Isoquinoline-Catalyzed Visible-Light-Mediated 1,2-/1,4-Thiosulfonylation Difunctionalization Reaction of Thiosulfates with Alkenes

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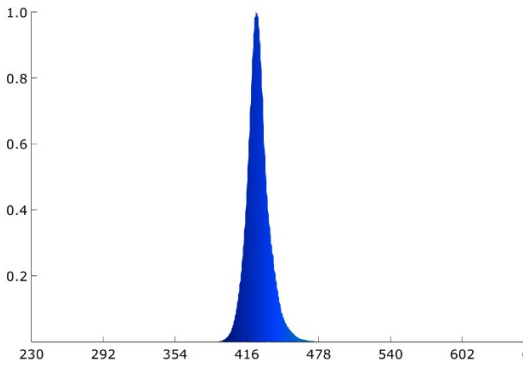
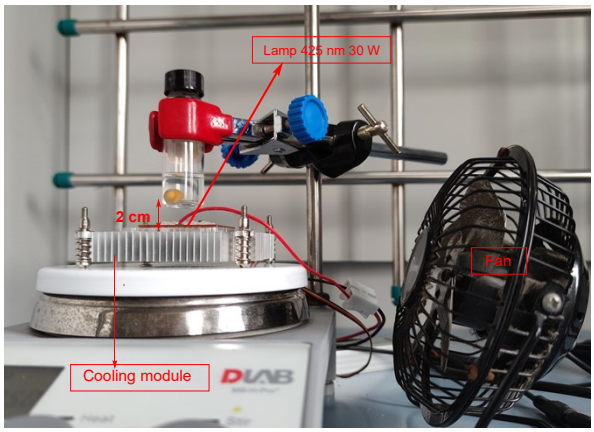
Contents

1. General information

Unless otherwise stated, all chemicals were acquired from commercial suppliers and utilized without additional purification. NMR spectra were collected using a JNM-ECZ600R/S1 spectrometer, with ^{1}H spectra obtained at 400 MH and 600 MHz, and ^{13}C spectra at 100 MHz and 150 MHz. Chemical shifts for ^{1}H NMR (at 400 MH and 600 MHz) were referenced to $CDCl_3$ (δ = 7.26). The chemical shifts for ^{13}C NMR (at 100 MHz and 150 MHz) were referenced to $CDCl_3$ (δ = 77.16). Thin-layer chromatography (TLC) was carried out on glass-backed silica plates. Column chromatography was conducted using silica gel (300-400 mesh) and eluted with a mixture of petroleum ether and ethyl acetate. Yields were calculated based on isolated compounds obtained after purification.

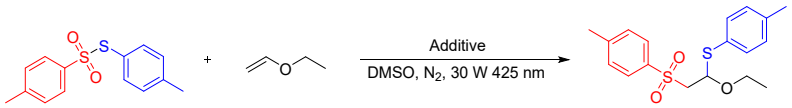
2. Reaction setup and light wavelength





3. Optimization of the reaction conditions

Table S1 Effects of additive[a,b]

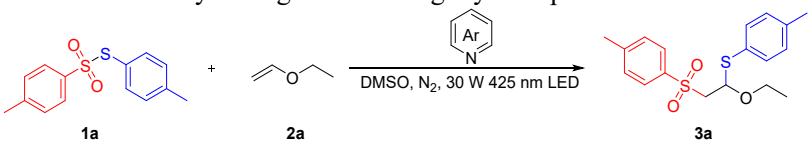


1a **2a** **3a**

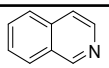
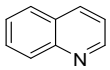
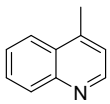
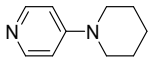
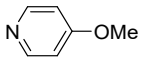
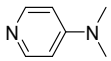
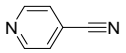
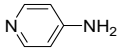
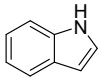
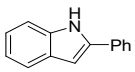
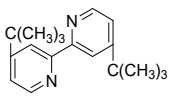
Entry	Additive	Solvent	30 W LEDs	Yield (%)[b]
1	**isoquinoline**	**DMSO**	**425 nm**	**91**
2	-	DMSO	425 nm	NR
3	Cs_2CO_3	DMSO	425 nm	NR
4	NaOH	DMSO	425 nm	NR
5	DBU	DMSO	425 nm	NR
6	TMEDA	DMSO	425 nm	NR

[a] Reaction conditions: **1a** (0.4 mmol), **2a** (0.8 mmol), Additive (0.08 mmol), 4 mL DMSO, N_2, 30 W 425 nm LED 12 h; NR = No Reaction. [b] ^{1}H NMR yield.

Table S2 Effects of aryl nitrogen-containing aryl compounds.[a,b]



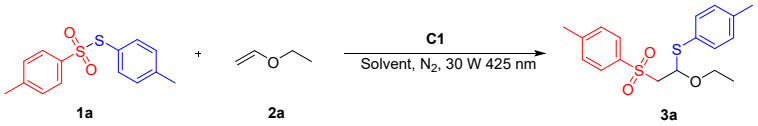
1a 2a 3a

Entry	Additive	Solvent	30 W LEDs	Yield (%)[b]
1	 **C1**	**DMSO**	**425 nm**	**91**
2	 **C2**	DMSO	425 nm	81
3	 **C7**	DMSO	425 nm	84
4	 **C4**	DMSO	425 nm	62
5	 **C3**	DMSO	425 nm	24
6	 **C9**	DMSO	425 nm	35
7	 **C8**	DMSO	425 nm	42
8	 **C5**	DMSO	425 nm	39
9	 **C10**	DMSO	425 nm	42
10	 **C6**	DMSO	425 nm	40
11	 **C11**	DMSO	425 nm	26
12		DMSO	425 nm	11

C12

[a] Reaction conditions: **1a** (0.4 mmol), **2a** (0.8 mmol), Additive (0.08 mmol), 4 mL DMSO, N_2, 30 W 425 nm LED 12 h. [b] ^{1}H NMR yield.

Table S3 Effects of solvent[a,b]

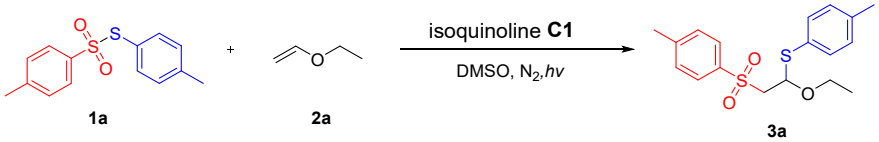


1a 2a 3a

Entry	Additive	Solvent	30 W LEDs	Yield (%) [b]
1	**C1**	**DMSO**	**425 nm**	**91**
2	**C1**	MeCN	425 nm	NR
3	**C1**	EA	425 nm	NR
4	**C1**	EtOH	425 nm	43
5	**C1**	MeOH	425 nm	36
6	**C1**	H_2O	425 nm	35
7	**C1**	DMF	425 nm	NR
8	**C1**	DCM	425 nm	NR

[a] Reaction conditions: **1a** (0.4 mmol), **2a** (0.8 mmol), **C1** (0.08 mmol), 4 mL Solvent N_2, 30 W 425 nm LED 12 h. [b] ^{1}H NMR yield.

Table S4 Effects of Light[a,b]

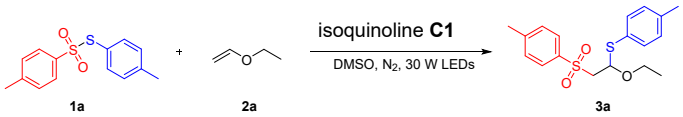


1a 2a 3a

Entry	Additive	Solvent	30 W LEDs	Yield (%) [b]
1	**C1**	**DMSO**	**425 nm**	**91**
2	**C1**	DMSO	410 nm	78
3	**C1**	DMSO	455 nm	NR
4	**C1**	DMSO	dark	NR

[a] Reaction conditions: **1a** (0.4 mmol), **2a** (0.8 mmol), **C1** (0.08 mmol), 4 mL Solvent, N_2, 30 W LEDs 12 h; NR = No Reaction. [b] ^{1}H NMR yield

Table S5 Equivalent of additive.[a,b]

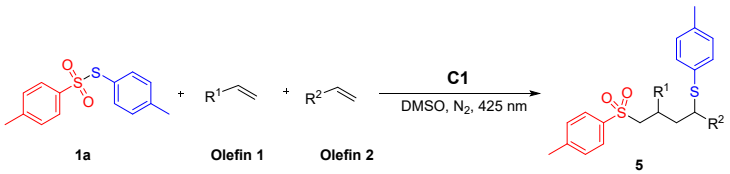


Entry	Equiv of **C1**	Solvent	30 W LEDs	Yield (%) [b]
1	0.1 eq	DMSO	425 nm	82
2	**0.2** eq	**DMSO**	425 nm	**91**
3	0.3 eq	DMSO	425 nm	92
4	1 eq	DMSO	425 nm	91
5	2 eq	DMSO	425 nm	91

[a] Reaction conditions: **1a** (0.4 mmol), **2a** (0.8 mmol), isoquinoline **C1**, 4 mL DMSO, N_2, 30 W 425 nm LED 12 h. [b] ^{1}H NMR yield

4. Attempt of combination two olefins.

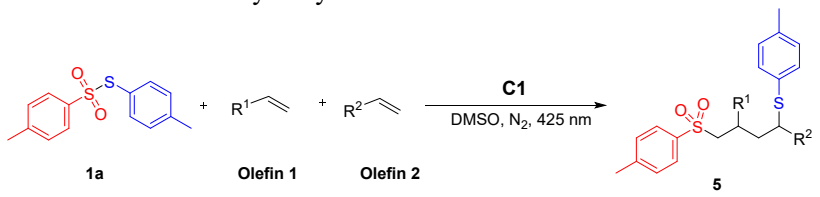
Table S6 Combination of vinyl ether and other olefins.

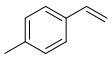
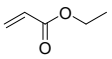
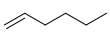
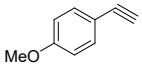


Entry	Olefin 1	Olefin 2	Yield(%)
1	**2a**	**2y**	80%
2	**2a**	**2a'**	NR
3	**2a**	**2b'**	NR
4	**2a**	**2c'**	NR
5	**2a**	**2d'**	NR
6	**2a**	**2e'**	NR
7	**2a**	**2f'**	NR
8	**2a**	**2g'**	NR

[a] Reaction Conditions: **1a** (0.4 mmol), **Olefin 1** (0.8 mmol), **Olefin 2** (0.8 mmol), isoquinoline **C1** (0.08 mmol), 4 mL DMSO, N_2, 30 W 425 nm LED 12 h. NR = No Reacion. [b] Isolated Yield.

Table S7 Combination of ethyl acrylate with other olefins



Olefin 1	Olefin 2	Yield(%)
 **2z**	 **2y**	NR
 **2ac**	**2y**	NR
 **2g**	**2y**	NR
 **2aa**	**2y**	NR
 **2ab**	**2y**	NR

[a] Reaction Conditions: **1a** (0.4 mmol), **Olefin 1** (0.8 mmol), **Olefin 2** (0.8 mmol), isoquinoline **C1** (0.08 mmol), 4 mL DMSO, N_2, 30 W 425 nm LED 12 h. NR = No Reacion. [b] Isolated Yield.

5. General operation

Thiosulfonate substrate (0.4 mmol), olefin substrate (0.8 mmol), isoquinoline **C1**(0.08 mmol), and 4 mL of DMSO were added to an N_2 atmosphere reaction flask filled with a magnetic stirrer. Irradiate with 30 W 425 nm blue light and stir for 12 h at room temperature. After the reaction, dilute hydrochloric acid was added to the reaction bottle to quench isoquinoline, and then the reaction solution was diluted with an appropriate amount of water, and ethyl acetate was used for extraction, and the organic phases were collected and merged. Subsequently, the organic layer is washed with a saturated sodium chloride solution and dried by anhydrous sodium sulfate, followed by concentration under reduced pressure to obtain a crude product. Finally, the crude product was purified by silica gel column chromatography (the eluent ratio is petroleum ether:ethyl acetate = 88:12) to obtain the target product.

6. Mechanistic experiments

UV-vis study.

In order to verify whether the reaction mechanism involves the EDA (Electron Donor-Acceptor) process, ultraviolet absorption spectroscopy was performed. 7 groups of samples were set up for testing, and each group of solvents was 4 mL of dimethyl sulfoxide (Figure S1). The test samples were weighed according to the reaction ratio: isoquinoline **C1** (0.13 mg, 1.0 μmol), 4-methylbenzene thiosulfonate **1a** (1.39 mg, 5.0 μmol), **2a** (0.72 mg, 10.0 μmol), and the samples were weighed and dissolved in DMSO according to the set group, and then ultraviolet absorption spectroscopy was carried out.

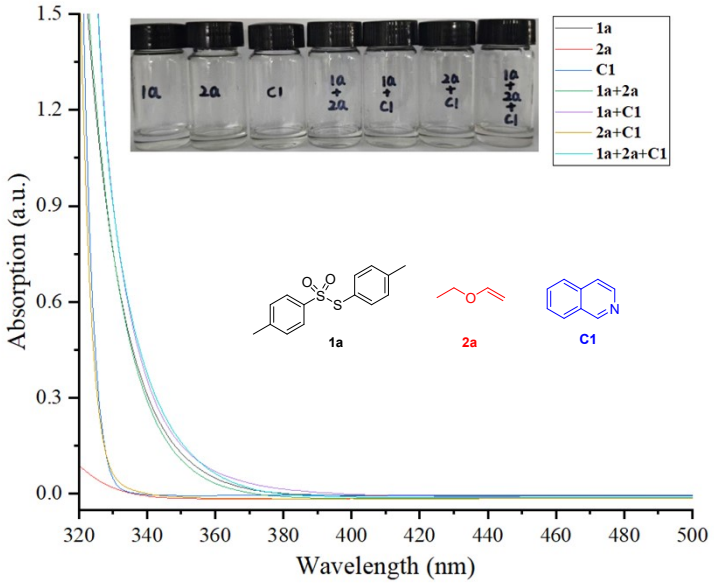


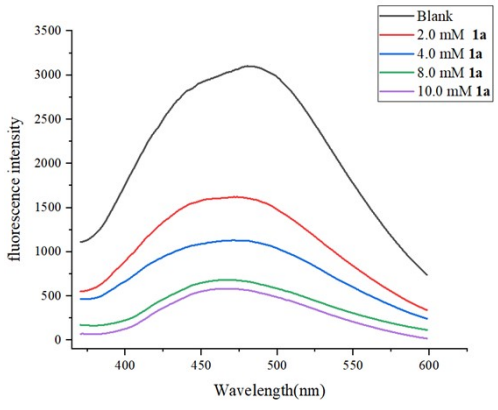
Figure S1 UV-vis study.

7. Stern-Volmer phosphorescence quenching studies

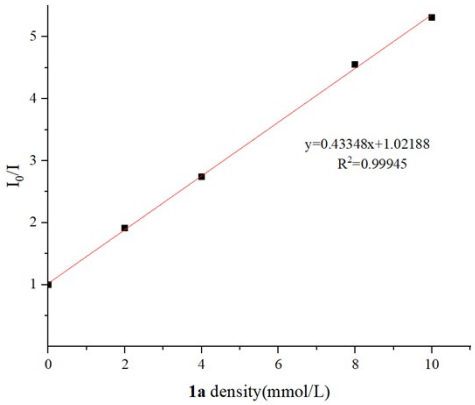
The samples were prepared mixing the isoquinoline **C1** with the required amount of thiosulfonate ester **1a** in a total volume of 1 mL of DMSO in a 10 × 10 mm light path quartz fluorescence cuvette. The concentration of isoquinoline **C1** is 10.0 mM.

(a) The excitation wavelength was fixed at 330 nm, the emission light was acquired from 320 nm to 600 nm.

(b) In Stern-Volmer quenching plot was constructed using the emission maximum intensity at 480 nm.



(a) Quenching of the isoquinoline emission in the presence of increasing amounts of thiosulfonate esters.



(b) Stern-Volmer quenching plot.

Figure S2 Fluorescence quench studies

8. Quantum yield measurement

The quantum yield of the reaction was measured by chemical actinometry using 425 nm blue LEDs using potassium ferrioxalate following the procedure of E. E. Wegner (J. Am. Chem. Soc.1966, 88, 394), J.N. Demas (J. Phys. Chem. 1981,85, 2766) and F. Glorius (Org. Let. 2018, 20,1546).

The photon flux of the spectrophotometer was determined by standard ferrioxalate actinometry. Potassium ferrioxalate solution 0.012 M:59.0 mg of $K_3[Fe(C_2O_4)]\cdot 3H_2O$ and 28 μL of H_2SO_4 (96%) were added to a 10 mL volumetric flask and filled to the mark with distilled water.1,10-Phenanthroline 0.01 M: 99.1 mg of 1,10-phenanthroline monohydrate were added to a 50 mL volumetric flask and filled to the mark with distilled water. Buffer solution: 4.94 g of NaOAc and 1 mL of H_2SO_4 (96%) were added to a 100 mL volumetric flask and filled to the mark with distilled water. Both solutions were stored in the dark.

To determine the photon flux of the spectrophotometer, 4 mL of the ferrioxalate solution (0.012 M) was placed in a 10 ml reaction flask containing a stirring bar, and irradiated for 60.0 s at λ = 425 nm. After 60.0 seconds of irradiation, take 0.1 mL of the sample and add it to 2 mL of buffer solution and 0.5 mL of 1,10-phenanthroline. Then add distilled water to make up the volume to 10 mL.

As a blank sample, a solution was prepared with 0.1 mL of non-irradiated potassium ferrioxalate solution (0.012 M), 2.0 mL of buffer solution and 0.5 mL of 1,10-phenanthroline 0.01 M solution in a 10 mL volumetric flask filled with distilled water to the mark. Conversion was calculated using eq 1. The molar concentration of Fe^{2+} was calculated to be 6.092×10^{-5} mol.

$$\text{mol}Fe^{2+} = \frac{V1\cdot V3\cdot \Delta A510}{1000\cdot V2\cdot l\cdot \varepsilon 510} \qquad (1)$$

$$= \frac{4.0mL\cdot 10\ mL\cdot 1.708}{1000\cdot 0.1\ mL\cdot 1\ cm\cdot 11100M^{-1}\cdot cm^{-1}} = 6.092\times 10^{-5}\ \text{mol}$$

where V1 is the irradiated volume (noting that the initial volume is 4.0 mL; V2 is the aliquot volume (0.1 mL), V3 is the final volume after addition of 1,10-phenanthroline and buffer solutions (10 mL), $\Delta A510$ is the difference in absorbance at 510 nm between the irradiated and non-irradiated solutions.l

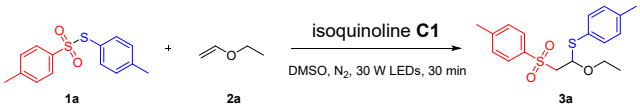
refers to the optical pathway (1 cm) and $\varepsilon 510$ is the extinction coefficient of the complex formed by Fe^{2+} and 1,10-phenanthroline (ca. 11100 $M^{-1}\cdot cm^{-1}$). The photon flux can be calculated using eq 2.

$$\text{Photon flux} = \frac{molFe^{2+}}{\phi \cdot t \cdot f} \qquad (2)$$

$$= \frac{6.092 \times 10^{-5}\, mol}{1.02 \cdot 60.0s \cdot 1} = 9.954 \times 10^{-7}\ \text{einstein}\cdot s^{-1}$$

Where ϕ is the quantum yield for the ferrioxalate actinometer (1.02 for a 0.012 M solution at λ=425 nm),[1] t is the time (60.0 s), and f is the fraction of light absorbed at λ = 425 nm ($f = 1 - 10^{-A425}$). The photon flux was calculated to be 9.954×10^{-7} einstein·s^{-1}.

Quantum yield determination



Thiosulfonate substrate **1a** (0.4 mmol), olefin substrate **2a** (0.4 mmol), isoquinoline **C1**(0.08 mmol), and 4 mL of DMSO were added to an N_2 atmosphere reaction flask filled with a magnetic stirrer. Irradiate with 30 W 425 nm blue light and stir for 60 min at room temperature. After the reaction, dilute hydrochloric acid was added to the reaction bottle to quench isoquinoline, and then the reaction solution was diluted with an appropriate amount of water, and ethyl acetate was used for extraction, and the organic phases were collected and merged. Subsequently, the organic layer is washed with a saturated sodium chloride solution and dried by anhydrous sodium sulfate, followed by concentration under reduced pressure to obtain a crude product. The sample was analyzed by ^{1}H NMR, and the integral values were used to calculate the data. The quantum yield was calculated using eq 3. the average yield of three experiments to be 0.077.

$$\phi = \frac{mol\ product}{Photon\ flux \cdot t \cdot f} \qquad (3)$$

Average yield of 3 experiments: 69.0% yield (avg. mmol= 0.276)

Sample quantum yield calculation:

$$\phi = \frac{2.76 \cdot 10^{-4}\, mmol}{9.954 \times 10^{-7}\, einstein \cdot s^{-1} \cdot 3600\ s \cdot 1} = 0.077$$

This result reveals that the radical chain process is not main pathway.

9. Another photoredox mechanism.

In addition to the energy transfer mechanism, there may also exist another photooxidation mechanism.

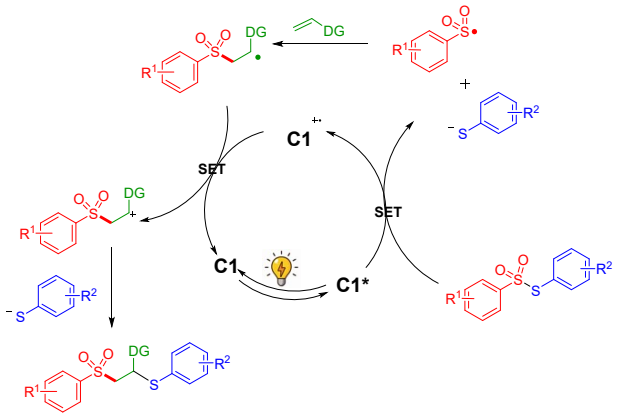
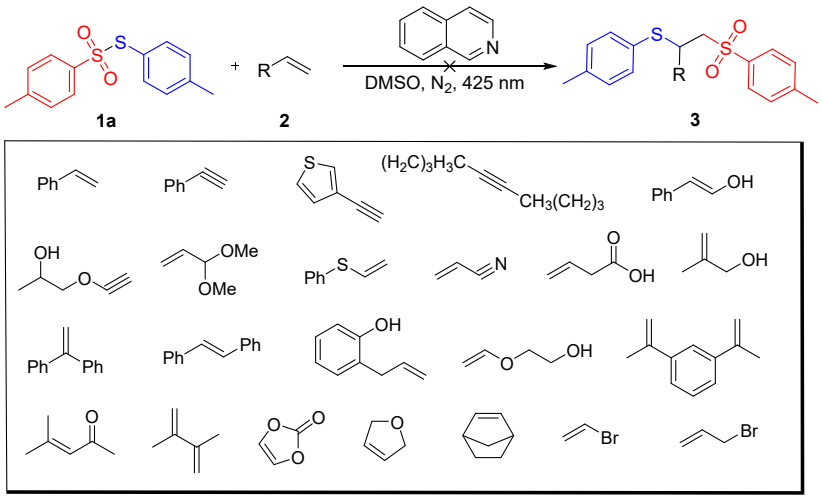


Figure S3 Another plausible photoredox pathway

10. Unsuccessful substrates

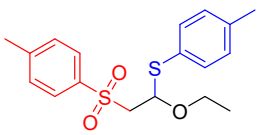


Scheme S1 Unsuccessful examples

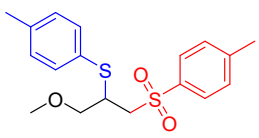
11. Characterization data

The known compounds are as follows: **3i**、**3j**、**3k**、**3o**、**3r**、**3t**、**3v**、**3x**. And the spectroscopic datas matched literature values.

(1-ethoxy-2-tosylethyl)(p-tolyl)sulfane (3a). Colorless liquid; Yield: 88%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.70 (d, *J* = 8.3 Hz, 2H), 7.32 – 7.25 (m, 4H), 7.10 (d, *J* = 7.8 Hz, 2H), 5.05 (dd, *J* = 9.5, 2.5 Hz, 1H), 3.94 (dq, *J* = 9.0, 7.1 Hz, 1H), 3.51 – 3.40 (m, 2H), 3.36 (dd, *J* = 9.1, 7.0 Hz, 1H), 2.43 (s, 3H), 2.34 (s, 3H), 1.01 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.58, 139.00, 137.45, 135.04, 129.99, 129.65, 128.26, 126.76, 82.14, 64.52, 62.66, 21.71, 21.29, 14.39. HRMS (ESI) calcd for [M+ Na^+]: C18H22O3S2Na 373.0908, found 373.0901.

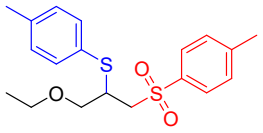


(1-methoxy-3-tosylpropan-2-yl)(p-tolyl)sulfane (3b). Colorless liquid; Yield: 86%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.69 (d, *J* = 8.3 Hz, 2H), 7.30



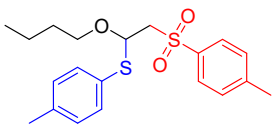
(d, *J* = 8.2 Hz, 2H), 7.17 (s, 2H), 7.04 (d, *J* = 7.8 Hz, 2H), 3.72 (dd, *J* = 9.9, 4.5 Hz, 1H), 3.63 – 3.55 (m, 3H), 3.32 (s, 3H), 3.20 (d, *J* = 13.0 Hz, 1H), 2.45 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.83, 138.27, 136.65, 133.22, 130.06, 129.96, 129.04, 128.12, 72.56, 59.10, 56.85, 43.05, 21.74, 21.23. HRMS (ESI) calcd for [M+Na$^+$]: C18H22O3S2Na 373.0908, found 373.0901.

(1-ethoxy-3-tosylpropan-2-yl)(p-tolyl)sulfane (3c). Colorless liquid; Yield: 85%; ^{1}H



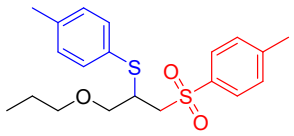
NMR (600 MHz, Chloroform-*d*) δ 7.69 (dd, *J* = 8.2, 1.9 Hz, 2H), 7.29 (d, *J* = 7.8 Hz, 2H), 7.17 (dd, *J* = 8.0, 1.8 Hz, 2H), 7.03 (d, *J* = 7.7 Hz, 2H), 3.73 (dd, *J* = 4.8, 1.6 Hz, 1H), 3.67 – 3.59 (m, 2H), 3.55 (s, 1H), 3.50 – 3.41 (m, 2H), 3.22 (d, *J* = 4.1 Hz, 1H), 2.44 (d, *J* = 1.8 Hz, 3H), 2.31 (d, *J* = 1.8 Hz, 3H), 1.20 – 1.12 (m, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.78, 138.12, 136.53, 133.10, 129.98, 129.90, 129.12, 128.08, 70.44, 66.72, 56.84, 43.10, 21.71, 21.20, 15.03. HRMS (ESI) calcd for [M+Na$^+$]: C19H24O3S2Na 387.1065, found 387.1061.

(1-butoxy-2-tosylethyl)(p-tolyl)sulfane (3d). Colorless liquid; Yield: 88%; ^{1}H NMR



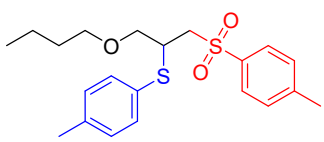
(600 MHz, Chloroform-*d*) δ 7.76 – 7.65 (m, 2H), 7.36 – 7.21 (m, 4H), 7.10 (d, *J* = 7.7 Hz, 2H), 5.04 (ddd, *J* = 9.1, 2.9, 1.3 Hz, 1H), 3.88 (dtd, *J* = 8.4, 6.9, 1.3 Hz, 1H), 3.51 – 3.42 (m, 2H), 3.28 (dtd, *J* = 7.8, 6.4, 1.3 Hz, 1H), 2.43 (s, 3H), 2.33 (s, 3H), 1.41 – 1.29 (m, 2H), 1.29 – 1.17 (m, 2H), 0.86 (td, *J* = 7.3, 1.3 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.48, 138.87, 137.43, 134.88, 129.91, 129.62, 128.11, 126.84, 82.32, 68.95, 62.54, 31.09, 21.62, 21.22, 19.25, 13.93. HRMS (ESI) calcd for [M+Na$^+$]: C20H26O3S2Na 401.1221, found 401.1218.

(1-propoxy-3-tosylpropan-2-yl)(p-tolyl)sulfane (3e). Colorless liquid; Yield: 86%; ^{1}H



NMR (400 MHz, Chloroform-*d*) δ 7.70 (d, *J* = 8.3 Hz, 2H), 7.28 (dd, *J* = 12.5, 8.1 Hz, 4H), 7.09 (d, *J* = 7.9 Hz, 2H), 5.03 (dd, *J* = 8.7, 3.3 Hz, 1H), 3.93 – 3.82 (m, 1H), 3.54 – 3.39 (m, 2H), 3.28 (d, *J* = 9.1 Hz, 1H), 2.42 (s, 3H), 2.33 (s, 3H), 1.41 – 1.28 (m, 2H), 1.28 – 1.15 (m, 2H), 0.85 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.51, 138.91, 137.44, 134.91, 129.94, 129.65, 128.14, 126.84, 82.33, 68.98, 62.56, 31.11, 21.65, 21.25, 19.28, 13.95. HRMS (ESI) calcd for [M+Na$^+$]: C20H26O3S2 Na 417.1534 found 417.1530.

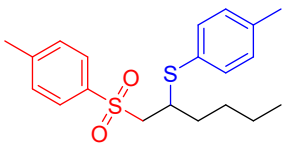
(1-butoxy-3-tosylpropan-2-yl)(p-tolyl)sulfane (3f). Colorless liquid; Yield: 87%; ^{1}H



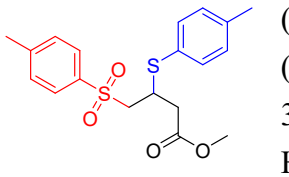
NMR (400 MHz, Chloroform-*d*) δ 7.75 – 7.66 (m, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.22 – 7.14 (m, 2H), 7.04 (d, *J* = 7.9 Hz, 2H), 3.72 (s, 1H), 3.63 (dd, *J* = 9.5, 4.7 Hz, 2H), 3.55 (dq, *J* = 8.7, 4.4 Hz, 1H), 3.43 – 3.33 (m, 2H), 3.22 (d, *J* = 3.9 Hz, 1H),

2.45 (s, 3H), 2.32 (s, 3H), 1.56 – 1.45 (m, 2H), 1.34 (d, *J* = 7.6 Hz, 2H), 0.91 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.78, 138.13, 136.67, 133.12, 130.02, 129.94, 129.28, 128.14, 71.22, 70.75, 56.91, 43.21, 31.65, 21.75, 21.24, 19.39, 14.02. HRMS (ESI) calcd for [M+Na$^+$]: $C_{21}H_{28}O_3S_2$ Na 415.1378 found 415.1376.

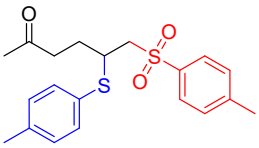
p-tolyl(1-tosylhexan-2-yl)sulfane (3g). Colorless liquid; Yield: 86%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.65 (d, *J* = 8.2 Hz, 2H), 7.29 (d, *J* = 7.9 Hz, 2H), 7.11 (d, *J* = 8.1 Hz, 2H), 7.02 (d, *J* = 7.9 Hz, 2H), 3.40 – 3.29 (m, 2H), 3.27 – 3.21 (m, 1H), 2.45 (s, 3H), 2.32 (s, 3H), 2.07 – 1.99 (m, 1H), 1.63 – 1.54 (m, 2H), 1.44 (dq, *J* = 7.1, 2.6 Hz, 1H), 1.38 – 1.27 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.76, 137.96, 136.60, 133.04, 130.00, 129.95, 129.37, 128.07, 60.74, 43.29, 33.05, 28.74, 22.40, 21.73, 21.22, 14.03. HRMS (ESI) calcd for [M+Na$^+$]: C20H26O2S2Na 385.1272 found 385.1270.



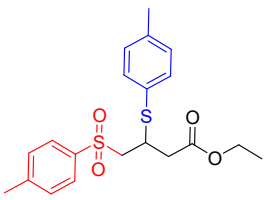
methyl 3-(p-tolylthio)-4-tosylbutanoate (3h). Colorless liquid; Yield: 80%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.69 (d, *J* = 8.3 Hz, 2H), 7.35 – 7.29 (m, 2H), 7.17 (d, *J* = 8.1 Hz, 2H), 7.09 – 7.02 (m, 2H), 3.73 (s, 3H), 3.71 – 3.63 (m, 1H), 3.42 – 3.33 (m, 2H), 3.16 (dd, *J* = 16.5, 4.0 Hz, 1H), 2.67 (dd, *J* = 16.5, 9.0 Hz, 1H), 2.46 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 171.08, 145.07, 138.84, 136.00, 134.01, 130.14, 130.08, 128.23, 128.16, 59.65, 52.06, 39.42, 38.09, 21.79, 21.28. HRMS (ESI) calcd for [M+Na$^+$]: C19H22O4S2Na found 401.0857 found 401.0853.



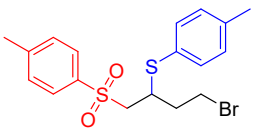
5-(p-tolylthio)-6-tosylhexan-2-one (3i)[2]. Colorless liquid; Yield: 84%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.69 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 7.09 (d, *J* = 8.2 Hz, 2H), 7.02 (d, *J* = 7.9 Hz, 2H), 3.43 – 3.32 (m, 2H), 3.20 (dd, *J* = 14.6, 9.8 Hz, 1H), 2.73 (td, *J* = 8.6, 6.4 Hz, 2H), 2.45 (s, 3H), 2.42 – 2.35 (m, 1H), 2.32 (s, 3H), 2.16 (s, 3H), 1.79 (td, *J* = 14.9, 9.6 Hz, 1H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 207.53, 144.91, 138.36, 136.34, 133.26, 130.13, 130.02, 128.64, 128.22, 60.97, 42.63, 40.58, 30.10, 27.46, 21.78, 21.25.



ethyl 3-(p-tolylthio)-4-tosylbutanoate (3j)[2]. Colorless liquid; Yield: 84%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.71 – 7.65 (m, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.18 – 7.13 (m, 2H), 7.03 (d, *J* = 7.9 Hz, 2H), 4.18 (q, *J* = 7.1 Hz, 2H), 3.72 – 3.59 (m, 1H), 3.45 – 3.31 (m, 2H), 3.14 (dd, *J* = 16.5, 4.1 Hz, 1H), 2.64 (dd, *J* = 16.5, 9.0 Hz, 1H), 2.45 (s, 3H), 2.32 (s, 3H), 1.28 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 170.57, 145.03, 138.76, 135.91, 133.97, 130.08, 130.04, 128.20, 128.14, 61.00, 59.62, 39.45, 38.24, 21.76, 21.25, 14.30.

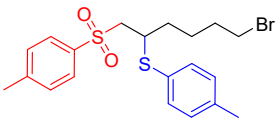


(4-bromo-1-tosylbutan-2-yl)(p-tolyl)sulfane (3k)[3, 4]. Colorless liquid; Yield: 86%; ^{1}H



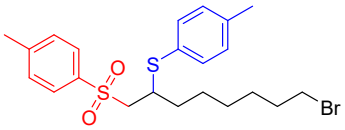
NMR (400 MHz, Chloroform-*d*) δ 7.67 (d, *J* = 8.4 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 7.10 (d, *J* = 8.1 Hz, 2H), 7.02 (d, *J* = 8.0 Hz, 2H), 3.71 (dt, *J* = 10.0, 5.0 Hz, 1H), 3.64 (dd, *J* = 6.3, 4.0 Hz, 1H), 3.50 – 3.36 (m, 2H), 3.27 – 3.16 (m, 1H), 2.77 – 2.66 (m, 1H), 2.46 (s, 3H), 2.33 (s, 3H), 2.05 – 1.93 (m, 1H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.99, 138.68, 135.78, 133.80, 130.19, 130.03, 128.34, 127.99, 60.77, 42.36, 35.60, 30.50, 21.80, 21.29.

(6-bromo-1-tosylhexan-2-yl)(p-tolyl)sulfane (3l). Colorless liquid; Yield: 88%; ^{1}H



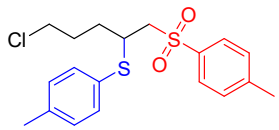
NMR (400 MHz, Chloroform-*d*) δ 7.65 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 7.13 (d, *J* = 8.1 Hz, 2H), 7.04 (d, *J* = 8.0 Hz, 2H), 3.46 – 3.31 (m, 4H), 3.22 (dd, *J* = 14.6, 10.3 Hz, 1H), 2.46 (s, 3H), 2.33 (s, 3H), 2.11 – 2.04 (m, 1H), 1.87 (d, *J* = 6.1 Hz, 2H), 1.67 – 1.56 (m, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.93, 138.28, 136.56, 133.28, 130.12, 130.07, 129.00, 128.09, 60.72, 43.16, 33.44, 32.37, 32.35, 25.27, 21.79, 21.27. HRMS (ESI) calcd for [M+Na$^+$]: C20H25BrO2S2Na 463.0377 found 463.0375.

(8-bromo-1-tosyloctan-2-yl)(p-tolyl)sulfane (3m). Colorless liquid; Yield: 85%; ^{1}H



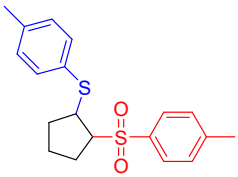
NMR (400 MHz, Chloroform-*d*) δ 7.65 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 7.11 (d, *J* = 8.2 Hz, 2H), 7.03 (d, *J* = 8.0 Hz, 2H), 3.45 – 3.28 (m, 4H), 3.24 (d, *J* = 9.8 Hz, 1H), 2.45 (s, 3H), 2.32 (s, 3H), 2.04 (d, *J* = 5.7 Hz, 1H), 1.90 – 1.80 (m, 2H), 1.66 – 1.57 (m, 2H), 1.44 (ddd, *J* = 9.6, 5.6, 2.4 Hz, 3H), 1.33 (dd, *J* = 7.9, 6.1 Hz, 2H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.81, 138.05, 136.59, 133.04, 130.03, 129.98, 129.26, 128.04, 60.69, 43.24, 33.94, 33.19, 32.78, 28.40, 28.05, 26.36, 21.75, 21.23. HRMS (ESI) calcd for [M+Na$^+$]: C22H29BrO2S2Na 491.0690 found 491.0688.

(5-chloro-1-tosylpentan-2-yl)(p-tolyl)sulfane (3n). Colorless liquid; Yield: 87%; ^{1}H



NMR (600 MHz, Chloroform-*d*) δ 7.67 (d, *J* = 8.3 Hz, 2H), 7.34 – 7.29 (m, 2H), 7.14 (d, *J* = 8.1 Hz, 2H), 7.05 (d, *J* = 7.9 Hz, 2H), 3.62 – 3.48 (m, 2H), 3.45 – 3.34 (m, 2H), 3.21 (dd, *J* = 14.9, 10.3 Hz, 1H), 2.45 (s, 3H), 2.33 (s, 3H), 2.20 (ddd, *J* = 13.8, 5.5, 3.4 Hz, 1H), 2.16 – 2.07 (m, 1H), 2.01 – 1.91 (m, 1H), 1.71 (d, *J* = 9.8 Hz, 1H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.97, 138.43, 136.52, 133.40, 130.15, 130.08, 128.71, 128.11, 60.80, 44.48, 42.84, 30.81, 29.83, 21.77, 21.26. HRMS (ESI) calcd for [M+Na$^+$]: C19H23ClO2S2Na 405.0726 found 405.0724.

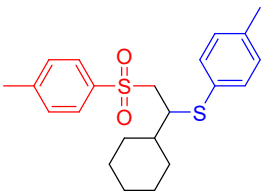
p-tolyl(2-tosylcyclopentyl)sulfane (3o)[3, 4]. Colorless liquid; Yield: 84%; ^{1}H NMR (400



MHz, Chloroform-*d*) δ 7.65 (d, *J* = 8.3 Hz, 2H), 7.27 (d, *J* = 8.2 Hz,

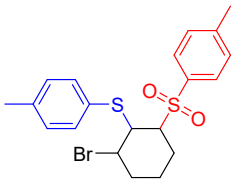
2H), 7.09 (d, *J* = 8.1 Hz, 2H), 7.00 (d, *J* = 7.9 Hz, 2H), 3.84 (dt, *J* = 6.7, 3.1 Hz, 1H), 3.42 (ddd, *J* = 8.4, 4.9, 3.0 Hz, 1H), 2.45 (s, 3H), 2.32 (s, 3H), 2.30 – 2.09 (m, 3H), 1.94 – 1.82 (m, 2H), 1.80 – 1.71 (m, 1H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.60, 137.86, 135.47, 132.99, 130.32, 129.88, 129.87, 128.66, 69.78, 48.56, 33.54, 26.12, 24.66, 21.77, 21.26.

(1-cyclohexyl-2-tosylethyl)(p-tolyl)sulfane (3p). Colorless liquid; Yield: 86%; ^{1}H



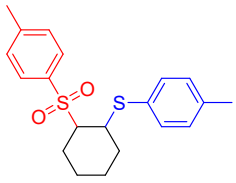
NMR (400 MHz, Chloroform-*d*) δ 7.77 (d, *J* = 8.3 Hz, 1H), 7.63 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 1H), 7.26 (d, *J* = 3.2 Hz, 1H), 7.12 (d, *J* = 8.1 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.50 (dd, *J* = 14.5, 8.9 Hz, 1H), 3.40 – 3.34 (m, 1H), 3.27 – 3.20 (m, 1H), 3.07 (d, *J* = 16.6 Hz, 2H), 2.45 (s, 2H), 2.44 (s, 3H), 2.32 (s, 3H), 2.05 – 1.94 (m, 1H), 1.65 (d, *J* = 2.2 Hz, 7H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.65, 137.50, 136.72, 136.52, 132.42, 130.81, 129.89, 128.08, 58.43, 54.61, 50.46, 40.37, 36.78, 32.92, 29.85, 27.77, 21.74, 21.22. HRMS (ESI) calcd for [M+Na^{+}]: C21H26O2S2Na 397.1272 found 397.1270.

(2-bromo-6-tosylcyclohexyl)(p-tolyl)sulfane (3q). Colorless liquid; Yield: 82%; ^{1}H



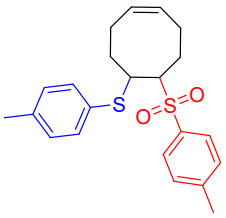
NMR (400 MHz, Chloroform-*d*) δ 7.65 (d, *J* = 8.3 Hz, 2H), 7.34 – 7.28 (m, 2H), 7.13 (d, *J* = 8.1 Hz, 2H), 7.04 (d, *J* = 8.0 Hz, 2H), 3.45 – 3.31 (m, 4H), 3.29 – 3.18 (m, 1H), 2.46 (s, 3H), 2.33 (s, 3H), 2.07 (ddd, *J* = 10.0, 8.2, 3.4 Hz, 1H), 1.87 (ddd, *J* = 6.9, 2.6, 1.1 Hz, 1H), 1.64 – 1.59 (m, 1H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.94, 138.28, 136.56, 133.28, 130.12, 130.08, 128.99, 128.09, 60.71, 43.16, 33.45, 32.37, 32.34, 25.27, 21.79, 21.27. HRMS (ESI) calcd for [M+Na^{+}]: C22H29BrO2S2Na 438.0323 found 438.0321.

p-tolyl(2-tosylcyclohexyl)sulfane (3r)[2]. Colorless liquid; Yield: 84%; ^{1}H NMR (600



MHz, Chloroform-*d*) δ 7.61 (d, *J* = 8.2 Hz, 2H), 7.28 – 7.26 (m, 2H), 7.05 (d, *J* = 8.1 Hz, 2H), 6.98 (d, *J* = 7.9 Hz, 2H), 3.72 (d, *J* = 3.8 Hz, 1H), 3.09 – 3.04 (m, 1H), 2.45 (s, 3H), 2.43 – 2.37 (m, 1H), 2.32 (s, 3H), 2.19 – 2.10 (m, 1H), 2.05 (dd, *J* = 15.0, 3.9 Hz, 1H), 1.97 – 1.89 (m, 1H), 1.77 (dd, *J* = 14.2, 4.1 Hz, 1H), 1.64 (dd, *J* = 10.7, 2.6 Hz, 1H), 1.57 (dq, *J* = 16.5, 4.3 Hz, 2H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.49, 137.59, 135.53, 132.31, 130.38, 129.97, 129.79, 128.68, 62.85, 43.30, 27.80, 21.75, 21.68, 21.42, 21.23, 21.08.

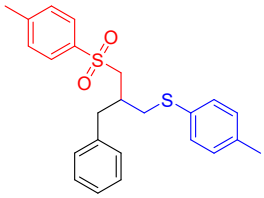
(Z)-p-tolyl(8-tosylcyclooct-4-en-1-yl)sulfane (3s). Colorless liquid; Yield: 79%; ^{1}H



NMR (400 MHz, Chloroform-*d*) δ 7.76 (d, *J* = 8.2 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 7.28 – 7.23 (m, 2H), 7.08 (d, *J* = 7.8 Hz, 2H), 3.18 (d, *J* = 4.8 Hz, 1H), 3.05 (d, *J* = 7.5 Hz, 1H), 3.02 – 2.92 (m, 1H),

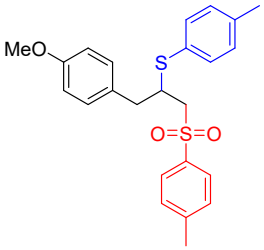
2.54 (d, J = 9.4 Hz, 1H), 2.44 (s, 3H), 2.31 (s, 3H), 2.10 – 2.01 (m, 1H), 1.97 (t, J = 6.8 Hz, 3H), 1.92 – 1.83 (m, 1H), 1.66 – 1.58 (m, 1H), 1.35 – 1.13 (m, 2H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.63, 137.08, 135.93, 132.20, 131.84, 129.92, 129.76, 128.70, 71.79, 53.63, 51.19, 44.20, 32.83, 31.76, 31.20, 29.00, 21.72, 21.15. HRMS (ESI) calcd for [M+Na$^+$]: C22H26O2S2Na 409.1272 found 409.1270.

(2-benzyl-3-tosylpropyl)(p-tolyl)sulfane (3t)[3]. Colorless liquid; Yield: 85%; ^{1}H NMR



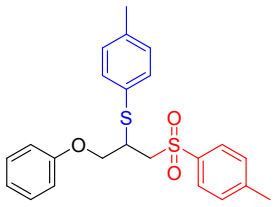
(400 MHz, Chloroform-*d*) δ 7.66 (d, J = 8.3 Hz, 2H), 7.34 – 7.23 (m, 7H), 7.09 – 6.96 (m, 4H), 3.61 (tt, J = 8.5, 4.4 Hz, 1H), 3.40 – 3.24 (m, 3H), 2.96 (dd, J = 14.3, 8.4 Hz, 1H), 2.45 (s, 3H), 2.32 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.85, 138.03, 137.69, 136.48, 132.95, 130.04, 130.02, 129.78, 129.41, 128.55, 128.14, 127.00, 59.44, 44.52, 39.59, 21.78, 21.25.

(1-(4-methoxyphenyl)-3-tosylpropan-2-yl)(p-tolyl)sulfane (3u). Colorless liquid;



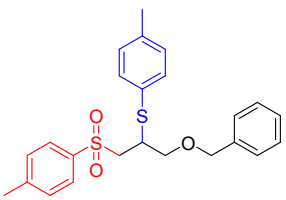
Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.66 (d, J = 8.3 Hz, 2H), 7.31 – 7.26 (m, 2H), 7.18 (d, J = 8.6 Hz, 2H), 7.05 (d, J = 8.2 Hz, 2H), 7.00 (d, J = 8.0 Hz, 2H), 6.85 (d, J = 8.6 Hz, 2H), 3.80 (s, 3H), 3.61 – 3.53 (m, 1H), 3.36 – 3.21 (m, 3H), 2.93 (dd, J = 14.4, 8.1 Hz, 1H), 2.45 (s, 3H), 2.31 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 193.64, 162.24, 158.55, 152.64, 144.69, 137.82, 132.72, 130.70, 129.89, 129.87, 127.99, 114.60, 113.83, 59.11, 55.23, 44.59, 38.51, 21.64, 21.10. HRMS (ESI) calcd for [M+Na$^+$]: C24H26O3S2 Na 449.1221 found 449.1217.

(1-phenoxy-3-tosylpropan-2-yl)(p-tolyl)sulfane (3v)[3]. Colorless liquid; Yield: 84%;



^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.73 (d, J = 8.3 Hz, 2H), 7.28 (ddd, J = 10.3, 7.1, 2.1 Hz, 6H), 7.09 (d, J = 7.9 Hz, 2H), 6.98 (s, 1H), 6.86 – 6.82 (m, 2H), 4.27 (dd, J = 10.0, 4.6 Hz, 1H), 4.22 – 4.17 (m, 1H), 3.79 – 3.73 (m, 2H), 3.38 (d, J = 10.2 Hz, 1H), 2.43 (s, 3H), 2.36 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 158.18, 144.98, 138.66, 136.37, 133.68, 130.18, 130.02, 129.55, 128.59, 128.09, 121.46, 114.84, 67.99, 56.94, 42.84, 21.78, 21.30.

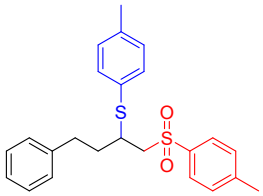
(1-(benzyloxy)-3-tosylpropan-2-yl)(p-tolyl)sulfane (3w). Colorless liquid; Yield:



86%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.68 (d, J = 8.3 Hz, 2H), 7.31 (dt, J = 15.6, 7.0 Hz, 7H), 7.16 (d, J = 8.2 Hz, 2H), 7.03 (d, J = 8.0 Hz, 2H), 4.57 – 4.44 (m, 2H), 3.80 (dd, J = 10.0, 4.6 Hz, 1H), 3.74 – 3.55 (m, 3H), 3.23 (dd, J = 13.9, 3.5 Hz, 1H), 2.44 (s, 3H), 2.32 (s, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.83, 138.24, 137.90, 136.63, 133.23, 130.06, 129.98, 129.18, 128.54, 128.17, 127.88,

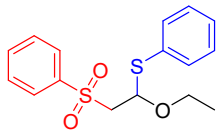
127.87, 73.33, 70.28, 57.03, 43.28, 21.78, 21.26. HRMS (ESI) calcd for [M+Na$^+$]: C24H26O3S2 Na 449.1221 found 449.1217.

(4-phenyl-1-tosylbutan-2-yl)(p-tolyl)sulfane (3x)[3, 4]. Colorless liquid; Yield: 86%; ^{1}H



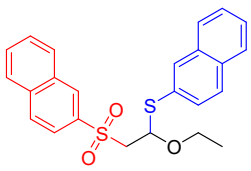
NMR (400 MHz, Chloroform-*d*) δ 7.37 (d, *J* = 8.3 Hz, 2H), 7.32 (t, *J* = 7.1 Hz, 2H), 7.28 – 7.21 (m, 3H), 7.15 (d, *J* = 8.0 Hz, 2H), 7.01 – 6.92 (m, 4H), 3.34 – 3.18 (m, 2H), 3.14 (s, 1H), 2.97 – 2.88 (m, 1H), 2.86 – 2.76 (m, 1H), 2.48 (ddp, *J* = 14.4, 6.1, 3.0 Hz, 1H), 2.42 (s, 3H), 2.30 (s, 3H), 1.84 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.56, 140.95, 138.01, 135.80, 133.04, 129.99, 129.84, 128.97, 128.92, 128.57, 128.13, 126.21, 60.70, 42.31, 34.49, 32.61, 21.71, 21.20.

(1-ethoxy-2-(phenylsulfonyl)ethyl)(phenyl)sulfane(4a). Colorless liquid; Yield: 84%;



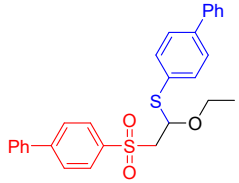
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.76 – 7.65 (m, 4H), 7.50 – 7.42 (m, 2H), 7.27 (dd, *J* = 8.5, 6.5 Hz, 2H), 5.13 (dd, *J* = 9.3, 2.9 Hz, 1H), 3.97 (s, 1H), 3.62 – 3.32 (m, 3H), 1.05 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 140.23, 134.67, 133.60, 130.48, 129.16, 129.01, 128.71, 128.10, 81.98, 64.46, 62.43, 14.30. HRMS (ESI) calcd for [M+Na$^+$]: C16H18O3S2Na 345.0595 found 345.0592.

(1-ethoxy-2-(naphthalen-2-ylsulfonyl)ethyl)(naphthalen-2-yl)sulfane (4b).



Colorless liquid; Yield: 80%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.41 (d, *J* = 1.8 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 3H), 7.85 (d, *J* = 1.8 Hz, 1H), 7.78 (d, *J* = 1.9 Hz, 2H), 7.72 (d, *J* = 8.3 Hz, 2H), 7.63 (dddd, *J* = 21.8, 8.1, 6.9, 1.4 Hz, 2H), 7.52 – 7.46 (m, 2H), 7.42 (dd, *J* = 8.5, 1.8 Hz, 1H), 5.28 (dd, *J* = 9.2, 2.9 Hz, 1H), 3.99 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.72 – 3.55 (m, 2H), 3.44 (dd, *J* = 9.1, 7.0 Hz, 1H), 0.95 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 137.15, 135.36, 134.19, 133.55, 133.00, 132.14, 131.31, 129.96, 129.45, 129.30, 129.26, 128.76, 128.04, 127.90, 127.80, 127.78, 127.70, 126.92, 126.76, 123.03, 82.22, 64.67, 62.64, 14.34. HRMS (ESI) calcd for [M+Na$^+$]: C24H22O3S2Na 445.0908 found 445.0904.

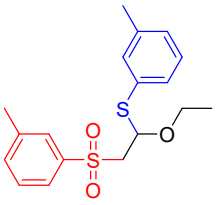
[1,1'-biphenyl]-4-yl(2-([1,1'-biphenyl]-4-ylsulfonyl)-1-ethoxyethyl)sulfane (4c).



Colorless liquid; Yield: 81%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 (d, *J* = 8.4 Hz, 2H), 7.73 (d, *J* = 8.5 Hz, 2H), 7.63 – 7.56 (m, 4H), 7.54 (d, *J* = 8.3 Hz, 2H), 7.52 – 7.43 (m, 7H), 7.39 (d, *J* = 7.3 Hz, 1H), 5.22 (dd, *J* = 7.7, 4.4 Hz, 1H), 4.02 (dd, *J* = 9.2, 7.1 Hz, 1H), 3.67 – 3.60 (m, 2H), 3.46 (dd, *J* = 9.2, 7.0 Hz, 1H), 1.07 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 146.59, 141.59, 140.06, 139.23, 138.75, 135.05, 129.38, 129.16, 128.97, 128.71, 127.83, 127.80, 127.63, 127.42, 127.09, 82.13, 64.60,

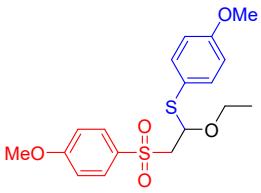
62.64, 14.40. HRMS (ESI) calcd for [M+Na$^+$]: C28H26O3S2Na 497.1221 found 497.1217.

(1-ethoxy-2-(m-tolylsulfonyl)ethyl)(m-tolyl)sulfane (4d). Colorless liquid; Yield: 82%;



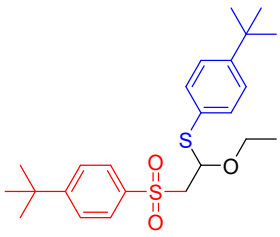
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.66 – 7.61 (m, 2H), 7.44 – 7.35 (m, 2H), 7.21 – 7.15 (m, 3H), 7.12 (s, 1H), 5.10 (dd, *J* = 6.9, 5.2 Hz, 1H), 3.93 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.55 – 3.49 (m, 2H), 3.37 (dd, *J* = 9.1, 7.0 Hz, 1H), 2.41 (s, 3H), 2.31 (s, 3H), 1.00 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 140.09, 139.17, 138.93, 135.21, 134.35, 131.60, 130.27, 129.50, 128.94, 128.87, 128.46, 125.27, 82.09, 64.46, 62.47, 21.33, 21.32, 14.28. HRMS (ESI) calcd for [M+Na$^+$]: C18H22O3S2Na 373.0908 found 373.0905.

(1-ethoxy-2-((4-methoxyphenyl)sulfonyl)ethyl)(4-methoxyphenyl)sulfane (4e).



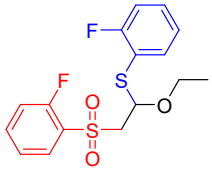
Colorless liquid; Yield: 86%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.74 (d, *J* = 8.9 Hz, 2H), 7.29 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.9 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 4.99 (dd, *J* = 9.6, 2.5 Hz, 1H), 3.94 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.85 (d, *J* = 0.8 Hz, 3H), 3.79 (d, *J* = 0.8 Hz, 3H), 3.51 – 3.31 (m, 3H), 1.04 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 163.76, 160.46, 137.10, 131.91, 130.41, 120.48, 114.77, 114.21, 82.15, 64.44, 62.79, 55.77, 55.44, 14.48. HRMS (ESI) calcd for [M+Na$^+$]: C18H22O5S2 Na 405.0806 found 405.0804.

(4-(tert-butyl)phenyl)(2-((4-(tert-butyl)phenyl)sulfonyl)-1-ethoxyethyl)sulfane (4f).



Colorless liquid; Yield: 84%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.76 (d, *J* = 8.6 Hz, 2H), 7.53 (d, *J* = 8.6 Hz, 2H), 7.31 (s, 4H), 5.07 (dd, *J* = 8.6, 3.3 Hz, 1H), 3.93 (dd, *J* = 9.0, 7.1 Hz, 1H), 3.57 – 3.47 (m, 2H), 3.32 (dd, *J* = 9.0, 7.0 Hz, 1H), 1.34 (s, 9H), 1.31 (s, 9H), 0.97 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 157.58, 152.03, 137.27, 134.59, 128.06, 126.99, 126.28, 126.05, 82.21, 64.44, 62.68, 35.33, 34.75, 31.33, 31.18, 14.35. HRMS (ESI) calcd for [M+Na$^+$]: $C_{24}H_{34}O_3S_2Na$ 457.1847 found 457.1844.

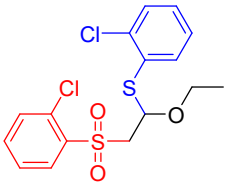
(1-ethoxy-2-((2-fluorophenyl)sulfonyl)ethyl)(2-fluorophenyl)sulfane (4g). Colorless



liquid; Yield: 81%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.89 – 7.86 (m, 1H), 7.64 – 7.60 (m, 1H), 7.47 – 7.44 (m, 1H), 7.40 – 7.37 (m, 1H), 7.32 – 7.28 (m, 1H), 7.19 – 7.16 (m, 1H), 7.14 – 7.12 (m, 2H), 5.10 (d, *J* = 9.3 Hz, 1H), 3.92 – 3.87 (m, 1H), 3.87 – 3.81 (m, 1H), 3.70 (dd, *J* = 14.9, 2.2 Hz, 1H), 3.26 – 3.21 (m, 1H), 0.78 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 163.18 (d, *J* = 247.4 Hz), 159.64 (d, *J* = 255.4 Hz), 137.63, 135.90 (d, *J* = 8.5 Hz), 131.54 (d, *J* = 8.2 Hz), 129.86, 128.60, 128.45, 124.79 (d, *J* = 3.9

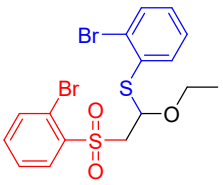
Hz), 124.47 (d, J = 3.8 Hz), 117.36, 117.05 (d, J = 21.5 Hz), 116.34 (d, J = 23.4 Hz), 82.26, 64.88, 61.85, 14.02. HRMS (ESI) calcd for [M+Na$^+$]: C16H16F2O3S2Na 381.0407 found 381.0405.

(2-chlorophenyl)(2-((2-chlorophenyl)sulfonyl)-1-ethoxyethyl)sulfane (4h).



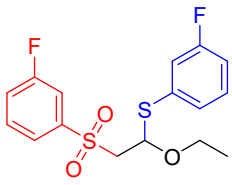
Colorless liquid; Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.06 (dd, J = 7.9, 1.6 Hz, 1H), 7.57 – 7.47 (m, 3H), 7.44 (dd, J = 7.8, 1.6 Hz, 2H), 7.31 – 7.18 (m, 2H), 5.18 (dd, J = 10.4, 2.2 Hz, 1H), 4.15 (dd, J = 14.9, 10.4 Hz, 1H), 3.85 (dd, J = 9.1, 7.1 Hz, 1H), 3.73 (dd, J = 14.8, 2.2 Hz, 1H), 3.24 (dd, J = 9.1, 7.0 Hz, 1H), 0.80 (t, J = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 138.24, 138.21, 136.11, 134.55, 132.79, 131.81, 131.08, 130.59, 130.43, 130.00, 127.47, 127.20, 82.62, 64.90, 59.97, 14.17. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Cl2O3S2Na 412.9816 found 412.9814.

(2-bromophenyl)(2-((2-bromophenyl)sulfonyl)-1-ethoxyethyl)sulfane(4i). Colorless



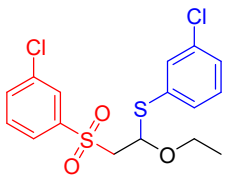
liquid; Yield: 85%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.09 (dd, J = 7.7, 2.0 Hz, 1H), 7.68 (dd, J = 7.6, 1.5 Hz, 1H), 7.60 (dd, J = 8.0, 1.5 Hz, 1H), 7.53 (dd, J = 7.8, 1.7 Hz, 1H), 7.44 (ddd, J = 11.5, 7.5, 1.7 Hz, 2H), 7.31 – 7.21 (m, 1H), 7.17 (dd, J = 7.9, 1.7 Hz, 1H), 5.19 (dd, J = 10.4, 2.2 Hz, 1H), 4.23 (dd, J = 14.9, 10.4 Hz, 1H), 3.83 (dd, J = 9.1, 7.1 Hz, 1H), 3.73 (dd, J = 14.8, 2.2 Hz, 1H), 3.25 (dd, J = 9.1, 7.0 Hz, 1H), 0.80 (t, J = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 139.64, 135.55, 135.21, 134.48, 133.58, 132.70, 131.34, 129.86, 128.75, 128.06, 127.72, 120.80, 82.57, 64.75, 59.22, 14.11. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Br2O3S2Na 477.8908 found 477.8905.

(1-ethoxy-2-((3-fluorophenyl)sulfonyl)ethyl)(3-fluorophenyl)sulfane (4j). Colorless



liquid; Yield: 86%;^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.64 – 7.62 (m, 1H), 7.56 – 7.50 (m, 2H), 7.35 – 7.27 (m, 2H), 7.18 – 7.16 (m, 1H), 7.12 – 7.09 (m, 1H), 7.05 – 7.02 (m, 1H), 5.16 (dd, J = 7.8, 4.4 Hz, 1H), 3.97 – 3.92 (m, 1H), 3.54 – 3.53 (m, 1H), 3.44 – 3.39 (m, 1H), 1.03 (t, J = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 162.50 (d, $J_{C\text{-}F}$= 249.7 Hz), 162.34 (d, $J_{C\text{-}F}$ = 251.9 Hz), 142.29 (d, $J_{C\text{-}F}$ = 6.5 Hz), 132.59 (d, $J_{C\text{-}F}$ = 7.8 Hz), 130.96, 130.89, 130.51, 130.43, 129.97 (d, $J_{C\text{-}F}$ = 3.2 Hz), 123.93 (d, $J_{C\text{-}F}$ = 3.4 Hz), 121.18, 121.05, 120.96, 120.84, 115.89 (d, $J_{C\text{-}F}$ = 21.1 Hz), 115.63 (d, $J_{C\text{-}F}$ = 24.4 Hz), 81.92, 64.66, 62.28, 14.23. HRMS (ESI) calcd for [M+Na$^+$]: C16H16F2O3S2Na 381.0407 found 381.0405.

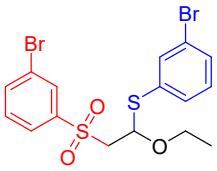
(3-chlorophenyl)(2-((3-chlorophenyl)sulfonyl)-1-ethoxyethyl)sulfane (4k). Colorless



liquid; Yield: 88%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.88 (t, J = 1.9 Hz, 1H), 7.78 – 7.75 (m, 1H), 7.66 – 7.63 (m, 1H), 7.51 (t, J = 7.9 Hz, 1H), 7.41 – 7.40 (m, 1H), 7.36 – 7.28 (m, 3H), 5.20 (dd, J = 8.5, 3.8 Hz, 1H), 4.03 – 3.95 (m, 1H), 3.63 – 3.53 (m, 2H), 3.50 – 3.42 (m, 1H), 1.09 (t, J = 7.1 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 141.82, 135.09,

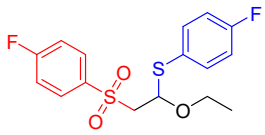
134.62, 134.00, 133.74, 132.43, 132.21, 130.34, 130.16, 128.91, 128.32, 126.19, 81.85, 64.57, 62.20, 14.16. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Cl2O3S2Na 412.9816 found 412.9814.

(3-bromophenyl)(2-((3-bromophenyl)sulfonyl)-1-ethoxyethyl)sulfane (4l). Colorless



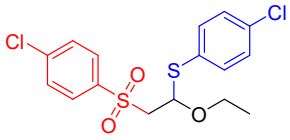
liquid; Yield: 87%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.98 (t, *J* = 1.9 Hz, 1H), 7.75 (dq, *J* = 8.1, 1.1 Hz, 2H), 7.51 (t, *J* = 1.8 Hz, 1H), 7.48 – 7.42 (m, 1H), 7.39 (t, *J* = 7.9 Hz, 1H), 7.34 – 7.29 (m, 1H), 7.18 (d, *J* = 7.9 Hz, 1H), 5.13 (dd, *J* = 8.4, 3.9 Hz, 1H), 3.93 (dd, *J* = 9.2, 7.1 Hz, 1H), 3.57 – 3.47 (m, 2H), 3.40 (dd, *J* = 9.2, 7.0 Hz, 1H), 1.04 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 142.05, 136.92, 136.75, 132.95, 132.58, 131.91, 131.24, 130.63, 130.52, 126.70, 122.96, 122.81, 81.95, 64.70, 62.31, 14.28. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Br2O3S2Na 477.8908 found 477.8905.

(1-ethoxy-2-((4-fluorophenyl)sulfonyl)ethyl)(4-fluorophenyl)sulfane (4m). Colorless



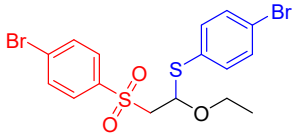
liquid; Yield: 88%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.83 (dd, *J* = 8.6, 5.2 Hz, 2H), 7.35 (dd, *J* = 8.2, 5.6 Hz, 2H), 7.18 (t, *J* = 8.7 Hz, 2H), 7.00 (t, *J* = 8.6 Hz, 2H), 5.06 (dd, *J* = 9.7, 2.4 Hz, 1H), 3.94 (p, *J* = 7.1 Hz, 1H), 3.52 – 3.35 (m, 3H), 1.01 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 165.88 (d, $J_{C\text{-}F}$ = 252.9 Hz), 163.37 (d, $J_{C\text{-}F}$ = 246.4 Hz), 137.19, 137.11, 136.40 (d, $J_{C\text{-}F}$ = 3.3 Hz), 131.11, 131.02, 125.22 (d, $J_{C\text{-}F}$ = 3.4 Hz), 116.41 (d, $J_{C\text{-}F}$ = 21.8 Hz), 81.91, 116.32 (d, $J_{C\text{-}F}$ = 22.6 Hz), 81.91, 64.52, 62.54, 14.36. HRMS (ESI) calcd for [M+Na$^+$]: C16H16F2O3S2Na 381.0407 found 381.0405.

(4-chlorophenyl)(2-((4-chlorophenyl)sulfonyl)-1-ethoxyethyl)sulfane (4n). Colorless



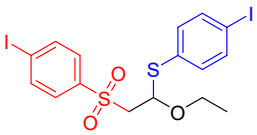
liquid; Yield: 89%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.85 – 7.79 (m, 2H), 7.61 (s, 1H), 7.51 (d, *J* = 7.7 Hz, 2H), 7.38 (dd, *J* = 7.6, 2.0 Hz, 2H), 7.29 (d, *J* = 2.0 Hz, 2H), 5.12 (dd, *J* = 8.4, 3.7 Hz, 1H), 3.92 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.59 – 3.43 (m, 2H), 3.35 (dd, *J* = 9.1, 7.0 Hz, 1H), 0.97 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 140.40, 138.76, 135.97, 135.26, 129.67, 129.40, 129.33, 128.70, 81.81, 64.58, 62.39, 14.31. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Cl2O3S2Na 412.9816 found 412.9814.

(4-bromophenyl)(2-((4-bromophenyl)sulfonyl)-1-ethoxyethyl)sulfane (4o). Colorless

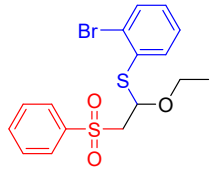


liquid; Yield: 87%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77 (d, *J* = 8.6 Hz, 2H), 7.53 – 7.47 (m, 2H), 7.30 (q, *J* = 8.7 Hz, 4H), 5.11 (d, *J* = 6.8 Hz, 1H), 3.94 (dd, *J* = 9.2, 7.1 Hz, 1H), 3.57 – 3.34 (m, 3H), 1.03 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 139.35, 136.21, 132.44, 132.41, 129.79, 129.42, 129.07, 123.51, 81.79, 64.68, 62.46, 14.38. HRMS (ESI) calcd for [M+Na$^+$]: C16H16Br2O3S2Na 477.8908 found 477.8905.

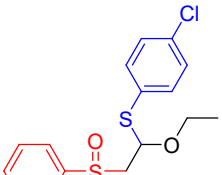
(1-ethoxy-2-((4-iodophenyl)sulfonyl)ethyl)(4-iodophenyl)sulfane (4p). Colorless liquid; Yield: 90%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.93 – 7.84 (m, 2H), 7.66 – 7.59 (m, 2H), 7.57 – 7.49 (m, 2H), 7.13 – 7.05 (m, 2H), 5.10 (dd, *J* = 9.0, 3.3 Hz, 1H), 3.92 (dd, *J* = 9.2, 7.1 Hz, 1H), 3.57 – 3.27 (m, 3H), 1.02 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 140.00, 138.39, 136.23, 130.33, 129.60, 101.61, 95.04, 81.77, 64.70, 62.43, 14.38. HRMS (ESI) calcd for [M+Na$^+$]: C16H16I2O3S2Na 596.8528 found 596.8520.



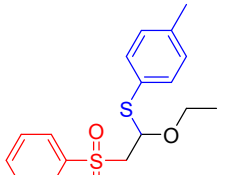
(2-bromophenyl)(1-ethoxy-2-(phenylsulfonyl)ethyl)sulfane (4q). Colorless liquid; Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.88 – 7.83 (m, 2H), 7.64 – 7.59 (m, 2H), 7.57 – 7.49 (m, 3H), 7.28 – 7.22 (m, 1H), 7.19 – 7.13 (m, 1H), 5.24 (t, *J* = 6.1 Hz, 1H), 3.89 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.64 (d, *J* = 6.1 Hz, 2H), 3.39 (dd, *J* = 9.1, 7.0 Hz, 1H), 0.97 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 140.20, 135.45, 133.61, 133.59, 132.91, 129.77, 129.20, 129.01, 128.68, 128.04, 128.02, 126.11, 82.70, 64.85, 61.94, 14.28. HRMS (ESI) calcd for [M+Na$^+$]:C16H17BrO3S2Na 422.9700 found 422.9695.



(4-chlorophenyl)(1-ethoxy-2-(phenylsulfonyl)ethyl)sulfane (4r). Colorless liquid; Yield: 83%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.86 – 7.81 (m, 2H), 7.61 (d, *J* = 7.5 Hz, 1H), 7.52 (dd, *J* = 8.5, 7.1 Hz, 2H), 7.33 – 7.23 (m, 4H), 5.11 (dd, *J* = 8.5, 3.6 Hz, 1H), 3.90 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.54 – 3.41 (m, 2H), 3.36 (dd, *J* = 9.2, 7.0 Hz, 1H), 0.98 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 140.16, 135.94, 135.16, 133.70, 129.37, 129.08, 128.89, 128.13, 81.92, 64.56, 62.35, 14.29. HRMS (ESI) calcd for [M+Na$^+$]: C16H17ClO3S2Na 379.0205 found 379.0215.

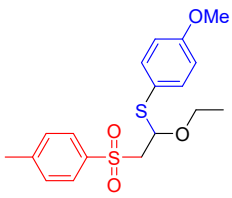


(1-ethoxy-2-(phenylsulfonyl)ethyl)(p-tolyl)sulfane (4s). Colorless liquid; Yield: 86%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.80 – 7.61 (m, 2H), 7.40 – 7.27 (m, 4H), 7.05 – 6.92 (m, 2H), 5.05 (dd, *J* = 9.4, 2.6 Hz, 1H), 3.91 (dd, *J* = 9.2, 7.1 Hz, 1H), 3.55 – 3.32 (m, 3H), 2.42 (s, 3H), 1.01 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 140.34, 139.05, 135.05, 133.60, 130.01, 129.03, 128.18, 126.63, 82.04, 64.47, 62.52, 21.29, 14.34. HRMS (ESI) calcd for [M + Na$^+$]: $C_{17}H_{20}O_3S_2Na$ 359.0752 found 359.0738.



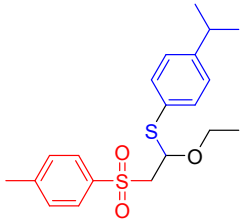
(1-ethoxy-2-tosylethyl)(phenyl)sulfane (4t). Colorless liquid; Yield: 84%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.71 (d, *J* = 7.1 Hz, 2H), 7.39 (d, *J* = 7.5 Hz, 2H), 7.33 – 7.28 (m, 4H), 5.11 (d, *J* = 11.9 Hz, 1H), 3.94 (p, *J* = 7.3 Hz, 1H), 3.56 – 3.33 (m, 3H), 2.43 (s, 3H), 1.02 (t, *J* = 7.7 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.64, 137.35, 134.73, 130.59, 129.68, 129.19, 128.71, 128.24, 82.10, 64.56, 62.60, 21.73, 14.39. HRMS (ESI) calcd for [M + Na$^+$]: $C_{17}H_{20}O_3S_2Na$ 359.0752 found 359.0750.

(1-ethoxy-2-tosylethyl)(4-methoxyphenyl)sulfane (4u). Colorless liquid; Yield: 88%;



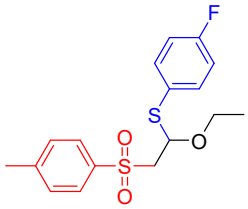
^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.73 – 7.65 (m, 2H), 7.32 – 7.27 (m, 4H), 6.84 – 6.76 (m, 2H), 4.98 (dd, *J* = 9.7, 2.4 Hz, 1H), 3.92 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.78 (d, *J* = 1.2 Hz, 3H), 3.48 (dd, *J* = 14.7, 2.4 Hz, 1H), 3.42 – 3.28 (m, 2H), 2.41 (s, 3H), 1.00 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 160.44, 144.51, 137.39, 137.02, 129.58, 128.16, 120.46, 114.73, 82.06, 64.40, 62.59, 55.38, 21.63, 14.32. HRMS (ESI) calcd for [M + Na$^+$]: C18H22O4S2Na 389.0857 found 389.0851.

(1-ethoxy-2-tosylethyl)(4-isopropylphenyl)sulfane (4v). Colorless liquid; Yield: 84%;



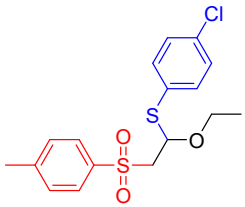
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.71 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.2 Hz, 4H), 7.15 (d, *J* = 8.1 Hz, 2H), 5.06 (dd, *J* = 8.9, 3.1 Hz, 1H), 3.94 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.58 – 3.30 (m, 3H), 2.89 (hept, *J* = 6.9 Hz, 1H), 2.43 (s, 3H), 1.24 (d, *J* = 7.0 Hz, 6H), 1.02 (t, *J* = 7.0 Hz, 4H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 149.80, 144.59, 137.38, 135.03, 129.65, 128.24, 127.38, 127.05, 82.14, 64.49, 62.65, 33.92, 23.97, 23.92, 21.70, 14.38. HRMS (ESI) calcd for [M+Na$^+$]: C20H26O3S2Na 401.1221 found 401.1217.

(1-ethoxy-2-tosylethyl)(4-fluorophenyl)sulfane (4w). Colorless liquid; Yield: 84%; ^{1}H



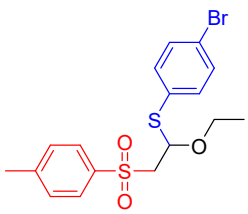
NMR (400 MHz, Chloroform-*d*) δ 7.69 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.28 (m, 4H), 6.98 (t, *J* = 8.6 Hz, 2H), 5.05 (dd, *J* = 9.4, 2.6 Hz, 1H), 3.95 – 3.87 (m, 1H), 3.49 – 3.35 (m, 3H), 2.42 (s, 3H), 1.01 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 163.30 (d, $J_{C\text{-}F}$ = 249.6 Hz), 144.68, 137.24, 137.11 (d, $J_{C\text{-}F}$ = 8.4 Hz), 129.67, 128.16, 125.37 (d, $J_{C\text{-}F}$ = 3.5 Hz), 116.31 (d, $J_{C\text{-}F}$ = 21.8 Hz), 81.96, 64.53, 62.49, 21.66, 14.32. HRMS (ESI) calcd for [M+Na$^+$]: C17H19FO3S2Na 377.0657 found 377.0655.

(4-chlorophenyl)(1-ethoxy-2-tosylethyl)sulfane (4x). Colorless liquid; Yield: 82%; ^{1}H



NMR (400 MHz, Chloroform-*d*) δ 7.70 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 8.2 Hz, 4H), 7.25 (d, *J* = 8.6 Hz, 2H), 5.09 (dd, *J* = 8.7, 3.4 Hz, 1H), 3.90 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.53 – 3.42 (m, 2H), 3.42 – 3.32 (m, 1H), 2.42 (s, 3H), 1.01 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 144.72, 137.24, 135.93, 135.12, 129.69, 129.34, 129.00, 128.19, 82.00, 64.60, 62.48, 21.69, 14.34. HRMS (ESI) calcd for [M+Na$^+$]: C17H19ClO3S2Na 393.0362 found 393.0360.

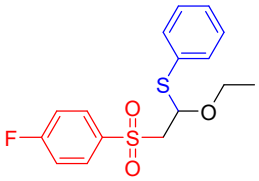
(4-bromophenyl)(1-ethoxy-2-tosylethyl)sulfane (4y). Colorless liquid; Yield: 85%; ^{1}H



NMR (400 MHz, Chloroform-*d*) δ 7.70 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.35 – 7.27 (m, 2H), 7.24 (d, *J* = 8.5 Hz, 2H), 5.10 (dd, *J* = 8.3, 3.8 Hz, 1H), 3.90 (dd, *J* = 9.1, 7.1 Hz, 1H), 3.54 – 3.33

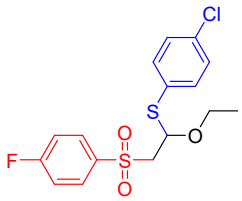
(m, 3H), 2.43 (s, 3H), 1.02 (t, J = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 144.72, 137.24, 136.09, 132.30, 129.72, 129.70, 128.20, 123.25, 81.95, 64.61, 62.48, 21.69, 14.34. HRMS (ESI) calcd for [M+Na$^+$]: C17H19BrO3S2Na 413.9959 found 413.9956.

(1-ethoxy-2-((4-fluorophenyl)sulfonyl)ethyl)(phenyl)sulfane (4z). Colorless liquid;



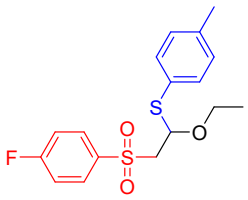
Yield: 82%; ^{1}H NMR (601 MHz, Chloroform-*d*) δ 7.83 (dd, J = 8.7, 5.1 Hz, 2H), 7.38 (d, J = 6.6 Hz, 2H), 7.33 – 7.28 (m, 3H), 7.17 (t, J = 8.5 Hz, 2H), 5.12 (dd, J = 9.6, 2.5 Hz, 1H), 3.98 – 3.93 (m, 1H), 3.55 – 3.45 (m, 2H), 3.41 – 3.36 (m, 1H), 1.02 (t, J = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 165.75 (d, $J_{C\text{-}F}$ = 256.1 Hz), 136.36 (d, $J_{C\text{-}F}$ = 3.1 Hz), 134.69, 131.02 (d, $J_{C\text{-}F}$ = 9.4 Hz), 130.30, 129.17, 128.75, 116.22 (d, $J_{C\text{-}F}$ = 22.8 Hz), 81.92, 64.42, 62.50, 14.33. HRMS (ESI) calcd for [M+Na$^+$]: C16H17FO3S2Na 363.0501 found 363.0495.

(4-chlorophenyl)(1-ethoxy-2-((4-fluorophenyl)sulfonyl)ethyl)sulfane (4aa). Colorless



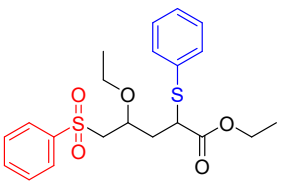
liquid; Yield: 81%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.87 – 7.83 (m, 2H), 7.33 – 7.26 (m, 4H), 7.20 (t, J = 8.6 Hz, 2H), 5.12 (dd, J = 9.4, 2.8 Hz, 1H), 3.98 – 3.90 (m, 1H), 3.55 – 3.36 (m, 3H), 1.03 (t, J = 7.1 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 165.71 (d, $J_{C\text{-}F}$ = 256.2 Hz), 136.20 (d, $J_{C\text{-}F}$ = 2.7 Hz), 135.90, 135.08, 130.97 (d, $J_{C\text{-}F}$ = 9.6 Hz), 129.28, 128.65, 116.21 (d, $J_{C\text{-}F}$ = 22.7 Hz), 81.77, 64.41, 62.34, 14.25. HRMS (ESI) calcd for [M+Na$^+$] C16H16ClFO3S2Na 397.0111 found 397.0108.

(1-ethoxy-2-((4-fluorophenyl)sulfonyl)ethyl)(p-tolyl)sulfane (4ab). Colorless liquid;



Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.85 (dd, J = 8.8, 5.1 Hz, 2H), 7.28 (d, J = 8.2 Hz, 2H), 7.19 (t, J = 8.5 Hz, 2H), 7.11 (d, J = 7.8 Hz, 2H), 5.08 (dd, J = 9.6, 2.6 Hz, 1H), 4.01 – 3.93 (m, 1H), 3.57 – 3.43 (m, 2H), 3.43 – 3.35 (m, 1H), 2.34 (s, 3H), 1.02 (t, J = 7.0 Hz, 3H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 165.73 (d, $J_{C\text{-}F}$ = 256.1 Hz), 139.04, 136.40 (d, $J_{C\text{-}F}$ = 3.2 Hz), 135.00, 131.02 (d, $J_{C\text{-}F}$ = 9.7 Hz), 129.95, 126.41, 116.18 (d, $J_{C\text{-}F}$ = 22.6 Hz), 81.92, 64.35, 62.54, 21.20, 14.32. HRMS (ESI) calcd for [M+Na$^+$]: C17H19FO3S2Na 377.0657 found 377.0655.

ethyl 4-ethoxy-5-(phenylsulfonyl)-2-(phenylthio)pentanoate (5a). Colorless liquid;



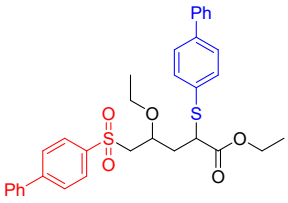
Yield: 80%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 – 7.89 (m, 2H), 7.69 – 7.64 (m, 1H), 7.60-7.54 (m, 2H), 7.44 – 7.38 (m, 2H), 7.31 – 7.29 (m, 3H), 4.65 – 4.61 (m, 1H), 4.07 – 3.94 (m, 3H), 3.70 – 3.62 (m, 1H), 3.44 – 3.36 (m, 1H), 3.23 – 3.08 (m, 2H), 2.18 – 1.96 (m, 2H), 1.20 (dt, J = 11.9, 6.5 Hz, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.56, 172.45, 139.22, 139.12, 134.47, 134.33, 133.98, 131.99, 131.89,

129.39, 129.37, 129.01, 128.95, 128.41, 128.34, 128.15, 86.32, 85.84, 64.59, 64.37, 61.43, 61.40, 57.47, 57.28, 38.84, 38.64, 38.27, 38.07, 14.76, 14.72, 14.13, 14.10. HRMS (ESI) calcd for [M+Na$^+$]: C21H26O5S2Na 445.1119 found 445.1118. *dr*=1:0.39

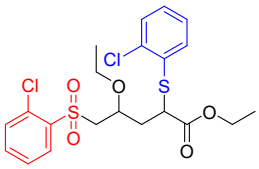
ethyl 4-ethoxy-2-(p-tolylthio)-5-tosylpentanoate (5b). Colorless liquid; Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79-7.76 (m, 2H), 7.37 – 7.25 (m, 4H), 7.12-7.08 (m, 2H), 4.58 – 4.53 (m, 1H), 4.07 – 3.95 (m, 3H), 3.68 – 3.59 (m, 1H), 3.41 – 3.34 (m, 1H), 3.19 – 3.04 (m, 2H), 2.45 (d, *J* = 3.2 Hz, 3H), 2.34 (s, 3H), 2.14 – 2.04 (m, 1H), 1.99 – 1.91 (m, 1H), 1.24 – 1.14 (m, 6H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 172.62, 172.52, 144.95, 144.93, 138.32, 138.30, 136.25, 136.10, 134.79, 134.66, 129.94, 129.92, 129.75, 129.70, 128.41, 128.33, 128.04, 127.95, 86.28, 85.82, 64.49, 64.29, 61.31, 61.29, 57.53, 57.37, 38.84, 38.62, 38.29, 38.09, 21.70, 21.23, 14.70, 14.67, 14.07, 14.05. HRMS (ESI) calcd for [M + Na$^+$]: $C_{23}H_{30}O_5S_2Na$ 473.1433 found 473.1439. *dr*=1:0.86

ethyl 5-((4-(tert-butyl)phenyl)sulfonyl)-2-((4-(tert-butyl)phenyl)thio)-4-ethoxypentanoate (5c). Colorless liquid; Yield: 73%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.82 – 7.78(m, 2H), 7.57 – 7.53 (m, 2H), 7.32 – 7.28 (m, 4H), 4.56 – 4.52 (m, 1H), 4.04 – 3.93 (m, 3H), 3.68 – 3.59 (m, 1H), 3.42 – 3.32 (m, 1H), 3.18 – 3.06 (m, 2H), 2.15 – 2.05 (m, 1H), 2.00 – 1.89 (m, 1H), 1.34 (d, *J* = 1.8 Hz, 9H), 1.30 (s, 9H), 1.20 – 1.13 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.66, 172.58, 157.93, 157.90, 151.46, 151.43, 136.16, 136.02, 134.46, 134.33, 128.32, 128.24, 128.17, 128.07, 126.37, 126.35, 126.06, 126.01, 86.26, 85.81, 64.48, 64.26, 61.30, 61.27, 57.50, 57.35, 38.93, 38.76, 38.32, 38.15, 35.38, 34.69, 31.34, 31.15, 14.77, 14.72, 14.12, 14.10. HRMS (ESI) calcd for [M+Na$^+$]: C29H42O5S2Na 557.2371 found 557.2369. *dr*=1:0.67

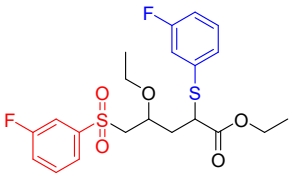
ethyl 4-ethoxy-5-(naphthalen-2-ylsulfonyl)-2-(naphthalen-2-ylthio)pentanoate (5d). Colorless liquid; Yield: 70%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.45 (s, 1H), 7.99 – 7.88 (m, 4H), 7.84 – 7.61 (m, 6H), 7.49 – 7.40 (m, 3H), 4.73 – 4.68 (m, 1H), 4.04 – 3.87 (m, 3H), 3.76 – 3.67 (m, 1H), 3.45 – 3.34 (m, 1H), 3.27 – 3.13 (m, 2H), 2.23 – 2.00 (m, 2H), 1.20 – 1.08 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.61, 172.50, 136.05, 135.93, 135.52, 135.52, 133.65, 133.53, 133.48, 132.81, 132.81, 132.27, 132.26, 131.30, 131.18, 130.36, 130.30, 129.73, 129.61, 129.58, 129.54, 129.51, 128.50, 128.44, 128.12, 127.89, 127.87, 127.82, 127.73, 126.65, 126.63, 126.61, 122.96, 122.91, 86.50, 86.04, 64.72, 64.52, 61.43, 61.41, 57.54, 57.34, 39.02, 38.82, 38.40, 38.18, 14.78, 14.76, 14.03, 13.99. HRMS (ESI) calcd for [M+Na$^+$]: C29H30O5S2Na 545.1432 found 545.1430. *dr*=1:0.5

ethyl 5-([1,1'-biphenyl]-4-ylsulfonyl)-2-([1,1'-biphenyl]-4-ylthio)-4-ethoxypentanoate (5e). 

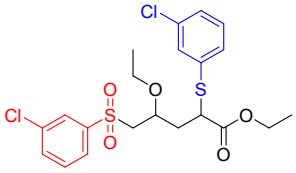
Colorless liquid; Yield: 71%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.96 – 7.93 (m, 2H), 7.77 – 7.73 (m, 2H), 7.61 – 7.55 (m, 4H), 7.51 – 7.42 (m, 9H), 7.36 (t, *J* = 7.0 Hz, 1H), 4.67 – 4.62 (m, 1H), 4.09 – 3.99 (m, 3H), 3.75 – 3.66 (m, 1H), 3.46 – 3.36 (m, 1H), 3.26 – 3.12 (m, 2H), 2.22 – 1.99 (m, 2H), 1.24 – 1.16 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.66, 172.54, 147.00, 141.06, 140.34, 140.29, 139.20, 139.16, 137.64, 137.48, 134.85, 134.71, 130.82, 130.73, 129.28, 129.26, 128.99, 128.91, 128.89, 128.86, 128.00, 127.76, 127.74, 127.67, 127.63, 127.51, 127.14, 86.31, 85.81, 64.66, 64.44, 61.51, 61.49, 57.60, 57.42, 38.90, 38.68, 38.36, 38.12, 14.82, 14.79, 14.19, 14.16. HRMS (ESI) calcd for [M+Na$^+$]: $C_{33}H_{34}O_5S_2Na$ 597.1745 found 597.1748. d*r*=1:0.67

ethyl 5-((2-chlorophenyl)sulfonyl)-2-((2-chlorophenyl)thio)-4-ethoxypentanoate (5f). 

Colorless liquid; Yield: 74%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.94 – 7.89 (m, 1H), 7.69 – 7.64 (m, 1H), 7.50 – 7.45 (m, 1H), 7.37 – 7.32 (m, 2H), 7.28 – 7.22 (m, 1H), 7.14 – 7.08 (m, 2H), 4.71 – 4.67 (m, 1H), 4.06 – 3.96 (m, 3H), 3.91 – 3.82 (m, 1H), 3.46 – 3.39 (m, 2H), 3.18 – 3.11 (m, 1H), 2.26 – 2.01 (m, 2H), 1.22 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.27, 172.21, 137.44, 137.30, 136.52, 136.44, 130.93, 130.83, 130.74, 127.10, 126.97, 124.83, 124.79, 124.58, 124.54, 118.79, 118.61, 117.42, 117.39, 117.21, 117.18, 116.24, 116.21, 116.00, 115.98, 86.37, 85.93, 64.93, 64.80, 61.46, 61.44, 56.64, 38.96, 38.85, 38.19, 37.94, 14.72, 14.65, 14.08, 14.06. HRMS (ESI) calcd for [M+Na$^+$]: C21H24Cl2O5S2Na 513.0340 found 513.0339. *dr*=1:1

ethyl 4-ethoxy-5-((3-fluorophenyl)sulfonyl)-2-((3-fluorophenyl)thio)pentanoate (5g). 

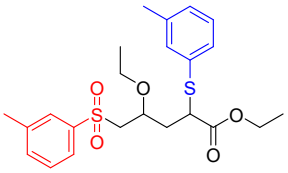
Colorless liquid; Yield: 73%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.71 – 7.68 (m, 1H), 7.62 – 7.53 (m, 2H), 7.39 – 7.33 (m, 1H), 7.29 – 7.23 (m, 1H), 7.20 – 7.11 (m, 2H), 7.02 – 6.97 (m, 1H), 4.68 – 4.64 (m, 1H), 4.10 – 3.91 (m, 3H), 3.70 – 3.61 (m, 1H), 3.45 – 3.36 (m, 1H), 3.23 – 3.07 (m, 2H), 2.19 – 1.99 (m, 2H), 1.25 – 1.16 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.36, 172.23, 162.57 (d, $J_{C\text{-}F}$= 248.9 Hz), 162.53 (d, $J_{C\text{-}F}$= 248.9 Hz), 134.37 (d, $J_{C\text{-}F}$ = 7.8 Hz), 134.14 (d, $J_{C\text{-}F}$ = 7.8 Hz), 131.39, 131.31, 130.28, 130.21, 130.20, 130.13, 129.71, 129.68, 129.48, 129.45, 124.23 (d, $J_{C\text{-}F}$ = 3.6 Hz), 124.18 (d, $J_{C\text{-}F}$ = 3.4 Hz), 121.47, 121.26, 120.88, 120.66, 120.45, 115.78 (d, $J_{C\text{-}F}$ = 24.4 Hz), 115.19 (d, $J_{C\text{-}F}$ = 21.1 Hz), 86.28, 85.69, 64.72, 64.49, 61.64, 61.62, 57.40, 57.17, 38.63, 38.47, 38.20, 37.96, 14.77, 14.70, 14.14, 14.11. HRMS (ESI) calcd for [M+Na$^+$]: C21H24F2O5S2Na 481.0931 found 481.0927. *dr*=1:0.88

ethyl 5-((3-chlorophenyl)sulfonyl)-2-((3-chlorophenyl)thio)-4-ethoxypentanoate (5h). 

Colorless liquid; Yield: 77%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.90 – 7.89 (m, 1H), 7.81 – 7.78 (m, 1H), 7.65 –

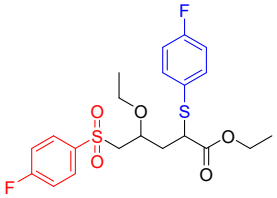
7.63 (m, 1H), 7.55 – 7.49 (m, 1H), 7.42 – 7.41 (m, 1H), 7.33 – 7.21 (m, 3H), 4.69 – 4.65 (m, 1H), 4.11 – 3.94 (m, 3H), 3.71 – 3.62 (m, 1H), 3.46 – 3.39 (m, 1H), 3.24 – 3.09 (m, 2H), 2.19 – 1.98 (m, 2H), 1.26 – 1.18 (m, 6H). ^{13}C NMR (150 MHz, Chloroform-*d*) δ 172.27, 172.14, 140.88, 140.83, 135.68, 135.66, 134.53, 134.46, 134.17, 134.11, 133.84, 133.77, 133.54, 132.23, 131.99, 130.75, 130.00, 129.94, 128.42, 128.29, 128.28, 126.50, 126.45, 86.28, 85.64, 64.69, 64.47, 61.61, 61.60, 57.36, 57.15, 38.62, 38.45, 38.12, 37.90, 14.72, 14.66, 14.12, 14.08. HRMS (ESI) calcd for [M+Na$^+$]: C21H24Cl2O5S2Na 513.0340 found 513.0339. *dr*=1:0.51.

ethyl 4-ethoxy-5-(m-tolylsulfonyl)-2-(m-tolylthio)pentanoate (5i). Colorless liquid;



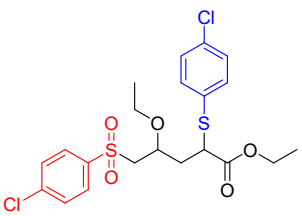
Yield: 76%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.70 – 7.66 (m, 2H), 7.45 – 7.40 (m, 2H), 7.22 – 7.08 (m, 4H), 4.62 – 4.58 (m, 1H), 4.07 – 3.91 (m, 3H), 3.67 – 3.58 (m, 1H), 3.42 – 3.32 (m, 1H), 3.20 – 3.07 (m, 2H), 2.44 – 243. (m, 3H), 2.32 – 2.31 (m, 3H), 2.04 – 1.95 (m, 1H), 2.15 – 2.08 (m, 1H), 1.22 – 1.13 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.63, 172.52, 139.67, 139.66, 139.06, 138.97, 138.75, 138.68, 135.00, 134.90, 134.72, 131.76, 131.63, 131.37, 131.24, 129.24, 129.22, 128.97, 128.95, 128.79, 128.73, 128.63, 128.59, 125.48, 125.43, 86.37, 85.84, 64.53, 64.30, 61.36, 61.34, 57.43, 57.27, 38.90, 38.70, 38.23, 38.03, 21.41, 21.39, 21.38, 14.74, 14.70, 14.11, 14.08. HRMS (ESI) calcd for [M+Na$^+$]: C23H30O5S2Na 473.1432 found 473.1431. *dr*=1:0.86

ethyl 4-ethoxy-5-((4-fluorophenyl)sulfonyl)-2-((4-fluorophenyl)thio)pentanoate (5j).



Colorless liquid; Yield: 74%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 – 7.87 (m, 2H), 7.40 – 7.35 (m, 2H), 7.25 – 7.19 (m, 2H), 7.02 –7.96(m, 3.0 Hz, 2H), 4.56 – 4.53 (m, 1H), 4.08 – 3.92 (m, 3H), 3.67 – 3.58 (m, 1H), 3.43 – 3.34 (m, 1H), 3.18 – 3.03 (m, 2H), 2.12 – 1.86 (m, 2H), 1.22 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.47, 172.33, 166.07 (d, $J_{C\text{-}F}$ = 256.8 Hz), 166.06 (d, $J_{C\text{-}F}$= 256.8 Hz), 163.11 (d, $J_{C\text{-}F}$ = 248.7 Hz), 163.07 (d, $J_{C\text{-}F}$ = 248.8 Hz), 135.22 (d, $J_{C\text{-}F}$ = 6.9 Hz), 135.19 (d, $J_{C\text{-}F}$ = 6.9 Hz), 137.03, 136.95, 136.82, 136.74, 131.36, 131.31, 131.27, 131.22, 126.51 (d, $J_{C\text{-}F}$ = 21.0 Hz), 126.48 (d, $J_{C\text{-}F}$ = 20.8 Hz), 116.82, 116.82, 116.60, 116.59, 116.27, 116.20, 116.05, 115.98, 86.13, 64.63, 64.43, 61.54, 61.52, 57.58, 57.41, 38.67, 38.46, 38.21, 37.99, 14.75, 14.71, 14.14, 14.11. HRMS (ESI) calcd for [M+Na$^+$]: C21H24F2O5S2Na 481.0931 found 481.0927. *dr*=1:0.49

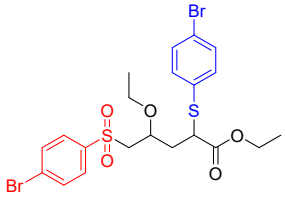
ethyl 5-((4-chlorophenyl)sulfonyl)-2-((4-chlorophenyl)thio)-4-ethoxypentanoate



(5k). Colorless liquid; Yield: 76%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.83 – 7.81 (m, 2H), 7.55 –7.51 (m, 2H), 7.36 – 7.32(m, 2H), 7.27 – 7.24 (m, 2H), 4.61 – 4.57 (m, 1H), 4.08 – 3.90 (m, 3H), 3.66 – 3.58 (m, 1H), 3.42 – 3.33 (m, 1H), 3.19 – 3.03 (m,

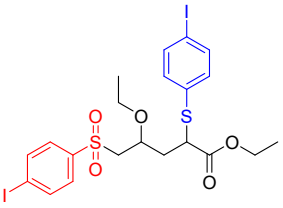
2H), 2.13 – 1.90 (m, 2H), 1.22 – 1.14 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.38, 172.24, 140.88, 140.87, 137.66, 137.57, 135.77, 135.57, 134.59, 134.57, 130.32, 130.14, 129.90, 129.85, 129.73, 129.21, 129.15, 86.14, 85.62, 64.68, 64.47, 61.60, 61.57, 57.50, 57.31, 38.66, 38.45, 38.20, 37.96, 14.75, 14.70, 14.14, 14.11. HRMS (ESI) calcd for [M+Na$^+$]: C21H24Cl2O5S2Na 513.0340 found 513.0339. *dr*=1:0.5

ethyl 5-((4-bromophenyl)sulfonyl)-2-((4-bromophenyl)thio)-4-ethoxypentanoate (5l).



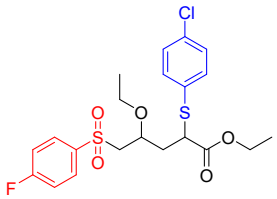
Colorless liquid; Yield: 78%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.76 – 7.68 (m, 4H), 7.41 (dd, 2H), 7.27 (dd, 2H), 4.62 – 4.58 (m, 1H), 4.08 – 3.92 (m, 3H), 3.67 – 3.58 (m, 1H), 3.41 – 3.35 (m, 1H), 3.20 – 3.03 (m, 2H), 2.14 – 1.92 (m, 2H), 1.23 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.37, 172.23, 138.19, 138.09, 135.95, 135.74, 132.75, 132.74, 132.17, 132.11, 131.04, 130.87, 129.96, 129.91, 129.48, 129.47, 122.70, 122.67, 86.09, 85.58, 64.69, 64.48, 61.62, 61.60, 57.48, 57.29, 38.67, 38.46, 38.20, 37.95, 14.76, 14.71, 14.16, 14.13. HRMS (ESI) calcd for [M+Na$^+$]: C21H24Br2O5S2Na 600.9330 found 600.9327. *dr*=1:0.5

ethyl 4-ethoxy-5-((4-iodophenyl)sulfonyl)-2-((4-iodophenyl)thio)pentanoate (5m).



Colorless liquid; Yield:76%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.93 –7.90 (dd, *J* = 5.0 Hz, 2H), 7.62 – 7.56 (m, 4H), 7.11 (t, *J* = 8.1 Hz, 2H), 4.62 – 4.58 (m, 1H), 4.07 – 3.89 (m, 3H), 3.66 – 3.57 (m, 1H), 3.44 – 3.32 (m, 1H), 3.17 – 3.02 (m, 2H), 2.13 – 2.06 (m, 1H), 2.00 – 1.93 (m, 1H), 1.23 – 1.14 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.37, 172.23, 138.85, 138.74, 138.73, 138.13, 138.07, 136.06, 135.99, 135.78, 131.99, 131.83, 129.76, 129.70, 129.49, 86.09, 85.58, 64.70, 64.49, 61.64, 61.61, 57.45, 57.26, 38.68, 38.48, 38.21, 37.96, 14.78, 14.73, 14.18, 14.15. HRMS (ESI) calcd for [M+Na$^+$]: C21H24I2O5S2Na 696.9052 found 696.9050. *dr*=1:1

ethyl 2-((4-chlorophenyl)thio)-4-ethoxy-5-((4-fluorophenyl)sulfonyl)pentanoate (5n).



Colorless liquid; Yield: 74%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 – 7.88 (m, 2H), 7.38 – 7.32 (m, 2H), 7.28 – 7.20 (m, 4H), 4.61 – 4.58 (m, 1H), 4.09 – 3.93 (m, 3H), 3.67 – 3.58 (m, 1H), 3.43 – 3.35 (m, 1H), 3.19 – 3.13 (m, 1H), 3.11 – 3.04 (m, 1H), 2.14 – 2.04 (m, 1H), 2.01 – 1.91 (m, 1H), 1.24 – 1.15 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.45, 172.30, 166.11 (d, $J_{C\text{-}F}$ = 257.3 Hz), 135.80, 135.60, 135.30 (d, $J_{C\text{-}F}$ = 3.2 Hz), 134.61 (d, $J_{C\text{-}F}$ = 2.7 Hz), 131.33 (d, $J_{C\text{-}F}$ = 9.7 Hz), 131.28 (d, $J_{C\text{-}F}$ = 9.7 Hz), 130.37, 130.18, 129.23, 129.17, 116.74 (d, $J_{C\text{-}F}$ = 22.5 Hz), 116.74 (d, $J_{C\text{-}F}$ = 22.7 Hz), 86.21, 85.66, 64.70, 64.49, 61.59, 61.57, 57.62, 57.43, 38.71, 38.49, 38.26, 38.02, 14.77, 14.72, 14.17, 14.14. HRMS (ESI) calcd for [M+Na$^+$]: C21H24ClFO5S2Na 497.0635 found 497.0632. *dr*=1:0.43

ethyl 4-ethoxy-5-((4-fluorophenyl)sulfonyl)-2-(p-tolylthio)pentanoate (5o). Colorless liquid; Yield: 72%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77 – 7.73 (m, 2H), 7.41 – 7.30 (m, 4H), 7.02 – 6.92 (m, 2H), 4.56 – 4.51 (m, 1H), 4.05 – 3.90 (m, 3H), 3.64 – 3.55 (m, 1H), 3.41 – 3.31 (m, 1H), 3.16 – 3.02 (m, 2H), 2.43 – 2.44 (m, 3H), 2.12 – 1.98 (m, 1H), 1.98 – 1.87 (m, 1H), 1.21 – 1.13 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.55, 172.44, 163.04 (d, J_{C-F} = 248.6 Hz), 163.02 (d, J_{C-F} = 248.7 Hz), 145.03, 145.00, 136.92, 136.84, 136.79, 136.71, 136.26, 136.14, 129.98, 129.96, 128.38, 128.31, 126.63 (d, J_{C-F} = 6.0 Hz), 126.60 (d, J_{C-F} = 6.1 Hz), 116.08 (d, J_{C-F} = 21.8 Hz), 116.03 (d, J_{C-F} = 21.7 Hz), 85.69, 64.56, 64.36, 61.39, 61.36, 57.51, 57.27, 38.61, 38.48, 38.23, 37.97, 21.71, 14.70, 14.66, 14.10, 14.07. HRMS (ESI) calcd for [M+Na^{+}]: C22H27FO5S2Na 477.1182 found 477.1180. *dr*=1:0,81

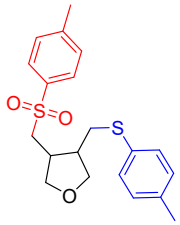
ethyl 5-((4-bromophenyl)sulfonyl)-4-ethoxy-2-(p-tolylthio)pentanoate (5p). Colorless liquid; Yield: 73%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77-7.74 (m 2.4 Hz, 2H), 7.42-7.39 (m, 2H), 7.36 – 7.33 (m, 2H), 7.29 – 7.23 (m, 2H), 4.62 – 4.58 (m, 1H), 4.07 – 3.89 (m, 3H), 3.64 – 3.56 (m, 1H), 3.42 – 3.33 (m, 1H), 3.17 – 3.04 (m, 2H), 2.43-2.44 (m, 3H), 2.14 – 2.05 (m, 1H), 2.01 – 1.92 (m, 1H), 1.23 – 1.14 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.44, 172.57, 145.09, 145.08 – 145.05 (m), 136.32, 136.20, 135.89, 135.78, 132.14, 132.09, 131.12, 131.08, 130.04, 130.03, 128.43, 128.36, 122.62, 86.18, 85.71, 64.65, 64.45, 61.49, 61.46, 57.55, 57.28, 38.65, 38.52, 38.31, 38.00, 21.78, 14.75, 14.72, 14.16, 14.13. HRMS (ESI) calcd for [M+Na^{+}]: C22H27BrO5S2Na 514.0483 found 514.0481. *dr*=1:0.5.

ethyl 4-ethoxy-5-((4-methoxyphenyl)sulfonyl)-2-(p-tolylthio)pentanoate (5q). Colorless liquid; Yield: 74%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77 – 6.73 (m, 2H), 7.35 – 7.26 (m, 4H), 6.83 – 6.79 (m, 2H), 4.48 – 4.43 (m, 1H), 4.05 – 3.94 (m, 3H), 3.79 (s, 3H), 3.66 – 3.56 (m, 1H), 3.38 – 3.31 (m, 1H), 3.16 – 3.01 (m, 2H), 2.43-2.44 (m, 3H), 2.10 – 1.96 (m, 1H), 1.91 – 1.83 (m, 1H), 1.23 – 1.12 (m, 6H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.68, 172.57, 160.11, 160.10, 144.98, 144.94, 136.93, 136.78, 136.28, 136.13, 129.96, 129.94, 128.43, 128.35, 121.75, 121.67, 114.56, 114.51, 86.23, 85.79, 64.51, 64.31, 61.33, 61.30, 57.58, 57.43, 55.40, 38.80, 38.57, 38.26, 38.09, 21.72, 14.73, 14.70, 14.10, 14.08. HRMS (ESI) calcd for [M+Na^{+}]: C23H30O6S2Na 489.1381 found 489.1380. *dr*=1:0.78.

diethyl 3-((p-tolylthio)methyl)-4-(tosylmethyl)cyclopentane-1,1-dicarboxylate (6a).[2, 5] Colorless liquid; Yield: 76%; ^{1}H NMR (400 MHz, Chloroform-d) δ 7.81 – 7.73 (m, 2H), 7.36 – 7.43 (m, 2H), 7.20 – 7.16 (m,

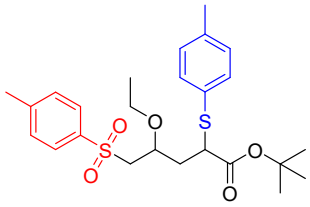
2H), 7.08 – 7.07(m, 2H), 4.19 – 4.12 (m, 4H), 3.23 – 3.17 (m, 1H), 3.10 – 3.04 (m, 1H), 2.84 – 2.80 (m, 1H), 2.76– 2.64 (m, 1H) , 2.58 – 2.48 (m, 2H) , 2.45 – 2.24 (m, 10H).. ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.44, 172.04, 144.87, 136.79, 136.59, 131.70, 130.76, 130.50, 130.05, 128.17, 61.92, 61.75, 58.52, 56.00, 41.43, 38.12, 38.05, 36.51, 34.92, 21.74, 21.11, 14.10, 14.08. HRMS (ESI) calcd for [M+Na$^+$]: C27H34O6S2Na 541.1694 found 541.1693. *dr*=1:0.24

3-((p-tolylthio)methyl)-4-(tosylmethyl)tetrahydrofuran (6b).[2] Colorless liquid;



Yield: 78%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.79 – 7.76 (m, 2H), 7.37 – 7.35 (m, 2H), 7.22 – 7.19 (m, 2H), 7.10 – 7.08 (m, 2H), 3.97 – 3.82 (m, 2H), 3.76 – 3.50 (m, 2H), 3.33 – 3.29 (m, 1H), 3.10 – 2.68 (m, 4H), 2.54-2.48 (m, 1H), 2.45 (s, 3H), 2.31 (s, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.13, 137.06, 136.42, 131.38, 130.86, 130.56, 130.15, 129.96, 128.12, 128.08, 71.81, 71.59, 54.92, 41.26, 36.52, 33.56, 21.71, 21.09. HRMS (ESI) calcd for [M+Na$^+$]: C20H24O3S2Na 399.1065 found 399.1063. *dr*=1:0.38

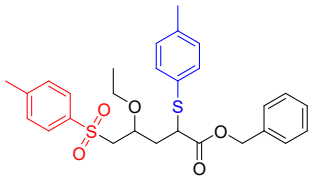
tert-butyl 4-ethoxy-2-(p-tolylthio)-5-tosylpentanoate (5a').



Colorless liquid; Yield: 82%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.78-7.75 (m, 2H), 7.36 – 7.23 (m, 4H), 7.08 (t, *J* = 8.2 Hz, 2H), 4.58 – 4.51 (m, 1H), 4.03 – 3.90 (m, 1H), 3.66 – 3.54 (m, 1H), 3.42 – 3.32 (m, 1H), 3.10 – 2.91 (m, 2H), 2.44-2.44 (m, 3H), 2.32 (s, 3H), 2.10 – 1.99 (m, 1H), 1.93 – 1.85 (m, 1H), 1.37 (s, 9H), 1.16 (dt, *J* = 13.9, 7.0 Hz, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 171.73, 171.57, 144.87, 138.34, 138.33, 136.45, 134.92, 134.75, 129.99, 129.97, 129.76, 129.73, 128.46, 128.36, 128.25, 128.06, 86.49, 86.06, 81.76, 81.70, 64.69, 64.33, 57.44, 57.40, 39.04, 38.97, 38.91, 38.58, 27.98, 27.97, 21.74, 21.27, 14.80, 14.77. HRMS (ESI) calcd for [M+Na$^+$]: C28H33NO4S2Na 501.1745 found 501.1741. *dr*=1:1

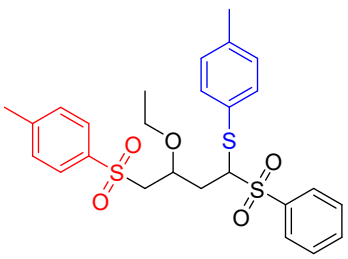
benzyl 4-ethoxy-2-(p-tolylthio)-5-tosylpentanoate (5b')

Colorless liquid; Yield: 79%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.76-7.73 (m, 2H),



7.37 – 7.30 (m, 7H), 7.26 – 7.20 (m, 2H), 7.06-7.04 (m, 2H), 5.07 – 4.95 (m, 2H), 4.49 – 4.43 (m, 1H), 3.94 – 3.87 (m, 1H), 3.67 – 3.59 (m, 1H), 3.28 – 3.09 (m, 3H), 2.44 (m, 3H), 2.32 (s, 3H), 2.16 – 1.89 (m, 3H), 1.13 – 1.08 (m, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.52, 172.38, 145.02, 138.38, 138.34, 136.21, 136.06, 135.56, 135.53, 134.84, 134.77, 130.01, 130.00, 129.79, 129.75, 128.69, 128.54, 128.52, 128.47, 128.44, 128.40, 127.87, 86.06, 85.66, 67.22, 67.17, 64.52, 64.31, 57.55, 57.33, 38.83, 38.56, 38.41, 38.13, 27.05, 21.78, 21.30, 14.73, 14.69. HRMS (ESI) calcd for [M+Na$^+$]: C28H32O5S2Na 535.1589 found 535.1584.*dr*=1:1.

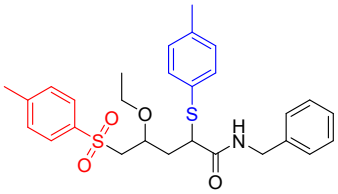
(3-ethoxy-1-(phenylsulfonyl)-4-tosylbutyl)(p-tolyl)sulfane (5c') Colorless liquid; Yield: 75%;^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.90-7.88 (m, 2H), 7.75-7.73 (m, 2H),



7.69 – 7.65 (m, 1H), 7.59 – 7.57 (m, 2H), 7.35 (d, *J* = 8.0 Hz, 2H), 7.26 – 7.22 (m, 2H), 7.08 (d, *J* = 7.6 Hz, 2H), 4.90 – 4.69

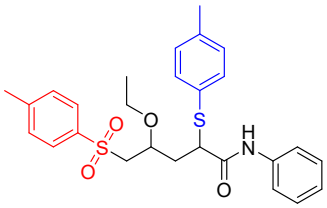
(m, 1H), 4.38– 4.32 (m, 1H), 3.42 – 2.97 (m, 4H), 2.45-2.46(m, 3H), 2.34-2.32 (m, 3H), 2.21 – 2.13 (m, 1H), 2.01 – 1.86 (m, 1H), 1.39 – 1.33 (m, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 145.33, 145.16, 139.05, 138.75, 138.70, 138.26, 136.73, 134.31, 134.03, 133.94, 130.27, 130.09, 129.97, 129.92, 129.52, 129.47, 128.29, 128.24, 128.01, 84.70, 84.39, 70.22, 70.08, 60.45, 59.86, 52.25, 51.41, 28.85, 23.12, 22.66, 21.82, 21.29. HRMS (ESI) calcd for [M+Na$^+$]: C26H30O5S3Na 541.1153 found 541.1150. *dr*=1:0.6

N-benzyl-4-ethoxy-2-(p-tolylthio)-5-tosylpentanamide (5d') Colorless liquid;



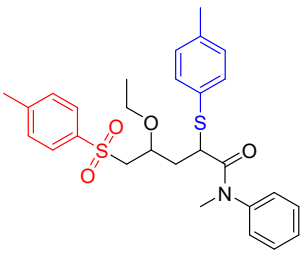
Yield: 72%; ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.77-7.75 (m, 2H), 7.35 – 7.24 (m, 9H), 7.09-7.08 (m, 2H), 6.32-6.03 (NH, m, 1H), 4.53 – 4.36 (m, 2H), 4.29 – 4.19 (m, 1H), 4.02 – 3.89 (m, 1H), 3.78 – 3.66 (m, 1H), 3.39 – 3.34 (m, 1H), 3.10 – 2.95 (m, 3H), 2.46-2.45 (m, 3H), 2.34-2.32 (m, 3H), 2.15 – 2.05 (m, 1H), 1.88 – 1.83 (m, 1H), 1.15 – 1.08 (m, 2H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 171.83, 171.58, 144.99, 138.55, 138.25, 138.00, 137.93, 136.79, 136.71, 134.91, 134.91, 134.43, 130.05, 130.00, 129.87, 129.82, 128.91, 128.85, 128.21, 128.13, 128.08, 128.02, 127.84, 127.70, 86.33, 85.65, 64.49, 63.82, 58.24, 57.93, 44.11, 44.06, 39.48, 39.08, 38.45, 38.21, 21.81, 21.33, 21.29, 14.89, 14.78. HRMS (ESI) calcd for [M+Na$^+$]: C28H33NO4S2Na 534.1749 found 534.1742. *dr*=1:1

4-ethoxy-N-phenyl-2-(p-tolylthio)-5-tosylpentanamide (5e')



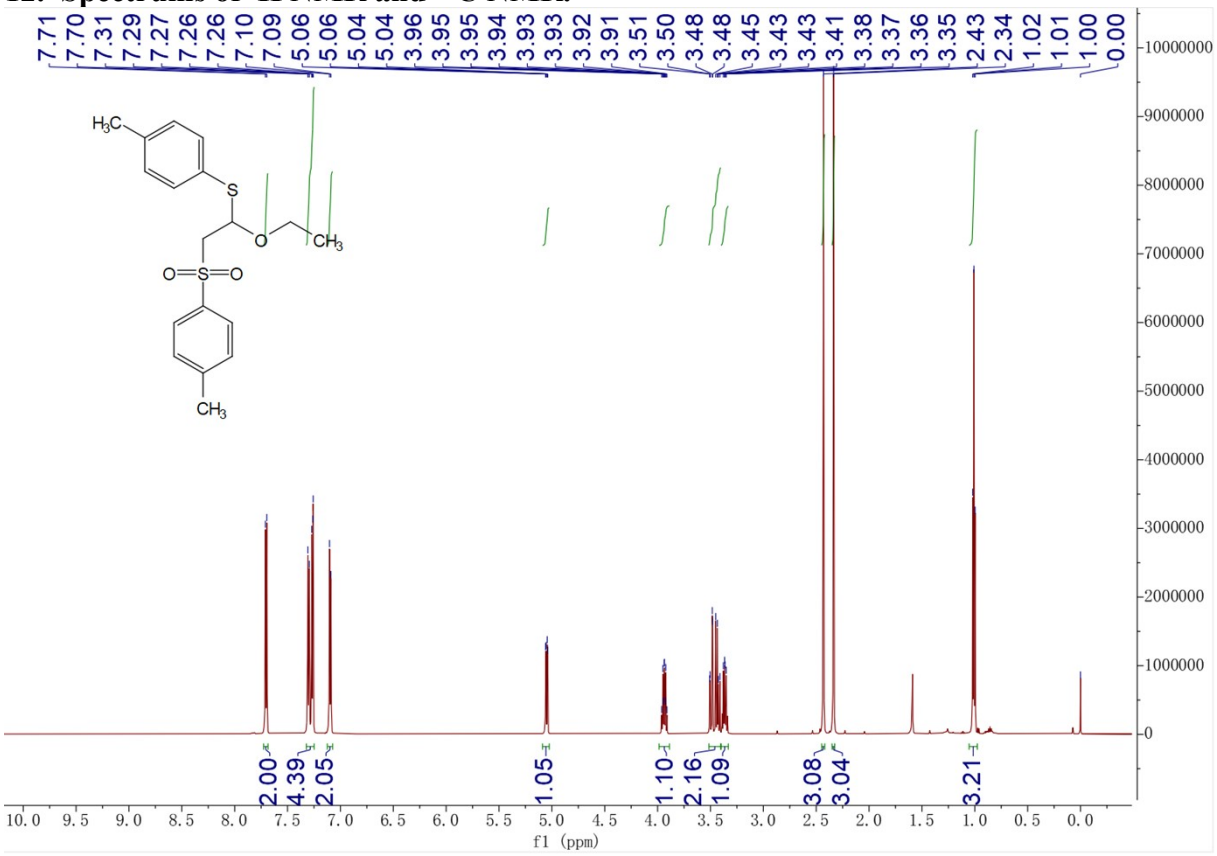
Colorless liquid; Yield: 66%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.9, 7.57 (s, NH, 0.56+0.49=1H), 7.72-7.77(m, 2H), 7.38 – 7.25 (m, 8H), 7.11 – 7.09 (m, 3H), 4.69 – 4.60 (m, 1H), 4.13 – 4.01 (m, 1H), 3.82 – 3.70 (m, 1H), 3.49 – 3.37 (m, 1H), 3.25 – 3.19 (m, 1H), 3.09 – 3.02 (m, 1H), 2.36 – 2.32 (m, 6H), 2.22 – 2.13 (m, 1H), 2.00 – 1.88 (m, 1H), 1.26 – 1.22 (m, 3H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 170.06, 169.98 , 145.17, 145.12, 138.73, 138.42, 137.69, 137.58, 136.35, 136.30, 134.93, 134.58, 130.07, 130.01, 129.98, 129.89, 129.09, 129.02, 128.14, 128.11, 127.27, 127.25, 124.70, 124.56, 119.92, 119.89, 86.56, 85.50, 64.76, 64.07, 58.34, 58.01, 39.72, 39.48, 39.36, 39.22, 30.34, 29.84, 21.70, 21.31, 15.04, 14.93. HRMS (ESI) calcd for [M+Na$^+$]: C27H31NO4S2Na 520.1592 found 520.1588. *dr*=1:0.55

4-ethoxy-N-methyl-N-phenyl-2-(p-tolylthio)-5-tosylpentanamide (5f') Colorless liquid; Yield: 75%; ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.61-7.65 (m, 2H), 7.34 – 7.40

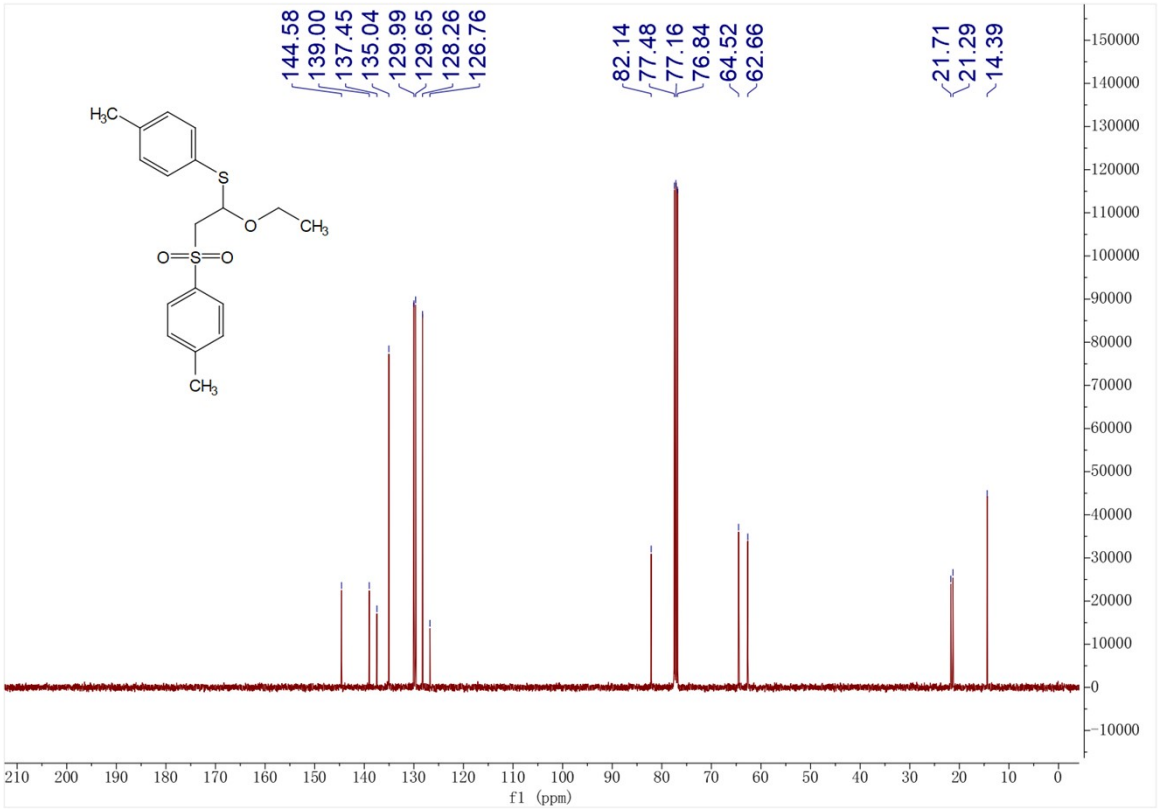


(m, 3H), 7.21 – 7.26 (m, 5H), 7.07 – 7.15 (m, 3H), 4.14 – 4.43 (m, 1H), 3.91 – 3.99 (m, 1H), 3.67 – 3.83 (m, 1H), 3.21-3.23 (m, 3H), 2.92 – 3.50 (m, 3H), 2.41-2.42 (m, 3H), 2.34 -2.35(m, 3H), 1.78 – 1.918 (m, 2H), 1.03 (t, *J* = 7.0 Hz, 1H), 0.89 (d, *J* = 7.0 Hz, 2H). ^{13}C NMR (100 MHz, Chloroform-*d*) δ 172.17, 172.15, 144.57, 144.53, 143.28, 143.10, 138.24, 138.20, 137.05, 136.87, 134.70, 134.66, 129.90, 129.82, 129.76, 129.65, 128.36, 128.18, 128.04, 127.98, 127.87, 87.51, 85.25, 64.16, 63.95, 57.92, 57.28, 39.09, 39.05, 38.03, 37.99, 35.55, 34.18, 21.72, 21.70, 21.30, 21.29, 14.68, 14.66. HRMS (ESI) calcd for [M+Na$^+$]: C28H33NO4S2Na 534.1749 found 534.1743. *dr*=1:0.67.

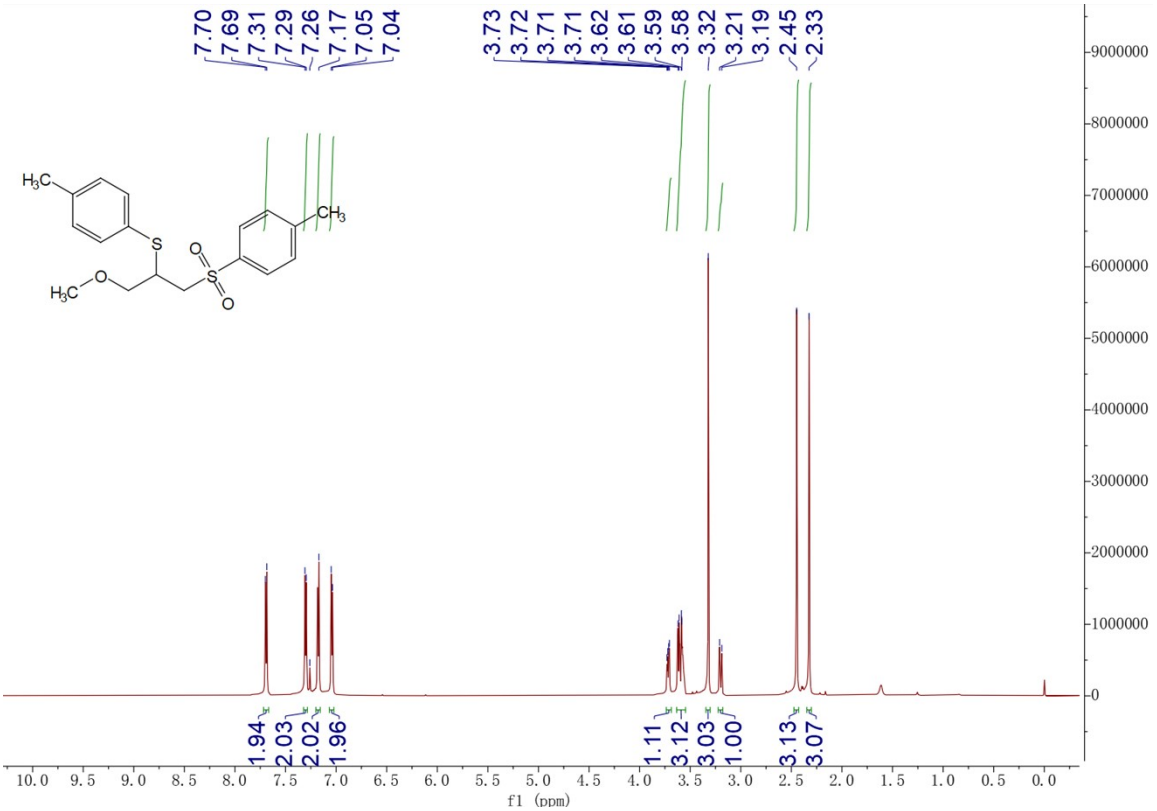
12. Spectrums of ^{1}H NMR and ^{13}C NMR.



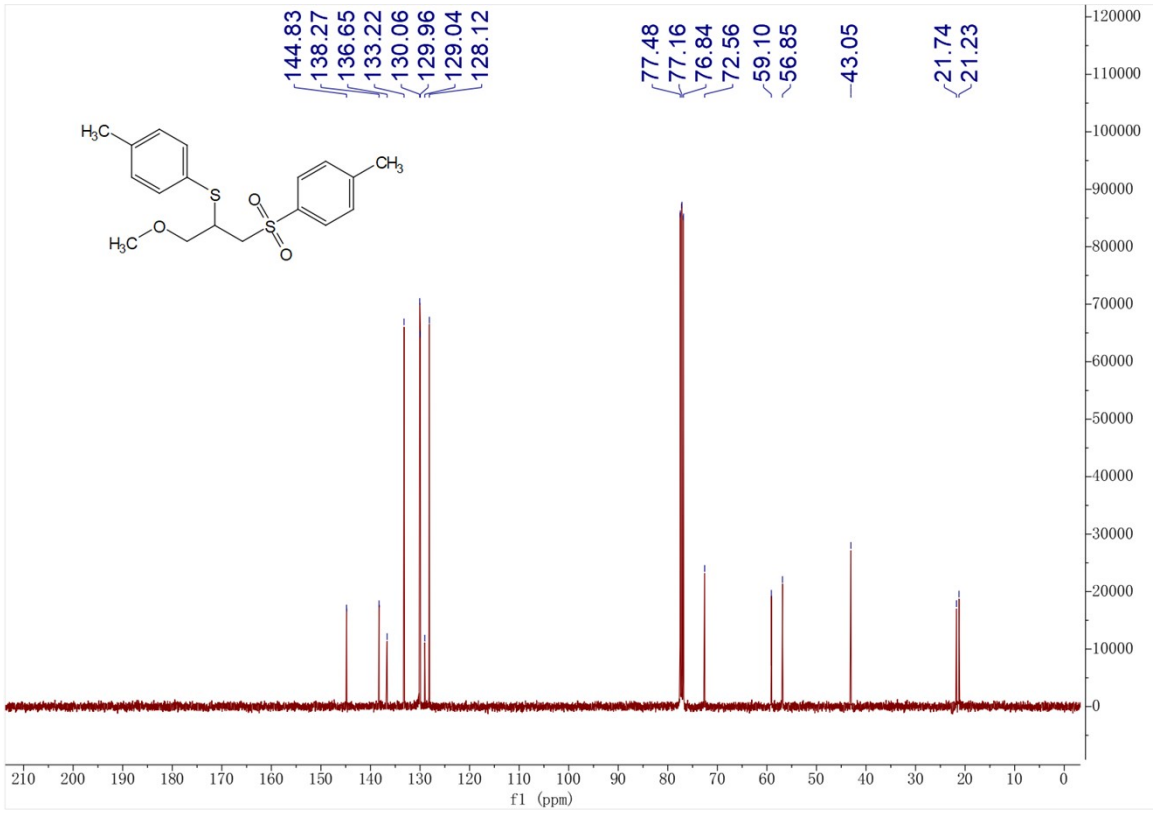
^{1}H NMR spectrum of **3a**



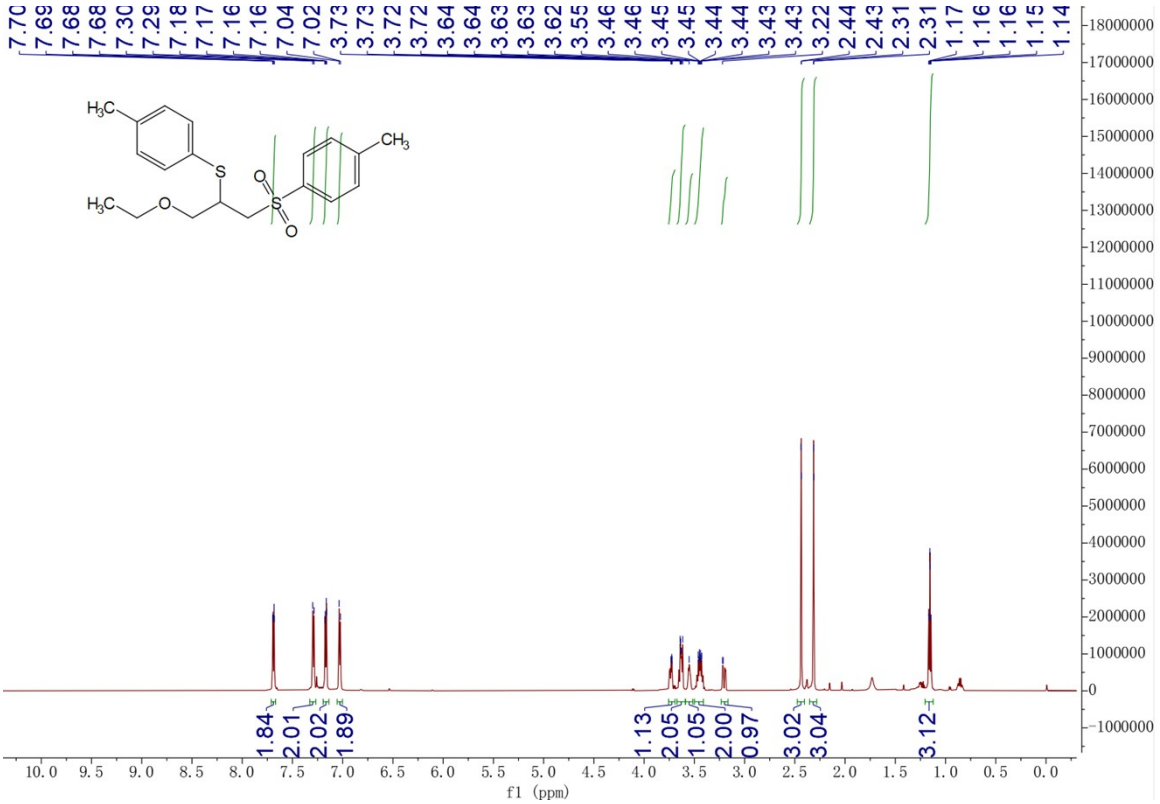
^{13}C NMR spectrum of **3a**



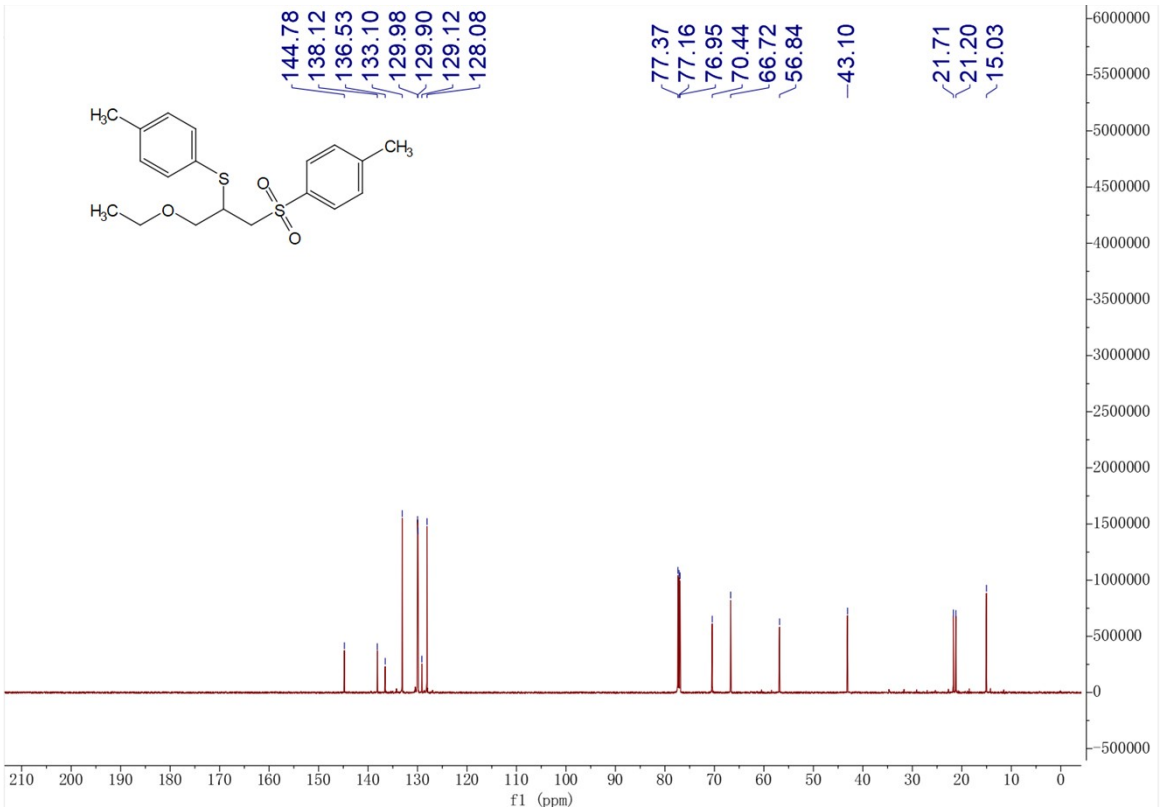
^{1}H NMR spectrum of **3b**



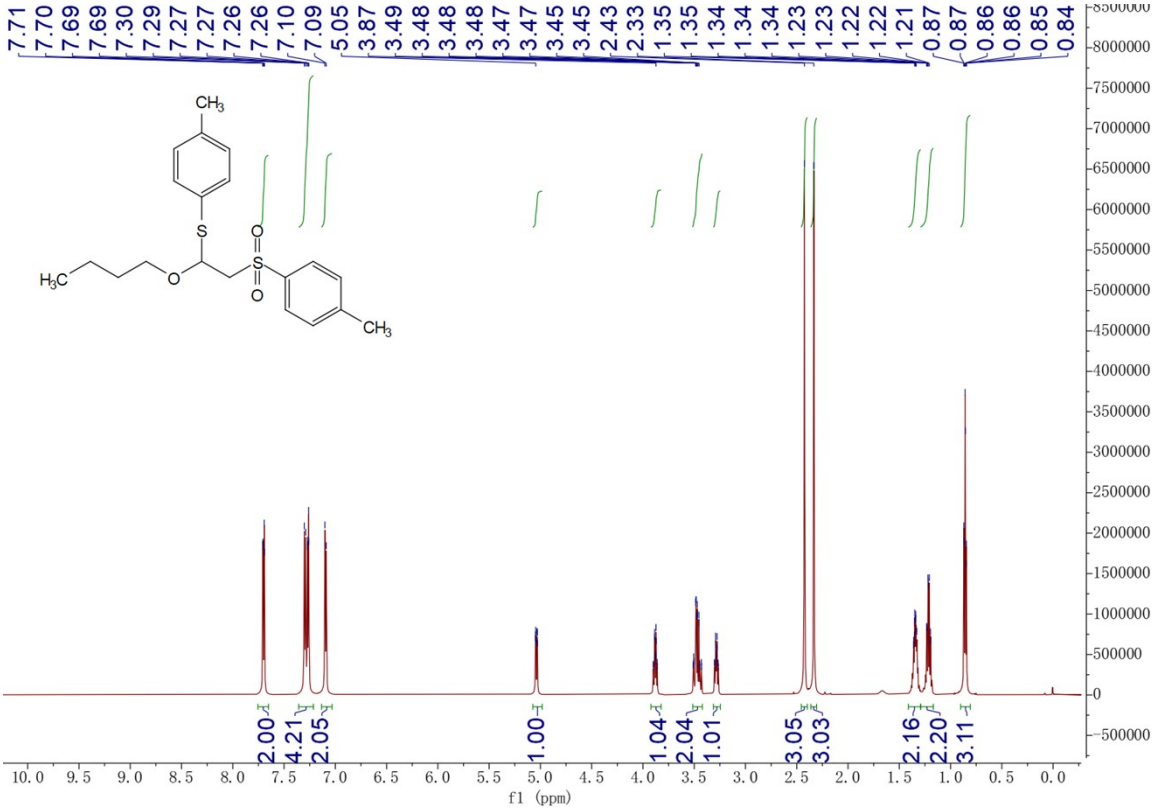
^{13}C NMR spectrum of **3b**



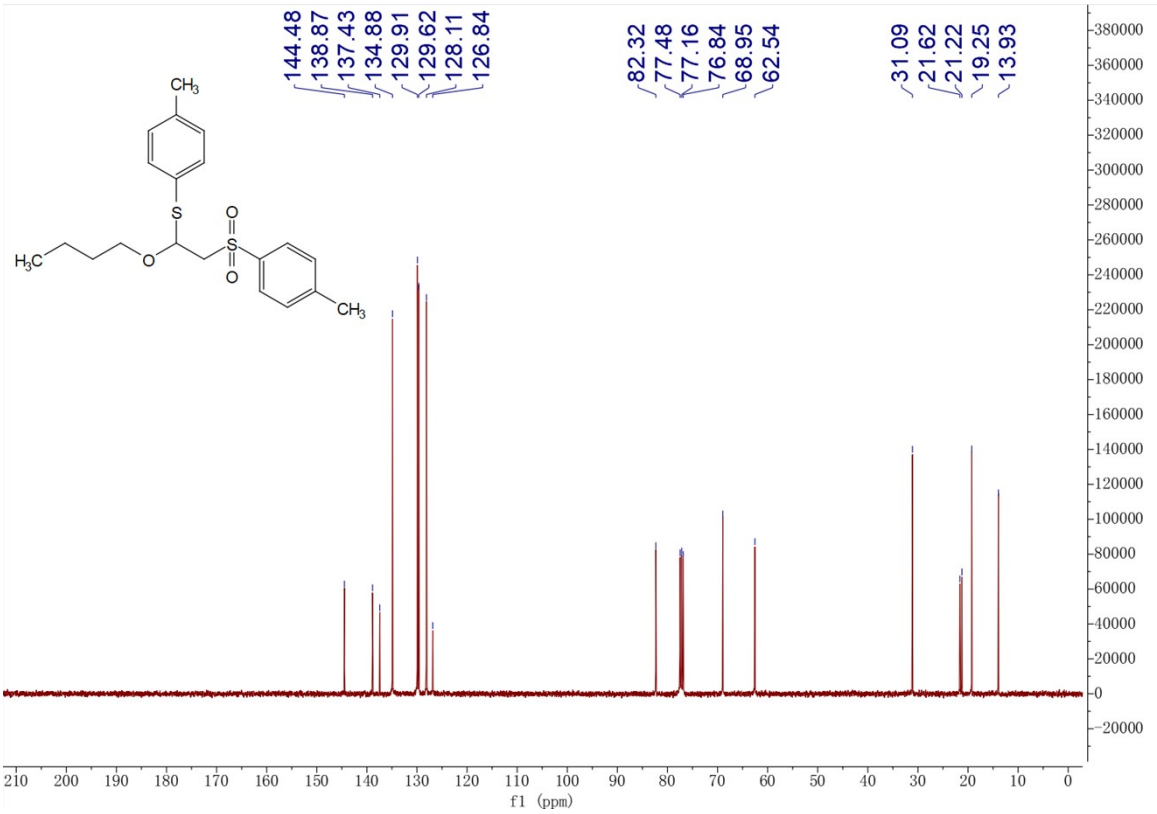
^{1}H NMR spectrum of **3c**



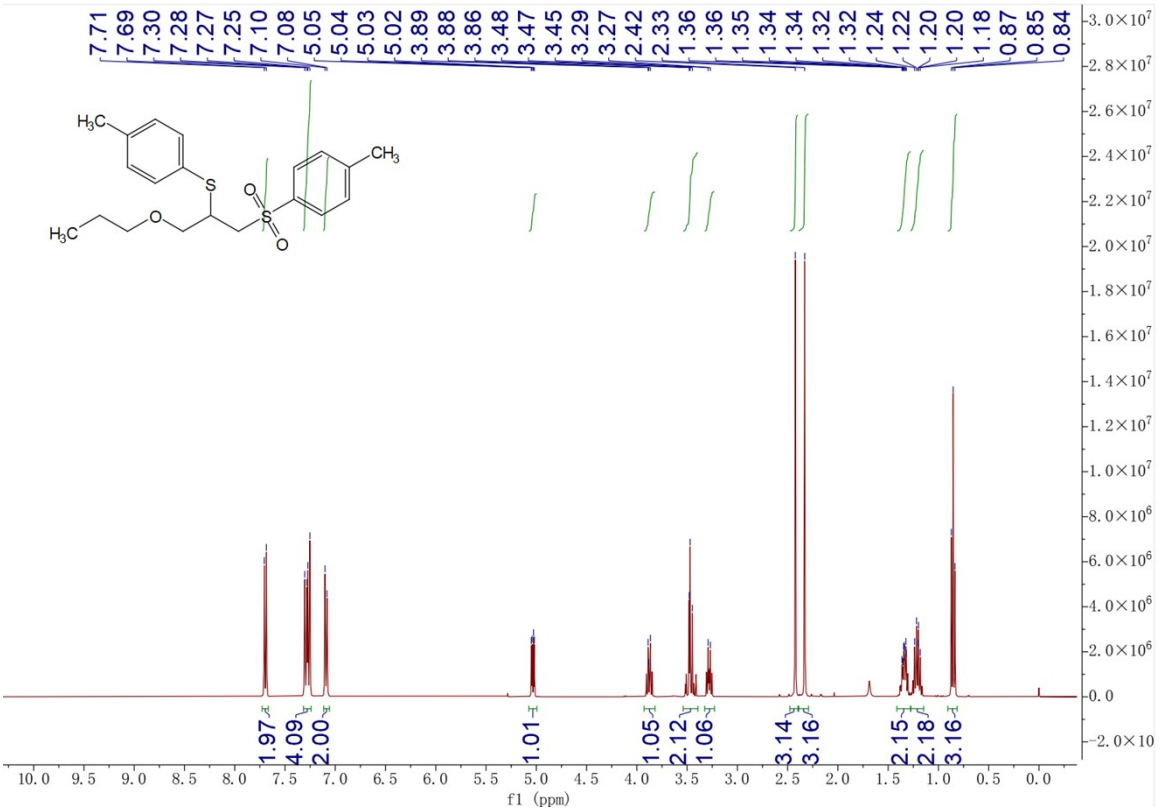
^{13}C NMR spectrum of **3c**



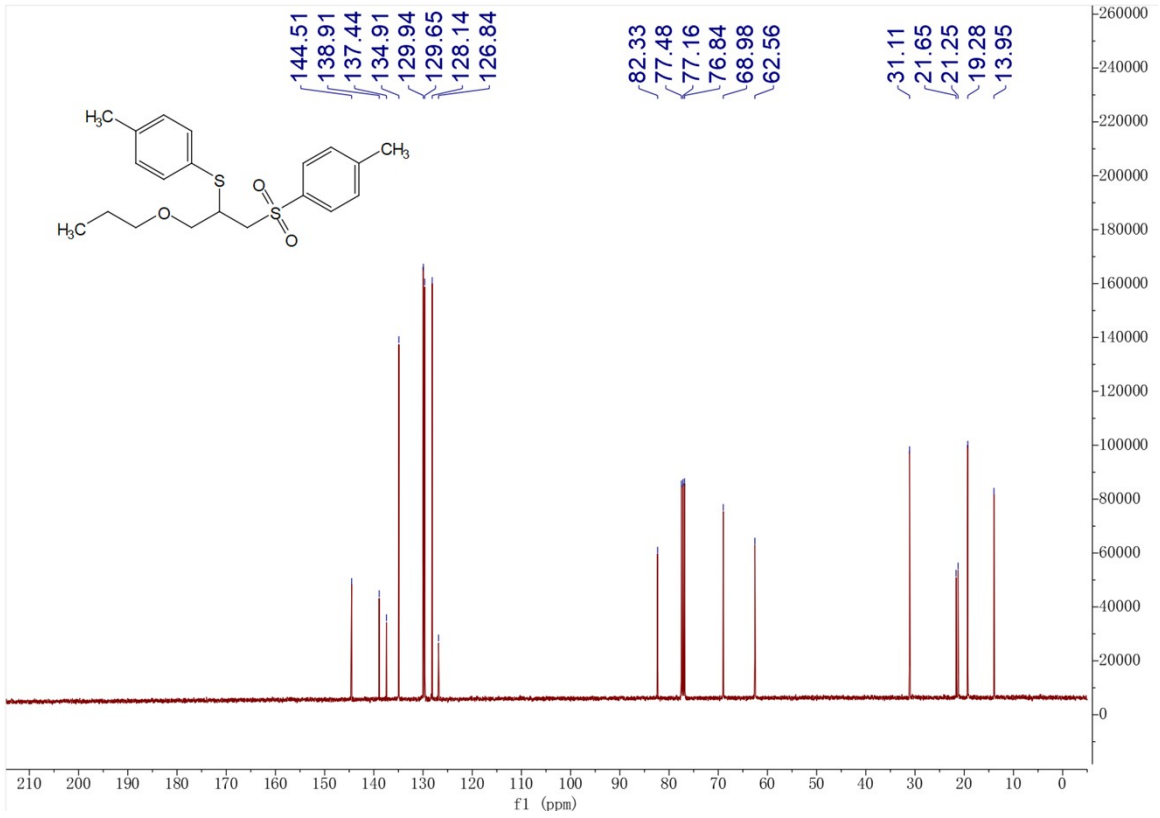
^{1}H NMR spectrum of **3d**



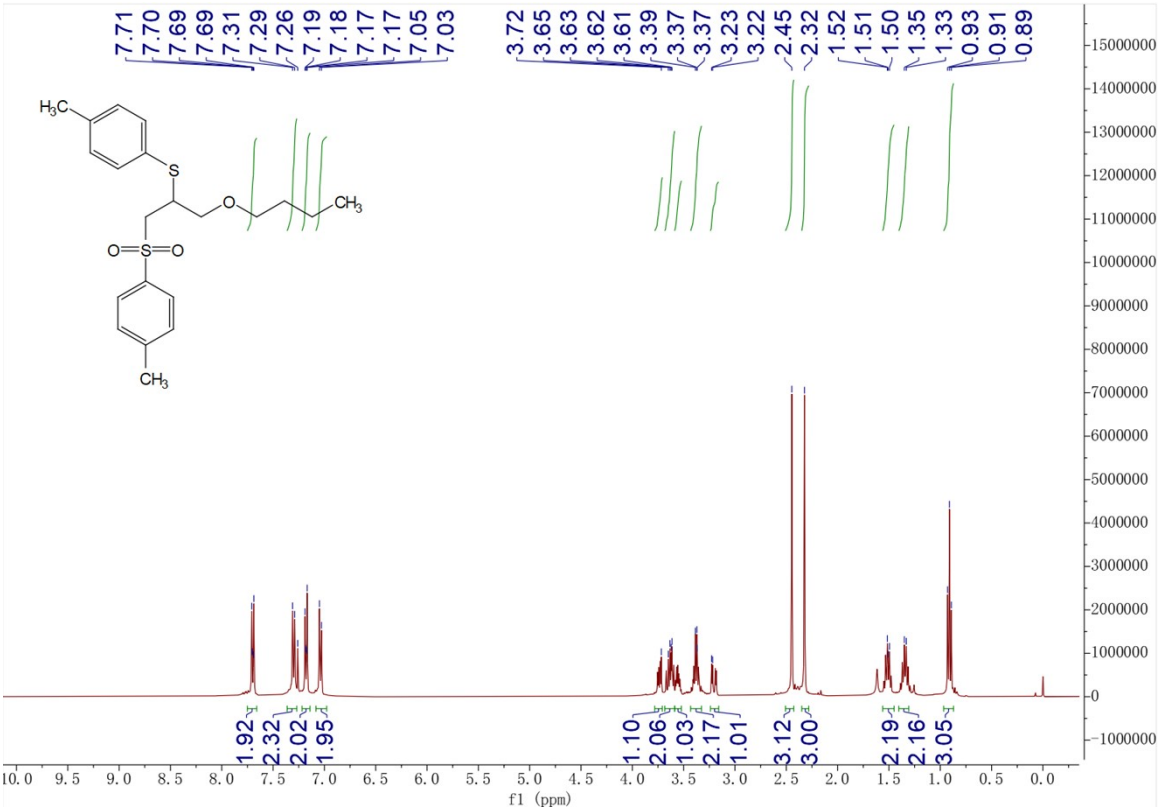
^{13}C NMR spectrum of **3d**



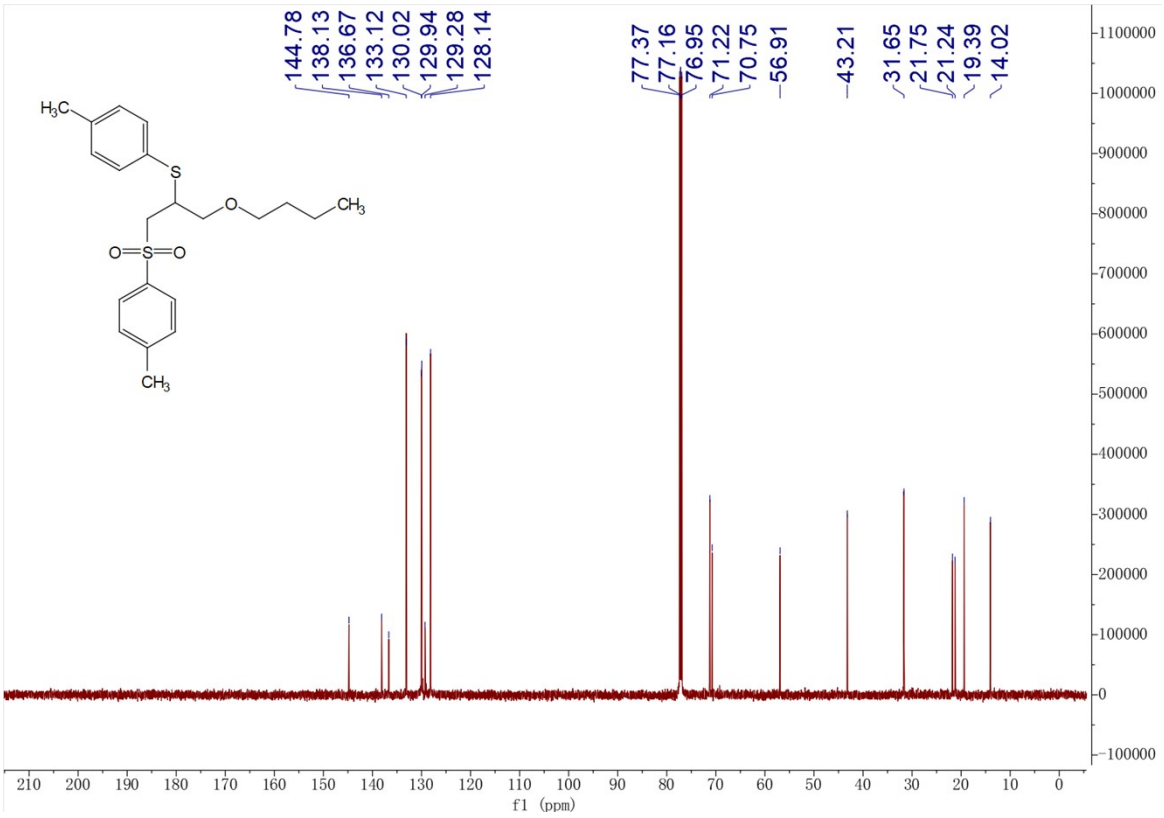
^{1}H NMR spectrum of **3e**



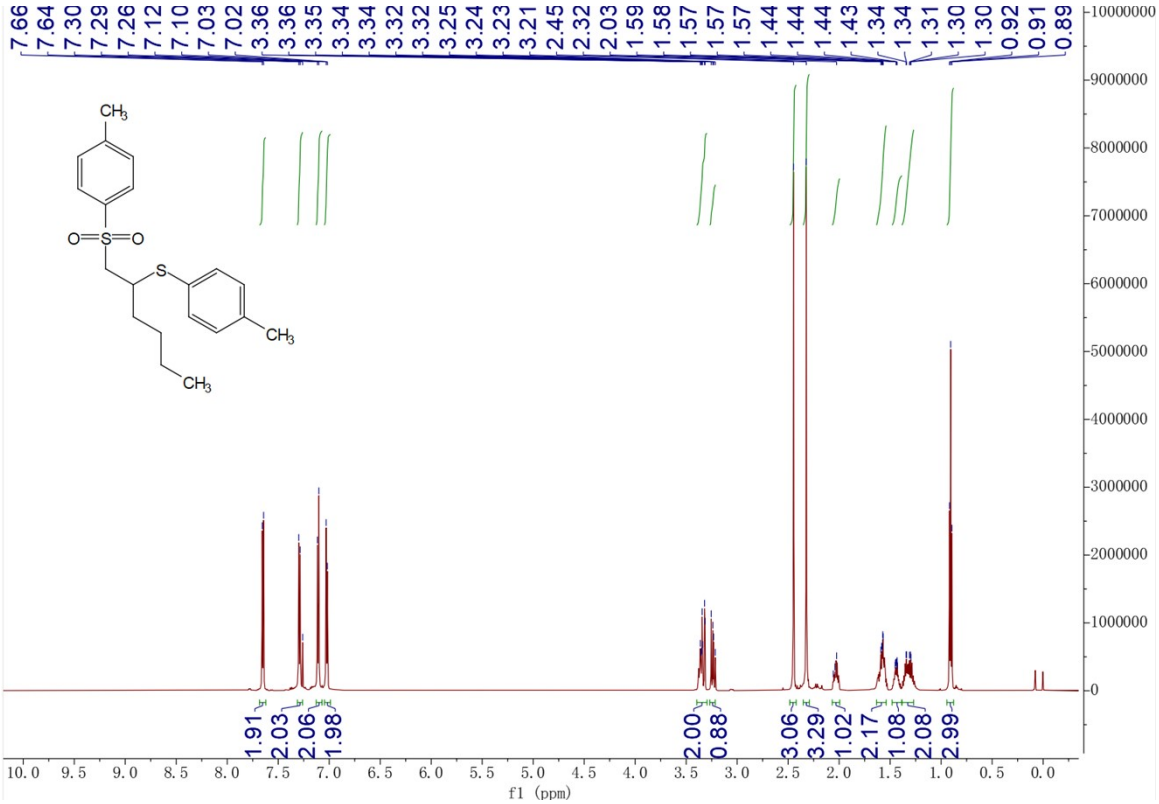
^{13}C NMR spectrum of **3e**



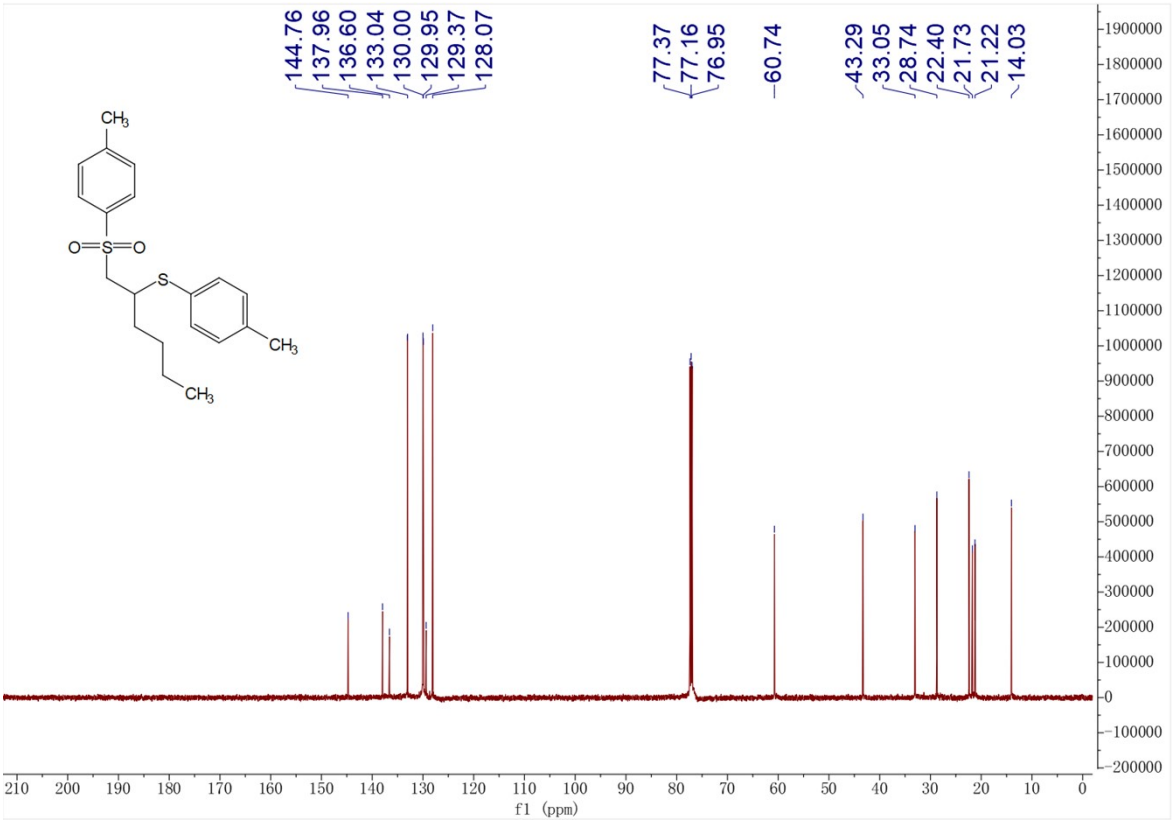
^{1}H NMR spectrum of **3f**



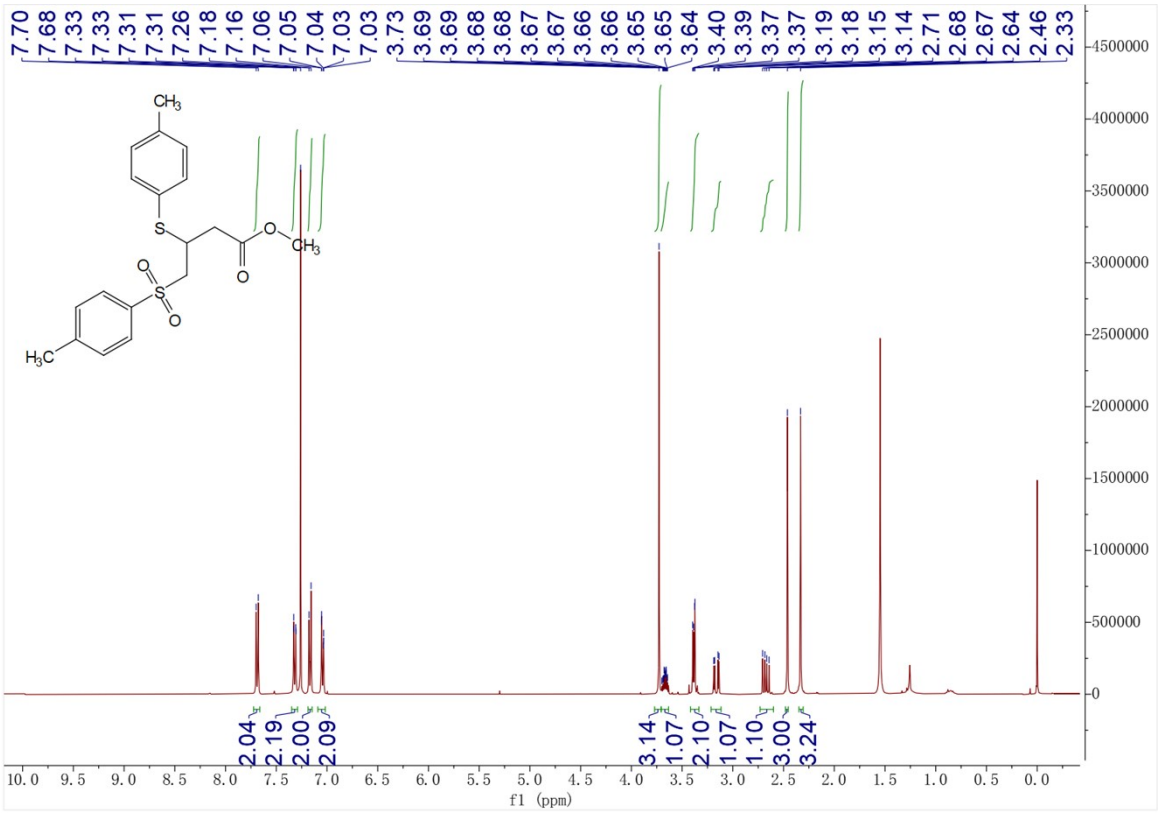
^{13}C NMR spectrum of **3f**



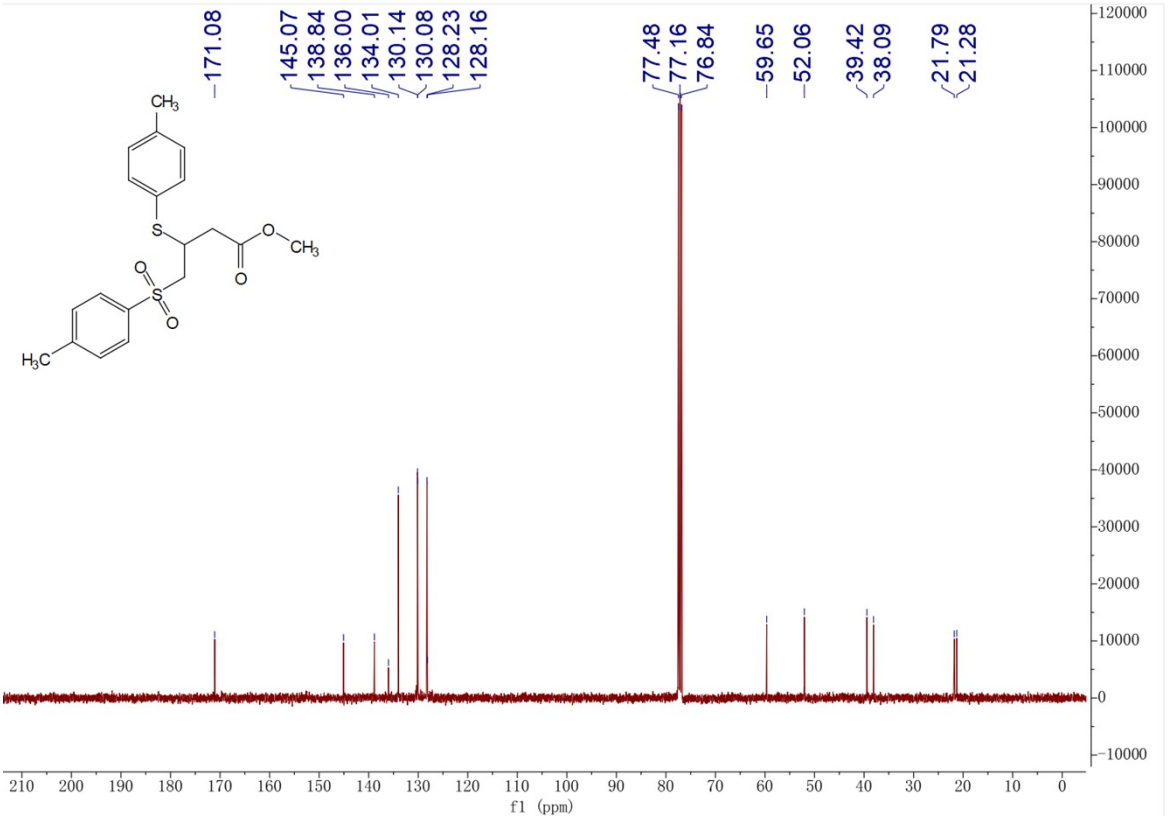
^{1}H NMR spectrum of **3g**



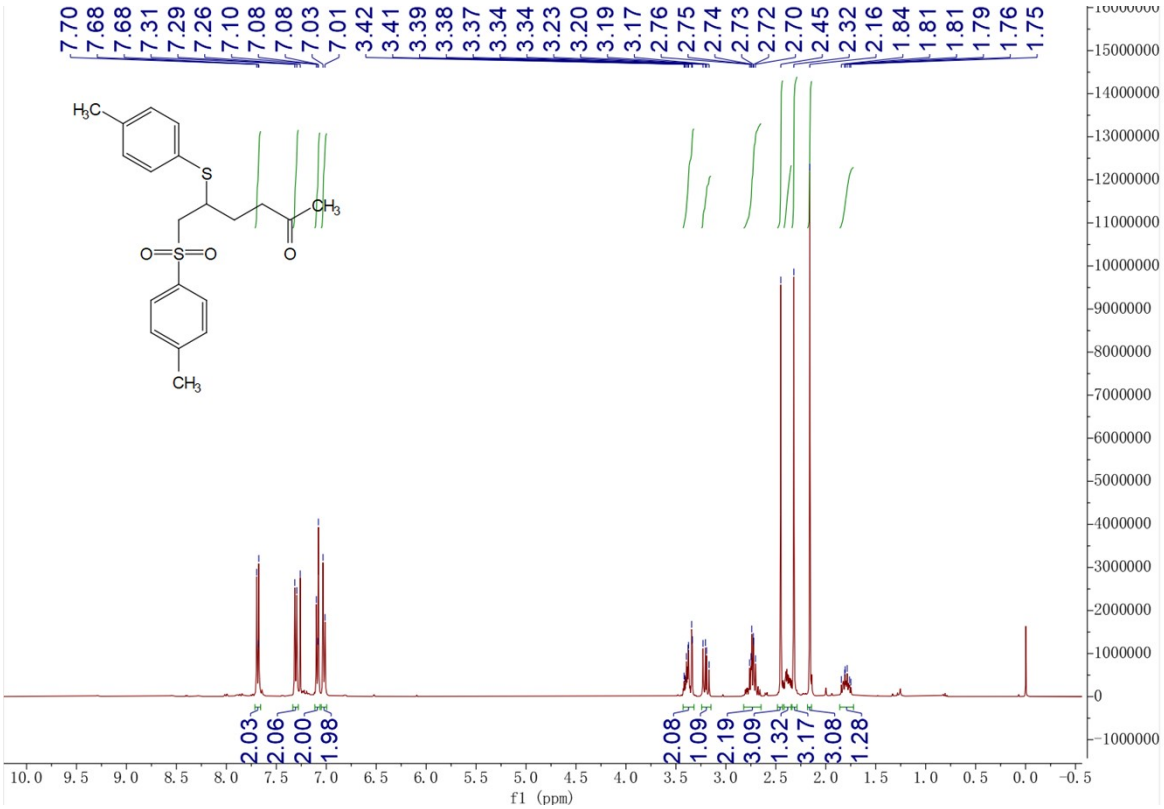
^{13}C NMR spectrum of **3g**



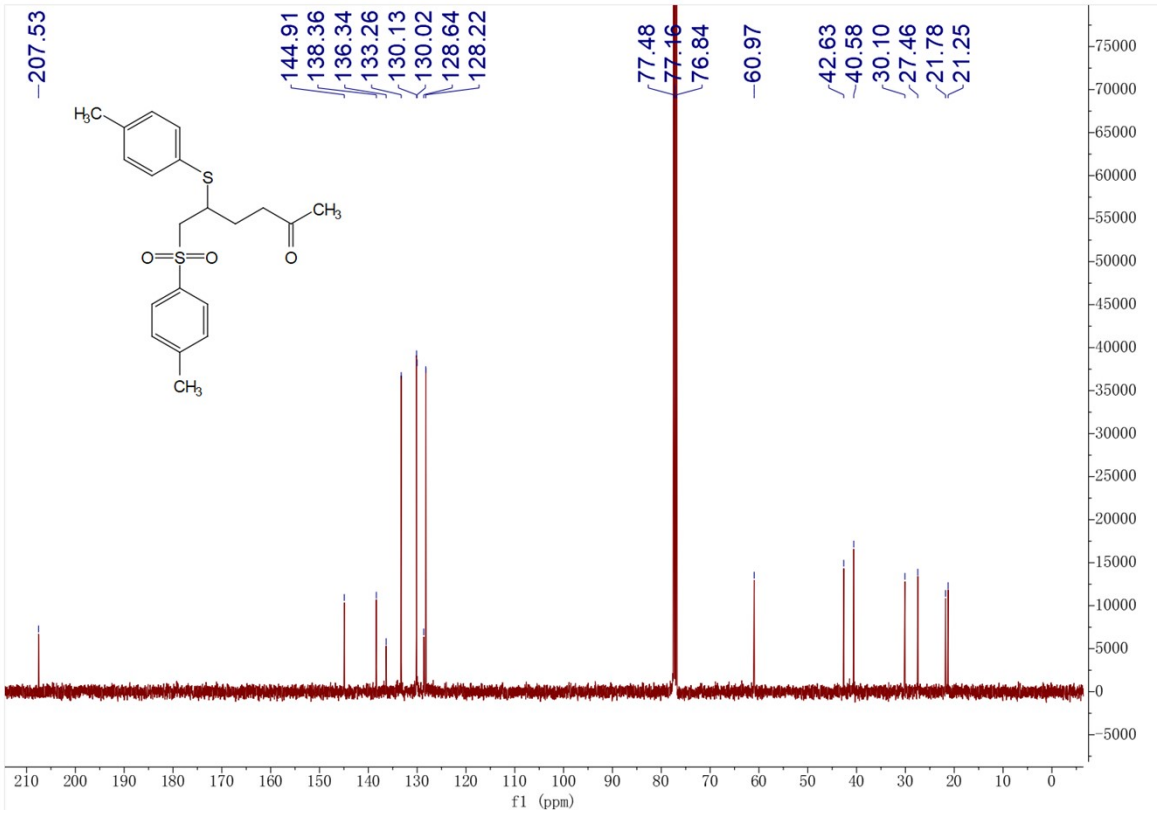
^{1}H NMR spectrum of **3h**



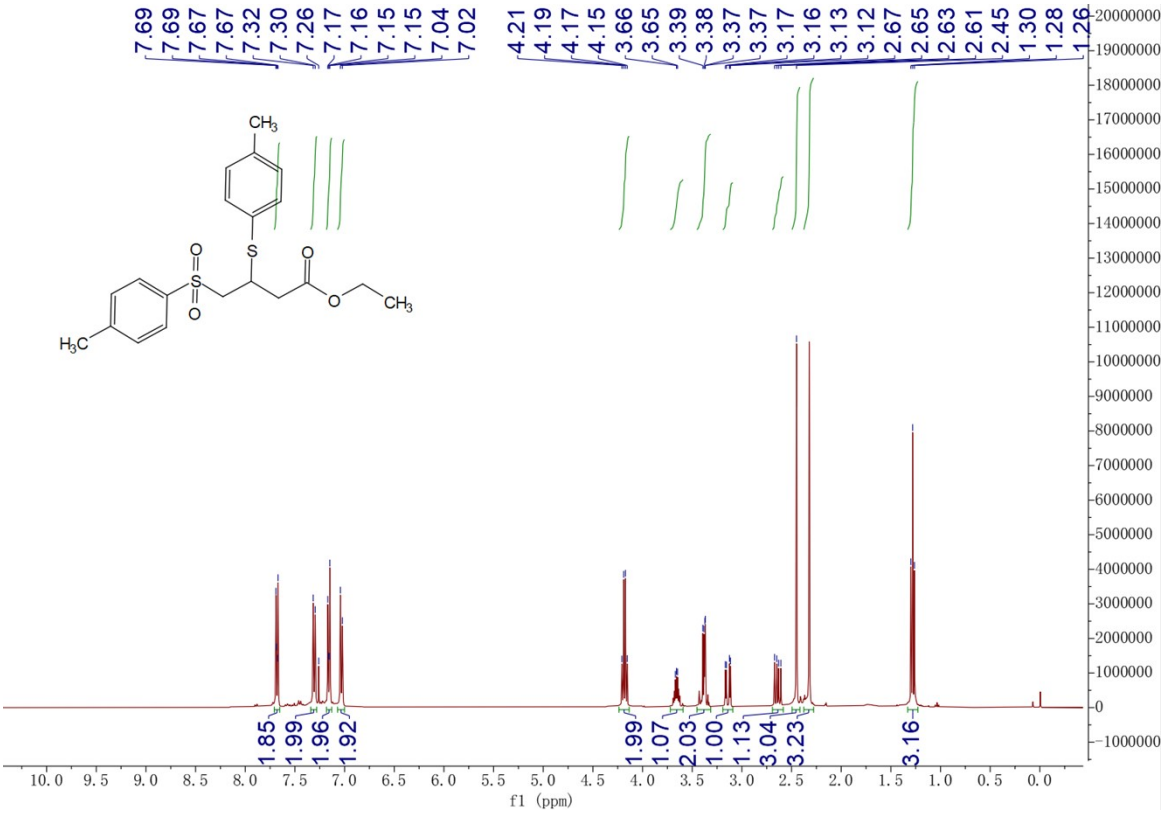
^{13}C NMR spectrum of **3h**



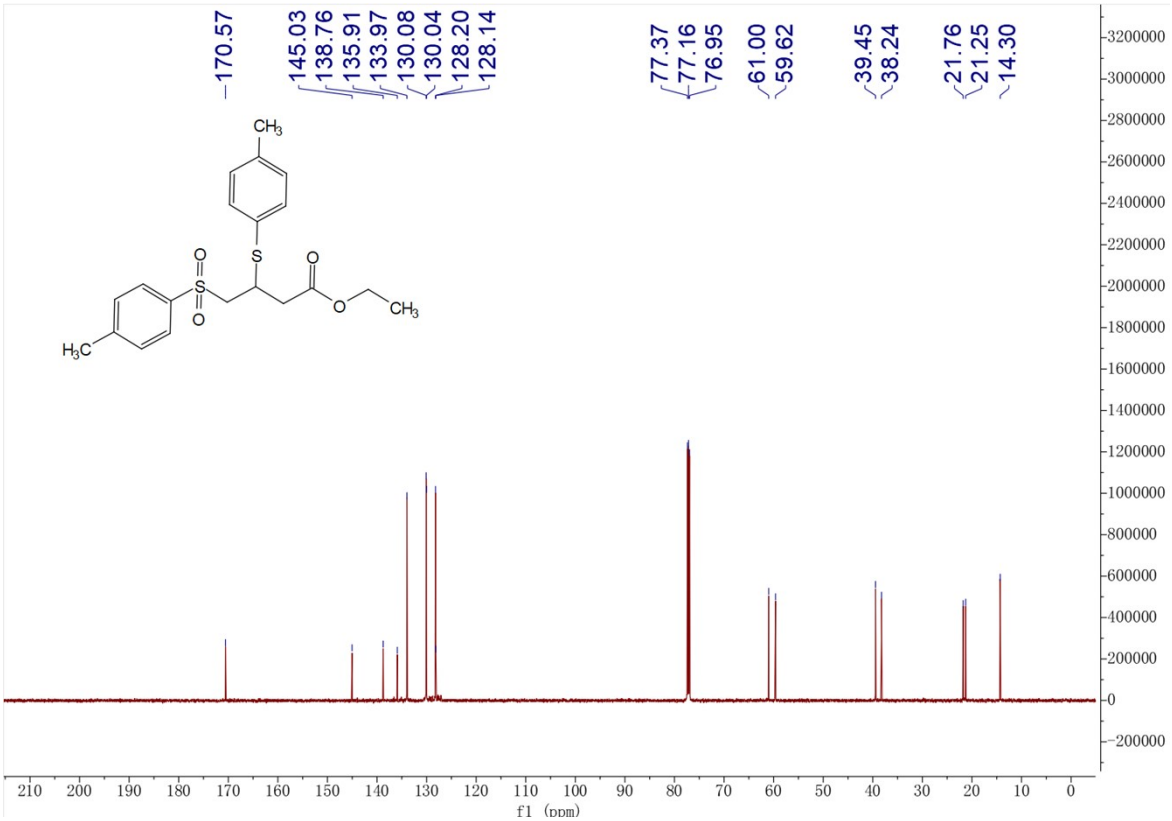
^{1}H NMR spectrum of **3i**



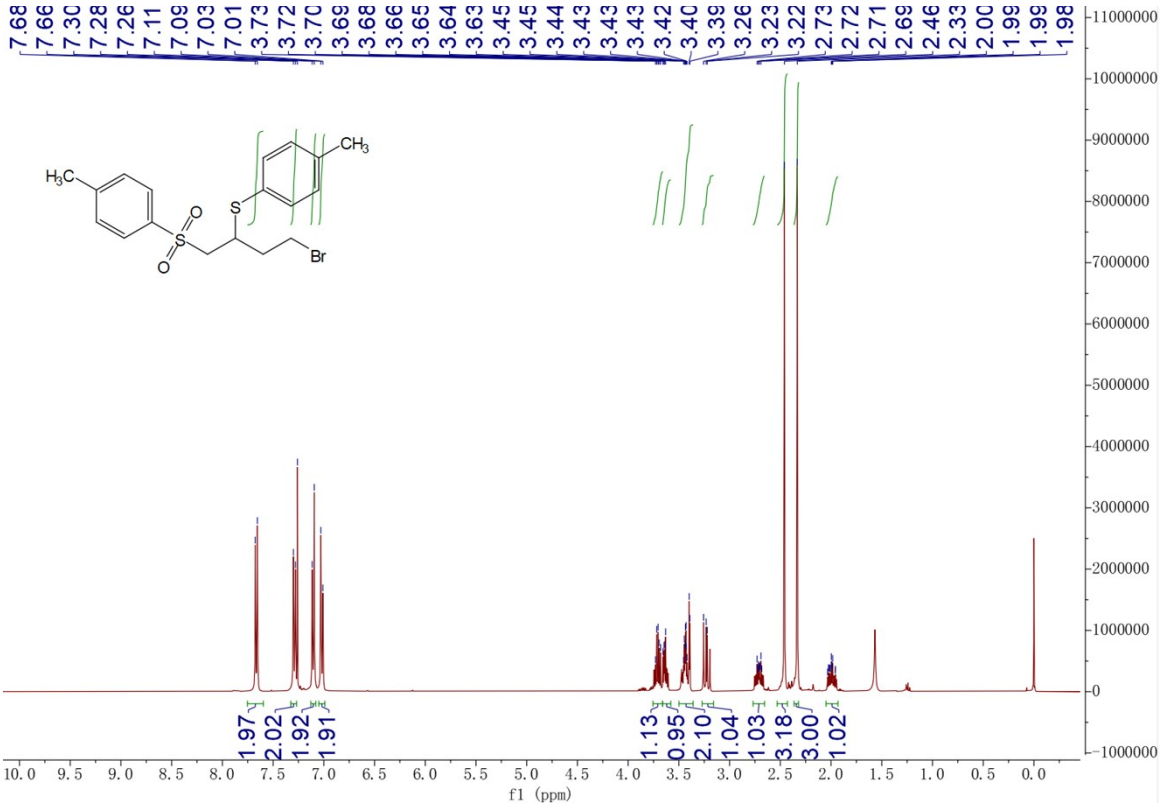
^{13}C NMR spectrum of **3i**



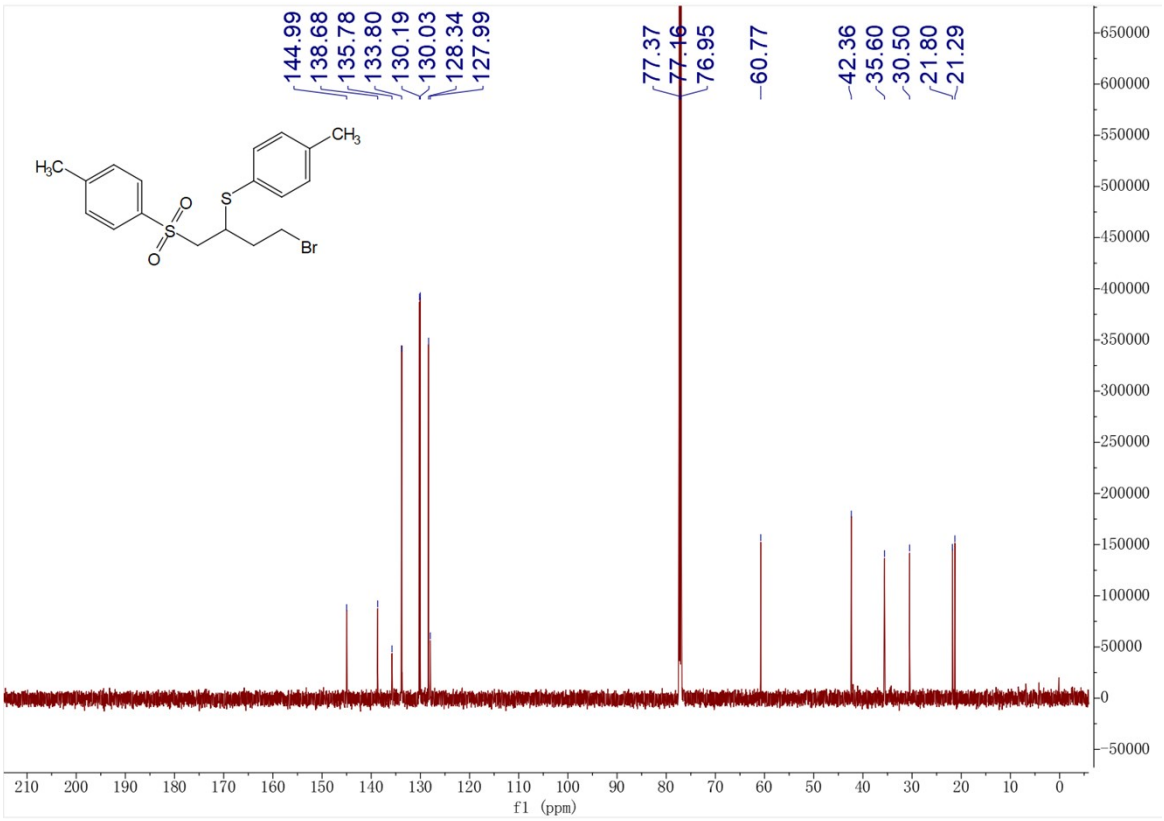
^{1}H NMR spectrum of **3j**



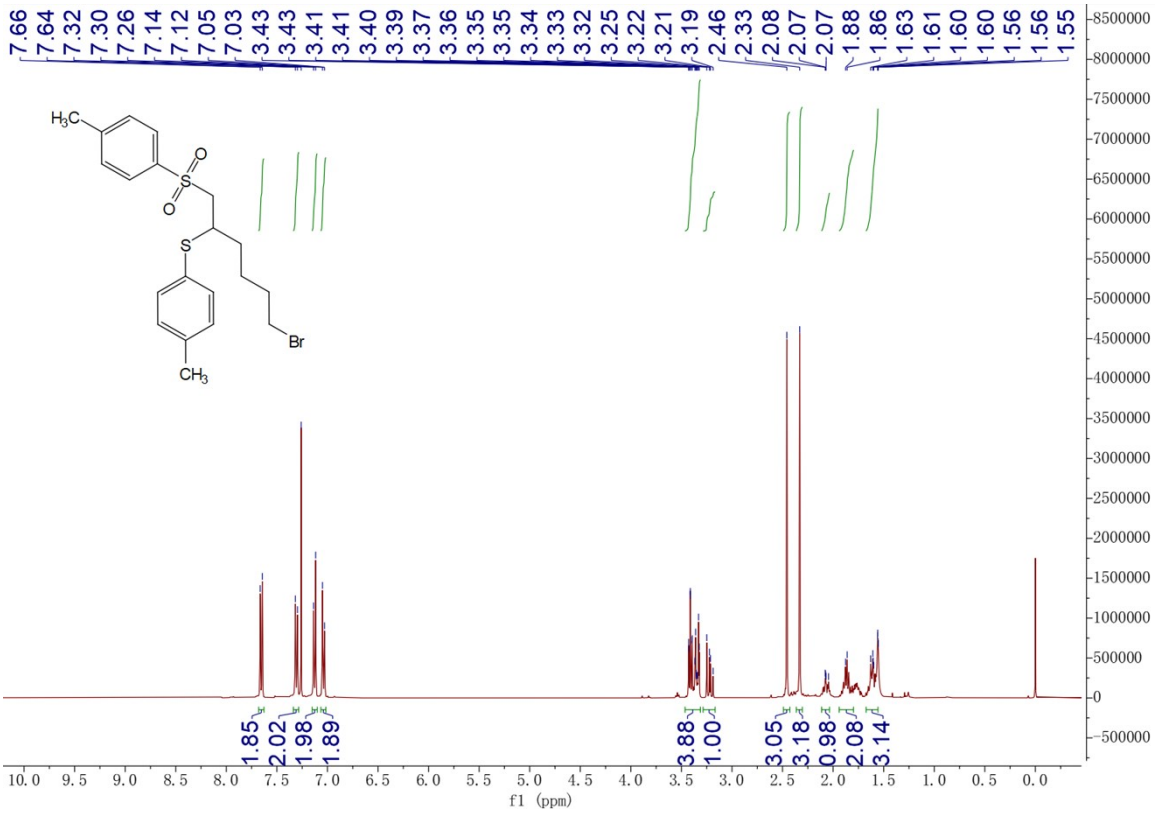
^{13}C NMR spectrum of **3j**



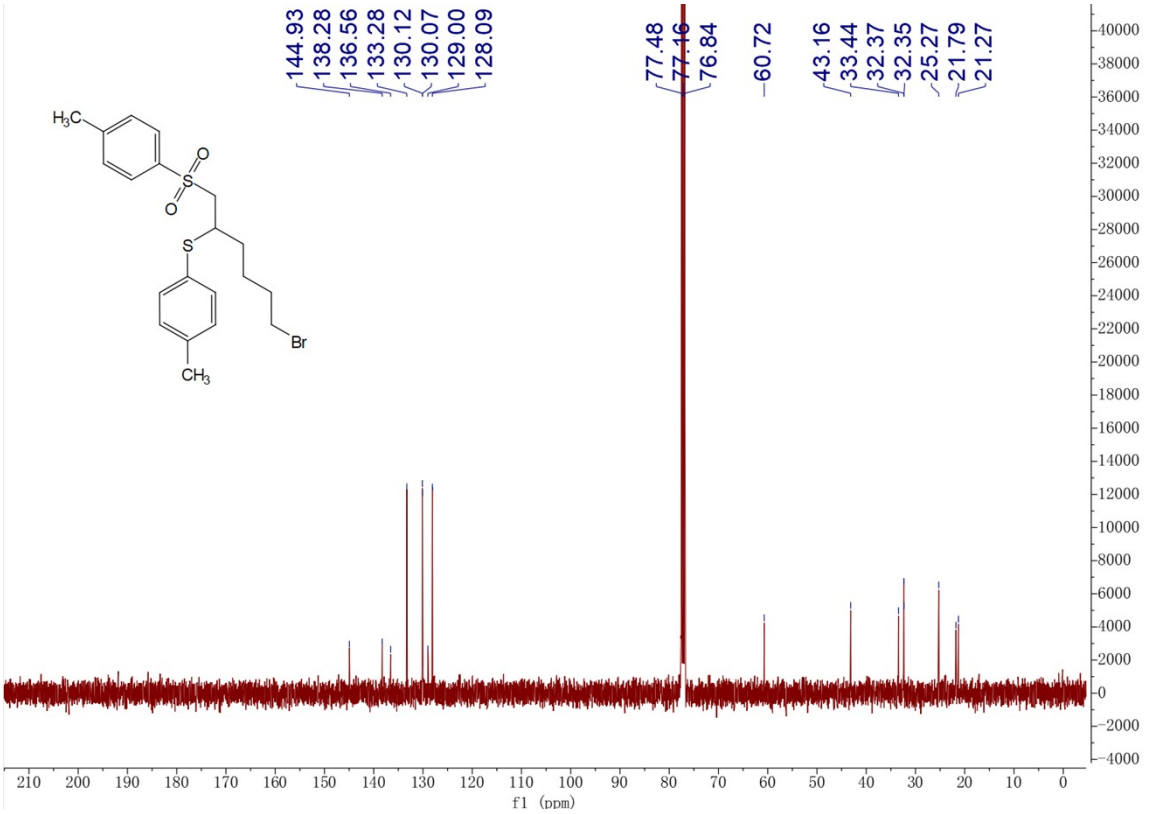
^{1}H NMR spectrum of **3k**



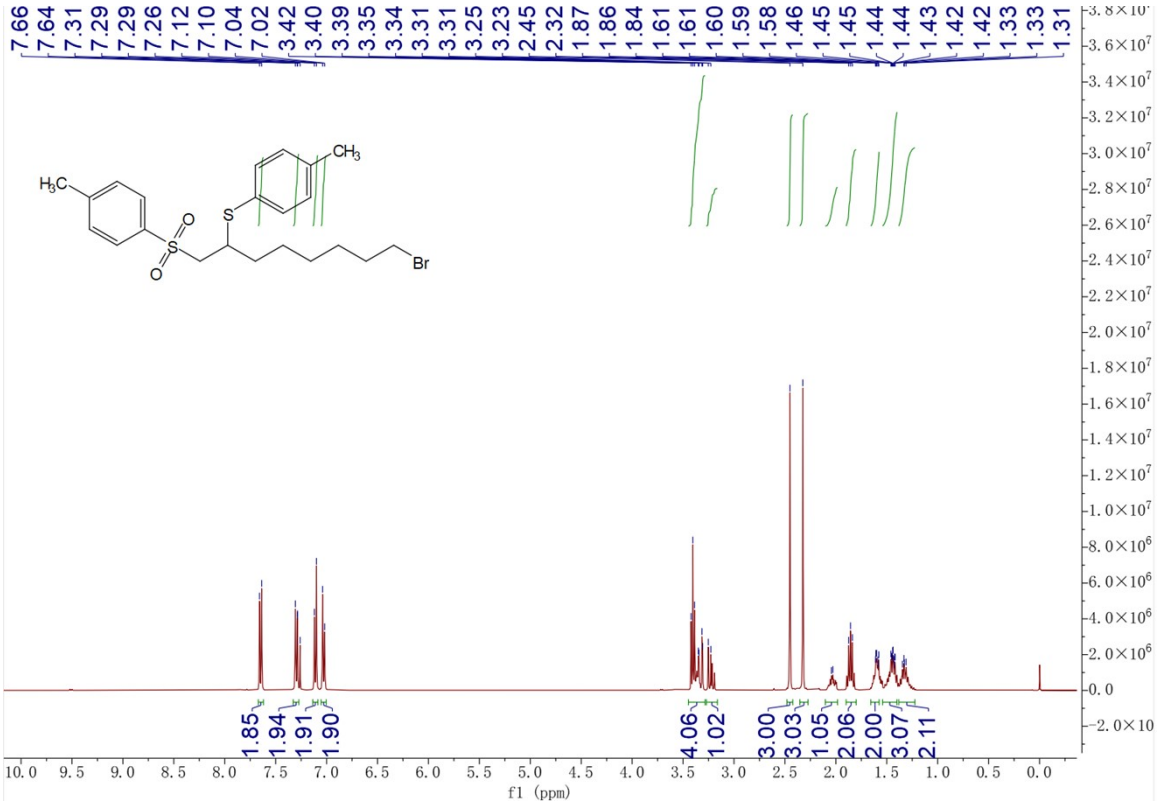
^{13}C NMR spectrum of **3k**



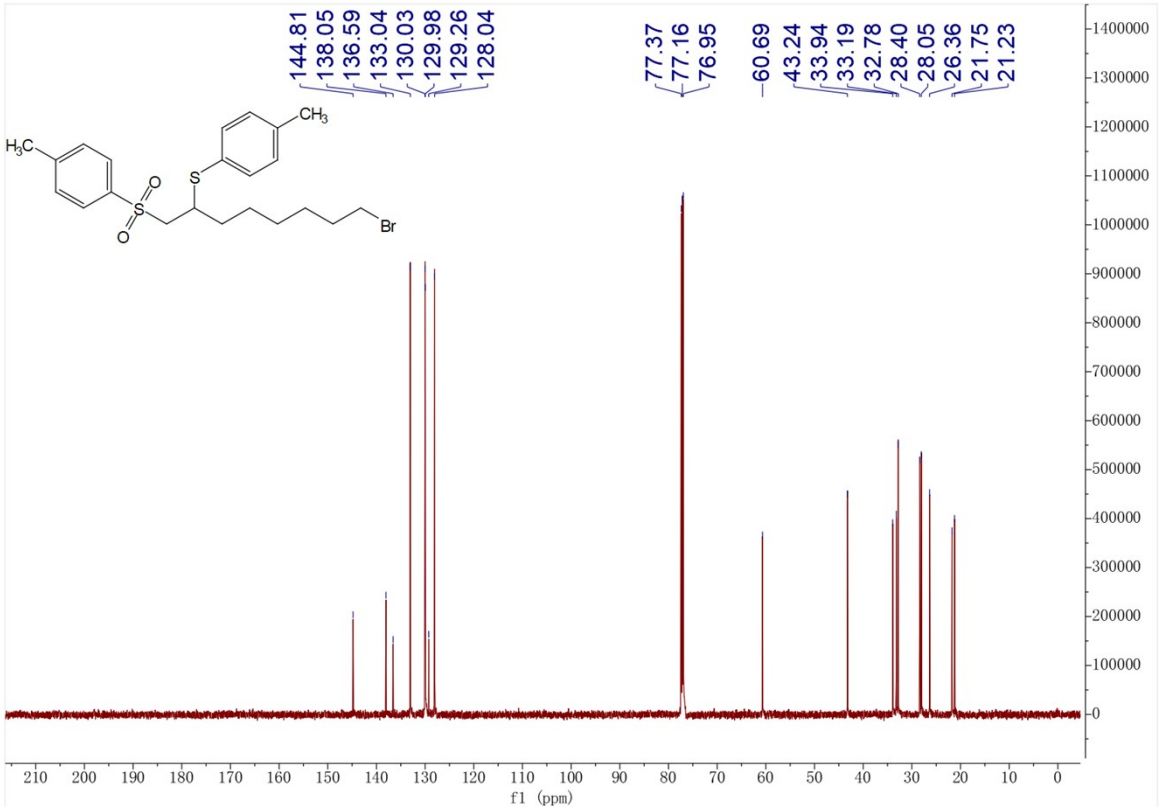
^{1}H NMR spectrum of **3l**



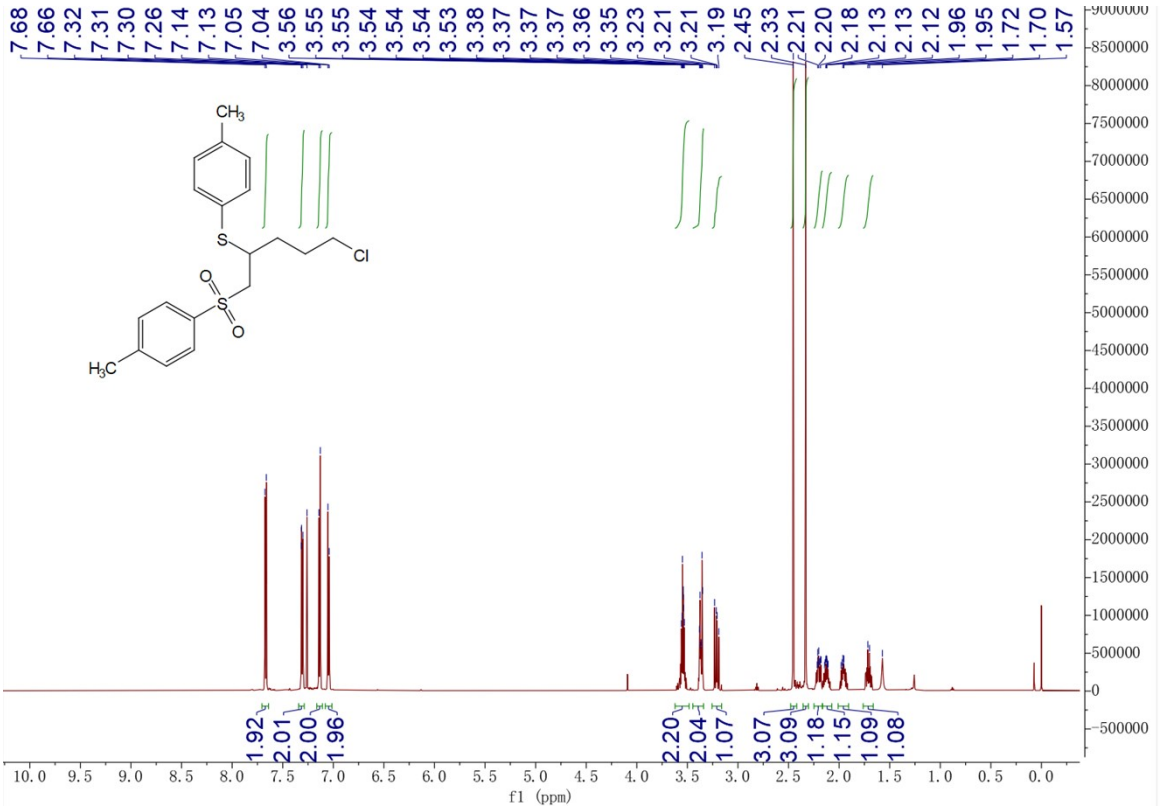
^{13}C NMR spectrum of **3l**



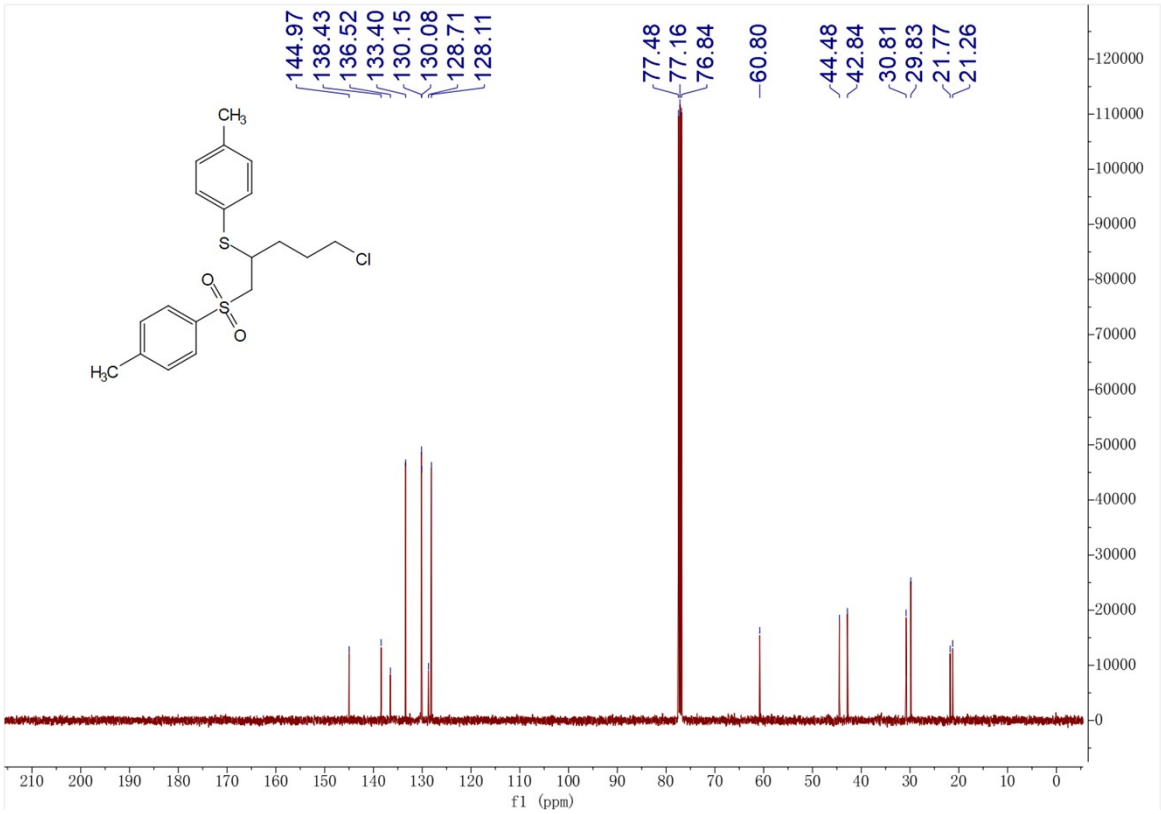
^{1}H NMR spectrum of **3m**



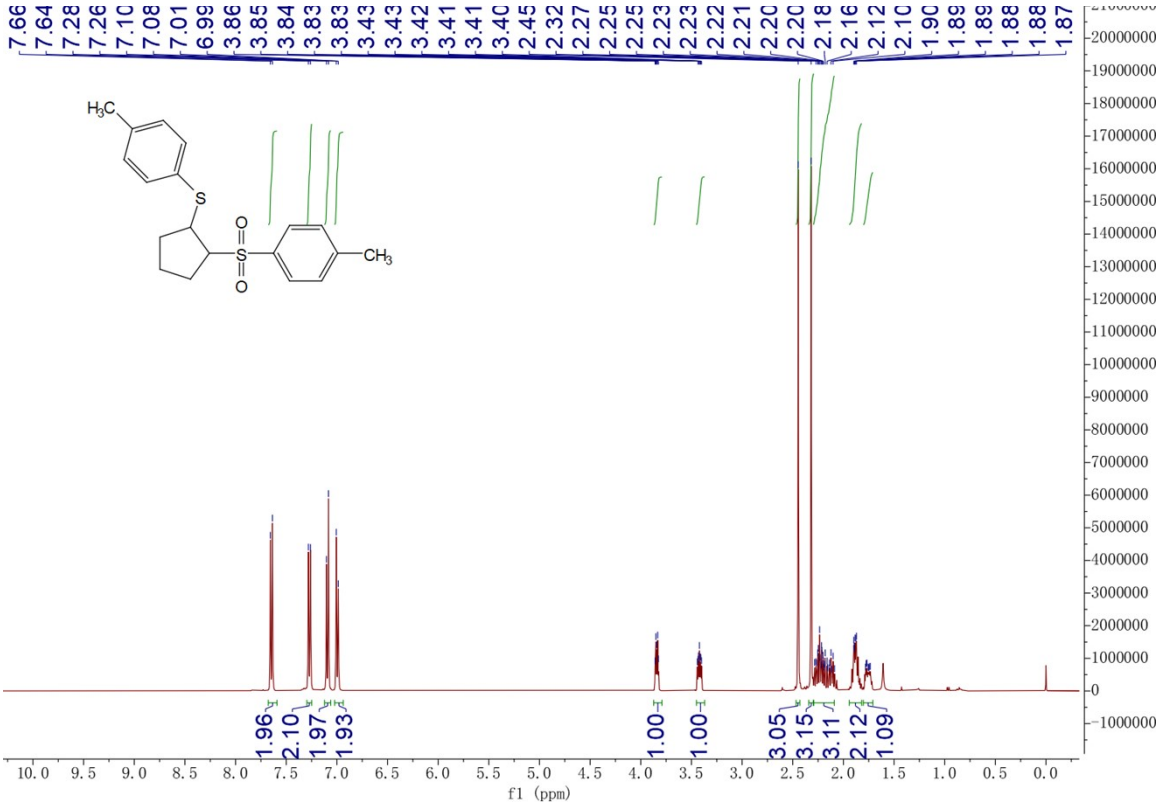
^{13}C NMR spectrum of **3m**



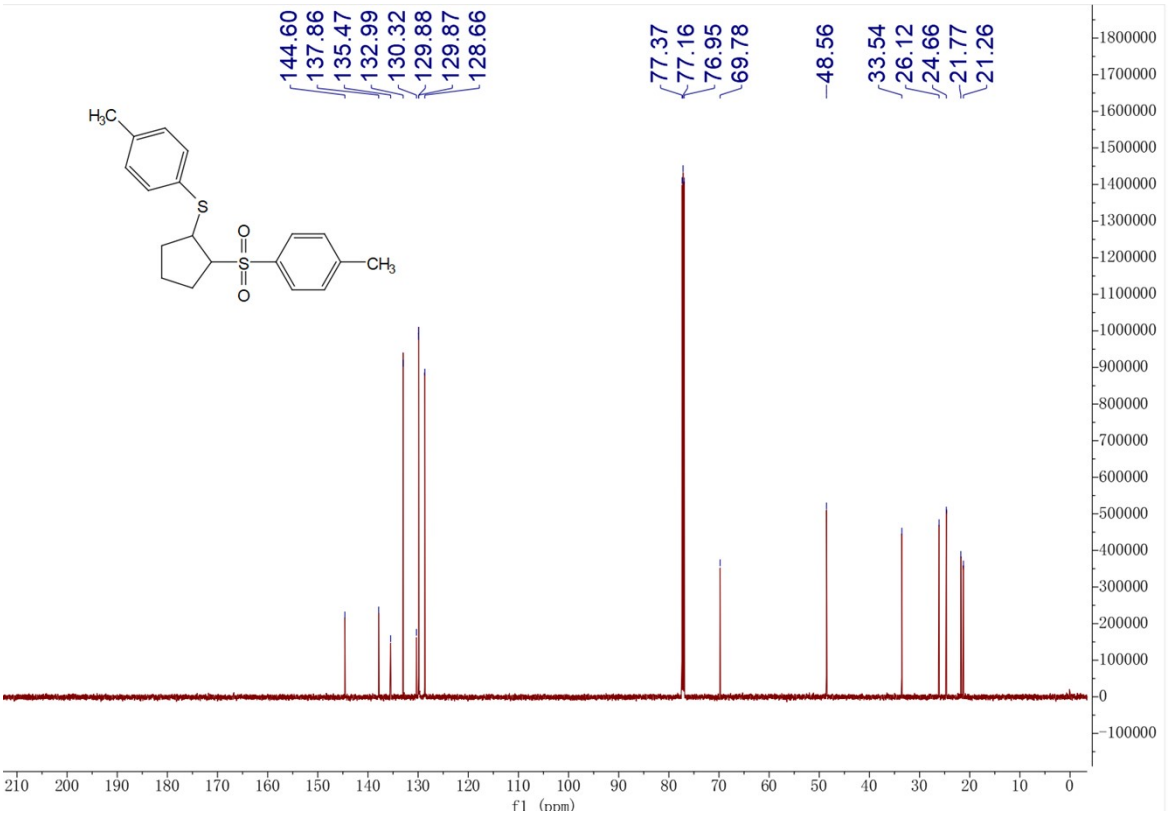
^{1}H NMR spectrum of **3n**



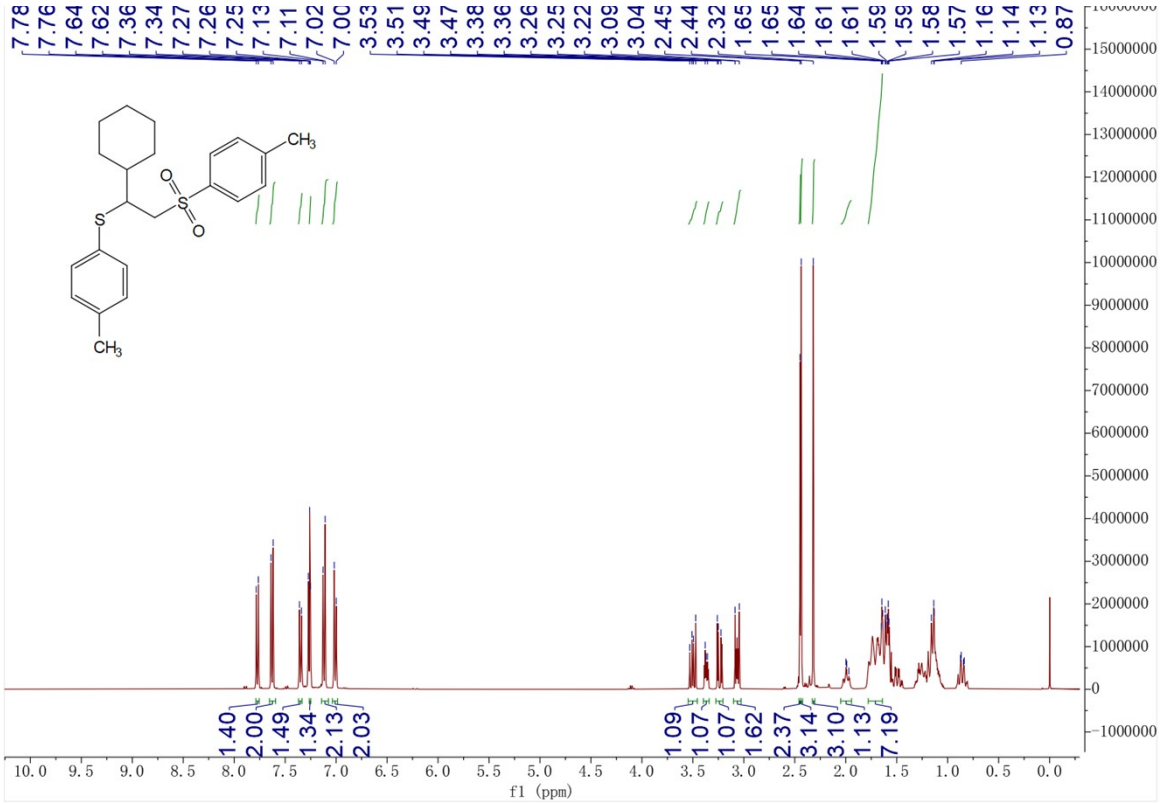
^{13}C NMR spectrum of **3n**



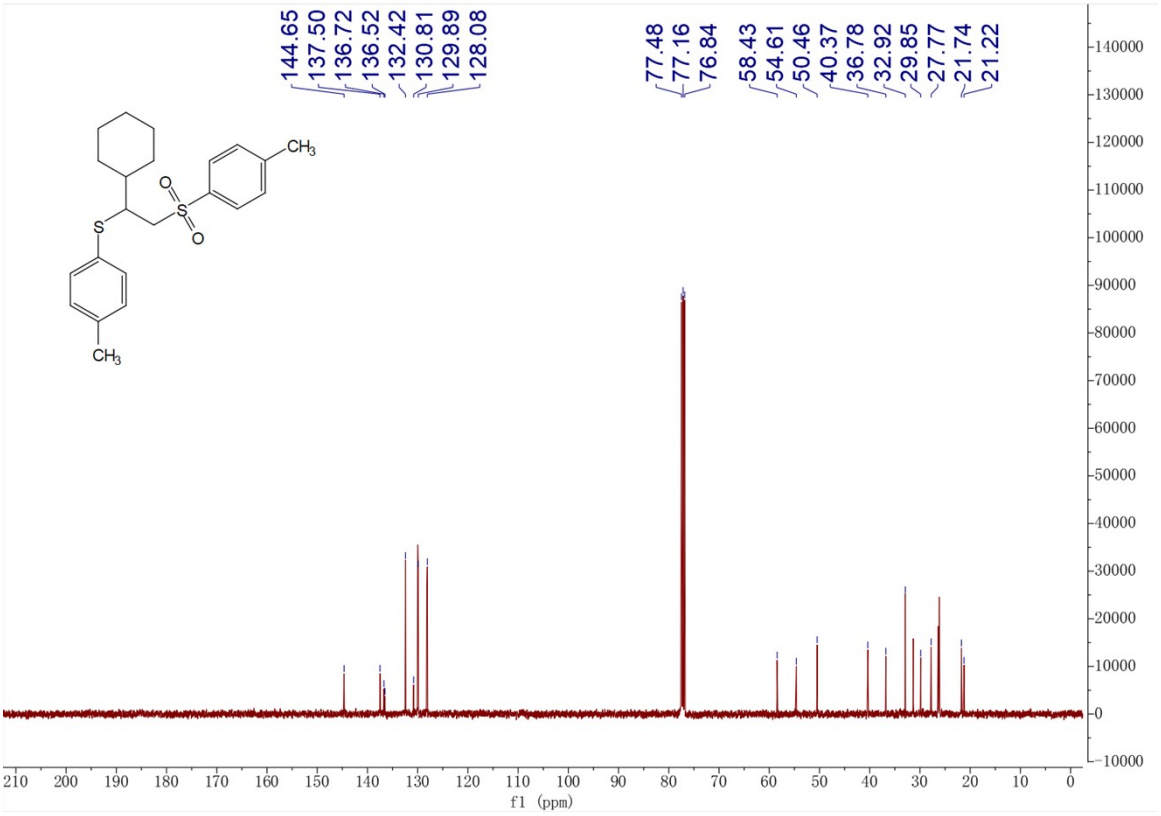
^{1}H NMR spectrum of **3o**



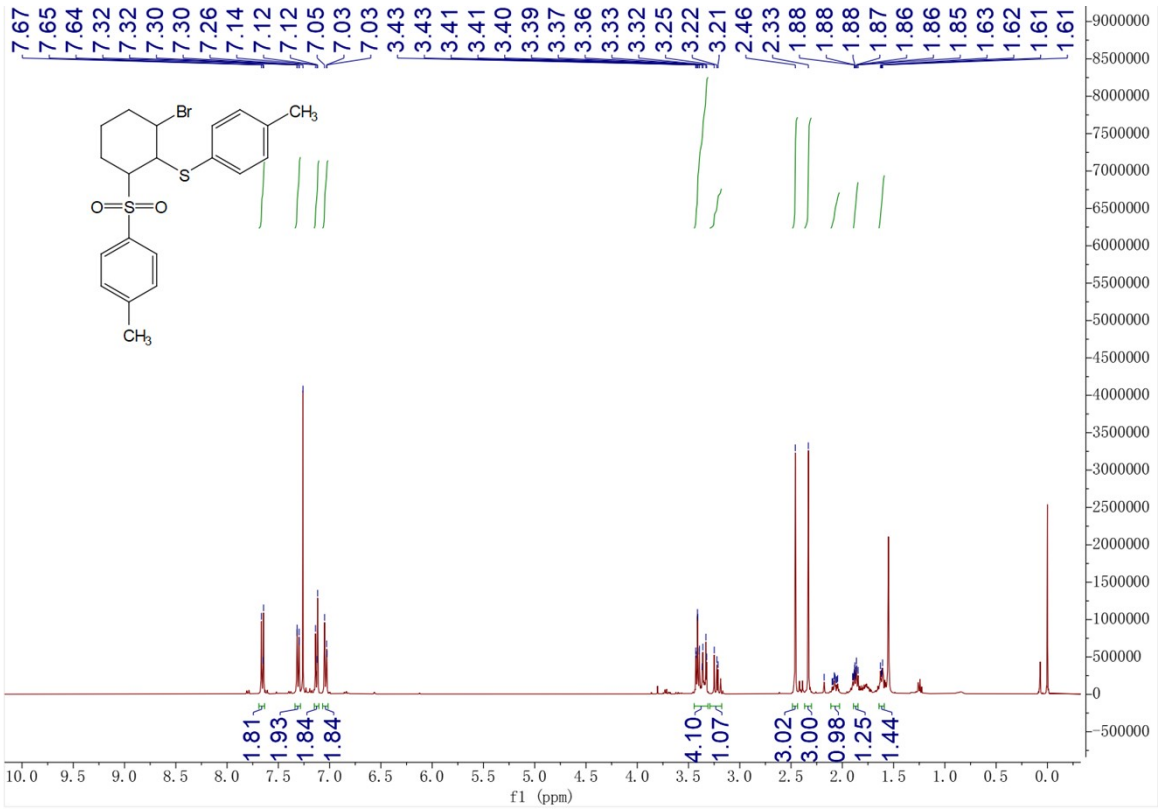
^{13}C NMR spectrum of **3o**



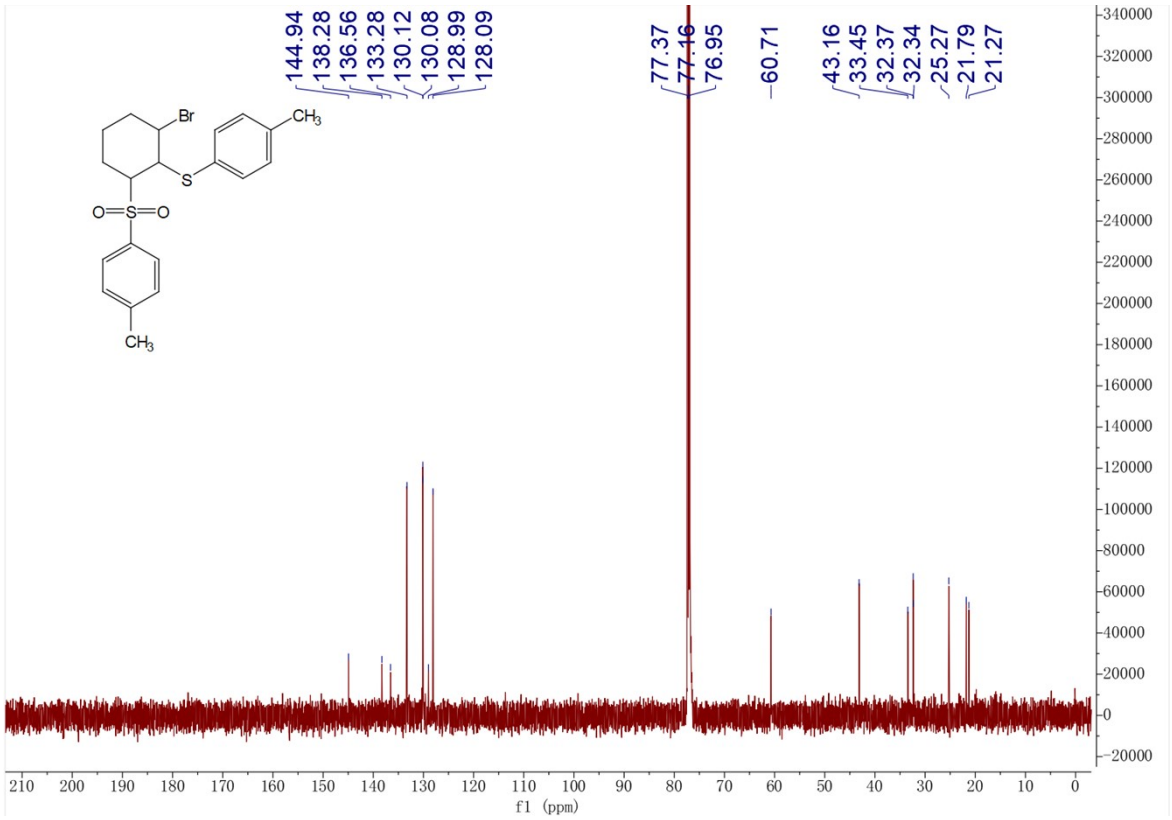
^{1}H NMR spectrum of **3p**



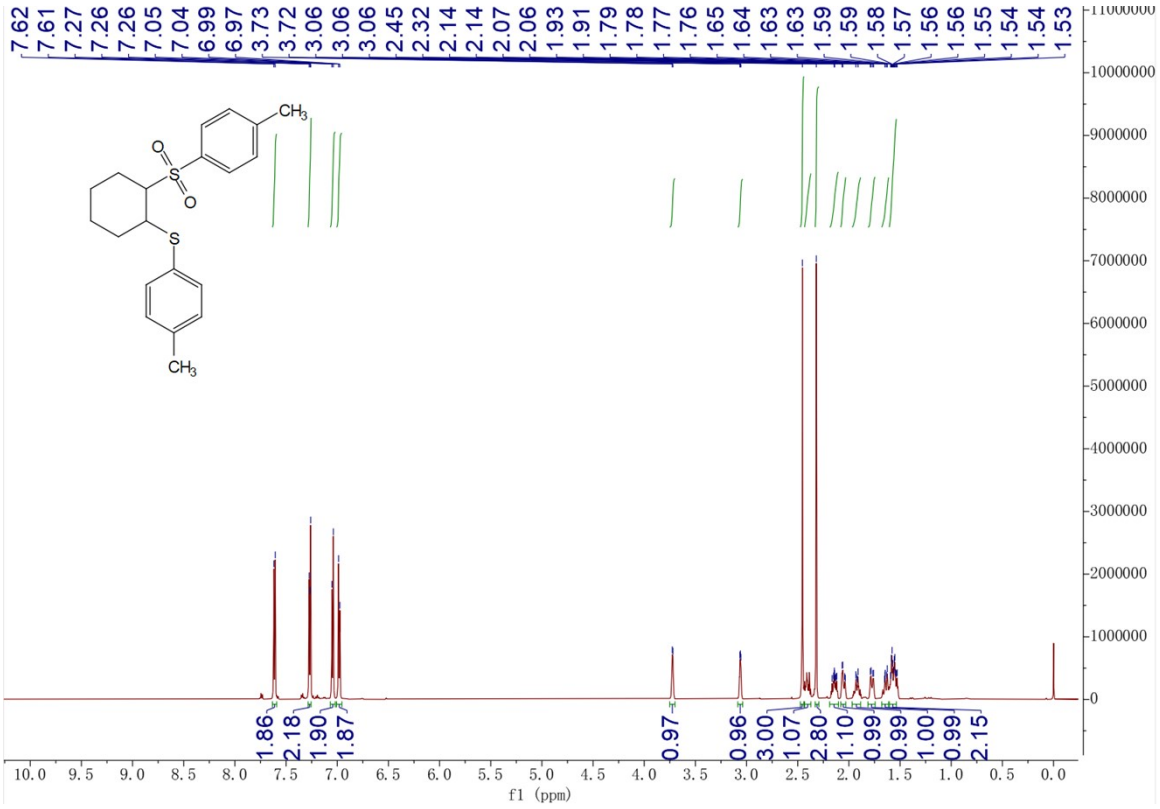
^{13}C NMR spectrum of **3p**



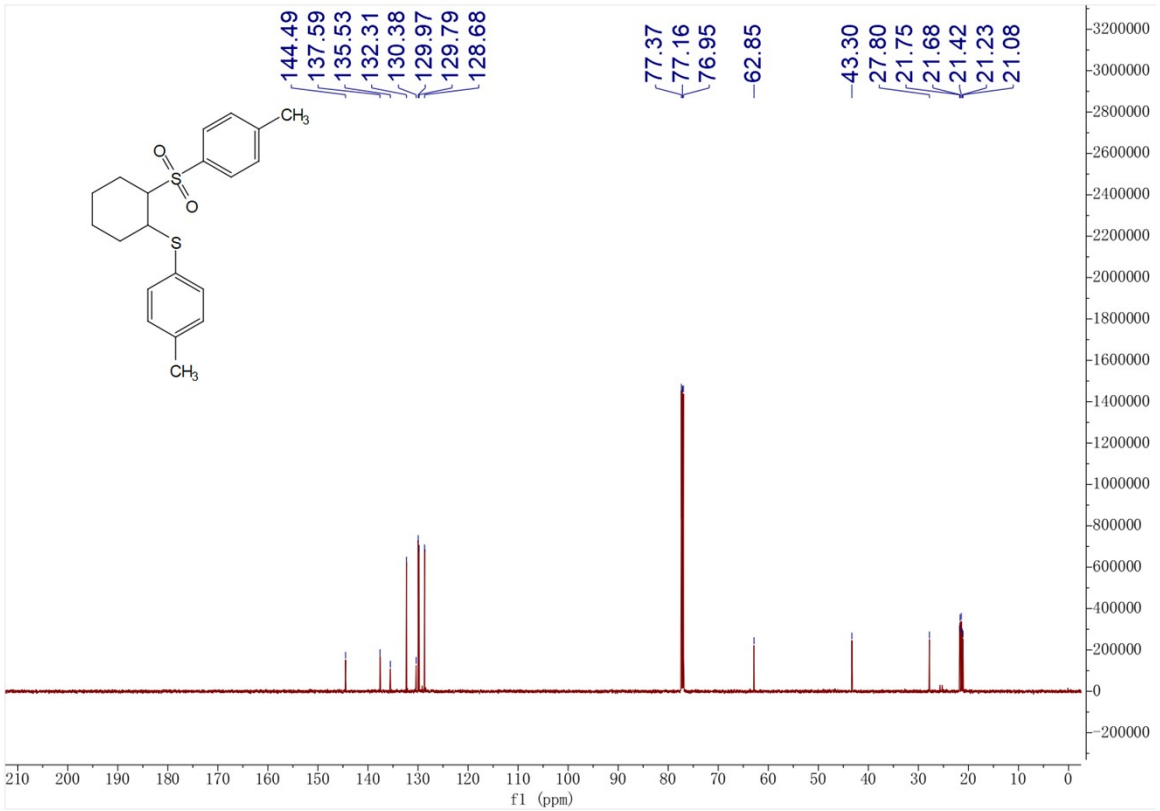
^{1}H NMR spectrum of **3q**



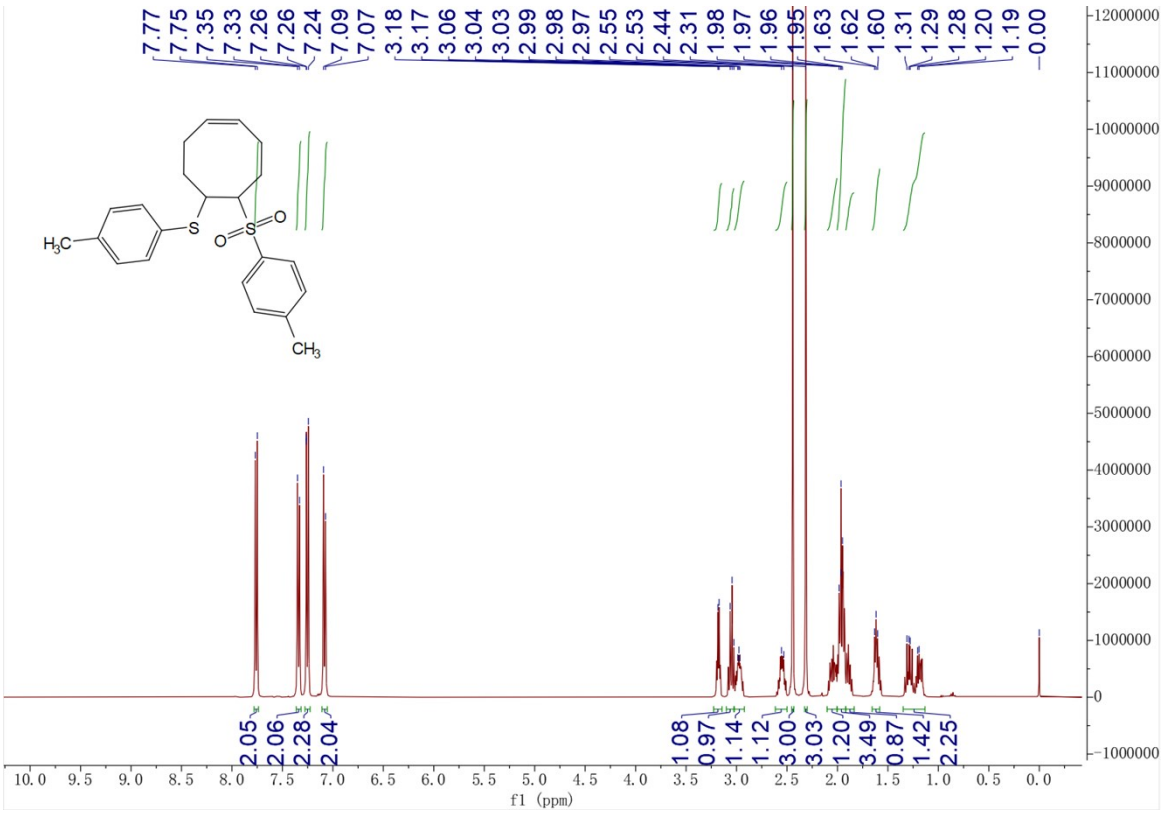
^{13}C NMR spectrum of **3q**



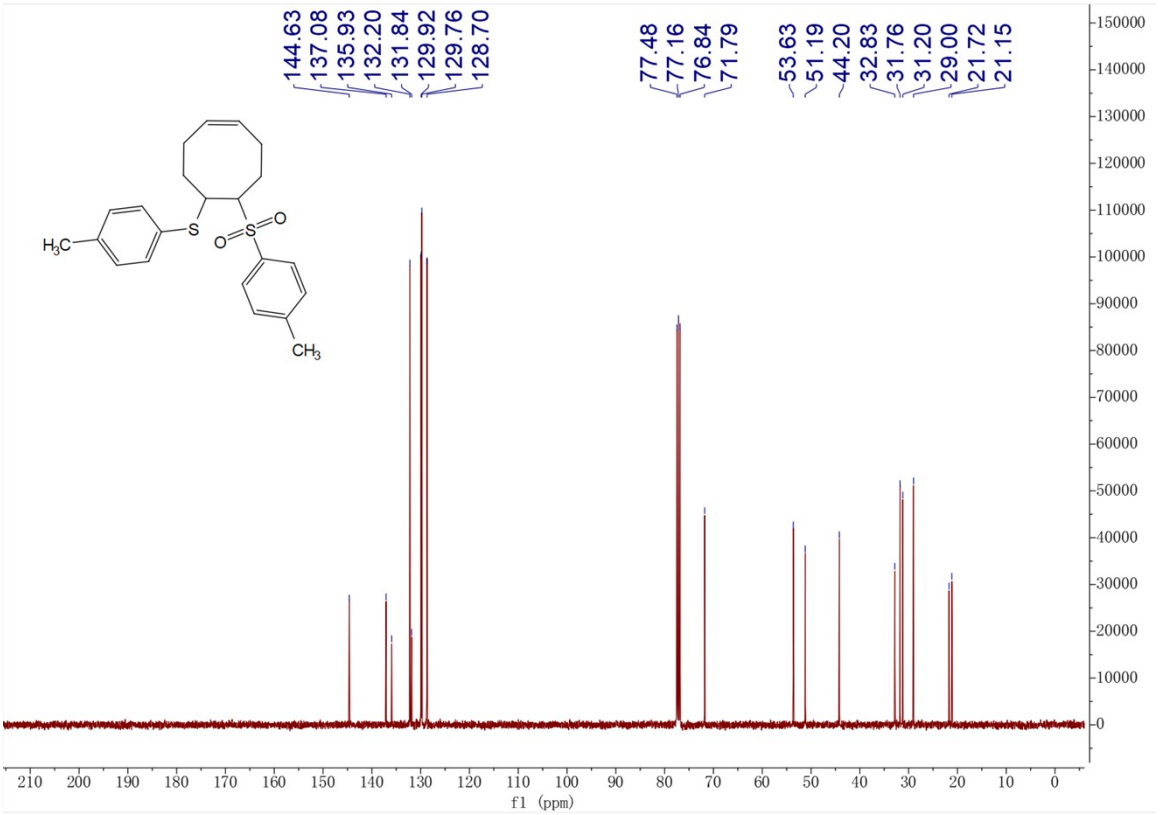
^{1}H NMR spectrum of **3r**



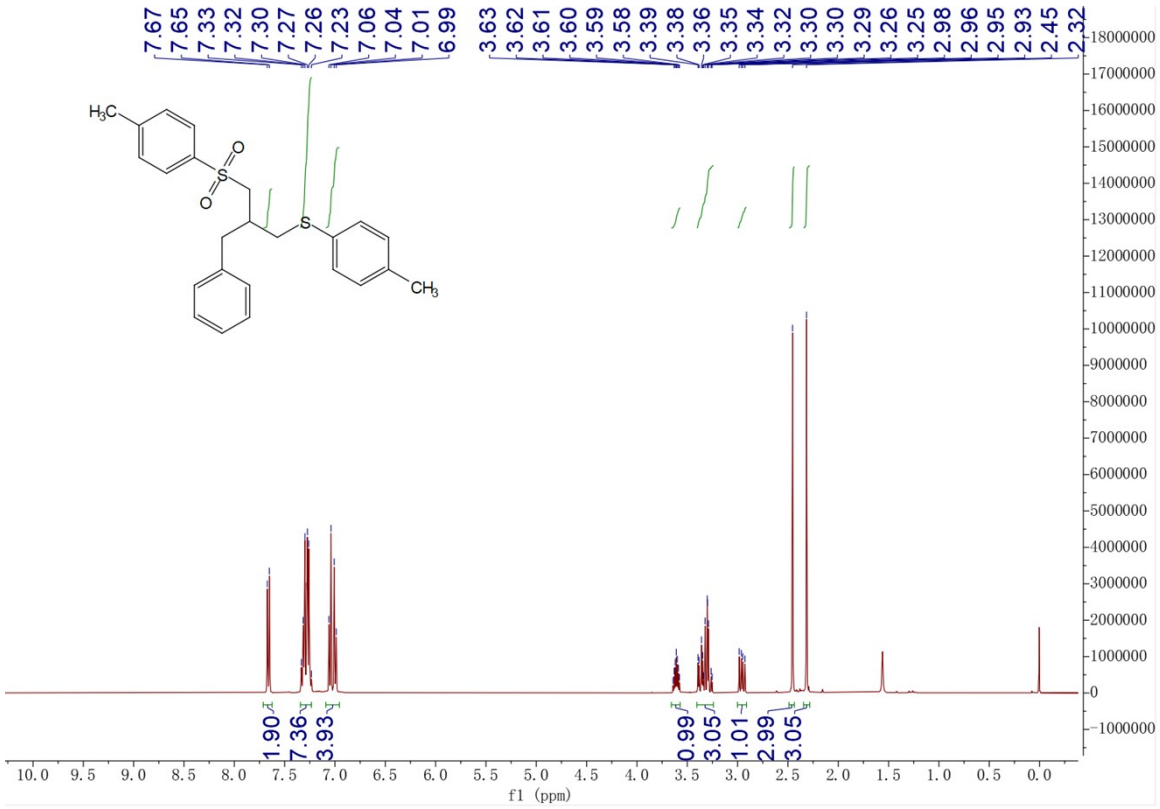
^{13}C NMR spectrum of **3r**



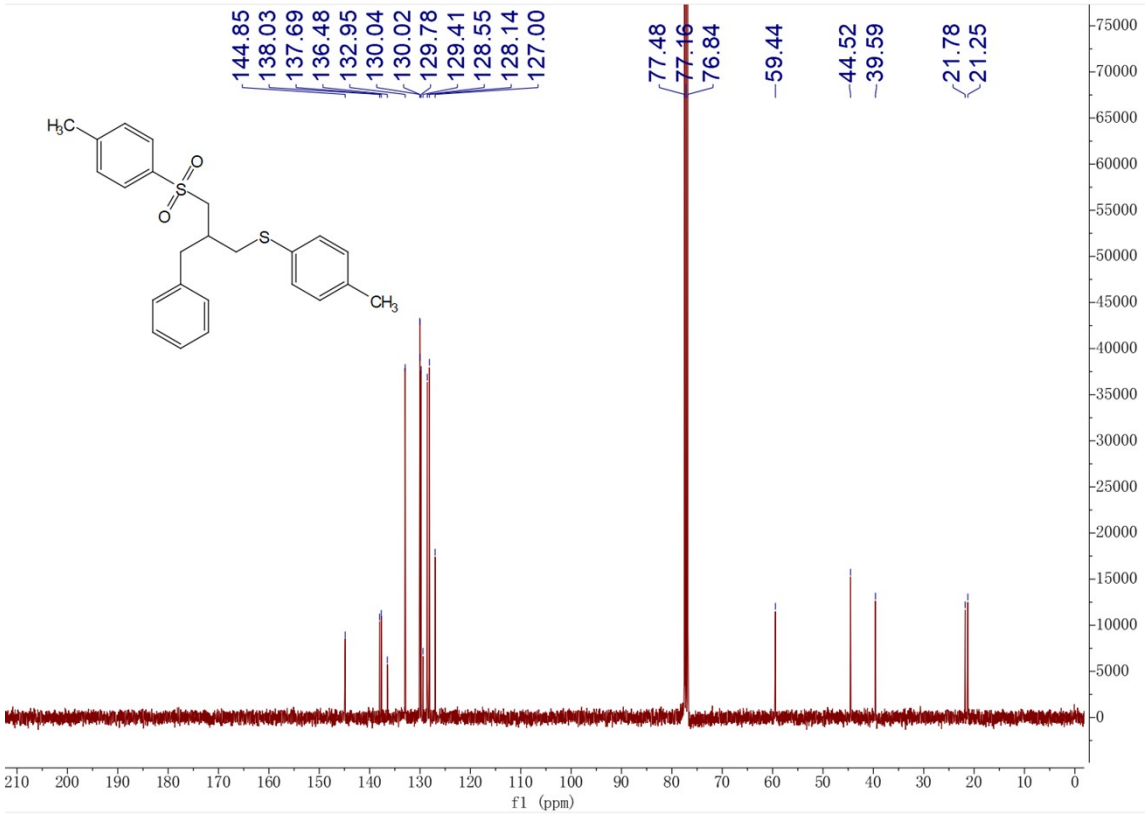
^{1}H NMR spectrum of **3s**



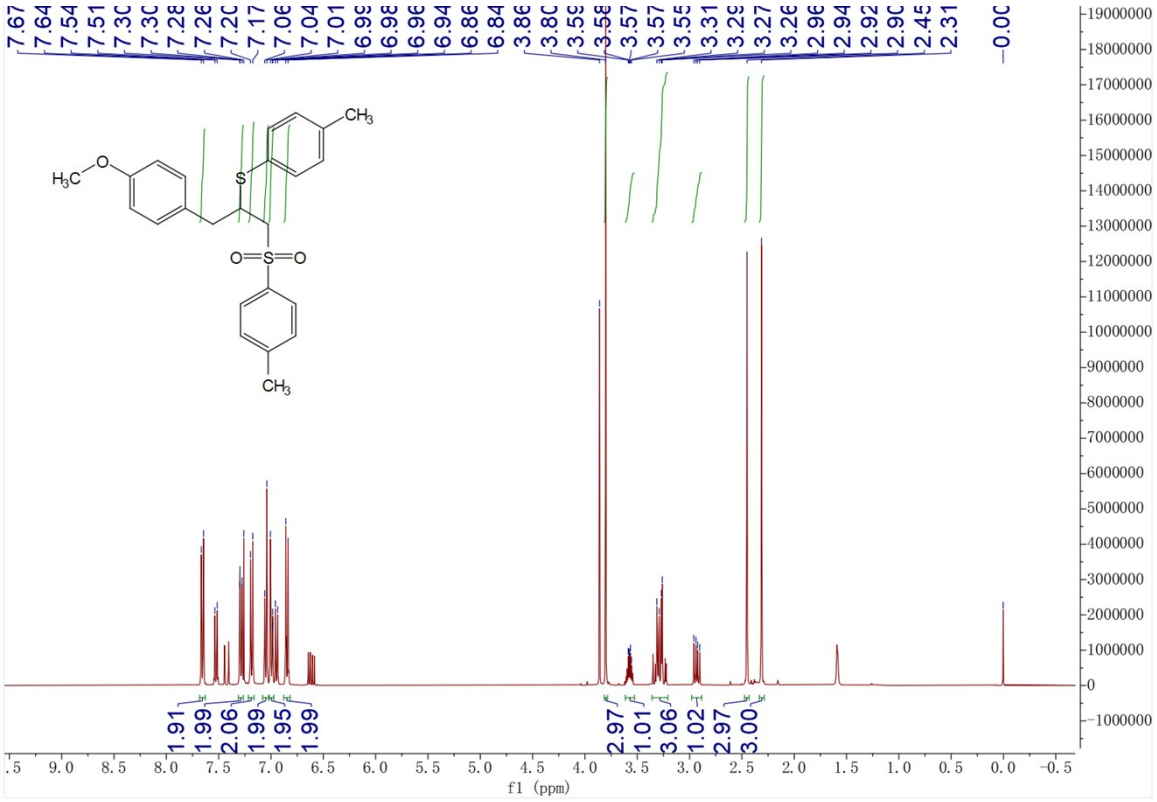
^{13}C NMR spectrum of **3s**



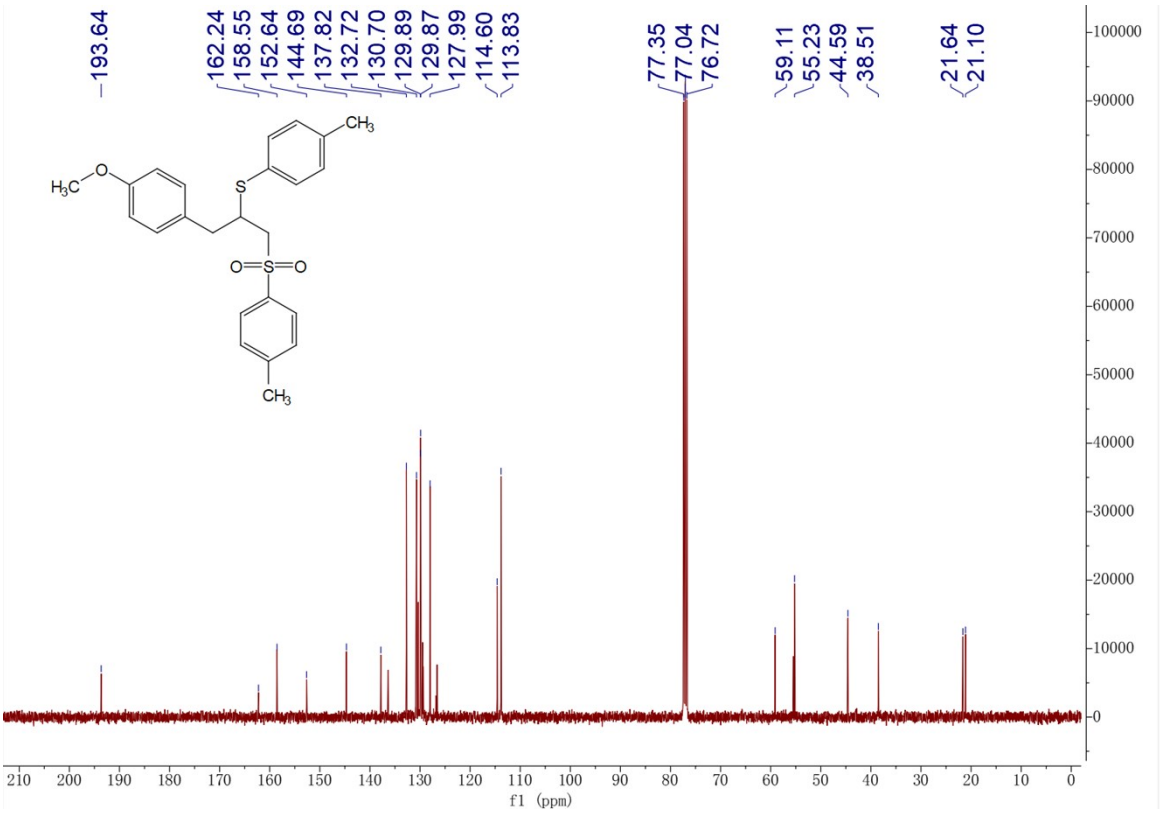
^{1}H NMR spectrum of **3t**



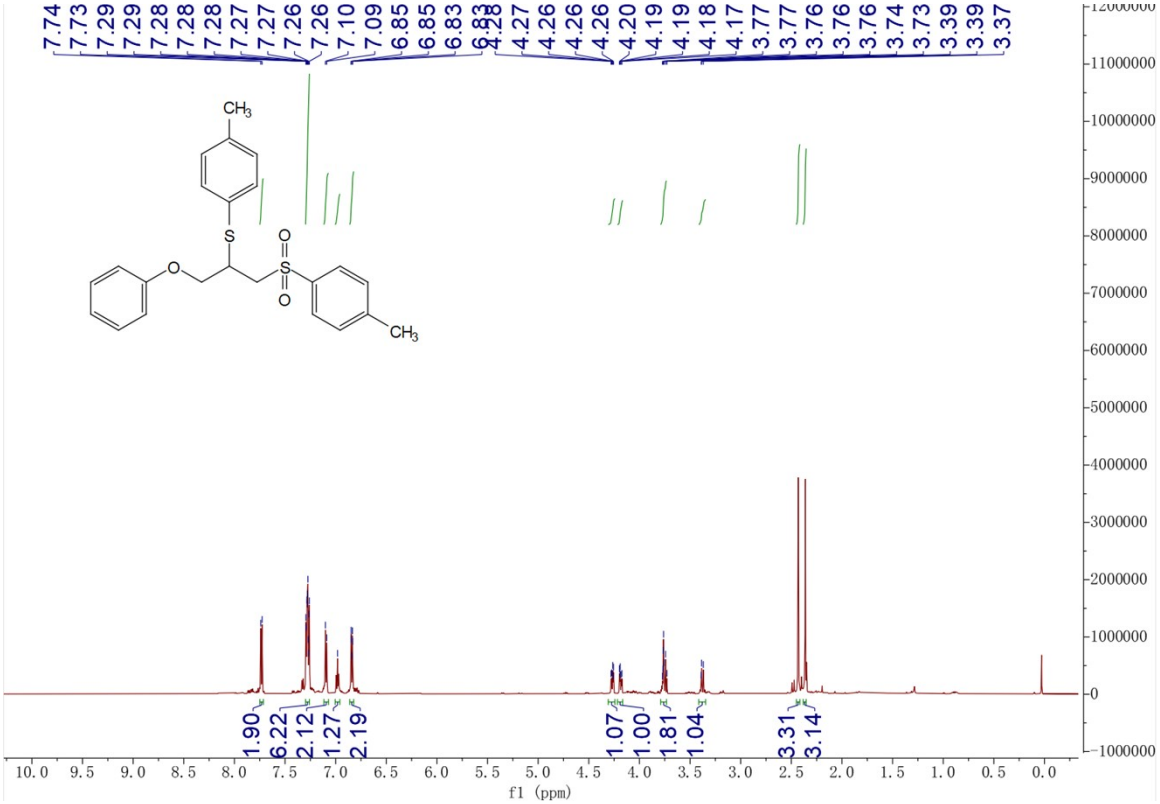
^{13}C NMR spectrum of **3t**



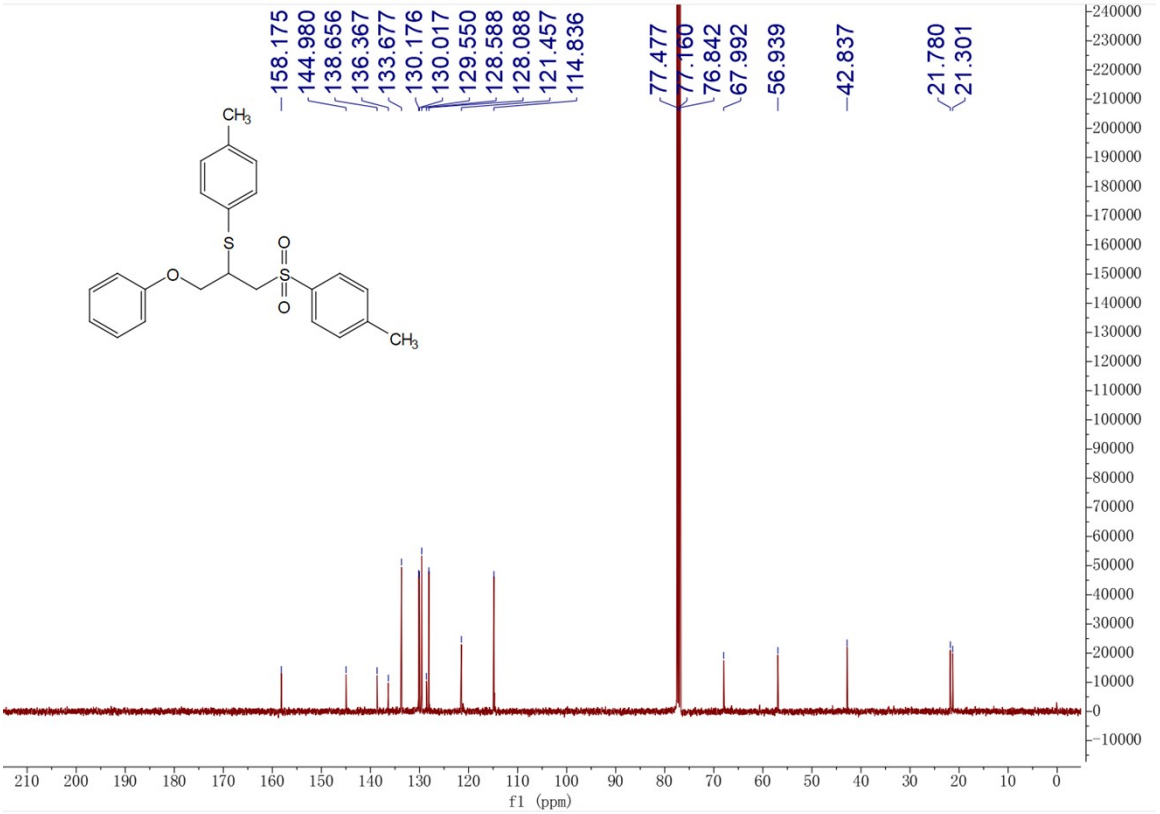
^{1}H NMR spectrum of **3u**



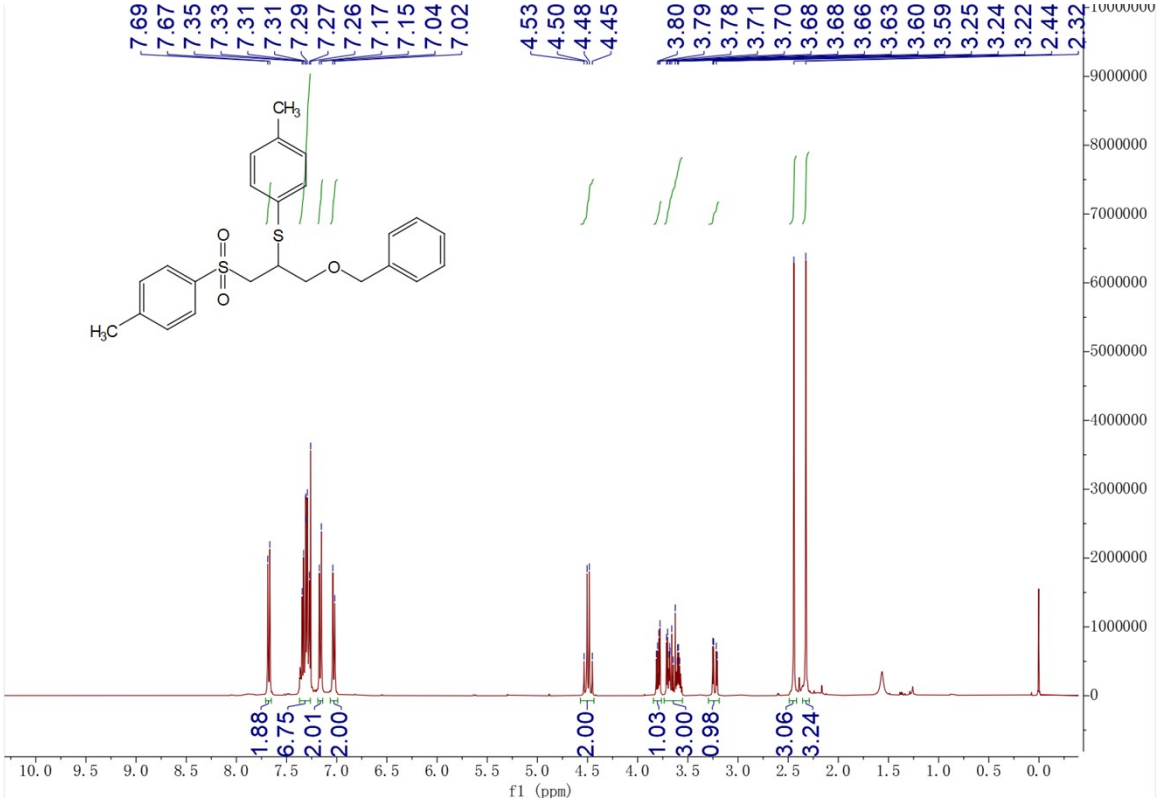
^{13}C NMR spectrum of **3u**



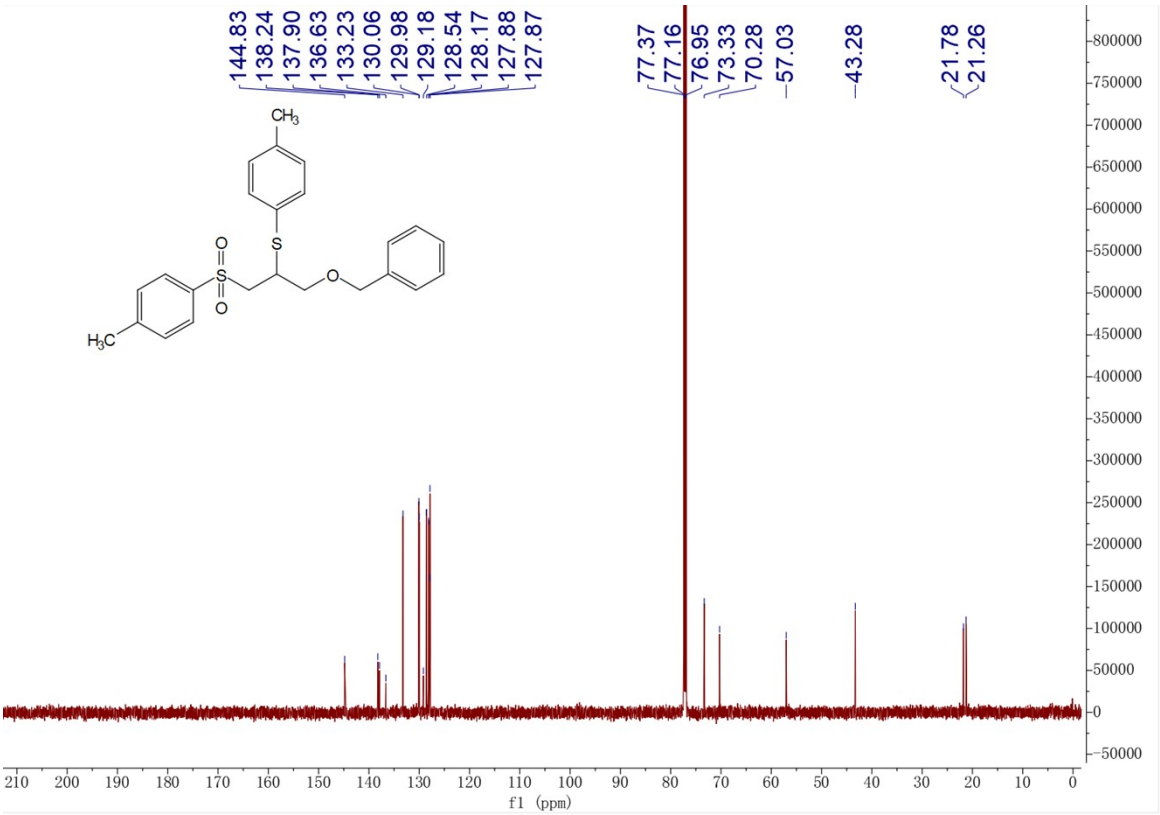
^{1}H NMR spectrum of **3v**



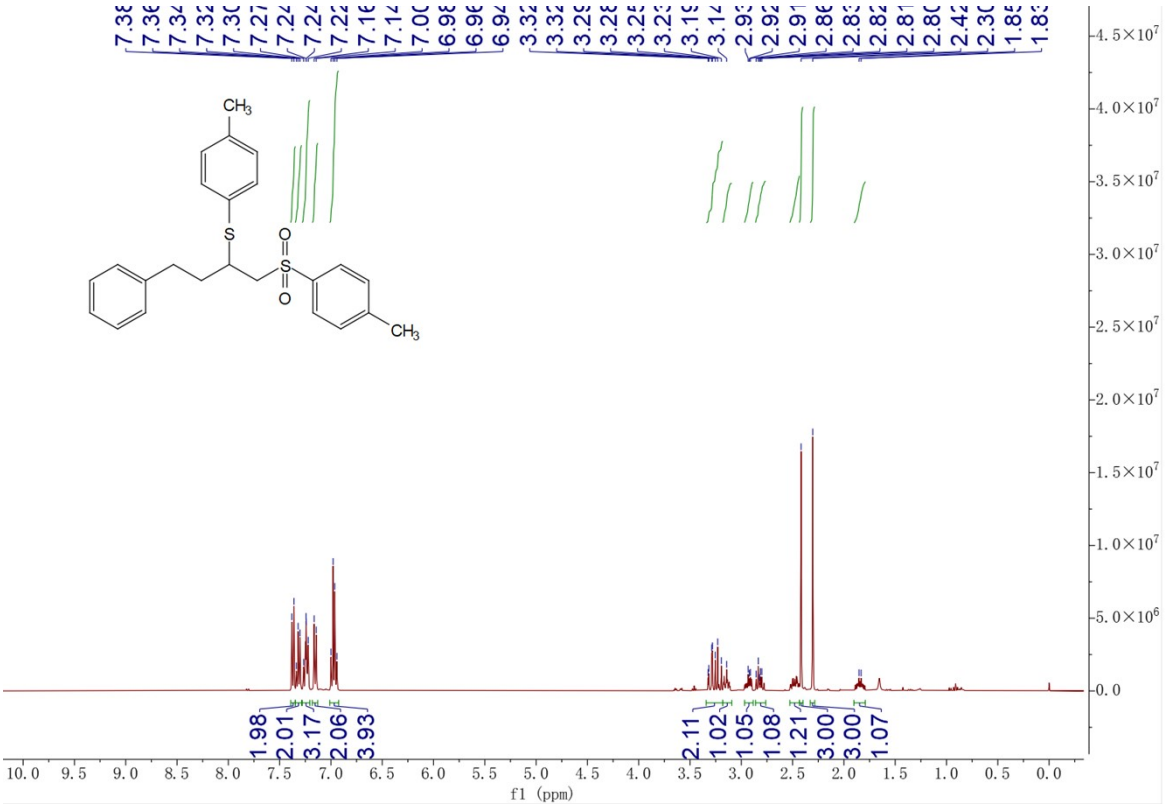
^{13}C NMR spectrum of **3v**



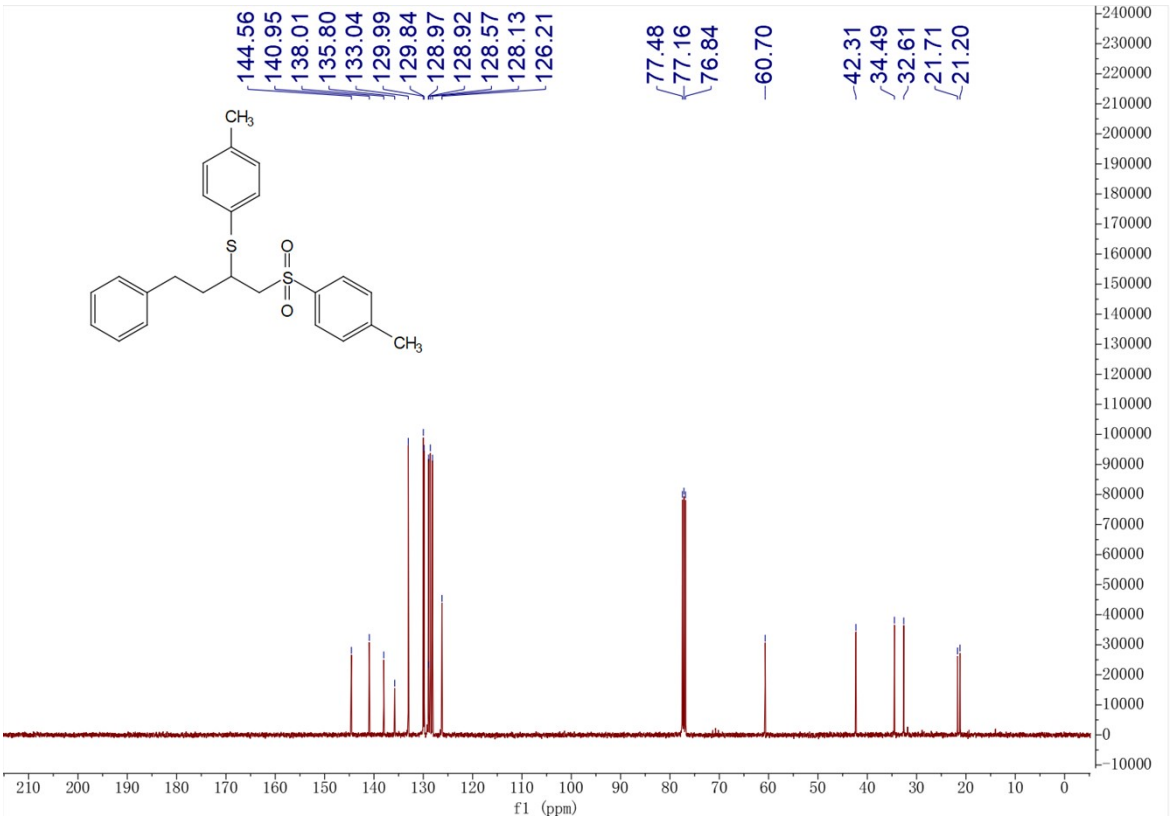
^{1}H NMR spectrum of **3w**



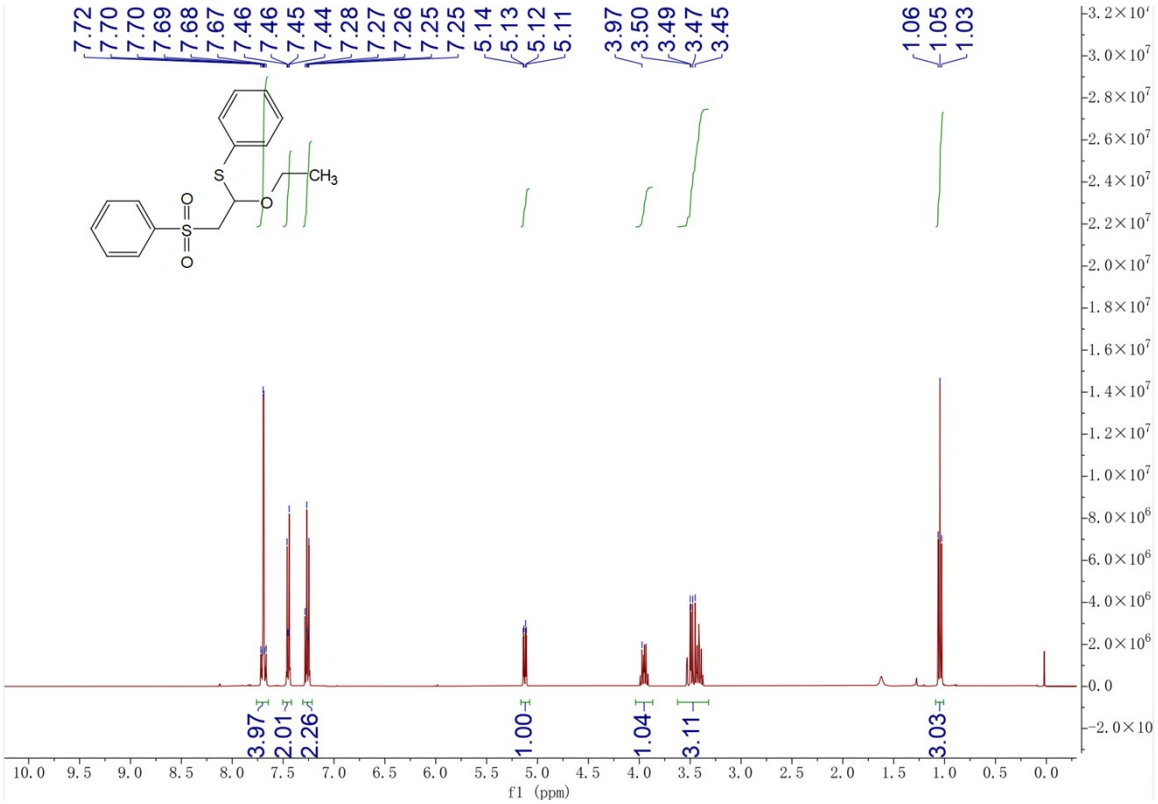
^{13}C NMR spectrum of **3w**



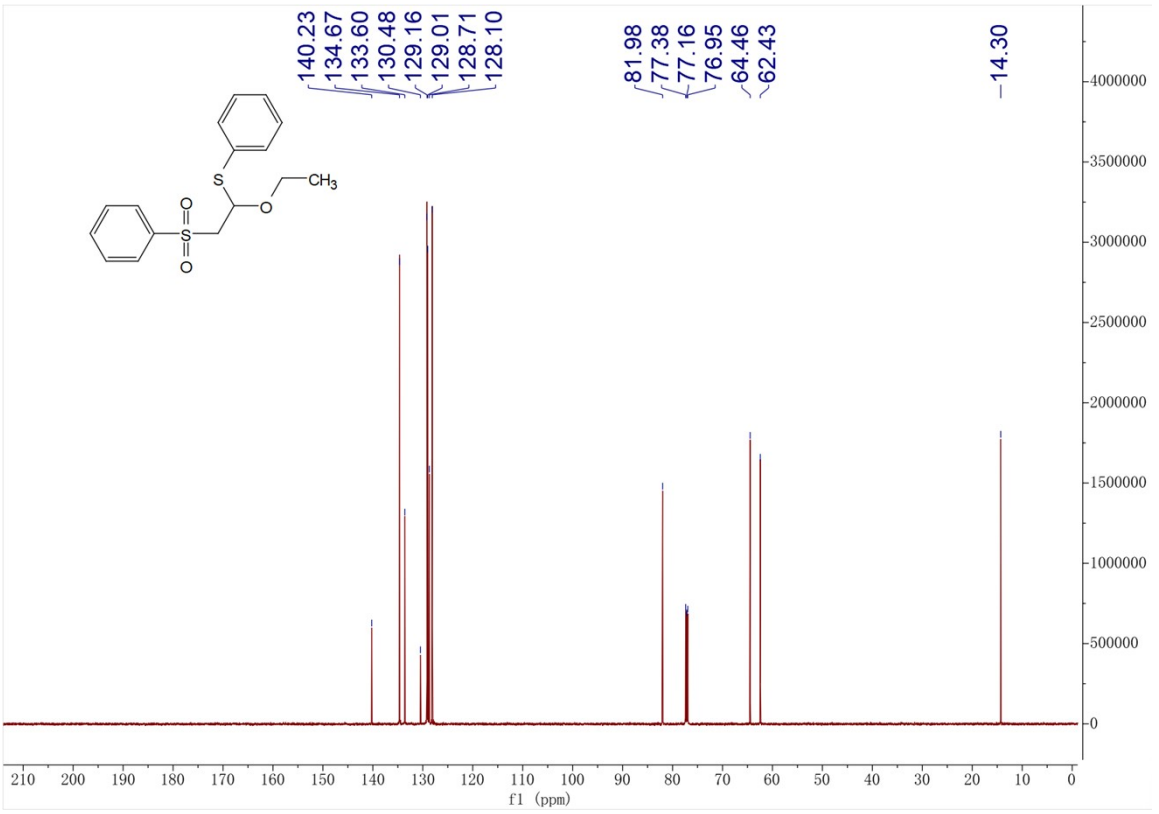
^{1}H NMR spectrum of **3x**



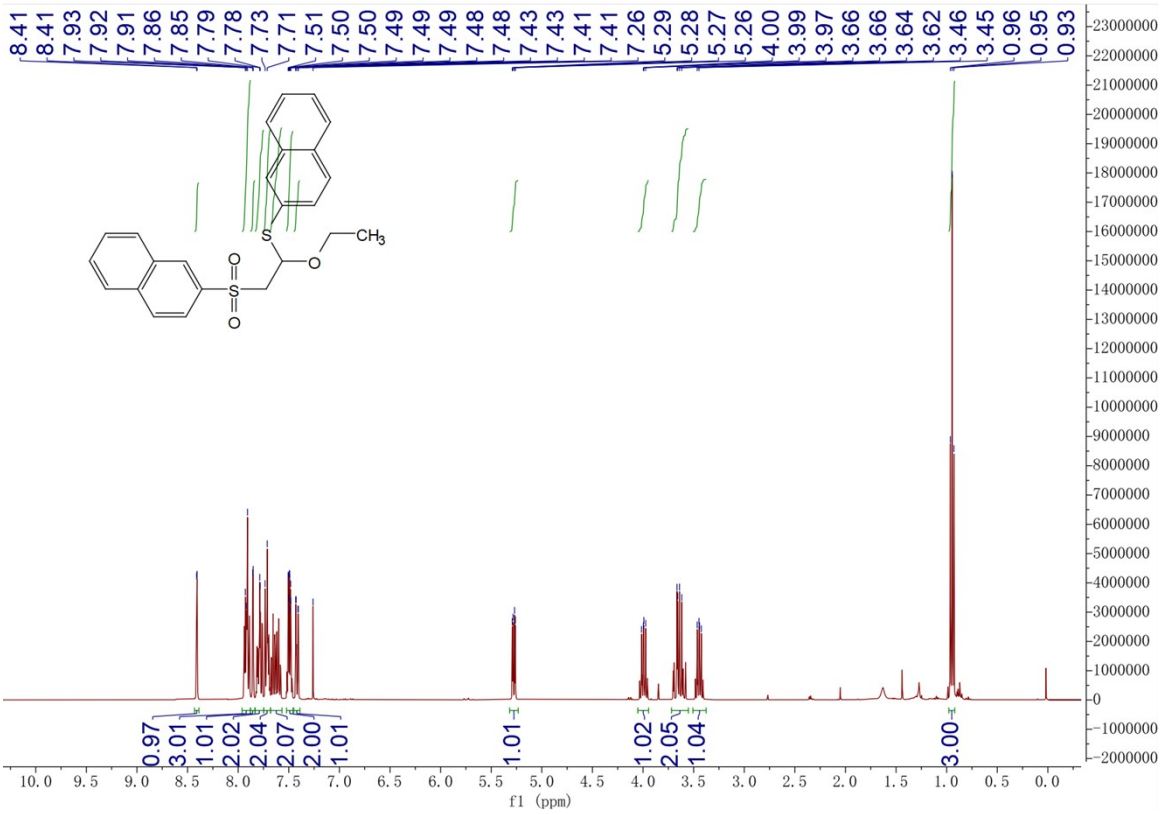
^{13}C NMR spectrum of **3x**



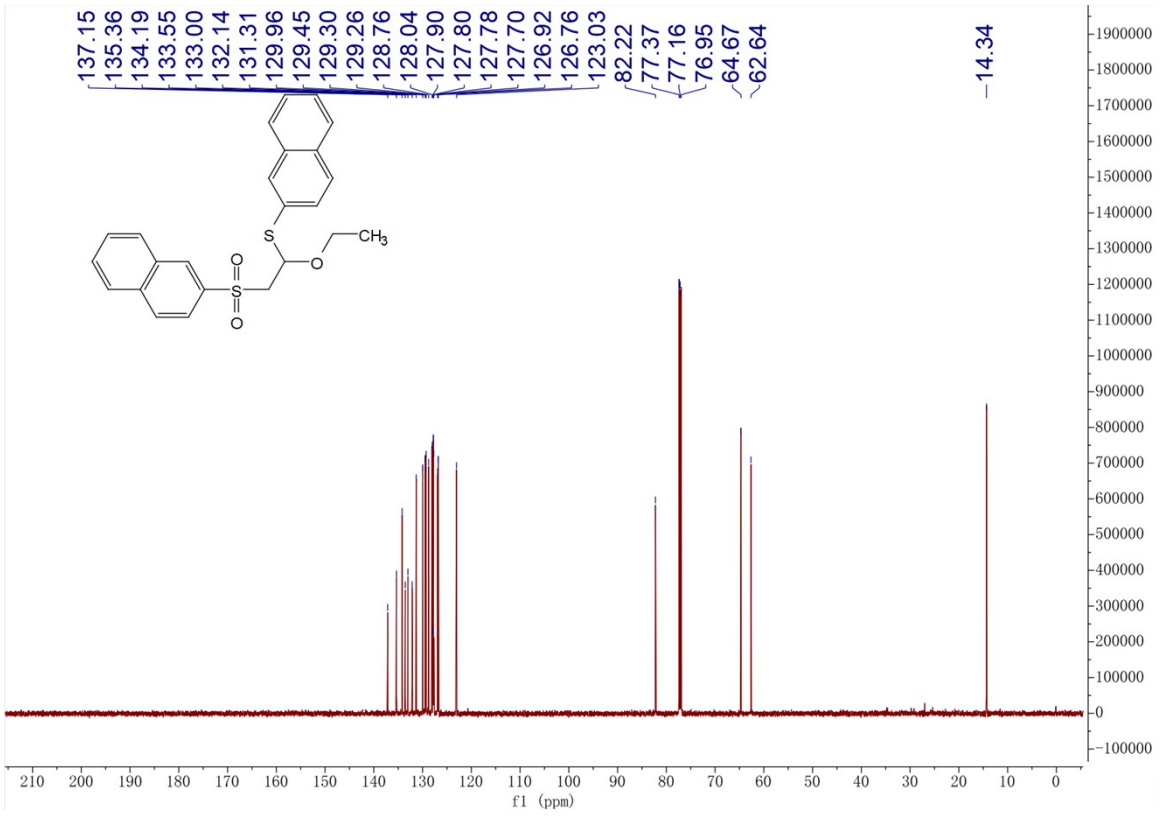
^{1}H NMR spectrum of **4a**



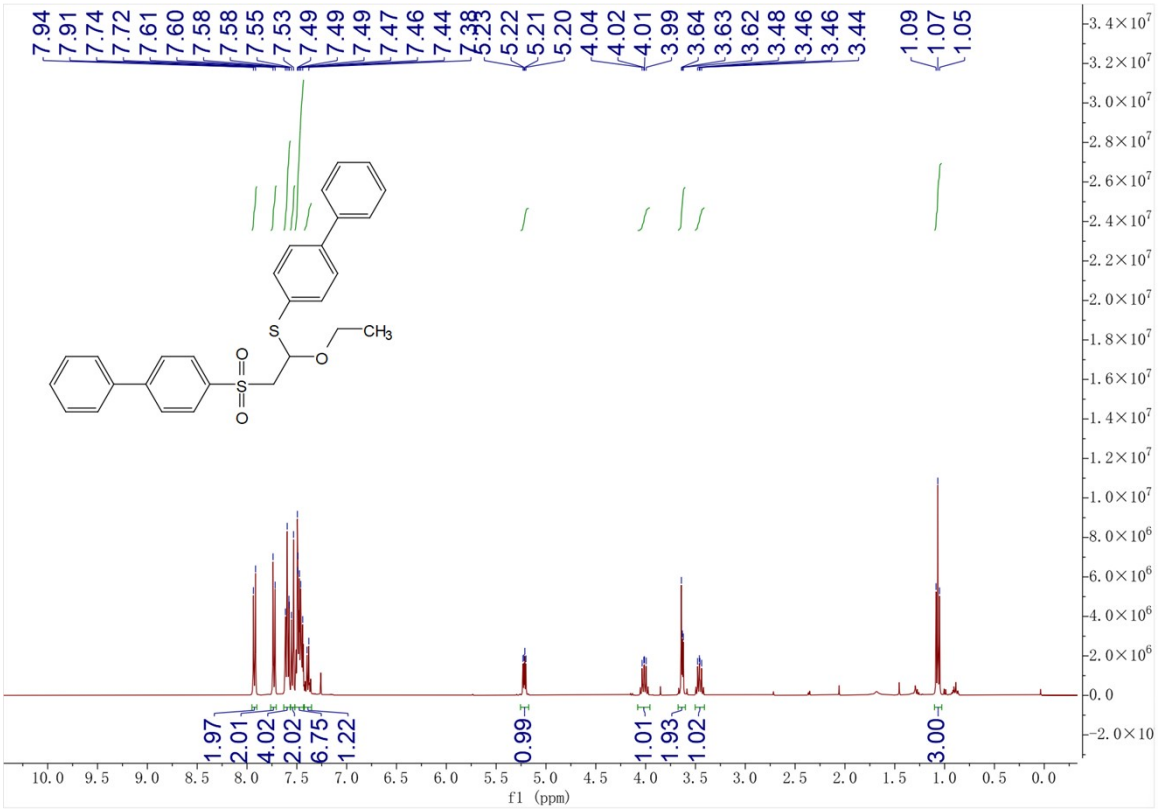
^{13}C NMR spectrum of **4a**



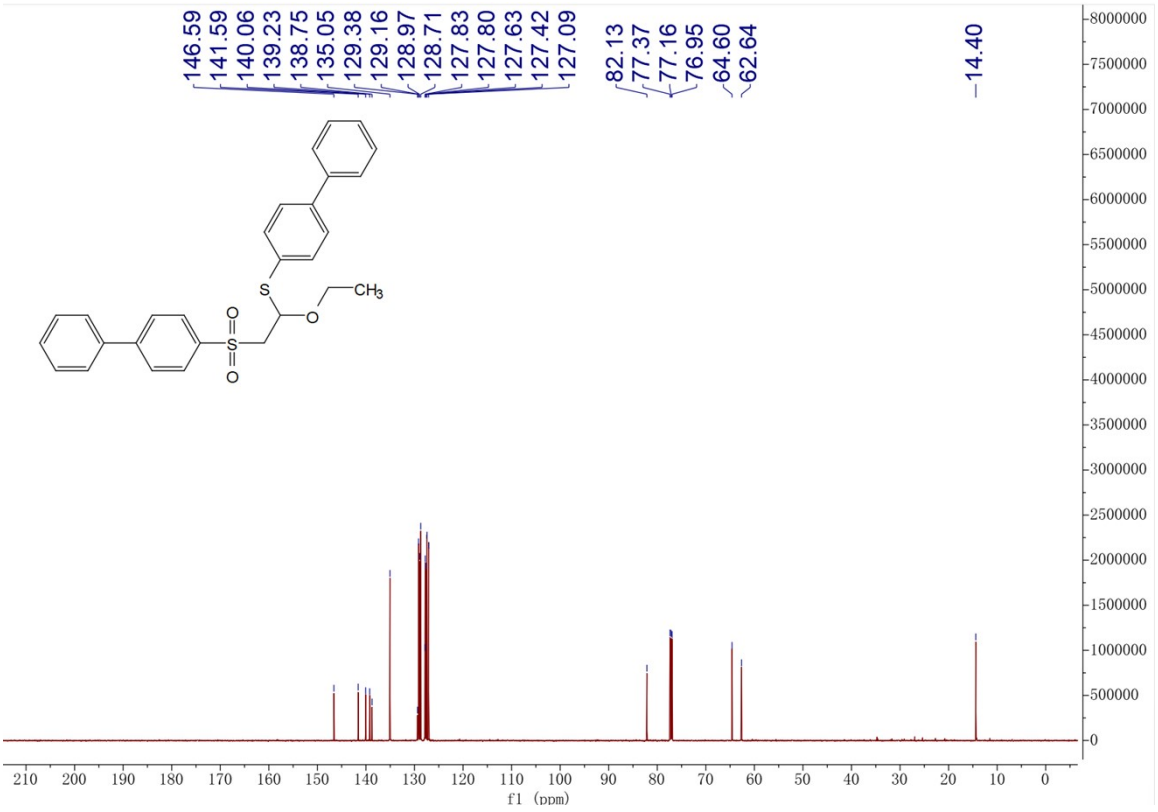
^{1}H NMR spectrum of **4b**



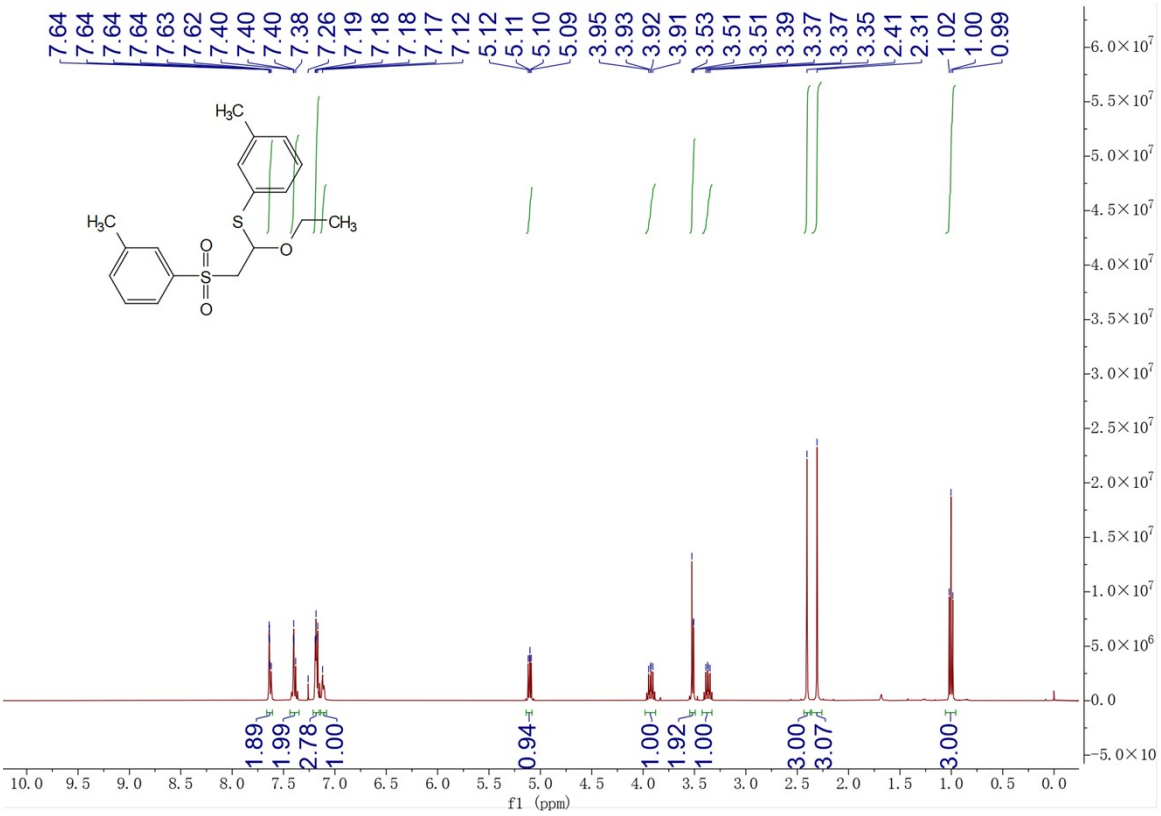
^{13}C NMR spectrum of **4b**



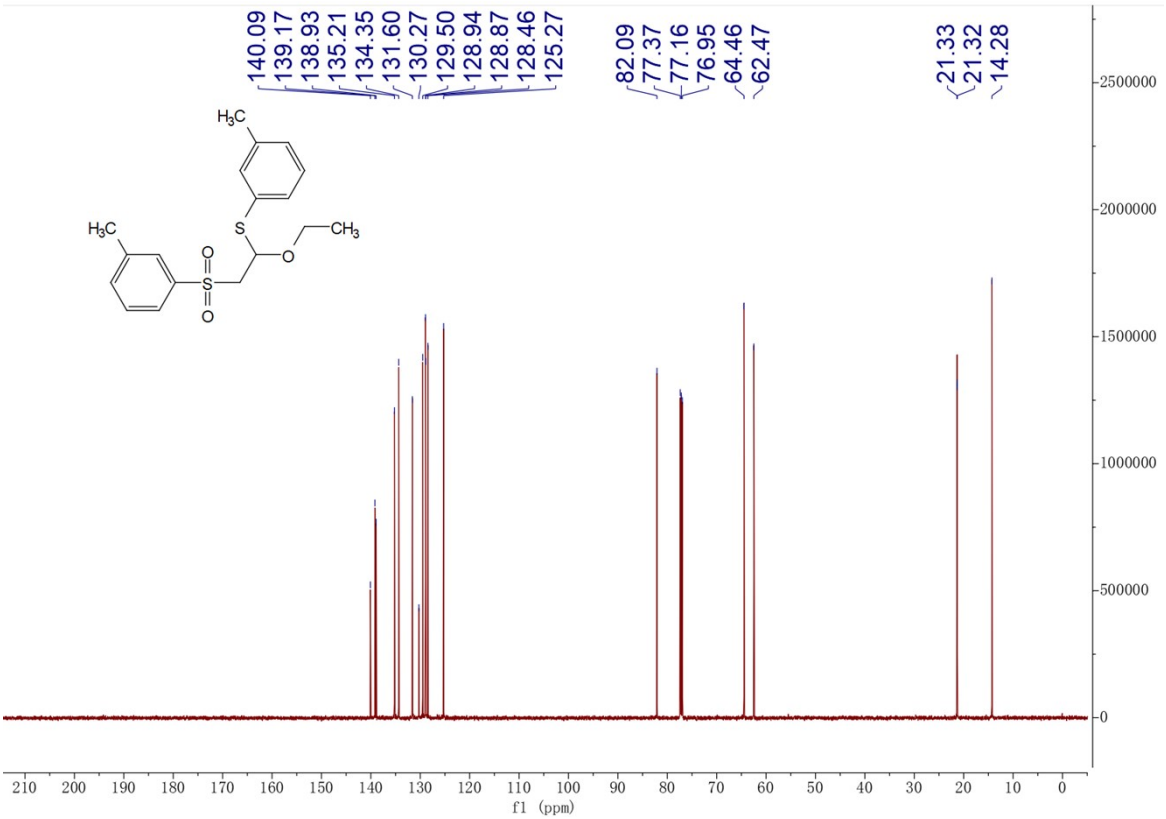
^{1}H NMR spectrum of **4c**



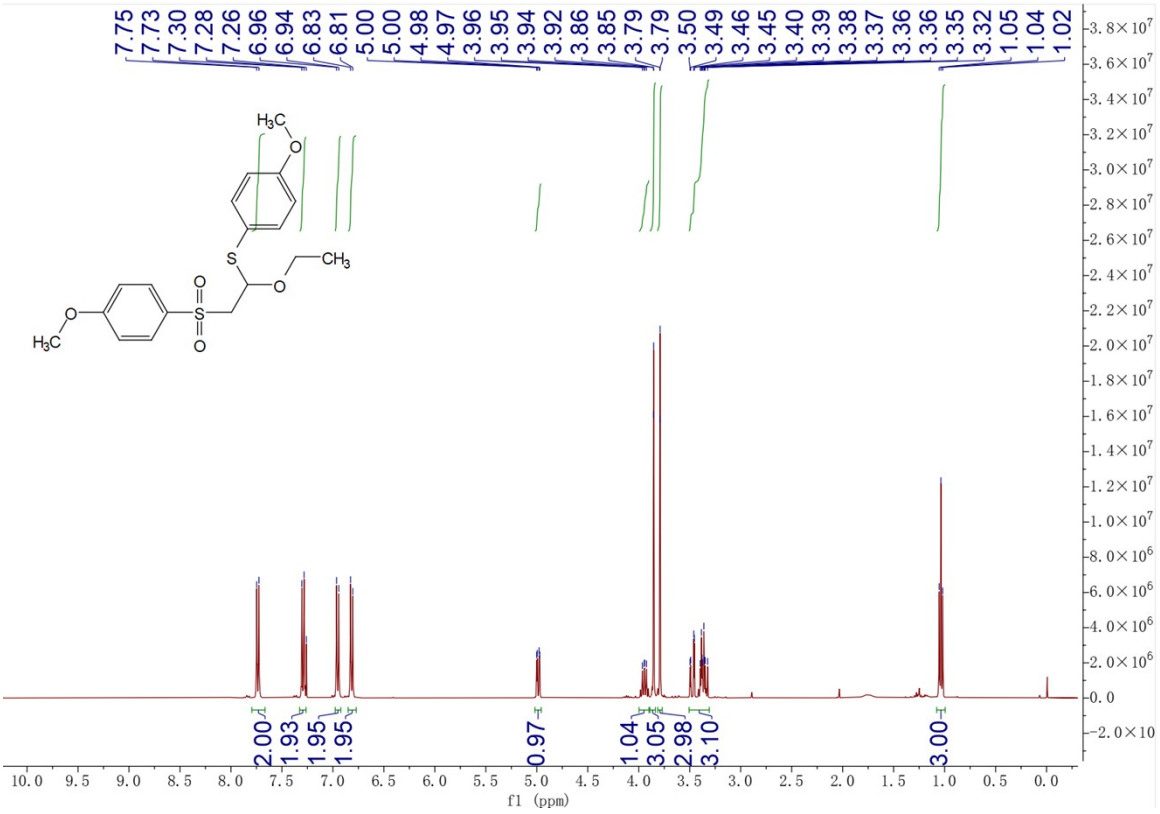
^{13}C NMR spectrum of **4c**



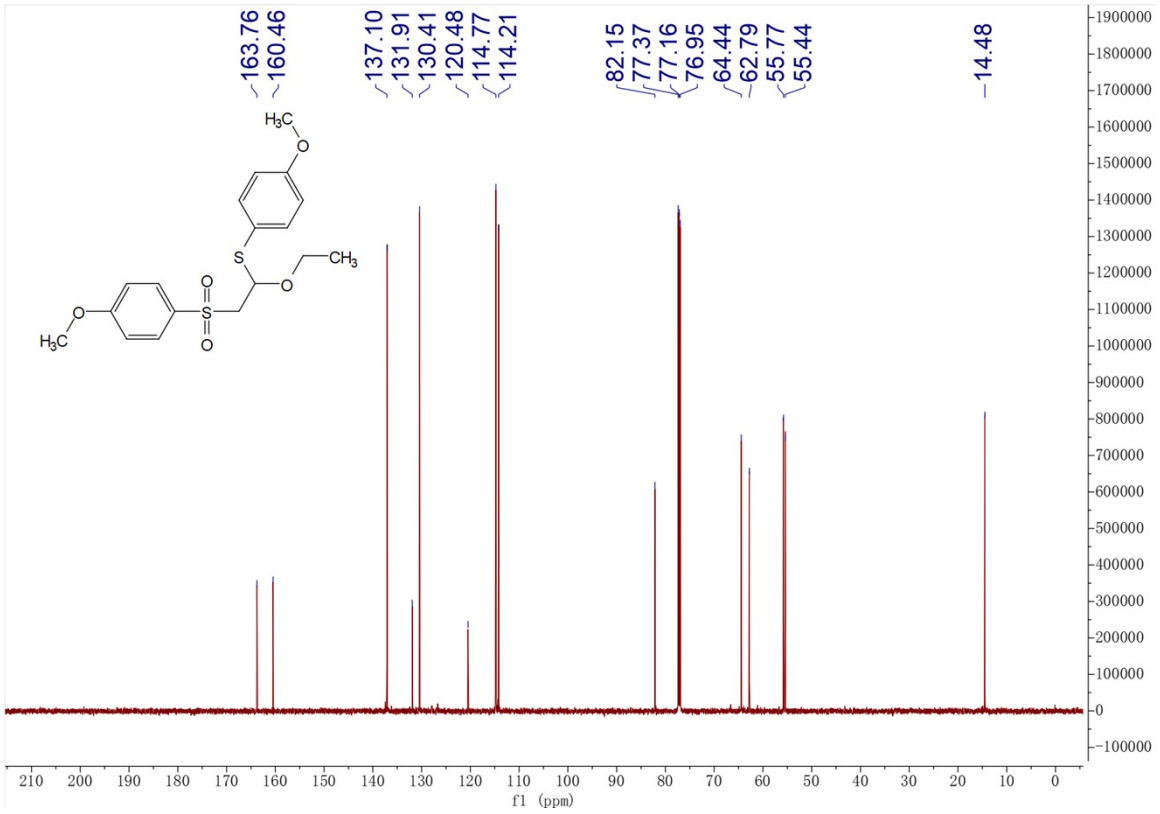
^{1}H NMR spectrum of **4d**



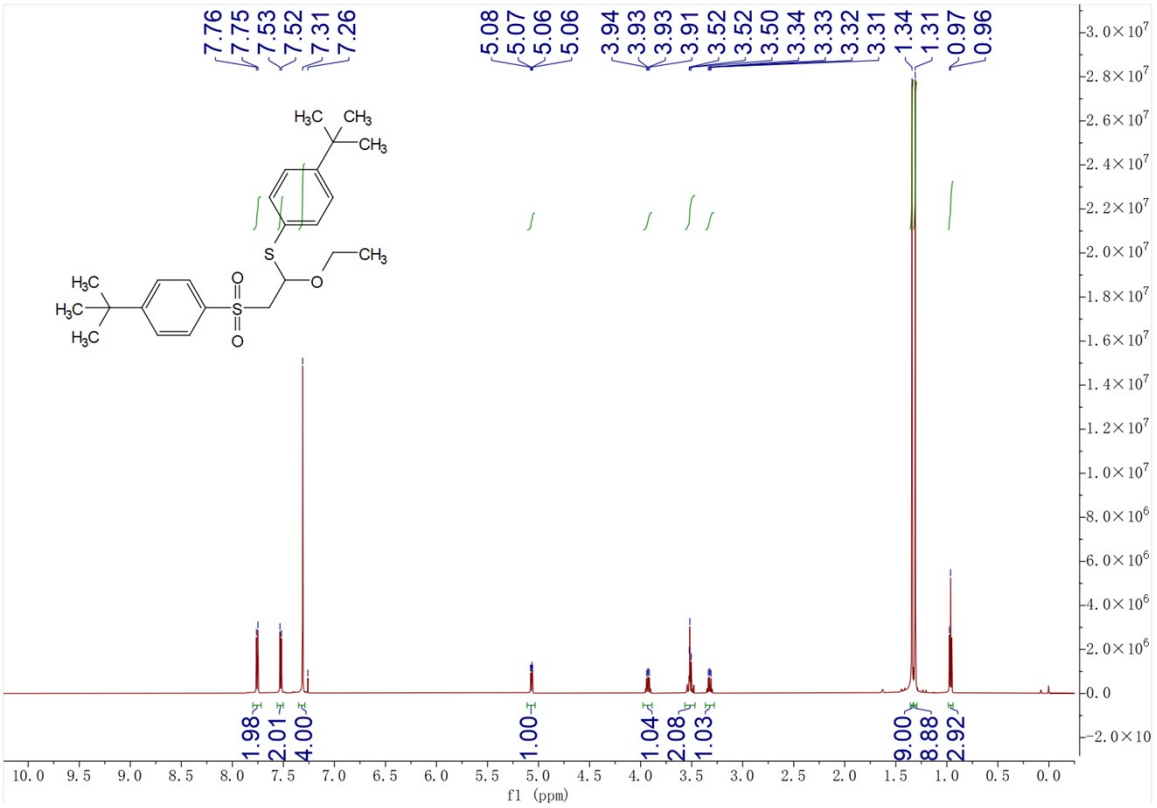
^{13}C NMR spectrum of **4d**



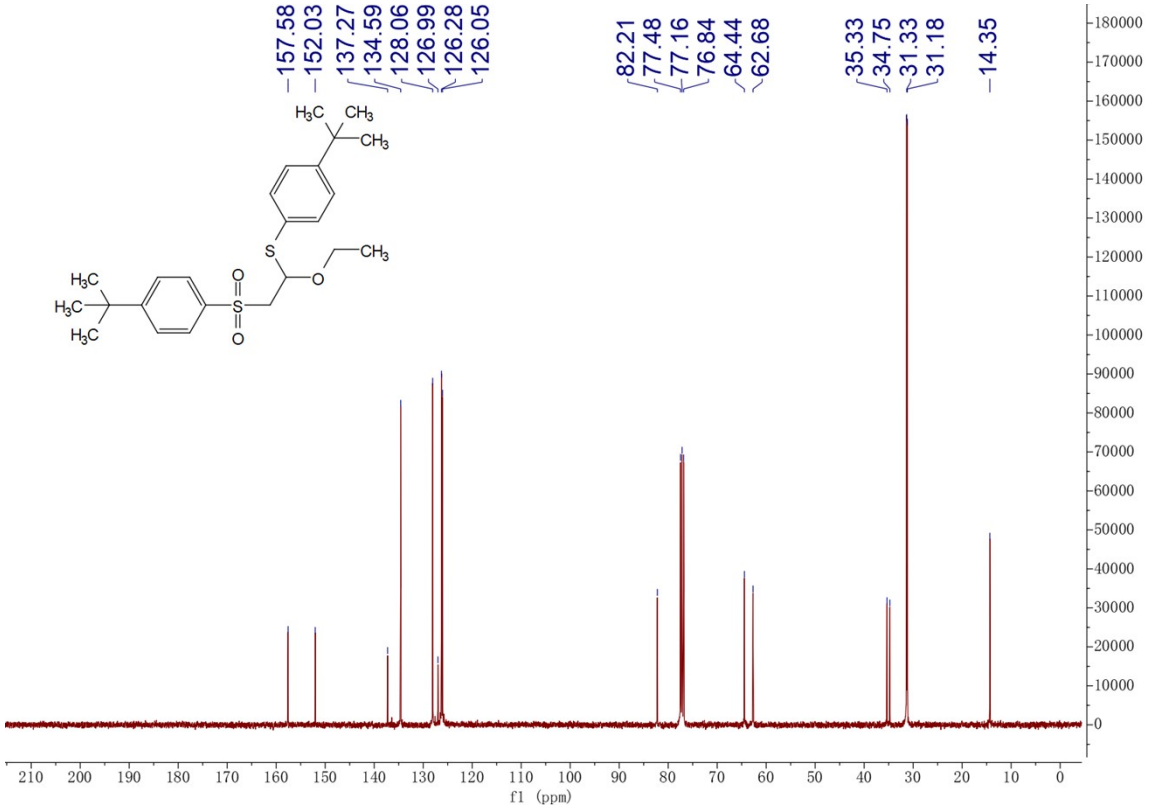
^{1}H NMR spectrum of **4e**



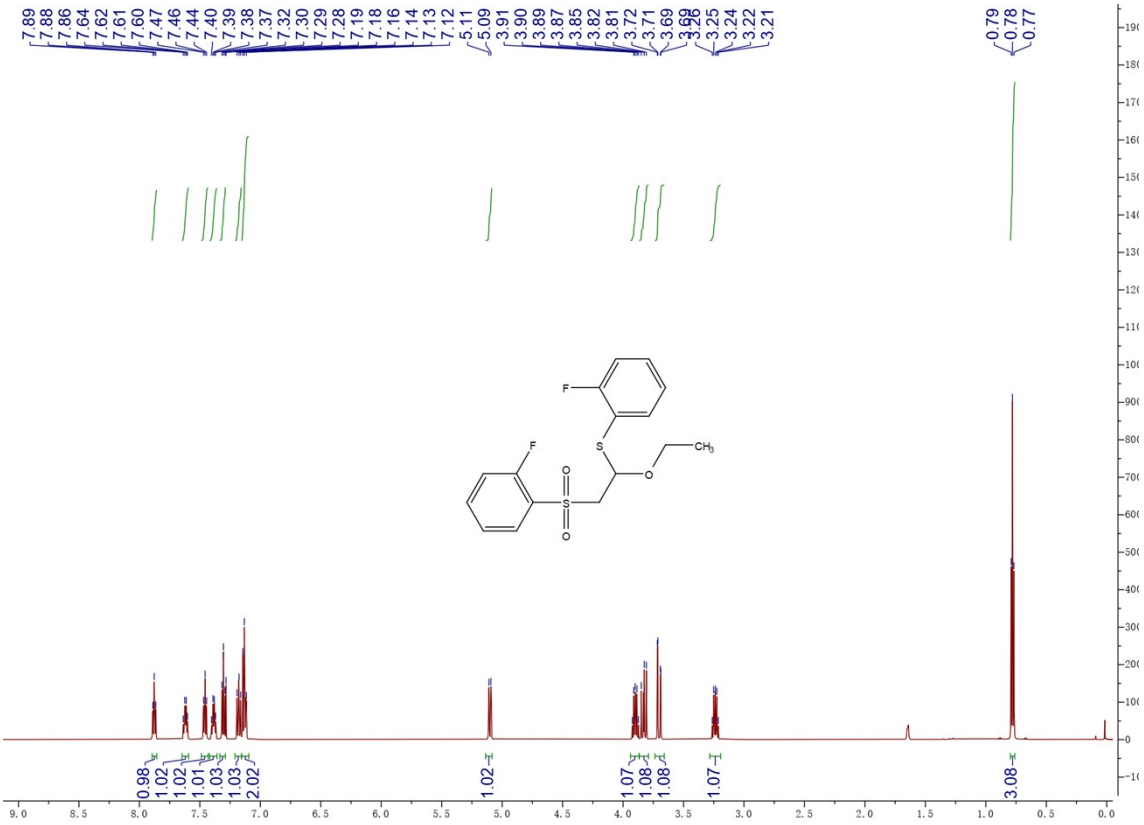
^{13}C NMR spectrum of **4e**



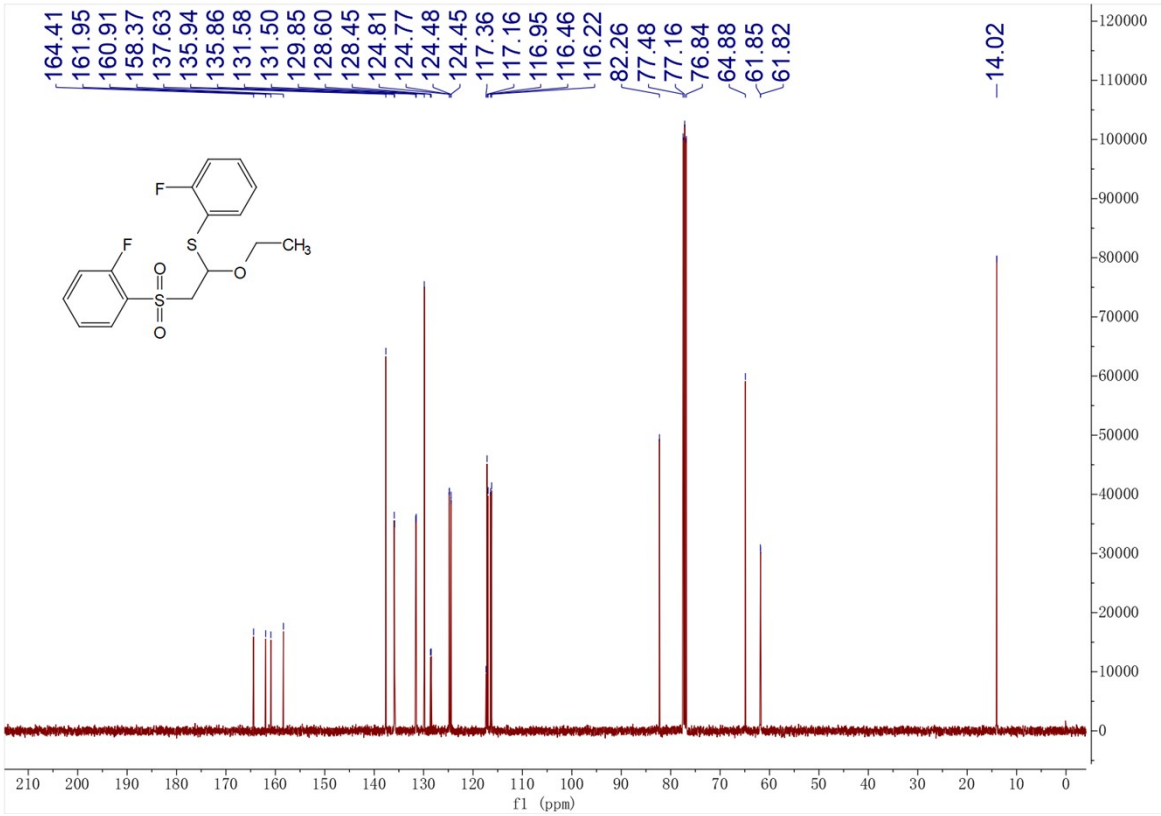
^{1}H NMR spectrum of **4f**



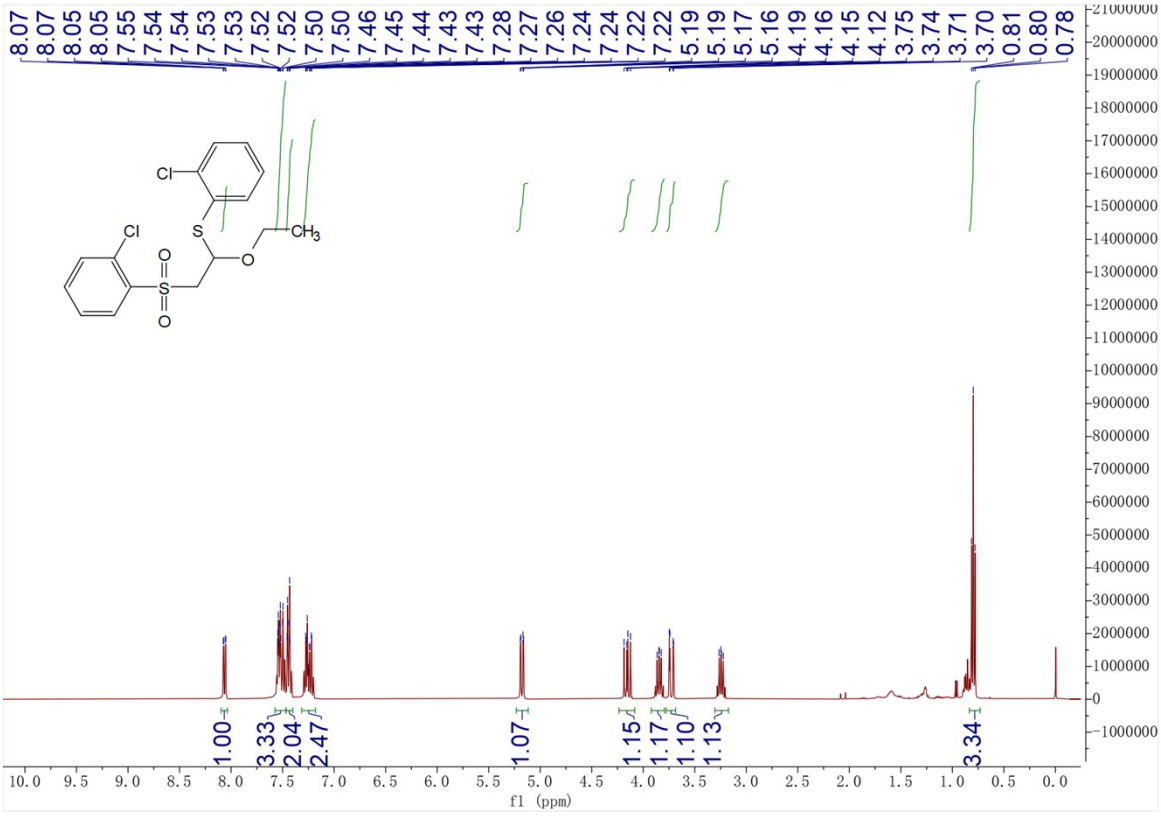
^{13}C NMR spectrum of **4f**



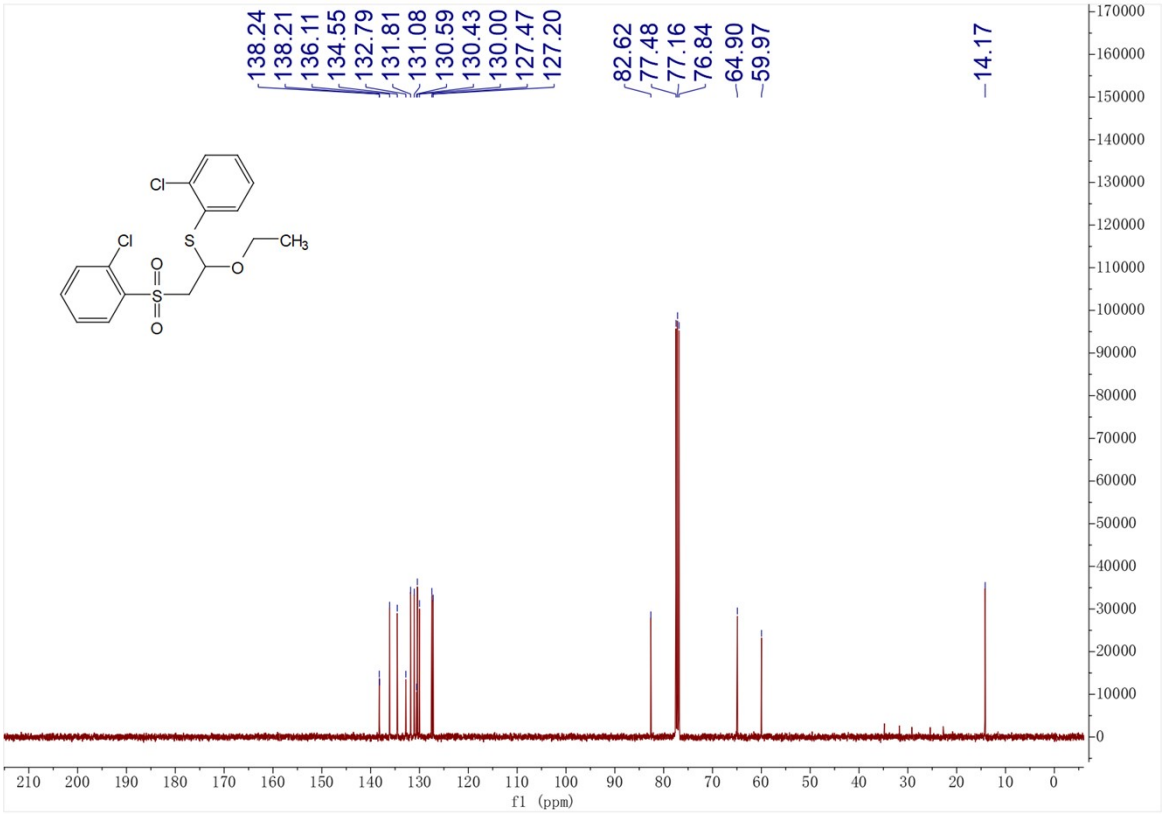
^{1}H NMR spectrum of **4g**



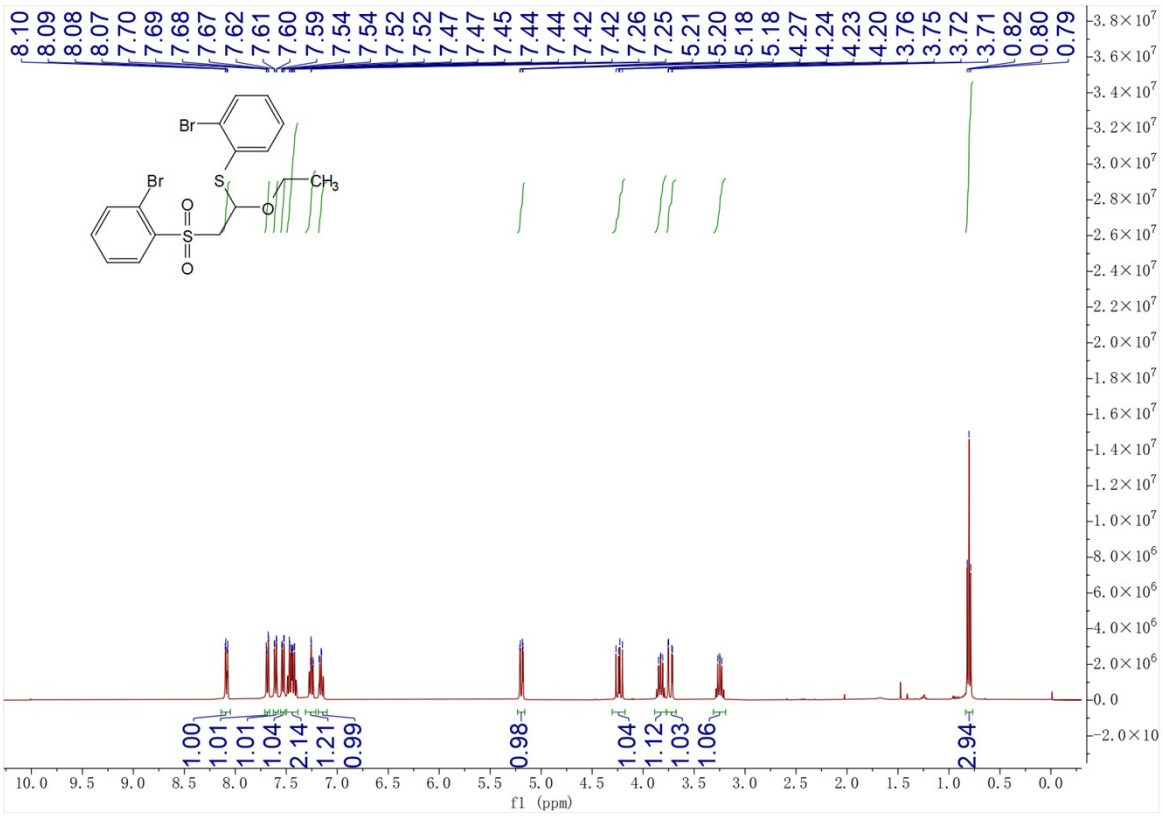
^{13}C NMR spectrum of **4g**



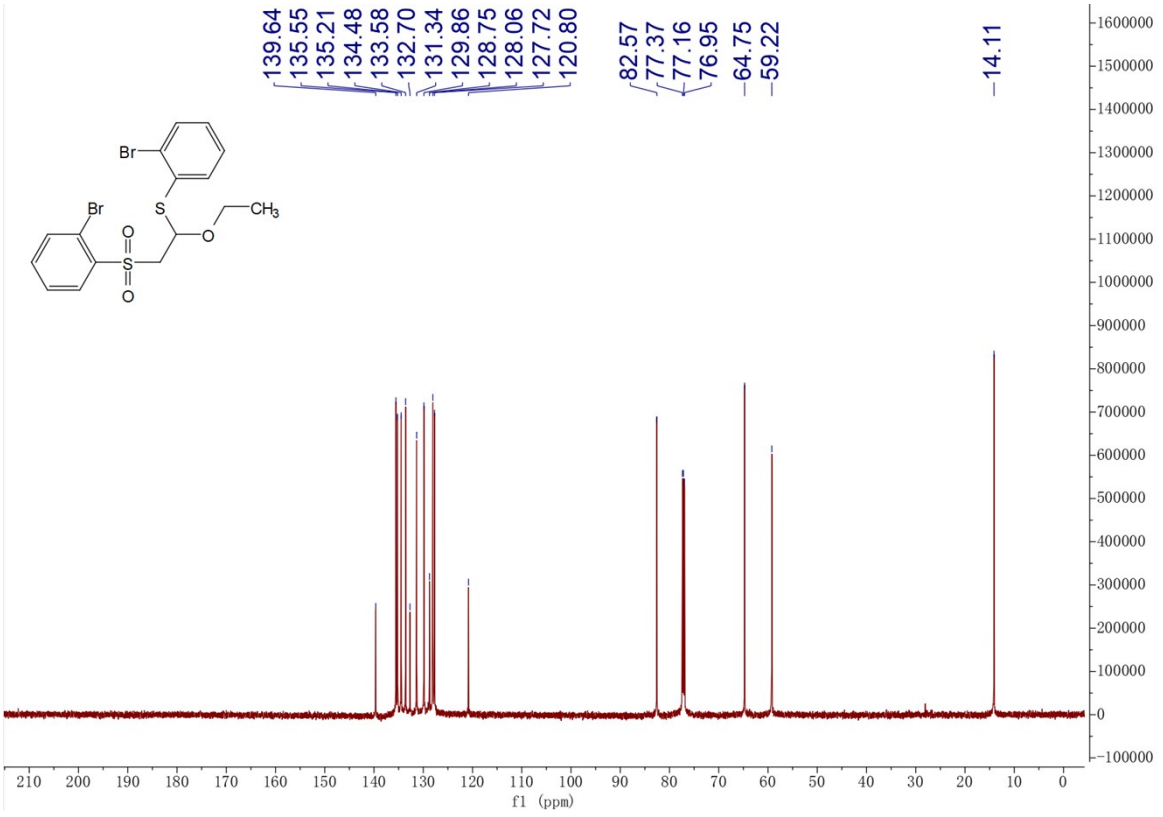
^{1}H NMR spectrum of **4h**



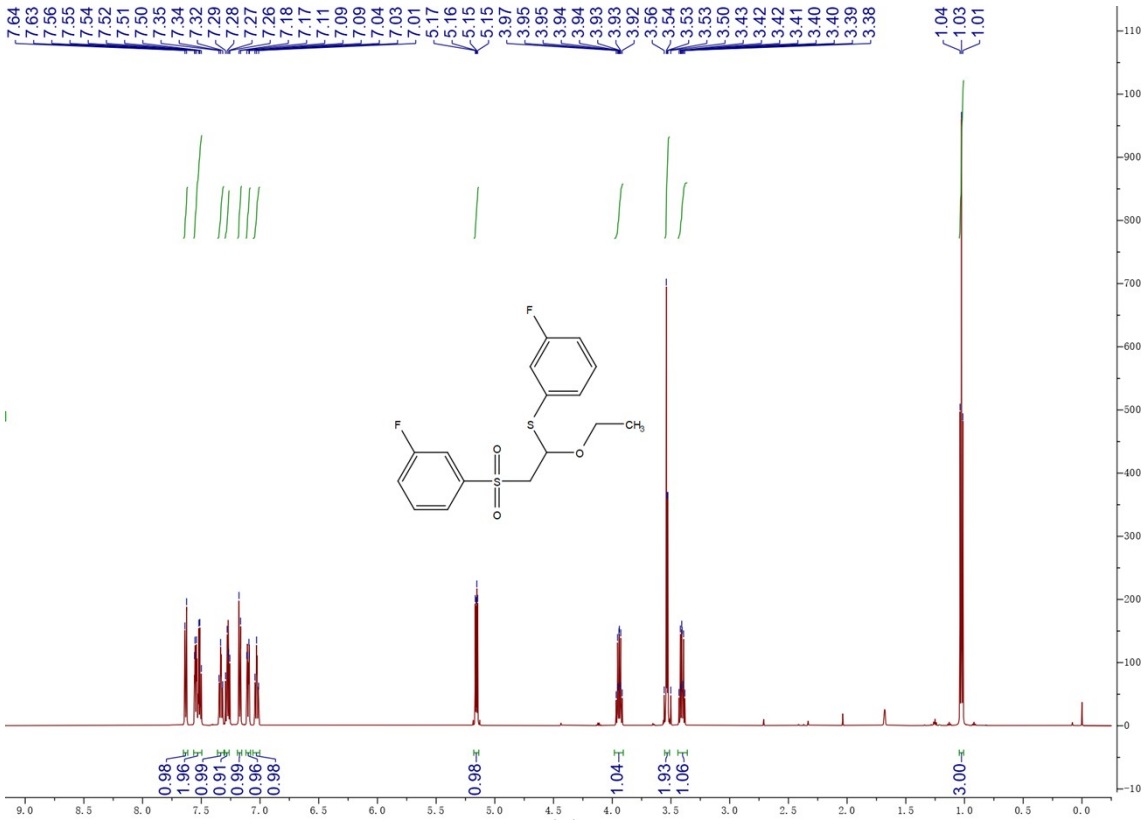
^{13}C NMR spectrum of **4h**



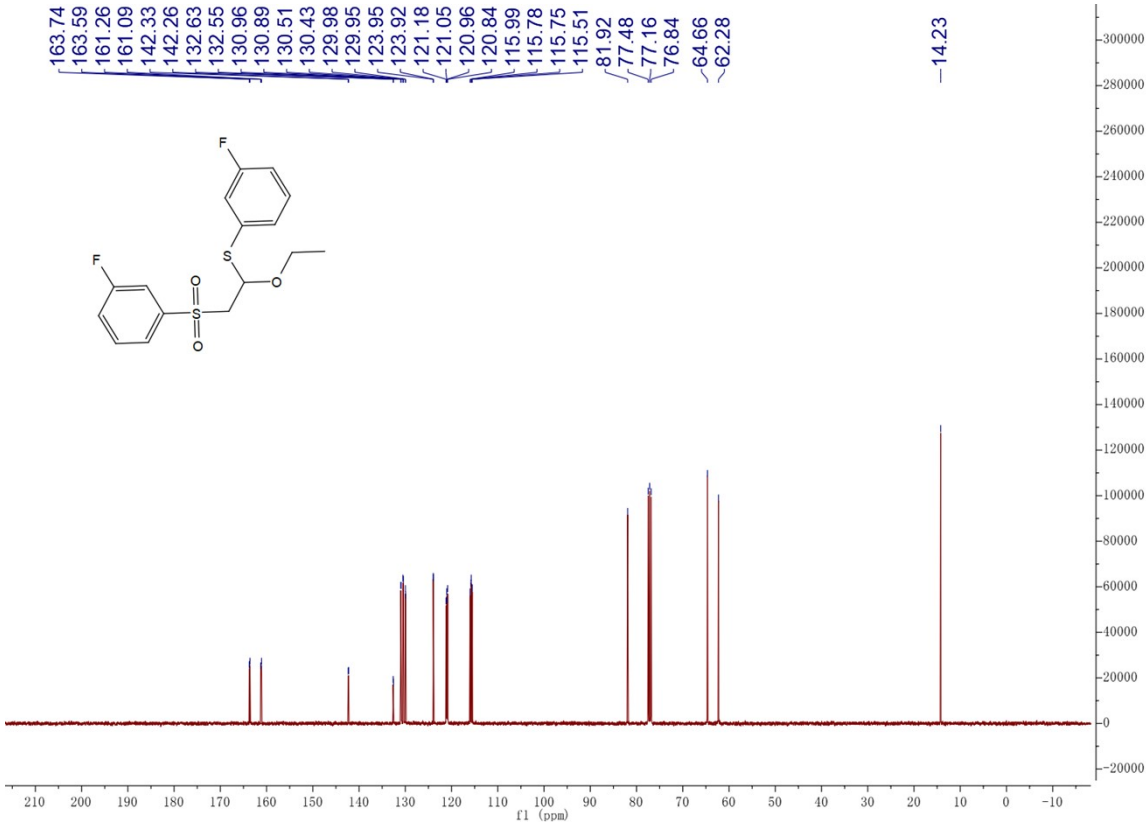
^{1}H NMR spectrum of **4i**



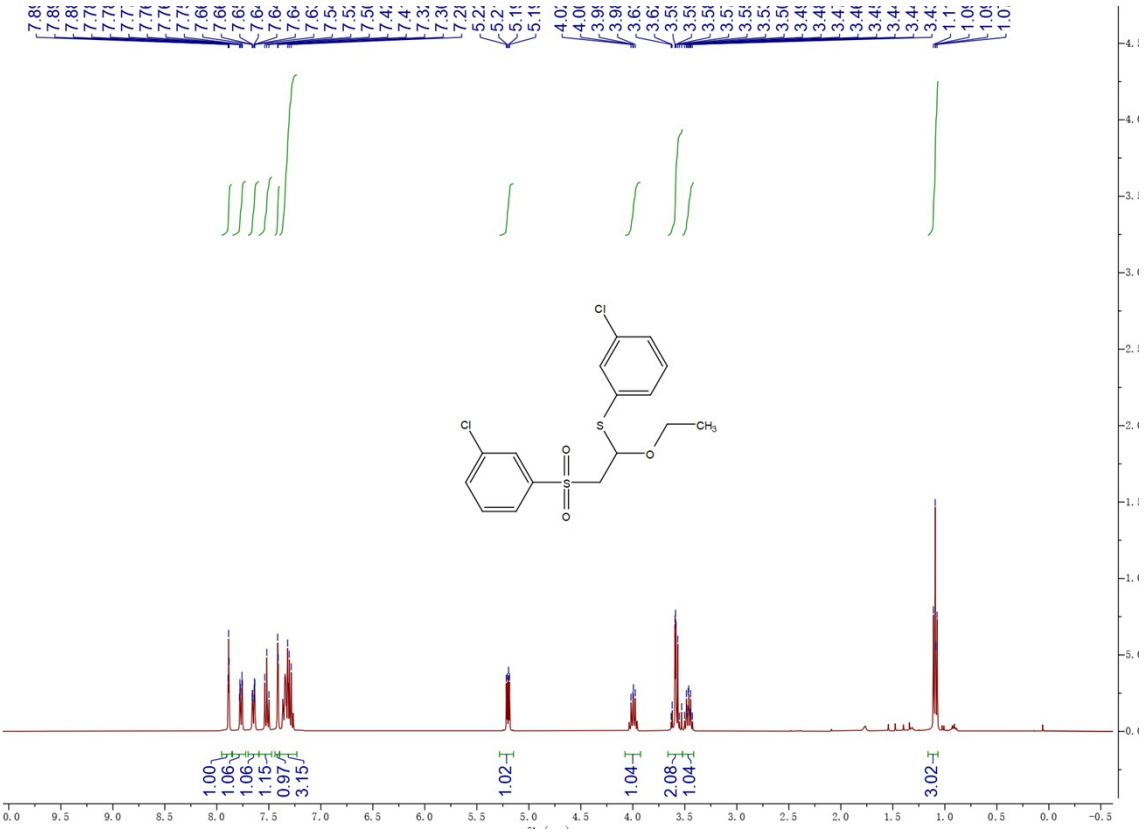
^{13}C NMR spectrum of **4i**



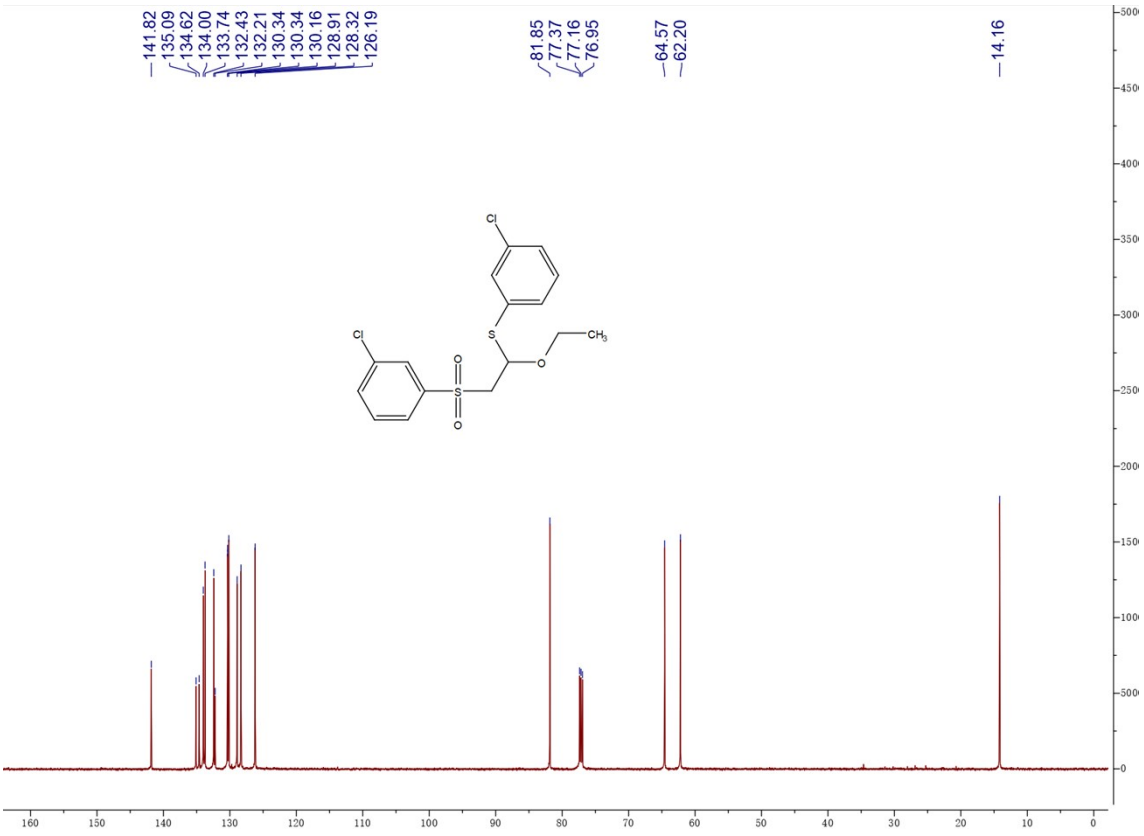
^{1}H NMR spectrum of **4j**



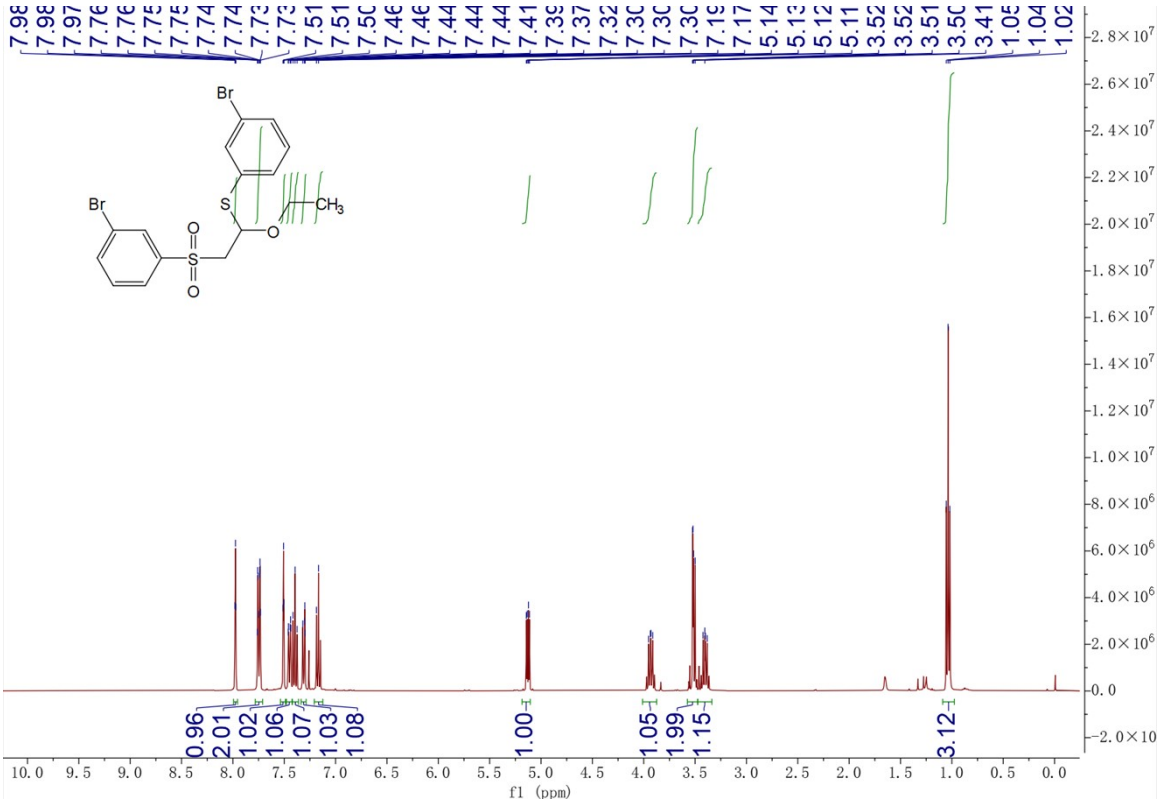
^{13}C NMR spectrum of **4j**



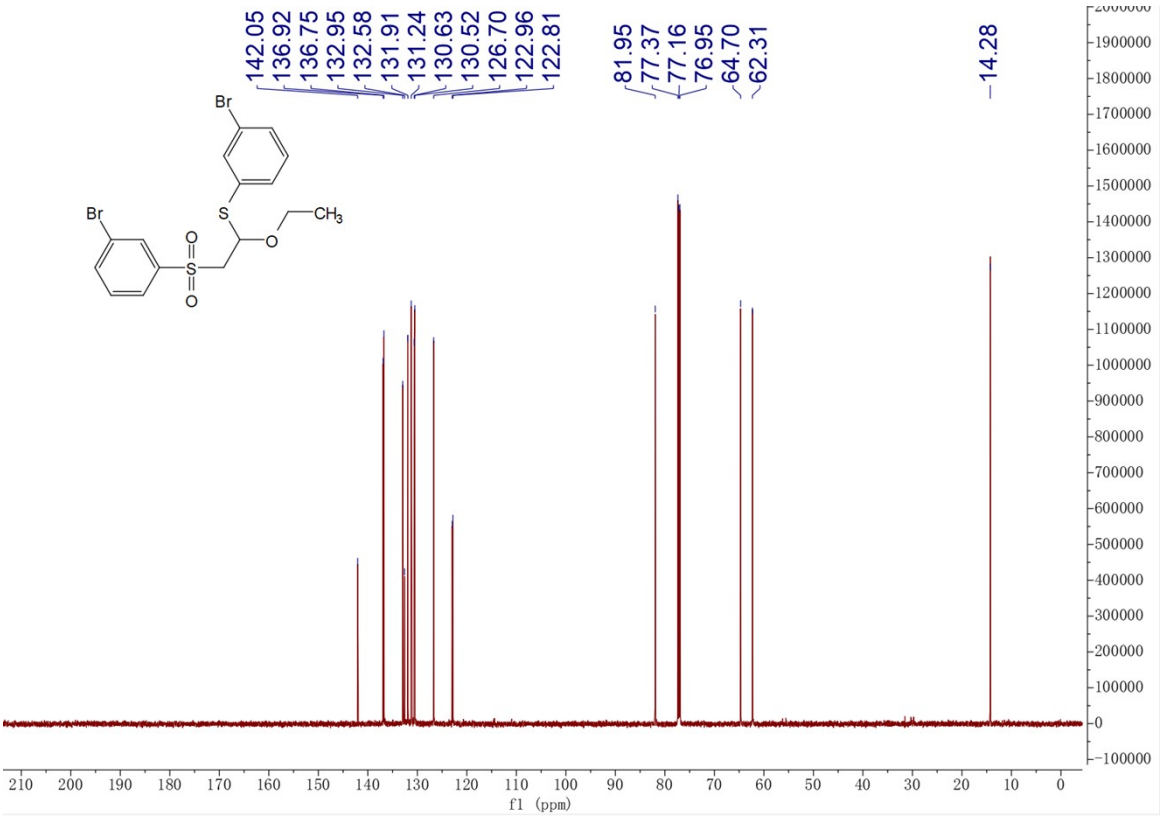
^{1}H NMR spectrum of **4k**



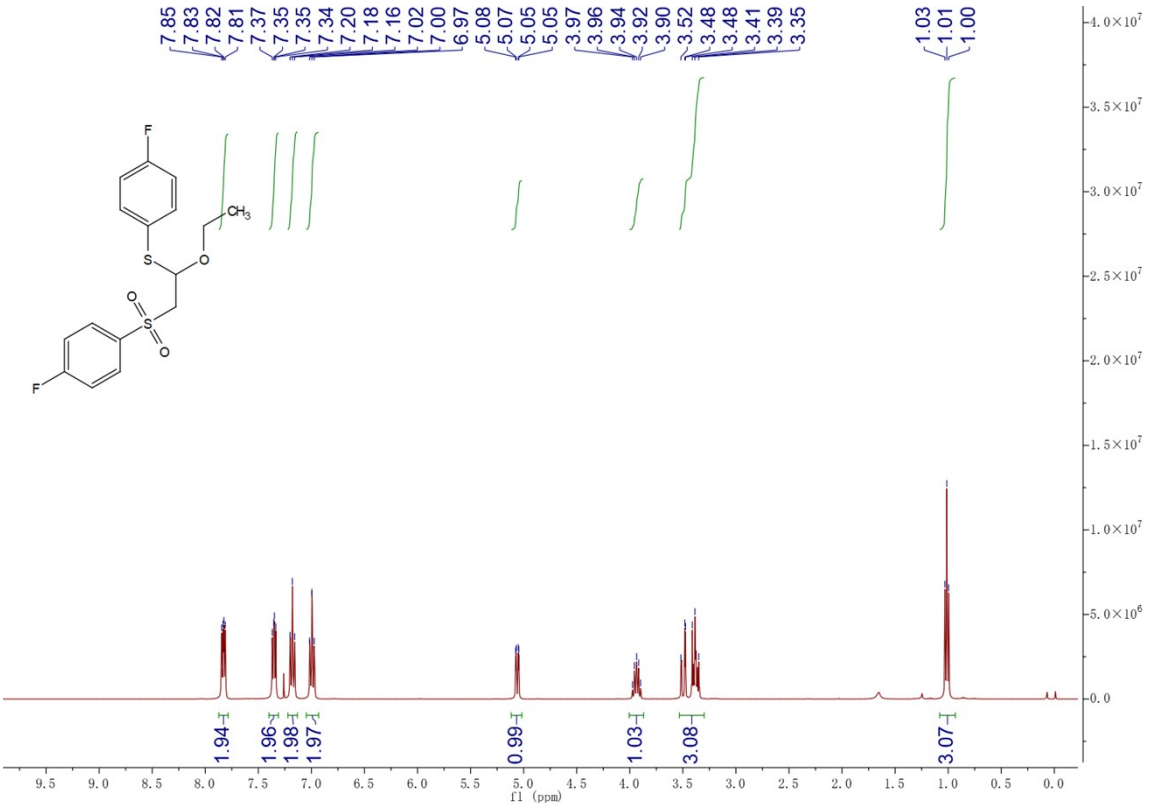
^{13}C NMR spectrum of **4k**



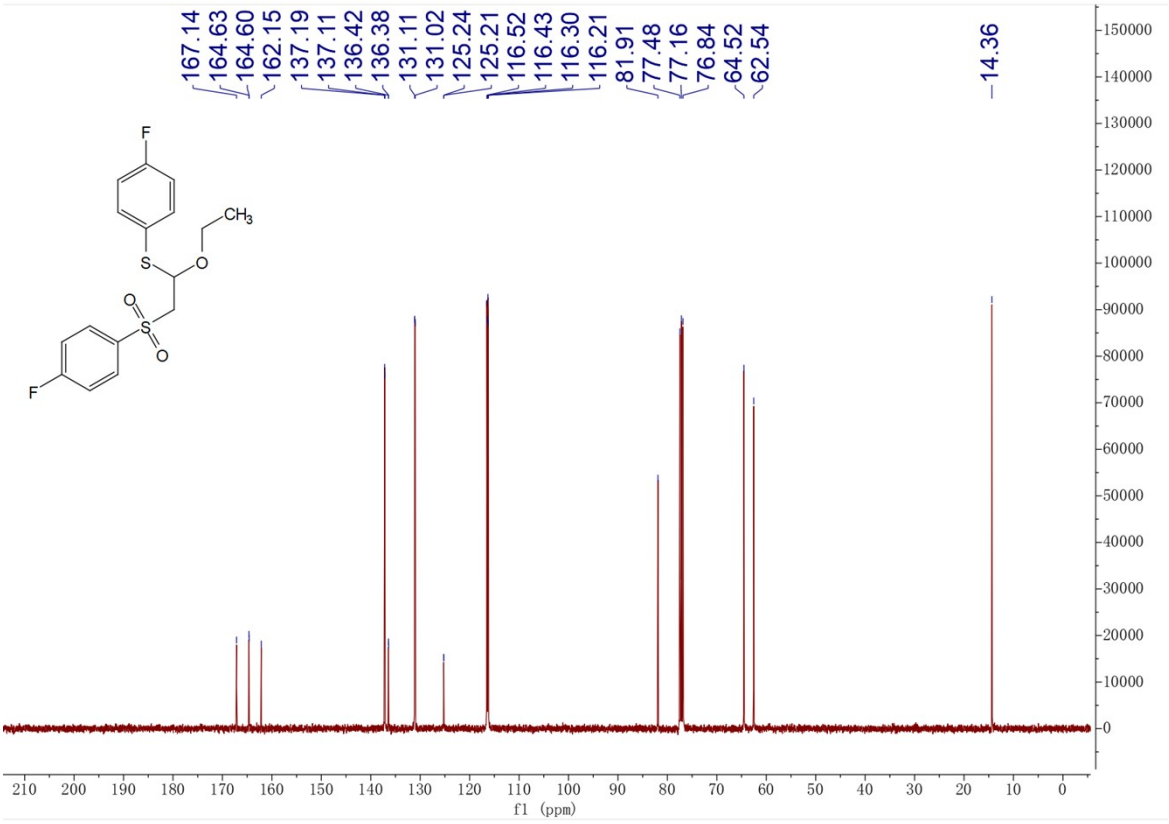
^{1}H NMR spectrum of **4l**



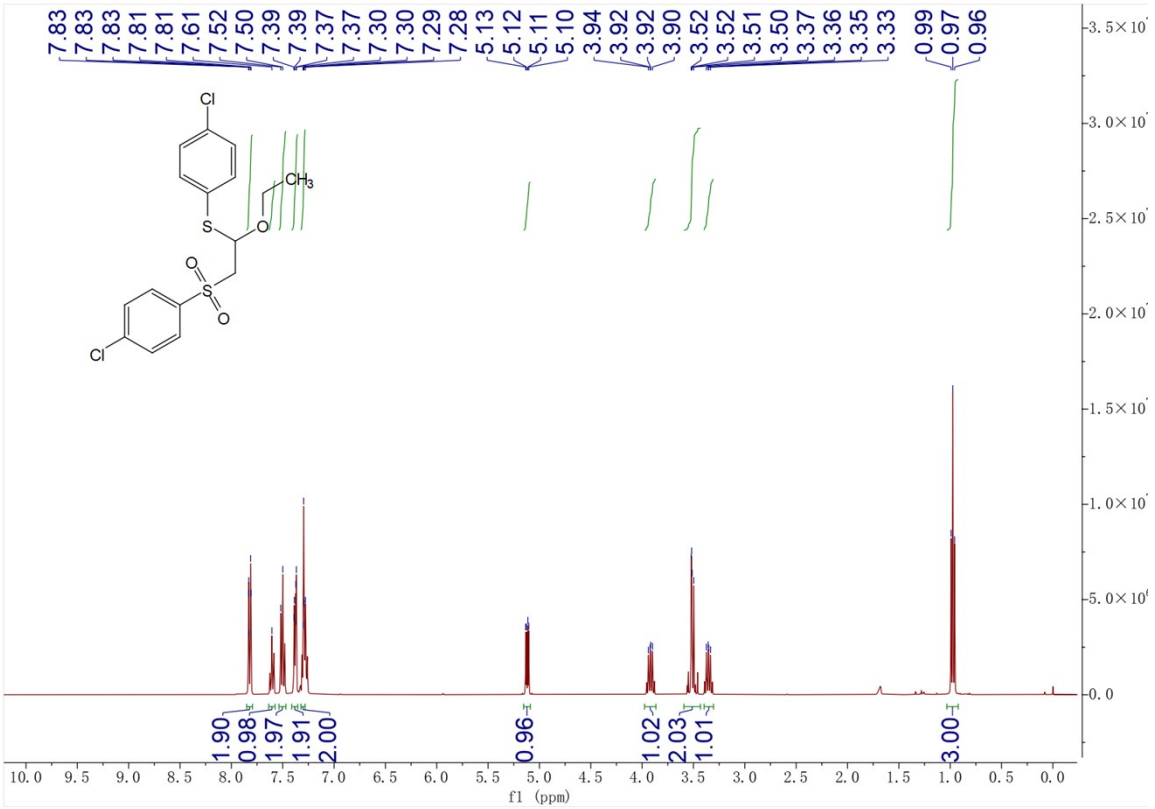
^{13}C NMR spectrum of **4l**



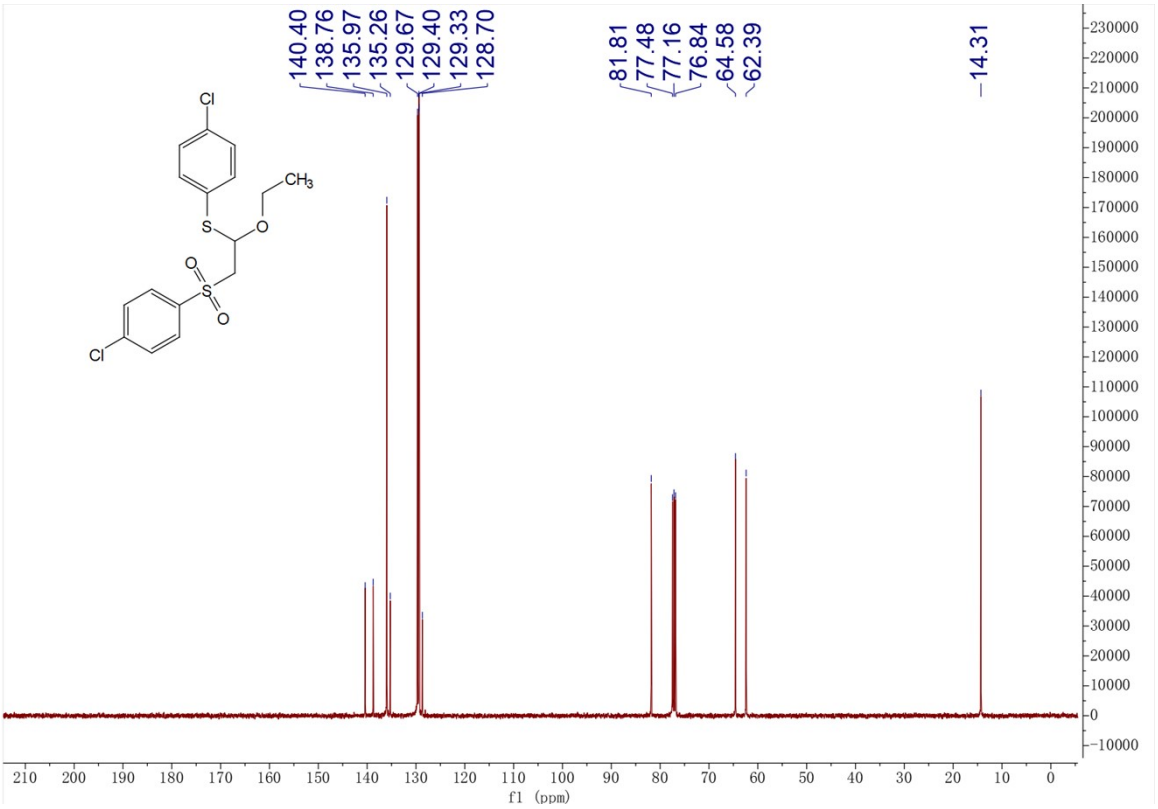
^{1}H NMR spectrum of **4m**



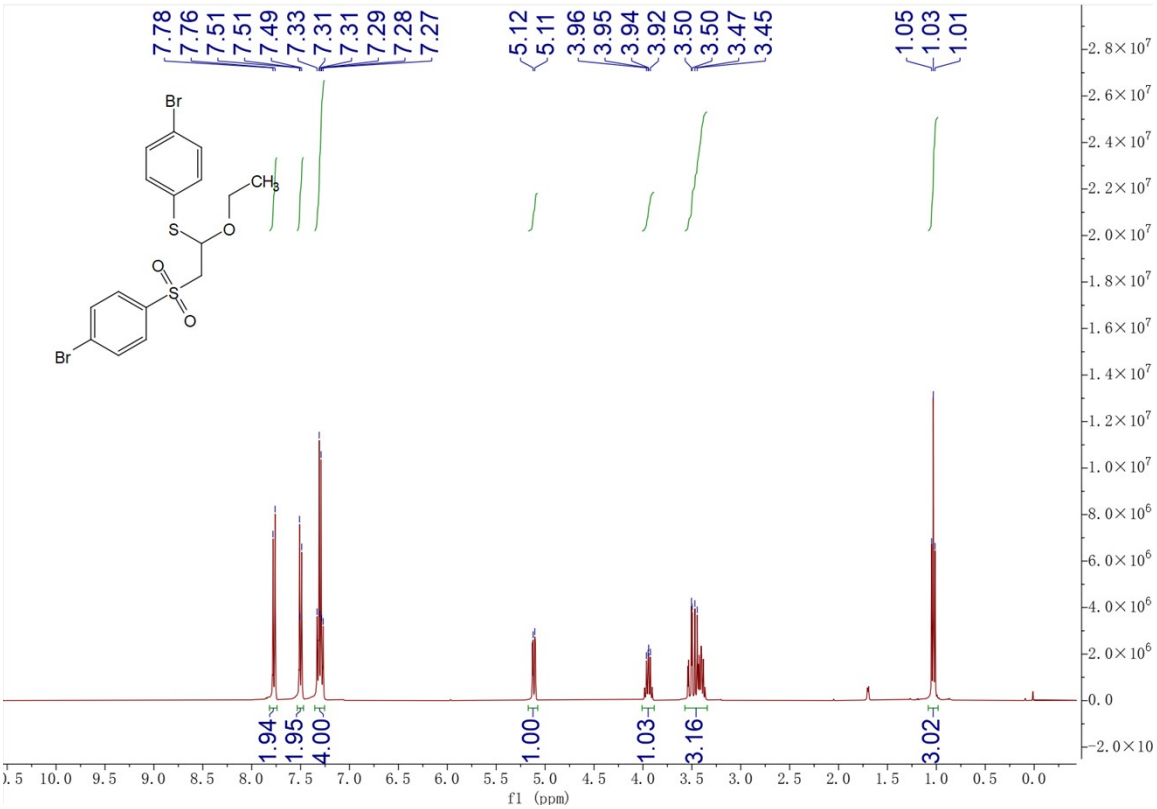
^{13}C NMR spectrum of **4m**



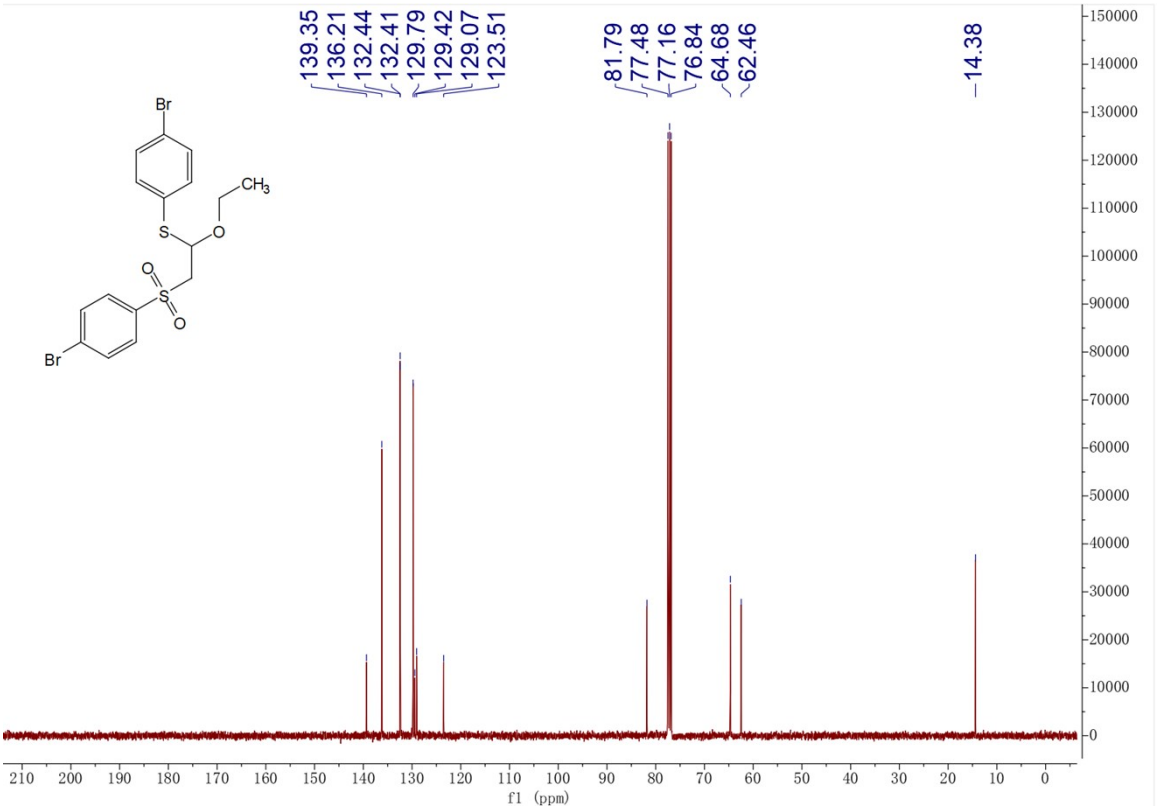
^{1}H NMR spectrum of **4n**



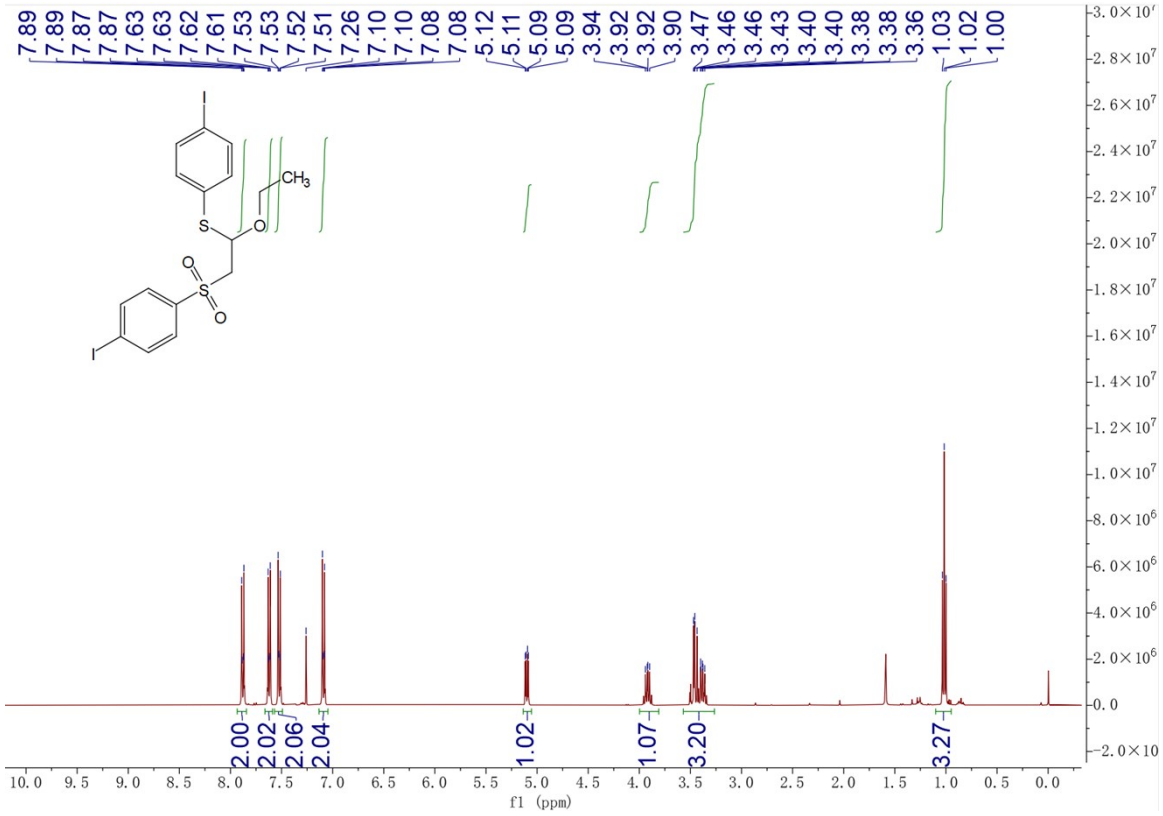
^{13}C NMR spectrum of **4n**



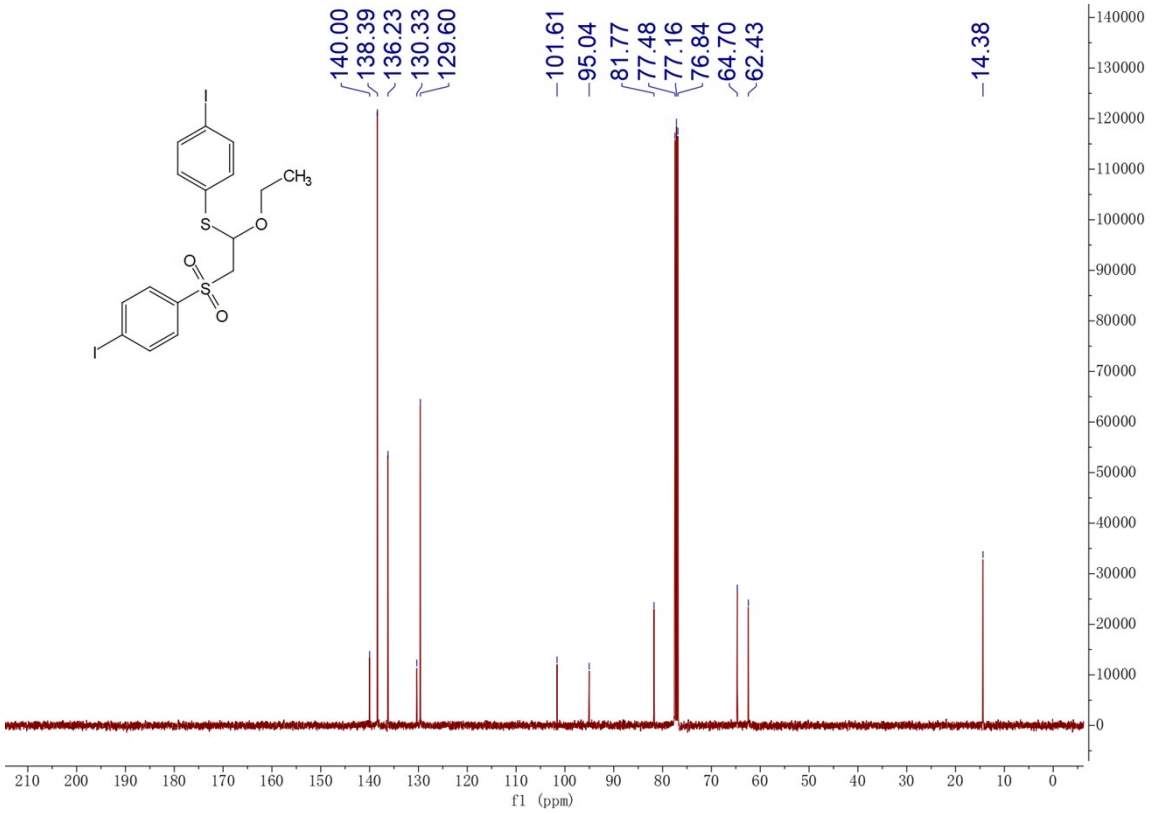
^{1}H NMR spectrum of **4o**



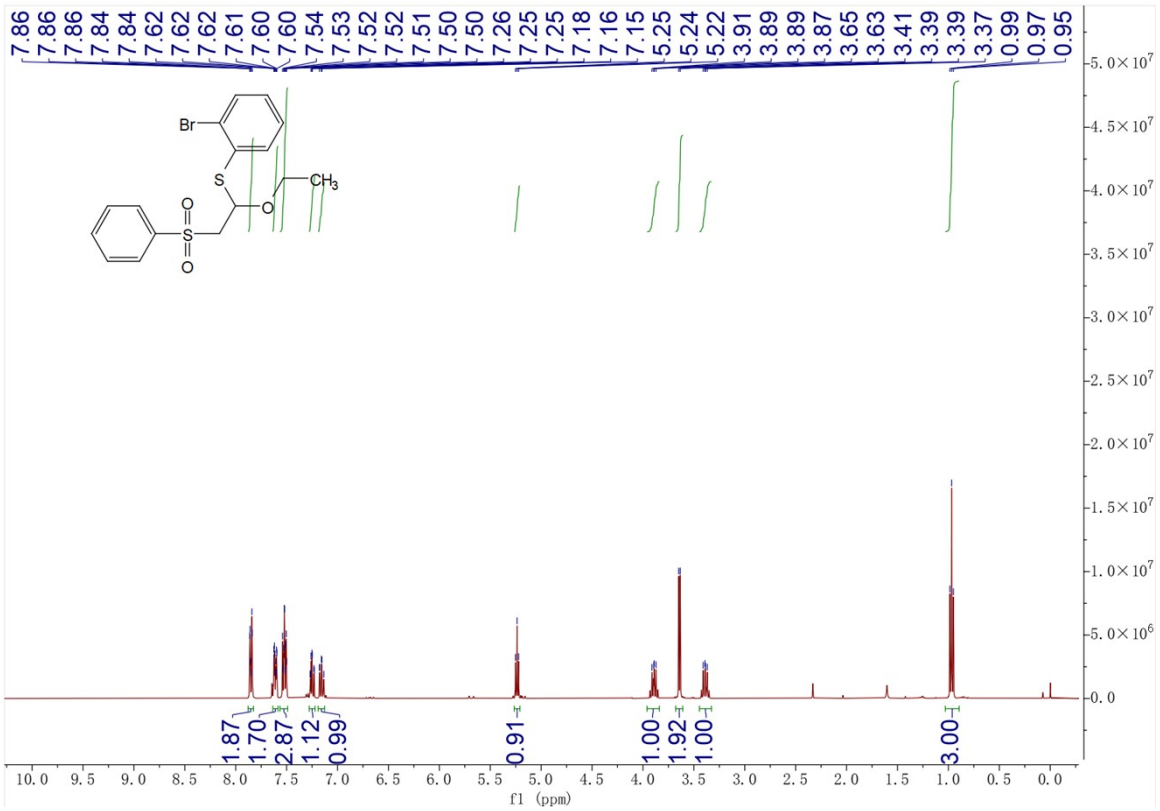
^{13}C NMR spectrum of **4o**



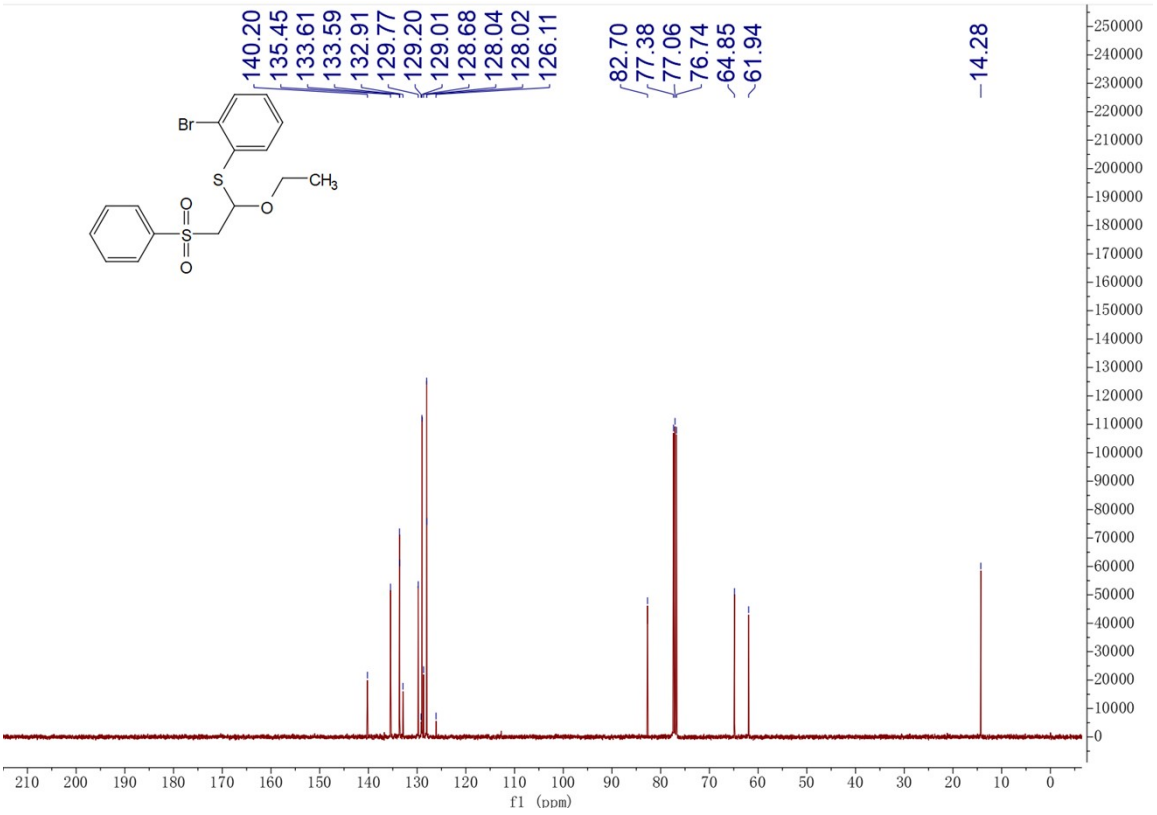
^{1}H NMR spectrum of **4p**



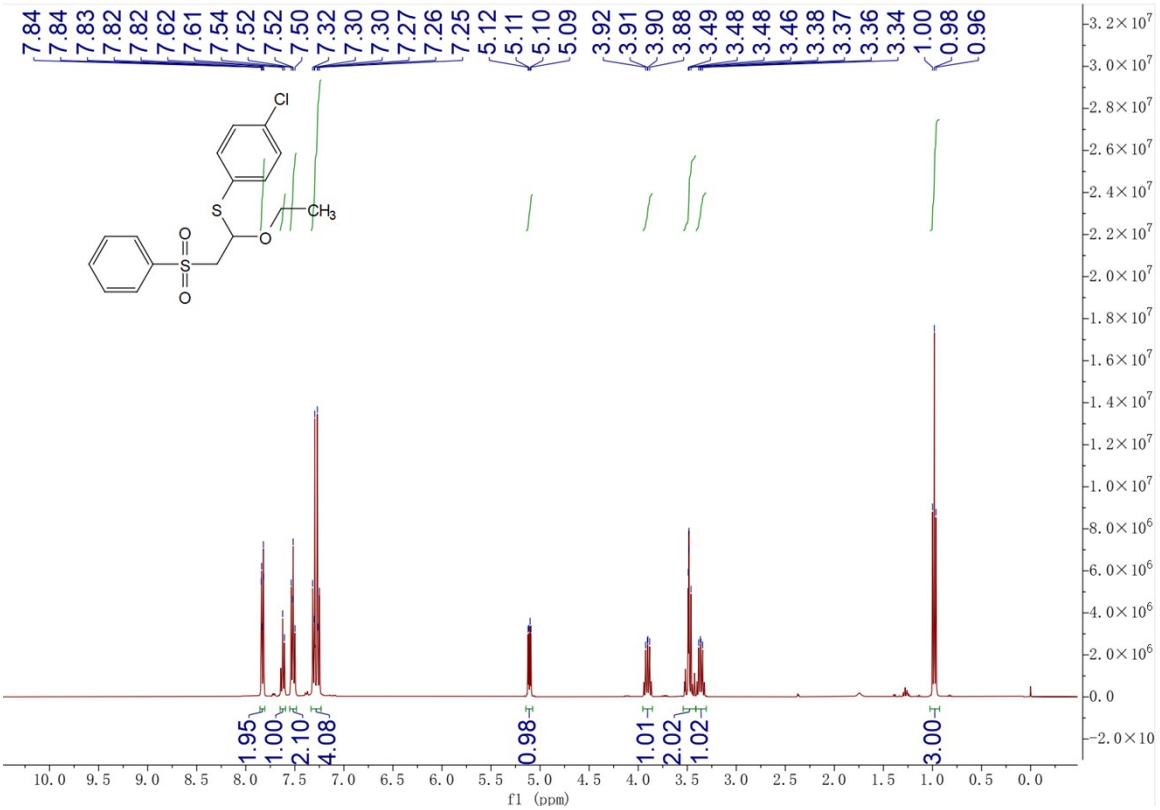
^{13}C NMR spectrum of **4p**



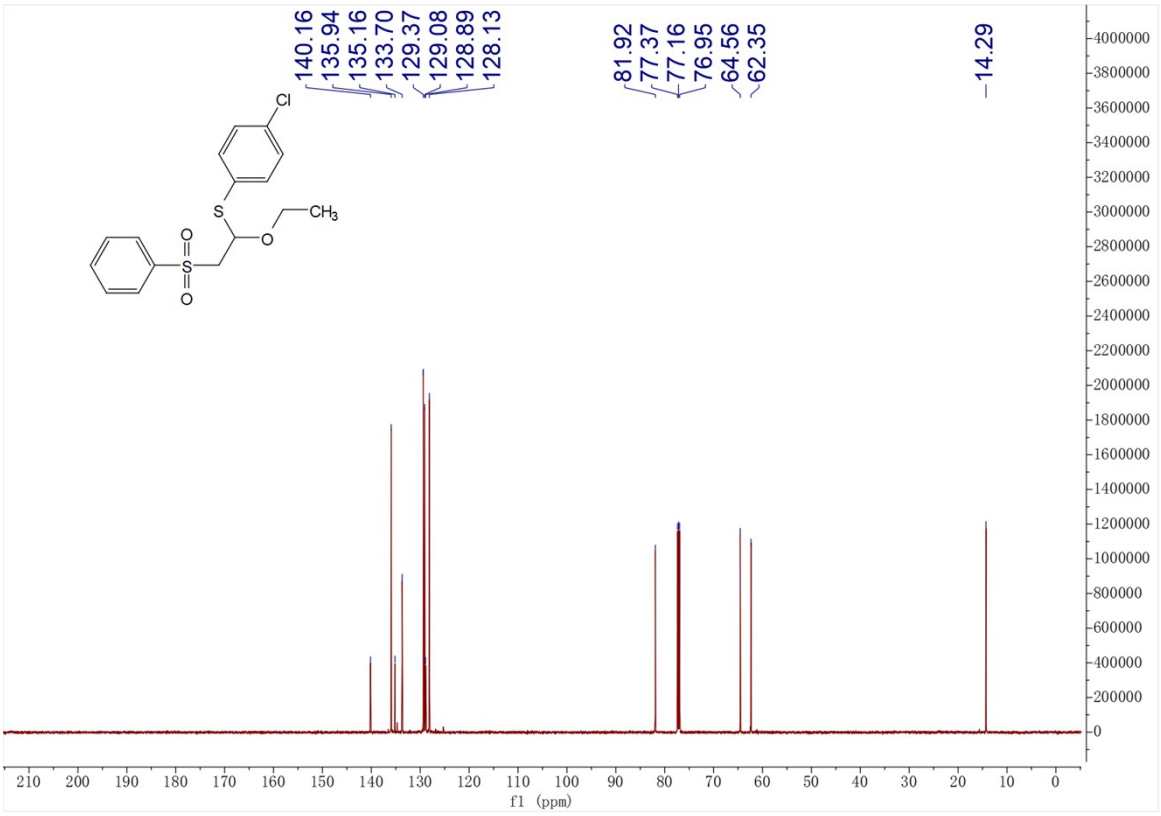
^{1}H NMR spectrum of **4q**



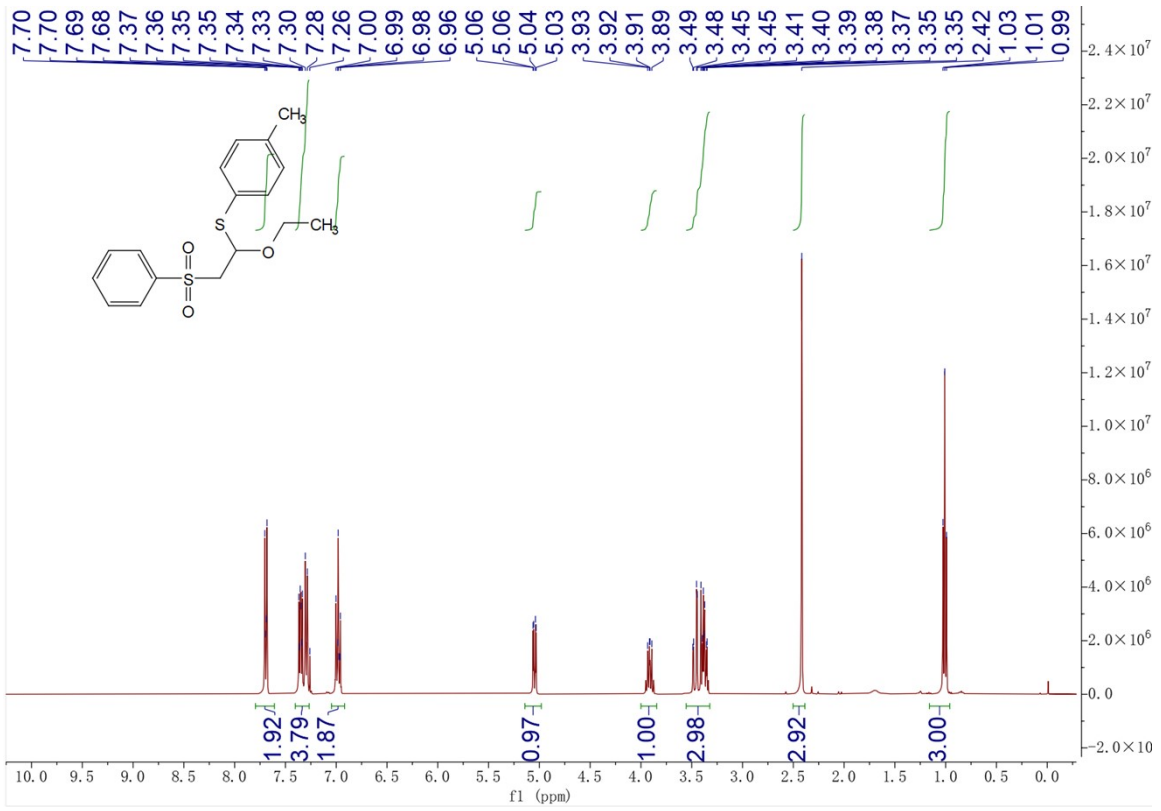
^{13}C NMR spectrum of **4q**



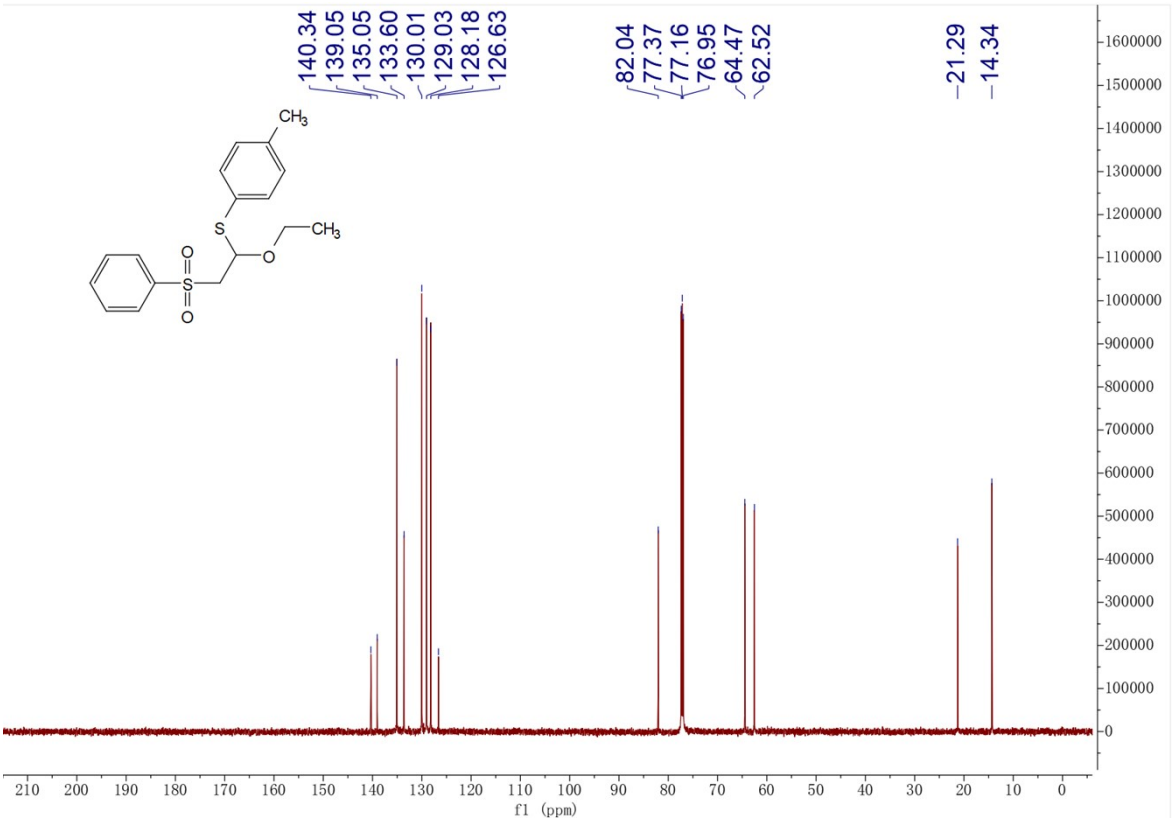
^{1}H NMR spectrum of **4r**



^{13}C NMR spectrum of **4r**

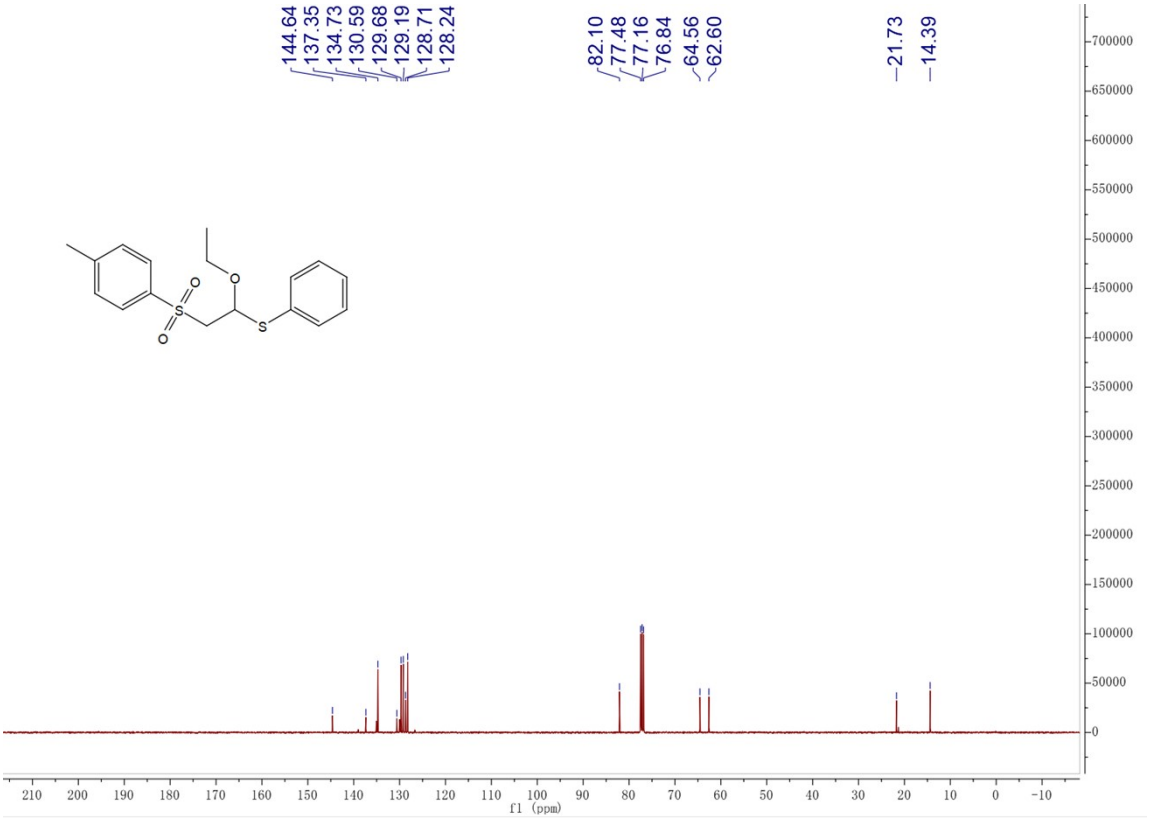


^{1}H NMR spectrum of **4s**

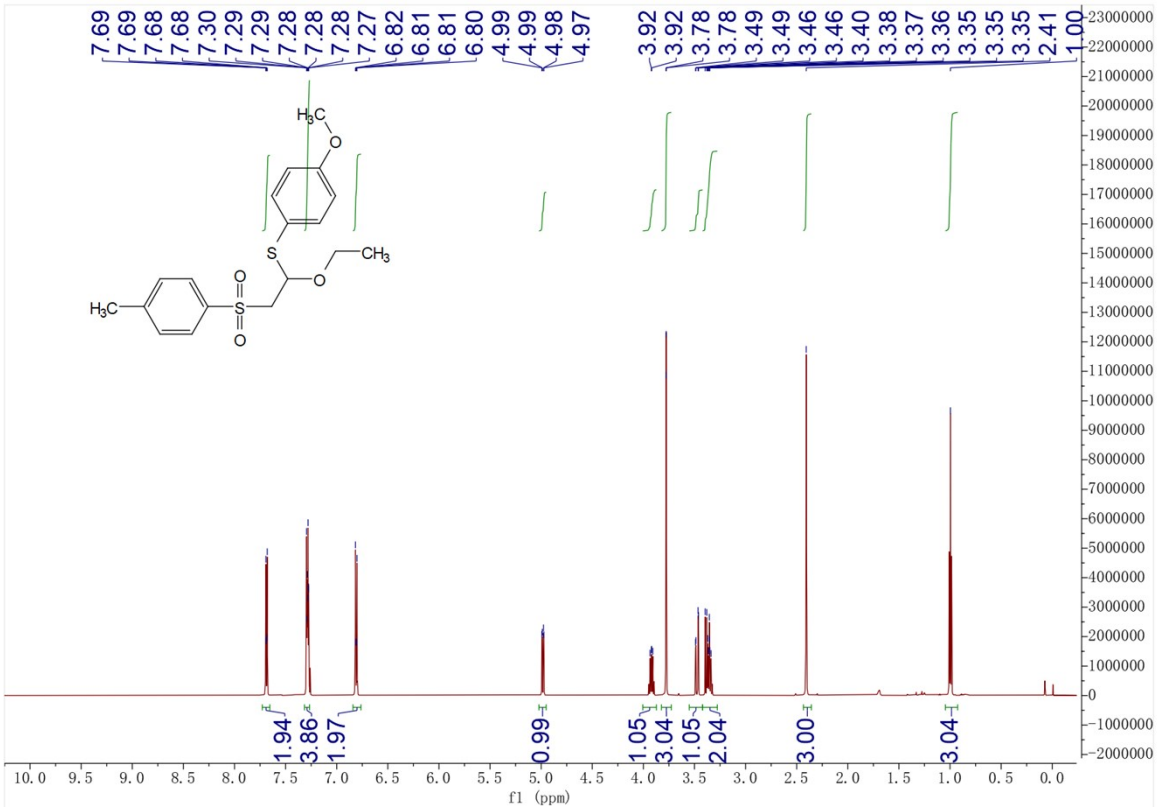


^{13}C NMR spectrum of **4s**

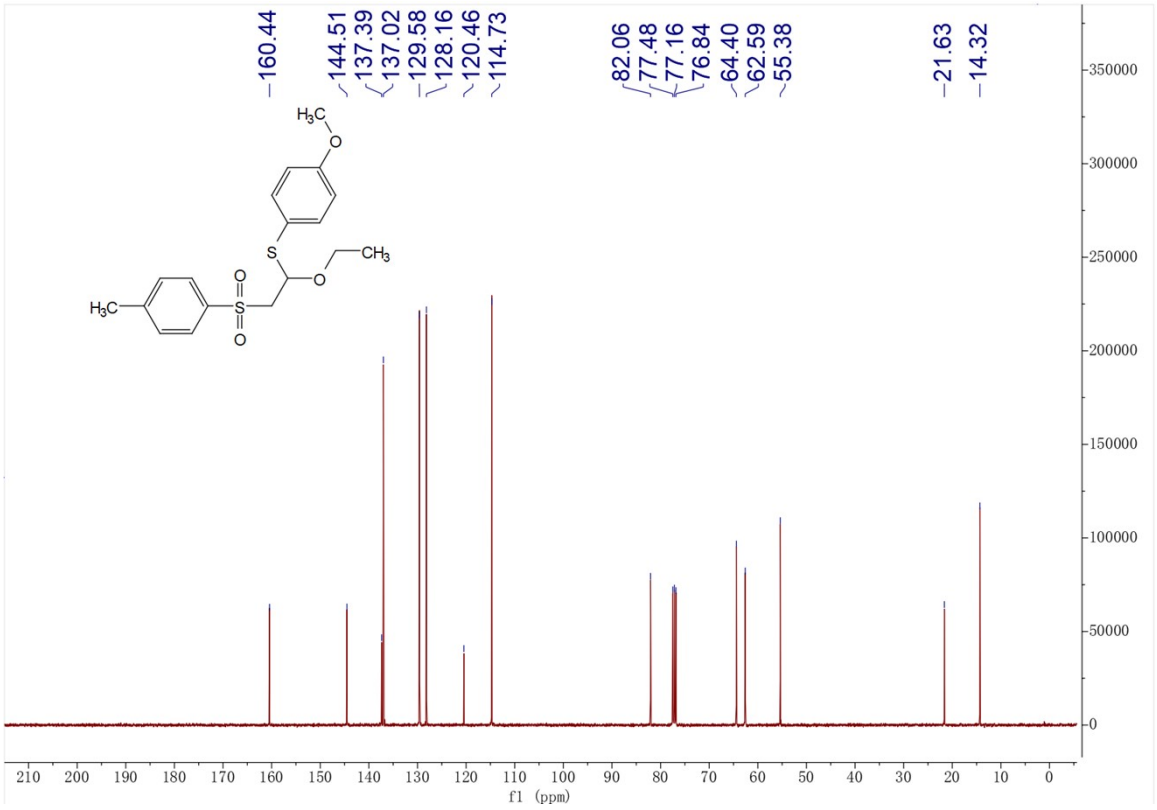
^{1}H NMR spectrum of **4t**



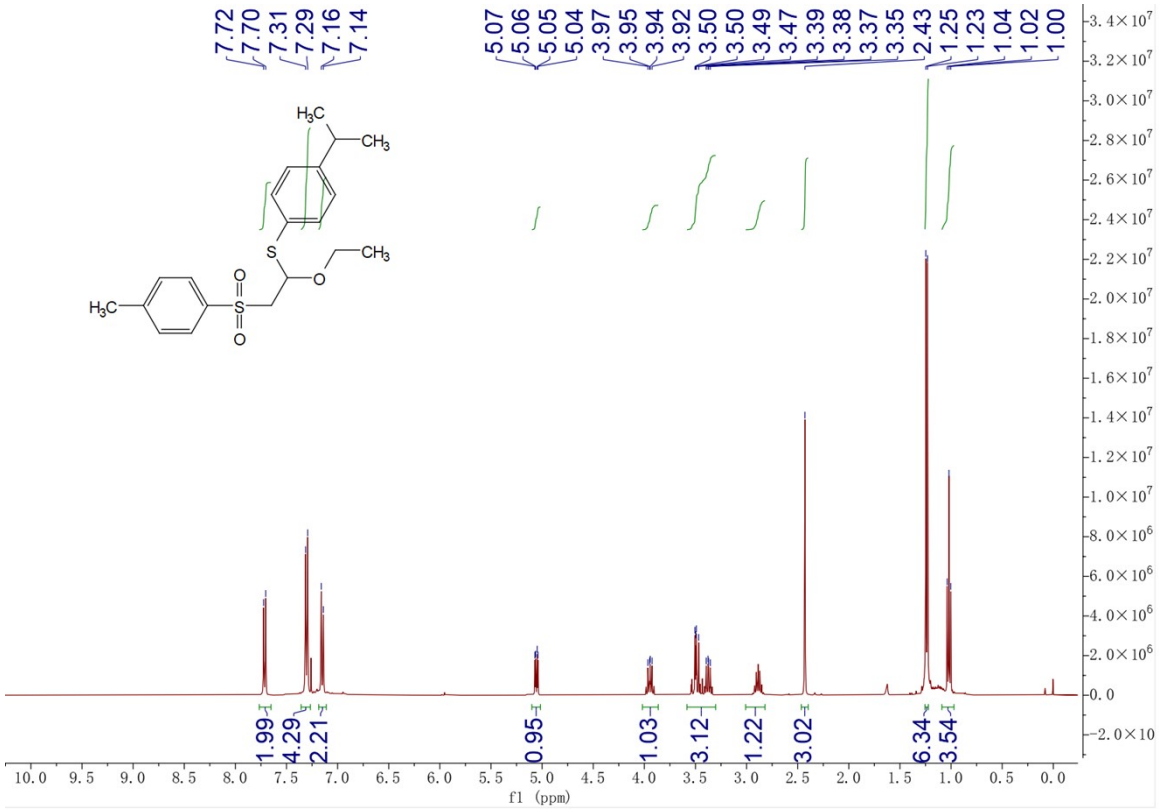
^{13}C NMR spectrum of **4t**



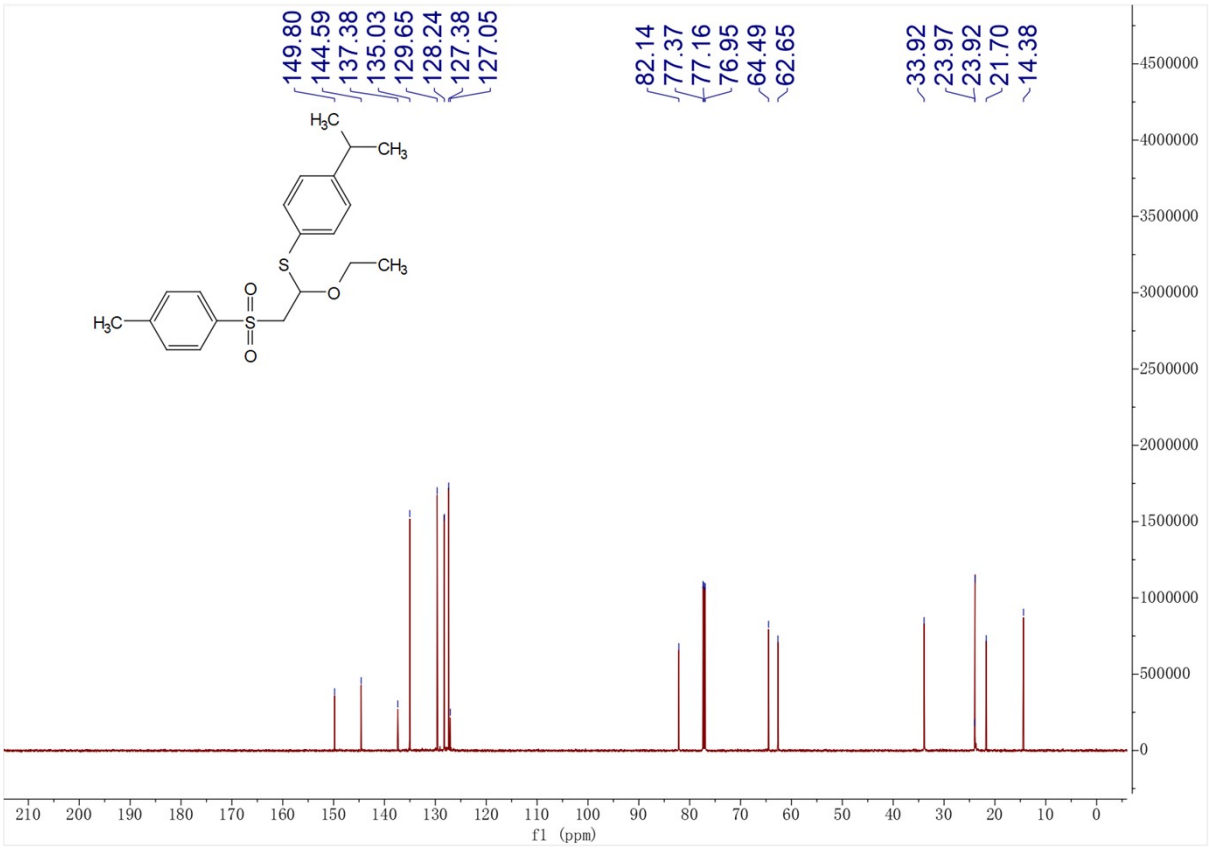
^{1}H NMR spectrum of **4u**



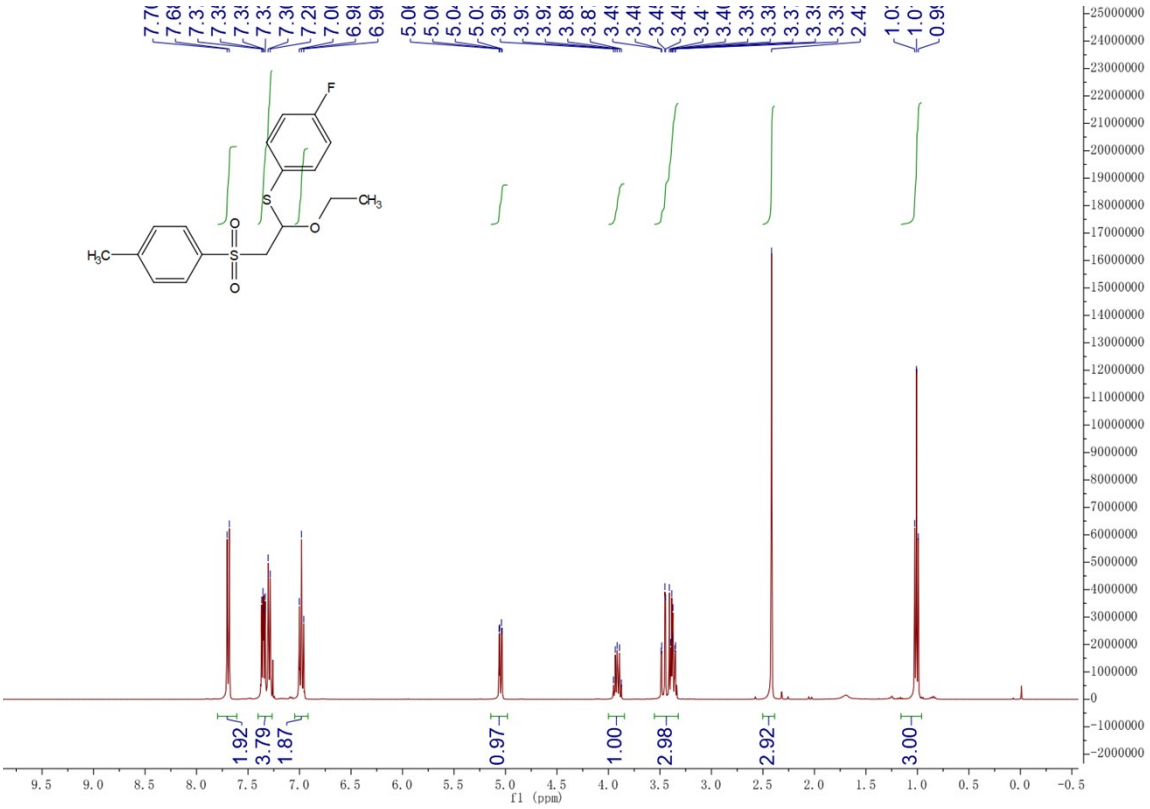
^{13}C NMR spectrum of **4u**



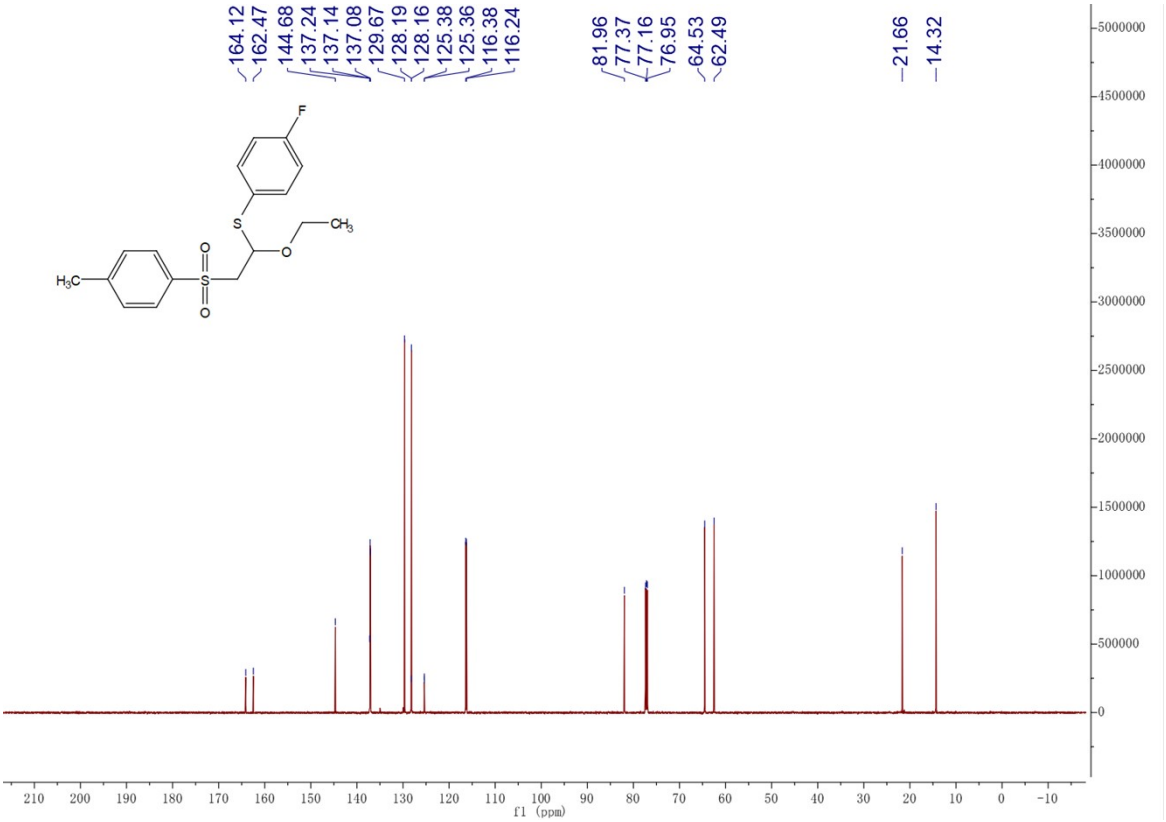
^{1}H NMR spectrum of **4v**



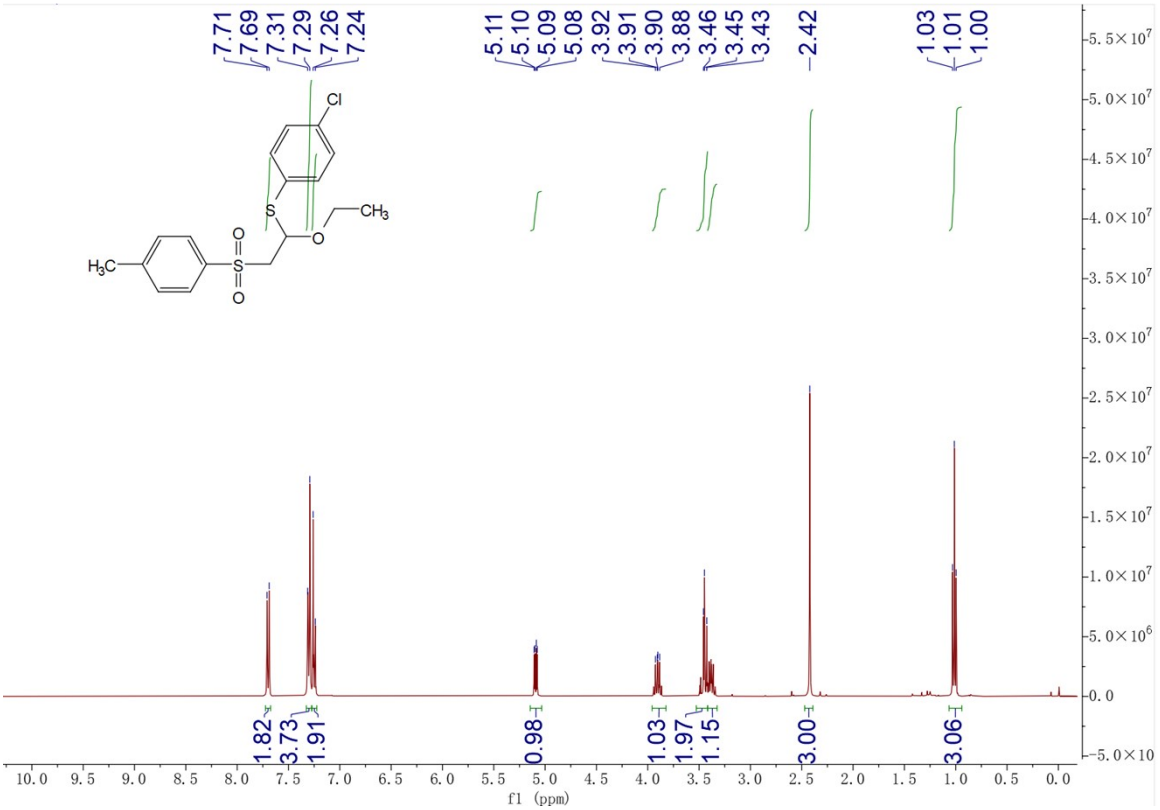
^{13}C NMR spectrum of **4v**



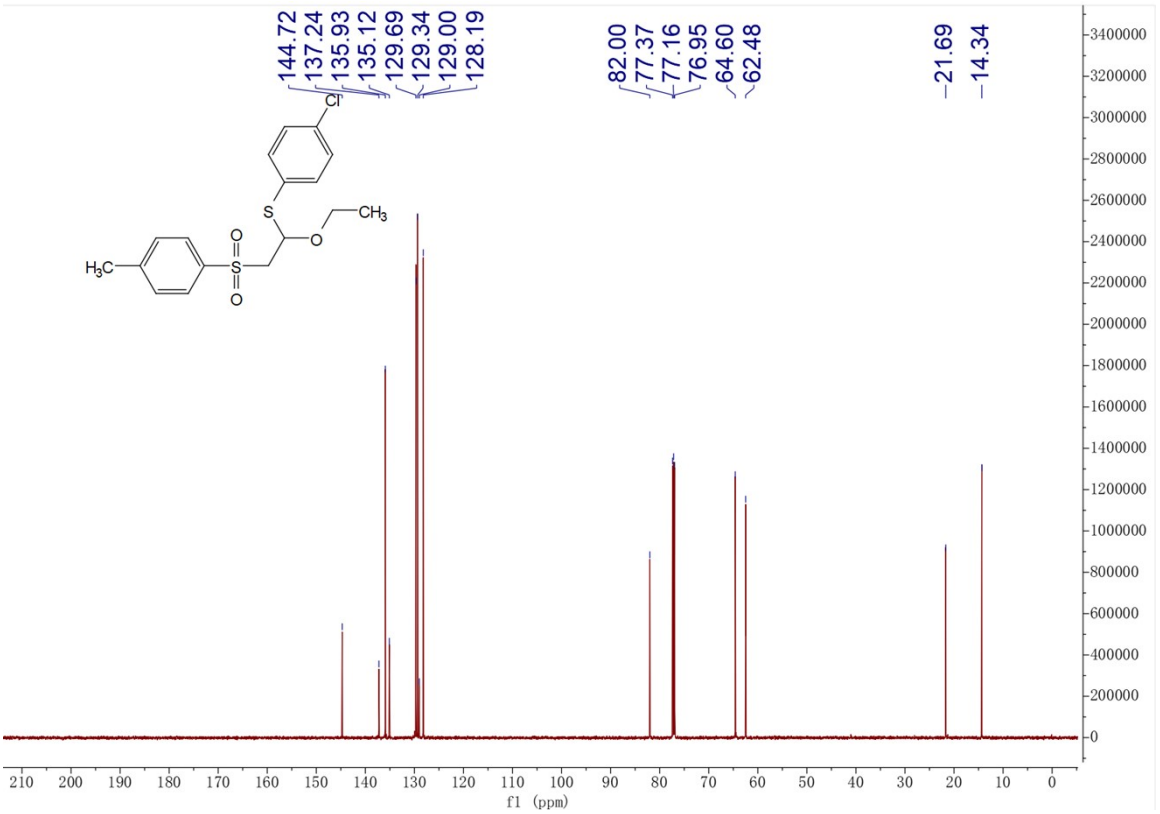
^{1}H NMR spectrum of **4w**



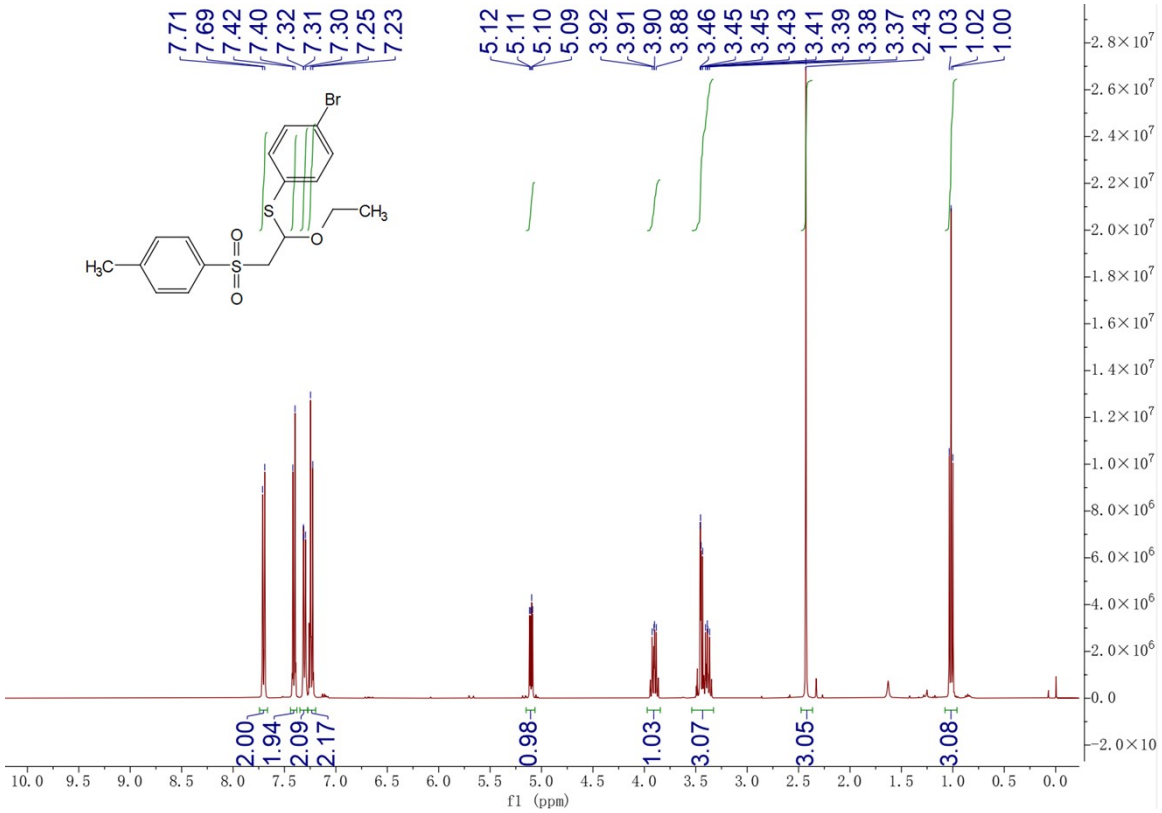
^{13}C NMR spectrum of **4w**



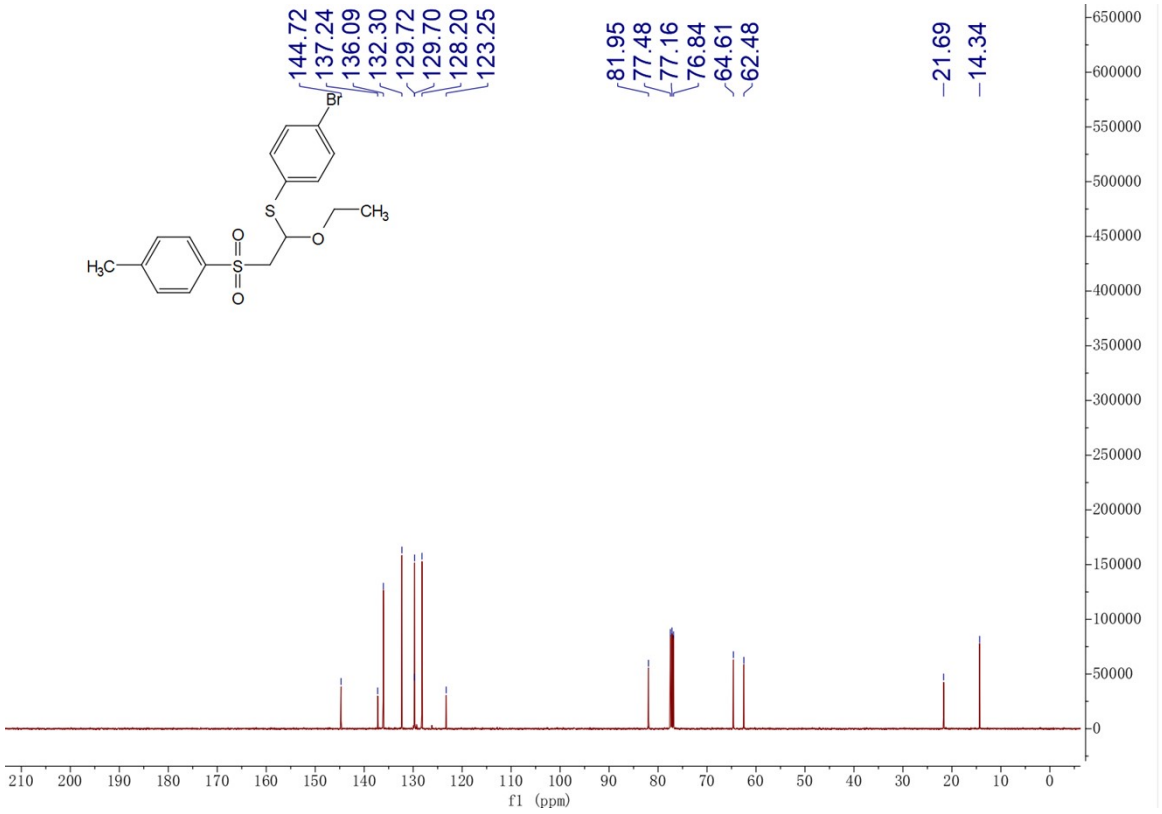
^{1}H NMR spectrum of **4x**



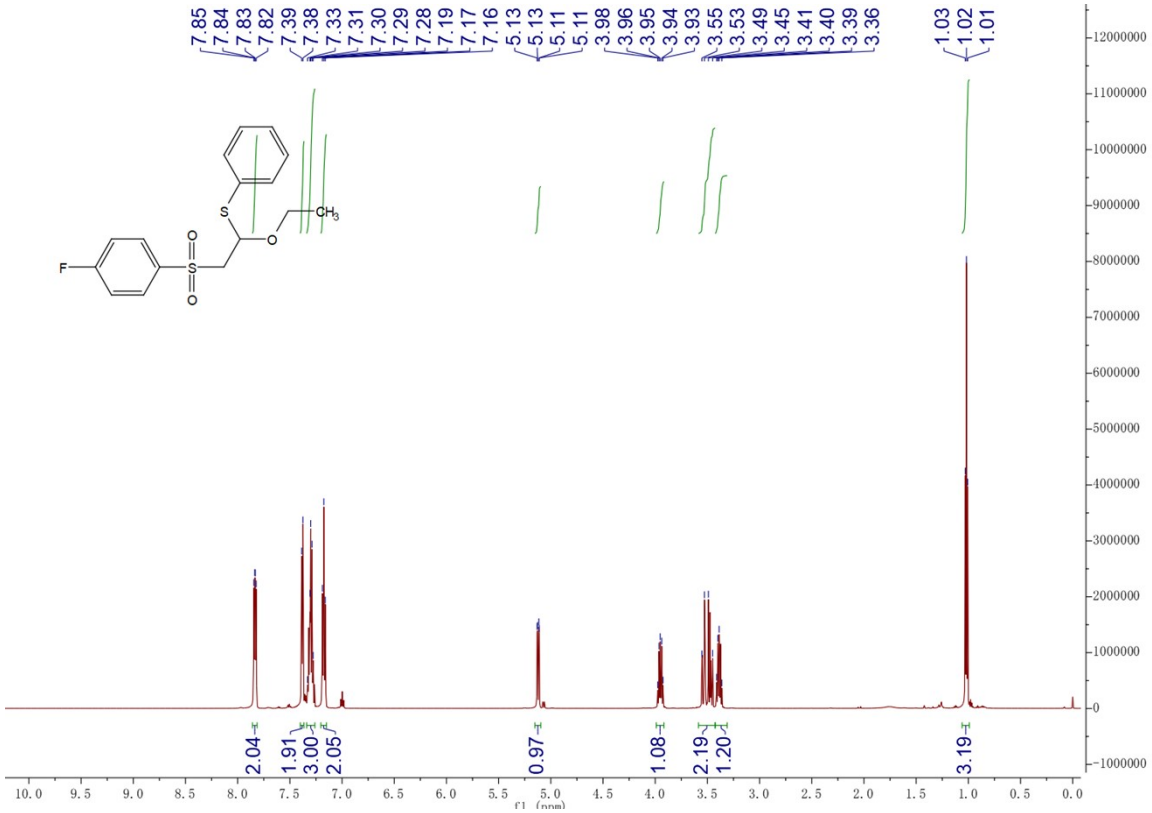
^{13}C NMR spectrum of **4x**



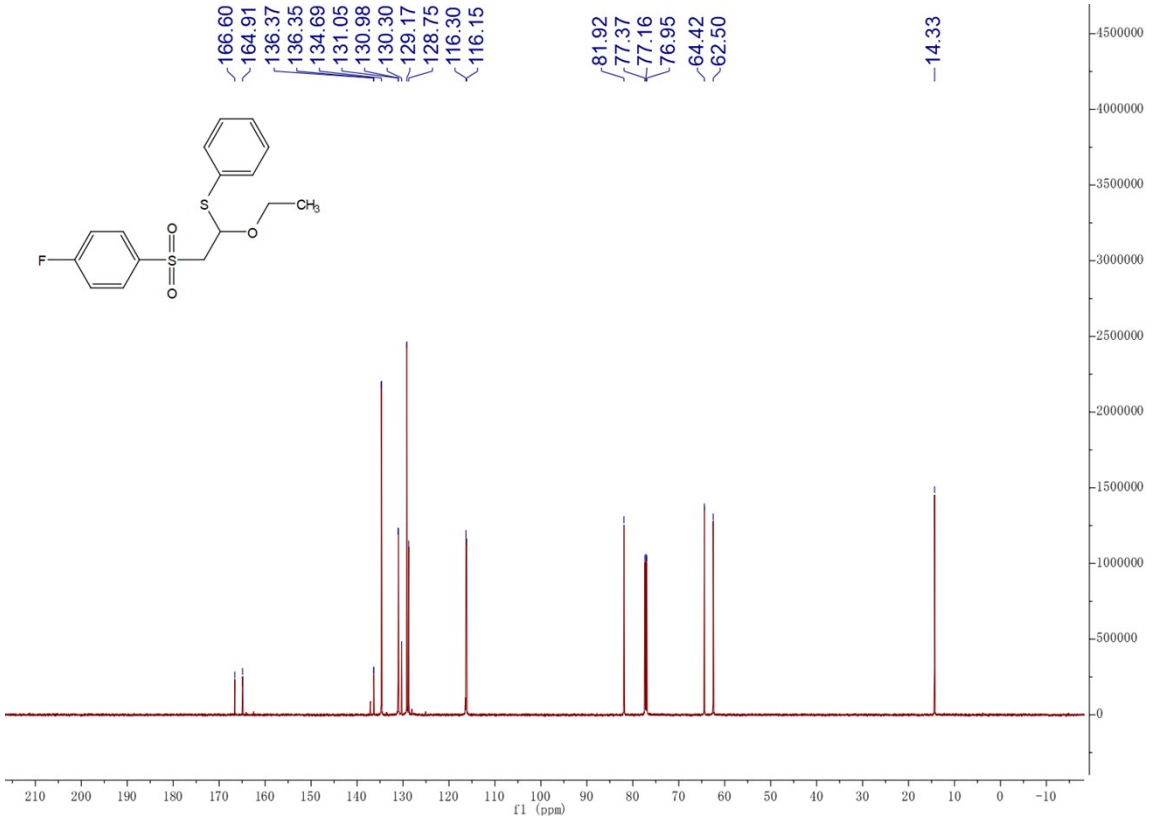
^{1}H NMR spectrum of **4y**



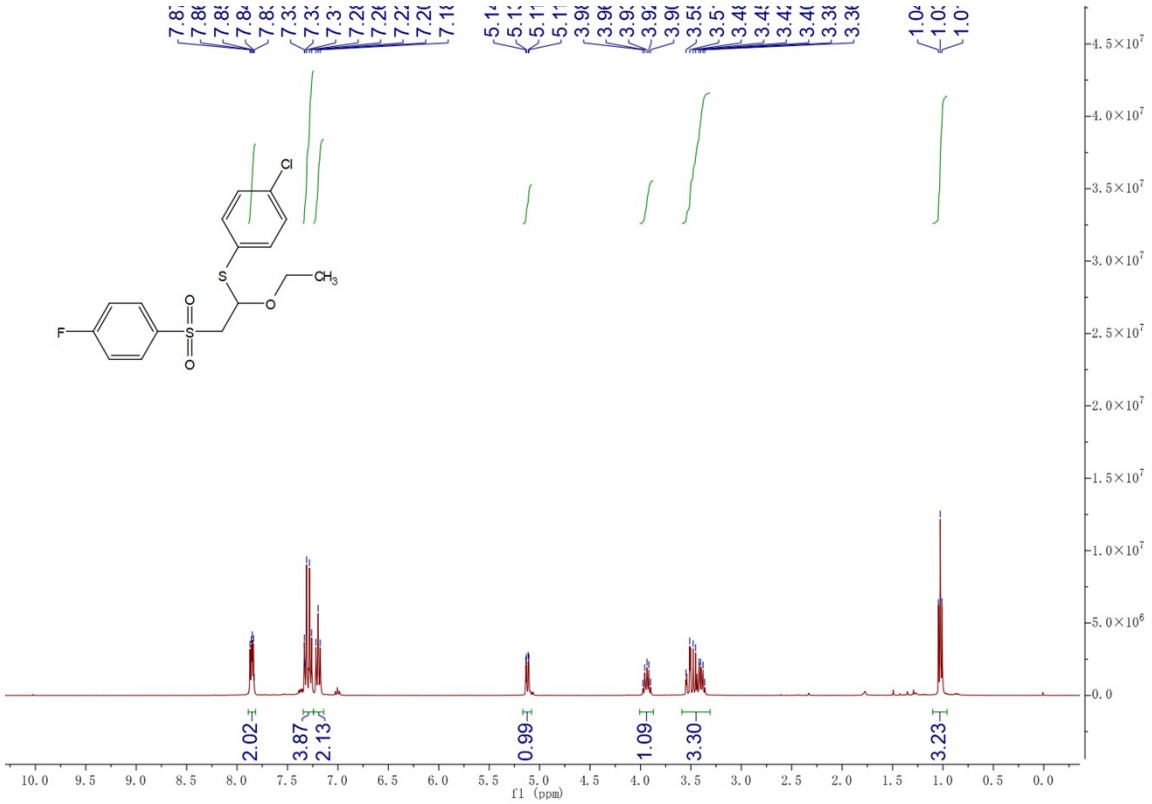
^{13}C NMR spectrum of **4y**



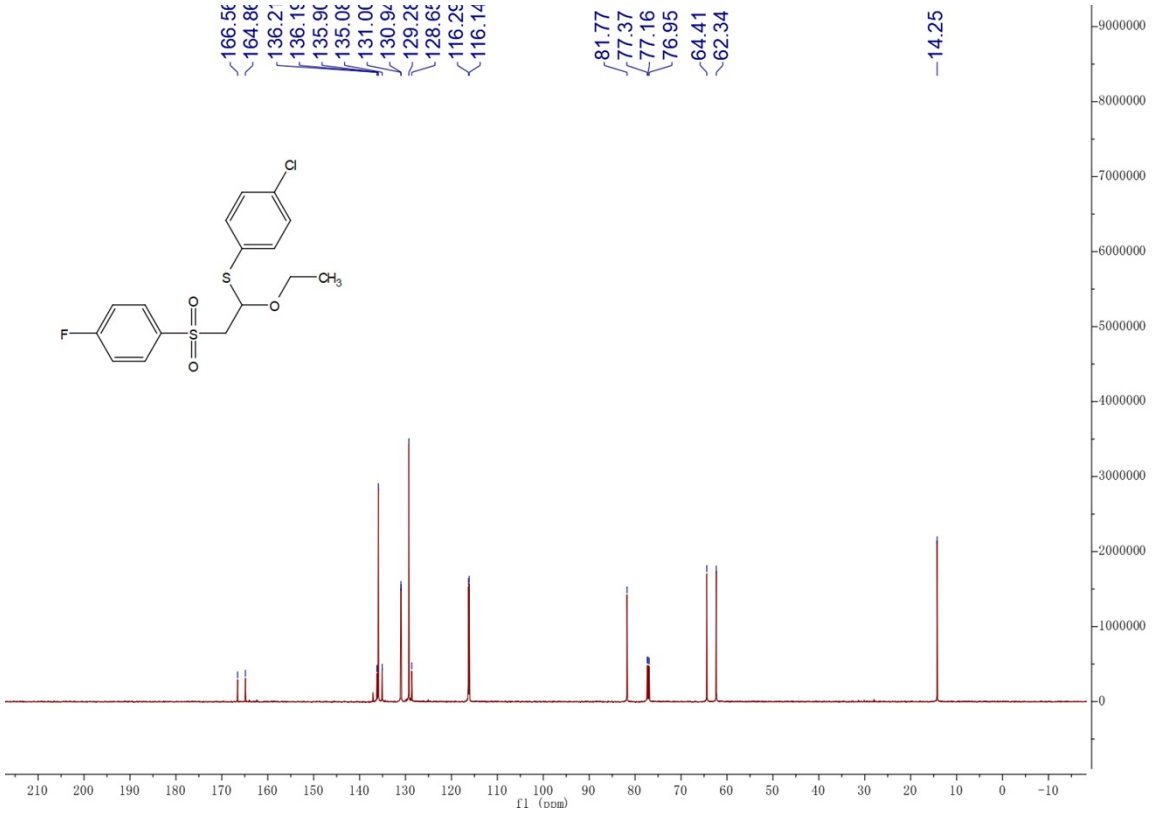
^{1}H NMR spectrum of **4z**



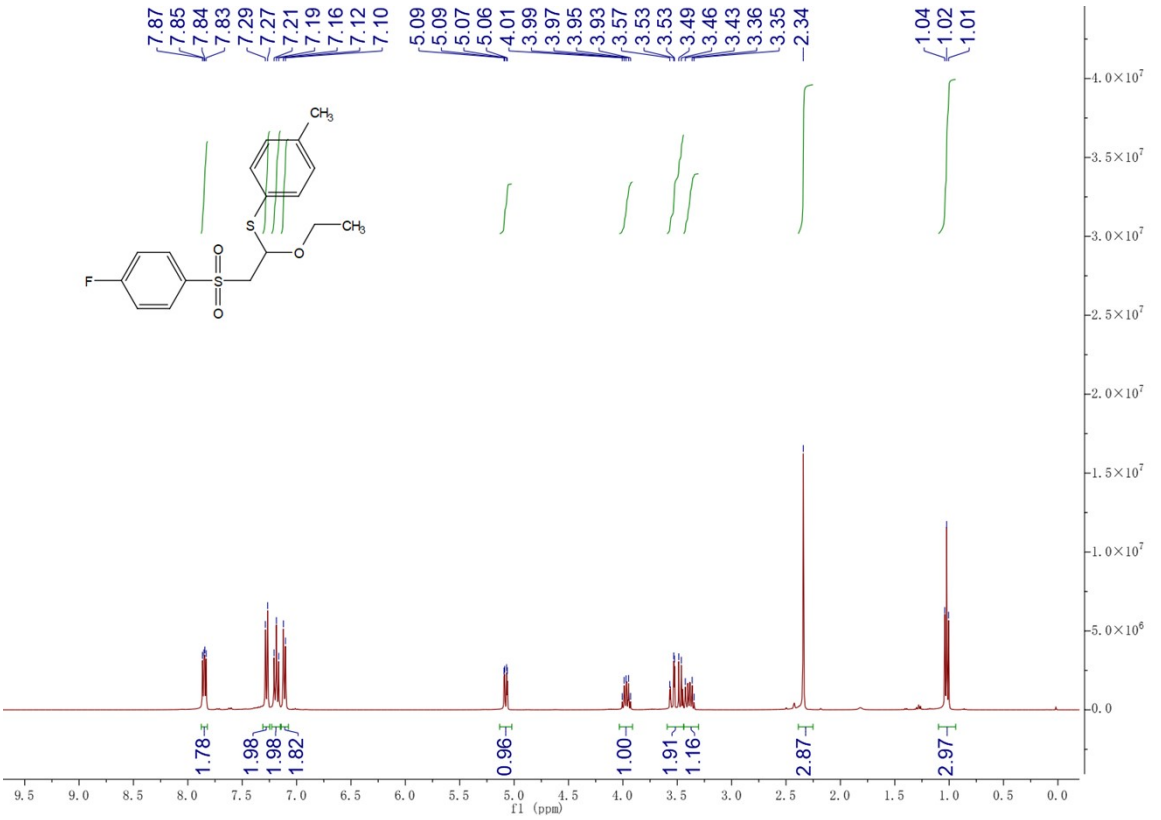
^{13}C NMR spectrum of **4z**



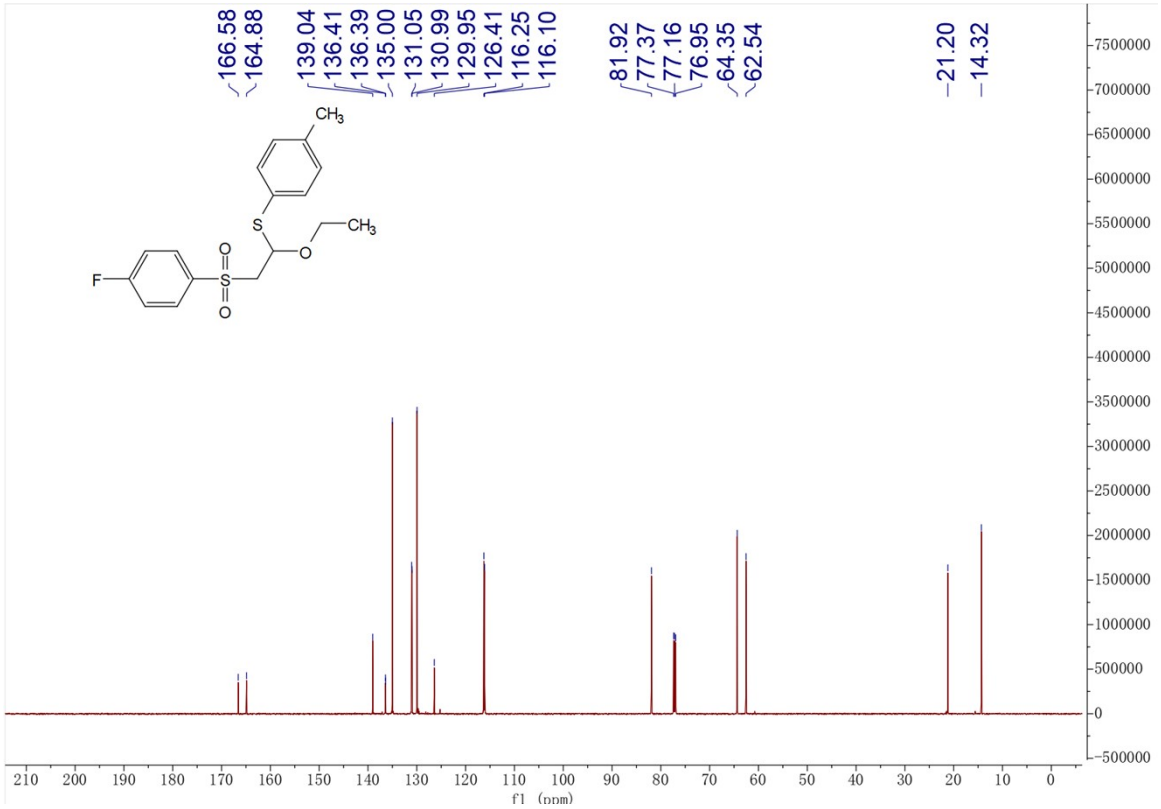
^{1}H NMR spectrum of **4aa**



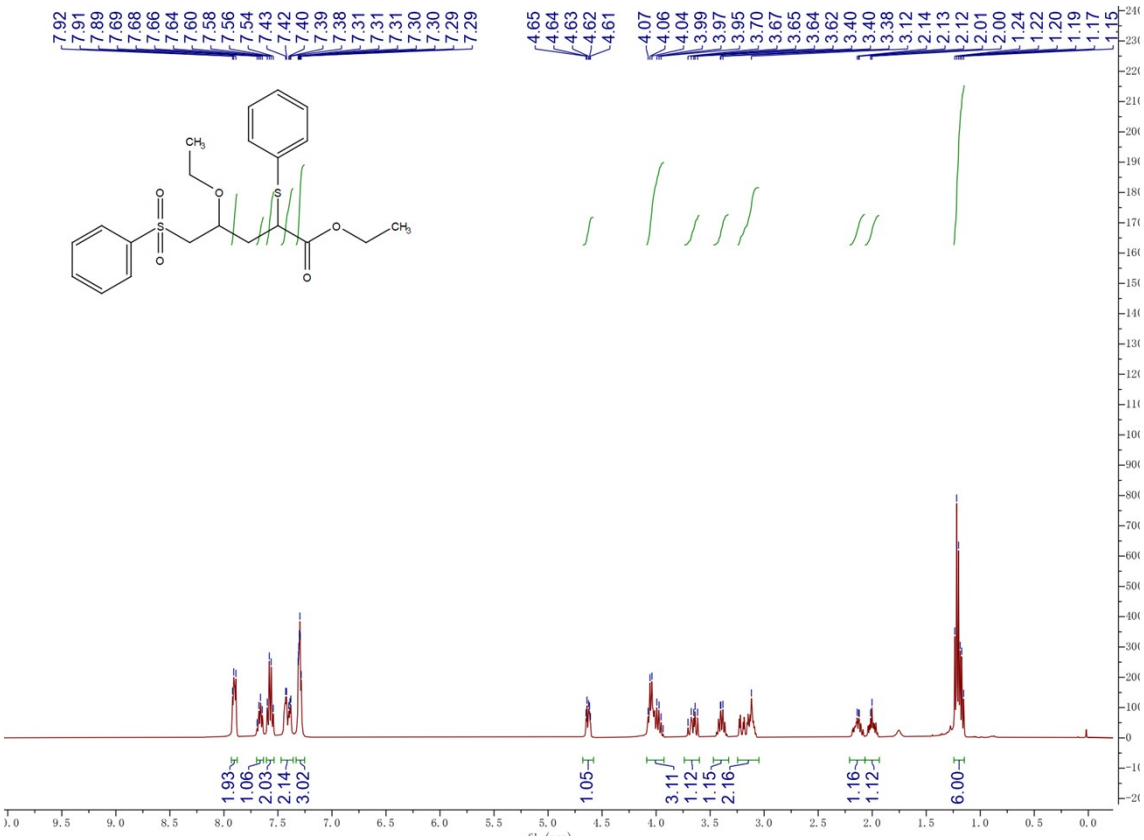
^{13}C NMR spectrum of **4aa**



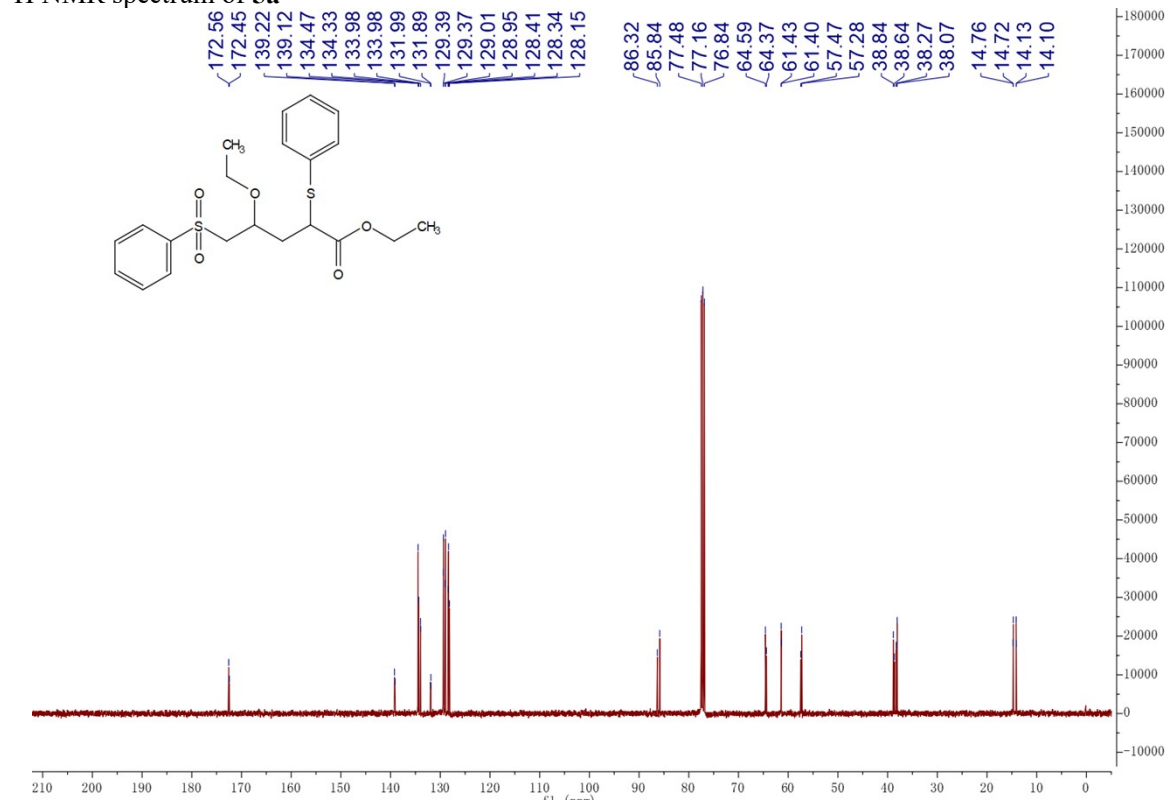
^{1}H NMR spectrum of **4ab**



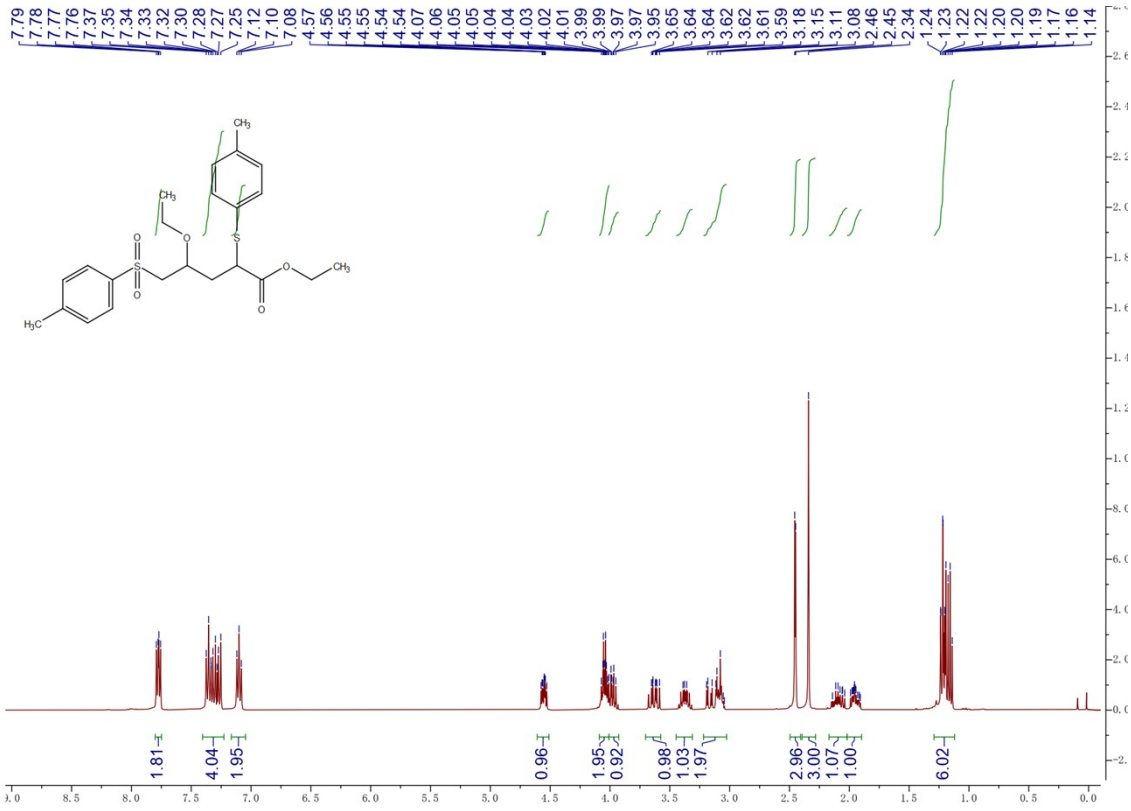
^{13}C NMR spectrum of **4ab**



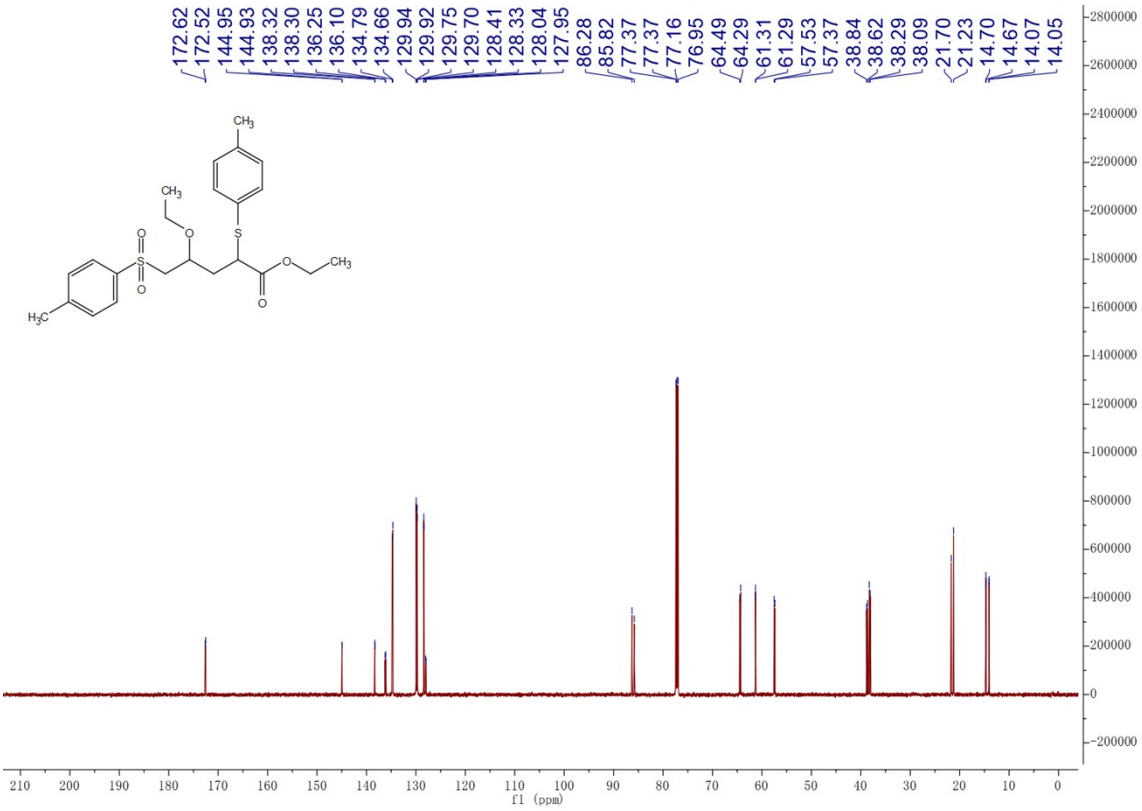
^{1}H NMR spectrum of **5a**



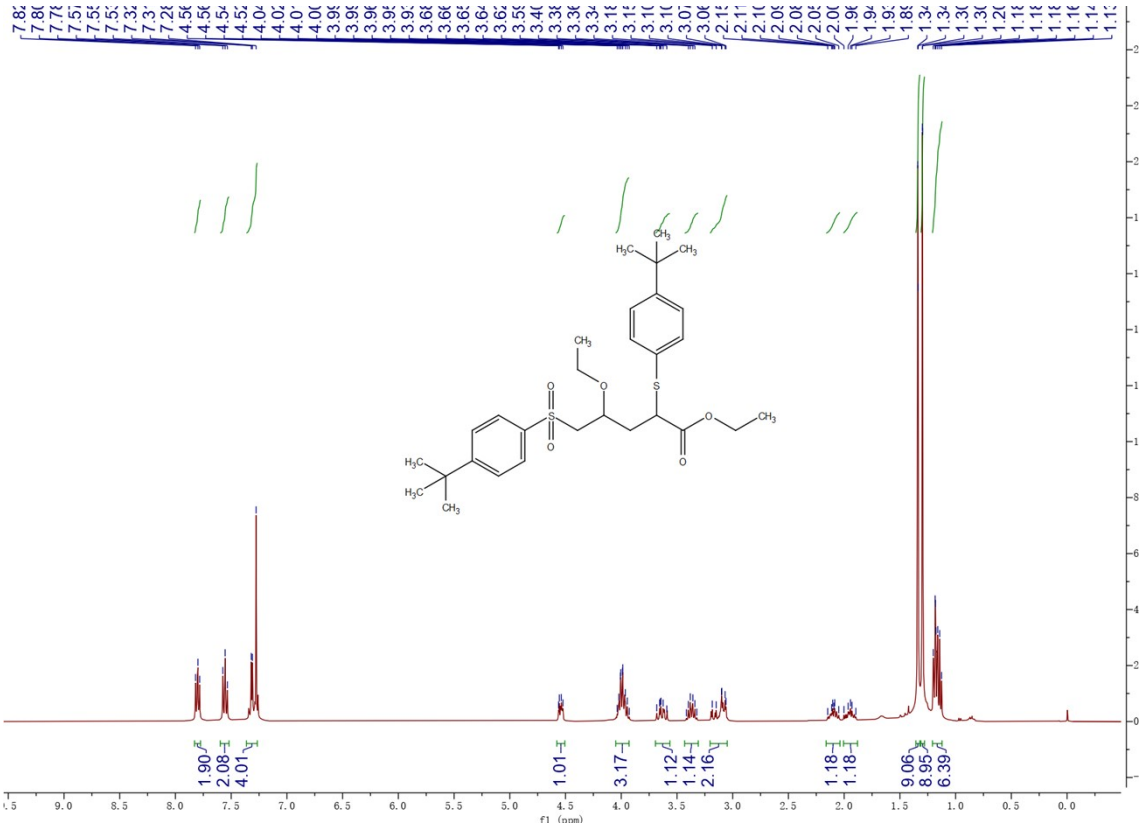
^{13}C NMR spectrum of **5a**



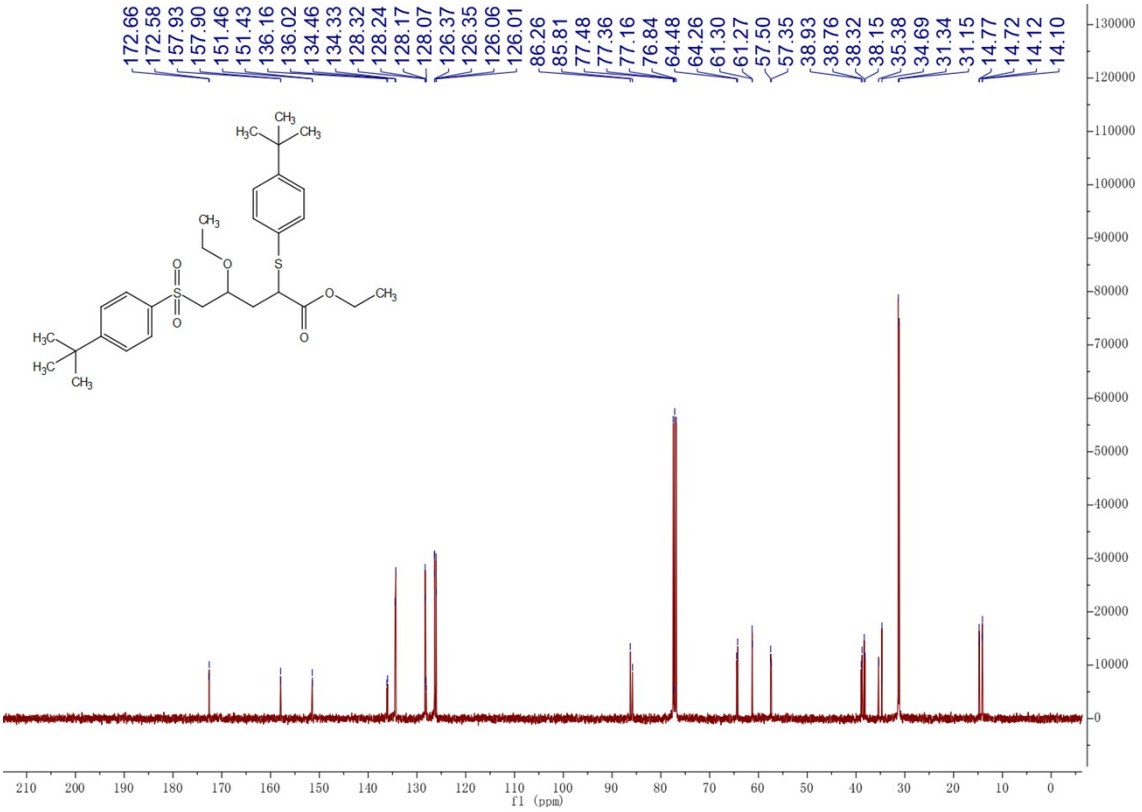
^{1}H NMR spectrum of **5b**



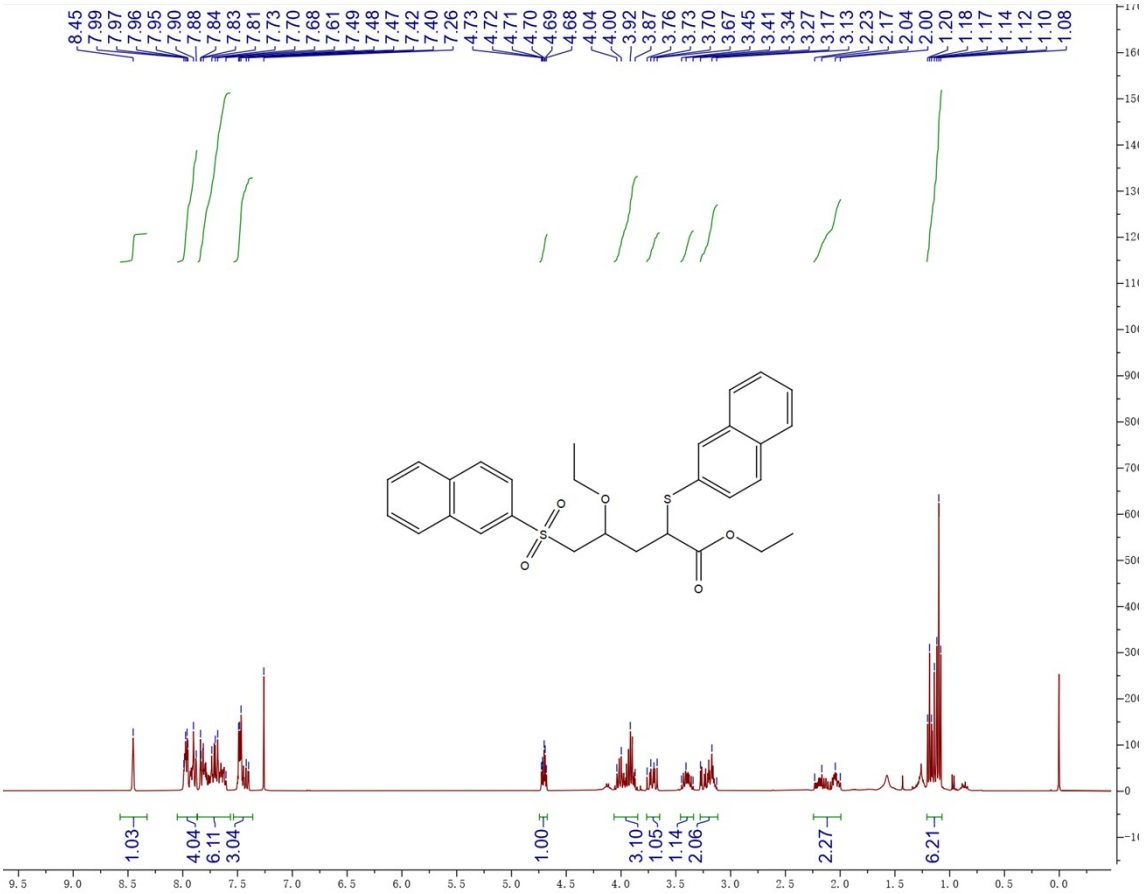
^{13}C NMR spectrum of **5b**



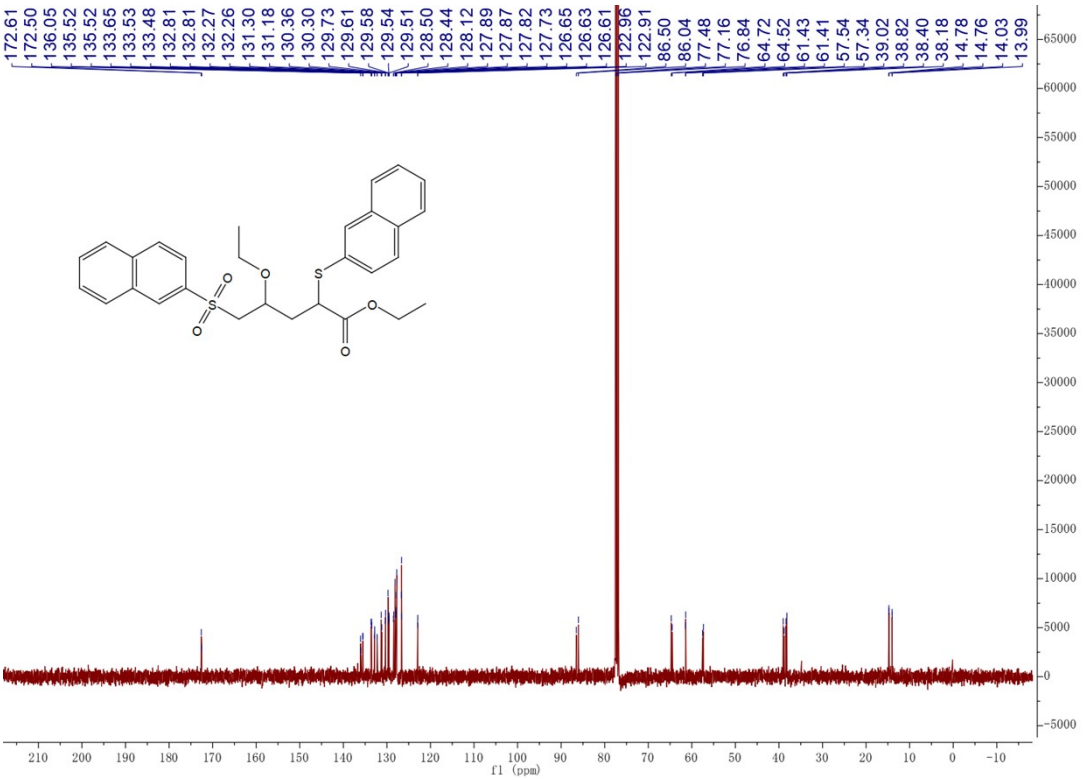
^{1}H NMR spectrum of **5c**



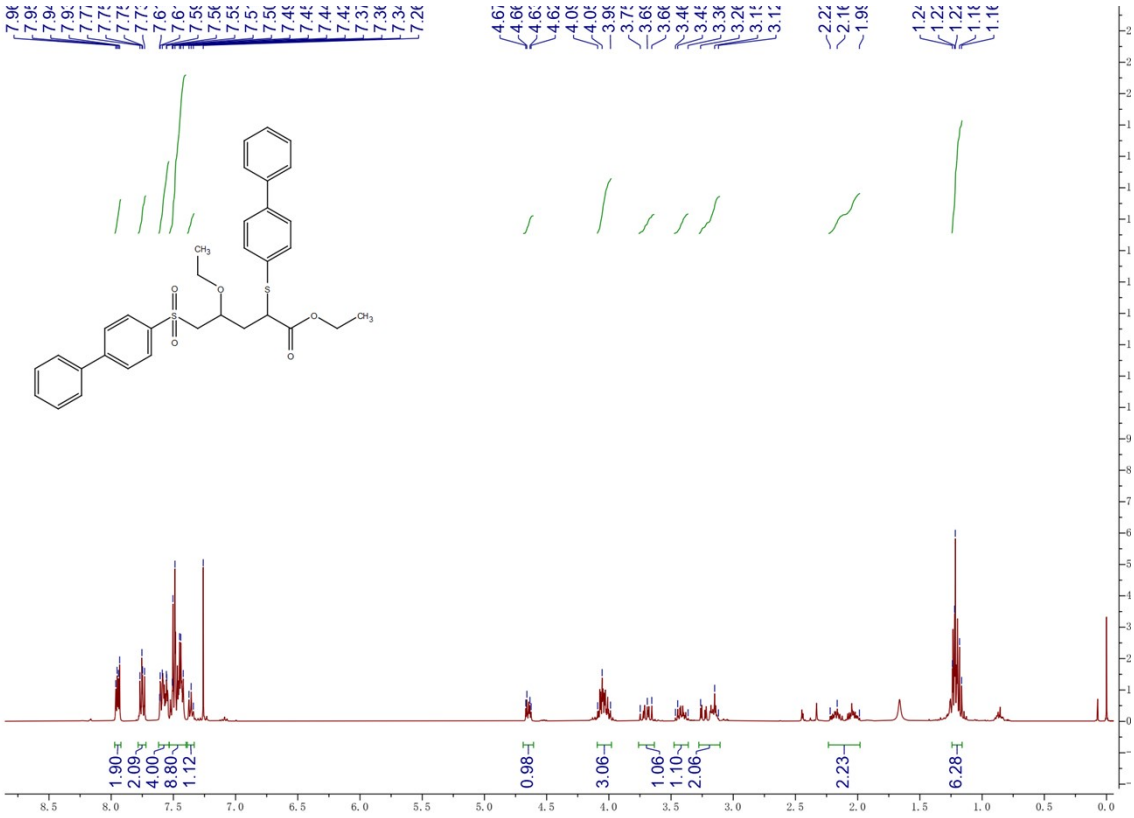
^{13}C NMR spectrum of **5c**



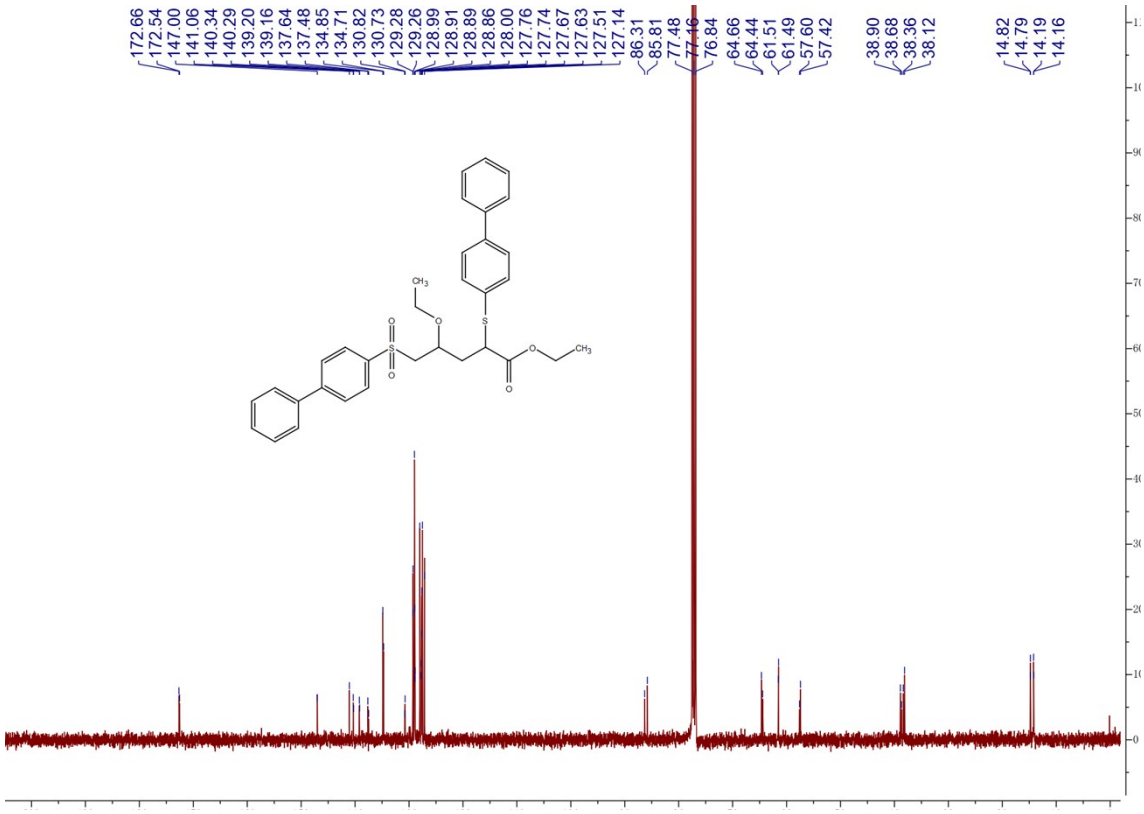
^{1}H NMR spectrum of **5d**



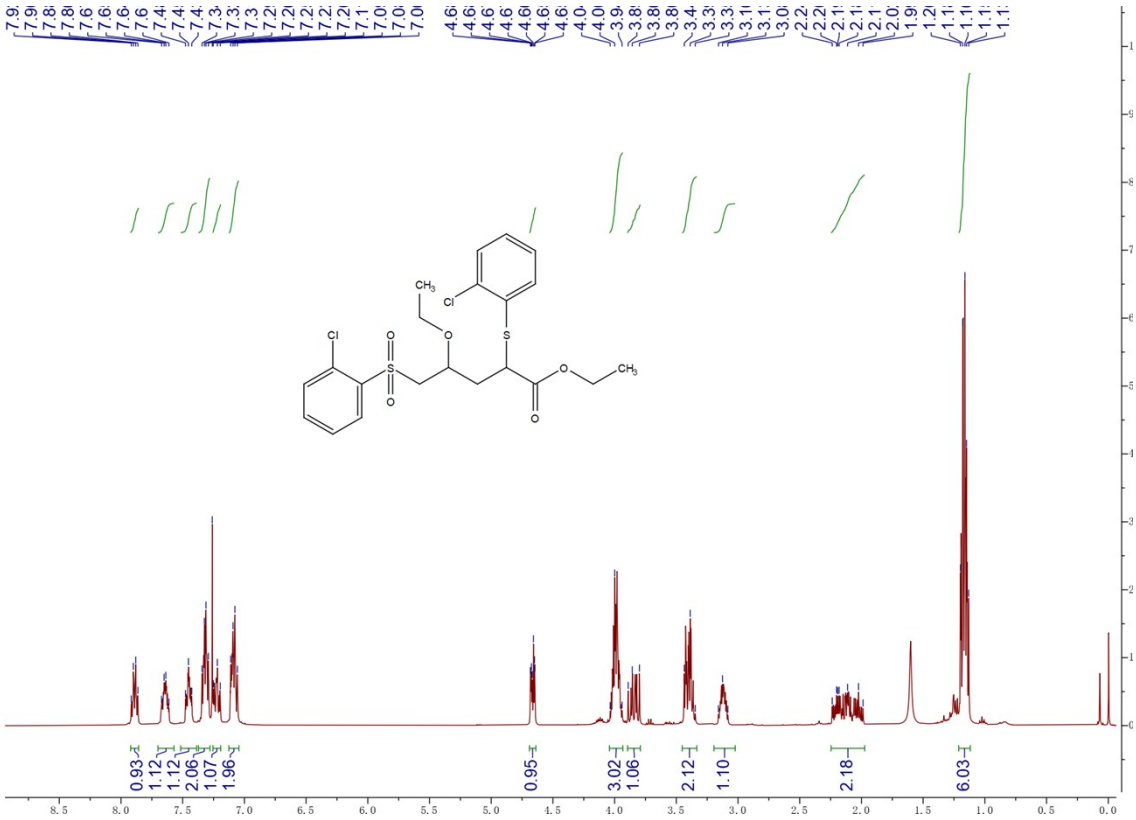
^{13}C NMR spectrum of **5d**



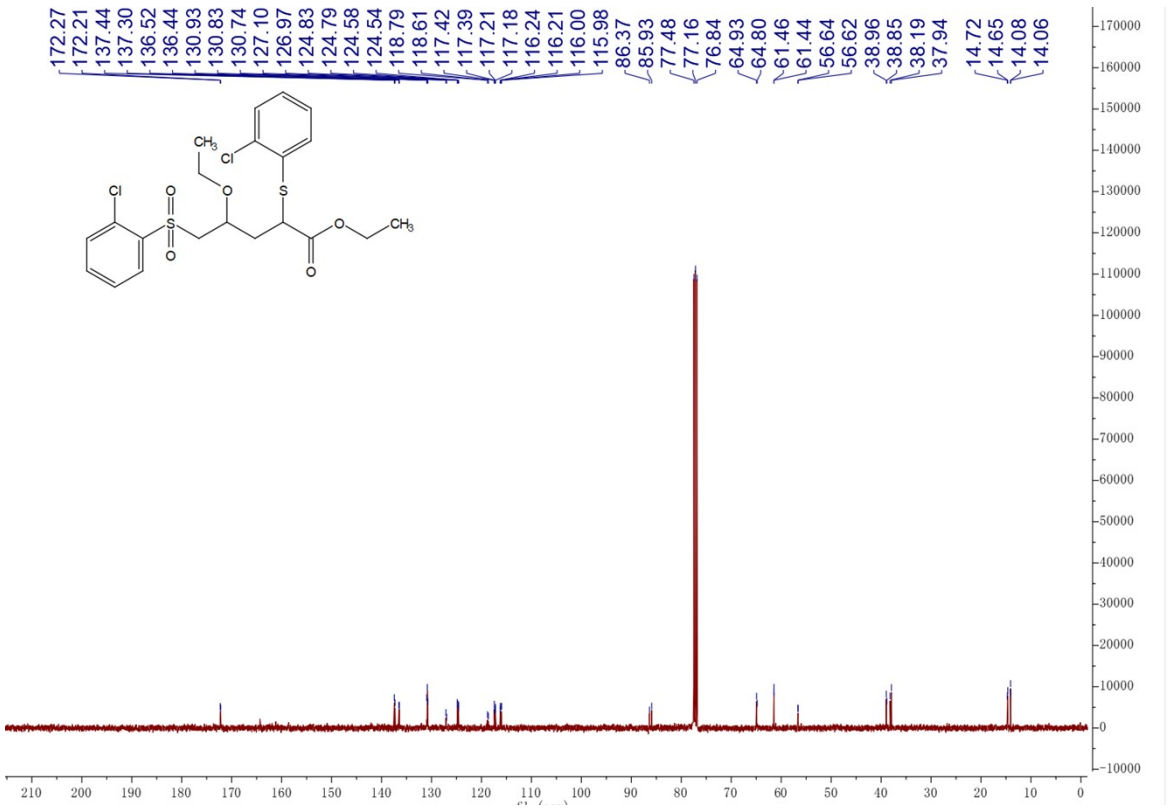
^{1}H NMR spectrum of **5e**



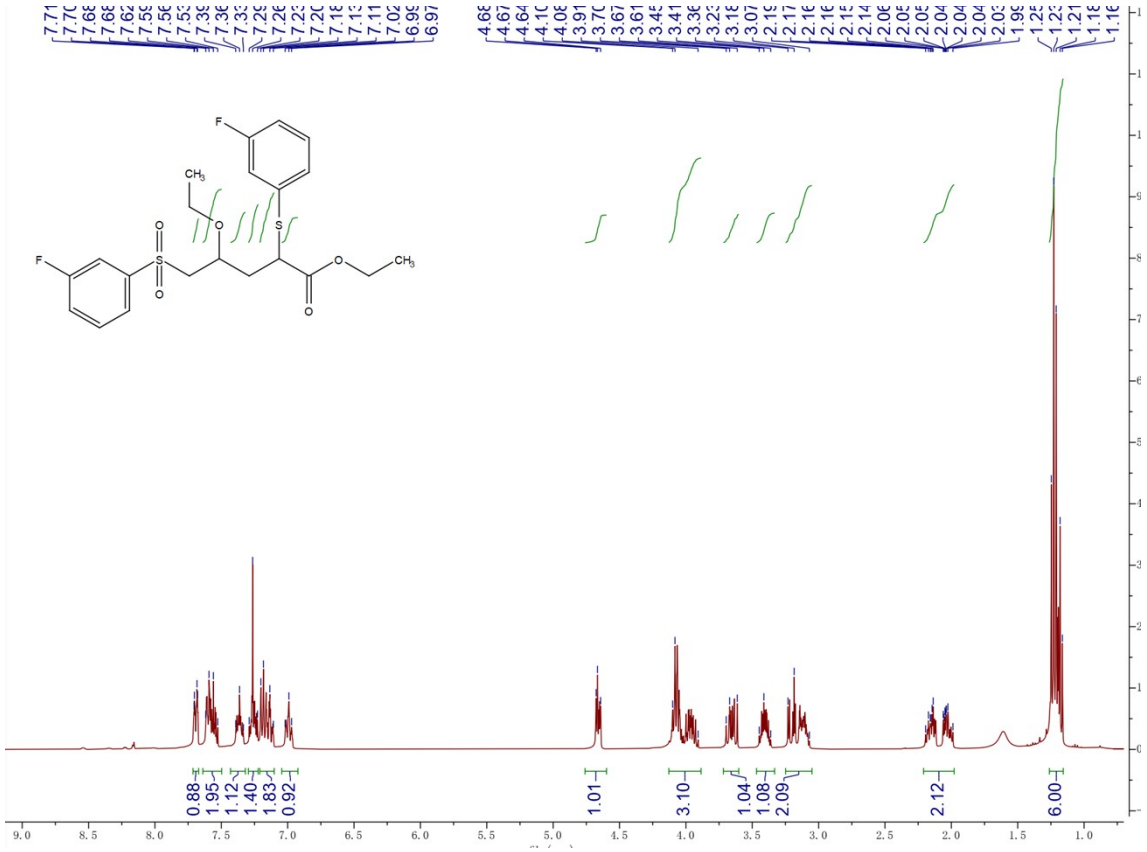
^{13}C NMR spectrum of **5e**



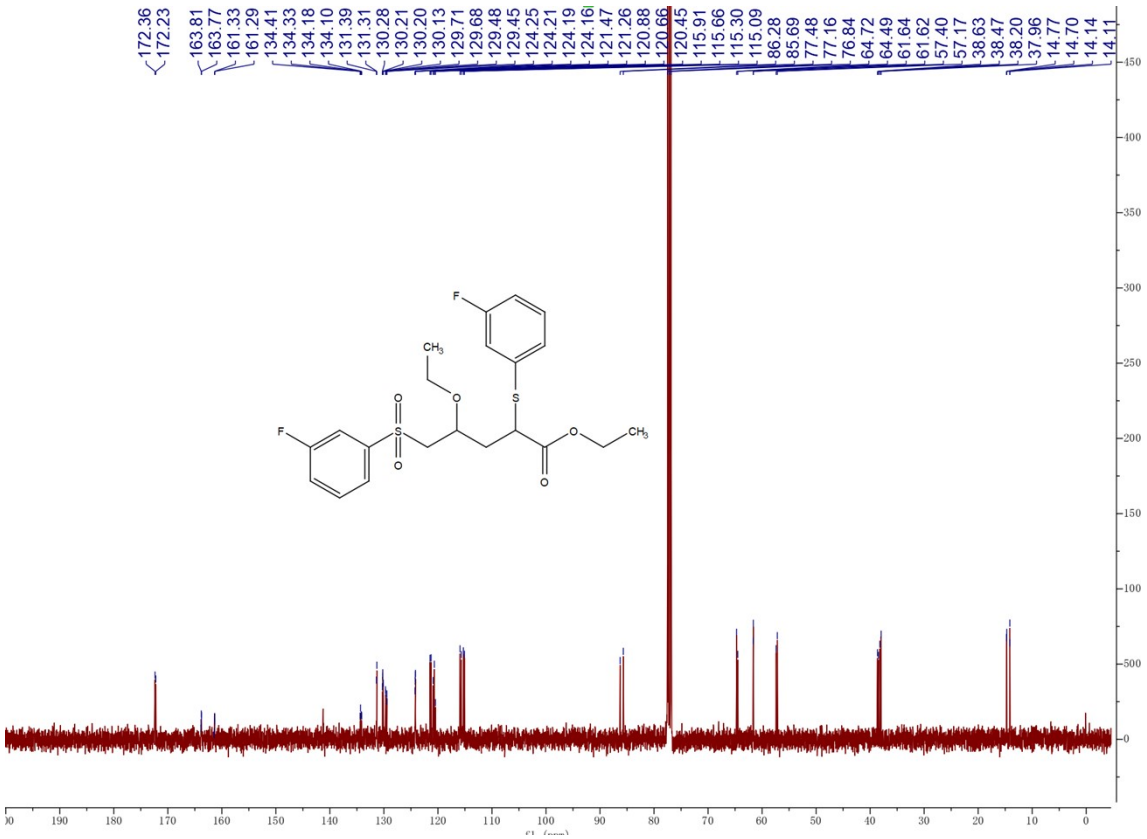
^{1}H NMR spectrum of **5f**



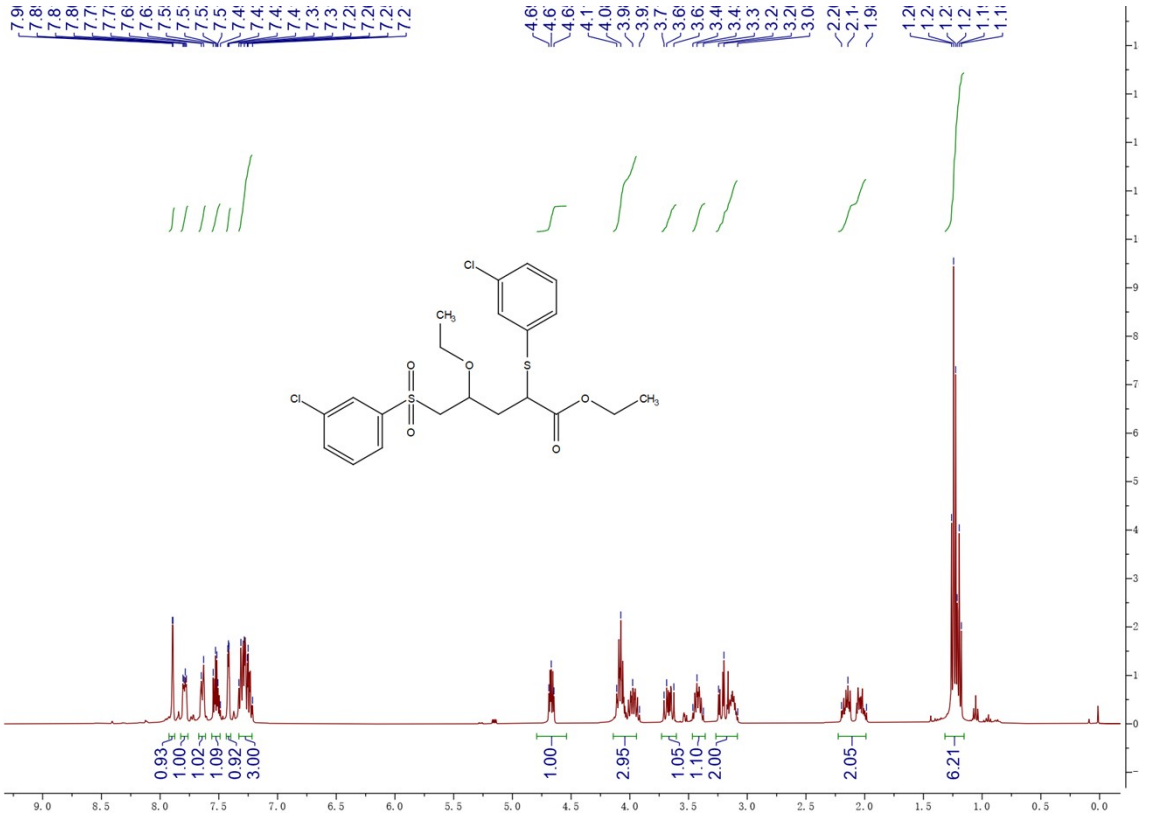
^{13}C NMR spectrum of **5f**



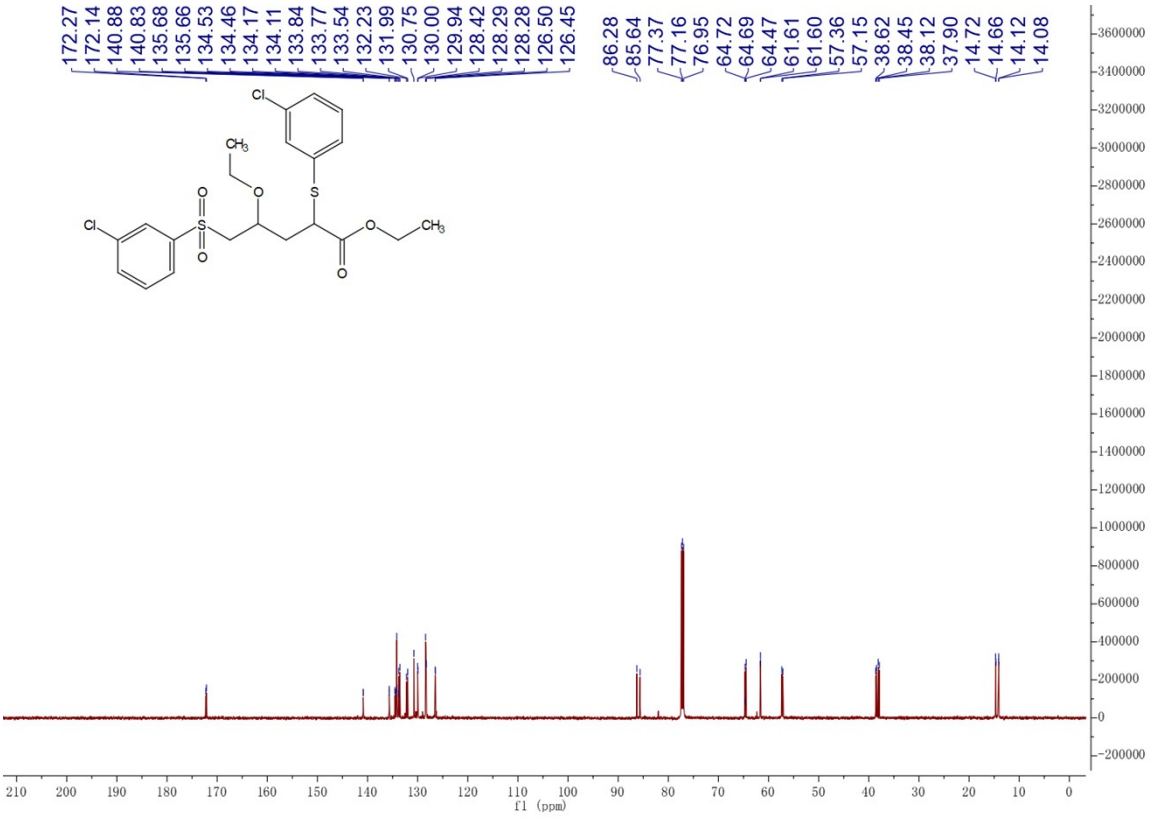
^{1}H NMR spectrum of **5g**



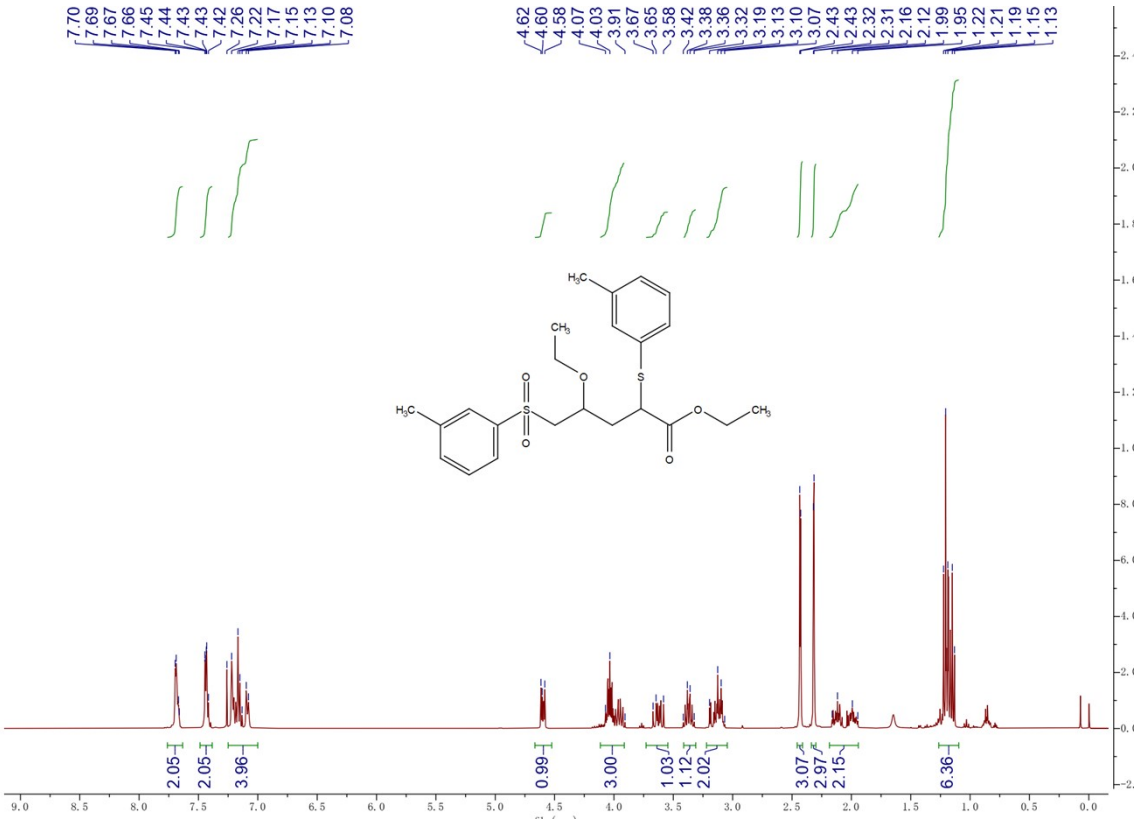
^{13}C NMR spectrum of **5g**



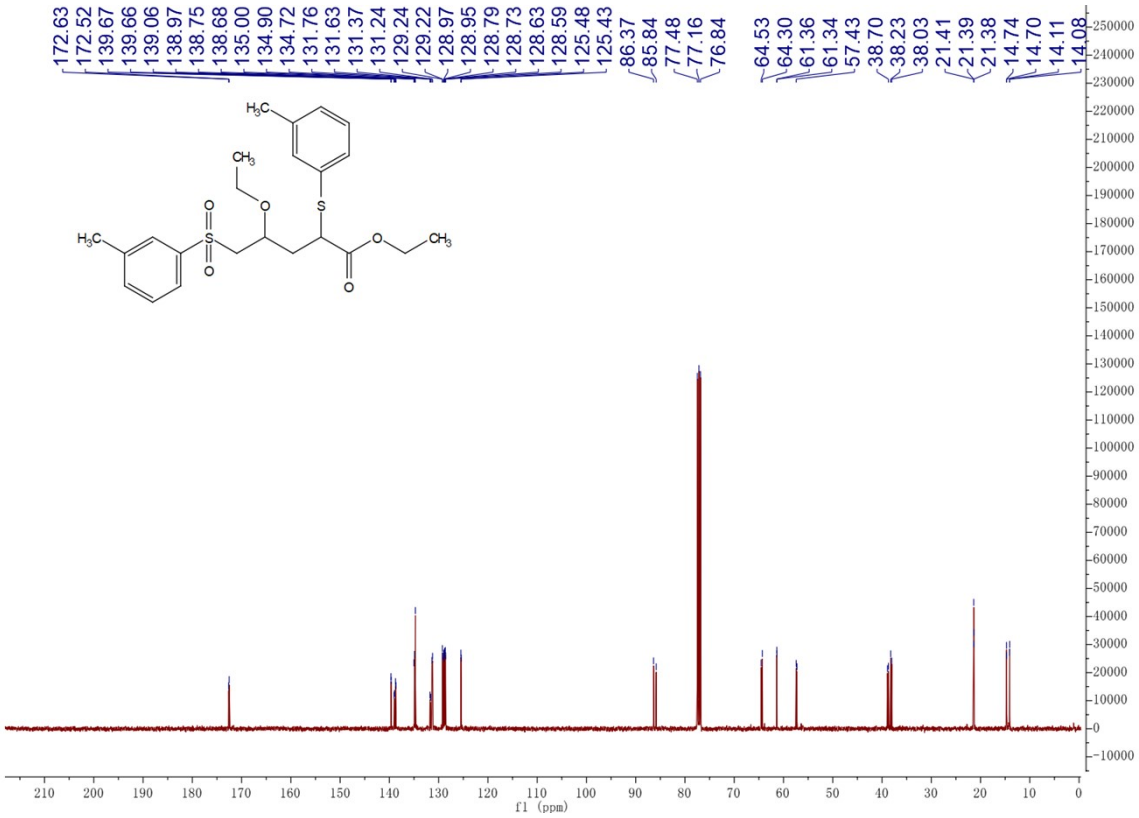
^{1}H NMR spectrum of **5h**



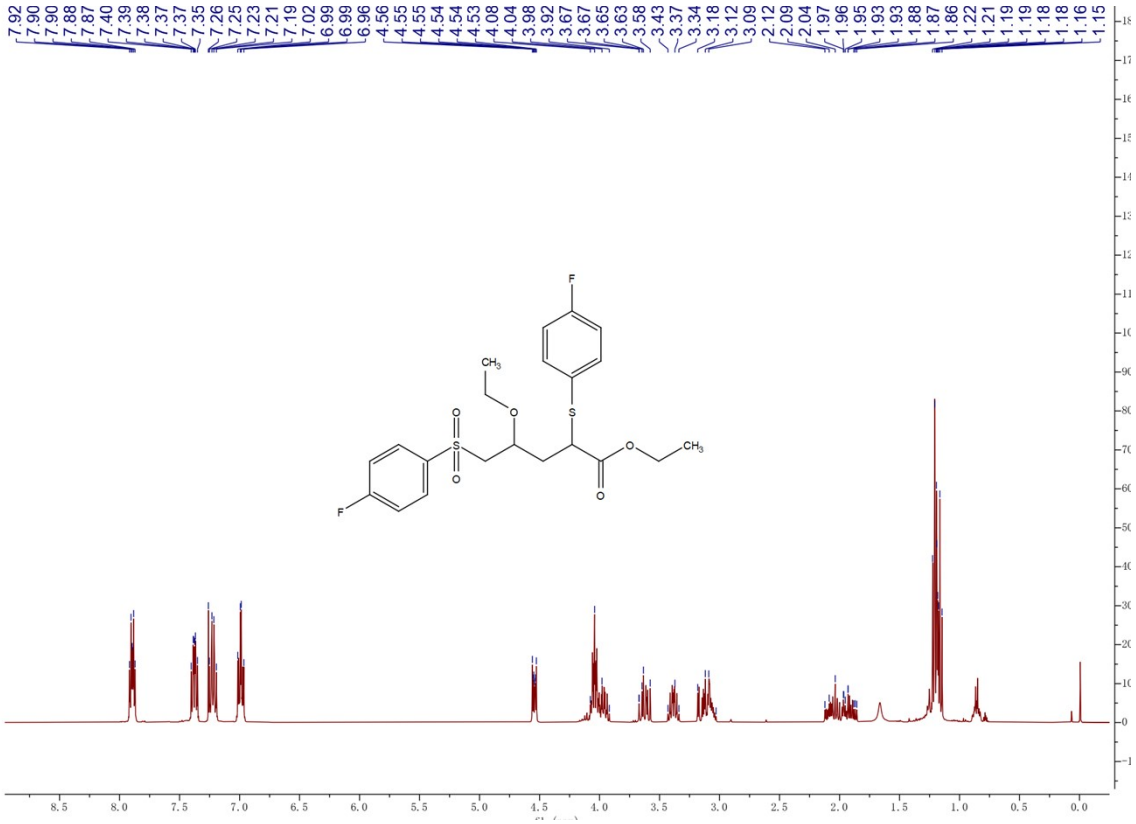
^{13}C NMR spectrum of **5h**



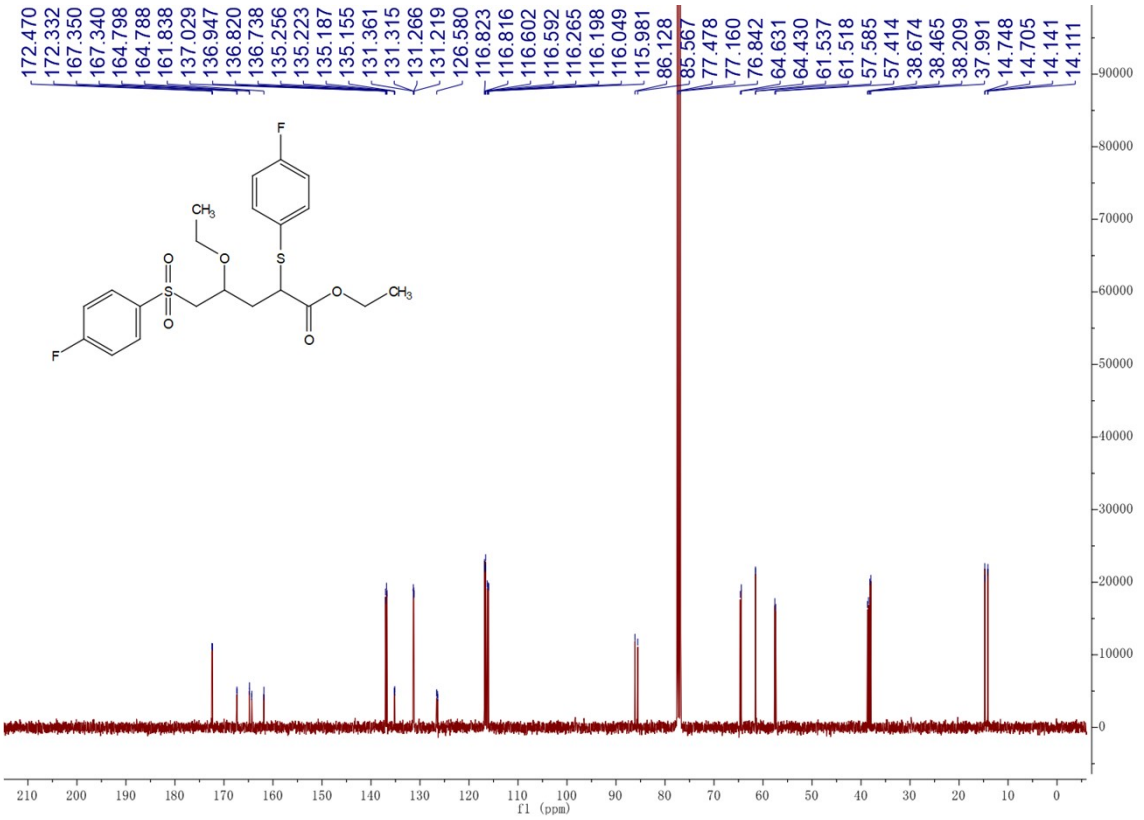
^{1}H NMR spectrum of **5i**



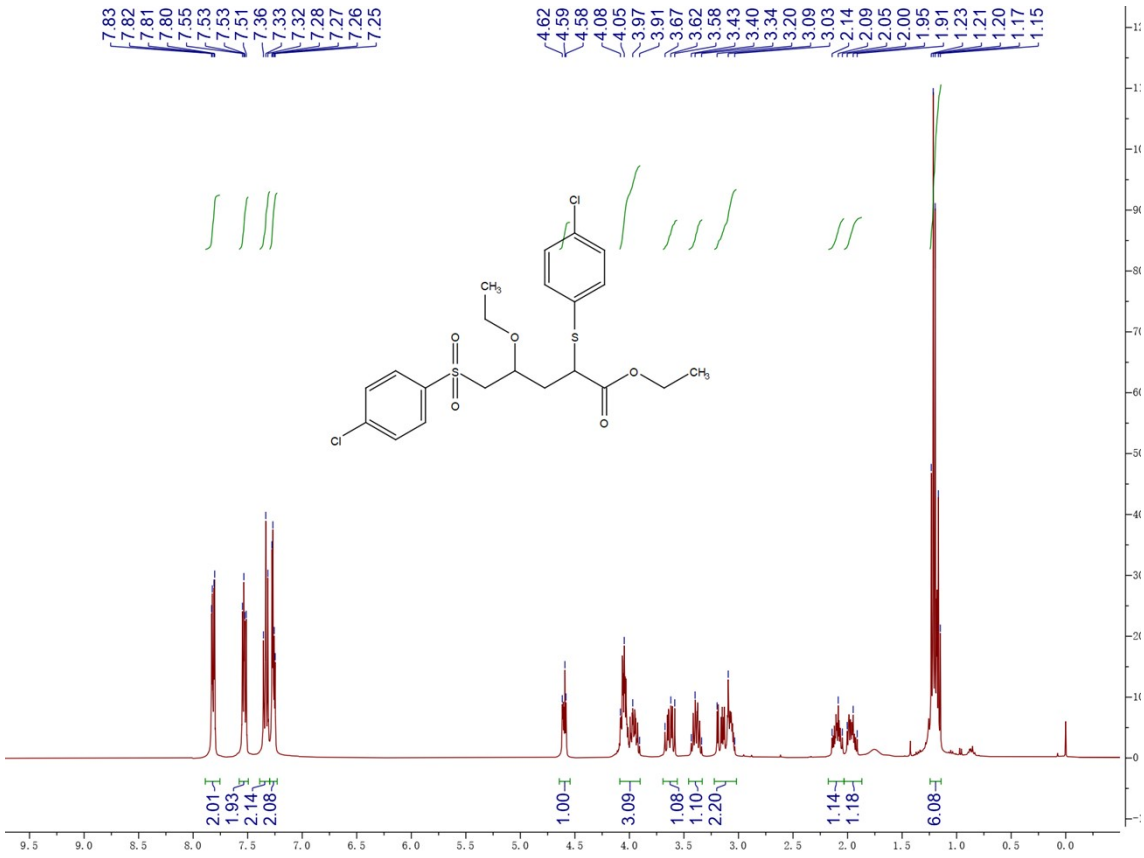
^{13}C NMR spectrum of **5i**



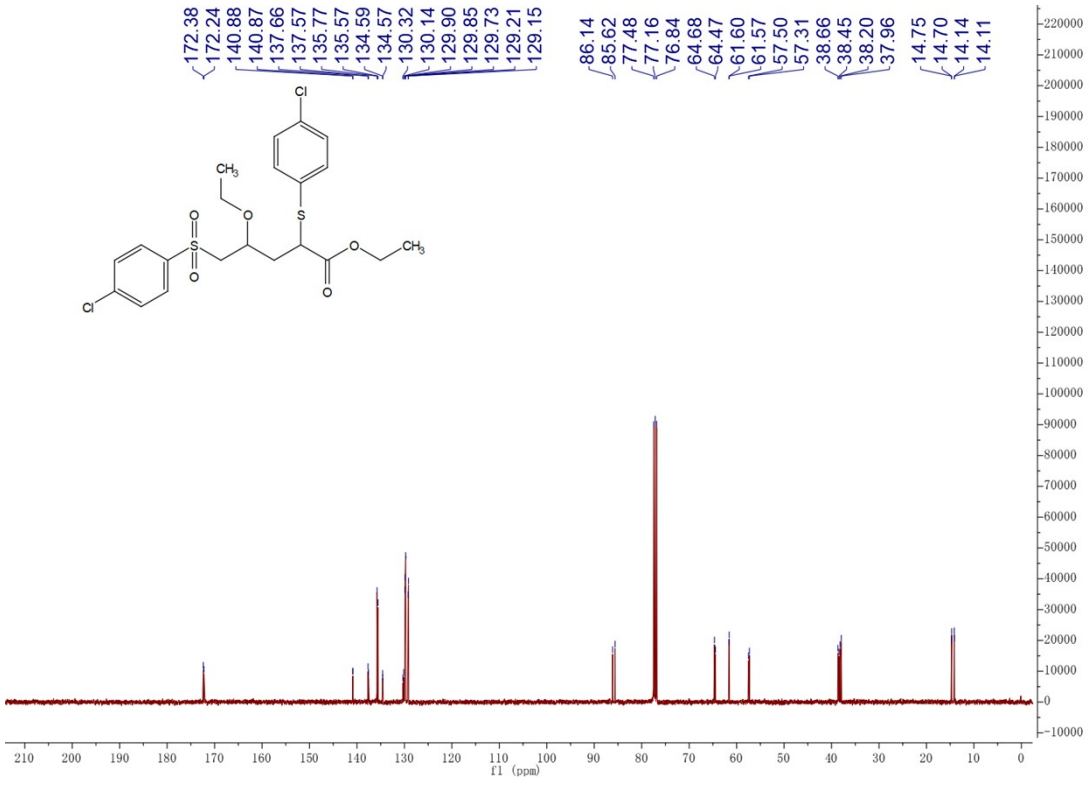
^{1}H NMR spectrum of **5j**



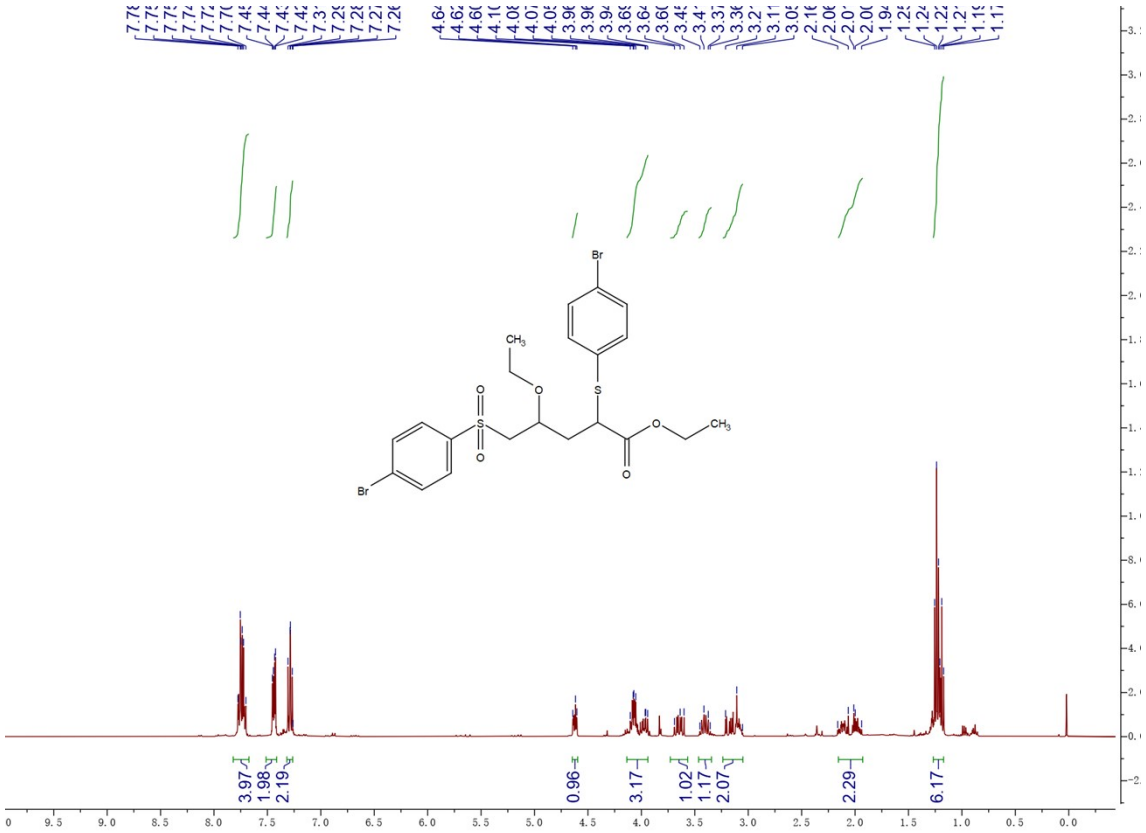
^{13}C NMR spectrum of **5j**



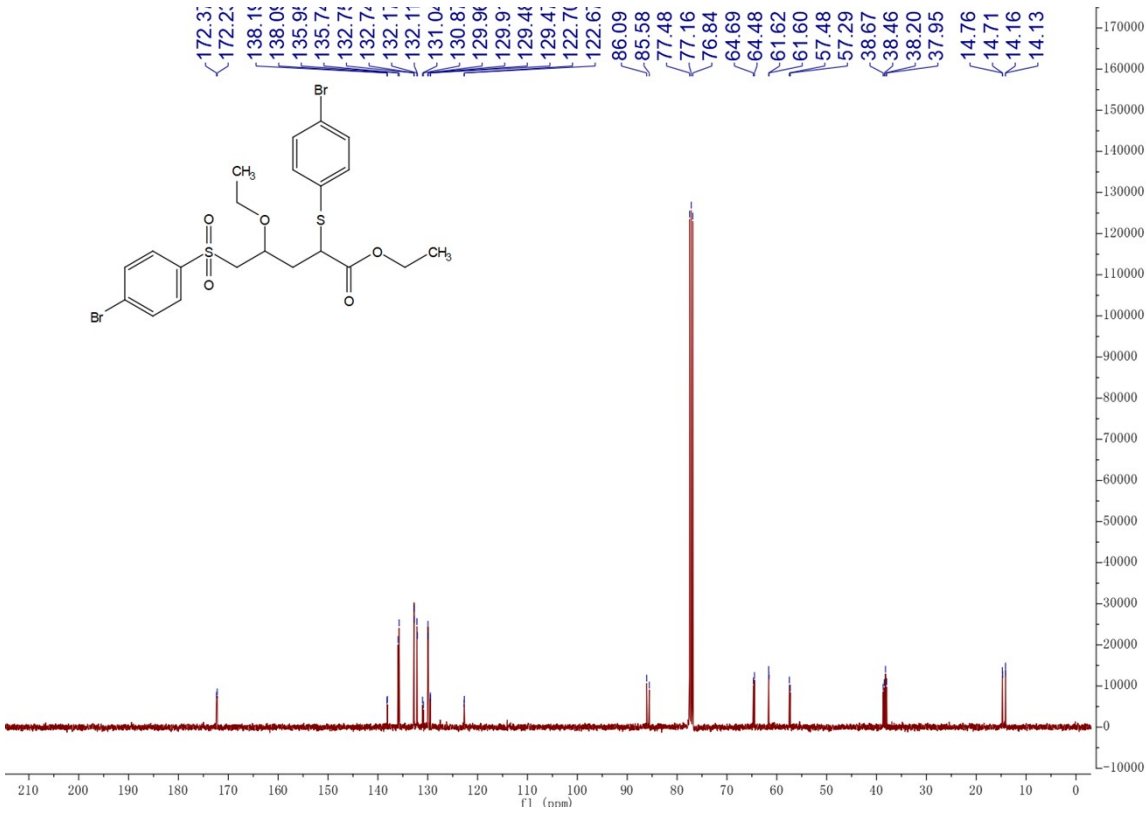
^{1}H NMR spectrum of **5k**



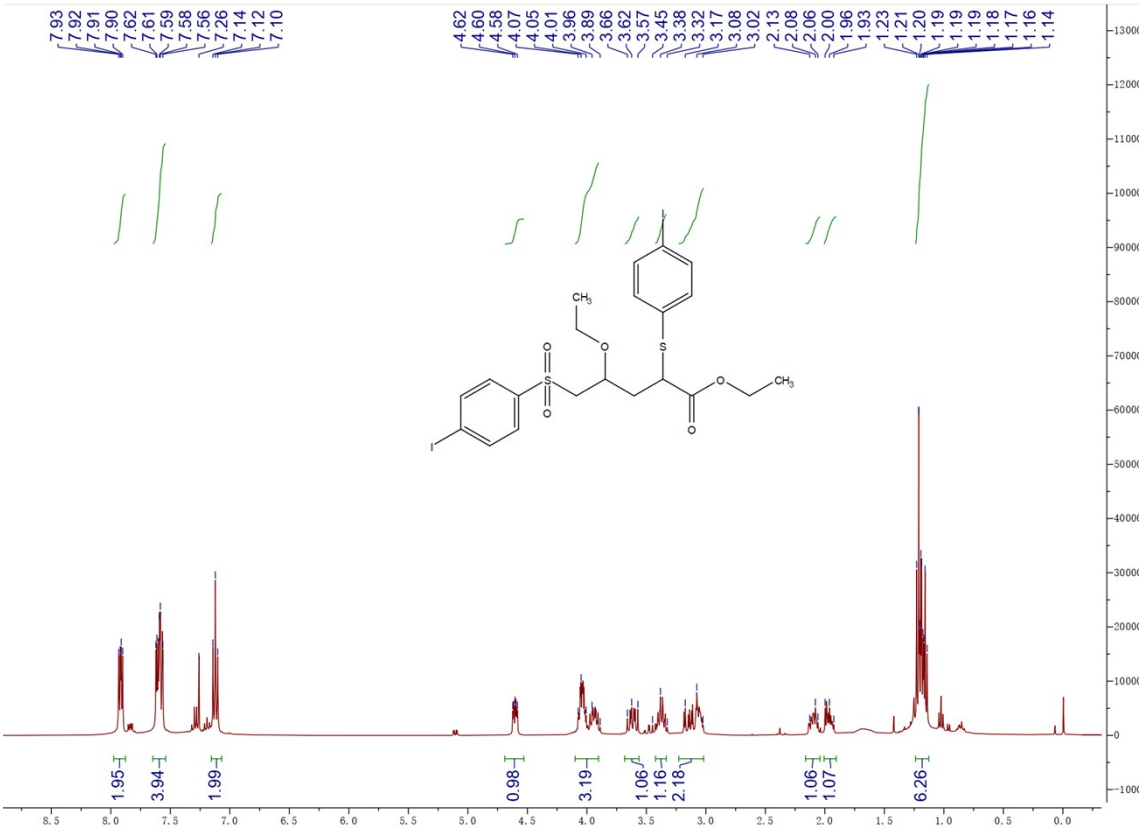
^{13}C NMR spectrum of **5k**



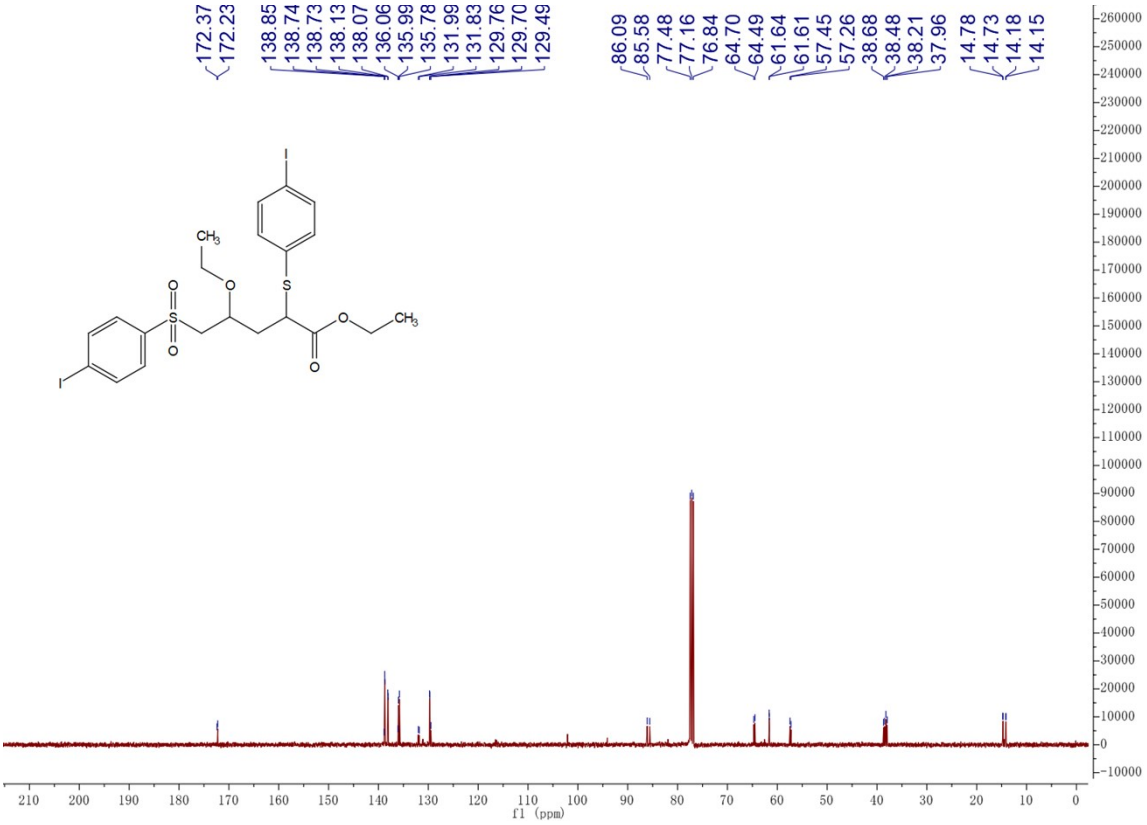
^{1}H NMR spectrum of **5l**



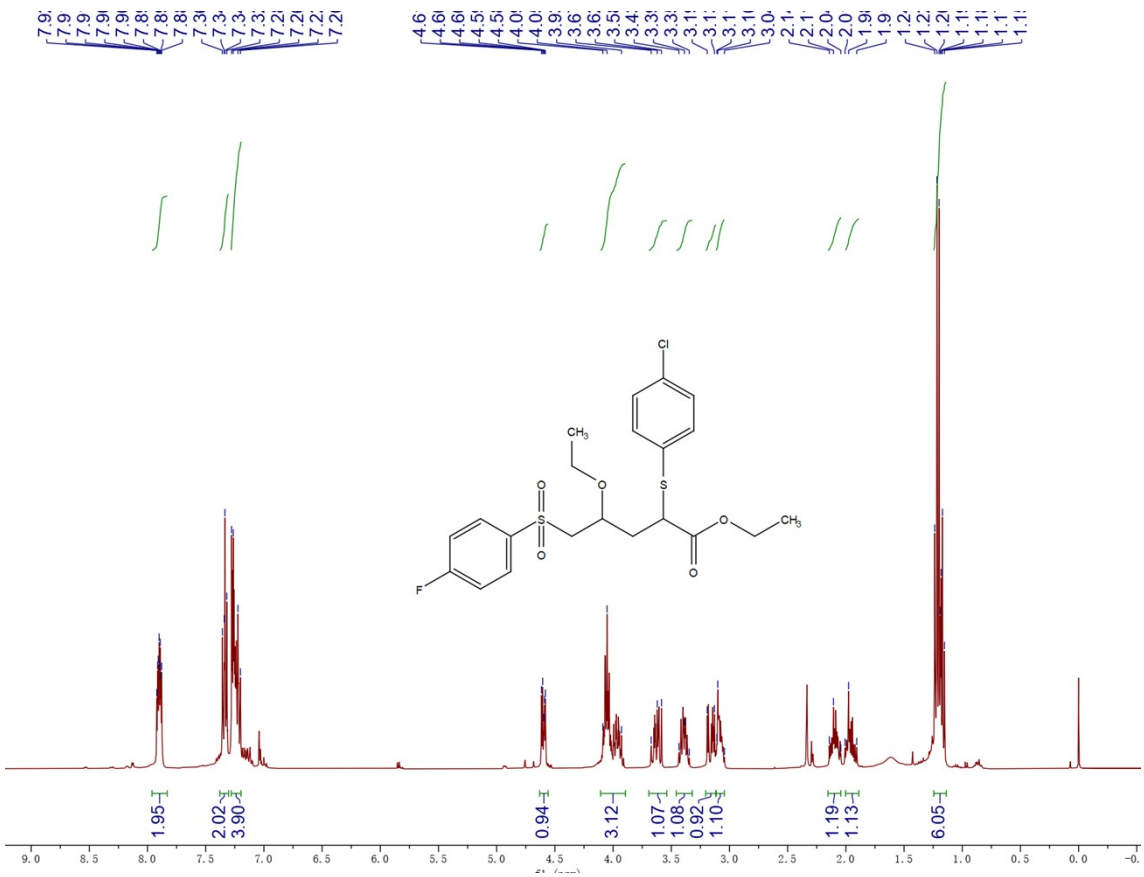
^{13}C NMR spectrum of **5l**



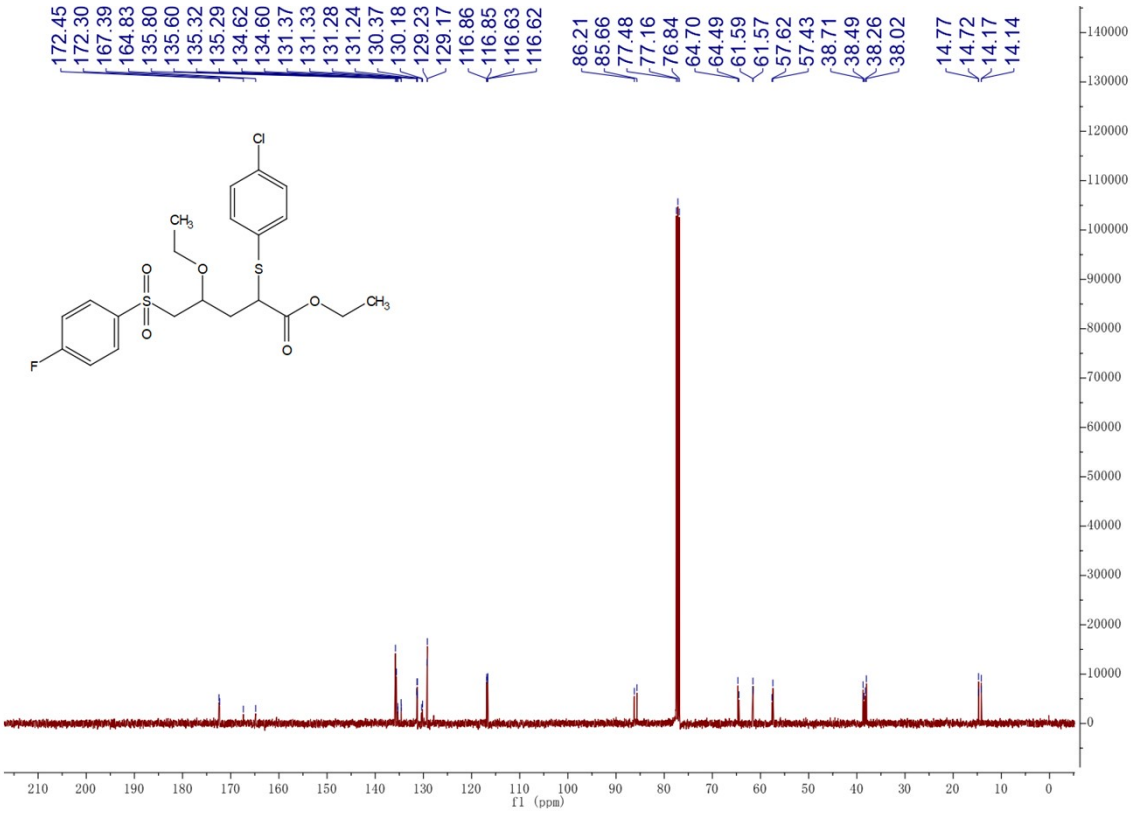
^{1}H NMR spectrum of **5m**



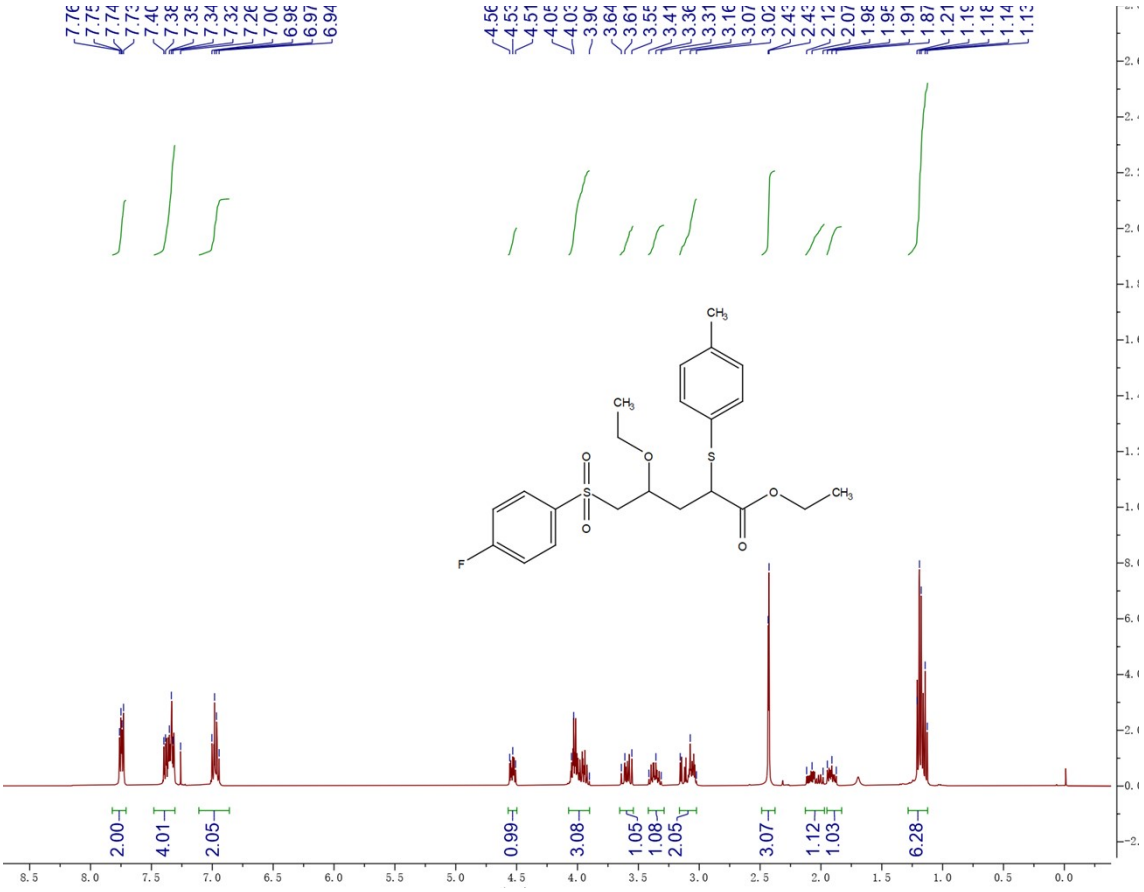
^{13}C NMR spectrum of **5m**



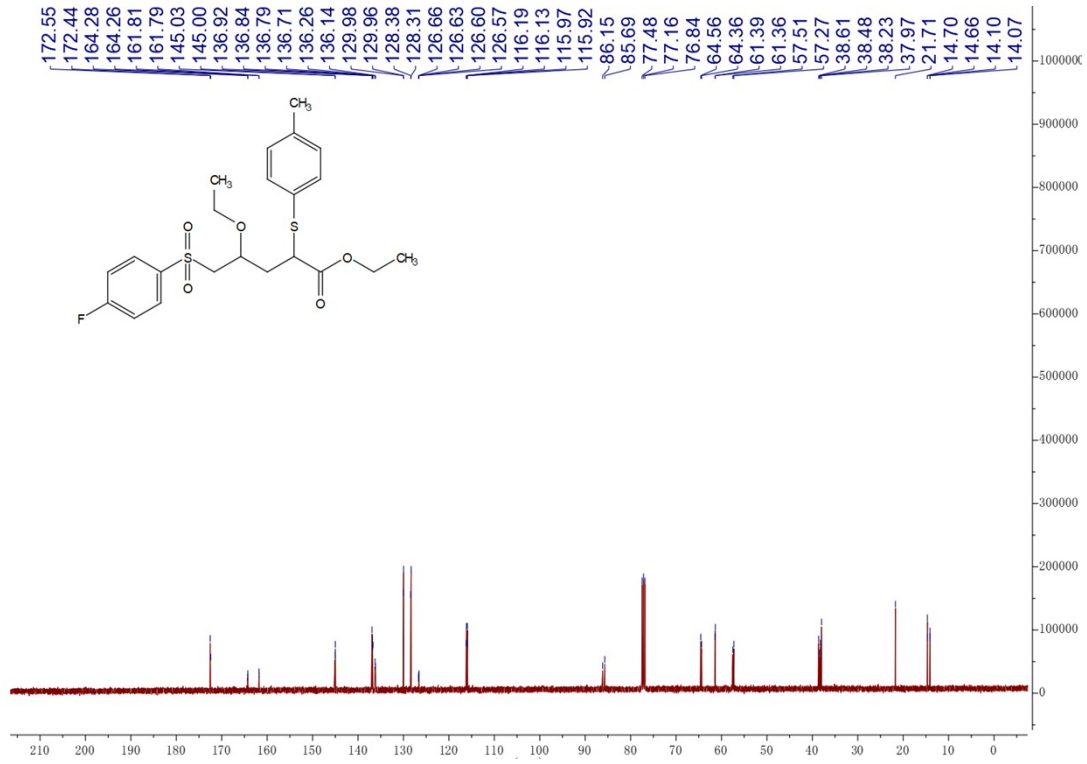
^{1}H NMR spectrum of **5n**



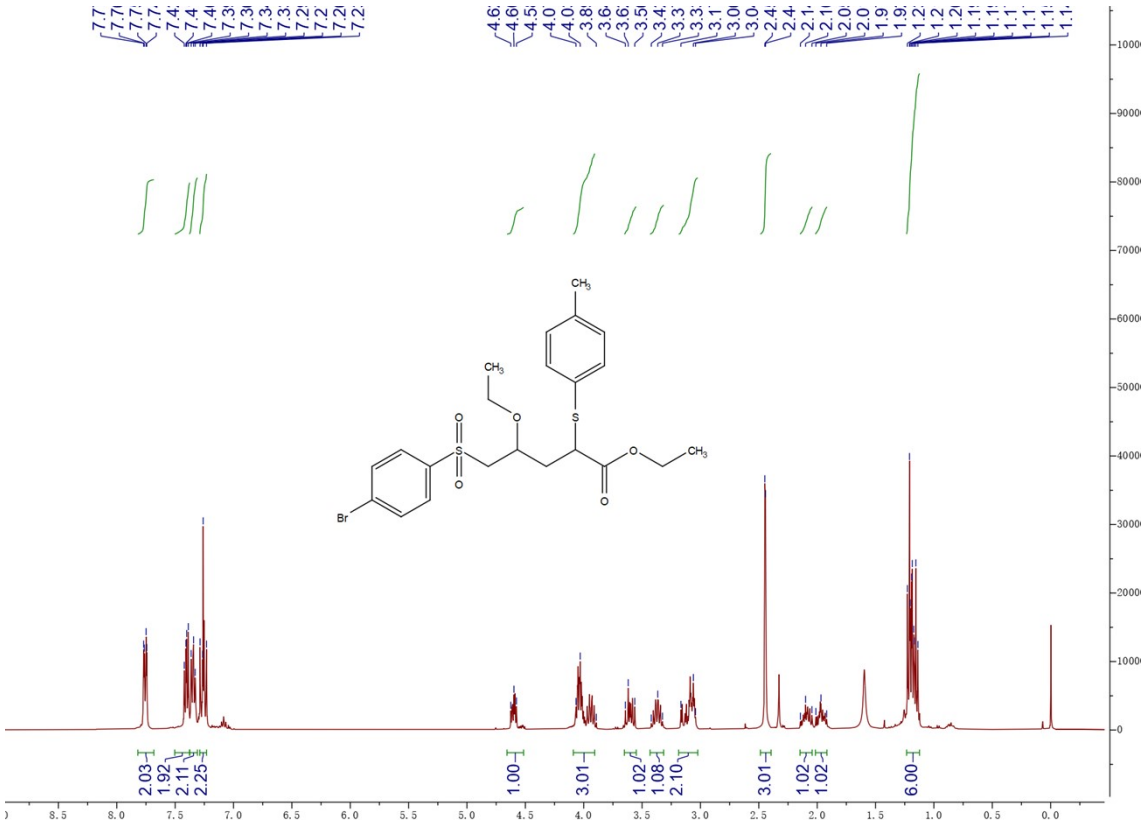
^{13}C NMR spectrum of **5n**



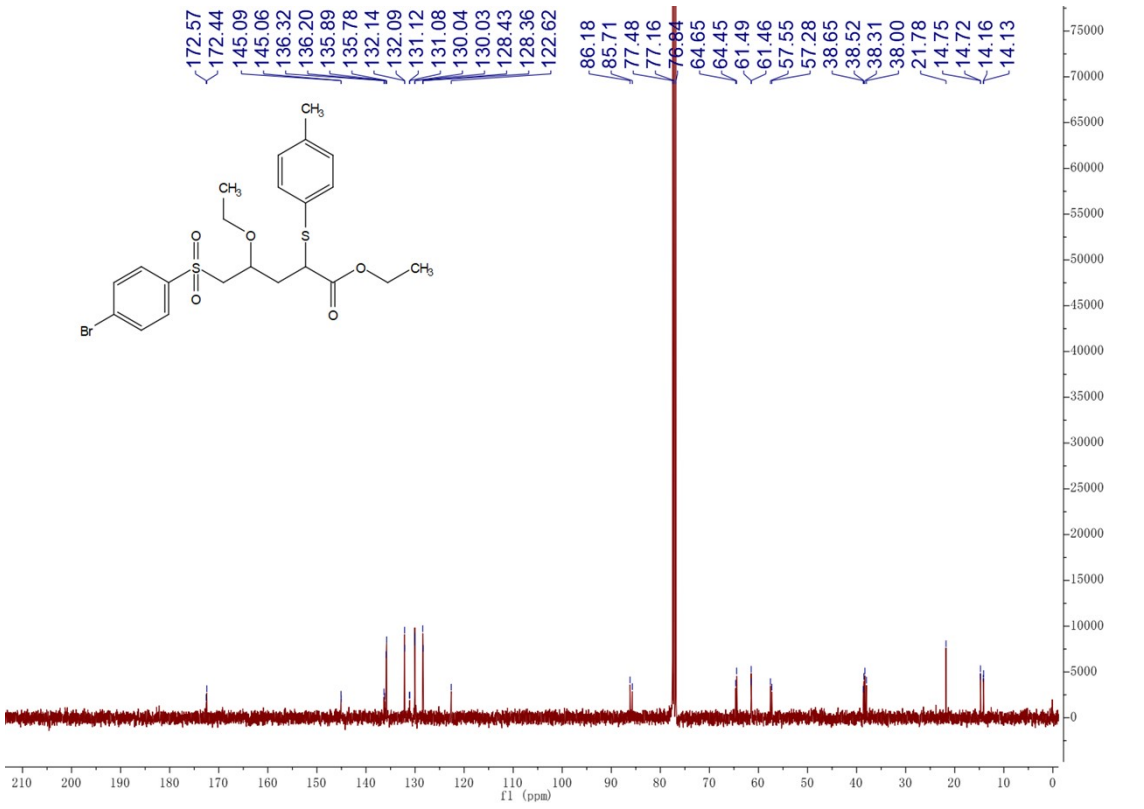
^{1}H NMR spectrum of **5o**



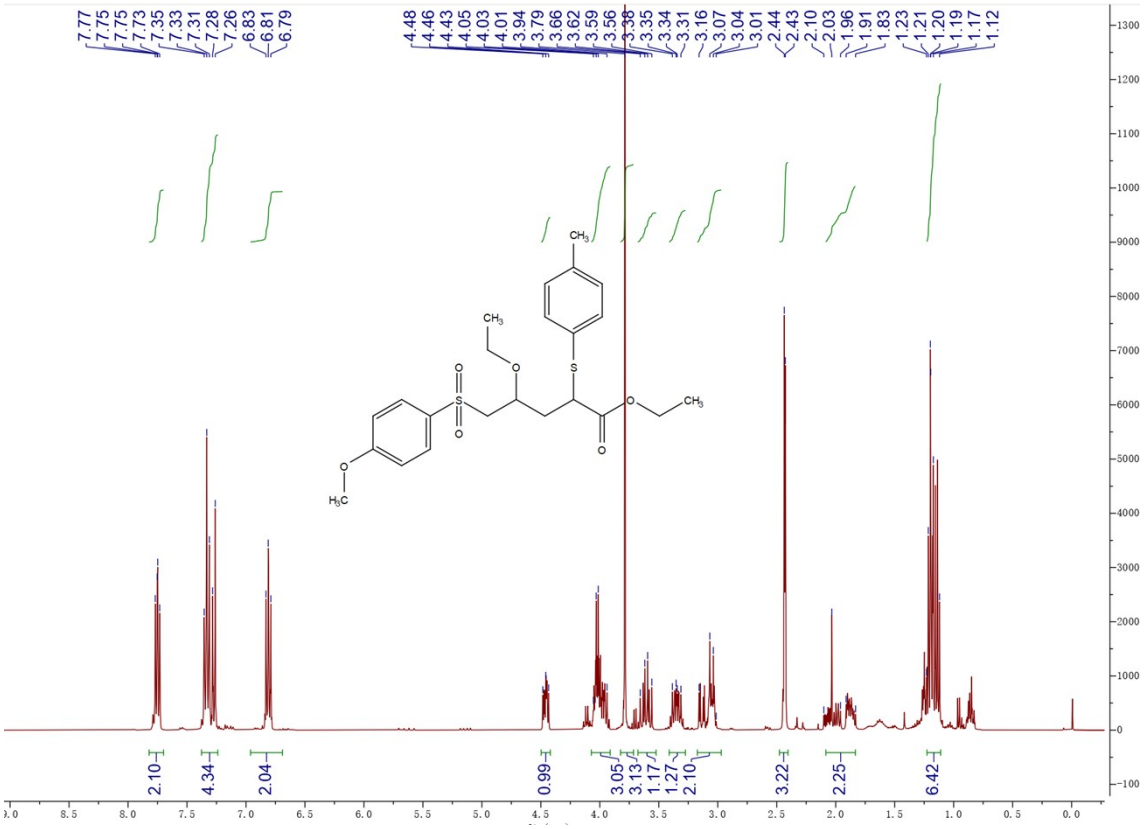
^{13}C NMR spectrum of **5o**



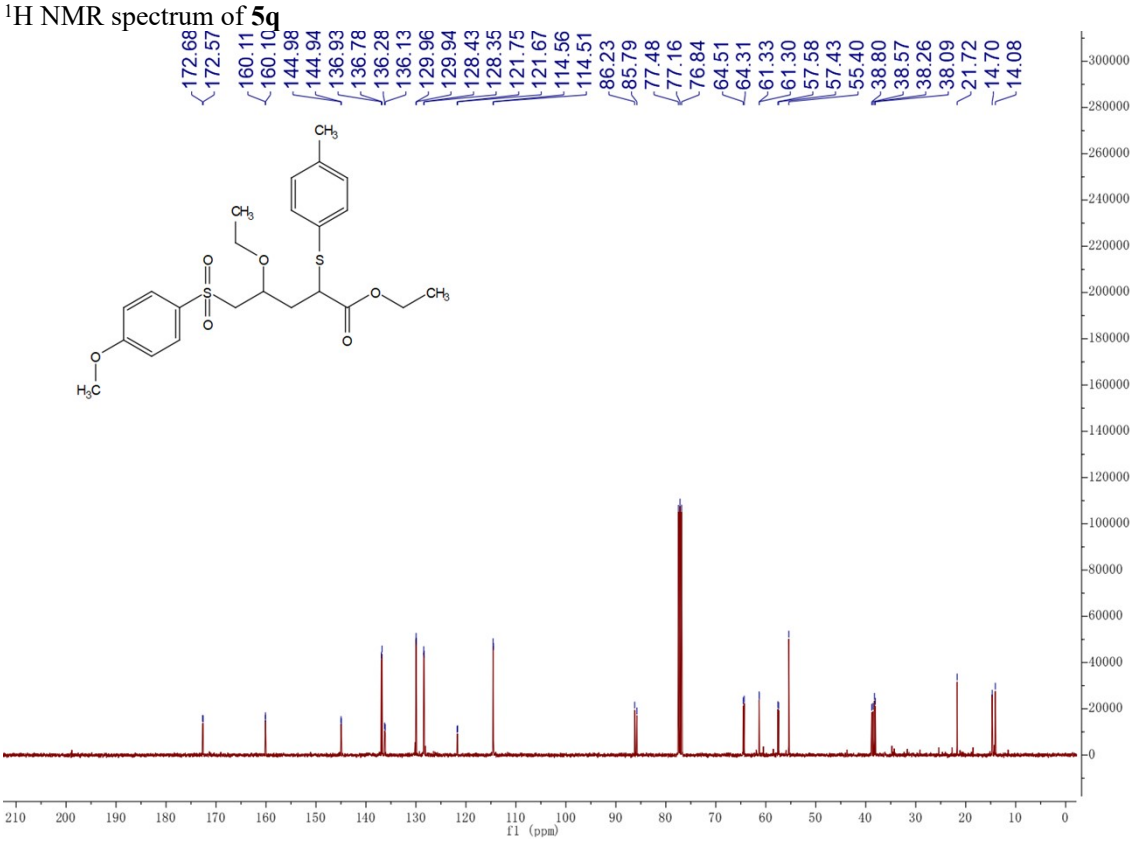
^{1}H NMR spectrum of **5p**



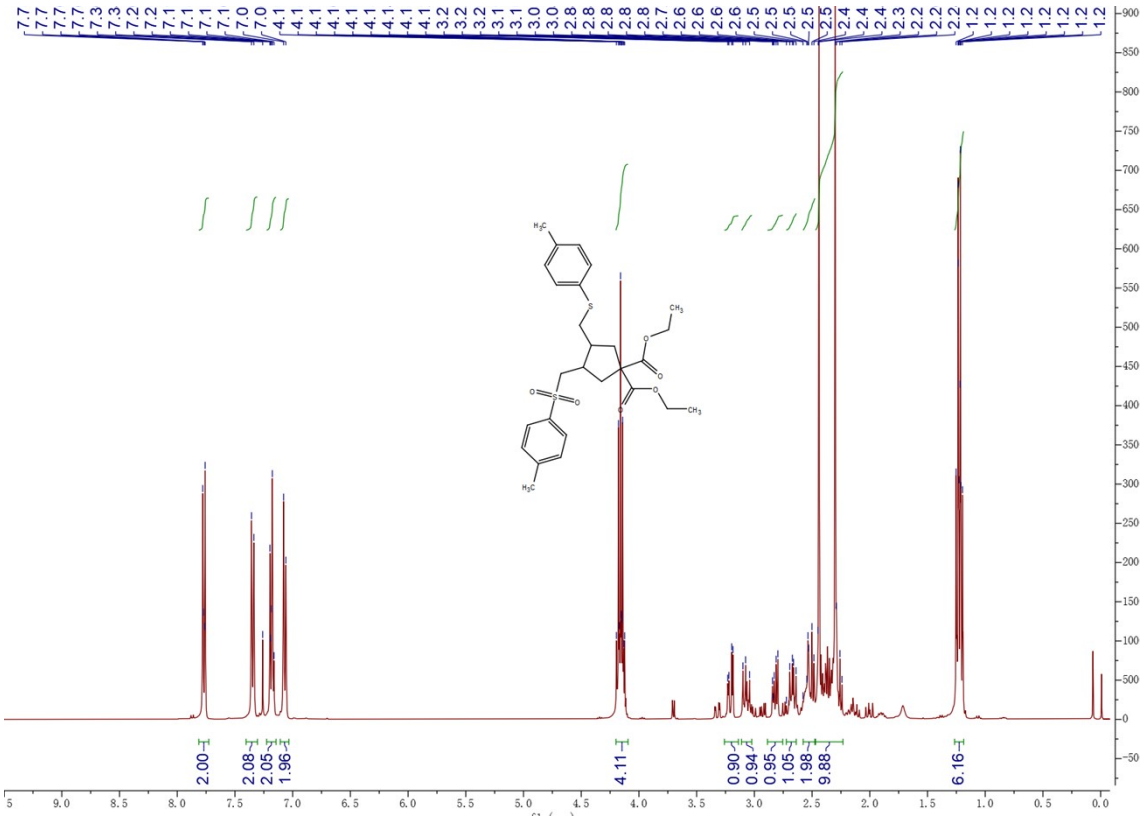
^{13}C NMR spectrum of **5p**



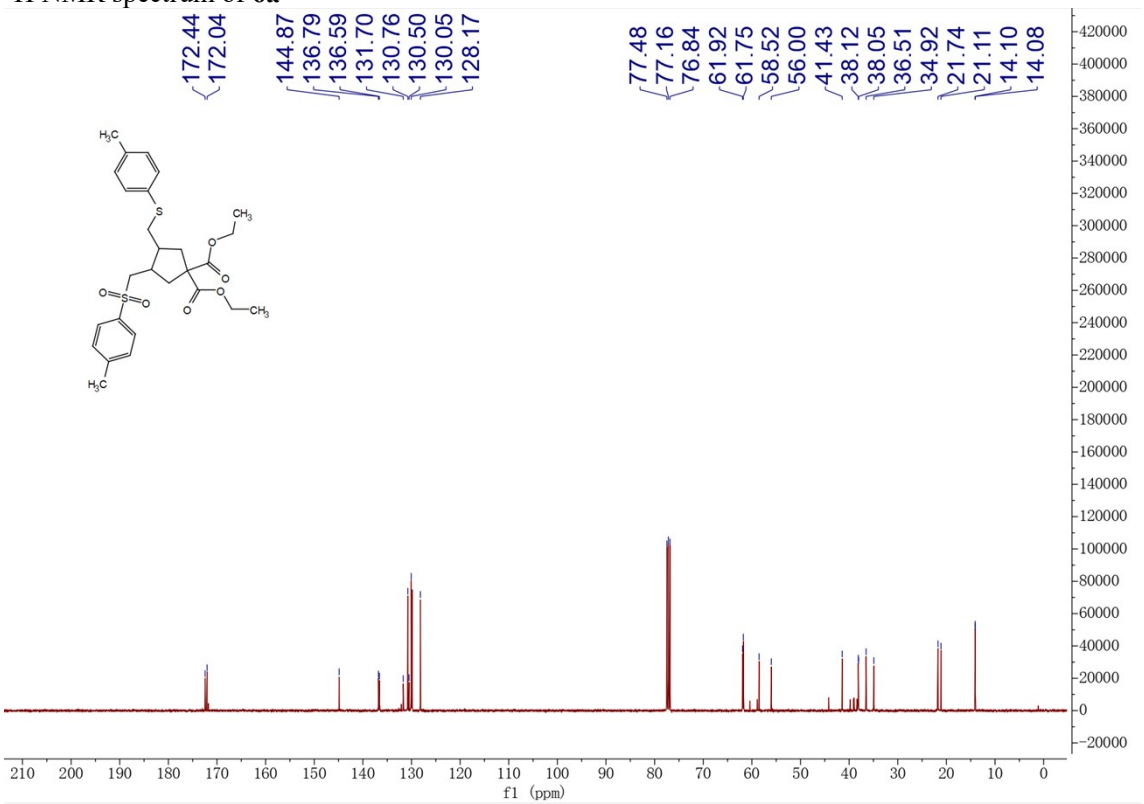
^{1}H NMR spectrum of **5q**



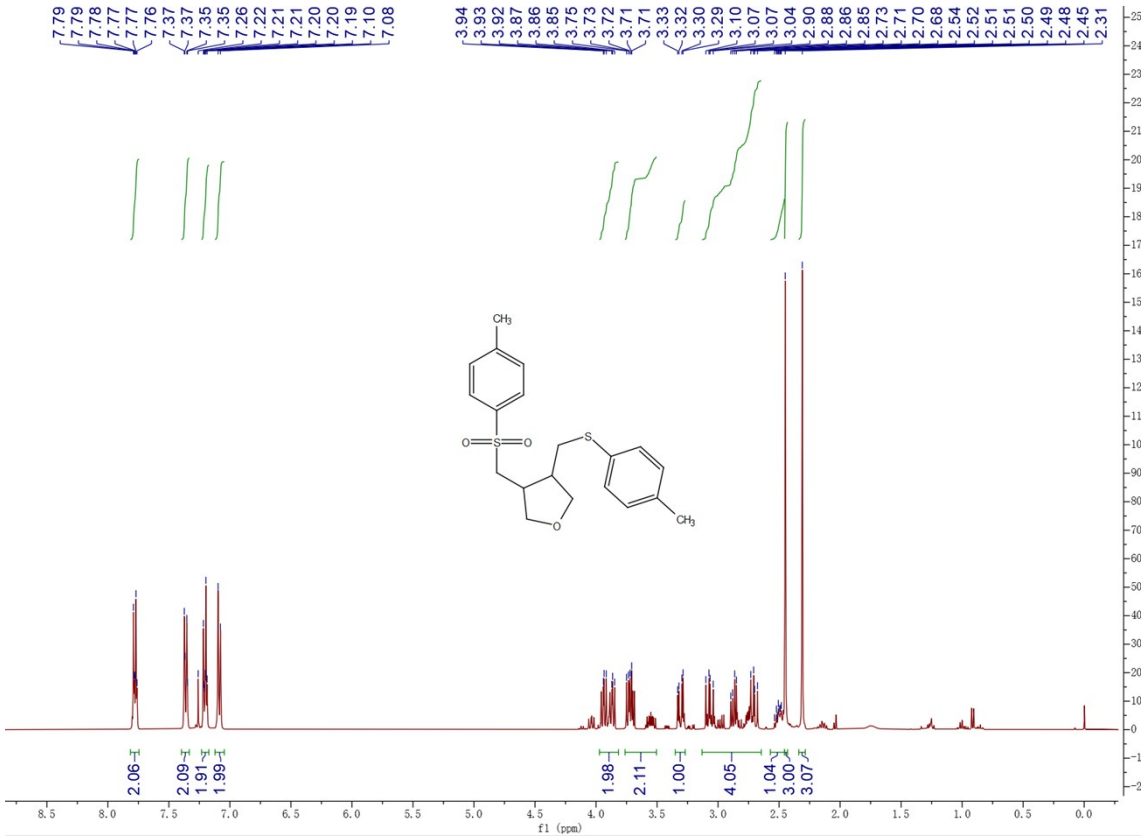
^{13}C NMR spectrum of **5q**



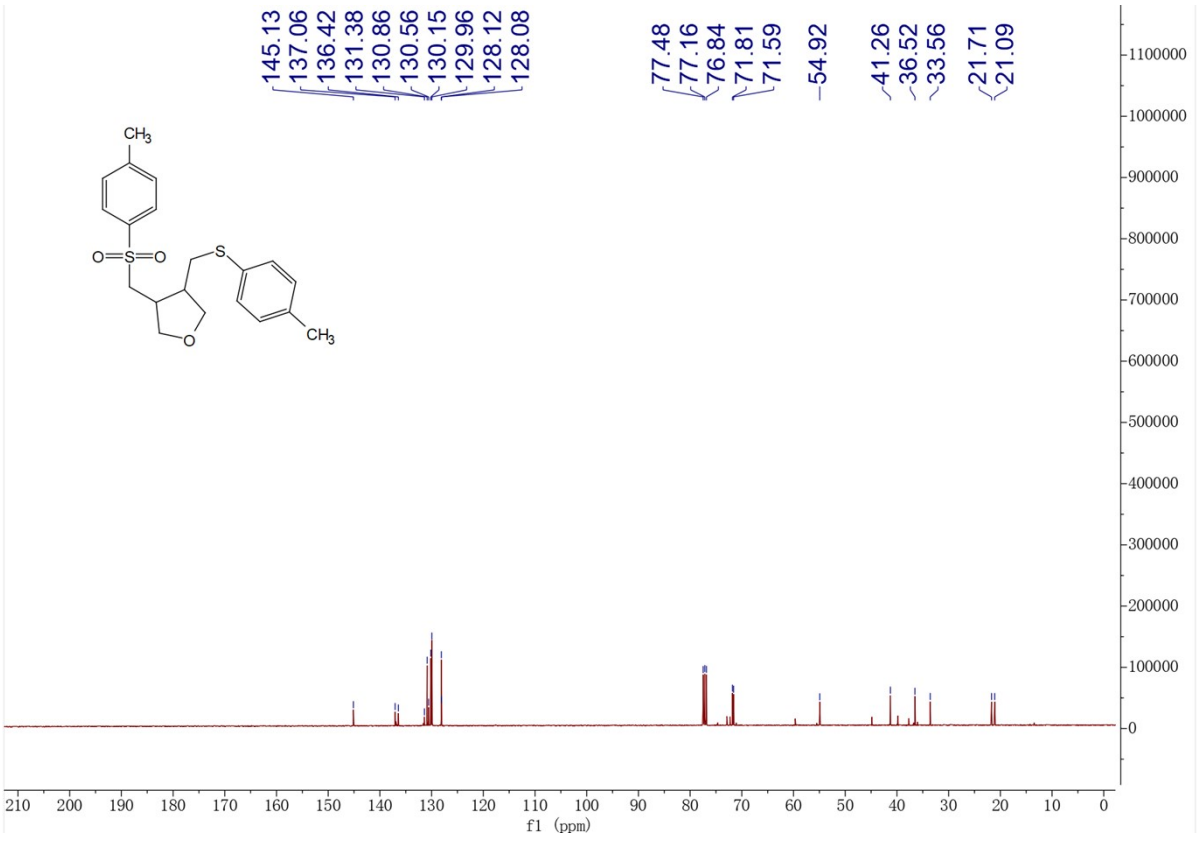
^{1}H NMR spectrum of **6a**



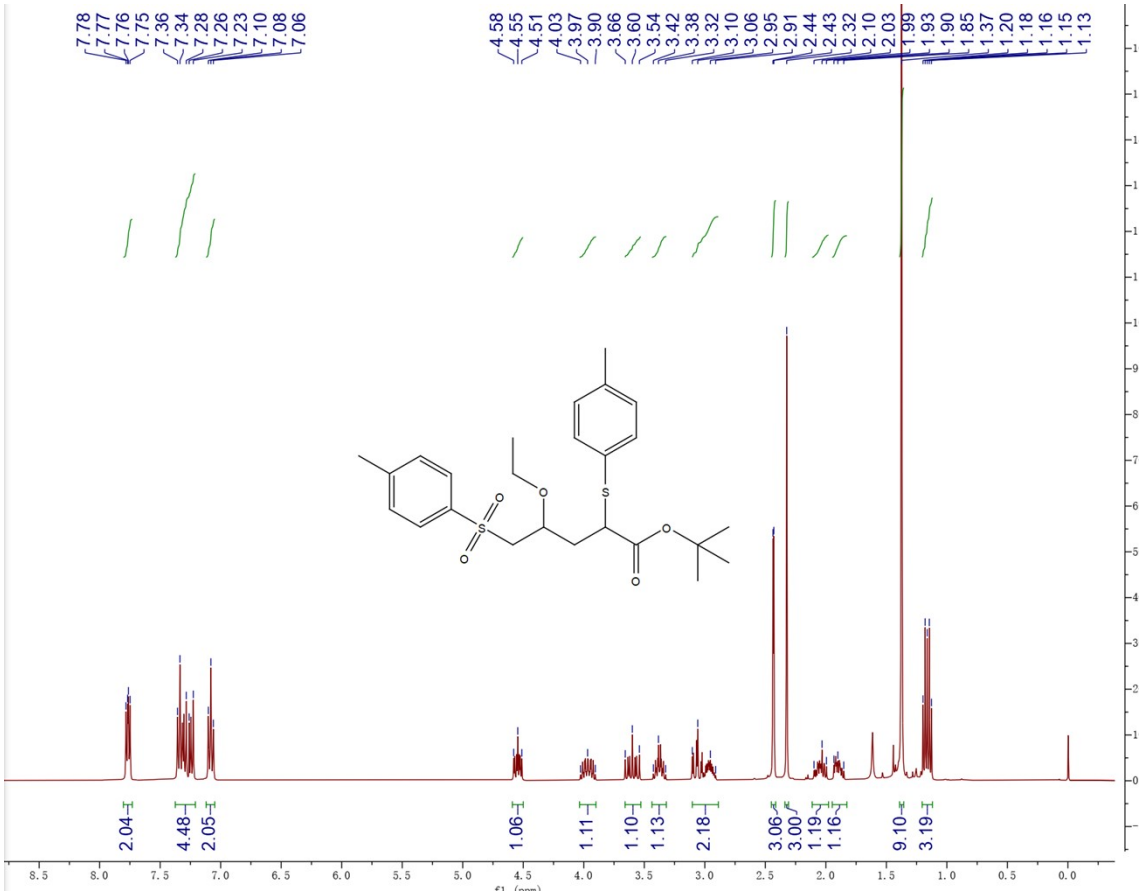
^{13}C NMR spectrum of **6a**



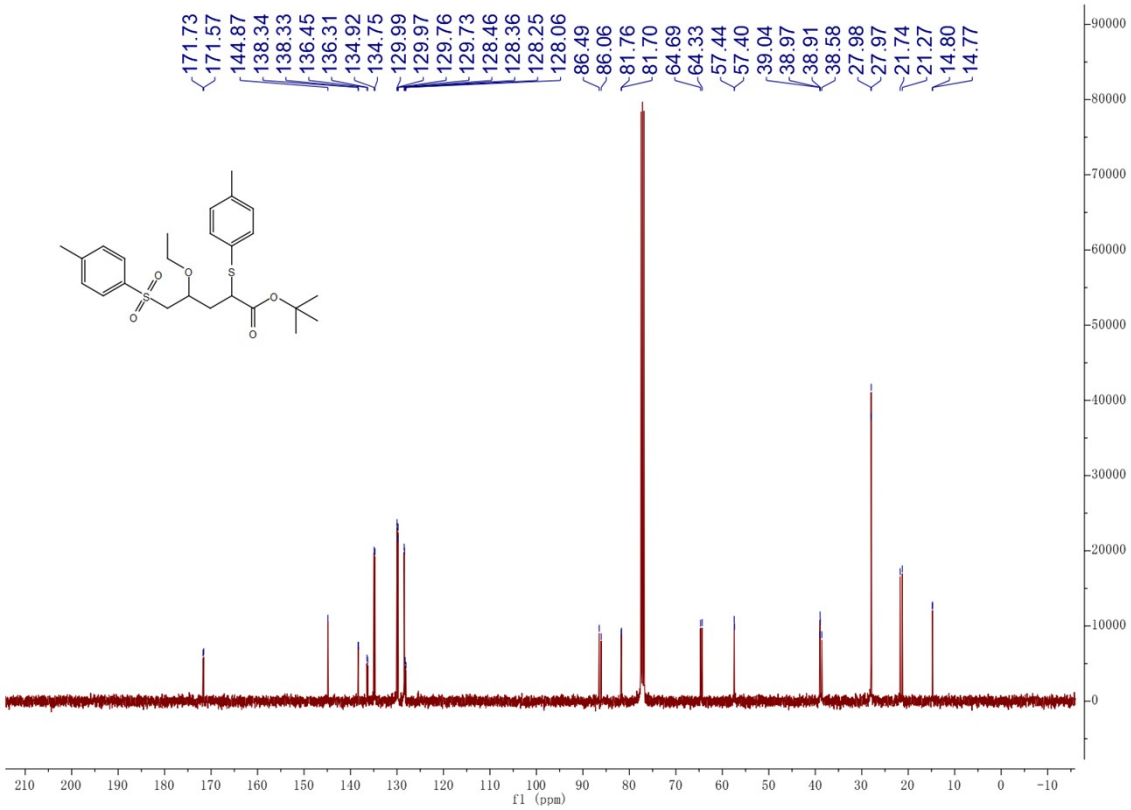
^{1}H NMR spectrum of **6b**



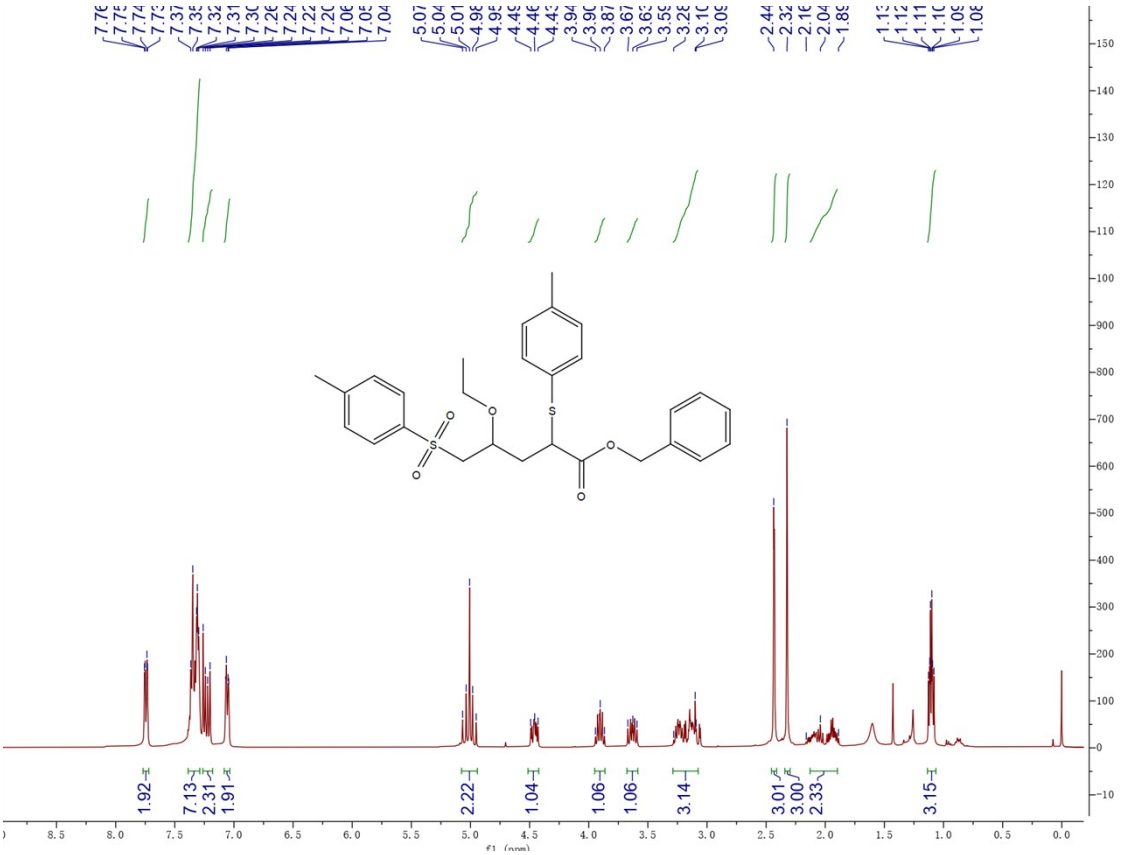
^{13}C NMR spectrum of **6b**



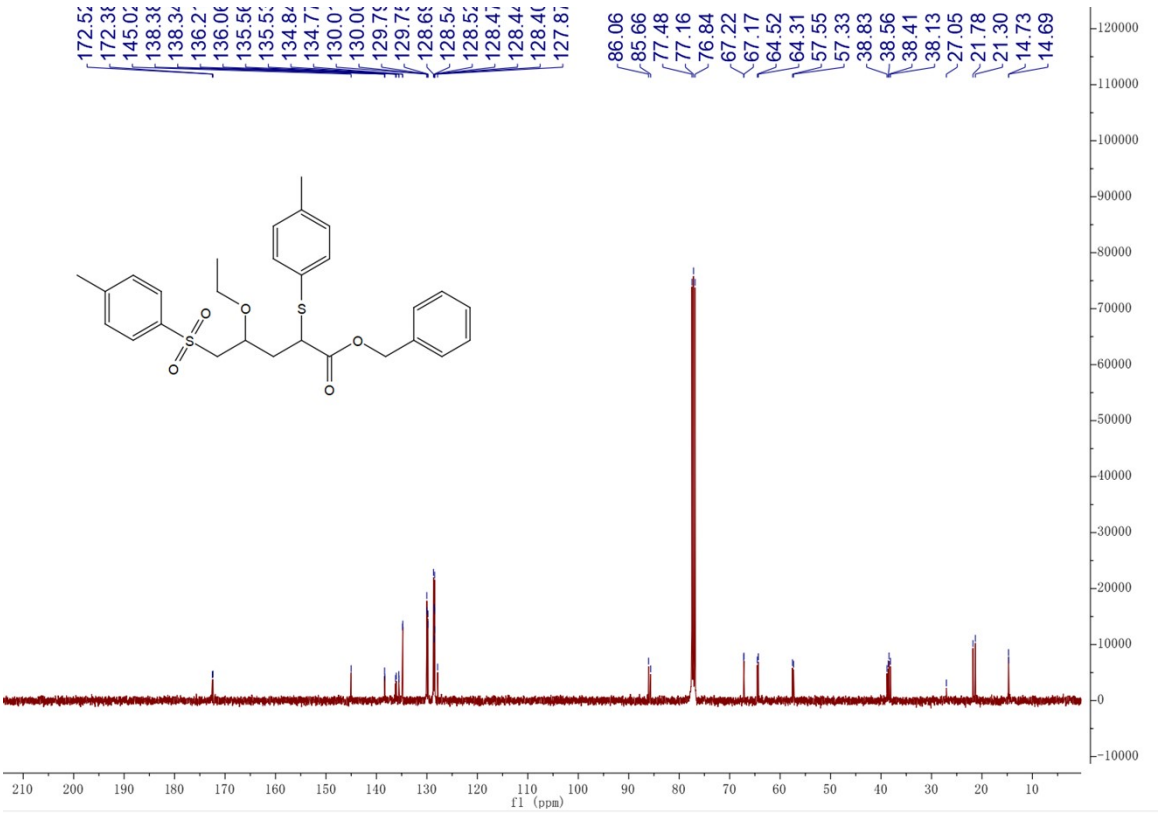
^{1}H NMR spectrum of **5a'**



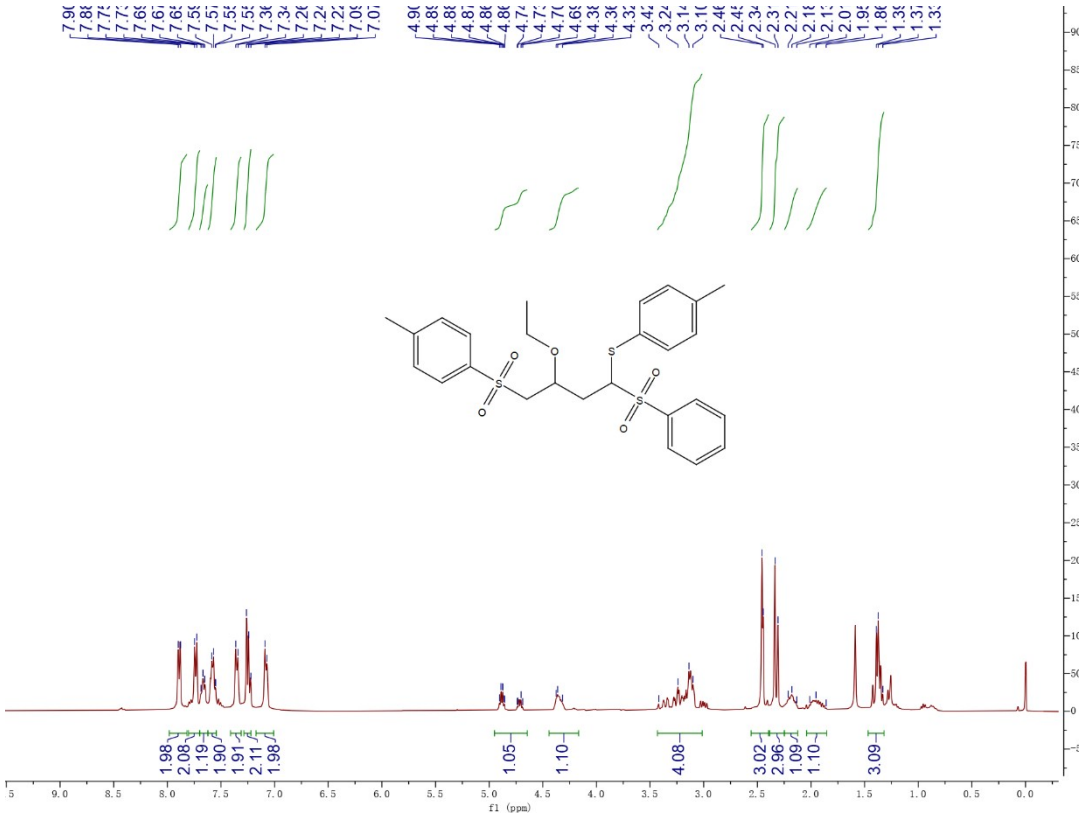
^{13}C NMR spectrum of 5a'



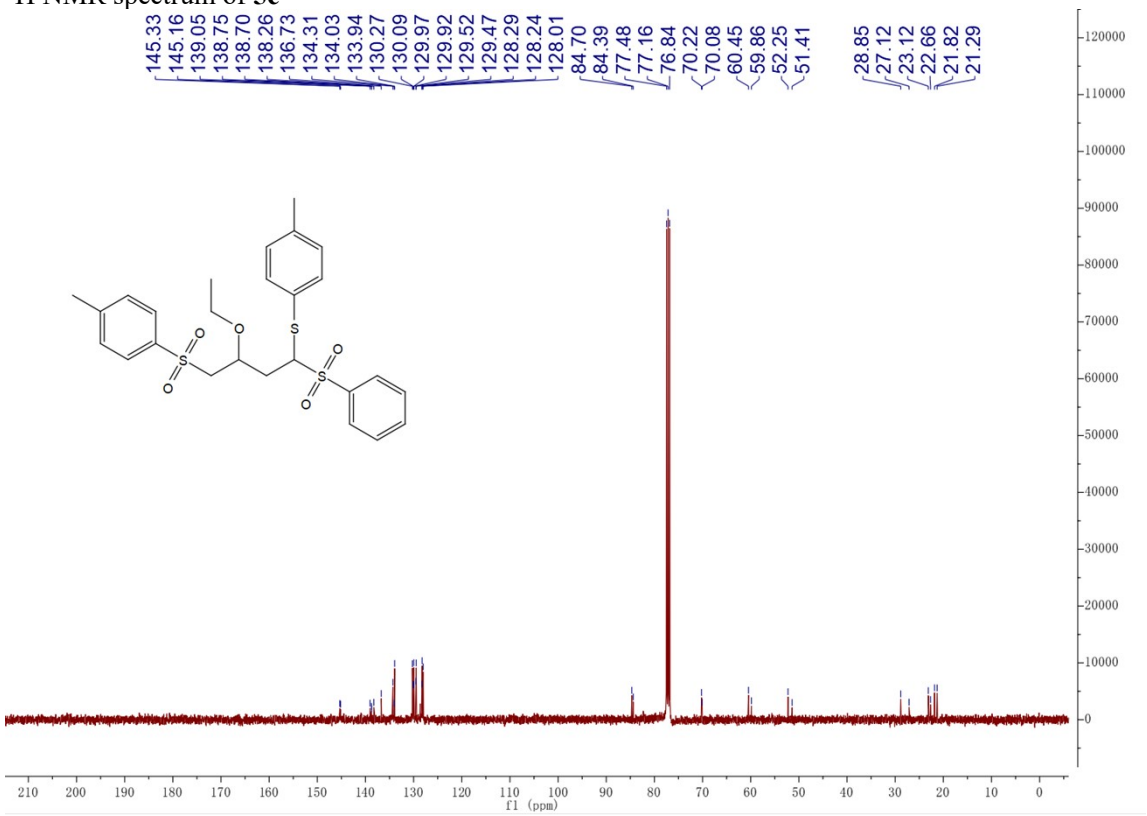
^{1}H NMR spectrum of **5b'**



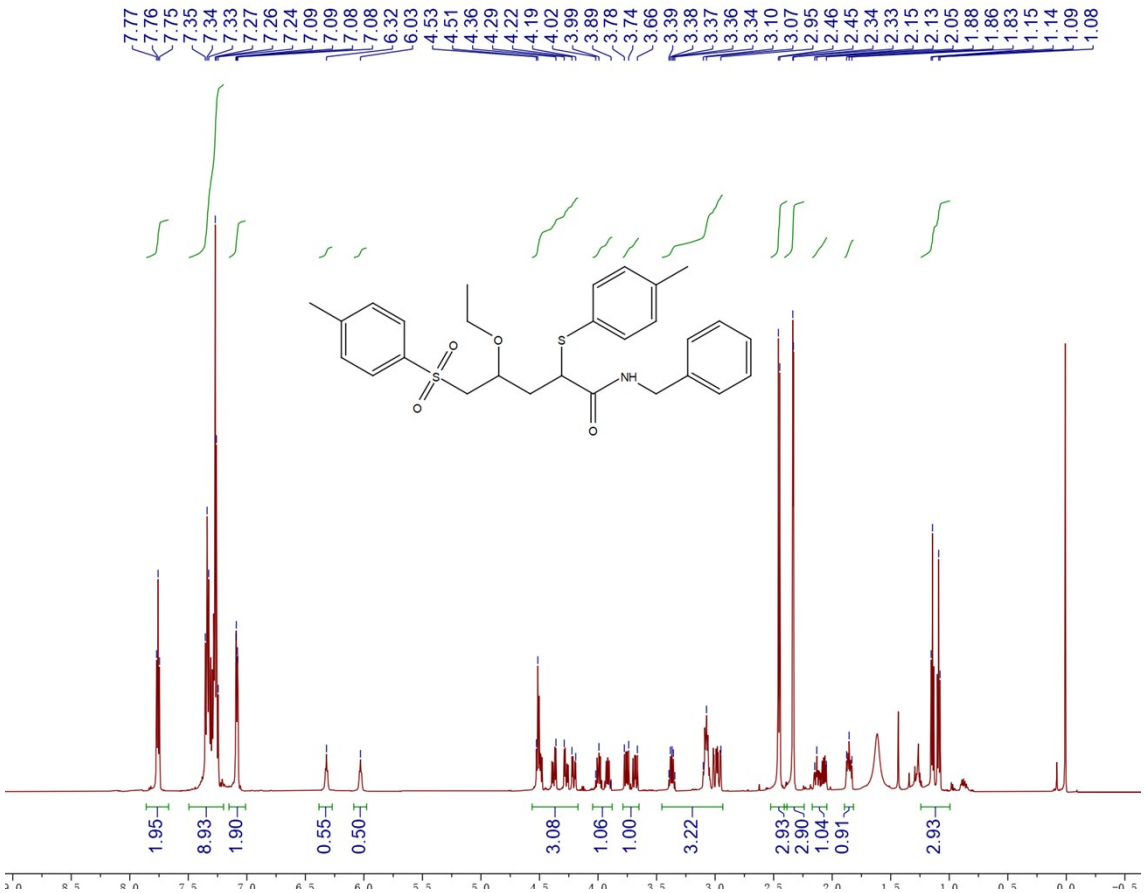
^{13}C NMR spectrum of **5b'**



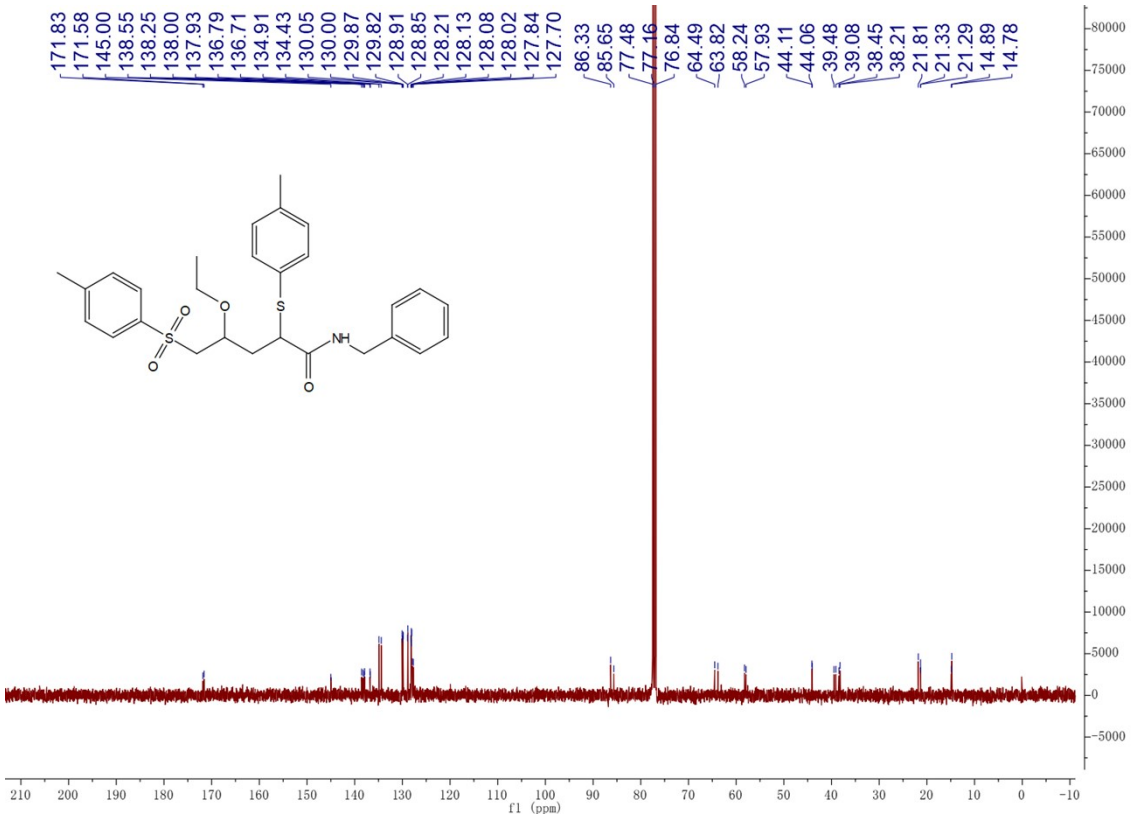
^{1}H NMR spectrum of **5c'**



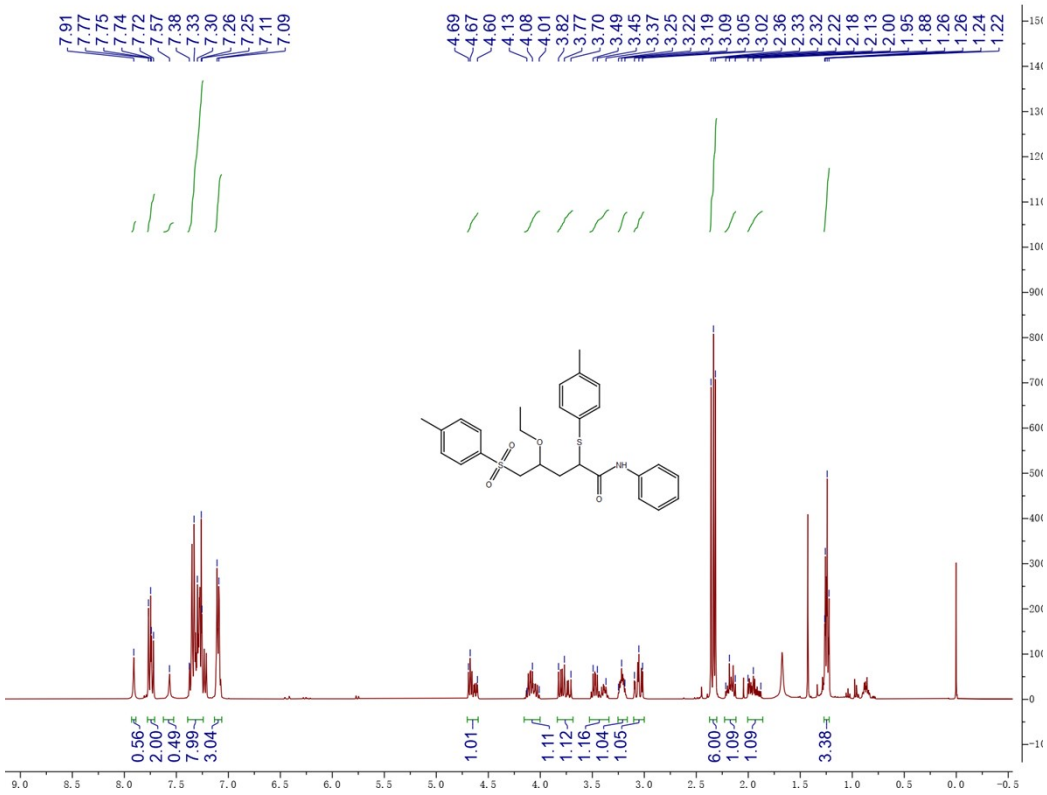
^{13}C NMR spectrum of **5c'**



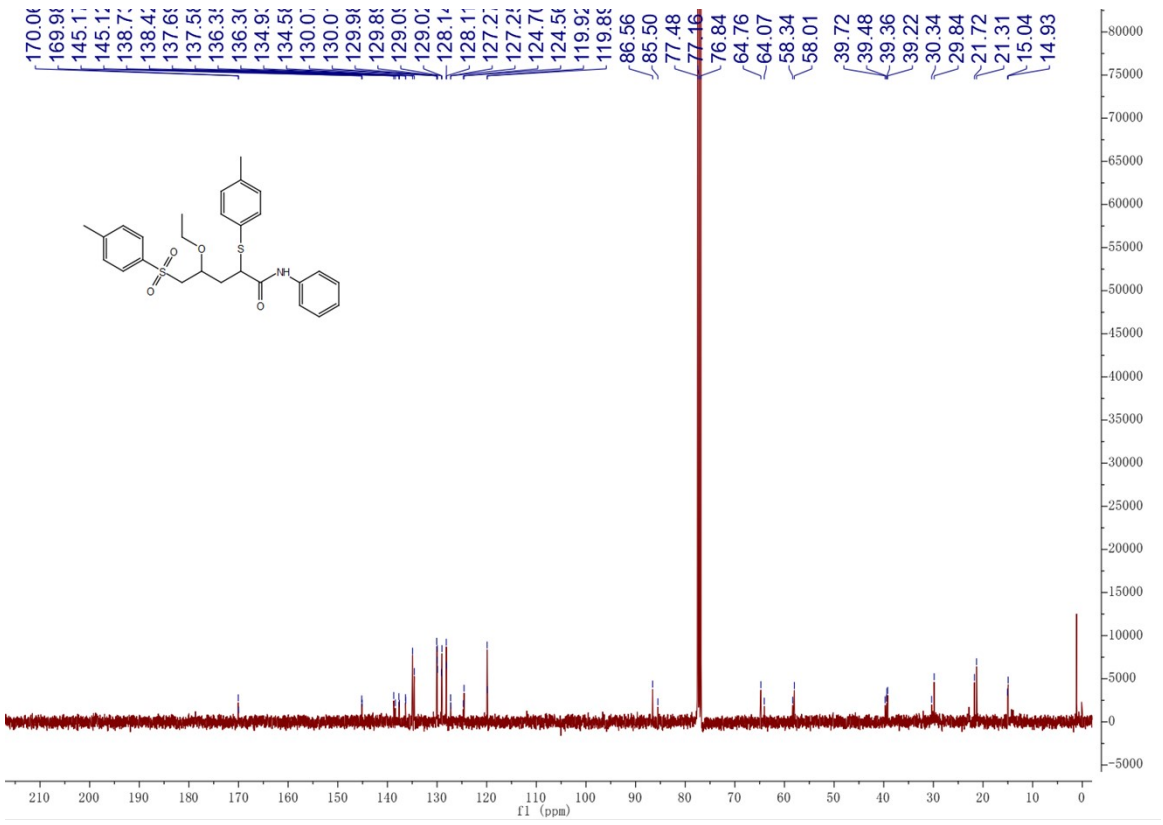
^{1}H NMR spectrum of **5d'**



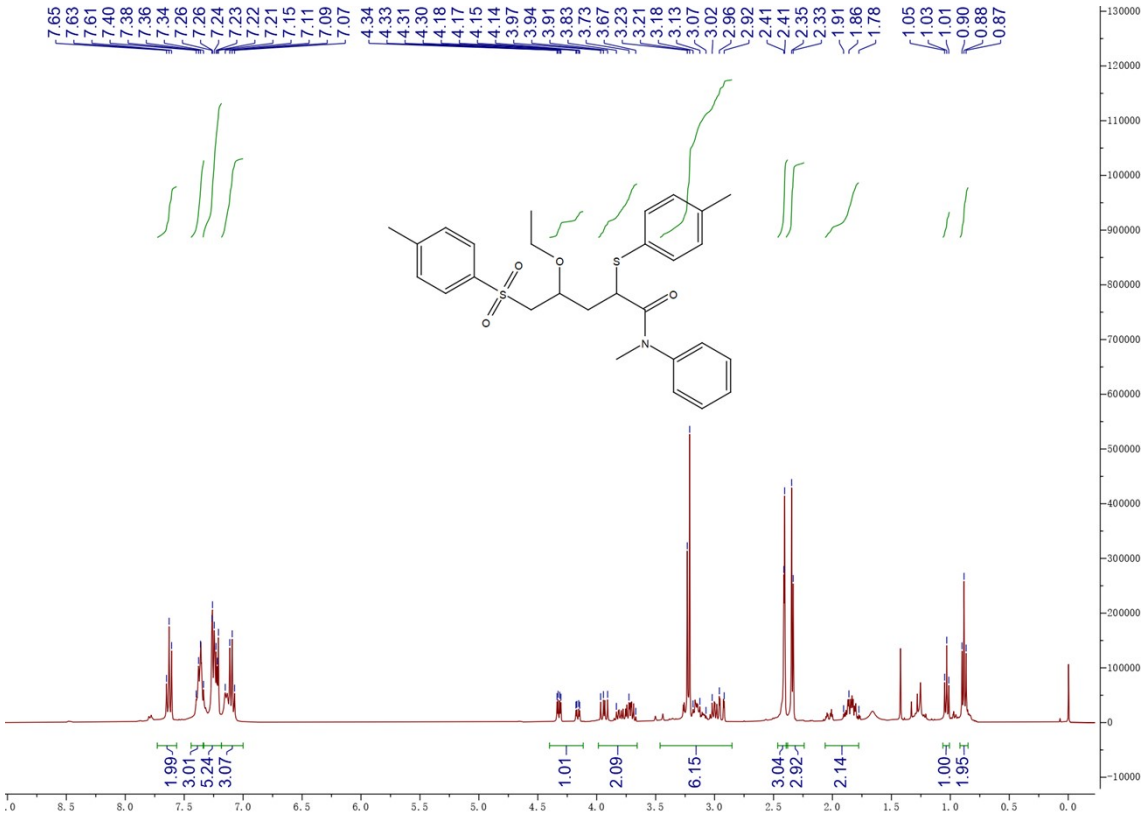
^{13}C NMR spectrum of **5d'**



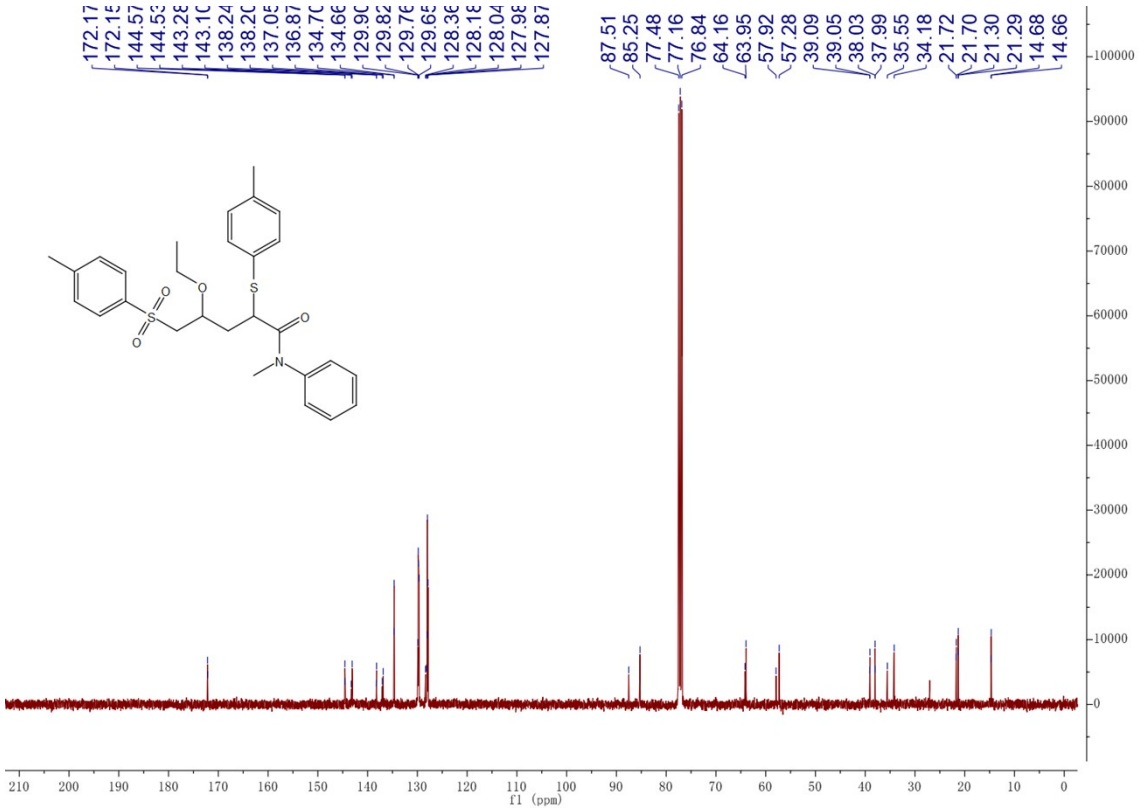
^{1}H NMR spectrum of **5e'**



^{13}C NMR spectrum of **5e'**



^{1}H NMR spectrum of **5f'**



^{13}C NMR spectrum of **5f'**

13. References

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