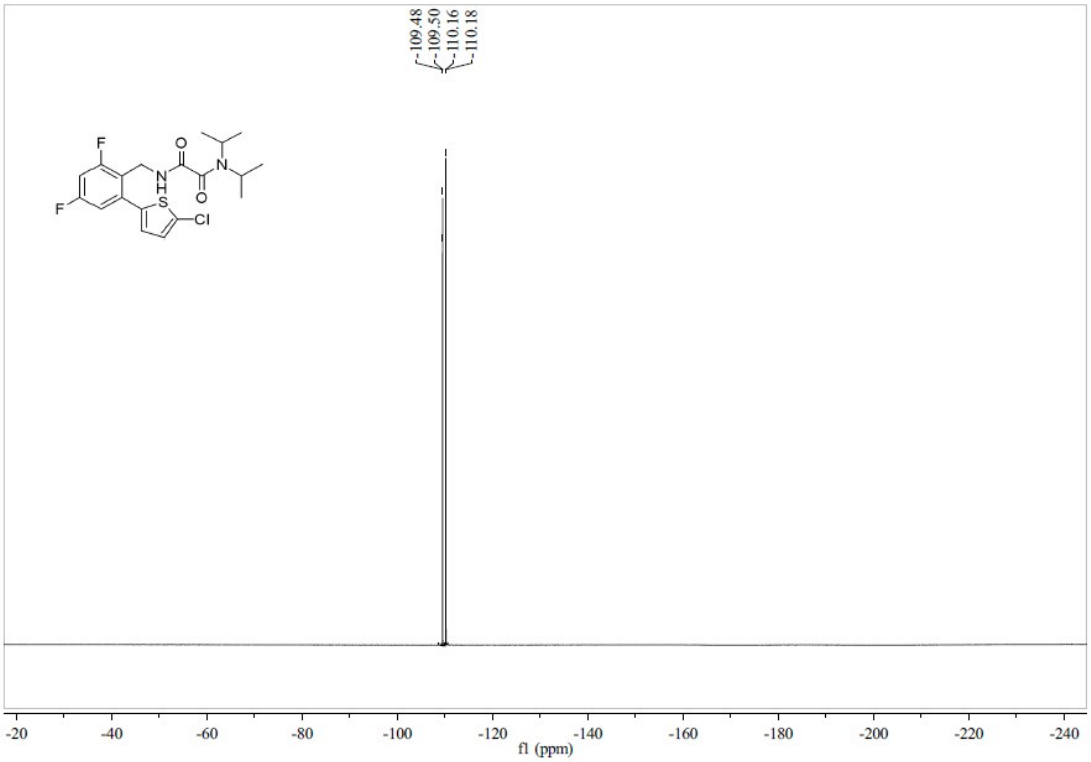
^{1}H NMR of compound **(1f)** [3]



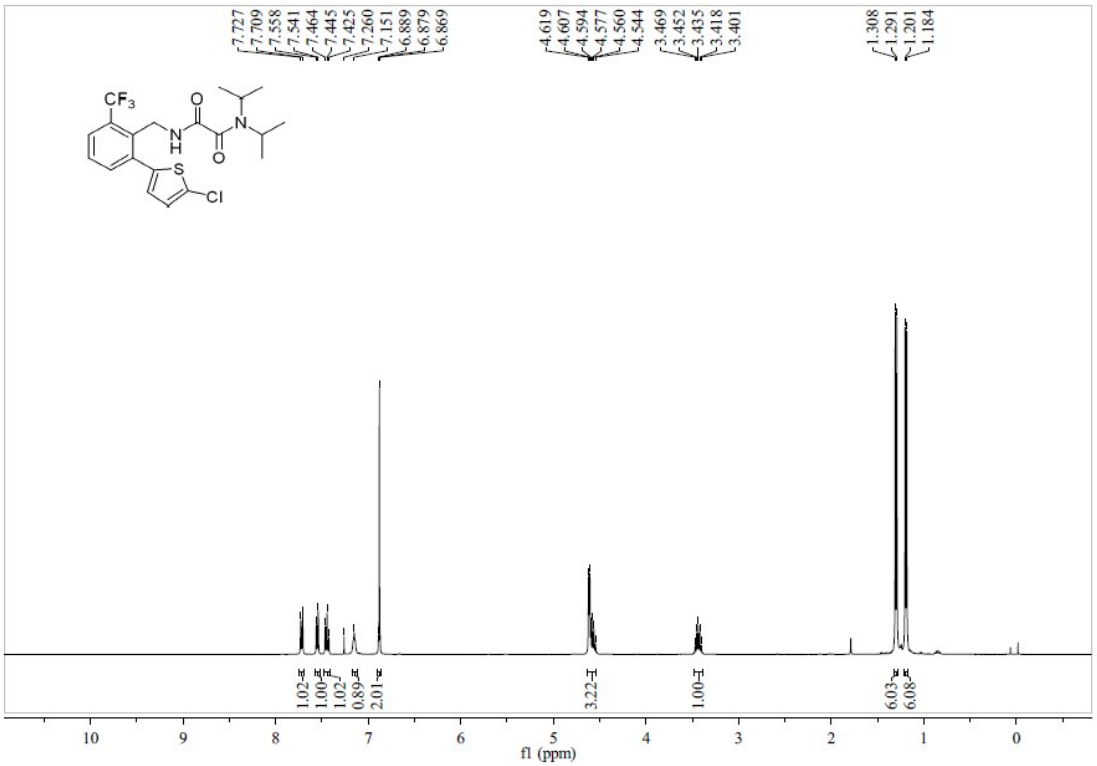
^{13}C NMR of compound **(1f)** [3]



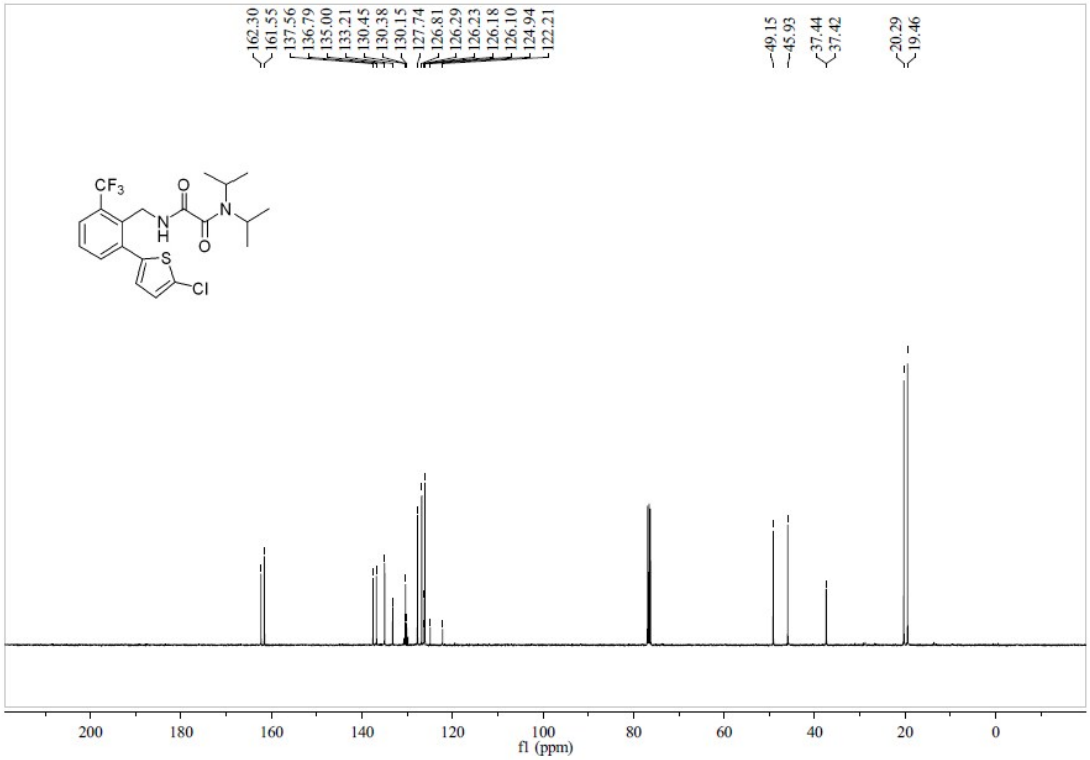
^{19}F NMR of compound **(1f)** [3]



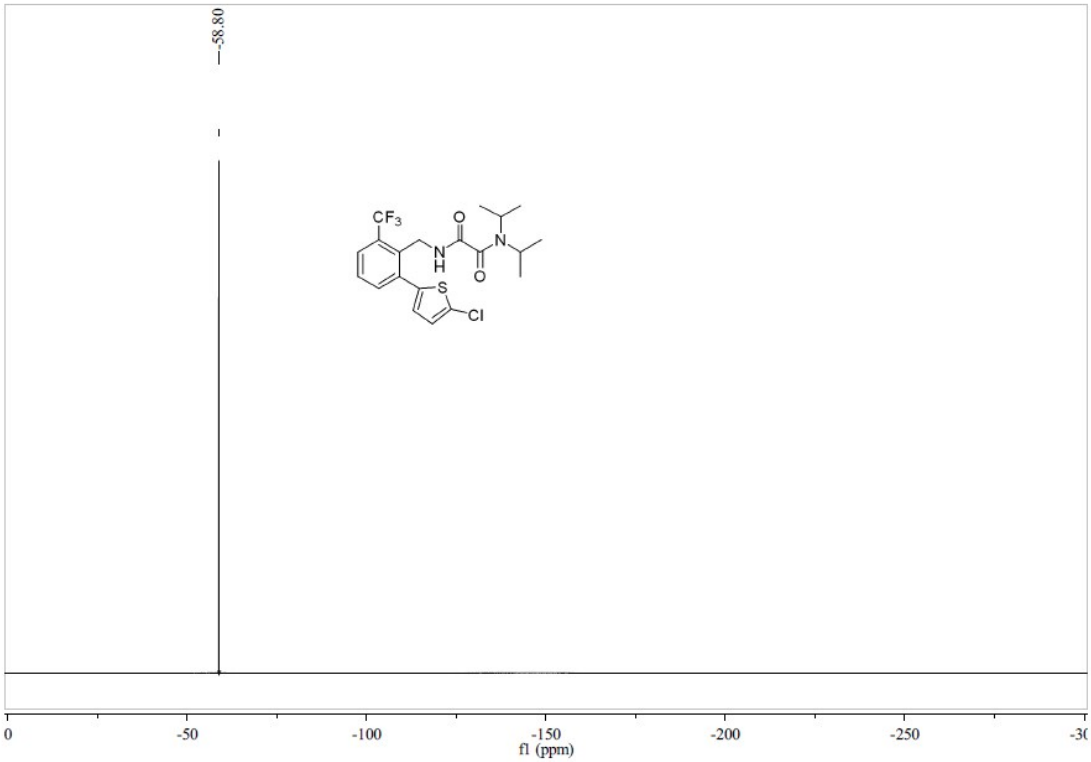
^{1}H NMR of compound **(1g)** [3]



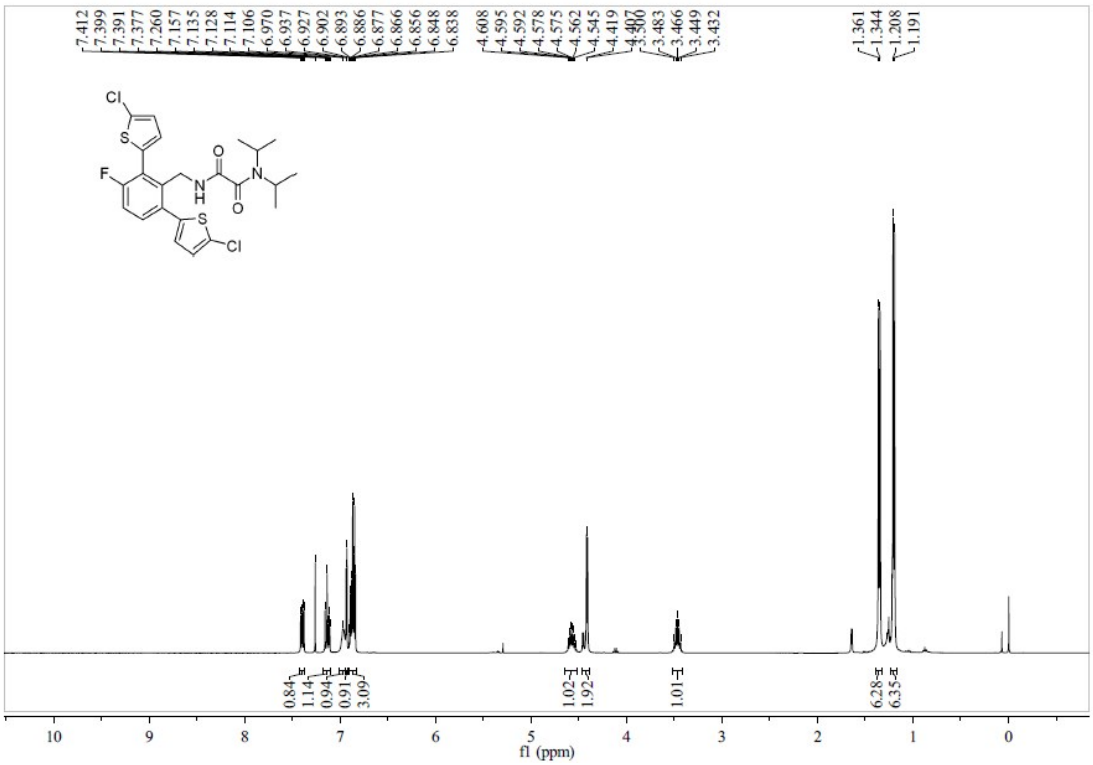
^{13}C NMR of compound **(1g)** [3]



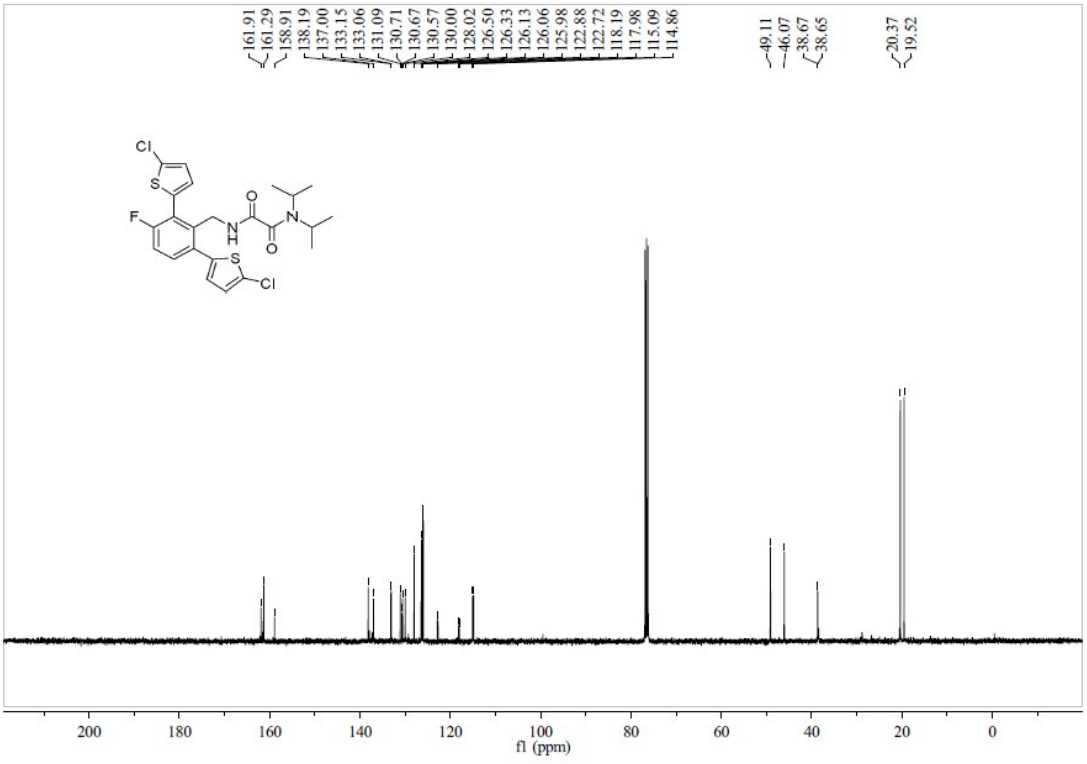
^{19}F NMR of compound **(1g)** [3]



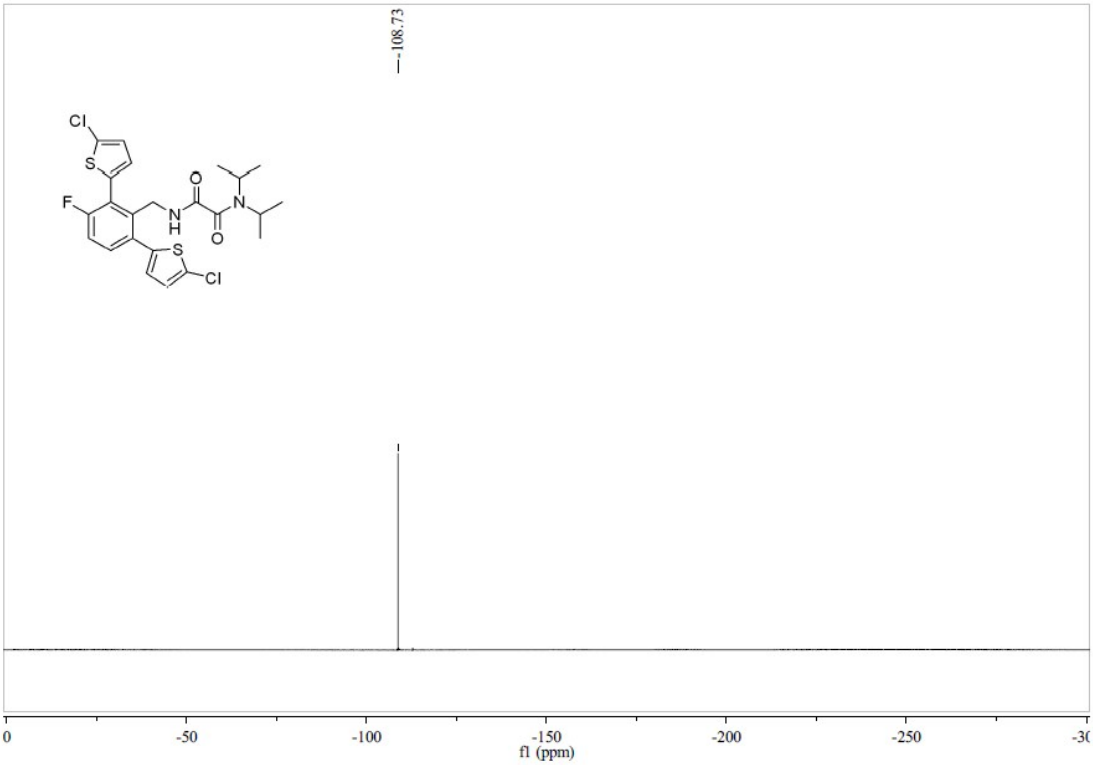
^{1}H NMR of compound **(1h)** [3]



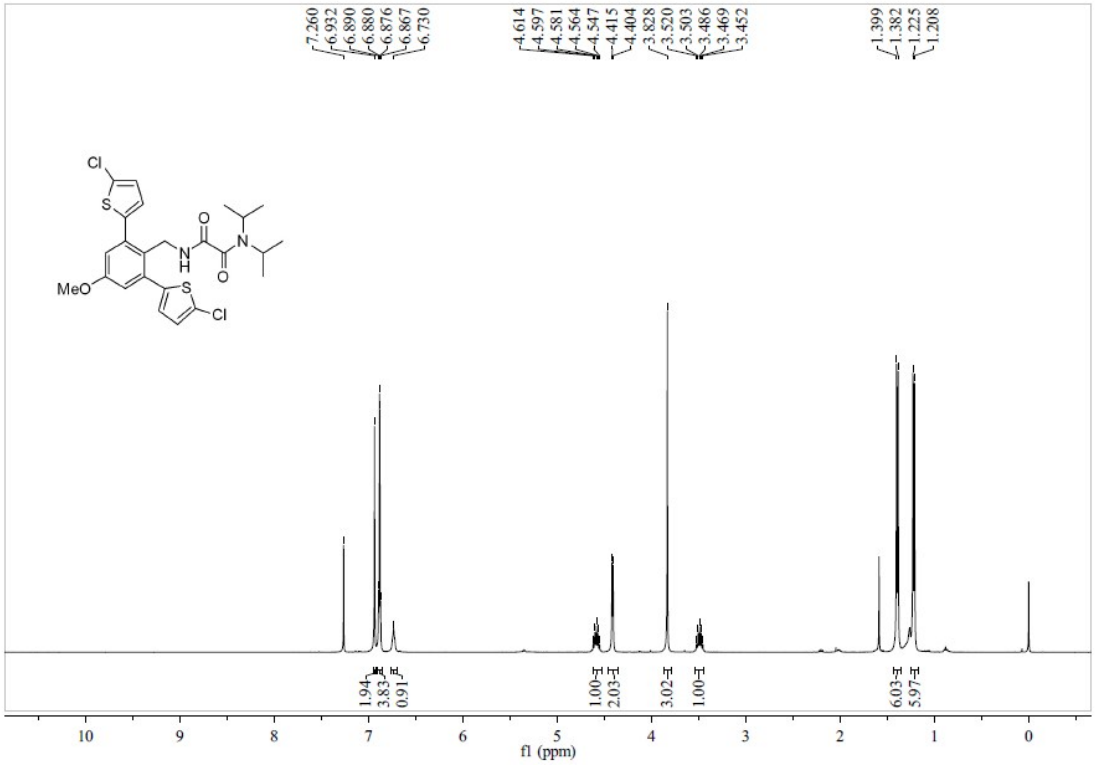
^{13}C NMR of compound **(1h)** [3]



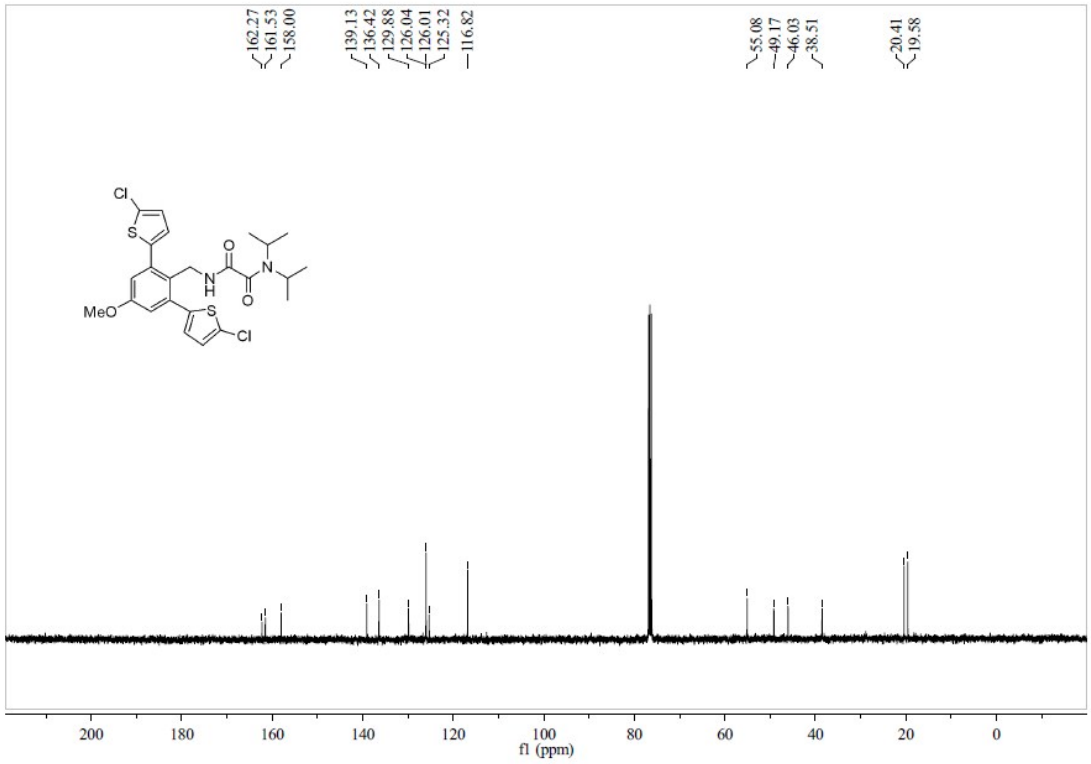
^{19}F NMR of compound **(1h)** [3]



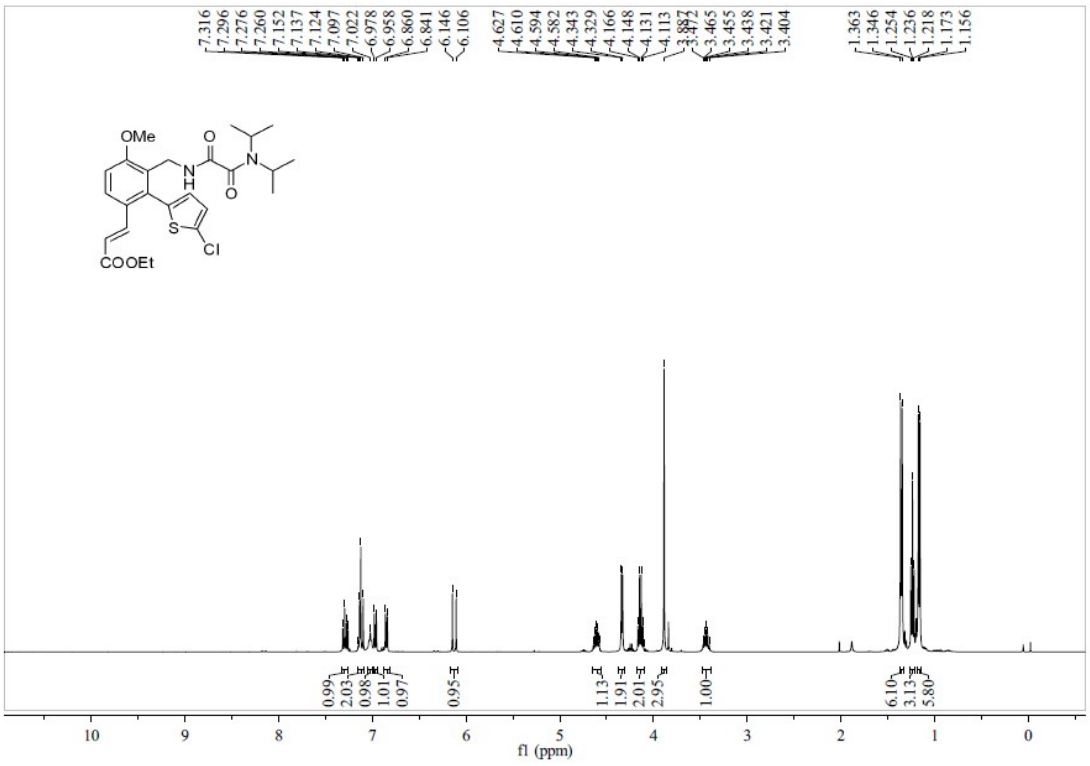
^{1}H NMR of compound **(1i)** [3]



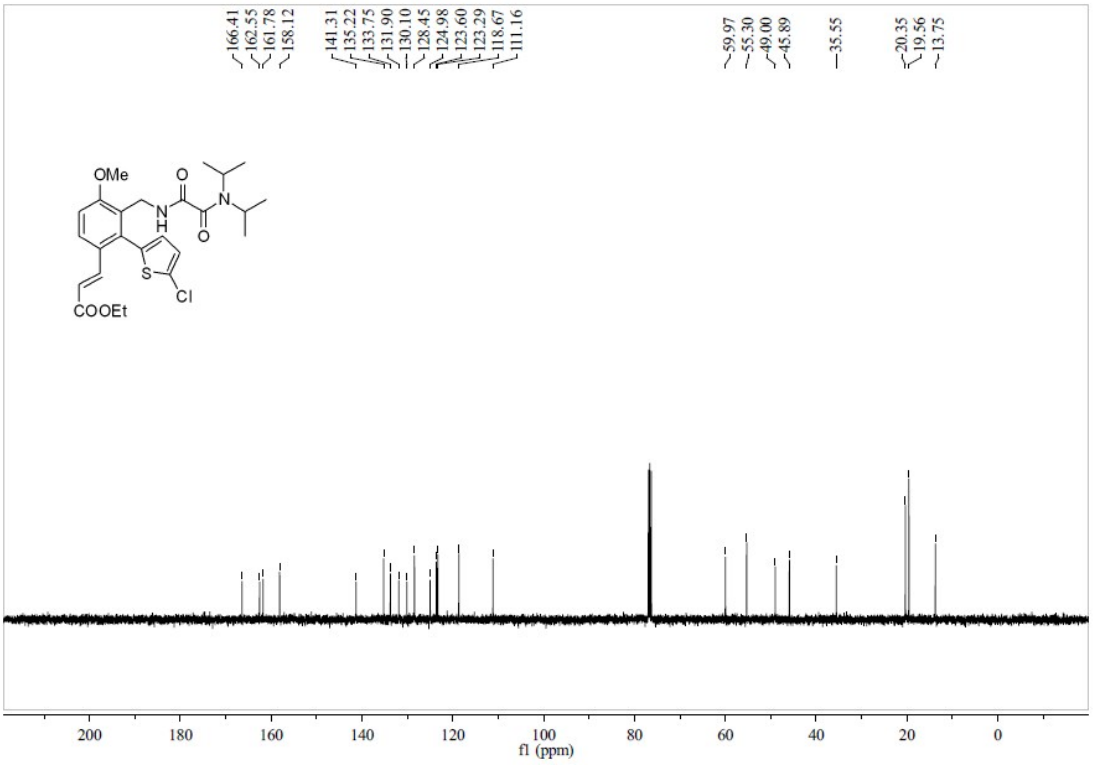
^{13}C NMR of compound **(1i)** [3]



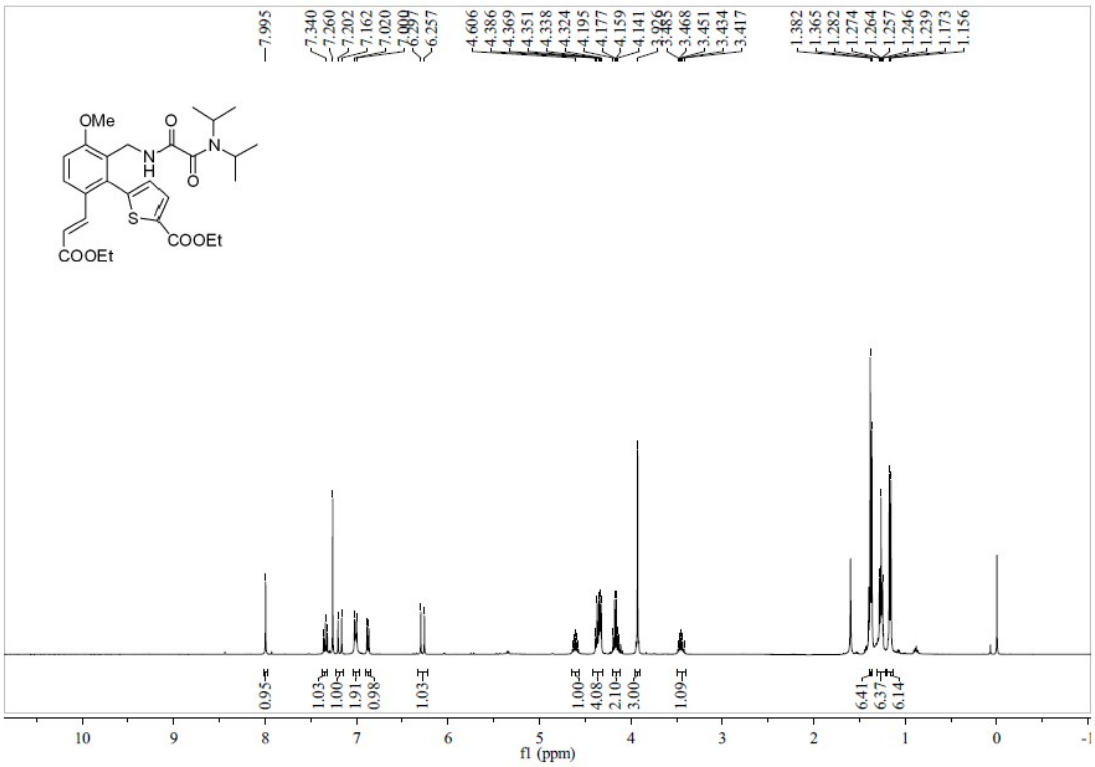
^{1}H NMR of compound **(3a)**



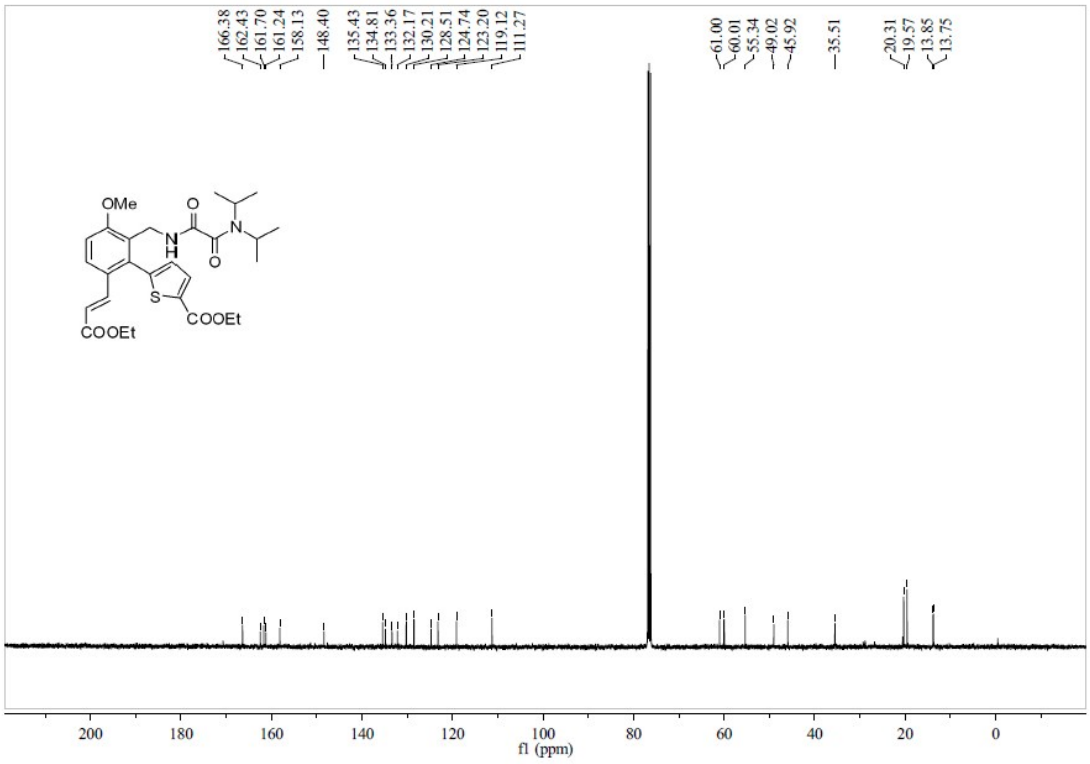
^{13}C NMR of compound **(3a)**



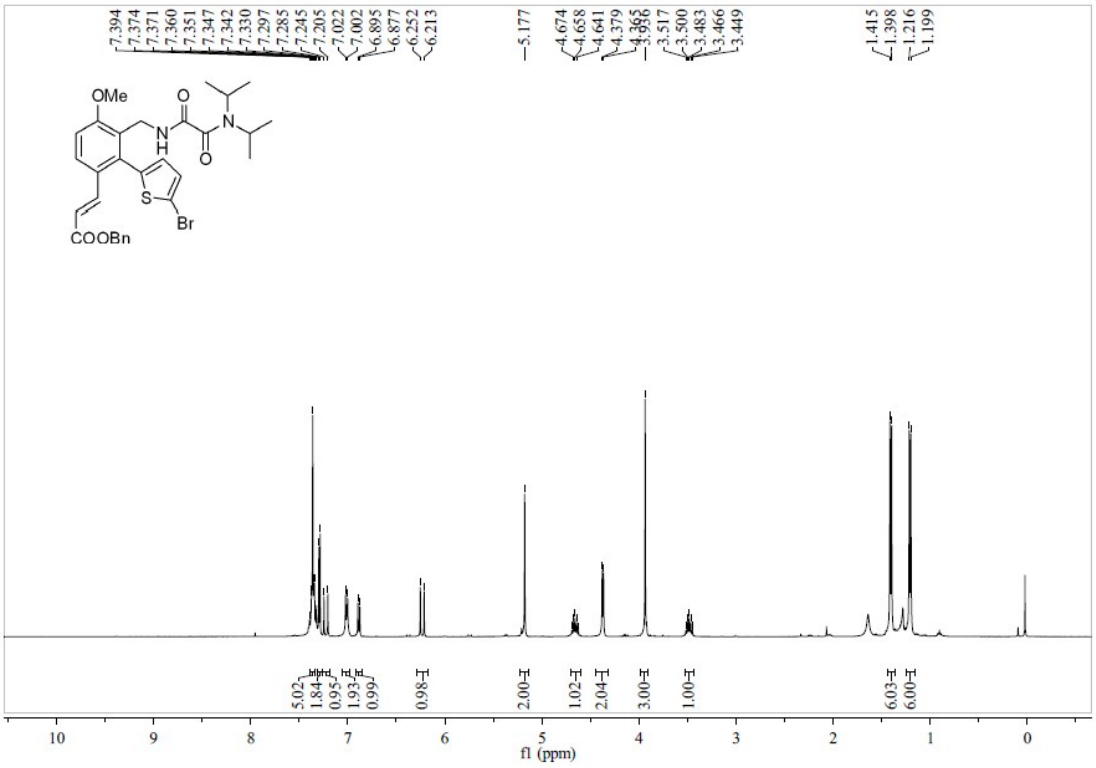
^{1}H NMR of compound **(3b)**



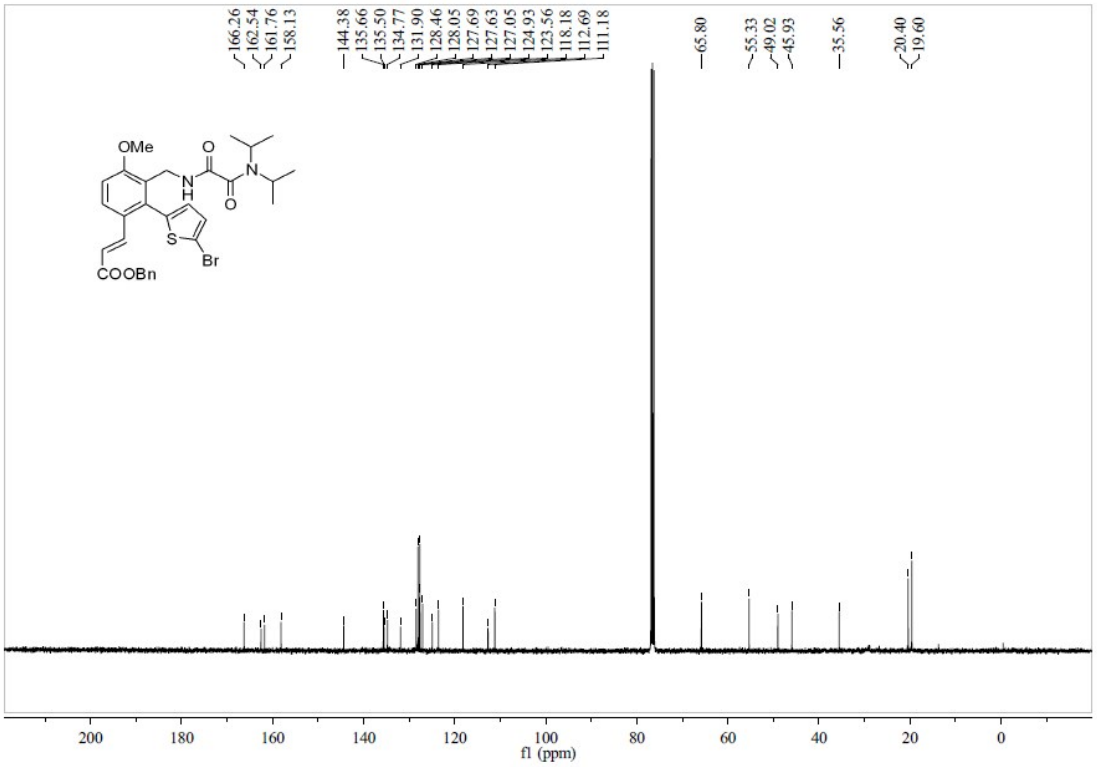
^{13}C NMR of compound **(3b)**



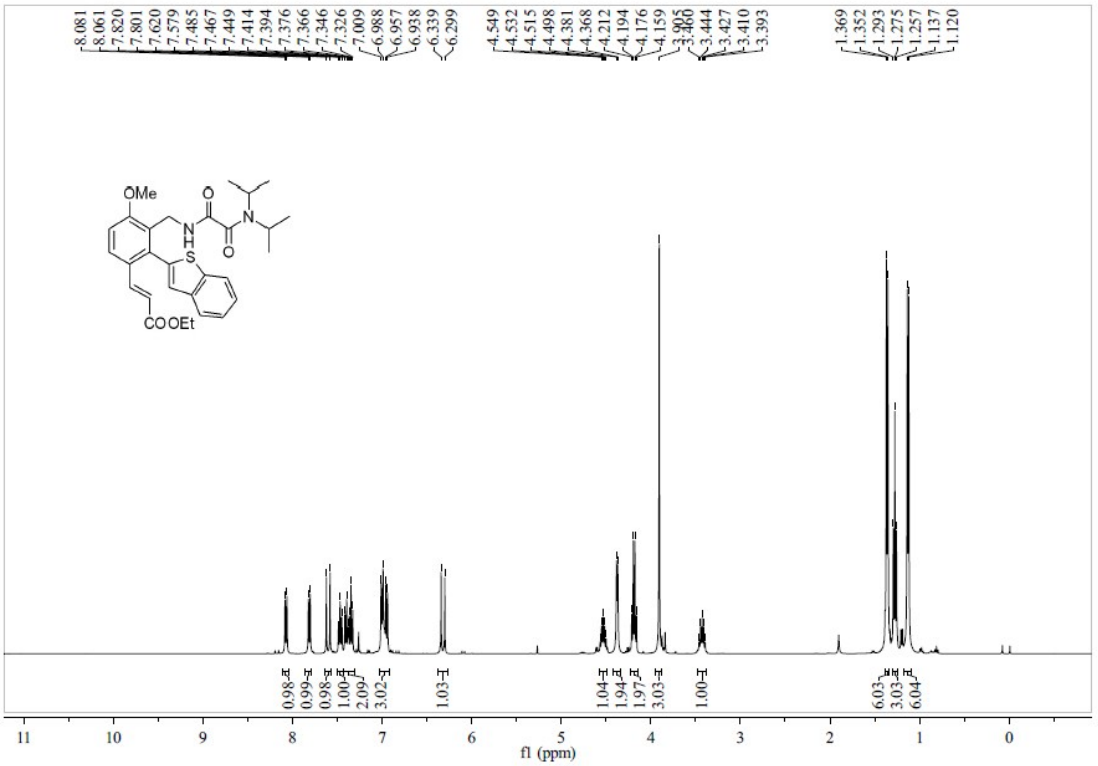
^{1}H NMR of compound **(3c)**



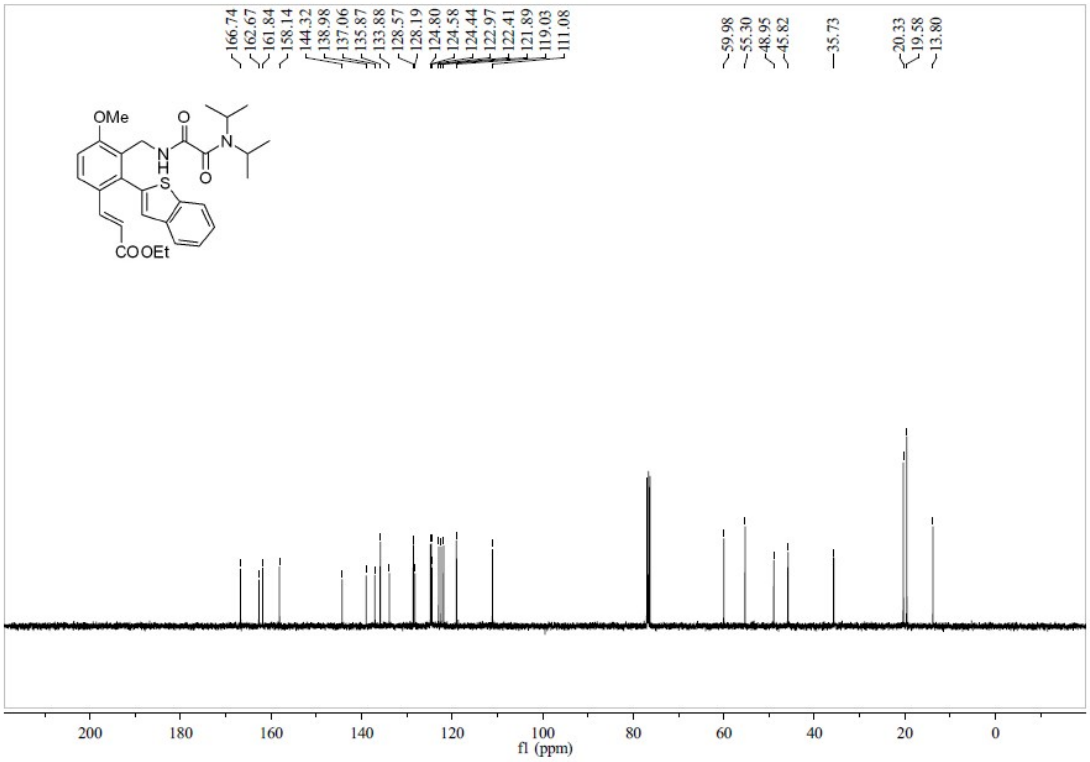
^{13}C NMR of compound **(3c)**



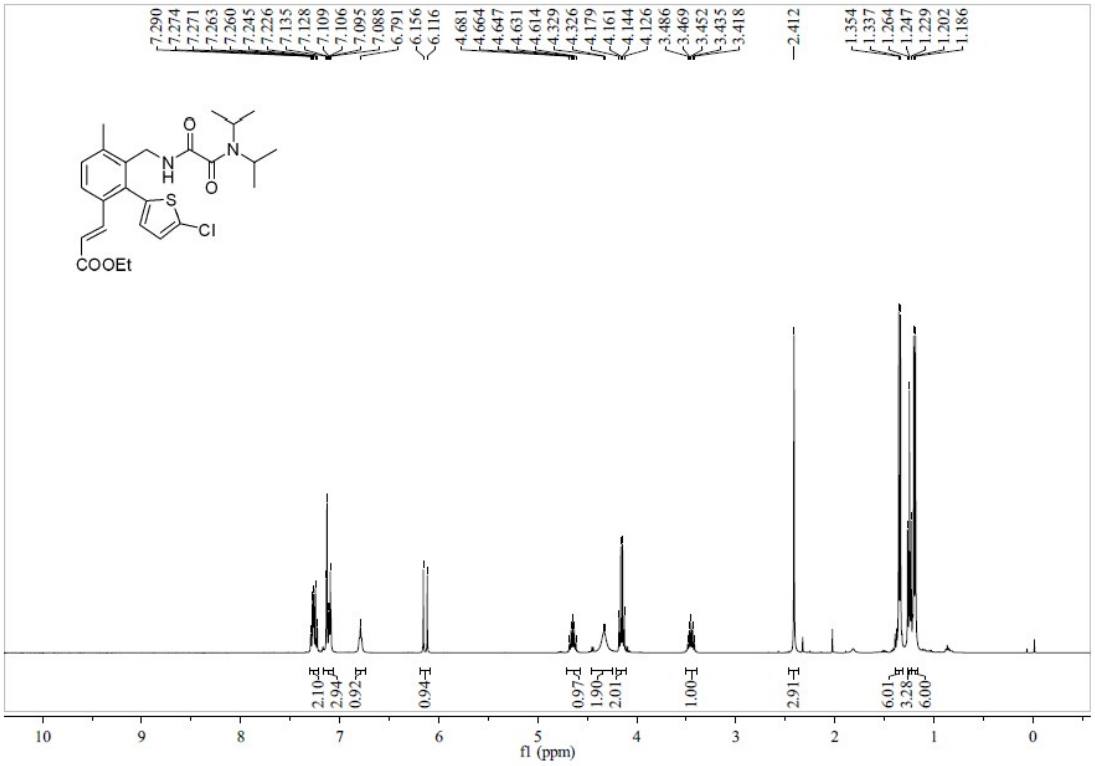
^{1}H NMR of compound **(3d)**



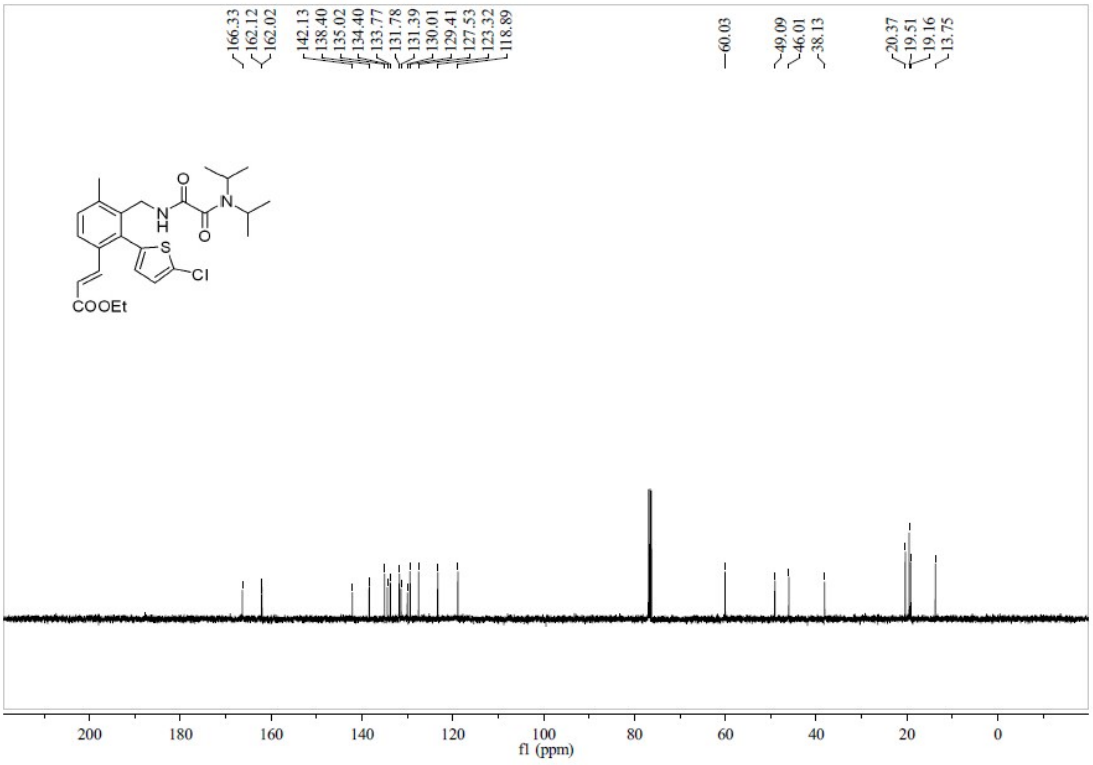
^{13}C NMR of compound **(3d)**



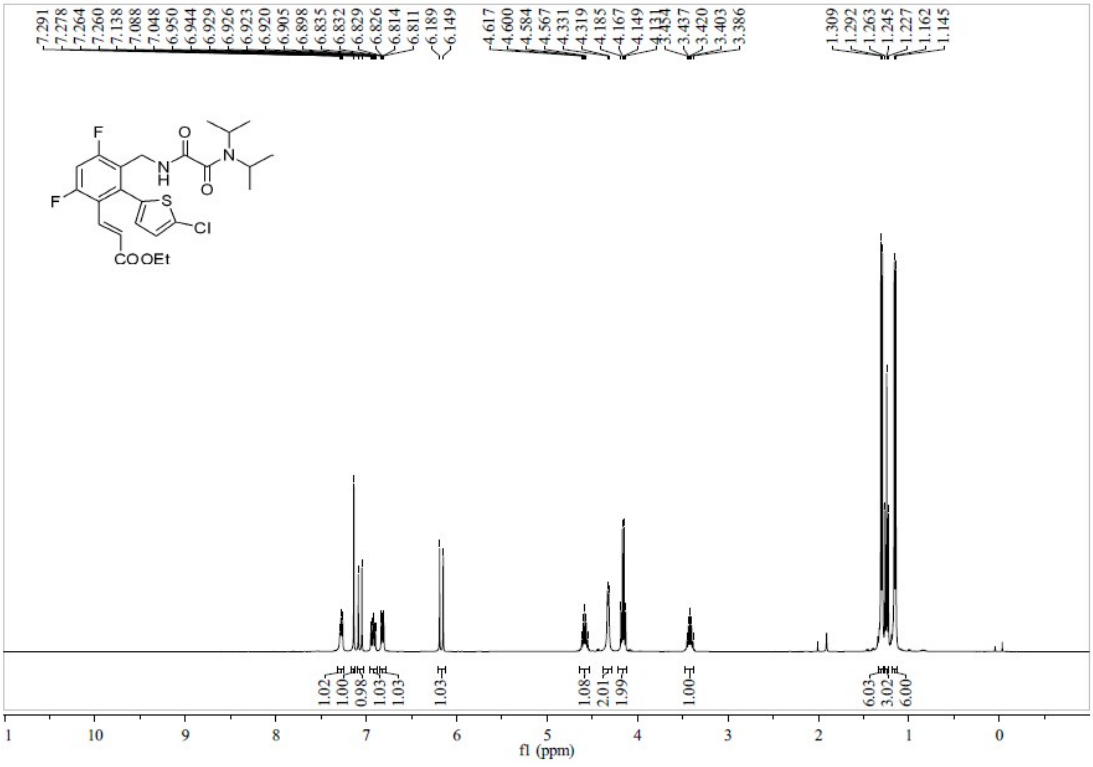
^{1}H NMR of compound **(3e)**



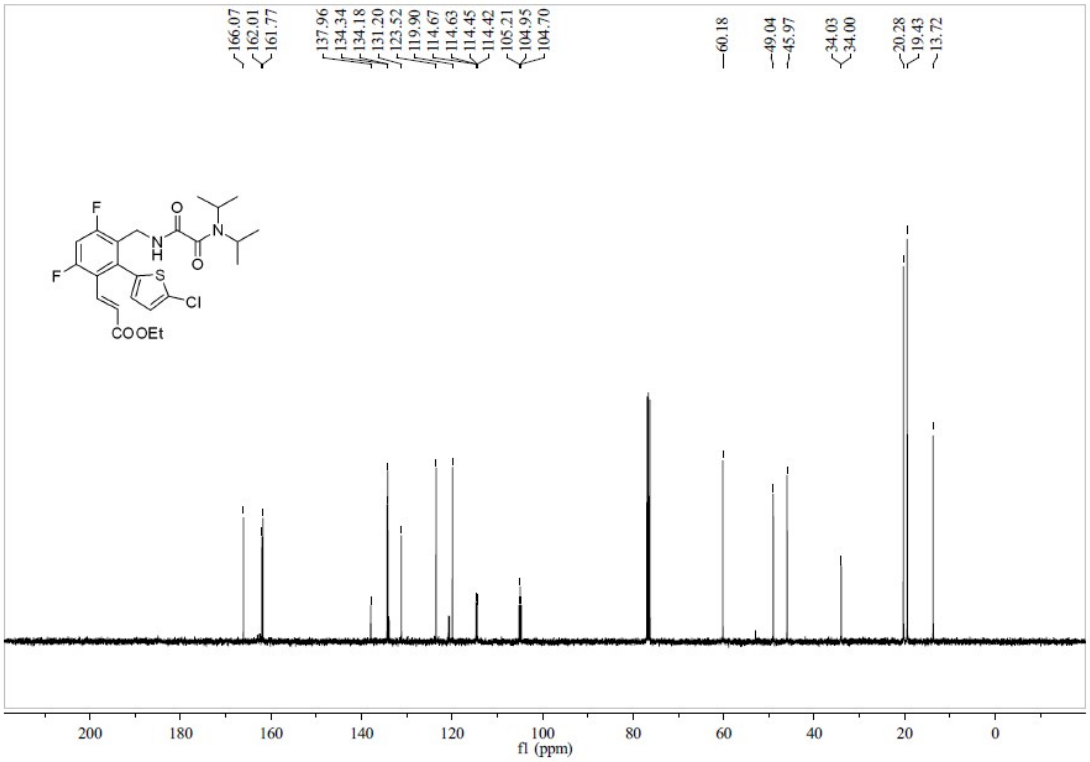
^{13}C NMR of compound **(3e)**



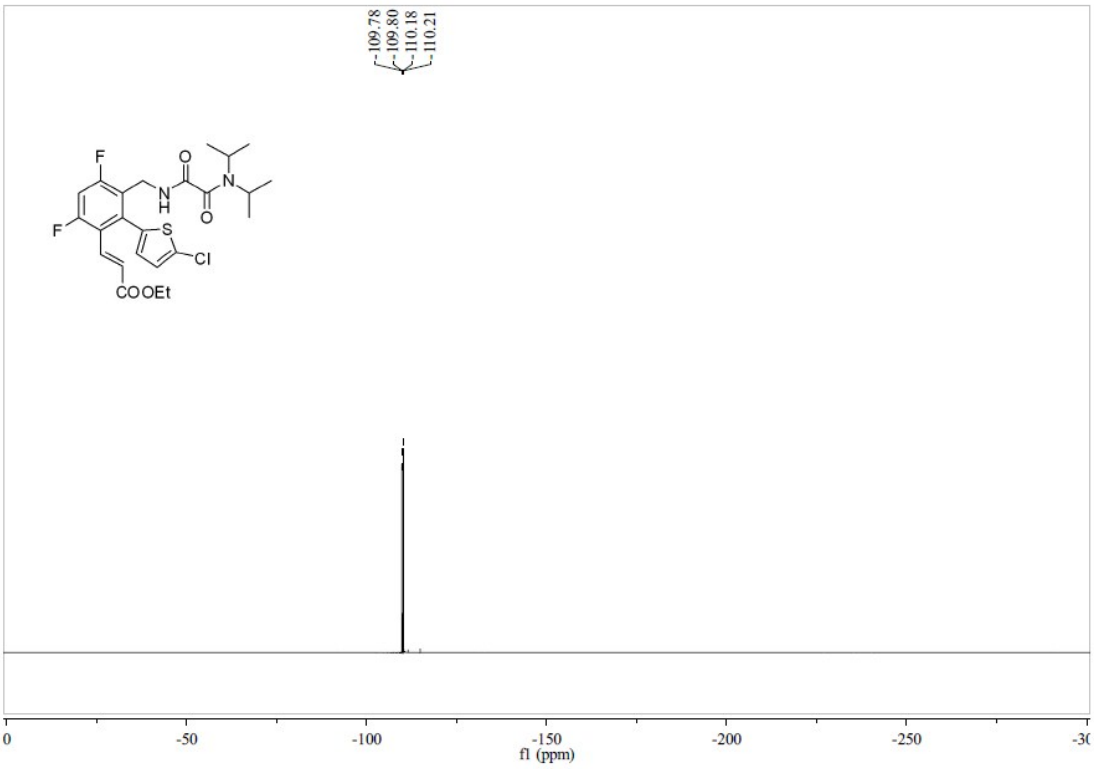
^{1}H NMR of compound **(3f)**



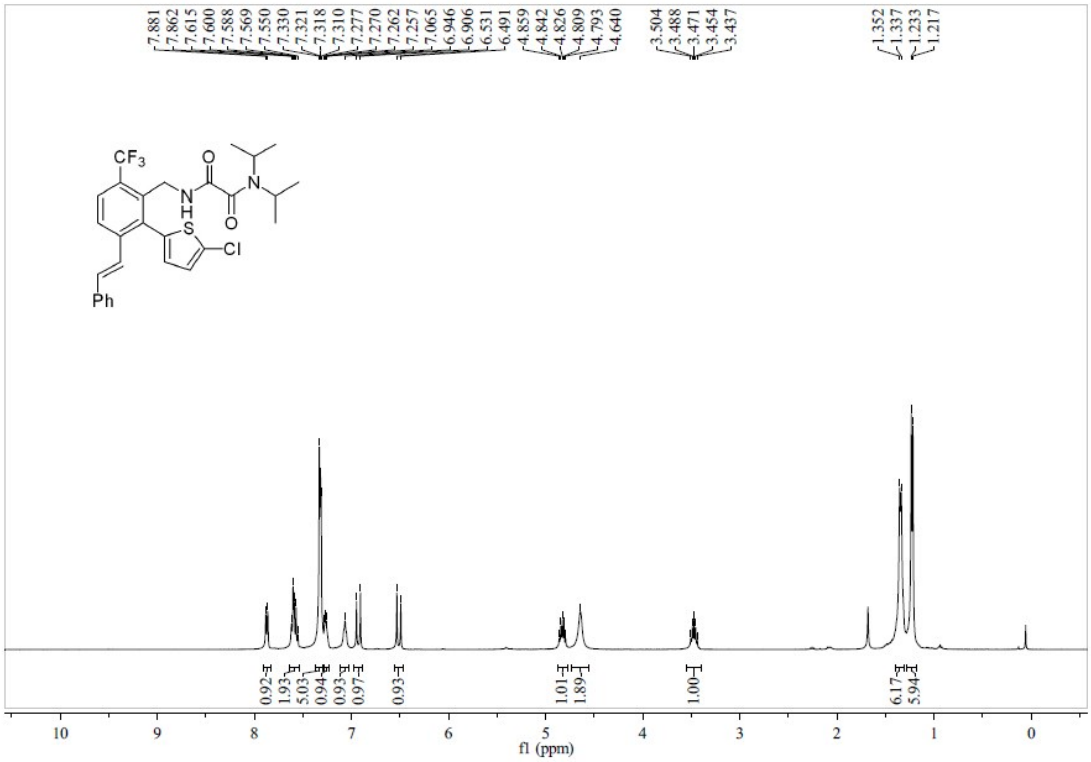
^{13}C NMR of compound **(3f)**



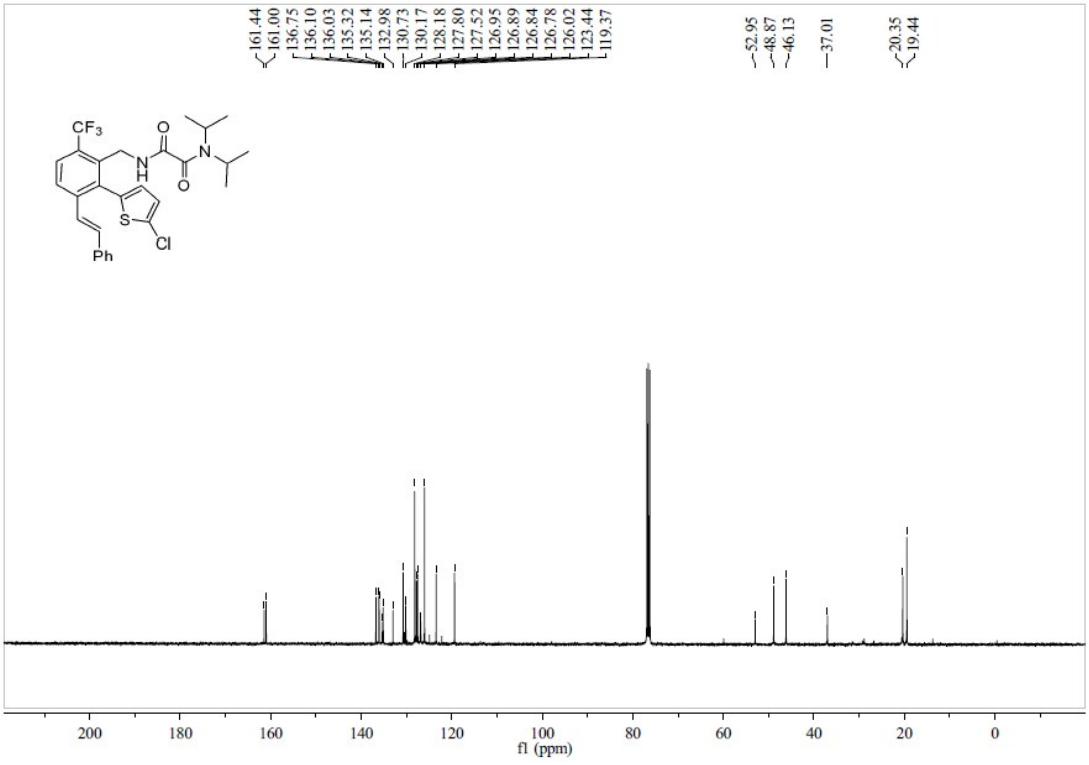
^{19}F NMR of compound **(3f)**



^{1}H NMR of compound **(3g)**



^{13}C NMR of compound **(3g)**



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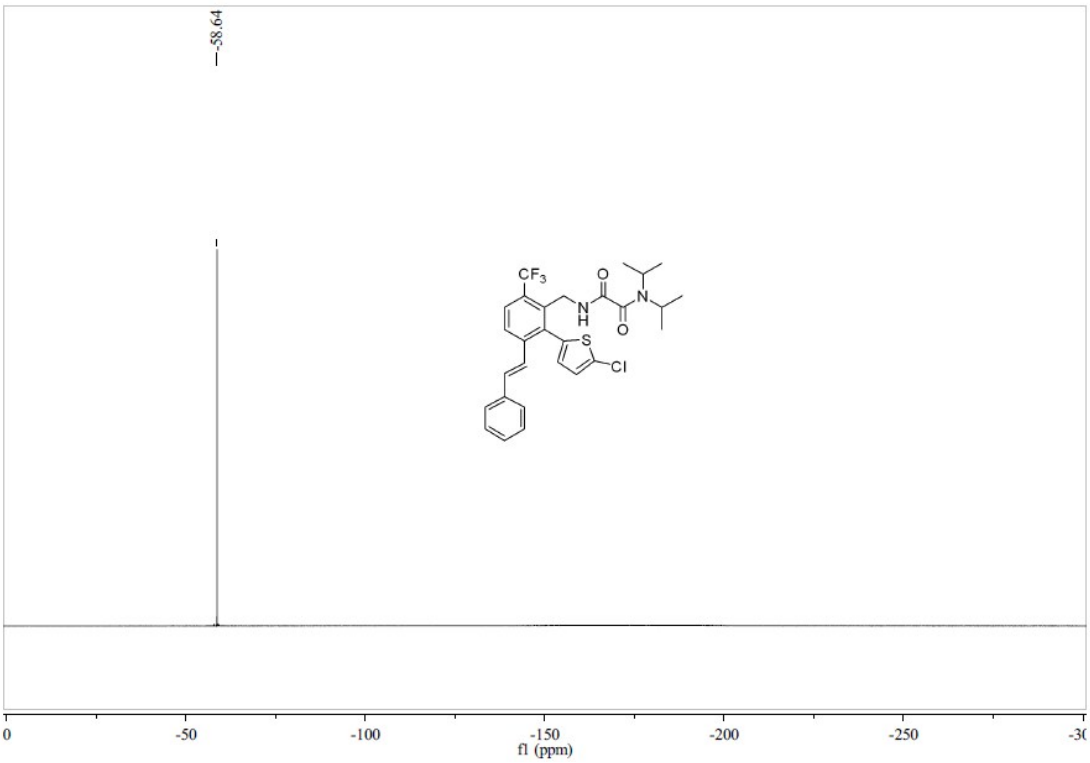
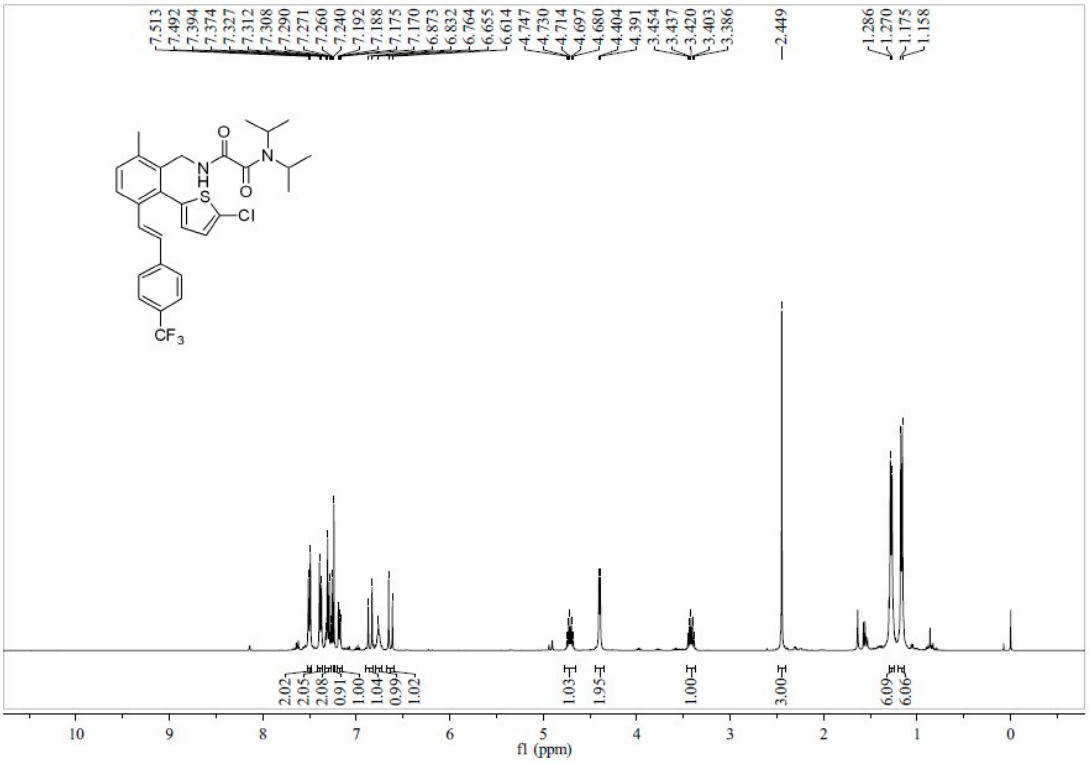
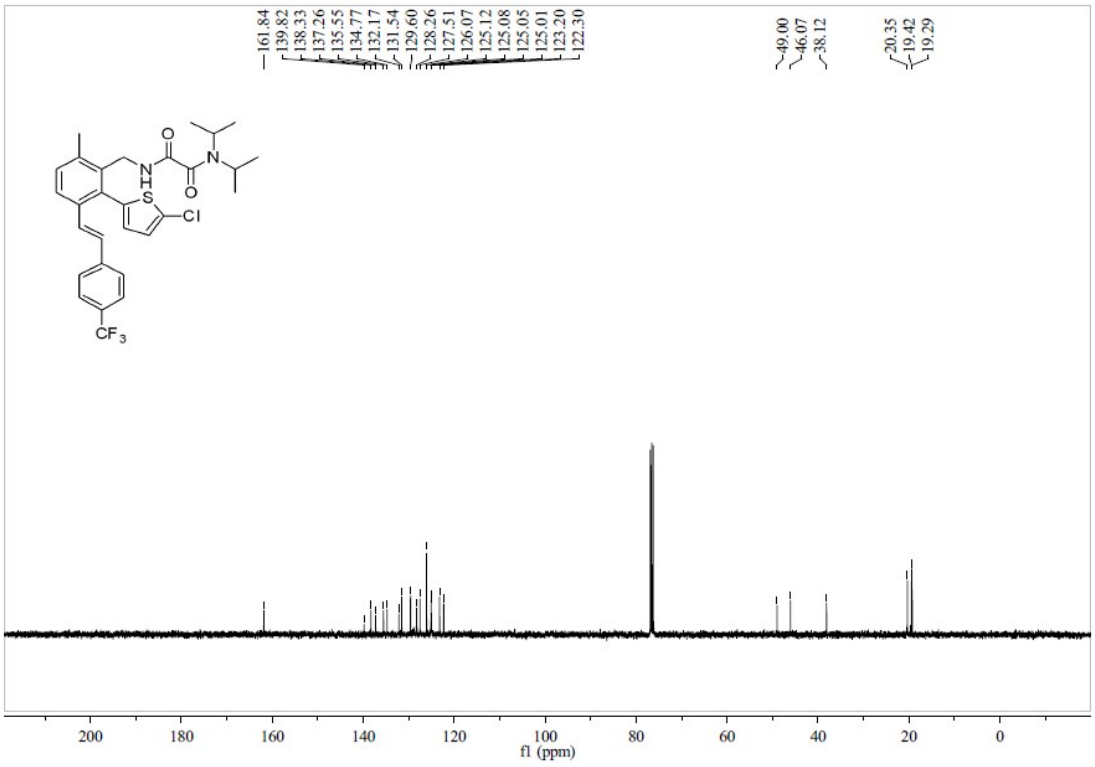


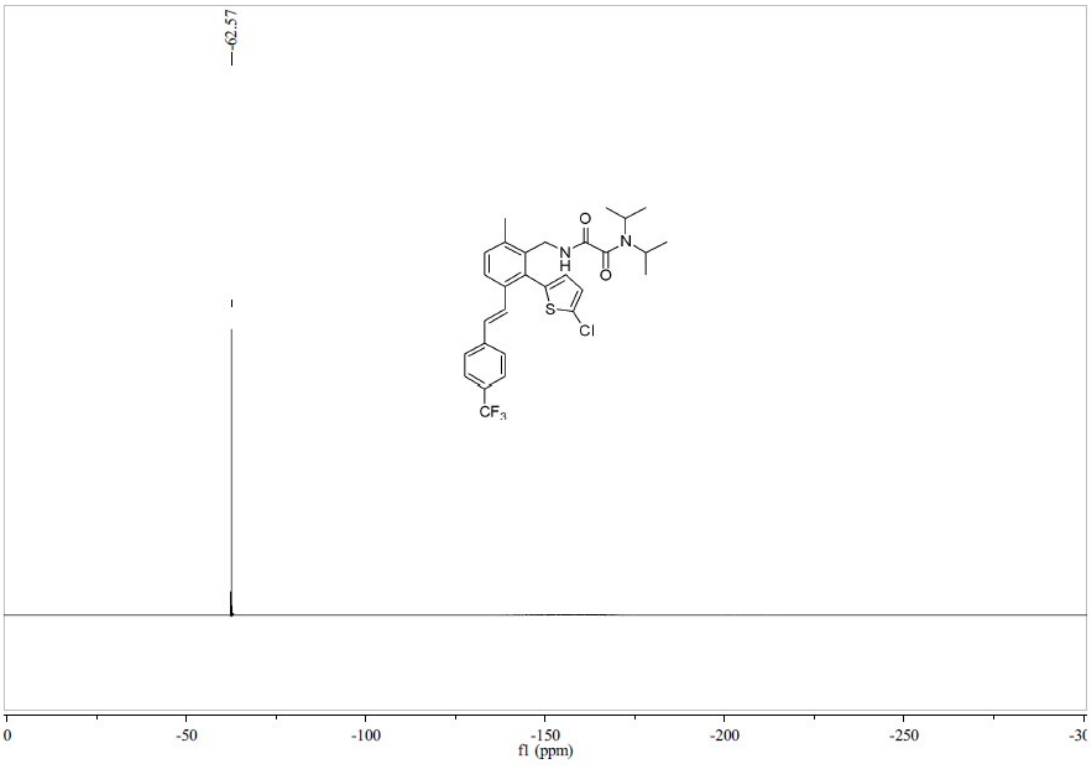
^{1}H NMR of compound **(3h)**



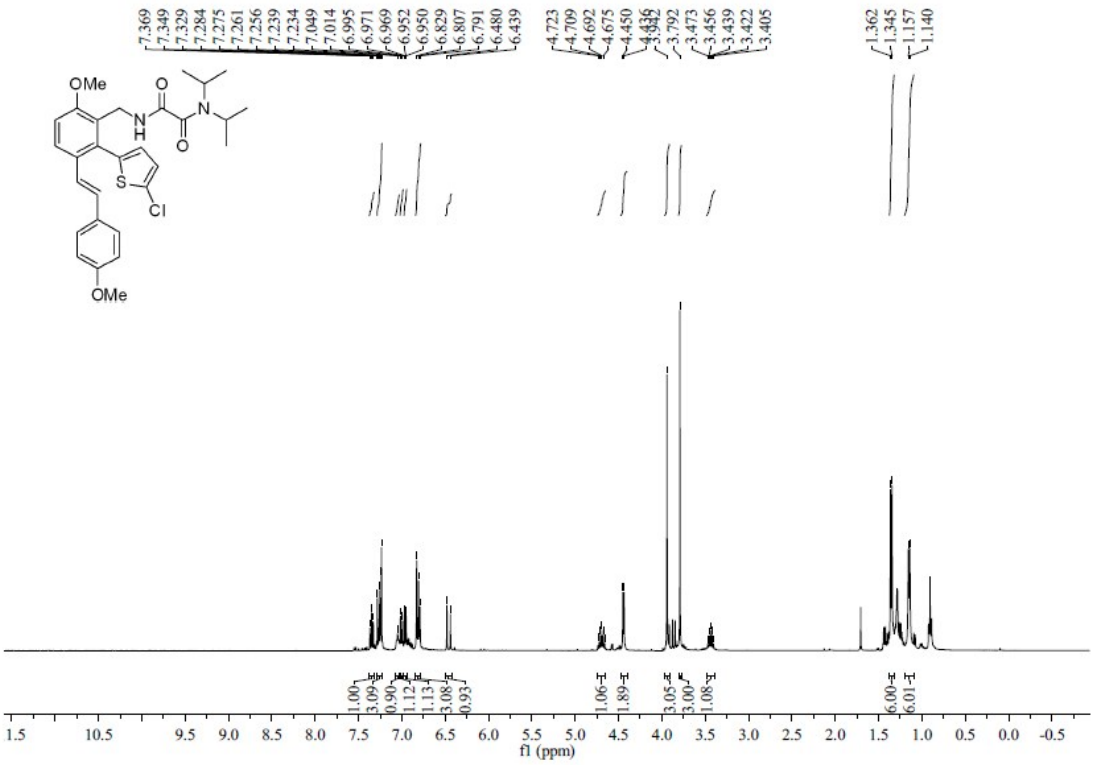
^{13}C NMR of compound **(3h)**



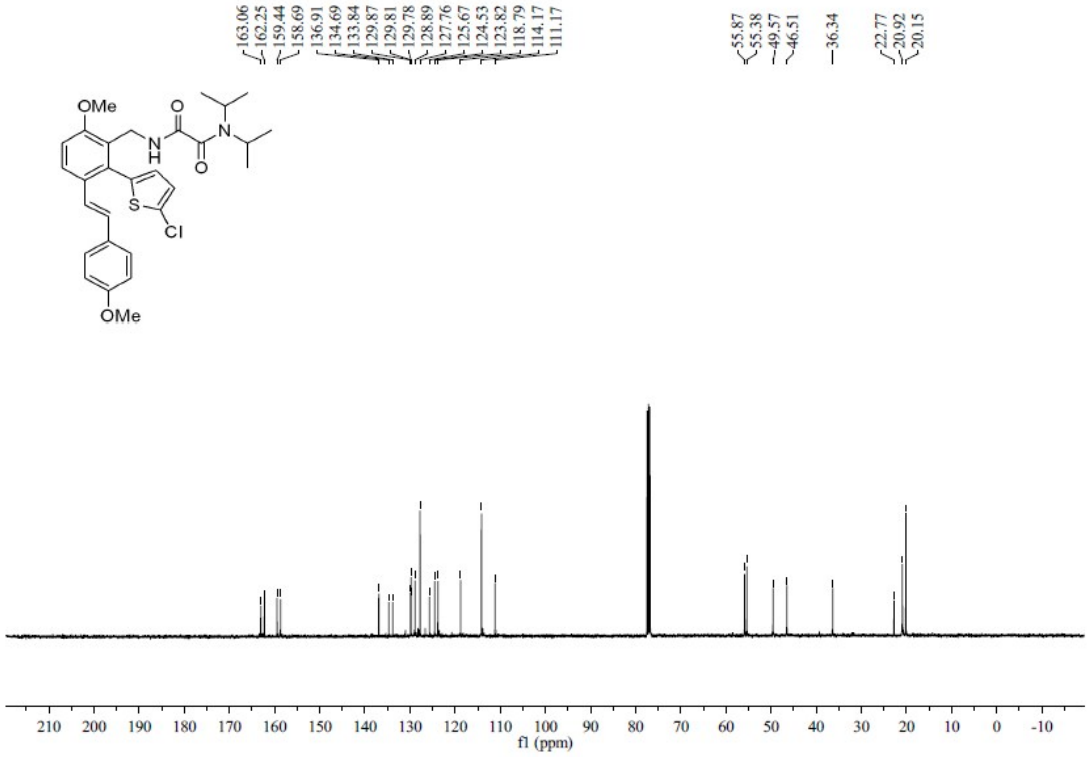
^{19}F NMR of compound **(3h)**



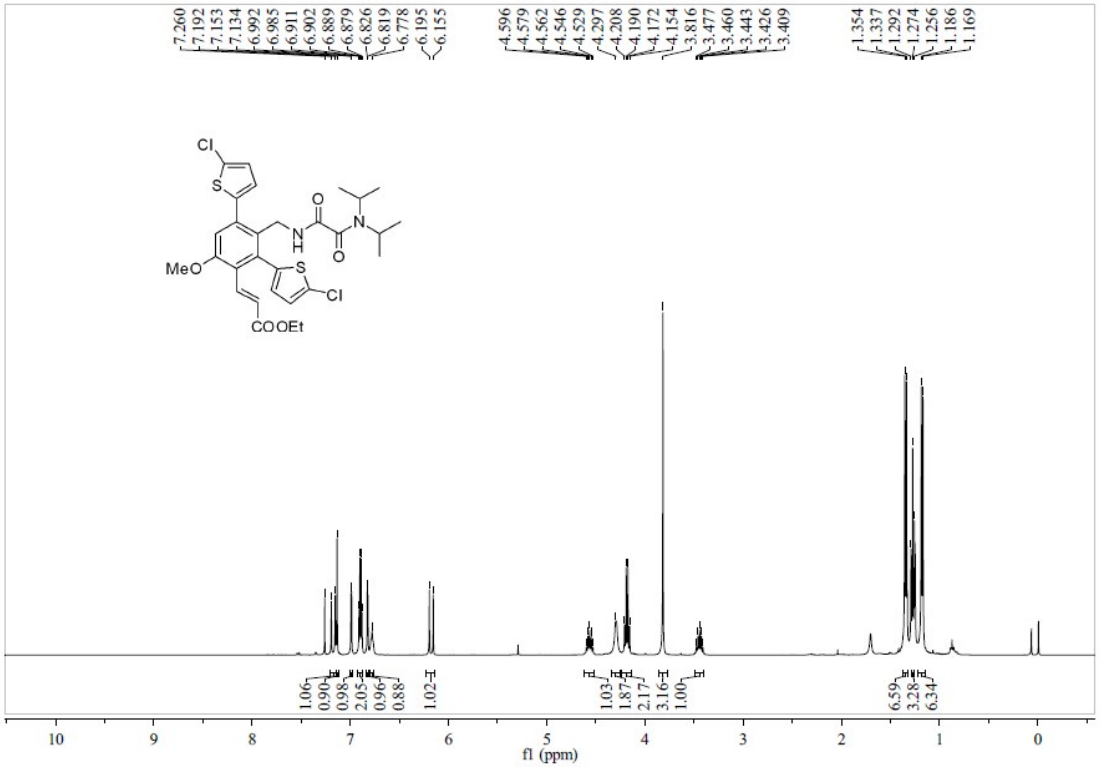
^{1}H NMR of compound **(3i)**



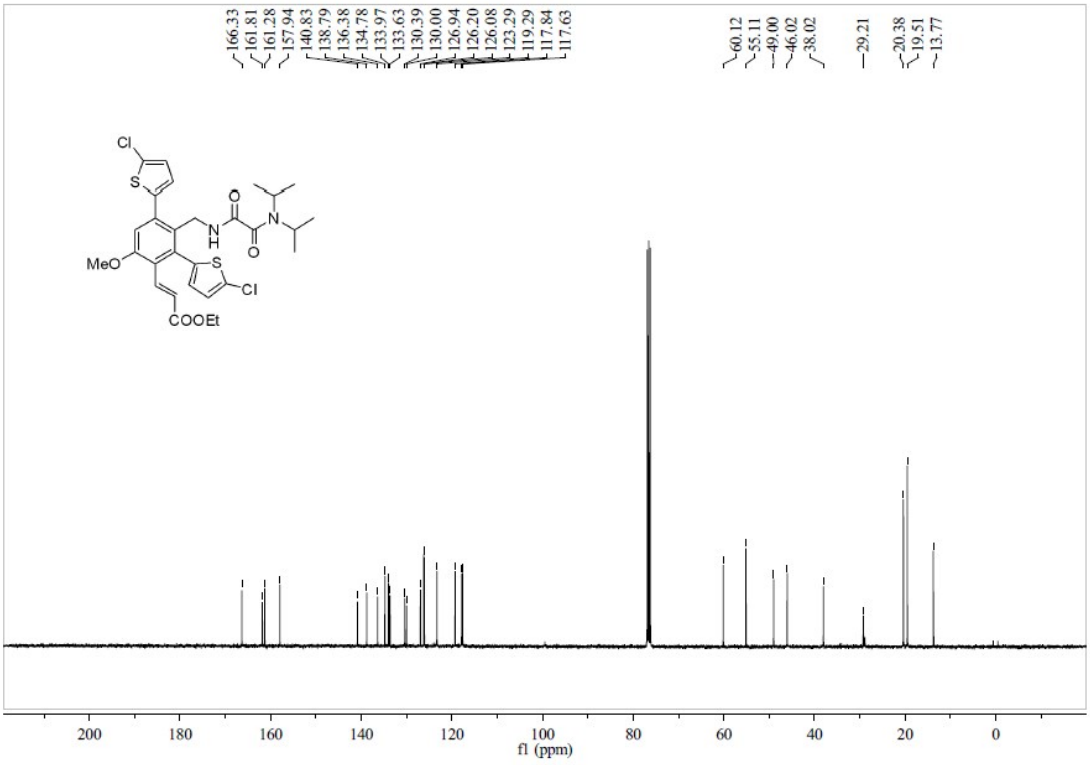
^{13}C NMR of compound **(3i)**



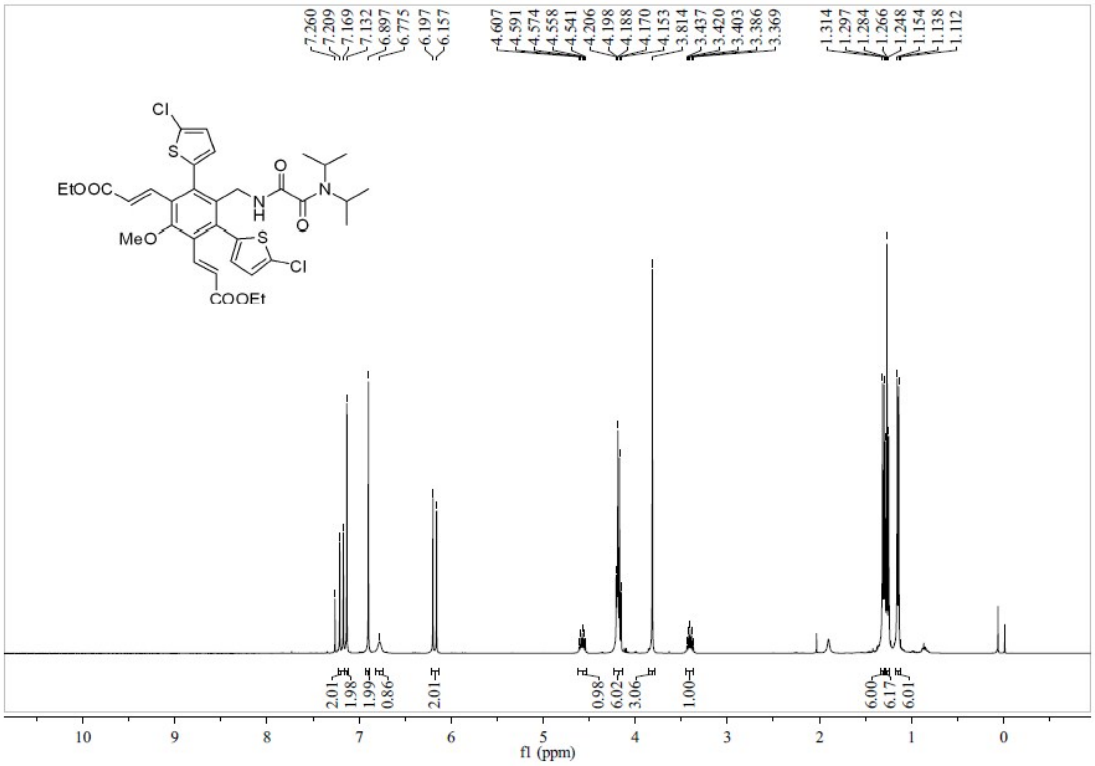
^{1}H NMR of compound **($3j_{mono}$)**



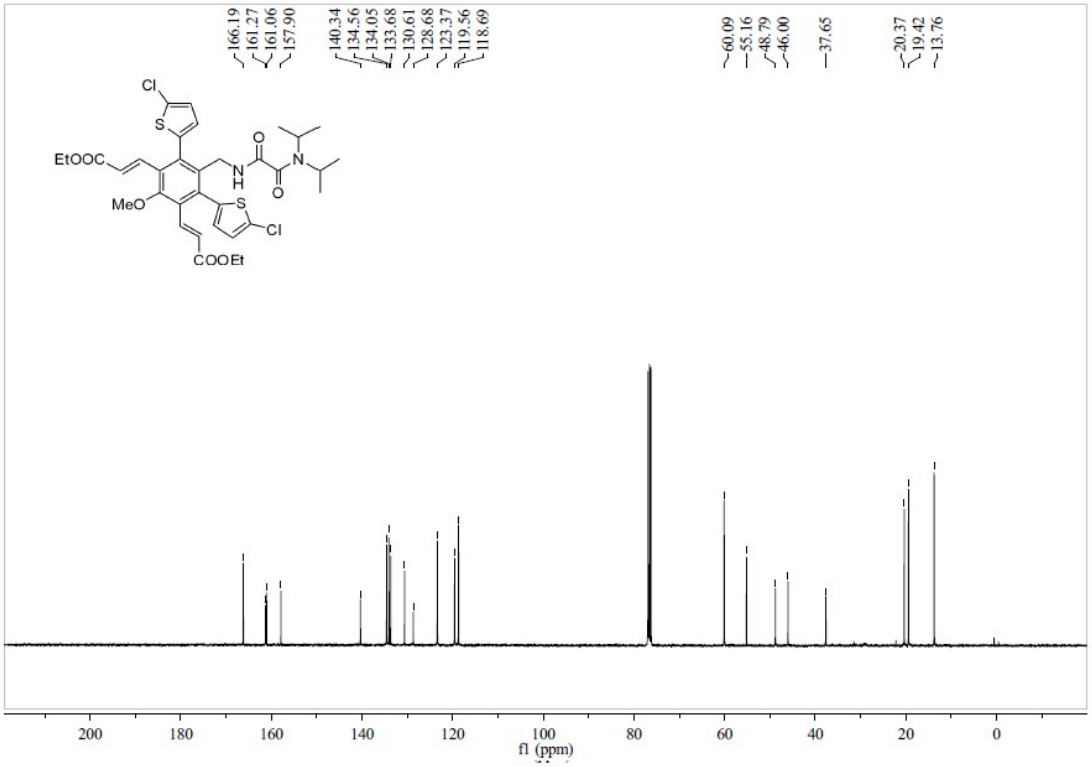
^{13}C NMR of compound **(3j$_{mono}$)**



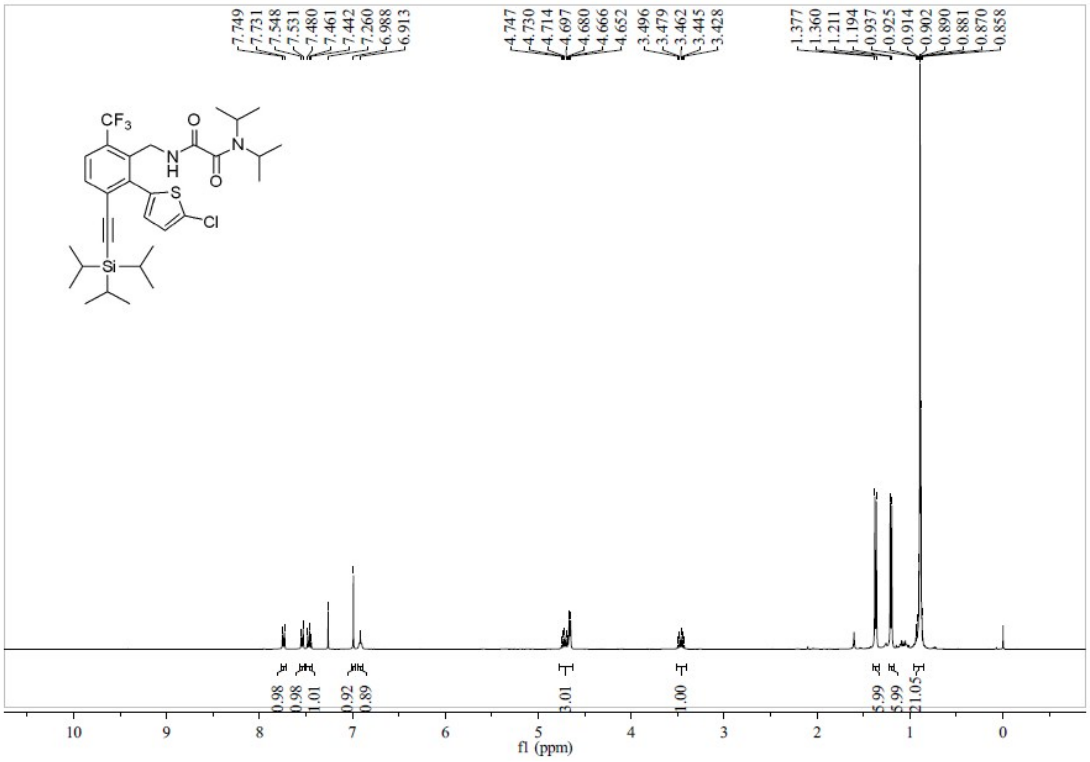
^{1}H NMR of compound **(3j$_{di}$)**



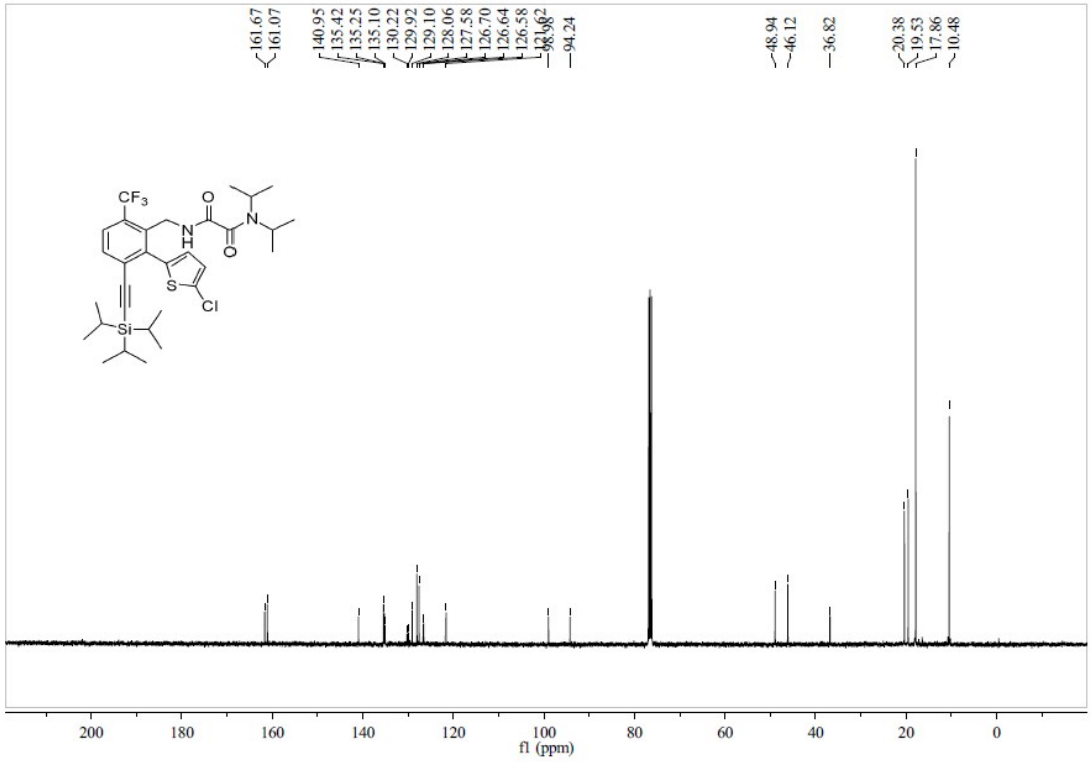
^{13}C NMR of compound **(3j$_{di}$)**



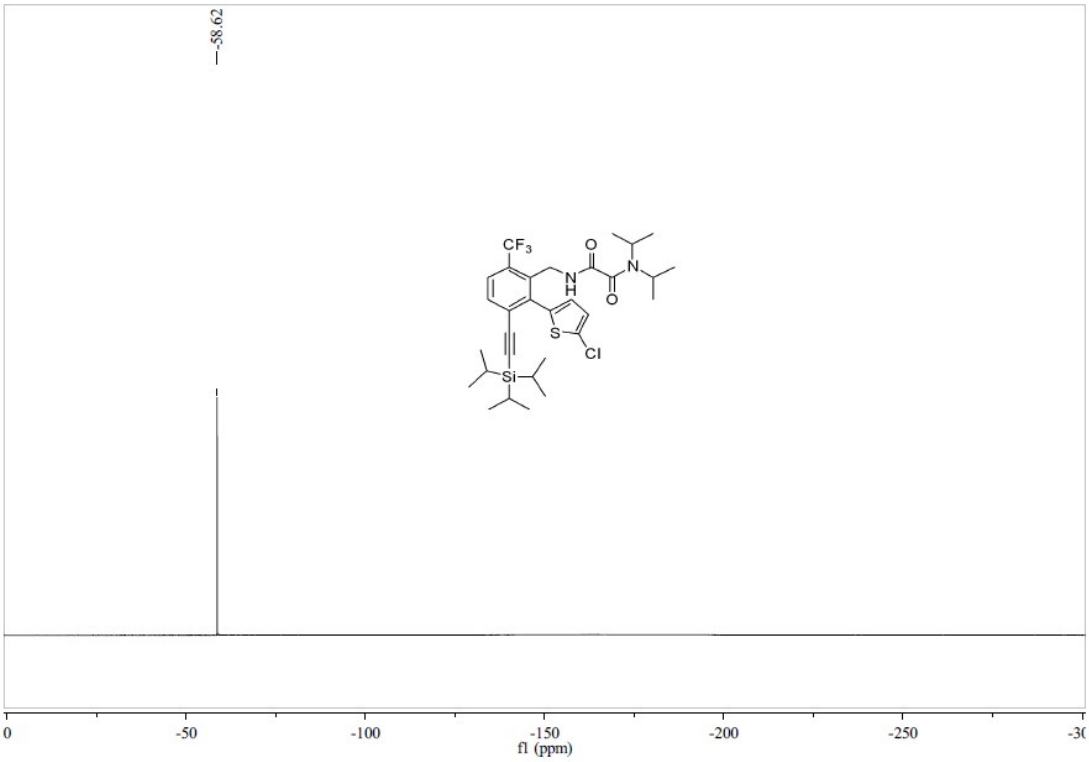
^{1}H NMR of compound **(5a)**



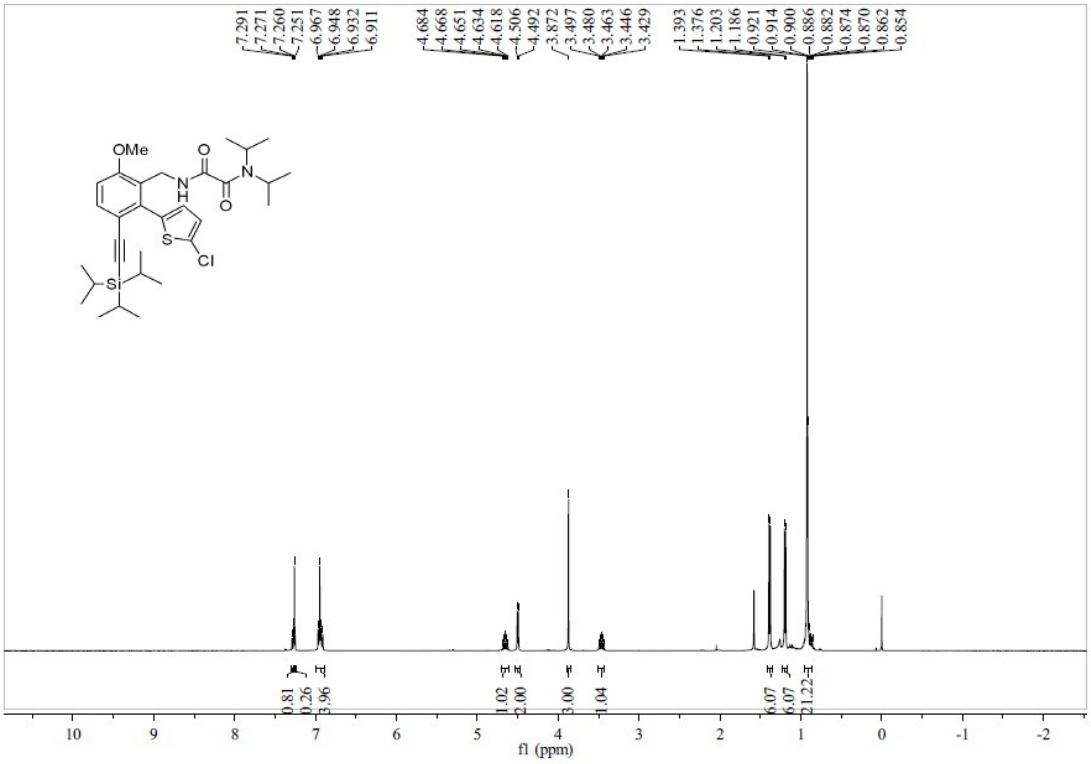
^{13}C NMR of compound **(5a)**



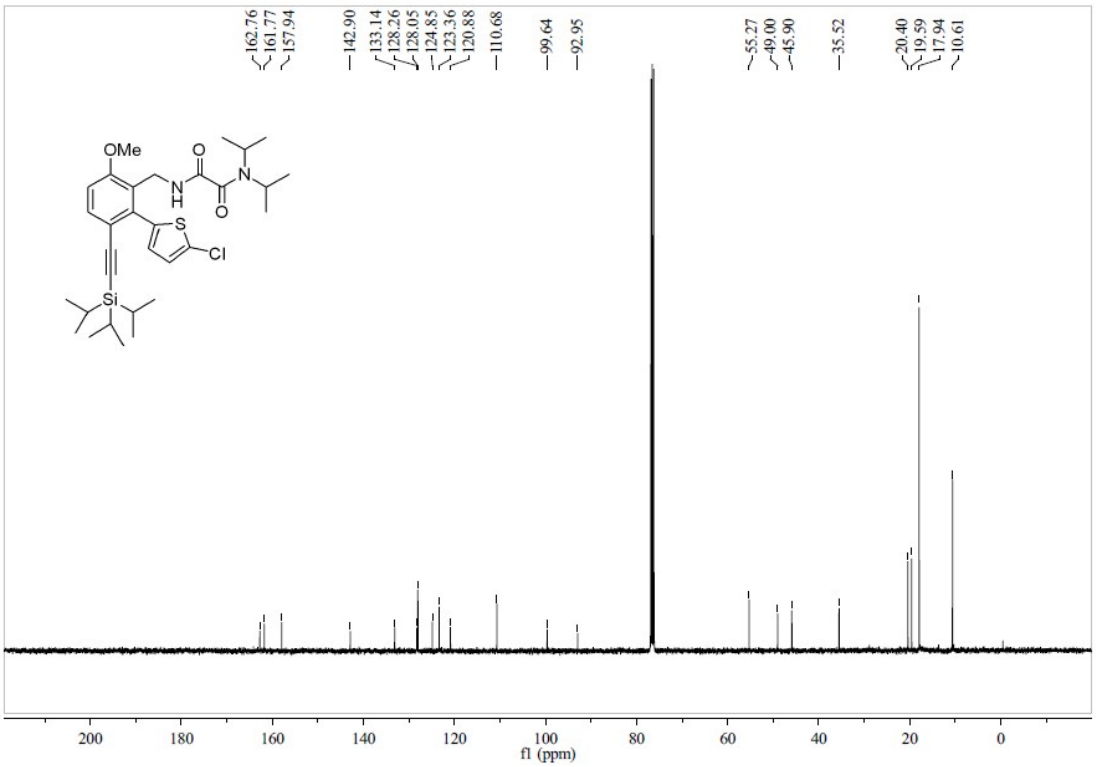
^{19}F NMR of compound **(5a)**



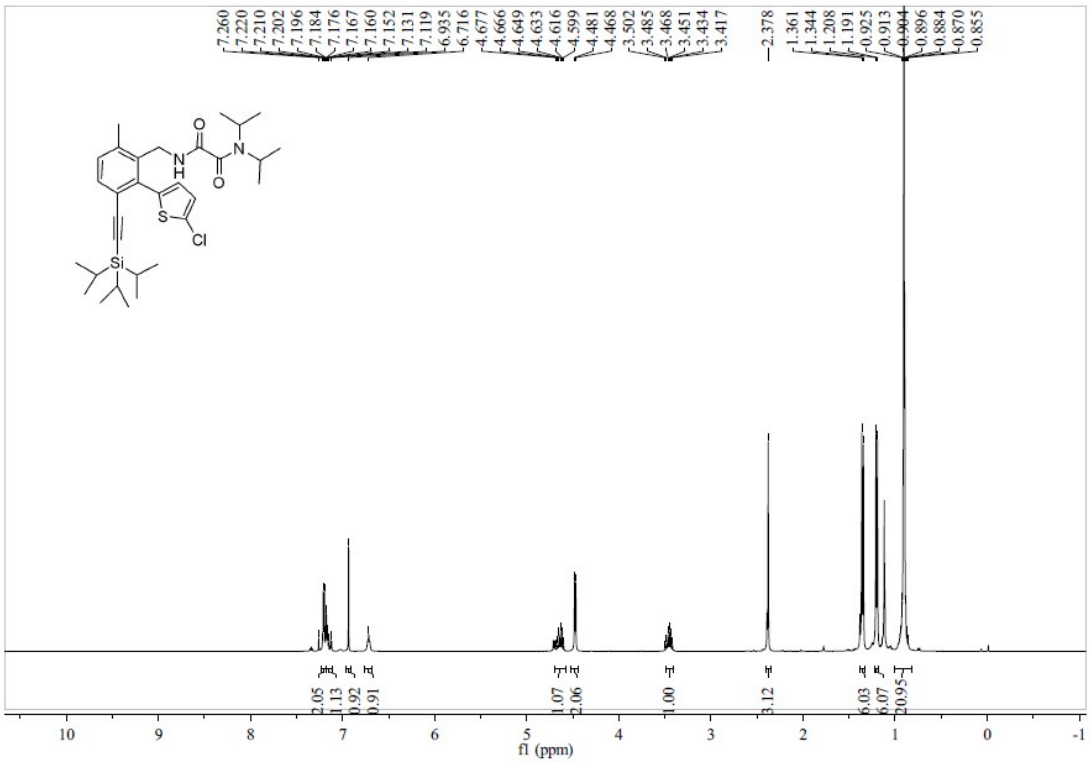
^{1}H NMR of compound **(5b)**



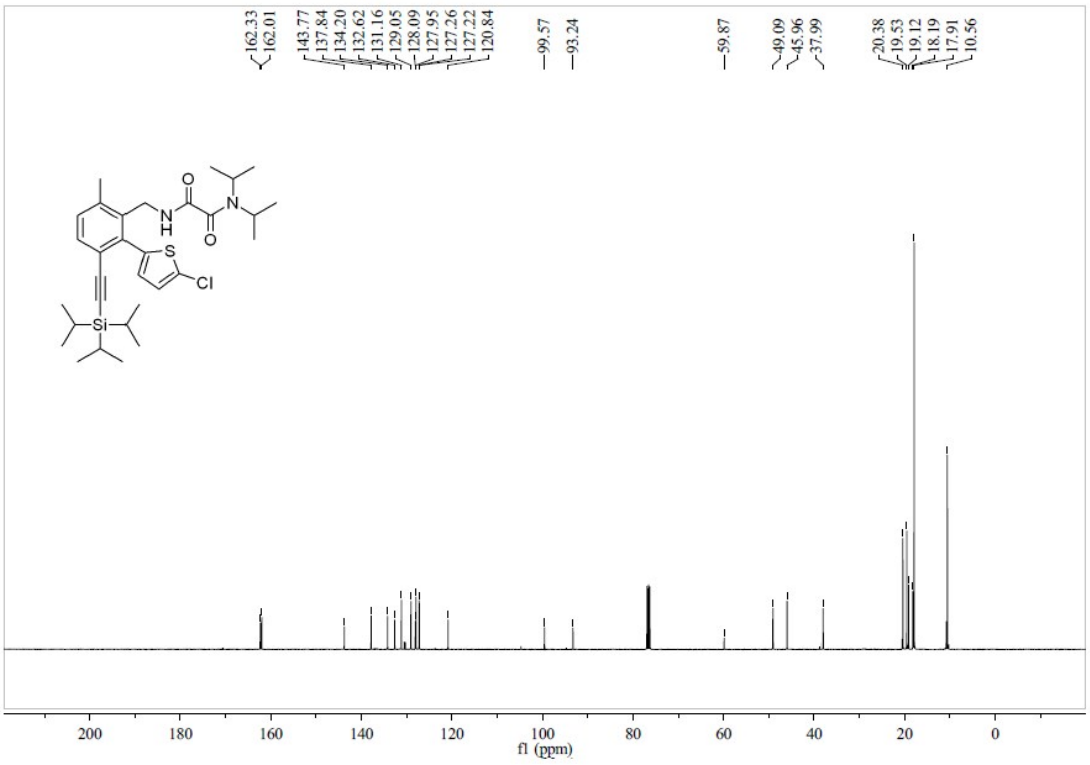
^{13}C NMR of compound **(5b)**



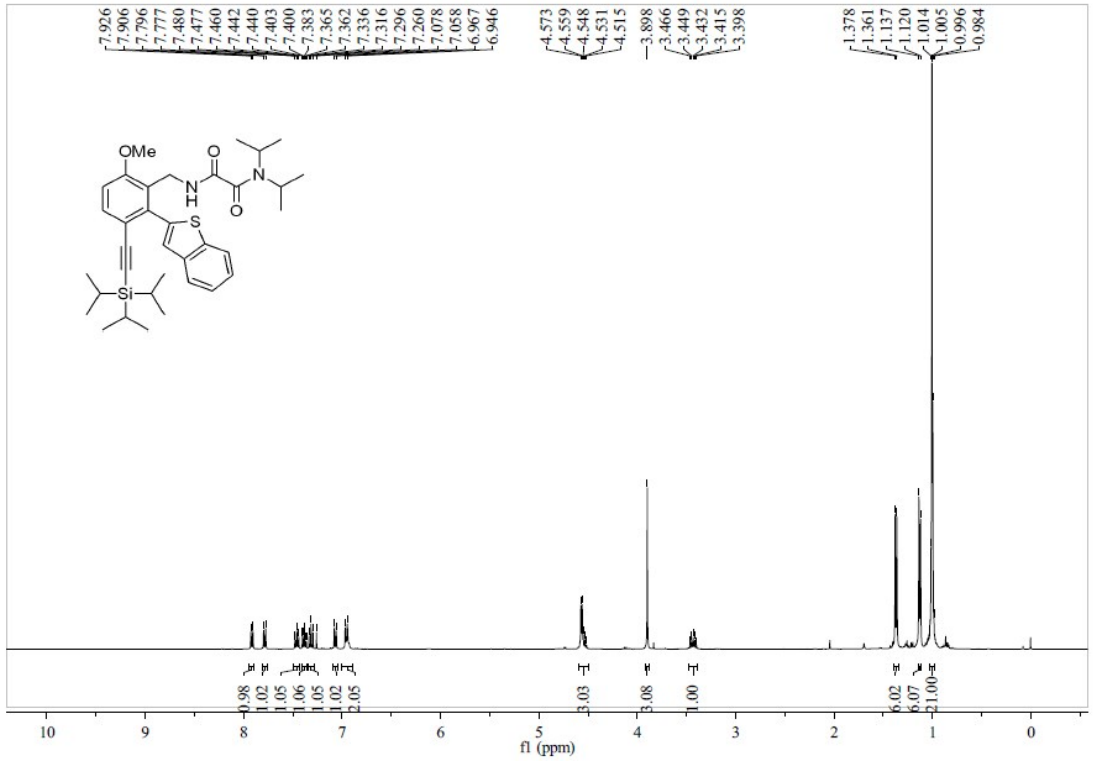
^{1}H NMR of compound **(5c)**



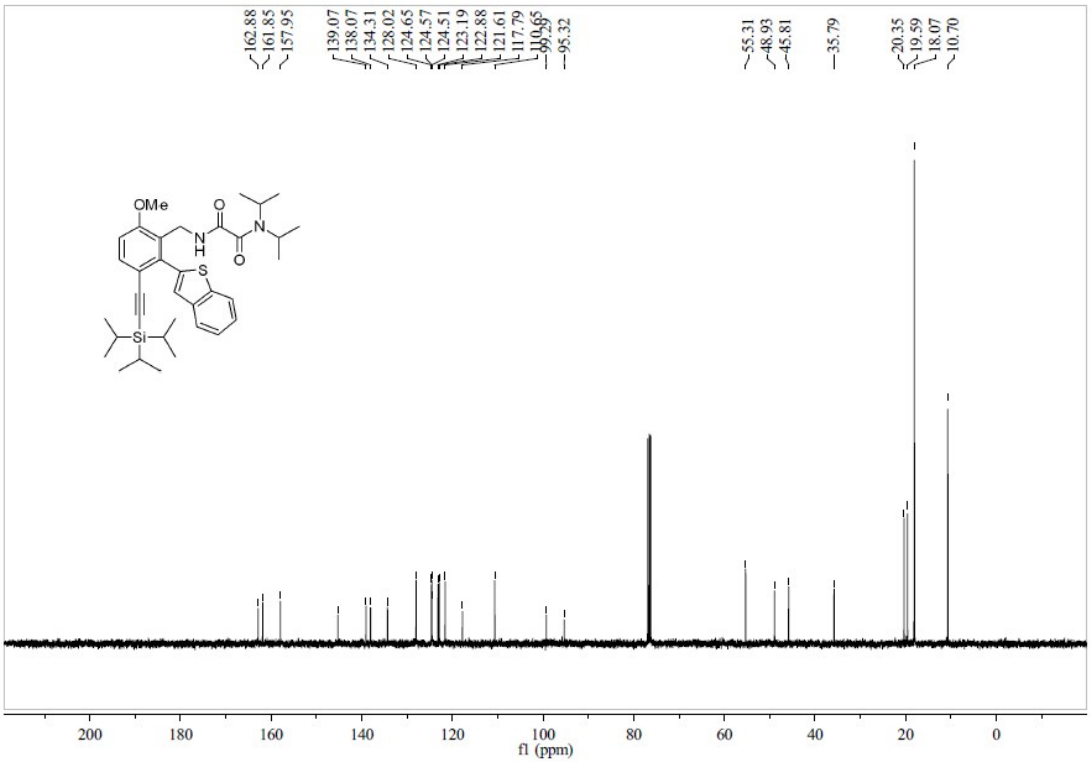
^{13}C NMR of compound **(5c)**



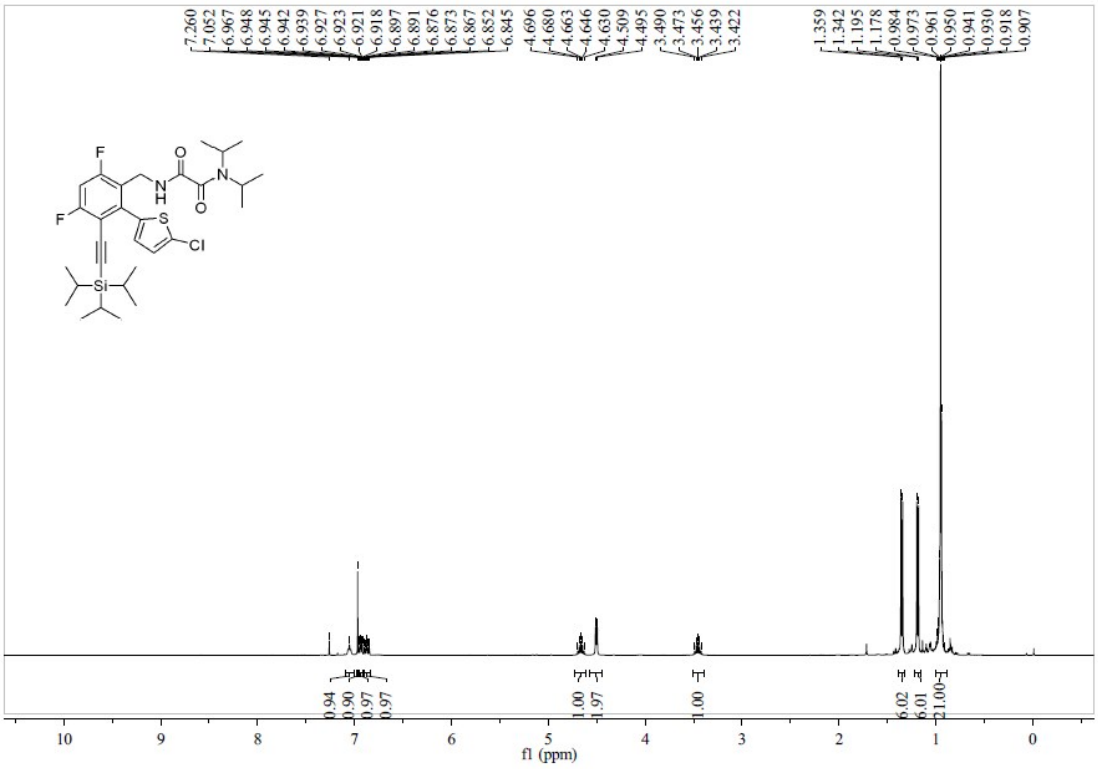
^{1}H NMR of compound **(5d)**



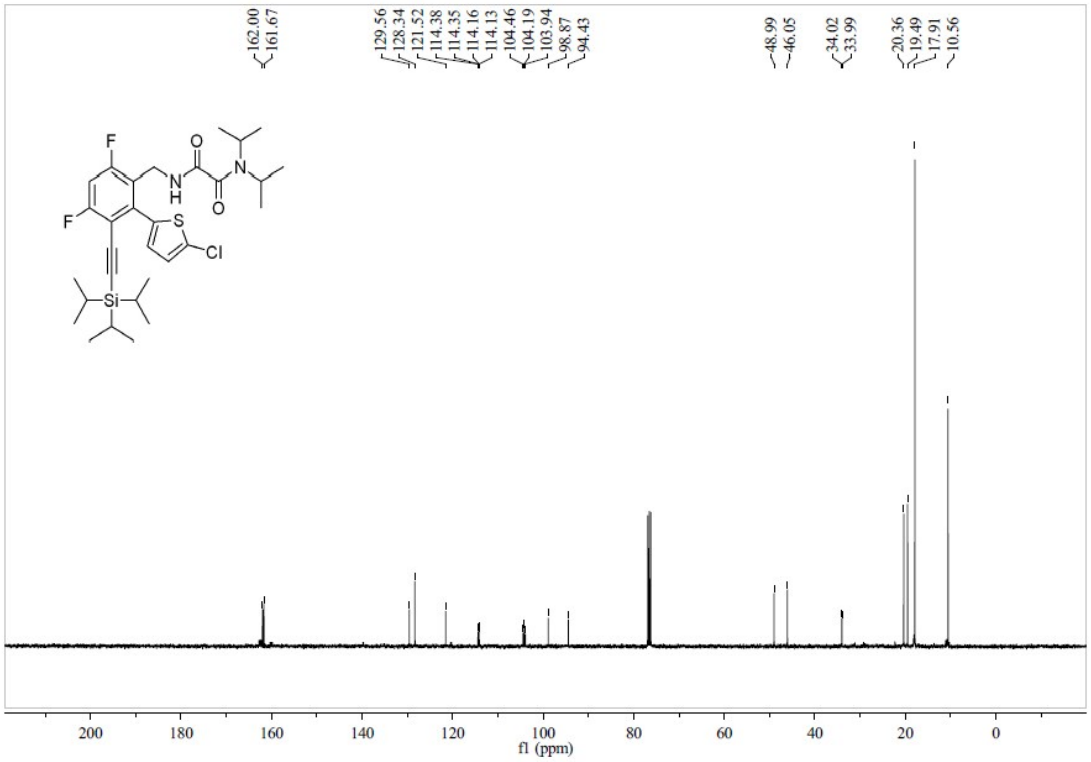
^{13}C NMR of compound **(5d)**



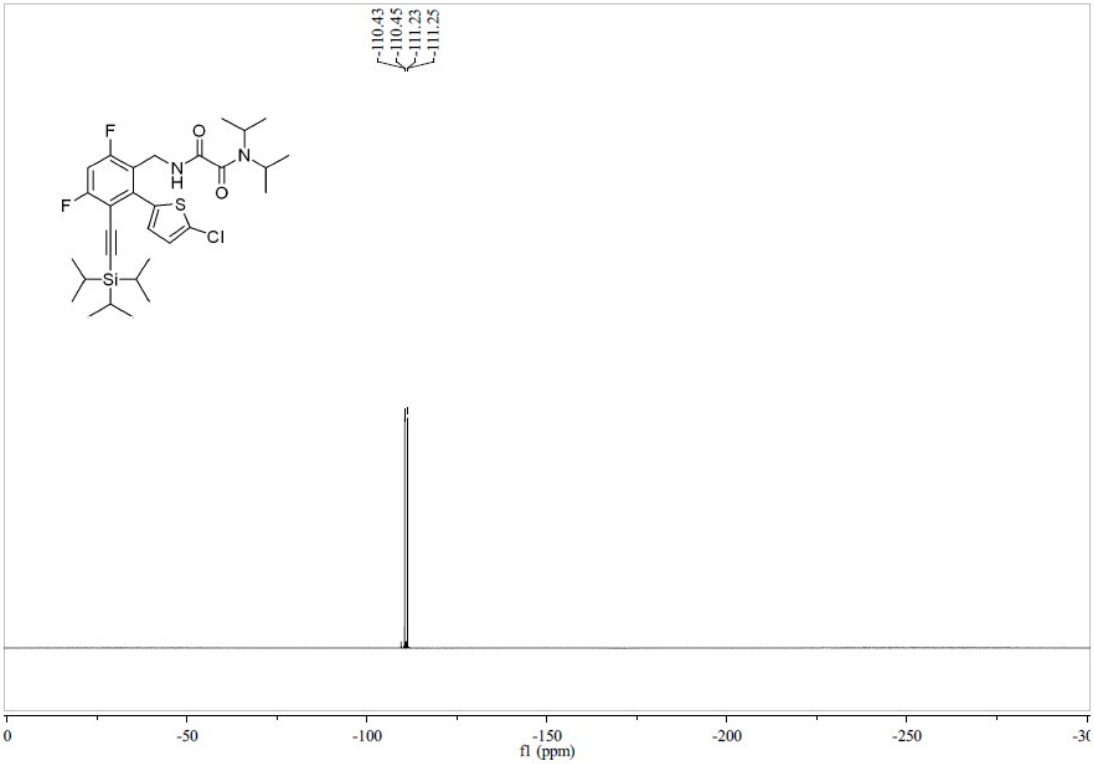
^{1}H NMR of compound **(5e)**



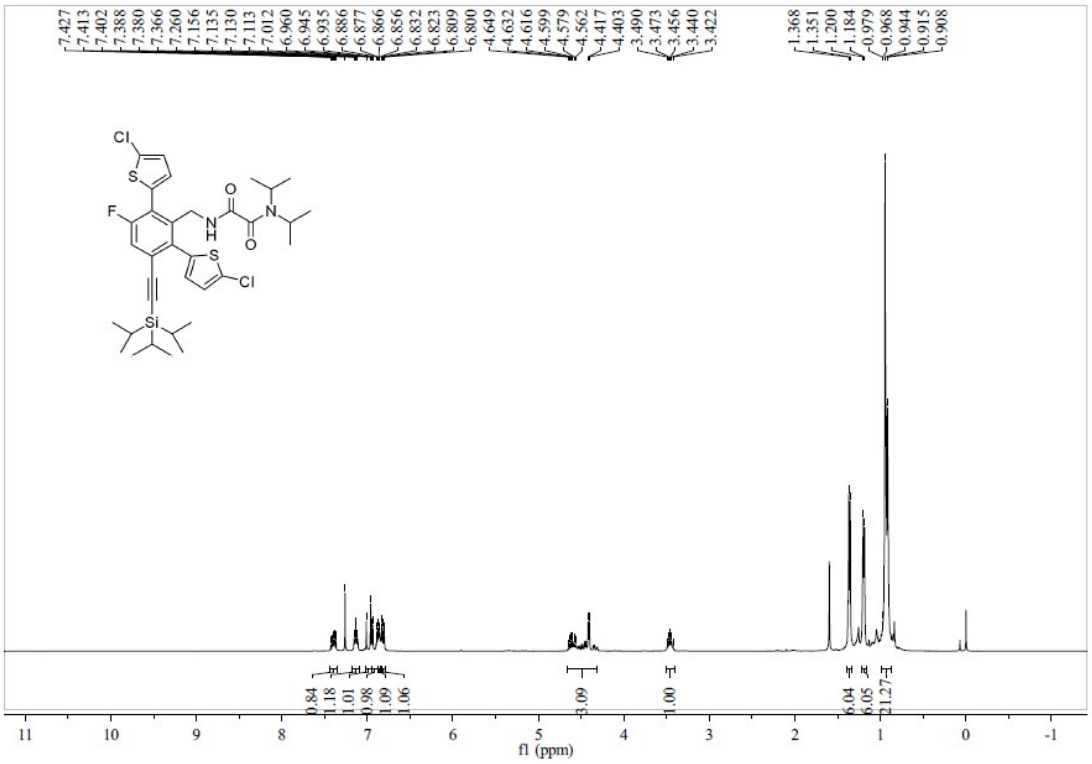
^{13}C NMR of compound **(5e)**



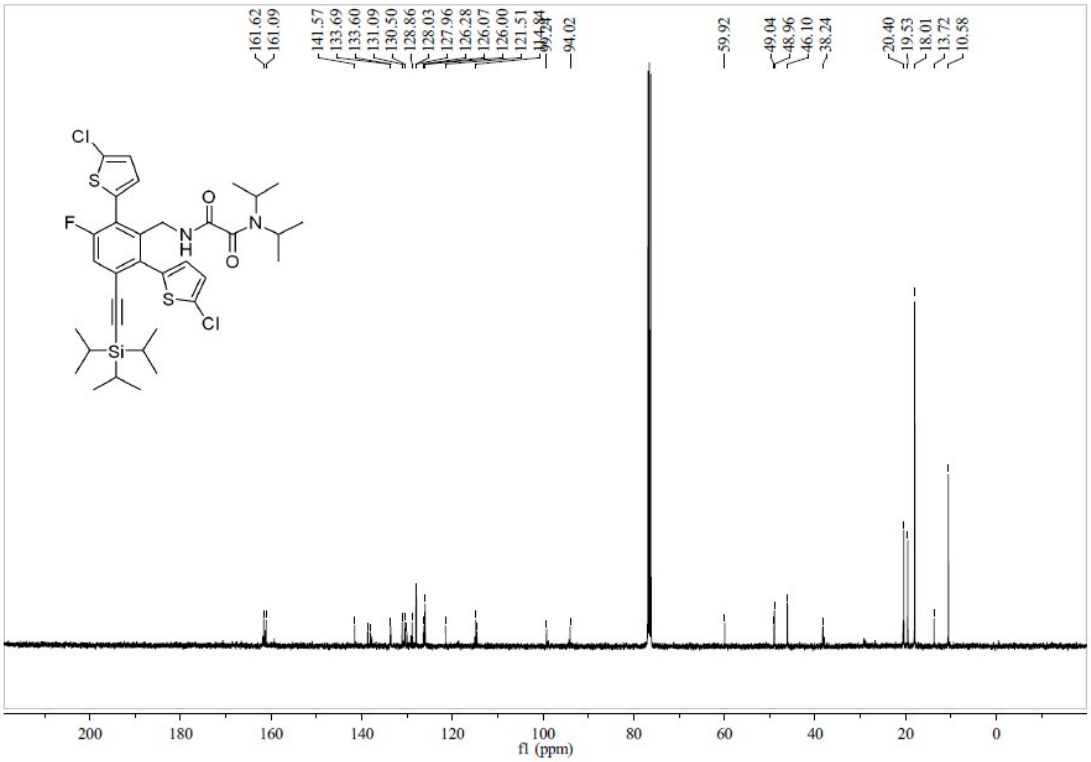
^{19}F NMR of compound **(5e)**



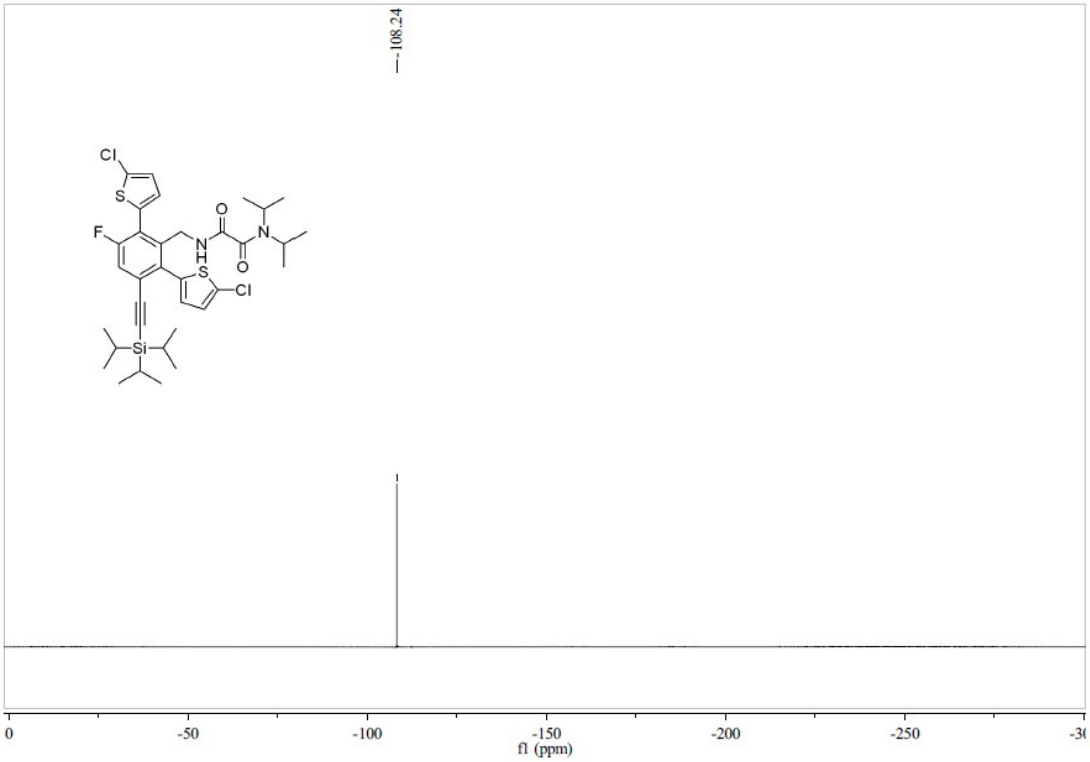
^{1}H NMR of compound **(5f$_{(o+o')di}$)**



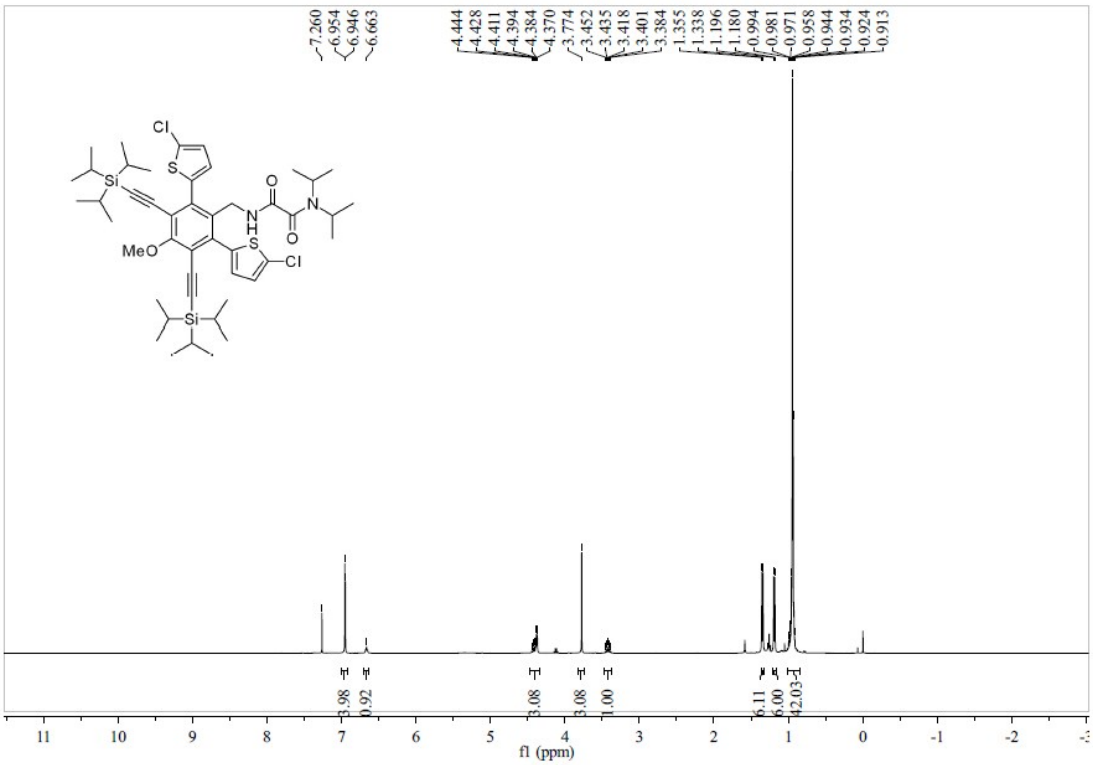
^{13}C NMR of compound **(5f$_{(o+o')di}$)**



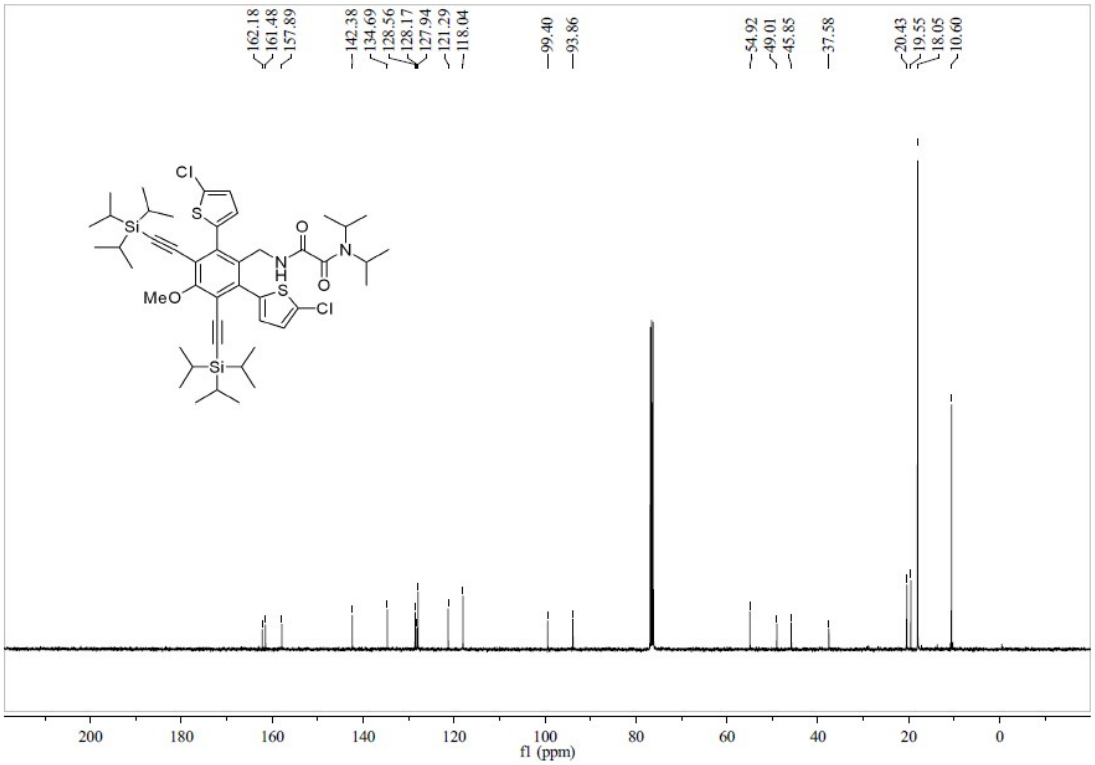
^{19}F NMR of compound **(5f$_{(o+o')di}$)**



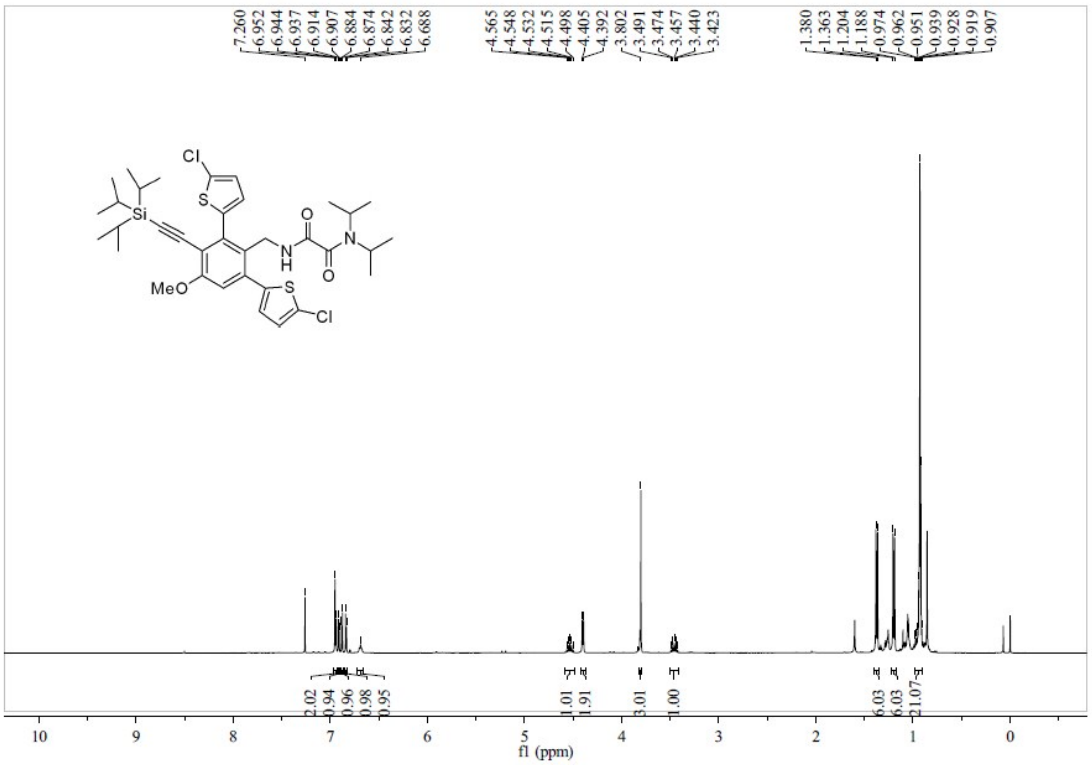
^{1}H NMR of compound **(5g)**



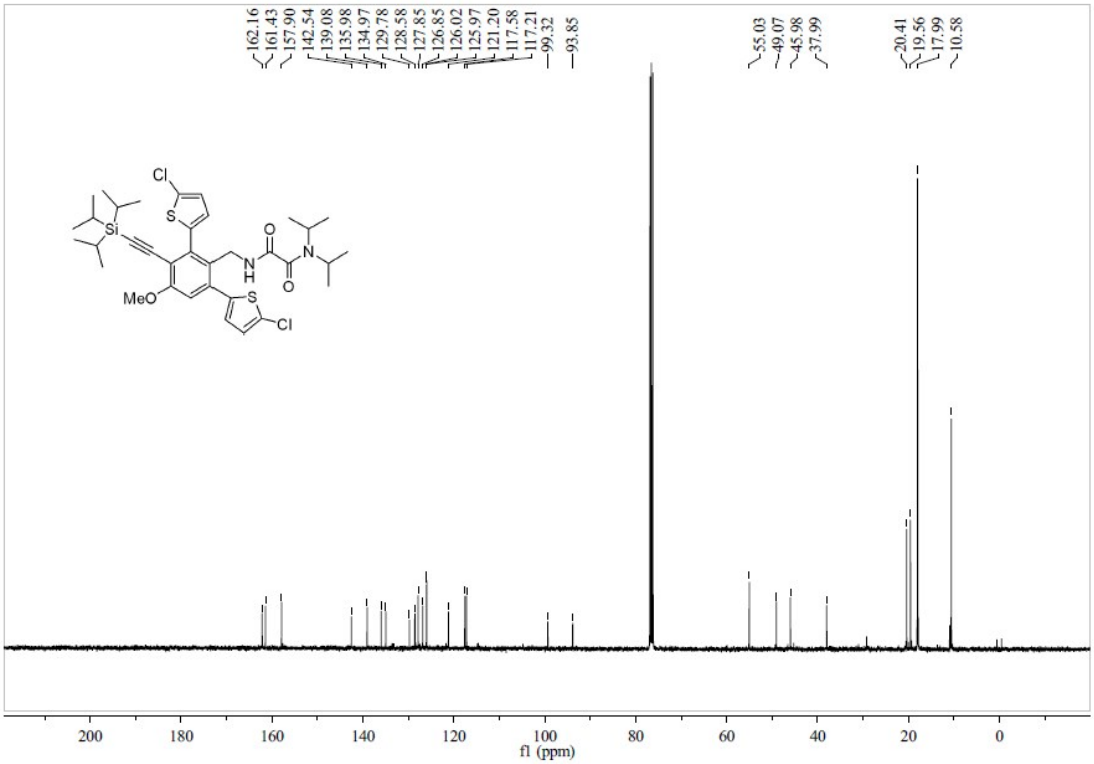
^{13}C NMR of compound **(5g)**



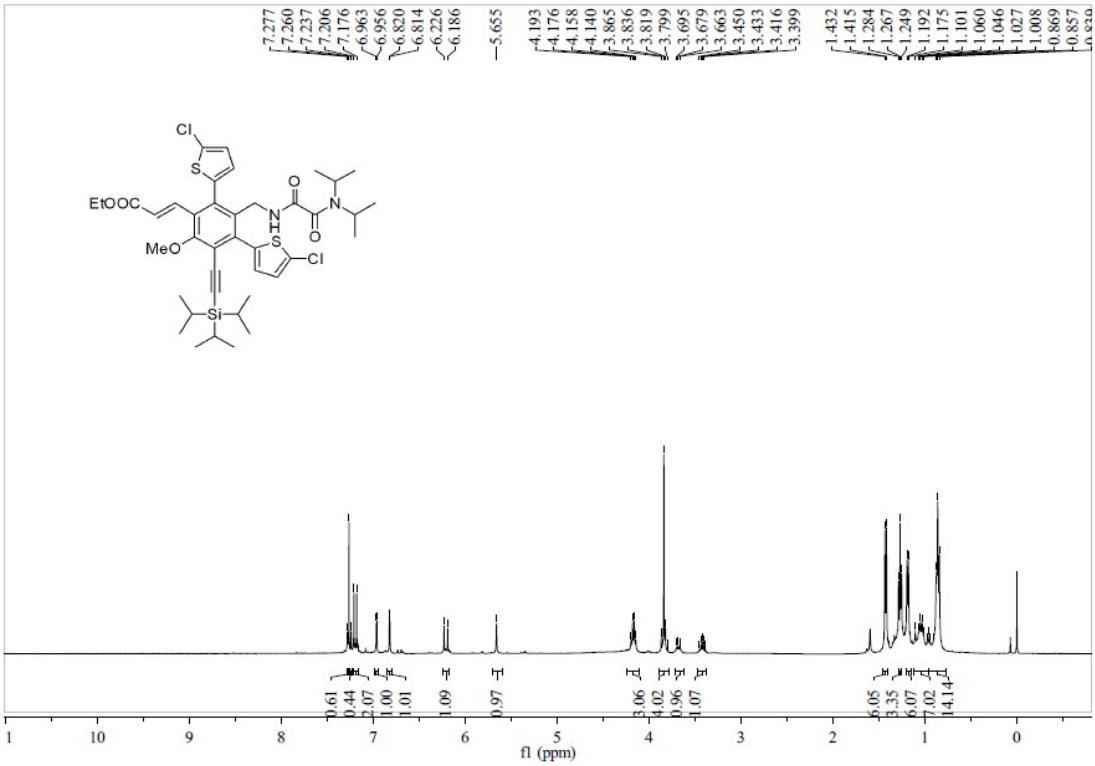
^{1}H NMR of compound **(5h)**



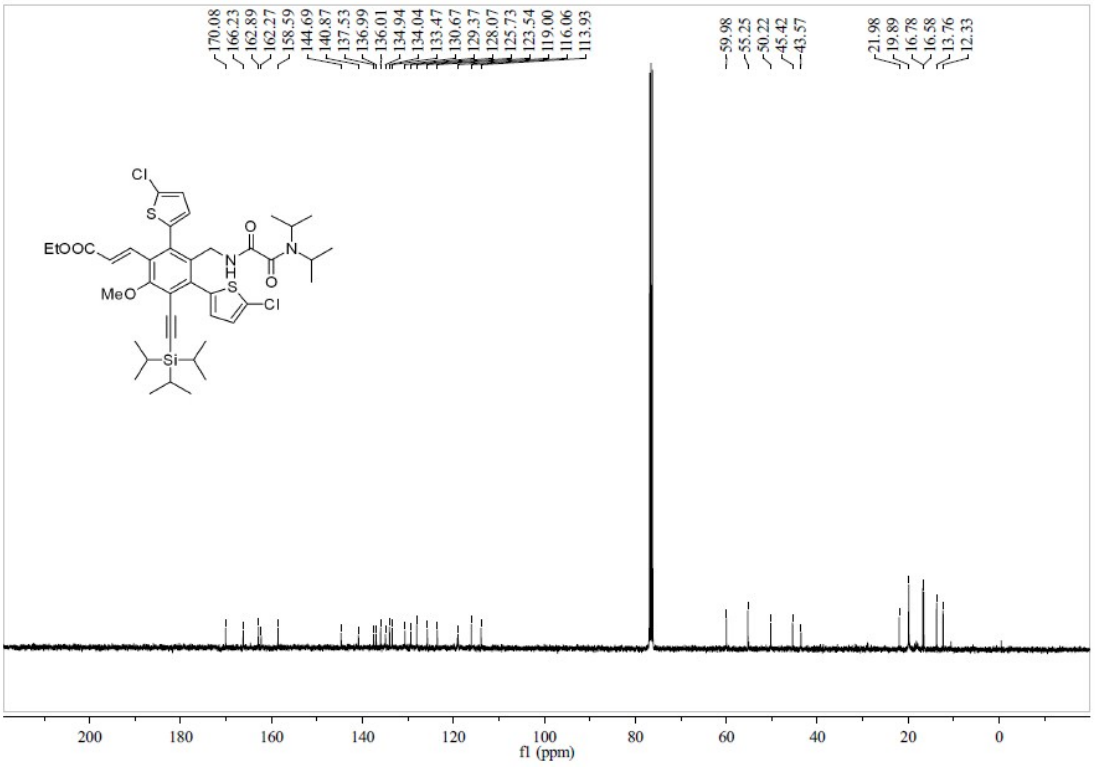
^{13}C NMR of compound **(5h)**



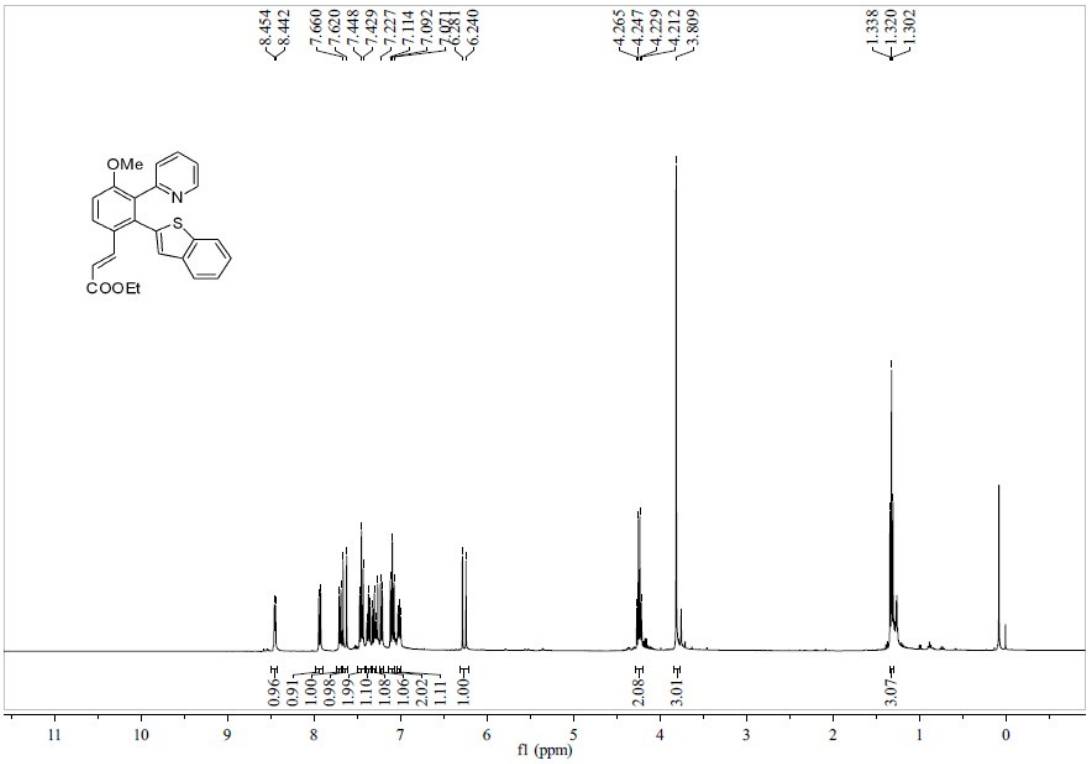
^{1}H NMR of compound **(5i)**



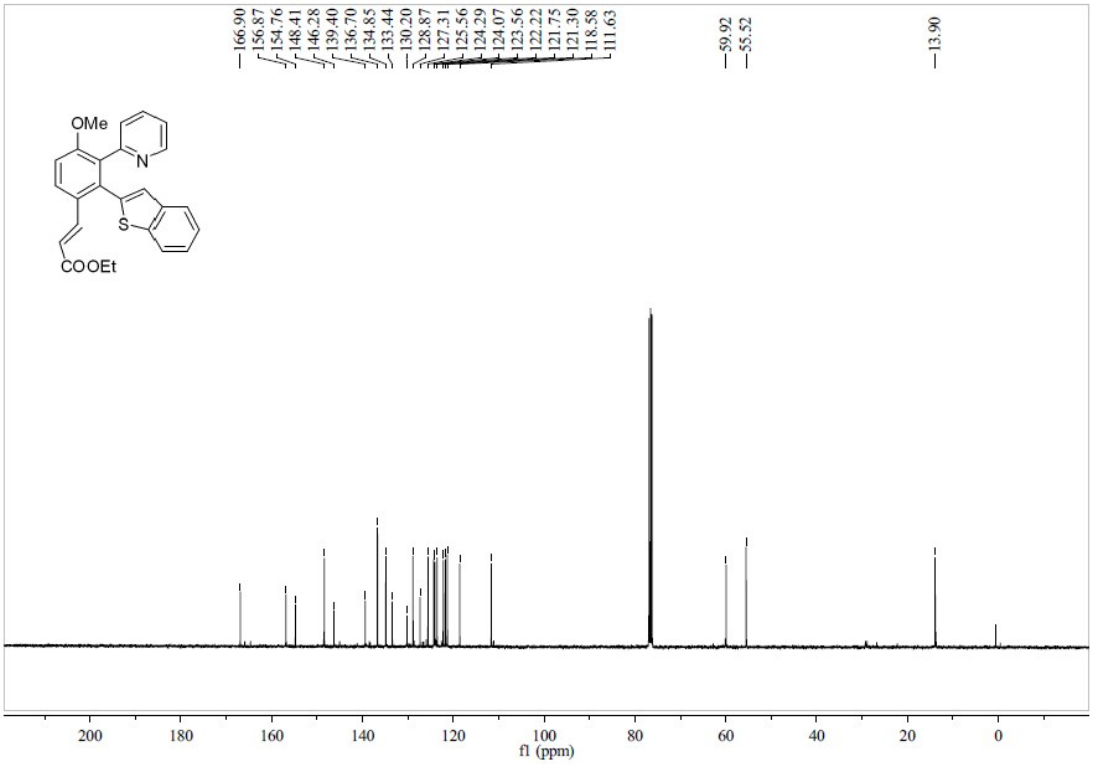
^{13}C NMR of compound **(5i)**



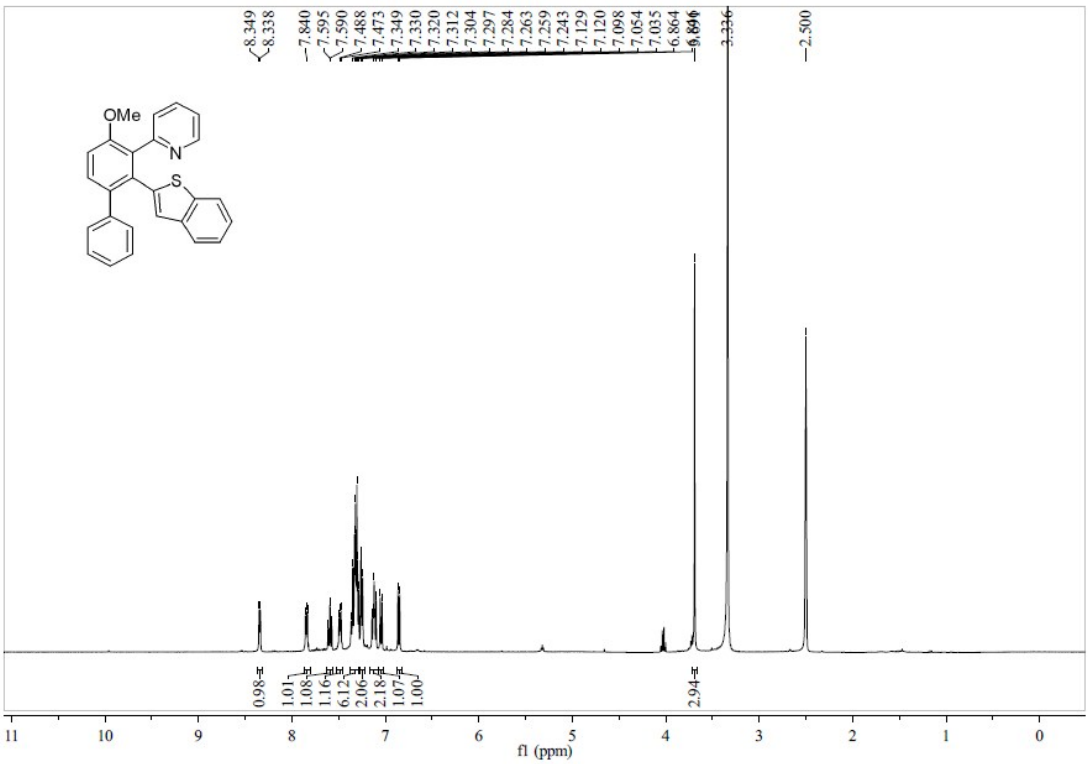
^{1}H NMR of compound **(7a)**



^{13}C NMR of compound **(7a)**



^{1}H NMR of compound **(8a)**



^{13}C NMR of compound **(8a)**