Supporting information for

Oxidant-controlled divergent construction of sulfenylsuccinimides and sulfonylsuccinimides via Mo-catalyzed C-S cross-coupling

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Experimental procedures and analytical data

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1. General information

The maleimides, thiols, H_2O_2(30% wt), $(NH_4)_6Mo_7O_{24}·4H_2O$, $(n\text{-}Bu)_4NBr$, $H_3PMo_{12}O_{40}$, all commercial reagents and metal catalyst were obtained from Energy Chemical, Sinopharm Chemical Reagent Co., Ltd and TCI, and used without further purification. ^1H, ^{13}C and ^{19}F NMR spectra were recorded on Bruker 600 MHz or Varian 400 MHz NMR spectrometer using $CDCl_3$ as solvent and TMS as an internal standard. Chemical shifts are reported in parts per million (ppm, δ). Reactions were monitored using thin-layer chromatography (TLC) on commercial silica gel plates (GF 254), and were performed under UV light (254 nm). Liquid chromatography was performed using forced flow (flash chromatography) on silica gel (SiO_2, 200 × 300 Mesh) purchased from Huanghai Chemical Co., Ltd. All the new products were further characterized by high resolution mass spectra (ESI-QTOF). IR spectra were recorded on a Nicolet iS10 FT-IR spectrophotometer (KBr pellets) over the region of 400-4000 cm^{-1}. The UV/Vis was tested on SHIMADZU UV2550 over the region of 800-200 nm.

2. General procedure for preparation of molybdenum catalyst

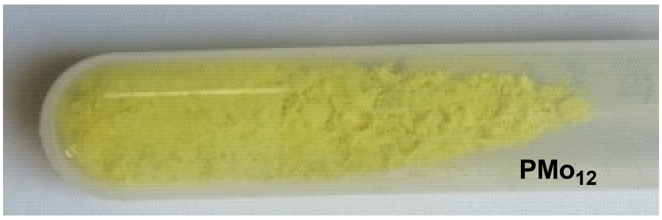
2. 1 Preparation of Mo_8

$$(NH_4)_6Mo_7O_{24}.4H_2O + (n\text{-}Bu)_4NBr \xrightarrow[\text{rt, 4 h}]{H_2O} [N(n\text{-}Bu)_4]_4Mo_8O_{26}$$

To a round-bottomed flask (200 mL) was added $(NH_4)_6Mo_7O_{24}·4H_2O$ (2 g, 1.5 mmol) and H_2O (50 mL), and then a solution of $(n\text{-}Bu)_4NBr$ (1.6 g, 5 mmol) in 50 mL H_2O was added dropwise within 0.5 hour. Then the resulting mixture was stirred at room temperature for another two hours and filtered to separate the white powder precipitates. Subsequently, the so-resulted powder was recrystallized three times from water to obtain analytically pure [**Mo₈**] (3 g, 86% yield, white solid). [N(*n*-Bu)$_4$]$_4$[*α*-Mo$_8$O$_{26}$] (2168). IR (KBr disks): 2979 (ν CH, s), 2948 (ν CH, s), 1633 (CN, m), 1491 (δ CH, m), 1380 (δ CH, m), 1353 (w), 1157 (w), 1069 (w), 1037 (w), 951 (ν MoO, s), 925 (ν MoO, s), 906 (ν MoO, s), 812 (w), 800 (w), 733 (w), 664 (ν MoOMo, vs), 560 (m), 522 (w) cm^{-1}. Spectral data were in accordance with the literature.[1]

2. 2 Preparation of PMo$_{12}$

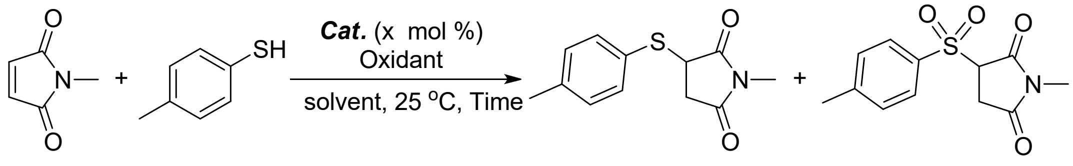
$$H_3PMo_{12}O_{40} + (n\text{-}Bu)_4NBr \xrightarrow[\text{rt, 4 h}]{H_2O} [N(n\text{-}Bu)_4]_3PMo_{12}O_{40}$$



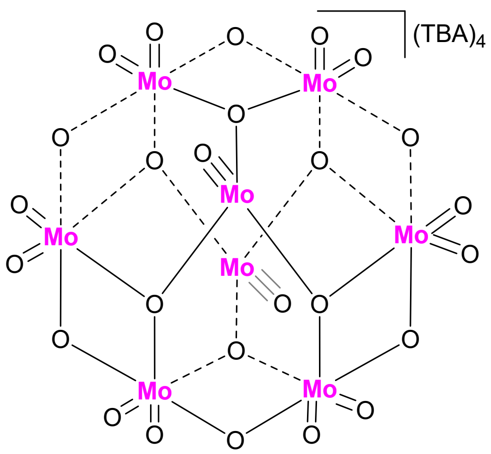
To a round-bottomed flask (200 mL) was added $H_3PMo_{12}O_{40}$ (2 g, 1.1 mmol) and H_2O (50 mL), and then a solution of (*n*-Bu)$_4$NBr (1.3 g, 3.85 mmol) in 50 mL H_2O was added dropwise within 1 hour. The reaction mixture was stirred at 25 °C for 4 h and the formed precipitate was filter and dried under vacuum to afford the crude product. The crude compound was recrystallized from acetonitrile to obtain analytically pure **PMo$_{12}$** product (1.6 g, 56%, yellow solid). [N(*n*-Bu)$_4$]$_3$PMo$_{12}$O$_{40}$ (2550): calcd. C 22.61, H 4.27, N 1.65; found C 22.55, H 4.32, N 1.71. IR (KBr Pellet): 2964 (ν C-H, s), 2941 (ν C-H, s), 2879 (ν C-H, s),1626 (C-N, m), 1482 (δ C-H, m), 1383 (δ C-H, m), 1068 (ν P-O, s), 955 (ν Mo=O, s), 884 (ν Mo-O-Mo, s), 810 (ν Mo-O-Mo, s) cm^{-1}. Spectral data were in accordance with the literature.[2]

3. Optimization of reaction conditions

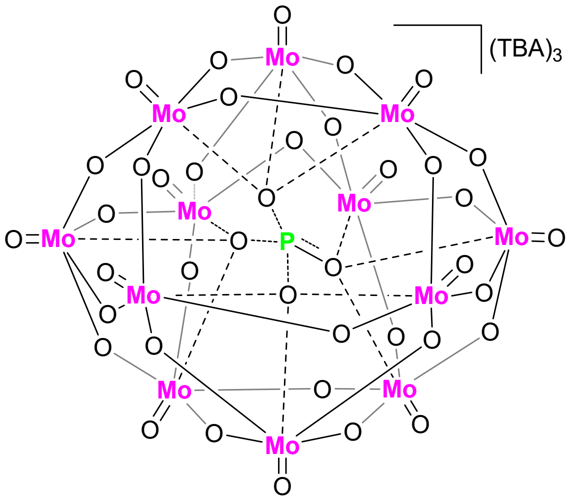
Table S1. Optimization of reaction conditions for **3a**^{a}



1a **2a** **3a** **4a**



Mo$_8$ = $[(Bu)_4N]_4[\alpha\text{-}Mo_8O_{26}]$

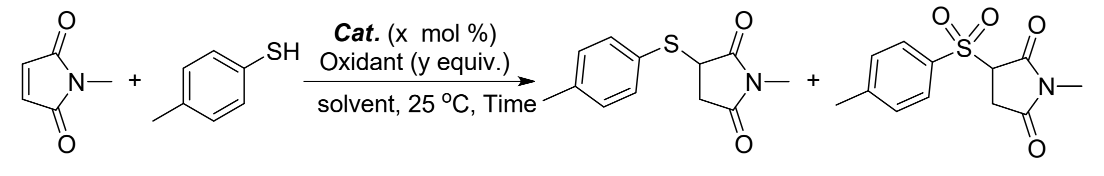


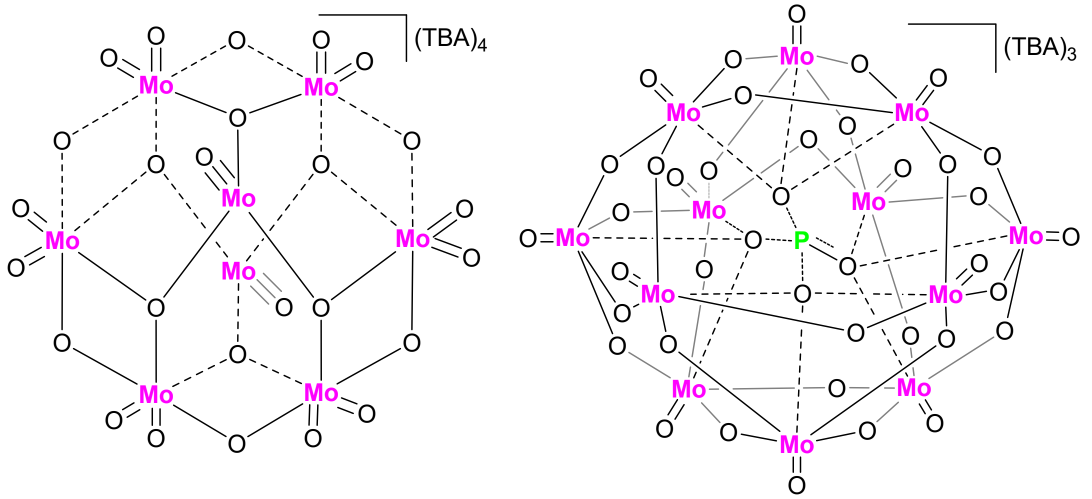
PMo$_{12}$ = $[(Bu)_4N]_3[PMo_{12}O_{40}]$

entry	Cat. (x mol%)	oxidant	solvent	time (h)	**3a** (%)[b]	**4a**(%)
1	**Mo$_8$**(1%)	Open air	EtOH	3	82	0
2	**PMo$_{12}$**(1%)	Open air	EtOH	3	96	0
3	$H_3PMo_{12}O_{40}$(1%)	Open air	EtOH	3	55	0
4	$Na_2MoO_4{\cdot}2H_2O$ (1%)	Open air	EtOH	3	41	0
5	MoO_3(1%)	Open air	EtOH	3	10	0
6	-	Open air	EtOH	3	<5	0
7	**PMo$_{12}$**(1%)	Open air	MeOH	3	90	0
8	**PMo$_{12}$**(1%)	Open air	Actone	3	52	0
9	**PMo$_{12}$**(1%)	Open air	MeCN	3	97	0
10	**PMo$_{12}$**(1%)	Open air	THF	3	15	0
11	**PMo$_{12}$**(1%)	Open air	H_2O	3	57	0
12	**PMo$_{12}$**(0.5%)	Open air	EtOH	3	80	0
13	**PMo$_{12}$**(1%)	Open air	EtOH	2	85	0

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.21 mmol), catalyst (x mol%), oxidant, Solvent (1 mL), 25 °C (oil bath), open air atmosphere. [b]Isolated yield.

Table S2. Optimization of reaction conditions for **4a**[a]





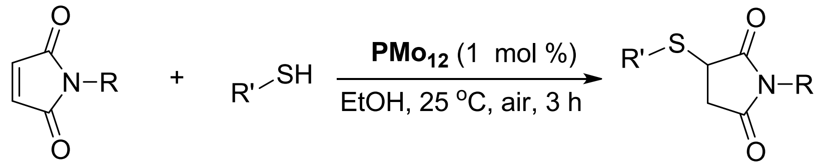
Mo8 = [(Bu)4N]4[α-Mo8O26]   **PMo12** = [(Bu)4N]3[PMo12O40]

entry	Cat. (x mol%)	oxidant(y equiv.)	solvent	time (h)	**3a** (%)[b]	**4a**(%)[b]
1	**PMo12**(1%)	H_2O_2 (3)	EtOH	3	5	90
2	**Mo8**(1%)	H_2O_2 (3)	EtOH	3	18	65
3	$H_3PMo_{12}O_{40}$(1%)	H_2O_2 (3)	EtOH	3	26	60
4	$Na_2MoO_4{\cdot}2H_2O$ (1%)	H_2O_2 (3)	EtOH	3	10	54
5	MoO_3(1%)	H_2O_2 (3)	EtOH	3	17	31
6	**PMo12**(1%)	H_2O_2 (3)	MeOH	3	20	72
7	**PMo12**(1%)	H_2O_2 (3)	Actone	3	14	57
8	**PMo12**(1%)	H_2O_2 (3)	MeCN	3	7	89
9	**PMo12**(1%)	H_2O_2 (3)	THF	3	19	38
10	**PMo12**(1%)	H_2O_2 (3)	H_2O	3	25	45
11	**PMo12**(1%)	O_2	EtOH	3	92	5
12	**PMo12**(1%)	Oxone (3)	EtOH	3	17	61
13	**PMo12**(1%)	H_2O_2 (3)	EtOH	2	15	81
14	**PMo12**(0.5%)	H_2O_2 (3)	EtOH	3	21	70

15	-	H_2O_2 (3)	EtOH	3	<5	<10

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.21 mmol), catalyst (x mol%), oxidant (y equiv.), solvent (1 mL), 25 ^{o}C, air atmosphere. [b]Isolated yield.

4. General procedure for synthesis of 3

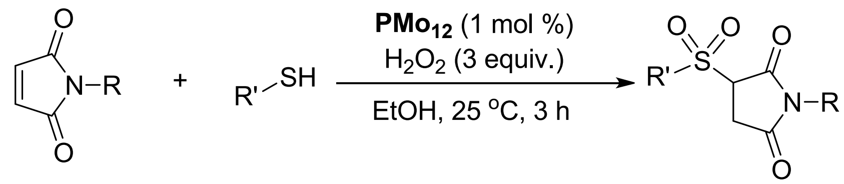


1, 0.2mmol **2,** 0.21mmol **3**

0.2 mmol scale: In a 10 mL tube was added **1** (0.2 mmol), **2a** (0.21 mmol, 1.05 equiv.), **PMo$_{12}$** (5.1 mg, 0.002 mmol, 0.01 equiv.), EtOH (2 mL). The reaction mixture was stirred at 25 °C for 3 h under open air atmosphere. Then the resulting mixture was evaporated under reduced pressure and purified by flash chromatography to afford the desired product.

10 mmol scale: In a 50 mL tube was added **1a** (1.11 g, 10 mmol), **2a** (1.35g, 11 mmol, 1.1 equiv.), **PMo$_{12}$** (128 mg, 0.05 mmol, 0.005 equiv.), EtOH (20 mL). Then the reaction mixture was stirred at 25 °C for 12 h uner open air atmosphere. Then the resulting mixture was vaporated under reduced pressure and purified by flash chromatography to afford the desired product **3a** (2.23g, 95% yield).

5. General procedure for synthesis of 4



1, 0.2mmol **2,** 0.21mmol **4**

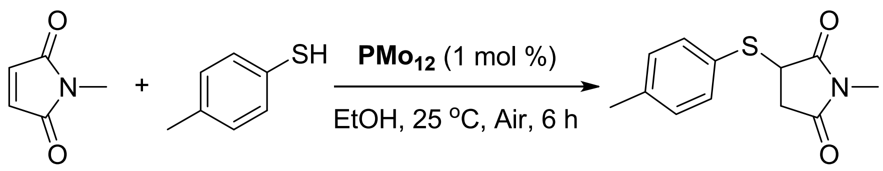
0.2 mmol scale: In a 10 mL tube was added **1** (0.2 mmol), **2** (0.21 mmol, 1.05 equiv.), **PMo$_{12}$** (5.1 mg, 0.002 mmol, 0.01 equiv.), H_2O_2 (70 mg, 0.6 mmol, 3 equiv.), and EtOH (2 mL,). The reaction mixture was stirred at 25 °C for 3 h under air atmosphere. Of note, the H_2O_2 was added in three parts and finished in two hours. Then the resulting mixture was evaporated under reduced pressure and purified by flash chromatography to afford the desired product.

10 mmol scale: In a 50 mL tube was added **1a** (1.11 g, 10 mmol), **2a** (1.35g, 11 mmol, 1.1 equiv.), **PMo_{12}** (128 mg, 0.05 mmol, 0.005 equiv.), EtOH (20 mL). Then H_2O_2 (3.5 g, 30 mmol, 3 equiv.) was slowly dropwise adding to the mixture within 6 h. After that, the reaction mixture was stirred at 25 °C for 12 h. Then the resulting mixture was vaporated under reduced pressure and purified by flash chromatography to afford the desired product **4a** (2.16 g, 81% yield).

6. Reuse of PMo_{12} catalyst

In a 20 mL tube was added **1a** (220 mg, 2 mmol), **2a** (275mg, 2.1 mmol), **PMo_{12}** (55 mg, 0.02 mmol), EtOH (8 mL). The reaction mixture was stirred at 25 °C for 6 h under open air atmosphere. In each run, the resulting mixture was evaporated under reduced pressure, and then washed thoroughly with ethyl acetate, and dried under vacuum. Subsequently, the dried catalyst was used further, without any purification or reactivation. The washing liquid was evaporated under vacuum, and the residue was purified by column chromatography.

Table S3. Recycling of **PMo_{12}** catalyst



1a, 2 mmol **2a,** 2.1 mmol **3a**

Number of runs	1	2	3	4	5
Isolated yield of **3a**	96	95	92	90	91

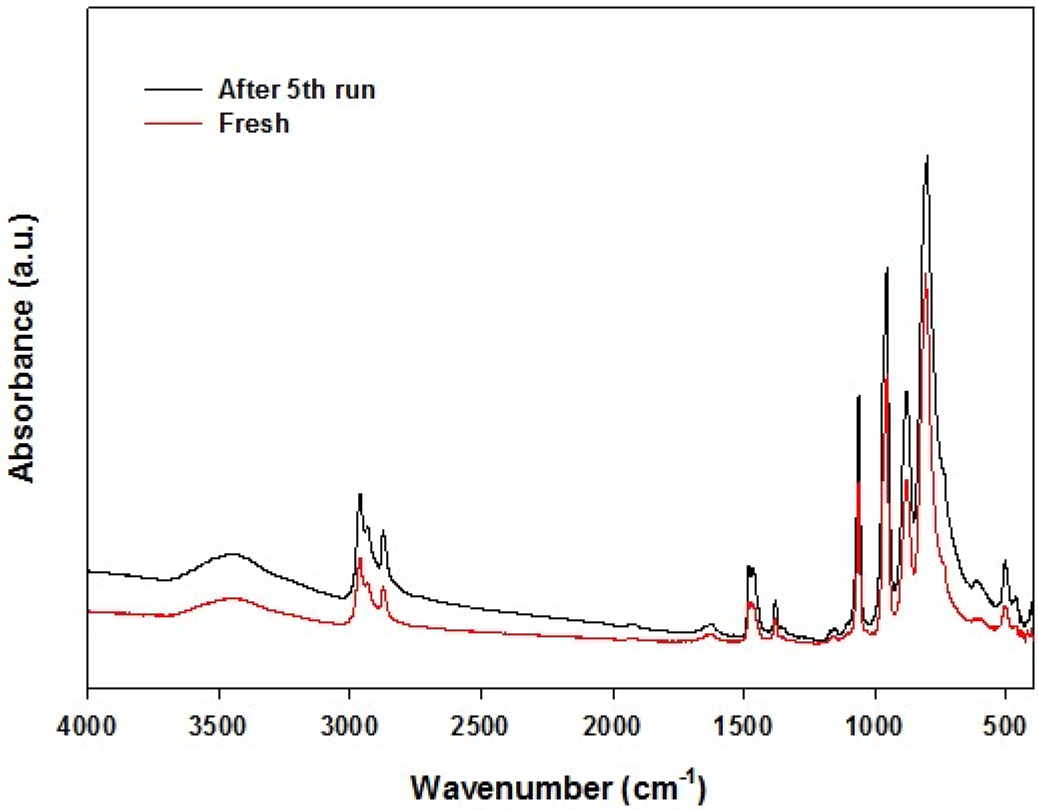
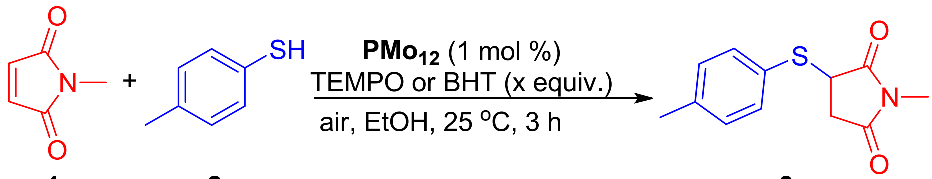


Figure S1. IR spectrums of the **PMo_{12}** catalyst

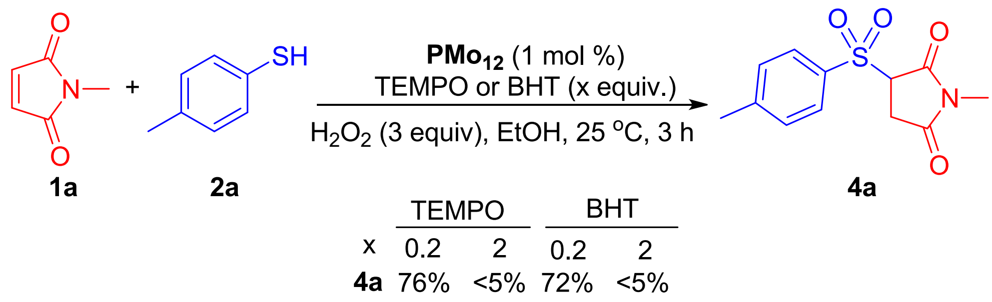
7. Radical trapping experiments



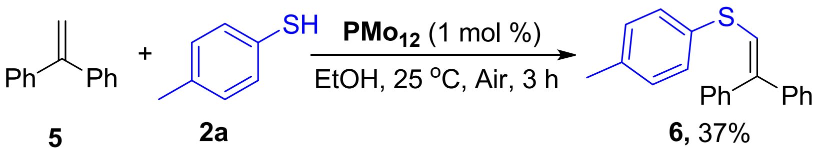
1a **2a** **3a**

	TEMPO		BHT	
x	0.2	2	0.2	2
3a	81%	<5%	79%	<5%

Maleimide **1a** (0.2 mmol, 23 mg), thiol **2a** (0.21 mmol, 30 mg), **PMo_{12}** catalyst (5.1 mg, 0.002 mmol), TEMPO or BHT (x equiv.), and EtOH (2 mL) were added to a 10 mL tube under open air atmosphere. The resulting mixture was stirred at 25 °C (oil bath) for 3 h. After completion, the solvent was removed under reduced pressure and the residue was quenched by saturated aq. NH_4Cl (1.0 mL). The resulting mixture was extracted with EtOAc (10 mL×2), dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The target product was detected in the mixture by ^1H NMR.

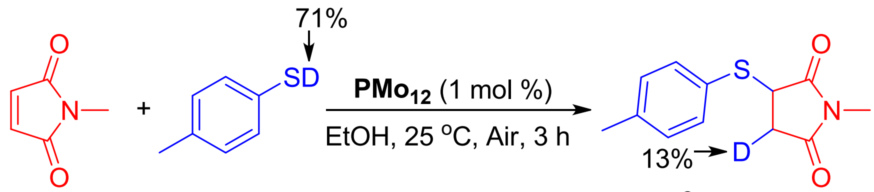


Maleimide **1a** (0.2 mmol, 23 mg), thiol **2a** (0.21 mmol, 30 mg), **PMo$_{12}$** catalyst (5.1 mg, 0.002 mmol), TEMPO or BHT (x equiv.), and EtOH (2 mL) were added to a 10 mL tube under open air atmosphere. The resulting mixture was stirred at 25 °C (oil bath) for 5 min. Afterwards, H_2O_2 (70 mg, 3.0 equiv.) was added into the mixture for three parts and finished in 2 h. After that, the reaction mixture was stirred at 25 °C (oil bath) for 3 hours. After completion, the solvent was removed under reduced pressure and the residue was quenched by saturated aq. NH_4Cl (1.0 mL). The resulting mixture was extracted with EtOAc (10 mL×2), dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The target product was detected in the mixture by ^{1}H NMR (<5%).



1,1-Diphenylethylene **5** (0.2 mmol), **2a** (30 mg, 0.21 mmol), **PMo$_{12}$** catalyst (5.1 mg, 0.002 mmol) and EtOH (1.5 mL) were added to a 10 mL tube under air atmosphere. The resulting mixture was stirred at 25 °C (oil bath) for3 h. After completion, the solvent was removed under reduced pressure and the residue was quenched by saturated aq. NH_4Cl (1.0 mL). The resulting mixture was extracted with EtOAc (10 mL×2), dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography to afford the compound **6** as a white solid (22 mg, 37% yield).

8. D-labeling experiments



In a 10 mL tube was added **1** (0.2 mmol), **2a-D** (0.21 mmol, 1.05 equiv.), **PMo_{12}** (5.1 mg, 0.002 mmol, 0.01 equiv.), EtOH (2 mL, 0.2 M). The reaction mixture was stirred at 25 °C for 3 h under open air atmosphere. Then the resulting mixture was evaporated under reduced pressure and purified by flash chromatography to afford the desired product. Then the product was detected by ^{1}H NMR (**Figure S2**).

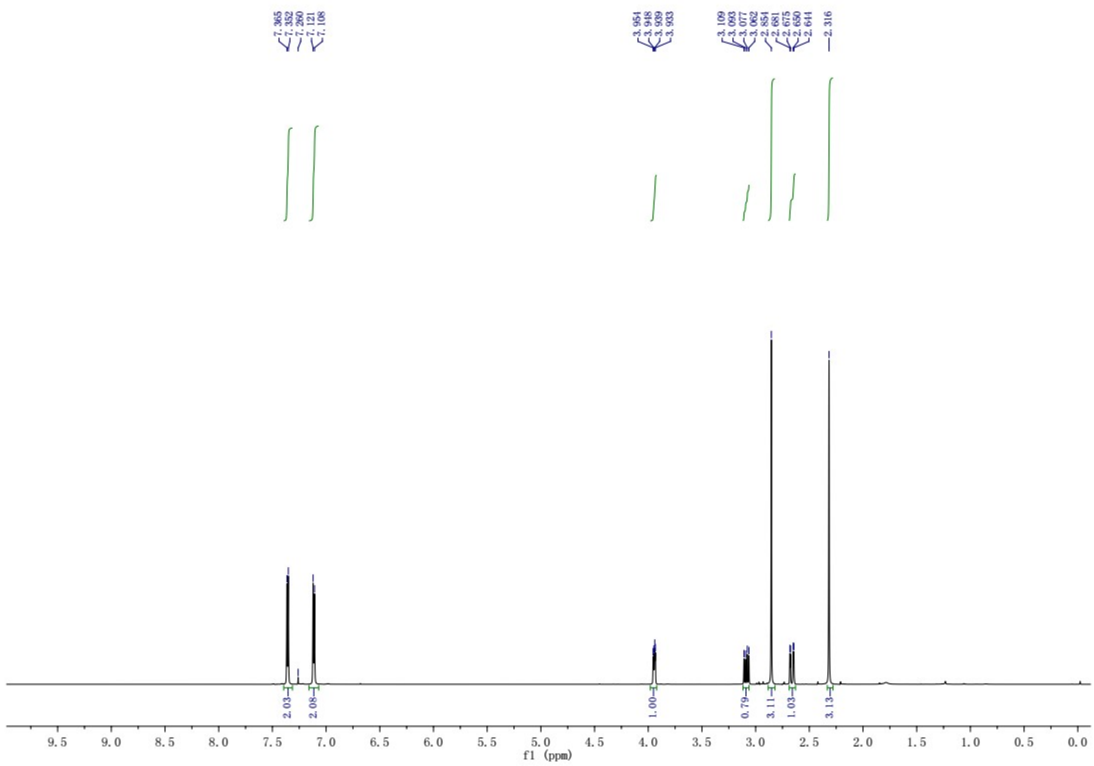
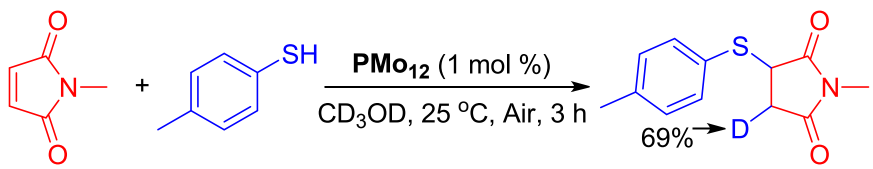


Figure S2. ^{1}H NMR



In a 10 mL tube was added **1** (0.2 mmol), **2a-D** (0.21 mmol, 1.05 equiv.), **PMo_{12}** (5.1 mg, 0.002 mmol, 0.01 equiv.), CD_3OD (1 mL, 0.2 M). The reaction mixture was stirred at 25 °C for 3 h under open air atmosphere. Then the resulting mixture was evaporated under reduced pressure and purified by flash chromatography to afford the desired product. Then the product was detected by ^{1}H NMR (**Figure S3**).

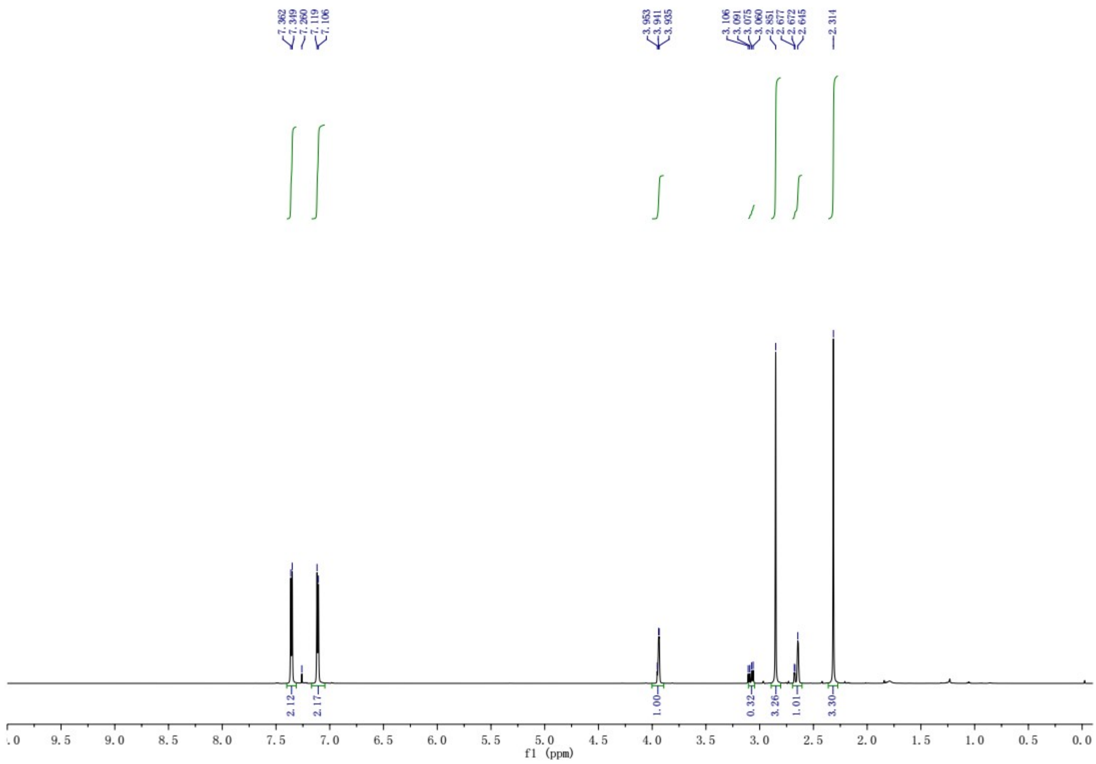
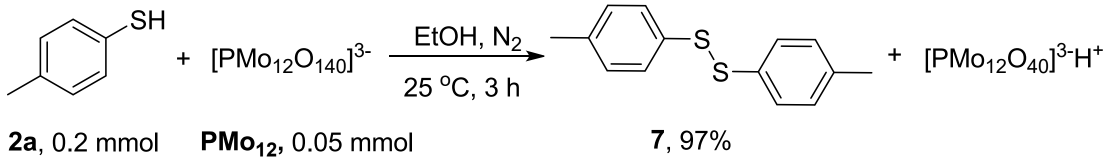


Figure S3. ^{1}H NMR

9. Synthesis and characterlization of $[PMo_{12}O_{40}]^{3-}H^+$ species



2a (26 mg, 0.2 mmol), **PMo$_{12}$**(128 mg, 0.05 mmol), and EtOH (2.0 mL) were added to a tube (10 mL) under N_2 atmosphere. The resulting mixture was stirred at 25 °C for 3 h. After completion, the resulting mixture was evaporated under reduced pressure, and then the solid was washed thoroughly with *n*-hexane, and dried under vacuum. Subsequently, the dried solid was tested by XPS. The washing liquid was evaporated under vacuum, and the residue was purified by column chromatography to give **7** in 97% yield.

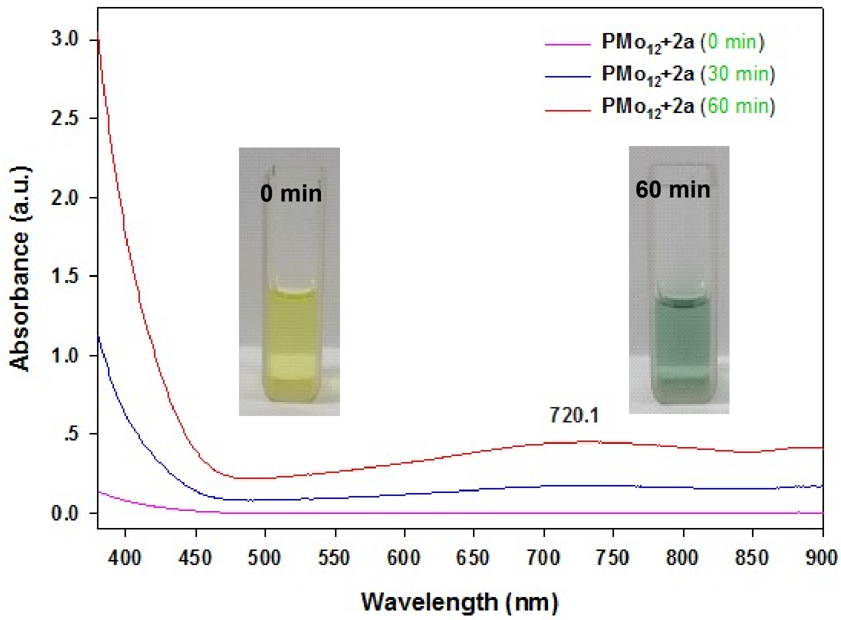


Figure S4. UV-Visible spectra of the complexes in MeCN solution, and the concentration is about 0.001 mmol/mL (based on [**Mo**]). All the test conditions are in N_2 atmosphere.

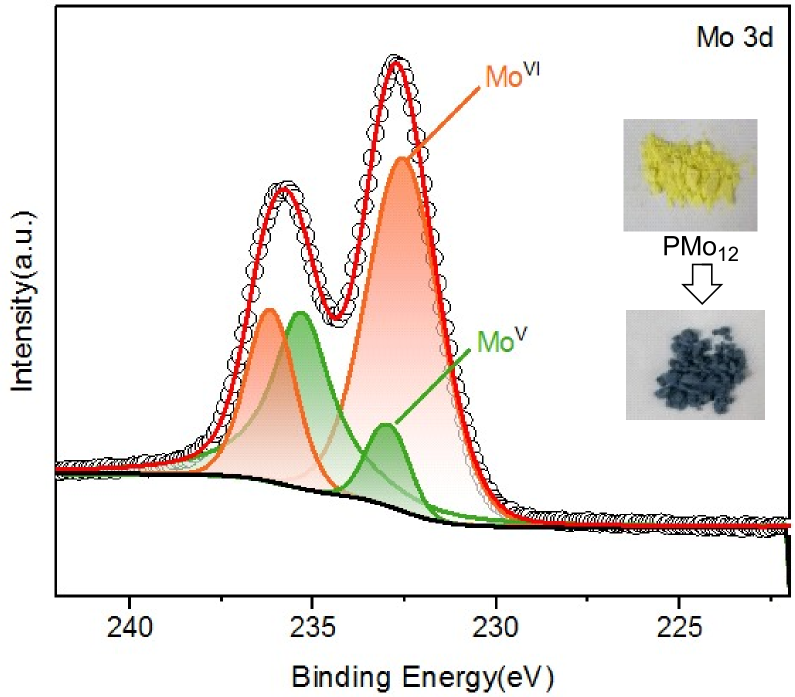
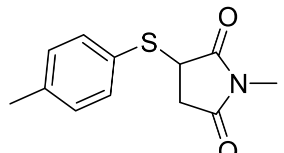


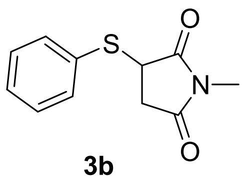
Figure S5. The XPS spectra of molybdenum element

10. Experimental characterization



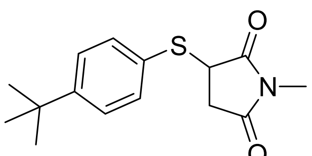
3a

1-methyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3a**). White solid, yield 45.1 mg (96%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.28. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.36 (d, *J*=7.8 Hz, 2H), 7.11 (d, *J*=7.8 Hz, 2H), 3.94 (dd, J=9.0, 3.6 Hz, 1H), 3.08 (dd, J=18.6, 9.6 Hz, 1H), 2.85 (s, 3H), 2.66 (dd, J=18.6, 3.6 Hz, 1H), 2.32 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.8, 174.7, 139.9, 134.9, 130.2, 126.4, 44.3, 36.1, 25.1, 21.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{12}H_{13}O_2NSNa$ 258.0559; Found 258.0555.



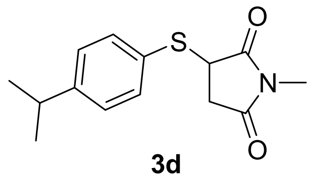
3b

1-methyl-3-(phenylthio)pyrrolidine-2,5-dione (**3b**). Colorless oil, yield 42.0 mg (95%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.50 (d, *J*=6.6 Hz, 2H), 7.32-7.36 (m, 3H), 4.02 (dd, J=9.0, 3.6 Hz, 1H), 3.13 (dd, J=18.6, 9.0 Hz, 1H), 2.89 (s, 3H), 2.66 (dd, J=18.6, 3.6 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.6, 174.5, 134.3, 130.4, 129.4, 126.4, 44.1, 36.3, 25.1. Spectral data were in accordance with the literature.[3]



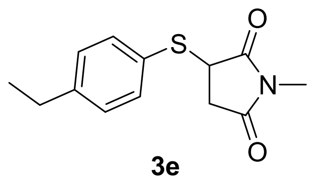
3c

3-((4-(tert-butyl)phenyl)thio)-1-methylpyrrolidine-2,5-dione (**3c**). Colorless oil, yield 51.0 mg (92%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.31. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.40 (d, *J*=8.4 Hz, 2H), 7.32 (d, *J*=8.0 Hz, 2H), 3.98 (dd, J=8.8, 3.6 Hz, 1H), 3.10 (dd, J=18.4, 8.8 Hz, 1H), 2.86 (s, 3H), 2.69 (dd, J=18.8, 4.0 Hz, 1H), 1.28 (s, 9H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.7, 174.6, 152.9, 134.4, 126.7, 126.4, 44.3, 36.3, 34.7, 31.2, 25.0. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{15}H_{19}O_2NSNa$ 300.1029; Found 300.1021.



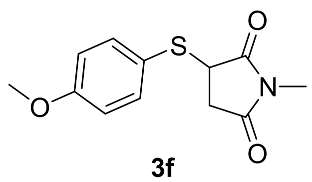
3d

3-((4-isopropylphenyl)thio)-1-methylpyrrolidine-2,5-dione (**3d**). Colorless oil, yield 51.0 mg (97%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.38 (d, *J*=7.8 Hz, 2H), 7.16 (d, *J*=7.8 Hz, 2H), 3.96 (dd, J=9.0, 3.6 Hz, 1H), 3.08 (dd, J=18.6, 9.0 Hz, 1H), 2.84-2.87 (m, 4H), 2.67 (dd, J=18.6, 3.6 Hz, 1H), 1.20 (d, *J*=7.2 Hz, 6H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.8, 174.7, 150.6, 134.8, 127.5, 126.9, 44.4, 36.3, 33.8, 25.0, 23.8. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{14}H_{17}O_2NSNa$ 286.0872; Found 286.0869.



3e

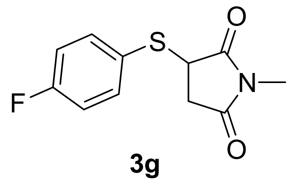
3-((4-ethylphenyl)thio)-1-methylpyrrolidine-2,5-dione (**3e**). Colorless oil, yield 47.8 mg (96%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.40 (d, *J*=7.8 Hz, 2H), 7.15 (d, *J*=7.8 Hz, 2H), 3.97 (dd, J=9.0, 3.6 Hz, 1H), 3.11 (dd, J=18.6, 9.0 Hz, 1H), 2.88 (s, 3H), 2.64 (dd, J=18.6, 3.6 Hz, 1H), 1.21 (t, *J*=7.2 Hz, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.8, 174.7, 146.1, 134.9, 129.0, 126.8, 44.3, 36.2, 28.5, 25.0, 15.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{13}H_{15}O_2NSNa$ 272.0716; Found 272.0715.



3f

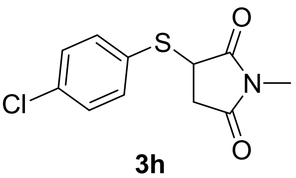
3-((4-methoxyphenyl)thio)-1-methylpyrrolidine-2,5-dione (**3f**). White solid, yield 47.7 mg (95%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.24. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.39 (d, *J*=8.0 Hz, 2H), 6.81 (d, *J*=8.0 Hz, 2H), 3.96 (dd, *J*=8.8, 3.6 Hz, 1H), 2.76 (s, 3H), 3.06 (dd, *J*=18.8, 9.2 Hz, 1H), 2.82 (s, 3H), 2.65 (dd, *J*=18.8, 3.2 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.8, 174.7, 161.0, 137.2, 120.0, 114.9, 55.4, 44.6, 36.0, 25.0. HRMS (ESI) m/z:

[M+Na]+ Calcd for $C_{12}H_{13}O_3NSNa$ 274.0508; Found 274.0502.



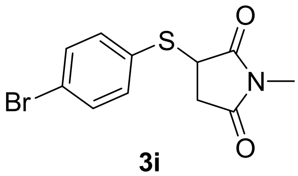
3g

3-((4-fluorophenyl)thio)-1-methylpyrrolidine-2,5-dione (**3g**). White solid, yield 44.9 mg (94%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.47-7.51 (m, 2H), 7.01 (t, *J*=4.4 Hz, 2H), 3.94 (dd, *J*=9.2, 3.6 Hz, 1H), 3.11 (dd, *J*=18.4, 8.8 Hz, 1H), 2.86 (s, 3H), 2.64 (dd, *J*=18.8, 4.0 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.5, 174.4, 163.0 (d, *J*=249 Hz), 137.1, 125.4, 116.7, 44.4, 36.0, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) = -110.6. HRMS (ESI) m/z: [M+Na]+ Calcd for $C_{11}H_{10}O_2NFSNa$ 262.0308; Found 262.0306.



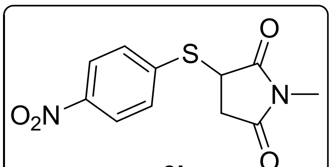
3h

3-((4-chlorophenyl)thio)-1-methylpyrrolidine-2,5-dione (**3h**). Colorless oil, yield 48.5 mg (95%); TLC (petroleum ether: AcOEt=4:1), R_f = 0.39. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.44 (d, *J*=8.4 Hz, 2H), 7.29 (d, *J*=8.4 Hz, 2H), 4.00 (dd, *J*=9.0, 3.6 Hz, 1H), 3.14 (dd, *J*=19.2, 9.6 Hz, 1H), 2.90 (s, 3H), 2.65 (dd, *J*=18.6, 3.6 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.5, 174.3, 135.7, 135.5, 129.6, 129.2, 44.1, 36.1, 25.2. HRMS (ESI) m/z: [M+Na]+ Calcd for $C_{11}H_{10}O_2NClSNa$ 278.0013; Found 278.0008.



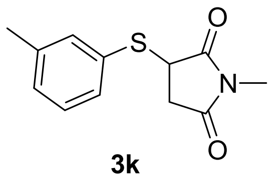
3i

3-((4-bromophenyl)thio)-1-methylpyrrolidine-2,5-dione (**3i**). White solid, yield 56.2 mg (94%); TLC (petroleum ether: AcOEt=4:1), R_f = 0.38. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.45 (d, *J*=8.4 Hz, 2H), 7.37 (d, *J*=8.4 Hz, 2H), 4.00 (dd, *J*=9.0, 4.2 Hz, 1H), 3.15 (dd, *J*=18.6, 9.0 Hz, 1H), 2.91 (s, 3H), 2.64 (dd, *J*=18.6, 4.2 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.4, 174.3, 135.5, 132.5, 129.9, 123.8, 44.0, 36.1, 25.2. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_2NBrSNa$ 321.9508; Found 321.9506.



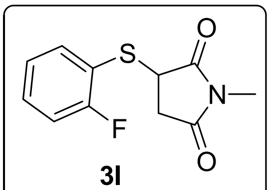
3j

1-methyl-3-((4-nitrophenyl)thio)pyrrolidine-2,5-dione (**3j**). White solid, yield 47.9 mg (90%); TLC (petroleum ether: AcOEt=4:1), R_f = 0.19. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 8.16 (d, *J*=9.0 Hz, 2H), 7.62 (d, *J*=9.0 Hz, 2H), 4.29 (dd, *J*=9.6, 4.8 Hz, 1H), 3.30 (dd, *J*=18.6, 9.0 Hz, 1H), 3.01 (s, 3H), 2.68 (dd, *J*=18.6, 4.2 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.1, 173.7, 146.9, 142.4, 130.2, 124.2, 42.4, 36.0, 25.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_4N_2SNa$ 289.0253; Found 289.0250.



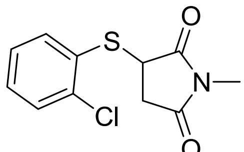
3k

1-methyl-3-(m-tolylthio)pyrrolidine-2,5-dione (**3k**). White solid, yield 44.7 mg (95%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.33. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.28-7.31 (m, 2H), 7.22 (t, *J*=7.8 Hz, 1H), 7.16 (d, *J*=7.8 Hz, 1H), 4.02 (dd, J=9.0, 3.6 Hz, 1H), 3.12 (dd, J=18.6, 9.6 Hz, 1H), 2.89 (s, 3H), 2.69 (dd, J=18.6, 3.6 Hz, 1H), 2.33 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.7, 174.6, 139.3, 134.8, 131.2, 130.1, 130.0, 129.2, 44.1, 36.3, 25.1, 21.2. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{12}H_{13}O_2NSNa$ 258.0559; Found 258.0557.



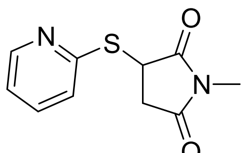
3l

3-((2-fluorophenyl)thio)-1-methylpyrrolidine-2,5-dione (**3l**). White solid, yield 42.5 mg (89%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.31. ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.51 (t, *J*=8.0 Hz, 1H), 7.34-7.39 (m, 1H), 7.08-7.13 (m, 2H), 4.12 (dd, *J*=8.0, 4.0 Hz, 1H), 3.11 (dd, *J*=20.0, 8.0 Hz, 1H), 2.92 (s, 3H), 2.66 (dd, *J*=20.0, 4.0 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.3, 174.4, 163.0 (d, *J*=247.5 Hz), 136.6, 131.8, 124.9, 117.9, 116.3, 42.8, 36.0, 25.1; ^{19}F NMR (376 MHz, $CDCl_3$): δ (ppm) = -106.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_2NFSNa$ 262.0308; Found 262.0302.



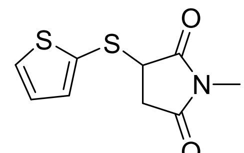
3m

3-((2-chlorophenyl)thio)-1-methylpyrrolidine-2,5-dione (**3m**). White solid, yield 38.3 mg (75%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.35. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.61 (d, *J*=2.4 Hz, 1H), 7.44-7.60 (m, 1H), 7.25-7.31 (m, 2H), 4.26 (dd, *J*=9.0, 4.2 Hz, 1H), 3.15 (dd, *J*=19.2, 9.0 Hz, 1H), 2.99 (s, 3H), 2.69 (dd, *J*=18.6, 3.6 Hz, 1H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.3, 174.4, 137.2, 134.8, 130.9, 130.3, 130.0, 127.5, 42.4, 35.8, 25.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_2NClSNa$ 278.0013; Found 278.0011.



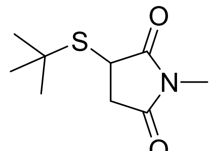
3n

1-methyl-3-(pyridin-2-ylthio)pyrrolidine-2,5-dione (**3n**). White solid, yield 40.0 mg (90%); TLC (petroleum ether: AcOEt=3:1), R_f = 0.28. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 8.20 (d, *J*=4.2 Hz, 1H), 7.46-7.48 (m, 1H), 7.15 (d, *J*=8.2 Hz, 1H), 6.95-6.97 (m, 1H), 4.28 (dd, *J*=9.6, 5.4 Hz, 1H), 3.22 (dd, *J*=18.6, 9.6 Hz, 1H), 3.04 (s, 3H), 2.89 (dd, *J*=18.0, 4.8 Hz, 1H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 176.2, 175.6, 155.8, 149.2, 136.6, 122.2, 120.2, 40.7, 36.8, 25.4. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{10}H_{10}O_2N_2SNa$ 245.0355; Found 245.0350.

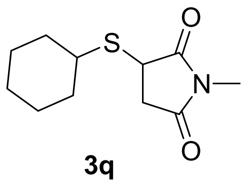


3o

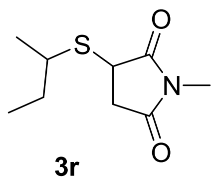
1-methyl-3-(thiophen-2-ylthio)pyrrolidine-2,5-dione (**3o**). White solid, yield 41.3 mg (91%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.44 (d, *J*=5.4 Hz, 1H), 7.20 (d, *J*=3.6 Hz, 1H), 7.00 (t, *J*=4.8 Hz, 1H), 3.84 (dd, *J*=9.0, 3.6 Hz, 1H), 3.11 (dd, *J*=18.6, 9.0 Hz, 1H), 2.83 (s, 3H), 2.76 (dd, *J*=19.2, 3.6 Hz, 1H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.2, 174.4, 137.8, 132.7, 128.2, 126.8, 45.7, 35.8, 25.2. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_9H_9O_2NS_2Na$ 249.9967; Found 249.9964.


3p

3-(tert-butylthio)-1-methylpyrrolidine-2,5-dione (**3p**). White solid, yield 8.4 mg (21%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.4. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 3.77 (dd, *J*=9.0, 4.2 Hz, 1H), 3.21 (dd, *J*=18.6, 9.0 Hz, 1H), 2.98 (s, 3H), 2.66 (dd, *J*=18.6, 4.2 Hz, 1H), 1.41 (s, 9H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 177.0, 175.1, 44.9, 39.2, 39.0, 31.3, 25.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_9H_{15}O_2NSNa$ 224.0716; Found 224.0715.

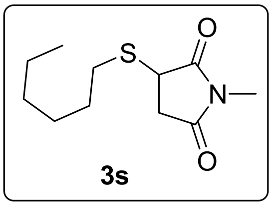

3q

3-(cyclohexylthio)-1-methylpyrrolidine-2,5-dione (**3q**). Cololess oil, yield 18.2 mg (40%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.42. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 3.79 (dd, *J*=9.0, 4.2 Hz, 1H), 3.16 (s, 1H), 3.10 (dd, *J*=18.6, 9.0 Hz, 1H), 2.97 (s, 3H), 2.49 (dd, *J*=18.6, 3.0 Hz, 1H), 2.08-2.09 (m, 1H), 1.91-1.92 (m, 1H), 1.72-1.77 (m, 2H), 1.58-1.59 (m, 1H), 1.22-1.37 (m, 5H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 177.0, 175.0, 43.8, 37.7, 36.6, 33.5, 32.9, 25.9, 25.7, 25.6, 25.1. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{17}O_2NSNa$ 250.0872; Found 250.0867.

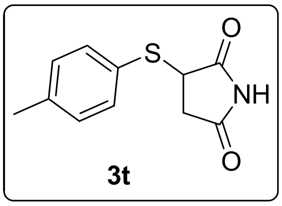

3r

3-(sec-butylthio)-1-methylpyrrolidine-2,5-dione (**3r**). Cololess oil, yield 14.9 mg (37%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.40. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 3.74 (dd, *J*=9.0, 3.0 Hz, 1H), 3.21 (dd, *J*=18.6, 9.0 Hz, 1H), 2.96 (s, 1H), 2.45-2.50 (m, 1H), 1.50-1.56 (m, 2H), 1.22-1.33 (m, 3H), 0.93-0.96

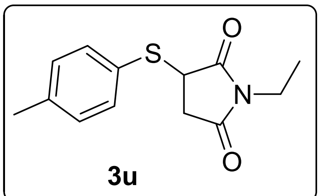
(m, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 177.0, 175.0, 42.1, 37.7, 36.6, 29.4, 25.1, 20.8, 11.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_9H_{15}O_2NSNa$ 224.0716; Found 224.0711.



3-(hexylthio)-1-methylpyrrolidine-2,5-dione (**3s**). Cololess oil, yield 16.0 mg (35%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.45. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 3.68 (dd, *J*=9.0, 3.6 Hz, 1H), 3.08 (dd, *J*=19.2, 9.6 Hz, 1H), 2.94 (s, 1H), 2.80-2.83 (m, 1H), 2.49 (dd, *J*=18.6, 3.0 Hz, 1H), 1.55-1.59 (m, 2H), 1.33-1.35 (m, 2H), 1.22-1.24 (m, 4H), 0.83 (t, *J*=7.2 Hz, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 176.7, 174.9, 39.1, 36.2, 31.7, 31.3, 28.9, 28.4, 25.0, 22.5, 14.0. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{19}O_2NSNa$ 252.1029; Found 252.1025.

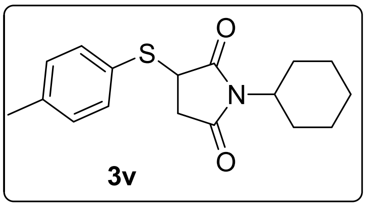


1-methyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3t**). White solid, yield 40.7 mg (92%); TLC (petroleum ether: AcOEt=3:1), R_f = 0.26. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 8.98 (s, 1H), 7.39 (d, *J*=8.4 Hz, 2H), 7.13 (d, *J*=7.8 Hz, 2H), 3.99 (dd, *J*=9.0, 3.6 Hz, 1H), 3.12 (dd, *J*=18.6, 9.6 Hz, 1H), 2.68 (dd, *J*=19.2, 4.2 Hz, 1H), 2.32 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 176.6, 175.4, 139.8, 134.8, 130.3, 126.5, 45.6, 37.0, 21.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{11}O_2NSNa$ 244.0403; Found 244.0398.

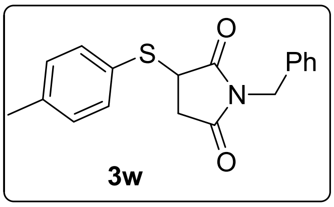


1-ethyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3u**). Colorless oil, yield 47.3 mg (95%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.36 (d, *J*=7.8 Hz, 2H), 7.10 (d, *J*=7.8 Hz, 2H), 3.90

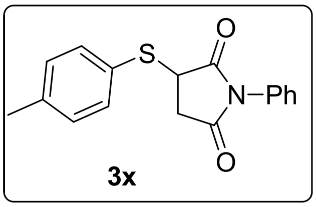
(dd, *J*=9.0, 4.2 Hz, 1H), 3.42 (q, *J*= 7.2 Hz, 2H), 3.07 (dd, *J*=18.6, 9.6 Hz, 1H), 2.65 (dd, *J*=19.2, 4.2 Hz, 1H), 2.30 (s, 3H), 0.99 (t, *J*= 7.2 Hz, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.5, 174.5, 139.9, 135.1, 130.1, 126.2, 44.1, 36.0, 34.0, 21.2, 12.7. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{13}H_{15}O_2NSNa$ 272.0716; Found 272.0710.



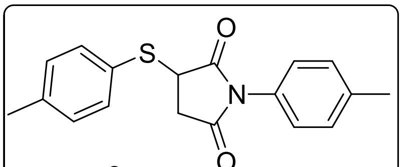
1-cyclohexyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3v**). Colorless oil, yield 57.0 mg (94%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.51. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.35 (d, *J*=7.8 Hz, 2H), 7.09 (d, *J*=7.8 Hz, 2H), 3.82-386 (m, 2H), 3.02 (dd, *J*=18.6, 9.6 Hz, 1H), 2.59 (dd, *J*=18.6, 4.2 Hz, 1H), 2.30 (s, 3H), 1.96-2.03 (m, 2H), 1.75-1.76 (m, 2H), 1.73(d, *J*= 3.0 Hz, 1H), 1.58-1.60 (m, 2H), 1.15-1.39 (m, 5H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.7, 174.7, 139.8, 135.1, 130.1, 126.2, 52.0, 43.7, 35.7, 28.6, 28.5, 25.8, 25.0, 21.2. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{17}H_{21}O_2NSNa$ 326.1185; Found 326.1182.



1-benzyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3w**). Colorless oil, yield 59.7 mg (96%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.45. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.25-7.27 (m, 7H), 6.97 (d, *J*=7.8 Hz, 2H), 4.54 (s, 2H), 3.90 (dd, *J*=9.0, 4.2 Hz, 1H), 3.06 (dd, *J*=18.6, 9.6 Hz, 1H), 2.63 (dd, *J*=18.6, 4.2 Hz, 1H), 2.28 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 175.5, 174.3, 139.7, 135.3, 135.0, 130.2, 128.9, 128.6, 128.0, 126.0, 44.1, 42.7, 35.7, 21.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{18}H_{17}O_2NSNa$ 334.0872; Found 334.0867.

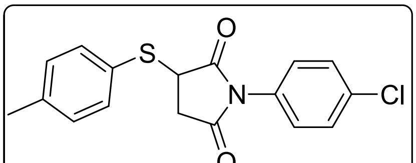


1-phenyl-3-(p-tolylthio)pyrrolidine-2,5-dione (**3x**). White solid, yield 56.4 mg (95%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.45 (d, *J*=7.8 Hz, 2H), 7.42 (t, *J*=7.8 Hz, 2H), 7.37 (t, *J*=7.8 Hz, 1H), 7.16 (d, *J*=7.8 Hz, 2H), 7.04 (d, *J*=7.8 Hz, 2H), 4.06 (dd, *J*=9.6, 3.6 Hz, 1H), 3.29 (dd, *J*=18.6, 9.6 Hz, 1H), 2.88 (dd, *J*=18.6, 3.6 Hz, 1H), 2.36 (s, 3H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 174.7, 173.7, 140.3, 135.6, 131.6, 130.3, 129.2, 128.8, 126.4, 125.9, 44.3, 36.3, 21.3. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{17}H_{15}O_2NSNa$ 320.0716; Found 320.0714.



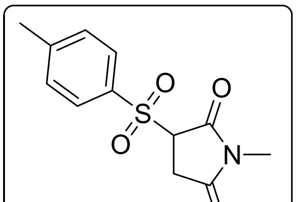
3y

1-(p-tolyl)-3-(p-tolylthio)pyrrolidine-2,5-dione (**3y**). White solid, yield 58.5 mg (94%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.31. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.46 (d, *J*=7.8 Hz, 2H), 7.22 (d, *J*=7.8 Hz, 2H), 7.17 (d, *J*=7.8 Hz, 2H), 6.91 (d, *J*=8.4 Hz, 2H), 4.06 (dd, *J*=9.6, 3.6 Hz, 1H), 3.28 (dd, *J*=18.6, 9.0 Hz, 1H), 2.87 (dd, *J*=19.2, 3.6 Hz, 1H), 2.36 (s, 6H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 174.8, 173.9, 140.2, 138.9, 135.6, 130.3, 129.8, 128.9, 126.2, 125.9, 44.3, 36.3, 21.3, 21.25. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{18}H_{17}O_2NSNa$ 334.0872; Found 334.0865.



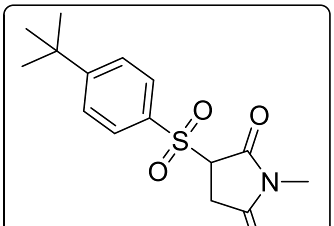
3z

1-(4-chlorophenyl)-3-(p-tolylthio)pyrrolidine-2,5-dione (**3z**). White solid, yield 60.2 mg (91%); TLC (petroleum ether: AcOEt=5:1), R_f = 0.30. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.45 (d, *J*=8.4 Hz, 2H), 7.39 (d, *J*=8.4 Hz, 2H), 7.17 (d, *J*=7.8 Hz, 2H), 7.00 (d, *J*=9.0 Hz, 2H), 4.086 (dd, *J*=9.6, 4.2 Hz, 1H), 3.31 (dd, *J*=18.6, 9.0 Hz, 1H), 2.90 (dd, *J*=18.6, 3.6 Hz, 1H), 2.36 (s, 6H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 174.4, 173.4, 140.4, 140.0, 135.6, 134.6, 130.4, 129.3, 127.6, 125.7, 44.3, 36.3, 21.3. Spectral data were in accordance with the literature.[4]



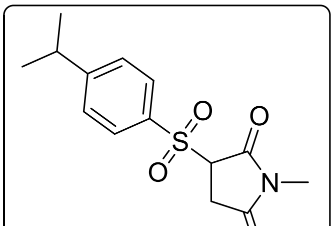
4a

1-methyl-3-tosylpyrrolidine-2,5-dione (**4a**). White solid, yield 48.1 mg (90%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.24. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.78 (d, *J*=8.4 Hz, 2H), 7.39 (d, *J*=8.4 Hz, 2H), 4.33 (dd, J=9.6, 4.2 Hz, 1H), 3.27 (dd, J=18.6, 9.0 Hz, 1H), 3.03 (dd, J=19.2, 3.6 Hz, 1H), 2.92 (s, 3H), 2.46 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.1, 168.7, 146.4, 133.5, 130.1, 129.4, 63.4, 29.9, 25.5, 21.8. Spectral data were in accordance with the literature.[5]



4b

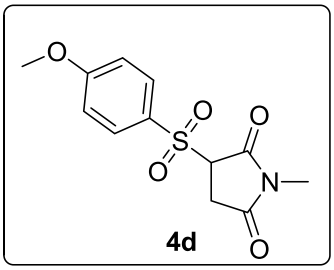
3-((4-(tert-butyl)phenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4b**). White solid, yield 52.5 mg (85%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.25. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.83 (d, *J*=8.4 Hz, 2H), 7.60 (d, *J*=8.4 Hz, 2H), 4.34 (dd, *J*=9.6, 4.2 Hz, 1H), 3.30 (dd, *J*=19.2, 9.6 Hz, 1H), 3.04 (dd, J=19.2, 3.6 Hz, 1H), 2.94 (s, 3H), 1.35 (s, 9H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.1, 168.7, 159.2, 133.5, 129.2, 126.5, 63.4, 35.5, 31.0, 30.0, 25.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{15}H_{19}O_4NSNa$ 332.0927; Found 332.0925.



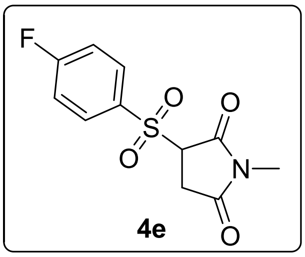
4c

3-((4-isopropylphenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4c**). White solid, yield 52.5 mg (89%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.25. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.83 (d, *J*=8.4 Hz, 2H), 7.45 (d, *J*=8.4 Hz, 2H), 4.32 (dd, *J*=9.6, 3.6 Hz, 1H), 3.32 (dd, *J*=18.6, 3.0 Hz, 1H), 3.01-3.07 (m, 2H), 2.95 (s, 3H), 1.29 (d, *J*=7.2 Hz, 6H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm)

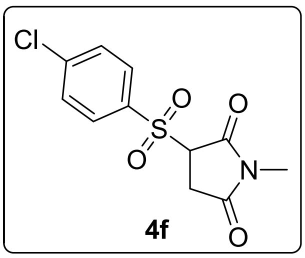
= 173.0, 168.7, 156.7, 133.8, 129.6, 127.6, 63.4, 34.4, 30.0, 25.5, 23.6, 23.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{14}H_{17}O_4NSNa$ 318.0770; Found 318.0772.



3-((4-methoxyphenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4d**). White solid, yield 53.2 mg (94%); TLC (petroleum ether: AcOEt=1:1), R_f = 0.21. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.79 (d, *J*=8.4 Hz, 2H), 7.02 (d, *J*=9.0 Hz, 2H), 4.31 (dd, *J*=9.6, 3.6 Hz, 1H), 3.87 (s, 3H), 3.23 (dd, J=19.2, 3.6 Hz, 1H), 3.02 (dd, J=19.2, 3.6 Hz, 1H), 2.91 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.2, 168.9, 164.8, 131.7, 127.6, 114.6, 63.5, 55.8, 30.1, 25.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{12}H_{13}O_5NSNa$ 306.0407; Found 306.0402.

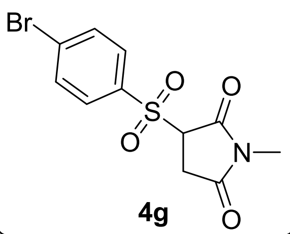


3-((4-fluorophenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4e**). White solid, yield 46.6 mg (86%); TLC (petroleum ether: AcOEt=1:1), R_f = 0.30. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.96 (dd, *J*=8.4, 4.8 Hz, 2H), 7.30 (t, *J*=8.4 Hz, 2H), 4.31 (dd, *J*=9.6, 3.6 Hz, 1H), 3.37 (dd, J=19.2, 3.6 Hz, 1H), 3.08 (dd, J=19.2, 3.6 Hz, 1H), 2.98 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.7, 168.6, 166.5 (d, *J*=258 Hz), 132.6, 132.5, 116.9, 116.8, 63.4, 29.6, 25.6; ^{19}F NMR (564 MHz, $CDCl_3$): δ (ppm) = -100.8. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_4NFSNa$ 294.0207; Found 294.0203.



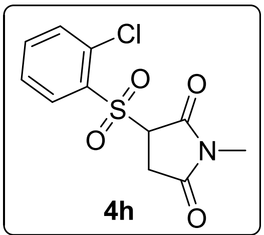
3-((4-chlorophenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4f**). White solid, yield 51.7 mg (90%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.25.

^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.85 (d, *J*=8.4 Hz, 2H), 7.58 (d, *J*=8.4 Hz, 2H), 4.34 (dd, *J*=9.6, 3.6 Hz, 1H), 3.31 (dd, J=19.2, 3.6 Hz, 1H), 3.07 (dd, J=19.2, 3.6 Hz, 1H), 2.96 (s, 3H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.7, 168.5, 142.0, 135.0, 130.9, 129.8, 63.4, 29.5, 25.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_4NClSNa$ 309.9911; Found 309.9905.



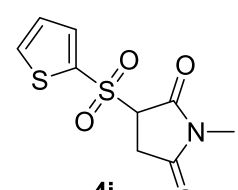
4g

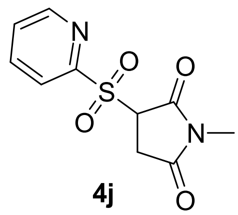
3-((4-bromophenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4g**). White solid, yield 52.8 mg (80%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.26. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.77 (d, *J*=9.0 Hz, 2H), 7.74 (d, *J*=9.0 Hz, 2H), 4.34 (dd, *J*=9.6, 4.2 Hz, 1H), 3.31 (dd, *J*=19.2, 3.6 Hz, 1H), 3.08 (dd, J=19.2, 3.6 Hz, 1H), 2.95 (s, 3H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.8, 168.5, 135.6, 132.8, 130.9, 125.6, 63.3, 29.5, 25.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_4NBrSNa$ 353.9406; Found 353.9402.

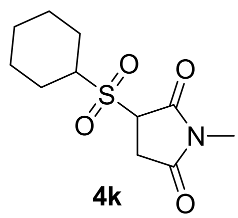


4h

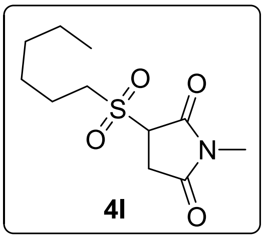
3-((2-chlorophenyl)sulfonyl)-1-methylpyrrolidine-2,5-dione (**4h**). White solid, yield 46.5 mg (81%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.24. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.79 (d, *J*=8.4 Hz, 1H), 7.51-7.58 (m, 2H), 7.44 (d, *J*=7.8 Hz, 1H), 4.38 (dd, *J*=9.0, 4.8 Hz, 1H), 3.00-3.06 (m, 4H), 2.35 (dd, J=18.0, 9.0 Hz, 1H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 174.3, 172.0, 138.2, 133.2, 130.3, 129.9, 128.3, 126.8, 59.7, 25.6, 24.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{10}O_4NClSNa$ 309.9911; Found 309.9907.


4i
1-methyl-3-(thiophen-2-ylsulfonyl)pyrrolidine-2,5-dione (**4i**). White solid, yield 44.0 mg (85%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.27. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.85 (d, *J*=5.4 Hz, 1H), 7.79 (d, *J*=4.2 Hz, 1H), 7.23 (t, *J*=4.2 Hz, 1H), 4.43 (dd, *J*=9.0, 3.6 Hz, 1H), 3.32 (dd, *J*=19.2, 3.6 Hz, 1H), 3.10 (dd, J=19.2, 3.6 Hz, 1H), 2.97 (s, 3H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.7, 168.3, 136.9, 136.4, 136.3, 128.4, 64.4, 30.3, 25.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_9H_9O_4NS_2Na$ 281.9865; Found 281.9863.

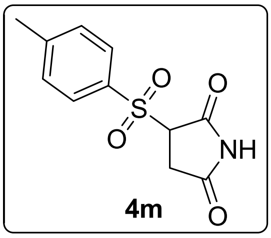

4j
1-methyl-3-(pyridin-2-ylsulfonyl)pyrrolidine-2,5-dione (**4j**). White solid, yield 38.6 mg (76%); TLC (petroleum ether: AcOEt=1:2), R_f = 0.21. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 8.77 (d, *J*=4.8 Hz, 1H), 8.09 (d, *J*=7.8 Hz, 1H), 8.03 (t, *J*=7.8 Hz, 1H), 7.64 (dd, *J*=7.8, 4.8 Hz, 1H), 5.05 (dd, *J*=10.2, 4.8 Hz, 1H), 3.44 (dd, *J*=19.2, 4.2 Hz, 1H), 3.14 (dd, J=18.6, 3.6 Hz, 1H), 2.97 (s, 3H); ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.1, 168.7, 155.5, 150.5, 138.4, 128.2, 123.4, 59.7, 29.0, 25.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{10}H_{10}O_4N_2SNa$ 277.0253; Found 277.0251.


4k
3-(cyclohexylsulfonyl)-1-methylpyrrolidine-2,5-dione (**4k**). Colorless oil, yield 18.1 mg (35%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.24. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 4.35 (dd, *J*=9.6, 3.6 Hz, 1H), 3.61 (t, J=12.0 Hz, 1H), 3.28 (dd, *J*=19.2, 3.6 Hz, 1H), 2.96-3.01 (m, 4H), 2.20 (d, *J*=8.0 Hz, 2H), 1.92-

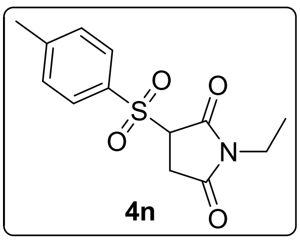
1.97 (m, 2H), 1.74(d, J=7.2Hz, 1H), 1.56-1.64 (m, 2H), 1.23-1.45 (m, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.4, 169.7, 60.1, 56.8, 27.9, 26.7, 25.0, 24.7, 22.5. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{17}O_4NSNa$ 282.0770; Found 282.0765.



3-(hexylsulfonyl)-1-methylpyrrolidine-2,5-dione (**4l**). Colorless oil, yield 16.2 mg (31%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.26. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 4.22 (dd, J=9.6, 4.2 Hz, 1H), 4.11 (dd, J=9.6, 6.6 Hz, 2H), 3.28 (dd, J=19.2, 4.2 Hz, 1H), 2.97-3.03 (m, 4H), 1.90 (p, J=7.8 Hz, 2H), 1.69 (t, J=7.2 Hz, 2H), 1.32-1.34 (m, 4H), 0.89 (t, J=6.0 Hz, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.1, 169.6, 59.8, 52.7, 31.1, 28.0, 27.7, 25.7, 22.3, 21.6, 13.9. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{19}O_4NSNa$ 284.0927; Found 284.0922.

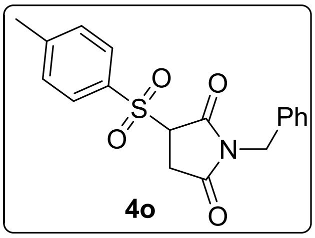


3-tosylpyrrolidine-2,5-dione (**4m**). White solid, yield 40.5 mg (80%); TLC (petroleum ether: AcOEt=1:1), R_f = 0.20. ^1H NMR (600 MHz, $CDCl_3$): δ (ppm) = 8.96 (s,1H), 7.78 (d, J=7.8 Hz, 2H), 7.39 (d, J=7.8 Hz, 2H), 4.39 (dd, J=7.8, 2.4 Hz, 1H), 3.25 (dd, J=19.2, 3.6 Hz, 1H), 3.07 (dd, J=19.2, 9.6 Hz, 1H), 2.46 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 173.6, 168.9, 146.5, 133.2, 130.2, 129.4, 64.6, 31.2, 21.8. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{11}H_{11}O_4NSNa$ 276.0301; Found 276.0295.

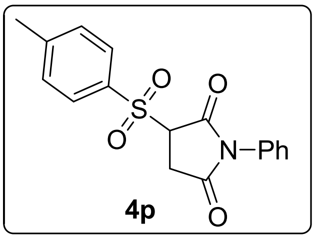


1-ethyl-3-tosylpyrrolidine-2,5-dione (**4n**). Colorless oil, yield

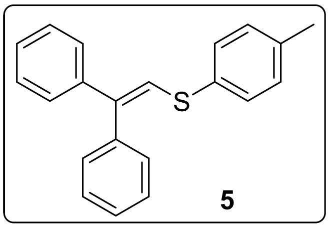
46.1 mg (82%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.26. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.79 (d, *J*=8.4 Hz, 2H), 7.39 (d, *J*=8.4 Hz, 2H), 4.30 (dd, *J*=9.6, 3.6 Hz, 1H), 3.49 (q, 7.2 Hz, 2H), 3.29 (dd, *J*=19.2, 3.6 Hz, 1H), 3.03 (dd, *J*=18.6, 9.6 Hz, 1H), 2.46 (s, 3H), 1.06 (t, *J*=7.2 Hz, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.8, 168.5, 146.3, 133.5, 130.1, 129.4, 63.4, 34.5, 30.0, 21.8, 12.6. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{13}H_{15}O_4NSNa$ 304.0614; Found 304.0612.

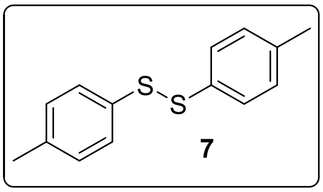


1-benzyl-3-tosylpyrrolidine-2,5-dione (**4o**). Colorless oil, yield 61.7 mg (90%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.28. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.71 (d, *J*=8.4 Hz, 2H), 7.27-7.31 (m, 7H), 4.59 (s, 2H), 4.30 (dd, *J*=9.6, 4.2 Hz, 1H), 3.30 (dd, *J*=9.6, 3.0 Hz, 1H), 3.04 (dd, *J*=19.2, 9.6 Hz, 1H), 2.44 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.7, 168.4, 146.3, 134.7, 133.2, 130.1, 129.4, 128.7, 128.6, 128.2, 63.4, 43.1, 30.0, 21.9. Spectral data were in accordance with the literature.[5]



1-phenyl-3-tosylpyrrolidine-2,5-dione (**4p**). White solid, yield 55.9 mg (85%); TLC (petroleum ether: AcOEt=2:1), R_f = 0.31. ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) = 7.82 (d, *J*=8.4 Hz, 2H), 7.38-7.45 (m, 5H), 7.14 (d, *J*=7.8 Hz, 2H), 4.46 (dd, *J*=9.6, 3.6 Hz, 1H), 3.47 (dd, *J*=19.2, 3.6 Hz, 1H), 3.21 (dd, *J*=19.2, 2.4 Hz, 1H), 2.46 (s, 3H); $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ (ppm) = 172.1, 167.9, 146.5, 133.4, 131.1, 130.2, 129.6, 129.3, 129.2, 126.4, 63.7, 30.1, 21.8. Spectral data were in accordance with the literature.[5]


(2,2-diphenylvinyl)(p-tolyl)sulfane (**5**). White solid, yield 22.3 mg (37%); TLC (petroleum ether), R_f = 0.80. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.38-7.50 (m, 7H), 7.28-7.33 (m, 5H), 7.19 (d, *J*=8.0 Hz, 2H), 6.85 (s, 1H), 2.38 (s, 3H); ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ (ppm) = 141.5, 140.1, 139.2, 137.0, 132.8, 130.1, 129.9, 129.8, 128.4, 128.3, 127.7, 127.1, 125.2, 21.1. Spectral data were in accordance with the literature.[6]


1,2-di-p-tolyldisulfane (**7**). White solid, yield 47.7 mg (97%); TLC (petroleum ether), R_f = 0.84. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) = 7.40 (d, *J*=7.6 Hz, 4H), 7.20 (d, *J*=7.6 Hz, 4H), 2.34 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$): δ (ppm) = 137.4, 133.9, 129.8, 128.5, 21.1. Spectral data were in accordance with the literature.[7]

11. Reference

[1] P. R. Marcoux, B. Hasenknopf, J. Vaissermann and P. Gouzerh, *Eur. J. Inorg. Chem.* 2003, 2406.

[2] (a) Wang, E.-B.; Hu, C.-W.; Xu, L. *Introduction to Polyacid Chemistry*. Beijing Chem Ind Press; 1998, p14. (b) A. Magerat, S. Hermans and E. M. Gaigneaux, *Appl. Catal. B Environ.* 2025, 375, 125432.

[3] B. H. Northrop, S. H. Frayne and U. Choudhary, *Polym. Chem.* 2015, **6**, 3415.

[4] D. Bag, R. Rahaman, A. S. Manna, S. Pal, R. Nandi, S. Aich, N. N. Ghosh and D. K. Maiti, *Org. Chem. Front.* 2024, **11**, 6503.

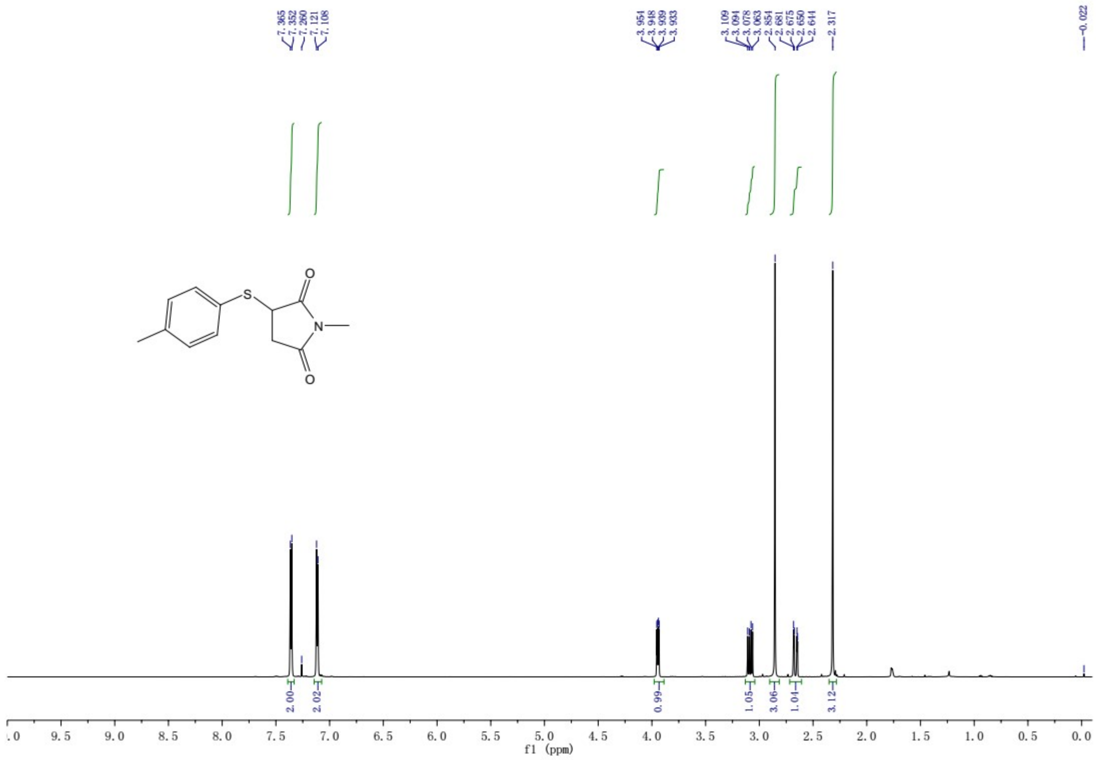
[5] H.-L. Ruan, Y.-L. Ma, K.-X. Man and S.-Y. Zhao, *J. Org. Chem.* 2022, **87**, 3762.

[6] N. Mukherjee and T. Chatterjee, *Green Chem.* 2023, **2**5, 8798.

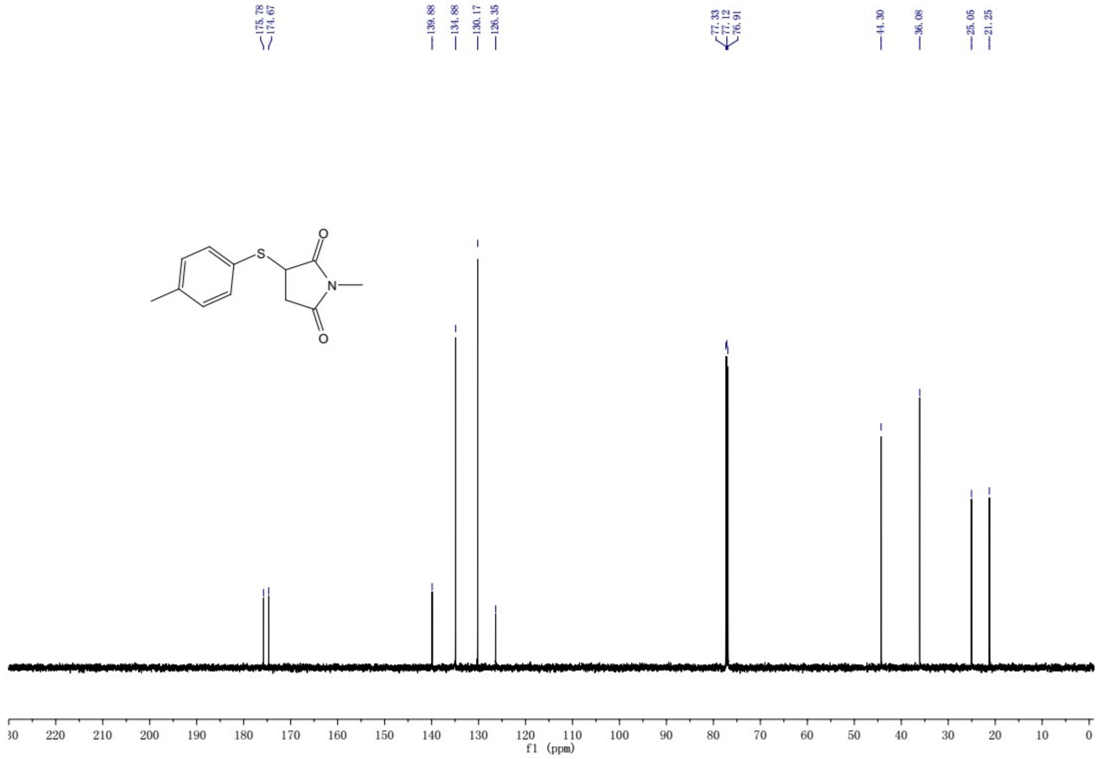
[7] Y. Zheng, F.-L.Qing, Y. Huang and X.- H. Xu, *Adv. Synth. Catal.* 2016, 358, 3477.

12. NMR spectra of products

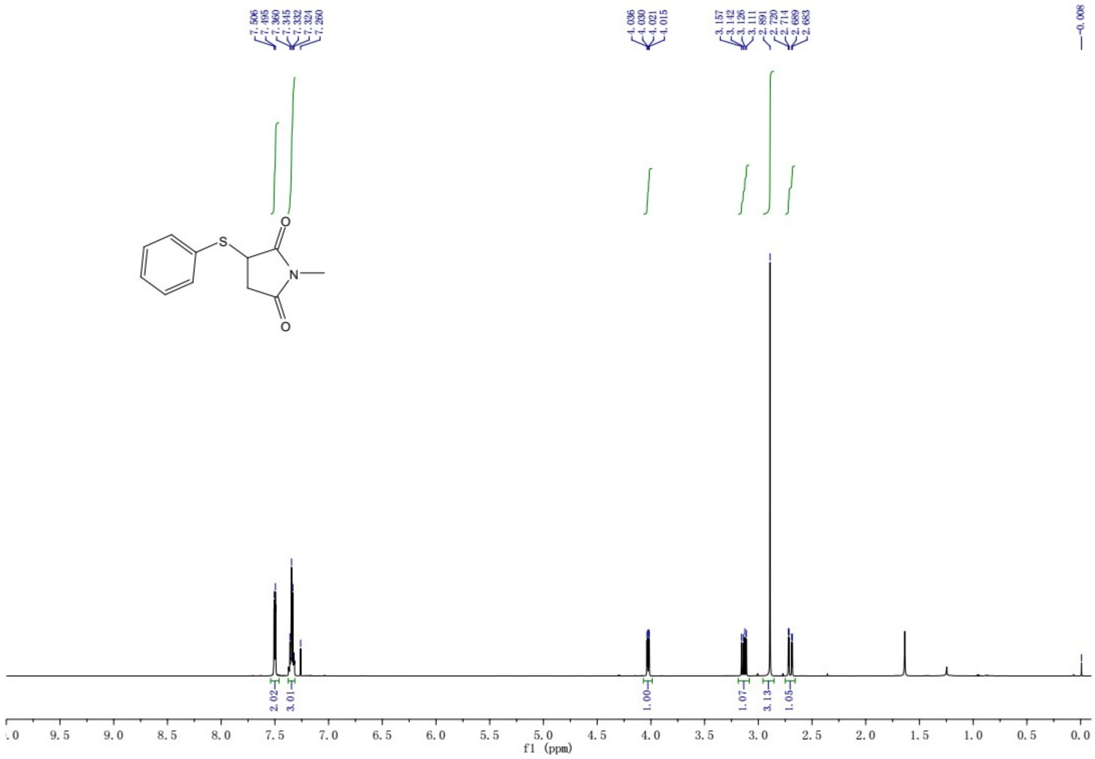
^{1}H NMR spectrum for compound **3a** ($CDCl_3$, 600 MHz)



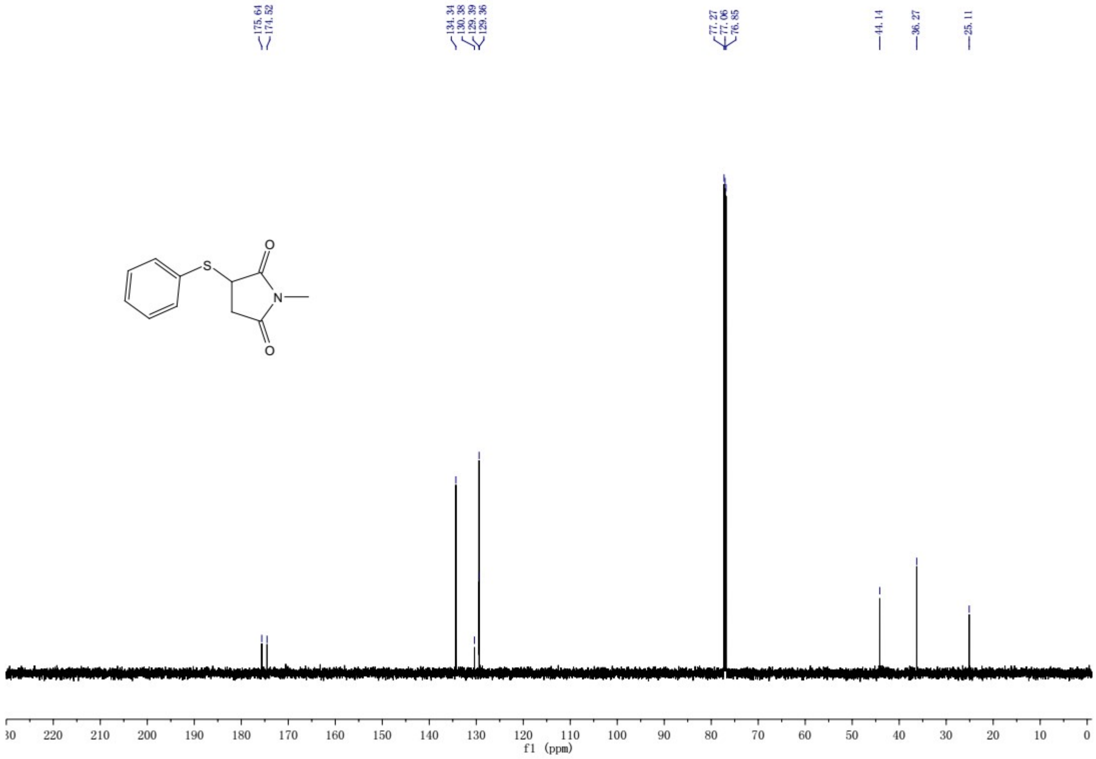
$^{13}C\{^1H\}$ NMR spectrum for compound **3a** ($CDCl_3$, 151 MHz)



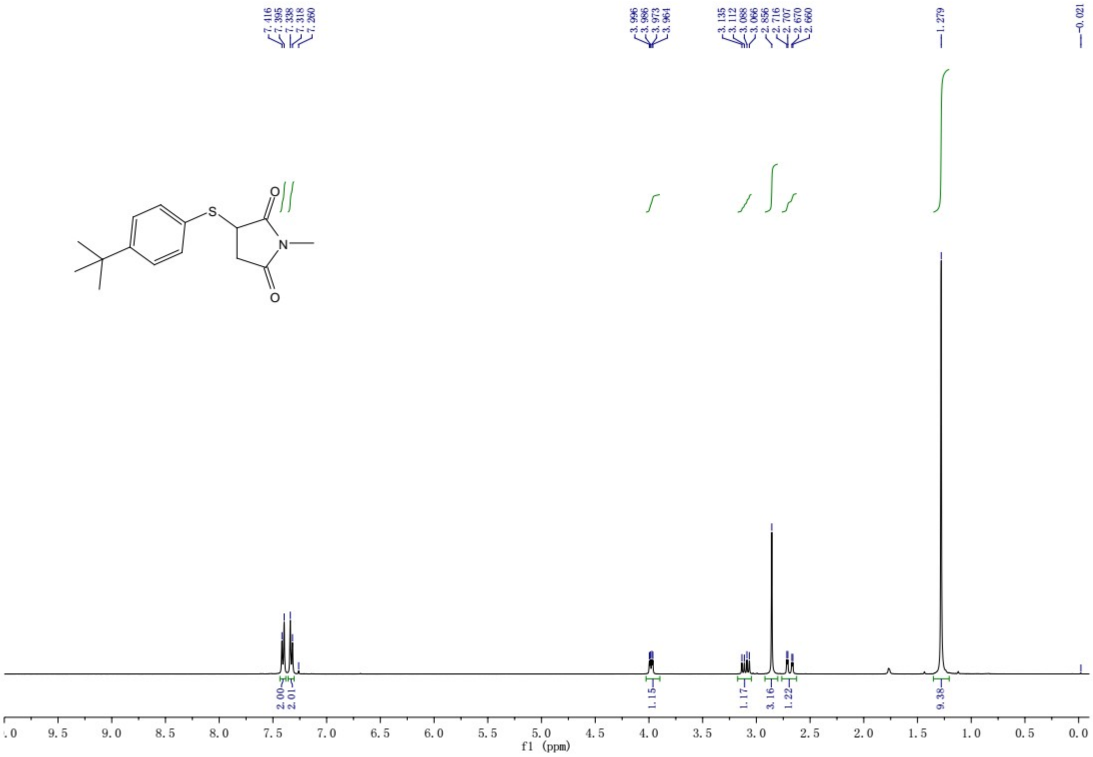
^{1}H NMR spectrum for compound **3b** ($CDCl_3$, 600 MHz)



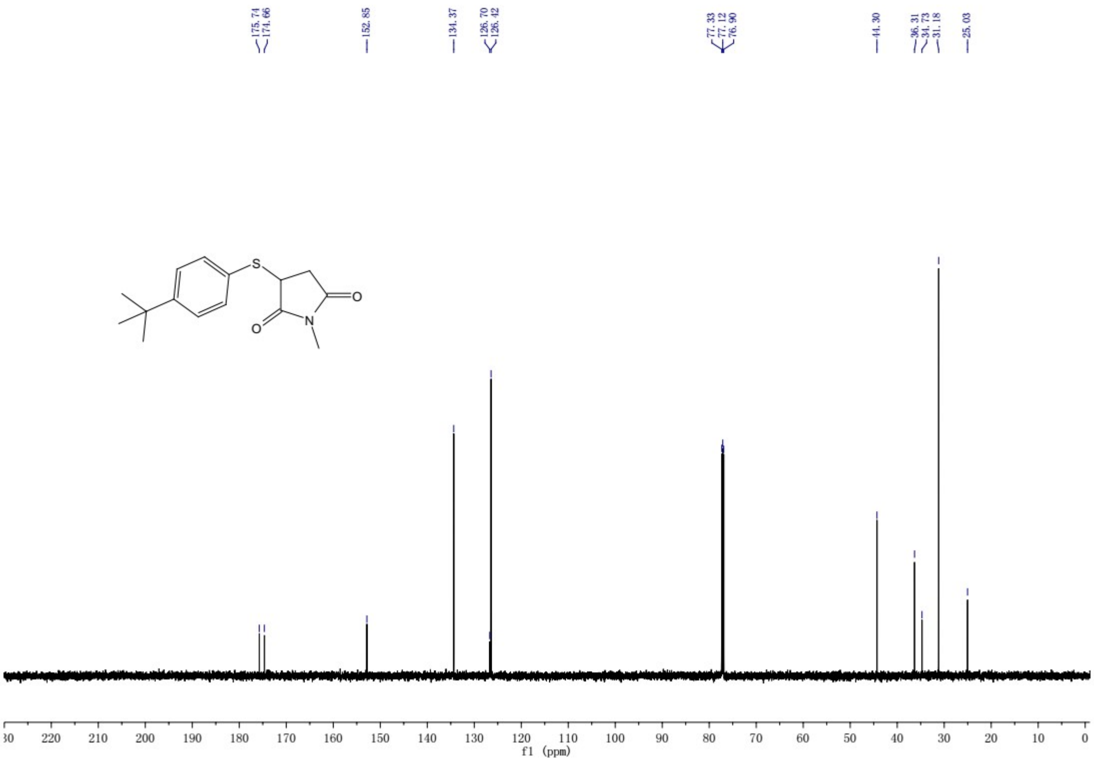
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3b** ($CDCl_3$, 151 MHz)



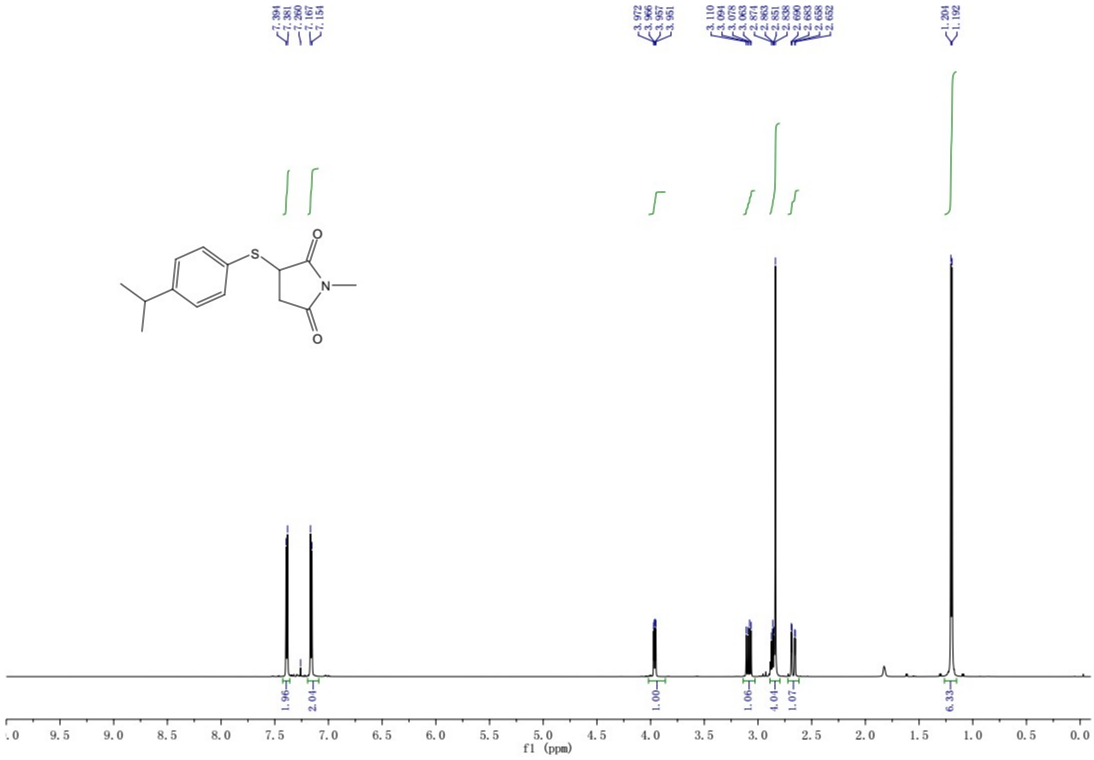
^{1}H NMR spectrum for compound **3c** ($CDCl_3$, 400 MHz)



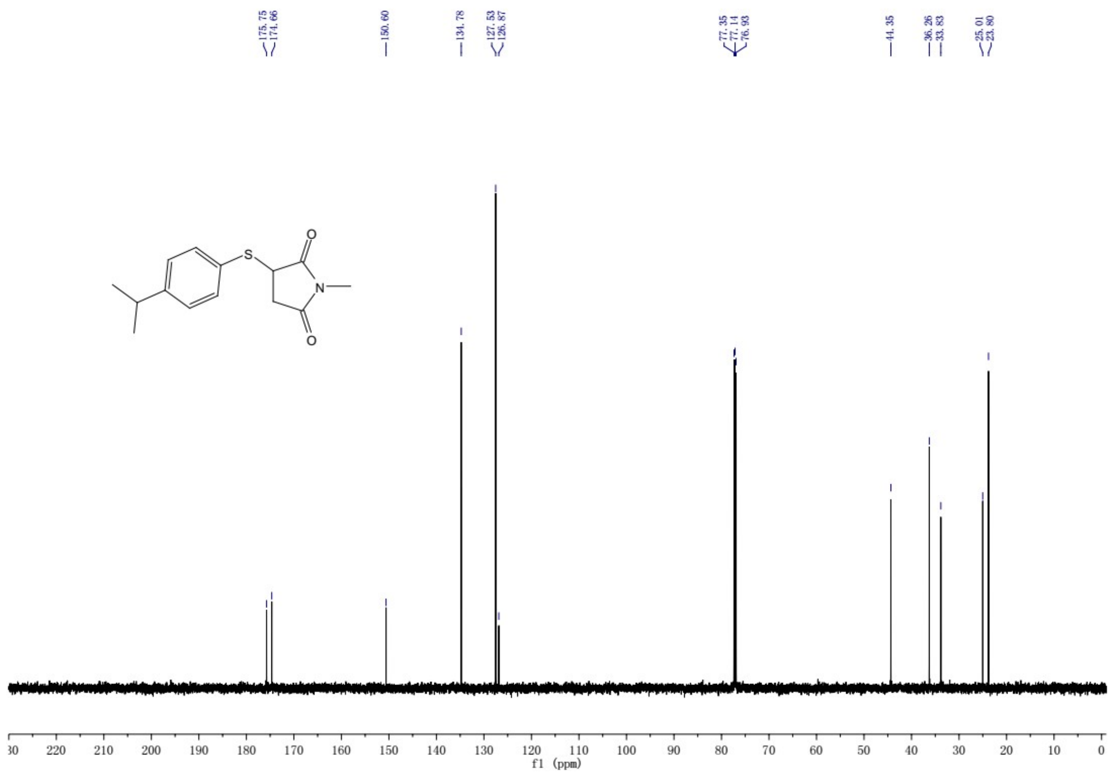
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3c** ($CDCl_3$, 151 MHz)



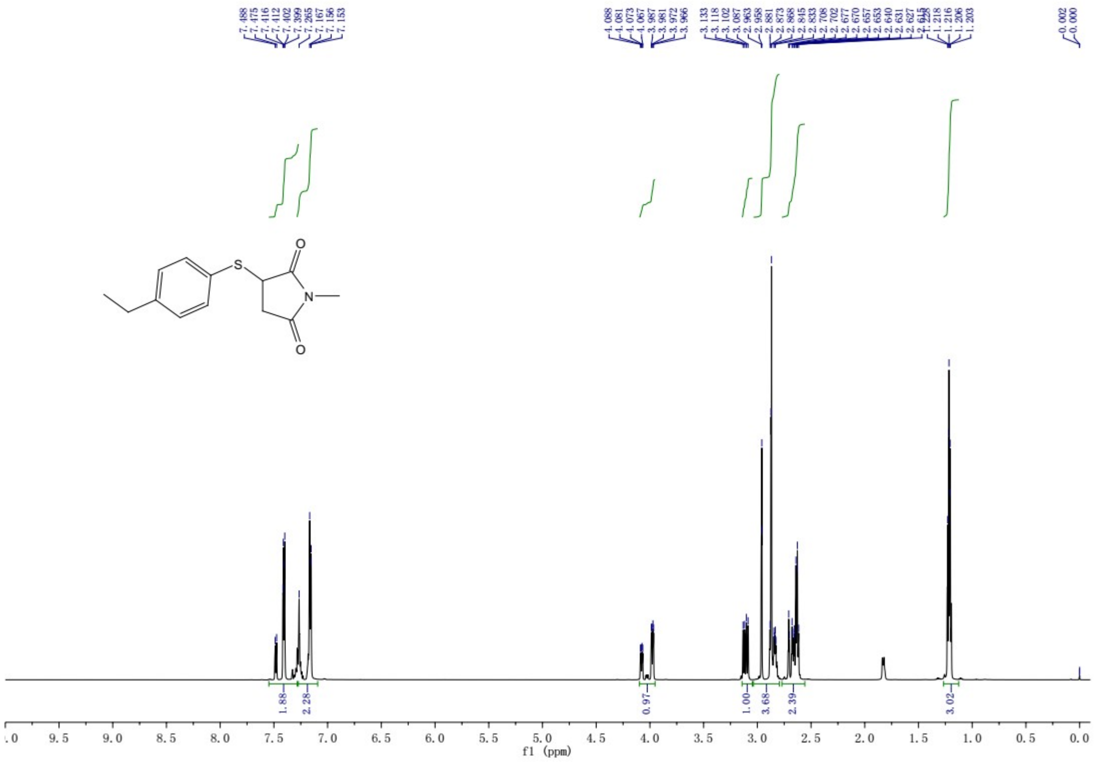
^{1}H NMR spectrum for compound **3d** ($CDCl_3$, 600 MHz)



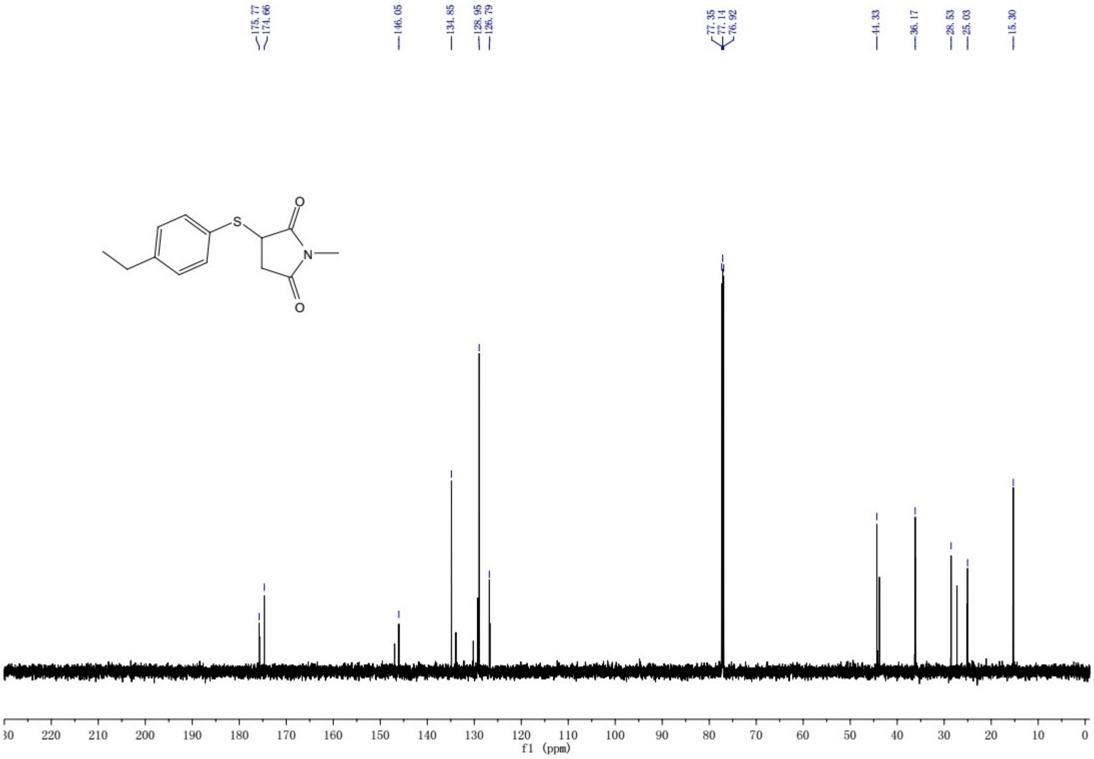
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3d** ($CDCl_3$, 151 MHz)



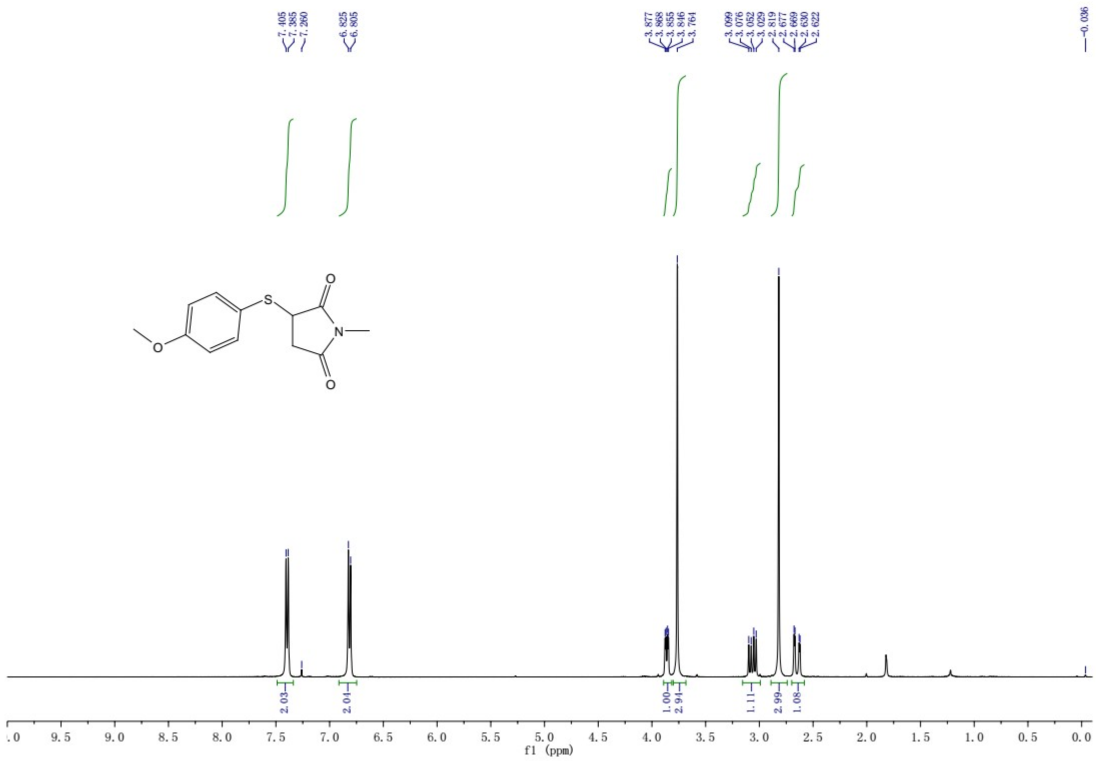
^{1}H NMR spectrum for compound **3e** ($CDCl_3$, 600 MHz)



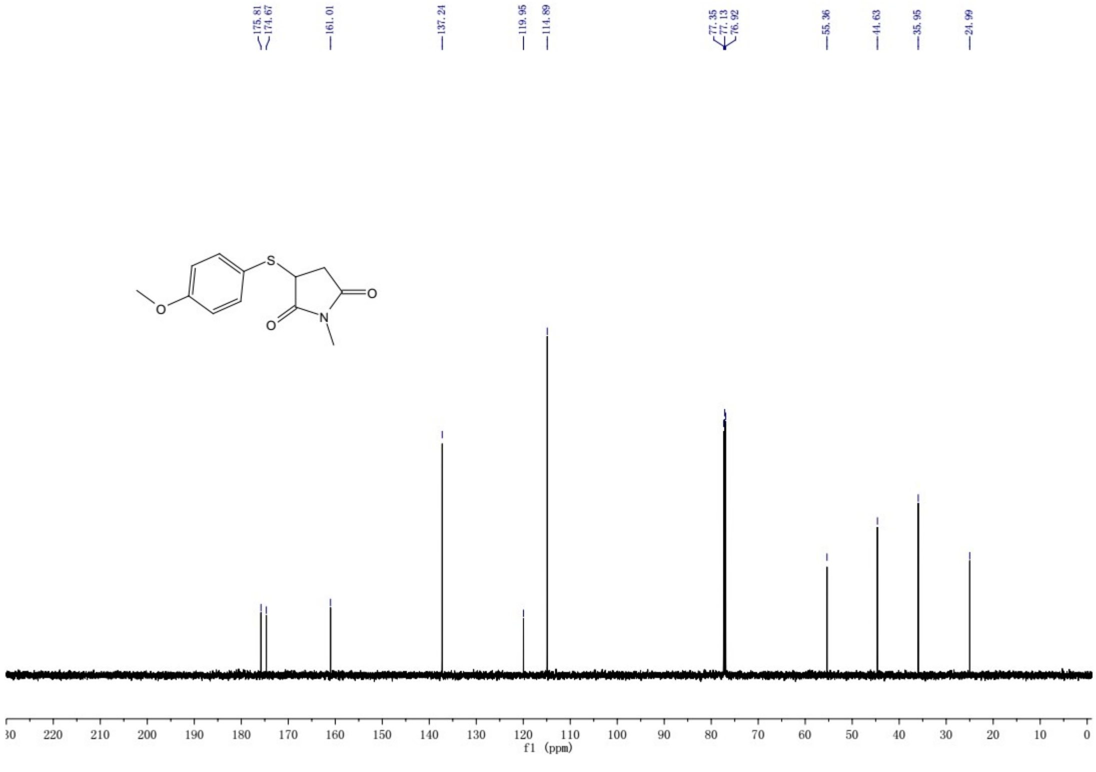
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3e** ($CDCl_3$, 151 MHz)



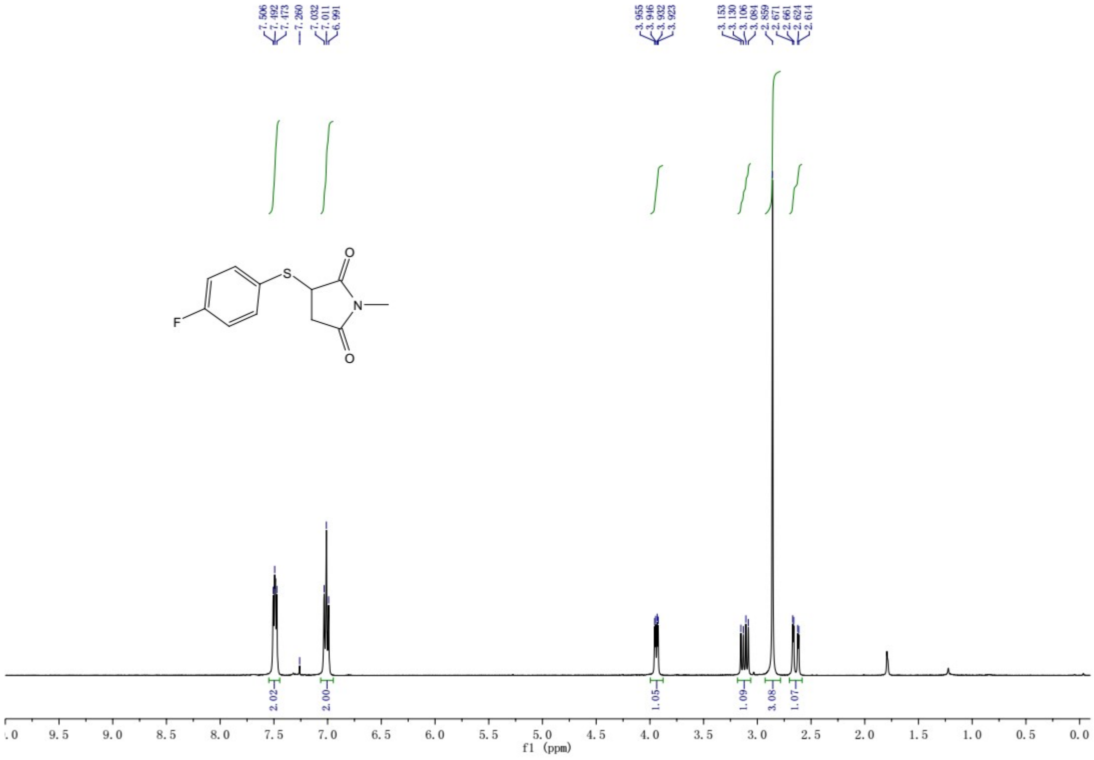
^{1}H NMR spectrum for compound **3f** ($CDCl_3$, 400 MHz)



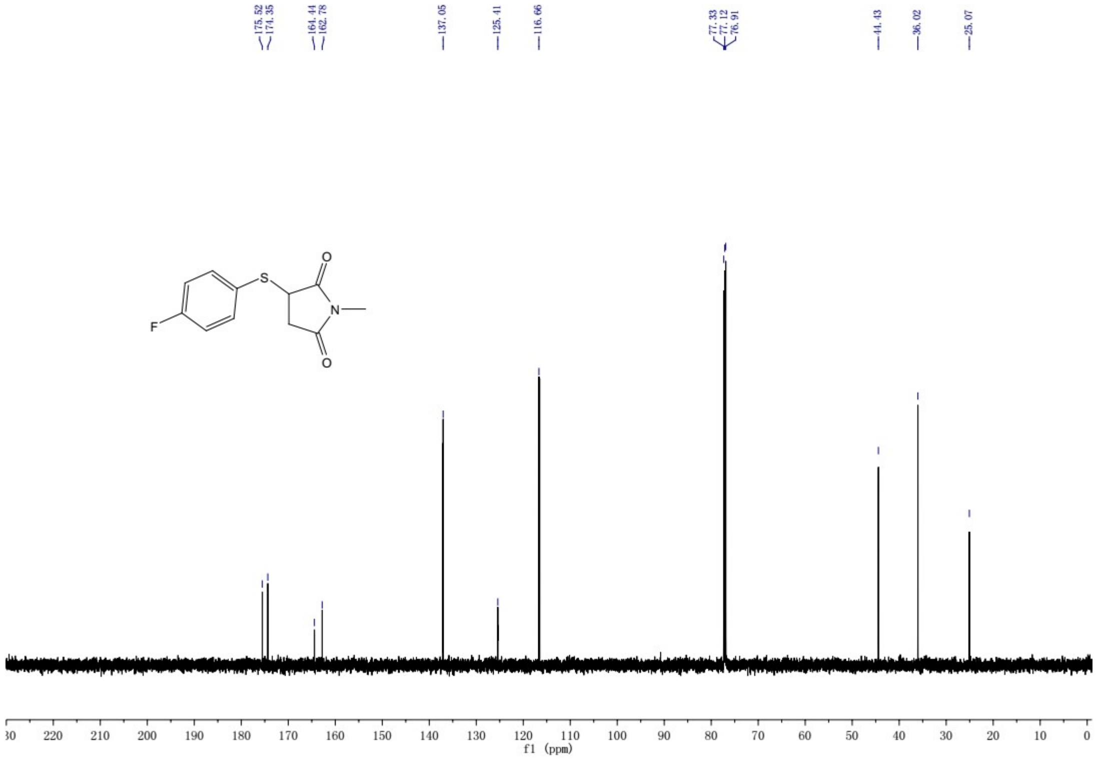
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3f** ($CDCl_3$, 151 MHz)



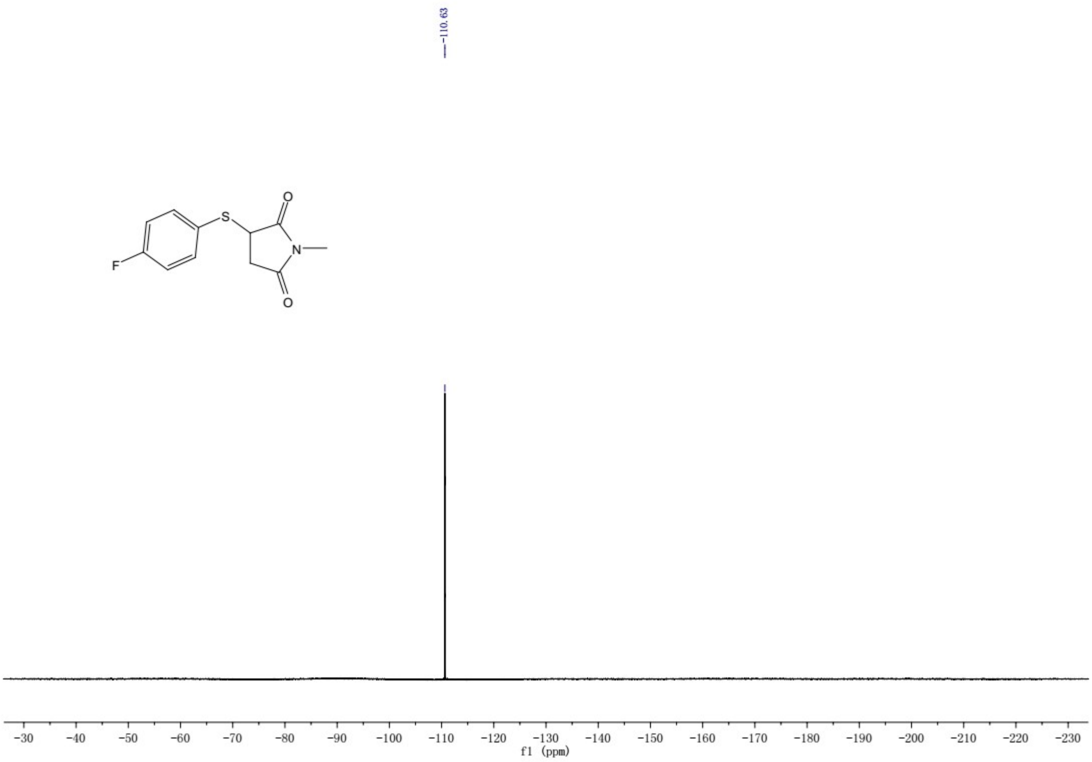
^{1}H NMR spectrum for compound **3g** ($CDCl_3$, 400 MHz)



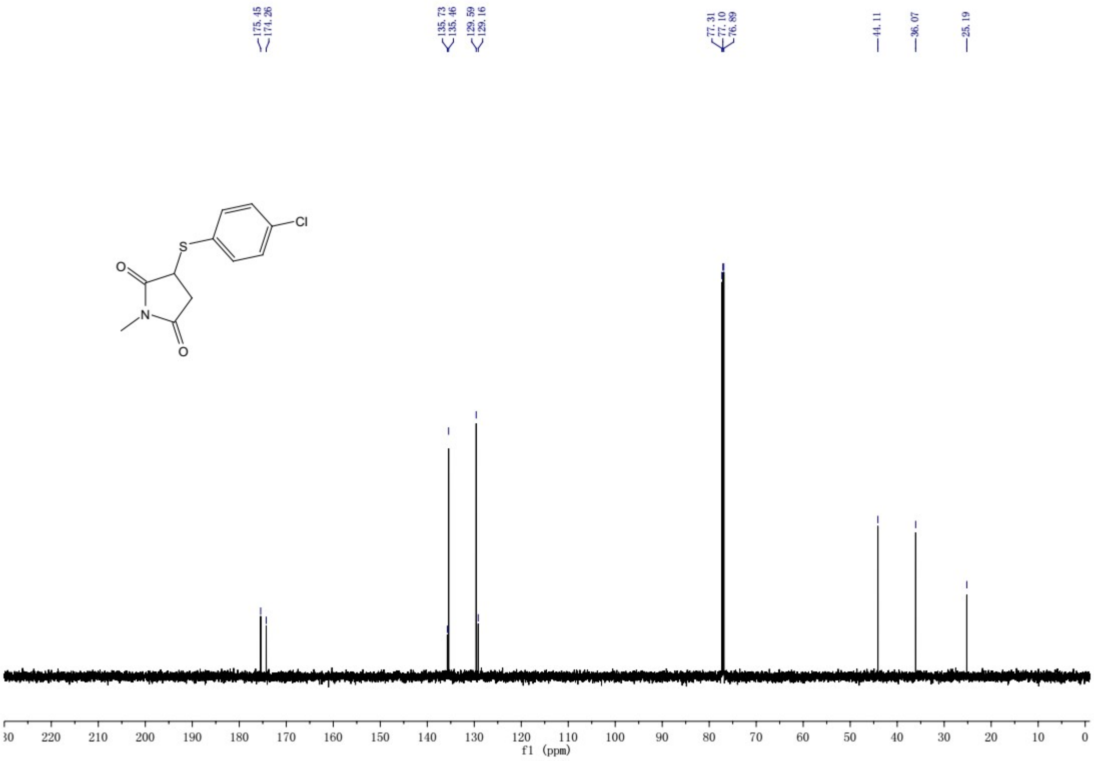
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3g** ($CDCl_3$, 151 MHz)



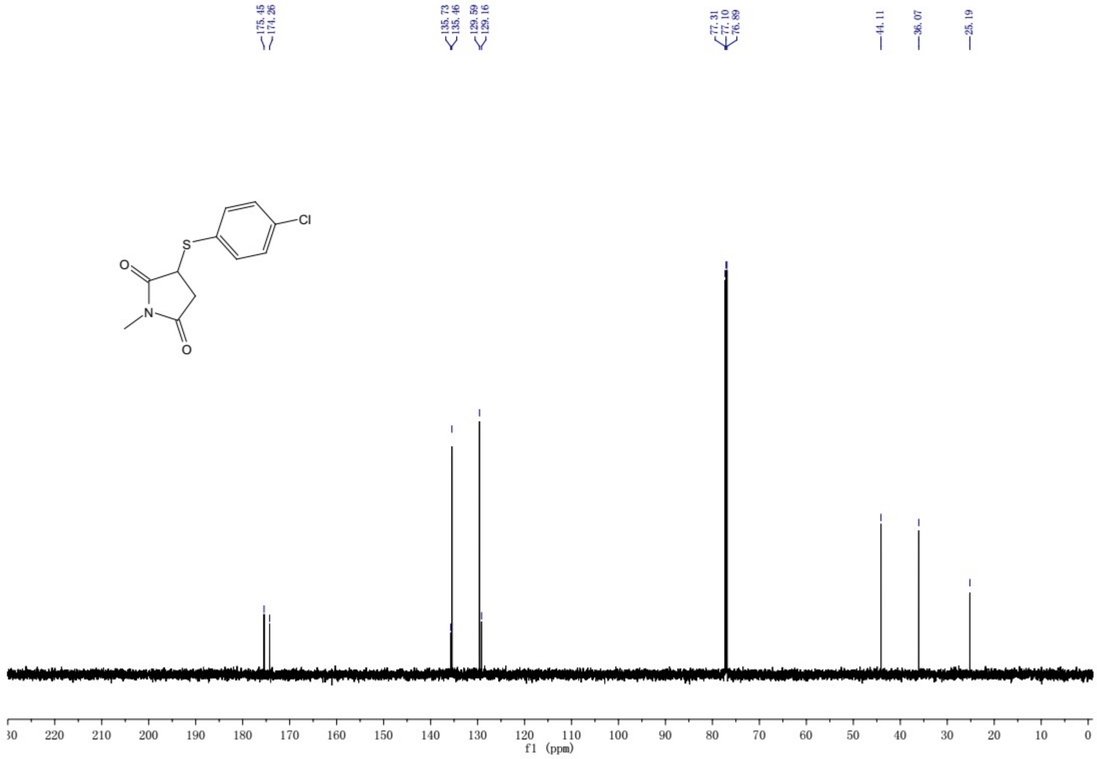
^{19}F NMR spectrum for compound **3g** ($CDCl_3$, 376 MHz)



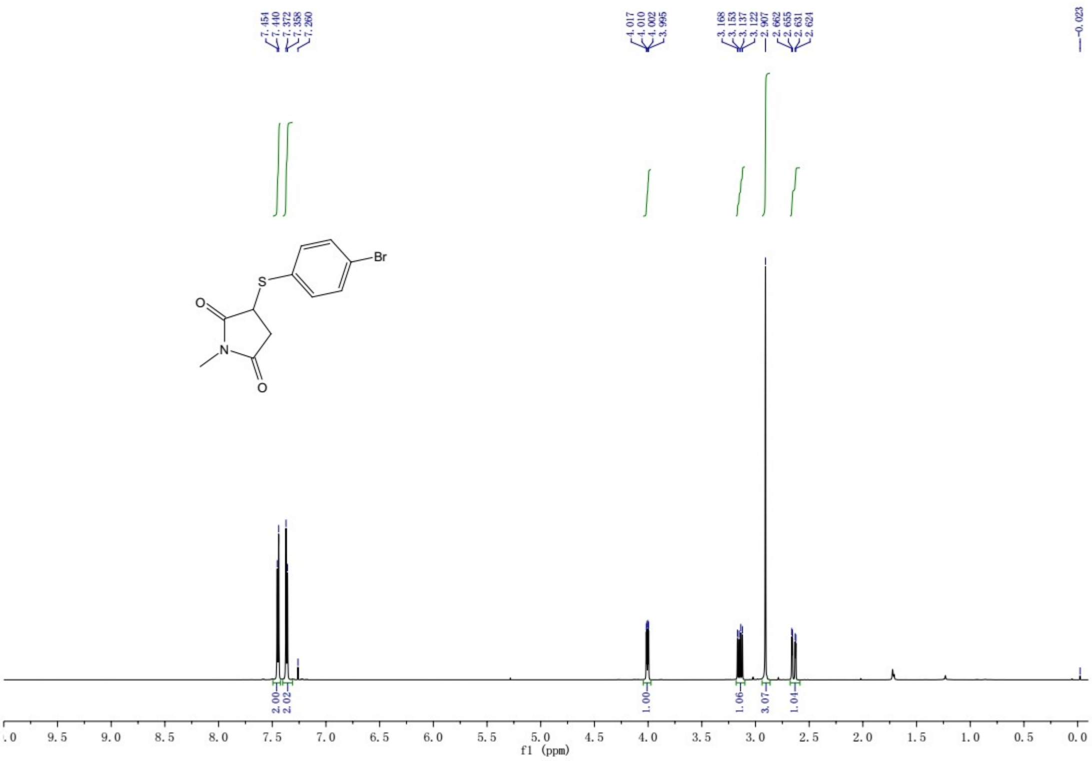
^{1}H NMR spectrum for compound **3h** ($CDCl_3$, 600 MHz)



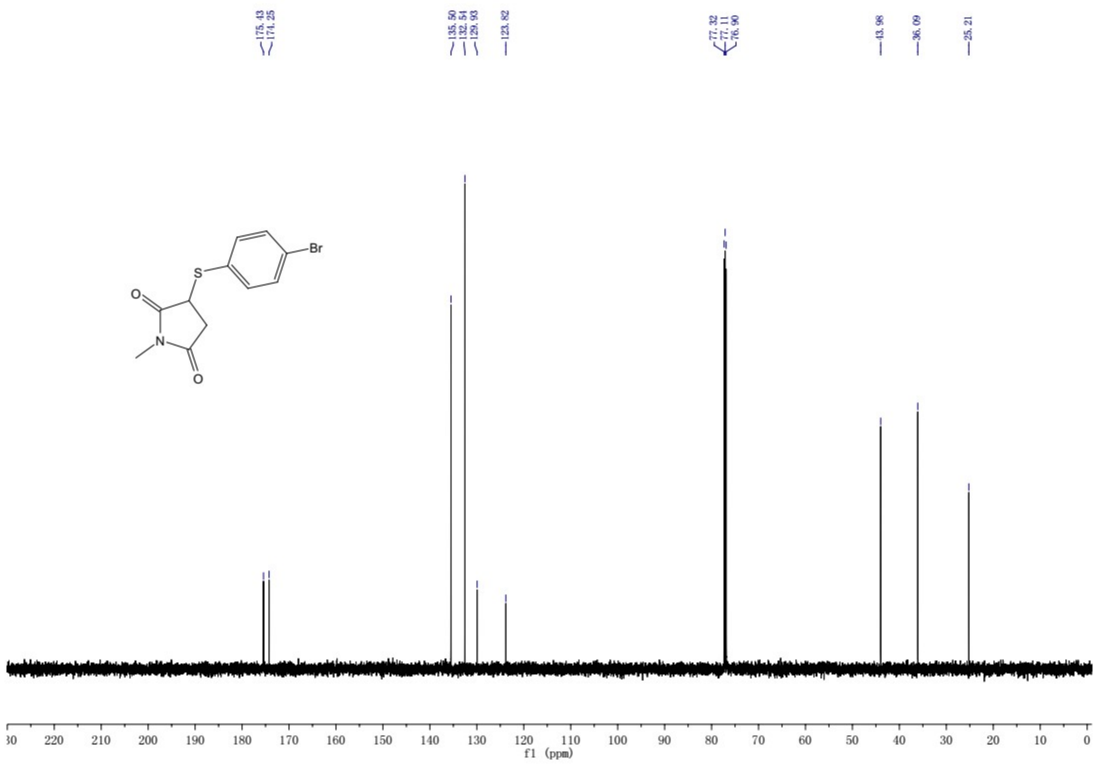
$^{13}C\{^1H\}$ NMR spectrum for compound **3h** ($CDCl_3$, 151 MHz)



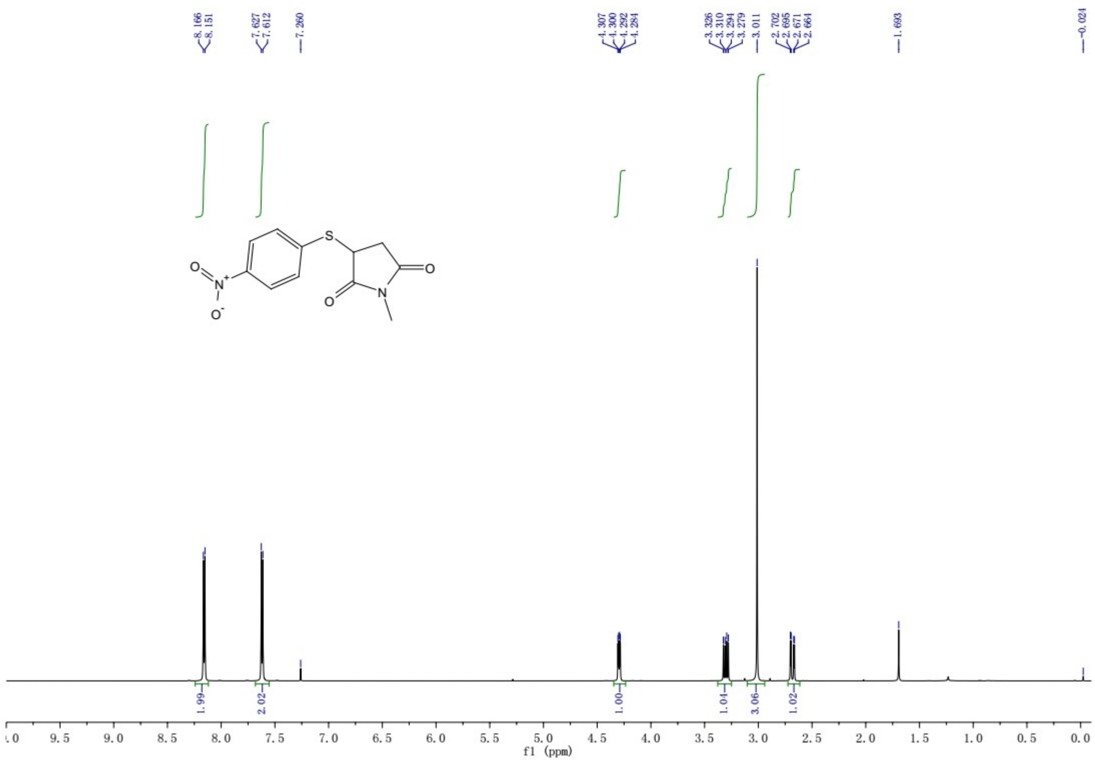
^1H NMR spectrum for compound **3i** ($CDCl_3$, 600 MHz)



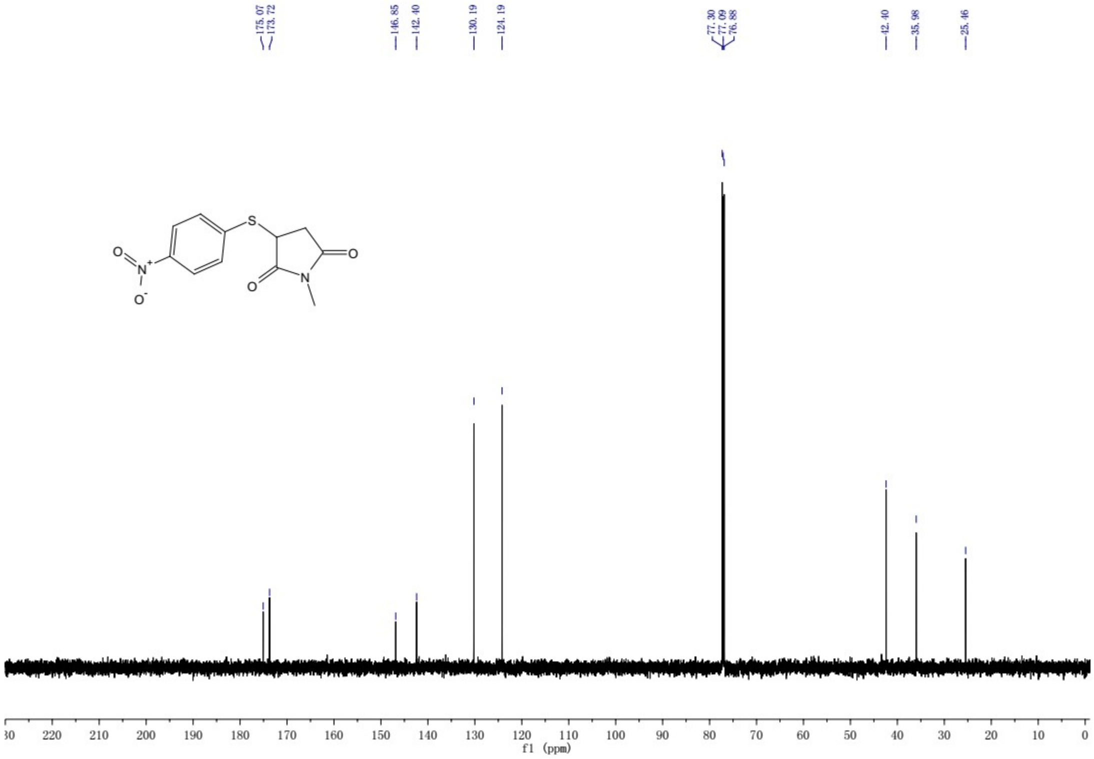
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3i** ($CDCl_3$, 151 MHz)



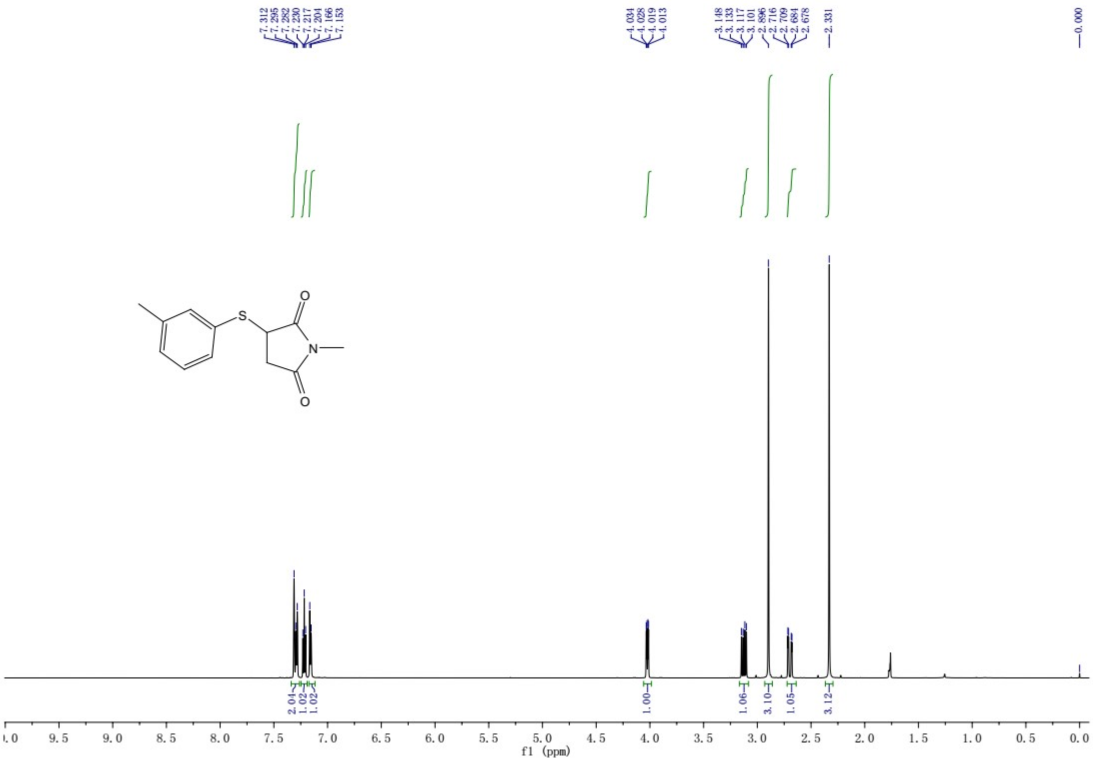
^{1}H NMR spectrum for compound **3j** ($CDCl_3$, 600 MHz)



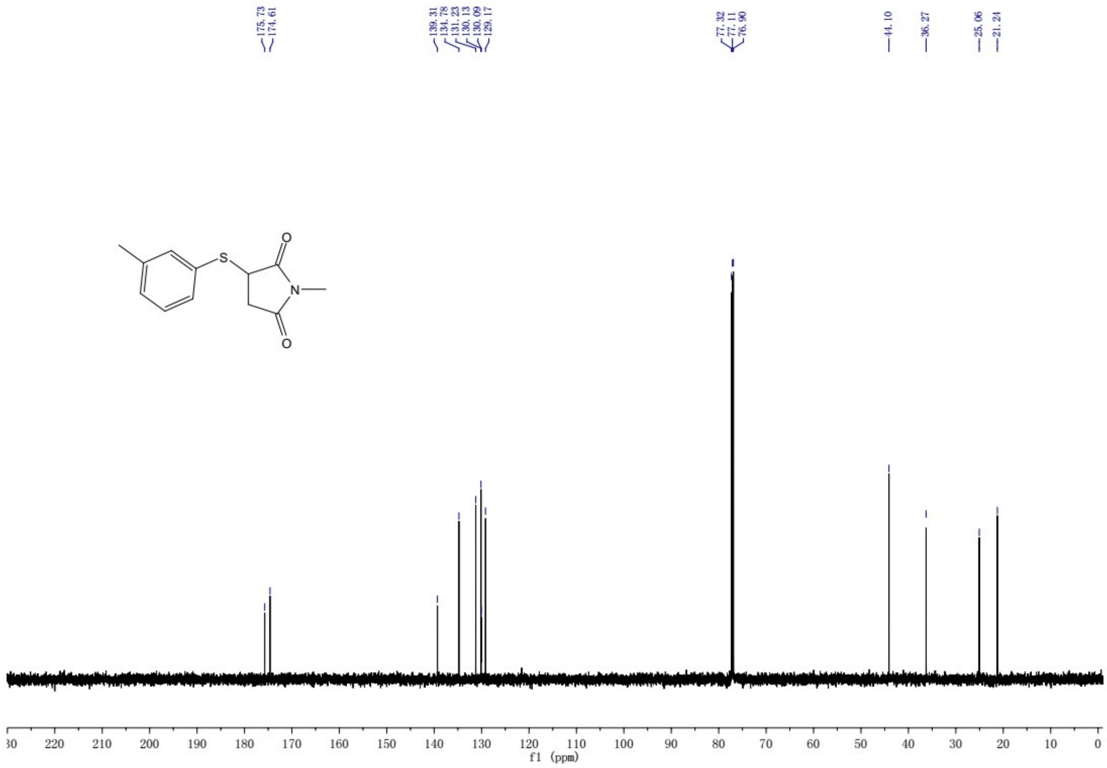
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3j** ($CDCl_3$, 151 MHz)



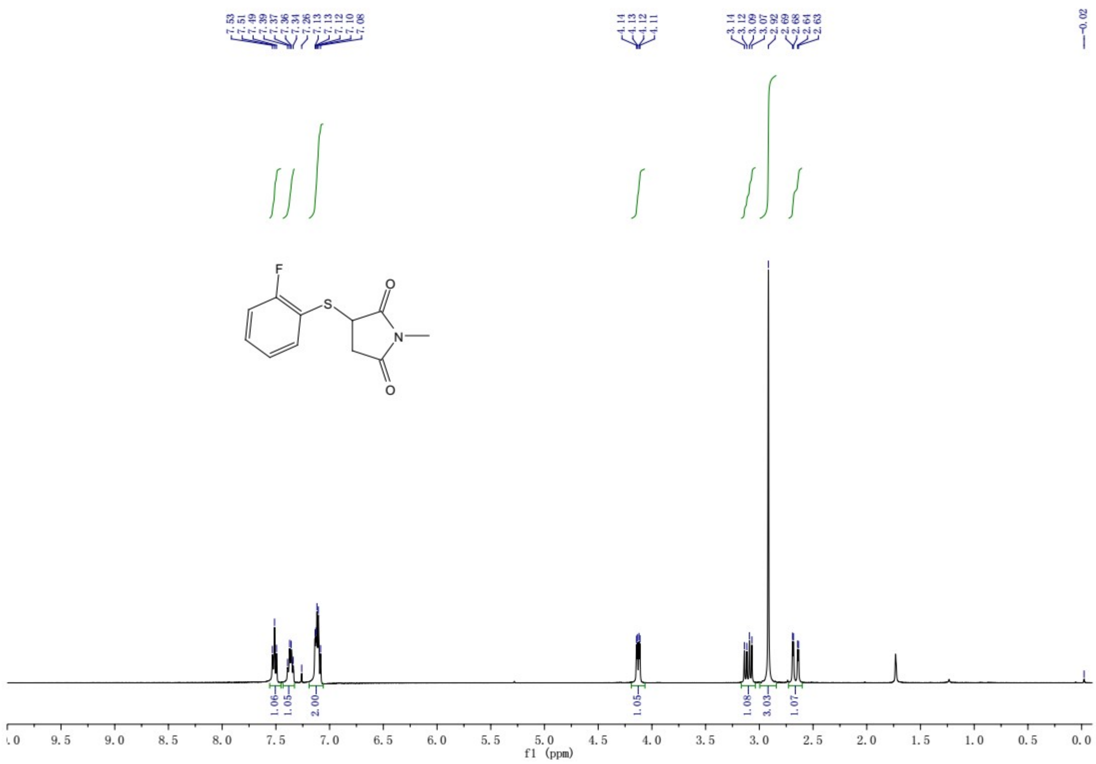
^{1}H NMR spectrum for compound **3k** ($CDCl_3$, 600 MHz)



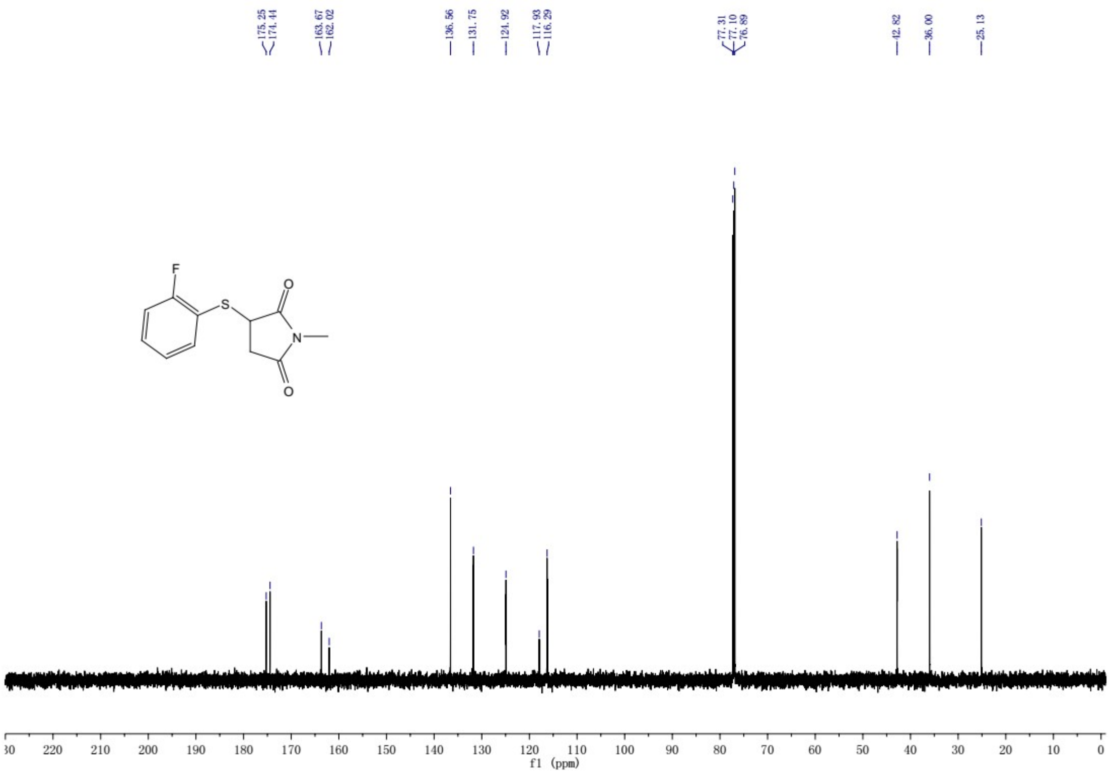
$^{13}C\{^1H\}$ NMR spectrum for compound **3k** ($CDCl_3$, 151 MHz)



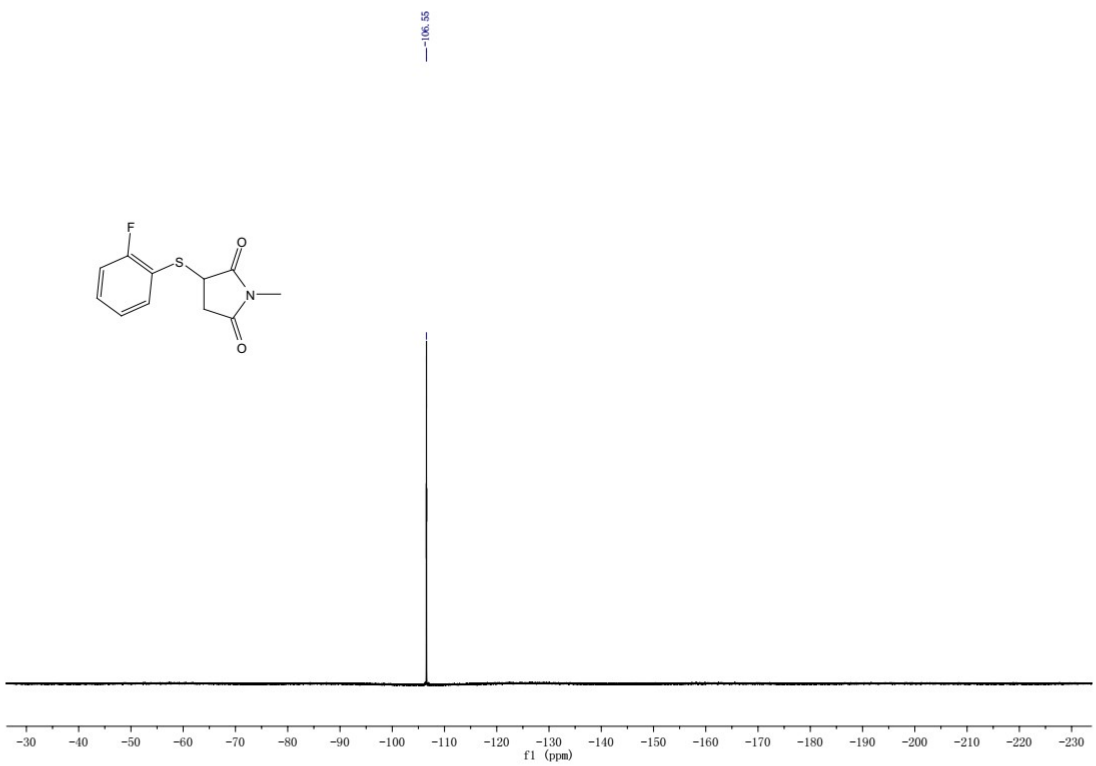
^1H NMR spectrum for compound **3l** ($CDCl_3$, 400 MHz)



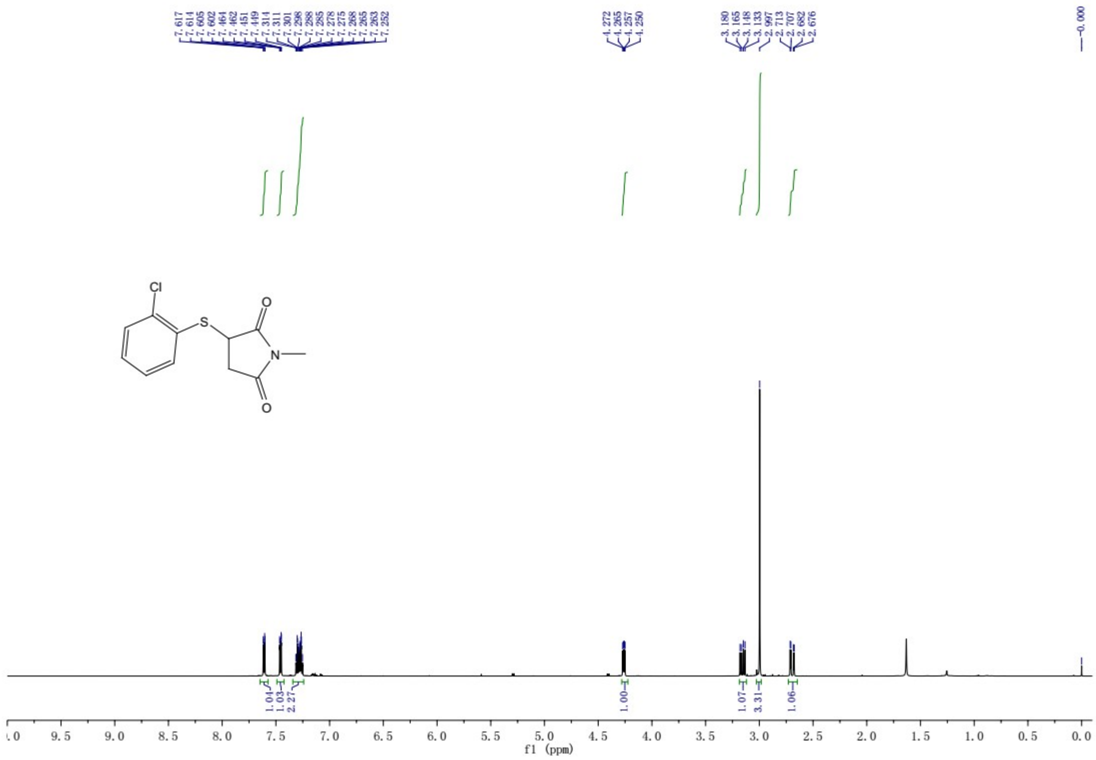
$^{13}C\{^1H\}$ NMR spectrum for compound **3l** ($CDCl_3$, 151 MHz)



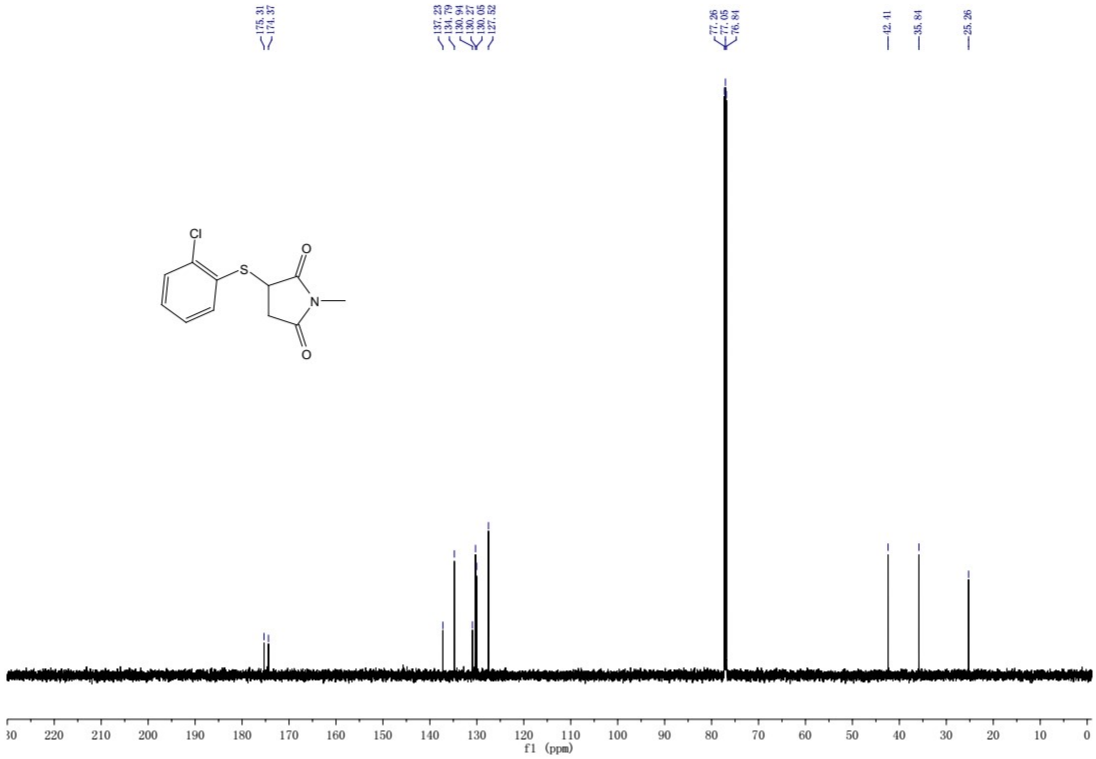
^{19}F NMR spectrum for compound **3l** ($CDCl_3$, 376 MHz)



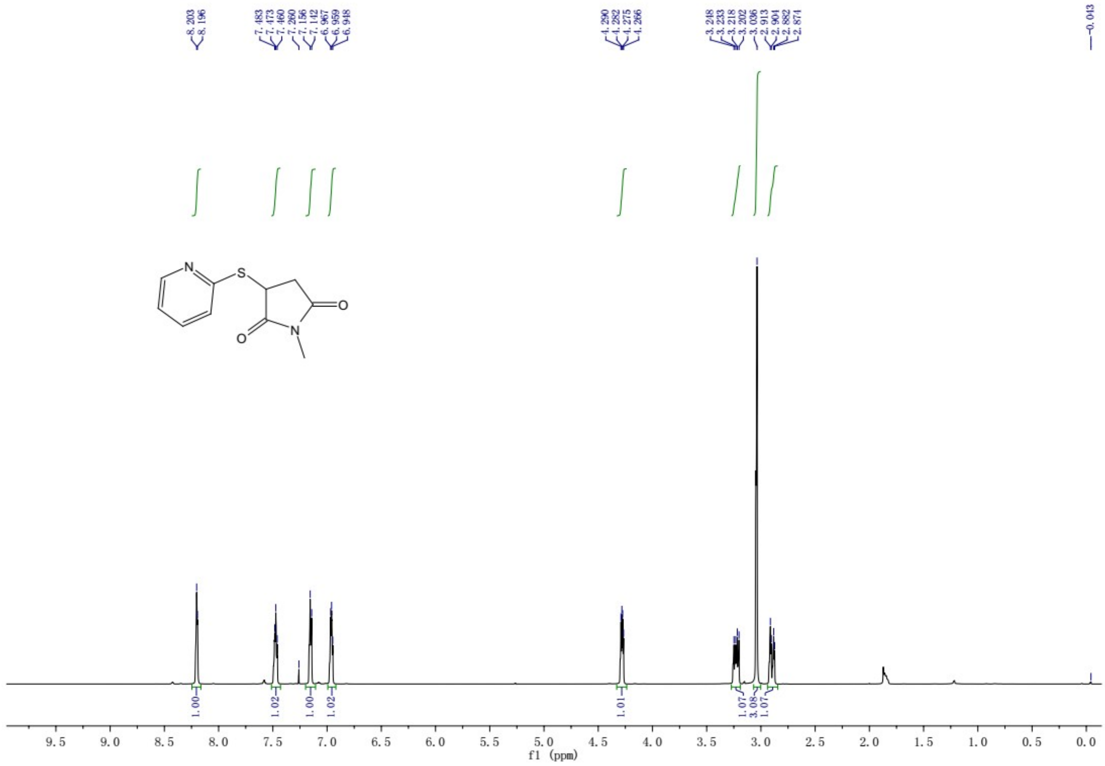
^{1}H NMR spectrum for compound **3m** ($CDCl_3$, 600 MHz)



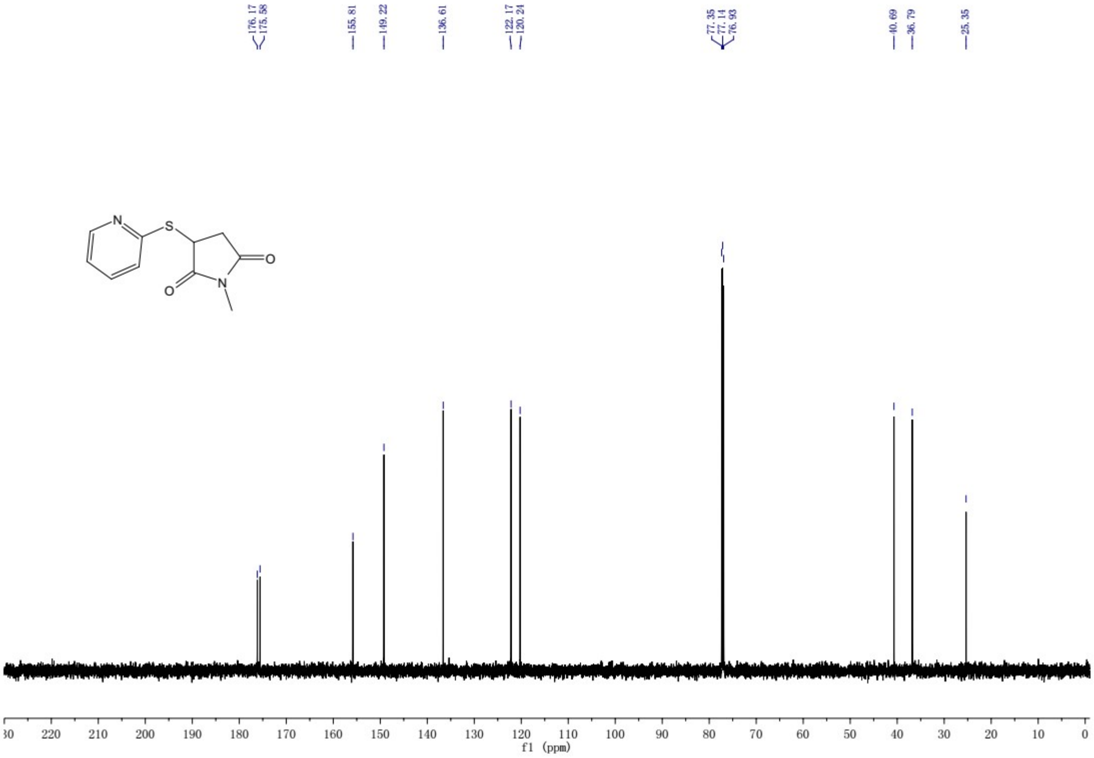
^{13}C{^{1}H} NMR spectrum for compound **3m** ($CDCl_3$, 151 MHz)



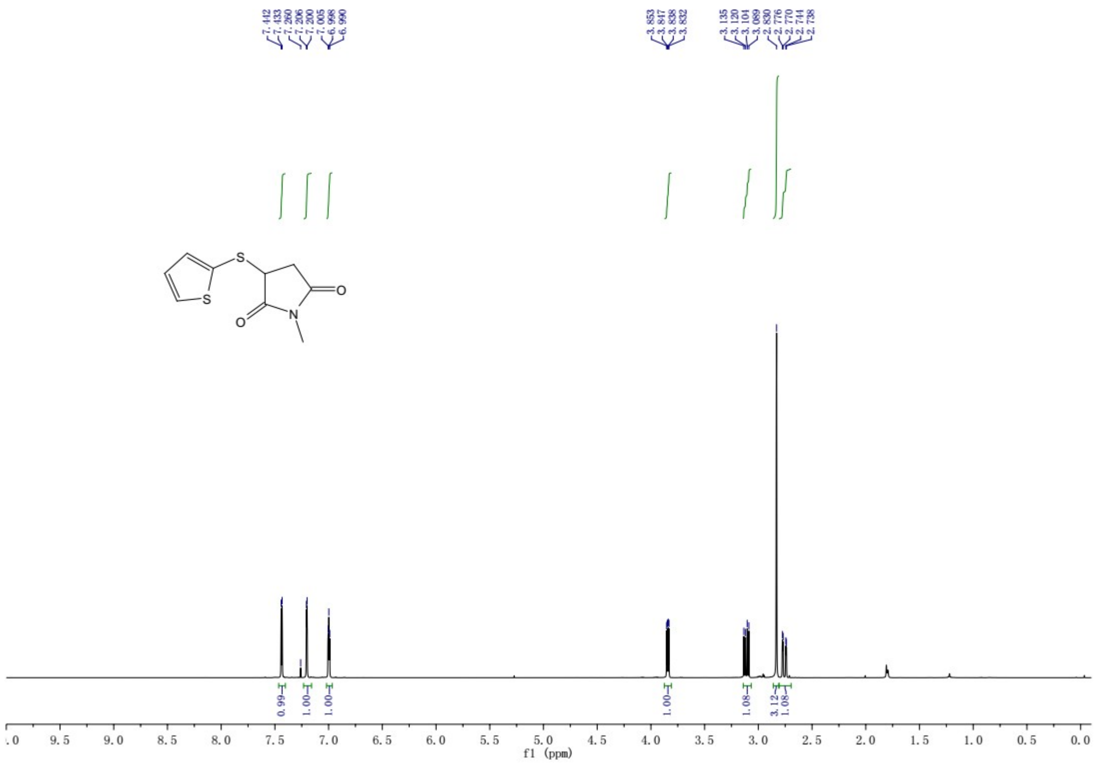
[1]H NMR spectrum for compound **3n** ($CDCl_3$, 600 MHz)



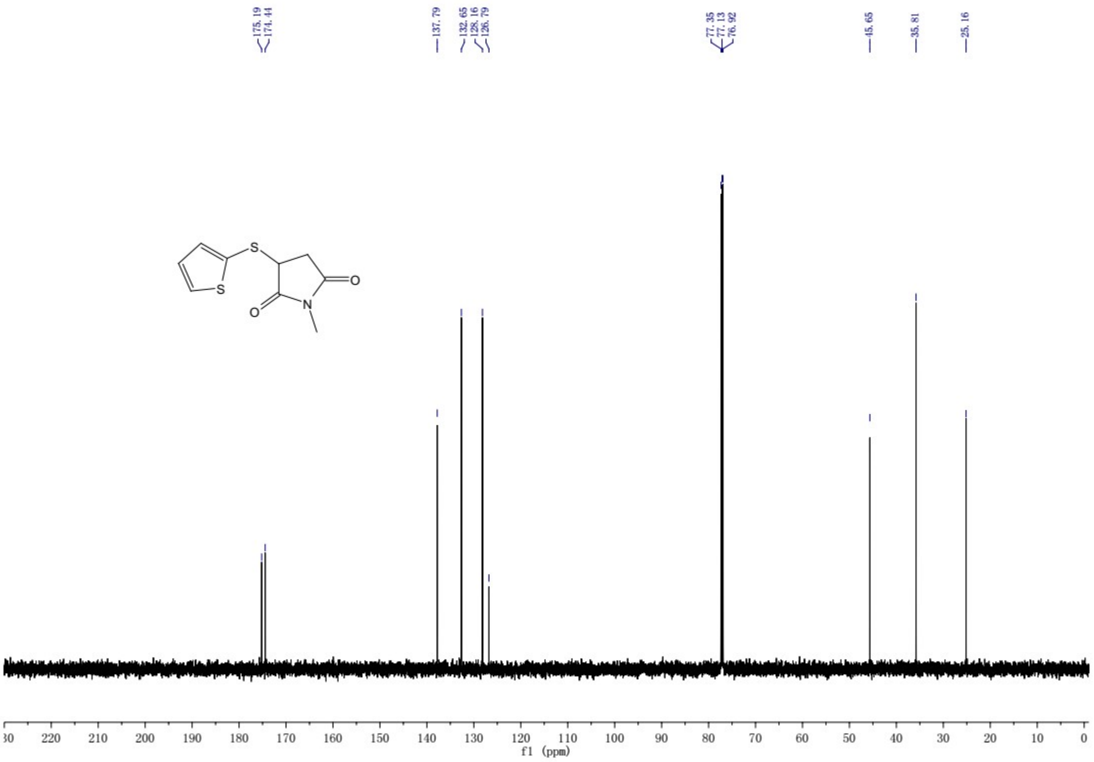
[13]C{[1]H} NMR spectrum for compound **3n** ($CDCl_3$, 151 MHz)



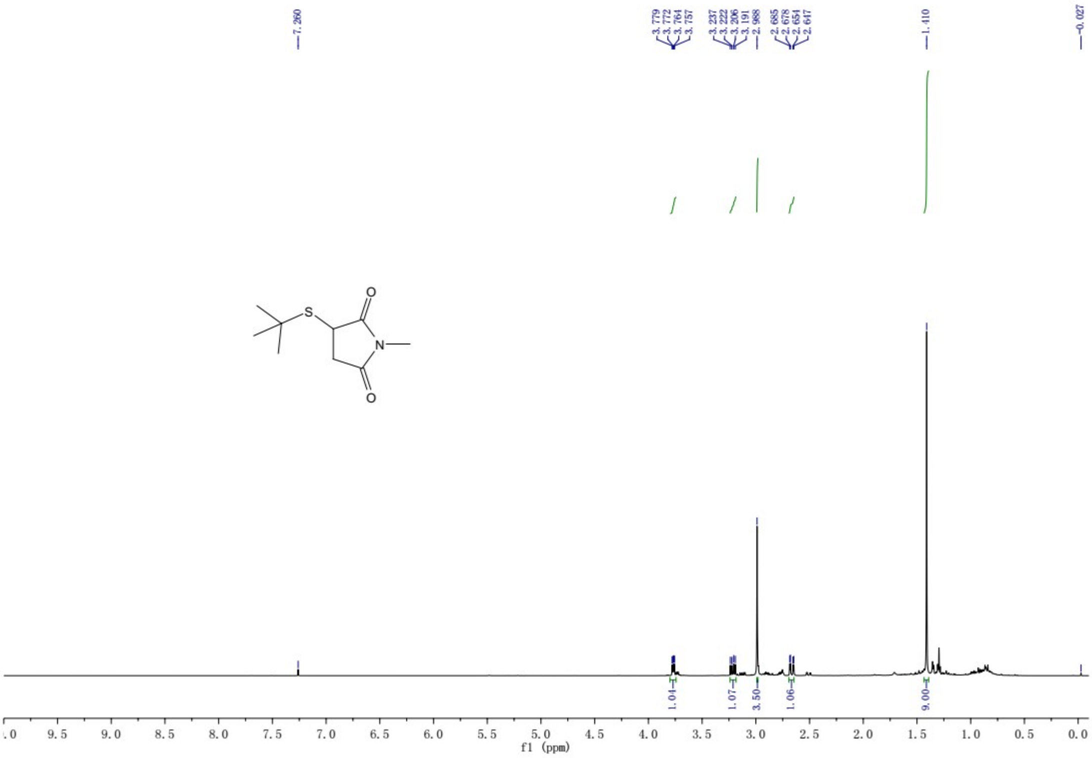
[1]H NMR spectrum for compound **3o** ($CDCl_3$, 600 MHz)



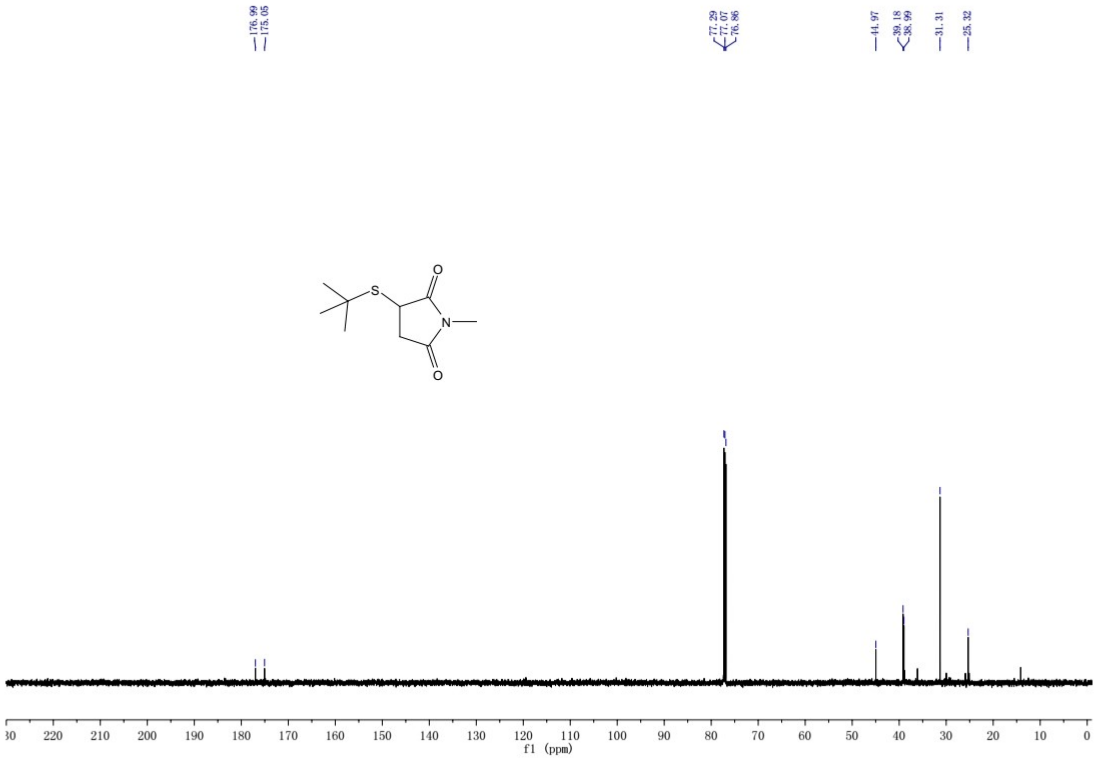
[13]C{[1]H} NMR spectrum for compound **3o** ($CDCl_3$, 151 MHz)



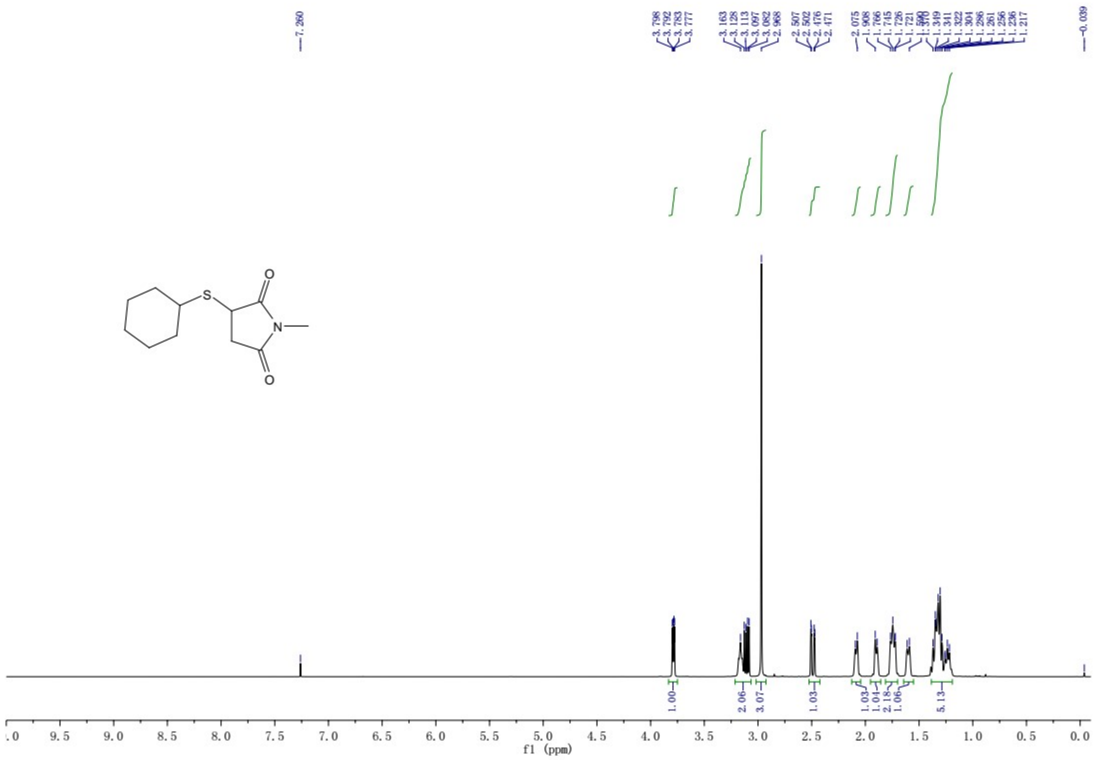
[1]H NMR spectrum for compound **3p** ($CDCl_3$, 600 MHz)



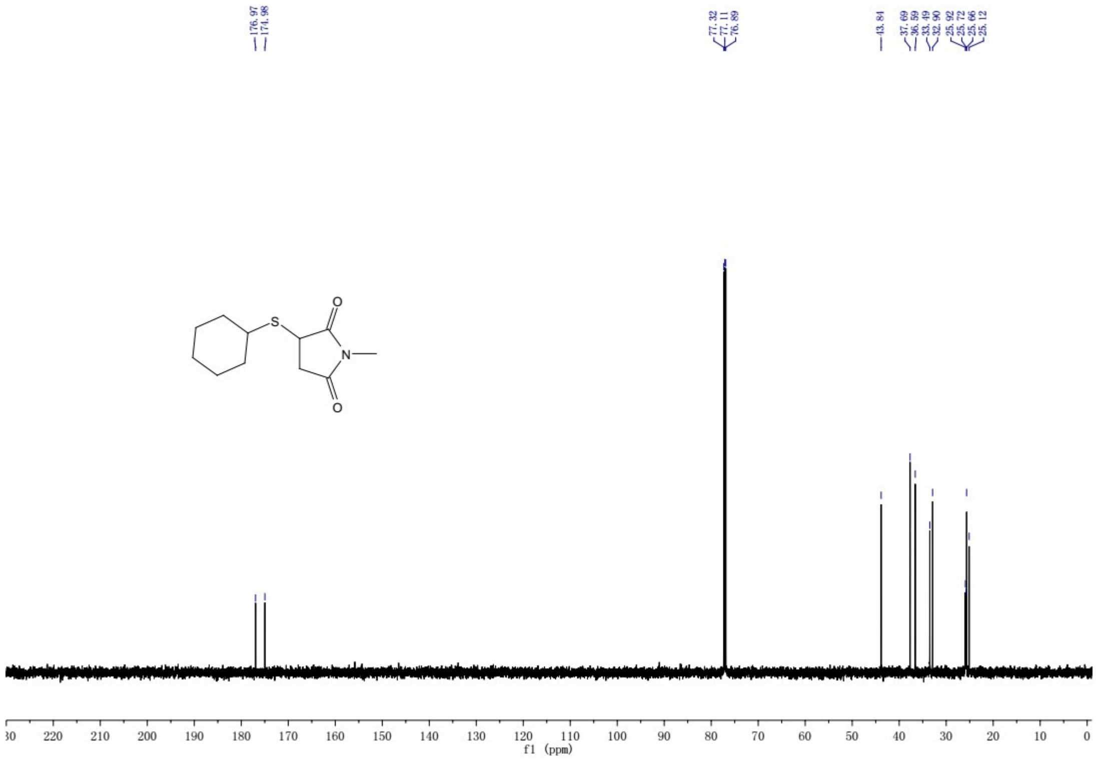
[13]C{[1]H} NMR spectrum for compound **3p** ($CDCl_3$, 151 MHz)



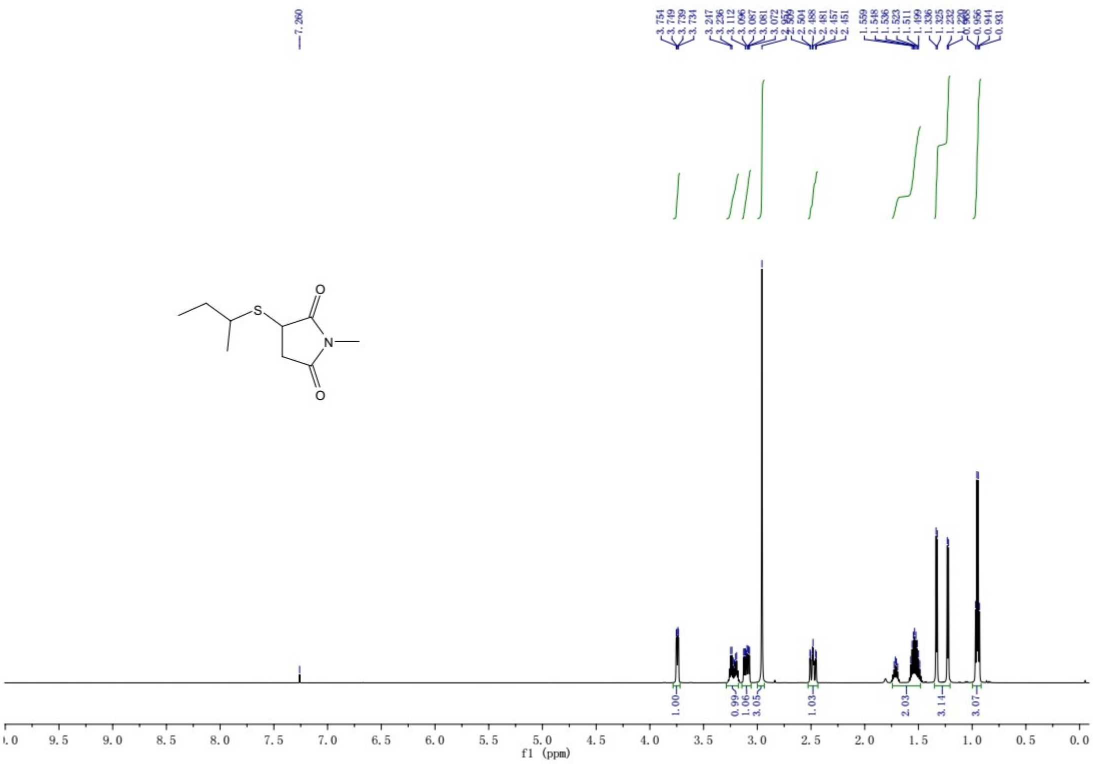
^{1}H NMR spectrum for compound **3q** ($CDCl_3$, 600 MHz)



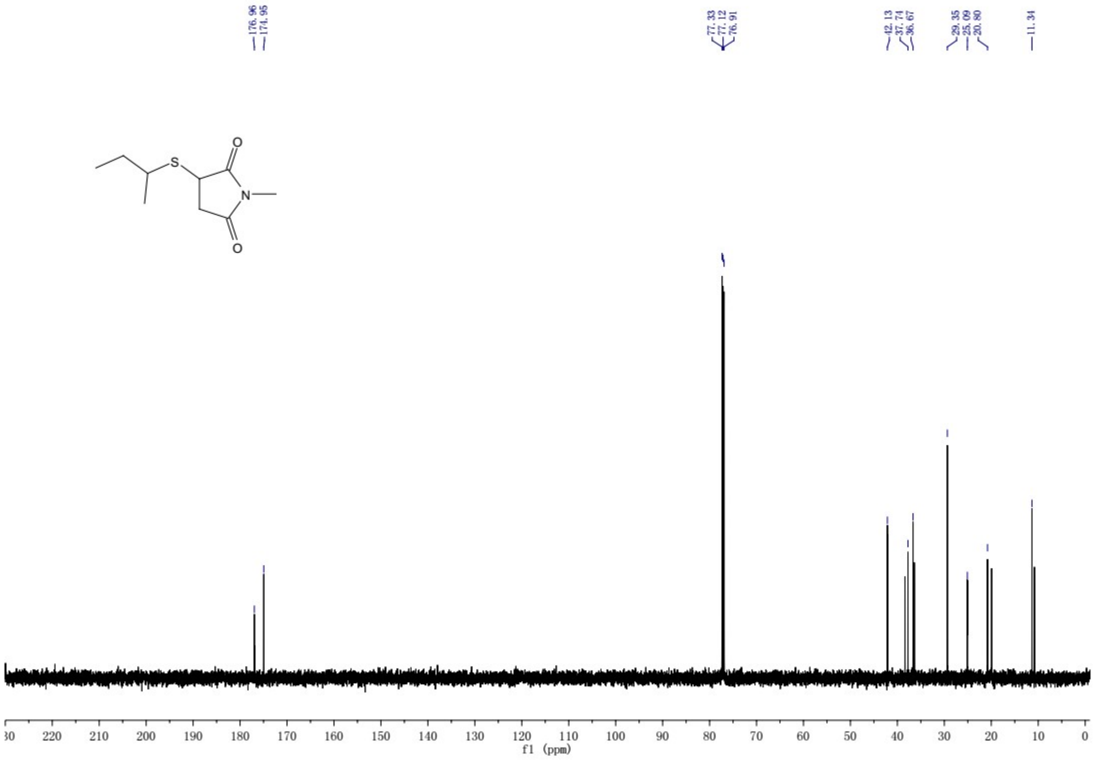
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3q** ($CDCl_3$, 151 MHz)



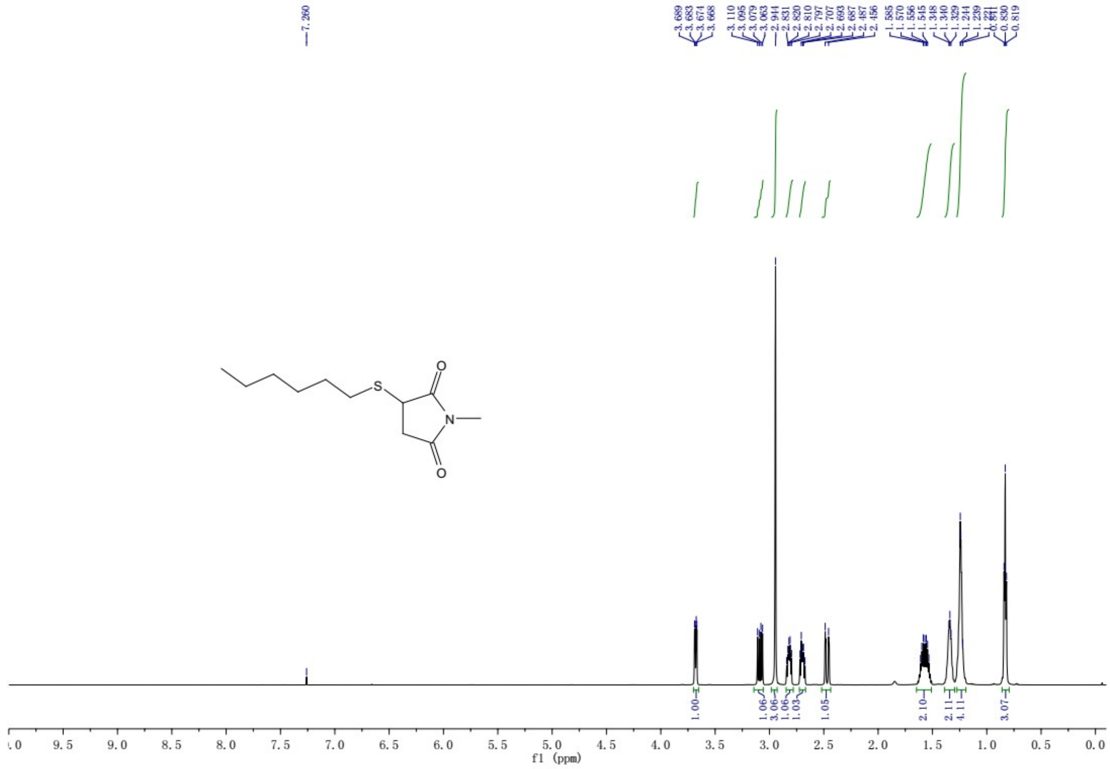
[1]H NMR spectrum for compound **3r** ($CDCl_3$, 600 MHz)



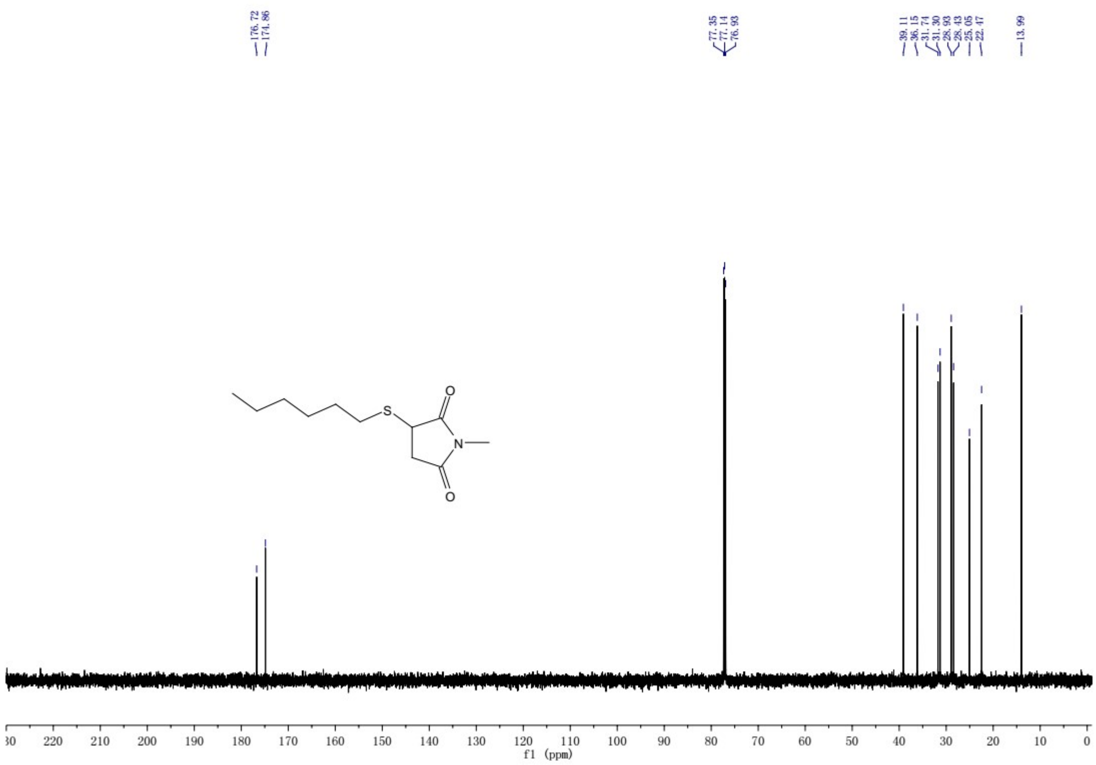
[13]C{[1]H} NMR spectrum for compound **3r** ($CDCl_3$, 151 MHz)



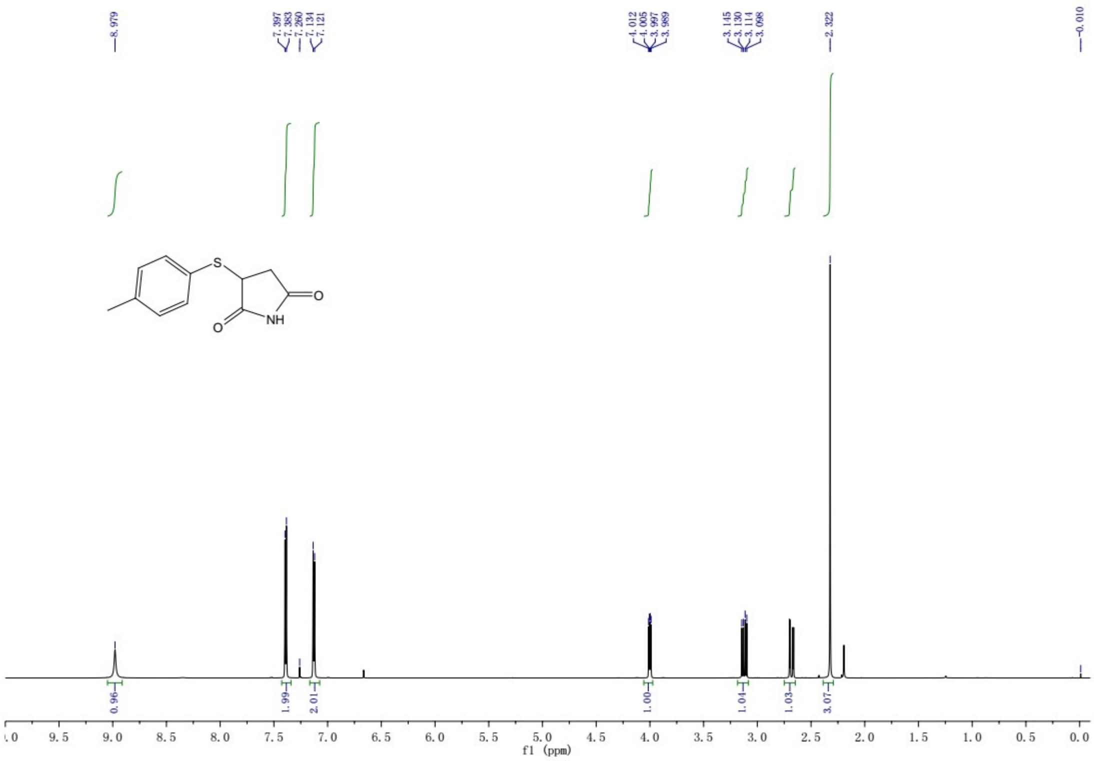
[1]H NMR spectrum for compound **3s** ($CDCl_3$, 600 MHz)



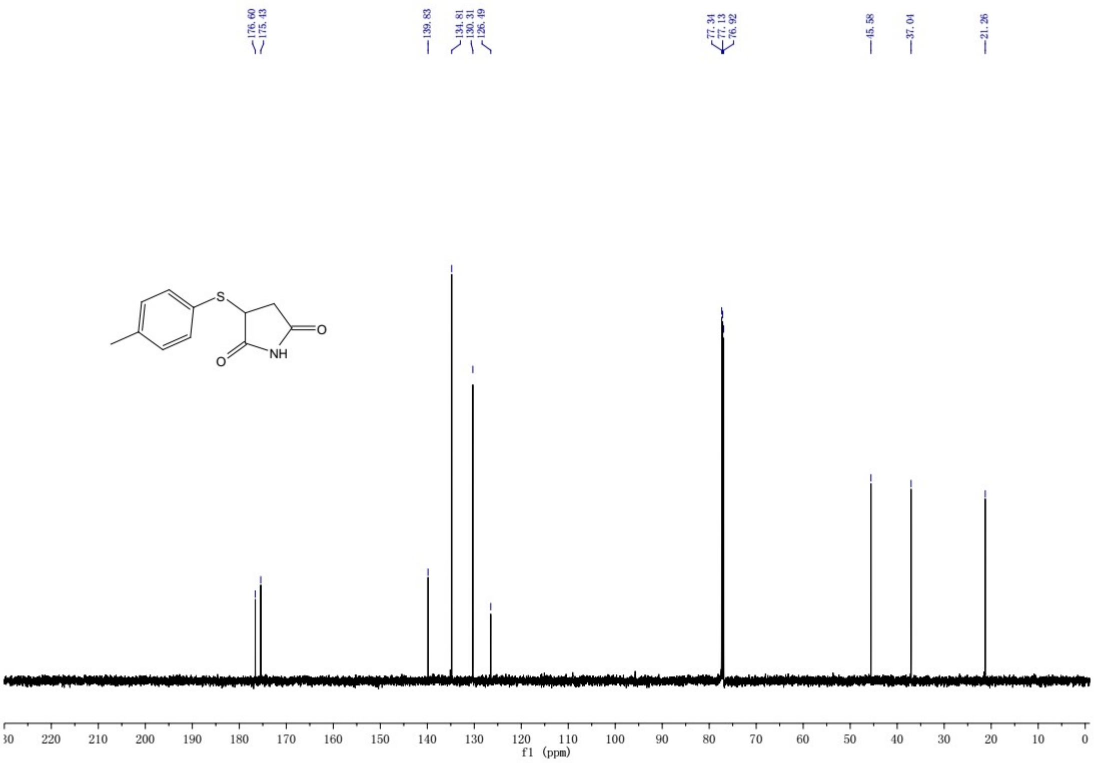
[13]C{[1]H} NMR spectrum for compound **3s** ($CDCl_3$, 151 MHz)



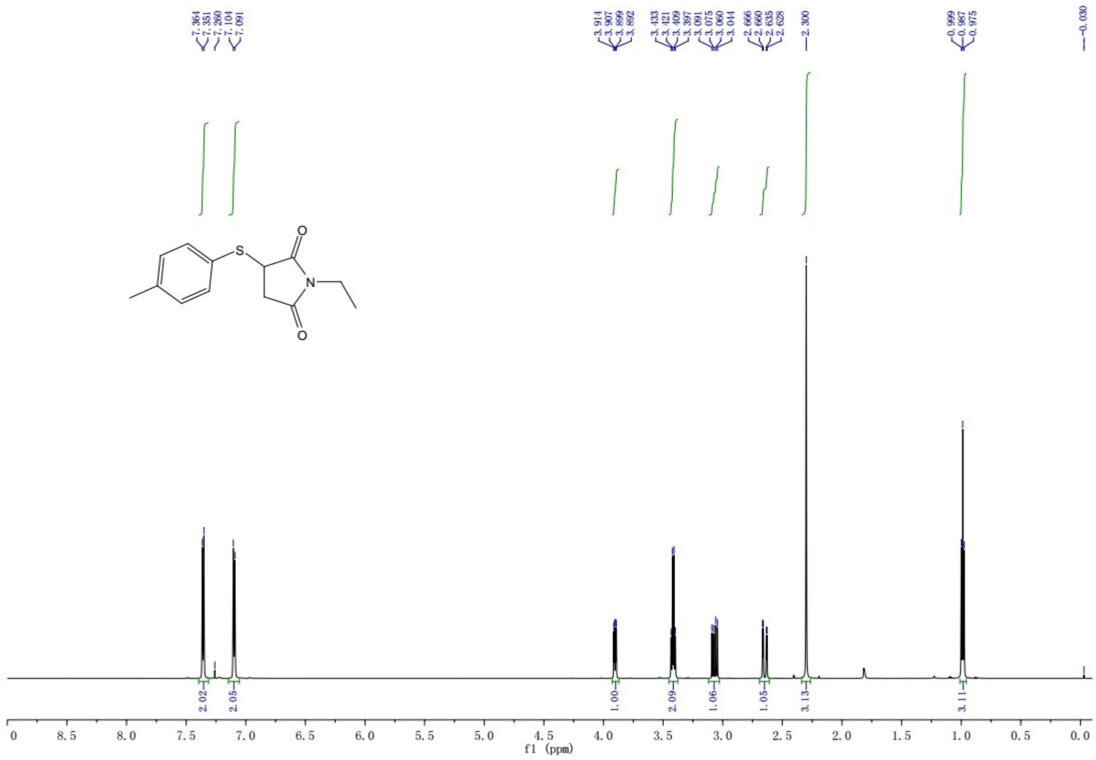
[1]H NMR spectrum for compound **3t** ($CDCl_3$, 600 MHz)



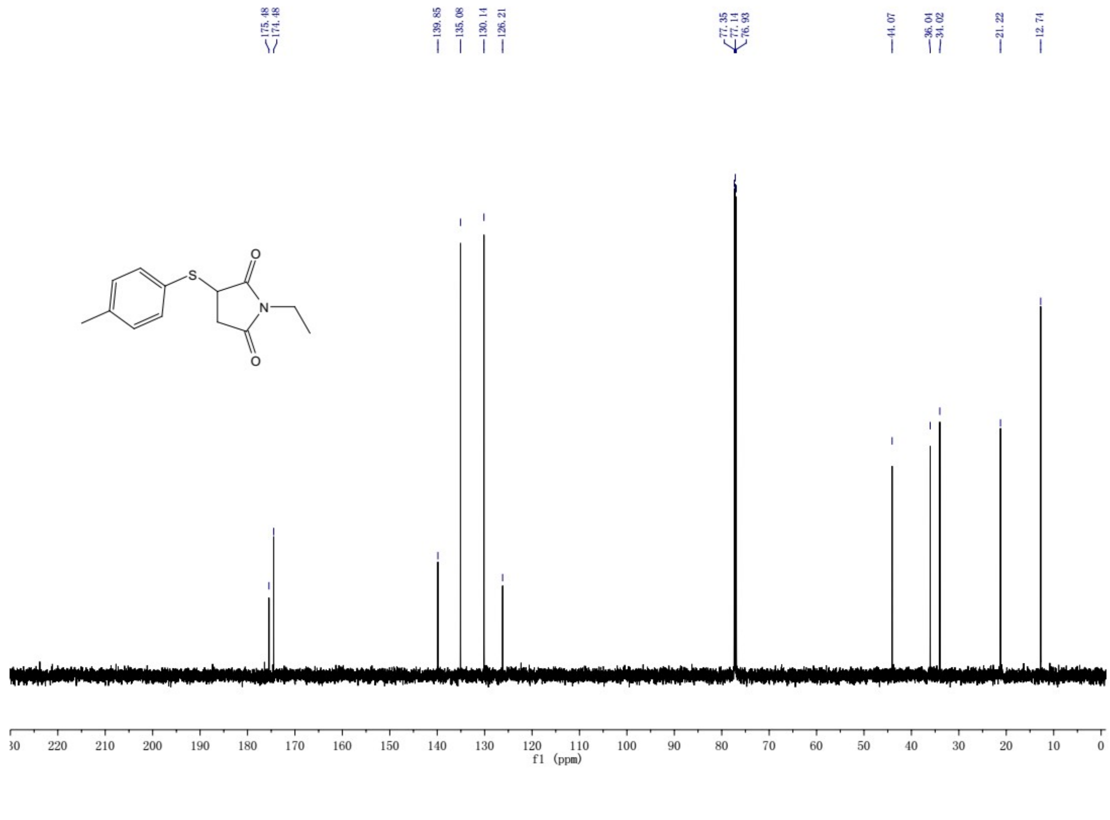
[13]C{[1]H} NMR spectrum for compound **3t** ($CDCl_3$, 151 MHz)



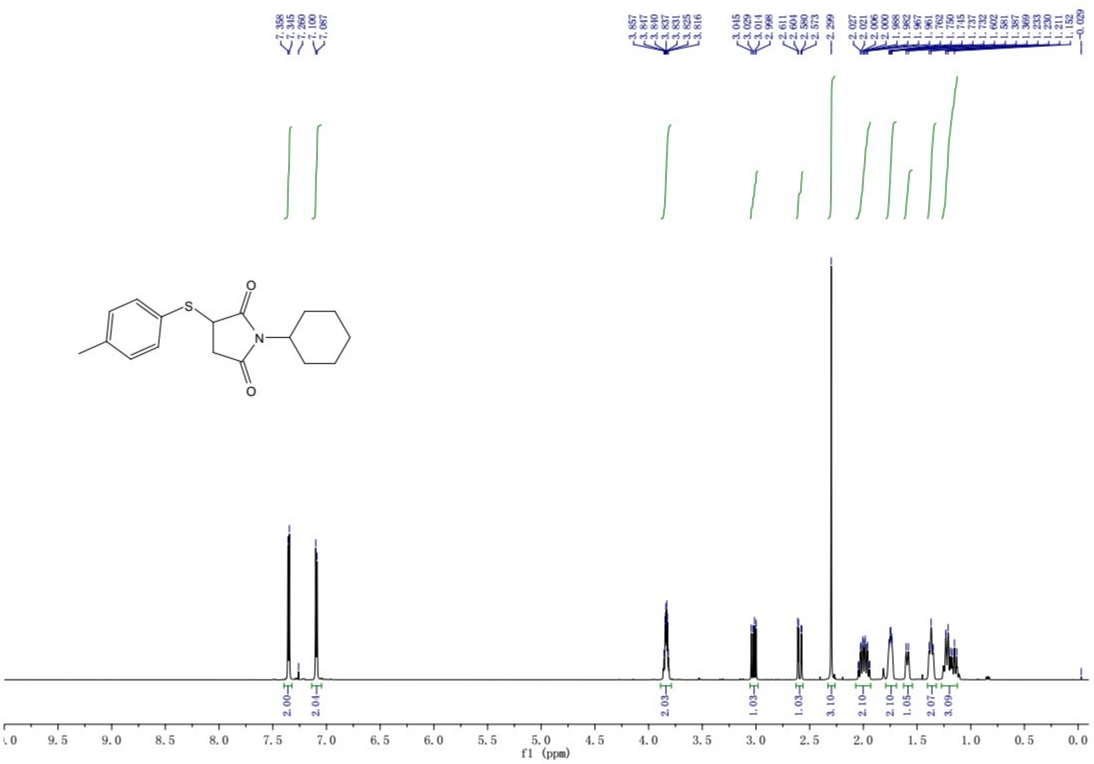
[1]H NMR spectrum for compound **3u** ($CDCl_3$, 600 MHz)



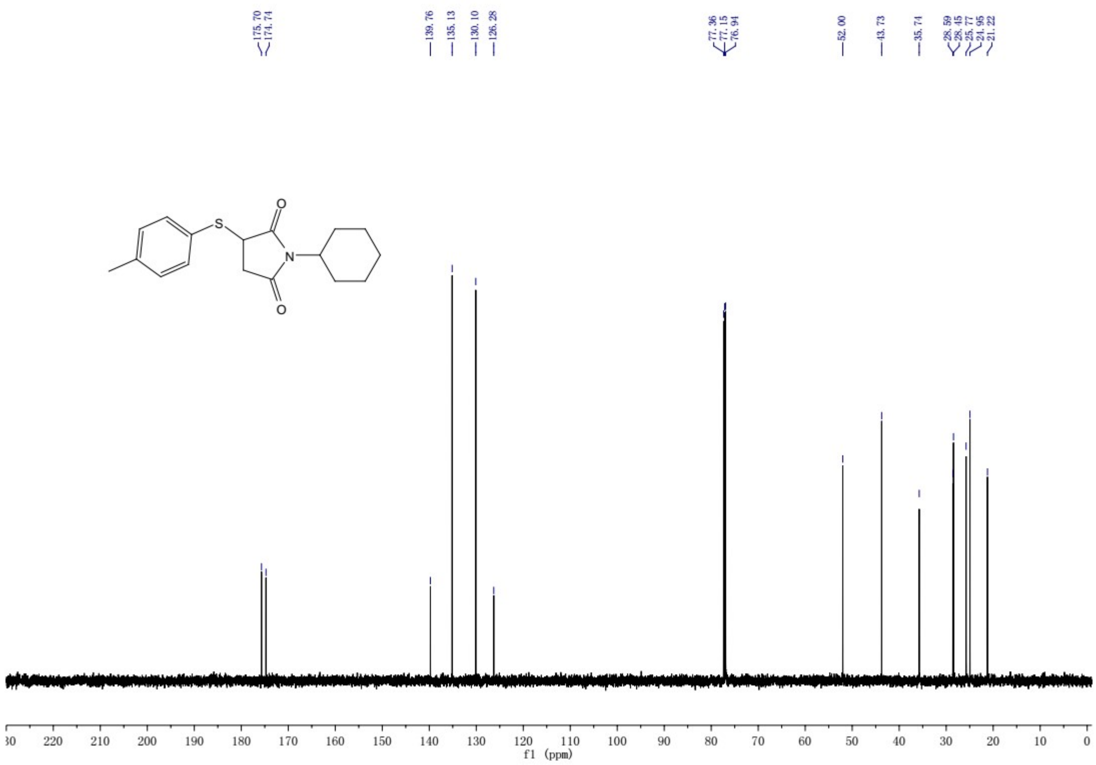
[13]C{[1]H} NMR spectrum for compound **3u** ($CDCl_3$, 151 MHz)



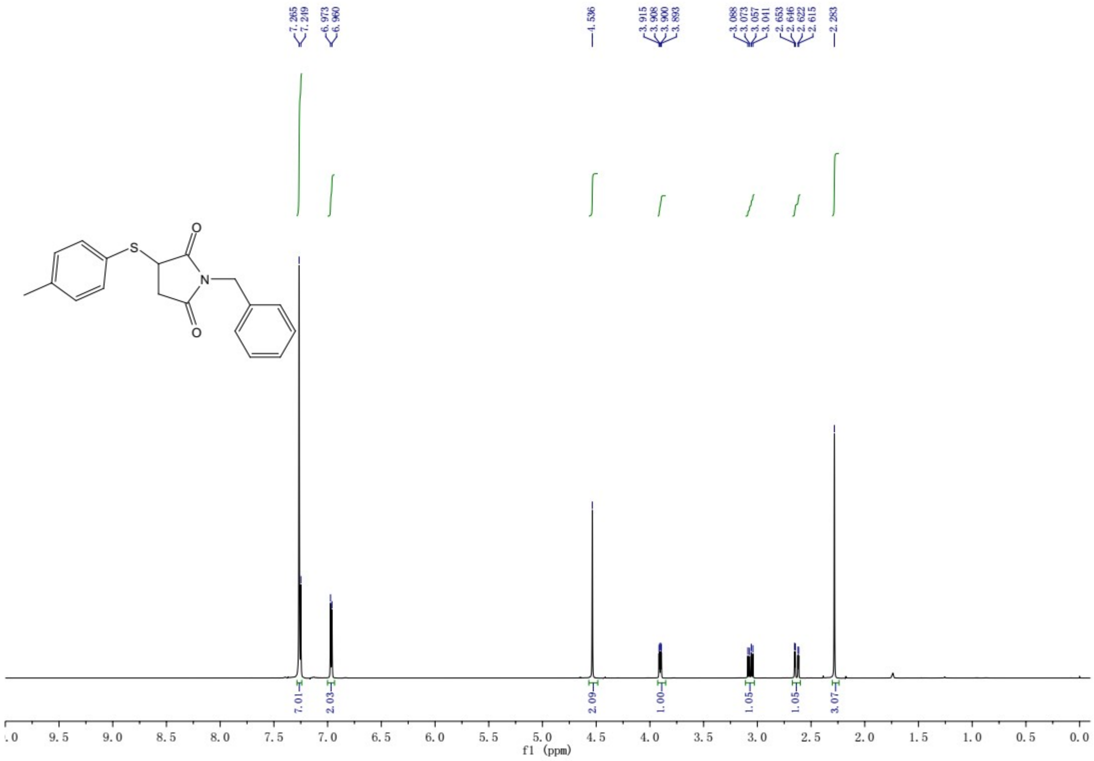
^{1}H NMR spectrum for compound **3v** ($CDCl_3$, 600 MHz)



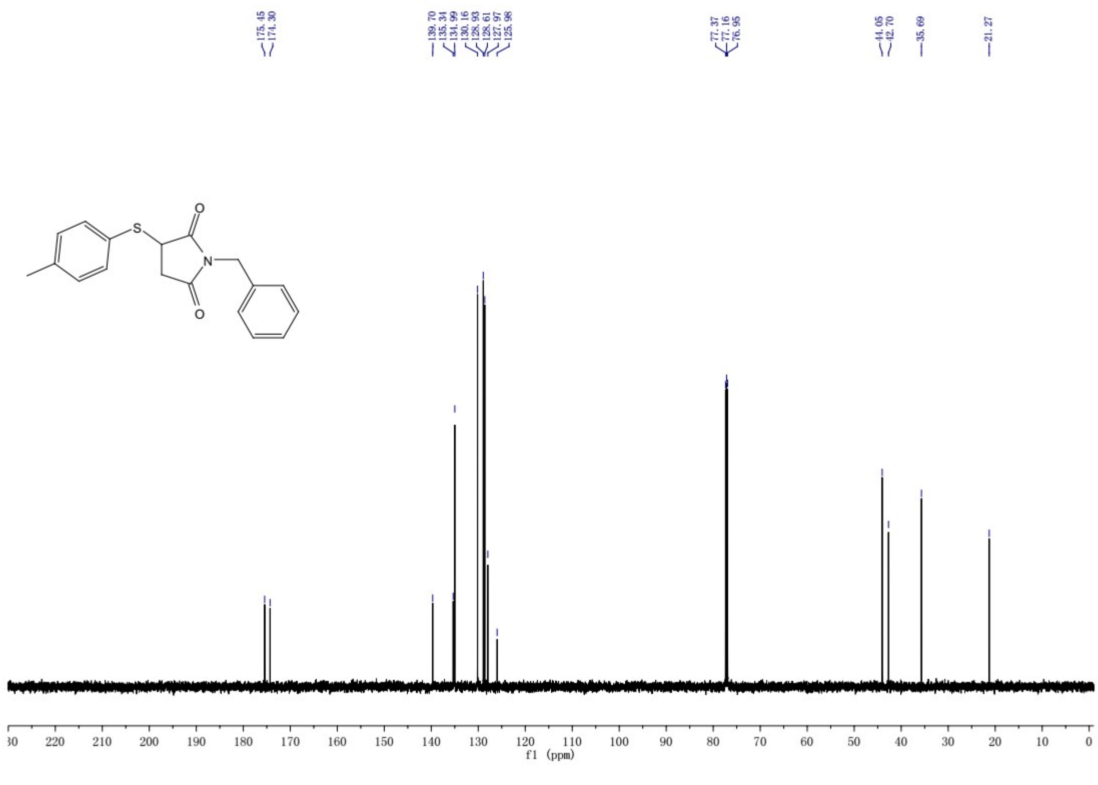
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3v** ($CDCl_3$, 151 MHz)



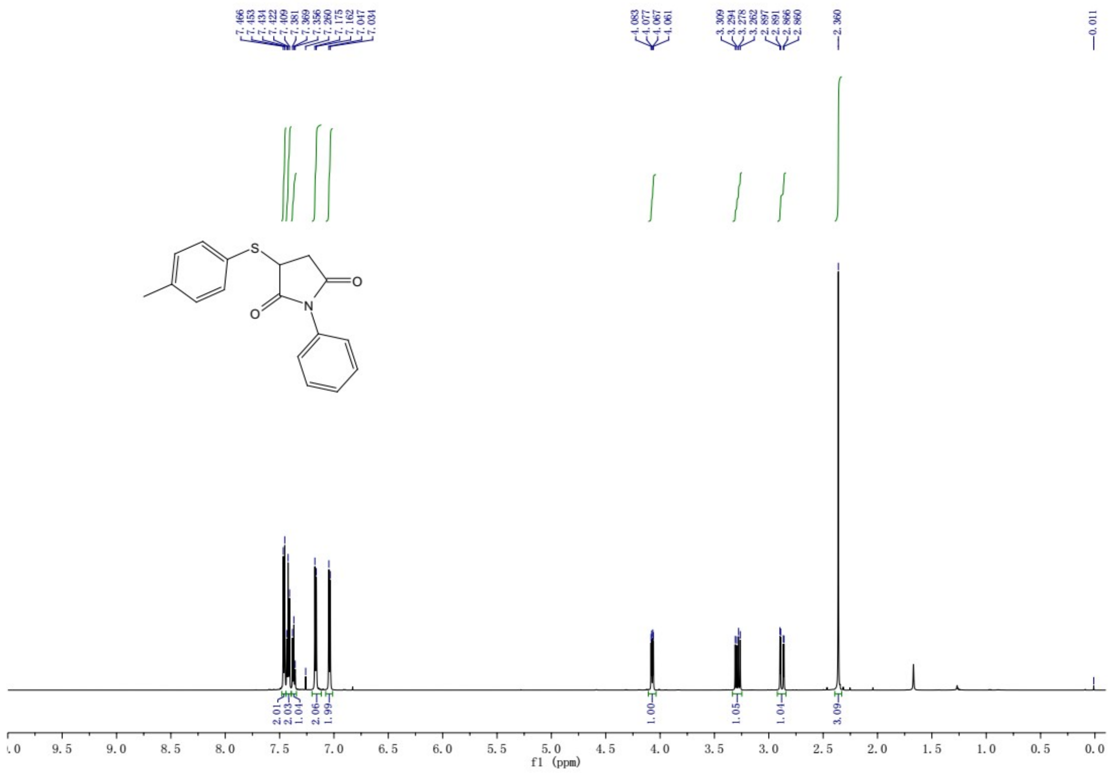
^1H NMR spectrum for compound **3w** ($CDCl_3$, 600 MHz)



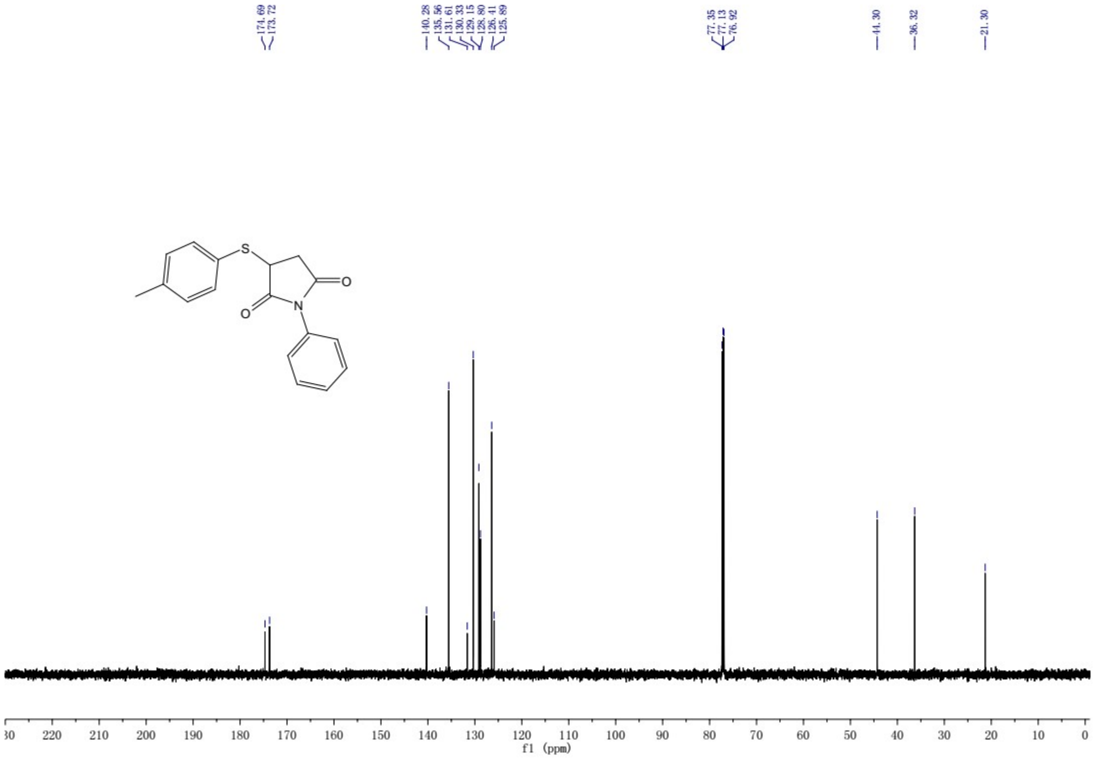
$^{13}C\{^1H\}$ NMR spectrum for compound **3w** ($CDCl_3$, 151 MHz)



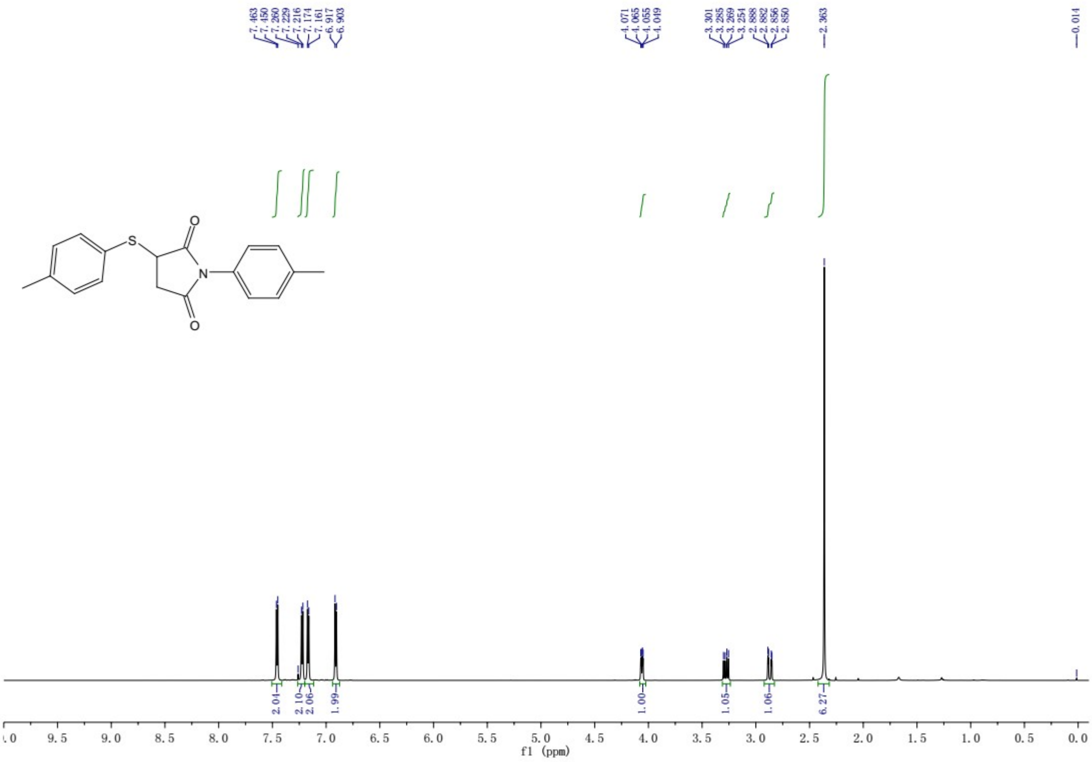
^1H NMR spectrum for compound **3x** ($CDCl_3$, 600 MHz)



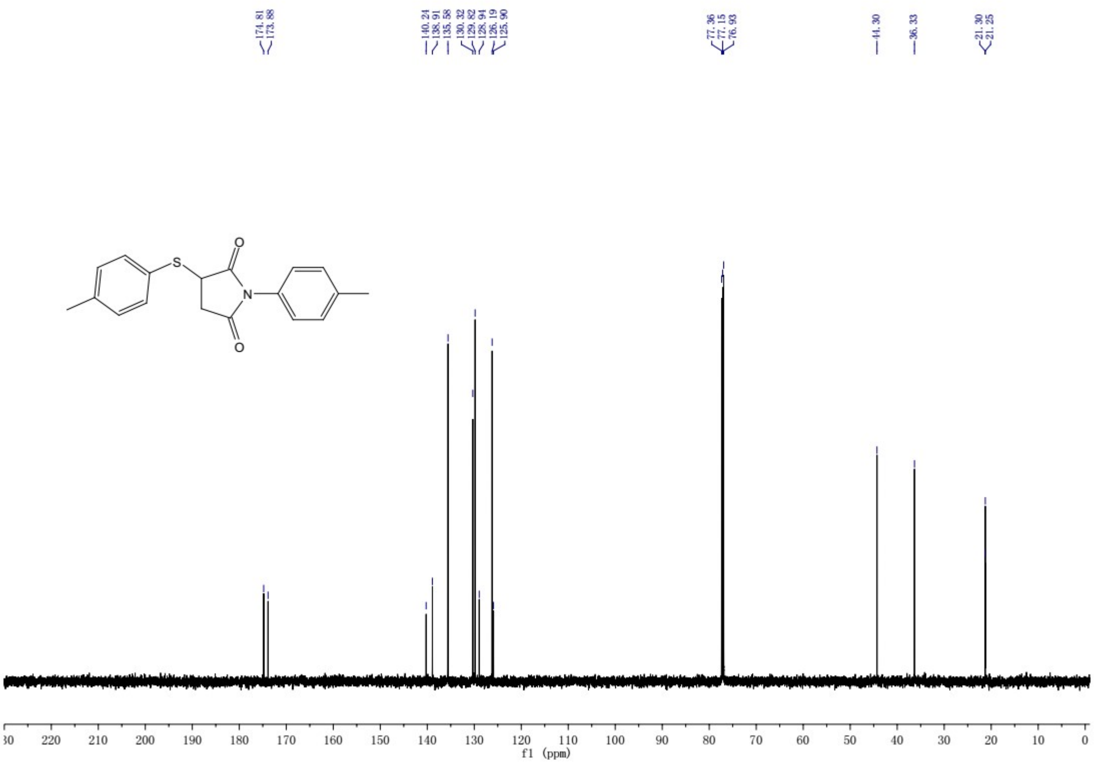
$^{13}C\{^1H\}$ NMR spectrum for compound **3x** ($CDCl_3$, 151 MHz)



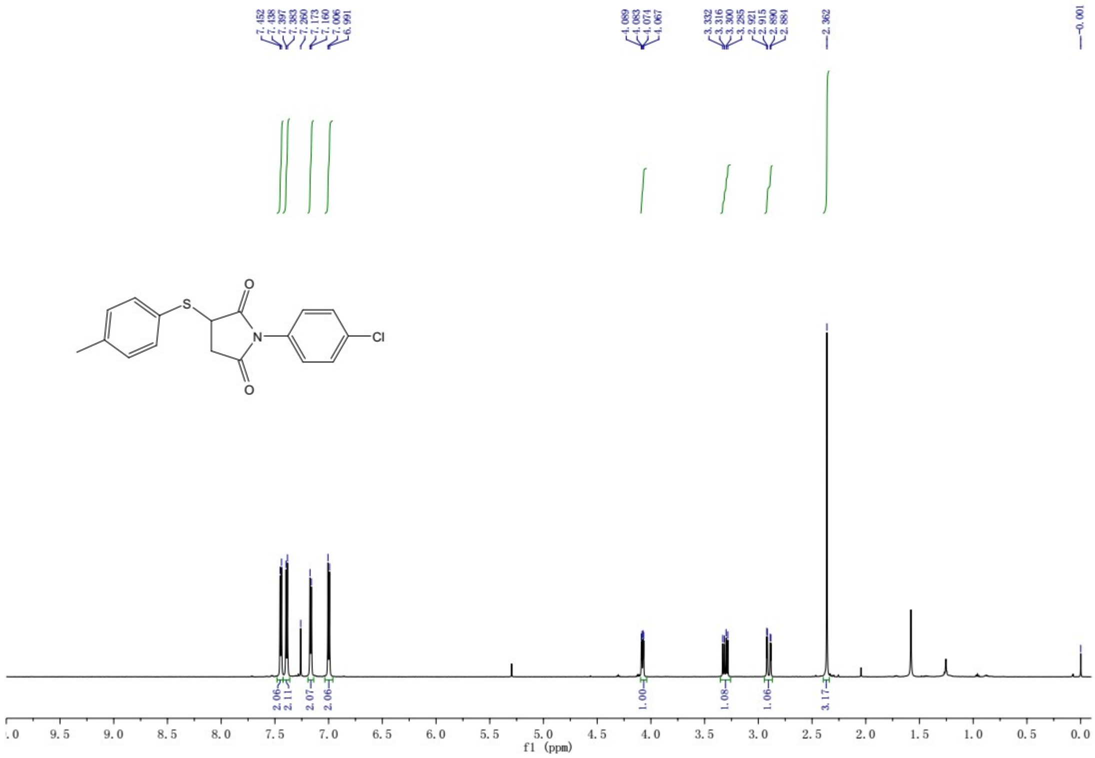
^{1}H NMR spectrum for compound **3y** ($CDCl_3$, 600 MHz)



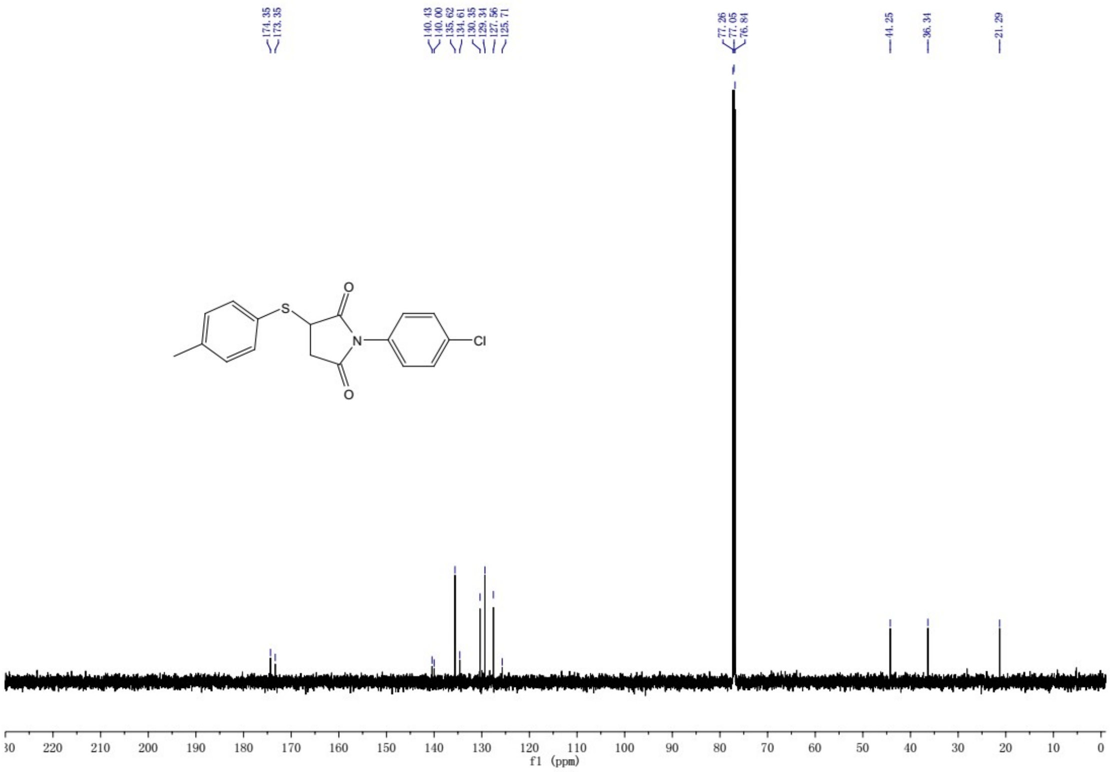
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3y** ($CDCl_3$, 151 MHz)



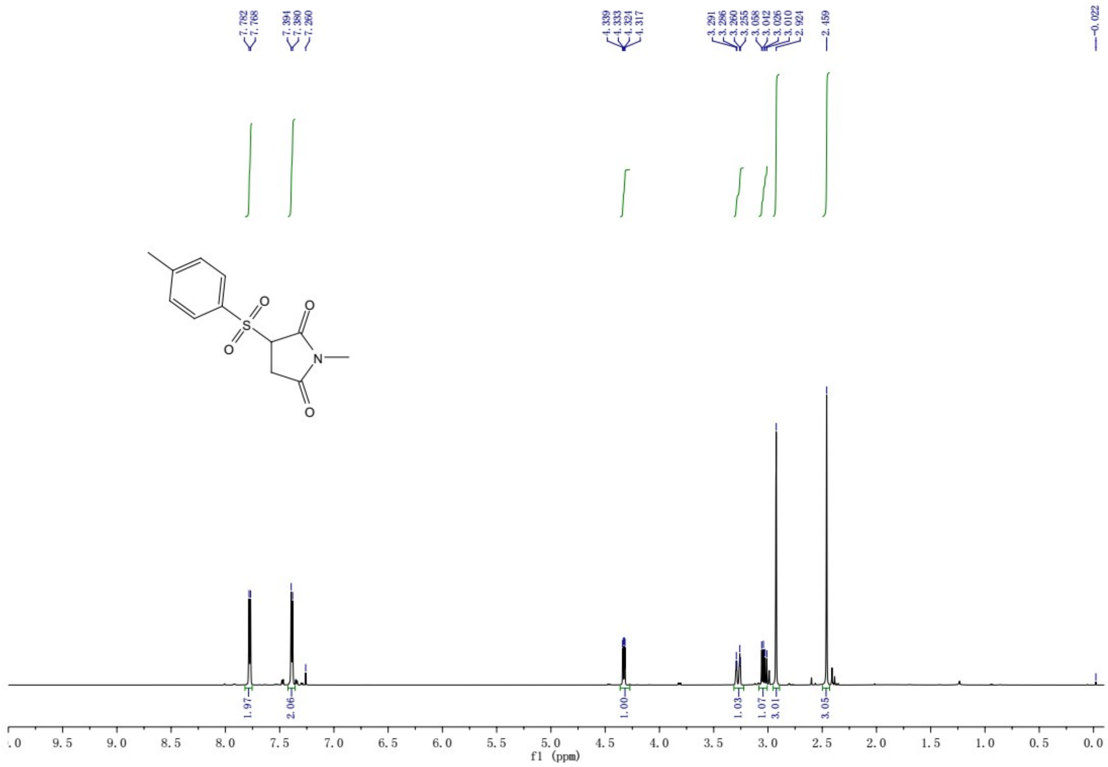
^{1}H NMR spectrum for compound **3z** ($CDCl_3$, 600 MHz)



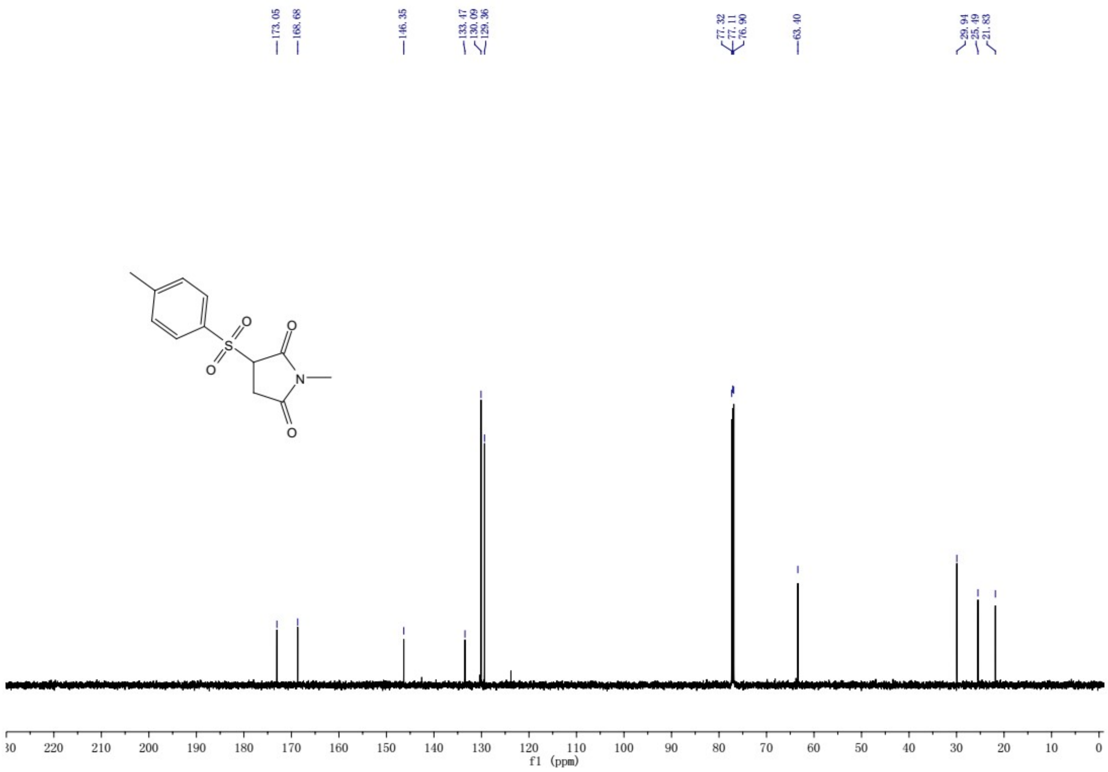
$^{13}C\{^{1}H\}$ NMR spectrum for compound **3z** ($CDCl_3$, 1501 MHz)



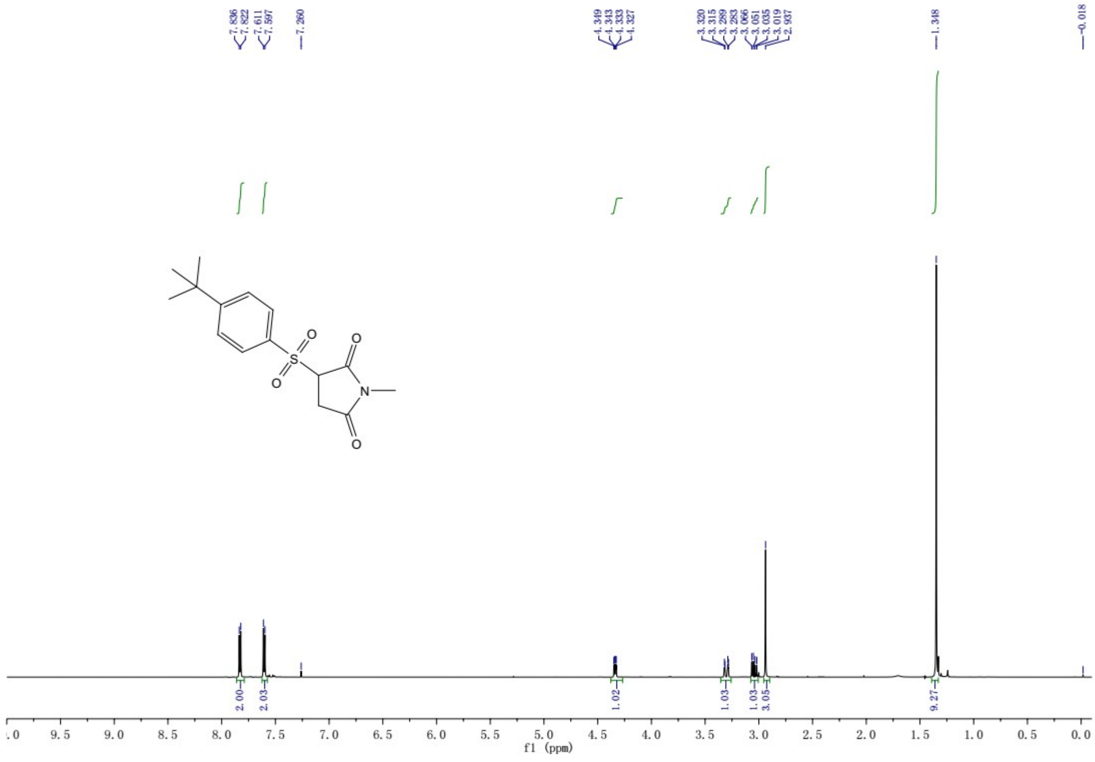
^1H NMR spectrum for compound **4a** ($CDCl_3$, 600 MHz)



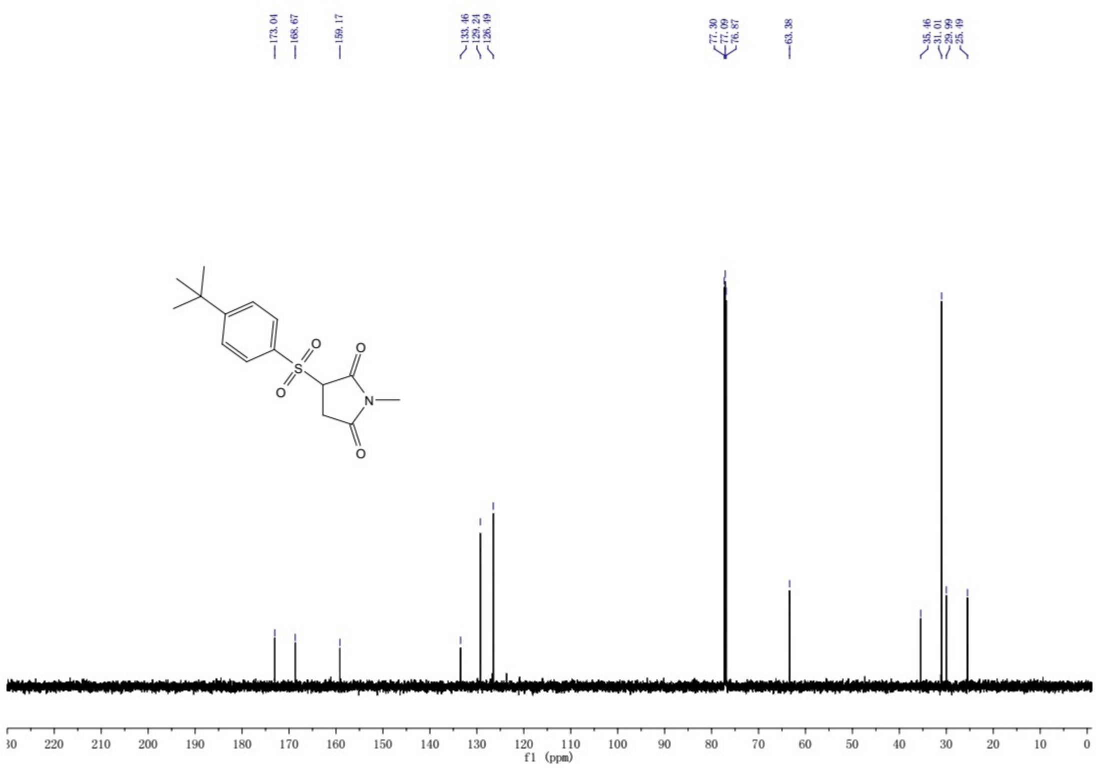
$^{13}C\{^1H\}$ NMR spectrum for compound **4a** ($CDCl_3$, 151 MHz)



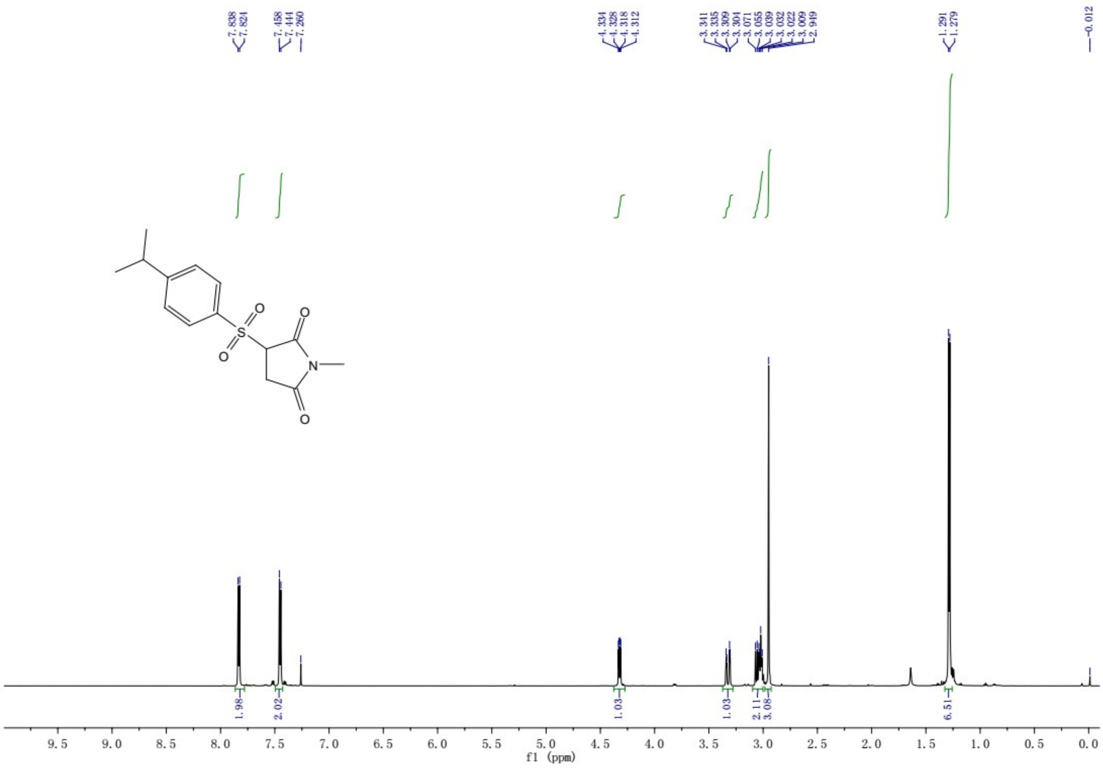
[1]H NMR spectrum for compound **4b** ($CDCl_3$, 600 MHz)



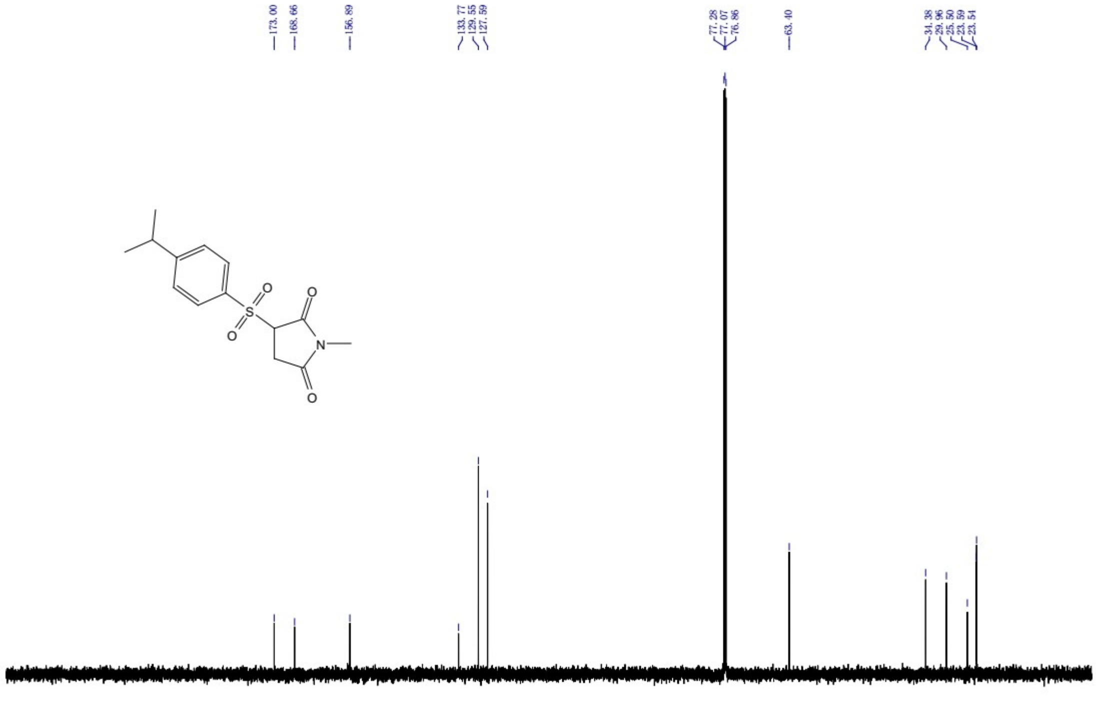
[13]C{[1]H} NMR spectrum for compound **4b** ($CDCl_3$, 151 MHz)



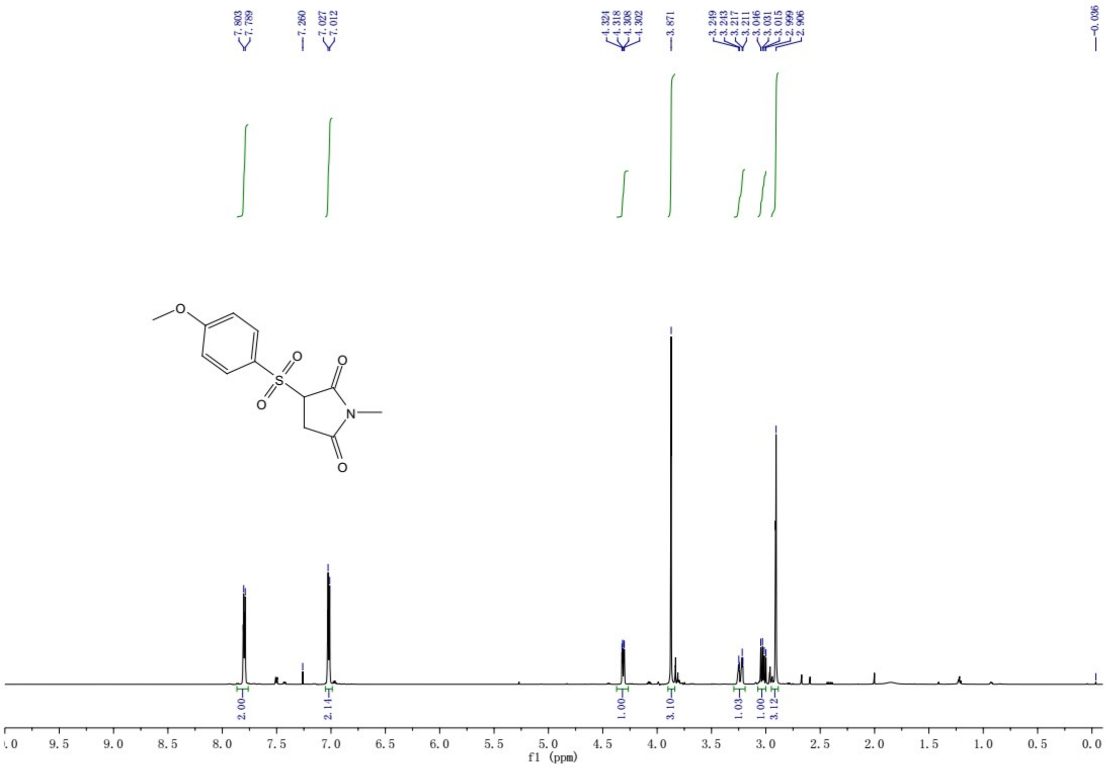
[1]H NMR spectrum for compound **4c** ($CDCl_3$, 600 MHz)



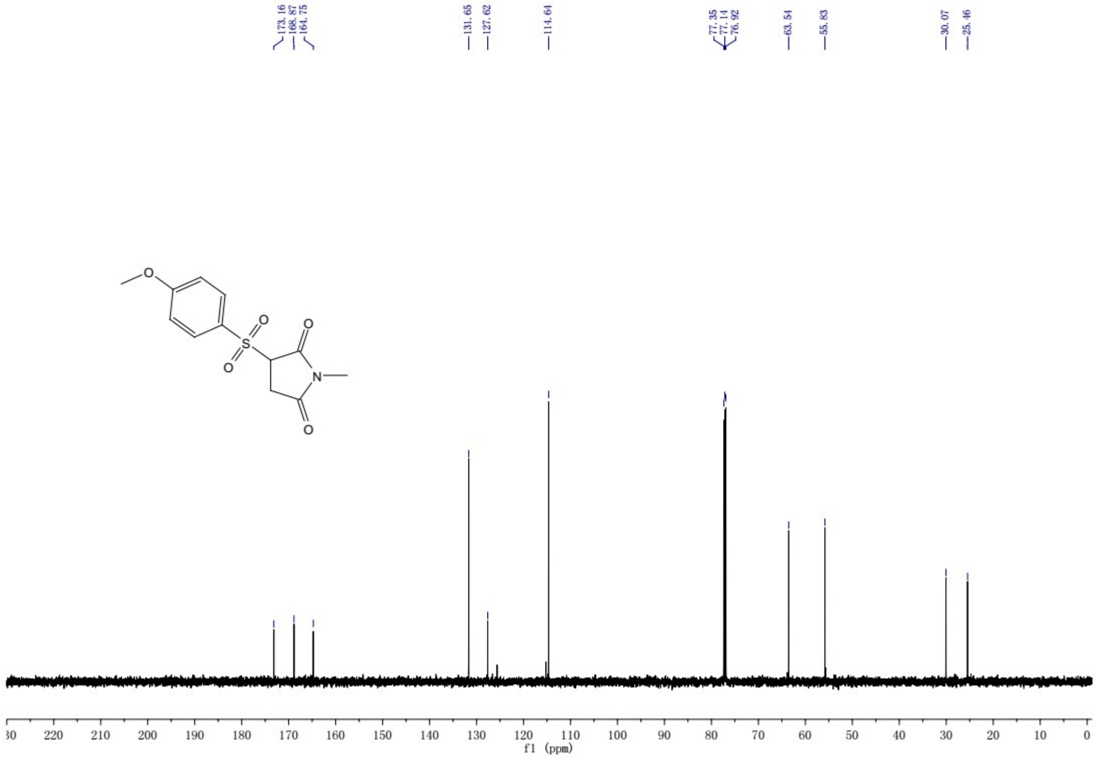
[13]C{[1]H} NMR spectrum for compound **4c** ($CDCl_3$, 151 MHz)



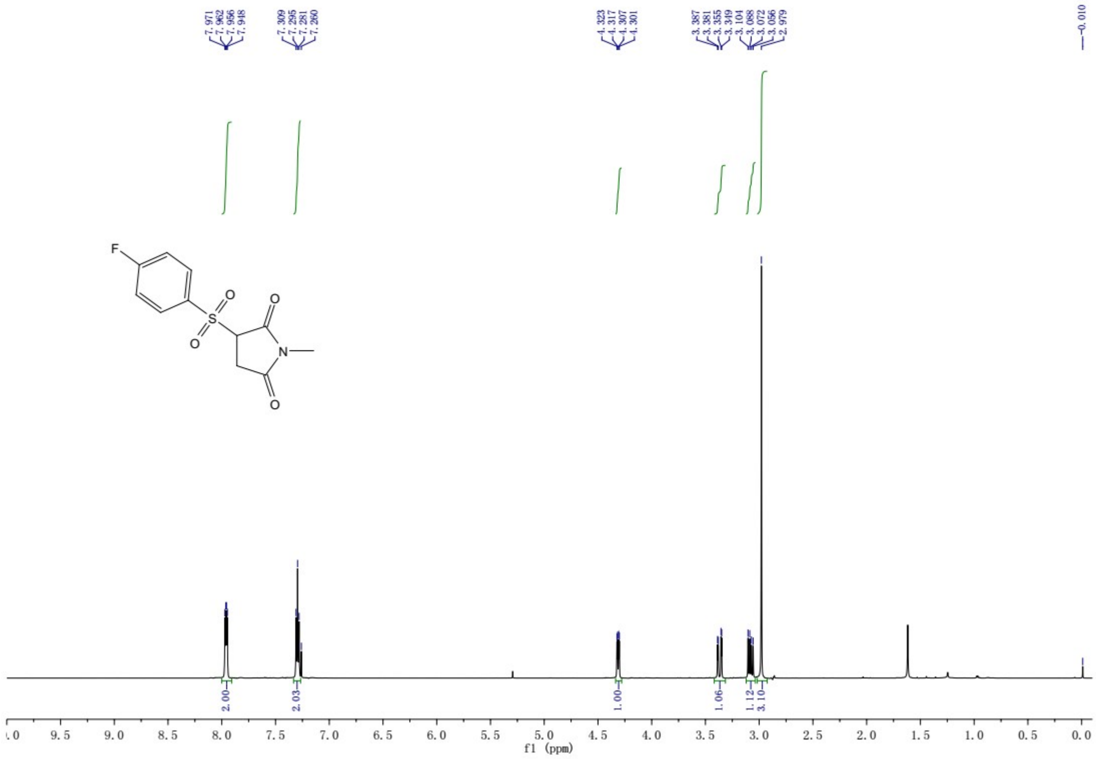
^{1}H NMR spectrum for compound **4d** ($CDCl_3$, 600 MHz)



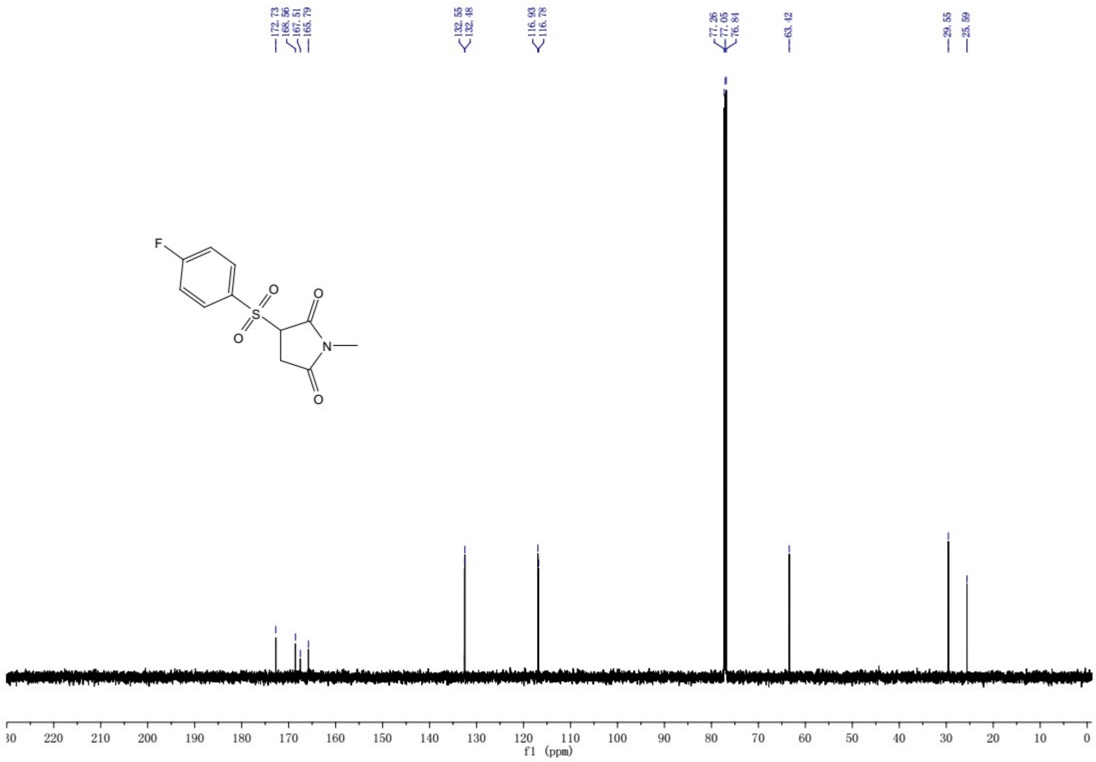
$^{13}C\{^{1}H\}$ NMR spectrum for compound **4d** ($CDCl_3$, 151 MHz)



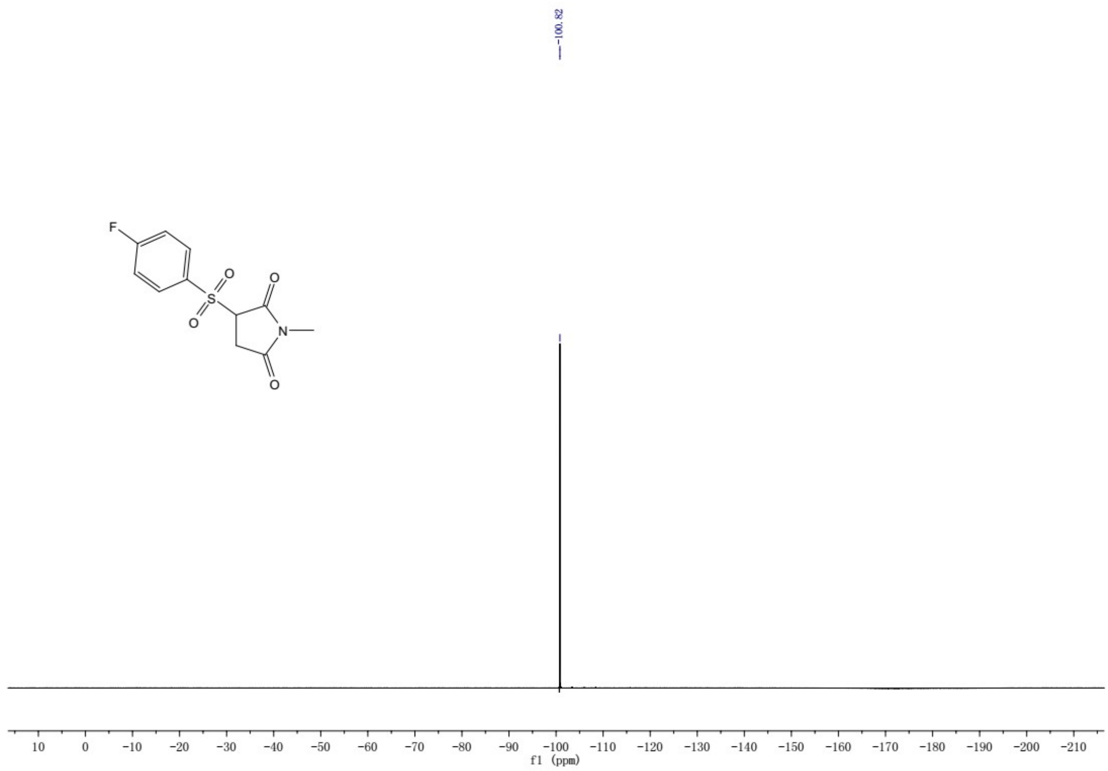
^1H NMR spectrum for compound **4e** ($CDCl_3$, 600 MHz)



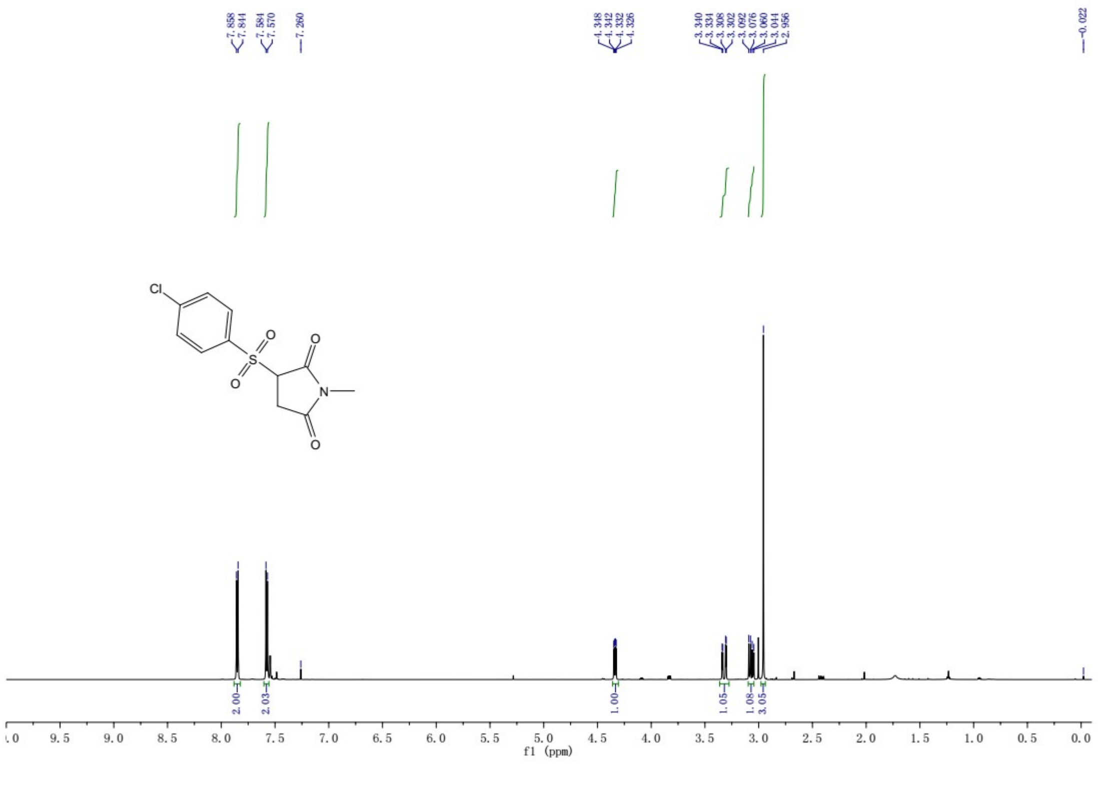
$^{13}C\{^1H\}$ NMR spectrum for compound **4e** ($CDCl_3$, 151 MHz)



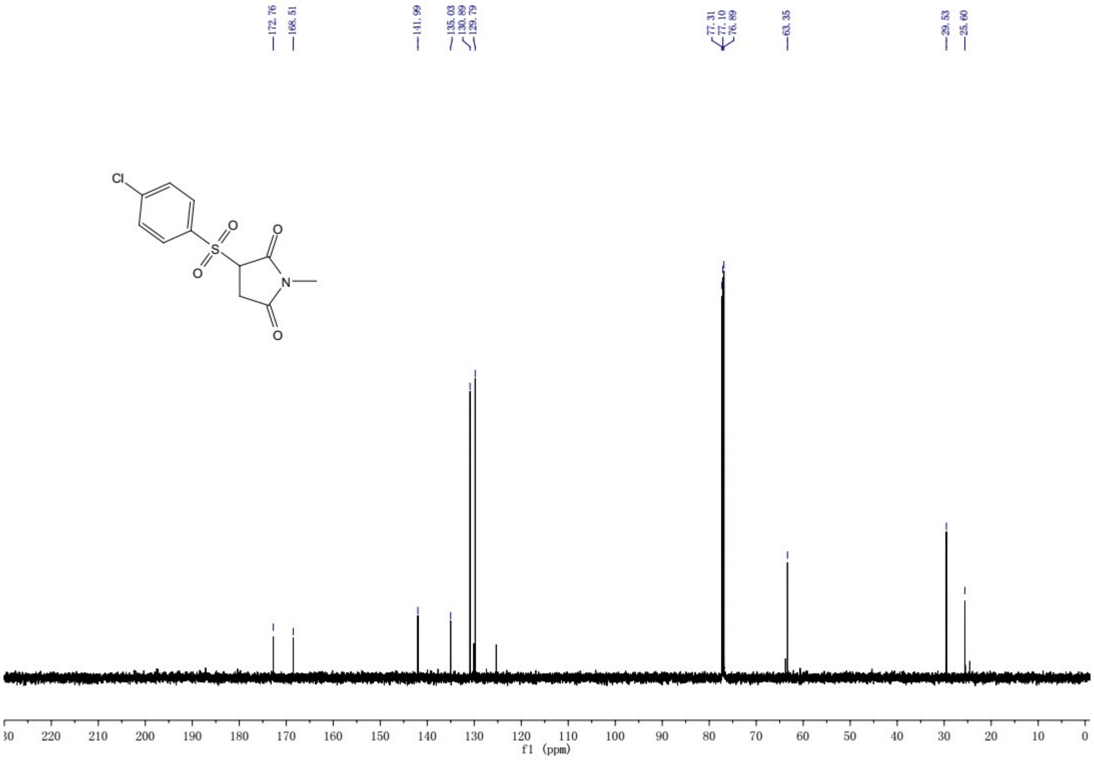
^{19}F NMR spectrum for compound **4e** ($CDCl_3$, 564 MHz)



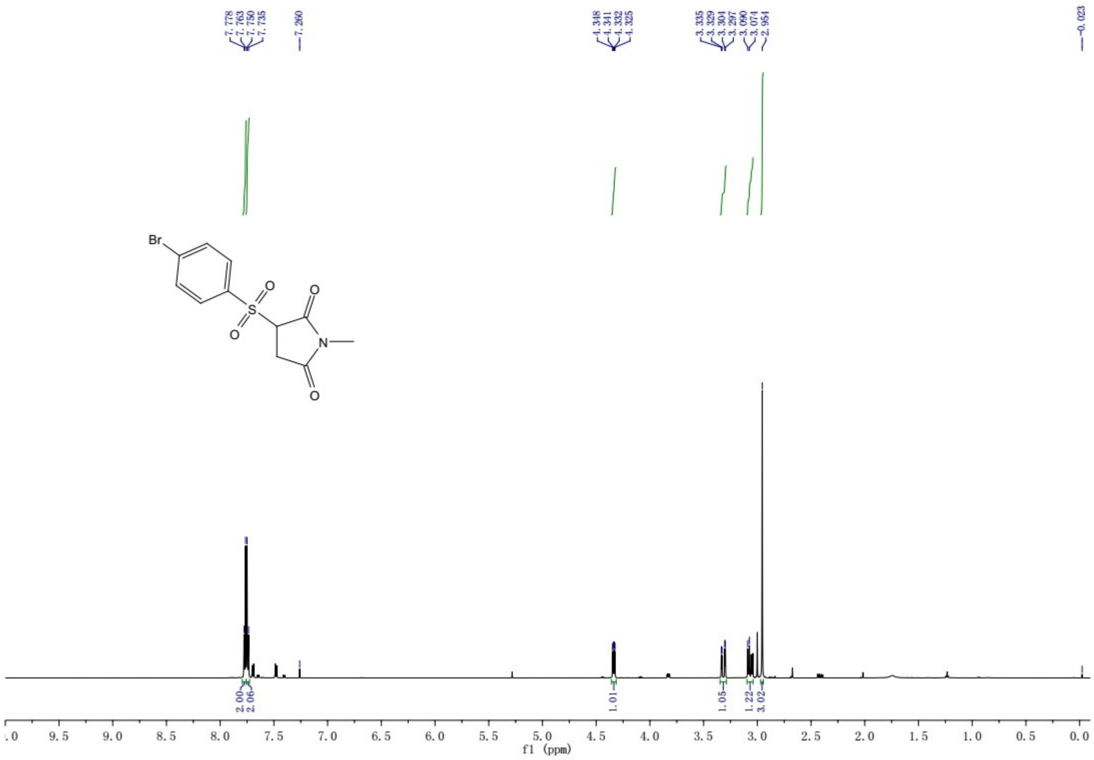
^{1}H NMR spectrum for compound **4f** ($CDCl_3$, 600 MHz)



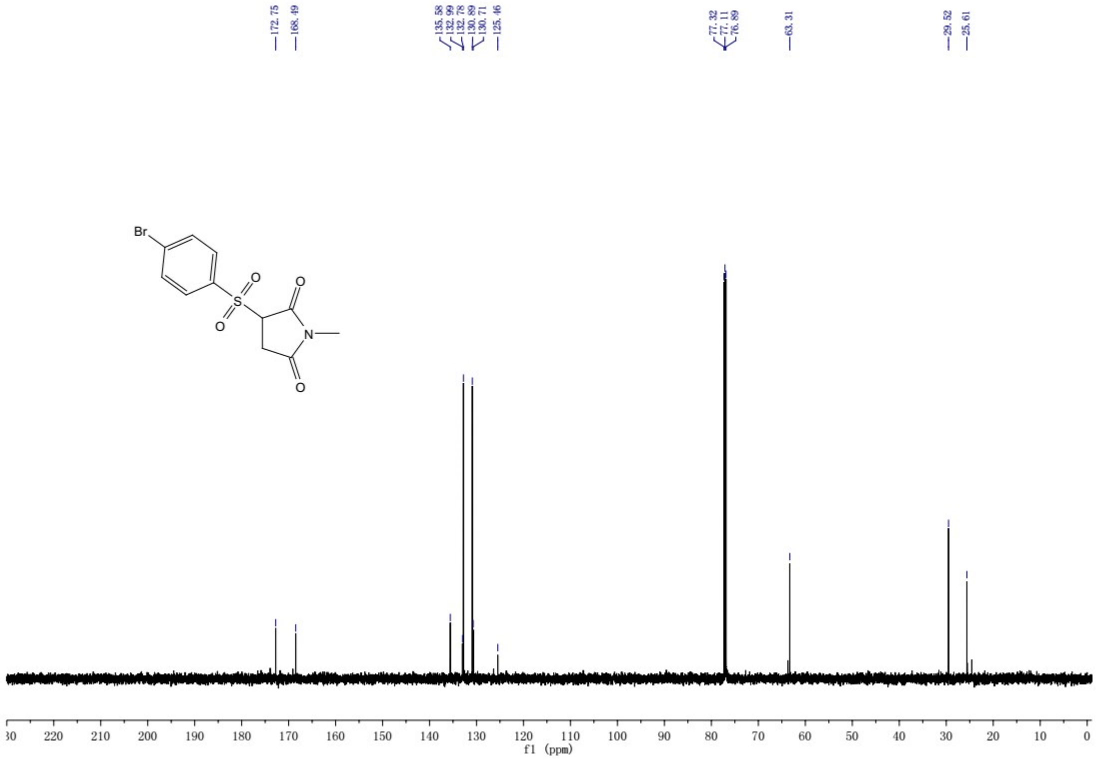
$^{13}C\{^{1}H\}$ NMR spectrum for compound **4f** ($CDCl_3$, 151 MHz)



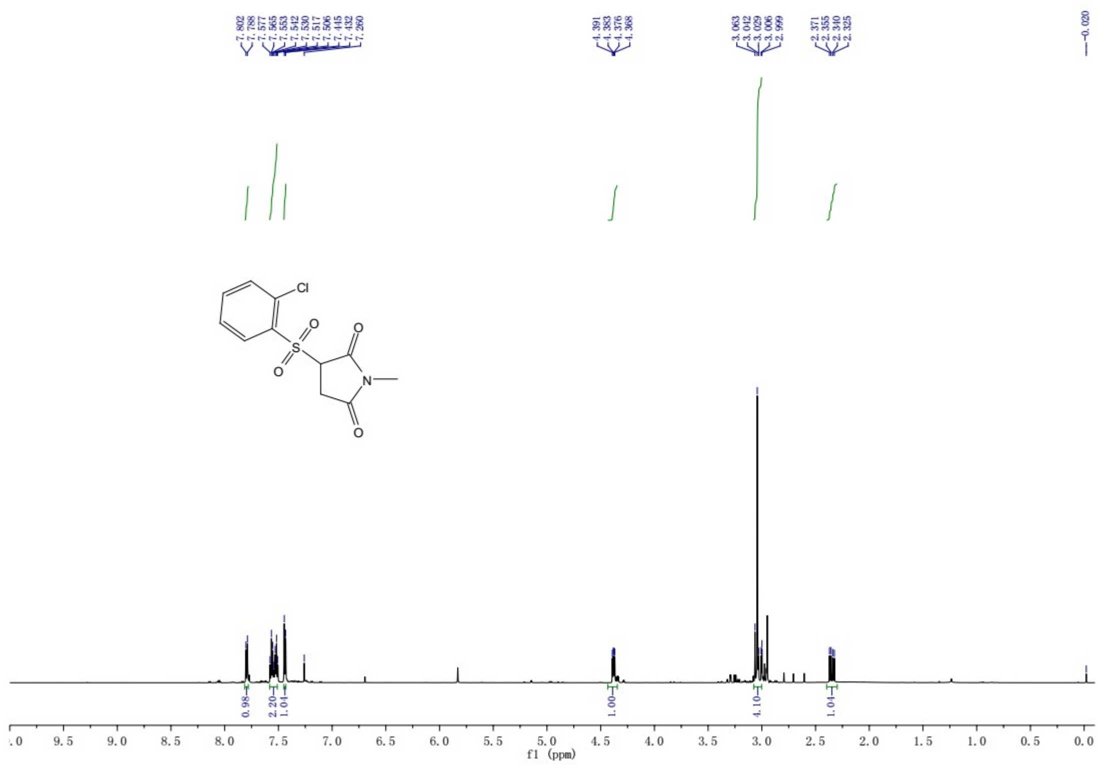
^{1}H NMR spectrum for compound **4g** ($CDCl_3$, 600 MHz)



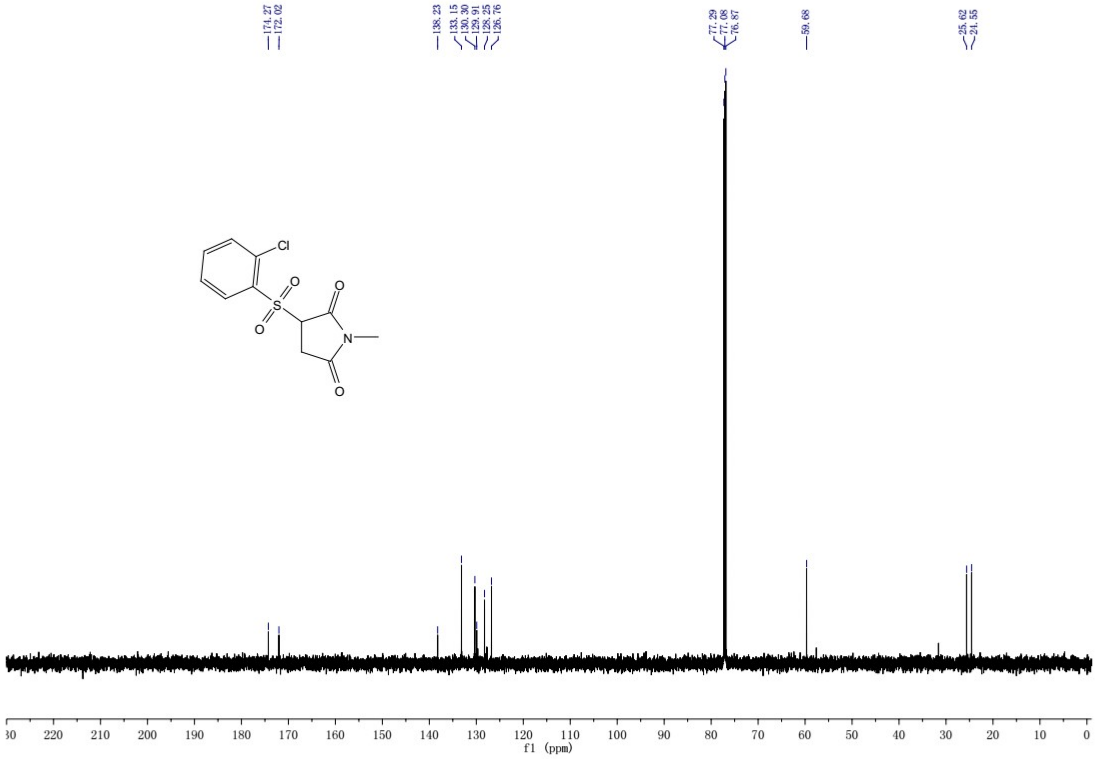
$^{13}C\{^1H\}$ NMR spectrum for compound **4g** ($CDCl_3$, 151 MHz)



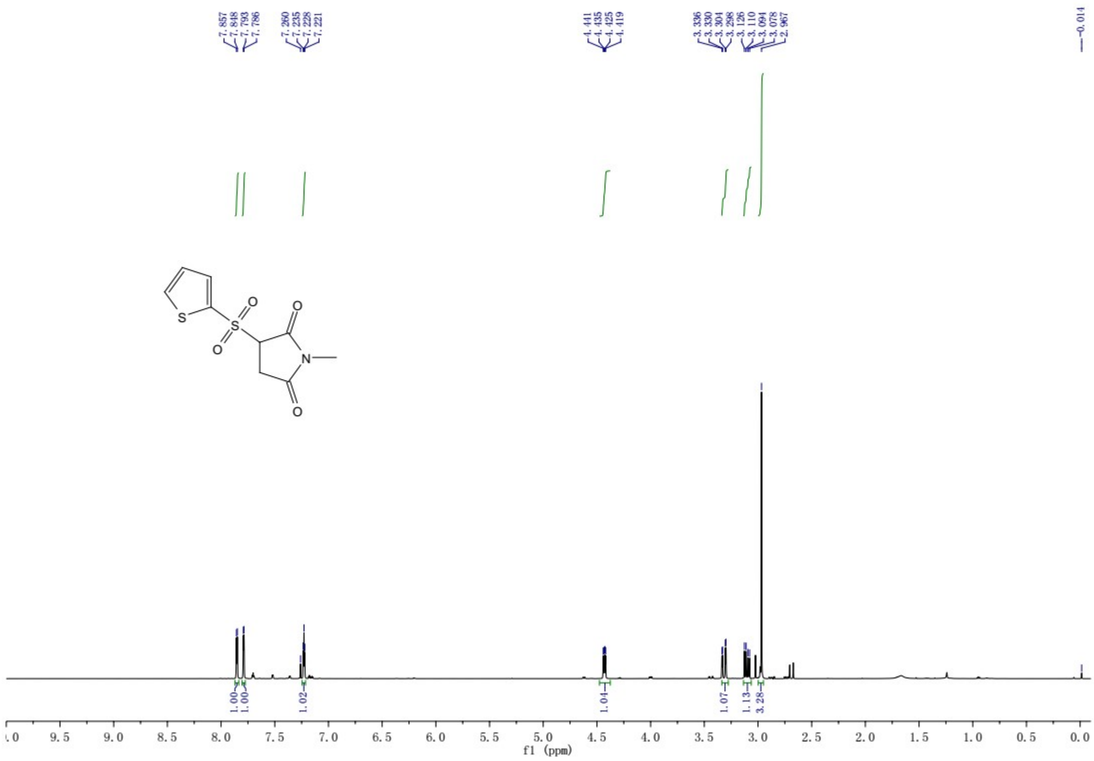
^1H NMR spectrum for compound **4h** ($CDCl_3$, 600 MHz)



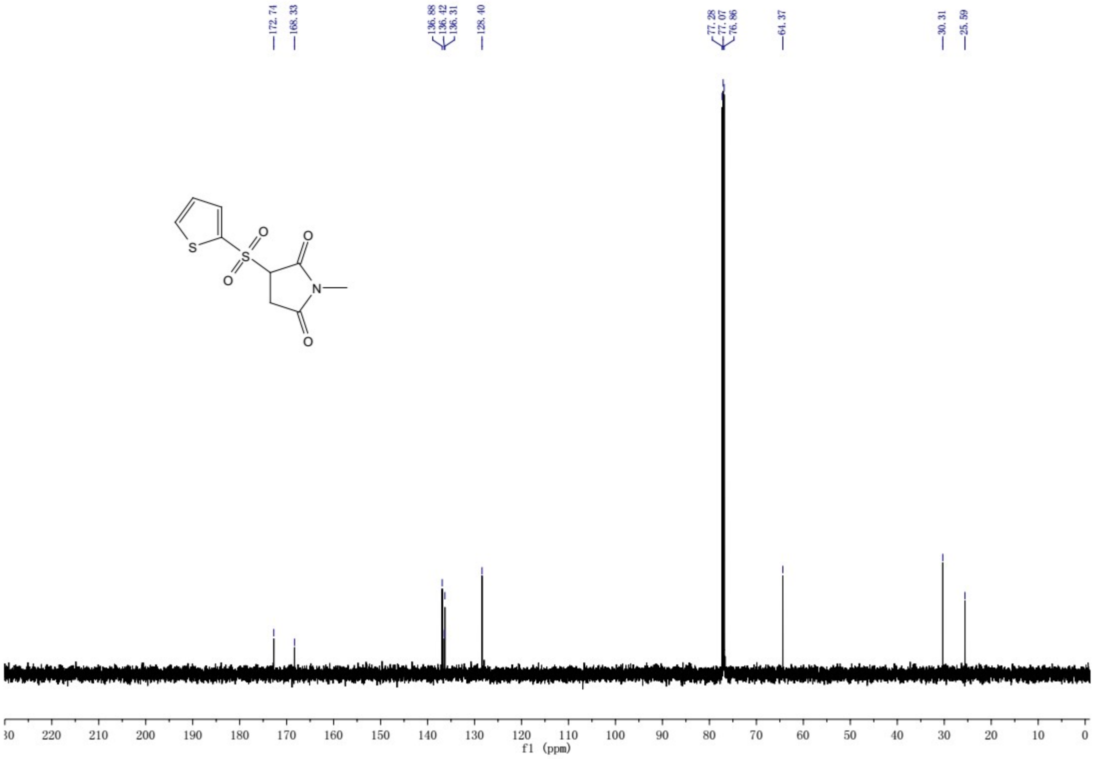
$^{13}C\{^1H\}$ NMR spectrum for compound **4h** ($CDCl_3$, 151 MHz)



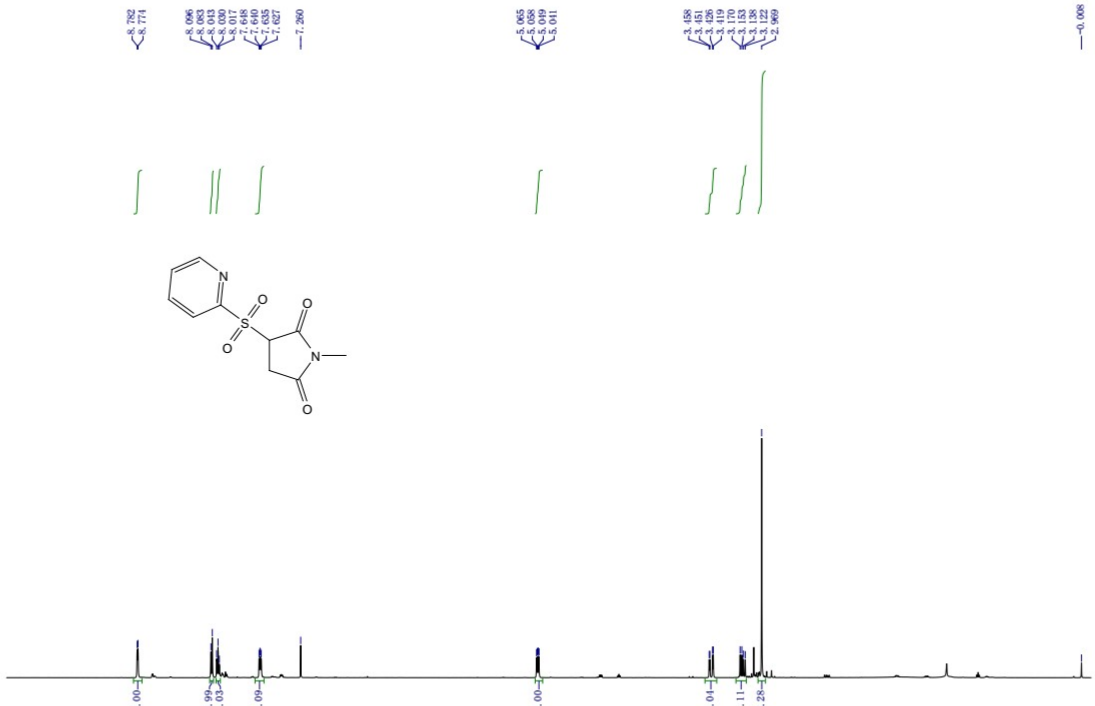
^1H NMR spectrum for compound **4i** ($CDCl_3$, 600 MHz)



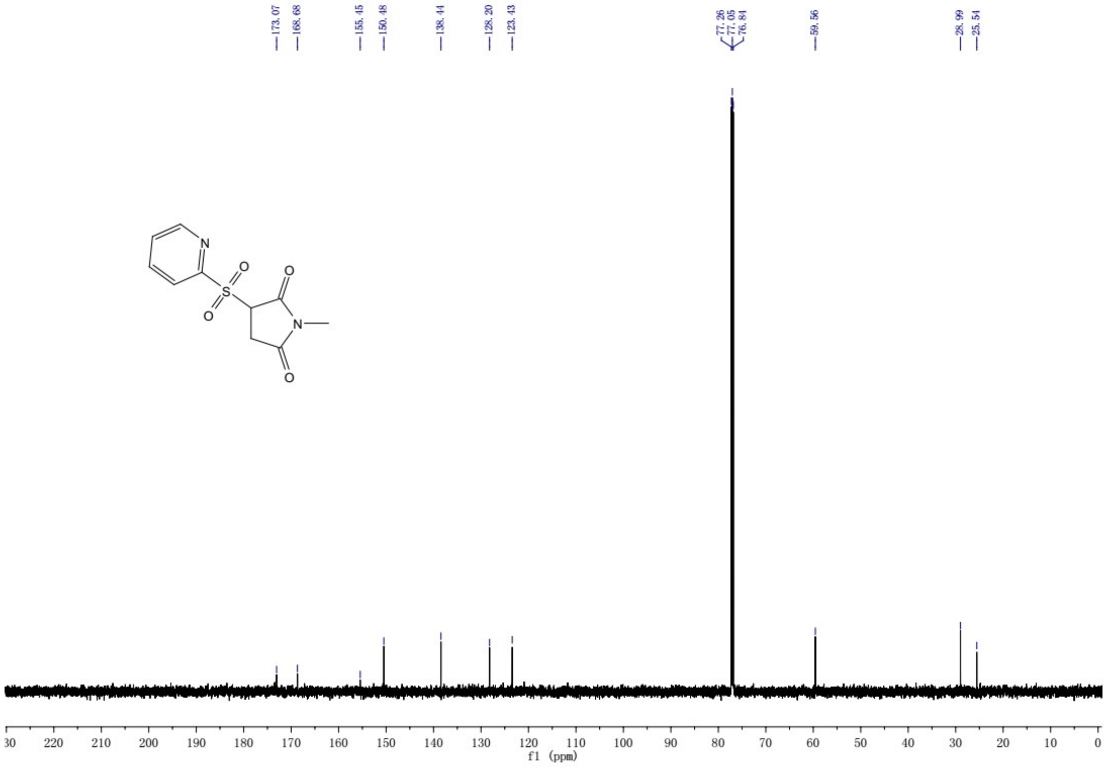
$^{13}C\{^{1}H\}$ NMR spectrum for compound **4i** ($CDCl_3$, 151 MHz)



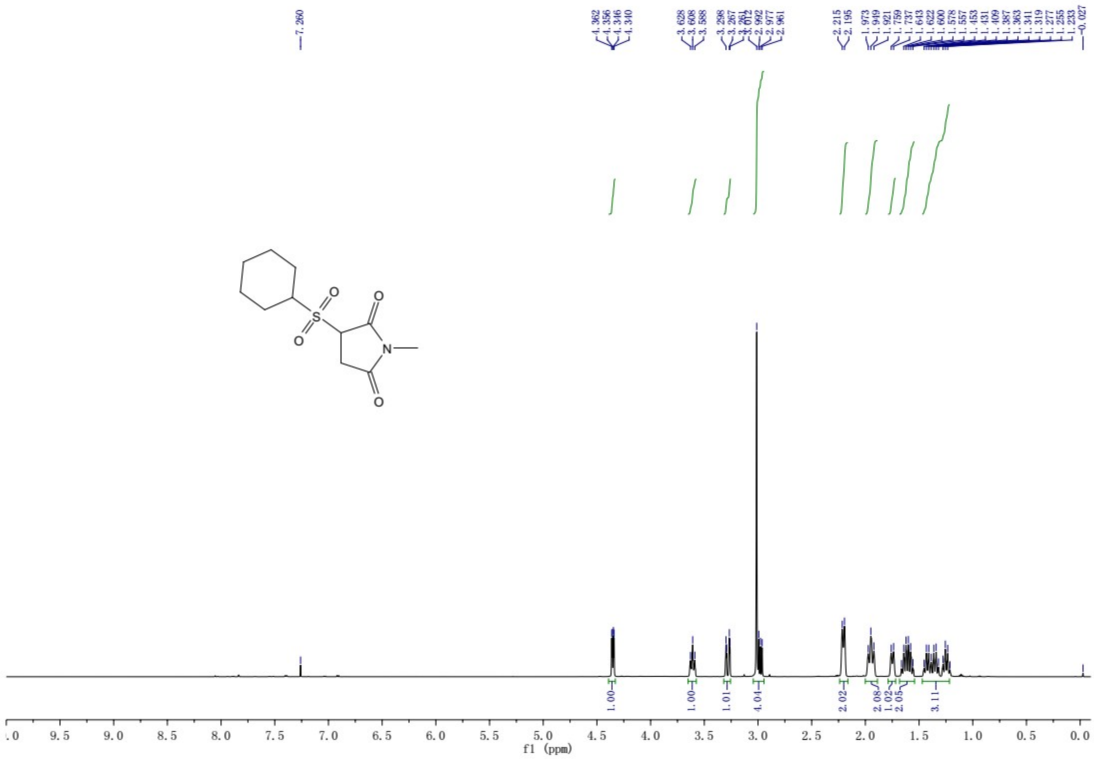
^{1}H NMR spectrum for compound **4j** ($CDCl_3$, 600 MHz)



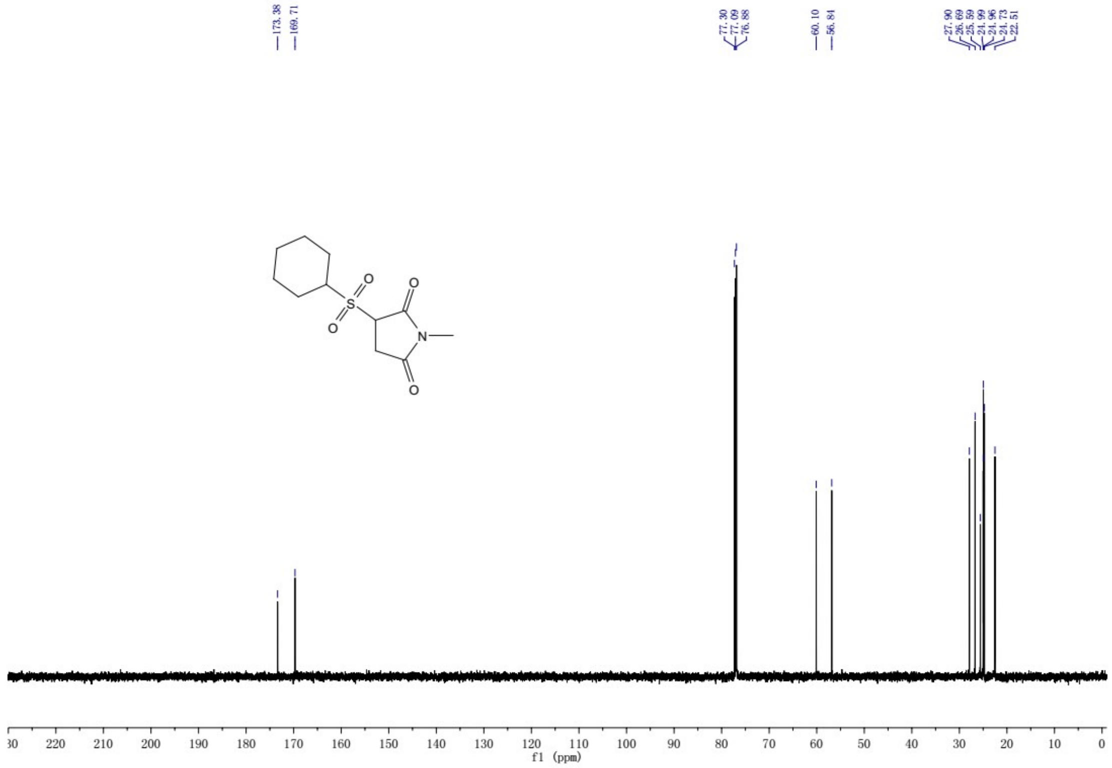
$^{13}C\{^1H\}$ NMR spectrum for compound **4j** ($CDCl_3$, 151 MHz)



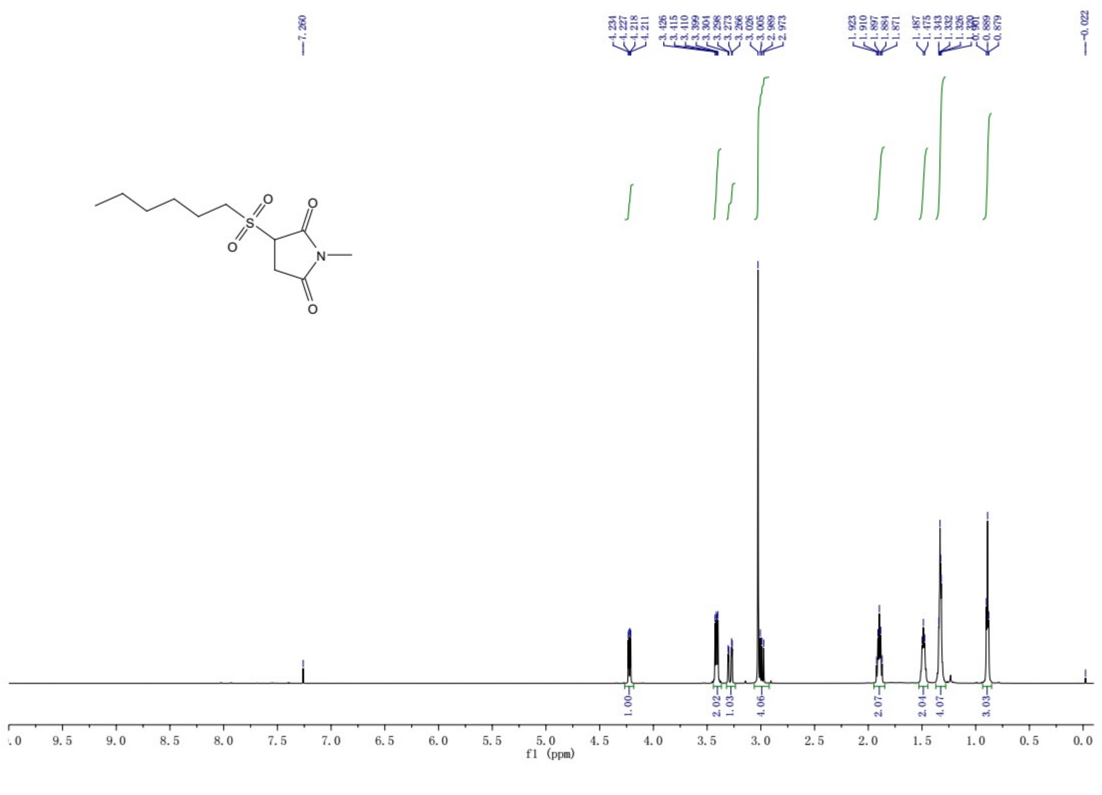
^1H NMR spectrum for compound **4k** ($CDCl_3$, 600 MHz)



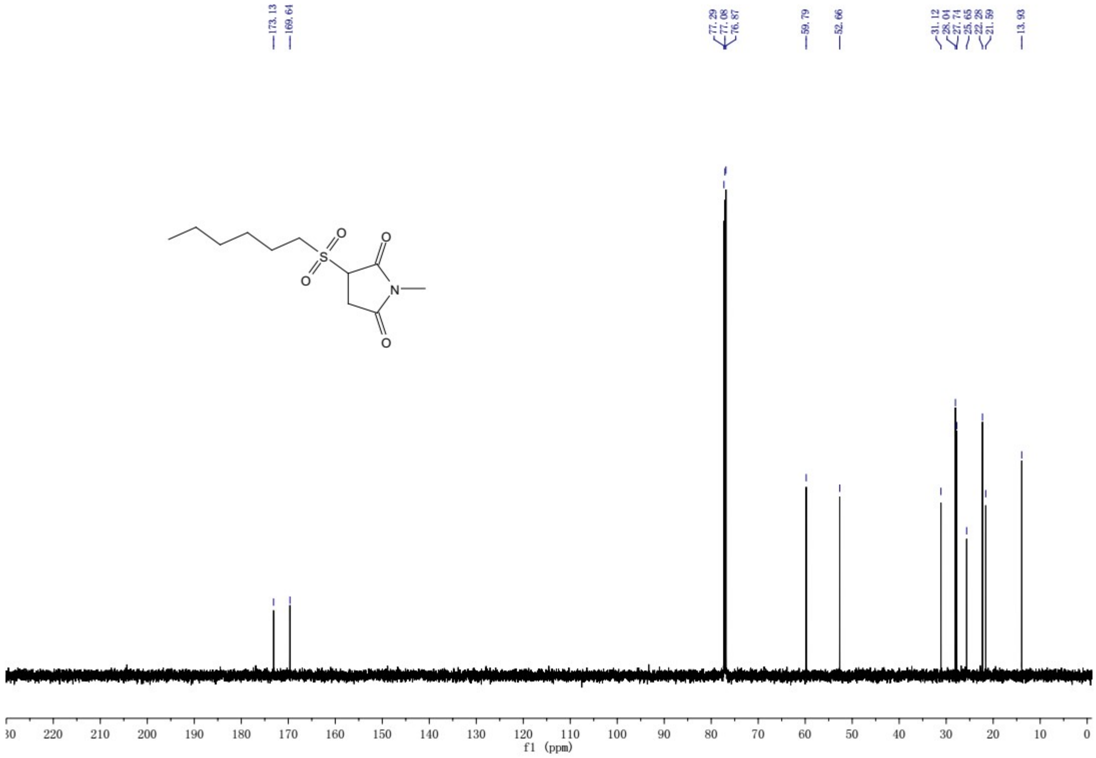
$^{13}C\{^1H\}$ NMR spectrum for compound **4k** ($CDCl_3$, 151 MHz)



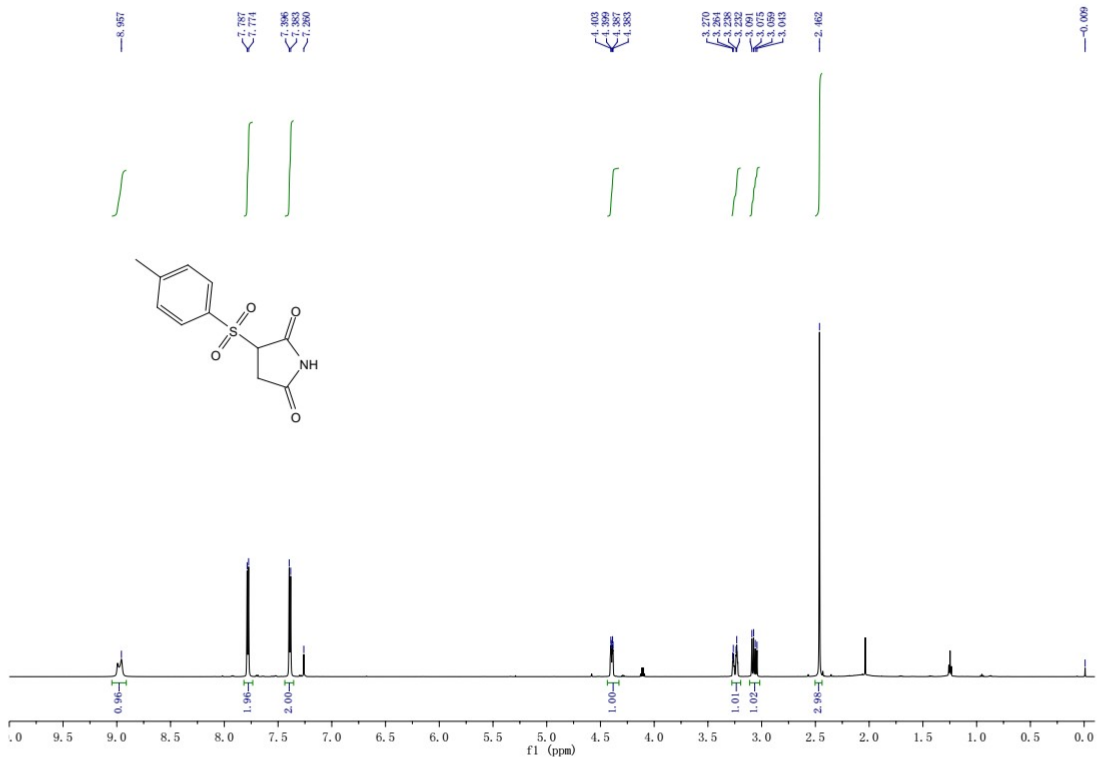
^1H NMR spectrum for compound **4l** ($CDCl_3$, 600 MHz)



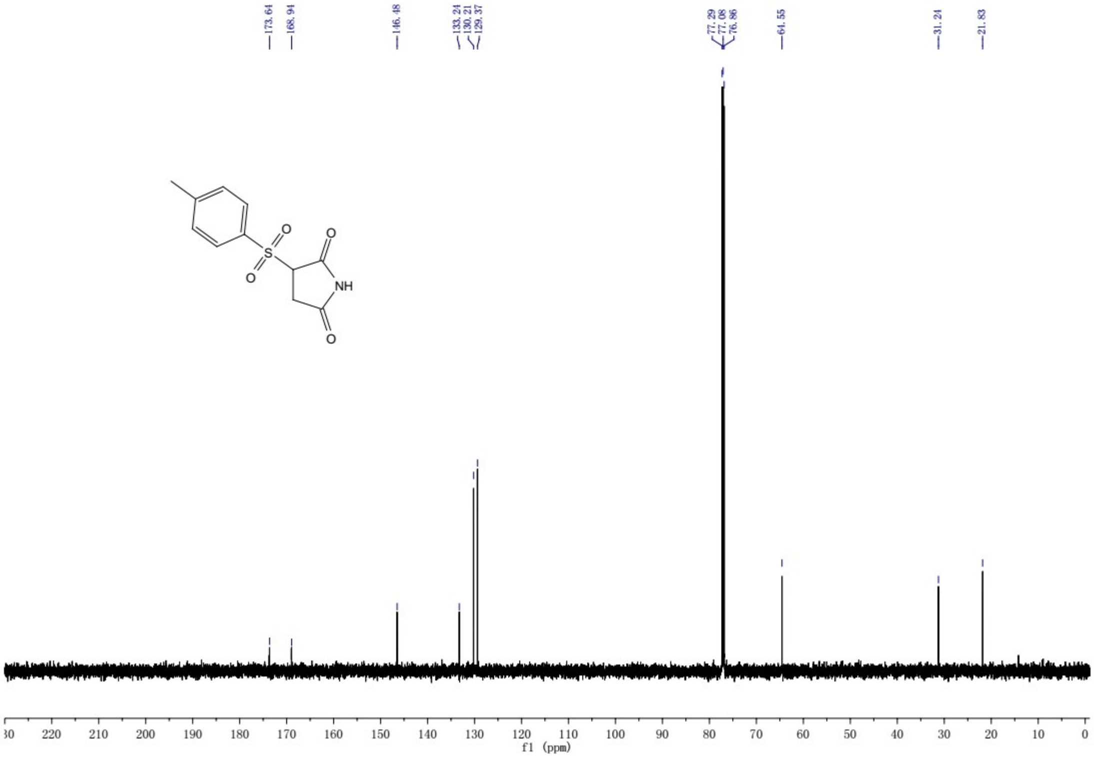
$^{13}C\{^{1}H\}$ NMR spectrum for compound **4l** ($CDCl_3$, 151 MHz)



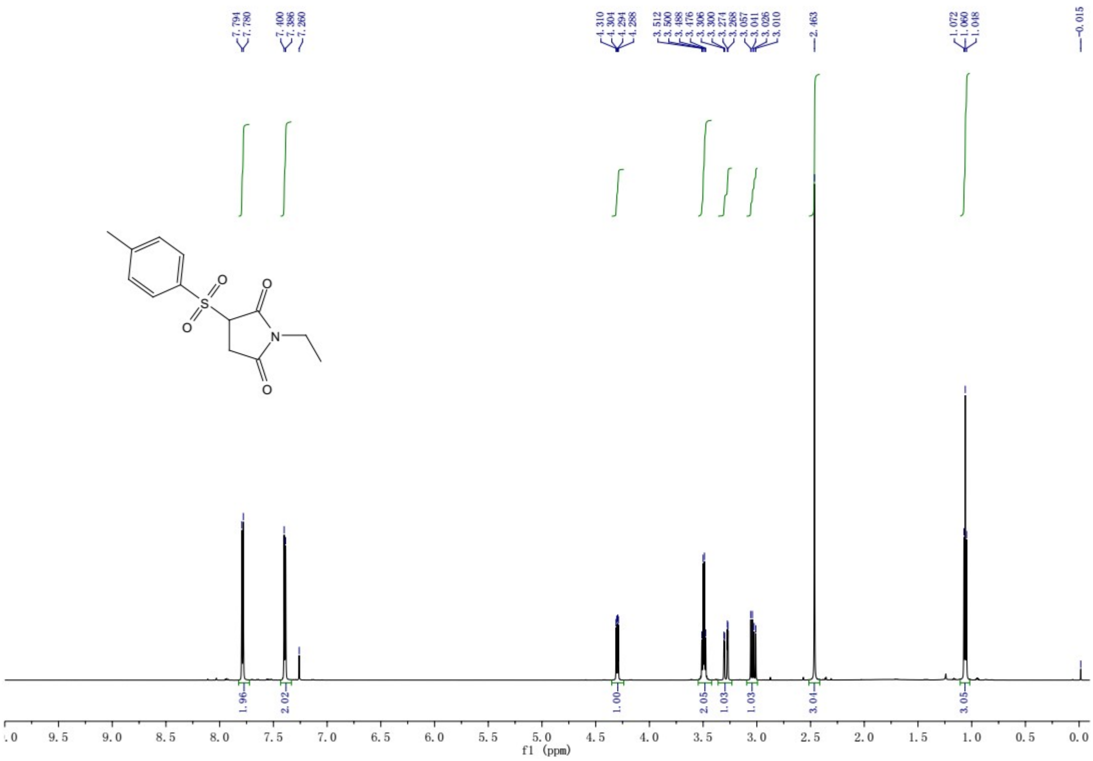
^{1}H NMR spectrum for compound **4m** ($CDCl_3$, 600 MHz)



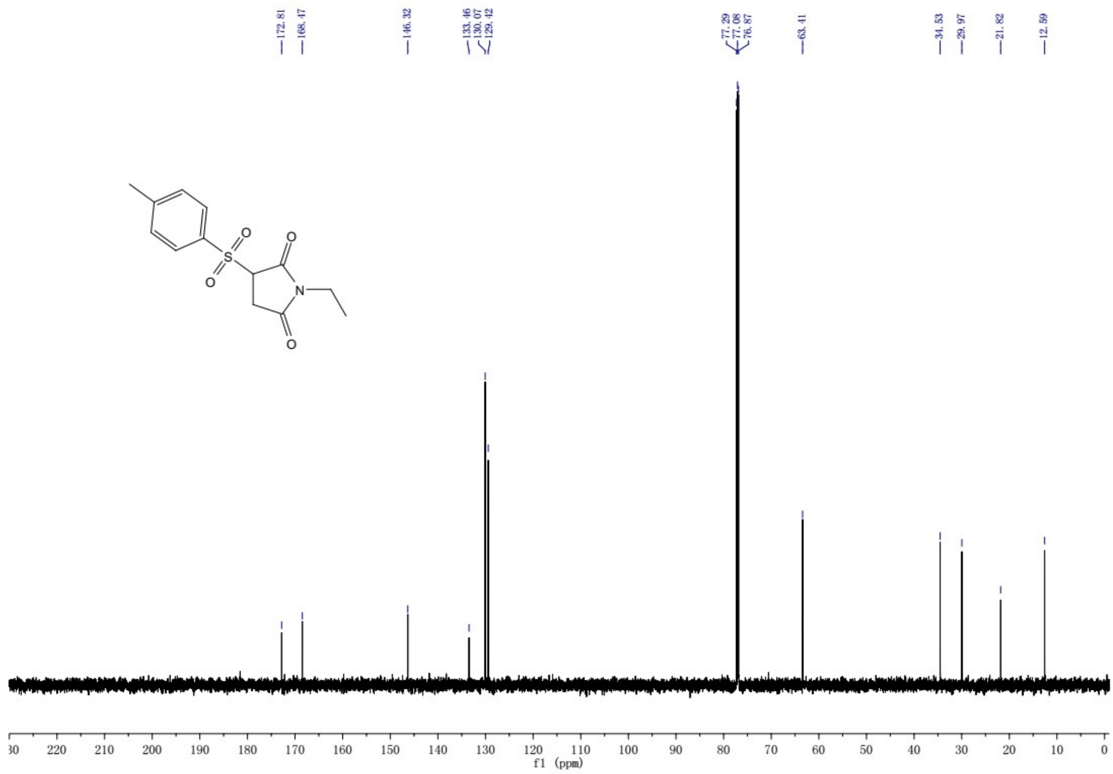
$^{13}C\{^1H\}$ NMR spectrum for compound **4m** ($CDCl_3$, 151 MHz)



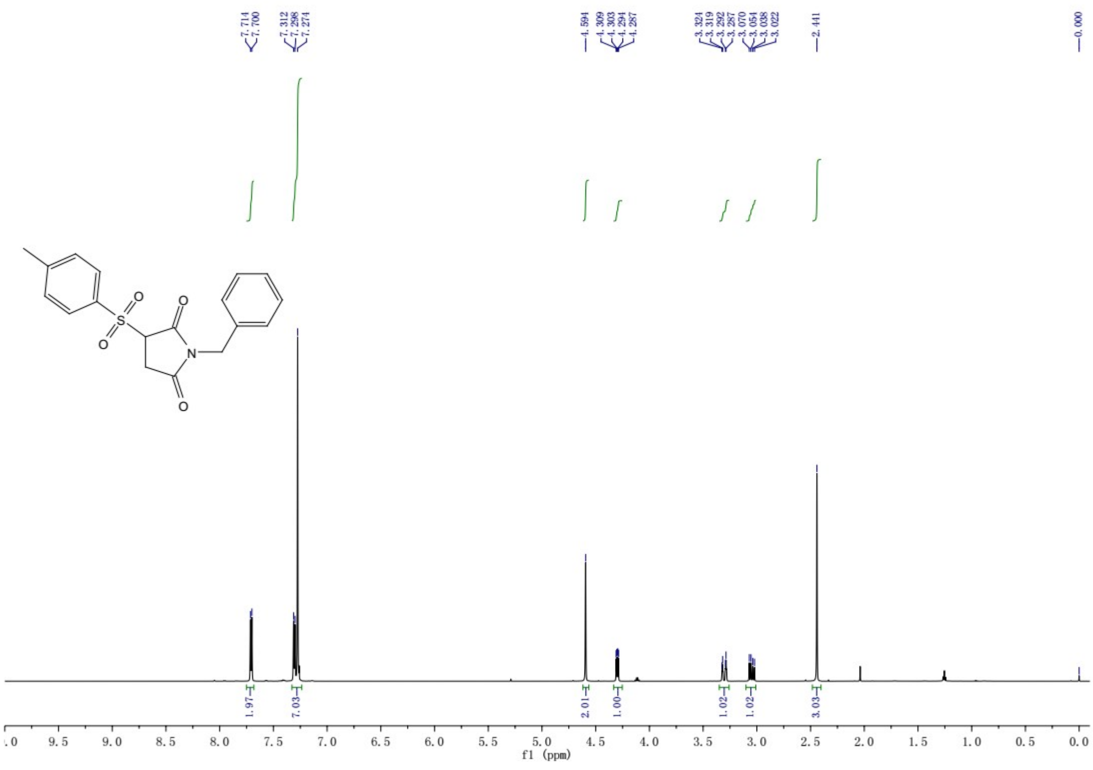
^1H NMR spectrum for compound **4n** ($CDCl_3$, 600 MHz)



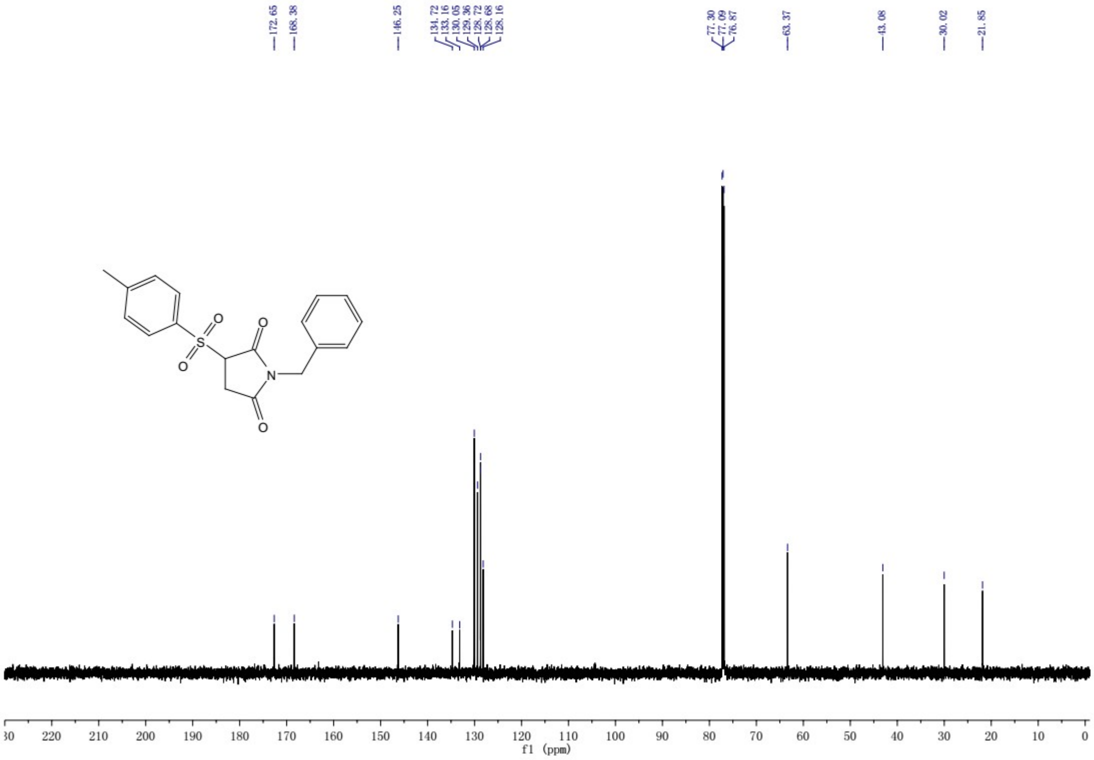
$^{13}C\{^1H\}$ NMR spectrum for compound **4n** ($CDCl_3$, 151 MHz)



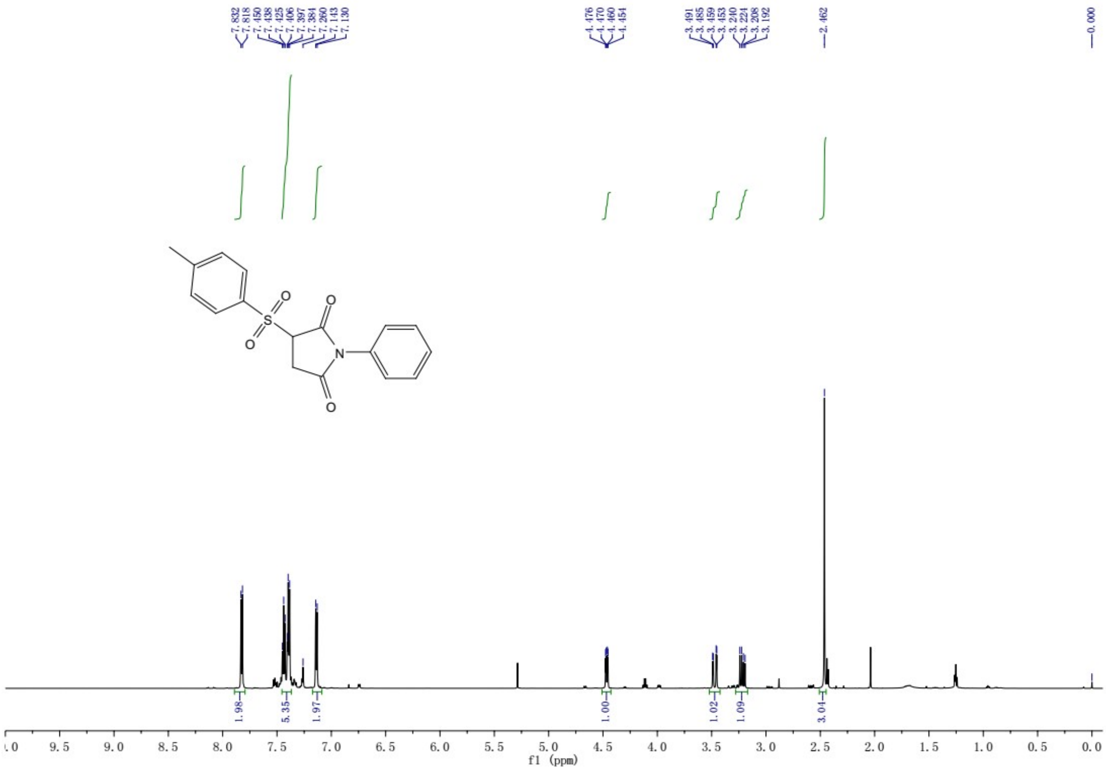
^1H NMR spectrum for compound **4o** ($CDCl_3$, 600 MHz)



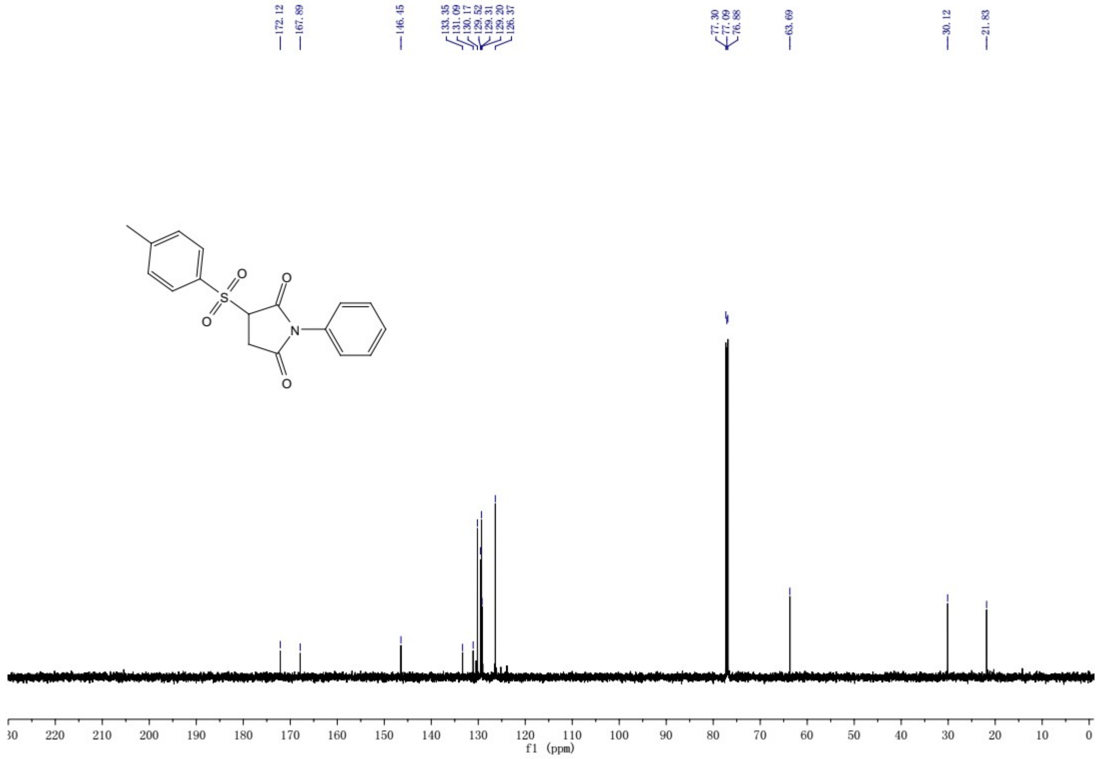
$^{13}C\{^1H\}$ NMR spectrum for compound **4o** ($CDCl_3$, 151 MHz)



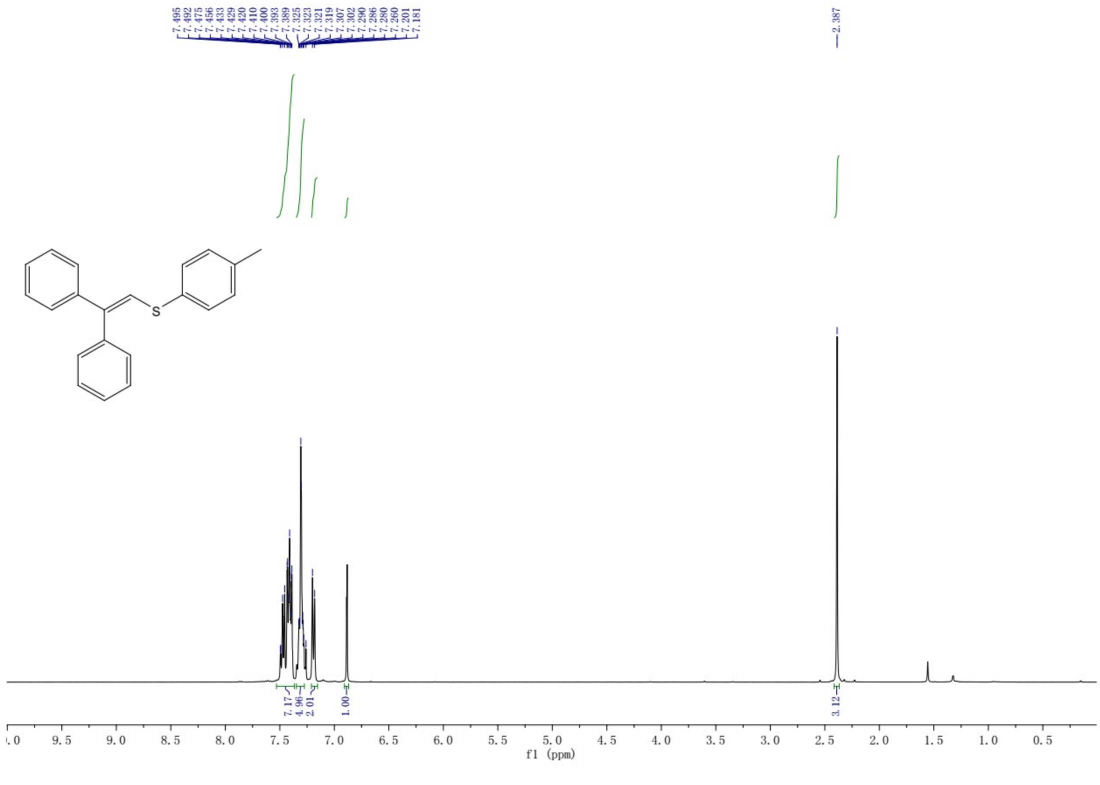
^1H NMR spectrum for compound **4p** ($CDCl_3$, 600 MHz)



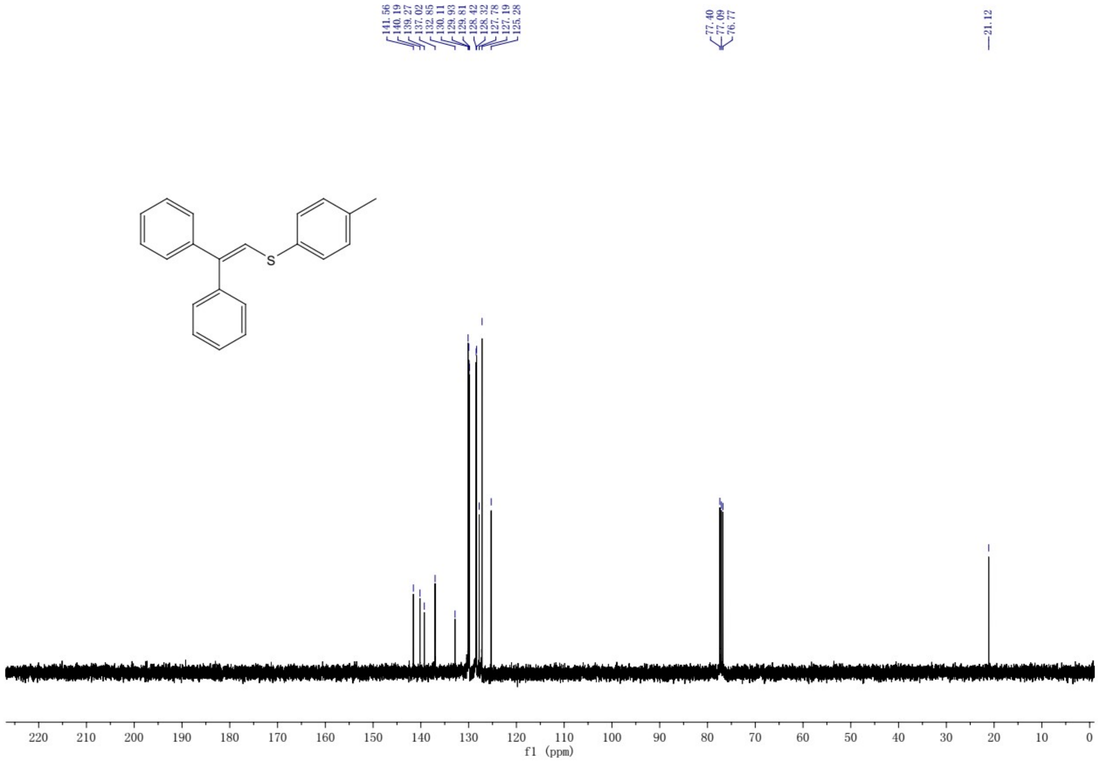
$^{13}C\{^1H\}$ NMR spectrum for compound **4p** ($CDCl_3$, 151 MHz)



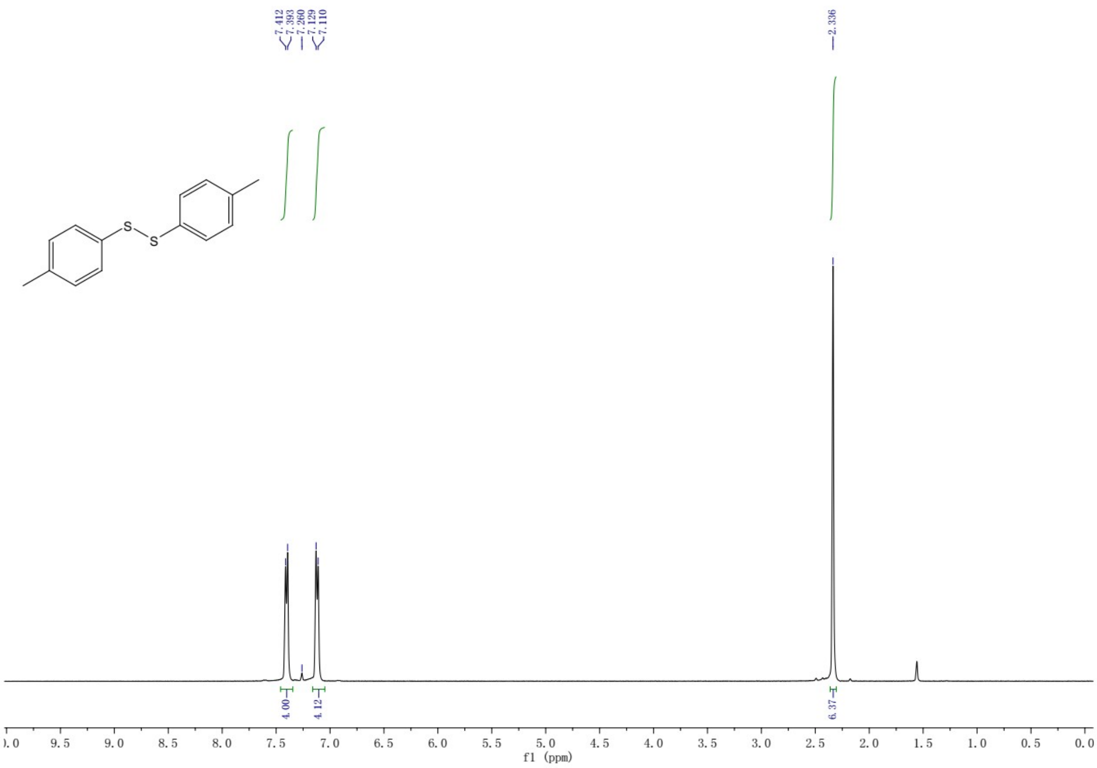
^1H NMR spectrum for compound **5** ($CDCl_3$, 400 MHz)



$^{13}C\{^1H\}$ NMR spectrum for compound **5** ($CDCl_3$, 101 MHz)



^1H NMR spectrum for compound **7** ($CDCl_3$, 400 MHz)



$^{13}C\{^{1}H\}$ NMR spectrum for compound **7** ($CDCl_3$, 101 MHz)