Supporting Information

Electrochemical Oxidative Carbonylation of Hydrazides for the Synthesis of 1,3,4-Oxadiazole-2(3*H*)-ones

Mengyu Peng, Mingzhe Li, Longqiang Zhao, Wenxiu Huang, Shoucai Wang,

Chen Kang, Guangbin Jiang,* Fanghua Ji*

Guangxi Key Laboratory of Electrochemical and Magnetochemical Function Materials, College of Chemistry and Bioengineering, Guilin University of Technology, 12 Jiangan Road, Guilin 541004, China.

E-mail: fanghuaji@glut.edu.cn
E-mail: jianggb@glut.edu.cn

Contents

A. Instrumentation and Chemicals

All purchased reagents and solvents were used without further purification unless otherwise noted. All the electrochemical reactions were performed in an undivided cell unless otherwise noted. The electrolysis instrument used is an adjustable DC regulated power supply (PGD-2303S) (Taiwan Gwinstek Electronic Technology Co., Ltd.). Cyclic voltammograms were obtained on a CHI 760E potentiostat (CH Instruments, Inc.). All the benzoylhydrazine, electrolyte, catalyzed and additives were purchased from WuXi AppTec. TecAnalytical thin-layer chromatography was performed by using commercially prepared 100-400 mesh silica gel plates (GF_{254}) and visualization was effected at 254 nm. ^{1}H and ^{13}C NMR spectras were recorded using a Bruker DRX-500 spectrometer using $CDCl_3$ or DMSO-d6 as solvent. Chemical shifts of 1 H NMR were reported relative to CDCl3 (δ 7.26) or DMSO-d6 (δ 2.50). Chemical shifts of 13C NMR were reported relative to CDCl3 (δ 77.0) or DMSO-d6 (δ 39.52). The data of HRMS was carried out on a high-resolution mass spectrometer (LCMS-IT-TOF). Melting points were determined with a Büchi Melting Point B-545 instrument.

B. Experimental Procedure

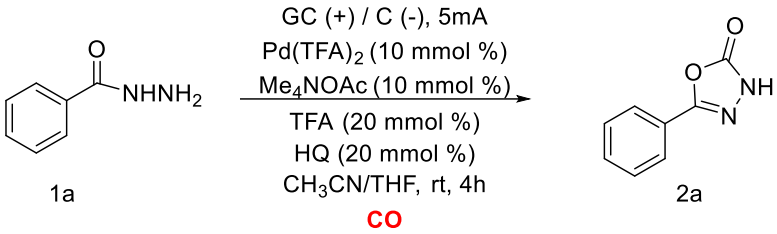
B1. General Procedures for the Electrolysis

B1.1 The Materials Used to Make the Electrolytic Cell

All the materials used to make the electrolytic cell were commercially available. The anode used graphite cloth (1x1.5 cm^2) and cathode used carbon rod (φ= 6 mm, working height = 1.5 cm)

Figure S1. The materials

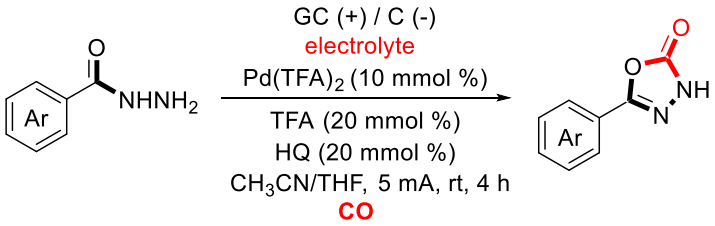
B1.2 General Procedure for the Synthesis of 2a.



Benzoylhydrazine (**1a**) (0.3 mmol, 1.0 equiv), $Pd(TFA)_2$ (0.03 mmol, 10 mmol %), Me_4NOAc (0.03 mmol, 10 mmol %), TFA (0.06 mmol, 20 mmol %), HQ (0.06 mmol, 20 mmol %), CH_3CN:THF(1:1, 5 mL), graphite cloth (1x1.5 cm^2) as anode, carbon rod (φ= 6 mm, working height = 1.5 cm) as the cathode anode, were added in an undivided cell with 5 mA constant current for 4 hours under balloon pressure of CO. After the reaction was completed (monitored by TLC), the resulting mixture was extracted with ethyl acetate, dried over anhydrous $MgSO_4$, filtered and evaporated in vacuo. The desired products **2a** were obtained in the corresponding yields after being purified by column chromatography on silica gel with a mixture of petroleum ether and ethyl acetate.

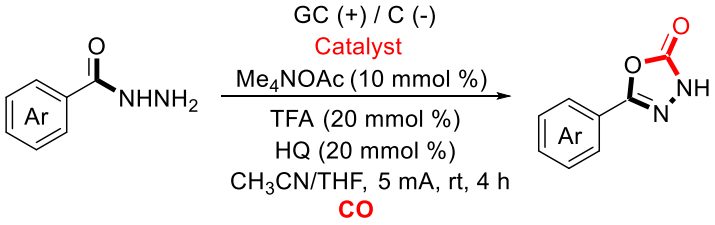
B2. Optimization of the Reaction Conditions

Table S1. Optimization of 2a



Entry[a]	Electolyte	Yield[b] (**2a** %)
1	$^{n}Bu_4NBF_4$	55
2	Et_4NBF_4	36
3	$^{n}Bu_4NOAc$	43
4	$^{n}Bu_4NI$	Trace
5	$LiClO_4$	Trace
6	$^{n}Bu_4NPF_6$	40
7	Et_4NBr	N.R.
8	$^{n}Bu_4NBr$	N.R.

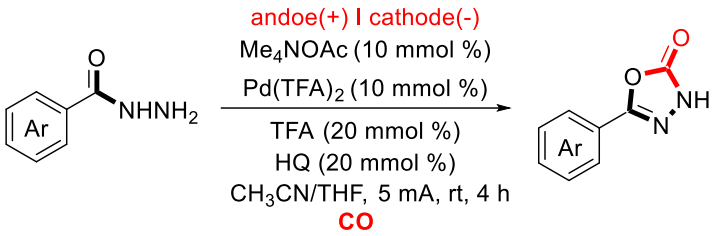
[a]Reaction conditions: **1a** (0.30 mmol), $Pt(TFA)_2$ (10.0 mmol%), Electolyte (10 mmol%), additives (20 mmol%), HQ (20 mmol%), CH_3CN/THF (1:1, 5ml) in an undivided cell with a graphite cloth anode, a graphite cathode, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.



Entry[a]	Catalyst	Yield[b] (**2a** %)
1	$Pd(OAc)_2$	67
2	$Pd(MeCN)Cl_2$	31
3	$PdCl_2$	33
4	$Pd(PPh_3)Cl_2$	28

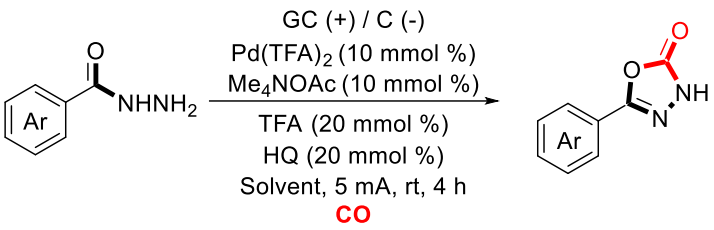
[a]Reaction conditions: **1a** (0.30 mmol), Catalyst (10.0 mmol%), Me_4NOAc (10 mmol%), additives

(20 mmol%), HQ (20 mmol%), CH_3CN/THF (1:1, 5ml) in an undivided cell with a graphite cloth anode, a graphite cathode, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.



Entry[a]	**anode/cathode**	Yield[b] (**2a** %)
1	C/SS	42
2	C/Pt	58
3	C/GC	36
4	C/C	23
5	C/Zn	N.R.
6	C/Mg	N.R.
7	GC/C	60
8	Pt/Ni	Trace

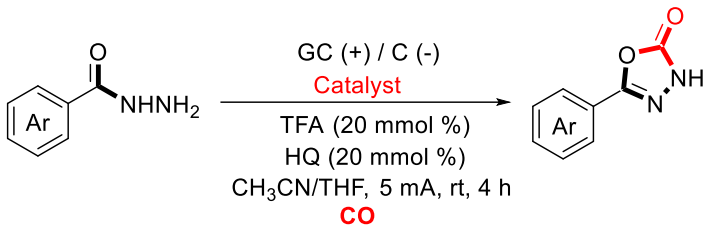
[a]Reaction conditions: **1a** (0.30 mmol), $Pt(TFA)_2$ (10.0 mmol%), Me_4NOAc (10 mmol%), additives (20 mmol%), HQ (20 mmol%), CH_3CN/THF (1:1, 5ml) in an undivided cell, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.



Entry [a]	Solvent	Yield[b] (**2a** %)
1	CH_3CN	68
2	DCE	29
3	DMF	N.R.
4	DMSO	32
5	EtOH	N.R.
6	THF	62
7	1,4-Dioxane	N.R.
8	acetone	N.R.

[a]Reaction conditions: **1a** (0.30 mmol), $Pt(TFA)_2$ (10.0 mmol%), Me_4NOAc (10 mmol%), TFA (20 mmol%), HQ (20 mmol%), Solvent (5 ml) in an undivided cell, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.

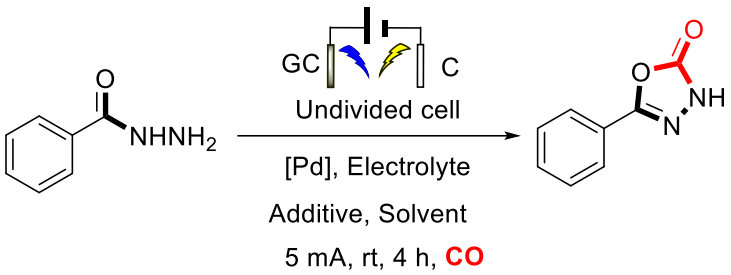
Table S2. Optimization of 2a with different catalysts



Entry [a]	Catalyst	Yield[b] (**2a** %)
1	$Cu(TFA)_2$	N.R.
2	$CuCl_2$	N.R.
3	$FeCl_3$	N.R.
4	$Fe(NO_3)_3$	N.R.
5	$NiCl_2$	N.R.
6	$Ni(PPh_3)Cl_2$	N.R.

[a]Reaction conditions: **1a** (0.30 mmol), Catalyst (10.0 mmol%), Me_4NOAc (10 mmol%), additives (20 mmol%), HQ (20 mmol%), CH_3CN/THF (1:1, 5ml) in an undivided cell with a graphite cloth anode, a graphite cathode, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.

Table S3. Optimization of 2a in the absence of HQ

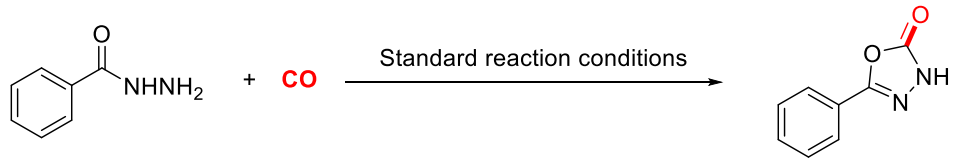


Entry [a]	Condition	Yield[b] (**2a** %)
1	$^nBu_4NOAc$	47
2	$^nBu_4NPF_6$	29
3	Et_4NBF_4	30
4	$PdCl_2$	30
5	$Pd(OAc)_2$	55
6	$Pd(PPh_3)Cl_2$	Trace
7	THF	61
8	DMSO	34
9	CH_3CN	58

[a]Reaction conditions: **1a** (0.30 mmol), Catalyst (10.0 mmol%), Electolyte (10 mmol%), additives (20 mmol%), HQ (20 mmol%), Solvent in an undivided cell with a graphite cloth anode, a graphite cathode, CO balloon, rt, 5 mA, 4 h, 2.5 F/mol. [b]Isolated yield. [c]N. R. = No Reaction.

C. Gram-Scale Experiment

Gram-Scale Reaction



1a, 8 mmol, 1.088 g

2a, 67%

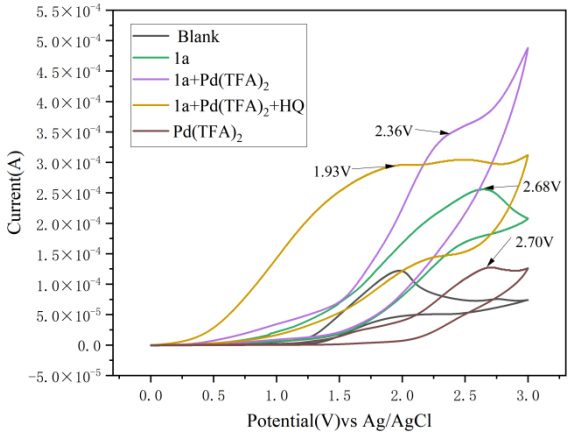
benzoylhydrazine (**1**) (8 mmol, 1.088 g), $Pd(TFA)_2$ (4 mmol %, 100 mg), Me_4NOAc (10 mmol %, 100 mg), TFA (10 mmol %, 115 mg), HQ (10 mmol %, 88 mg), CH_3CN:THF(1:1, 120 mL), graphite cloth (40 mm × 50 mm) as anode, carbon rod (φ= 6 mm, working height = 15 cm) as the cathode anode, were added in an undivided three-necked bottle (250 mL) with 10 mA constant current for 24 hours under balloon pressure of CO. After the reaction was completed (monitored by TLC), the resulting mixture was extracted with ethyl acetate, dried over anhydrous $MgSO_4$, filtered and evaporated in vacuo. The desired products **2a** were obtained in the corresponding yields after being purified by column chromatography on 200-300 mesh silica gel with a mixture of petroleum ether and ethyl acetate (petroleum : EtOAc= 5 : 1).

D. Preliminary Mechanistic Studies

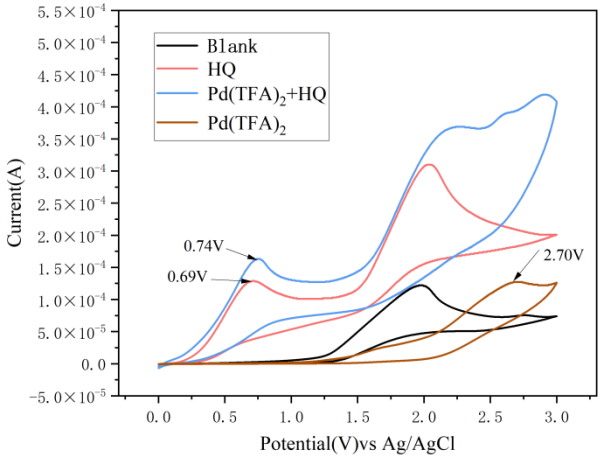
D.1. Cyclic Voltammetry Experiments

The cyclic voltammetry experiments were carried out with a computer-controlled electrochemical analyzer for electrochemical measurements. The experiment was performed in a three-electrode cell (volume 15 mL) with CH_3CN as the solvent, $^nMe_4NOAc$ (0.05 M) as the supporting electrolyte, the tested compound (0.1 M), glassy carbon (diameter 3 mm) as the working electrode, Pt wire as the auxiliary electrode, and Ag/AgCl (saturated aqueous KCl) as the reference electrode. The scan speed was 50 mV/s. The potential ranges investigated were 0 V to +3.0 V vs Ag/AgCl (saturated aqueous KCl) for background.

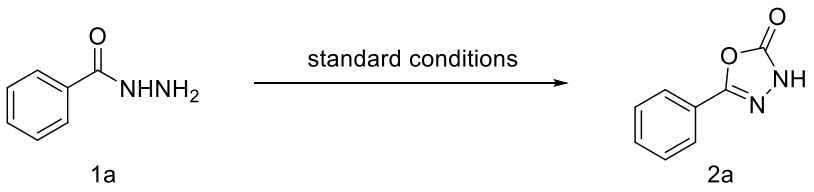
(a) CV of 1a and additives



(b) CV of catalytic and additive



E. H_2 Detection Experiments



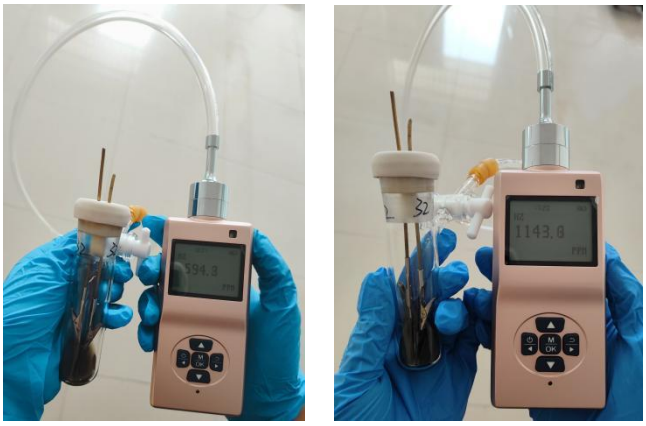
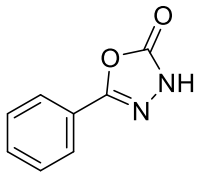


Figure S2 H_2 detection experiment by a H_2 detector

In order to prove the mechanism, the model reaction of benzoylhydrazine (**1a**), were monitored by a H_2 detector under standard conditions. Just as shown in Figure S2, as the reaction proceeded, the H_2 was observed clearly and the concentration increased gradually.

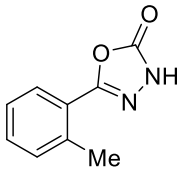
F. Characterisation Data

5-Phenyl-1,3,4-oxadiazol-2(3*H*)-one (2a)



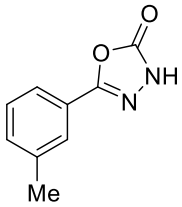
Yield 40.4 mg (83%, white solid); ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.24 (s, 1H), 7.88 (d, *J* = 7.7 Hz, 2H), 7.51 (dt, *J* = 15.1, 7.3 Hz, 3H). $^{13}C\{^{1}H\}$ NMR (125 MHz, $CDCl_3$) δ 155.35, 155.25, 131.78, 129.02, 125.82, 123.76. HRMS (ESI-TOF) m/z: $[M+Na]^+$ Calcd ($C_8H_6N_2NaO_2$ 185.0321); Found 185.0322.

5-(*o*-tolyl)-1,3,4-oxadiazol-2(3*H*)-one (2b)



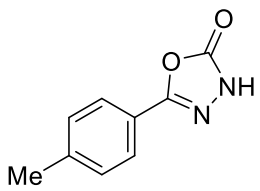
Yield 32.6 mg (72%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.76-7.66 (m, 1H), 7.49-7.42 (m, 1H), 7.41-7.34 (m, 2H), 2.53 (s, 3H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 154.71, 154.59, 137.35, 132.13, 131.38, 128.18, 126.82, 123.30, 21.82.

5-(*m*-tolyl)-1,3,4-oxadiazol-2(3*H*)-one (2c)



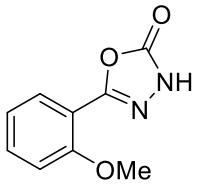
Yield 29.5 mg (65%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.55 (s, 1H), 7.74-7.50 (m, 2H), 7.49-7.22 (m, 2H), 2.37 (s, 3H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 154.94, 154.34, 139.16, 132.55, 129.58, 126.02, 124.38, 122.89, 21.26.

5-(*p*-tolyl)-1,3,4-oxadiazol-2(3*H*)-one (2d)



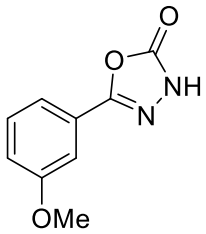
Yield 29.5 mg (65%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.52 (s, 1H), 7.67 (d, J = 8.2 Hz, 2H), 7.35 (d, J = 8.0 Hz, 2H), 2.37 (s, 3H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.95, 154.38, 141.96, 130.22, 125.66, 121.71, 21.53.

5-(2-methoxyphenyl)-1,3,4-oxadiazol-2(3*H*)-one (2e)



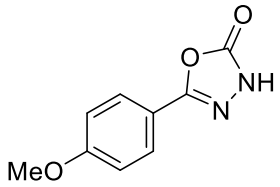
Yield 34.6 mg (60%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.49 (s, 1H), 7.75 – 7.44 (m, 1H), 7.27 – 6.95 (m, 1H), 3.87 (s, 1H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 157.92, 155.71 – 154.71 (m), 153.12, 133.50, 129.62, 121.22, 113.21, 113.17, 56.33 (d, J = 5.4 Hz).

5-(3-methoxyphenyl)-1,3,4-oxadiazol-2(3H)-one (2f)



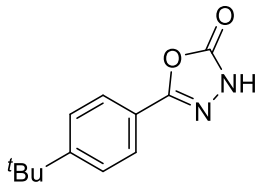
Yield 31.1 mg (54%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.60 (s, 1H), 7.47 (t, J = 8.0 Hz, 1H), 7.38 (d, J = 7.6 Hz, 1H), 7.27 (s, 1H), 7.15 (d, J = 8.1 Hz, 1H), 3.83 (s, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 160.06, 154.91, 154.12, 131.03, 125.67, 118.03, 110.46, 55.85.

5-(4-methoxyphenyl)-1,3,4-oxadiazol-2(3*H*)-one (2g)



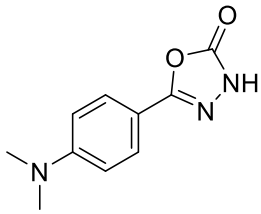
Yield 27.5 mg (55%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.45 (s, 1H), 7.72 (d, J = 8.3 Hz, 2H), 7.08 (d, J = 8.4 Hz, 2H), 3.82 (s, 3H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 162.07, 155.00, 154.31, 127.53, 116.78, 115.14, 55.91.

5-(4-(tert-butyl)phenyl)-1,3,4-oxadiazol-2(3*H*)-one (2h)



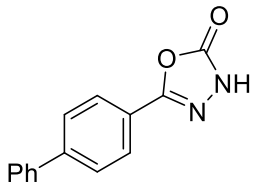
Yield 45.6 mg (79%, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.54 (s, 1H), 7.71 (d, J = 8.2 Hz, 2H), 7.55 (d, J = 8.2 Hz, 2H), 1.29 (s, 9H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.97, 154.78, 154.32, 126.48, 125.56, 121.73, 35.20, 31.25.

5-(4-(dimethylamino)phenyl)-1,3,4-oxadiazol-2(3*H*)-one (2i)



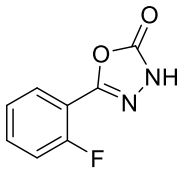
Yield 26.9 mg (50 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.11 (s, 1H), 7.76 (d, J = 8.5 Hz, 2H), 6.71 (d, J = 8.6 Hz, 2H), 2.99 (s, 4H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 168.00, 153.54, 131.37, 117.40, 117.37, 111.21, 40.12.

5-([1,1′-biphenyl]-4-yl)-1,3,4-oxadiazol-2(3*H*)-one (2j)



Yield 44.6 mg (70 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) 12.59 (s, 1H), 7.86 (t, J = 7.1 Hz, 4H), 7.74 (d, J = 7.7 Hz, 2H), 7.50 (d, J = 7.6 Hz, 1H), 7.43 (d, J = 7.4 Hz, 1H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.98,143.32, 139.31, 129.59, 128.75, 127.87, 127.28, 126.34, 123.37.

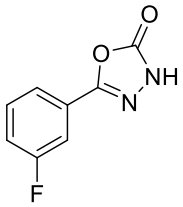
5-(2-fluorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2k)



Yield 31.3 mg (58 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.71 (s, 1H), 7.81 (t, J = 7.6 Hz, 1H), 7.63 (q, J = 7.1 Hz, 1H), 7.44-7.35 (m, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 159.52 (d, J

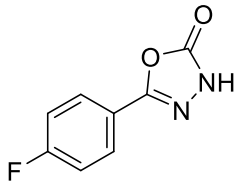
= 255.0 Hz), 154.66, 150.97 (d, *J* = 5.1 Hz), 133.95 (d, *J* = 8.4 Hz), 128.93, 125.62 (d, *J* = 4.0 Hz), 117.44 (d, *J* = 20.3 Hz), 112.69 (d, *J* = 11.0 Hz). ^{19}F NMR (471 MHz, DMSO-d_6) δ -111.43.

5-(3-fluorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2l)



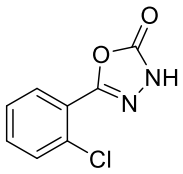
Yield 31.8 mg (59 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.69 (s, 1H), 7.66-7.54 (m, 4H), 7.43 (t, *J* = 7.9 Hz, 1H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 162.70 (d, *J* = 243.8 Hz), 154.78, 153.26 (d, *J* = 3.5 Hz), 132.11 (d, *J* = 8.7 Hz), 126.56 (d, *J* = 8.5 Hz), 121.99 (d, *J* = 2.9 Hz), 118.87 (d, *J* = 21.1 Hz), 112.50 (d, *J* = 24.5 Hz). ^{19}F NMR (471 MHz, DMSO-d_6) δ -111.49 (q, *J* = 8.7 Hz).

5-(4-fluorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2m)



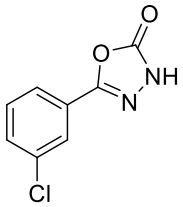
Yield 27.8 mg (60 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.60 (s, 1H), 7.83 (dd, *J* = 8.3, 5.3 Hz, 2H), 7.37 (t, *J* = 8.6 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 164.19 (d, *J* = 248.8 Hz), 154.89, 153.54, 128.33 (d, *J* = 8.8 Hz), 121.08 (d, *J* = 3.8 Hz), 116.90 (d, *J* = 22.5 Hz). ^{19}F NMR (471 MHz, DMSO-d_6) δ -108.12 (td, *J* = 9.0, 4.3 Hz).

5-(2-chlorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2n)



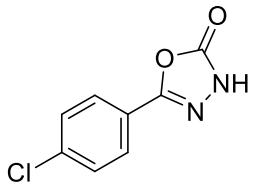
Yield 38.2 mg (65 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.76 (s, 1H), 7.82 (d, *J* = 7.7 Hz, 1H), 7.67-7.47 (m, 3H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.69, 152.41, 133.13, 131.62 (d, *J* = 5.4 Hz), 130.77, 128.20, 123.23.

5-(3-chlorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2o)



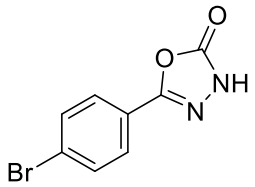
Yield 35.7 mg (70 %, white solid); mp 135.7-151.4 ℃. ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.72 (s, 1H), 7.74 (d, J = 7.6 Hz, 3H), 7.61 (dd, J = 27.5, 7.9 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.73, 153.06, 134.41, 131.70 (d, J = 2.7 Hz), 126.40, 125.20, 124.38. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_8H_6ClN_2O_2$ 197.0112); Found 197.0116 .

5-(4-chlorophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2p)



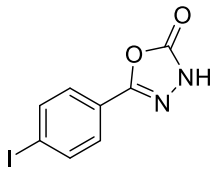
Yield 34.7 mg (68 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.67 (s, 1H), 7.91-7.70 (m, 2H), 7.62 (dd, J = 8.7, 2.2 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6)) δ 154.84, 153.48, 136.53, 129.88, 127.52, 123.34.

5-(4-bromophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2q)



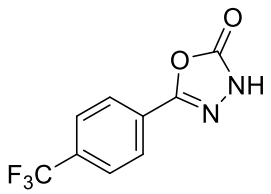
Yield 43.7 mg (68 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.67 (s, 1H), 7.74 (q, J = 8.3 Hz, 4H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.82, 153.58, 132.78, 127.64, 125.37, 123.69.

5-(4-iodophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2r)



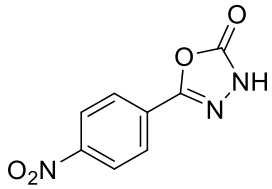
Yield 42.5 mg (54 %, white solid); mp 215.5-220.7 ℃. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.92 (d, J = 8.1 Hz, 1H), 7.55 (d, J = 8.2 Hz, 1H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 153.74, 138.54, 127.30, 124.18, 98.86. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_8H_6IN_2O_2$ 288.9468); Found 288.9474.

5-(4-(trifluoromethyl)phenyl)-1,3,4-oxadiazol-2(3*H*)-one (2s)



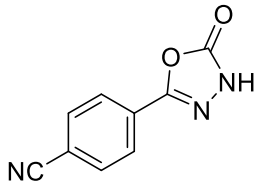
Yield 33.7 mg (55 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 13.23-12.36 (m, 1H), 7.97 (d, J = 8.1 Hz, 2H), 7.88 (d, J = 8.1 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.74, 153.10, 131.45 (q, J = 31.3 Hz), 128.18, 127.44, 126.61 (q, J = 3.8 Hz), 126.47, 124.19 (d, J = 270.0 Hz). ^{19}F NMR (471 MHz, DMSO-d_6) δ -61.67.

5-(4-nitrophenyl)-1,3,4-oxadiazol-2(3*H*)-one (2t)



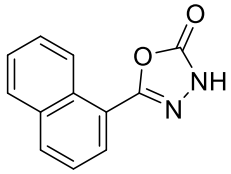
Yield 23.4 mg (43 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.94 (s, 1H), 8.36 (d, J = 8.7 Hz, 2H), 8.03 (d, J = 8.8 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.69, 152.79, 149.18, 130.04, 127.00, 124.94.

4-(5-oxo-4,5-dihydro-1,3,4-oxadiazol-2-yl)benzonitrile (2u)



Yield 22.8 mg (47 %, white solid); mp 148.5−153.7 °C. ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.88 (s, 1H), 8.02 (d, J = 8.2 Hz, 2H), 7.95 (d, J = 8.2 Hz, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 154.70, 152.99, 133.68, 128.46, 126.40, 118.64, 113.94. HRMS (ESI-TOF) m/z: [M+Na]$^{+}$ Calcd ($C_9H_5N_3NaO_2$ 210.0274); Found 210.0279.

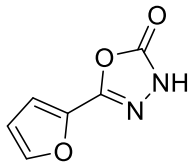
5-(naphthalen-1-yl)-1,3,4-oxadiazol-2(3*H*)-one (2v)



Yield 29.6 mg (53 %, white solid); mp 158.5−163.1 °C. ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.80 (s, 1H), 8.88 (d, J = 8.6 Hz, 1H), 8.16 (d, J = 8.2 Hz, 1H), 8.07 (d, J = 8.1 Hz, 1H), 8.02 (d, J = 7.3 Hz,

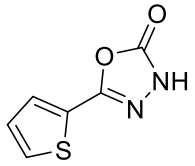
1H), 7.71 (t, *J* = 7.7 Hz, 1H), 7.65 (td, *J* = 7.8, 7.4, 3.2 Hz, 2H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 154.56, 154.36, 133.85, 132.62, 129.41, 129.17, 128.56, 128.18, 127.20, 125.75, 125.50, 120.42. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_{12}H_9N_2O_2$ 213.0659); Found 213.0664.

5-(Furan-2-yl)-1,3,4-oxadiazol-2(3*H*)-one (2w)



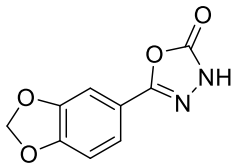
Yield 29.2 mg (77 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.64 (s, 1H), 7.97 (s, 1H), 7.14 (d, *J* = 3.5 Hz, 1H), 6.77-6.67 (m, 1H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 154.25, 147.77, 146.77, 139.20, 113.71, 112.70.

5-(thiophen-2-yl)-1,3,4-oxadiazol-2(3*H*)-one (2x)



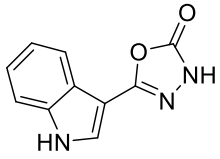
Yield 22.6 mg (53 %, white solid); mp 120.7−122.3 °C. ^{1}H NMR (500 MHz, DMSO-d_6) δ 12.58 (s, 1H), 7.86 (d, *J* = 5.0 Hz, 1H), 7.63 (d, *J* = 3.6 Hz, 1H), 7.23 (t, *J* = 4.3 Hz, 1H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 154.49, 151.04, 130.85, 129.55, 128.87, 125.79. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_6H_5N_2O_2S$ 169.0066); Found 169.0072.

5-(benzo[d][1,3]dioxol-5-yl)-1,3,4-oxadiazol-2(3*H*)-one (2y)



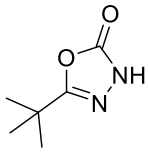
Yield 25.9 mg (48 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.40 – 7.30 (m, 1H), 7.27 (t, *J* = 2.0 Hz, 1H), 7.07 (dd, *J* = 8.1, 2.2 Hz, 1H), 6.14 (d, *J* = 2.2 Hz, 2H). $^{13}C\{^{1}H\}$ NMR (125 MHz, DMSO-d_6) δ 155.15, 154.08, 150.40, 148.48, 120.86, 118.27, 109.39, 105.45, 102.45.

5-(1H-indol-3-yl)-1,3,4-oxadiazol-2(3H)-one (2z)



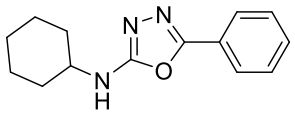
Yield 31.9 mg (60 %, white solid); mp 89.8−93.5 ℃. ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.91 (s, 1H), 11.80 (s, 1H), 8.06 – 7.97 (m, 2H), 7.46 (d, J = 7.8 Hz, 1H), 7.20 – 7.13 (m, 2H). ^{13}C{^{1}H} NMR (125 MHz, DMSO-d_6) δ 166.39, 136.89, 132.72, 126.46, 122.59, 121.43, 121.03, 112.65, 107.82. HRMS (ESI-TOF) m/z: $[M+Na]^+$ Calcd ($C_{10}H_7N_3NaO_2$ 224.0430); Found 224.0436.

5-(tert-butyl)-1,3,4-oxadiazol-2(3*H*)-one (2aa)



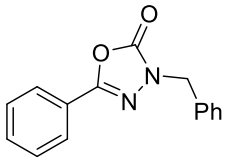
Yield 18.3 mg (43 %, white solid); ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.21 (s, 1H), 1.14 (s, 9H). ^{13}C NMR (125 MHz, DMSO-d_6) δ 177.08, 37.92, 27.72.

N-cyclohexyl-5-phenyl-1,3,4-oxadiazol-2-amine (3a)



Yield 61.3 mg (84 %, white solid); mp 111.8−114.5 °C. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.92 – 7.77 (m, 1H), 7.74 (d, J = 7.6 Hz, 1H), 7.57 – 7.46 (m, 2H), 3.42 (s, 1H), 2.00 – 1.92 (m, 1H), 1.71 (t, J = 4.5 Hz, 1H), 1.30 (p, J = 7.2 Hz, 2H). ^{13}C{^{1}H} NMR (126 MHz, DMSO-d_6) δ 163.38, 157.76, 130.81, 129.67, 125.51, 124.81, 52.27, 32.75, 25.64, 24.83. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_{14}H_{18}N_3O_2$ 244.1444); Found 244.1450.

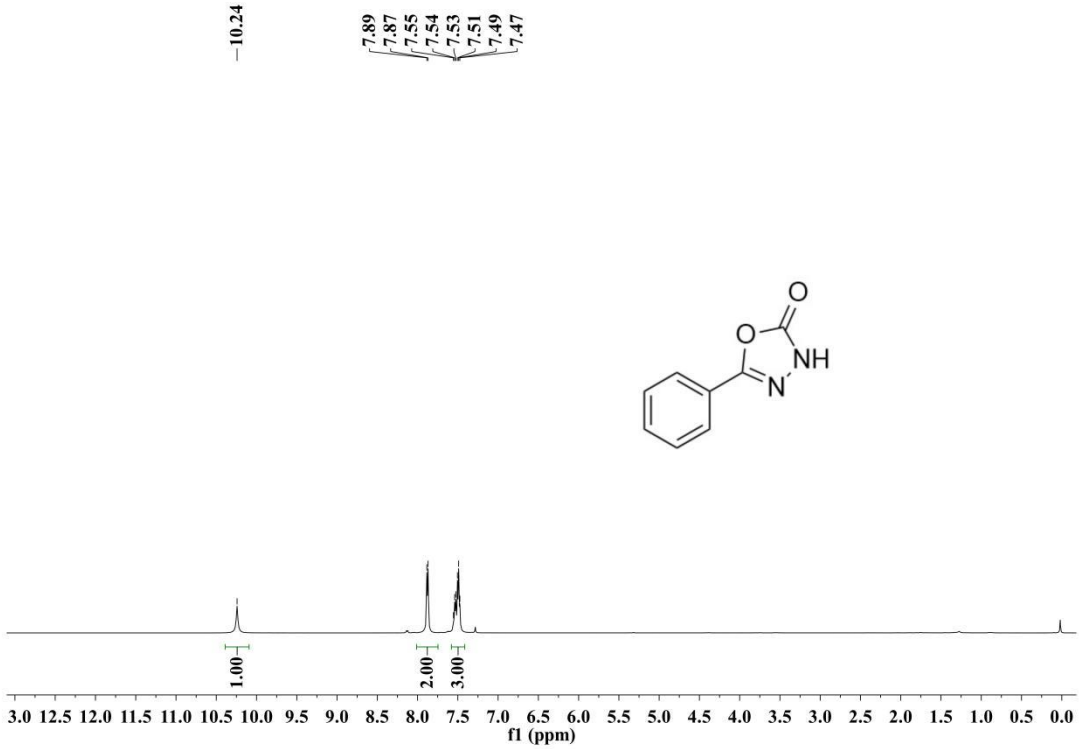
3-benzyl-5-phenyl-1,3,4-oxadiazol-2(3H)-one (3b)



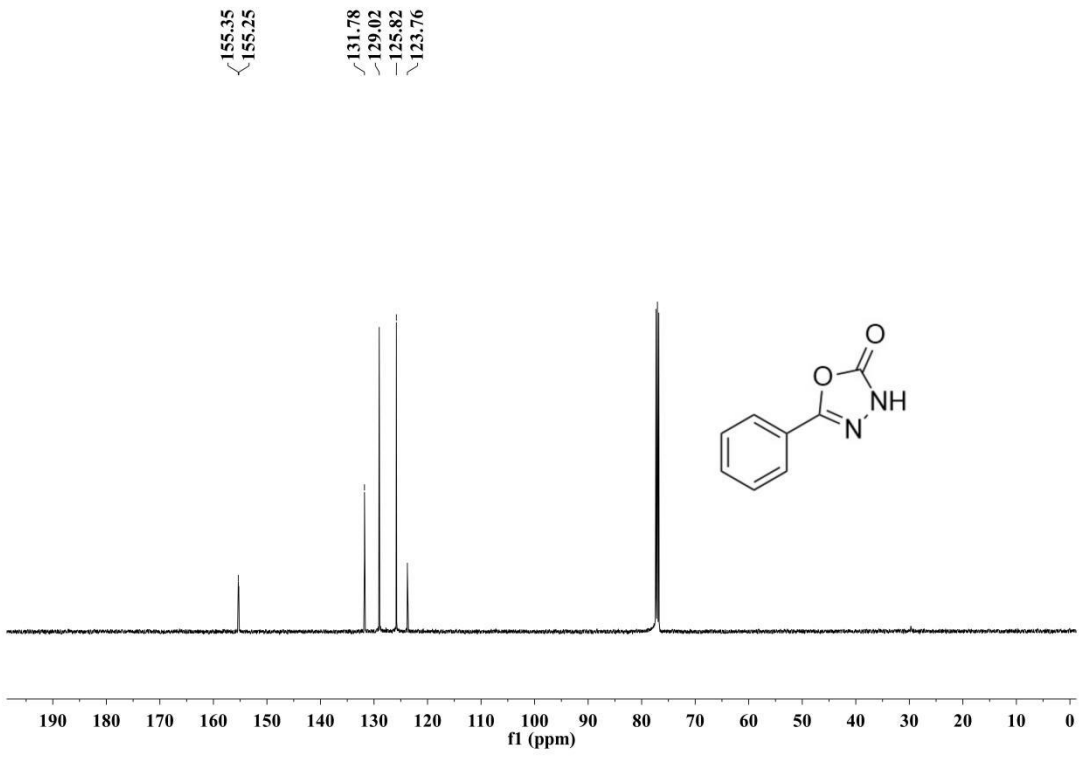
Yield 5.2 mg (73 %, white solid); mp 116.3−119.1 °C. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.85 (d, J = 7.5 Hz, 1H), 7.43 (dtd, J = 28.8, 14.7, 14.1, 7.0 Hz, 4H), 4.98 (s, 1H). ^{13}C{^{1}H} NMR (126 MHz, DMSO-d_6) δ 153.59, 153.37, 134.98, 131.57, 128.91 (d, J = 5.2 Hz), 128.37 (d, J = 7.9 Hz), 125.72, 123.85, 49.79. HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd ($C_{15}H_{13}N_2O_2$ 253.0972); Found 253.0977.

G. Copies of ^{1}H, ^{13}C and ^{19}F NMR Spectra

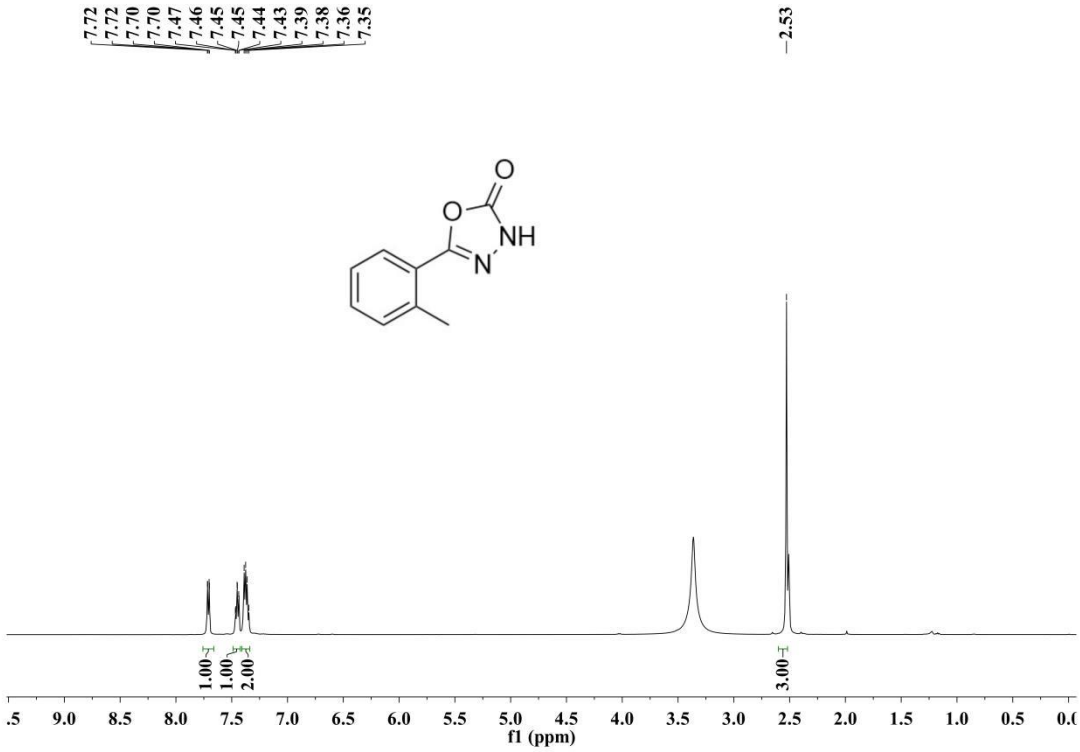
^{1}H NMR spectrum of 2a (500 MHz, $CDCl_3$)



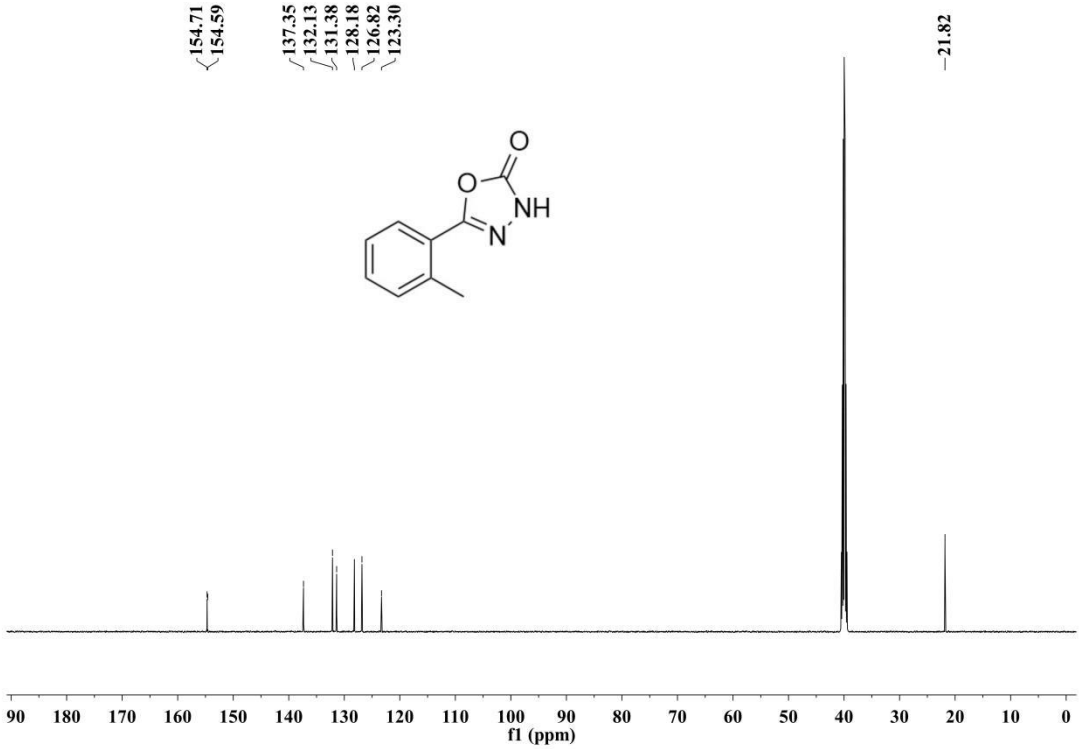
$^{13}C\{^{1}H\}$ NMR spectrum of 2a (125 MHz, $CDCl_3$)



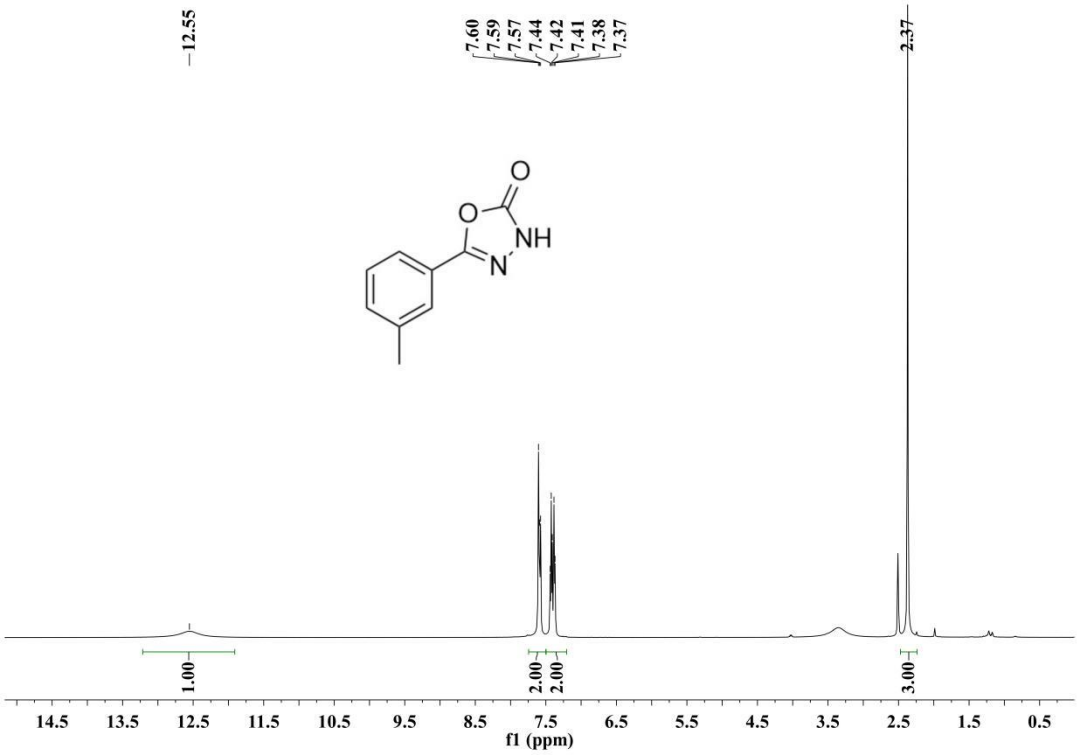
^{1}H NMR spectrum of 2b (500 MHz, DMSO)



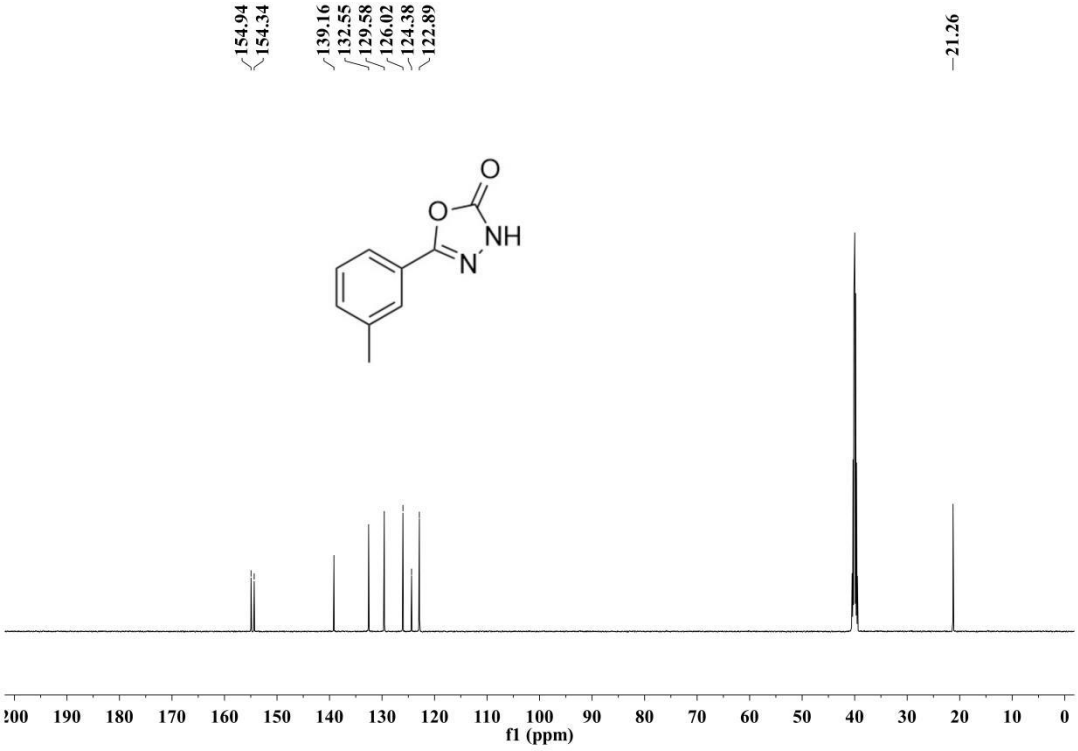
^{13}C{^{1}H} NMR spectrum of 2b (125 MHz, DMSO)



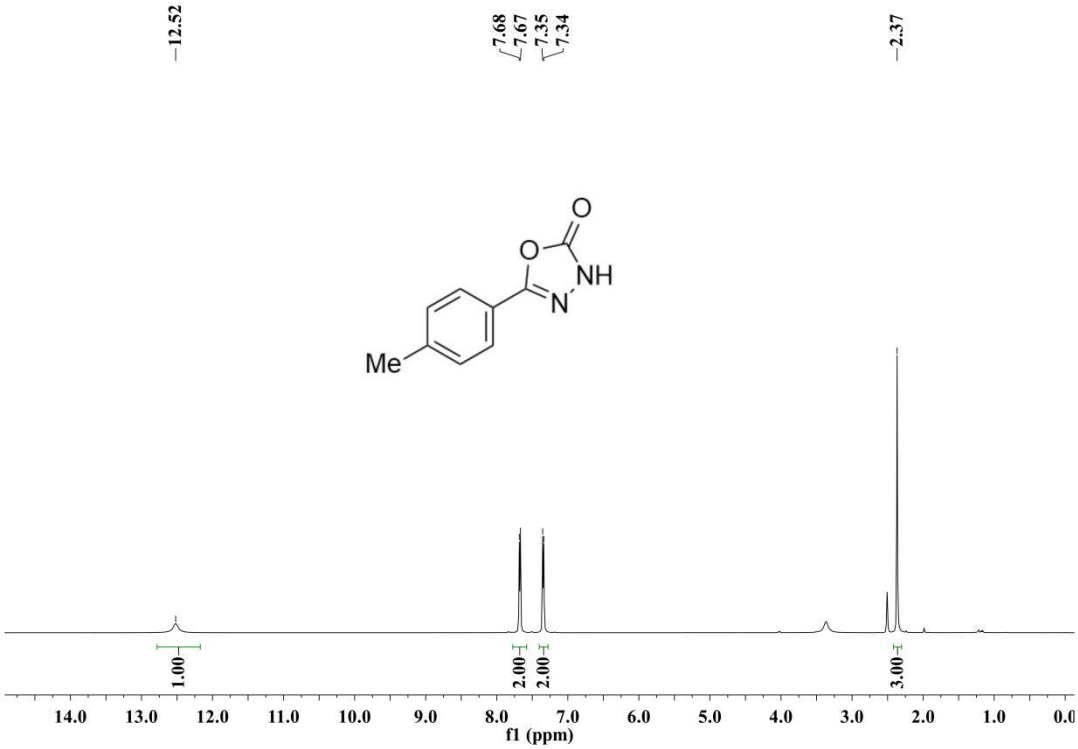
^{1}H NMR spectrum of 2c (500 MHz, DMSO)



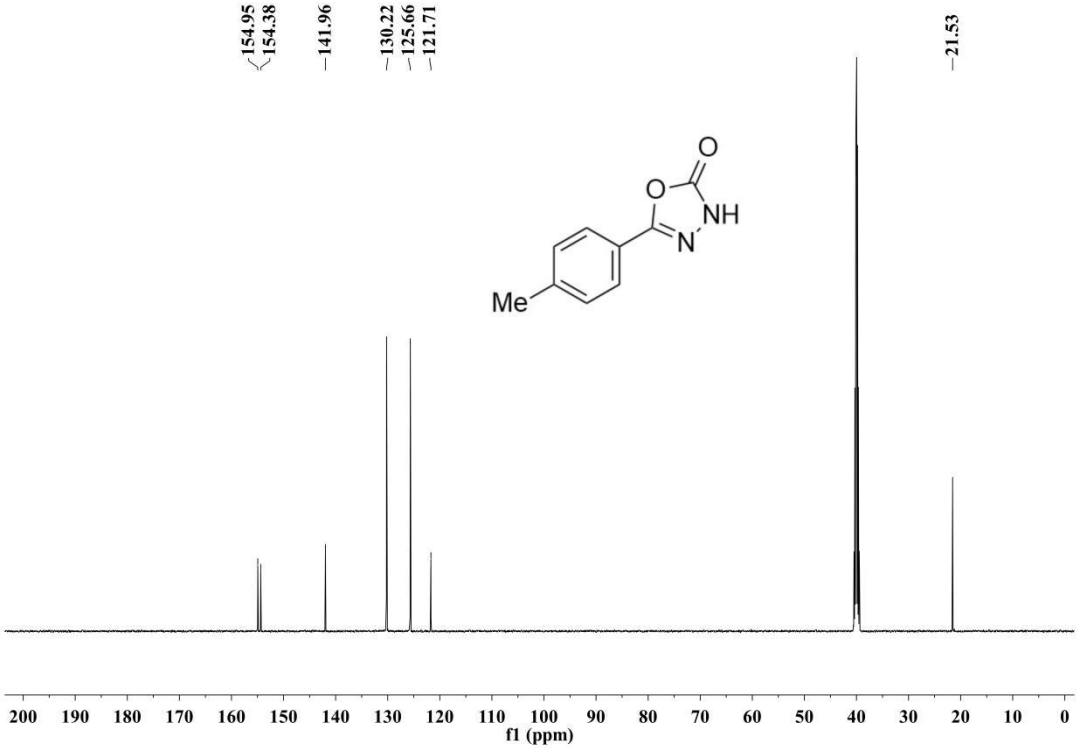
^{13}C{^{1}H} NMR spectrum of 2c (125 MHz, DMSO)



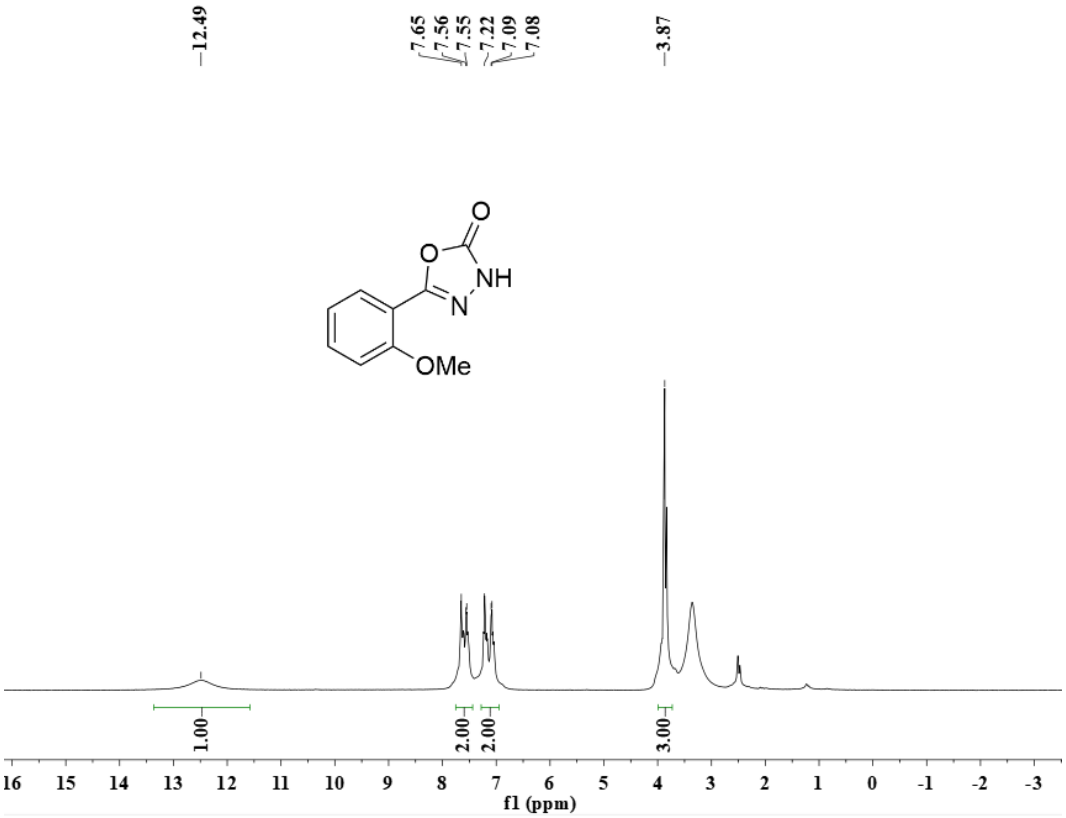
^{1}H NMR spectrum of 2d (500 MHz, DMSO)



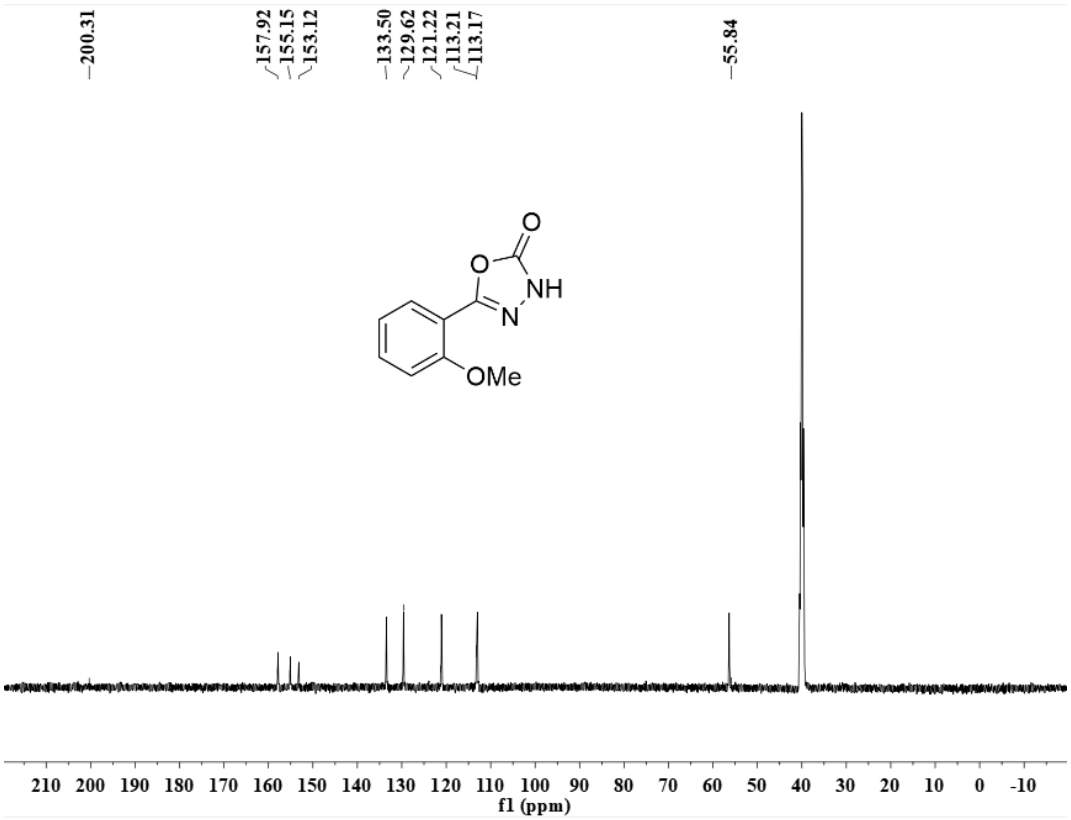
^{13}C{^{1}H} NMR spectrum of 2d (125 MHz, DMSO)



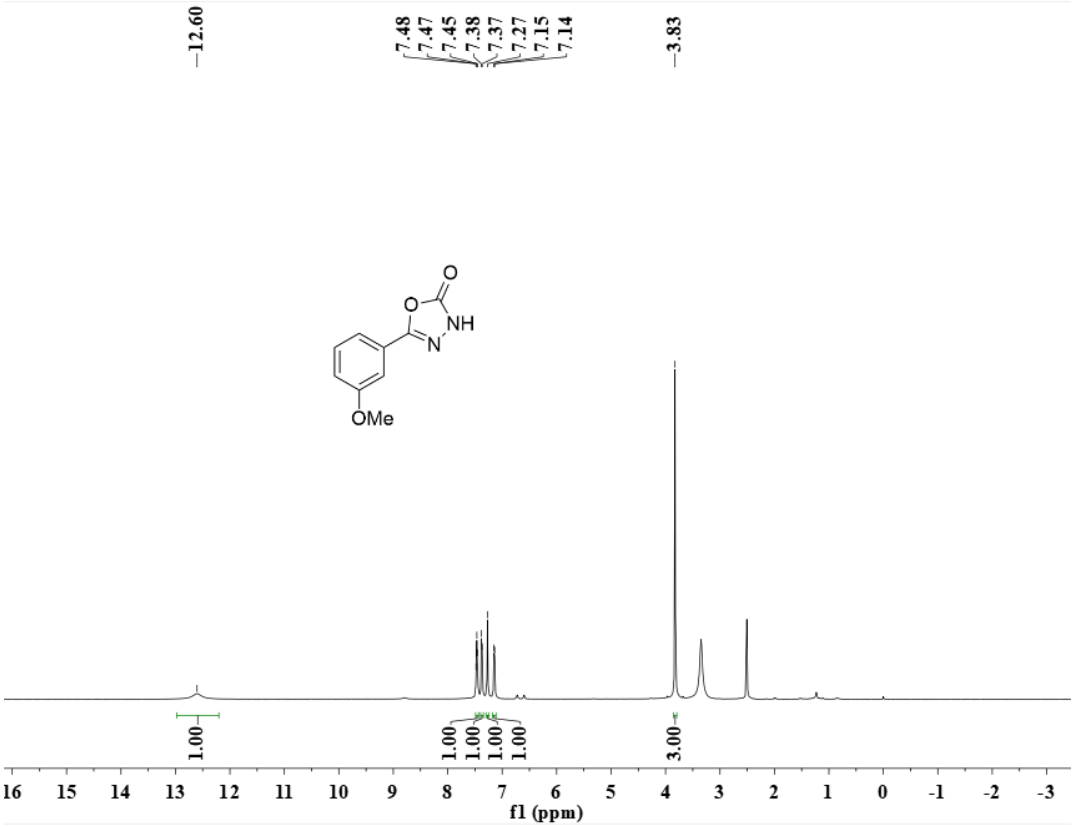
^{1}H NMR spectrum of 2e (500 MHz, DMSO)



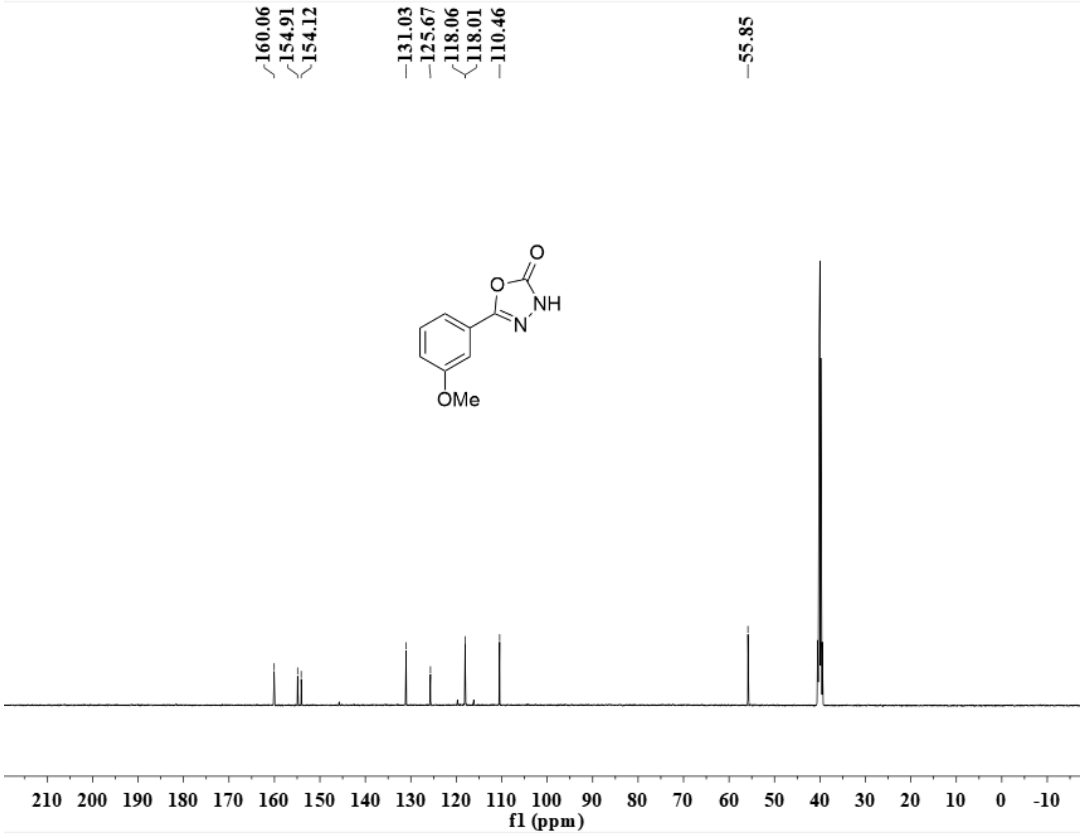
^{13}C{^{1}H} NMR spectrum of 2e (125 MHz, DMSO)



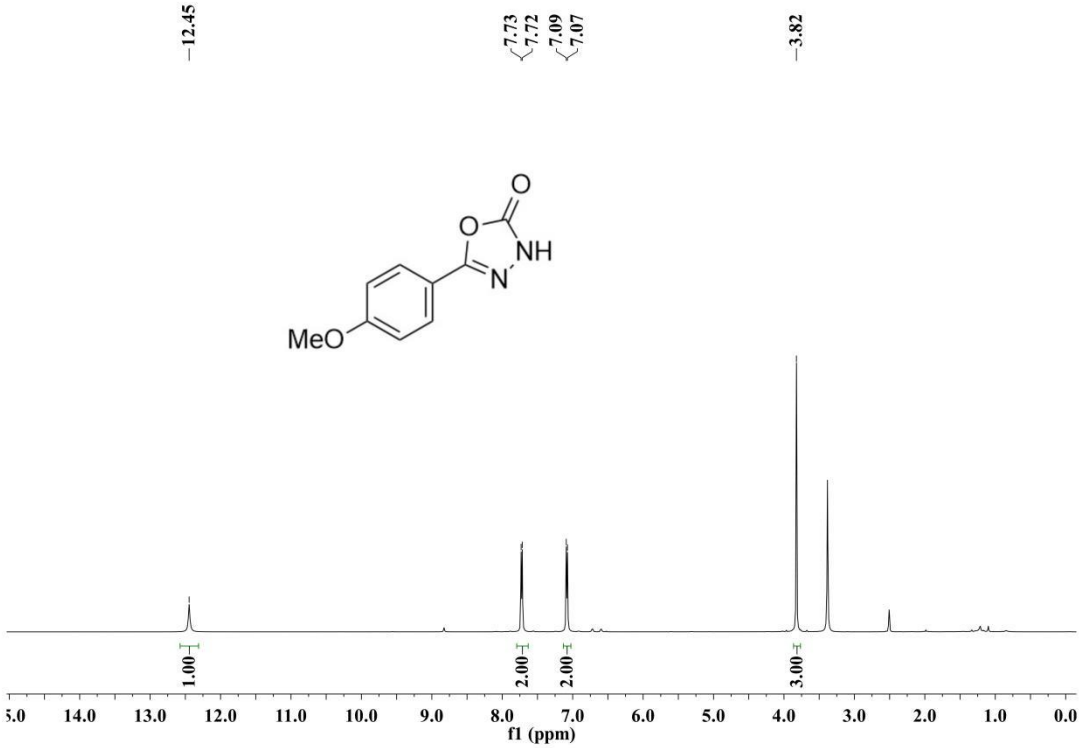
^{1}H NMR spectrum of 2f (500 MHz, DMSO)



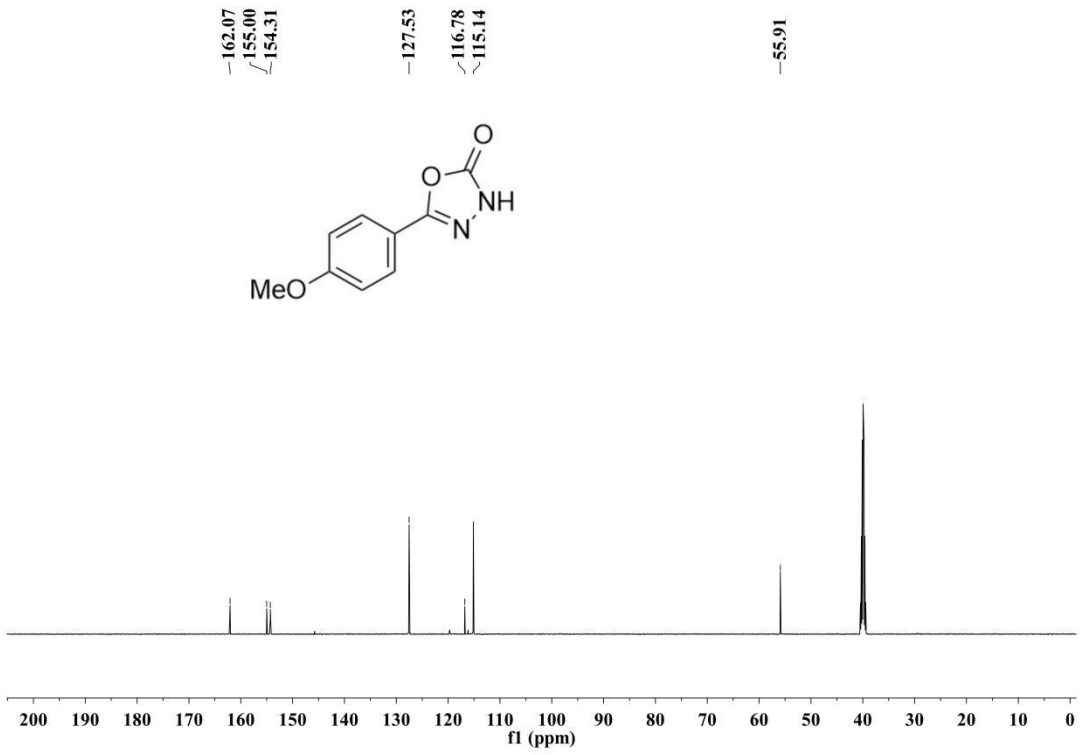
^{13}C{^{1}H} NMR spectrum of 2f (125 MHz, DMSO)



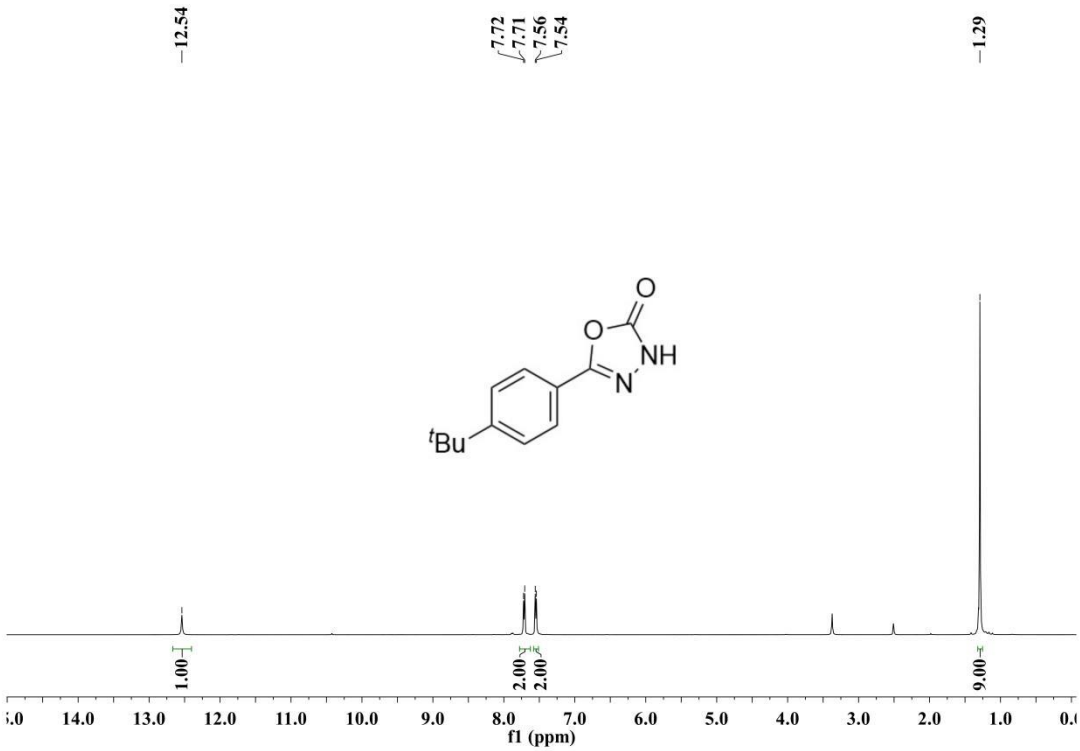
^{1}H NMR spectrum of 2g (500 MHz, DMSO)



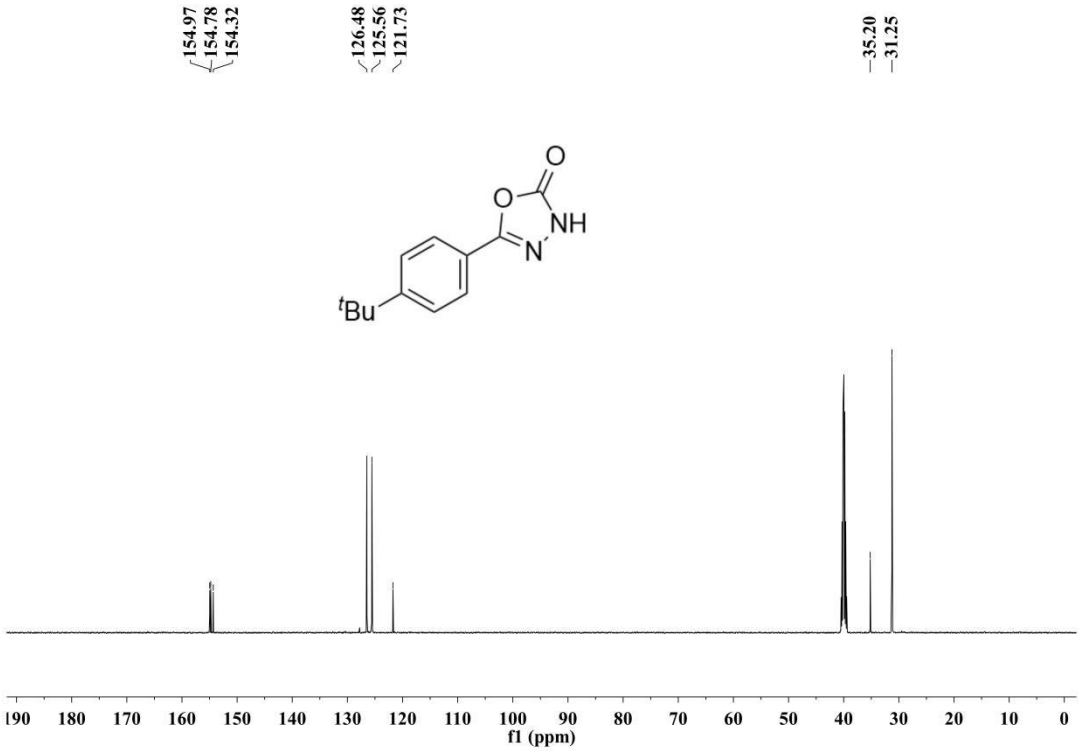
^{13}C{^{1}H} NMR spectrum of 2g (125 MHz, DMSO)



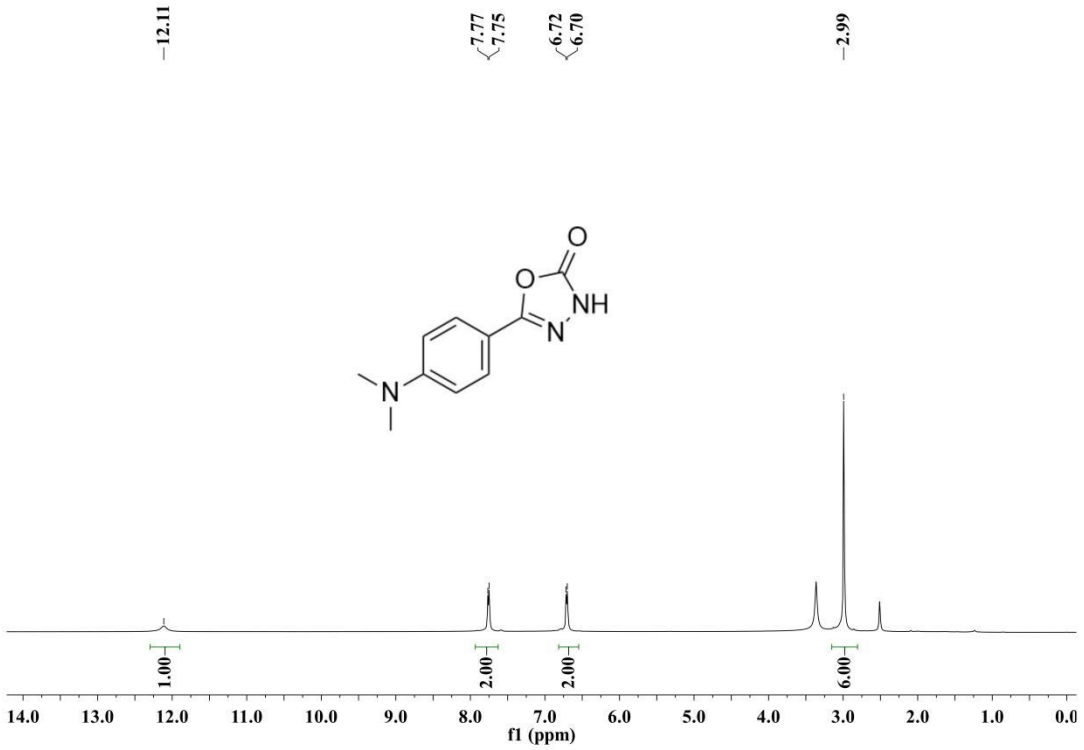
^{1}H NMR spectrum of 2h (500 MHz, DMSO)



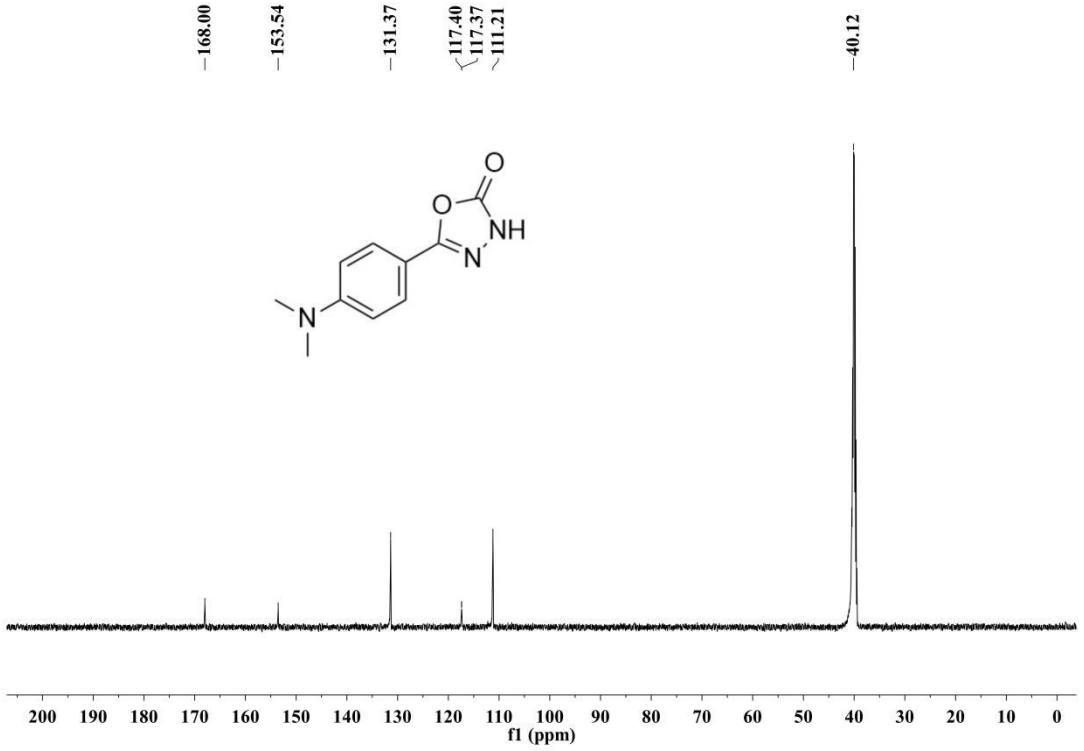
^{13}C{^{1}H} NMR spectrum of 2h (125 MHz, DMSO)



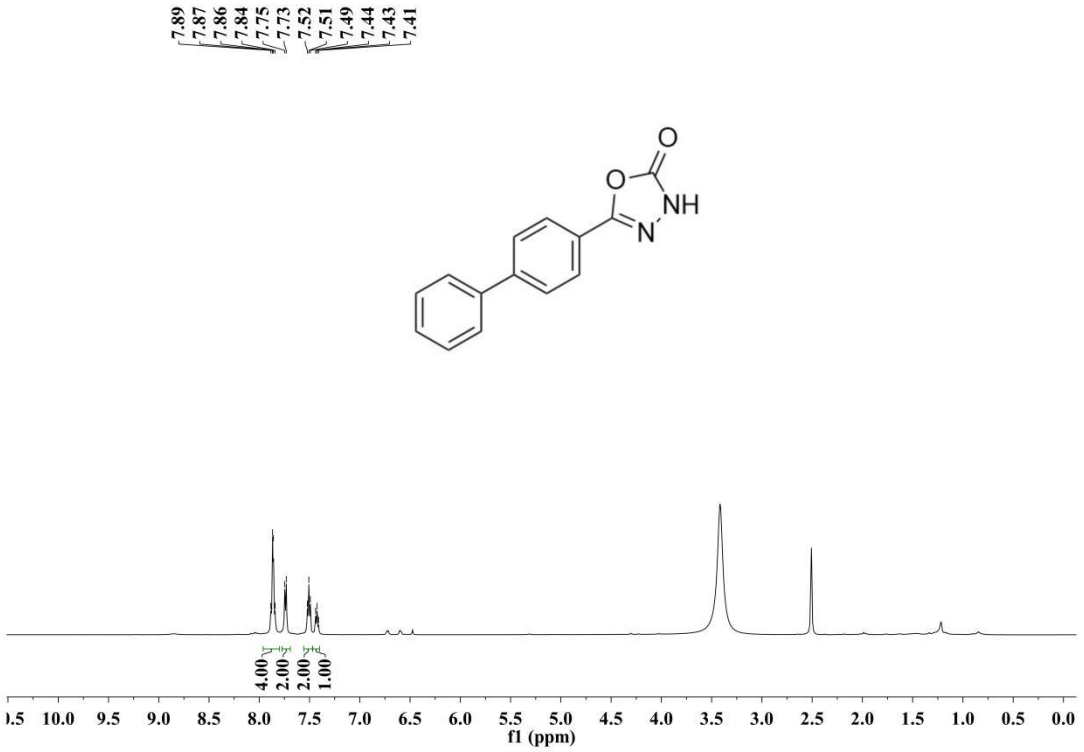
^{1}H NMR spectrum of 2i (500 MHz, DMSO)



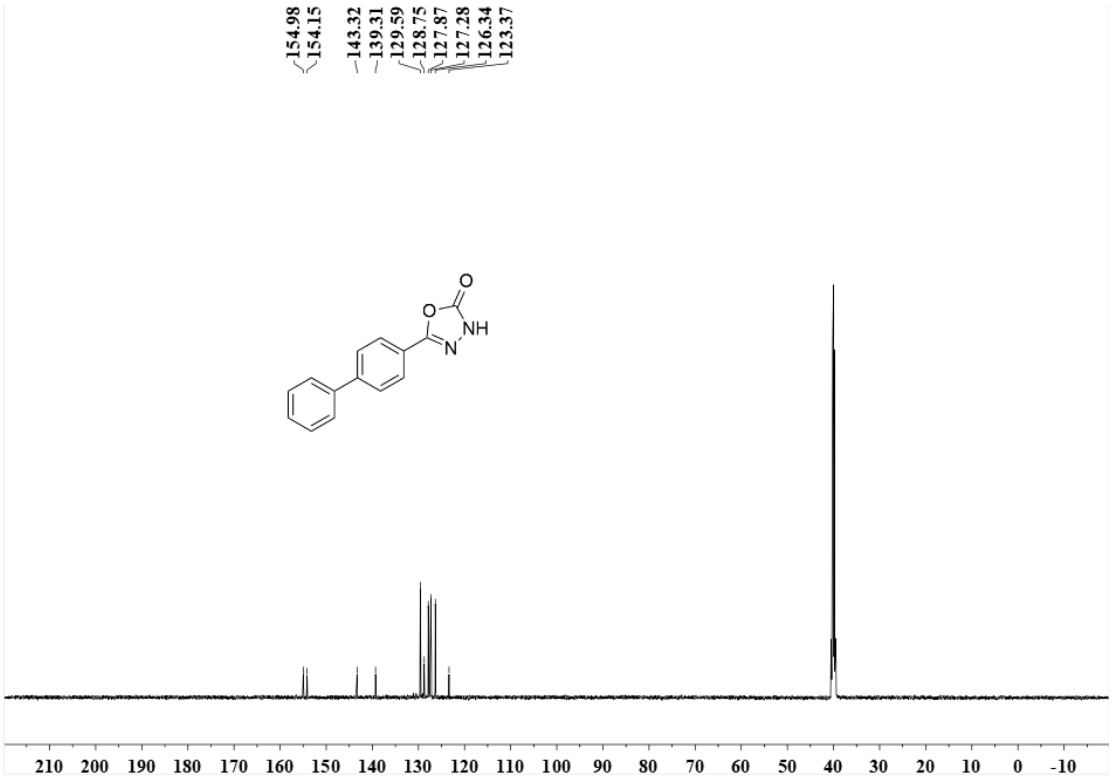
^{13}C{^{1}H} NMR spectrum of 2i (125 MHz, DMSO)



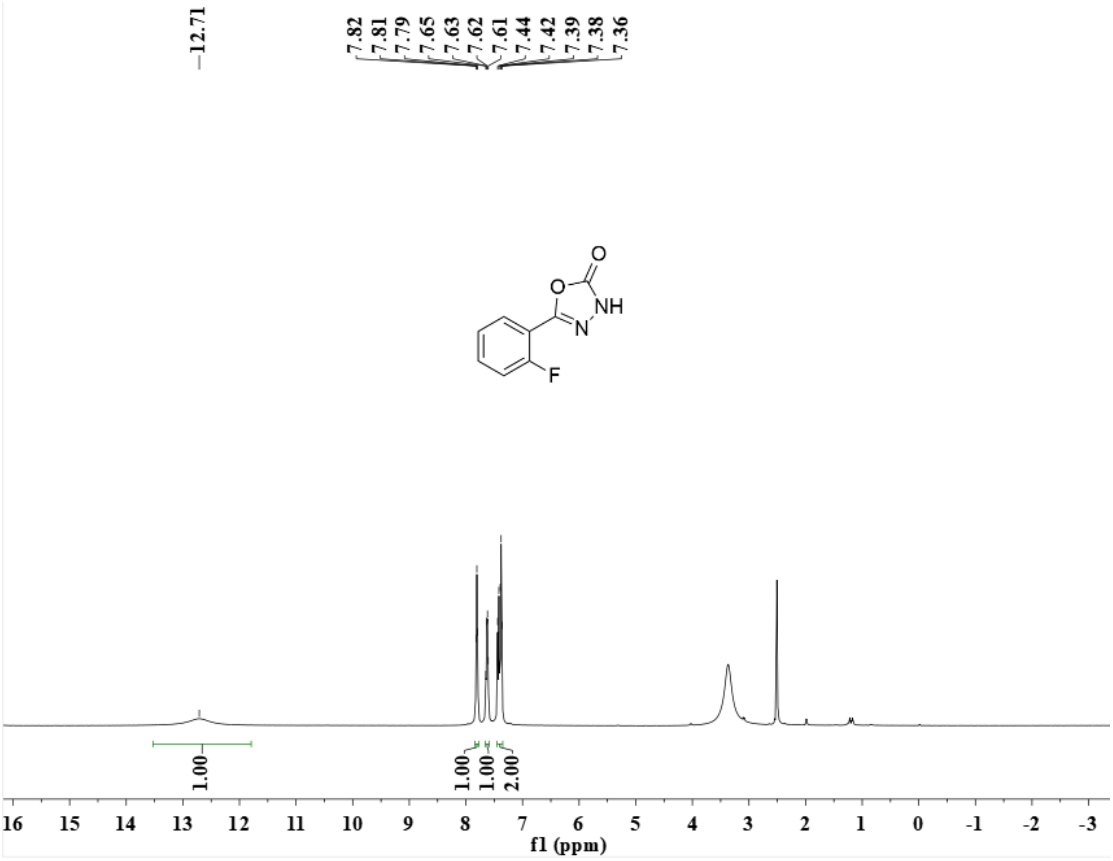
^{1}H NMR spectrum of 2j (500 MHz, DMSO)



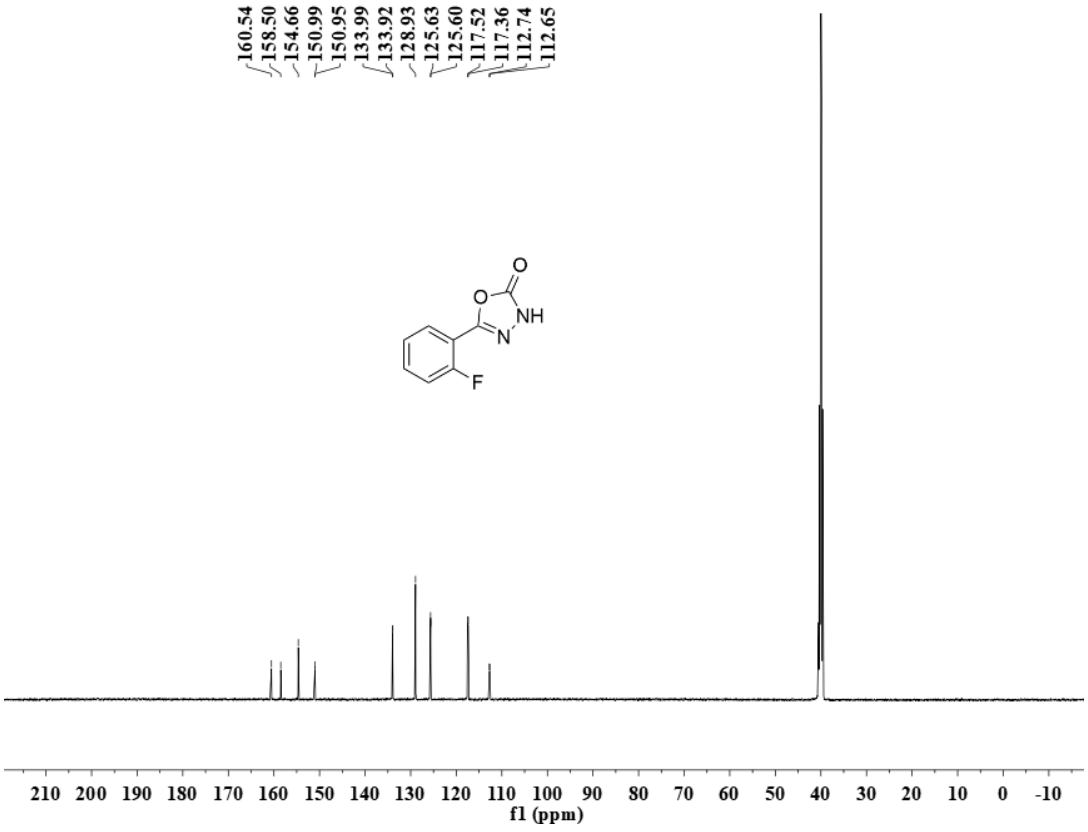
^{13}C{^{1}H} NMR spectrum of 2j (125 MHz, DMSO)



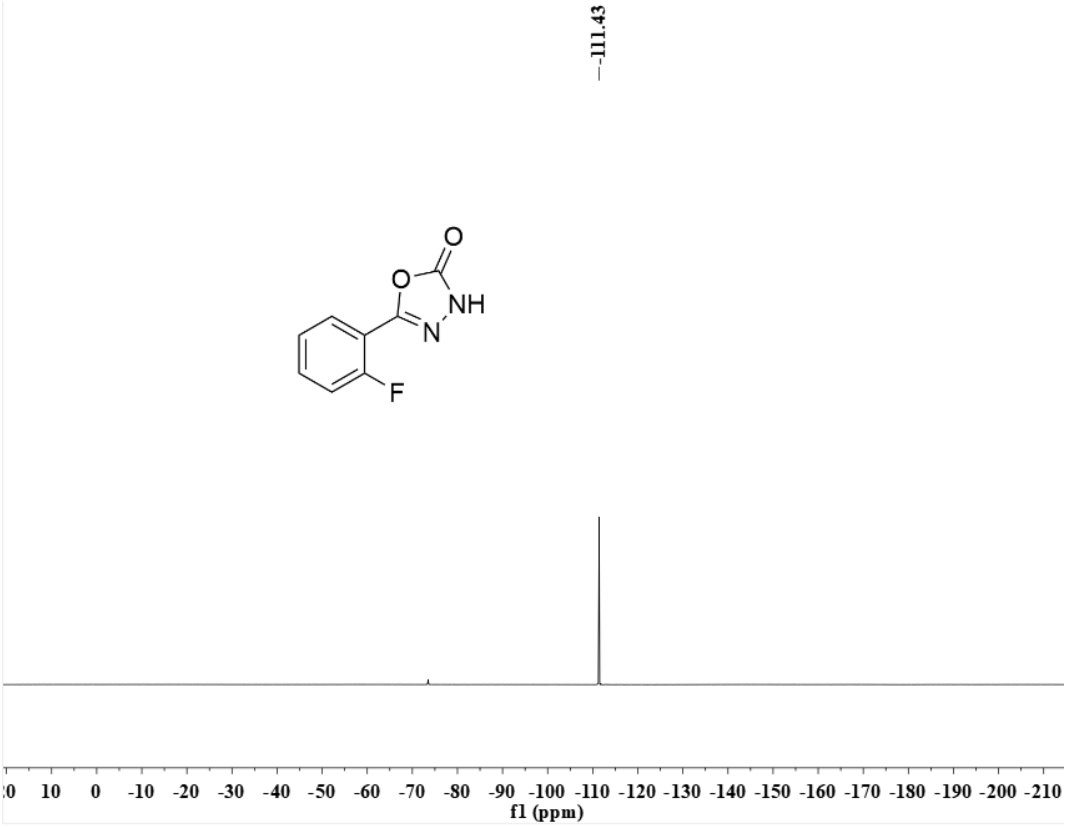
^{1}H NMR spectrum of 2k (500 MHz, DMSO)



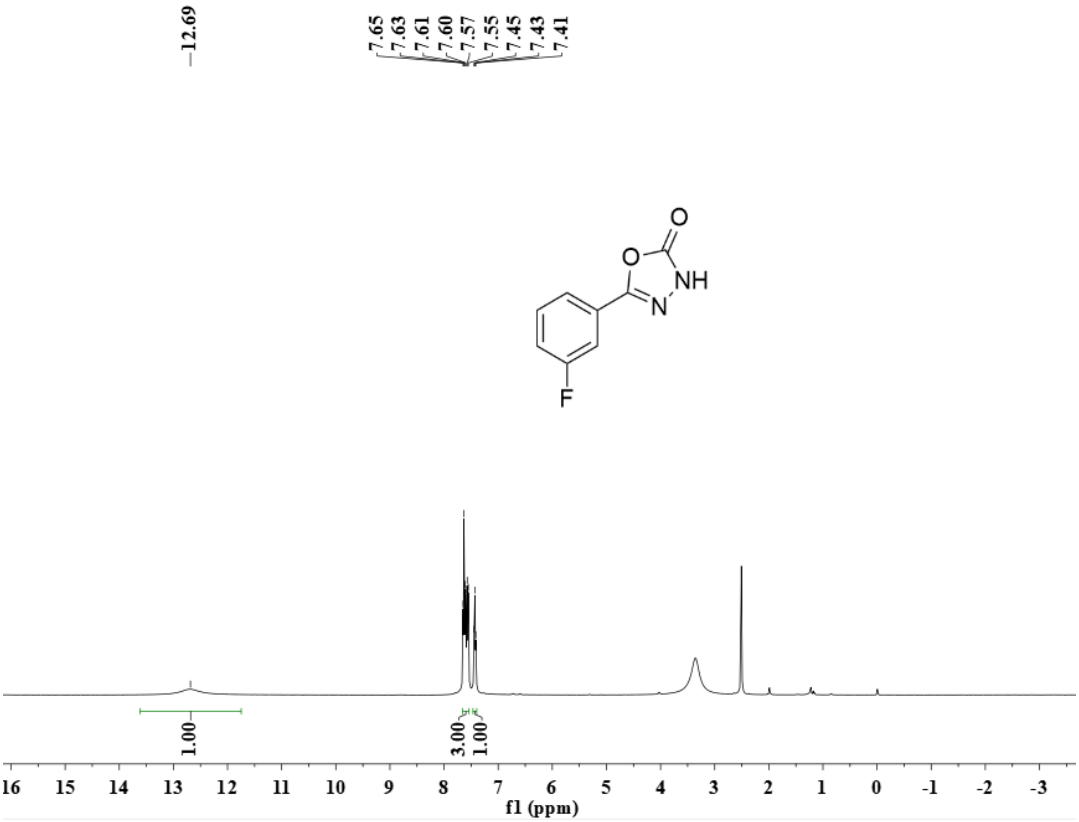
^{13}C{^{1}H} NMR spectrum of 2k (125 MHz, DMSO)



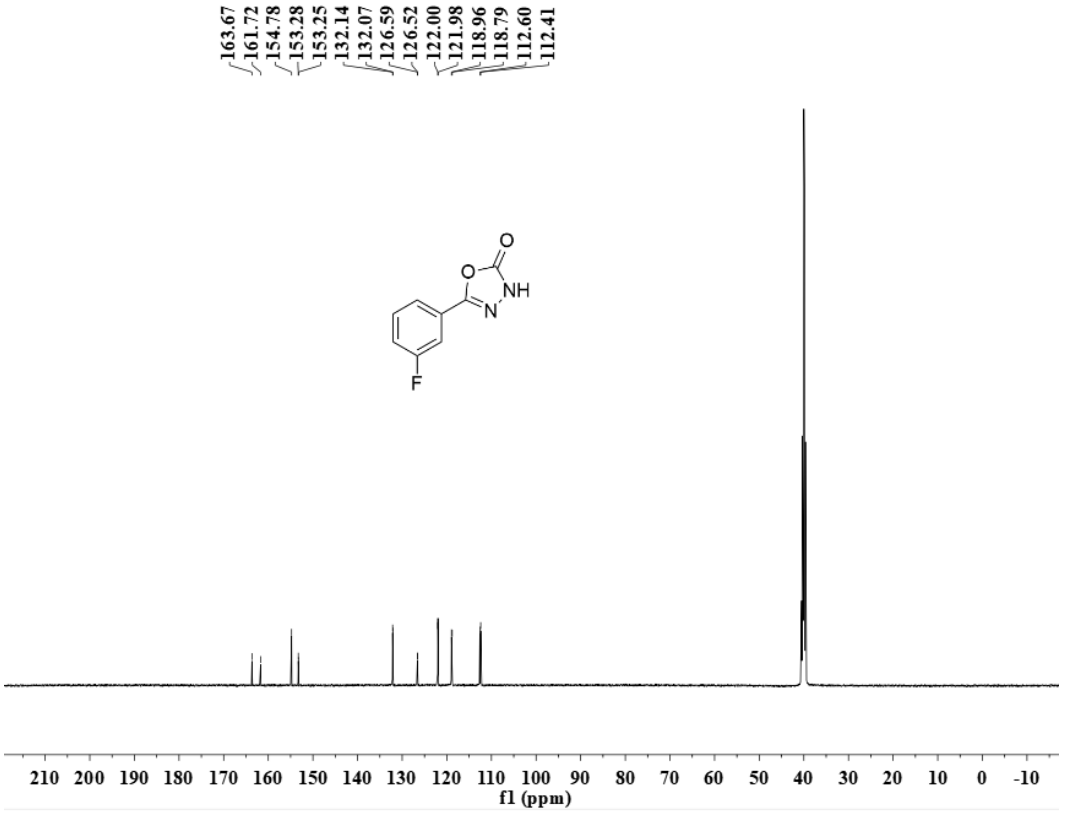
^{19}F NMR spectrum of of 2k (125 MHz, DMSO)



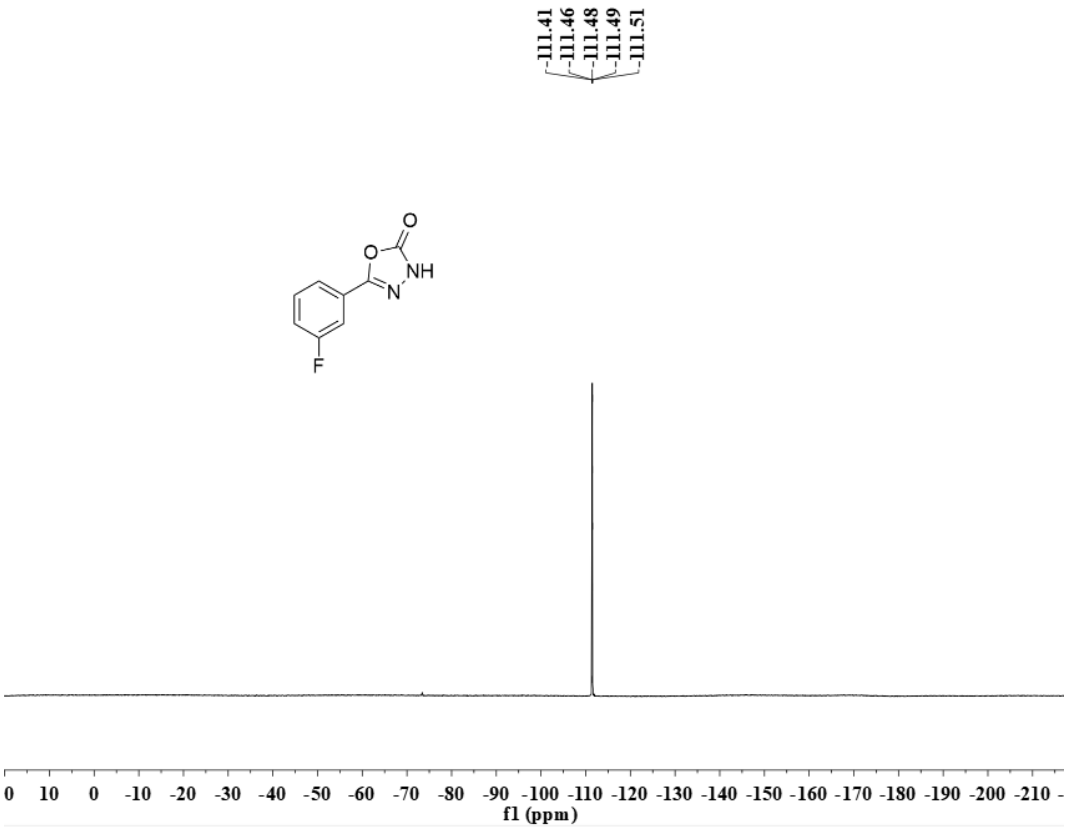
^{1}H NMR spectrum of 2l (500 MHz, DMSO)



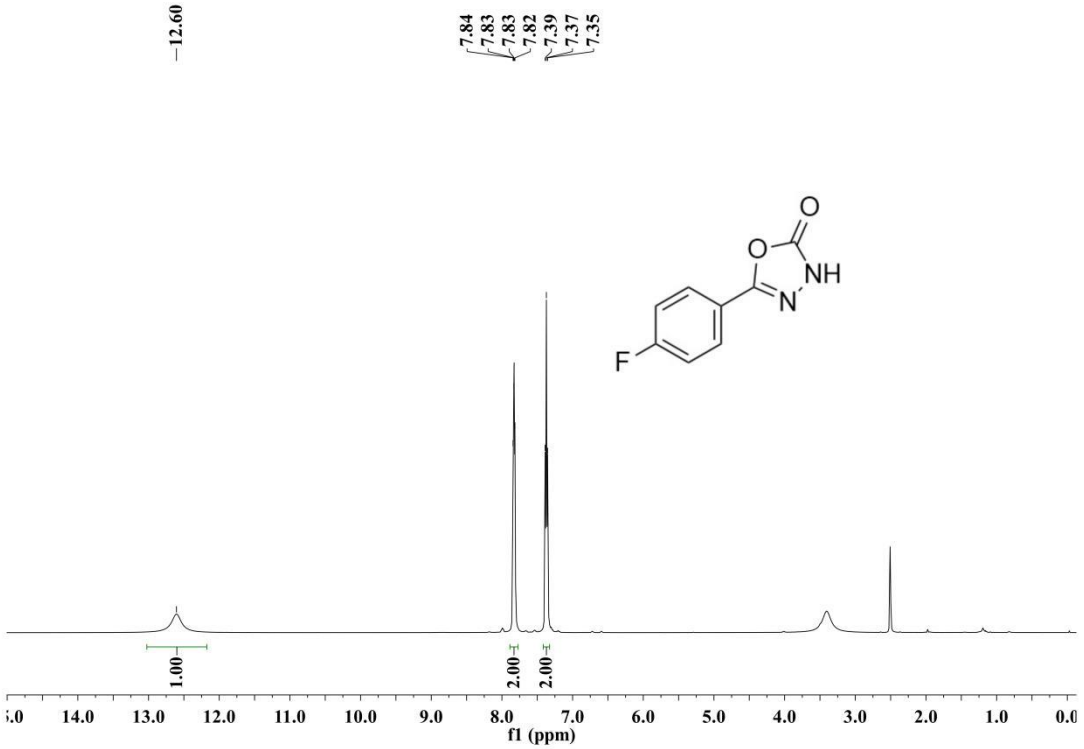
$^{13}C\{^{1}H\}$ NMR spectrum of 2l (125 MHz, DMSO)



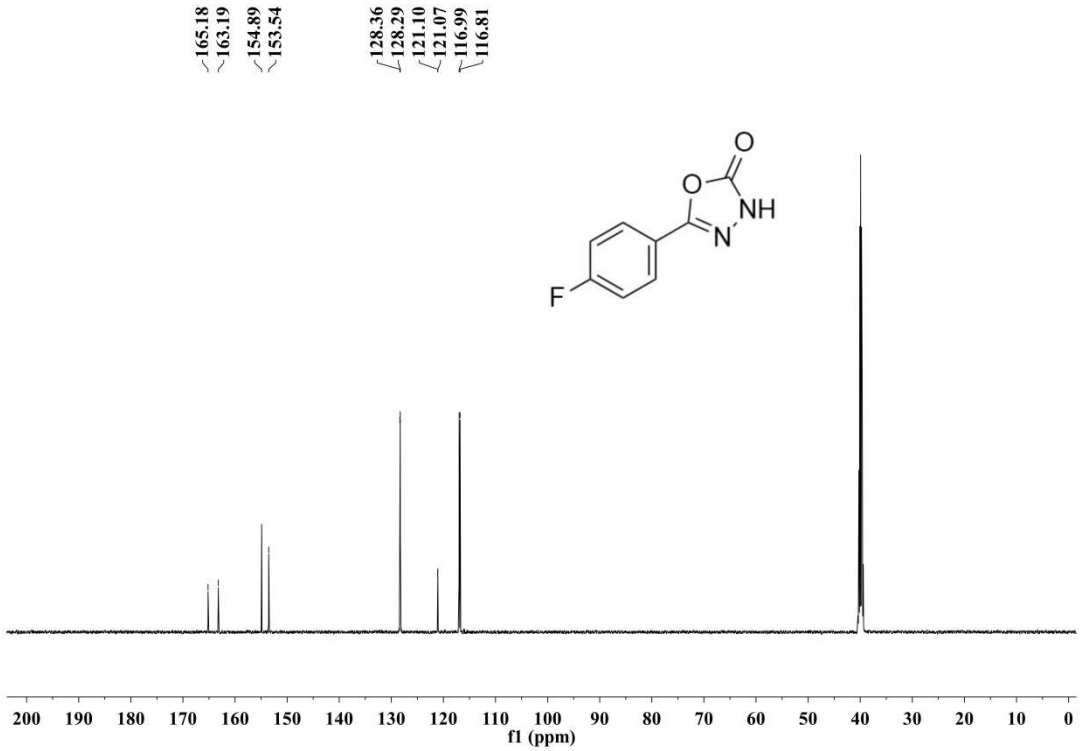
^{19}F NMR spectrum of of 2l (125 MHz, DMSO)



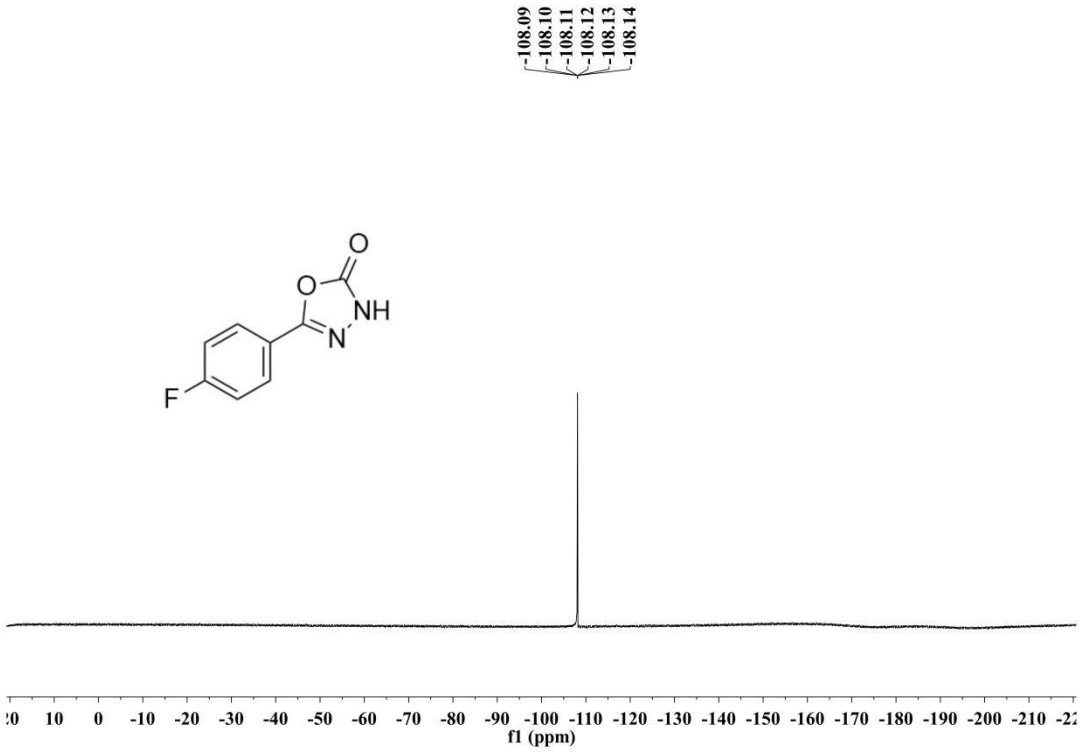
^{1}H NMR spectrum of 2m (500 MHz, DMSO)



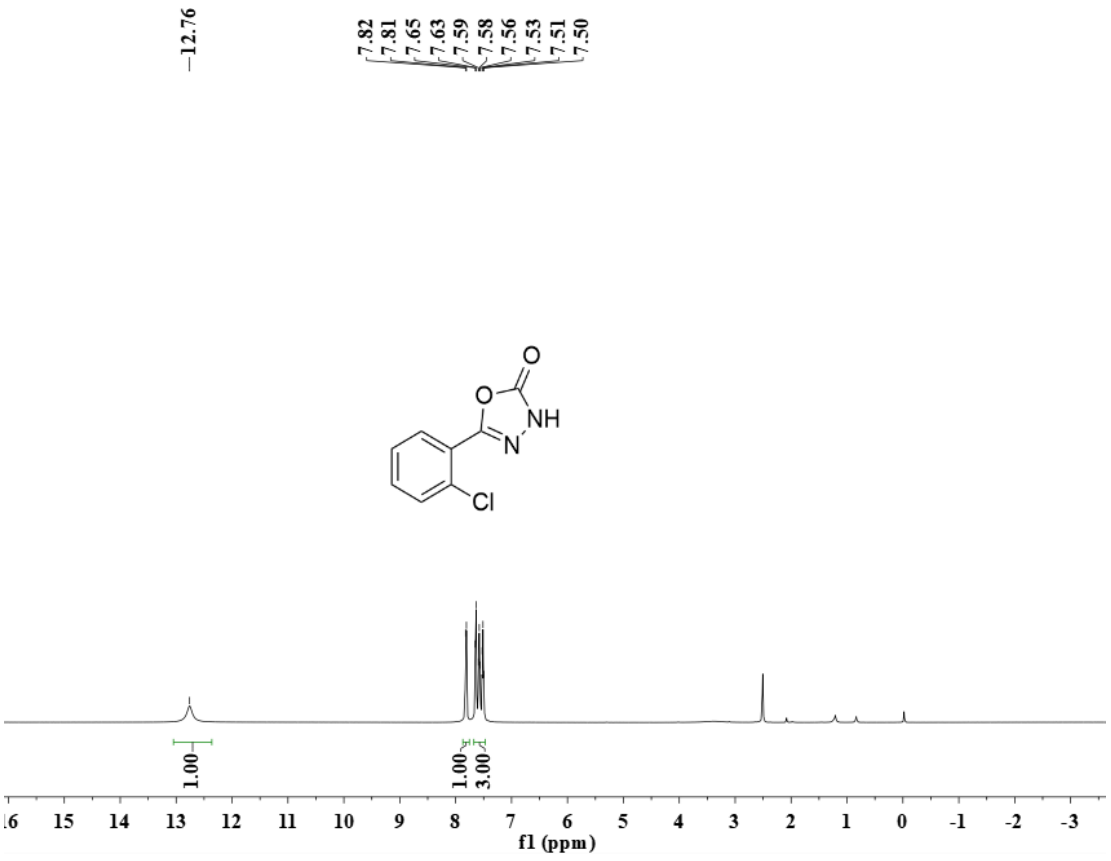
^{13}C{^{1}H} NMR spectrum of 2m (125 MHz, DMSO)



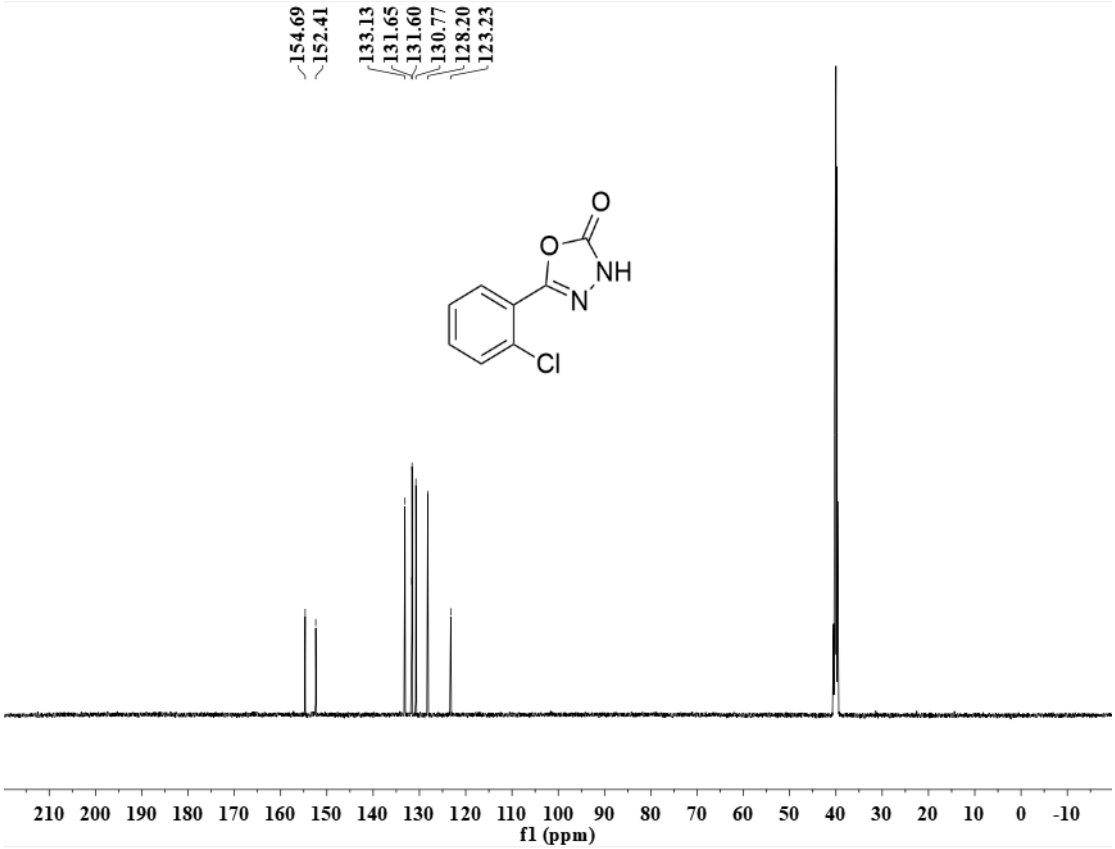
^{19}F NMR spectrum of of 2m (125 MHz, DMSO)



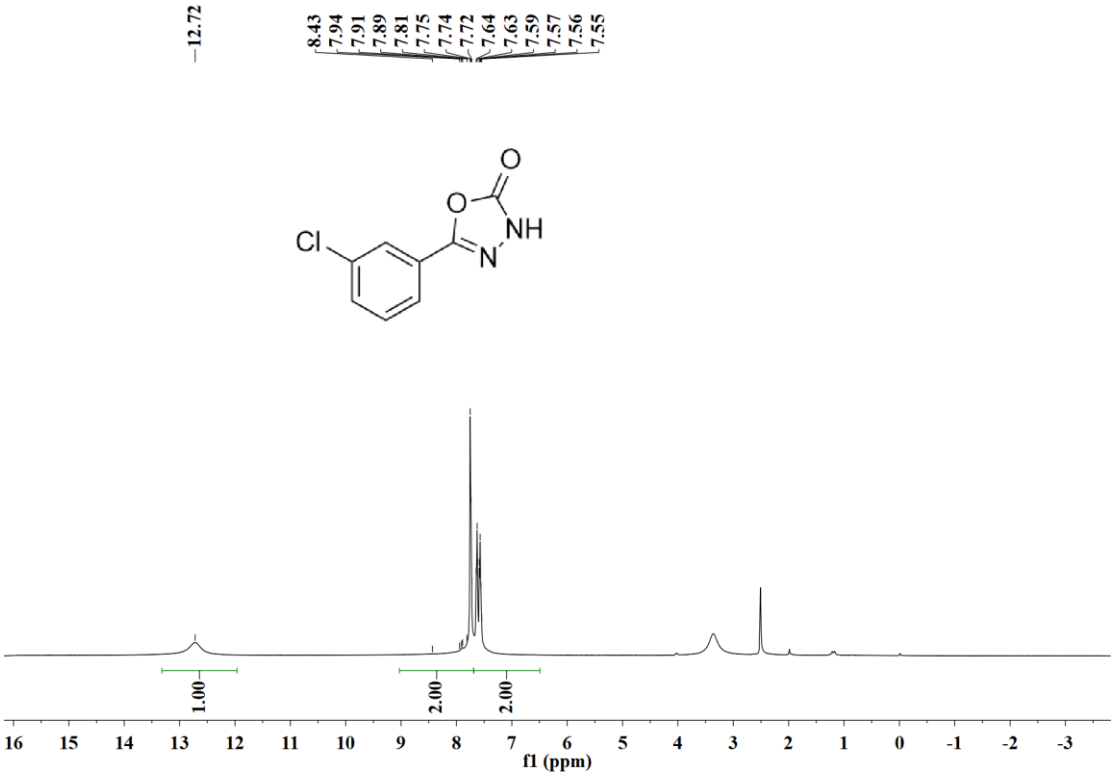
^{1}H NMR spectrum of 2n (500 MHz, DMSO)



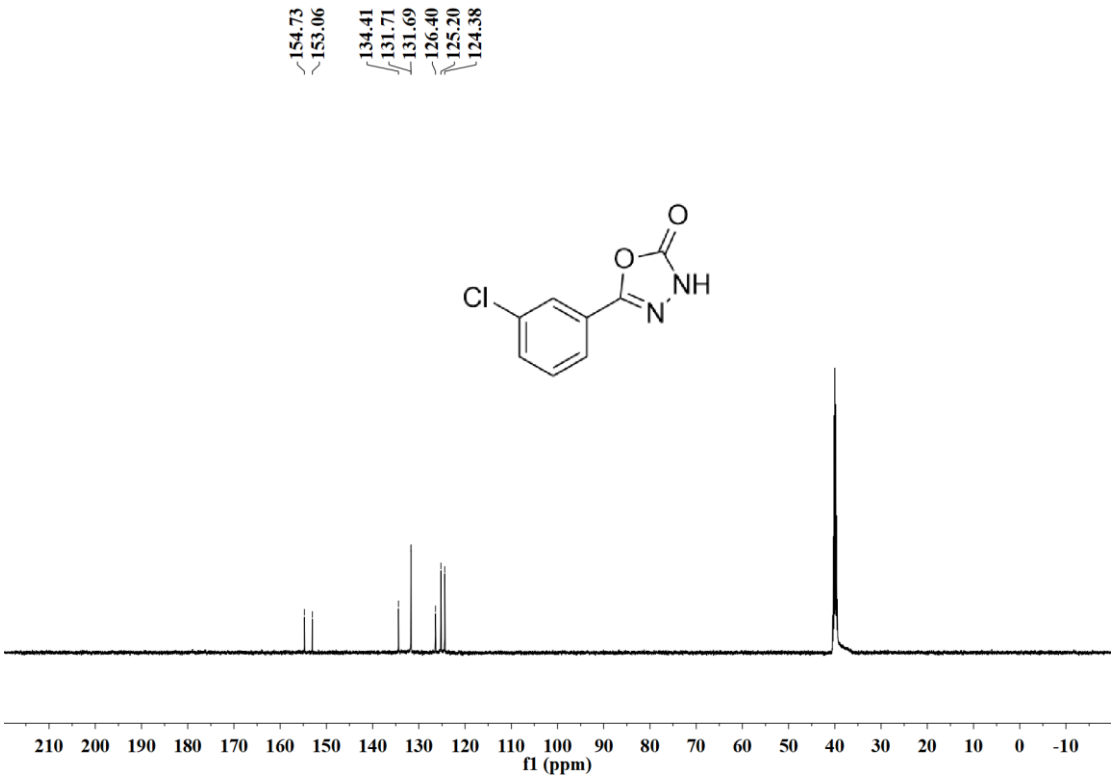
$^{13}C\{^{1}H\}$ NMR spectrum of 2n (125 MHz, DMSO)



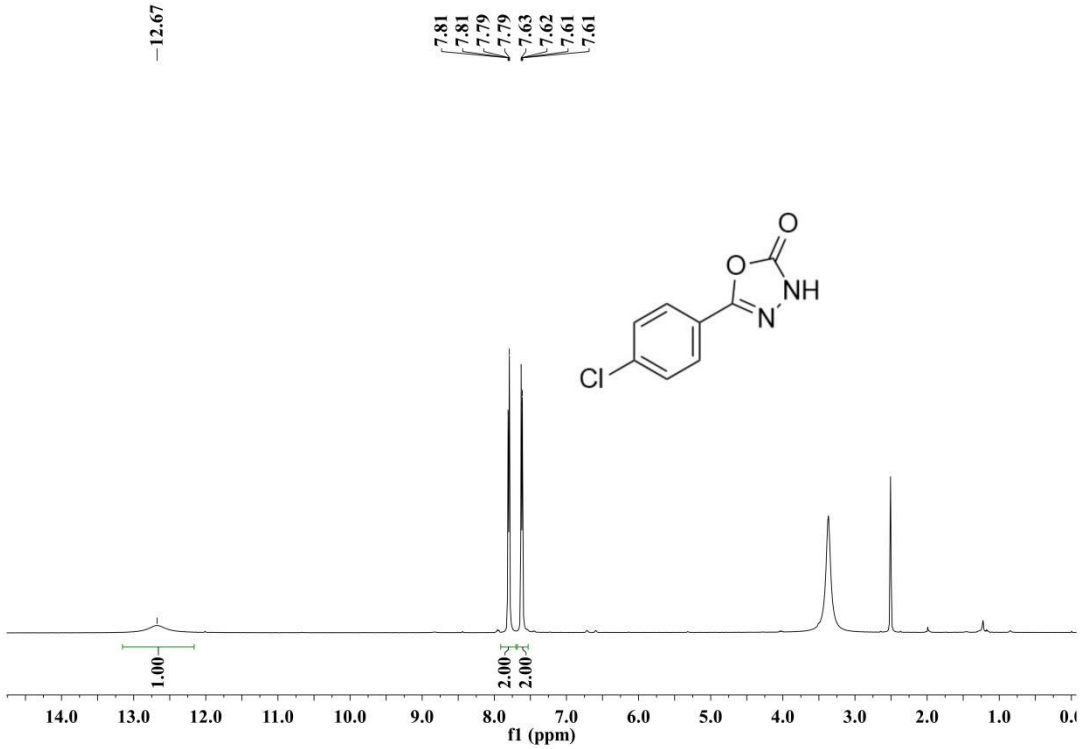
^{1}H NMR spectrum of 2o (500 MHz, DMSO)



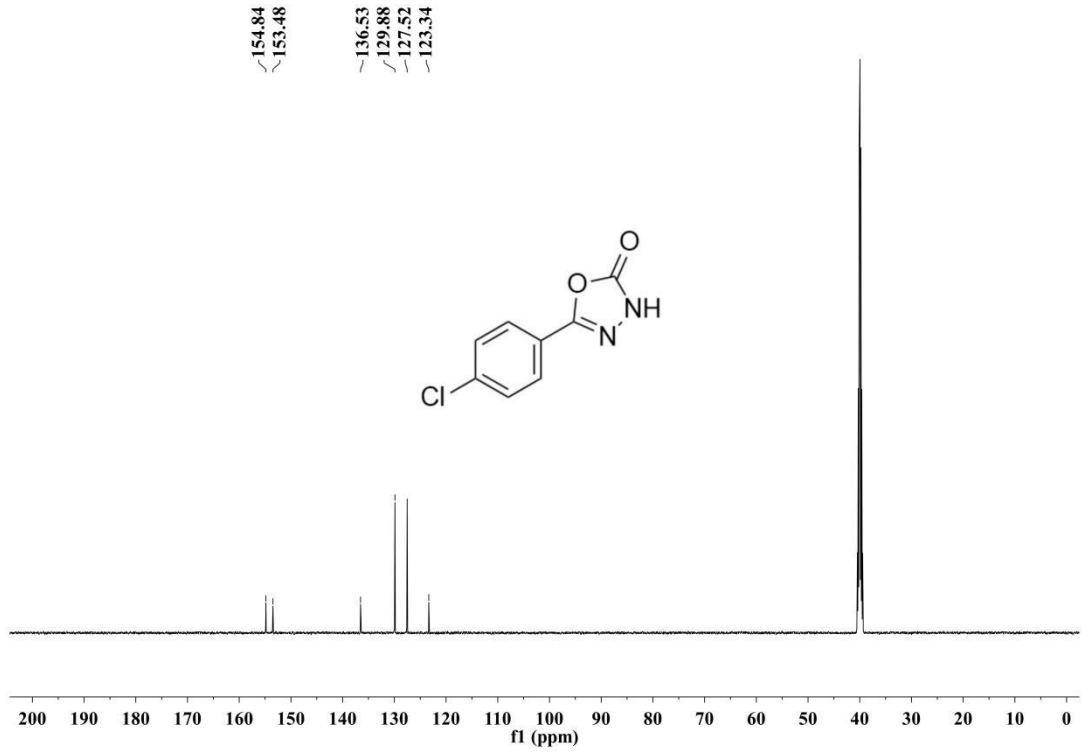
$^{13}C\{^{1}H\}$ NMR spectrum of 2o (125 MHz, DMSO)



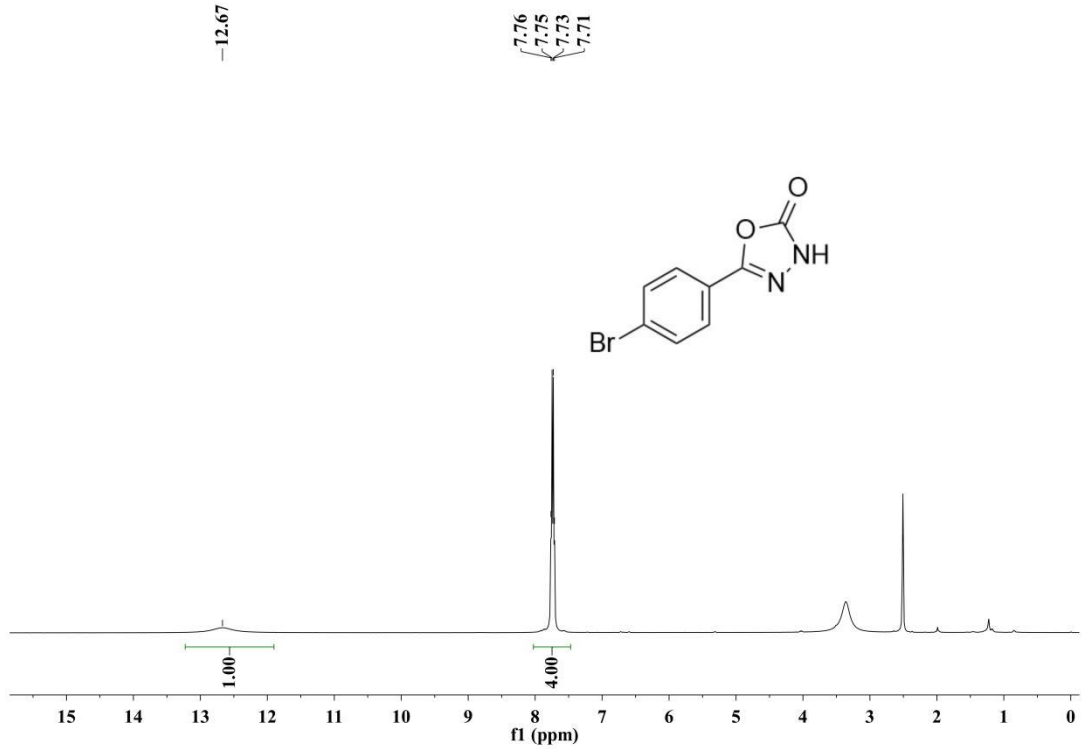
^{1}H NMR spectrum of 2p (500 MHz, DMSO)



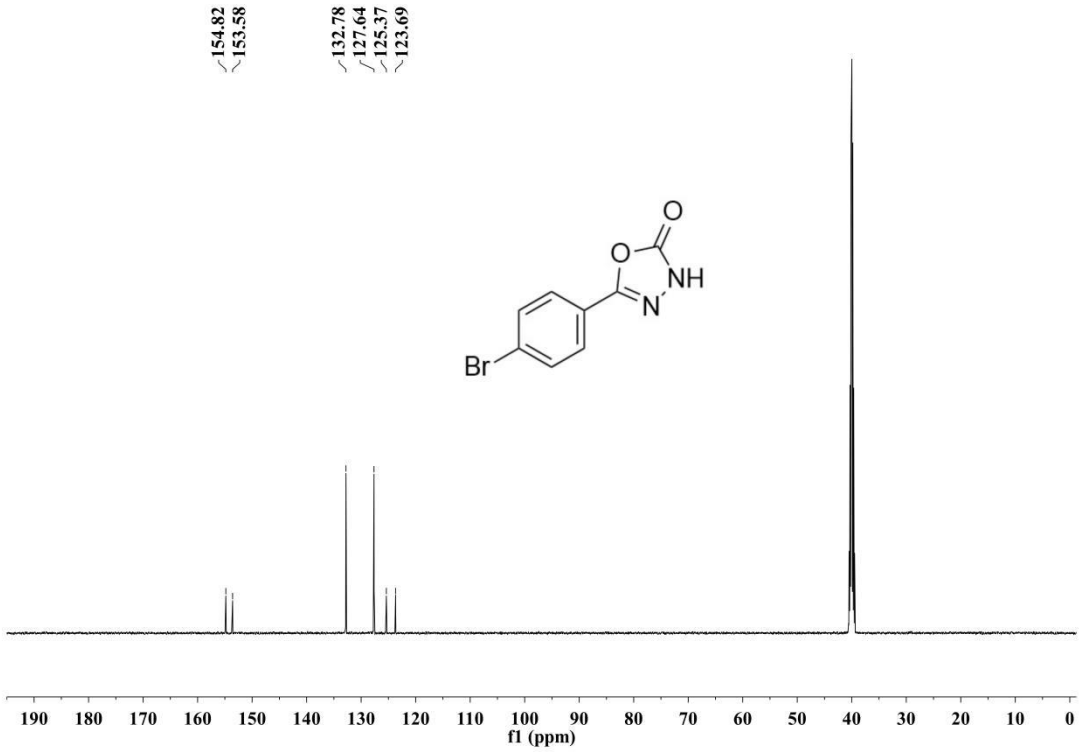
$^{13}C\{^{1}H\}$ NMR spectrum of 2p (125 MHz, DMSO)



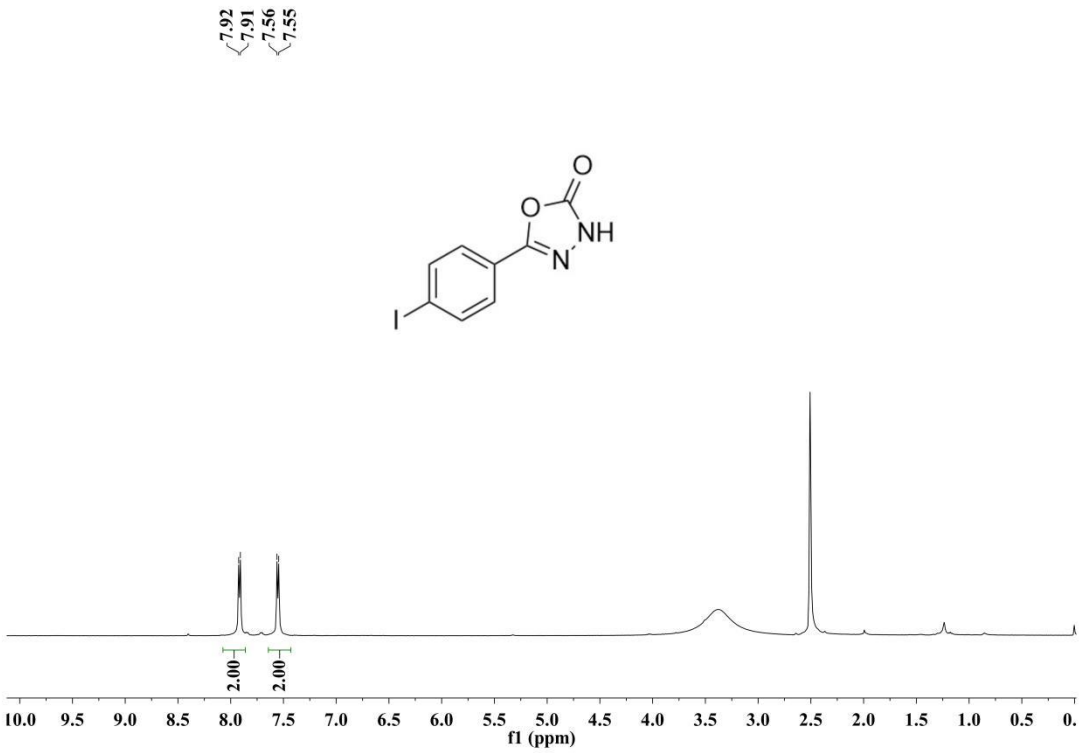
^{1}H NMR spectrum of 2q (500 MHz, DMSO)



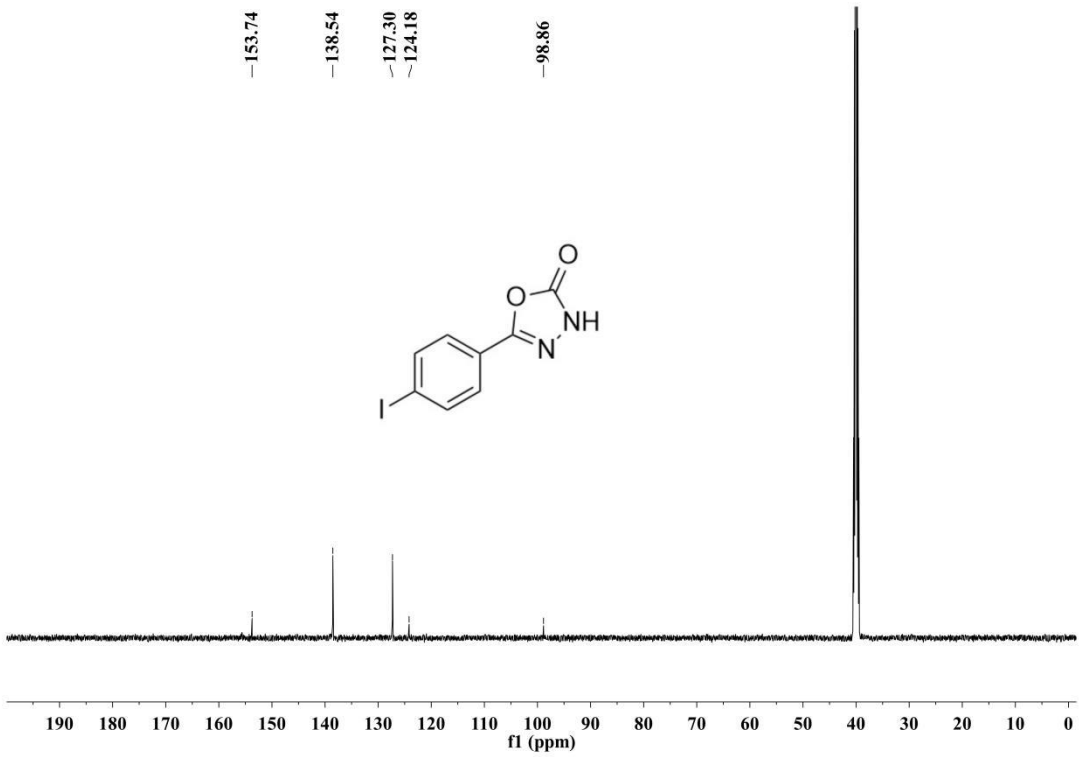
$^{13}C\{^{1}H\}$ NMR spectrum of 2q (125 MHz, DMSO)



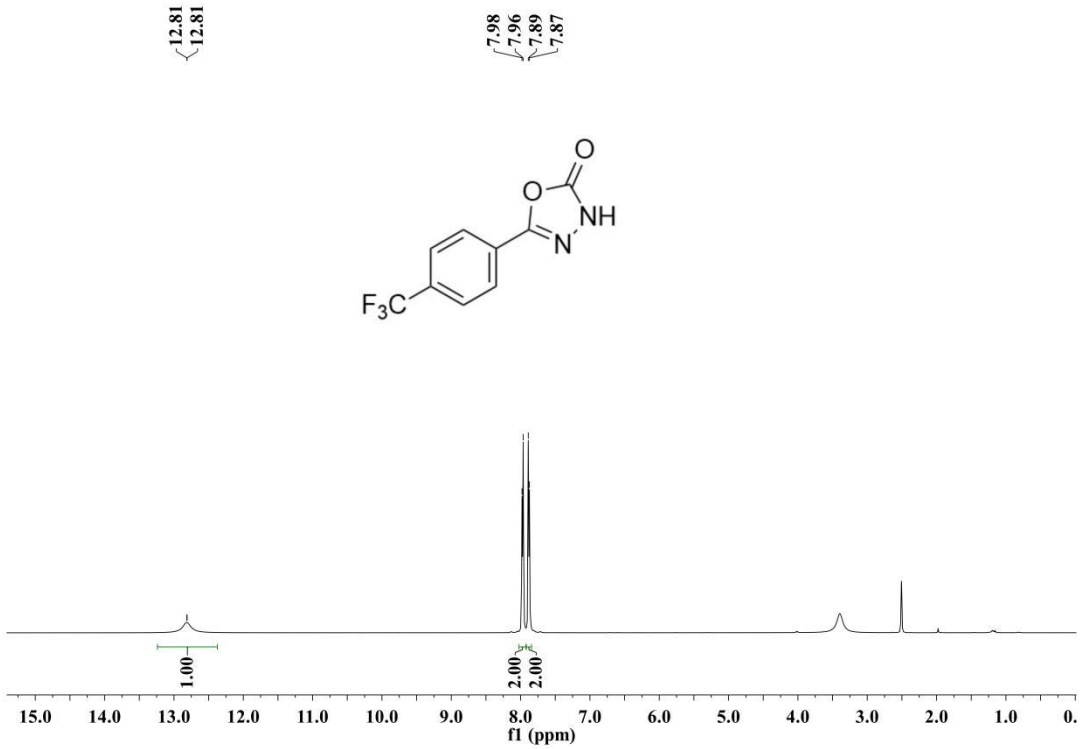
^{1}H NMR spectrum of 2r (500 MHz, DMSO)



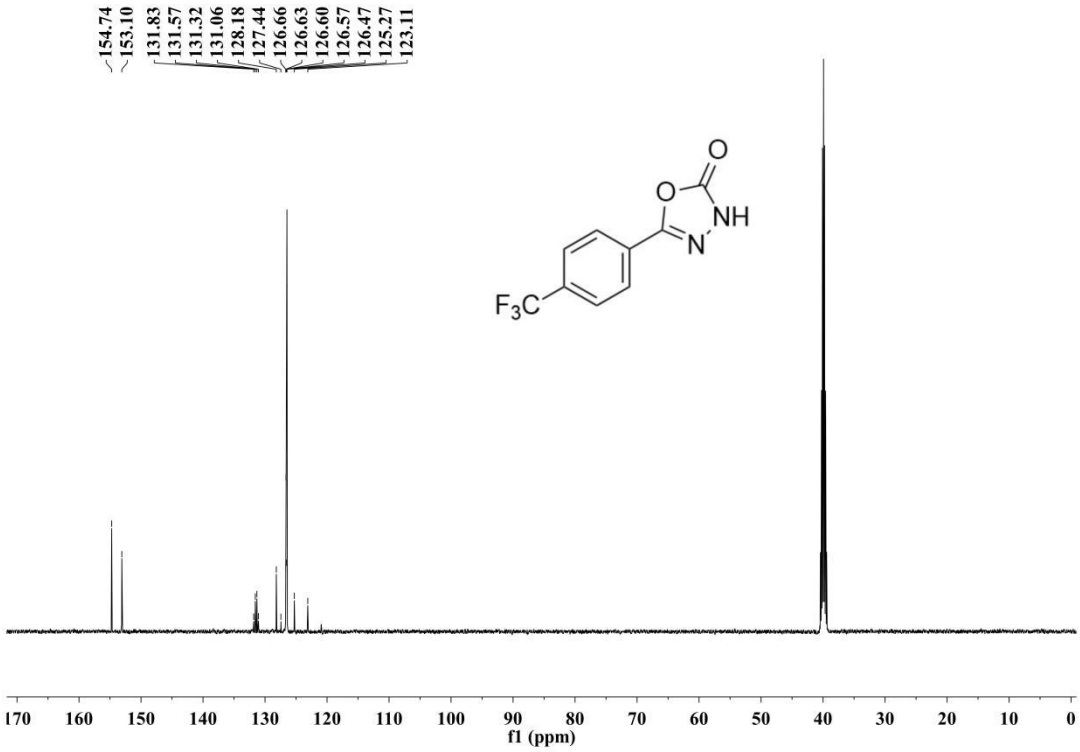
$^{13}C\{^{1}H\}$ NMR spectrum of 2r (125 MHz, DMSO)



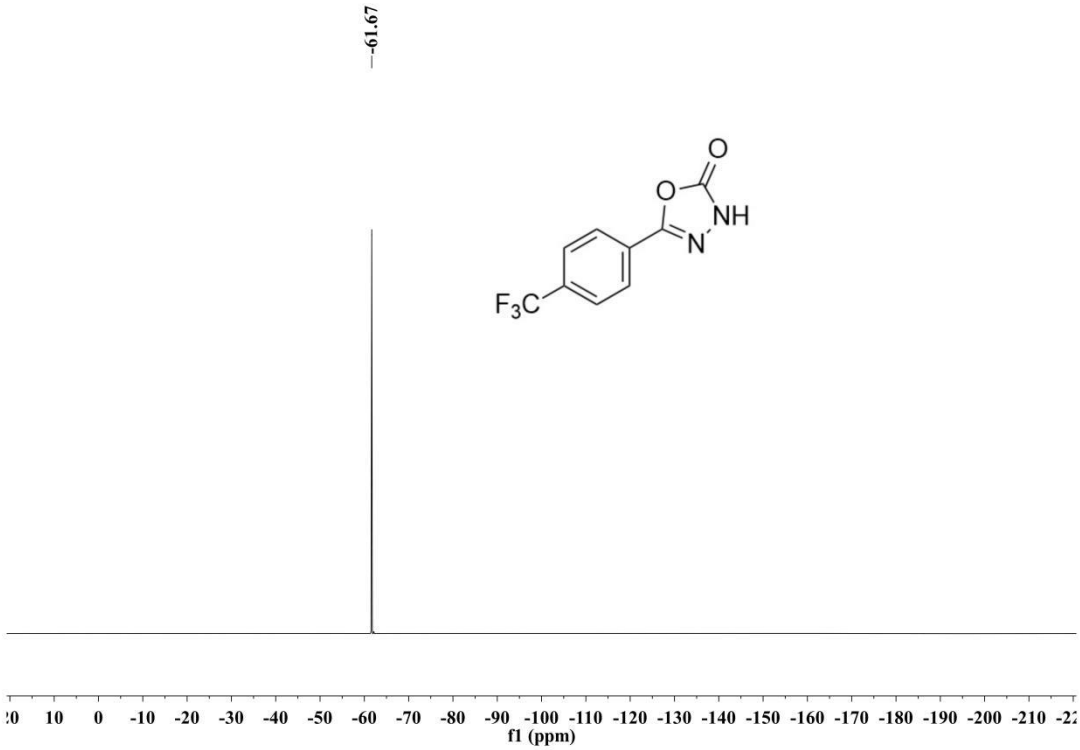
^{1}H NMR spectrum of 2s (500 MHz, DMSO)



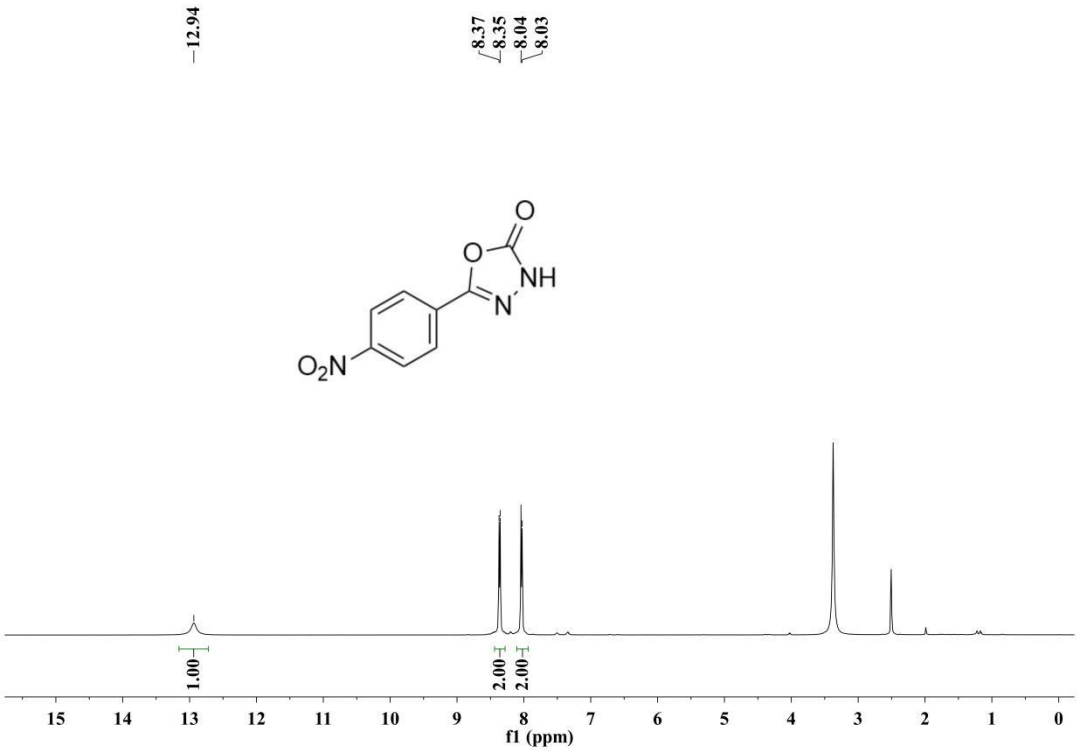
$^{13}C\{^{1}H\}$ NMR spectrum of 2s (125 MHz, DMSO)



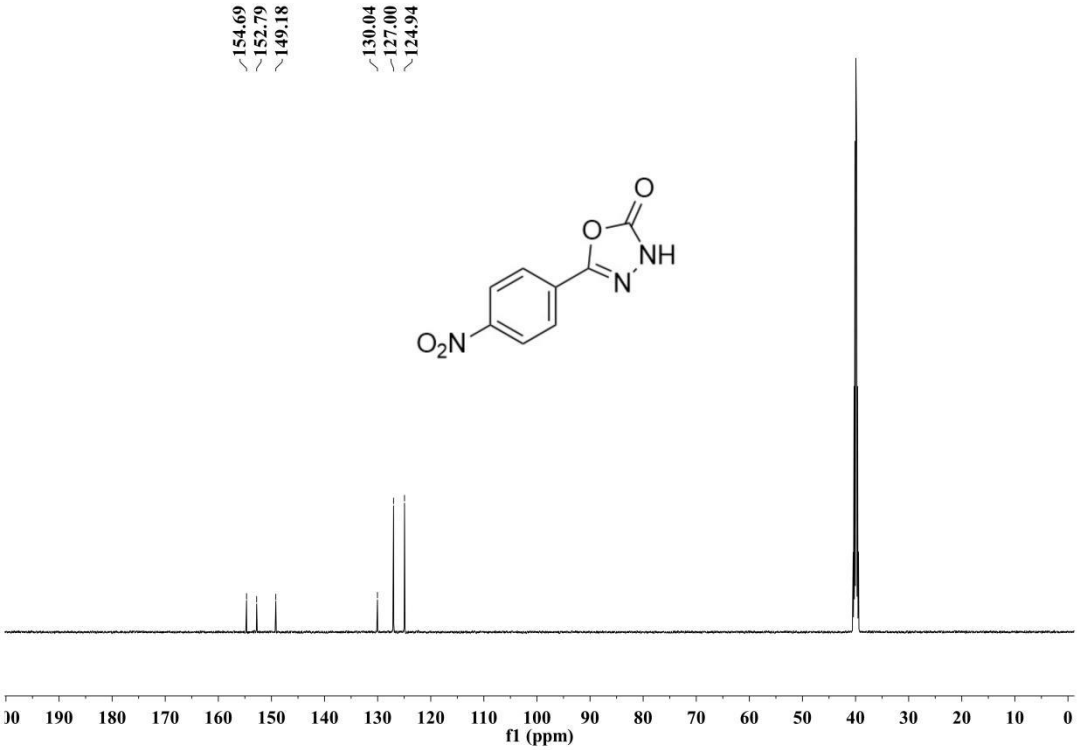
^{19}F NMR spectrum of of 2s (125 MHz, DMSO)



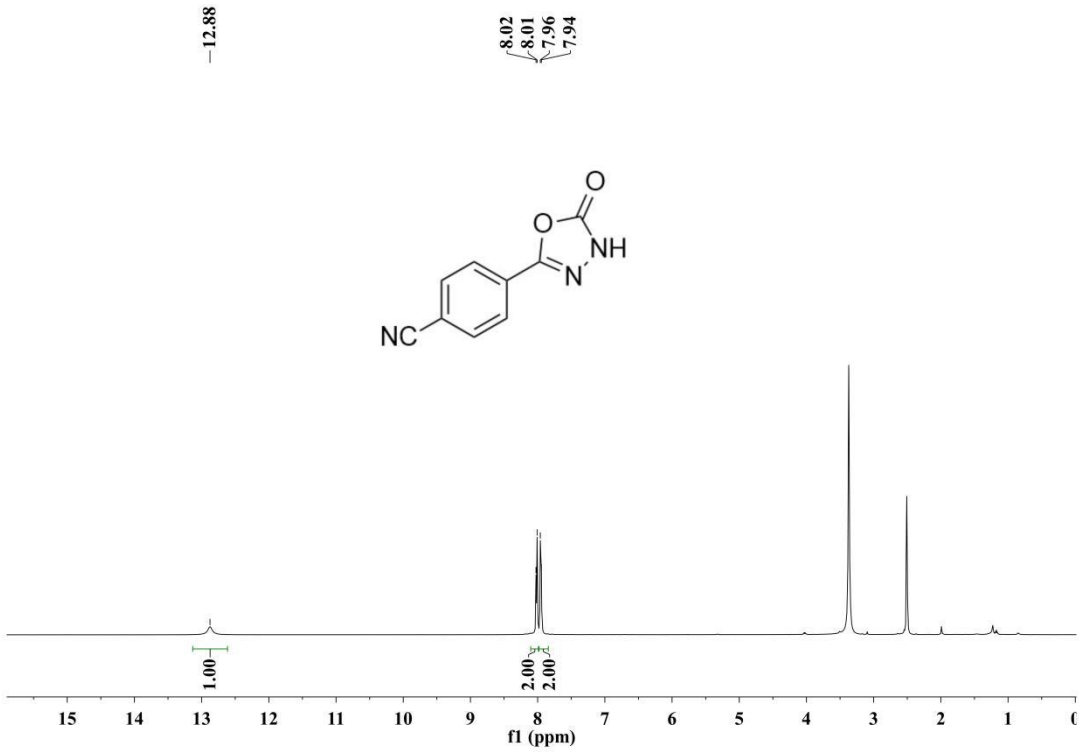
^{1}H NMR spectrum of 2t (500 MHz, DMSO)



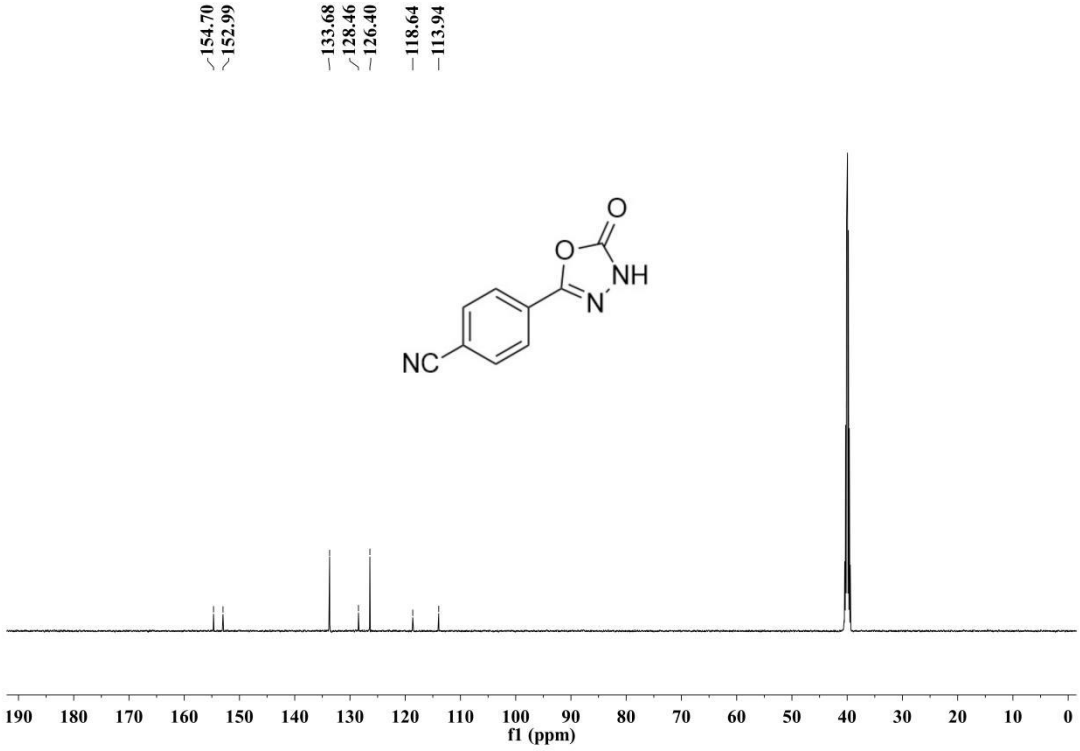
^{13}C{^{1}H} NMR spectrum of 2t (125 MHz, DMSO)



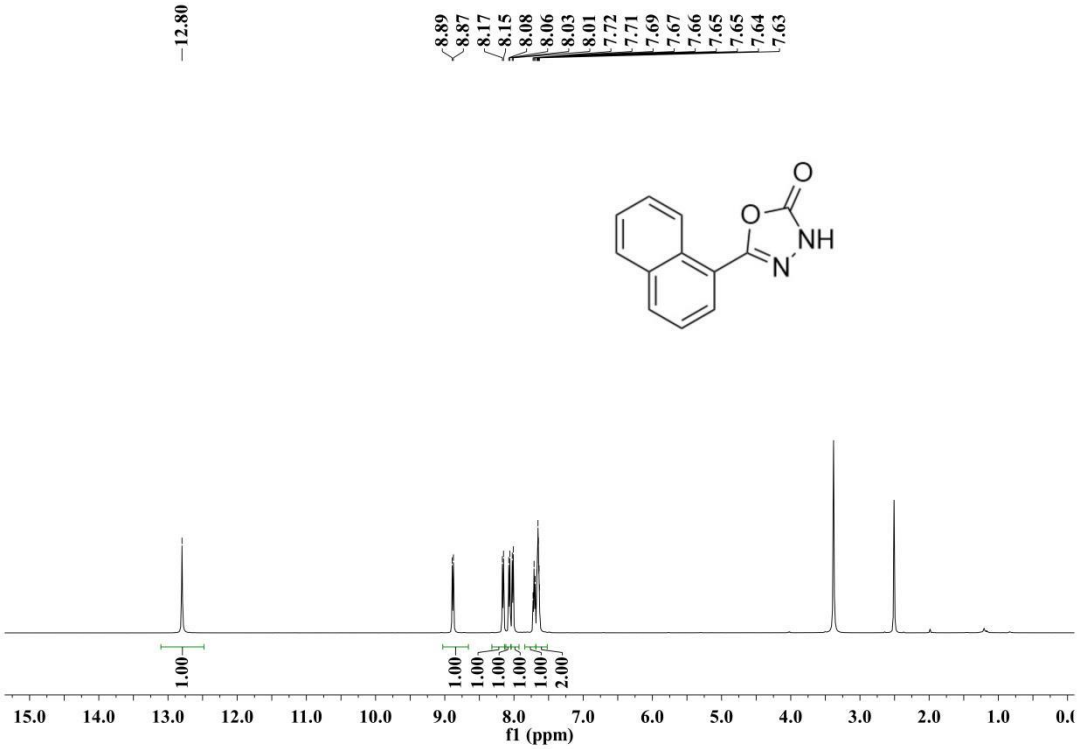
^{1}H NMR spectrum of 2u (500 MHz, DMSO)



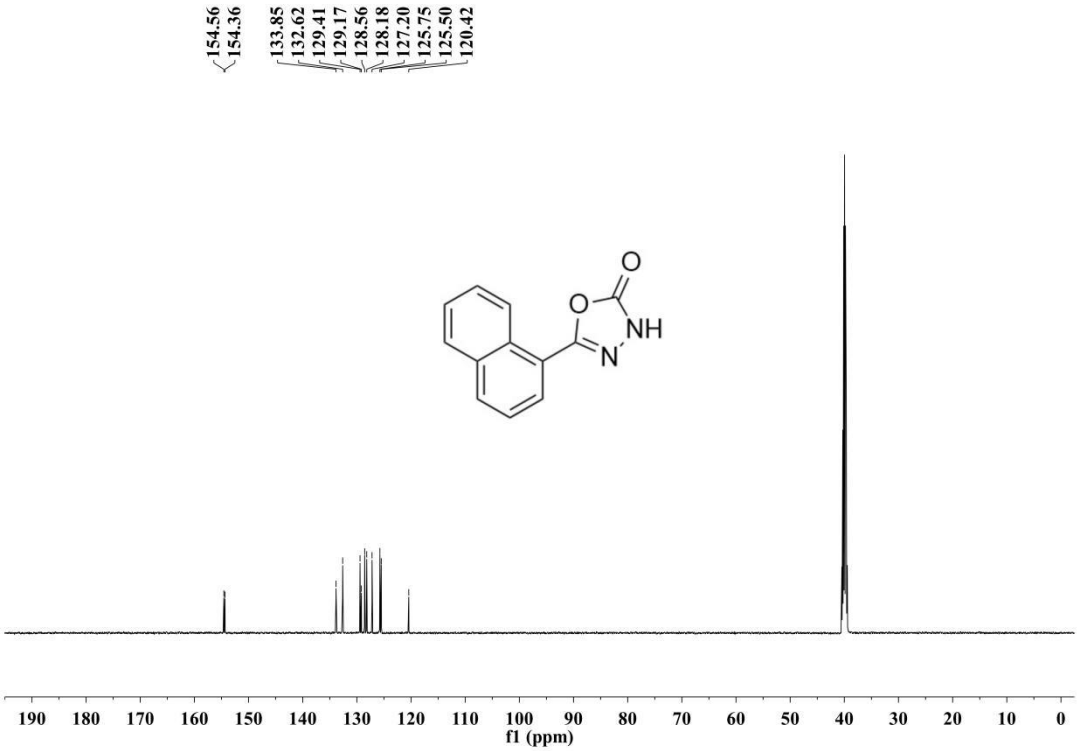
^{13}C{^{1}H} NMR spectrum of 2u (125 MHz, DMSO)



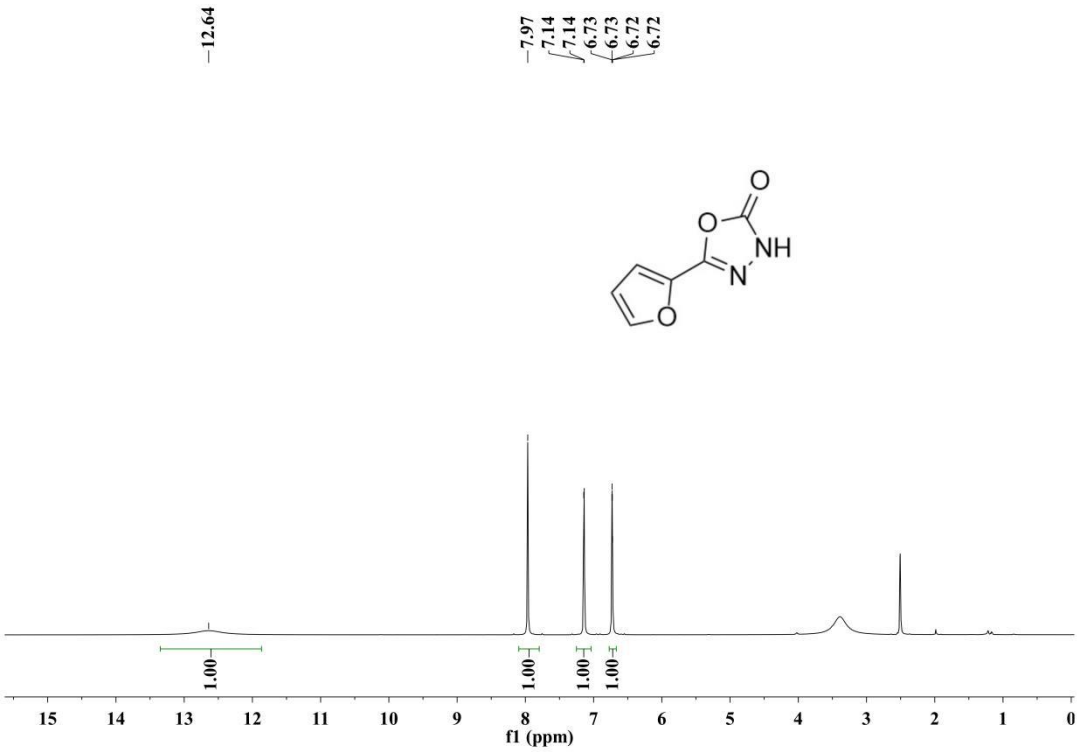
^{1}H NMR spectrum of 2v (500 MHz, DMSO)



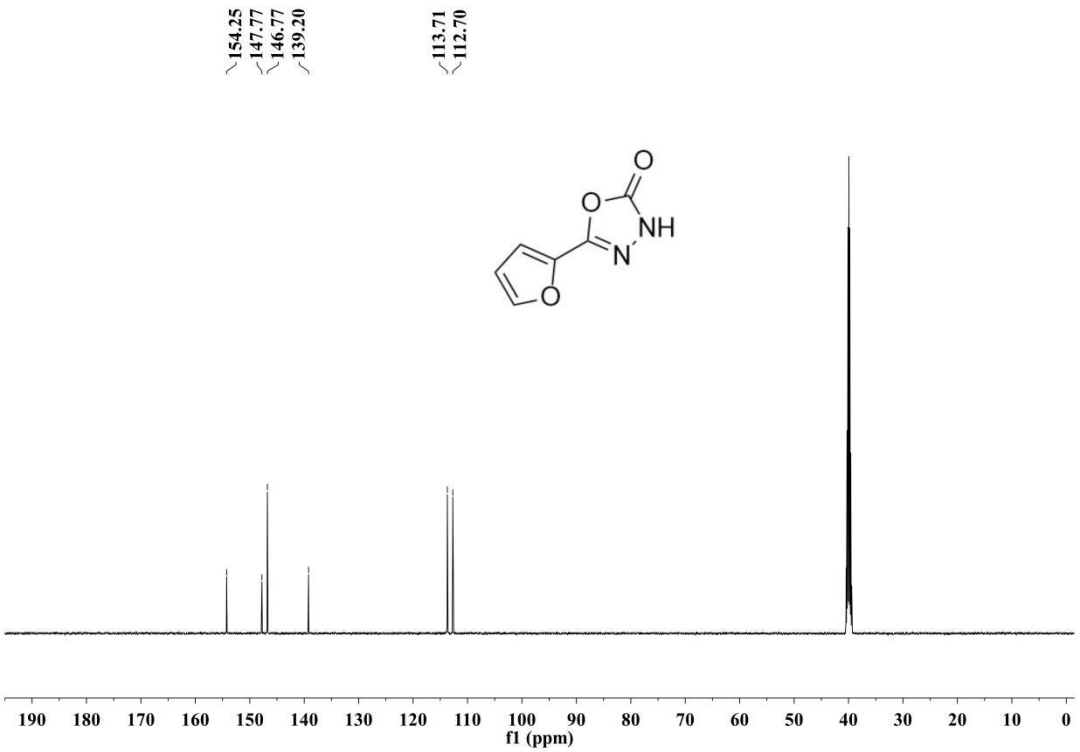
^{13}C{^{1}H} NMR spectrum of 2v (125 MHz, DMSO)



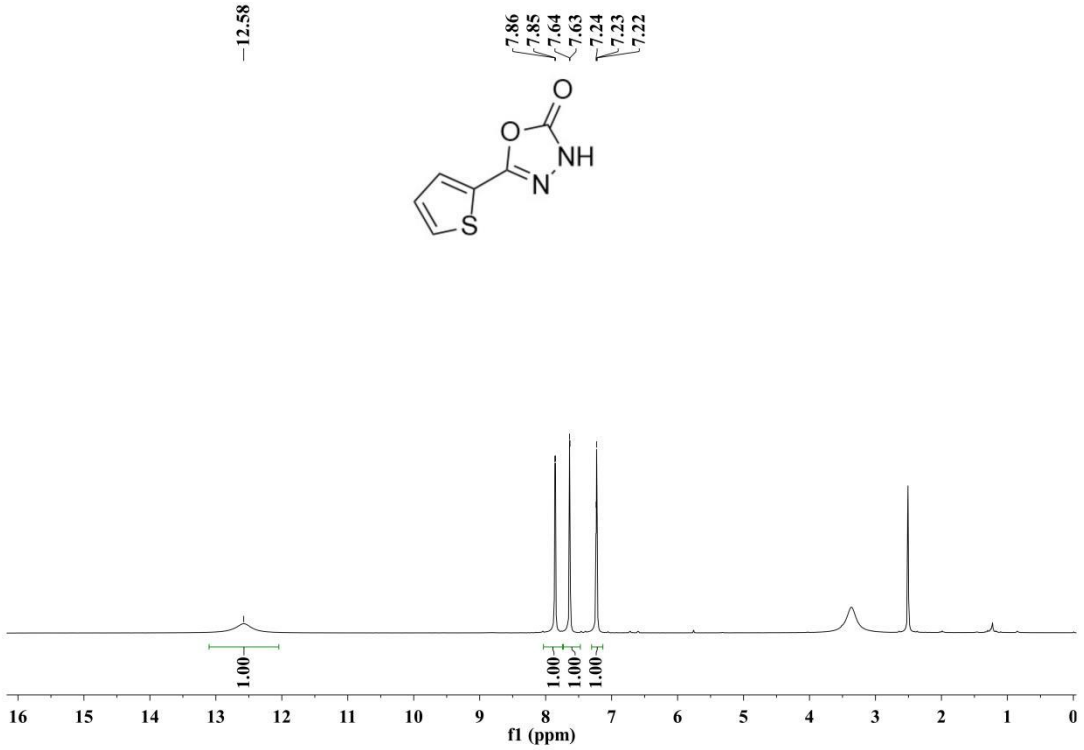
^{1}H NMR spectrum of 2w (500 MHz, DMSO)



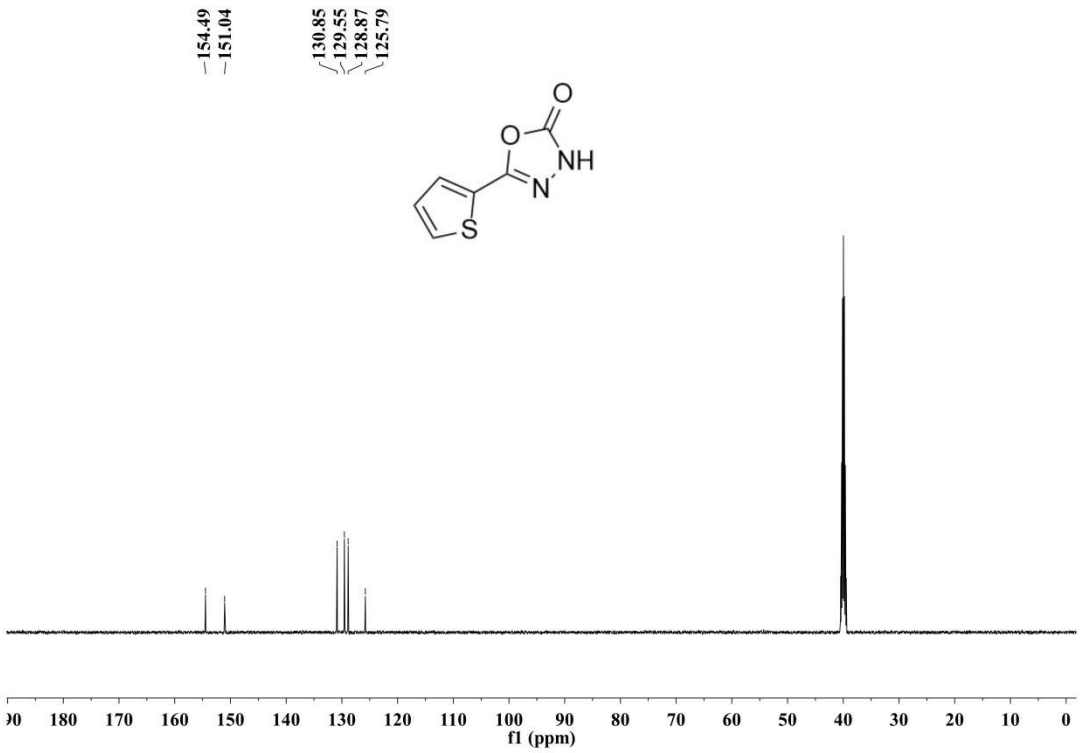
^{13}C{^{1}H} NMR spectrum of 2w (125 MHz, DMSO)



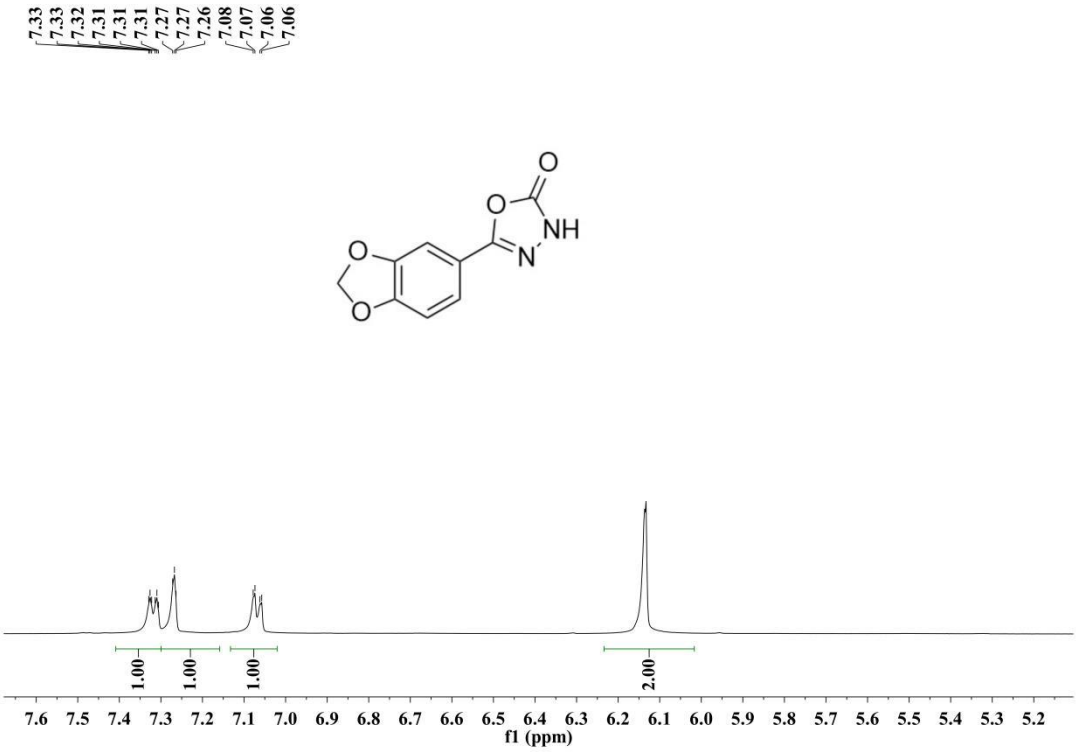
^{1}H NMR spectrum of 2x (500 MHz, DMSO)



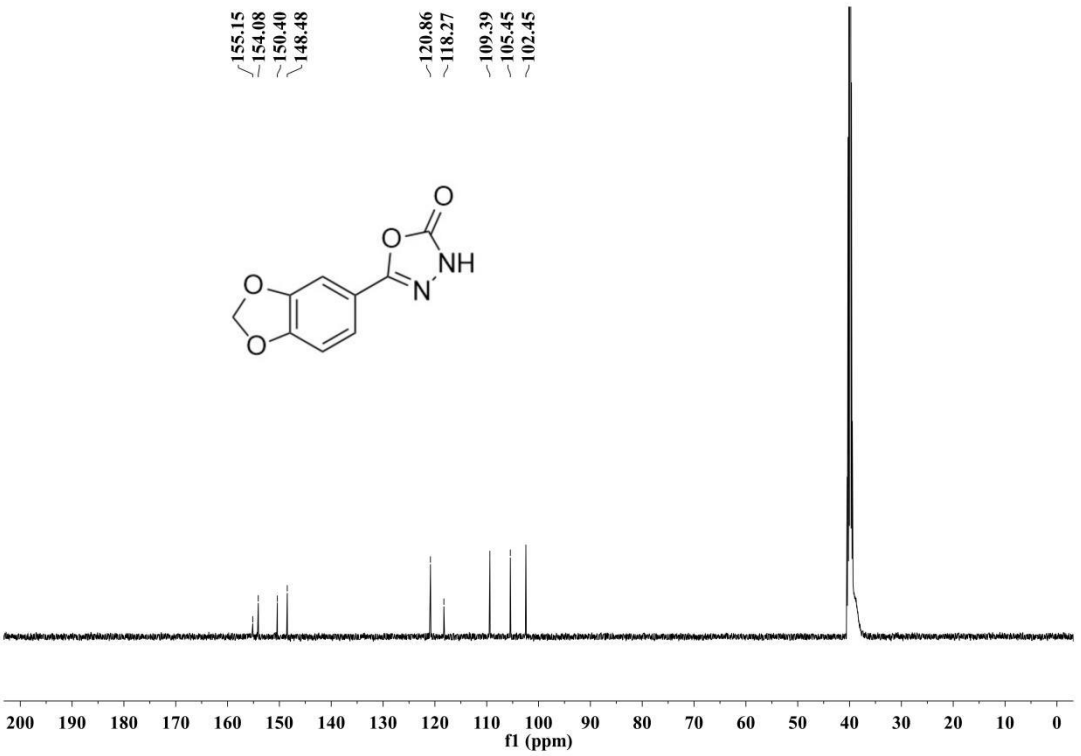
^{13}C{^{1}H} NMR spectrum of 2x (125 MHz, DMSO)



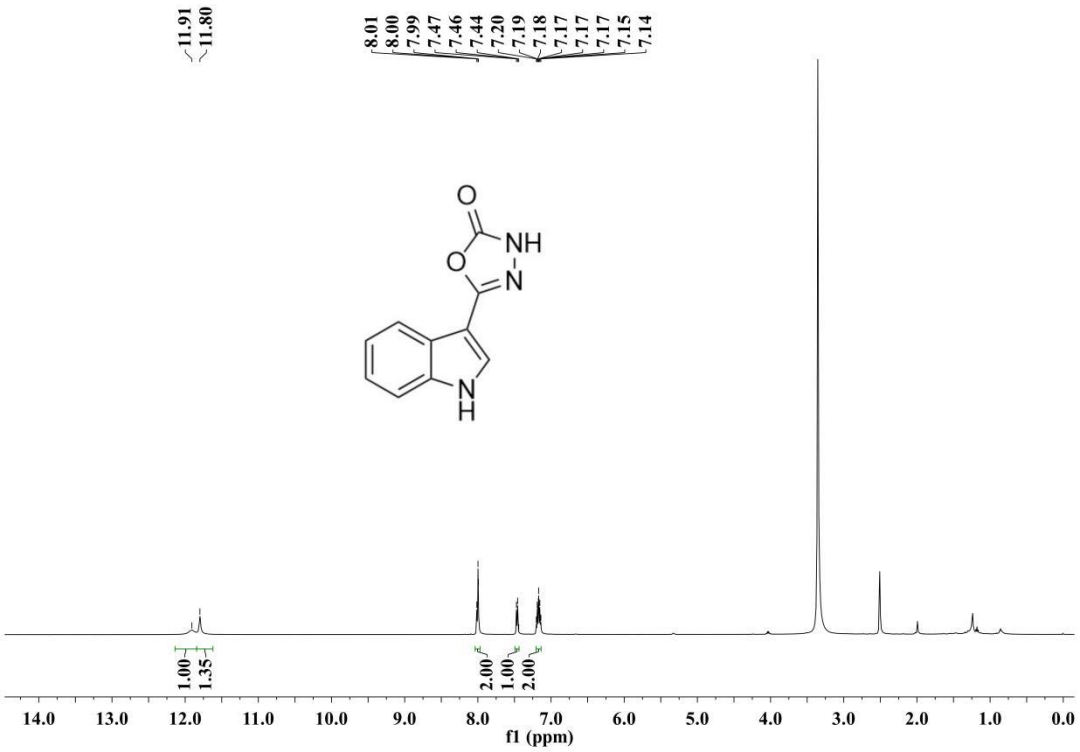
^{1}H NMR spectrum of 2y (500 MHz, DMSO)



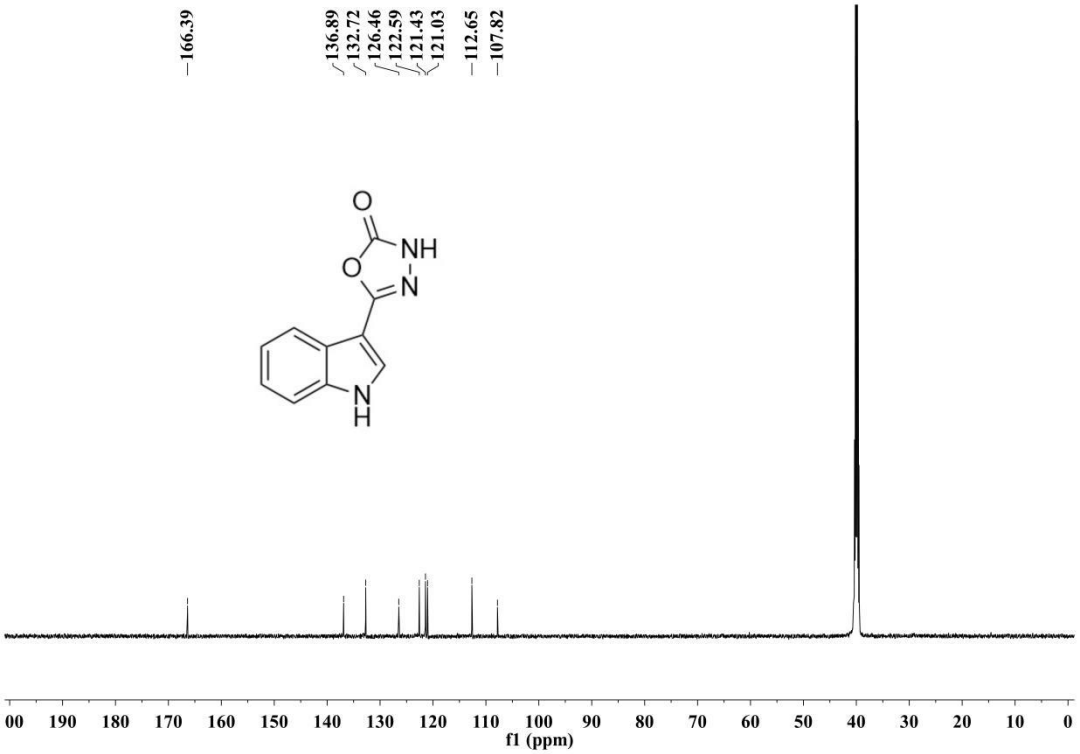
^{13}C{^{1}H} NMR spectrum of 2y (125 MHz, DMSO)



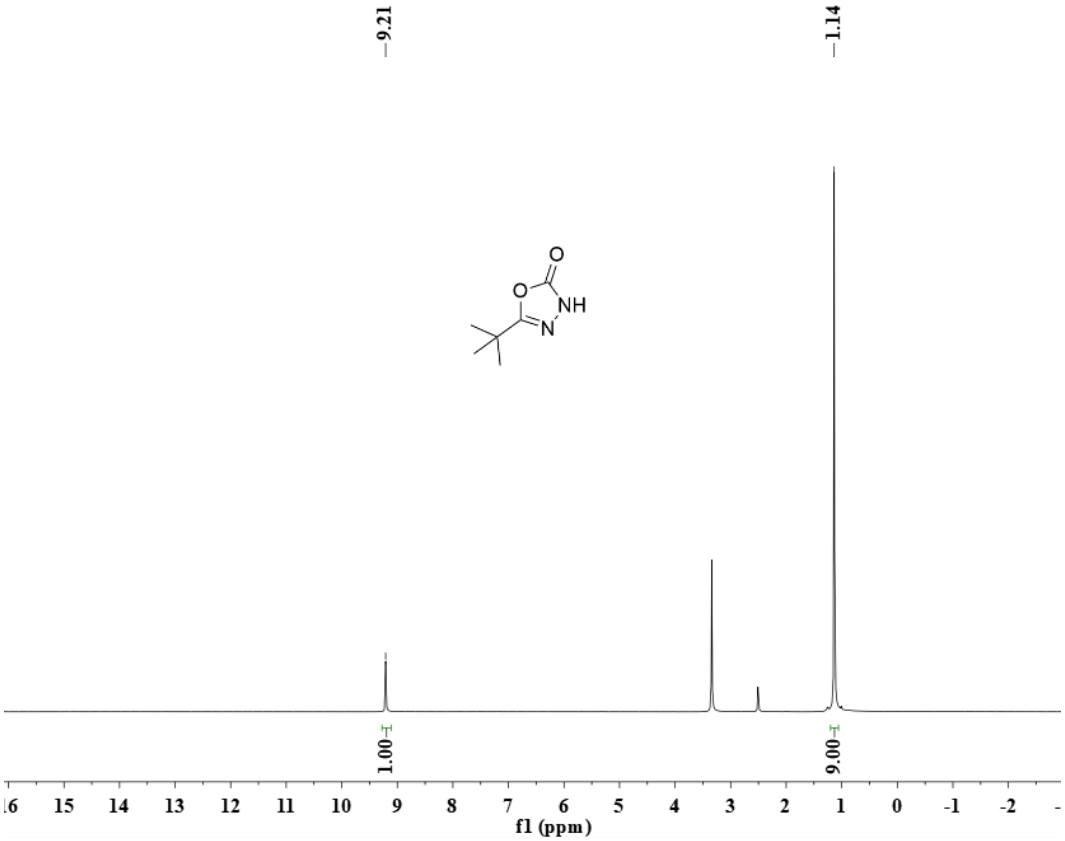
^{1}H NMR spectrum of 2z (500 MHz, DMSO)



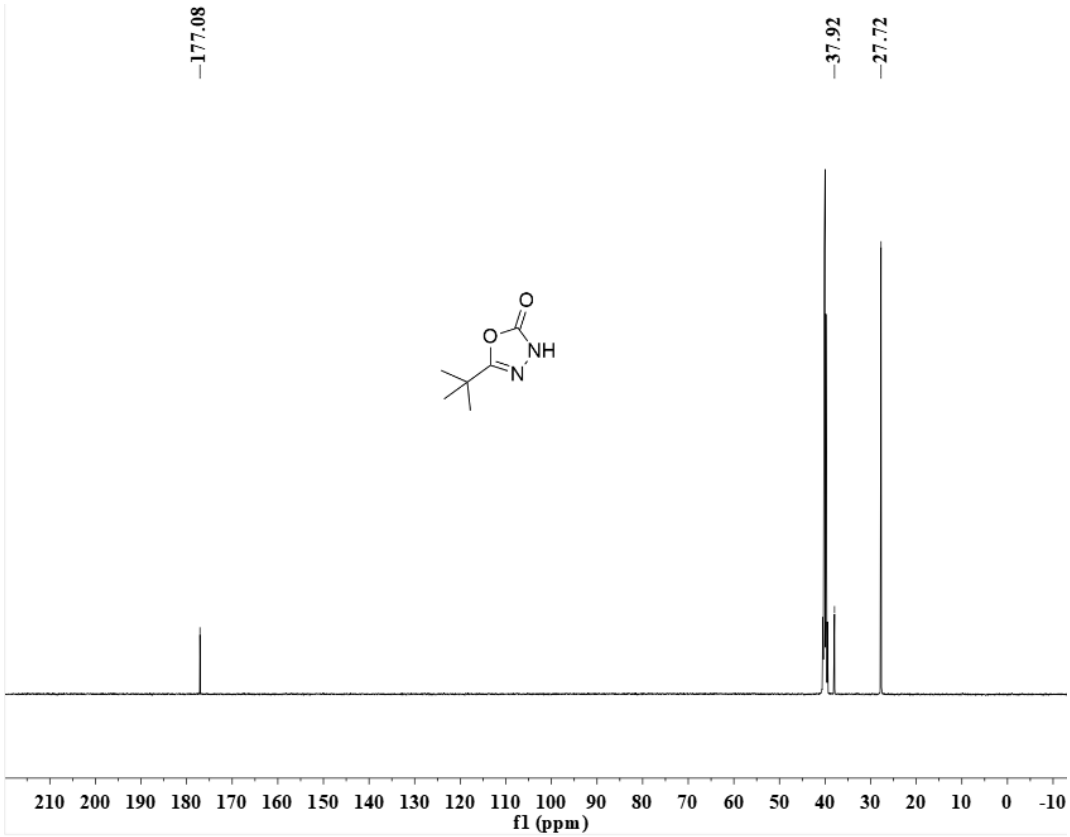
^{13}C{^{1}H} NMR spectrum of 2z (125 MHz, DMSO)



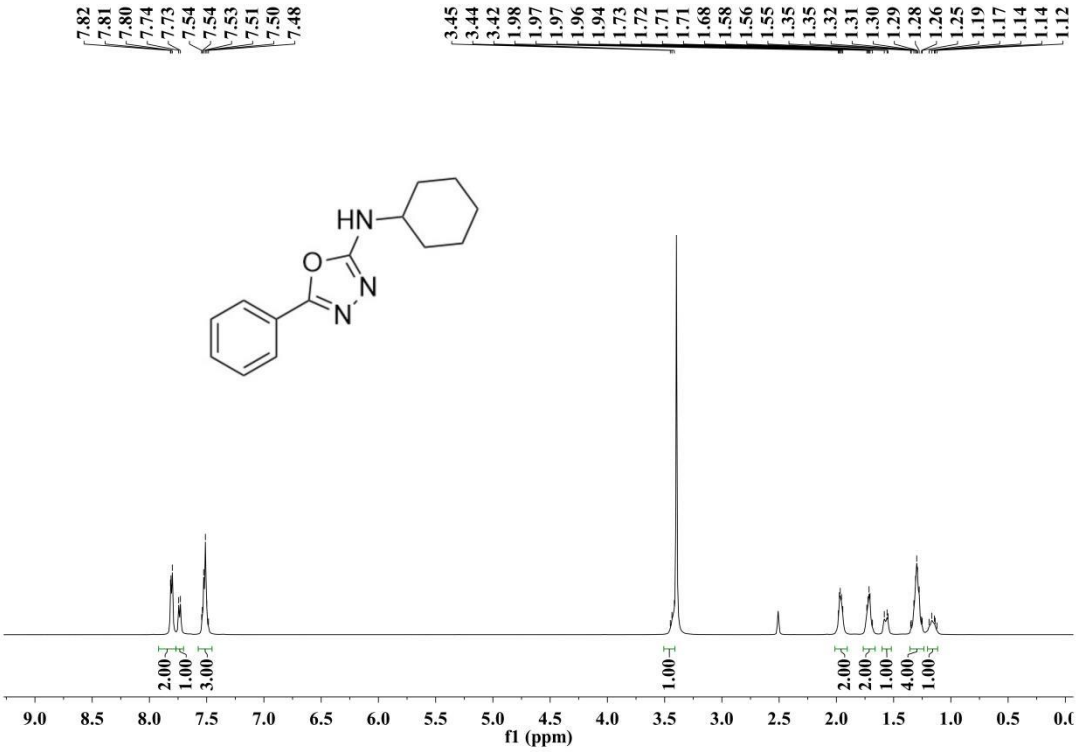
^{1}H NMR spectrum of 2aa (500 MHz, DMSO)



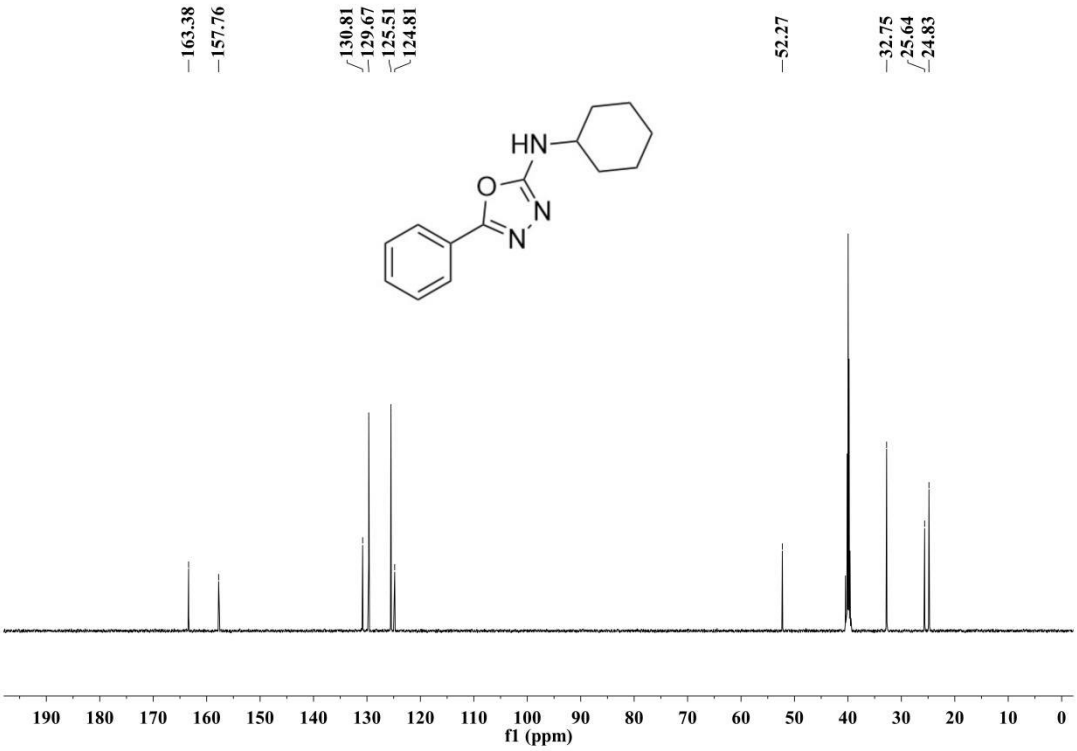
^{13}C{^{1}H} NMR spectrum of 2aa (125 MHz, DMSO)



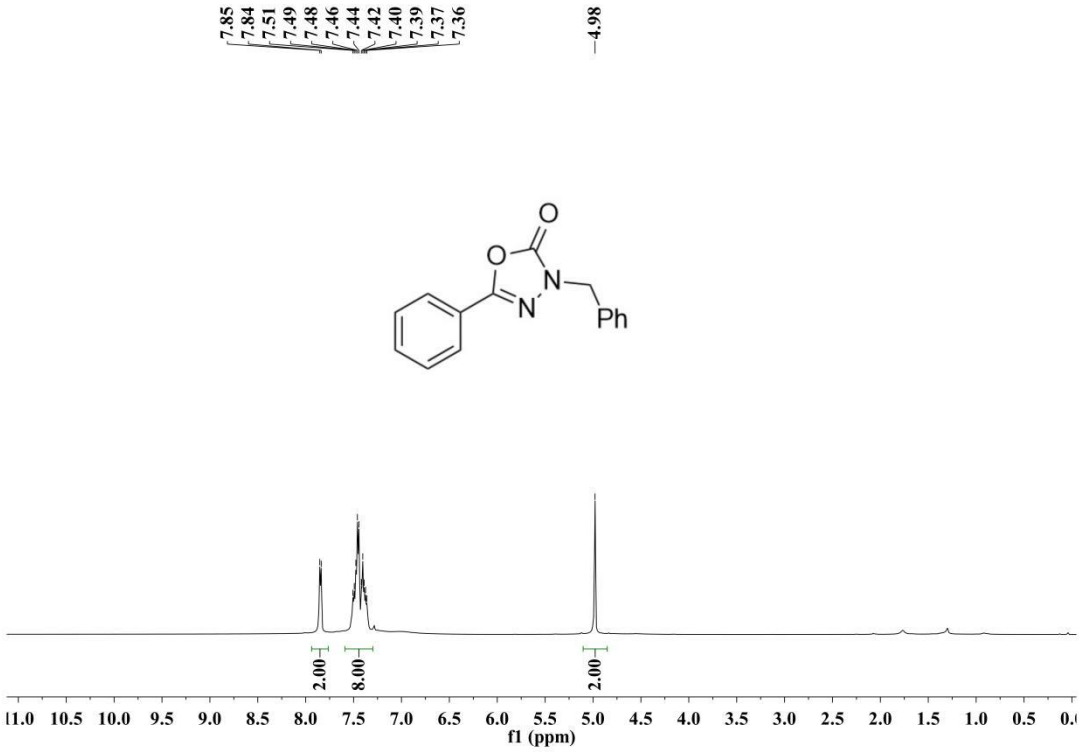
^{1}H NMR spectrum of 3a (500 MHz, DMSO)



^{13}C{^{1}H} NMR spectrum of 3a (125 MHz, DMSO)



^{1}H NMR spectrum of 3b (500 MHz, DMSO)



^{13}C{^{1}H} NMR spectrum of 3b (125 MHz, DMSO)